Renewable Energy

How trade policy supports deployment and value addition in developing countries

International Trade Centre

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About the paper

This paper explores global trade in solar photovoltaic and wind energy components, analysing trade flows, tariffs and non-tariff measures, with a focus on seven developing countries: the Dominican Republic, Ecuador, Kenya, Mauritius, the Philippines, Senegal and Viet Nam.

The main findings are that low tariffs have reduced the cost of renewable energy deployment by enabling access to affordable imports. The analysis offers policy options for developing countries, including stronger regulatory frameworks, investment in export market knowledge, regional market expansion and capacity building in customs and standards. Trade agreements can also attract foreign investment and ease market entry of experts.

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Foreword

The warnings are growing fast, both in number and fervour: the window to stay within the Paris Agreement's 1.5°C temperature limit is narrowing and, with it, the prospects of ensuring that future generations will not have to face the most calamitous impacts of a warming planet. This threat is not just on some distant horizon; countries around the world are already experiencing previews of the potential devastation to come, amid natural disasters and shifting weather patterns that are disrupting lives and livelihoods.

This is a toll that, while felt by all, affects some more harshly than others. As United Nations Secretary-General António Guterres told leaders at the start of the World Climate Action Summit in December 2023, 'Climate chaos is fanning the flames of injustice.' There are, however, tried and tested solutions, he noted, including renewable energy, 'the gift that keeps on giving'.

There are indeed promising developments on the renewable energy front. Today, solar photovoltaic (PV) and wind technologies play a leading role in new electricity capacity installations. At the level of international policy, governments at the United Nations Framework Convention on Climate Change 28th Conference of the Parties (COP28) issued a clear signal in favour of these technologies. In the final decision for the first Global Stocktake under the Paris Agreement, the treaty's parties called for increasing renewable energy capacity three-fold by the end of this decade.

How this commitment will translate into practice over the coming years – including in new and updated nationally determined contributions – remains to be seen. Despite major strides forward, including the move by many governments to set their own renewable energy targets, significant limitations remain to deploying renewable energy installations at a faster pace.

This paper is part of the International Trade Centre's (ITC) contribution towards helping governments tackle those limitations and get closer to achieving that COP28 renewable energy goal. Using ITC Trade Map, the paper analyses the trade in solar PV and wind system components and how it can help improve access to these components and services while building value in supply chains in developing countries.

The authors' use of case studies shows that there are already best practices from which to draw. Additionally, the recommendations in this paper show clearly that trade has an important role to play in supporting faster renewable energy deployment, especially in developing economies.

Pamela Coke-Hamilton
Executive Director
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Contents

BOXES, FIGURES AND TABLES

Acronyms

Unless otherwise specified, all references to dollars ($) are to United States dollars. Percentages may not add up to 100% due to rounding.

COP28	28th Conference of the Parties
APEC	Asia-Pacific Economic Cooperation
ASEAN	Association of Southeast Asian Nations
CPC	Central Product Classification
EU	European Union
FTA	Free trade agreement
GATS	General Agreement on Trade in Services
GDP	Gross domestic product
GW	Gigawatt
HS	Harmonized System
IEA	International Energy Agency
IISD	International Institute for Sustainable Development
IRENA	International Renewable Energy Agency
ITC	International Trade Centre
MSMEs	Micro, small and medium-sized enterprises
MFN	Most-favoured nation
NTMs	Non-tariff measures
PV	Photovoltaic
QI4SD	Quality Infrastructure for Sustainable Development
RE	Renewable energy
TBT	Technical barriers to trade
TESSD	Trade and Environmental Sustainability Structured Discussions
WTO	World Trade Organization

Executive summary

There is an urgent need to reduce greenhouse gas emissions across the global economy. The energy sector is the largest contributor to man-made emissions, responsible for around 75% of the total. To meet their international climate change commitments, countries need to decarbonize their energy production while working to electrify the economy.

This paper analyses the role of trade policies in improving the availability of components for renewable energy (RE) in developing countries and thus deployment as well building local value in supply chains. It describes the global trade in solar photovoltaic (PV) and wind energy system components, highlighting the opportunities this provides to developing countries.

The paper also analyses trade trends and tariff/non-tariff market access requirements in seven developing countries: Dominican Republic, Ecuador, Kenya, Mauritius, the Philippines, Senegal and Viet Nam. Based on the findings, the paper presents recommendations for trade policy to RE deployment, value addition and export promotion from developing countries.

Chapter 1 outlines that the rapid deployment of RE technologies is a core component to achieve this decarbonized electrification goal. Solar photovoltaic and wind (onshore and offshore) technologies accounted for 91% of new RE installations in 2022. They are mature technologies and cost-competitive against fossil fuel energy systems.

Investment in clean energy must be tripled by 2030 from the average over 2016–20. There is also a need for large investment in energy infrastructure. Removing fossil fuel subsidies improves the competitiveness of renewables compared to energy derived from fossil fuels, while delays in connecting to the grids hamper deployment.

Trade and trade policy also have a role to play to deploy renewables. Reducing tariffs lowers the costs for project developers to access components of RE systems. Harmonization and mutual recognition of standards can facilitate smooth flow of RE goods across borders.

Chapter 2 analyses the manufacture, import and export of utility-scale solar PV and wind system components and explores global trends for developing countries in 2013–22. The analysis shows that the components of solar PV and wind energy are either specialized or less specialized, with the latter in particular offering opportunities for developing countries to develop a manufacturing sector and export.

For solar PV systems: Developing countries, mostly China, have doubled their solar PV component exports, cutting costs and reshaping global supply chains. China's market shares ranged from 74% to more than 96% for 'upstream' products in 2021. Other developing countries, including Viet Nam and Malaysia, emerge as key exporters of specialized components, capturing 9% and 6% of the market share, respectively.

Developing countries other than China accounted for 30% of global market share. Further, developing countries' (excluding China) imports of less specialized components rose, particularly inverters and electrical components. This surge of more than 67% illustrates an early stage in their RE deployment.

For wind systems: Developed countries and China dominate manufacturing and trade in turbines and rotor blades. China, Germany and Denmark are the three largest exporters of specialized components. Developing countries (excluding China) are rising contributors by value to exports of less specialized wind energy components, i.e. structure and electrical cables. Mexico and Viet Nam emerge as key exporters of towers. Developing countries have also steadily increased imports of less specialized components.

Chapter 3 examines the trade in RE goods and services in seven developing countries. These countries were selected based on their participation in the International Trade Centre's Climate Competitiveness project. The main findings from the analysis show:

- Low tariffs, either most-favoured nation or those offered under various unilateral or bilateral trading arrangements, have eased the deployment of RE technologies by facilitating access to affordable imports. A case in point is Viet Nam, where duty-free imports of solar cells from China helped establish a large solar module industrial base.
- Several factors explain the growth of Viet Nam's solar panel manufacturing industry and can offer valuable insights for other developing countries. These include low import tariffs on upstream products (as mentioned above), large investments made by United States-based and China-based firms, a good national quality infrastructure and tariff exemption on Vietnamese solar panels offered by the United States.
- The seven case study countries face various non-tariff, regulatory measures when exporting to current and promising export markets. Some regulations are also applied at home (on both exports and imports). To address the trade barriers that these measures represent and to tap into export opportunities – only a fraction of which are being realized – a solid national regulatory framework, compliance capacity, quality infrastructure and capacity building for laboratory personnel as well as customs officials are vital.

  Further, better regulation and standards are key to facilitating imports of high-quality inputs and assure quality along the value chain.
- Exports of RE components by most of the seven case study countries are largely regional. There lies considerable promise for further expansion of exports within regions and in other neighbouring markets. This points to the relevance of regional trade agreements and shows that there would be value to incorporating provisions on RE goods and services in them.
- High-tech, specialized components such as solar modules, wind turbines and rotor blades are promising for countries with well-established manufacturing sectors. However, smaller countries can also expand their footprint in global value chains by building capacity to manufacture less specialized components including electric cables and inverters.

Based on these findings, **Chapter 4** outlines possible policy actions for developing countries to speed up deployment and add value.

A key step in this direction would be for these countries to establish a national regulatory framework to ensure safety, quality and performance of domestically produced as well as imported goods. Countries should also invest in understanding regulatory requirements in promising export markets by enabling access to market intelligence tools for businesses so they can identify export opportunities and regulatory requirements in important markets. Countries must encourage engagement with manufacturers and traders to understand obstacles to exports of RE goods that they commonly face in their key markets or at home.

Given that regional markets present opportunities, an emphasis on harmonization and mutual recognition of standards and conformity assessment procedures and a solid regional quality infrastructure network can both promote and facilitate trade. This must go hand in hand with building capacity and skills of customs, national standards bureau, laboratory staff and relevant government agencies such as environmental ministries to facilitate the smooth flow of RE goods.

Trade agreements must be leveraged to promote foreign investments in concerned RE sectors as well as easy entry of professionals and experts.

When used effectively, tariff and non-tariff trade tools can encourage easy access to RE goods (imports) as well as access to promising markets (exports). To the extent possible, developing countries should try to negotiate these requirements effectively under various trade agreements.

The study identified future research priorities, including preparing examples of success stories of developing countries integrating into value chains for RE products and services, the impact of trade policies on the supply of critical minerals and implications for RE deployment, and the role of quality and standards infrastructure in the establishment of competitive assembly, manufacturing and export sectors.

CHAPTER 1

Renewable energy deployment and value addition

Renewable energy deployment and value addition

Case for renewable energy

There is an urgent need to cut global greenhouse gas emissions to mitigate climate change. The energy sector is the largest contributor to anthropogenic greenhouse gas emissions, responsible for around 75% of total emissions (World Resources Institute, 2020).

The Intergovernmental Panel on Climate Change's *Sixth Assessment Report* notes that solar photovoltaic (PV) and wind are technically viable and cost-effective technologies. According to the International Renewable Energy Agency (IRENA), solar PV and wind technologies accounted for 91% (267 gigawatts [GW] out of 295GW) of new renewable energy (RE) installations in 2022 (IRENA, 2023).

RE also contributes to a wide range of other benefits compared to alternatives (notably fossil fuel-based generation), including employment, increased energy security, reliability and resilience, stable costs of electricity and improved public health (IRENA, 2016; Union of Concerned Scientists, 2017).

The International Energy Agency's (IEA) net-zero scenario estimates that a tripling of investment by 2030 in clean energy is needed from the average over 2016–20. Large investment is also needed in energy infrastructure, which includes investment in electricity grids as its major component. However, developing countries face budgetary constraints. Delays in connecting to the grids and delaying in planning permits also hamper deployment.

Nonetheless, growth in renewables creates opportunities for developing countries. Solar PV and wind energy systems are characterized by low- and highly specialized components and supporting services. Low-specialized components in particular offer opportunities for developing countries to build domestic manufacturing capacity and develop regional and international export.

The International Institute for Sustainable Development (IISD) highlights opportunities to produce locally and create value in 'ancillary components or services, such as structures, mounting equipment, electrical components, and civil work for renewable energy projects and blades, as well as foundation, cabling, maintenance, repair and civil work for wind energy projects' (IISD, 2021).

Trends in solar PV and wind components trade

Solar PV and wind energy systems are made up of specialized and non-specialized components (known as the bill of materials) that contribute to the cost of the installation. These are subject to different tariff and non-tariff market access requirements and have different export potential in each country. Hence, a need to closely identify and describe them:

Solar PV components and costs

The bill of materials for a typical utility-scale solar PV installation includes modules, inverter, structure and electrical components.[1] See Appendix XVI for an illustration.

As described in Table 1 below, solar PV modules represent 30%–50% of total costs and are imported in most countries. Around 10% each of these costs are for the inverter, the structure and other electrical components. These categories could be supplied locally or imported.

Civil work also represents around 10% of costs and is sourced locally. The goods identified in the category of solar PV modules (or unassembled PV cells) can only be used for this purpose, i.e. there is no 'dual use'.[2] As we move down the list to structural parts and electrical goods, the uses of the goods become less specialized and are common to many other uses beyond solar PV systems. Civil works are generally sourced locally.

Table 1 Bill of materials for a typical utility-scale installation

Components and component services, including operation and maintenance	HS6 Code (2022)	Indicative percentage of balance of materials	Usual sourcing
Solar PV modules[3]	8541.42; 8541.43 (2022). 8541.40 (pre-2022)	30–50	Global
Inverter	8504.40; 8504.90	5–10	Global/local
Structure (racking & mounting)*	7005.10; 7007.19; 7009.91; 7610 (7610.90 is 'Aluminium frames')	7–10	Global/local
Electrical	8544	3–11	Global/local
Civil work (including instrumentation and control, engineering, procurement and construction contracts)	Includes: 9028.30, 9030.31, 9030.32, 9030.82 (monitoring and control systems)	7–13	Local

Source: IISD, 2021, updated to include Harmonized System (HS) Code 2022 revisions. Codes in italics are from the HS Code list of 2017 (https://www.wcotradetools.org/en/harmonized-system). *Additional codes from work on value chains by the United Kingdom as presented during Trade and Environmental Sustainability Structured Discussions (TESSD), 16–17 March 2023 (https://www.wto.org/english/tratop_e/tessd_e/tessd_e.htm) includes also: Sheets – EVA (3920.10), Back (3907.61, 3907.62); Copper stringing (7408.19, 7419.80); String connectors (8544.49); J-box (8536.90); Potting agent (3907.30); Silicon Sealant (3910.00). British materials presented to TESSD also include diagrams showing the goods and services needed for the production of solar PV modules in detail (https://docs.wto.org/dol2fe/Pages/SS/directdoc.aspx?filename=q:/INF/TESSD/W23.pdf&Open=True).

Wind turbines

The main components of a wind turbine installation are turbine blades, the turbine, the nacelle and the tower (see Appendix XVII for an illustration). Table 2 shows the bill of materials for a wind turbine installation. The top two rows of the table show goods that are mostly specific to wind energy projects. The goods covered by the HS codes become less specific in their potential uses as we move down the table.

The turbine typically accounts for around 18% of total costs and is high tech, sourced from specialist global manufacturers.[4] The rotor blades are also highly specialized, featuring a variety of composites and other advanced materials.

Both the rotor blades and tower comprise around 15% respectively of costs and, depending on a country's manufacturing capacity, can be sourced locally or imported. Approximately 25%–50% of costs are typically sourced locally.

Table 2 Bill of materials for an onshore wind turbine installation

Components and component services incl. operations and maintenance	HS code (2022)	Indicative percentage of balance of materials	Usual sourcing
Wind turbine including generator, gearbox and nacelle	8502.31; 8483.40	~18	Global
Rotor blades incl. ball bearings, hubs	8412.80; 8412.90	13–15	Global/local
Tower	7308.20	16–18	Global/local
Transformer, power convertor	8504	~2.3	Global/local
Electrical	8544; 8537; 9028.30; 9032	10–13	Local
Civil work (incl. foundation, instrumentation and control, engineering procurement and construction contracts, transportation)	Includes: 9028.30 (Electrical equipment: meters); 9015.80 (Meteorological equipment/ sensors)	15–37	Local

Note: Analysis based on International Renewable Energy Agency (IRENA), 2017, 2020a, 2020b

Source: IISD, 2021. HS Codes (2022) from World Trade Organization [WTO], 2023)

Services supporting the RE project cycle

Services are required across the RE project cycle from development, construction and installation through to operations, maintenance and decommissioning. Certain services may be unavailable in some countries, representing a barrier to the development of RE projects (WTO, 2023). UN Trade and Development (2023) notes that, 'international trade in services can allow a broader sourcing of quality, reliable and affordable services that are relevant inputs to the energy sector's transition to sustainable energy'.

The WTO's Trade and Environmental Sustainability Structured Discussions present a general and indicative list of services '… important for the development, installation, operation and decommissioning of renewable energy projects' (WTO, 2024) (Table in Appendix XV).

This includes the relevant Central Product Classification (CPC) codes and descriptions of what these categories of services refer to. The CPC is used as a common classification for services[5], analogous to HS codes for goods. Other environmental services lists exist, for example, the European Union's (EU) free trade agreement (FTA) with New Zealand; Singapore Australia Green Economy Agreement, the Organisation for Economic Co-operation and Development (OECD), and Asia-Pacific Economic Cooperation (APEC).

Services are 'embedded in the planning and development of renewable energy projects' and are wide-ranging. It is also notable that services are often provided together with goods. For example, a provider of equipment would frequently source both the goods and the services required.

The WTO (2023) notes that the dominant mode of supply for renewable energy services is the establishment of a commercial presence by a foreign investor (Mode 3), while the movement of natural persons (Mode 4) is, 'particularly important for the construction, installation, maintenance and repair of renewable energy facilities'. UN Trade and Development (2023) notes the increasingly important role played by information and communications services for the automation of energy systems and data analytics. The fact that these two modes of supply are predominant also offers interesting opportunities for developing countries.

Indeed, commercial presence (Mode 3) amounts to foreign services suppliers investing in third countries to develop a local establishment, thereby bringing capital and expertise and contributing to economic development and capacity building in the concerned countries. In turn, movement of natural persons (Mode 4) allows experts and technicians to travel and participate in the development of local projects. This often results in knowledge transfers and in local staff upskilling.

Services inputs constitute 20%–25% of the total production costs in a company's PV production process, primarily due to its focus on mid-value chain activities such as solar cell production and module assembly (ITC, 2015). Material inputs make up 75% of the total costs.

Services make up a greater share of costs in higher value-added activities, such as solar power plant construction. This is also the case for the development of other RE technologies including offshore wind power, where services (engineering, construction, maritime transport, repair and maintenance, etc.) represent a substantial share of the cost structure.

Trade and trade-related policies supporting renewables deployment

A range of trade policies support the promotion of trade in renewable energy goods and services. A review by TESSD (2023) (see Appendix II) includes inter alia the following policies with respect to services:

- Improving regulatory transparency through better access to information on regulatory frameworks applied to services relevant to renewable energy
- Applying good regulatory practices for licensing and authorization procedures
- Facilitating authorization, certification and licensing procedures relating to investment in the renewable energy sector
- Improving market access to facilitate the establishment of commercial presence as well as the supply of services through other modes to support the development of renewable energy sectors
- Regulatory cooperation to address regulatory divergences and heterogeneity

With respect to goods, TESSD highlights the following trade or trade-related policies:

- Trade facilitation measures to streamline or expedite the movement of goods related to RE projects across borders
- Simplification of regulatory processes related to trade in renewable energy goods, including through establishing clear and transparent guidelines for permits, certification and quality control
- Cooperation on technical regulations, labelling, certification and conformity assessment procedures, including in the Technical Barriers to Trade Committee/ WTO.
- Cooperation on supply-chain traceability and reliable certification can help improve consumer confidence in the sustainability credentials of renewable energy goods across complex supply chains
- Harmonization and mutual recognition of standards can facilitate trade by ensuring that goods meet a common set of criteria and are integrated into existing energy systems
- Market access commitments and preferential treatment for renewable energy goods, and key materials needed for their production, in bilateral and regional trade agreements
- Preferential tariff treatment for low-carbon goods related to renewable energy
- Reduction of import tariffs on final products and intermediate inputs important for renewable energy projects and supply chains. A project-based approach may be one option, among others, to reduce tariffs.
- Government support in the form of non-discriminatory, WTO-compliant financial incentives to stimulate demand and production of renewable energy goods

To address developing-country needs and interests and international cooperation, TESSD highlights the following:

- Collaboration to identify how to facilitate investments in renewable energy projects in developing countries
- More discussion on the sharing of technology in the renewable energy sector
- Support to address financing barriers
- Support to facilitate the development of a skilled workforce

Drivers of renewable energy deployment in seven case study countries

Seven developing countries have been selected as case studies to analyse drivers of renewable energy deployment. A review of the literature uncovered the factors driving RE deployment in the countries.

Key findings include:

- The **reduction of the costs** of solar PV have created business opportunities across customer sizes and locations. The Philippines is among countries that have sought to exploit opportunities, with micro, small and medium-sized enterprises (MSMEs) at the forefront of deployment of solar PV to small customers. They have been able to offer the solutions and after-sales service needed.
- **MSMEs' own demand** is also an opportunity for RE, notably as they look to reduce and stabilize their electricity costs in a country where electricity prices have traditionally been high. The Philippines has a wide range of suppliers with private-sector operators a part of the system for a long time. Nonetheless, middle-income households still struggle to afford solar PV and strategies to bring prices down should be explored.
- Mauritius has also encouraged RE deployment for all customer sizes, with an **integrated approach to strategy and planning** looking to drive a radical change away from the oil, coal and bagasse (sugar cane waste) that have dominated generation until recently. The Mauritius Renewable Energy Roadmap 2030 focuses on expanding and enhancing the grid and its storage. Access to finance is a key constraint to deployment.[6]
- The Dominican Republic is also **focusing on the grid and storage**, which could otherwise act as a constraint on the progress it has made deploying both wind and solar PV. Long-term contracts for the electricity generated and a range of incentives for RE (established in 2007 under Law 57-07), as well as a more recent commitment to cut bureaucratic 'red tape', has backed that progress.
- Kenya has expanded RE rapidly in the past 15 years, similarly based around **long-term contracts (generally power purchase agreements) and by offering a range of incentives to RE** as part of a fiscal regime designed to be attractive to both foreign and domestic investors. Kenya has also used **public–private partnerships** to drive deployment of both its geothermal and wind resources.

- Senegal has **attracted investment from a wide range of sources**, with utility-scale solar PV and wind investments supported by domestic sources along with the World Bank Group and other international financiers.
- Ecuador is looking to attract further private investment to add more solar PV and wind to the 75% of its electricity already generated from hydro, following a major public-sector investment programme over the last 15 years. **Low electricity prices**, with residential and commercial customers supplied at below cost, **represent a further challenge** to convince private-sector investors that their revenue needs from projects can be met.
- Viet Nam used generous long-term **power purchase agreements** to increase its solar PV and wind capacities. This rapid build-out pressured the grid's ability to absorb the extra electricity and has led to a reassessment of what prices and incentives should be offered in the future. Beyond the need to continue to attract finance for projects, Viet Nam is weighing another challenge common to all the countries assessed: how to enable further RE deployment by meeting the necessary major expansion and upgrading of the electricity grid, associated control systems and storage.


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CHAPTER 2

Global trends in the trade of solar PV and wind power

Global trends in the trade of solar PV and wind power

This chapter analyses global trends to find patterns that are especially significant for developing countries.

Solar PV

Among developing countries, China has doubled its solar PV exports, cutting costs and reshaping global supply chains, while Viet Nam and Malaysia have emerged as key exporters of specialized components.

China is the world's leading producer of modules and other 'upstream' products (including polysilicon, wafers, cells and modules). As noted in Chapter 1, solar modules made up 30%–50% of the 'bill of materials' of a solar PV project.

China's market share ranged from 74% to more than 96% for solar PV 'upstream' products in 2021 (Figure 14, see Appendix IV). This dominance has driven down the costs of solar PV dramatically, but has led to 'imbalances in supply chains', i.e. there is low range of supply sources (see Appendix, IEA notes, 2022).

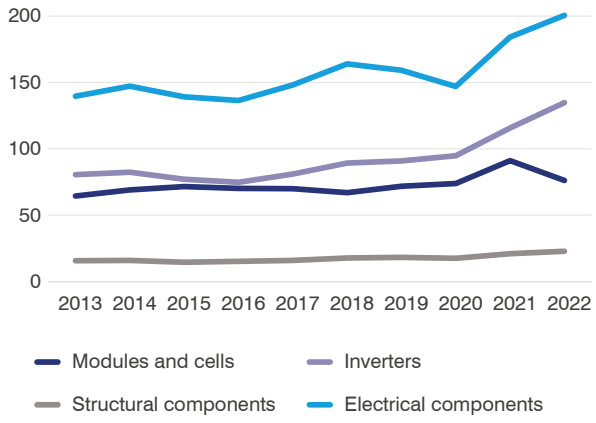
Developing countries including China dominate solar PV export, representing upwards of 90% of the global solar PV module and cell export market, with about 30% coming from countries other than China. Viet Nam and Malaysia have become key players in global exports of specialized solar PV components, holding 9% and 6% of the market share in 2022, with average annual growth rates of 48% and 3% over the past decade, respectively.

Developing countries saw a surge in imports of less specialized components, particularly inverters and electrical component imports.

Imports of specialized components by developing countries grew from $16.6 billion in 2013 to a peak of $30.3 billion in 2021, before falling sharply to $19.8 billion in 2022 (see Figure 2). The initial growth phase indicates a strong global push to expand solar capacity. As an example, imports of solar inverters nearly doubled to reach $99.2 billion in 2022, as well as electrical components increasing by 50% (see Figure 2).

Wind systems

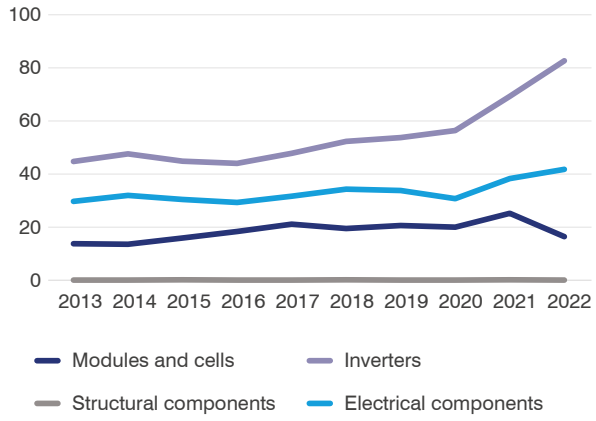
Figure 1 Global imports of solar PV components



Note: Imports are shown in billions of dollars

Source: ITC Trade Map

Figure 2 Global imports of solar PV components



Note: Imports are shown in billions of dollars

Source: ITC Trade Map

Developed countries and China lead manufacturing and trade in upstream components.

The wind system specialized components market was valued at $36.7 billion in 2022. It is projected to grow to $39.11 billion by 2030 (Vantage Market Research, 2023).

The three largest global suppliers of wind turbines in 2021 were Denmark's Vestas (17.7%), China's Goldwind (11.8%) and Siemens Gamesa (a German-Spanish entity), with 9.7%. A further 12 companies, mainly based in China, supplied most of the remaining 60% of the market.

Germany, Denmark and China are major exporters of specialized components for wind systems. They have established themselves as leaders in RE technology, particularly in wind systems. Denmark, with its strong focus on renewable energy and expertise in wind energy technology, also holds a notable market share in wind turbine exports (7%) and rotor blades (12%).

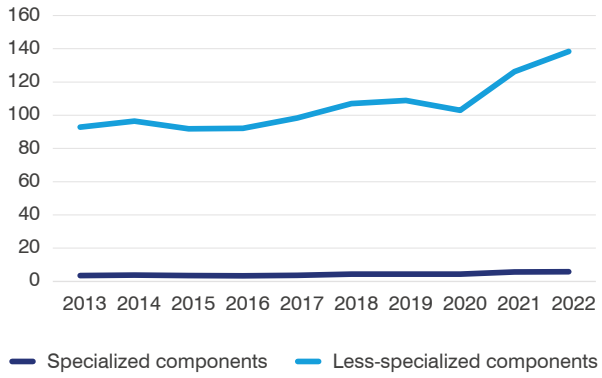
China has become the major player in the wind energy export market, with turbine and rotor blade exports of $3.8 billion in 2022. The country holds around 18% of the shares of these markets.

Developing countries (excl. China) are rising contributors to wind energy exports of less specialized components.

Developing countries steadily increased imports of less specialized components from $107.2 billion in 2013 to $138.6 billion in 2022. For exports, their main contributions remain in less specialized elements, such as electrical components, and transformers, which rose from $92.8 billion to $138. billion (see Figure 3 and Figure 4). Exports of towers illustrate the rising importance of developing countries: Mexico and Viet Nam are key exporters, holding 14% and 8% of the global market shares, respectively.

This indicates a rising prominence of developing countries in the global market for both imports and exports of less specialized components and potentiallygreater integration into global supply chains.

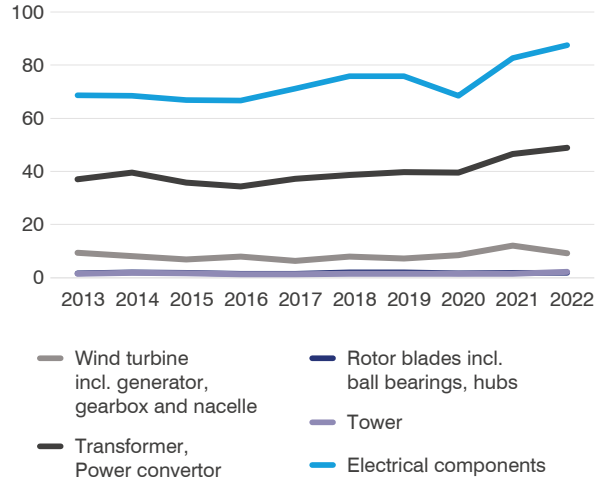
Figure 3 Developing country (excl. China) exports of wind system components



Note: Exports are shown in billions of dollars

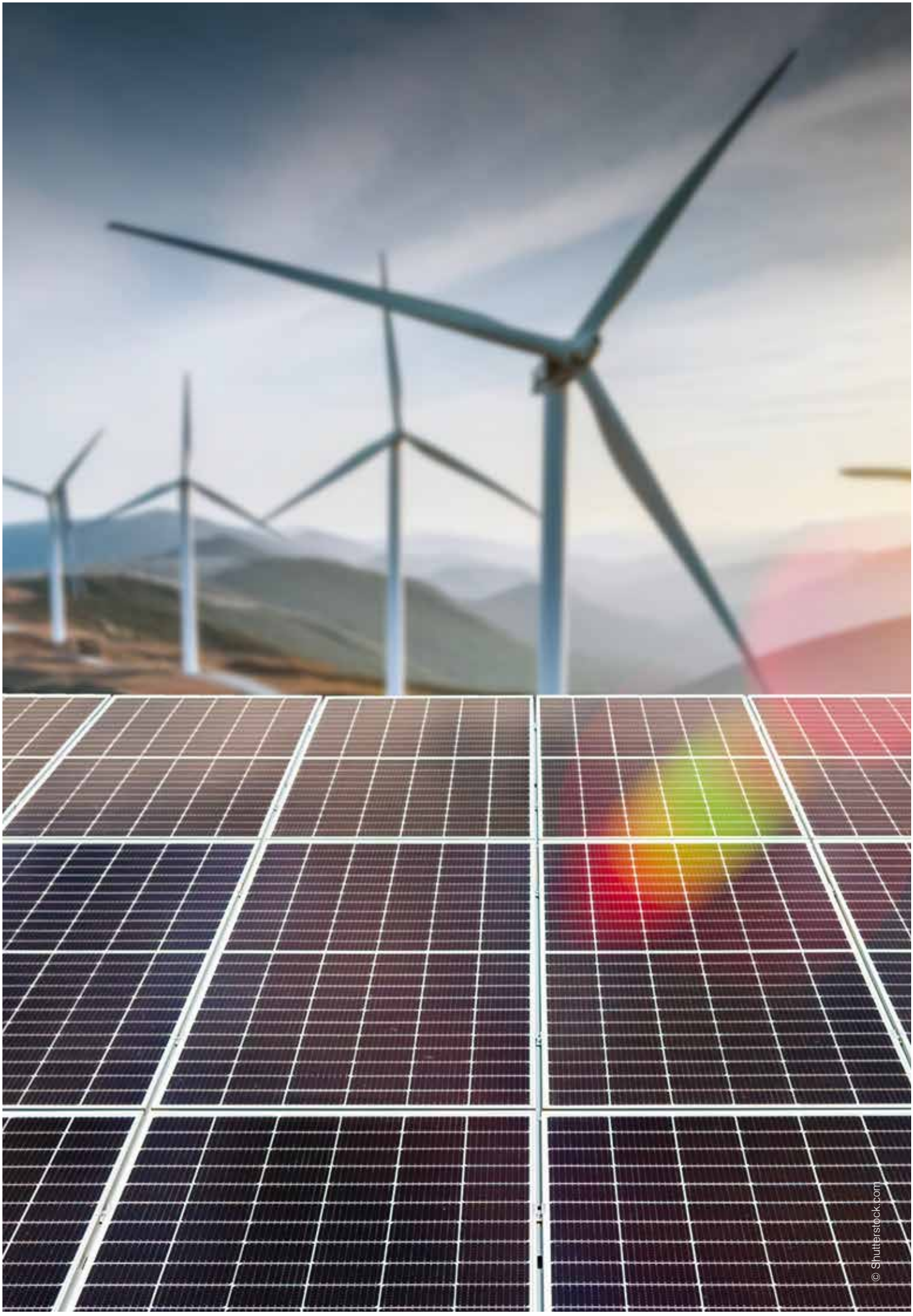
Source: ITC Trade Map

Figure 4 Developing country (excl. China) imports of wind system components



Note: Imports are shown in billions of dollars

Source: ITC Trade Map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CHAPTER 3

Trade of solar PV and wind components in seven developing countries

Trade of solar PV and wind components in seven developing countries

This chapter reviews trade flows and market access conditions for components of solar PV and wind systems in seven developing economies: Dominican Republic, Ecuador, Kenya, Mauritius, the Philippines, Senegal and Viet Nam. This includes an analysis of tariffs, exports and import requirements that the countries apply and that are faced in their current and promising export markets.

Based on the key trends observed for the seven countries, the chapter draws out lessons on how developing countries can facilitate local deployment of renewable energy systems and tap their potential in promising export markets (as identified by ITC's export potential indicator[7]), and create jobs and integrate into global renewable energy value chains. Underpinning the argument is that boosting trade can enable dissemination of climate-friendly goods and technologies, ultimately reducing emissions.

Open trade regimes help developing countries faciliate deployment of RE components

Imports of specialized components have surged in all seven countries

The seven countries boosted imports of specialized components, indicating deployment of solar PV in recent years, with wind turbines also deployed in the Dominican Republic, Kenya and Viet Nam. Data derived from trade statistics for these countries corroborate this trend, indicating that:

- Imports of specialized components (including solar PV modules) in Viet Nam and Philippines climbed. Solar PV module imports in the Philippines and Viet Nam rose from $76 million and $374 million in 2013 to $621 million and $1.7 billion in 2022, respectively – increases of more than eight and four times. Imports peaked (exceeding $5 billion) in 2020; this signals a national effort to boost solar capacity.
- Senegal also experienced a large increase in imports of solar PV components – they more than doubled from $1.7 million in 2013 to $3.9 million in 2022. According to *Plan Sénégal Emergent,*[8] the country has seen advancements in solar technology, more foreign investment and supportive government policies. These factors have enabled Senegal to achieve greater energy independence and sustainability and fostered a burgeoning solar industry.
- Imports of specialized components of wind turbines, i.e. generator, gearbox and nacelle as well as rotor blades including ball bearings and hubs, rose for six of the seven countries from 2013 to 2022. While growth was 'lumpy' – with unpredictable peaks and troughs, reflecting when projects or batches of projects were developed – countries overall imported more of these components in the past few years than they did a decade ago (see Appendix VII for import trends of select components). This reflects different stages of market maturity and cycles of project deployment for wind systems.

  Over the same period, Viet Nam saw a sharp rise in imports of wind turbines including generator, gearbox and nacelle, with a short but dramatic boom period in 2021, when imports of this component amounted to about $3 billion. Imports by the Philippines more quadrupled to $86.6 million from $18 million in this period and those by Dominican Republic almost quadrupled to $28.8 million from $7.6 million.

  Dominican Republic's imports of rotor blades including ball bearings and hubs climbed by 30 times from less than half a million dollars in 2013 to $20.7 million in 2022. This highlights the country's recent boom in the development of wind energy projects, fuelled in part by efforts to reach a national goal of 25% of electricity generated from renewable sources by 2025.[9] Dominican Republic is a leader in renewable energy in the Caribbean today, with construction of two new wind farms underway.[10]

Tariffs on high-tech solar PV and wind components are low and import regulations few.

The seven case study countries have maintained low import tariffs on specialized components. The use of local content requirements is minimal. Further, few regulations are applied on imports. While less regulation is probably because these products are new and innovative and have smaller markets, these factors combined have contributed to boost imports, facilitating deployment.

- The average applied tariffs on specialized components of solar PV modules are low: zero in six of the seven countries and 1% in Viet Nam. Imports of specialized components of wind turbines also face low tariffs: both average most-favoured nation (MFN) and average applied tariffs across the seven countries are 3% on wind turbine including generator, gearbox and nacelle. Senegal and Viet Nam apply the highest average MFN tariffs (7%).

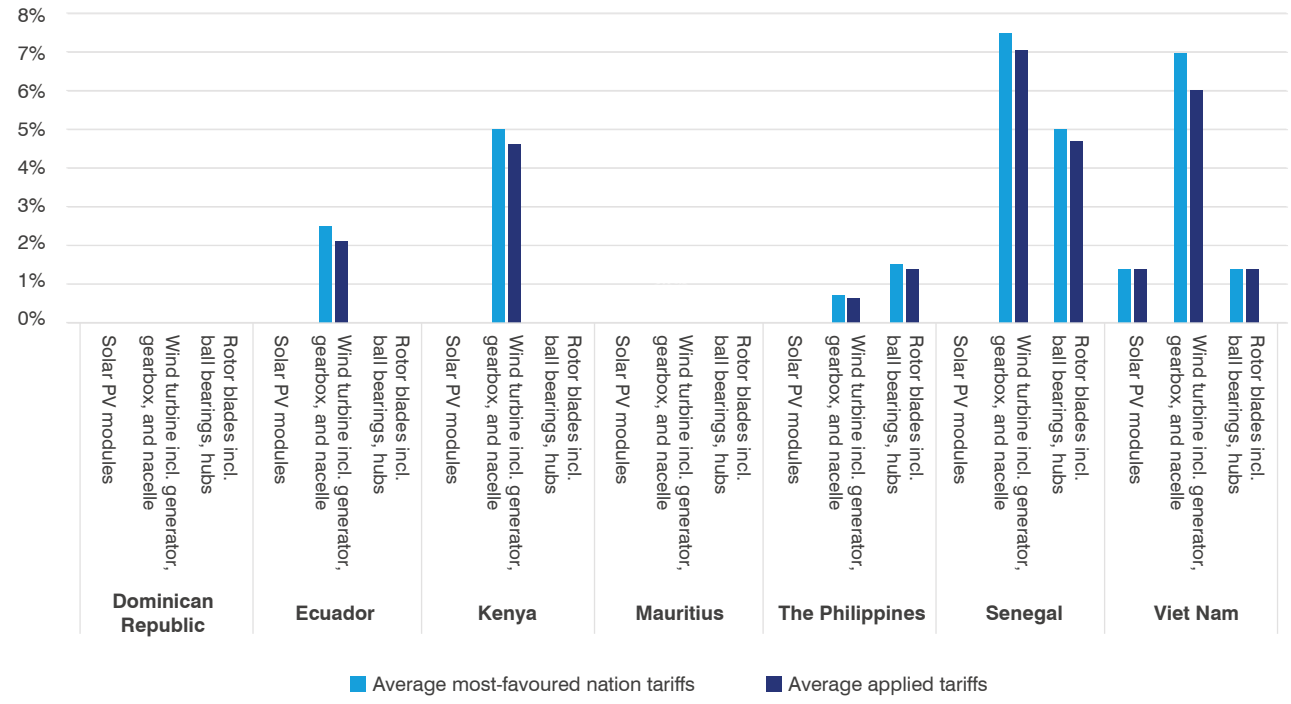
  Tariffs on rotor blades including ball bearings and hubs are also very low: the average MFN and applied tariffs are zero in Dominican Republic, Ecuador, Kenya and Mauritius, 1% in the Philippines and Viet Nam, and 5% in Senegal.

Figure 5 shows the average tariffs applied by the seven countries on imports of solar PV and wind components. MFN tariffs represent the 'maximum' rate applied, while applied tariffs are the actual tariffs, i.e. the 'minimum' rate applied.

Even when MFN tariffs exceed zero, countries grant duty-free access to some partners under trade agreements. Key suppliers including China, the United States and India enjoy duty-free access through FTAs with, for example, ASEAN (covering the Philippines and Viet Nam) and the Central America Free Trade Agreement (covering Dominican Republic and Ecuador) as well as various bilateral trade deals.

Tariff data are shown for the latest year available and ranges in 2022–24. For instance, for solar PV structures, the Philippines under ASEAN grants a 0% preferential tariffs to member countries instead of 15% rate applied with MFN.

Figure 5 Tariffs on specialized components of solar PV and wind systems



Source: ITC Market Access Map

Tariffs on imports of specialized components for both solar PV installations and wind systems are below the global average in the seven case study countries.

- Most of these countries apply a limited number of regulations on imports of solar PV installation and wind system components. Dominican Republic has no regulations on imports while Ecuador, Kenya, Mauritius and Senegal apply a few measures, not exceeding three to four requirements. Tables 1, 2 and 3 in Appendix VII offer a comprehensive overview of the import requirements imposed by the seven countries for specialized components (solar PV modules, wind turbines and rotor blades).
- Dominican Republic is the only country among the seven that applied local content requirements. It required a 35% local content requirement for renewable energy projects to qualify for a 10-year tax exemption (applicable up to 2020)[11]

KEY MESSAGE

Free trade underpinned by low import tariffs and few import regulations has facilitated deployment of renewable energy systems in the seven case study countries. This is illustrated by a rapid surge in component imports for most of these countries in the last decade that surpassed, in most cases, global import growth rates.

This especially holds true for specialized components such as solar PV modules, wind turbines including generator, gearbox and nacelle, and rotor blades. Keeping tariffs low, at least in the short term, and using import regulatory measures cautiously can help developing countries deploy renewable energy.

Viet Nam exemplifies how countries can promote local value creation

Exports of solar PV installation components have climbed. Viet Nam's exports of specialized solar PV modules surged to $6.9 billion in 2022 from $135 million in 2013, making it the world's second-largest supplier after China and accounting for nearly 10% of global exports. Solar PV modules made up almost 2% of Viet Nam's export basket in 2022. More than 75% of Vietnamese solar PV module exports went to North America that year, with the United States the main destination (exports worth $5 billion). East Asia – notably Singapore, China and Hong Kong, China – was also an important market.

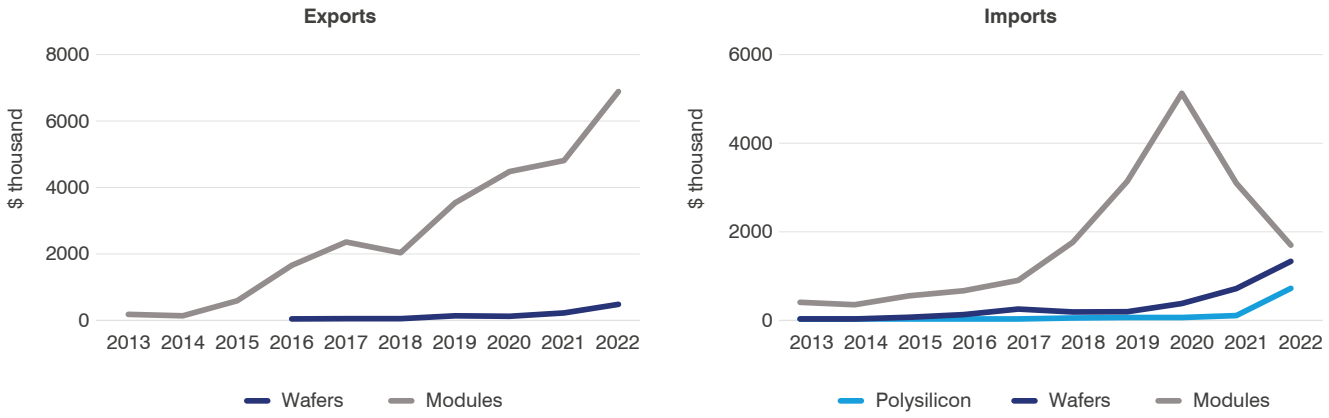
Vietnamese exports have also grown in the less specialized category. Exports of inverters and other static converters grew to $3.4 billion in 2022 from $331 million in 2013. Viet Nam accounted for 3% of global exports of inverters and static converters in 2022, 2% of structure (racking and mounting), and 5% of electrical cables.

Viet Nam's success is due to a variety of factors including:

- **Large investments were made by firms based in the United States and China**, which together accounted for almost all of Viet Nam's solar panel supply in 2022.[12] Data from the General Department of Customs show that 99% of solar panels assembled in Viet Nam in 2019 were imported and mainly purchased from China, then assembled and processed for export in Viet Nam.[13] In 2022, Viet Nam imported unassembled solar PV modules worth $1.6 billion and exported assembled modules worth $6.3 billion, indicating considerable value addition and a growing solar module assembly industry locally.

  The country is now involved in upstream manufacture and supply chains, including of polysilicon, wafers and cells, and it continues to assemble imported solar cells into PV modules. Interests based in the United States and China own most plants supporting upstream and panel-assembly activities, but Vietnamese ownership is growing. 'Cell production increased from just 37 MW in 2014 to 3.75 GW in 2021; module output increased from 1.2 GW to 8.5 GW over the same period' (Wood Mackenzie, 2022a).

Figure 6 Viet Nam's exports and imports along the solar panel value chain



Source: ITC Trade Map

Figure 6 shows that while imports of cells and modules (for assembly into panels) dominated imports up to 2020, Vietnamese imports of polysilicon have surged in recent years, rising 30 times to $689.5 million in 2022 from $24.9 million in 2018.

Wafer imports also climbed sharply in this period, rising to $438.6 million in 2022 from $3.7 million in 2018. Solar module exports grew by more than three times to $6.9 billion in 2022 from $2 billion in 2018. These trends indicate that imported upstream products (wafers and polysilicon) underwent further value addition to make solar modules. This points to a growing solar panel manufacturing capacity in Viet Nam.

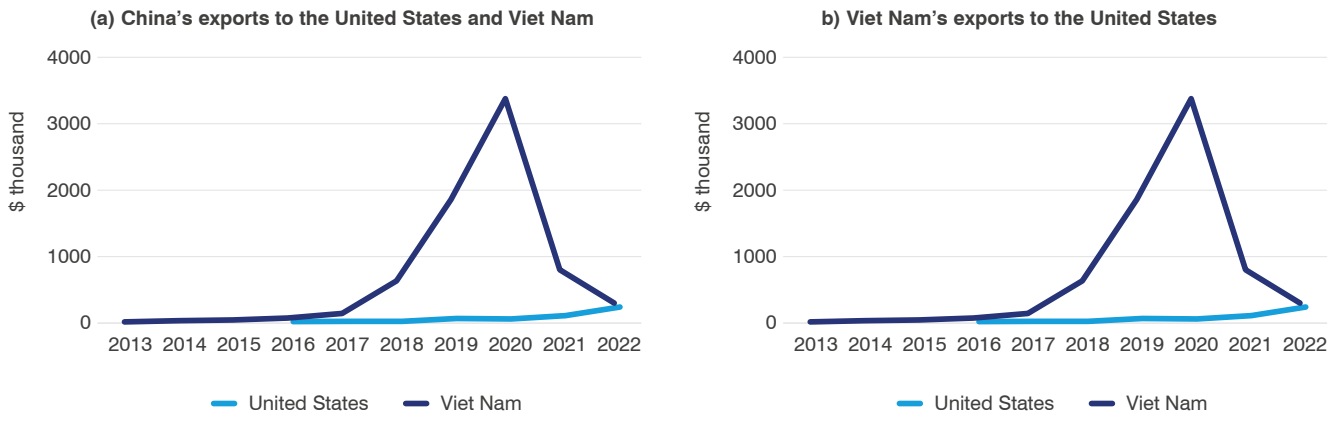
Do and Burke note that improving the solar sector has been a deliberate government policy to 'develop the solar power generation as a new economic sector' within the National Strategy for Green Growth 2012 and the subsequent Renewable Energy Development Strategy 2015 (Do and Burke, 2021). 'The importance of the sector has been re-emphasized in the recent Political Bureau Resolution no. 55 on National Energy Development Orientations.'

- **Low import tariffs on components enable easy imports,** as explained above. **Duty-free access to key export markets**, either under MFN terms or under regional trade agreements such as the ASEAN FTA, the United States–Viet Nam and EU–Viet Nam bilateral trade agreement, ASEAN–China and the ASEAN–Japan FTA.
- **Impact of US trade policy, including the introduction of taxes on Chinese solar PV imports into the United States.** The US decision in 2018[14] to impose 30% duties on imports of Chinese solar cells and modules was followed by an immediate increase in exports from Viet Nam to the United States, with an associated rise in imports from China.

The trade data shown in Figure 7 illustrate this story. Panel (a) shows that China's exports of solar PV modules to the United States had already started to fall in 2016, when the United States applied anti-dumping tariffs on some Chinese solar modules.[15] In 2018, when the United States extended these tariffs to all solar cells and modules,[16] Chinese exports to Viet Nam also rose sharply. This indicates a diversion of exports. Viet Nam's exports to the United States began to boom in 2018, as shown in Panel (b).

Together, these data signal that solar PV modules manufactured in China that were diverted from the US market to Viet Nam in 2018 ultimately found their way to the United States. Viet Nam subsequently established a large solar panel manufacturing industry.[17] This is consistent with the current trend of Chinese businesses increasingly building their presence overseas, in countries such as Viet Nam, Thailand or Mexico.[18]

Figure 7 Trade in solar PV modules ($ thousand)



Source: ITC Trade Map

- **Ability to conform to quality/safety regulations and standards.** With a strong emphasis on quality and product performance in its own national regulations, Viet Nam can comply with the relatively onerous import requirements of major markets such as China, the United States and Japan, which apply as many as 40 different regulations on exporters of solar PV modules, particularly vis-à-vis technical barriers to trade (TBT). This assures importers that the goods are up to standard (see Viet Nam's regulations in Appendix VII).

  These import requirements pertain to labelling, product quality, safety and performance, testing, inspections and storage and transportation conditions. This is also reflected in Viet Nam's above-average score on various dimensions of the Quality Infrastructure for Sustainable Development (QI4SD) Index, which indicates a good national quality infrastructure and, in turn, reliable quality, usability, performance and other characteristics of manufactured goods and processes (see detailed description and scores on QI4SD in Appendix VIII).

Other reasons for Viet Nam's success include a strategic location, the size of the Vietnamese market and its established position as a manufacturer of many other goods – especially of supportive industries such as steel manufacturing and construction, including electrical components and semiconductors.

KEY MESSAGE

Viet Nam's solar PV module exports have grown fiftyfold in the past decade, facilitated by factors including duty-free imports of upstream products from China, large investments made by international firms, trade agreements with key regional markets, opportunities arising from US–China trade tensions and a strong national quality infrastructure enabling compliance with import requirements applied by its major export markets. The experience of Viet Nam in building manufacturing capacity in upstream solar components provides valuable insights for countries looking to enter renewables value chains.

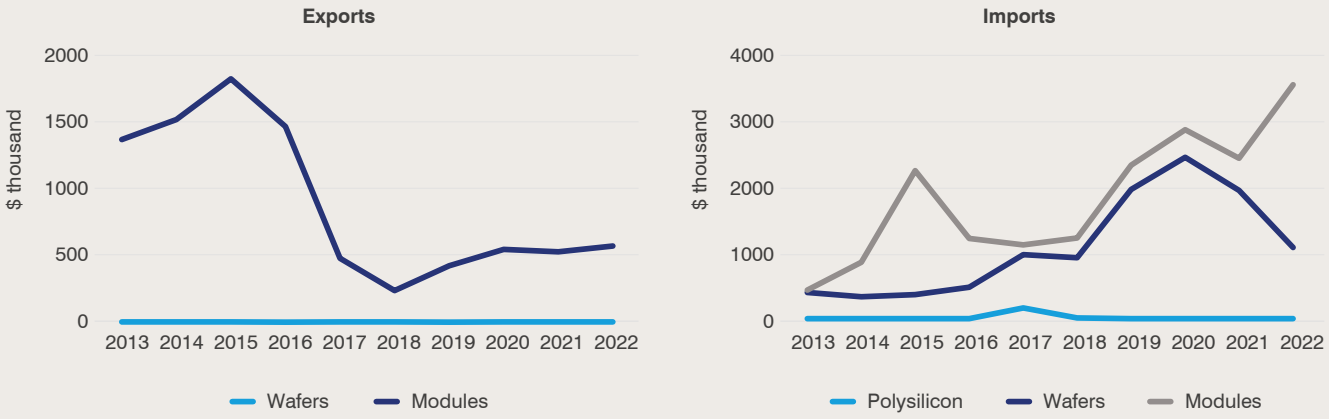
Box 1: The Philippines's experience with solar PV deployment

The Philippines shares some of the same conditions as Viet Nam, as Figure 8 illustrates. The country had significant plant manufacturing of solar panels in 2013–16. Like in Viet Nam, the Philippine industry benefited from the introduction of taxes on Chinese solar PV imports into the United States in 2018, rapidly growing US demand for imports of panels and the proximity of the Philippines to key regional markets. Furthermore, the Philippines already has a major manufacturing base, including for electrical components and semiconductors, and a relatively large domestic market for all goods.

While the global trend signals a general rise in solar PV module exports, Philippine exports fell in 2015–18. Exports of solar PV modules were substantial in 2013–16, averaging $1.4 billion, but they dropped to $511.5 million in 2017. This sudden decline is attributed to a large US-based solar manufacturer and developer closing its assembly facility and moving it to Mexico to cut costs and to be closer to its core market in the Americas.

Many investors have announced plans to locate solar manufacturing capacity in the Philippines. The country appears well-placed to become a major manufacturing centre.

Figure 8 The Philippines' exports along the solar panel value chain



Source: Trade Map

There is scope for the Philippines to build up solar PV module manufacture again. The country has $788.4 million of untapped export potential for solar PV modules. Almost half of this room for growth is in the United States and China, where an export potential of $189.4 million and $171.6 million, respectively, is yet to be realized.

Yet, challenges remain. While the Philippines has ambitious targets to double its renewable power capacity by 2030, the uptake of renewables has been surprisingly low due to the large private corporations that own, operate and continue to invest in new coal, natural gas and diesel.

The Asian Development Bank estimates that there is the potential for the Philippines to aspire to a production capacity of 3–5GW would enable a 5%–10% increase in competitiveness with regional leaders. The priority supporting mechanisms to achieve scale include increasing the ease of doing business, increasing workforce training and operational excellence, and increasing investment by $150 million to $250 million over 3–5 years. (Asian Development Bank, 2023).

Source: ITC Trade Map, ADB 2023.

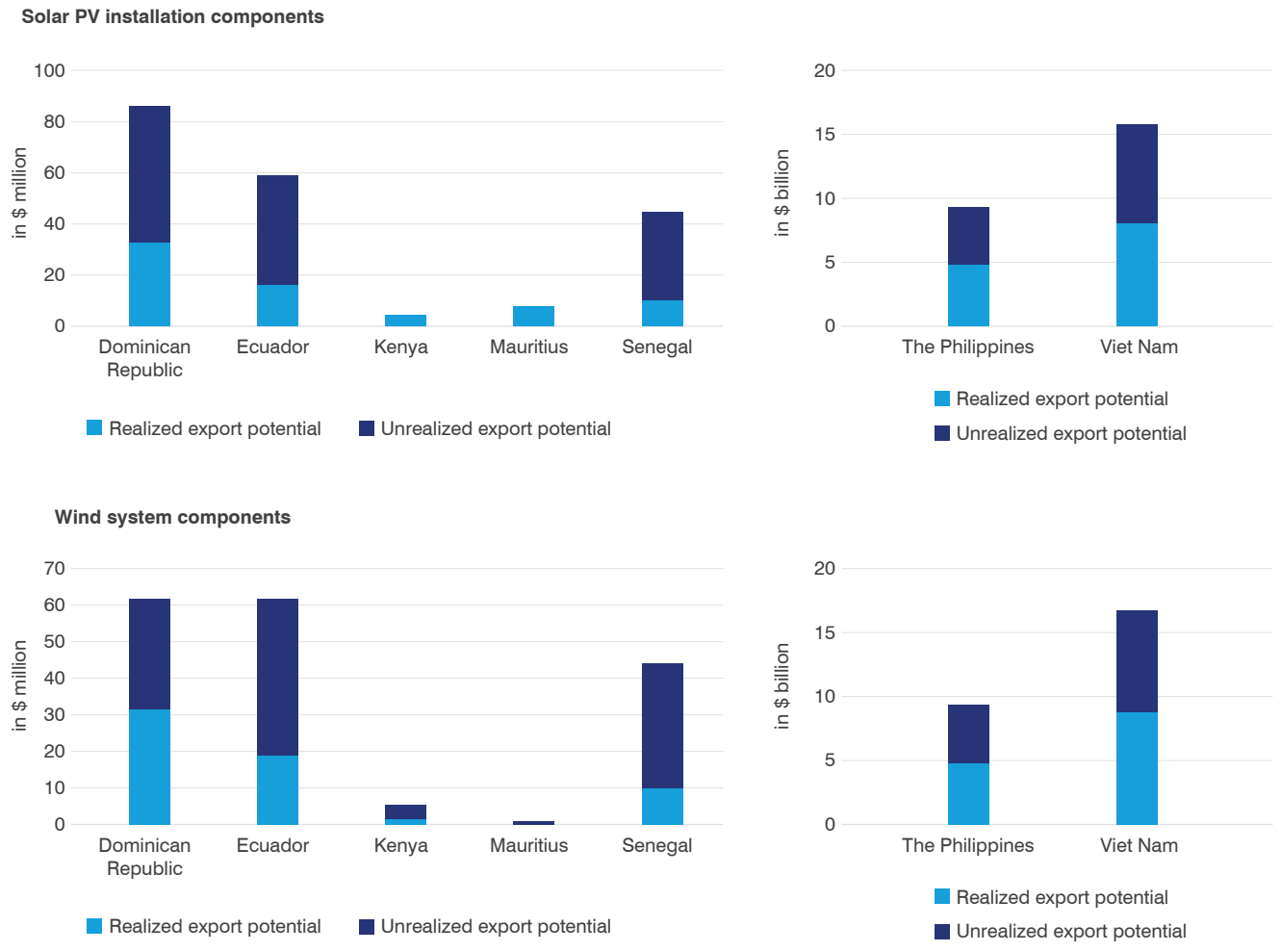
Regulatory compliance is key to long-term export competitiveness

Countries realize only a small share of their export potential. ITC's export potential indicator identifies opportunities for export growth in existing and new markets by considering measures of supply, demand and ease of trade. Looking beyond natural resources and vessels, it highlights promising products diversifying a country's bilateral trade portfolio (see Figure 9). The potential is projected into the future in this case, to 2028.[19]

This growth will be realized either from expected growth in GDP and demand in the coming years (referred to as dynamic or growth-based export potential) or by addressing trade frictions that arise due to a lack of information about the rules and regulations of the target market and difficulty complying with them and meeting the (quality) preferences of its consumers (referred to as static or friction-based export potential).

For specialized solar components, i.e. solar PV modules, the Philippines has room to expand its exports to the United States ($189.4 million), China ($171.6 million) the Netherlands ($64.7 million), Viet Nam ($46.4 million) and Germany ($43 million). Both the Philippines and Viet Nam can boost their exports of specialized wind components to China and the United States, and Germany, Republic of Korea and Japan are promising markets.

Figure 9 Realized vs unrealized export potential, by component type



Source: Authors' calculations based on data in Export Potential Map

For less specialized components, the United States, China, Japan and Republic of Korea are among the most promising markets

- **Exporters face technical and non-technical regulations.** Exporting is largely duty-free for all seven case study countries, so tariffs do not hinder market access. As such, regulatory requirements imposed by destination markets are a key barrier, particularly in larger markets such as the United States, China, Japan, and Republic of Korea. Exporters encounter numerous import regulations in these destination countries.
- Technical measures make up a large share of requirements in export markets, especially those applied for TBT-related reasons such as product characteristic requirements; technical specifications and quality requirements; related processes and production methods; and measures such as labelling and packaging in relation to environmental protection, consumer safety and national security (see Figure 10). These also cover all conformity-assessment measures related to technical requirements, such as certification, testing and inspection.

Table 3 NTMs applied by the United States on Vietnamese solar PV modules and cells

Requirement	Regulation	Summary	Authority	Scope	Validity
Labelling requirements	Hazardous Materials Regulations	Requires labelling on hazardous material packages for safety.	Pipeline and Hazardous Materials Safety Administration, DOT	Global	Since April 1976
Marking requirements	Hazardous Materials Regulations	Specifies marking requirements on hazardous packages for identification and compliance.	Pipeline and Hazardous Materials Safety Administration, DOT	Global	Since April 1976
Packaging requirements	Hazardous Materials Regulations	Details packaging standards for hazardous materials.	Pipeline and Hazardous Materials Safety Administration, DOT	Global except Canada	Since April 1976
TBT on production processes	Requirements for Electrically Operated Toys	Sets standards on materials, quality, and production records for children's electric toys.	Consumer Product Safety Commission	Global	Since September 1973
TBT on transport and storage	Hazardous Materials Regulations	Specifies safe transport and storage conditions for hazardous materials.	Pipeline and Hazardous Materials Safety Administration, DOT	Global except Canada	Since April 1976
Product quality/safety	Emergency Lighting and Power Systems for Vessels	Standards for emergency lighting and power systems on vessels.	Coast Guard, Department of Homeland Security	Global	Since April 1982
Testing requirements	Certification for LED Lamps	Establishes testing for LED lamp specs (power, brightness, efficiency).	Department of Energy	Global	Since July 2016
Certification for LED lamps	Energy Compliance	Requires certification reports to confirm LED product compliance.	Department of Energy	Global	Since July 2016
Certification for hazardous materials	Hazardous Materials Certification	Mandates certification on shipping papers for hazardous materials compliance in transport.	Pipeline and Hazardous Materials Safety Administration, DOT	Global except Canada	Since September 2011
Processing history	Mandatory Greenhouse Gas Reporting	Requires greenhouse gas reporting for imported product processing history.	Environmental Protection Agency	Global	Since October 2009

Note: This table outlines the key non-tariff measures and regulations required for export to the United States, covering safety, environmental impact and certification standards for solar PV modules and cells

Source: ITC Market Access Map (2023).

Compliance with these regulations necessitates a solid national quality infrastructure. For all seven case study countries, there is scope to strengthen this (see detailed description and scores on QI4SD in Appendix VIII).

- **Non-technical requirements, notably 'non-automatic licensing procedures', are common in some export markets.** Non-automatic licensing procedures are control measures designed to prohibit or restrict imports. They include measures limiting the quantity of goods that can be imported, regardless of whether they come from different sources or a specific supplier.

  Approval of such requirements is granted on a discretionary basis, or specific criteria may have to be met before it is granted.[20] Some countries also apply these requirements to contain imports to address current account imbalances (for countries with persistent trade deficits) and less import dependency in the protected sector.

  China, for instance, applies as many as six such measures on imports of specialized components: solar PV modules; wind turbines including generator, gearbox and nacelle, and rotor blades including ball bearings and hubs. The United States, Japan, Nigeria and Hong Kong, China, also impose such measures, albeit fewer of them.

  Another non-technical requirement is prohibiting imports for non-economic reasons,[21] applied mostly by China, on imports of specialized components of both solar PV installations and wind turbines. The international classification of non-tariff measures (NTMs) describes these requirements as 'hard' measures traditionally used in trade policy.[22]

- **Some of the seven countries apply export regulations – both technical and non-technical.** For instance, Viet Nam requires exporters of the specialized components of both solar PV installations and wind turbines to meet certain standards of product quality, safety and performance as well as undergo testing prior to export. This is to ensure that goods being exported from the country are up to standard.

  Likewise, the Philippines requires exporters of wind turbine components to comply with labelling and packaging criteria for TBT-related reasons. Kenya requires exporters of specialized components of wind turbines to obtain licences before export, and exporters of all components of both solar PV installations and wind turbines to pay export taxes and duties (see Appendix IX for full details of export requirements applied by countries).

The limited number of import regulations applied by countries implies a low entry bar for renewable goods but has implications for quality.

As discussed earlier in this chapter, most countries reviewed apply a limited number of regulations on imports of both solar PV installation and wind system components. While this may imply easy access to imported components, it could expose countries to low-quality imports. This may undermine plant performance and competitiveness by reducing the availability of high-quality inputs and technologies that may be available to competitors in more strongly regulated countries.[23]

Appendix IX offers a comprehensive overview of the import requirements imposed by the seven countries.

KEY MESSAGE

With access to major markets being duty-free, it is the ability of exporters to comply with the non-tariff requirements applied in current and promising markets that will determine market access. Countries have room to expand their exports in several markets. To tap into this potential and boost market share, they need to invest in building a strong capacity to comply with both technical and non-technical regulations.

Regional markets must be leveraged to expand exports

Exports of renewable energy system components are largely regional. More than 95% of Dominican Republic's exports of all components of solar PV installations in 2021 were to North America and the Caribbean. Countries in the Americas were top destination markets for Ecuador in 2022, accounting for nearly all its exports. Kenya exports mainly to the East African Community and Common Market for Eastern and Southern Africa member states.

The main export destination for Senegal is Economic Community of West African States countries, while Madagascar and South Africa were top export markets for Mauritius. Countries in East Asia and North America are the primary destination markets for the Philippines. The main export destination for Viet Nam's solar PV modules is North America and, to some extent, East Asia, notably Singapore, China and Hong Kong, China.

The markets closer to home hold the most promise. More than half of the total unrealized export potential of the Dominican Republic and Ecuador lies in North America, the Caribbean and South and Central America. Markets in Europe and the Middle East hold the most potential for Kenya, representing close to half of its total unrealized export potential. For Mauritius, Southern Africa and Europe account for 60% of export potential. Likewise, more than half of the unrealized export potential of the Philippines and Viet Nam lies in East and Southeast Asia.

Senegal is an exception, with the Pacific being the most promising market. However, nearly a fifth of the country's unrealized export potential lies in Europe and Western Africa. See Appendix XIII for more information on the seven case study countries' export potential.

Regional concentration of exports can be attributed to FTAs. Examples of trade agreements that contribute to regional exports are the Canada–Dominican Republic–United States FTA, the Comprehensive and Progressive Agreement for Trans-Pacific Partnership, the EU–Viet Nam FTA, the ASEAN–China FTA, the EU–West Africa economic partnership agreement and the interim EU economic partnership agreement with Eastern and Southern Africa. While the export values are small, these accords can enable more exports[24] (See Appendix XIV).

While not a formal trade deal, the 2012 APEC[25] Leaders' Declaration is worth a mention. Under this statement, APEC economies agreed to reduce their applied tariff rates on 54 environmental goods – including solar panels, wind turbines and bamboo flooring – to 5% or less by the end of 2020.[26] This could be a factor in explaining the Philippines' high export value to Singapore, China, Hong Kong, China, Chile and Canada – other APEC member states.

However, the data do not show any clear difference in exports since the APEC tariff reduction. Export growth of solar PV and wind system components remained stable during the period.

KEY MESSAGE

With numerous free trade agreements in force, regional markets have been and can be promising for increasing exports and creating regional value chains in renewable energy systems. Fully exploiting such trade arrangements and incorporating in them provisions to facilitate trade in environmental goods can help tap into the potential for exports that these markets present.

Less specialized goods: An opportunity for countries with limited manufacturing capacity

- Smaller economies increase trade in less specialized components. Viet Nam and the Philippines are the only countries of the seven reviewed that have major manufacturing capacity of specialized components. Yet these other countries both export and import less specialized products. Viet Nam's exports of inverters and other static converters grew tenfold – to $3.4 billion in 2022 from $331 million in 2013 – and quadrupled in 2017–22.

  Dominican Republic, Ecuador and Kenya boosted exports, though export values were low. Exports of structures for racking and mounting grew eight times for Dominican Republic, six times for the Philippines and five times for Viet Nam in 2013–22. Kenya, Mauritius and Ecuador also exported more structures for racking and mounting in 2022, relative to 2013 or 2017, though the export values weresmall.

- Senegal and Ecuador boosted exports of electrical cables – by 4.5 times to $77.2 million and 3.8 times to $69 million, respectively, in 2022 compared to 2013. Imports of some less specialized components also grew from 2013 to 2022. There was strong import growth for inverters[27] and other static converters, particularly for Dominican Republic (3.1 times) – far exceeding average global growth (1.3 times

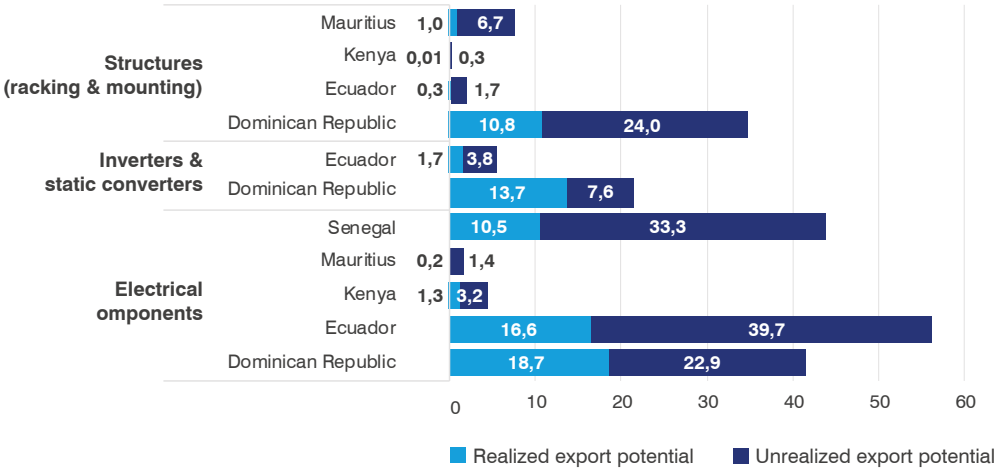
  Imports of structures for racking and mounting also rose, especially for Senegal, Dominican Republic and Kenya. In the electrical cables category, import growth was highest for Dominican Republic and Mauritius.

While exports and imports of specialized wind turbine components account for a very small share in each country's trade basket, the share of less specialized components is relatively higher. For instance, structures for racking and mounting accounted for 0.5% of Mauritian exports in 2022; inverters and static converters made up 1% and 2% of Viet Nam's and the Philippines' export baskets, respectively, and electrical component exports accounted for close to 4%, 1.5% and 2% of the export baskets of the Philippines, Senegal and Viet Nam.

Smaller countries have high export potential in less specialized inputs. Figure 10 shows that almost 75% of Senegal's export potential ($33.3 million) in electrical component markets is unrealized. Up to 70% of Ecuador's export potential in these markets ($39.7 million) and about 55% of Dominican Republic's ($22.9 million) also are unrealized.

Dominican Republic and Ecuador have the potential to increase exports of inverters and static converters by $7.6 million and $3.8 million, respectively. Structures for racking and mounting also offer some potential: Dominican Republic has a room to increase its exports by $24 million, Ecuador by $1.7 million, Mauritius by $6.7 million and Kenya by $300,000.

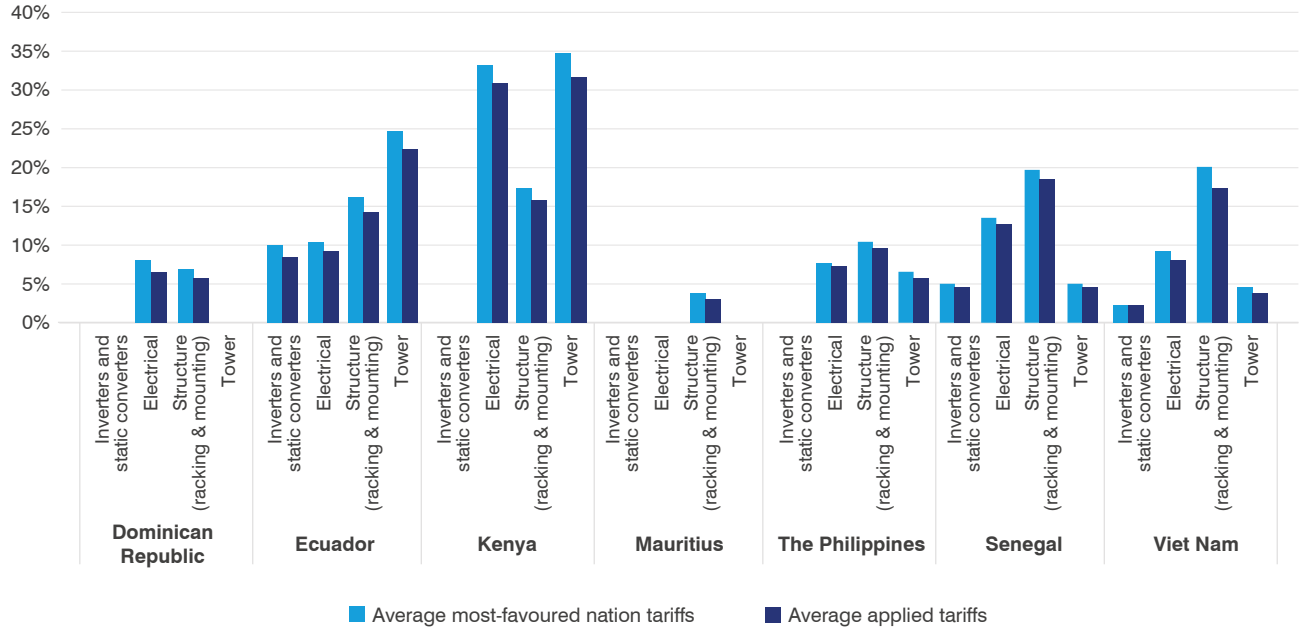
Figure 10 Smaller countries have unrealized potential in less specialized components



Note: Figures are in millions of dollars.

Source: Authors' calculations based on data in Export Potential Map.

Figure 11 Tariffs on less specialized components of solar PV installations and wind turbines



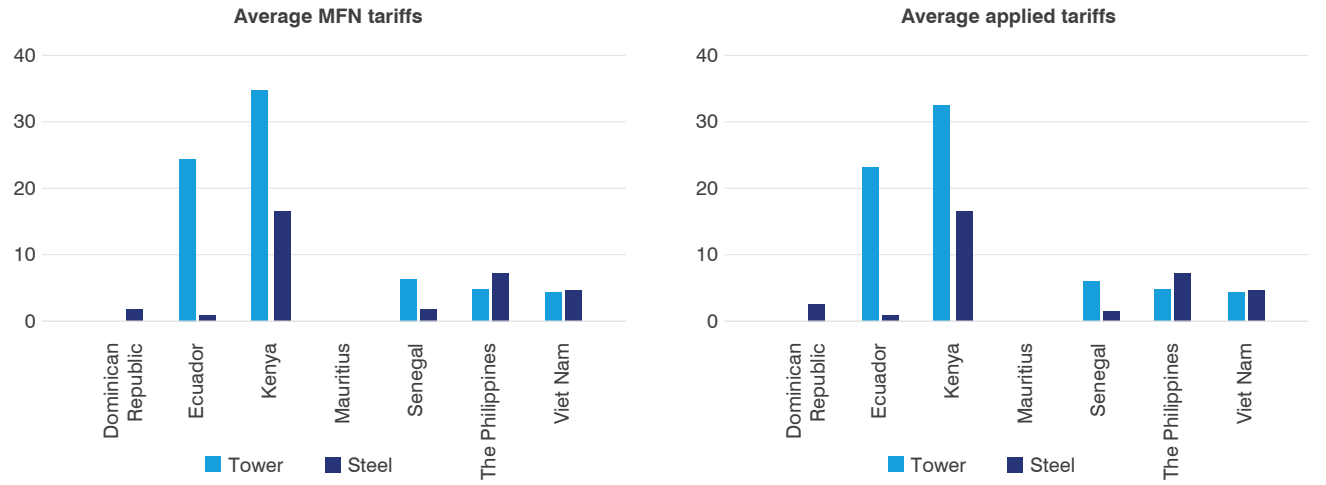
Note: Tariff data are shown for the latest year available and ranges in 2022–24.

Source: ITC Market Access Map

Tariffs on less specialized components are generally higher than those on specialized components. Figure 12 illustrates that some countries – such as Ecuador (around 25%) and Kenya (more than 30%) – apply high tariffs on imports of towers, which can be used for wind and other purposes. Kenya also imposes high import tariffs (exceeding 30%) on imported electrical cables. Imports of structures for racking and mounting, commonly used in solar PV installations, also face tariffs exceeding 15% in Ecuador and Kenya.

Import tariffs on towers and steel are compared to determine whether the high tariffs on towers are being used for defensive purposes. Figure 12 shows that most countries' tariffs on steel imports are lower than those on towers, indicating that they may want to be able to import steel at a low cost to advance domestic manufacturing of less specialized towers.

Figure 12 Average tariffs applied to wind tower and steel



Note: Steel HS codes considered are 7208, 7209 and 7210.

Source: ITC Market Access Map.

Imports of less specialized components face non-tariff measures. Six of the seven case study countries apply non-technical measures on imports of less specialized components. These include control measures aimed at prohibiting and restricting imports. Countries mainly regulate imports by applying import licensing requirements for reasons other than TBT, as well as absolute prohibition on imports for non-economic reasons.[28] As explained above, such measures are generally aimed at banning or restricting imports or quantities of imports with an intent to boost local jobs and develop infant industries.

KEY MESSAGE

For developing countries with small-scale manufacturing capacities, less specialized renewable energy components such as electrical cables, inverters and static converters or structures for racking and mounting offer promising avenues for participating in global value chains. There is already a positive export trend for such components, along with unexploited potential for exports.

Countries maintain high tariffs and apply restrictive non-tariff measures as well. Adopting a progressive approach to liberalization for these components to give countries time to develop their nascent industries and extending market access gradually can support their integration into RE value chains. As industries grow, so will jobs.

The analysis in this section has shown how the seven case study countries have fared on trade – both exports and imports – of RE components as well as the opportunities for deployment and value-addition and the challenges. These countries are importing more of these goods, often made possible by fewer trade measures, both tariff and non-tariff.

Plenty of opportunities await on the export side as well, especially in markets closer to home and for less specialized components that require smaller manufacturing scale.

Based on an assessment of trade and market access requirements in these markets, this chapter has touched on some key strategies that developing countries may adopt to tap into trade opportunities: a progressive approach to liberalization for RE goods; establishing regulations and standards for them, strengthening capacity to comply with technical regulations applied in export markets, investing in national quality infrastructure and fully using existing regional trade agreements can all serve as stepping stones.

CHAPTER 4

Policy options for developing countries

Policy options for developing countries

Based on a review of trends, this chapter summarizes key policy considerations for developing countries to facilitate trade in components of solar PV and wind energy systems and improve conditions for deployment, export promotion and integration of developing countries in the supply chain. It also briefly examines the implications for trade policy.

Some policy options drawn from the analysis align with recommendations made under TESSD. These pertain to simplifying regulatory processes, strengthening cooperation on RE-related technical regulations through mutual recognition or harmonization, and negotiating preferential market access for renewable energy goods under PTAs.

In addition, incentivizing investments in RE projects, enabling access to foreign expertise and technologies, and supporting skill development for workers are other suggestions emerging from the analysis that reiterate some of the TESSD recommendations geared specifically towards developing countries.

The findings also call for initiating discussions around some additional policy options.

These pertain to encouraging developing countries to adopt or establish regulations and standards for RE goods; enabling/easing access to market intelligence tools; providing technical assistance towards development of RE export strategies; strengthening quality infrastructure; supporting skills development of not only those engaged in RE goods manufacturing, but also the customs, staff of standards bureaus and other relevant national agencies, and laboratory personnel; and promoting local industries by enabling progressive liberalization of tariffs on RE goods where there is potential to expand exports.

These may be elaborated as follows:

Develop regulations and standards for RE goods

The relatively low number of technical regulations imposed on RE goods, as seen in the reviewed countries, may present a risk around the quality and safety of both imported and domestically produced components. Specifically, countries lack adequate TBT-related measures on product technical specifications/quality or conformity-assessment measures such as certification, testing and inspection requirements. This is understandable given that RE components, especially the specialized ones, are new and innovative products with smaller market sizes.

Helping countries establish national regulatory standards on these goods through adoption of international standards can improve the level of quality and safety of RE products and technologies, facilitating local deployment as well as exports

Identify and address non-tariff trade barriers

Countries demonstrate high untapped export potential in several RE components. To tap into this, they must:

- **Invest in market intelligence tools to fill data and information gaps** so businesses can identify export opportunities and to enhance transparency around requirements in foreign markets.
- **Engage with manufacturers and traders of components** to learn how regulatory requirements applied at home and in export markets affect local value-addition and exports. Seek to understand the nature of support and capacity businesses need to be able to comply with these requirements.
- **Focus export promotion efforts and export strategies** on high-potential RE components.

Invest in regional value chains for RE goods and services

Developing countries that are part of regional trade agreements could collectively leverage comparative strengths of plurilateral trade agreement members and economies of scale offered by regional markets. Such provisions, especially if extended as a priority to RE goods, could help create and strengthen regional value chains. The way to do this is as follows:

- Avoid imposing conditions that differ from those in regional markets and which will make imports either less available or more costly for importers.
- In trade agreements, pursue opportunities to collaborate on mutual recognition of standards and conformity assessment measures and on research and development in the context of regional trade agreements. Incorporate provisions on environmental goods and services that have specific commitments on market access and national treatment. The EU–Singapore FTA, which provides for mutual recognition of conformity assessment for RE products, can serve as a good model. Chapter 7 of this FTA is fully dedicated to non-tariff barriers to renewable energy generation in trade.
- Consider investing in regional hubs for quality infrastructure to share costs of quality infrastructure, particularly among developing countries. This will also encourage equivalence of standards in the region, driving regional trade.

Invest in quality infrastructure and skills development

Developing countries should periodically review quality of infrastructure and associated regulation, ideally in conjunction with producers, importers, officials and other stakeholders, to identify bottlenecks and other constraints and to identify solutions. Further, strengthen skills development for workers engaged in the production and export of RE goods, laboratory personnel as well as of officials of customs, national standards bureaus and other agencies responsible for ensuring the quality and safety of locally produced and imported RE goods.

Promote foreign investment in RE value chains and access to foreign expertise

Given the significance of foreign investment in promoting the assembly and manufacturing of RE goods, as evidenced by the studies on Viet Nam, countries may wish to offer incentives for foreign investors by, for instance, designing appropriate provisions in the context of bilateral investment treaties (relevant to foreign investment in goods) as well as services chapters in trade agreements that are attractive to RE firms seeking to invest in developing countries by establishing a local presence (Mode 3).

Improving market access and national treatment commitments and streamlining licensing and authorization procedures for foreign suppliers of RE services would

help facilitate the development of renewable energy infrastructures. This would be especially relevant with respect to the provision of RE services through the establishment of a commercial presence (Mode 3) and through the movement of natural persons (Mode 4).

These two modes of supply are the main ways through which RE services are supplied. They may contribute to economic development and capacity building in developing countries as foreign service suppliers bring capital and expertise, share knowledge and contribute to local staff upskilling.

At the international level, seek funds through Aid for Trade, the Green Climate Fund, bilateral donors and/or regional and multilateral development banks. Infrastructure-oriented funding designed to strengthen and expand electricity infrastructure, including grids, at a national and regional level could also indirectly promote investments in RE deployment and thereby trade in associated goods and services.

Introduce performance requirements in services schedules of commitments

Developing countries may have flexibility to introduce performance requirements in their General Agreement on Trade in Services (GATS) schedules of commitments as a pre-condition for temporary movement of foreign service providers (Mode 4) or to establish the commercial presence of service providers (Mode 3). Such conditions could include a requirement to train the local workforce or bring in high-quality equipment or state-of-the-art technology. This can pertain to RTAs or unilateral liberalization.

On GATS commitments, the most likely improvements could be applying Services Domestic Regulation disciplines in environment and environment-related service sectors. Most members have committed to applying these disciplines to sectors where commitments already exist.

Negotiate market requirements with key trade partners to build RE capacities

To make room for local industries to grow, allow countries to 'liberalize' tariffs progressively on RE goods where they demonstrate high export potential. Negotiate non-technical regulatory requirements such as non-automatic licensing requirements (applied for reasons other than TBT) as well as associated formalities and documentary requirements in FTAs with key export markets such as China and the United States to boost market access. This can be done under existing bilateral and regional trade deals.

Further research

This study has identified further research priorities to accelerate deployment of RE and support increased local value creation. Some of the most relevant and pressing issues related to trade include:

- extent of value-creation opportunities in services associated with RE and its relationship to the deployment of solar and wind.
- review on regulatory reform and investment/services facilitation to support deployment of RE
- the impact of trade policies (e.g. export taxes and restrictions) on the supply of critical minerals and implications for RE deployment
- the role of quality and standards infrastructure in establishing competitive assembly, manufacturing and export sectors.
- the role of complementary domestic policies to support the development of value chains and deployment of RE

APPENDICES

APPENDIX I
Barriers to trade in services for renewable energy

The WTO (2023) notes that while there are 'few barriers that specifically impact trade in renewable energy services', 'barriers that apply to services more generally will have an impact on trade in renewable energy services'. Table 4 presents what members of TESSD discussions at the WTO consider to constitute barriers to trade in environmental services.

Barriers affecting market entry and operations categories mainly target foreign service providers looking to enter markets. Services barriers also apply to domestic providers – for example, lengthy, costly or burdensome licensing and authorization procedures and lack of transparency about the regulatory framework applied to services related to RE projects, including on licensing requirements. Delays and uncertainty discourage supply.

Table 4 Barriers to services trade related to RE projects

Conditions on market entry
▪ Limitations on the legal types or forms of commercial presence or requirements for joint ventures with domestic entities ▪ Limitations on foreign equity ▪ Limitations on the number or types of services that can be provided and economic needs tests ▪ Investment screening procedures ▪ Conditions to obtain authorization to supply a service, including those related to licensing procedures, qualification requirements (including limited recognition of third-country diplomas and professional qualifications) or nationality or residency requirements
Conditions on operations
▪ Procurement policies and subsidy policies that favour domestic service suppliers ▪ Local content or performance requirements, including requirements to hire host country nationals ▪ Limitations affecting the movement of professionals or the duration of stay of foreign service suppliers, including for technical and managerial personnel from abroad ▪ Regulatory barriers such as restrictions to cross-border data flows that restrict digitally delivered services
Administrative procedures and regulatory transparency
▪ Lengthy, costly or burdensome licensing and authorization procedures for the supply of RE services ▪ Regulatory heterogeneity, including different qualification requirements and procedures and different licensing requirements ▪ Lack of transparency about the regulatory framework applied to services related to renewable energy projects, including on licensing requirements

Source: WTO, 2024

APPENDIX II
TESSD advisory to promote renewables

Below is a non-exhaustive list of opportunities and approaches identified by TESSD members to promote trade in renewable energy services and goods. It also addresses the needs and interests of developing countries and international cooperation.

Table 5 List to promote renewable energy goods and services trade

Opportunities and approaches to promote trade in renewable energy services
■ Improve regulatory transparency through better access to information on regulatory frameworks applied to services relevant to renewable energy. This could include giving companies, including MSMEs, practical information on the requirements they must fulfil to export relevant services. Work on regulatory databases by the WTO and the World Bank or by the Organisation for Economic Co-operation and Development could enhance transparency on measures affecting trade in services relevant to renewable energy.
■ Apply good regulatory practices for licensing and authorization procedures. Good practices can reduce the time and costs needed to deal with administrative procedures and may be particularly beneficial for allowing MSMEs to engage in international trade. Examples could be drawn from disciplines related to services domestic regulation to promote transparency, predictability and efficiency of authorization procedures for service providers.
■ Facilitate authorization, certification and licensing procedures relating to investment in the renewable energy sector through the adoption of non-arbitrary and non-discriminatory rules.
■ Improve market access to facilitate the establishment of commercial presence as well as the supply of services through other modes to support the development of RE sectors. Market access may be improved by reducing barriers to services trade relevant for renewable energy or by increasing transparency through binding commitments, including for services where barriers are already low.
■ Regulatory cooperation can support trade in renewable energy and related services by addressing regulatory divergences and heterogeneity.
■ Include sustainability skills as a requirement for recognition by accredited bodies to better promote environmental goals.
■ Continue building empirical knowledge on services trade and its role in energy markets to account for issues of magnitude when setting priorities to remove impediments to services trade.
Opportunities and approaches to promote trade in renewable energy goods
■ Adopt trade facilitation measures to streamline or expedite the movement of goods related to renewable energy projects across borders. This could include sharing best practices on trade facilitation measures, including in the context of the implementation of the WTO Trade Facilitation Agreement and regional initiatives, to simplify customs procedures.
■ Simplify regulatory processes related to trade in renewable energy goods, including by establishing clear and transparent guidelines for permits, certification and quality control.
■ Cooperate on technical regulations, labelling, certification and conformity assessment procedures, including in the TBT Committee/WTO. This could include sharing information on the regulatory requirements for renewable energy goods with the aim of minimizing regulatory fragmentation. Also, regarding carbon measurement and related certifications, cooperation could help minimize divergence in methodologies and enhance transparency on certification requirements as well as qualified third-party certification institutions.
■ Cooperation on supply-chain traceability and reliable certification can improve consumer confidence in the sustainability credentials of RE goods across complex supply chains.
■ Harmonization and mutual recognition of standards can facilitate trade by ensuring that goods meet a common set of criteria and are integrated into energy systems. Encourage inclusivity of technical committees of international standards-making bodies.
■ Include market access commitments and preferential treatment for renewable energy goods, and key materials needed for their production, in bilateral and regional trade agreements.

- Offer preferential tariff treatment for low-carbon goods related to renewable energy. Lower tariffs on goods that comply with carbon standards could incentivize the reduction in carbon emissions in the production of goods along renewable energy supply chains.
- Reduce import tariffs on final products and intermediate inputs important for renewable energy projects and supply chains. A project-based approach may be one option to reduce tariffs.
- Government support in the form of non-discriminatory, WTO-compliant financial incentives could stimulate demand and production of renewable energy goods.
- Prioritize renewable energy goods in public procurement to stimulate demand and set a standard for the private sector to follow. Implementing the WTO Government Procurement Agreement can help with the dissemination of renewable energy technologies.
- Collaborate on proposals for HS amendments to allow for better identification of the goods needed to meet environmental and climate objectives. This could take the form of a letter to the World Customs Organization outlining proposals for HS reform supported by the TESSD membership and other relevant co-sponsors. Distinct codes can support the monitoring of trade in environmental technologies and more targeted trade policy.

Opportunities and approaches to address developing country needs and interests and international cooperation

- Collaborate on identifying how to facilitate investments in renewable energy projects in developing countries. In this context, disciplines related to negotiations on investment facilitation for development could help developing countries attract foreign direct investment, among other things.
- Discuss sharing technology in the renewable energy sector in view of a balanced approach.
- Support to address financing barriers.
- Support to facilitate the development of a skilled workforce.
- International cooperation to develop common frameworks to accelerate the development of renewable energy projects and facilitate cross-border energy trade.
- International collaboration or support to enhance the resilience of supply chains.
- Development cooperation aimed at the deployment of renewable energy technologies.

Source: WTO, 2024.

TESSD recommendations for trade policy to support renewable energy deployment

Recommendations that can be highlighted include applying good regulatory practices for licensing and authorization procedures in the RE services sector, addressing regulatory divergences and heterogeneity that impact service providers, developing accredited sustainability skills, clear and transparent guidelines for quality control on RE goods, harmonization and mutual recognition of standards and cooperation on technical regulations, labelling, certification and conformity assessment procedures, including with use of the TBT Committee/WTO.

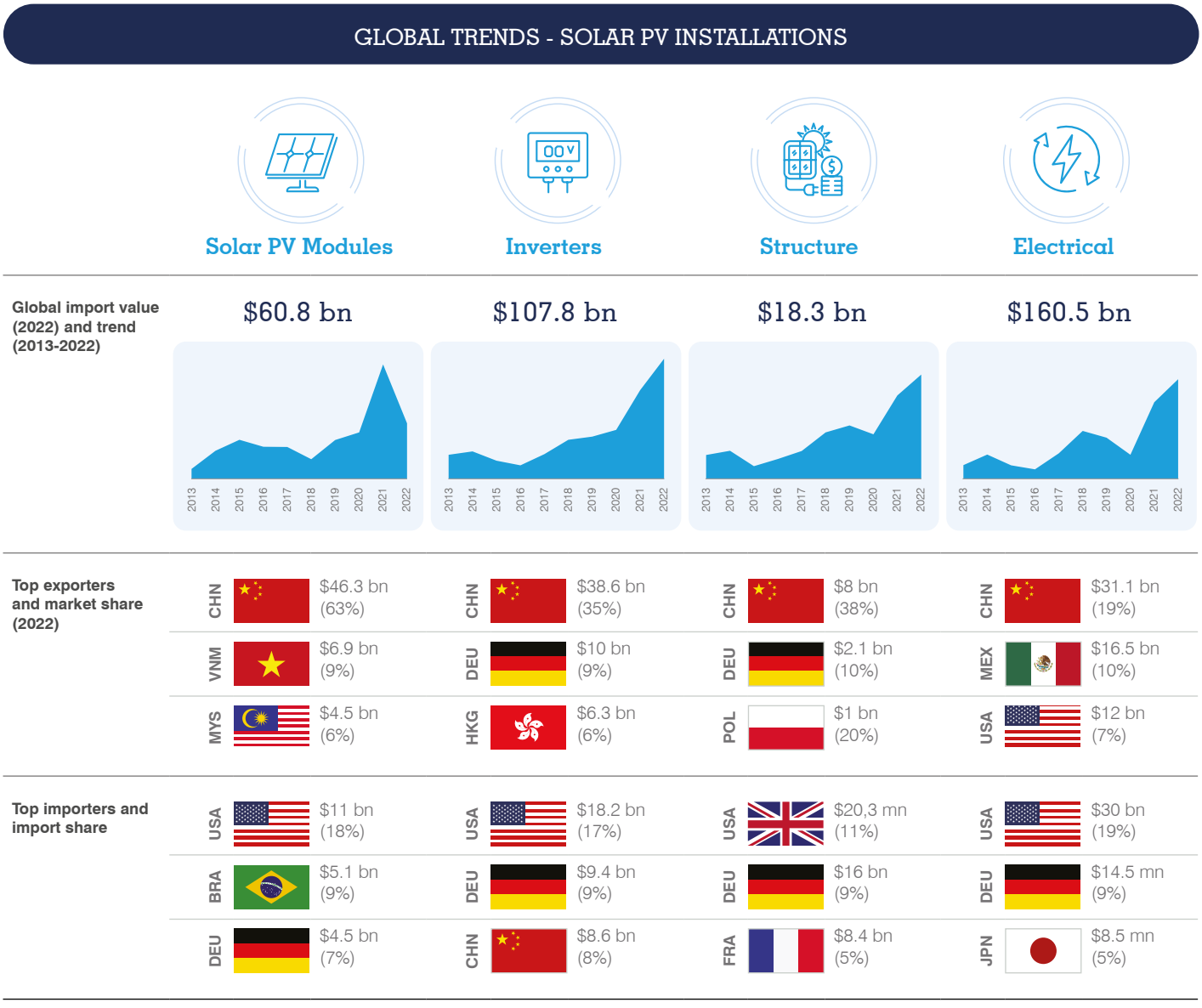
All these recommendations support this paper's recommendation to further develop RE quality infrastructure that benefits both high-quality RE deployment domestically as well as value creation for manufacturers and service providers to access competitive export markets.

TESSD recommendations at the WTO's 13th Ministerial Conference that support the paper's findings on addressing market access barriers including tariff and non-tariff measures include reducing barriers to services trade relevant for renewable energy by increasing transparency through binding commitments, including for services where barriers are already low, trade facilitation measures to streamline or expedite the movement of goods related to renewable energy projects across borders, and preferential tariff treatment for low-carbon goods related to renewable energy.

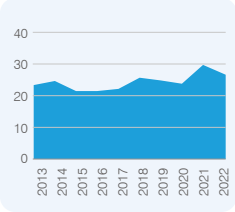
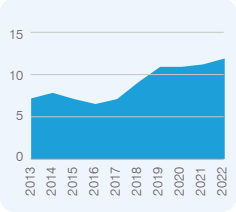
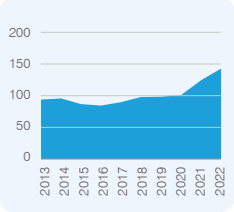
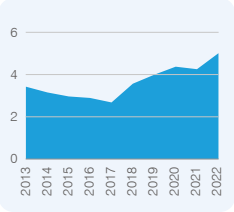
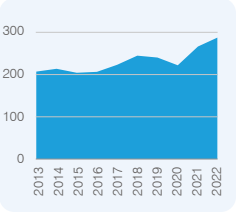
In addition, benefits to RE goods and services exporters to tap into bilateral and regional opportunities can be supported by the TESSD recommendation of market access commitments and preferential treatment for renewable energy goods, and key materials needed for their production, in bilateral and regional trade agreements.

APPENDIX III
TESSD advisory to promote renewables

Figure 13 Summary of global trade trends for solar PV and wind systems components

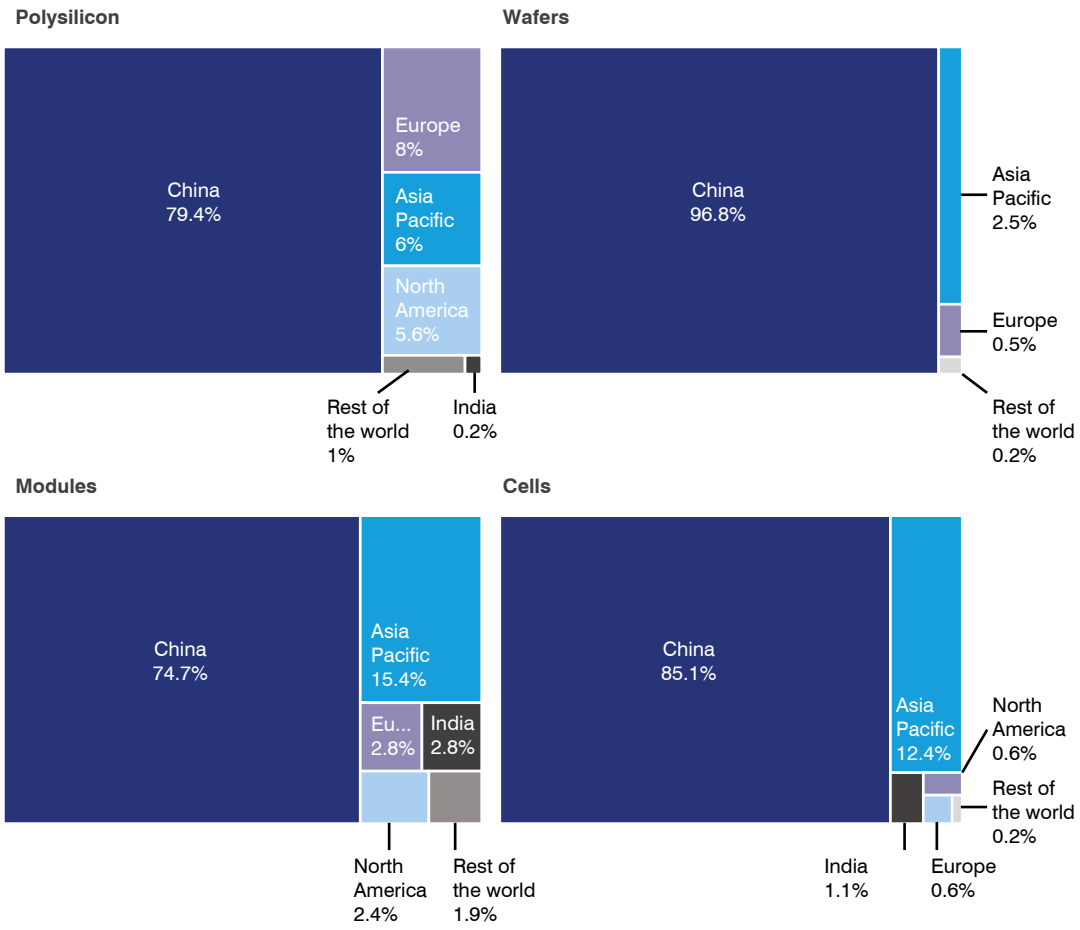


GLOBAL TRENDS - WIND SYSTEMS

	Wind turbines	Rotor blades	Tower	Transformer	Electrical
Global import value (2022) and trend (2013-2022)	$26.5 bn	$12.2 bn	$5.2 bn	$143.9 bn	$282.6 bn
					
Top exporters and market share (2022)	DEU $5 bn (18%) CHN $5 b (n17%) ITA $2 bn (8%)	CHN $2 bn (23%) USA $1 bn (14%) DNK $1 bn (12%)	CHN $1 bn (14%) MEX $1 bn (14%) USA $1 bn (13%)	CHN $48 bn (33%) DEU $12 bn (9%) HKG $10 bn (7%)	CHN $51 bn (18%) DEU $28 bn (10%) MEX $26 bn (9%)
Top importers and import share	USA $4 bn (15%) CHN $20 bn (7%) CAN $17 bn (6%)	USA $3 bn (26%) DEU $1 bn (11%) FIN $7 bn (6%)	UK $1 bn (12%) TWN $1 bn (12%) USA $.4 bn (8%)	USA $23 bn (16%) CHN $12 bn (8%) DEU $12 bn (8%)	USA $51 bn (18%) DEU $27 bn (9%) CHN $18 bn (7%)

APPENDIX IV
Share of manufacturing capacity in solar PV by country/region

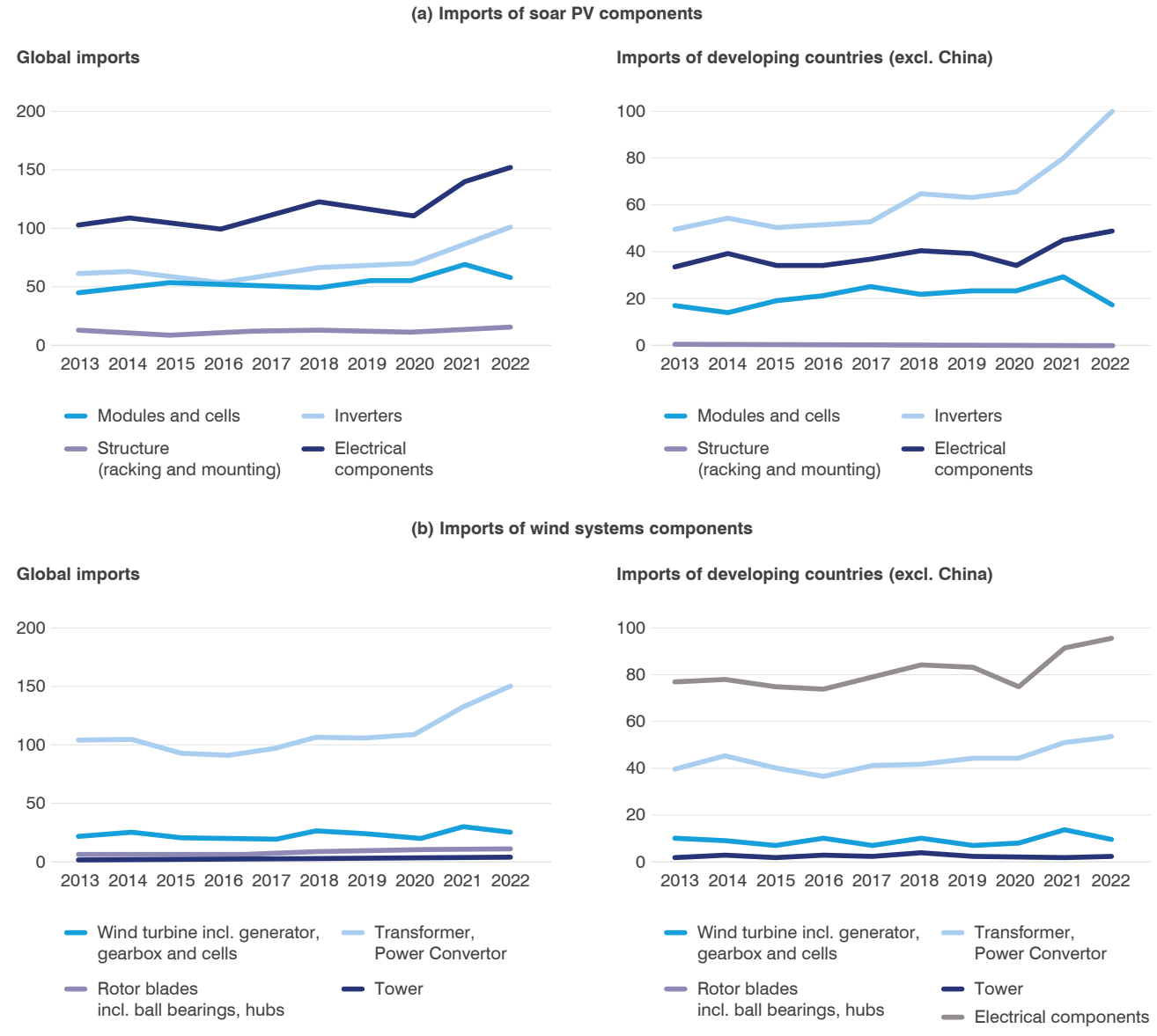
Figure 14 Manufacturing capacity in polysilicon, wafers, modules and cells by country/region, 2021



Source: Conte, 2022.

APPENDIX V
Import trends for solar PV and wind turbines

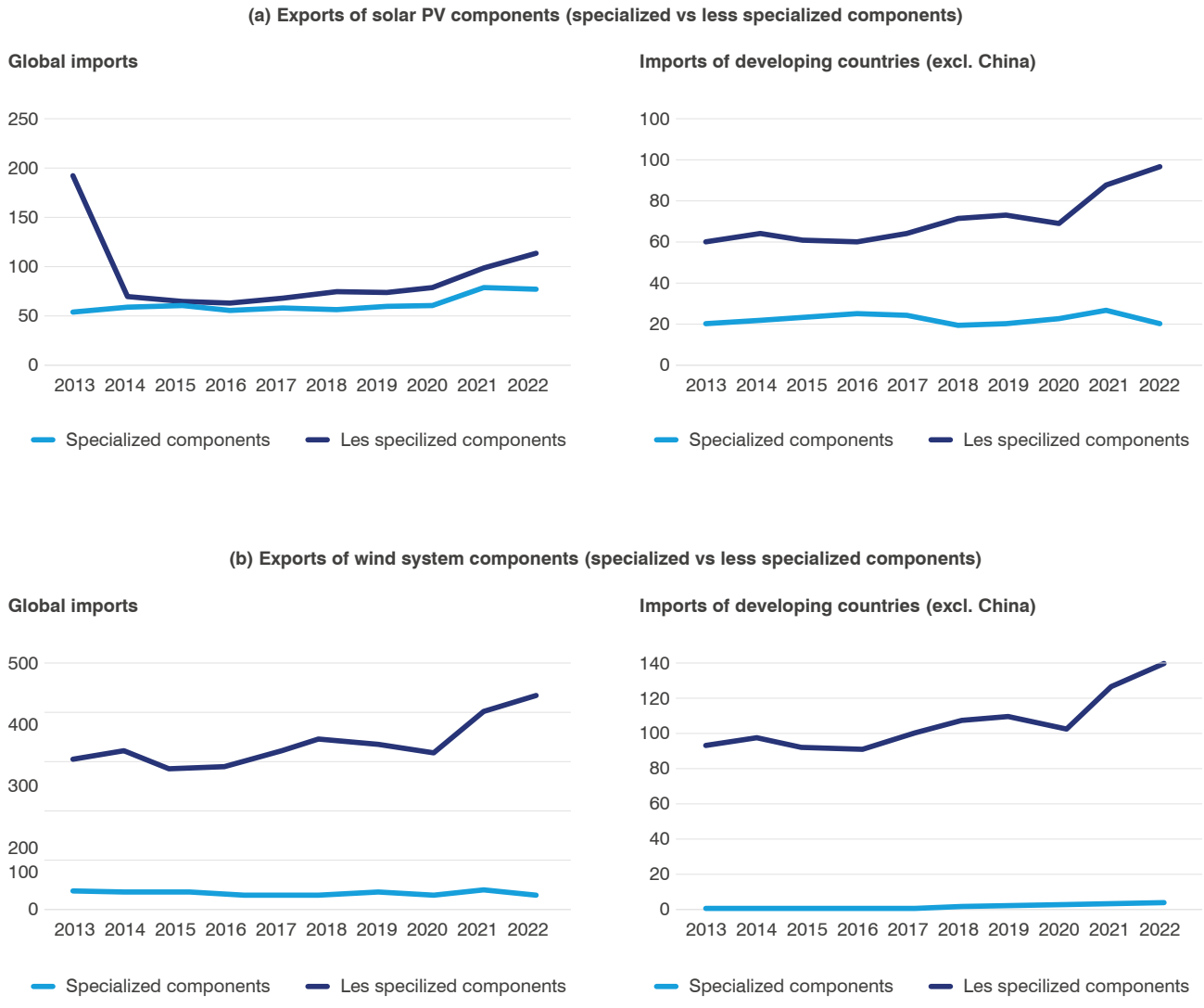
Figure 15 Global import trends for select components of solar PV installations and wind turbines



Source: ITC Trade Map

APPENDIX VI
Export trends of solar PV and wind

Figure 16 Global export trends for select components of solar PV installations and wind turbines



APPENDIX VII
Export potential methodology

Potential export value accounts for demand, supply, ease of trade between the countries, tariffs and expected GDP, and population growth over the next five years. The estimated dollar value serves as a benchmark for comparison with actual exports and should not be interpreted as a ceiling. The actual trade value may be below or above the potential value.

The export potential indicator is built on three components:[29]

- The supply side in the export potential indicator is based on the projected market share. As a result, the share of country i's exports of product k in total exports of product k, multiplied by the exporter's expected GDP growth rate (relative to expected GDP growth of other exporters of the same product) capture the relative increase in overall supply performance.
- This indicator is corrected for global tariff advantages of country i in product k: it is meant to capture projected market share, and thus supply performance, in the absence of tariffs (the impact of tariffs on exports to a particular market will be considered in the demand component). A filter to remove re-exported products is applied in certain manufacturing sectors.
- The demand component is based on projected imports, thus market j's imports of product k, augmented by expected growth of GDP per capita (subject to estimated revenue elasticities of import demand per capita at sector and development level). The indicator also considers the future tariff advantage in the target market and the bilateral distance as compared to the average distance over which the target market usually imports the product.
- Ease of trade is based on the ratio of actual trade between exporter i and market j for products with potential relative to their hypothetical trade if exporter i had the same share in market j as it has in world markets. The numerator captures the actual trade between the exporter i and market j and the denominator captures trade complementarities between the exporter i and market j.

  If Ease $>$ 1, country i finds it easier to trade with market j than with world markets on average, augmenting the potential to trade any product with market j. This can reflect in a high numerator, resulting, for instance, from the two countries being near to each other, sharing the same language or culture, or having established commercial links in the past. It can also reflect in a low denominator due to a limited complementarity of the countries' export and import baskets.

  By contrast, if Ease $<$ 1, country i finds it relatively more difficult to trade with market j, lowering its potential to trade with that market across all products.

Using these three components, we calculate the potential export values in 2028 for each product a country already exports consistently, in dollar terms, to any given market, including markets currently not served.[30]

The estimated potential export value in 2028 can then be compared to the current export value to identify growth opportunities: the gap constitutes the unused export potential. Note that, for any given product, the unused export potential may refer to opportunities to increase exports to an existing partner or, importantly, to opportunities to diversify into new markets. Additionally, the unused export potential maybe associated to changes expected in coming years (growth trends or tariff changes), or to existing frictions.

Key terms:

1. **Realized export potential:** This value captures the extent to which the export potential has already been used for this product, market or supplier. At the most disaggregated level, by country, product and market, the realized potential corresponds to the potential to actual exports gap (in % terms) whenever potential > actual exports and to 100% whenever potential < actual exports.

   At the aggregate level (e.g. export potential in a regional market or by sector), the realized potential may be below 100% even though aggregated actual exports exceed potential exports. This occurs when individual exporter-product-market combinations still hold underused potential that should not be masked by the fact that others have exceeded their potential.

2. **Unrealized export potential:** This value captures the extent to which export potential is not yet used for this product, market or supplier. It is measured at the most disaggregated level, by country, product and market. At this level, whenever actual exports are smaller than export potential, unrealized export potential equals the difference between export potential and actual exports. Where actual exports exceed export potential, unrealized export potential is zero. Unrealized export potential can be static or dynamic.

   a. **Static unrealized export potential:** Static unrealized export potential is the part of unrealized export potential driven by frictions that inhibit current trade.

   b. **Dynamic unrealized export potential:** Dynamic unrealized export potential is the part of unrealized export potential driven by expected growth of demand and supply in the future. It is estimated according to expected GDP and population growth, and with a time horizon of five years.

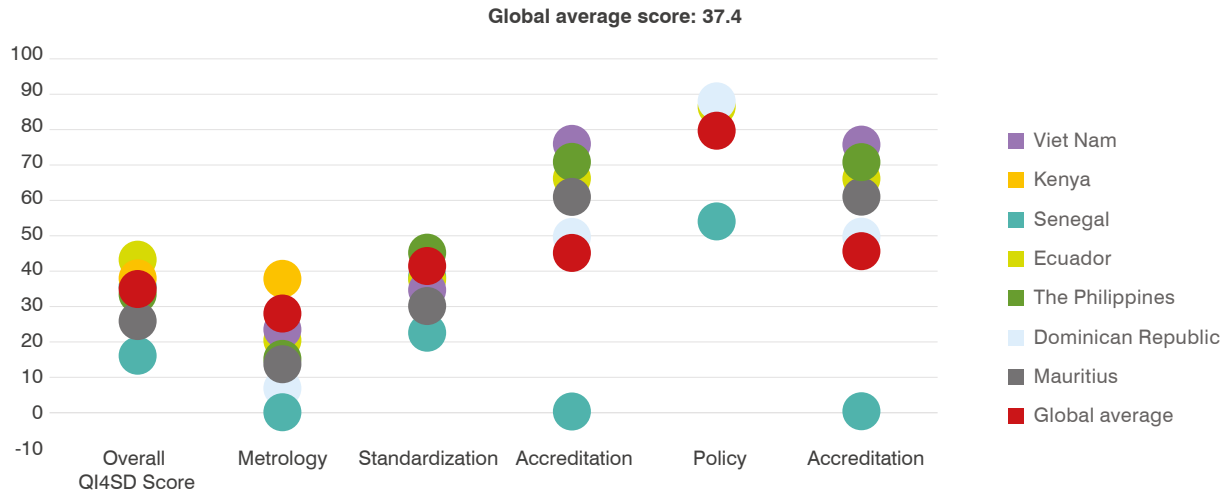
APPENDIX VIII
Quality Infrastructure for Sustainable Development Index

A robust national quality infrastructure (QI) and standards can play an important role in enabling the development, deployment and diffusion of renewable energy technologies.[31] While there is no index to assess the readiness of a country's QI, targeted to renewable energies, the United Nations Industrial Development Organization's Quality Infrastructure for Sustainable Development (QI4SD) Index can provide general insights into a country's and/or region's QI readiness (to support the United Nations Sustainable Development Goals.) The index is decomposed into five dimensions that are captured with 36 indicators. Those dimensions are:

1. **Metrology [measurement]:** Underpins the quality of manufactured goods and processes through accurate and reliable measurement.
2. **Standardization:** Assesses international expertise and knowledge regarding usability, quality, safety, performance, or any other characteristics required by users, buyers and producers
3. **Conformity Assessment:** Provides scientific and technical evidence of whether or not products meet standards or other requirements; are fit and safe for humans, animals, and the environment; and whether or not processes are organized and managed in conformity with accepted good practices.
4. **Accreditation:** Assesses support available to ensure correct functioning of conformity assessment systems.
5. **Policy:** Provides insights into policies that the national government has in place to promote and support QI.

The Figure below summarizes the QI4SD scores for the seven countries. The global average for the index is 37.4. The Dominican Republic, Kenya, the Philippines and Viet Nam all have indices close to this value. Ecuador's QI Index is significantly higher than the average and that for the Senegal is significantly lower.

Figure 17 Country scores and ratings relative to the global average across all dimensions



Note: Scores on "policy" dimension are not available for Kenya, Mauritius, The Philippines or Viet Nam

Source: Quality Infrastructure for Sustainable Development Index (unido.org)

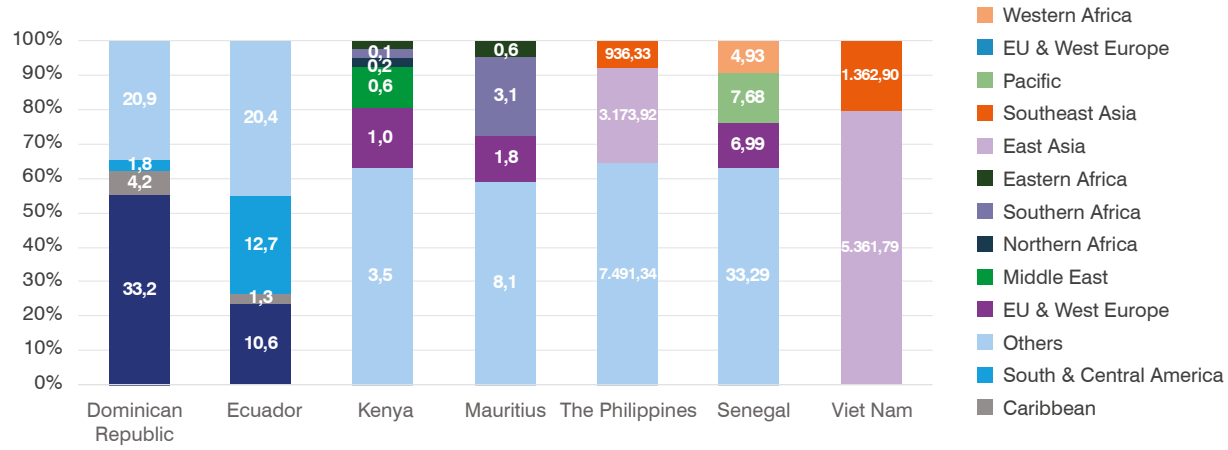
On *metrology*, all countries except Kenya score below the global average, indicating room to strengthen design and efficiency in the manufacture of products. On *standardization*, only the Philippines scores above the global average. The scores against *conformity assessment* are below the global average for all seven countries, indicating that much more could be done to set in place a systematic procedure for verifying whether products meet the required standards.

All countries except Senegal score well on *accreditation*, while Dominican Republic and Ecuador do well on the *policy* dimension. Scores on this dimension are not available for Kenya, Mauritius, the Philippines or Viet Nam.

The index is across all Sustainable Development Goals, whereas solar PV and wind installations do not contribute to all of these. The low score on conformity assessment reveals a concerning trend, with all seven countries displaying generally low performance in this area. This suggests a pressing need for substantial enhancements to ensure that products meet specified standards and regulations.

APPENDIX IX
Unrealized export potential for all components, by region ($ million)

Figure 18 Unrealized export potential for all components

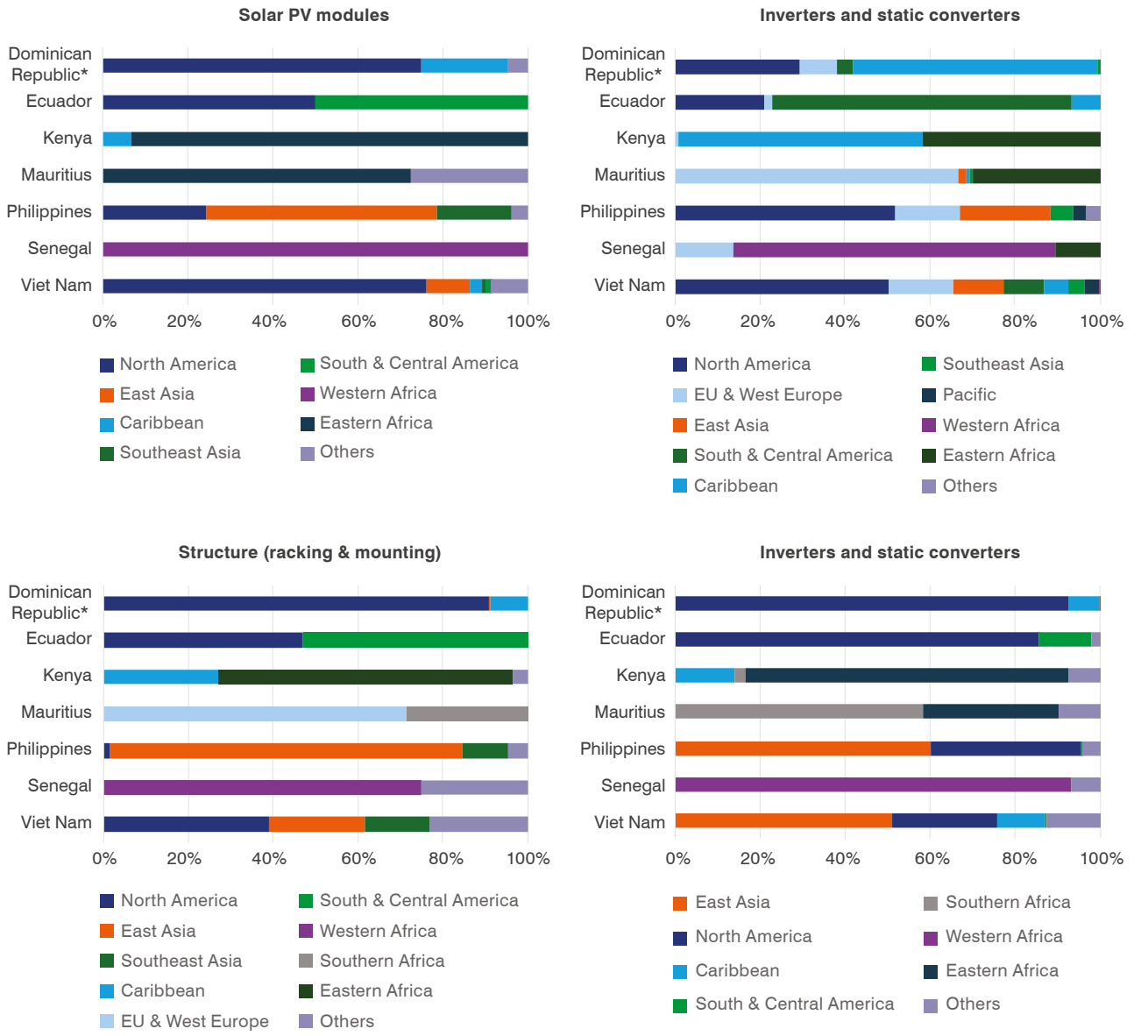


Note: Authors calculations based on ITC Export Potential Map.

Source: The regions are assigned using ITC's regional groupings, which can be accessed here. No solar PV modules were exported by Dominican Republic in 2022, so data for 2021 have been used.

APPENDIX X
Share of solar PV component exports, by region in 2022 ($ million)

Figure 19 Share of solar PV components exports

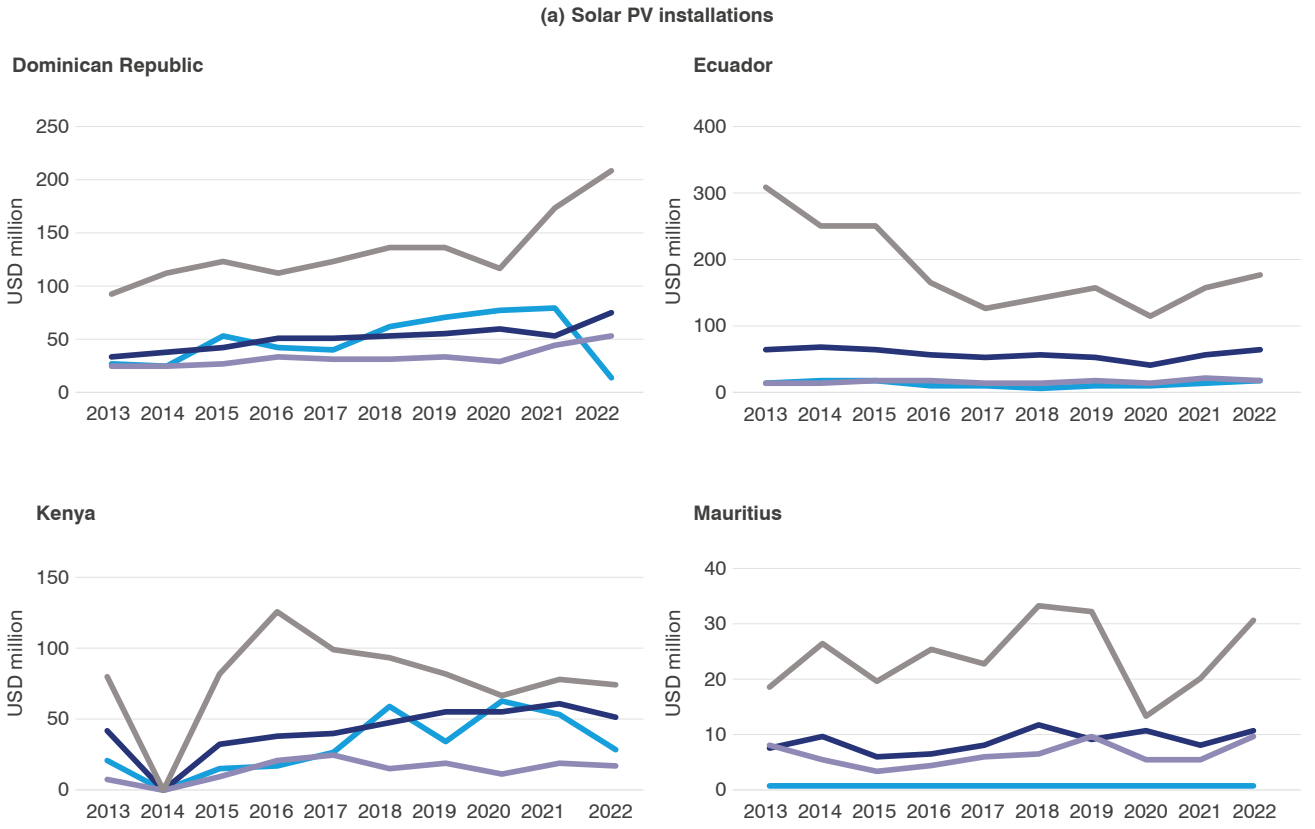


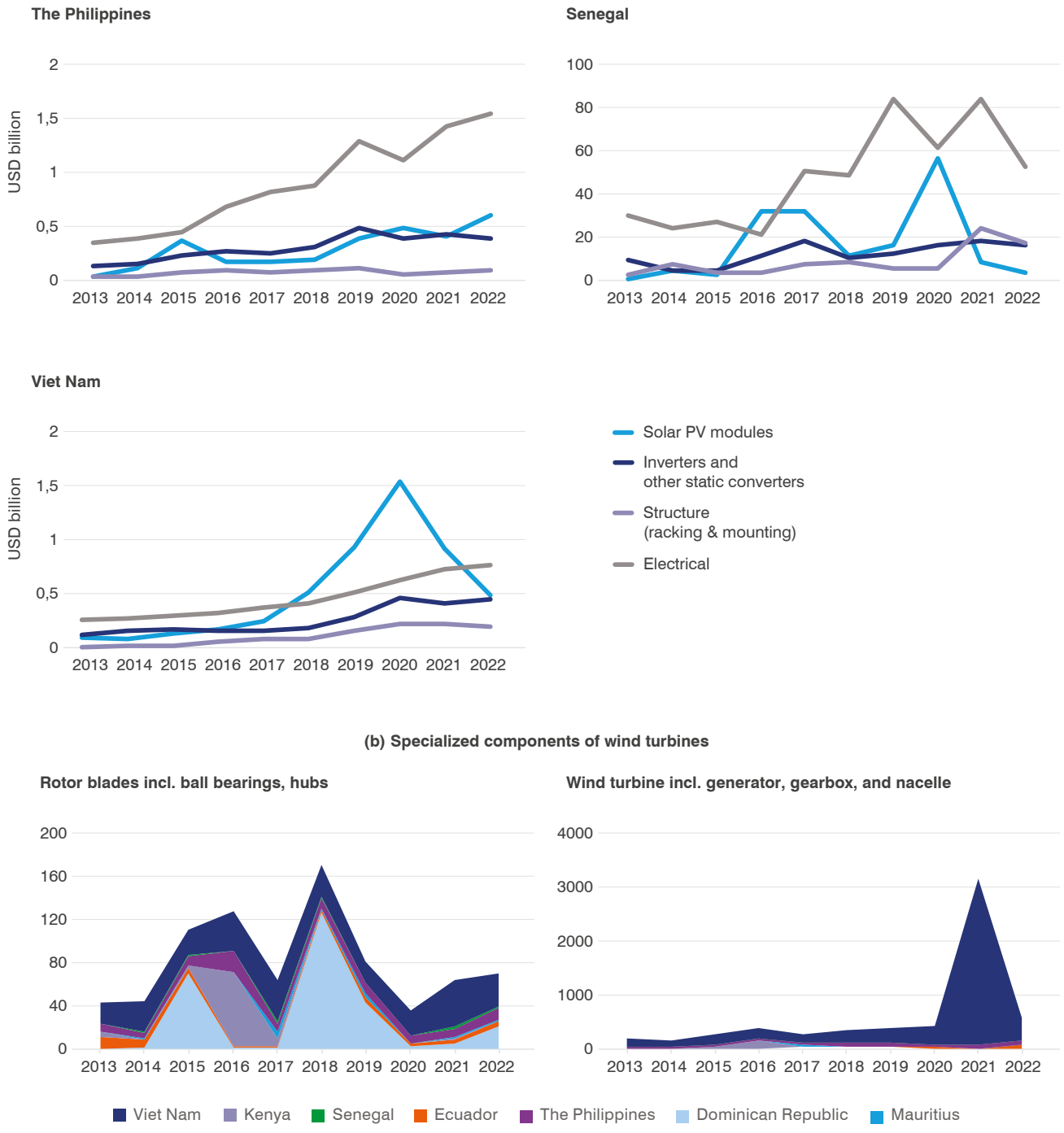
Note: The regions are assigned using ITC's regional groupings which can be accessed here. Since no solar PV modules were exported by Dominican Republic in 2022, data for 2021 has been used

Source: ITC Trade Map

APPENDIX XI
Import trends for select components of solar PV and wind turbines

Figure 20 Import trends for select components of solar PV and wind turbines





Source: ITC Trade Map

APPENDIX XII
Import requirements applied on specialized components

The tables below highlights both specific regulations for these products and general import requirements applicable to all goods. For each NTM, the table indicates whether the requirement is applicable in each country, helping exporters understand the regulatory landscape. The table gives a clear idea to identify the necessary compliance measures for entering these markets.

Table 6 Number and type of import requirements applied on solar PV modules

NTM chapter	Import requirement applied by	Dominican Republic	Ecuador	Kenya	Mauritius	Philippines	Senegal	Viet Nam
A	Labelling requirements for sanitary/ phytosanitary reasons	n.a	n.a	×	1	×	n.a	×
B	Labelling requirements for TBT-related reasons	n.a	n.a	×	1	×	n.a	1
	Marking requirements	n.a	n.a	×	×	1	n.a	×
	Packaging requirements	n.a	n.a	×	×	×	n.a	×
	TBT regulations on production processes	n.a	n.a	×	×	×	n.a	×
	Testing requirement	n.a	n.a	×	×	×	n.a	×
	Certification requirement	n.a	n.a	2*	×	×	n.a	2
	Inspection requirement	n.a	n.a	×	×	×	n.a	3
	Traceability requirements, n.e.s.	n.a	n.a	×	×	×	n.a	×
	Conformity assessment related to TBT, n.e.s.	n.a	n.a	×	×	×	n.a	1
C	Pre-shipment inspection	n.a	n.a	×	1	×	n.a	×
	Other formalities, n.e.s.	n.a	n.a	×	×	1	n.a	×
E	Non-automatic import-licensing procedures other than authorizations covered under sanitary/phytosanitary and TBT chapter	n.a	n.a	×	1	×	n.a	×
	Licensing procedures with no specific ex ante criteria	n.a	n.a	×	×	×	n.a	×
	Licensing for specified use	n.a	n.a	×	×	×	n.a	×

G	Advance payment of customs duties	n.a	n.a	×	×	1	n.a	×
	Advance payment requirements	n.a	n.a	×	×	×	n.a	×
	Finance measures n.e.s.	n.a	n.a	×	×	×	n.a	1
H	Measures affecting competition	n.a	n.a	×	×	1	n.a	×
	Measures affecting competitions, n.e.s.	n.a	n.a	×	×	×	n.a	1
N	Intellectual property rights	n.a	n.a	×	11*	×	n.a	×
O	Certificate of origin issued by authority	n.a	n.a	×	1	×	n.a	×
Total import requirements applied to this product					1			5
Total import requirements applied to all products				2	15	4		4
Total import requirements applied				2	16	4		9

*Import requirements apply not only to this specific product, but also to all kind of products imported by the country.

Note: 1. '×' no import requirement reported for this type of measure.
2. 'n.a' import requirements are not available for this product/country.

Source: ITC Market Access Map.

Table 7 Number and type of import requirements applied on wind turbine incl. generator, gearbox and nacelle

NTM chapter	Import requirement applied by	Dominican Republic	Ecuador	Kenya	Mauritius	Philippines	Senegal	Viet Nam
A	Labelling requirements	n.a	n.a	×	1*	×	n.a	×
B	Restricted use of certain substances	n.a	n.a	×	×	×	n.a	×
	Labelling requirements	n.a	n.a	×	1*	2	n.a	1
	Marking requirements	n.a	n.a	×	×	2*	n.a	×
	Packaging requirements	n.a	n.a	×	×	×	n.a	×
	TBT regulations on transport and storage	n.a	n.a	×	×	1	n.a	×
	Production or post-production requirements, n.e.s.	n.a	n.a	×	×	×	n.a	×
	Product-quality, safety or -performance requirement	n.a	n.a	×	×	×	n.a	×
	Testing requirement	n.a	n.a	×	×	1	n.a	×
	Certification requirements	n.a	n.a	2*	×	×	n.a	1*
	Inspection requirements	n.a	n.a	×	×	×	n.a	1
	Traceability requirements, n.e.s.	n.a	n.a	×	×	1	n.a	×
	Conformity assessment related to TBT, n.e.s.	n.a	n.a	×	×	×	n.a	1

C	Pre-shipment inspection	n.a	n.a	×	1*	×	n.a	×
	Other formalities, n.e.s.	n.a	n.a	×	×	2*	n.a	×
E	Non-automatic import-licensing procedures other than authorizations covered under sanitary/phytosanitary and TBT chapters	n.a	n.a	×	×	3	n.a	×
	Licensing for economic reasons	n.a	n.a	×	×	1	n.a	×
	Licensing for specified use	n.a	n.a	×	×	2	n.a	×
	Prohibition for non-economic reasons	n.a	n.a	×	×	1	n.a	1
	Prohibition for the protection of environment	n.a	n.a	1	×	×	n.a	×
G	Advance payment of customs duties	n.a	n.a	×	×	1*	n.a	×
	Finance measures n.e.s.	n.a	n.a	×	×	×	n.a	1*
H	Measures affecting competition	n.a	n.a	×	×	1*	n.a	×
	Measures affecting competitions, n.e.s.	n.a	n.a	×	×	×	n.a	1*
N	Patents	n.a	n.a	×	1*	×	n.a	×
	Geographical indication	n.a	n.a	×	1*	×	n.a	×
	Copyright	n.a	n.a	×	1*	×	n.a	×
	Trademark	n.a	n.a	×	1*	×	n.a	×
	International	n.a	n.a	×	2*	×	n.a	×
	Criminal remedies	n.a	n.a	×	2*	×	n.a	×
	Civil remedies	n.a	n.a	×	2*	×	n.a	×
	Intellectual property, n.e.s.	n.a	n.a	×	1*	×	n.a	×
O	Certificate of origin issued by authority	n.a	n.a	×	1*	×	n.a	×
Total import requirements applied to this product				1		12		4
Total import requirements applied to all products				2	15	6		3
Total import requirements applied				3	15	18		7

*Import requirements apply not only to this specific product, but also to all kind of products imported by the country.

Note: 1. '×' no import requirement reported for this type of measure.
2. 'n.a' import requirements are not available for this product/country.

Source: ITC Market Access Map.

Table 8 Number and type of import requirements applied on rotor blades incl. ball bearings, hubs

NTM chapter	Import requirement applied by	Dominican Republic	Ecuador	Kenya	Mauritius	Philippines	Senegal	Viet Nam
A	Labelling requirements	n.a	n.a	×	1*	×	n.a	×
B	Labelling requirements	n.a	n.a	×	1*	1	n.a	1
	Marking requirements	n.a	n.a	×	×	2*	n.a	×
	TBT regulations on transport and storage	n.a	n.a	×	×	1	n.a	×
	Testing requirement	n.a	n.a	×	×	1	n.a	×
	Certification requirements	n.a	n.a	2*	×	×	n.a	2*
	Inspection requirements	n.a	n.a	×	×	×	n.a	1
	Traceability requirements, n.e.s.	n.a	n.a	×	×	1	n.a	×
C	Pre-shipment inspection	n.a	n.a	×	1*	×	n.a	×
	Other formalities, n.e.s.	n.a	n.a	×	×	2*	n.a	×
E	Non-automatic import-licensing procedures other than authorizations covered under sanitary/phytosanitary and TBT chapters	n.a	n.a	×	×	3	n.a	×
	Licensing for specified use	n.a	n.a	×	×	1	n.a	×
	Prohibition for non-economic reasons	n.a	n.a	×	×	1	n.a	1
	Prohibition for the protection of environment	n.a	n.a	1	×	×	n.a	×
G	Advance payment of customs duties	n.a	n.a	×	×	1*	n.a	×
	Finance measures n.e.s.	n.a	n.a	×	×	×	n.a	1*
H	Measures affecting competition	n.a	n.a	×	×	1*	n.a	×
	Measures affecting competitions, n.e.s.	n.a	n.a	×	×	×	n.a	1*
N	Patents	n.a	n.a	×	1*	×	n.a	×
	Geographical indication	n.a	n.a	×	1*	×	n.a	×
	Copyright	n.a	n.a	×	1*	×	n.a	×
	Trademark	n.a	n.a	×	1*	×	n.a	×
	International	n.a	n.a	×	2*	×	n.a	×
	Criminal remedies	n.a	n.a	×	2*	×	n.a	×
	Civil remedies	n.a	n.a	×	2*	×	n.a	×
	Intellectual property, n.e.s.	n.a	n.a	×	1*	×	n.a	×
O	Certificate of origin issued by authority	n.a	n.a	×	1*	×	n.a	×
Total import requirements applied to this product				1	0	9		3
Total import requirements applied to all products*				2	15	6		4
Total import requirements applied				3	15	15		7

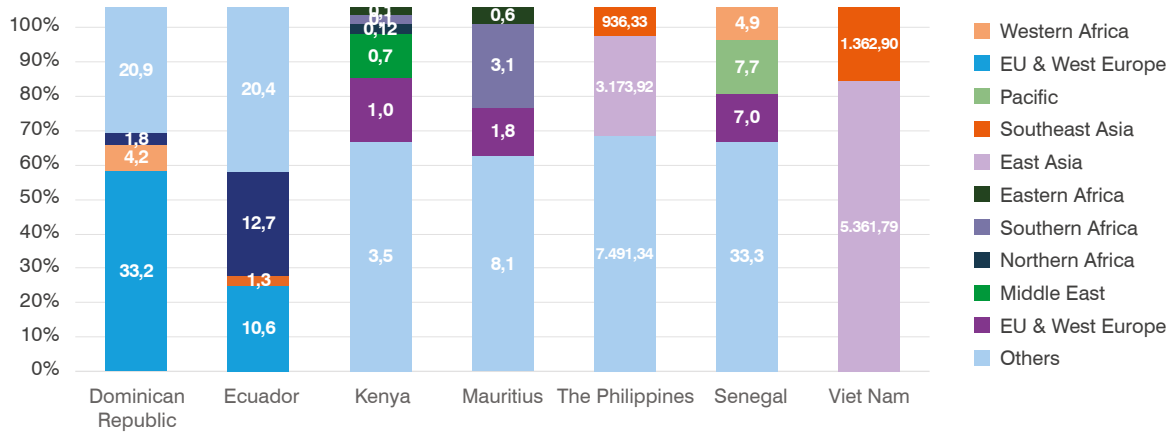
*Import requirements apply not only to this specific product, but also to all kind of products imported by the country.

Note: 1. '×' no import requirement reported for this type of measure.
2. 'n.a' import requirements are not available for this product/country.

Source: ITC Market Access Map.

APPENDIX XIII
Unrealized export potential for all components, by region

Figure 21 Unrealized export potential for all components, by region ($ million)



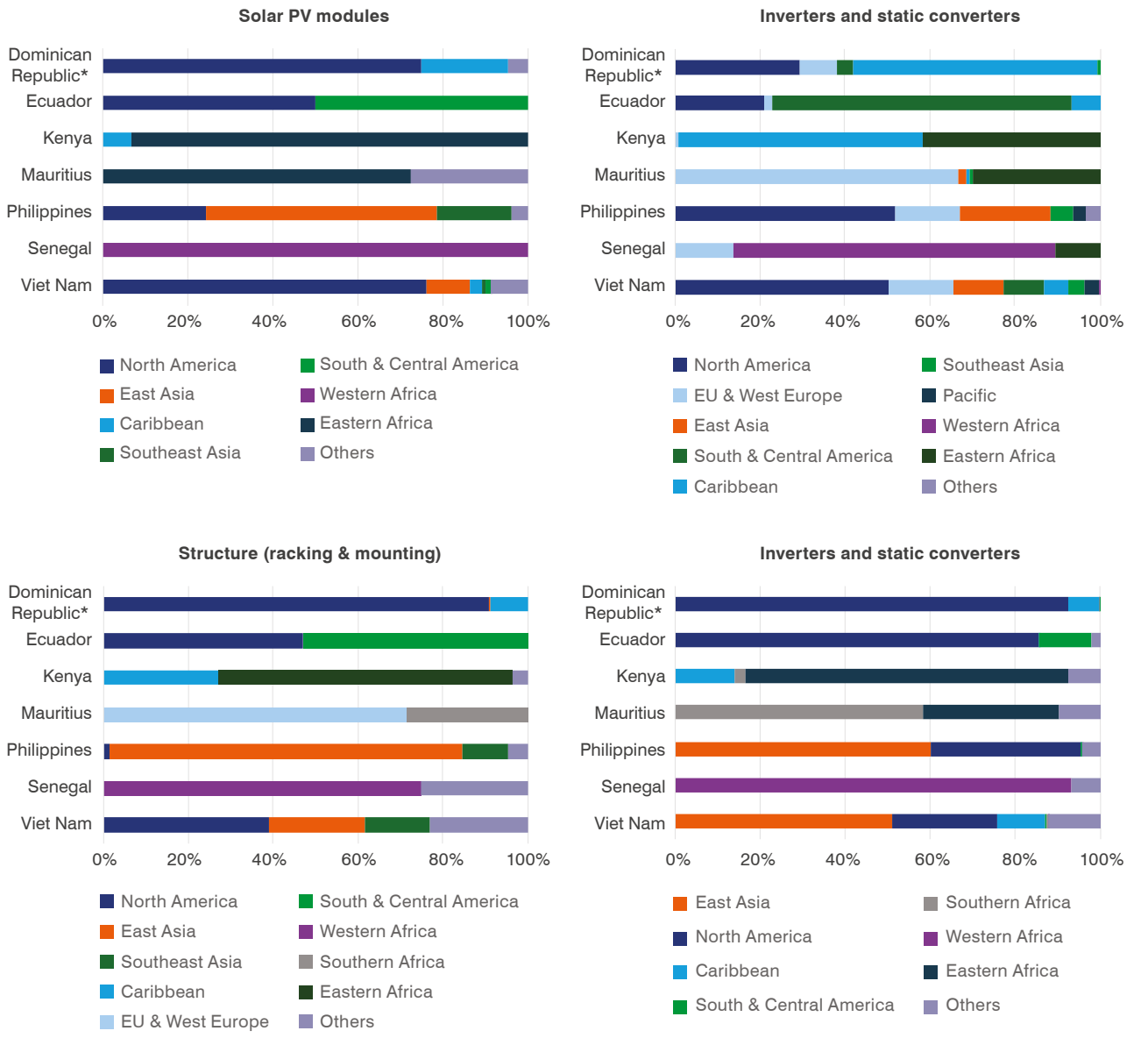
*Dominican Republic exported no solar PV modules in 2022, so data for 2021 have been used.

Note: The regions are assigned using ITC's regional groupings, which can be accessed here.

Source: Authors calculations based on ITC Export Potential Map.

APPENDIX XIV
Share of solar PV installation component exports, by region

Figure 22 Share of solar PV installation component exports, by region in 2022 ($ million)



*Dominican Republic exported no solar PV modules in 2022, so data for 2021 have been used.

Note: The regions are assigned using ITC's regional groupings, which can be accessed here.

Source: ITC Trade Map

APPENDIX XV
TESSD indicative list of services for RE projects

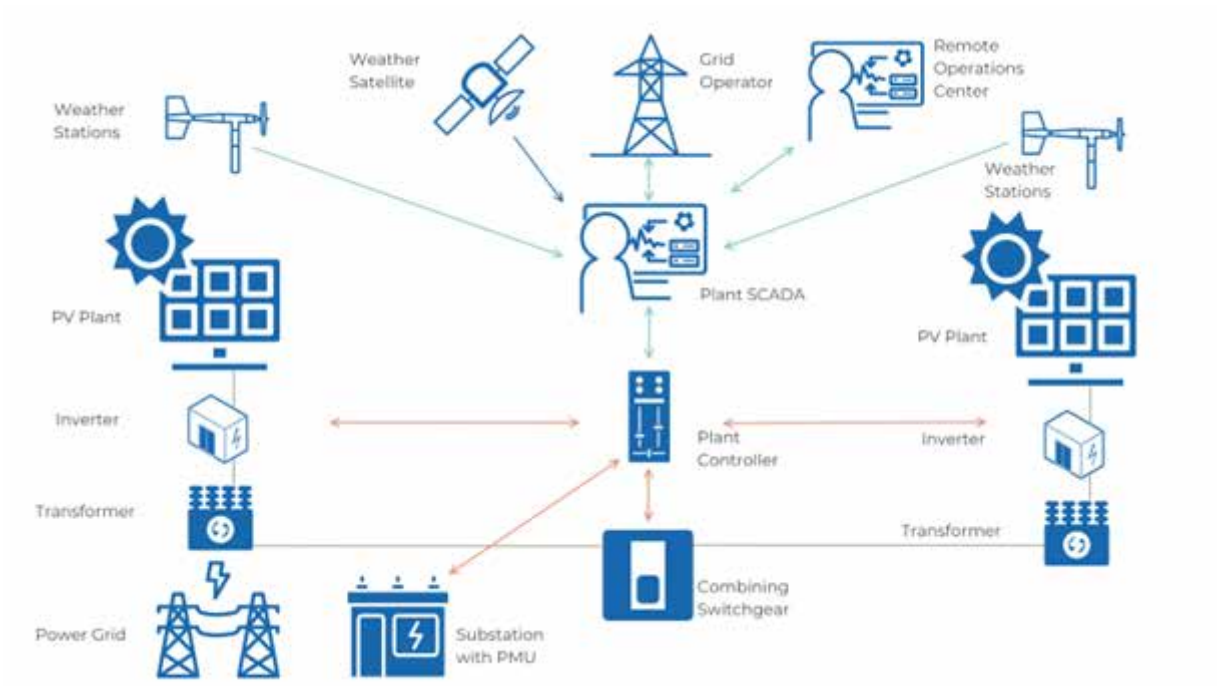
Table 9 Number and type of import requirements applied on wind turbine incl. generator, gearbox and nacelle

Service	CPC 2.1	CPC 2.1 Description
Architectural services	8321	Architectural services and advisory services
Urban planning services	83221	Urban planning services
Site identification and evaluation services		
Nature and landscape protection services		
Engineering services for energy projects	83324	Engineering services for power projects
Engineering design services for industrial processes and production	83322	Engineering design services for industrial and manufacturing projects
Testing and analysis, including certification	8344	Technical testing and analysis services
Environmental consulting services	83931	Environmental consulting services
Construction services	54	Construction services
	54262	General construction services of power plants
	54252	General construction services of local cables and related works
	53242	Long-distance communication and power lines (cables)
	54233	General construction of dams
Installation and assembly services for renewable energy projects	546	Installation services (part of construction services)
	873	Installation services (other than construction) – physical placement, configuration, set-up, calibration and testing of proper operation of various types of machinery and equipment
	87360	Installation services of electrical machinery and apparatus n.e.c. (electric motors, generators and transformers)
Logistics and transport services	65	Freight transport services
Financial services	711	Financial and related services

Service	CPC 2.1	CPC 2.1 Description
	71140	Financial leasing services
Regulatory services (as provided by public sector)		
Professional and business services, auditing, legal	821	Legal services
	822	Accounting, auditing and bookkeeping services
Consulting and advisory services	831	Management consulting and management services; information technology services
Wholesale trade services	61	Wholesale trade services
Operation services for renewable energy projects	8631	Support services to electricity transmission and distribution
	83115	Operations management consulting services
Maintenance and repair for renewable energy projects	871	Maintenance and repair services of fabricated metal products, machinery and equipment
Grid connection and monitoring		
Renewable energy storage services such as batteries		
Recycling	894	Materials recovery (recycling) services, on a fee or contract basis
Waste treatment and disposal services	94339	Other non-hazardous waste treatment and disposal services
Research and development services	8111	Basic research services in natural services and engineering
	8112	Applied research services in natural services and engineering
Services related to the manufacturing, sale, delivery and installation of renewable energy systems	8113	Experimental development services in natural services and engineering

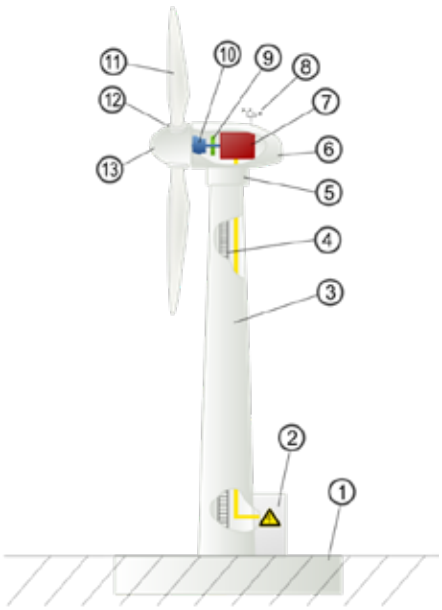
APPENDIX XVI
Components for a typical utility-scale PV power plant and wind turbine

Figure 23 Components for a typical utility-scale PV power plant



Source: National Renewable Energy Laboratory, 2016.

Figure 24 Main components of a wind turbine



1. Foundation
2. Connection to electric grid
3. Tower
4. Access ladder
5. Wind orientation (yaw) control
6. Nacelle
7. Generator
8. Anemometer
9. Brake
10. Gearbox
11. Rotor blade
12. Blade pitch control
13. Rotor hub

Source: Wikimedia Commons, 2007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Endnotes

1 Components other than the PV module are often referred to as the balance of system

2 It was on panels and cells that India levied custom duties of 40% and 25%, respectively, in 2022 as it looked to favour domestic production over imports (for example: https://www.reuters.com/business/energy/india-may-exempt-30-gw-solar-plants-equipment-duty-sources-2023-01-11/).

3 Where HS 8541.42 is 'PV cells not assembled in modules or made into panels' and HS 8541.43 is 'PV cells assembled in modules or made into panels'. HS 8541.40, from HS Code versions prior to 2022, also included light-emitting diodes.

4 Components other than the turbine are sometimes referred to as the balance of plant.

5 The Central Product Classification (CPC) is a product classification for goods and services promulgated by the United Nations Statistical Commission. It is intended to be an international standard for organizing and analyzing data on industrial production, national accounts, trade, prices and so on.' (https://en.wikipedia.org/wiki/Central_Product_Classification#:~:text=The%20Central%20Product%20Classification%20(CPC,trade%2C%20prices%20and%20so%20on.)

6 https://sdgs.un.org/partnerships/mauritius-renewable-energy-roadmap-2030#:~:text=Renewable%20Energy%20Roadmap%202030%20was,of%20renewable%20energy%20by%202030.

7 The export potential is an indicator developed by ITC that provides a potential export value for goods already exported by the country in new or existing target markets. It combines three components: supply, demand and ease of trade. The supply and demand components are projected into the future (to 2028) using expected gross domestic product (GDP) and population growth rates as well as forward-looking tariffs for goods (see Annex IV for a full description of the methodology to calculate the export potential indicator).

8 Plan Sénégal Emergent. See https://www.sentresor.org/app/uploads/pap2_pse.pdf

9 Renewables 'boom' in the Dominican Republic, but some feel sidelined (dialogue.earth)

10 *Ibid.*

11 Law 57-07 on Incentives for Development of Renewable Energy Sources and its Special Regimes – Policies - IEA

12 US Exempts Tariffs on Vietnamese Solar Panels for 2 Years (vietnam-briefing.com)

13 The solar battery paradox (thanhnien.vn)

14 https://www.seia.org/sites/default/files/2019-12/SEIA-Section-201-Factsheet-Dec2019.pdf

15 The US-China Trade Wars and the Solar Industry | US Solar Fund UK

16 Q&A | Solar Tariffs and the US Energy Transition - Center on Global Energy Policy at Columbia University SIPA | CGEP %

17 International Renewable Energy Agency (2022). *Renewable energy and jobs: Annual Review.*

18 Chinese businesses target Vietnam and Mexico as trade tensions with US rise (ft.com)

19 See Annex IV for a full description of the methodology for calculating the export potential indicator.

20 *Ibid*

21 Decree No. 7 of 2008 of the Ministry of Commerce, the General Administration of Customs and the General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China, promulgating the Administrative Measures for the Import of Mechanical and Electrical Products (mofcom.gov.cn)

22 International Classification of Non-tariff Measures - 2019 edition (unctad.org)

23 Sweeping away outdated trade regulations improves competitiveness in developing countries (worldbank.org)

24 World Trade Report 2022: Climate change and international trade (wto.org)

25 APEC members are Australia; Brunei Darussalam; Canada; Chile; People's Republic of China; Hong Kong, China; Indonesia; Japan; Republic of Korea; Malaysia; Mexico; New Zealand; Papua New Guinea; Peru; the Philippines; the Russian Federation; Singapore; Chinese Taipei; Thailand; the United States; Viet Nam.

26 Only three of the HS codes we consider are on the APEC list - 8502.31 (wind turbines), 8504.90 (inverters) and 8541.40 (solar PV panels).

27 HS code refers only to 'static converters', which include inverters for all purposes but not transformers.

28 The NTMs are identified based on the International Classification of Non-Tariff Measures

29 See additional details on the methodology in Decreux and Spies (2016).

30 Not all products are considered. Those that are classified as harmful or not relevant to export potential are omitted from calculations. A full list of the products excluded can be found here.

31 Quality and standards (irena.org)

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