



TECHNOLOGY AND INNOVATION REPORT 2023

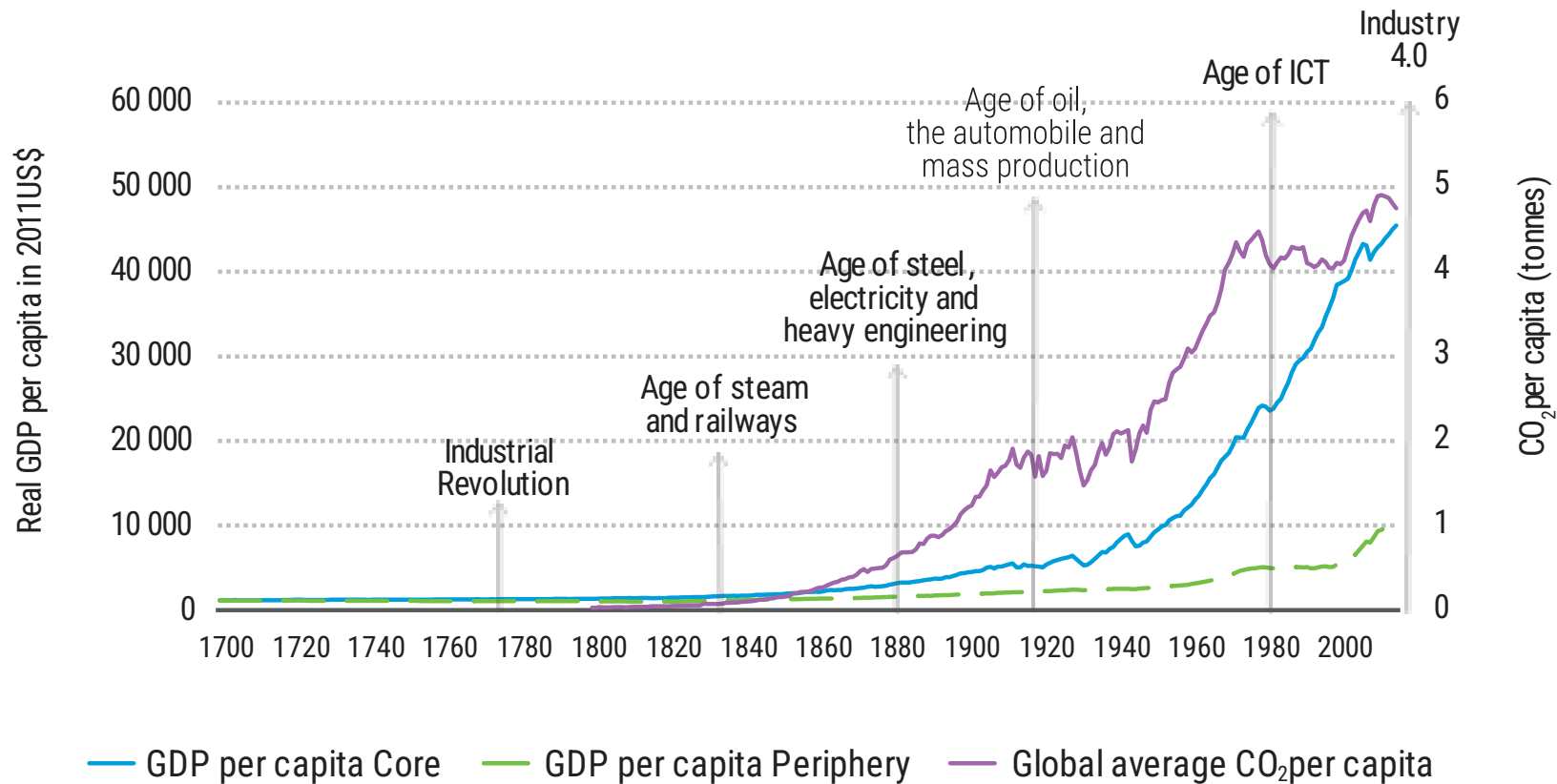
Opening green windows
*Technological opportunities
for a low-carbon world*

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Developing countries must catch the green technological revolution early

The great divide, rise in CO₂ per capita, and waves of technological change

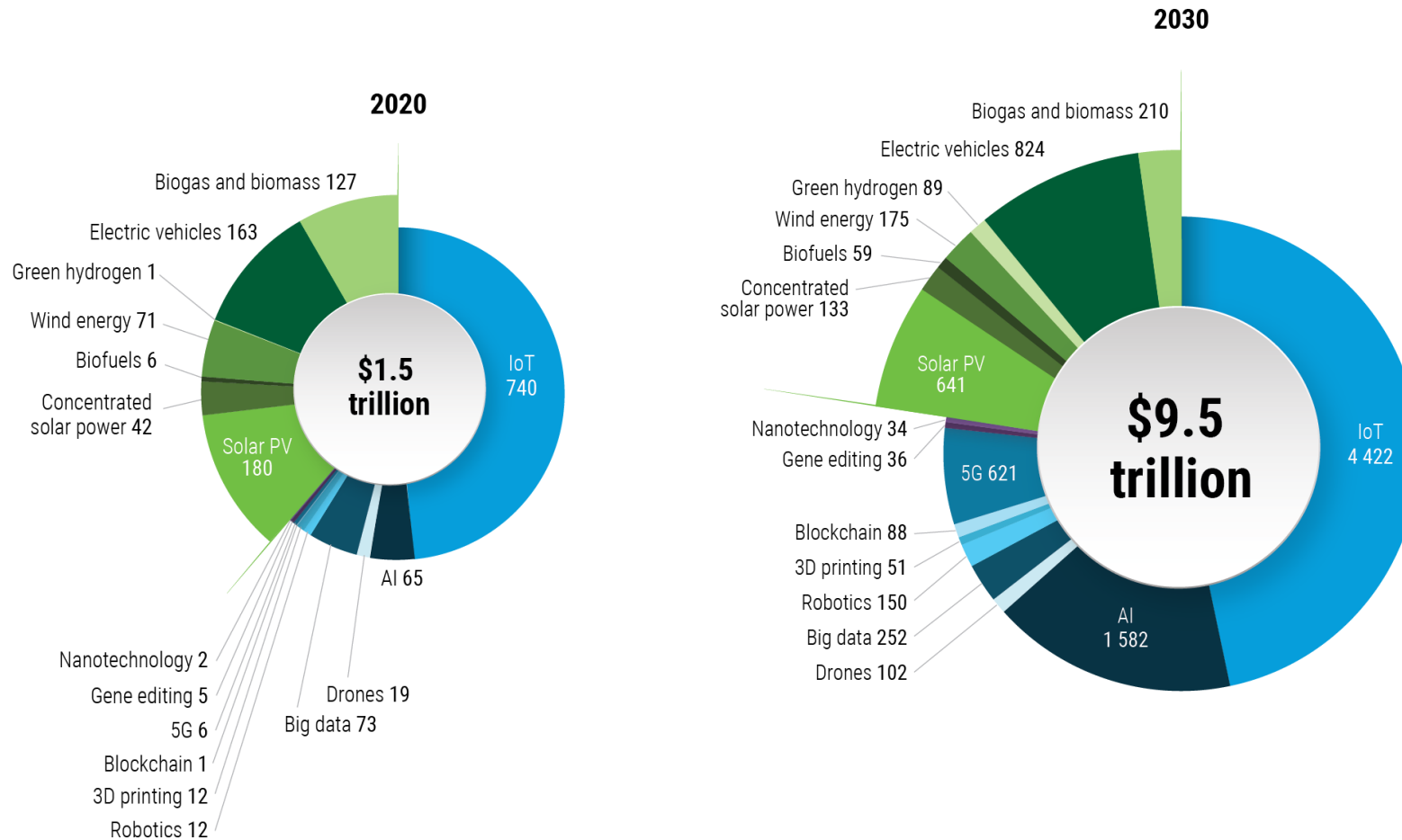


Notes: "Core" corresponds to Western European countries and Australia, Canada, New Zealand, the United States and Japan. "Periphery" corresponds to the rest of the world.

Source: UNCTAD, based on data from Our World in Data and the Maddison Project Database, version 2018, Bolt et al. (2018), Perez (2002), and Schwab (2013).

There are enormous opportunities in the development of green frontier technologies

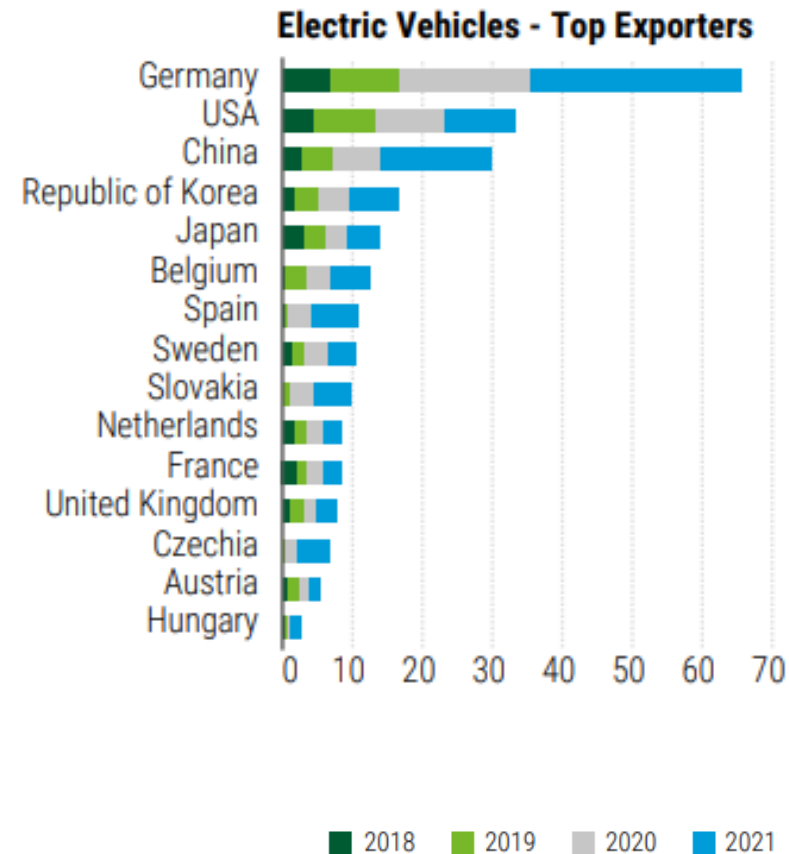
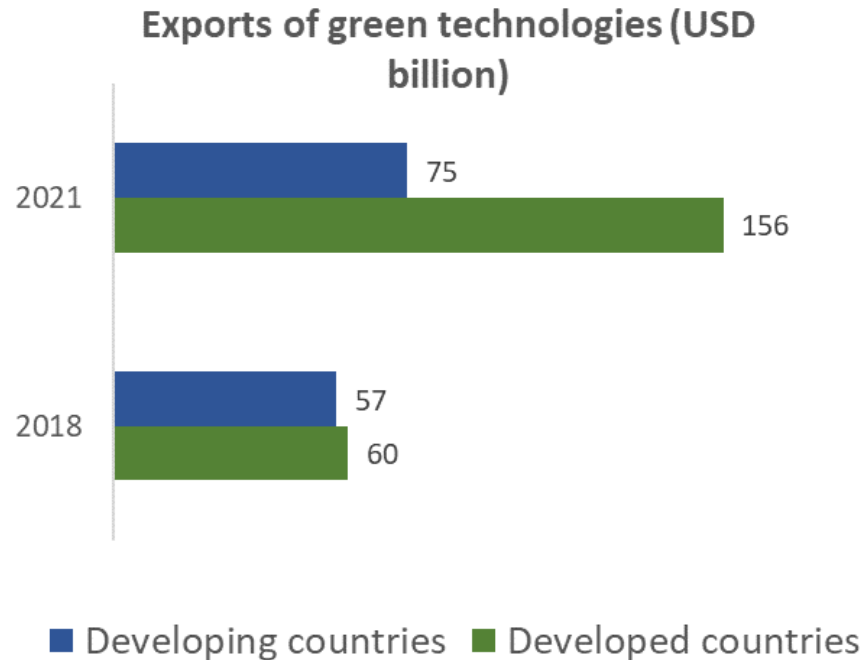
Market size estimates of frontier technologies, \$ billion



Source: UNCTAD based on various estimates.

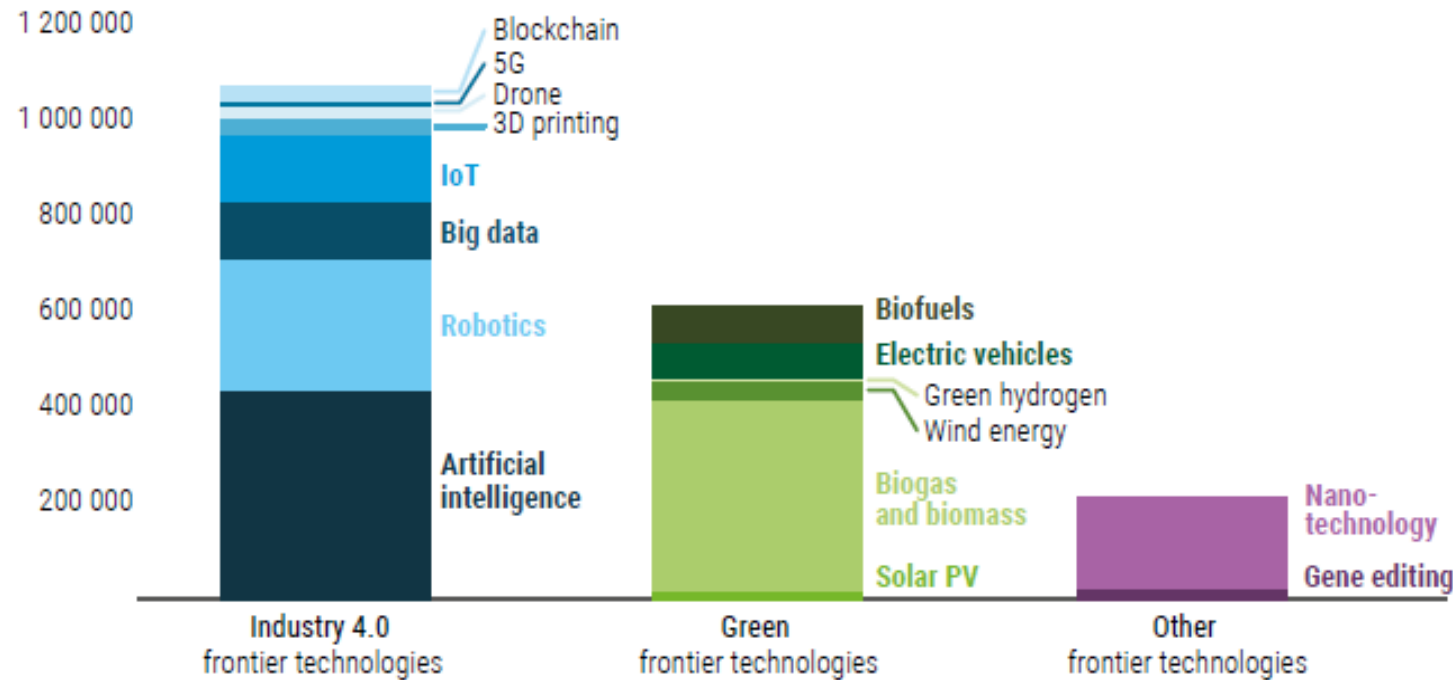
But so far, developed economies are seizing most of the opportunities

Technology imports and exports by top countries, 2018-2021 (USD billions)



There is significant concentration of knowledge creation in terms of publications

Number of publications on frontier technologies, 2000 – 2021



Source: UNCTAD calculations based on data from Scopus.

Top 3 countries

Wind energy:

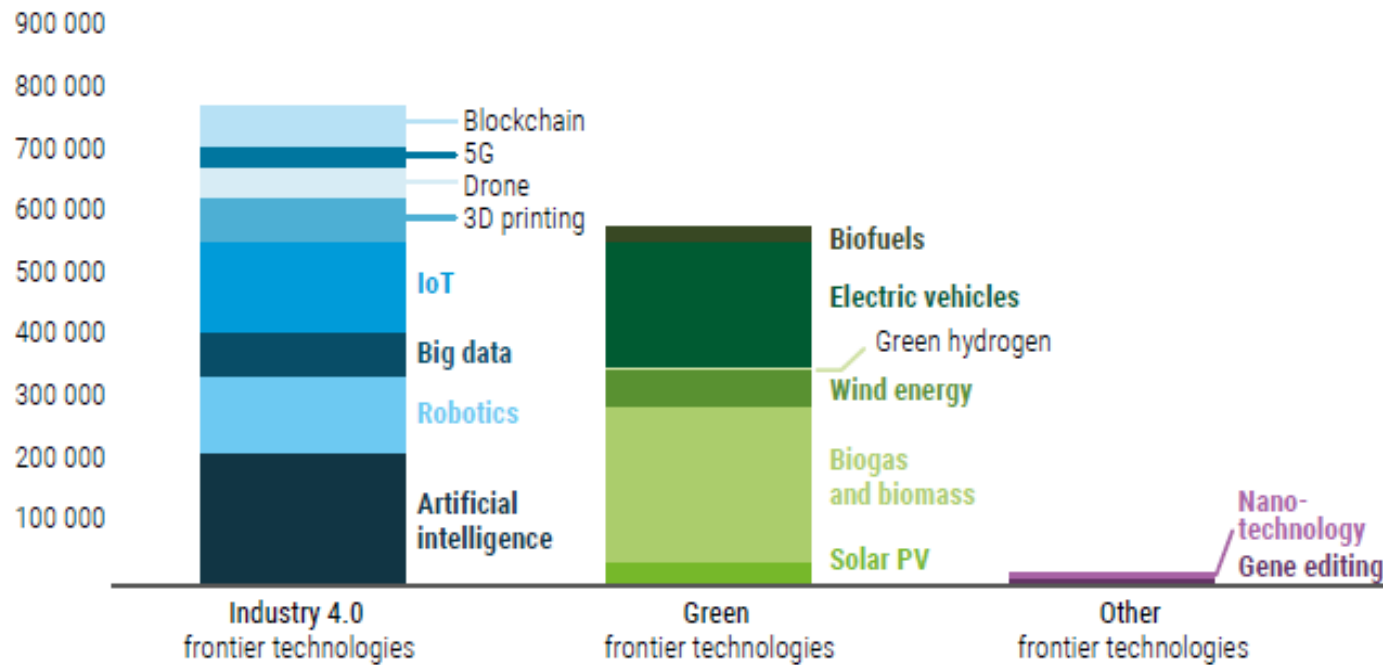
China (5,376)
 United States (5,359)
 India (4,254)

Solar PV:

India (6,619)
 United States (2,850)
 China (1,692)

...and in terms of patents

Number of patents for frontier technologies, 2000 – 2021



Source: UNCTAD calculations based on data from PatSeer.

Top 3 countries

Wind energy:

China (32,991)
 Germany (11,630)
 United States (2,927)

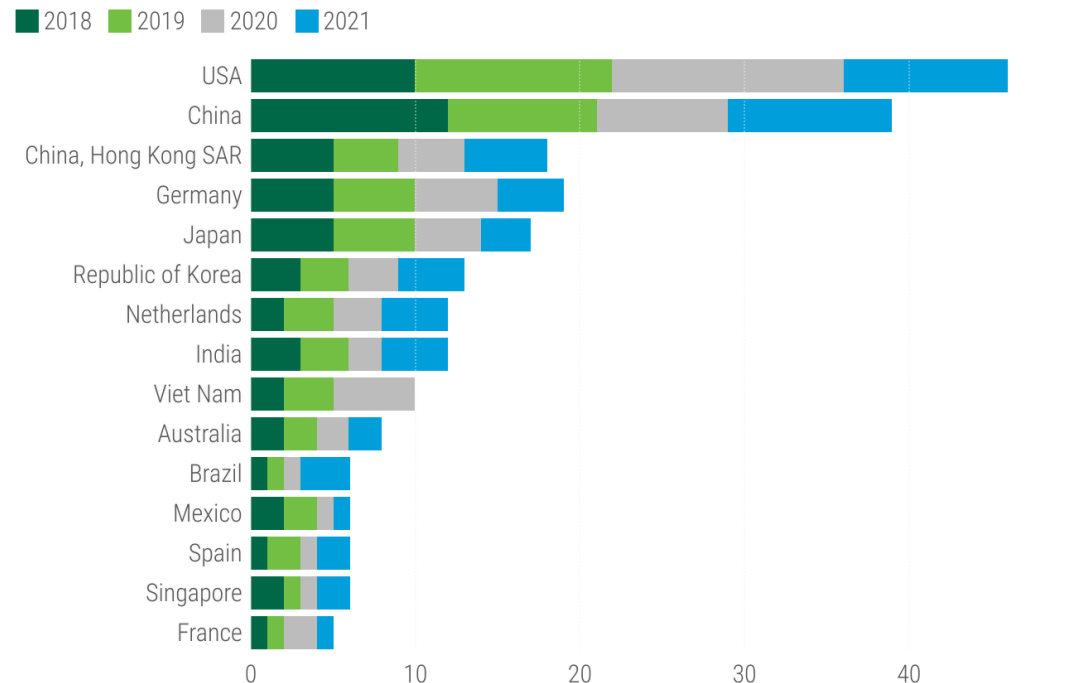
Solar PV:

China (31,361)
 Republic of Korea (1,792)
 United States (1,578)

The trade of green technologies has expanded significantly in the last few years

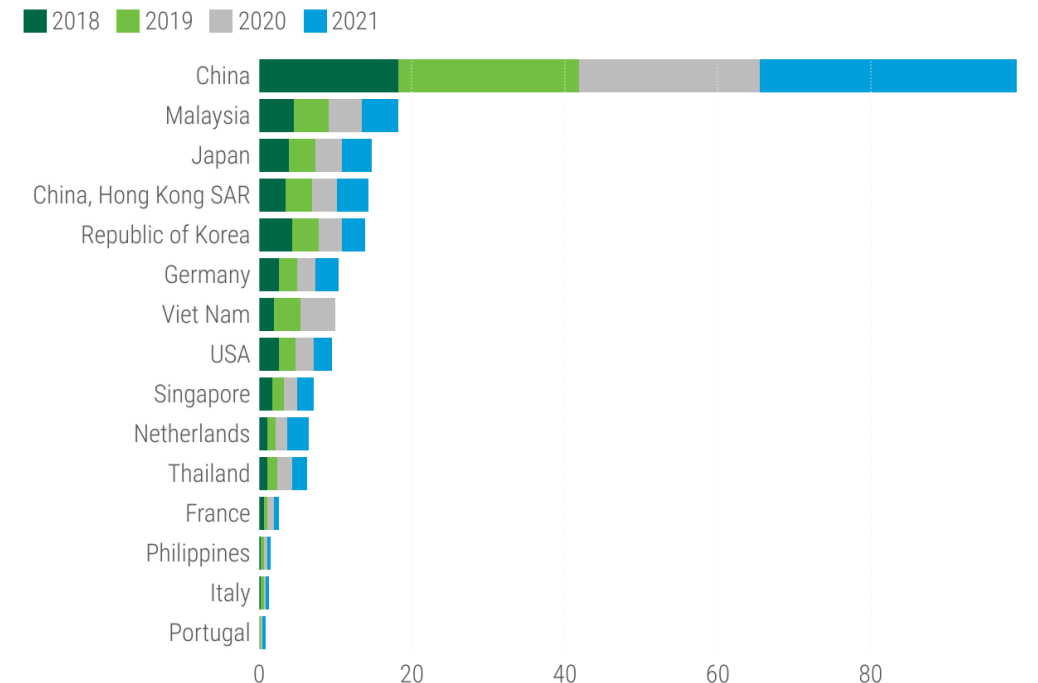
Solar PV imports and exports by top countries, 2018-2021 (USD billions)

Solar PV: Top Importers



Source: UNCTAD

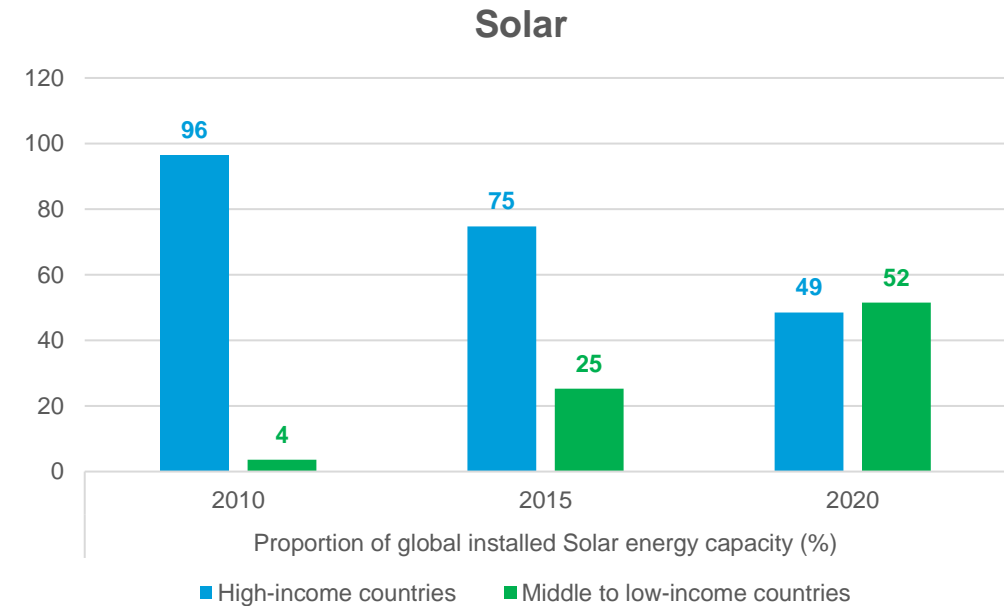
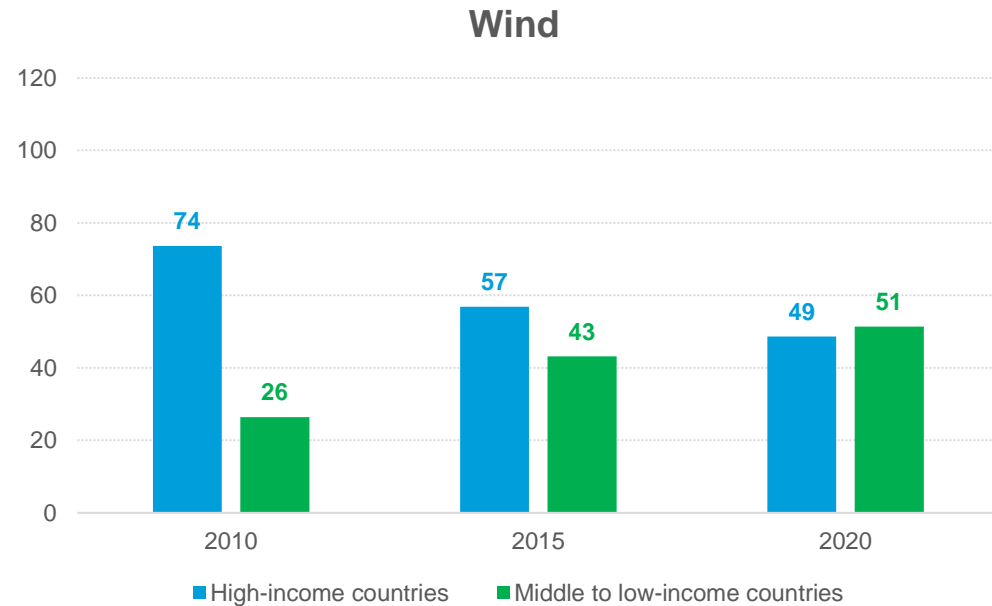
Solar PV: Top Exporters



Source: UNCTAD

Installed capacity is expanding in middle- and low-income countries

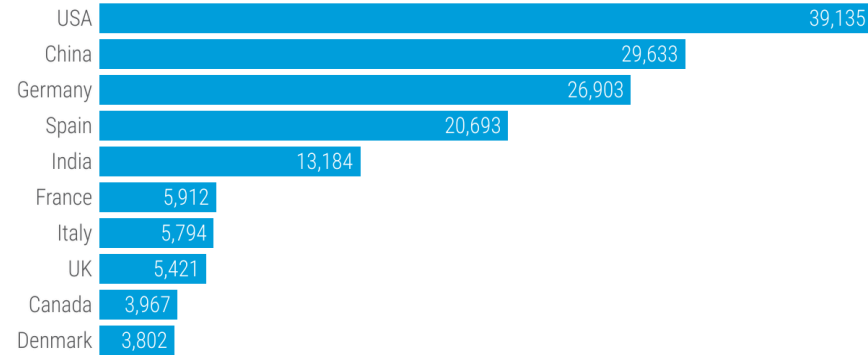
Installed renewable energy capacity by regions (percentage of world total)



Expansion of installed capacity

Wind in 2010

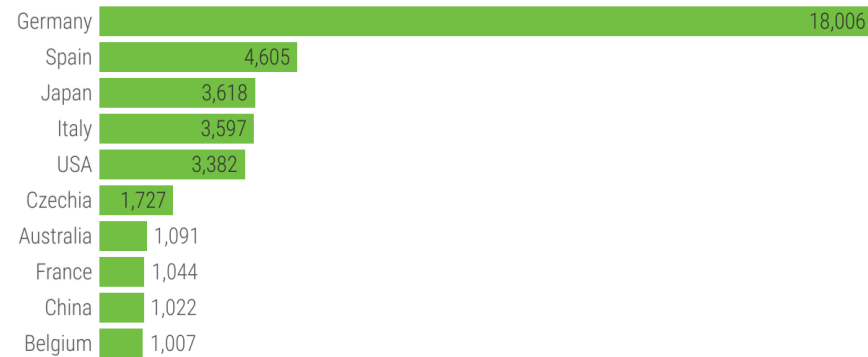
Installed capacity (MW)



Source: UNCTAD based on IRENASTAT (2021)

Solar in 2010

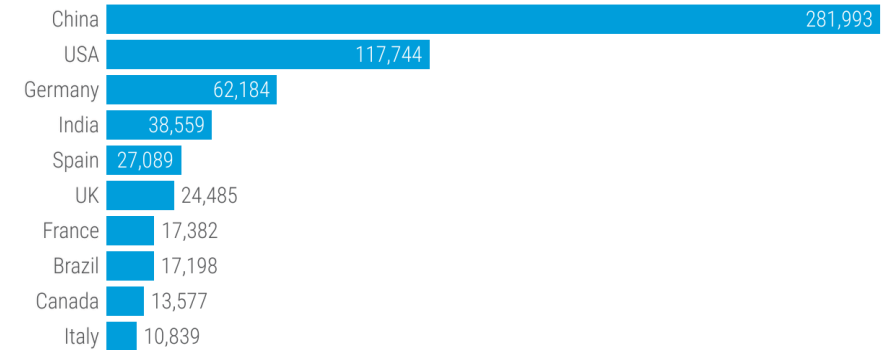
Installed capacity (MW)



Source: UNCTAD based on IRENASTAT (2021)

Wind in 2020

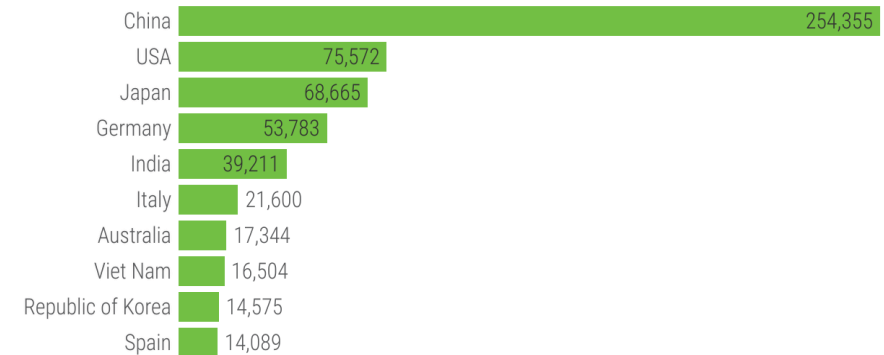
Installed capacity (MW)



UNCTAD based on IRENASTAT (2021)

Solar in 2020

Installed capacity (MW)



Source: UNCTAD based on IRENASTAT (2021)

OPENING GREEN WINDOWS

Technological opportunities for a low-carbon world

Frontier technologies readiness index combining ICT, skills, R&D, industrial capacity and finance indicators

	Rank in 2022	Rank in 2021	Movement in rank	ICT ranking	Skills ranking	R&D ranking	Industry ranking	Finance ranking
Top 10								
United States of America	1	1	—	11	18	2	16	2
Sweden	2	4	▲	6	2	16	11	18
Singapore	3	5	▲	7	8	17	4	17
Switzerland	4	2	▼	21	13	12	5	5
Netherlands	5	6	▲	4	9	15	10	31
Republic of Korea	6	7	▲	15	26	3	9	7
Germany	7	9	▲	24	17	5	12	40
Finland	8	17	▲	22	5	21	20	30
China, Hong Kong SAR	9	15	▲	9	23	29	2	1
Belgium	10	11	▲	13	4	23	19	48
Selected transition and developing economies								
Russian Federation	31	27	▼	43	32	13	54	69
China	35	25	▼	117	92	1	8	4
Brazil	40	41	▲	50	55	18	51	57
India	46	43	▼	95	109	4	22	75
South Africa	56	54	▼	71	77	36	67	25



Paths to seize benefits from the new technological revolution

1

Developing and using
renewable energy
technologies

2

Greening traditional
global value chains
by switching to digital
technologies

3

Diversifying towards
production sectors
that are more
complex and greener

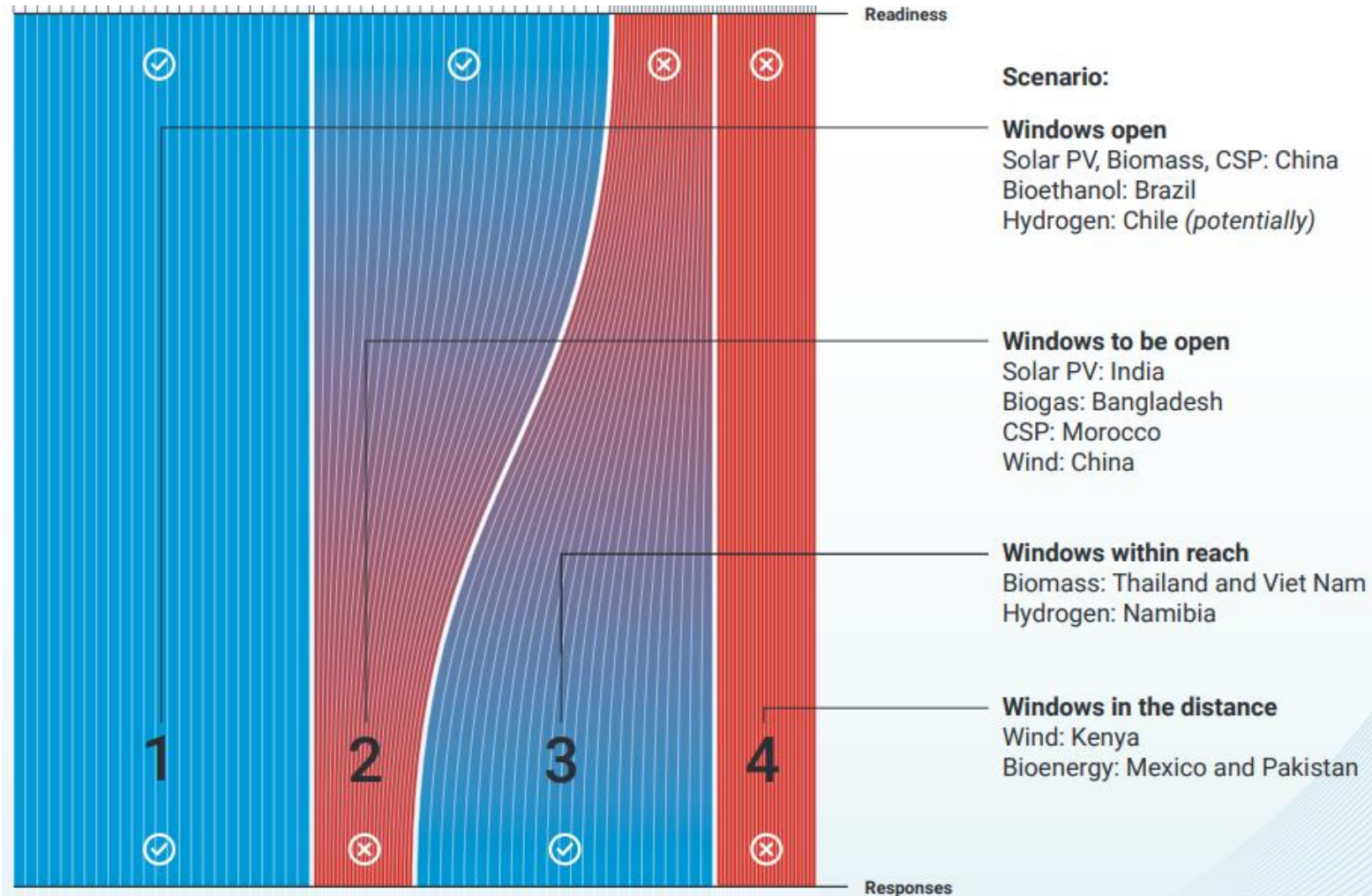
1

Developing and using
renewable energy
technologies

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Technological opportunities for a low-carbon world

Combining strong initial conditions and strong responses make up the best scenario to seize GWOs but weak conditions can be compensated by strong efforts

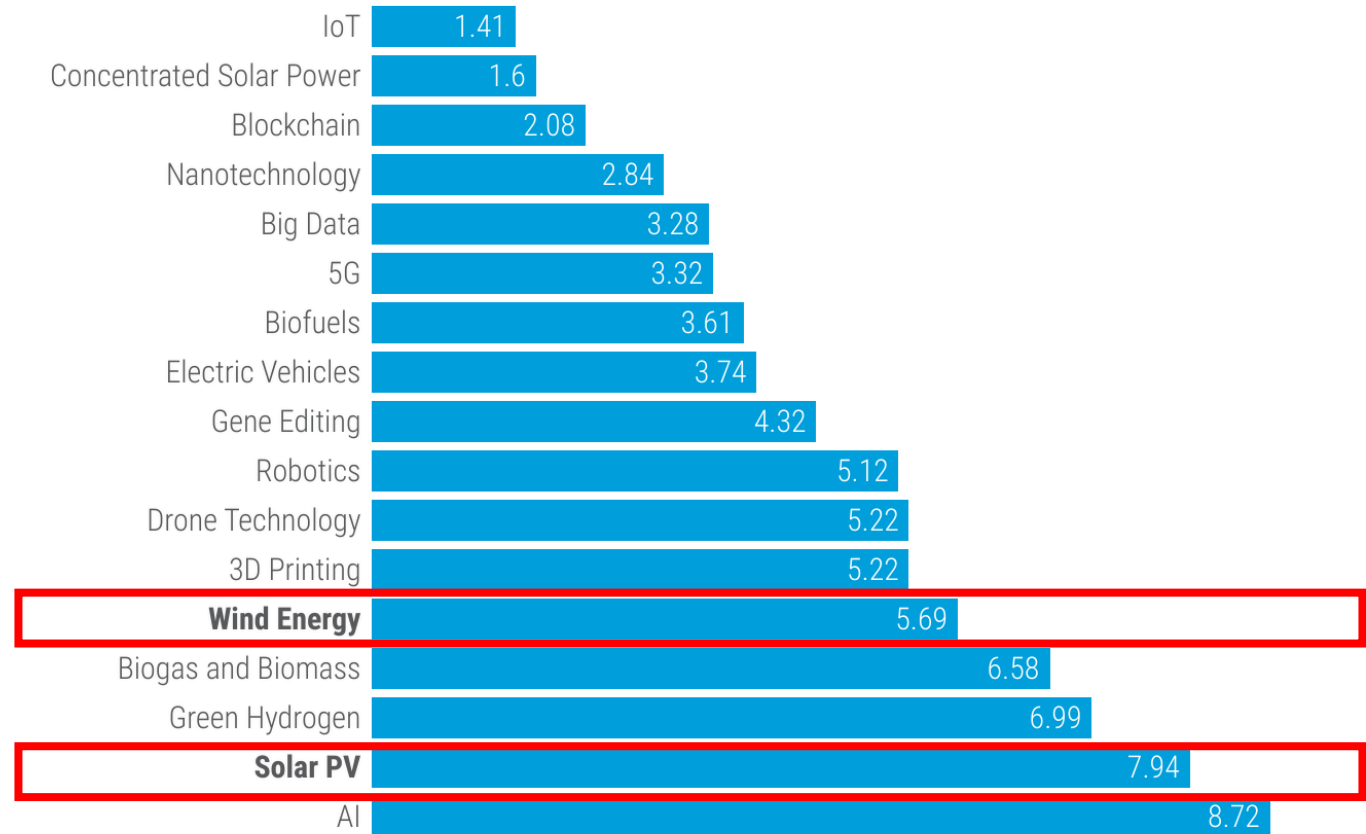


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Technological opportunities for a low-carbon world

The level of maturity influences the barriers for newcomers in each sector

Patent maturity of frontier technologies



For each technology, the number in the bar graph shows the patent maturity, which is the difference between the weighted average year of the 20 most cited patents between 2000 and 2021

Source: UNCTAD

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Technological opportunities for a low-carbon world

The level of tradability influences both competitive dynamics and modes of learning

Dimensions of tradability	Capital equipment and inputs	Energy generation technology	Green energy outputs
Bioethanol	<i>Medium</i> (Distillery equipment)	<i>Low</i> (Ethanol distillery)	<i>High</i> (Ethanol)
Biogas (a)	<i>Low</i> (Heavy-duty machinery)	<i>Low</i> (Biogas plant, e.g., waste to energy)	<i>High</i> (Gas)
Biogas (b)	<i>High</i> (Anaerobic digestion equipment)	<i>Low</i> (Biogas digester)	<i>High</i> (Gas)
Biomass	<i>Low</i> (Equipment)	<i>Low</i> (Direct-fired biomass plant)	<i>Medium</i> (Electricity)
Solar PV	<i>High</i> (Industrial robots, assembly line designs)	<i>High</i> (Solar PV Panels)	<i>Medium</i> (Electricity)
CSP	<i>Low</i> (Heavy duty machinery)	<i>Low</i> (Solar farm)	<i>Medium</i> (Electricity)
Wind power	<i>Low</i> (Heavy duty machinery, steel)	<i>Medium</i> (Wind turbines)	<i>Medium</i> (Electricity)
Green Hydrogen	<i>Medium</i> (Electrolysis equipment)	<i>Low</i> (Conversion facility)	<i>High</i> (Ammonia)

Wind power

Increasingly deployed in developing countries

Depend on natural conditions (inshore and offshore)

GWO from policies to promote renewables, the changing preference from public and institutional investors, and technological developments

China has managed to exploit foreign markets

Differences in the degree to which economic activities are localized and the importance of foreign firms

Limited, technological upgrading in upper-middle-income countries (limited to services in the deployment chain instead of production activities in the manufacturing chain).

Trade policies have been the part of the incentives to develop green industries

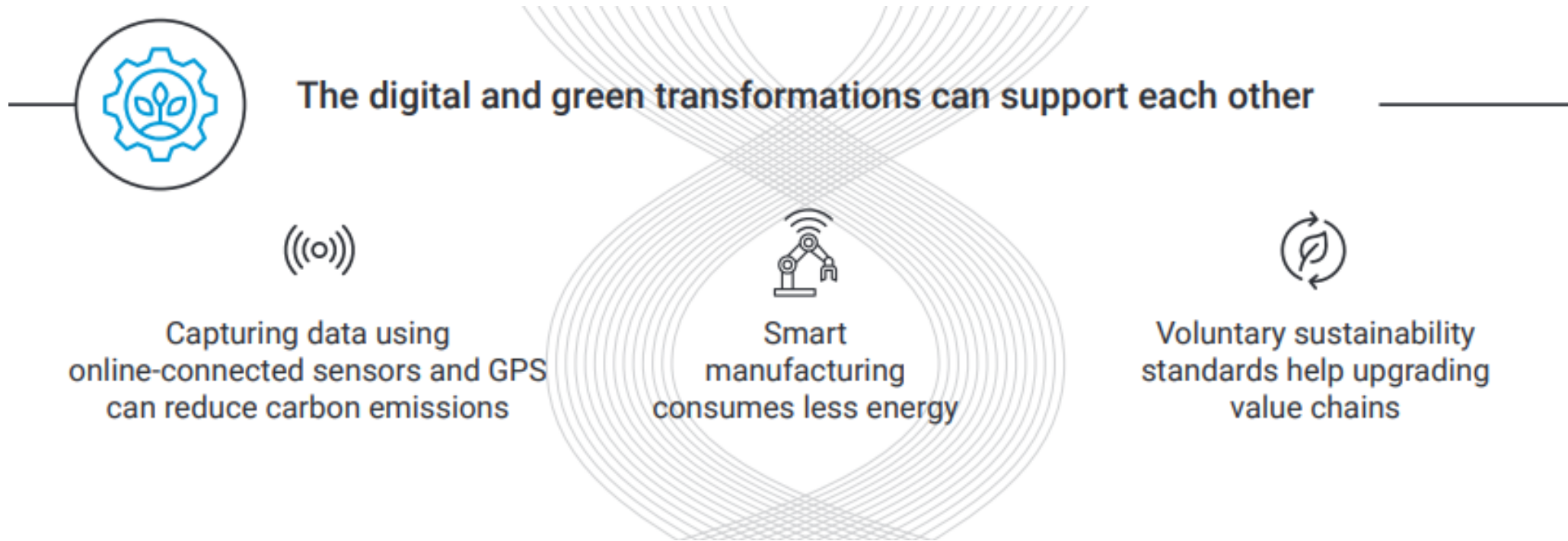
Incentive policies to green technologies

Developing and developed countries have implemented a mix of direct and indirect incentive measures to develop green industries

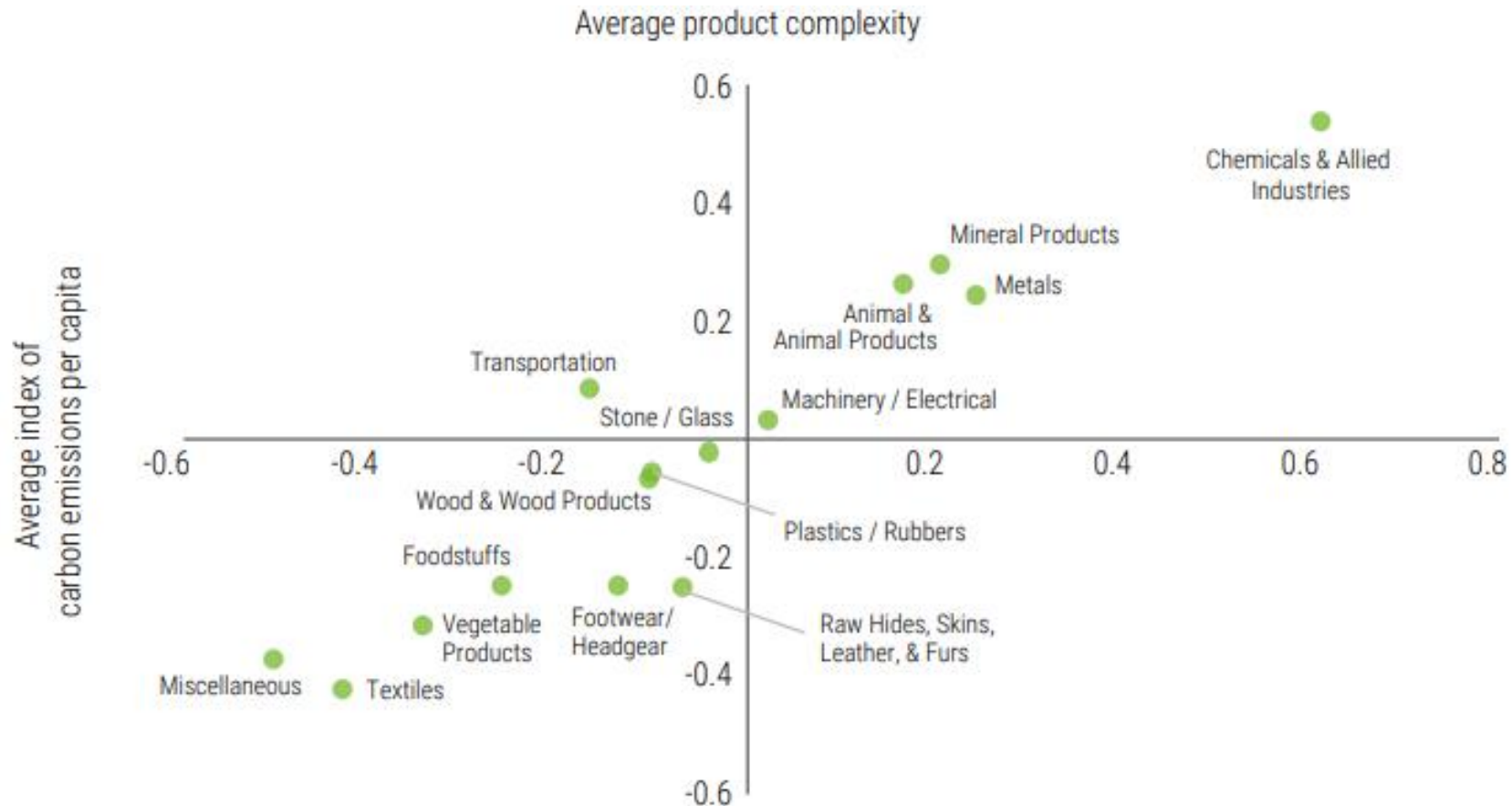
Support policies	Examples of implementing countries
Local content requirements	China, South Africa, India, Morocco, Brazil, Canada, Spain
Favourable custom duties	India, South Africa, Thailand, Mexico, Denmark, Germany, Australia, China
Export credit assistance	Denmark, Germany
Quality certification	India, China, Denmark, Germany, USA, Japan
Financial and tax incentives	India, Kenya, Morocco, Brazil, Thailand, China, Canada, Australia, Spain, USA, Germany, Denmark
Research and development	Morocco, Brazil, Denmark, Germany
Feed-in-tariffs of fixed price	Iran, Kenya, China, Brazil, India, Germany, Denmark, Spain, Netherlands, Japan
Mandatory RE targets	Australia, UK
Government tendering	South Africa, Brazil, India, China, UK, Canada, Japan

Source: UNCTAD based on multiple sources

The digital and the green transformations can be twins if there are strong enough policy responses



There is a path to diversify towards more complex and greener production, but taking it might be harder for developing countries

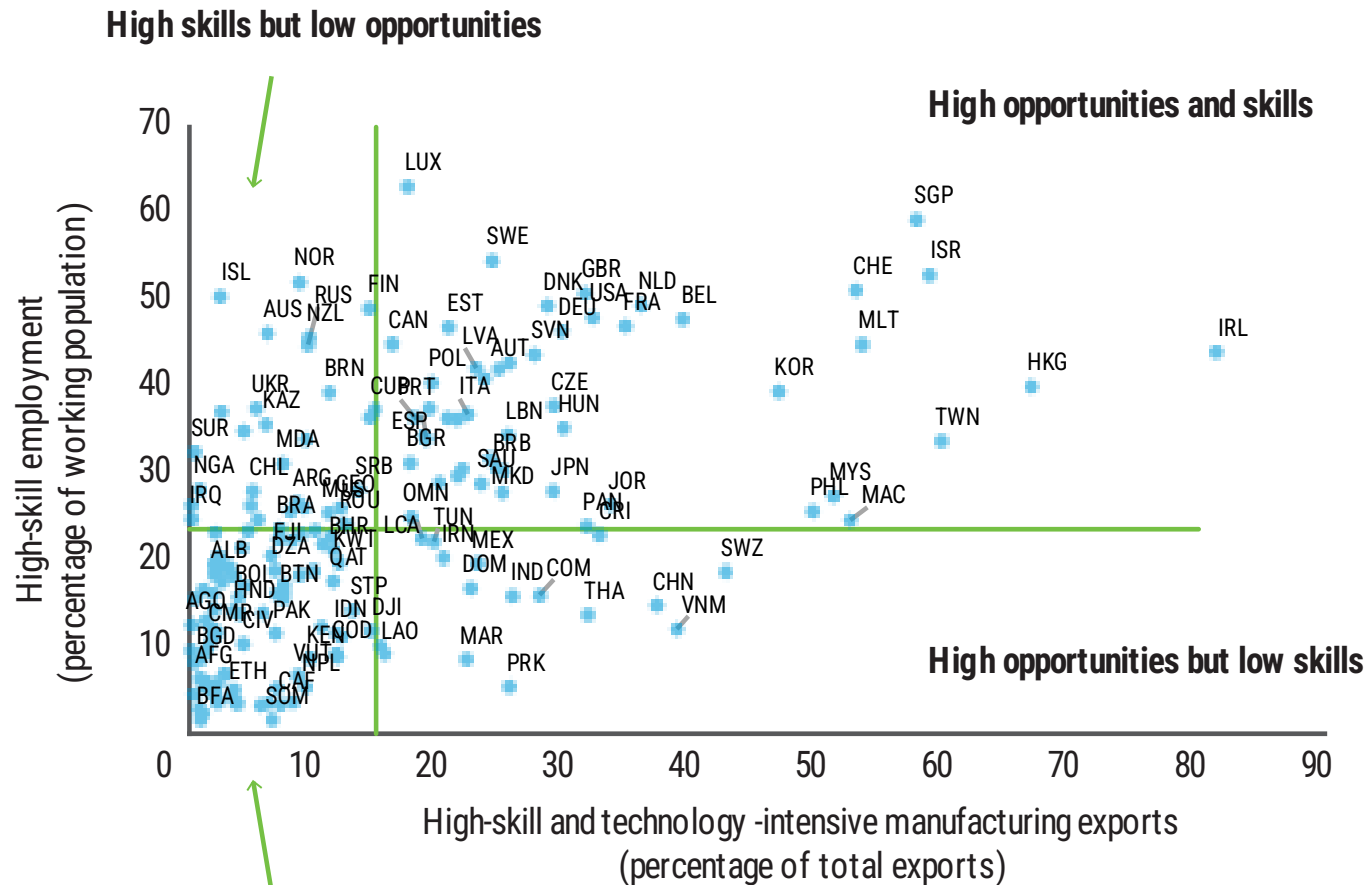


Source: UNCTAD based on data from the United Nations Commodity Trade Statistics Database (COMTRADE).

Note: On both axes, zero represents the global average, and 1 is the standard deviation of the distribution.

Challenge: Low level of existing technological and innovative capacities

Readiness to benefit from the diffusion of Industry 4.0



Opening green windows



Set the direction towards green technologies and innovation

Align environmental and industrial policies
Invest in more complex and greener sectors
Incentives and infrastructure to shift demand



Build green productive and innovative capacities

Invest in R&D
Raise awareness of green technologies
Develop digital infrastructure and skills

International cooperation

Consistency between international agreements on trade, intellectual property and climate change is critical for green technology revolution

Trade rules should permit developing countries to protect infant green industries through tariffs, subsidies and public procurement

Intellectual property should have greater flexibilities for developing countries with regard to green technologies

Conclusion

Technologies already exist

Political will needed

Developing countries should catch the green technological revolution early

Thank you!

<https://unctad.org/tir2023>



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