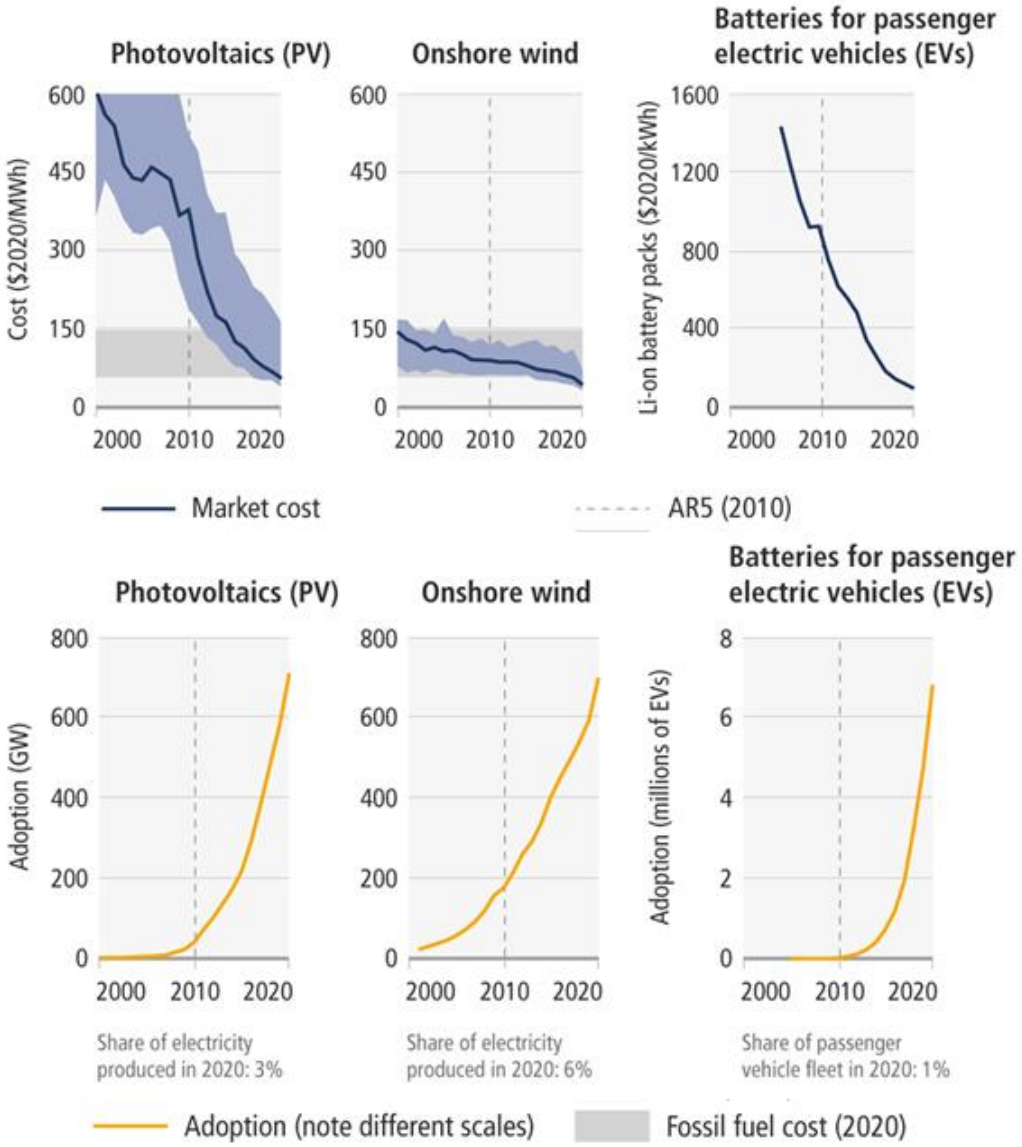
Innovation, technology development, and transfer:

Key messages from IPCC AR6 WG III Chapter 16 and further reflections for GST

Strong unit cost reductions in several granular technologies



Unit costs only

Some options are increasingly **technically viable**, rapidly becoming **cost-effective**, and have relatively **high public support**.

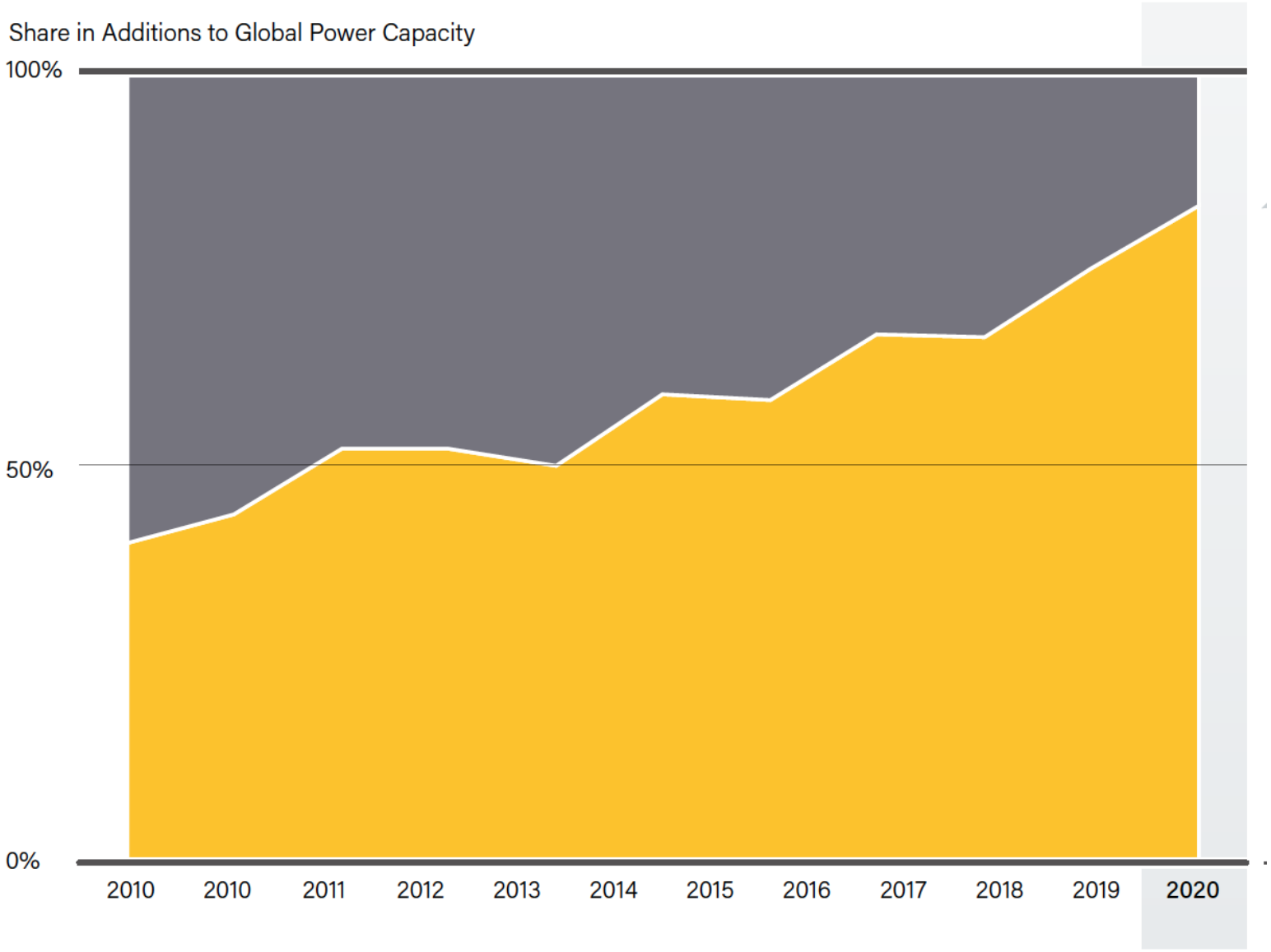
Many options face **institutional** barriers

Adoption of low-emission technologies is **slower in most developing countries**, particularly the least developed ones

Learning is a significant contributor to cost reductions

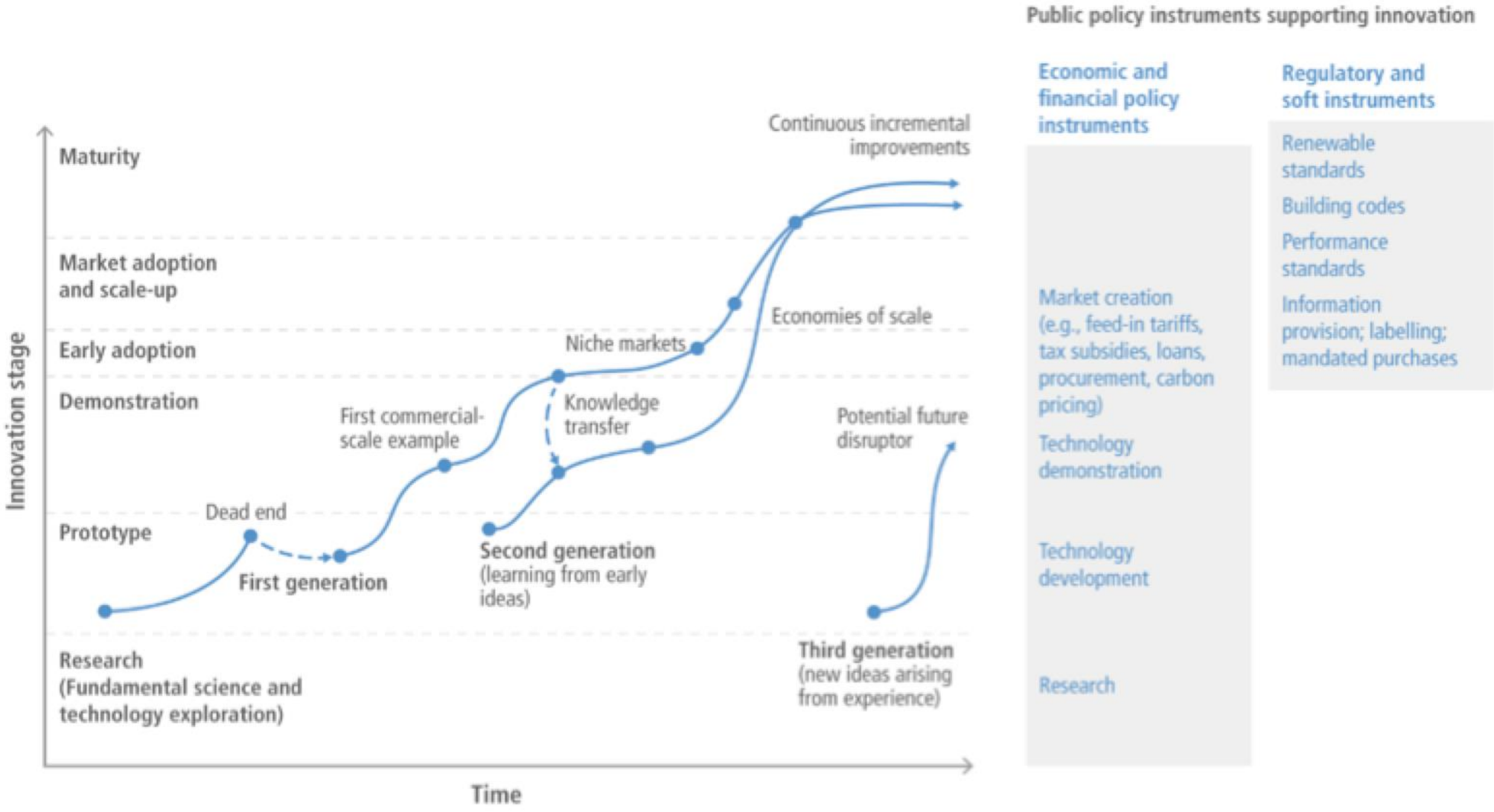
Source: IPCC AR6 WGIII

Technology can be an enabler of accelerated mitigation



Source: GSR 2021

Technological development is not linear



Source: IPCC AR6 WGIII

… but systemic

Involves a range of actors (universities, research organizations, technology firms, consultancies, law firms, govt agencies, CSOs...)

that interact with each other in order to achieve specific objectives (e.g., generate new knowledge, develop new products)

All embedded in an institutional context (that includes formal rules, such as laws, and informal restraints, such as culture and codes of conduct) that govern the behaviour of the actors and interactions among them

These "innovation systems" underpin the process of successful development and deployment of new and improved technologies

How to monitor?

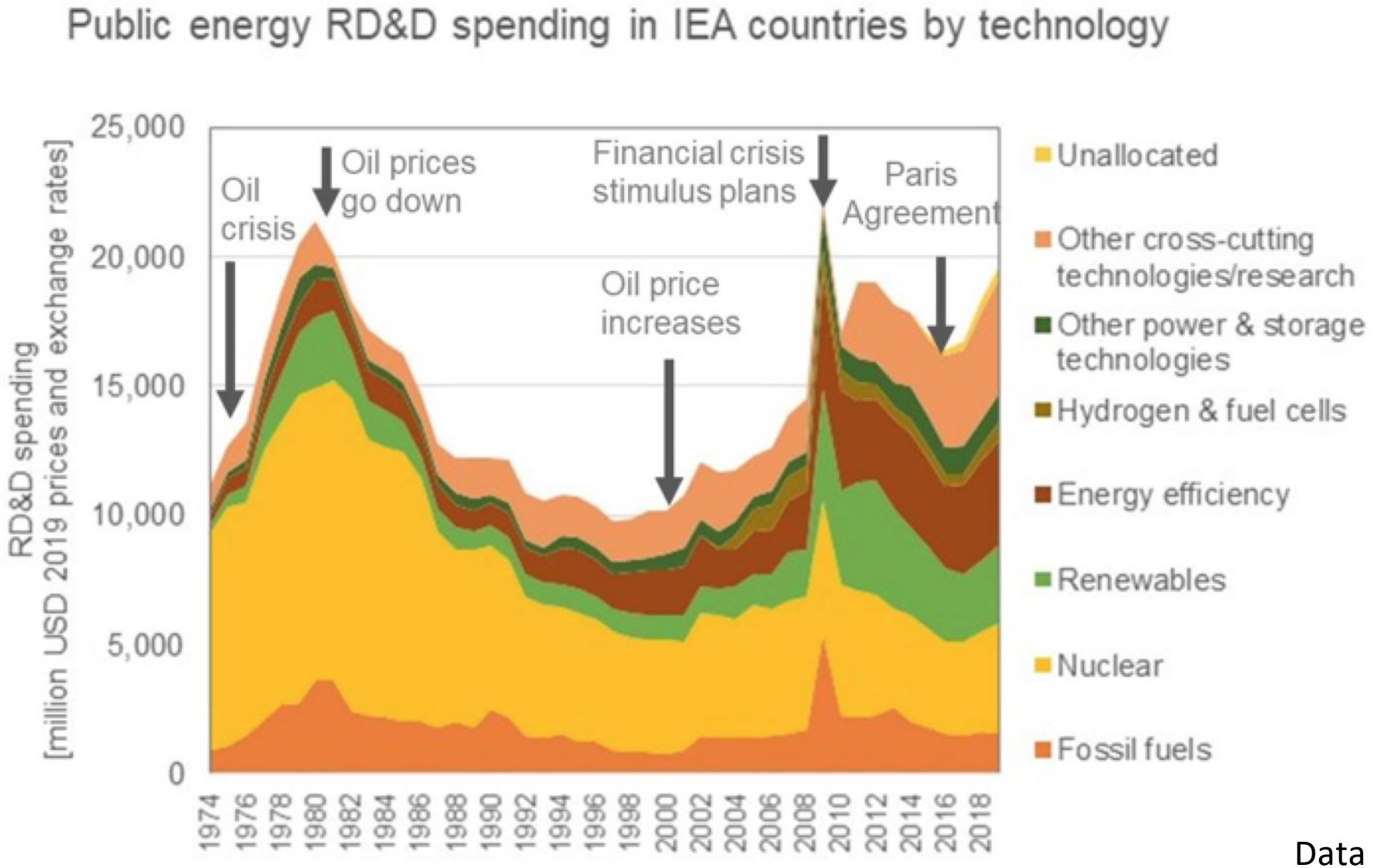
Function	Input indicators	Output indicators	Outcome indicators	Actors	Policies	Structural and systemic indicators
Knowledge development	Higher education investments R&D investments Number of researchers R&D projects over time	Scientific publications Highly-cited publications Patents New product configurations	Number of technologies developed (proof-of-concept/prototypes) Increase in number of researchers Learning rates	Governments Private corporations Universities	Research programs and strategies IPR policies International technical norms (e.g. standards) Higher education policies	Well-defined processes to define research priorities Stakeholder involvement in priority-setting
Knowledge diffusion	R&D networks Number of research agreement Number of research exchange programs Number of scientific conferences	Citations to literature or patents Public-private co-publications Co-patenting Number of co-developed products International scientific co-publications Number of workshops and conferences	Number of licensed patents Number of technologies transferred Knowledge-intensive services exports Number of patent applications by foreigners Number of researchers working internationally	Governments Private corporations Scientific societies Universities	Development of communication centres Facilitation of the development of networks Open-access publication policies IPR policies International policy: e.g. treaties, clean development mechanism	Accessibility to exchange programs Strength of linkage among key stakeholders Participation to framework agreements ICT access
Guidance of search	Policy action plans and long-term targets Shared strategies and roadmaps Articulation of interest from lead customers Expectations of markets/profits	Level of media coverage Scenarios and foresight projects	Budget allocations Mission-oriented innovation programs	Governments Interest groups Media	Targets set by government of industry Innovation policies Credible political support	Media strength
Resource mobilization	Access to finance Graduate in STEMS Gross expenditures on R&D/total expenditures Domestic credit to private sector Number of researchers in R&D per capita Public energy R&D expenditures/total expenditures Expenditure on education Investment in complementary assets and/or infrastructure (e.g. Charging infrastructure for EVs, smart grids) Venture capital on deals	Number of green projects/technologies funded Share of domestic credit granted to low-carbon technology projects Share of domestic credit granted to projects developing complementary assets/infrastructure	Employment in knowledge-intensive activities Employment in relevant industries Scale of innovative activities Rate of growth of dedicated investment Availability of complementary assets and infrastructure	Governments Private firms Private investors (angel, venture capital, private equity) Banks	Financial resources support Development of innovative financing International agreements (e.g. technology agreements) Infrastructure support Project/program evaluation Innovation policies Higher education policies	
Entrepreneurial activities	No. of new entrants % of clean energy start-ups/incumbents access to finance for clean-tech start up	SMEs introducing product or process innovation Market introduction of new technological products Number of new businesses Experimental application projects Creative goods exports		Private firms Government Risk-capital providers Philanthropies	Ease of starting a business Risk-capital policies Start-up support programs Incubator programs	Start-up support services
Market formation	Public market support High-tech imports	Market penetration of new technologies Increase in installed capacity No of niche markets Number of technologies commercialized	Environmental performance Level of environmental impact on society Renewable energy jobs Renewable energy production Trade of energy technology and equipment High-tech exports	Private firms Governments institutions regulating trade, finance, investment, environment, development, security, and health issues	Environmental and Energy Regulation Fiscal and financial incentives Cleantech-friendly policy processes Transparency Specific tax regimes	Resource endowments Attractiveness of renewable energy infrastructure Coordination across relevant actors (e.g., renewable energy producers, grid operators, and distribution companies)

Source: IPCC AR6 WGIII

Policies can strengthen innovation

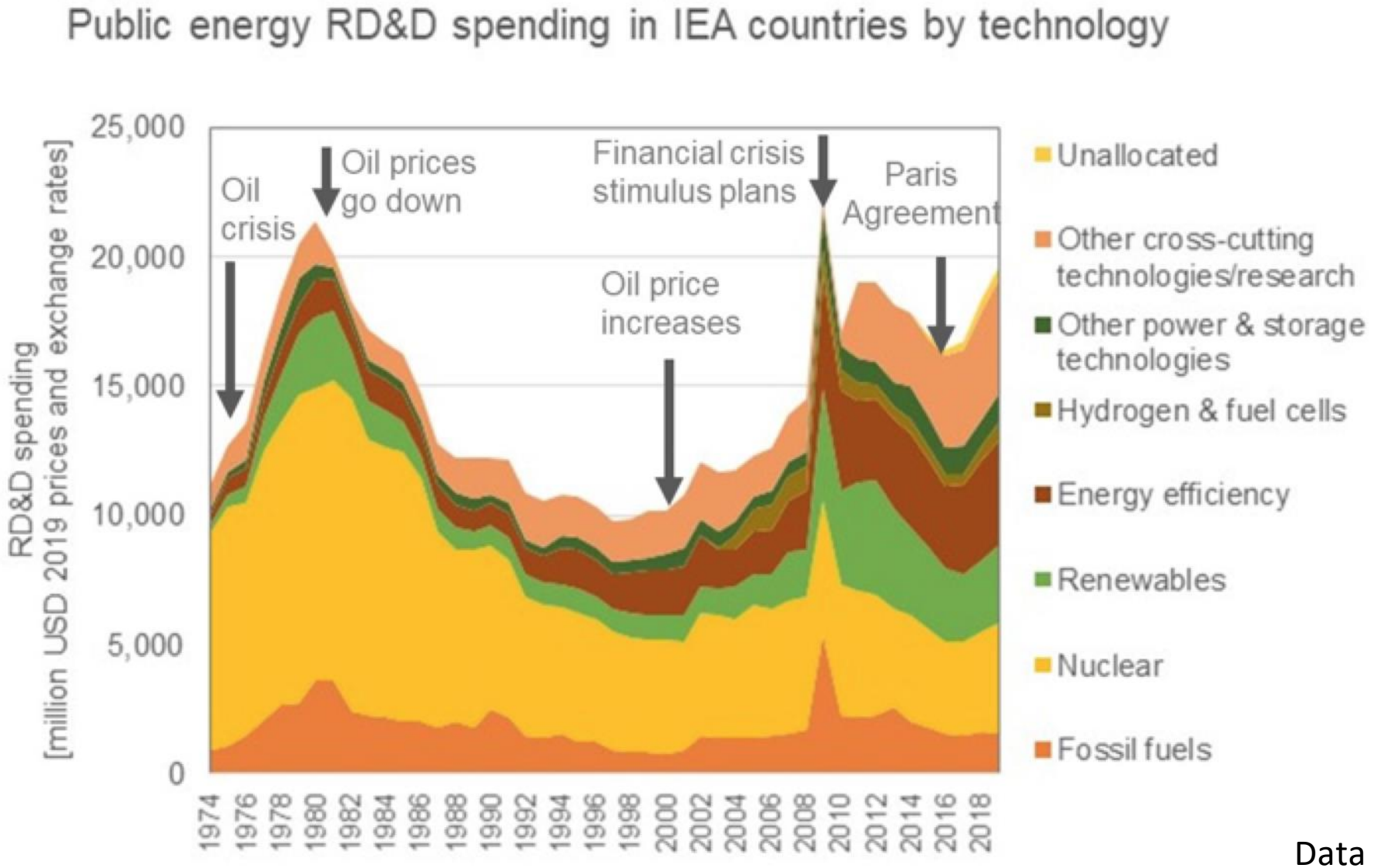
- Creation of markets (e.g., feed-in tariffs, subsidies/tax rebates for EV, standards and labeling program for energy-efficient appliances)
- Removal of systemic barriers such as information provision to public, enhanced interaction between academia and industry, increased legitimacy for low-emission technologies
- Greater investments in public RD&D (substantial increases in last couple of decades – but still only at about same level as post-oil crisis rise)

Greater investments in public research, development and demonstration



Data source: IEA

RD&D spending data limited for non-OECD countries, non-energy and private sector



Data source: IEA

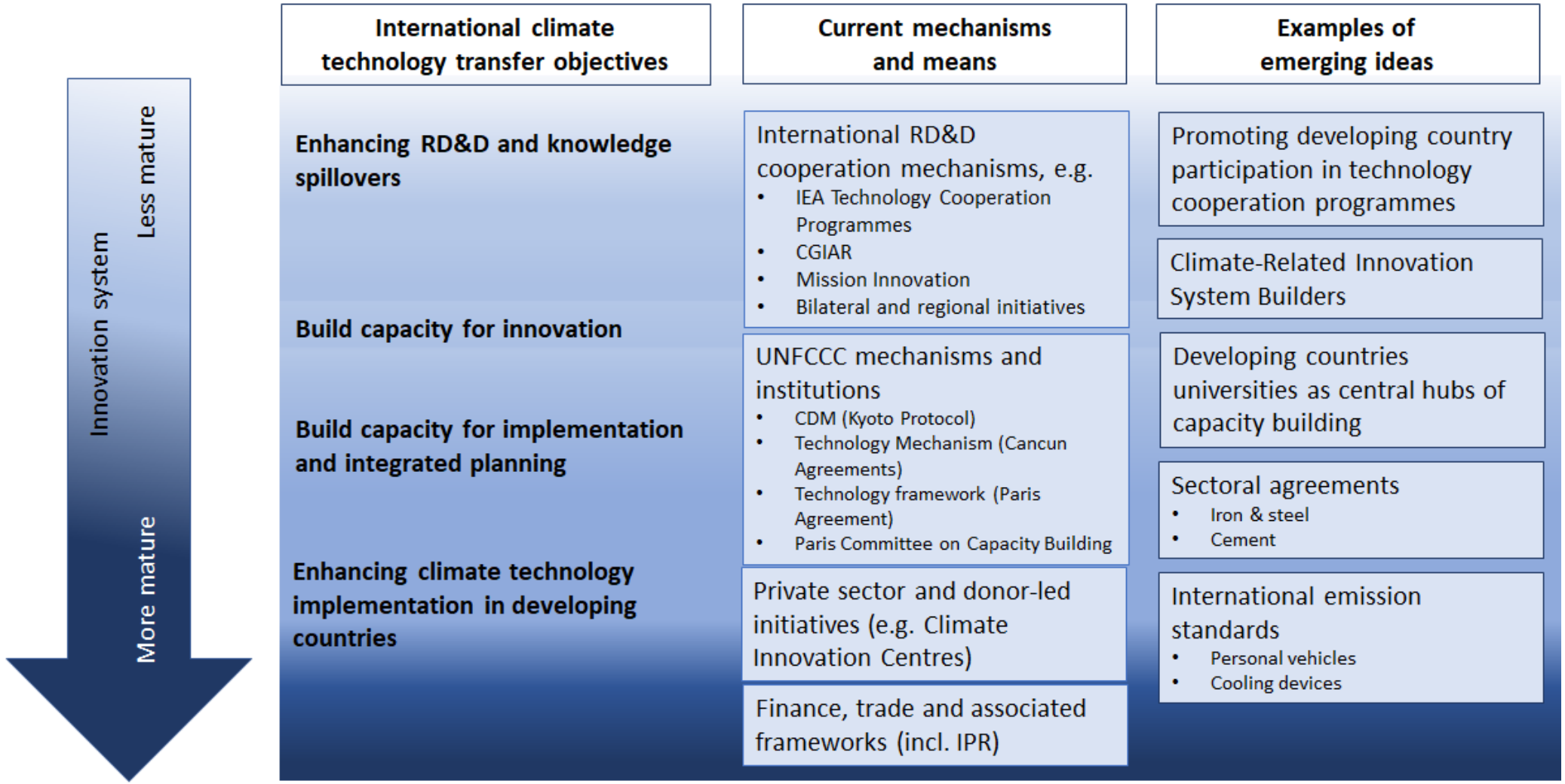
Developing countries have lagged in benefitting from technological opportunities

- Broadly, developing countries have not been as adept as industrialized countries at deploying low-carbon technologies
  - ✓ Higher (financing) costs
  - ✓ Lack of supporting technological systems/infrastructure
  - ✓ Weaker planning and implementation capacity
  - ✓ Human resource constraints
  - ✓ Other development priorities
- Developing countries have not benefitted in the same way
  - ✓ Low-value jobs, foreign dependencies and environmental impacts
- Enhanced technology and capacity to improve these aspects

International cooperation on innovation is a critical enabler for accelerated mitigation

- International cooperation can play an important role in supporting developing countries in their efforts to develop, adapt and deploy climate technologies
- Therefore great benefit to strengthening international cooperation efforts
- Many different channels (multilateral, plurilateral, and bilateral) and focii (R&D, deployment support) of international cooperation
- New ideas and approaches: "Innovation Cooperation", CRIBs, universities as capacity-building hubs, ...

New and emerging ideas for international cooperation on innovation



Source: IPCC AR6 WGIII

Global Stocktake: tentative reflections on indicators of progress in technology development and transfer

Technology RD&D

- Research, development and demonstration spending
- Number of fte working in mitigation and adaptation-related R&D

Technology transfer

- Tracking trade flows, technology sales
- Methods from technology transfer in CDM?

Sustainable development aspects of technology

Innovation systems: institutional capacity, functional approach, …

International efforts on technology: Collaborative RD&D, multilateral and bilateral support, …

Thank you

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