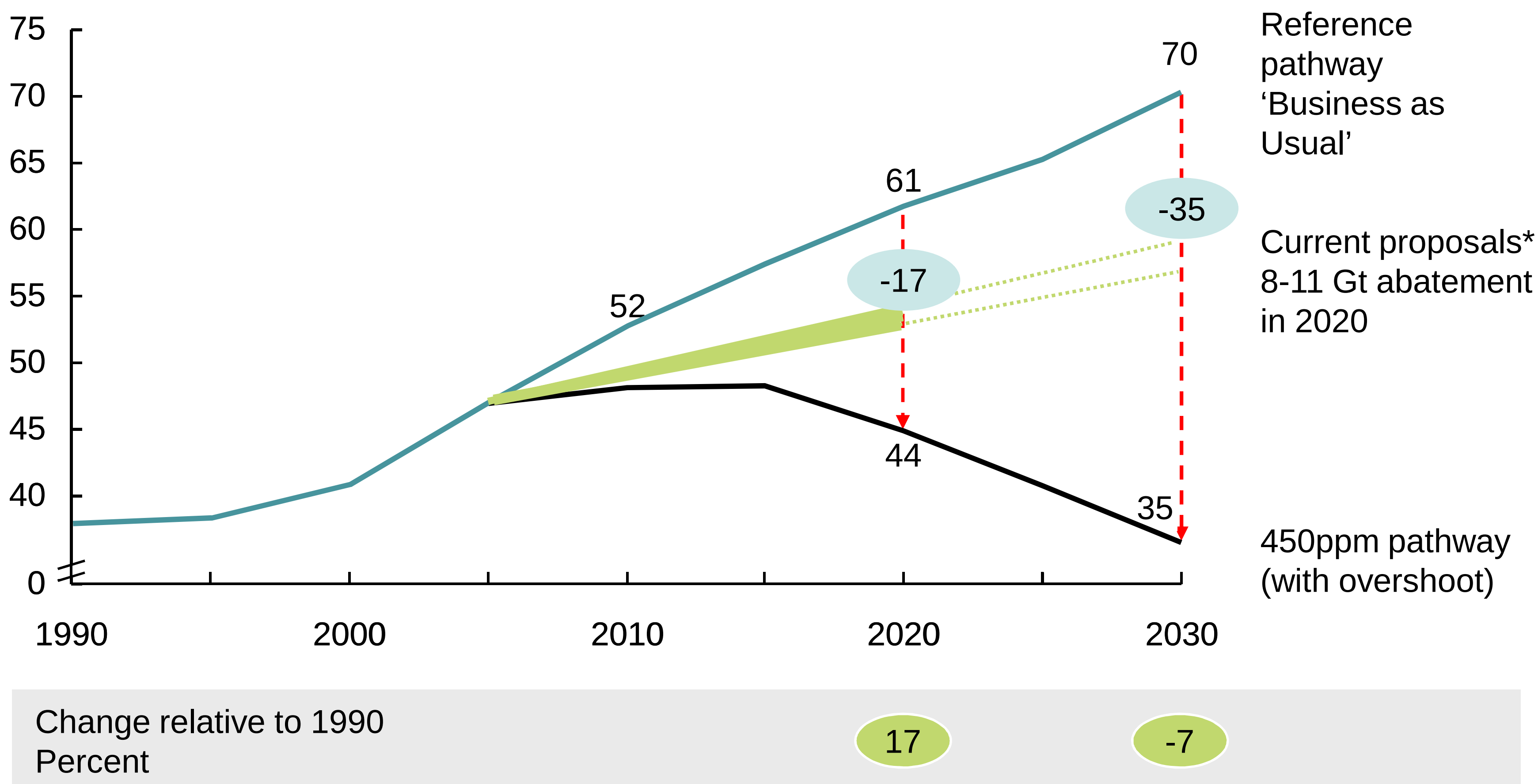
Technology Transfer

High level conference on technology transfer
October 22-23, 2009;

New Delhi, India

17 Gt of reductions below "Business as Usual" in 2020 are required for a 450ppm, 2℃ pathway

Global GHG emissions, Gt CO_2e per year

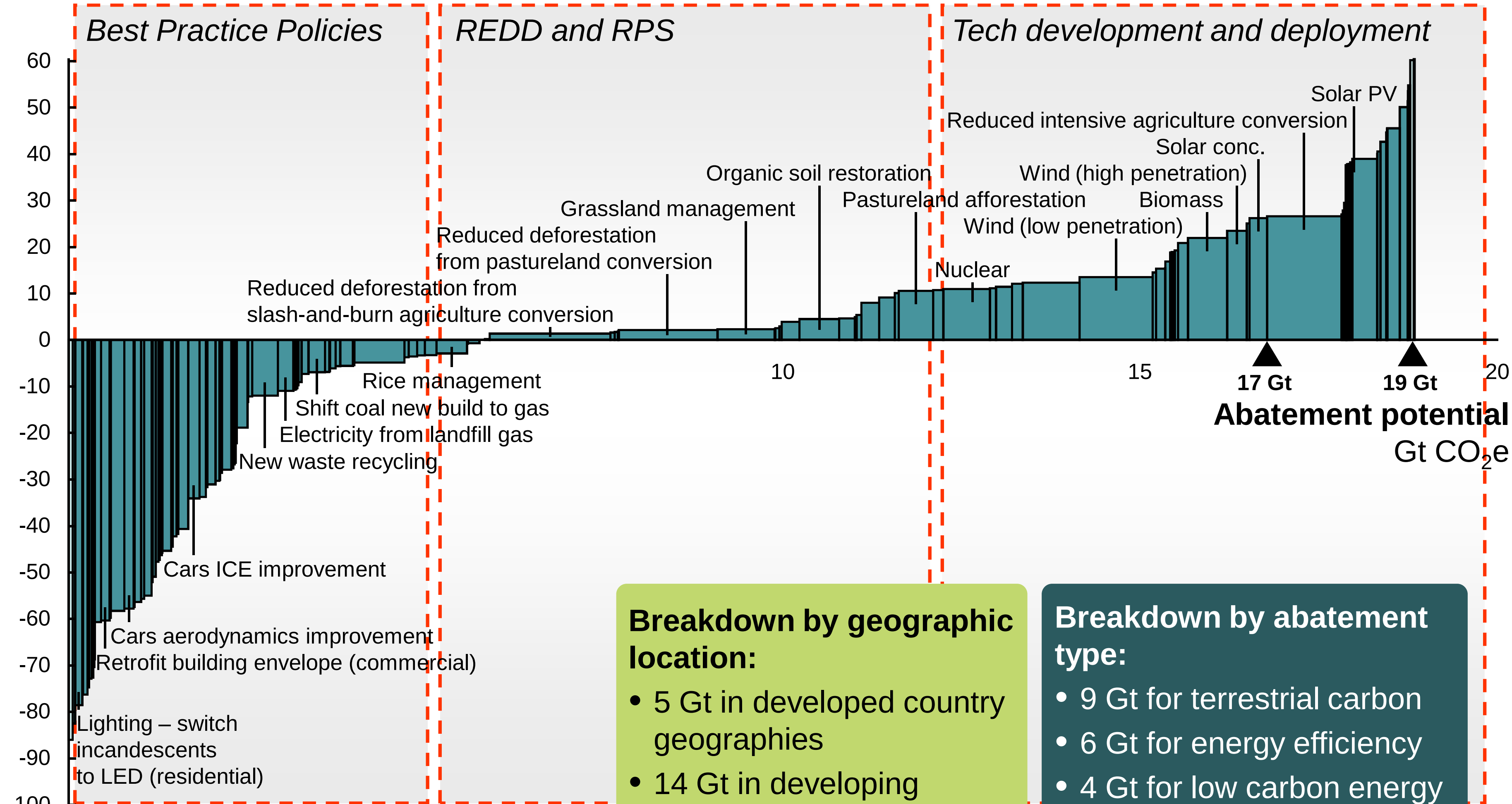


* US – 17-28% below 2005 level by 2020; EU – 20-30% from 1990 level by 2020; China - Reduce energy consumption per national income by 20% between 2005–10; Russia - stabilise emissions at ~30% below 1990; Brazil - Reduce deforestation rates by 70% by 2017, equivalent to 4.8b tons less CO2 emitted cumulatively; Japan - Reduce 80% by 2050 from current levels; Canada - 20% reduction from 2006 level by 2020; Mexico - Reduce emissions from 2002 levels by 50% by 2050, plus proposals from 12 smaller Annex 1 countries. Assumptions have been made on timeline and pathway to calculate abatement in 2020

Source: McKinsey Global GHG Abatement Cost Curve v2.0; Houghton; IEA; US EPA; den Elzen, van Vuuren; Project Catalyst analysis

The McKinsey Cost Curve identifies 19 Gt of abatements by 2020 making it technically feasible to achieve 450ppm

McKinsey global GHG abatement cost curve, 2020* (up to costs of €60/t, excluding transaction costs, 4% discount rate)



Breakdown by geographic location:

- 5 Gt in developed country geographies
- 14 Gt in developing country geographies

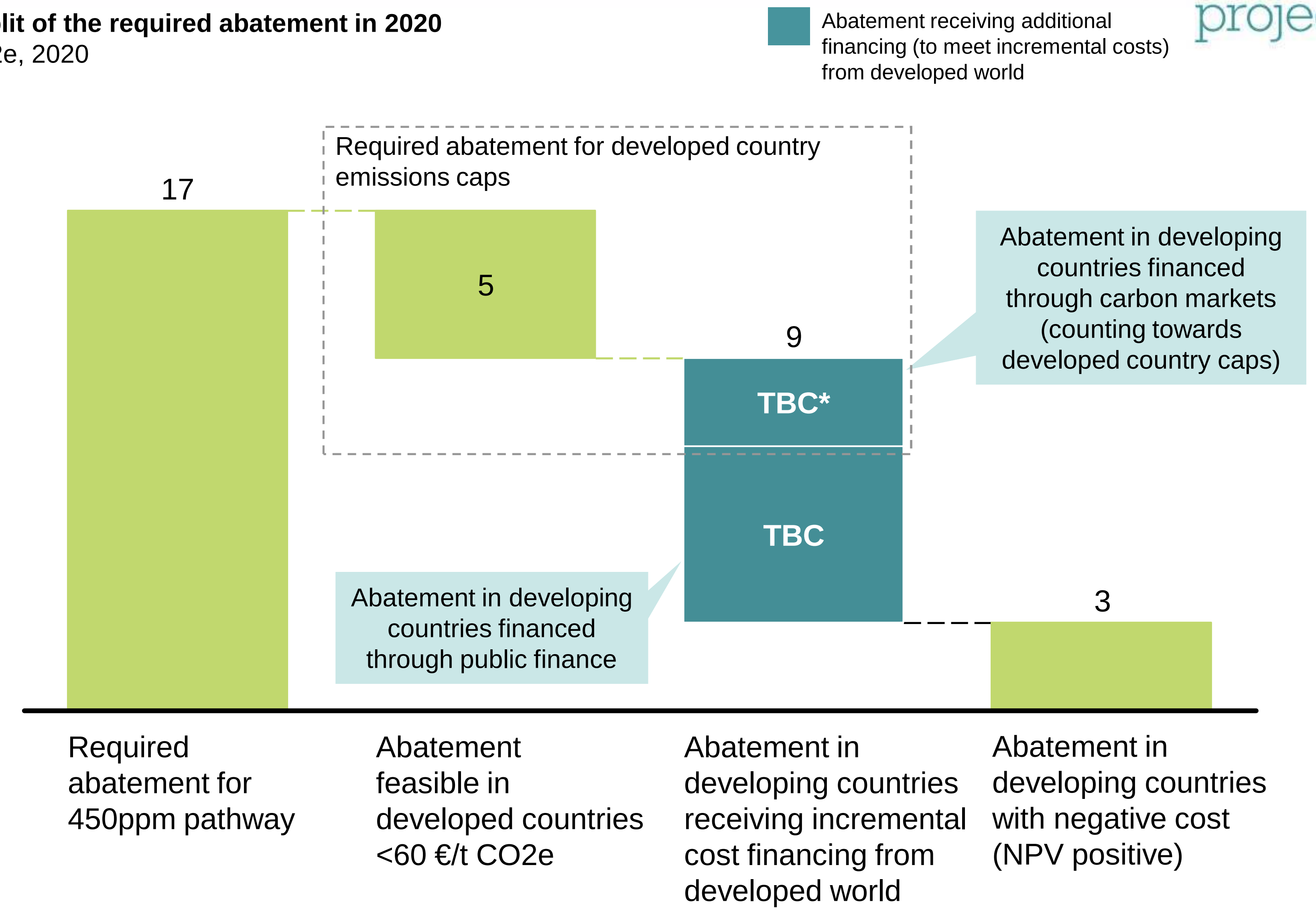
Breakdown by abatement type:

- 9 Gt for terrestrial carbon
- 6 Gt for energy efficiency
- 4 Gt for low carbon energy supply

Source: McKinsey Global GHG Abatement Cost Curve v2.0

Developed countries need to capture the 5Gt of domestic opportunity and provide finance for 9Gt in developing countries

The Split of the required abatement in 2020
Gt CO2e, 2020



* Amount will depend on size of emissions cap adopted. Under a 25% aggregated developed country cap this will equal 3 Gt; under a 40% cap, 6Gt

Source:McKinsey Global GHG Abatement Cost Curve v2.0, team analysis

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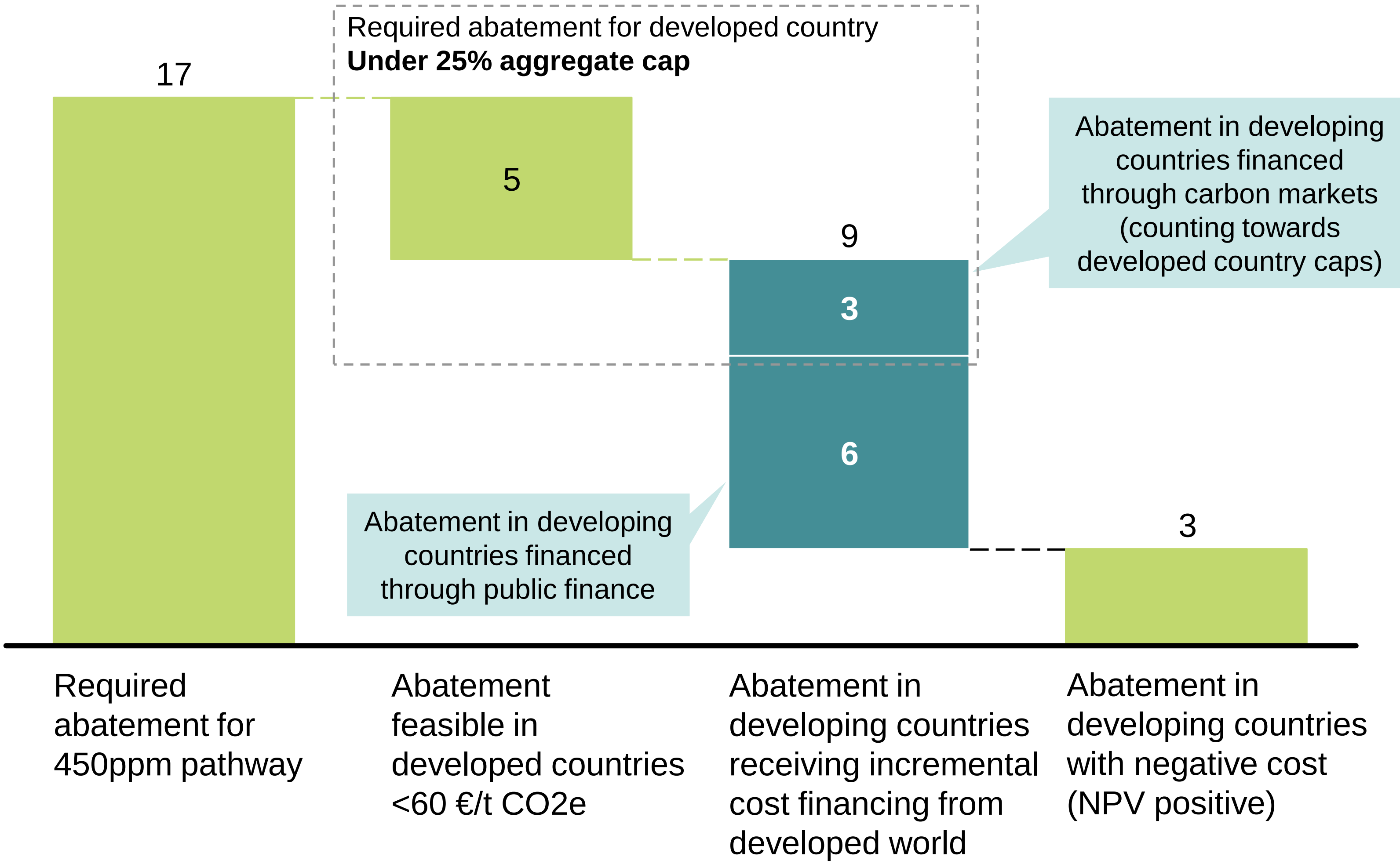
25% aggregate developed world cap could deliver 3 Gt of offsets

The Split of the required abatement in 2020
Gt CO2e, 2020

Abatement receiving additional financing (to meet incremental costs) from developed world



Source:McKinsey Global GHG Abatement Cost Curve v2.0, team analysis

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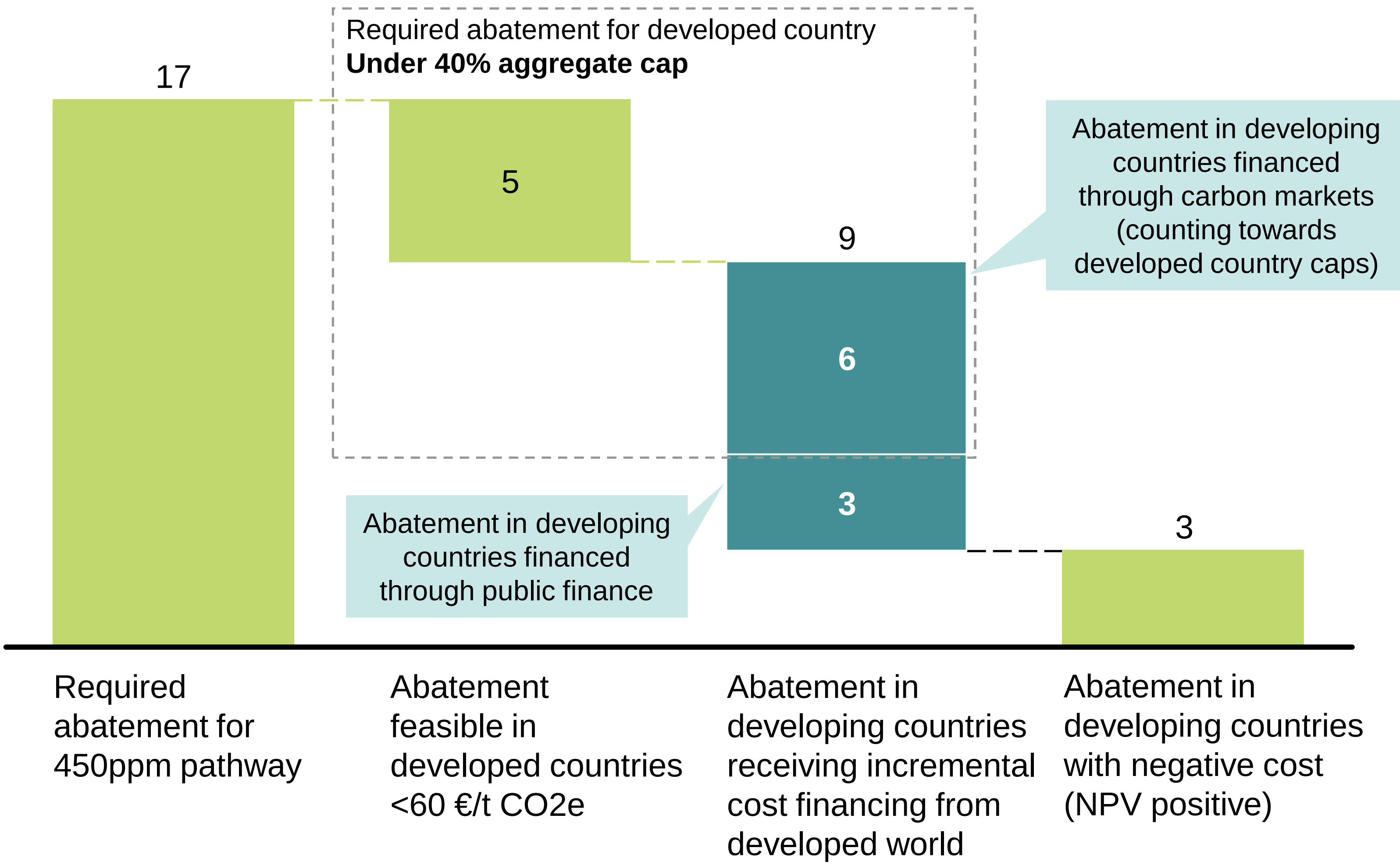
40% aggregate developed world cap could deliver 6 Gt of offsets

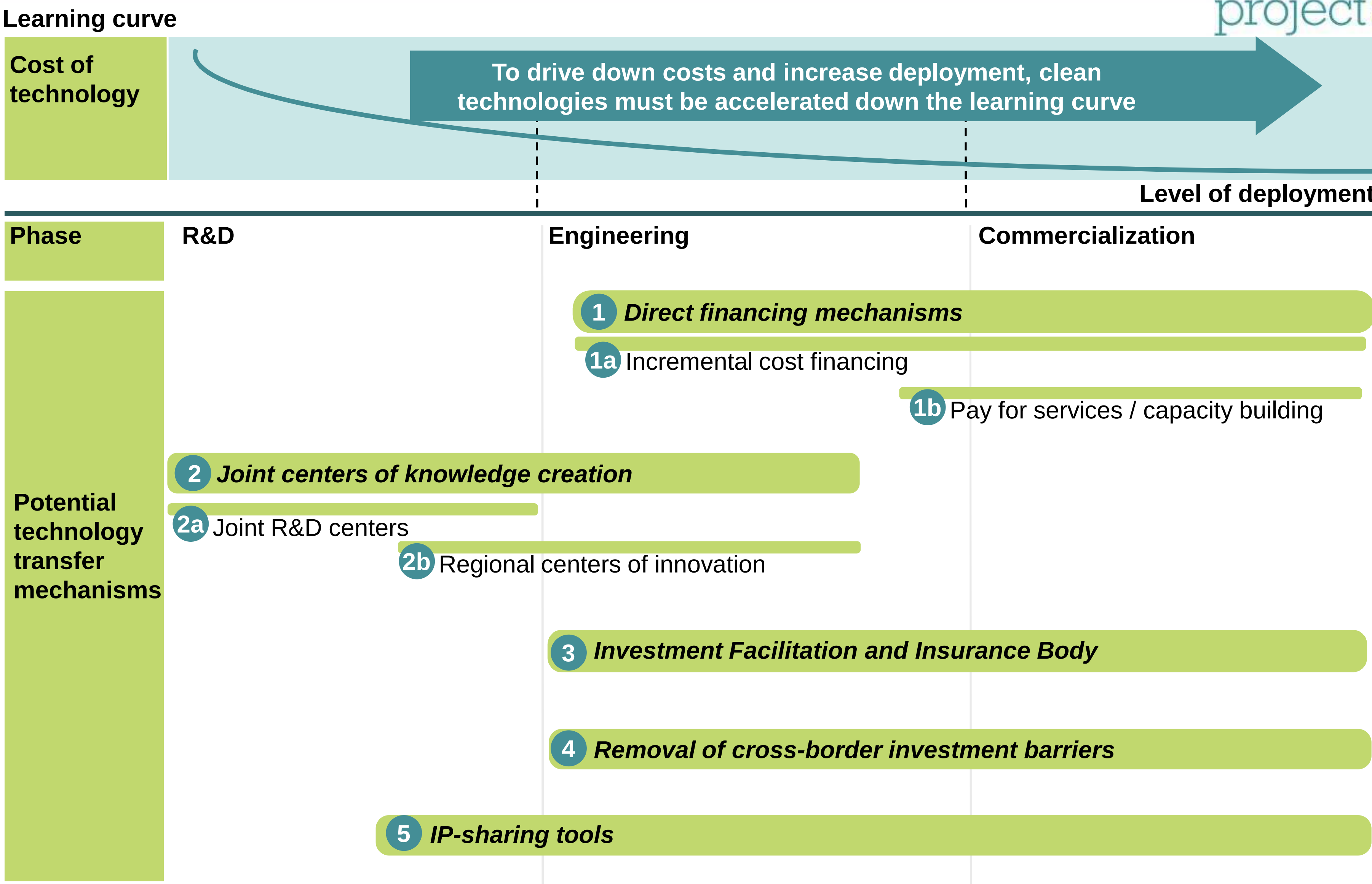
The Split of the required abatement in 2020
Gt CO_2e, 2020

Abatement receiving additional financing (to meet incremental costs) from developed world



Source:McKinsey Global GHG Abatement Cost Curve v2.0, team analysis

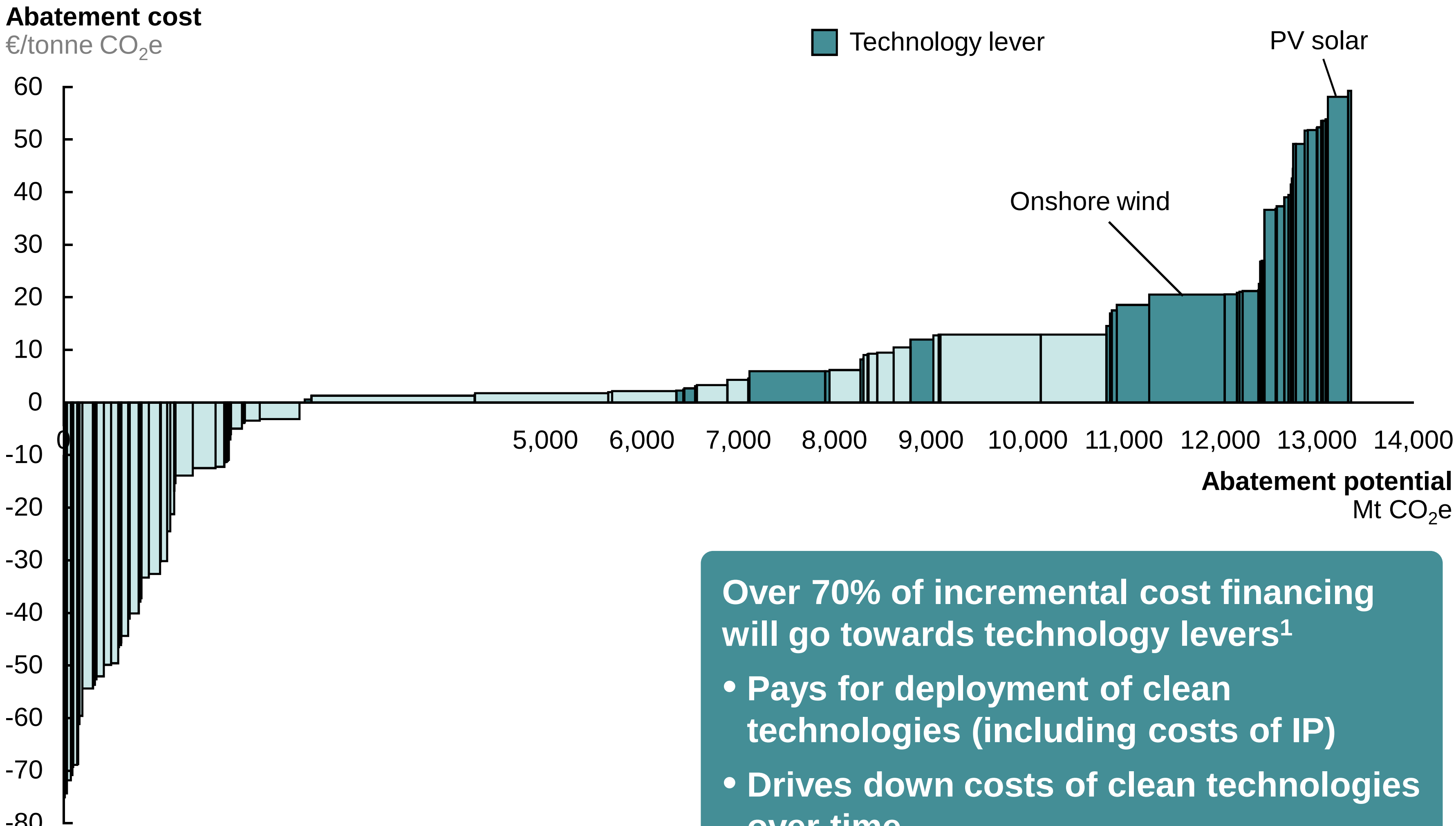
In addition to financing, a variety of technology transfer mechanisms can help drive costs down the learning curve



SOURCE: Project Catalyst technology white paper; expert interviews; team analysis

1a. Incremental cost financing: over 70% of the incremental cost financing supports technology levers (to 60 euros)

Developing country cost curve, 2020 (up to costs of €60/tonne, excluding transaction costs, 10% discount rate)



Over 70% of incremental cost financing will go towards technology levers[1]

- **Pays for deployment of clean technologies (including costs of IP)**
- **Drives down costs of clean technologies over time**

1 Exact dollar figures for incremental costs on technology levers ranges from €35-85 billion over the time period

Source: McKinsey Global GHG Abatement Cost Curve v2.0

For China, over 85% of full incremental cost financing would go towards the clean technology levers (to 60 euros)

China country cost curve, 2020 (up to costs of €70/tonne, excluding transaction costs, 10% discount rate)

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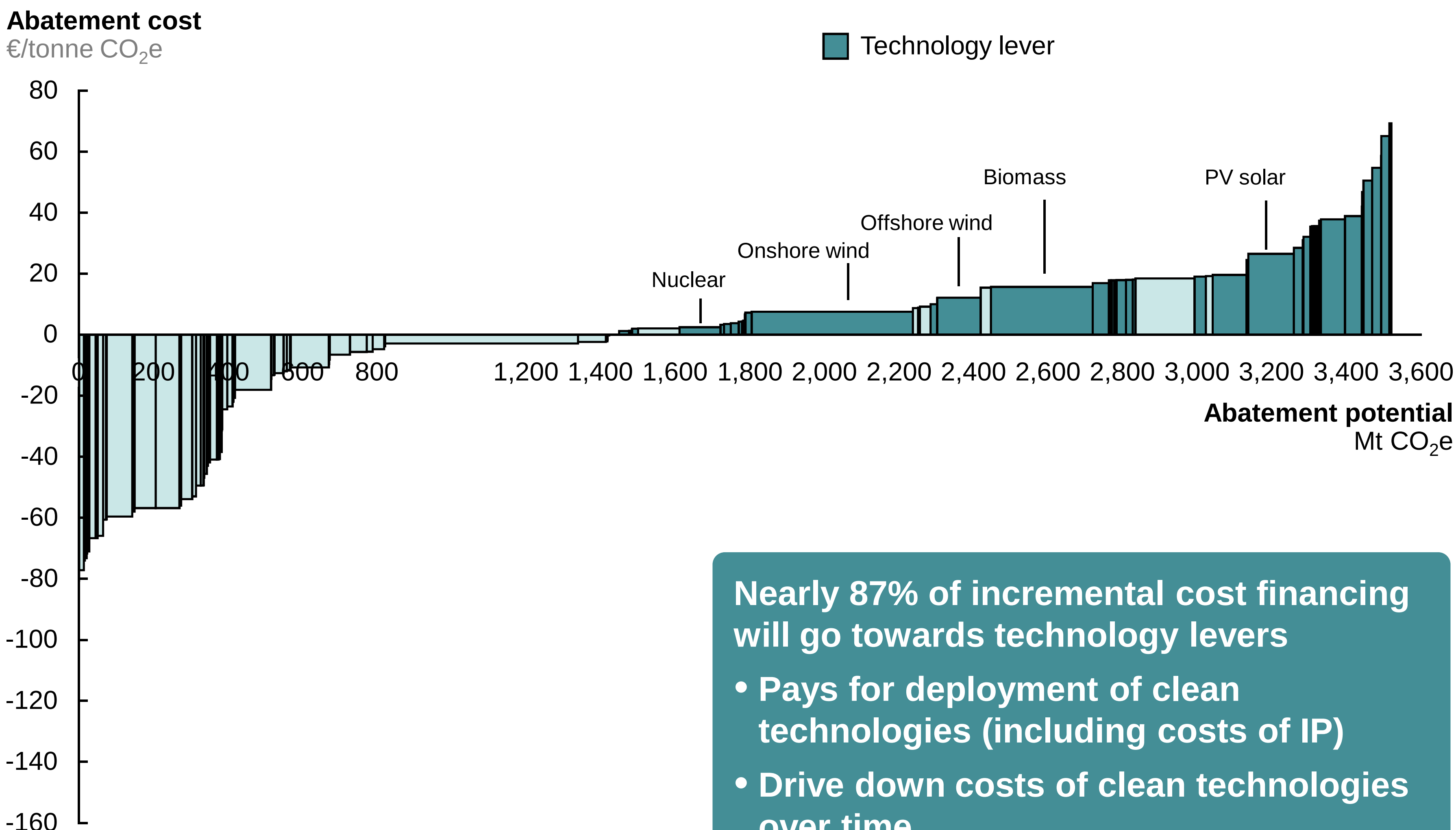

Nearly 87% of incremental cost financing will go towards technology levers

- **Pays for deployment of clean technologies (including costs of IP)**
- **Drive down costs of clean technologies over time**

Source: McKinsey Global GHG Abatement Cost Curve v2.0

1b. Pay for services /capacity building is direct financing that addresses important infrastructure and operational know-how gaps

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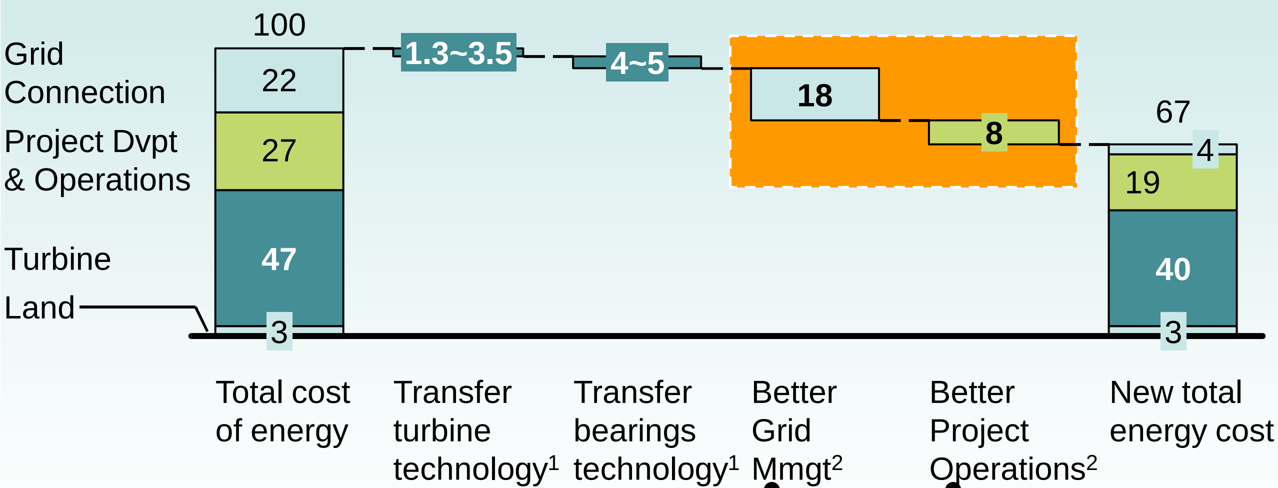
Deployment of clean technologies requires know-how / human capabilities across the value chain. In many instances (e.g., China's wind industry), this is the barrier to deployment and a bigger lever for cost reduction than reducing product costs

Generation cost of electricity for China wind industry, 2008

100% = RMB 0.7-0.8 / kwh[4]



25% wind farm not connected to the grid in 2008

10% less efficient than best practice

Pay for services/capacity building can accompany/replace a portion of incremental cost financing:

- Capacity building in the early years **builds the foundation** for technology deployment
- Pay for services can **address inefficiencies** in existing systems
- These technology transfers are **less contentious** as there is less threat of export back to developed country home markets

Case study: China wind power

- **Addresses largest cost reduction lever (26%) -** Improved grid connectivity and project management could generate an additional energy output valued at ~RMB 20 billion[2] from 2010 to 2020
- **Minimal Cost -** could cost as little as ~RMB 300 MM[3]

1 Includes all aspects of IP, both patents and know-how/process IP

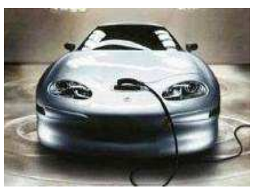
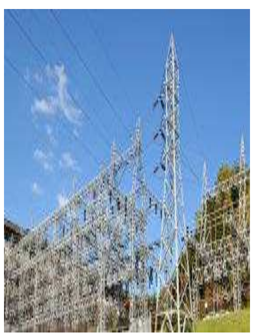
2 Assumes State Grid and Chinese wind farm operators can solve the problems in 2015 by self-learning gradually, but that 4% grid connectivity and 6% operation can be improved today through int'l companies train/teach operational know how. Assuming annual utilization can be improved to 2000 hours/yr, portion of wind farms connected to the grid increases from 75% to 79%, 50GW of wind farms installed before 2015 benefit

3 Assume 400 experts/engineers stay in China for 1 year with annual compensation of $100k/person to train/teach Chinese wind farms/grid operators, with average training period of 3 months, in order to achieve the saving potentials in grid connectivity and wind farm operations

4 Cost of wind power is estimated taking into account all wind farms installed whether or not they are connected to the grid

SOURCE: Expert interviews; Literature search; Annual reports; McKinsey analysis

Technology deep dives show that key deployment levers often reside beyond current technology gaps

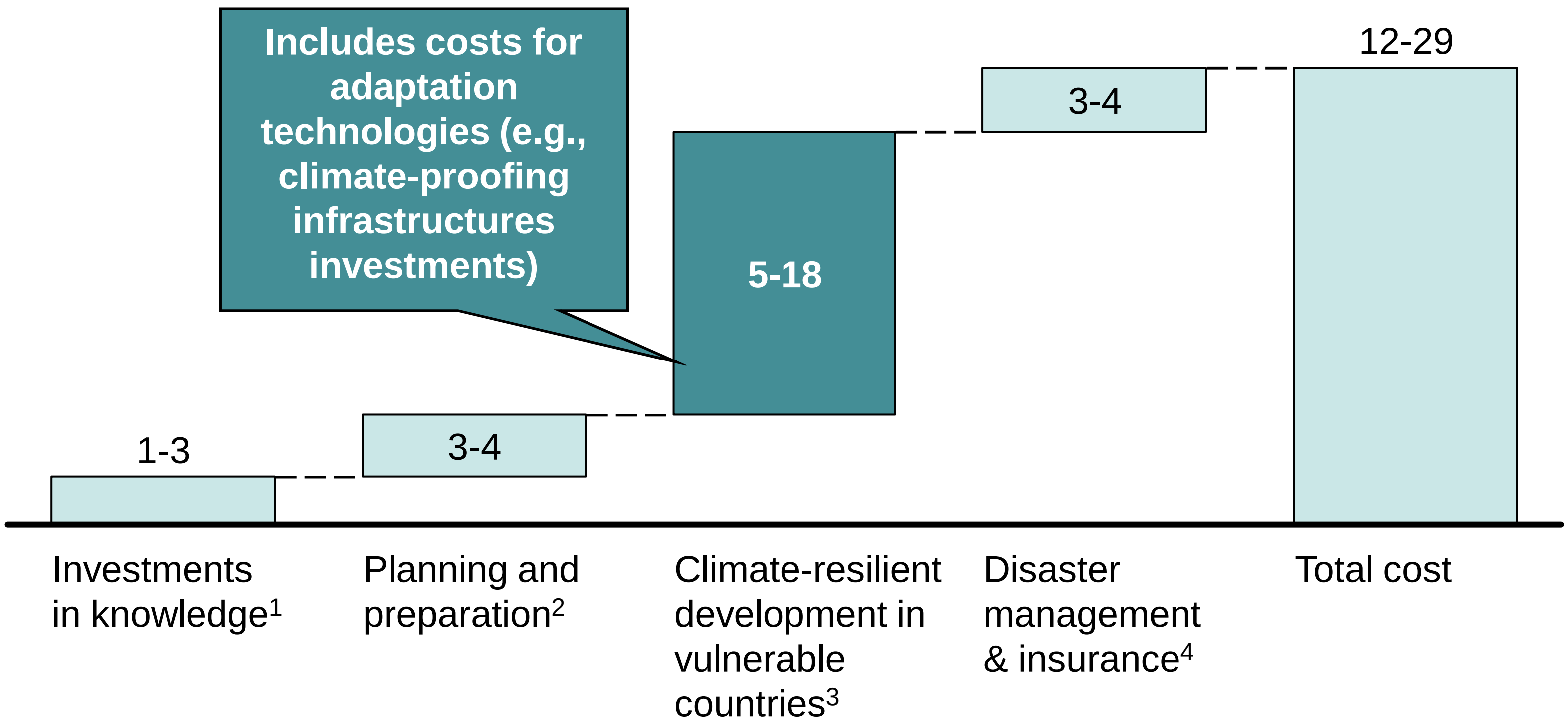
		Technology gaps	Technology transfer benefits	Key deployment levers
On-shore wind		• Bearing • >2MW turbine	• **~4-5%** cost reduction[1] from bearing technology transfer • **~1.5%-3.5%** cost reduction[1] from >2MW turbine transfer	• **Service:** Grid connectivity and wind farm operations **~26%** reduction[1] potential • **Technology transfer**
Solar		• Silicon production • Thin film PV	• **~1%** cost reduction[1] from silicon technology transfer • **20-25%** cost reduction[1] from transferring current leading thin film technology	• **Portfolio approach** to allow new PV innovations to reach scale, winning technology potentially with **~60%** cost reduction[1]
EV		• Next-gen Li-ion batteries • Electric motors • Inverter (IGBT)	• **~2%** EV cost reduction from better LFP battery technology	• **Portfolio approach** to allow next-gen batteries to reach scale, ~**30%** cost reduction potential in EV
Smart Grid		• Battery storage • Demand side management • Low-voltage-fault-ride-through (LVFRT) conditions for wind connectivity	• **~22%** cost reduction potential from transferring NaS battery technology that can be used for grid storage	• **Collaborate** on system architecture best practices, policies, scientific energy planning • **Transfer** of a few key technologies (e.g., LVFRT, storage, ultra-high voltage) • Global **co-investment**

1 Total generation cost of electricity, including capital expenditures such as equipments, construction and installation, as well as operational expenditures

SOURCE: Expert interviews; literature search; team analysis

1a. Financing flows for adaptation will also fund technology transfer of adaptation technologies

2030 estimated annual adaptation funding requirements (for public sector actions)
€ billion p.a

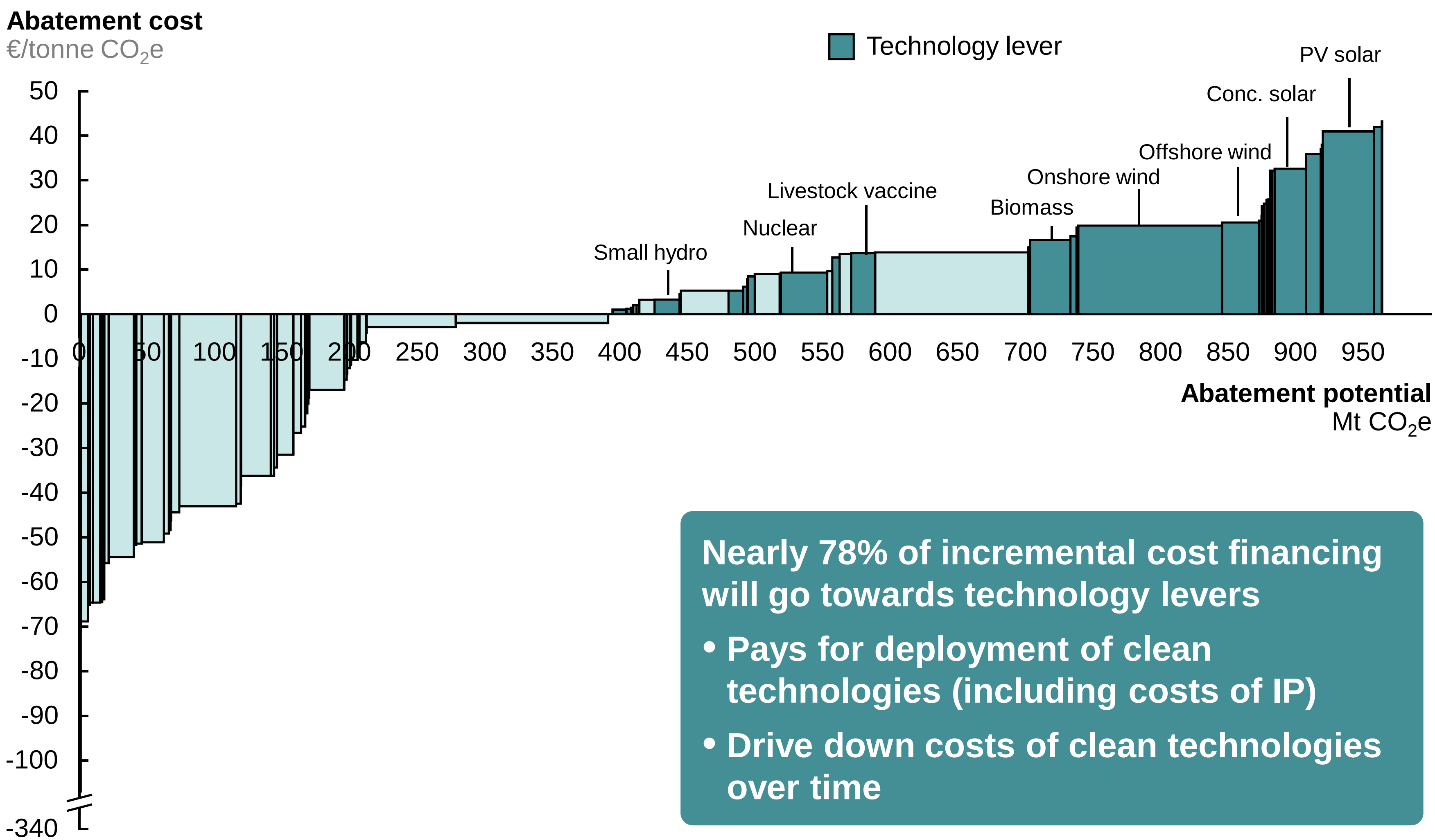


1 Figures based on benchmarking of existing leading institutions (e.g., NOAA, NASA, Not Office, CGIAR)
2 Figures calculated by scaling costs of UK Environment agency to non-Annex I countries by GDP (€3 billion pa using quadratic function; €4 billion pa using linear function)
3 Figures based on UNFCCC cost estimates, only for most vulnerable countries, extending to all developing countries would increase costs by €9-32 billion p.a
4 Figures based on Munich Climate Insurance Initiative proposal

Source: NASA; UK Mot Office; NOAA; CGIAR; UNFCCC; NAPAs; Munich Climate Insurance Initiative, EM-DAT International Disaster database; Project Catalyst analysis

For India, over 75% of full incremental cost financing would go towards the clean technology levers (to 60 euros)

India country cost curve, 2020 (up to costs of €50/tonne, excluding transaction costs, 10% discount rate)

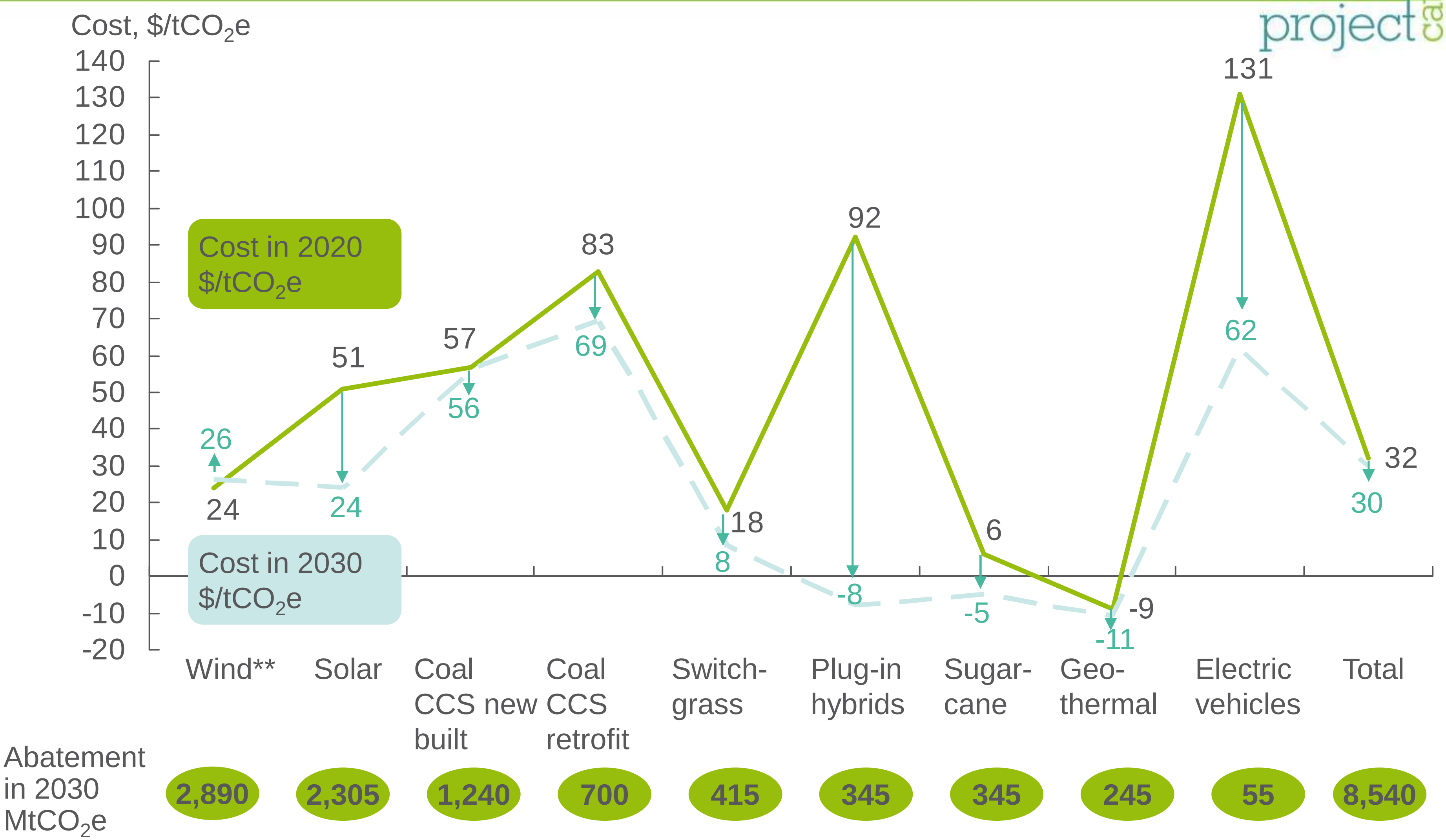


Nearly 78% of incremental cost financing will go towards technology levers

- **Pays for deployment of clean technologies (including costs of IP)**
- **Drive down costs of clean technologies over time**

Source: McKinsey Global GHG Abatement Cost Curve v2.0

1a. The costs of clean technologies across the board will drop significantly as a result

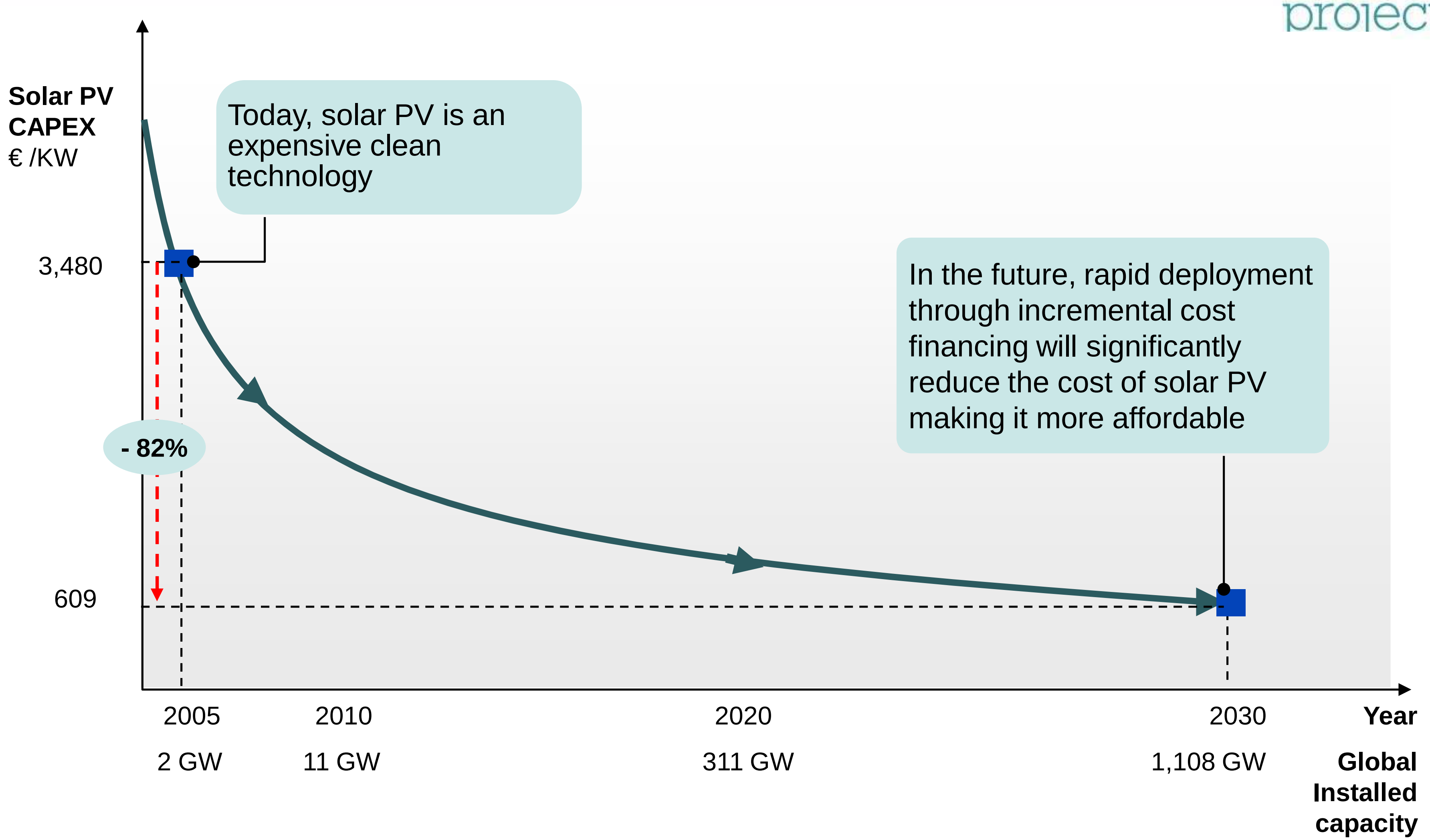


* These costs are the weighted average of all abatement opportunities operative in the relevant year (even if the infrastructure was built/started in earlier years; not the actual costs of new technology deployment in that year)

** Increase in costs due to shift from onshore to offshore and other more expensive sites over period

Source: McKinsey Global Greenhouse Gas Abatement Cost Curve v2.0; Project Catalyst analysis

1a. Incremental cost financing deploys clean technologies in developing countries helping to reduce their costs in the process

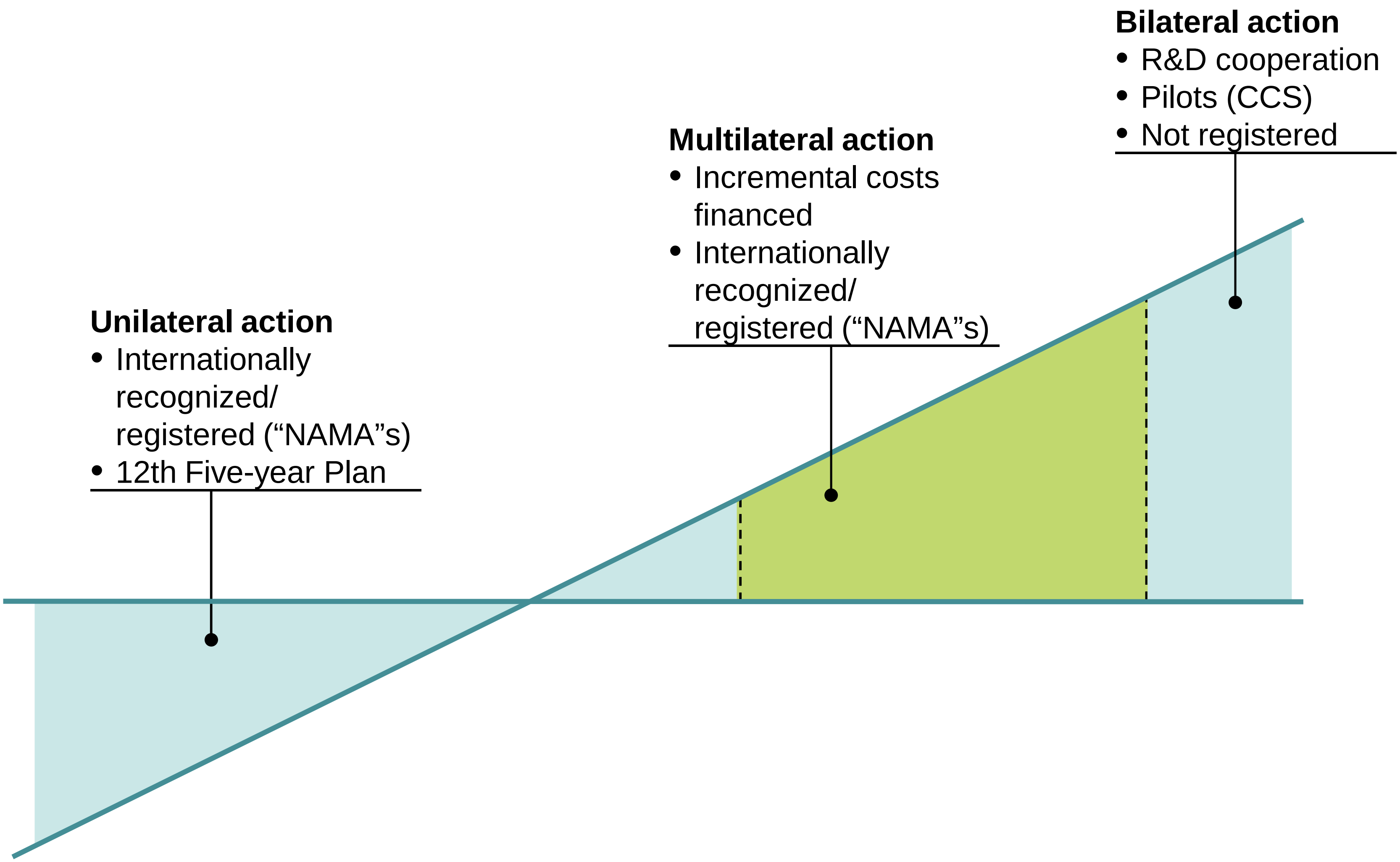


Note: Assumes 80% learning rate based on historical rates, meaning the cost of solar PV would decrease by 20% when installed capacity doubles. Installed capacity is based on global solar deployment, developing country installed capacity will be 803 GW

SOURCE: McKinsey Global Greenhouse Gas Abatement Cost Curve v2.0; Project Catalyst analysis

Developing countries can take unilateral action against low cost levers, but require multilateral/bilateral assistance for positive cost levers

Potential actions along the GHG Abatement Cost Curve



2. Joint centers for knowledge creation will be critical in developing new technologies and adapting existing ones to local conditions

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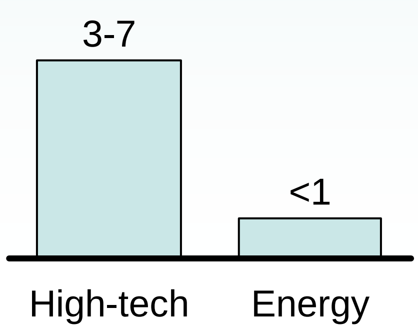
R&D spend in the energy domain needs to be accelerated through government intervention

Barriers in R&D phase

- Private sector under-investment due to maturity terms that exceed their investment timeframe (typically 7 years or less)
- Inventions are not fully commercialized due to poor links between public research institutions and private sector
- R&D spend in energy severely lags research in other high-tech areas

R&D spend by industry
Percent of sales



Joint centers for knowledge creation will both develop new low-carbon technologies and adapt and deploy existing technologies

Joint R&D Centers

- Does both **fundamental and applied** research
- US-China Joint Energy Center can be a pilot
- R&D centers encourage public/private partnerships
- Joint demonstrations of key technologies (e.g., CCS)

Regional Centers of Innovation

- Program **headquartered in Africa**, with locations throughout the developing world
- Adapt technologies to local context for both mitigation and adaptation purposes
- Use local and international experts
- Modelled after the **Alliance of CGIAR centers**
- Focuses on capacity building and technology training
- Climate prizes funded within the UNFCCC encourage international research into “orphan” technology areas

SOURCE: Hal Harvey technology paper, Project Catalyst Technology White Paper

Technology for the poor has dual benefits of life quality improvement and carbon abatement for G77 countries

Orphan technology is important to improve the lives of the poor

- **Better health**
  - better health facilities, cleaner air, access to clean water, better nutrition, etc.
- **Better education**
  - higher education levels, quality of schools improves, allow more studying, etc.
- **Further development**
  - Improved agricultural productivity, improved infrastructure, lighting and saved time collecting fuels, etc.

However, many of these technologies will not be available w/o help from developed countries

- **Electrification**
  - Lanterns
  - Smaller solar modules

- **Cooking**
  - Cook stoves using briquettes from biowaste

- **Agriculture**
  - Drought resistant seeds
  - Drip irrigation system

- **Water**
  - Deep ground water pump
  - Waste water treatment
  - Water purification technology
- Most orphan technologies need to **be adapted** and **made cheaper**

Providing these technologies to the poor has significant impact on their lives and carbon reduction, with limited costs

- **Electrification – Lantern**
  - 70M HH can be equipped with solar powered CFL lighting
  - Carbon abatement opportunity is ~10 Mton CO_2e in 2020
  - Cost of ~1.3B per year in 2020
- **Cooking – cook stove**
  - Affect ~600 million population in Africa by reducing reliance on fuel wood and charcoal for cooking, reducing 550 million m^3 of wood consumption per year by 2030
  - Save forestation and reduce death and disease through smoke inhalation
  - Limited cost as briquettes made from mashing biowaste such as banana waste, and no need for mechanical equipment
- **Agriculture** - **drip irrigation**
  - Reduce water usage by 75%
  - Cost of at least $3 billion per year

SOURCE: literature searches; Grantham Institute; Interviews with TERI

3. The Investment Facilitation and Insurance Body (IFIB) would accelerate the pace of market-driven technology transfer (JV, licensing) by addressing information and IPR market failures

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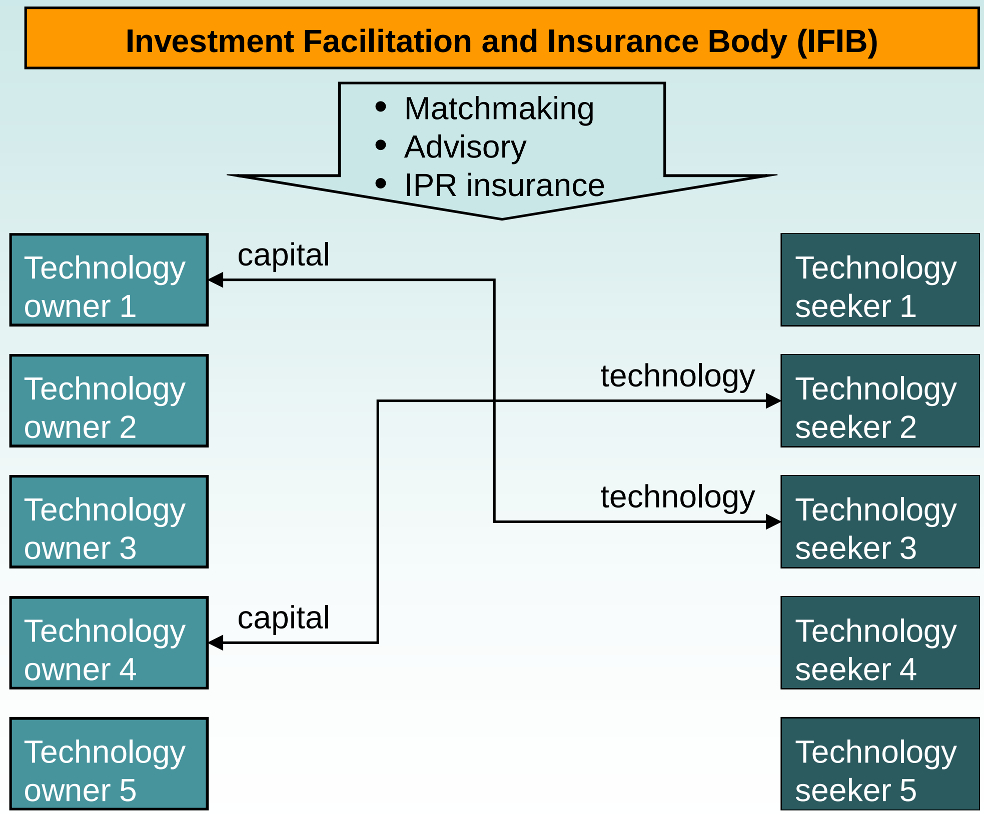
A lack of information and concerns about IP infringement slow the pace of technology diffusion in some regions

- Large potential for mutual benefit between **startups in need of capital** to bridge the "valley of death" to scale their technologies, and **wealthy foreign businesses looking to adopt new technologies**
- Currently, technology owners may not engage in such deals or may not produce/deploy their best technologies abroad due to market failures of:
  - **Information:** technology owners do not know which foreign businesses to partner with; foreign businesses don't know what technologies are available
  - **IPR risk:** for small companies, IPR infringement with no litigious recourse could doom the enterprise
- OPIC's 38-year success provides a model of how government insurance bodies can stimulate private investment

The IFIB would address these market failures by providing a market place for businesses to meet and where IPR would be insured

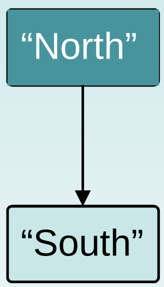


SOURCE: Industry and expert interviews, http://OPIC.gov

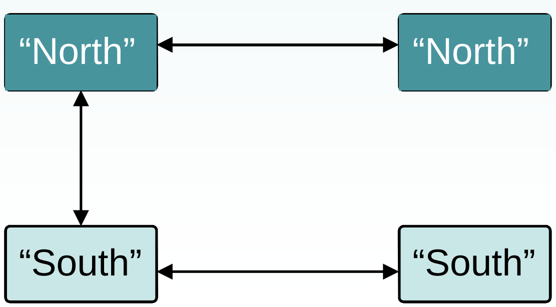
4. Removal of cross-border investment barriers – Agreements to reduce / limit barriers to overseas investment/trade will help facilitate technology transfer

Trade/FDI are the private sector's way of transferring technology, and it does so in all directions

Conventional thinking: Technology transfer flows from North to South



In actuality: Technology transfer between South-South, North-North, and South-North are just as important



Trade/FDI barriers can have significant negative repercussions and need to be reduced/limited

- Negative effects from reduced trade/FDI:
  - **Under-investment in technologies** resulting in slowed innovation and more "valley of death" instances
  - Potential **large capital sources are under-utilized**
  - Negative feelings of **distrust and inequality**
- While trade/FDI are difficult diplomacy issues with scope beyond climate change, special circumstances could be created for climate-change related technologies
  - **Visas:** Expedited visas for climate change-related visits
  - **Trade:** UNFCCC can work with WTO to create special category for climate-change technologies with agreed limitations on tariff and non-tariff trade barriers
  - **FDI:** UNFCCC can work with WTO to create transparent, global standards for when climate change technology purchases can be blocked
    - Only for national security, not for economic security
    - Predictability of review process in terms of timing
    - Ensured confidentiality for all parties

SOURCE: Industry and expert interviews

5. IP-sharing tools - new business models for increasing the pace of technology diffusion while respecting IPR that is critical for incentivizing innovation

The current IPR regime encourages private sector innovation but is weak at stimulating diffusion

- Current IPR system is designed to provide **incentives for innovation** which will be critical as most needed clean technologies don't exist yet
- However, **clean technologies average 24 years before entering the mass-market**; this diffusion time must be sharply reduced to meet climate goals
- Additionally, current cooperation on innovation and technology development is usually **intranational instead of international**

Innovative IP-sharing tools may speed up the diffusion of clean technologies while maintaining the incentives for innovation

- **Patent Pools**. For certain classes of technology, participants of a patent pool program can gain access to each member's technology in order to innovate on the shoulders of other's research. Actually using a member's patent would still require a license
- **Open Sourcing Design**. Less complex technologies could invite engineers around the world to iterate and improve open source devices. Anyone could produce these devices subject to the open source license, with profit potential in manufacturing and service contracts
- **Global Commons**. Internationally agreed emergency technologies could be held under a "Global Commons" program where anyone could use this technology for free
- **Marching Rights**. When public funds are used to create a technology but no effort is made to produce it, compulsory licensing by the funding government(s) can play a role
- **International arbitration panel** Hear claims of patent abuse or unreasonable refusal to deal in ESTs

SOURCE: Industry and expert interviews, Chatham House: Who owns our low-carbon future?

BACKUP

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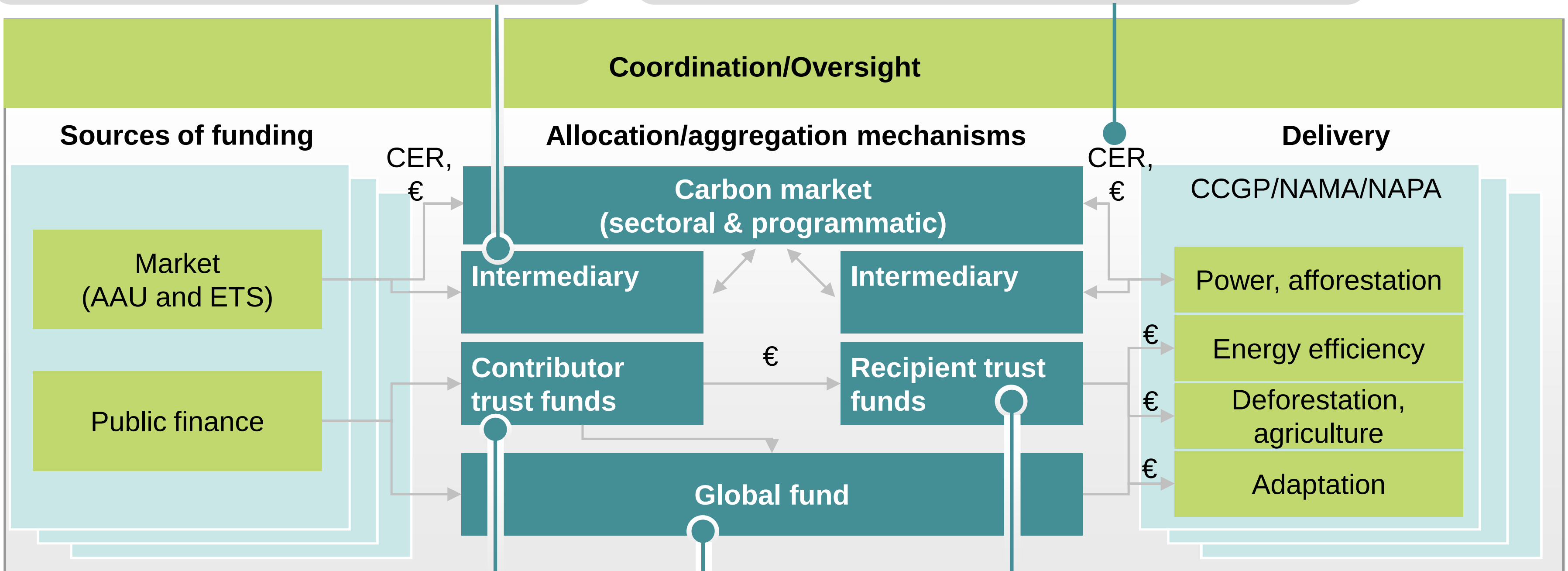
Financial mechanism: Country level funds

- Intermediation on supply and/or demand side; direct access to carbon market only in places without intermediation

- Markets primarily in form of sector programmes, plus some sector (no-lose) caps



- Contributor countries provide financing in form of cash to contributor funds
- Contributor and recipient funds go through ‘matching’ process

- Global fund (~20%) created for
  – Adaptation
  – Mitigation action not funded by national contributor funds
  – IFIB

- Recipient trust funds compete for funding based on quality of LCGPs/NAMAs/NAPAs
- Recipient funds could be national or regional
- They are sole issuer of credits

The investment facilitation portion addresses informational failures while the insurance portion addresses IPR concerns

Investment Facilitation

- Investment Facilitation and Insurance Body (IFIB) addresses:
  - **Who to partner with.** Small firms entering foreign markets often are unaware of the best regional players
  - **How to structure the deal.** Navigating local rules and regulations is tough for smaller companies. The IFIB would provide advisory services about how to partner with local expertise
  - **How to protect IP.** For a small company, IP infringement with no ability to litigate and recoup losses could destroy the firm
- Structured as an independent body under the auspices of the UNFCCC with a Board of Governors representing key countries
- Applicable to Solar, Wind, EV, and Smart Grid technologies

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Insurance

- Developing nation and developed nation co-insure risk of IP infringement
  - **IP valued based on lost potential profits.** Valuations often differ wildly, but amount would be agreed upon before execution of insurance
  - **Co-insurance aligns incentives.** Since the developing nation is an underwriter of the insurance, they are encouraged to strongly protect the IPR of the firm
  - **Insurance covers 50% of losses.** To reduce fraud, the insurance does not cover the entire cost of the infringement
- Some risks will be tough to overcome
  - Protecting IPR requires alignment among the developing nation's legislative bodies, police bodies, and judiciary bodies
  - Valuing IP infringement in the future is a contentious issue
  - The developing nation must gain value from having the firm conduct business in their region; technology transfer procedures must be formalized

SOURCE: Expert interviews, McKinsey analysis

IPR insurance example: Acme, Inc. sets up a factory to produce better gearboxes for wind turbines in Nigeria

Fundamentals

International sales	$50M
Estimated African market	~$75M over next 5 years
Current profit margin on widgets	10%
Expected profit margin on gearboxes produced in Nigeria	20%
Length of patent	5 years

Infringement insurance

- In case of theft, litigation against a Nigerian firm unlikely
- Nigeria agrees to co-insure 25% of the value of Acme's lost profit if gearbox technology is stolen
- USA co-insures 25% of value

- Valuation of Acme's lost profits[1] based on:
  - **But-for of the infringer.** No African firms would be able to create a legal substitute within the 5 year patent life
  - **Price erosion.** If the IP is stolen, Acme's product would be forced to sell at only 5% of margin to compete
  - **Lost sales.** Since there would be no substitutes available, Acme's total addressable market would have been $75M in Africa over lifetime of the patent
  - **No-reimportation risk.** A potential infringer would not have the capability to export gearboxes to the rest of the world

In the event of infringement, Nigeria and the USA would each refund the company $2.2M

1 Lost profits = incremental profits on lost sales + profits lost due to price erosion. If sales would drop to 1/3 of what they would be, lost profits = (0.20 * (2/3) * $75M) + (0.15 * (1/3) * $75M) = $5M + $3.75M = $8.75M

The IFIB fills in the gaps between the needs and haves of both startups and developing nations' well-capitalized businesses

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There is a complementary matching between startup technology owners and capital-rich, technology-seeking developing nations' businesses…

Startups need …

- Funding to scale up
- Mass production to prove tech
- Local partners and knowledge
- IPR protection
- To reach IPO quickly

Developing nations' businesses have …

- Capital
- Manufacturing expertise and facilities
- Local know how to get things done in China

Startups have …

- Potential winning tech
- R&D and innovation capability
- Potential willingness to give up some portion of foreign markets

Developing nations' businesses need …

- Access to new technologies (not N-1 versions)
- Learn how to do R&D and continuously innovate

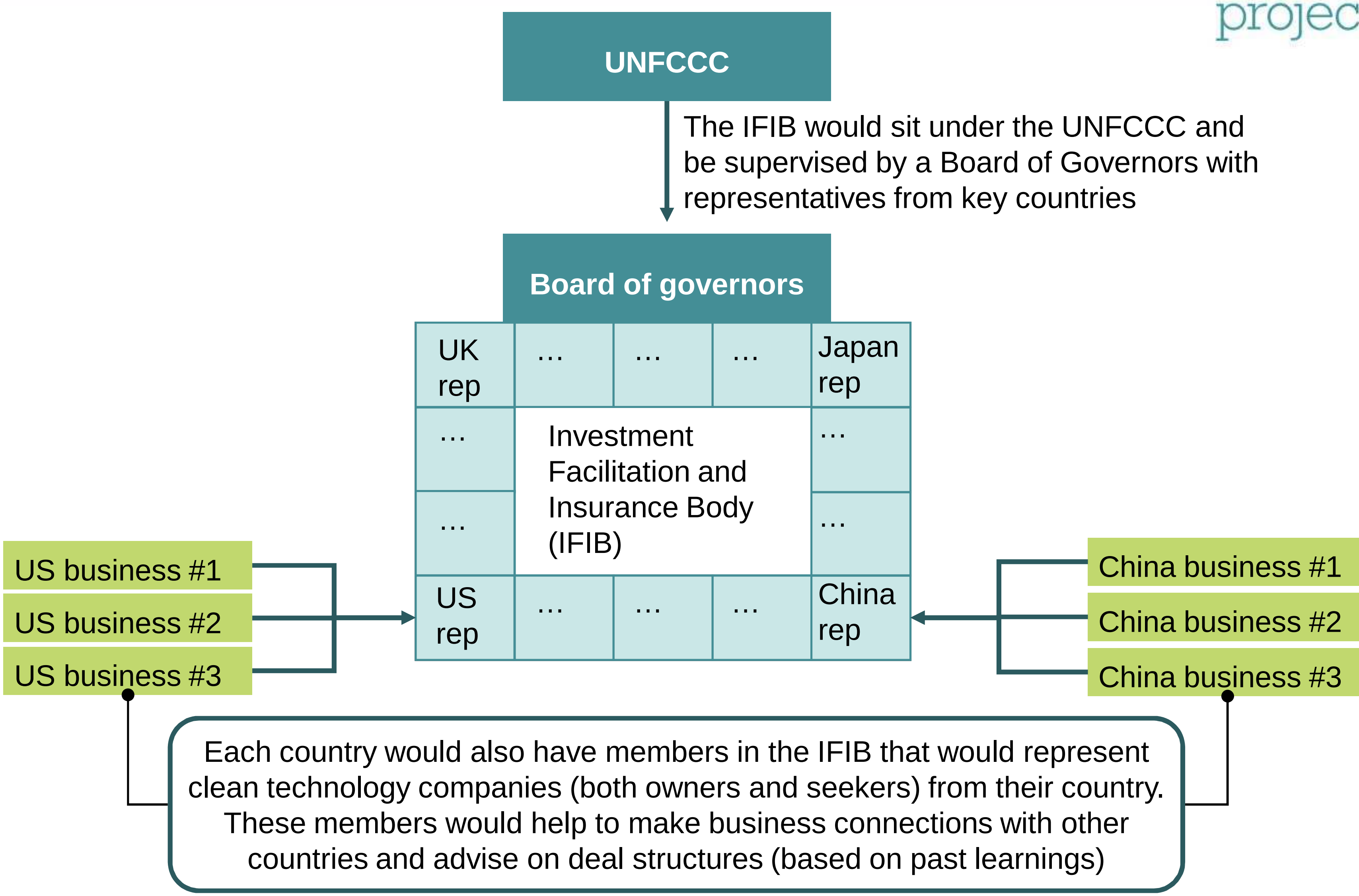
… however, 3 major concerns prevent startups from entering into more partnerships

1. How can I make sure I find the right partner?
2. How can I structure a deal that protects my interests?
3. How can I ensure my IP will be protected?

The Investment Facilitation and Insurance Body (IFIB) would create more partnerships by addressing these concerns

SOURCE: Interviews; team analysis

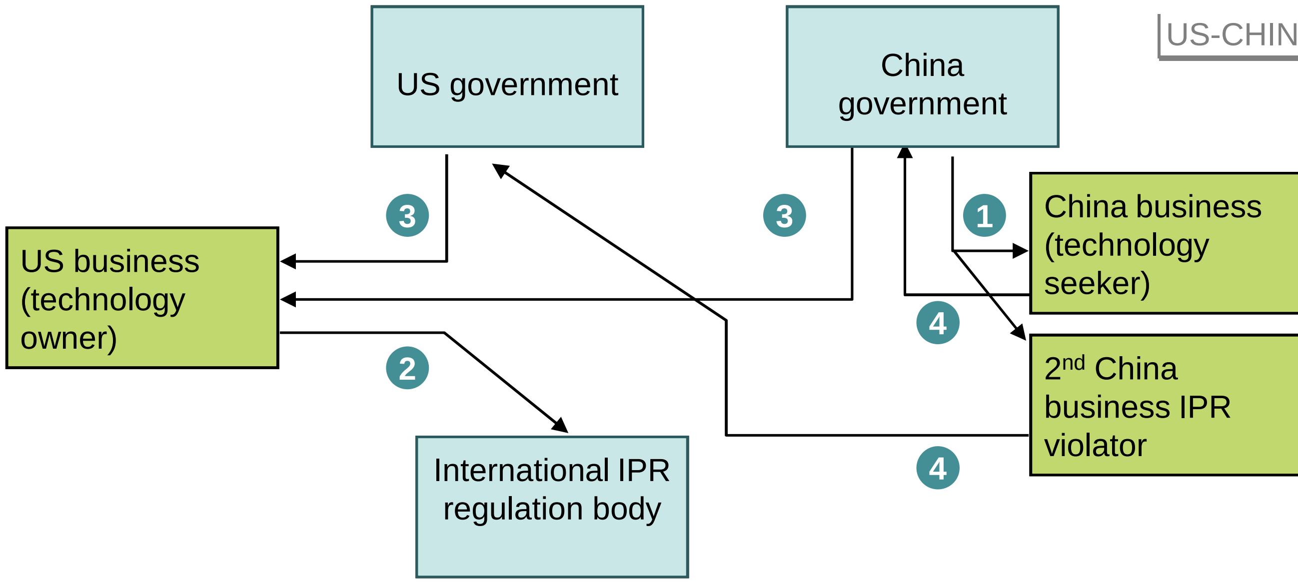
IFIB governance structure



SOURCE: Interviews; team analysis

Liabilities for IPR infringement would be insured bilaterally by the governments of the technology owner and seeker for any deals under the IFIB

US-CHINA EXAMPLE



Any deal reached under the IFIB would be provided with insurance against IPR infringement. The process would occur as follows

1. Ideally, China proactively protects against IPR infringement, responding quickly to any concerns from the US technology owner by shutting down the IP violators (could be original technology seeker or a different company)
2. If the technology owner still notices IPR infringement, it can seek arbitration from International IPR regulation body and receive quick repayment
3. US and China governments would collectively provide quick payment of the arbitration amount to the US technology owner
4. The IP violators would then be charged and forced to repay the amounts to the US and China governments

- **Liability amount would be assessed based upon reasonable royalty payments or lost profits and could receive a cap**
- **The cost of such a system would be budgeted at USD 100 MM/year worldwide**
- **The risk of incidence would be reduced given the government's involvement and the high-profile, international nature of the deals**
- **Insurance could be ended after some period of time (10 years)**

SOURCE: Expert interviews; team analysis