



TECHNOLOGY AND INNOVATION REPORT 2023

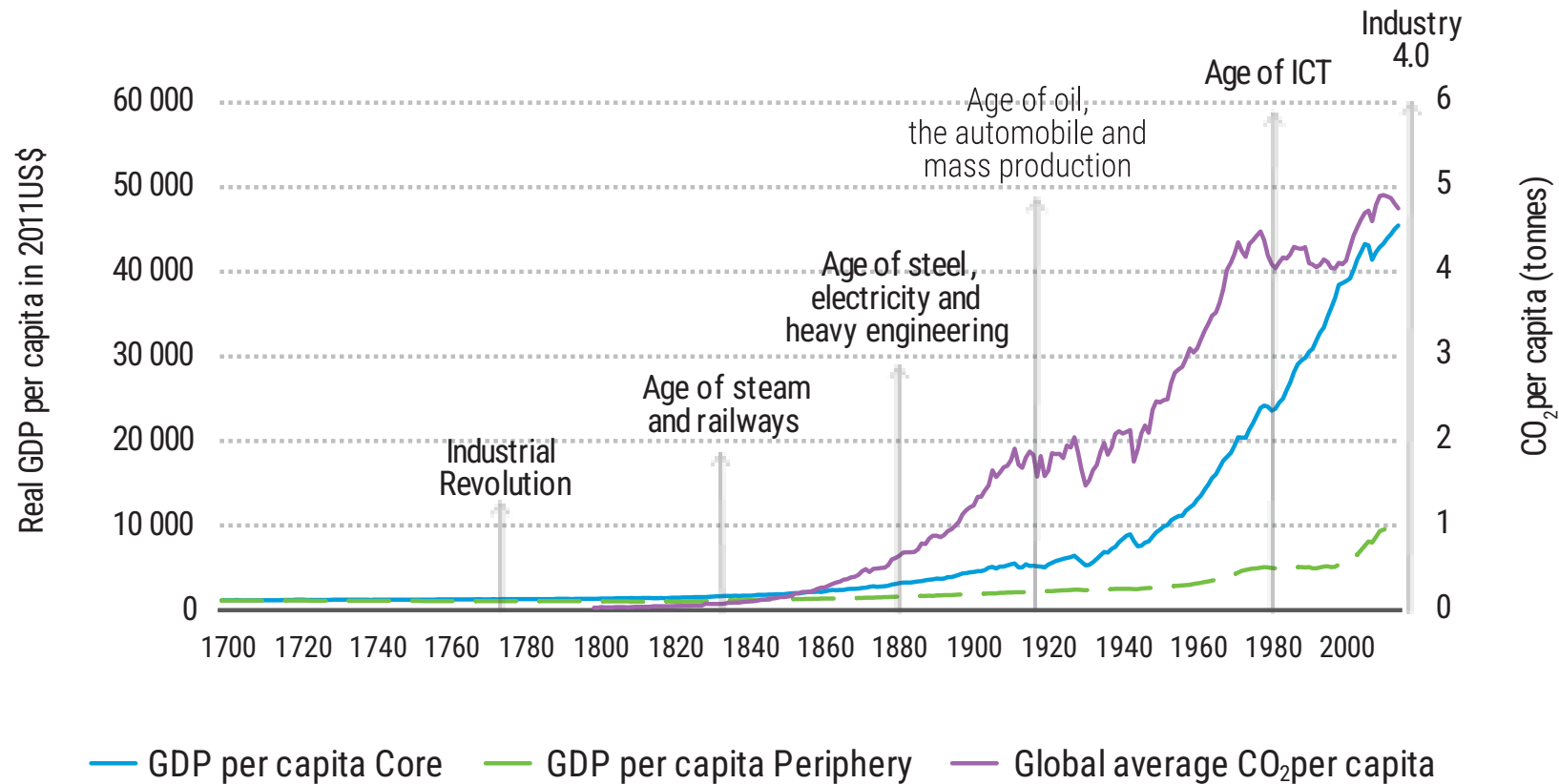
Opening green windows
*Technological opportunities
for a low-carbon world*



UNITED NATIONS
UNCTAD

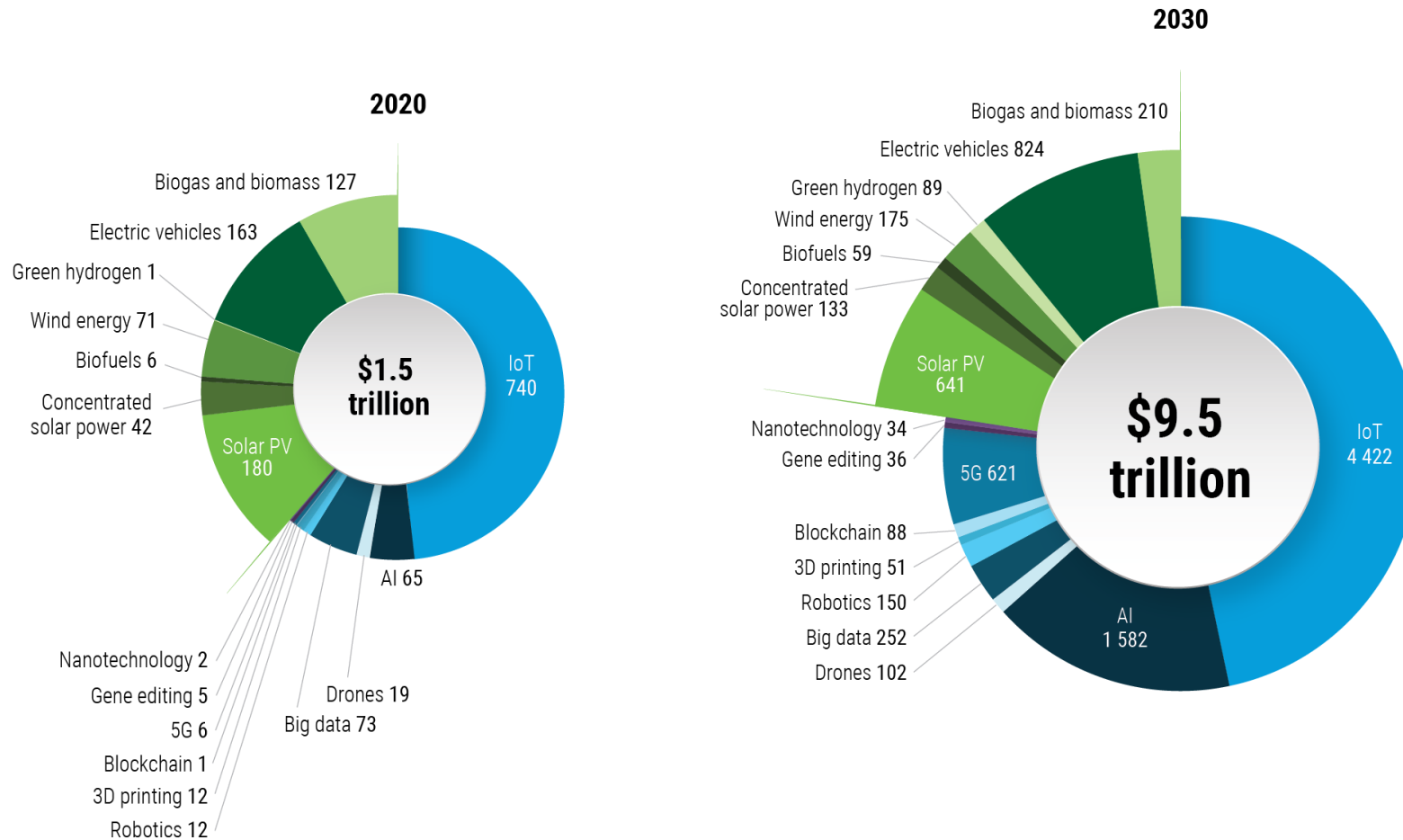
Developing countries must catch the green technological revolution early

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



There are enormous opportunities in the development of green frontier technologies

Market size estimates of frontier technologies, \$ billion



OPENING GREEN WINDOWS

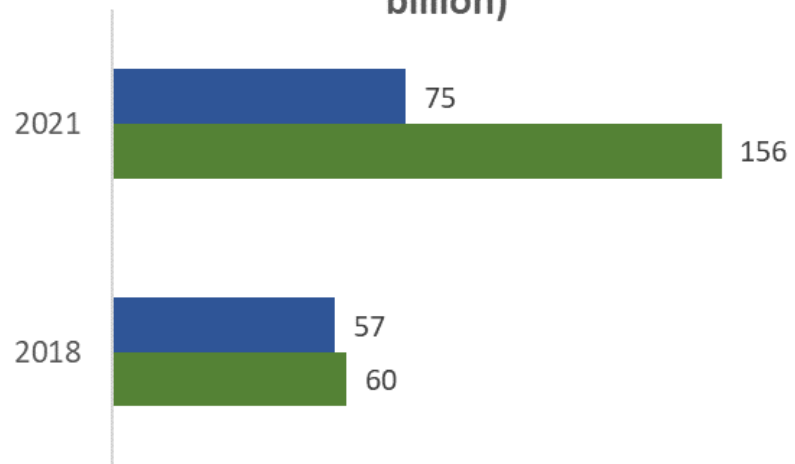
Technological opportunities for a low-carbon world

Key indicators of frontier technologies

Category:	AI	IoT	Big data	Blockchain	3D printing	Robotics	Drones	5G
Publications	438 619	139 805	1 19 555	27 964	36 367	276 027	23 526	13 045
Patents	214 365	147 906	72 184	63 767	70 799	122 940	48 613	32 412
Price	Video/speech analysis AI : \$36,000-56,000 Intelligent recommendation engine: \$20,000-\$35,000	ECG monitors: \$3,000-\$4,000 Energy management system: from \$27,000	Data warehouse (cloud storage): ~\$359,951/year Data warehouse (on-premises storage): ~\$372,279/year	NFT marketplace: \$50,000-\$130,000 Decentralized Autonomous Organization (DAO): \$3,500-\$20,000 Cryptocurrency exchange app: \$50,000-\$100,000	Entry-level 3D printer: \$100+ Industrial 3D printer: \$10,000+	\$50,000 - \$150,000 for industrial robot	Commercial drone: \$2000+ Military drone: \$800,000 to \$400 million	\$60-70+/monthly for unlimited US 5G network access
Market size	\$65 billion (2020) \$1,582 billion (2030)	\$740 billion (2020) \$4,422 billion (2030)	\$73 billion (2020) \$252 billion (2030)	\$1 billion (2020) \$88 billion (2030)	\$12 billion (2020) \$51 billion (2030)	\$12 billion (2020) \$150 billion (2030)	\$19 billion (2020) \$102 billion (2030)	\$6 billion (2020) \$621 billion (2030)
Major providers	Alphabet, Amazon, IBM, Microsoft, Alibaba and Tencent	Accenture, TCS, IBM, EY, Capgemini, HCL and Cognizant	Amazon, Microsoft, IBM, Google, Oracle, SAP and HP	Alibaba, Amazon, IBM, Microsoft, Oracle and SAP	Stratasys, 3D Systems, Materialise NV, EOS GmbH and General Electric	ABB, Fanuc, KUKA, and Yaskawa (industrial robotics), Alphabet/Waymo, Aptiv, GM, Tesla (autonomous vehicles)	3D Robotics, DJI Innovations, Parrot, Yuneec (commercial), Boeing, Lockheed Martin, Northrop Grumman (military)	Ericsson, Huawei, Nokia, ZTE, Samsung, and NEC
Major users	Retail, banking, discrete manufacturing	Manufacturing, home, healthcare and finance	Banking, discrete manufacturing and professional services	Banking, process manufacturing and discrete manufacturing	Discrete manufacturing, healthcare and education	Discrete manufacturing, process manufacturing and resource industry	Utilities, construction and discrete manufacturing	Mobile operators, industrial automation, manufacturing

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

Exports of green technologies (USD billion)



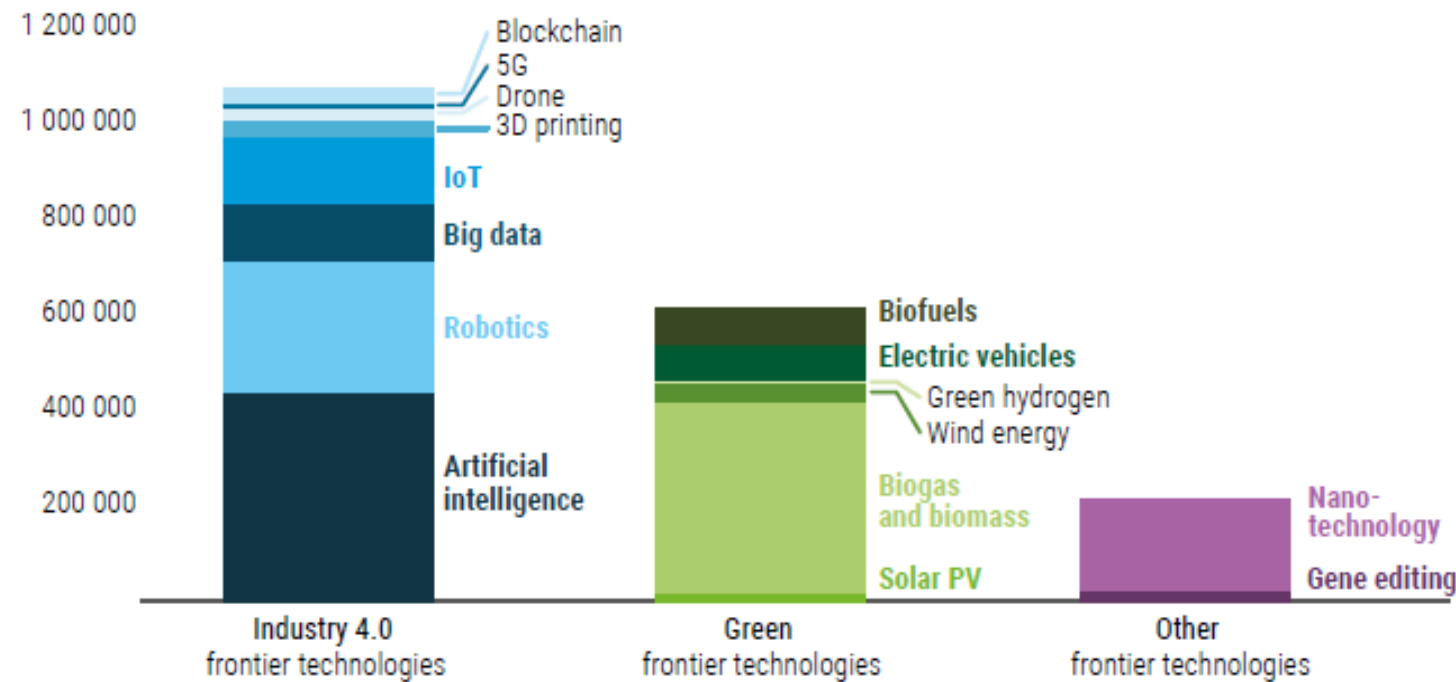
■ Developing countries ■ Developed countries

Top green frontier technology providers

Solar PV	Biofuels	Wind energy	Green hydrogen	Electric vehicles	Concentrated solar power	Biogas and biomass
Jinko Solar	Archer Daniels Midland	GE Power	Siemens Energy	Tesla	Abengoa Solar	Future Biogas
JA Solar	ALTEN Group	Mitsubishi Heavy Industries	Linde	Ford	Iberolica Group	Air Liquide
Trina Solar	Louis Dreyfus	ABB	Toshiba Energy	Hyundai	ENGIE	PlanET Biogas Global
Canadian Solar	Brasil Bio Fuels	Siemens Gamesa Renewable Energy	Air Liquide	Chevrolet	NextEra Energy Resources	Ameresco
Hanwa Q cells	BIOX Corp	Goldwind	Nel ASA	BYD	BrightSource Energy	Quantum Green
	Renewable Energy Group	Enercon	Air Products and Chemicals	Volkswagen		Envitech Biogas
	Wilmar international		Guangdong Nation-Synergy Hydrogen Power Technologies	Renault-Nissan-Mitsubishi Alliance		Weltec Biopower

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:

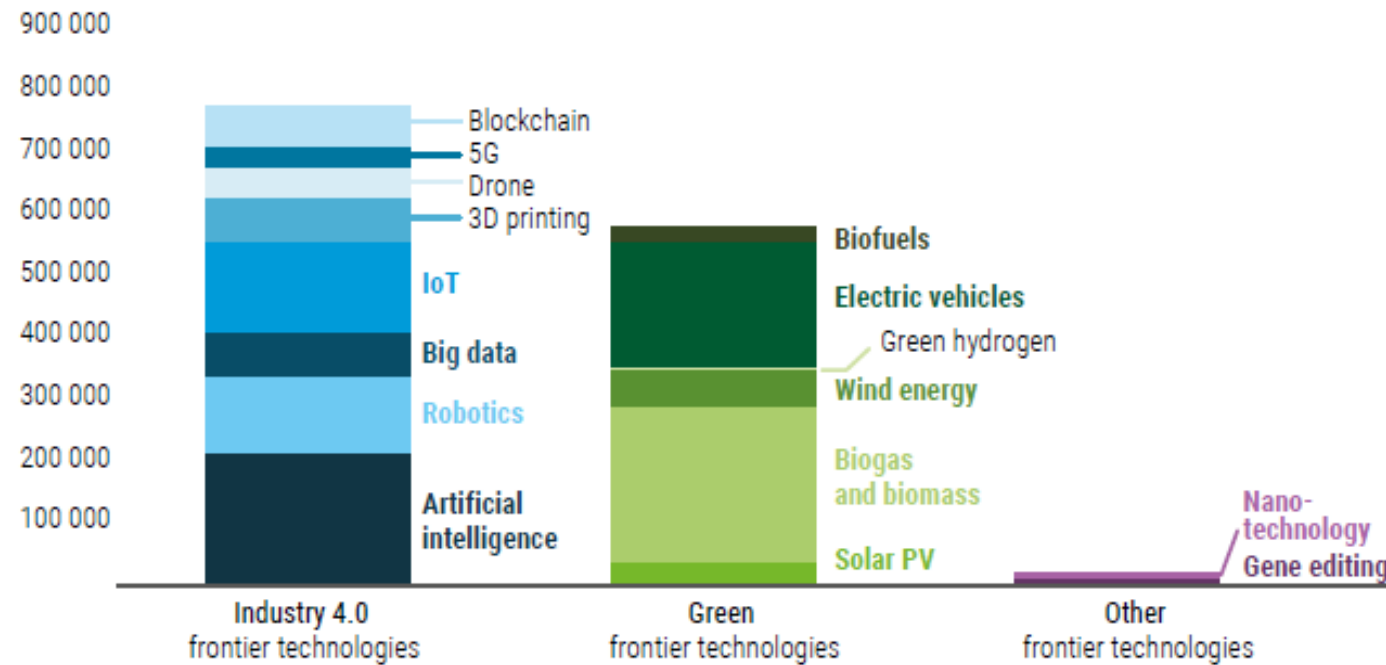
China (5,376)
United States (5,359)
India (4,254)

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:

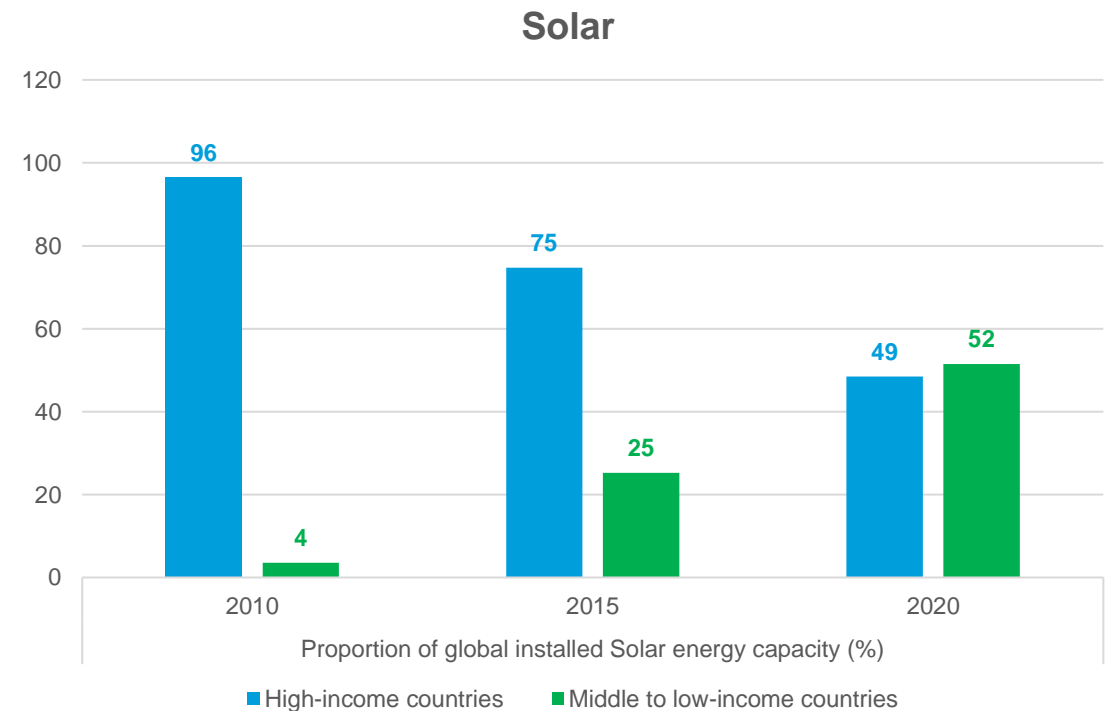
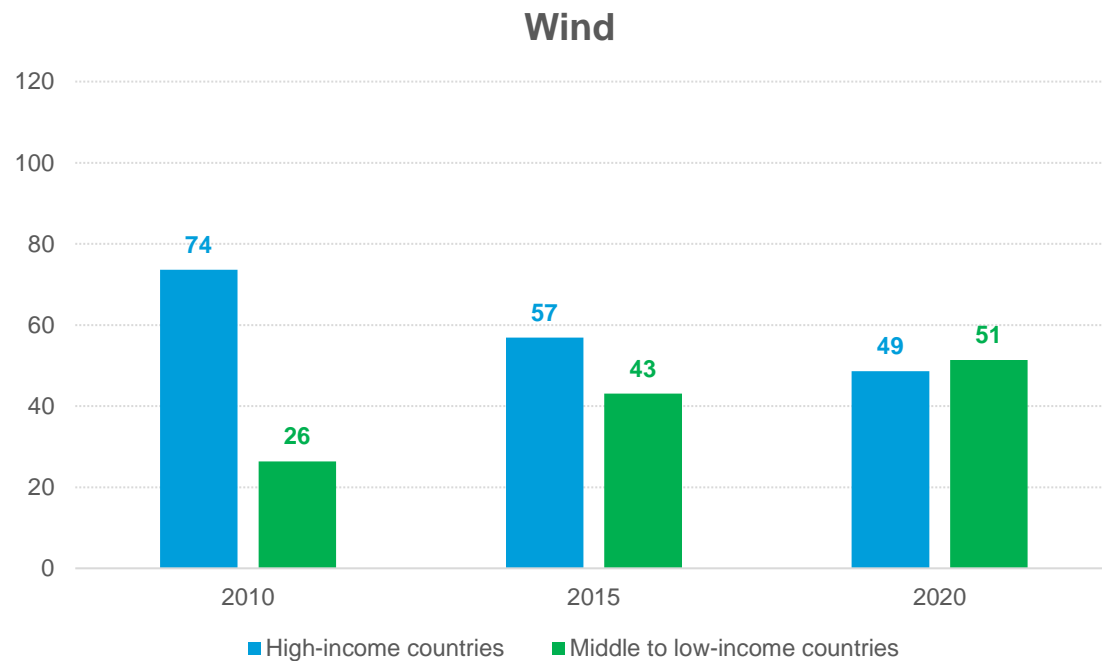
China (31,361)

Republic of Korea (1,792)

United States (1,578)

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

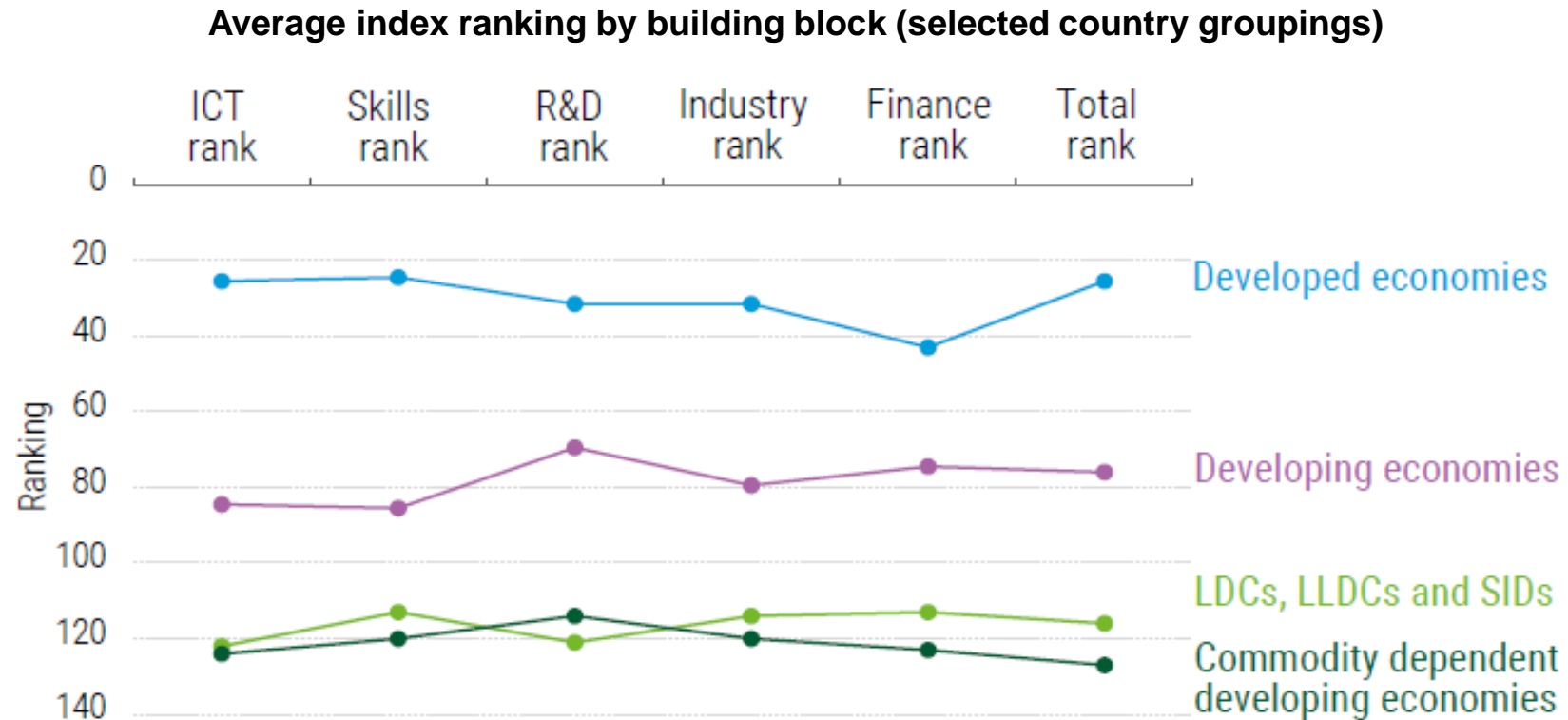
Installed renewable energy capacity by regions (percentage of world total)



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

Developing countries have lower rankings for ICT connectivity and skills



Source: UNCTAD.

Paths to seize benefits from the green technological revolution

1

Developing and using
renewable energy
technologies

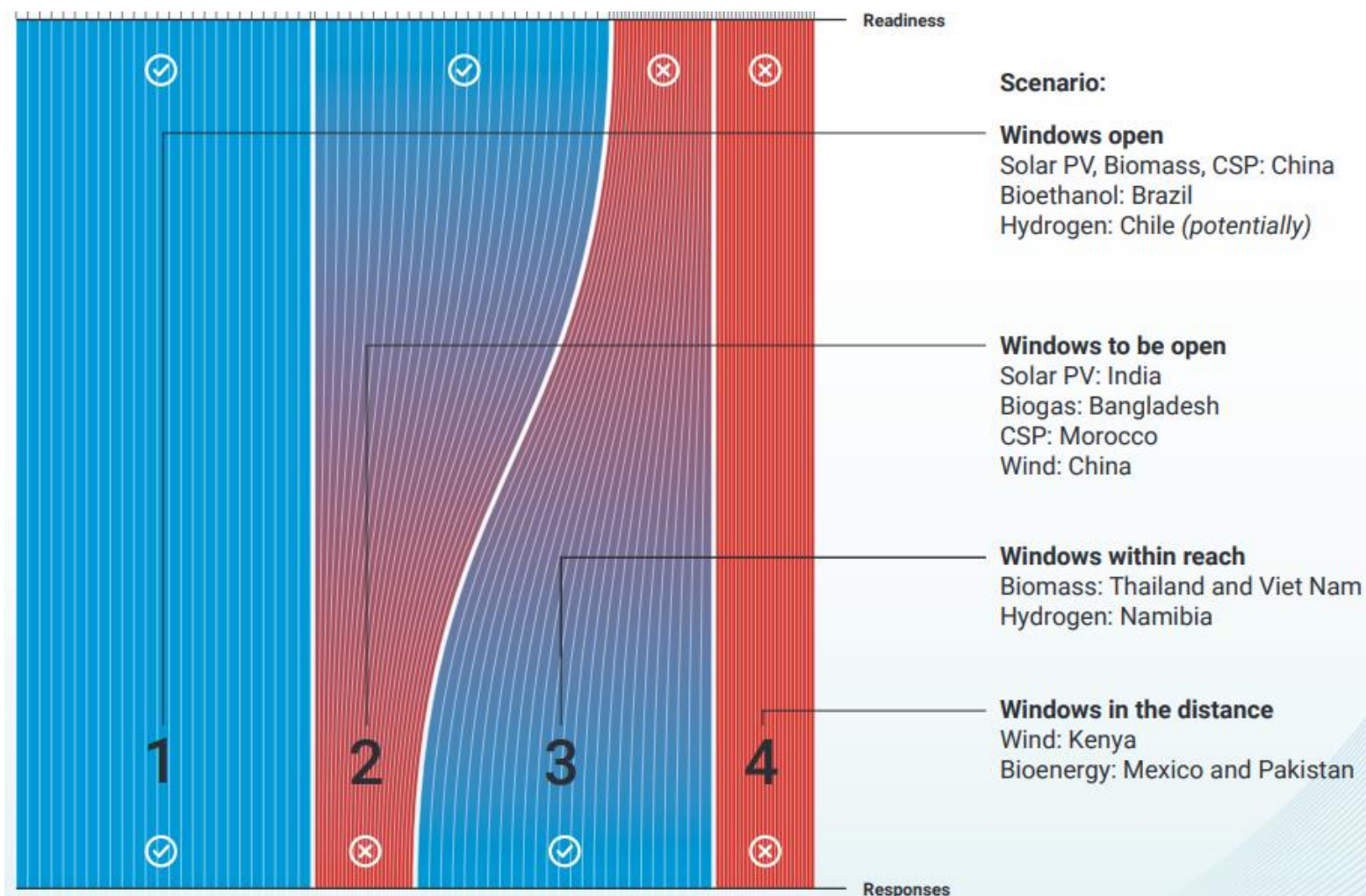
2

Greening traditional
global value chains
by switching to digital
technologies

3

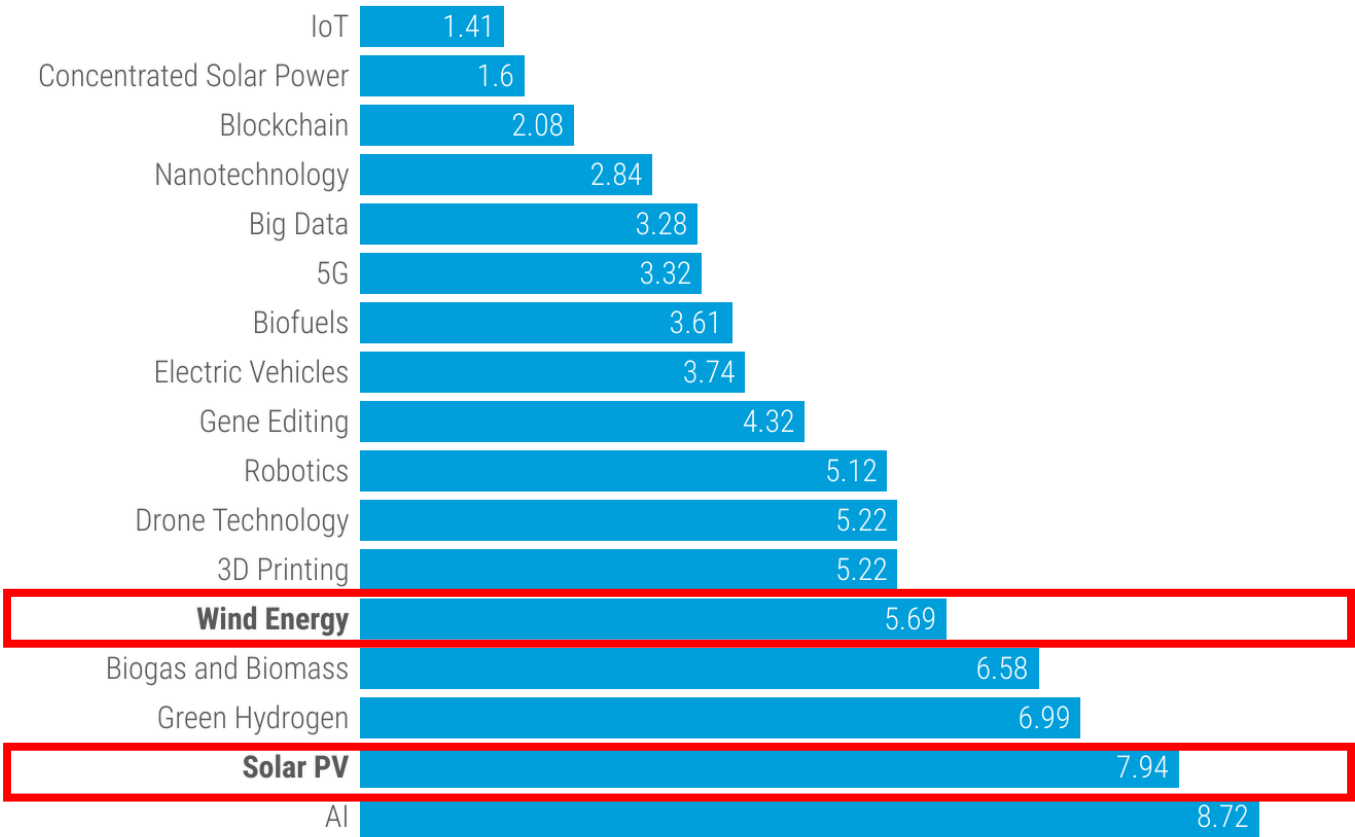
Diversifying towards
production sectors
that are more
complex and greener

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



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

Trade policies offer 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

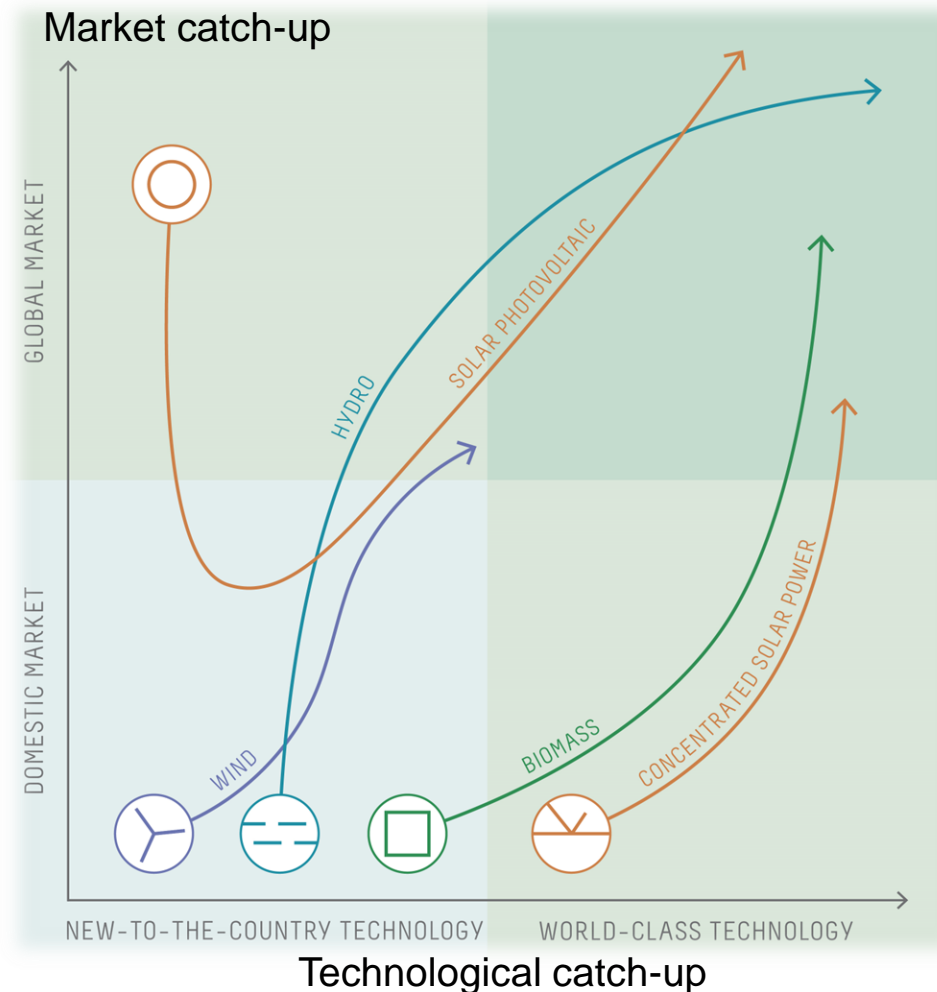
Three driving forces for creating green windows

Public institutions

Domestic markets

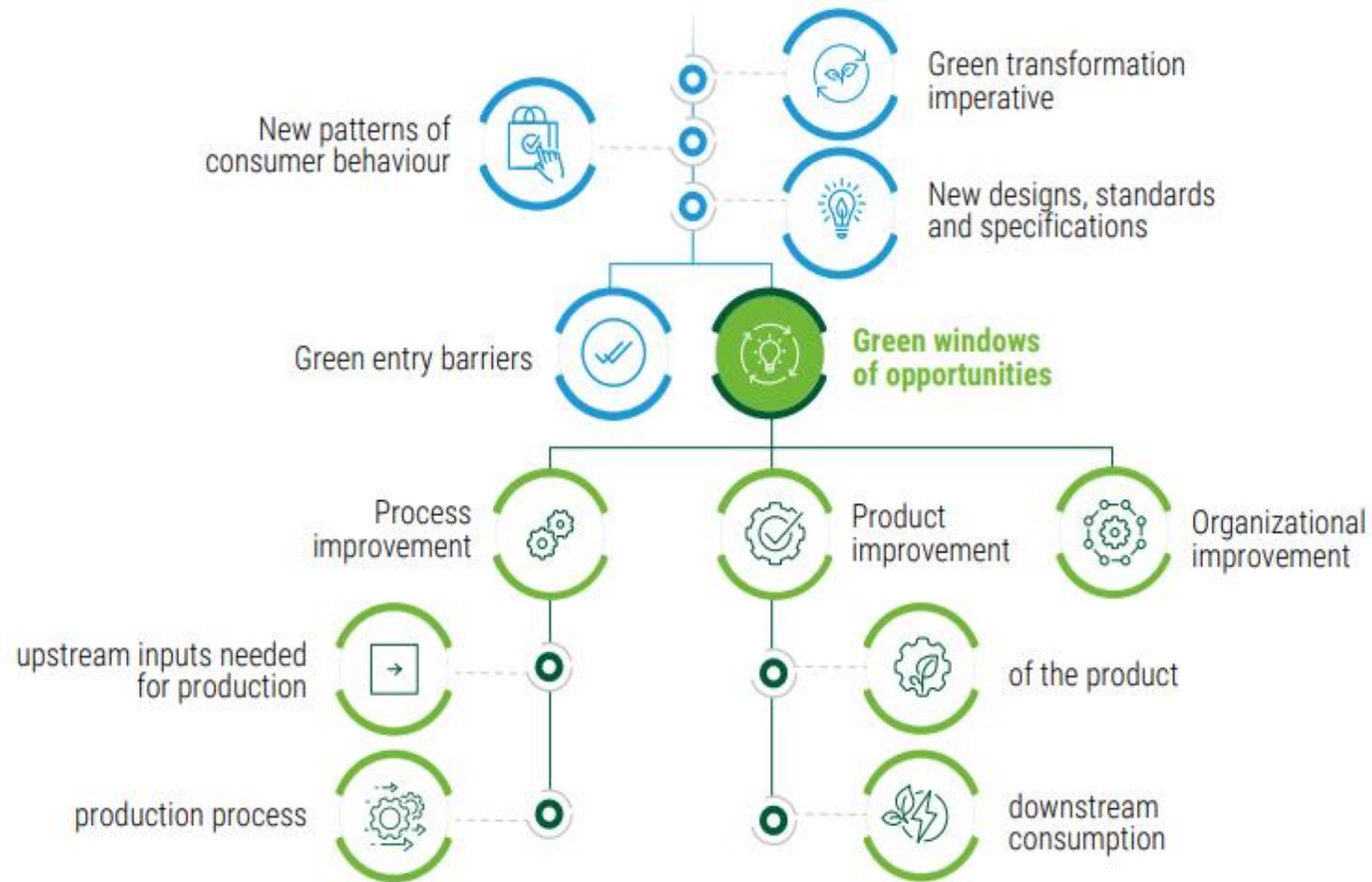
Research and development

Latecomer catch-up in five green sectors in China

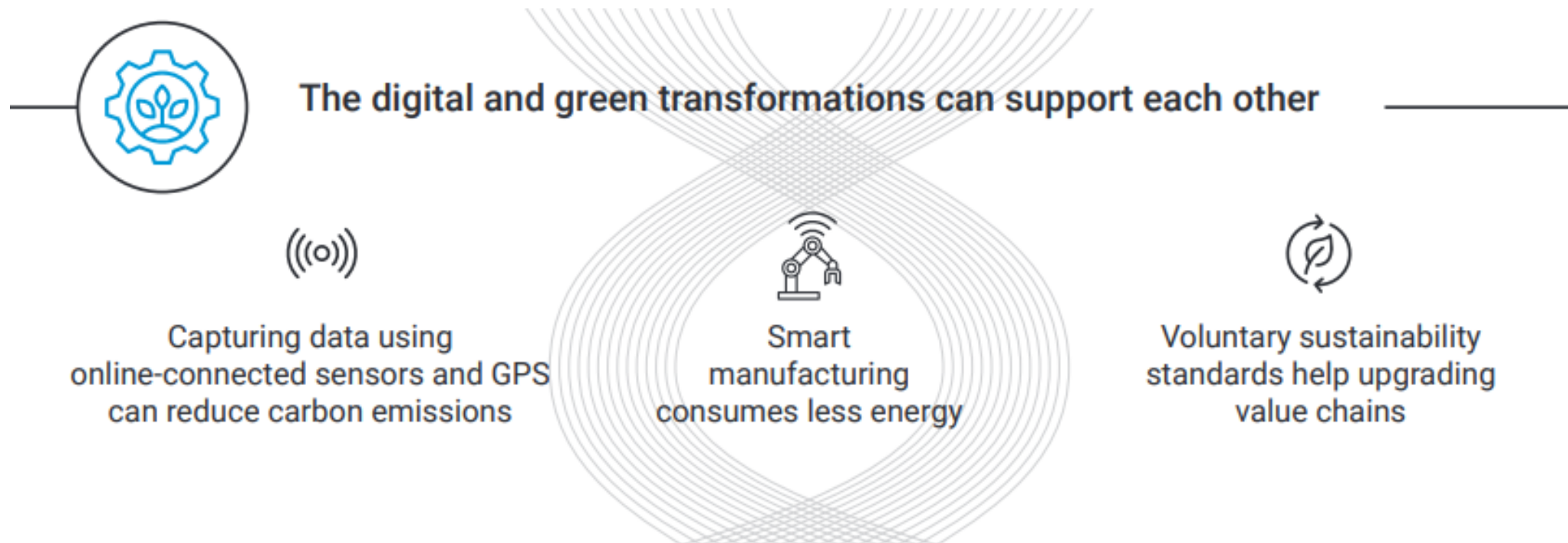


Source: Lema, R., Fu, X., Rabelotti, R. (2021) Green windows of opportunity: latecomer development in the age of transformation toward sustainability

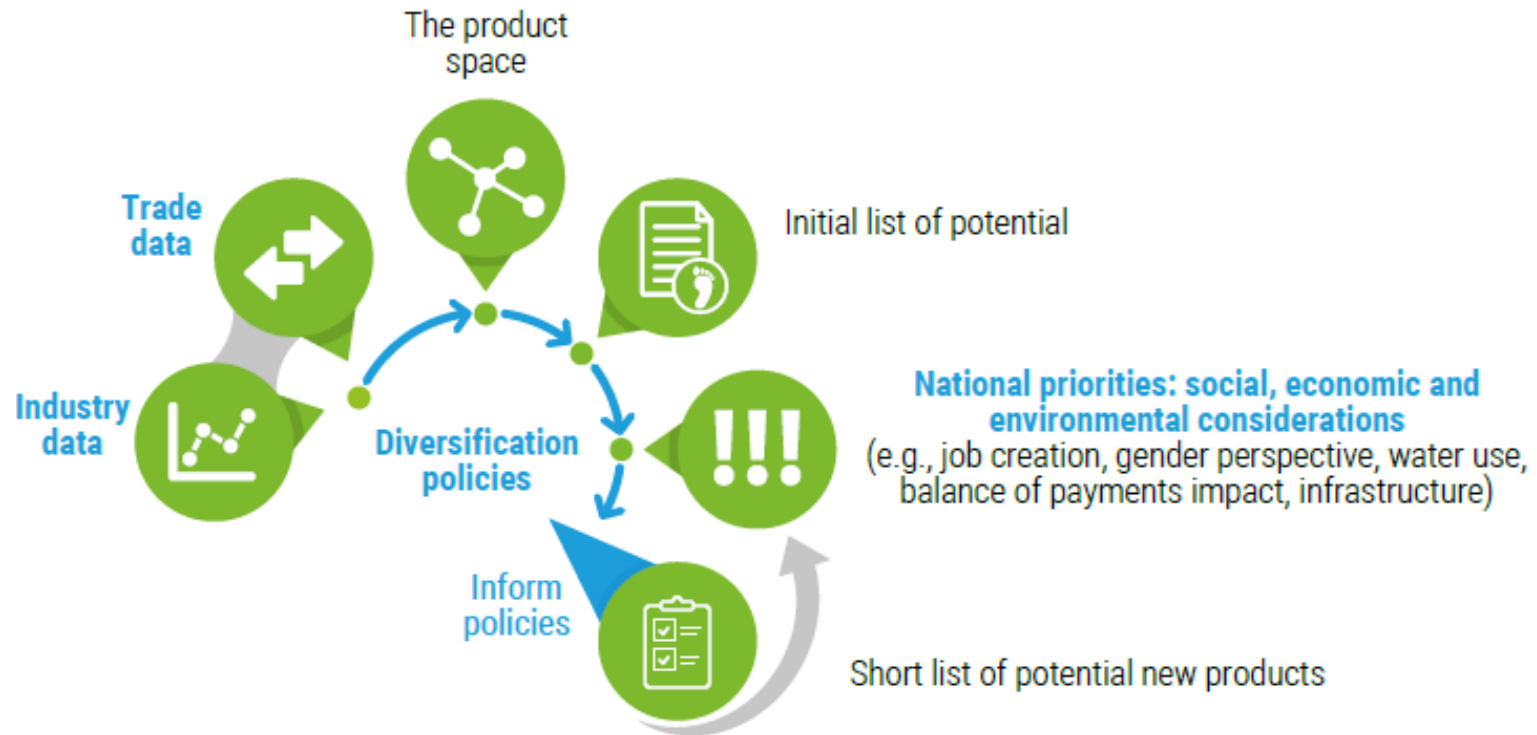
Steps for greening GVCs



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



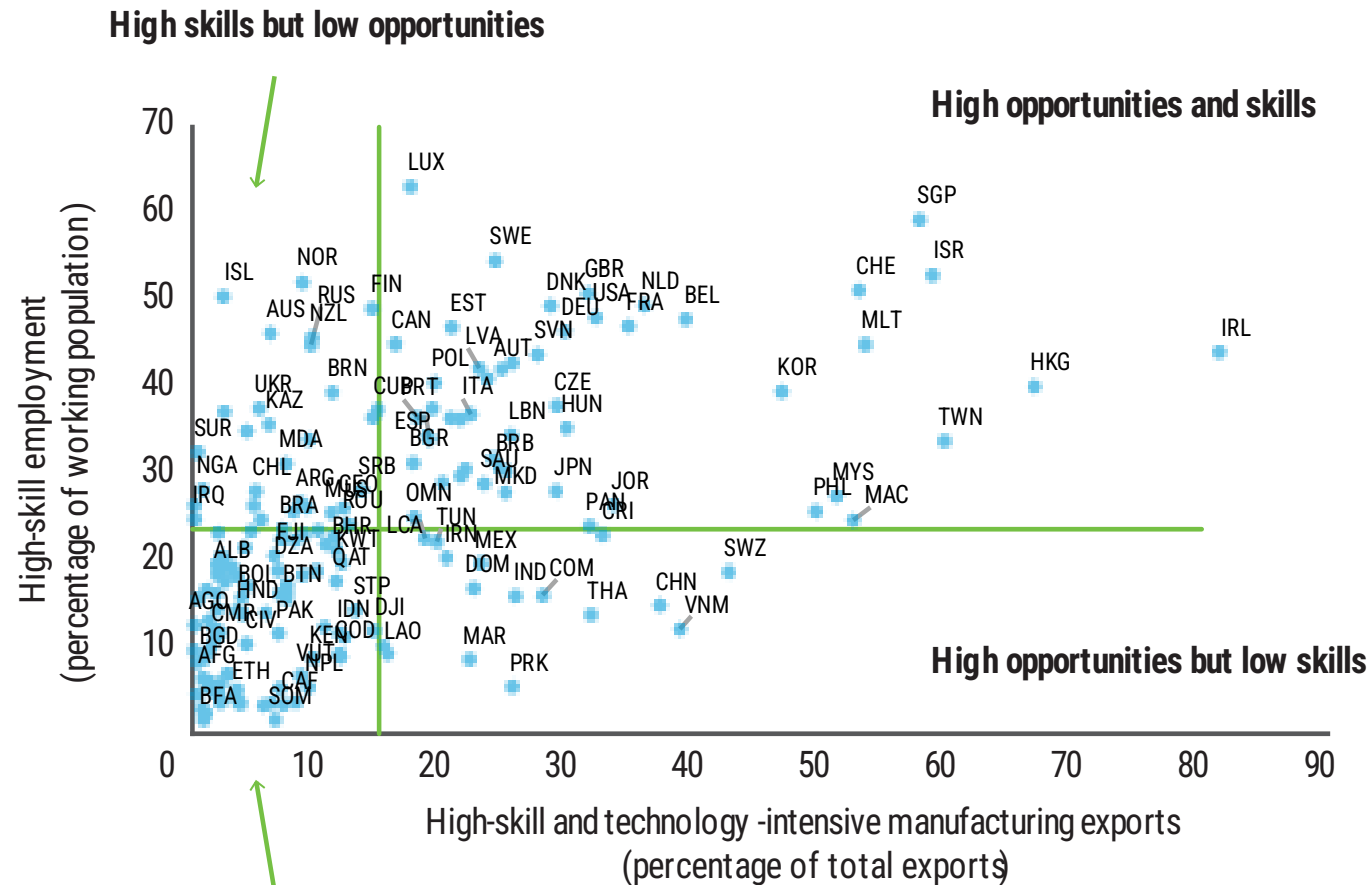
Identifying and prioritizing sectors that more complex and greener



Source: UNCTAD.

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
Develop digital infrastructure and skills
Raise awareness of green technologies

International cooperation

Cooperation through international trade

Greater flexibility in the international intellectual property rights system

Partners for green technology

Multilateral and open innovation

Assessing technologies

Regional and South-South cooperation in science, technology and Innovation

Conclusion

Technologies already exist

Political will needed

Developing countries should catch the green technological revolution early

Thank you!



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Multi-year Expert meeting on

Investment, Innovation and Entrepreneurship for Productive Capacity-building and Sustainable Development

27–28 September 2023

Palais des Nations, Geneva

