Opening green windows
Technological opportunities for a low-carbon world

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The green windows of opportunity framework

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Green windows of opportunity: latecomer development in the age of transformation toward sustainability

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Abstract

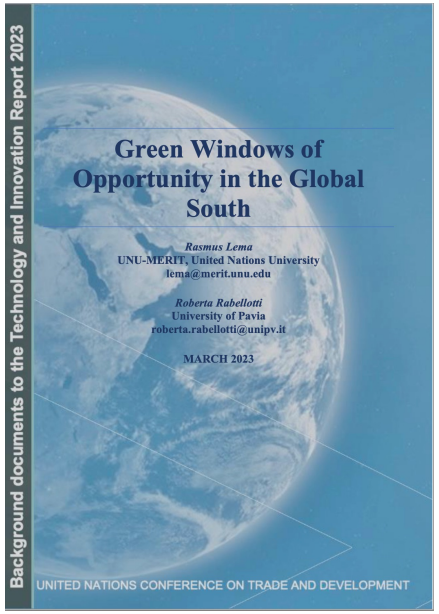
The world is in the early stages of a paradigm transition toward a global green economy. In this article, we propose the notion of green windows of opportunity, highlighting the importance of institutional changes in the creation of new opportunities for latecomer development. We emphasize how demand and mission-guided technical change influence the directionality of latecomer development and highlight the important role emerging economies may attain in the global green transformation. We provide important insights regarding opportunities for green development in emerging economies, how these opportunities emerge in different renewable energy sectors and their implications for the global green economy.

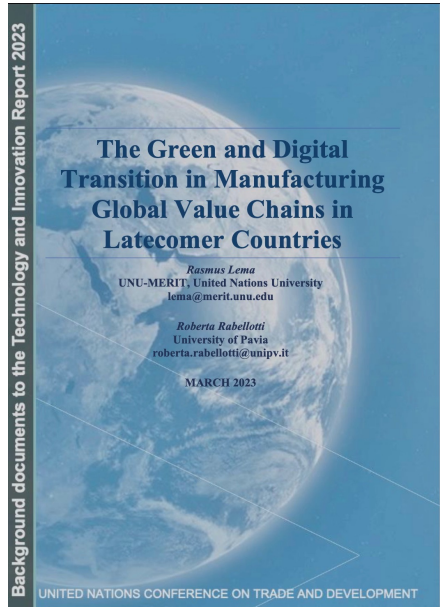
JEL classification: L10, L50, O10, O20, O30, Q20, Q40

1. Introduction

Although the transformation toward a global green economy is still in its early stages, there is little doubt that a major disruption in the capitalist world economy is under way. As popular pressure increases in line with the mounting global effects of climate change, the transformation agenda and associated investments in the green economy are likely to accelerate (Mazzucato and Perez, 2015; Roberts and Geels, 2019; Schmitz and Scoones, 2019).

Until recently, the idea of green growth was limited to the advanced economies, with developing countries reluctant to take up the challenge of sustainability. Today, the dichotomic relationship between green transformation and latecomer development, inherent in the environmental Kuznets curve (Stern, 2004), has been turned on its head. The "clean up later" model where developing countries wait for the environmental Kuznets curve to set in (Altenburg and Pegels, 2020) is being replaced by a leapfrog strategy, which offers an alternative way to bypass the high pollution models of growth. Countries such as China, India, Brazil, and South Africa, are not only reacting to the paradigm change but also are actively contributing to the green transformation, adopting environmental transformation policies and supporting the emergence of domestic sustainability-oriented industries (Mathews, 2013; Harrison *et al.*, 2017).





9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

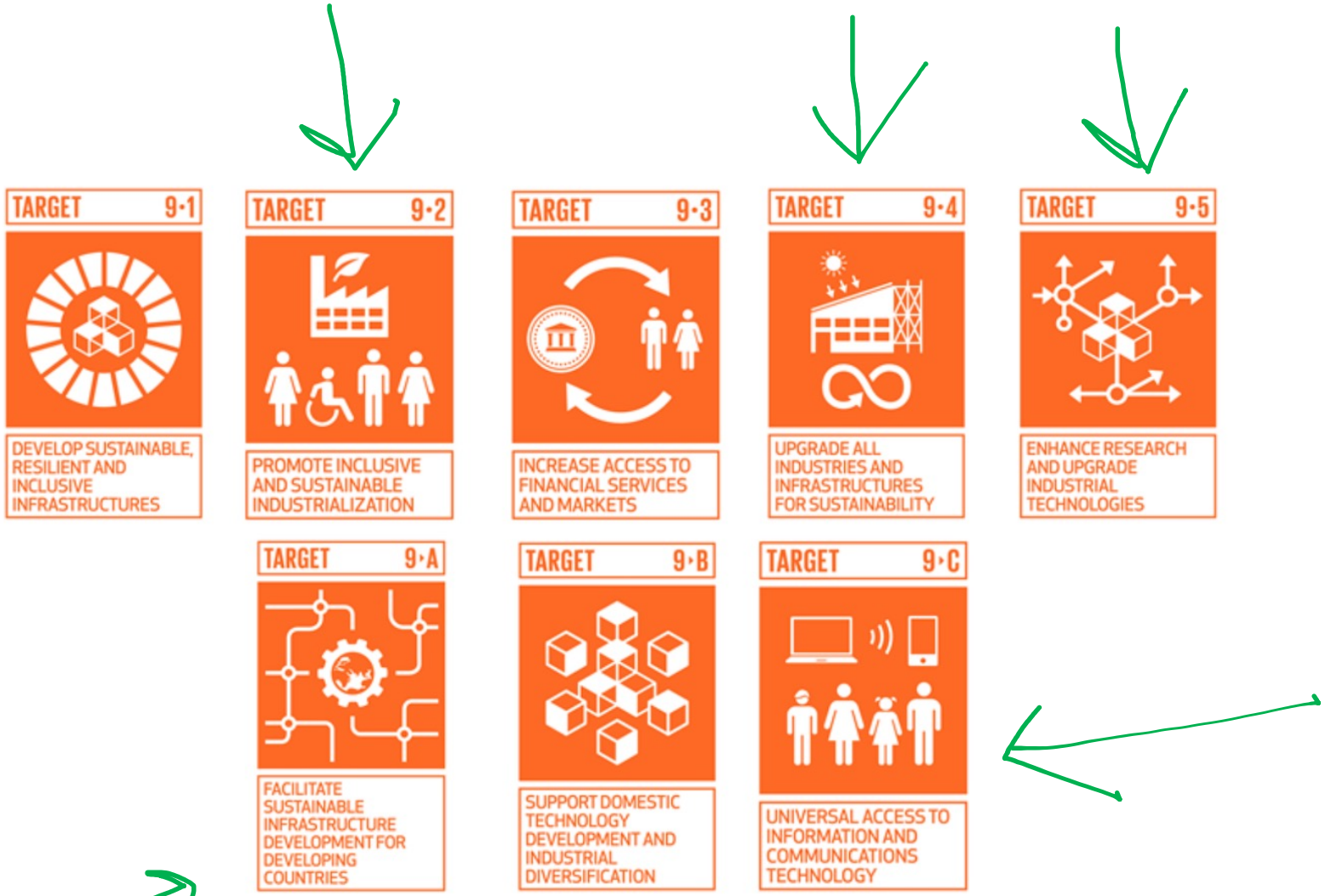
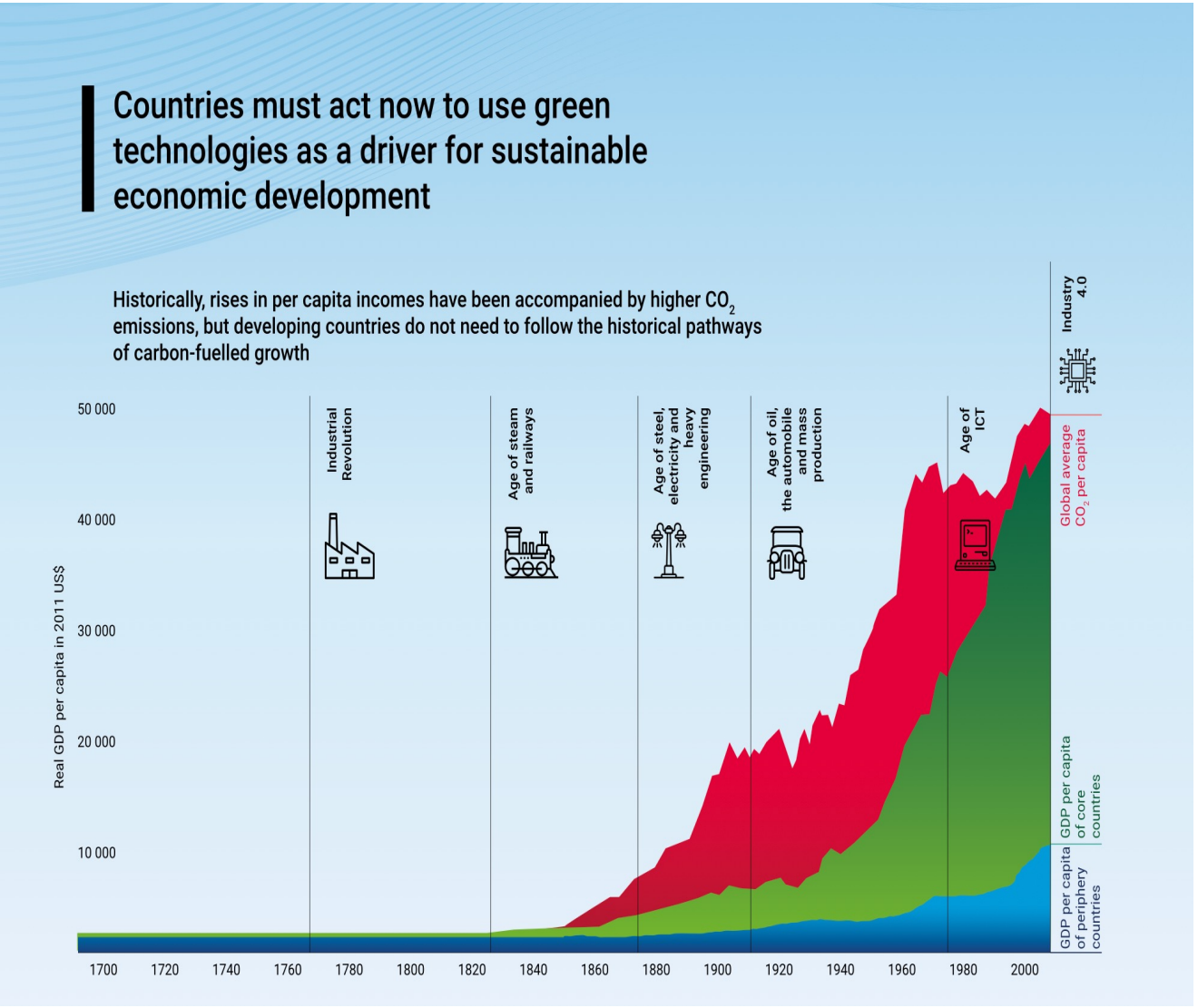


Figure 9.2. Key targets for SDG 9

But also……


SUSTAINABLE DEVELOPMENT GOALS
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS
SUSTAINABLE DEVELOPMENT GOALS

Developing countries must catch the green technological revolution early

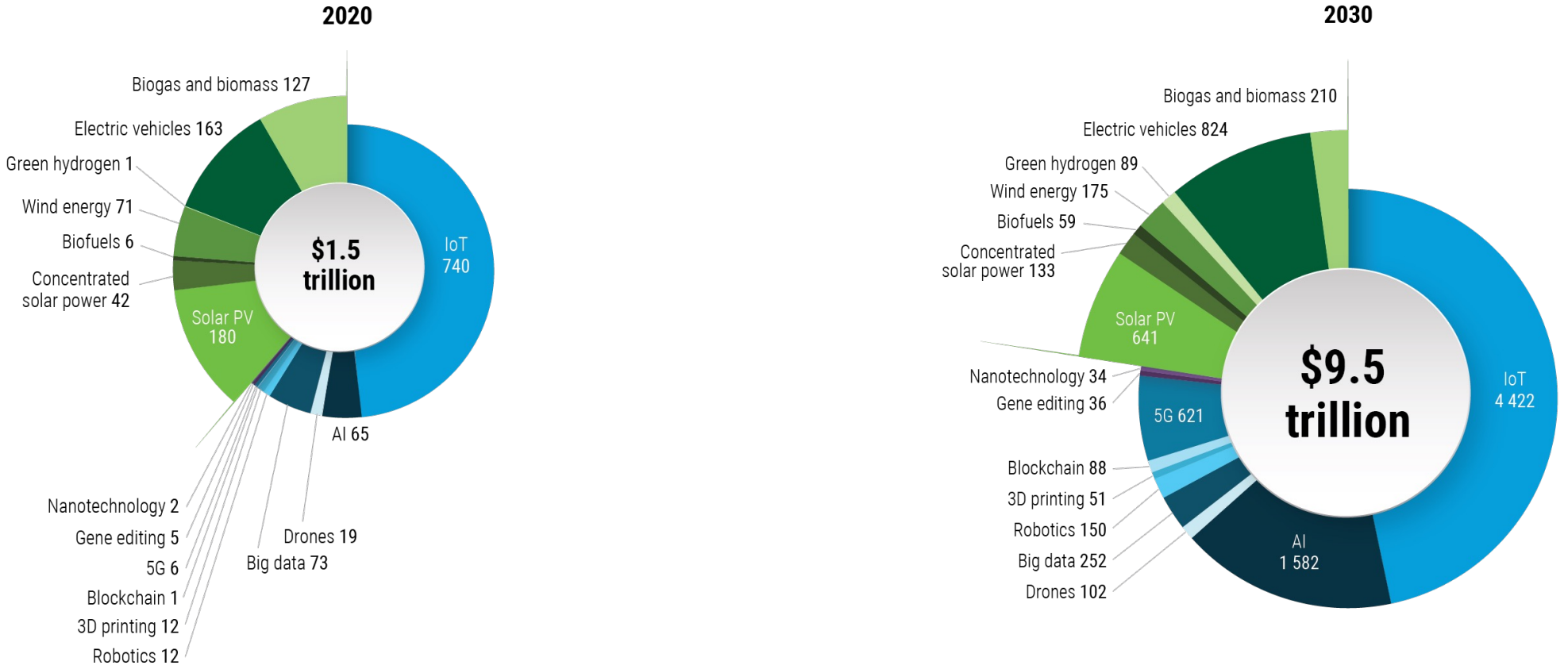


- Historically when per capita income has increased this has been accompanied by increases in CO2.
- This model of economic growth does not work anymore.
- Latecomers should from the outset develop differently rather than catch up along established pathways

Grow first and clean up later models are not viable!

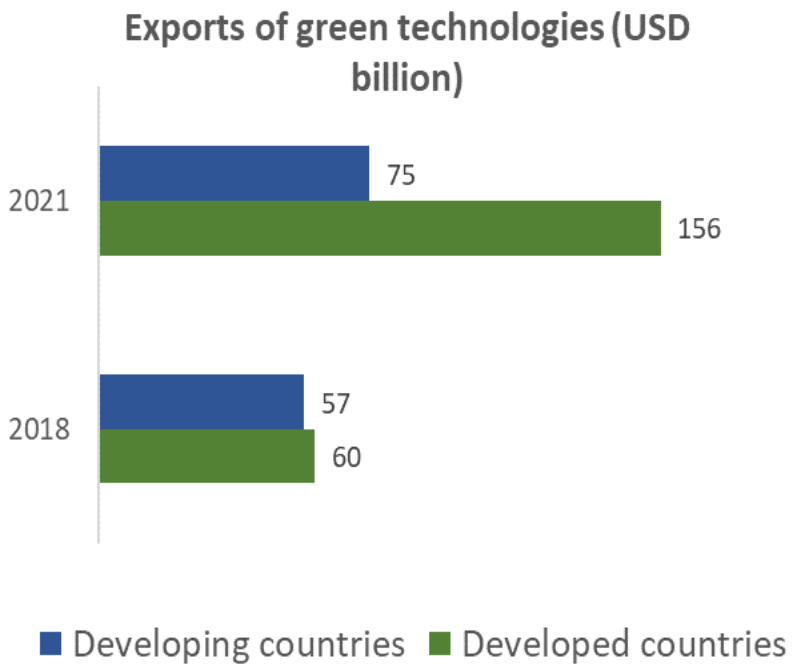
There are enormous opportunities in the development of green frontier technologies

Market size estimates of frontier technologies, $ billion



Source: UNCTAD based on various estimates.

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



Top green frontier technology providers

Biofuels	Wind energy	Green hydrogen	Electric vehicles	Concentrated solar power	Biogas and biomass
Archer Daniels Midland	GE Power	Siemens Energy	Tesla	Abengoa Solar	Future Biogas
ALTEN Group	Mitsubishi Heavy Industries	Linde	Ford	Iberolica Group	Air Liquide
Louis Dreyfus	ABB	Toshiba Energy	Hyundai	ENGIE	PlanET Biogas Global
Brasil Bio Fuels	Siemens Gamesa Renewable Energy	Air Liquide	Chevrolet	NextEra Energy Resources	Ameresco
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

Source: UNCTAD based on various sources.

Notes: American companies in dark blue, Chinese companies in orange, others from developed economies in light blue and developing economies in yellow.

To harness the full potential of green frontier technologies, developing countries have to move fast

How developing countries can harness the full potential of green frontier technologies?

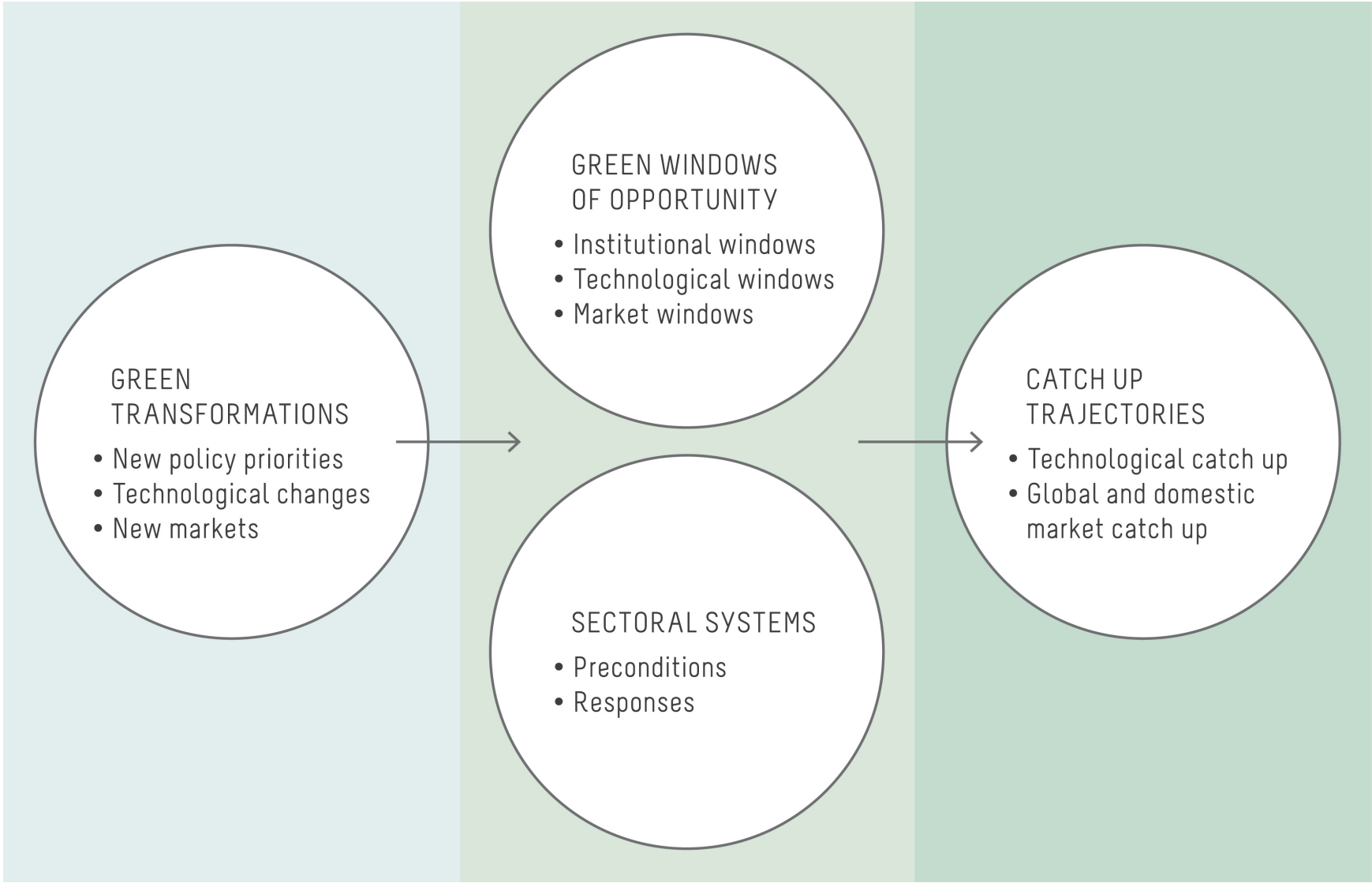
Research questions

1. Does the green economy offer opportunities for latecomer catch-up in developing countries?
2. What characterizes the capacity of developing countries to seize these opportunities?
3. What policy options can support developing countries in their efforts to take advantage of GWOs?

How?

Evidence about cases from a large set of countries at different levels of development and sustainability-oriented industries, analysed following an analytical framework developed in Lema et al. (2020).

The GWO framework



1. Green Windows of opportunities

2. Sectoral system of production and innovation: preconditions and responses of public and private actors

3. Catch up trajectories resulting from the interactions of GWO with stakeholders' actions

Windows of opportunity

- As suggested by Perez & Soete (1988), development paths are prompted by different windows of opportunity:
- **Technological windows:** e.g., in the electronic industry the shift from analog to digital technologies provided an opportunity for Korean s firms to seize control of the market from the incumbent Japanese firms;
- **Demand windows**: a new type of demand (e.g., demand for low-cost car in emerging countries), rise of new consumers (e.g., wine industry) or a change in the business cycle;
- **Institutional windows:** the establishment of public R&D programs that affect the learning process and the accumulation of capabilities of domestic firms or the provision of subsidies, tax reduction, export support, regulations, and public standards (e.g., renewable energies).

When a WoO opens up

- Latecomers respond depending on their learning processes, their level of capabilities, organization and strategies as well as the level of development of their innovation system;
- Incumbents also respond but they may be subject to "incumbent traps";
- Different windows and different responses from incumbents and latecomers determine the successive catch-up trajectories.

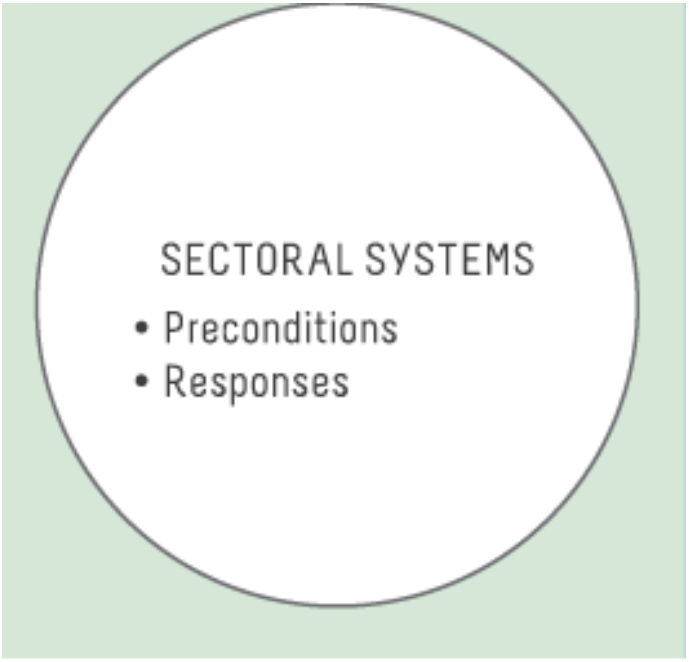
Green windows of opportunity

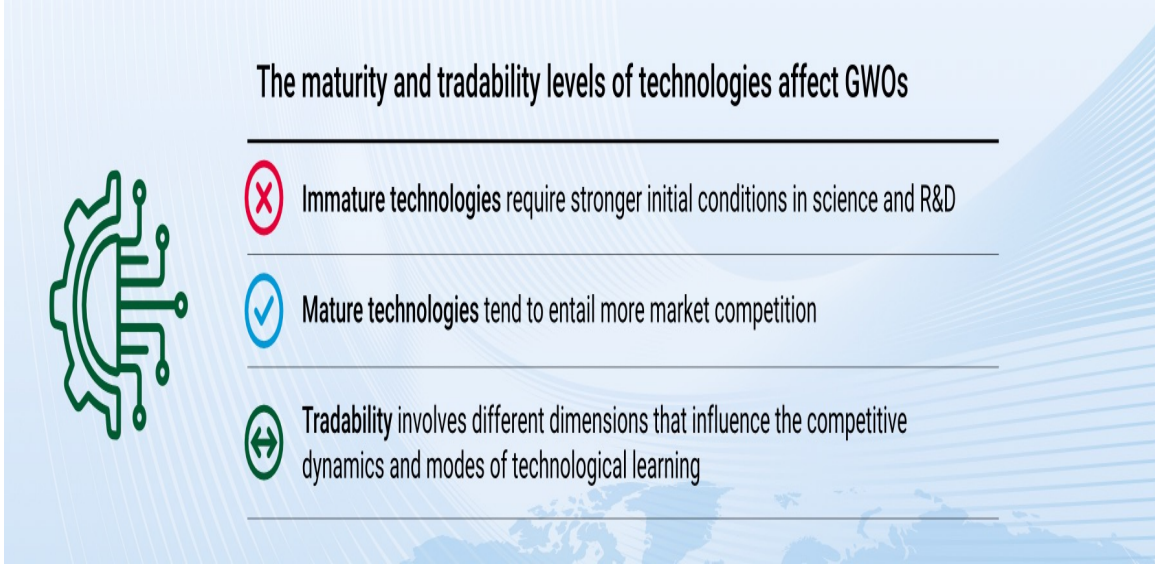
- In green sectors, there are exceptional local, national, and international efforts contributing to creating and scaling up new technologies, based on mounting environmental pressure and negative externalities.
- GWO are mainly endogenous, created by governments and influenced by national and global environmental and industrial policies;

- Examples are:
  - **China**:2006 Renewable Energy Promotion Law; Golden Sun Demonstration Program; Ride the Wind Program.
  - **Brazil**: Sugarcane-based ethanol fuel program.
  - **India**:2020 National Electric Mobility Mission Plan.
  - **Brazil, Chile, Uruguay, Viet Nam, Turkey, Morocco, Namibia and South Africa**: existing or forthcoming green hydrogen national strategies.

Sectoral systems: preconditions & responses

- The ability to take advantage of GWOs in developing countries differs across green technologies and countries.
- To investigate and understand how they differ, we focus on two components of the sectoral system:
  - the preconditions to take advantage of the opportunity
  - the strategic responses of public and private actors for seizing the GWOs
- Responses to GWOs differ depending on technological maturity and tradability.





Seizing GWOs: four scenarios

Combining different levels of existing preconditions and responses we propose four different possible scenarios

Responses / Preconditions	Strong	Weak
Strong	**Scenario 1: Windows open** Solar PV, Biomass, CSP – China Bioethanol – Brazil Hydrogen – Chile (potentially)	**Scenario 2: Windows to be open** Solar PV – India Biogas – Bangladesh CSP – Morocco Wind – China
Weak	**Scenario 3: Windows within reach** Biomass – Thailand and Viet Nam Hydrogen – Namibia	**Scenario 4: Windows in the distance** Wind – Kenya Bioenergy –Mexico and Pakistan

Source: UNCTAD.

Scenario 1: Windows open
Example: Renewables in China

- Preconditions: China have sufficient preconditions including a large internal market, a diversified industrial structure and well-developed related capabilities such as, for example, design and engineering capabilities for biomass plant construction.

- Responses:
  - Co-design of environmental and industrial policies.
  - Diffusion of knowledge among firms and knowledge institutions, such as government stimulation of knowledge spillovers with loose enforcement of property rights and diffusion through state-owned design institutes in biomass.
  - Acquisition of foreign technology through licensing activity and cross-border acquisitions of foreign firms in solar PV and biomass.
  - Public R&D experimentation in CSP.

Scenario 2: Windows to be open
Example: Solar in India and Biogas in Bangladesh

- **India: National Solar Mission** prioritized deployment at low costs above domestic manufacturing, and this resulted in a high dependency on imports.
  - Insufficient attention was paid to training, promotion of linkages with domestic companies and R&D to boost domestic competitiveness.
  - When local content requirements were introduced, there were not enough domestic capabilities to effectively mitigate import dependence due to the lack of domestic business creation in the early stages.

- **Bangladesh**: R&D investments in **biogas energy projects** was not complemented with the strengthening of the production system
  - No appropriate incentives to encourage biogas plant installations.
  - Very little has been done to increase awareness among farmers about the potential of correct waste management

Scenario 3: Windows within reach
Example: Biogas in Thailand

- Preconditions: Limited initial experience, absence of domestic firms and fragmentation of actors
  - Factories (e.g. of casava starch) were not interested to invest in biogas production due to high investment costs
  - Pilot projects supplied by foreign firms (no domestic suppliers in the 1990s/2000s)

- Responses: Proactive strategy of the Minister of Energy to attract private investors to the biogas industry
  - Financial subsidies for the construction and design of biogas production plants, tax incentives for firms involved in waste transformation;
  - Small Power Purchase Tariff program for increasing the proportion of electricity generation from biogas;
  - Enforcement of an environmental law taxing companies producing pollution;
  - Support for the strengthening of the sectoral innovation system.

The wind sector

Responses / Preconditions	Strong	Weak
Strong	**Windows open** China (2010)	**Windows to be open** China (2020) India
Weak	**Windows within reach** Ethiopia	**Windows in the distance** Kenya

China
Windows to be open

- Active industrial policy
- Active approach by firm: licensing, co-design, firms 'acquisitions;
- Catching up close to frontier in 2010;
- Now falling behind in post-turbine, hybrid technology due to insufficient IS response.

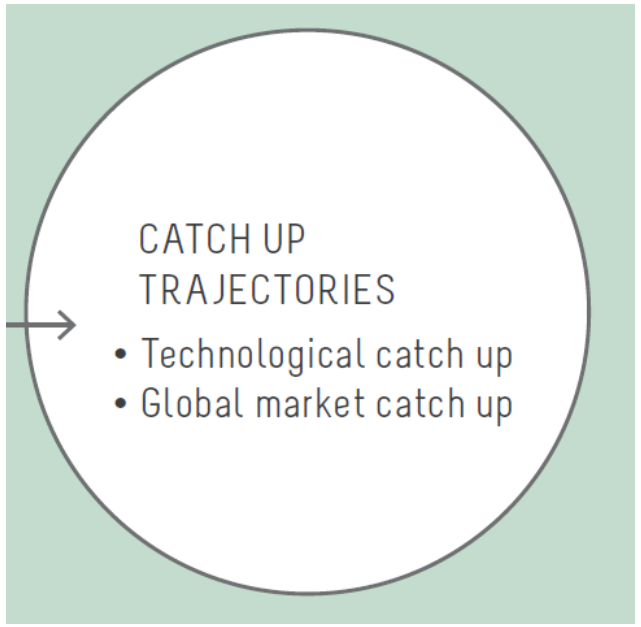
Ethiopia
Windows within reach

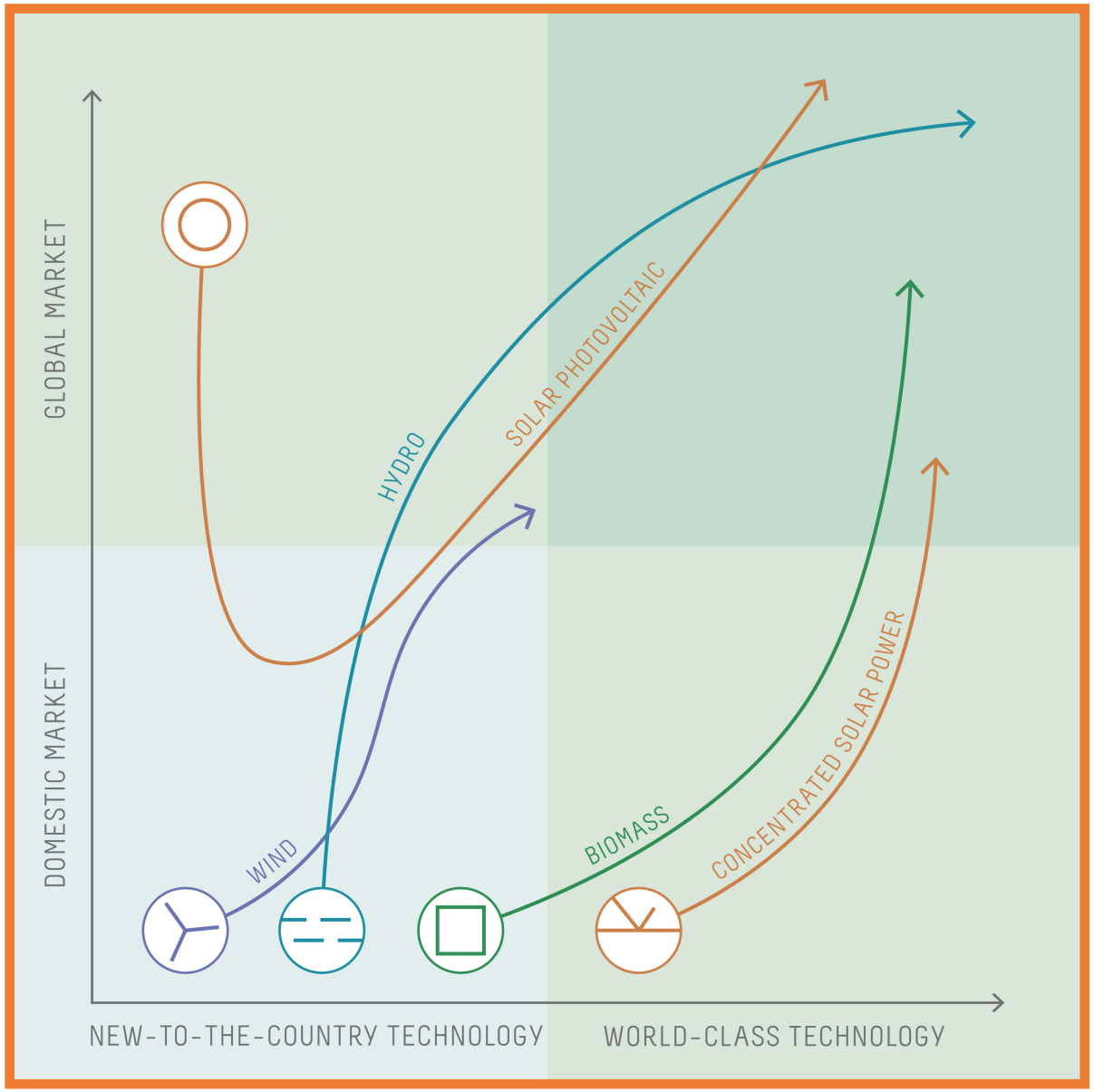
- Wind part of energy policy and planning;
- Active role in designing wind projects to guarantee maximum local learning;
- Still limited industrial outcome but local learning secured.

Kenya
Windows in the distance

- Driven largely by external funds and support;
- Ad-hoc project approval with no industrial conditionalities attached;
- Virtually zero local content and learning;
- Small number of local jobs in O&M.

Catch-up trajectories

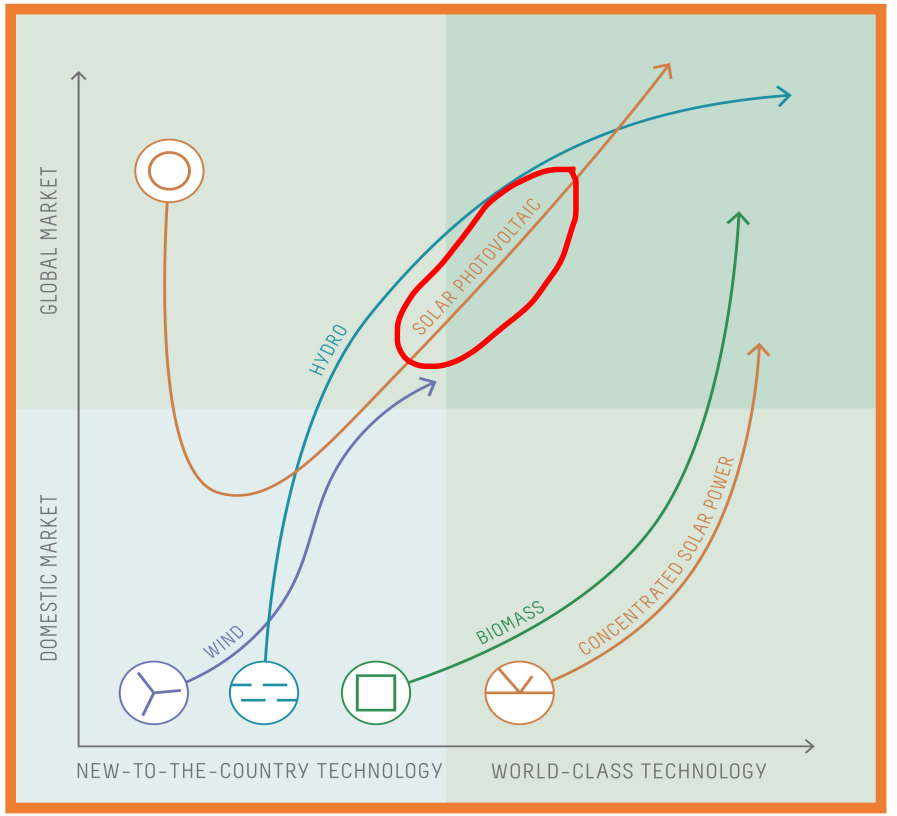




Trajectory #1
From learning from exporting to domestic strengthening and then to global leadership

Chinese Solar PV Industry

- ❖Learning from export started in the global market exporting solar panels made with imported technology
- ❖Substitution of international demand with domestic demand, after a fall in the global market, thanks to the incentives created by public policy
- ❖Huge investments in building domestic technological capacity and the whole solar value chain
- ❖Back to international markets as technological and market leaders.



Who Controls the Solar Panel Supply Chain?

The Manufacturing Process for Solar PV Panels

The primary material for solar PV manufacturing which is melted and cast into ingots.

Polysilicon ingots are sliced into thin wafer sheets ranging from 150-280 micrometers in thickness.

The wafer is then cleaned and doped to manufacture a crystalline solar cell.

Multiple cells are wired together and laminated to form modules, before being connected to panels.

Share of Manufacturing Capacity by Country/Region in 2021

China made up **55%** of global solar panel manufacturing capacity in 2010, with its share rising to **84%** in 2021.

The total value of global solar PV related trade increased by more than **70%** YoY to reach over **$40B** in 2021.

ELEMENTS

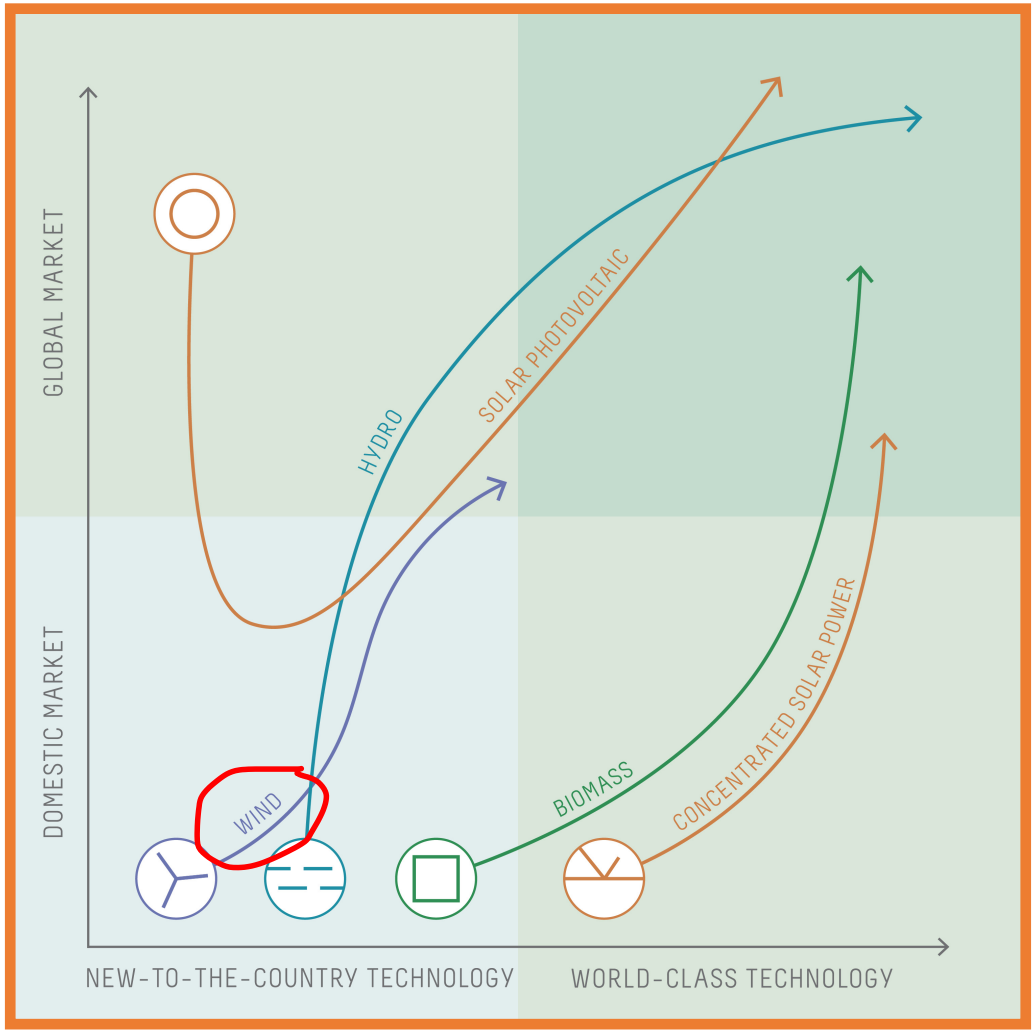
Source: IEA

ELEMENTS.VISUALCAPITALIST.COM

Trajectory #4
From domestic imitation to limited global progression

Chinese Wind Industry

- Complex and rapidly evolving technology regimes
- Increasing role of digital technologies and hybrid-digital technologies
- Technology gap and limited exports



The role of digital technologies in RE

- The digital and green transformations have developed largely in parallel, with their own trajectories and with separate drivers and policy domains.
- This is now beginning to change.
  - Digital technologies can help accelerate progress towards the 17 SDGs and particularly, to realize the goals related with environmental sustainability (e.g., SDG 7 - Affordable and clean energy - or SDG 13 - Climate change action)
  - The twin - green and digital - goals are increasingly seen to complement each other, and digital technologies such as AI, cloud computing, IoT are expected to help the economy become greener.

Some examples

Smart manufacturing technologies

- Fixed and mobile sensors in harvesting and logging equipment to provide precise information on tree species, biodiversity counts, or illegal logging
- Online-connected sensors and GPS tracking systems in logistics
- 3D printing instead of traditional production methods

Data processing technologies

- Blockchain
  - Increase traceability
  - Track faulty products or components
- Artificial intelligence
  - To reduce energy consumption and optimize green energy use in smart grids
  - In agriculture, to plan shipping and delivery of perishable goods

Challenges for digitalization in latecomer countries

- Import and adoption of advanced digital technologies is still limited to a small number of emerging economies
- Production is limited to an even smaller set of advanced economies plus China
- Heterogeneity also within countries at firm level, with only a minority of (larger) companies adopting digital technologies, while the majority is still involved only in industry 2.0 technologies.
- Large digital capability gap between the leading most digitalized companies and their suppliers.
- Large gap existing between urban and rural areas, where very often digital infrastructures are lacking, making it impossible to spread digital technologies.

In latecomer countries the digital and green transitions may not yet be twins, but rather related through the extended family!

Opening & Harnessing Green Windows

Set the direction towards green technologies and innovation

International cooperation

- Trade rules should permit developing countries to protect infant green industries through tariffs, subsidies and public procurement
- Consistency between international agreements on trade, intellectual property and climate change is critical for green technology revolution
- Intellectual property should have greater flexibilities for developing countries with regard to green technologies
- To address the financial constraint the role of international cooperation should be key but so far the resources made available have been insufficient
- Better coordination between public and private actors, and also between domestic and international actors, is needed to reduce systemic redundancies and maximize the impact of investments

Conclusion

Developing countries should catch the green technological revolution early

Political will is needed

Developing countries must be supported as they make the transition to renewable energy

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