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World Bank Flagship Report

INDUSTRIAL DECARBONIZATION IN EAST ASIA

Download the full report and open-source computer model

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INDUSTRIAL DECARBONIZATION IN EAST ASIA

Key Findings

Why prioritize industrial decarbonization in East Asia?

How to decarbonize?
Four Technical Pillars

What are the costs?

Implementation barriers -
Four Enabling Foundations

Recommendations:
The Policy Package

Importance

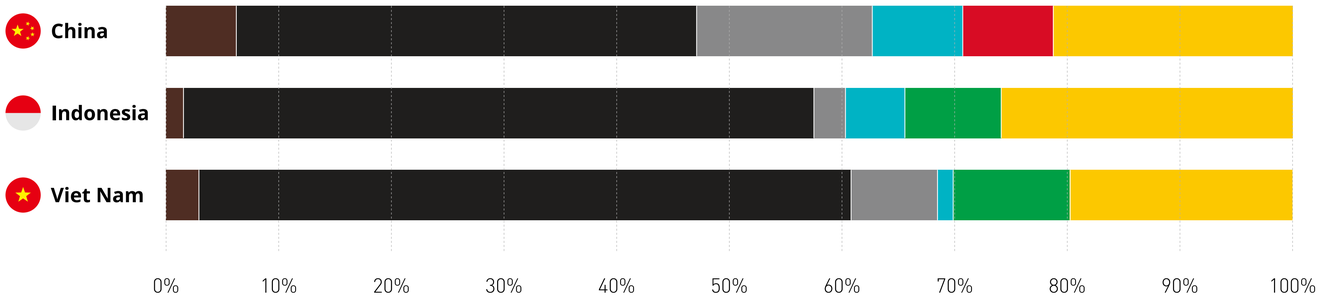
- **40 percent of the global industrial output is produced in East Asia**
- **Industry is the powerhouse for GDP (38%) and jobs (29%)**
- **Industry is the largest final energy user (including industrial electricity consumption):**
  - *47% in China*
  - *44% in Indonesia*
  - *51% in Viet Nam*
- **Most of the industrial energy use is fossil fuels like coal, coke, petroleum, and natural gas (65-71%)**

Industry's Contribution to GDP, Jobs, and Emissions

	Industry contribution to GDP (%)	Share of employment in industry (%)	CO_2 intensity of GDP (kg CO_{2e} per 2015 USD)	Industry share of CO_2 emissions* (%)
World average	26	24	0.4	30
EAP region	38	29	0.7	50
China	38	32	0.6	65
Indonesia	40	22	0.6	48
Viet Nam	37	31	1.0	57

** includes direct and indirect emissions*

Industrial Sector Energy Use by Fuel Type



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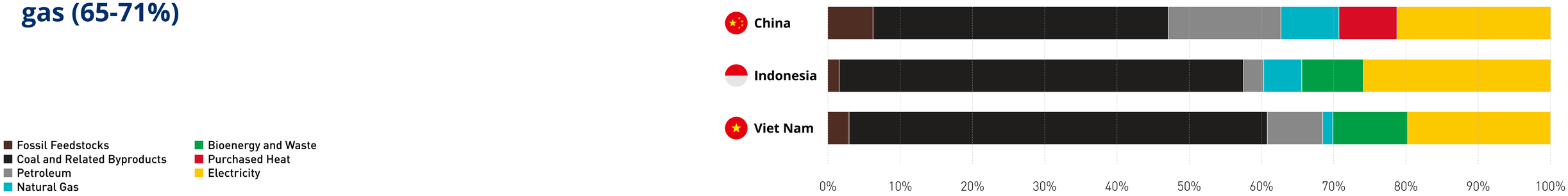

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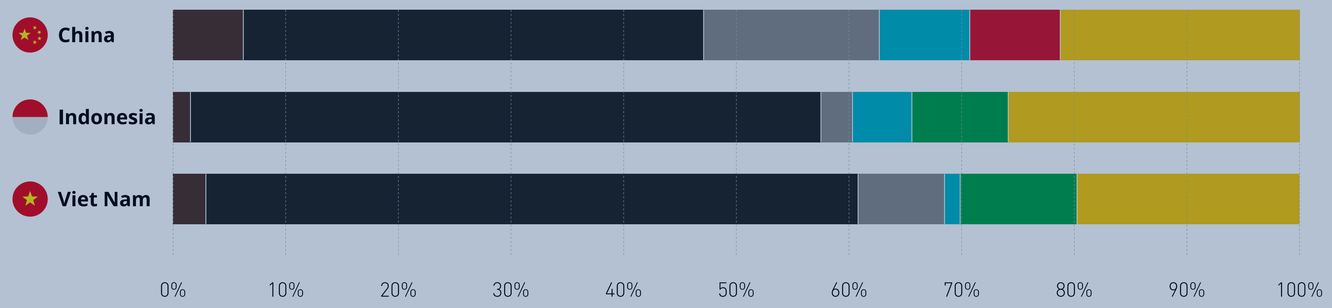

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INDUSTRIAL DECARBONIZATION IN EAST ASIA

Opportunities and Benefits

ACHIEVE TECHNOLOGICAL LEADERSHIP

IMPROVE ENERGY SECURITY

ADDRESS CLIMATE CHANGE

PROTECT PUBLIC HEALTH

CREATE HIGH-QUALITY JOBS

ENSURE LONG-TERM ECONOMIC SUCCESS*

* as carbon-based tariffs and green supply chains emerge

Methodology

» **We developed an open-source, data-driven model to chart actionable pathways for cleaning up industry. The model organizes technology interventions into six tiers based on costs and adoption-readiness.**

Tier 1 Efficiency

Energy efficiency, material efficiency, and product longevity

Tier 2a Easy Electrification

Electrification of low-temp heat, non-thermal processes, and secondary steelmaking

Tier 2b Other Electrification

Electrification of medium- and high-temp heat

Tier 3 Carbon Capture, Utilization, and Storage (CCUS)

In non-metallic minerals, iron & steel, & non-ferrous metals

Tier 4a Green Hydrogen Combustion

In chemicals, refining, iron & steel, and non-metallic minerals

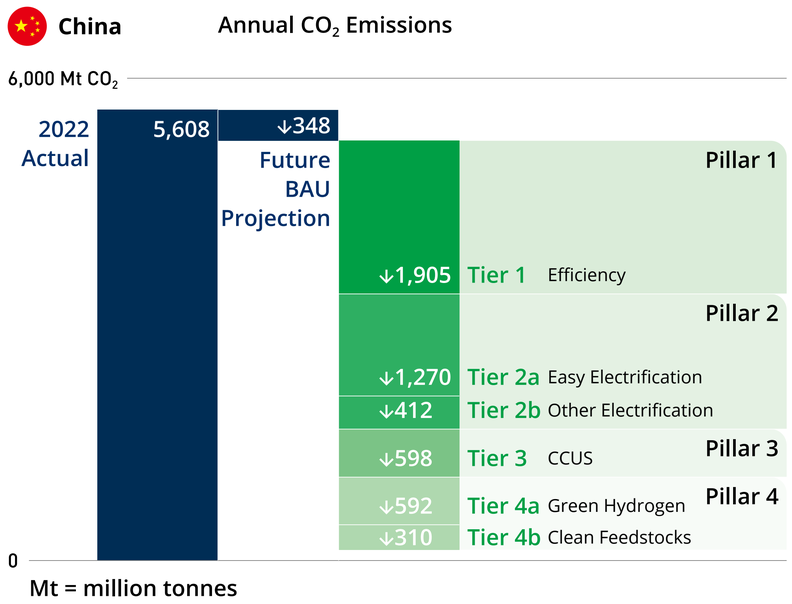
Tier 4b Clean Chemical Feedstocks

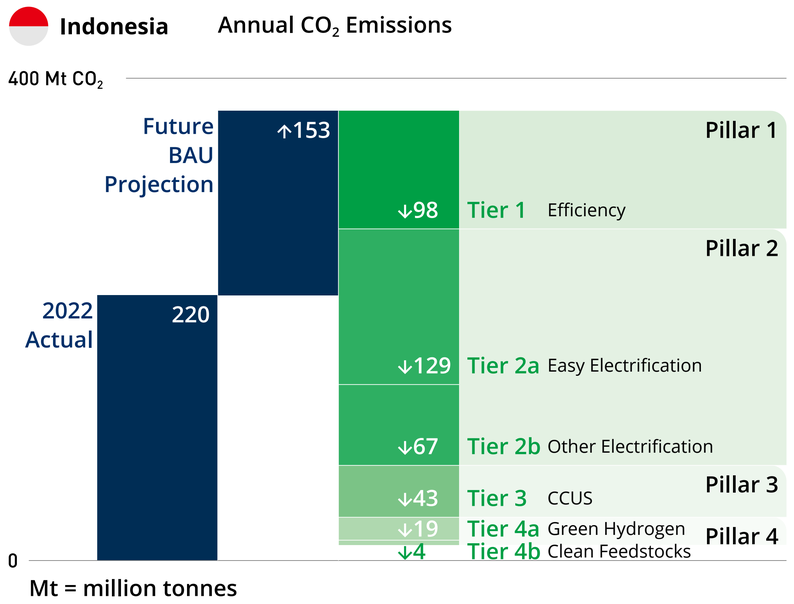
Green hydrogen, blue hydrogen, and bioenergy feedstocks

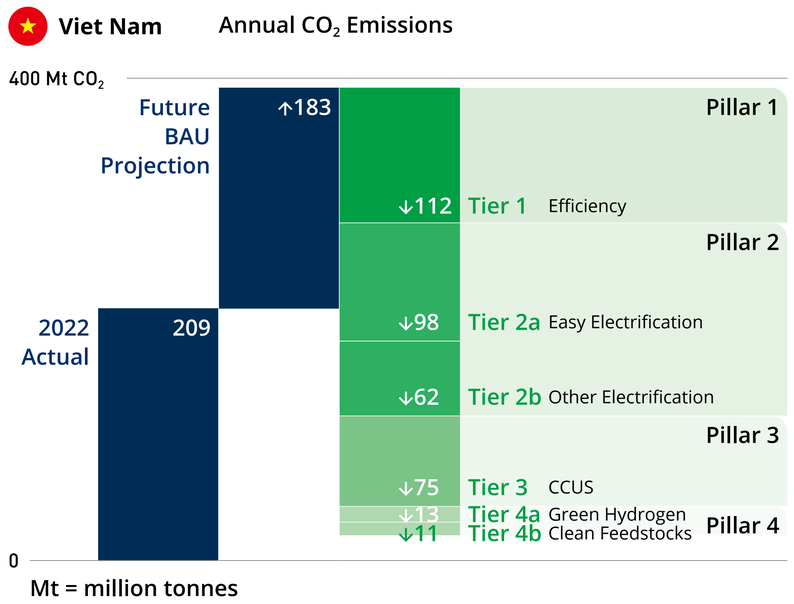
Abatement Potential

» **Today's technologies can cumulatively eliminate 98-99% of industrial emissions by mid-century**

» **Efficiency and Electrification Pillars have the greatest CO_2 abatement potential**







Industrial Sector Total
Abatement Potential

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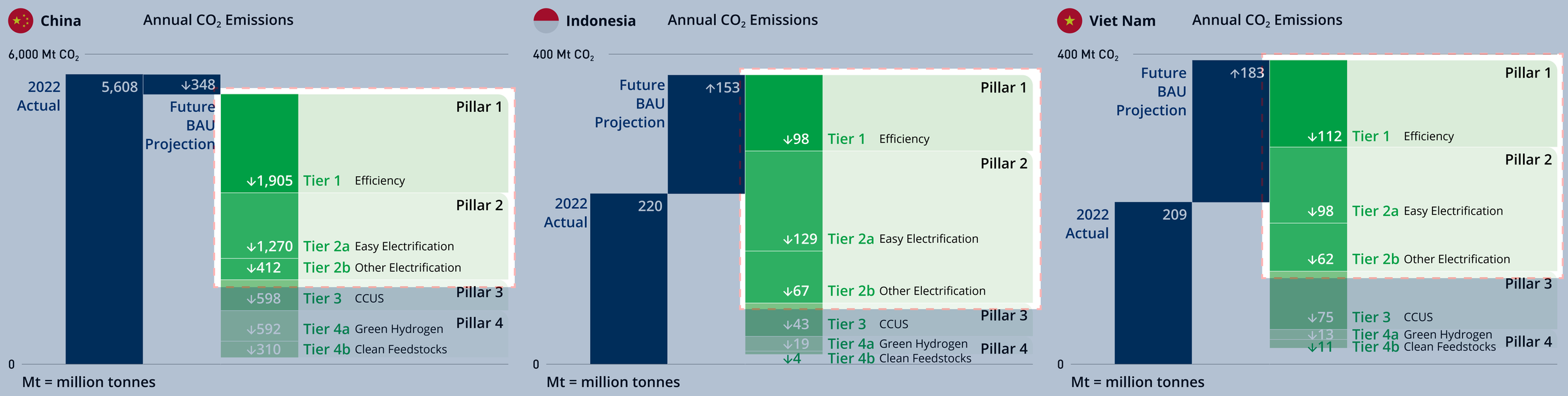
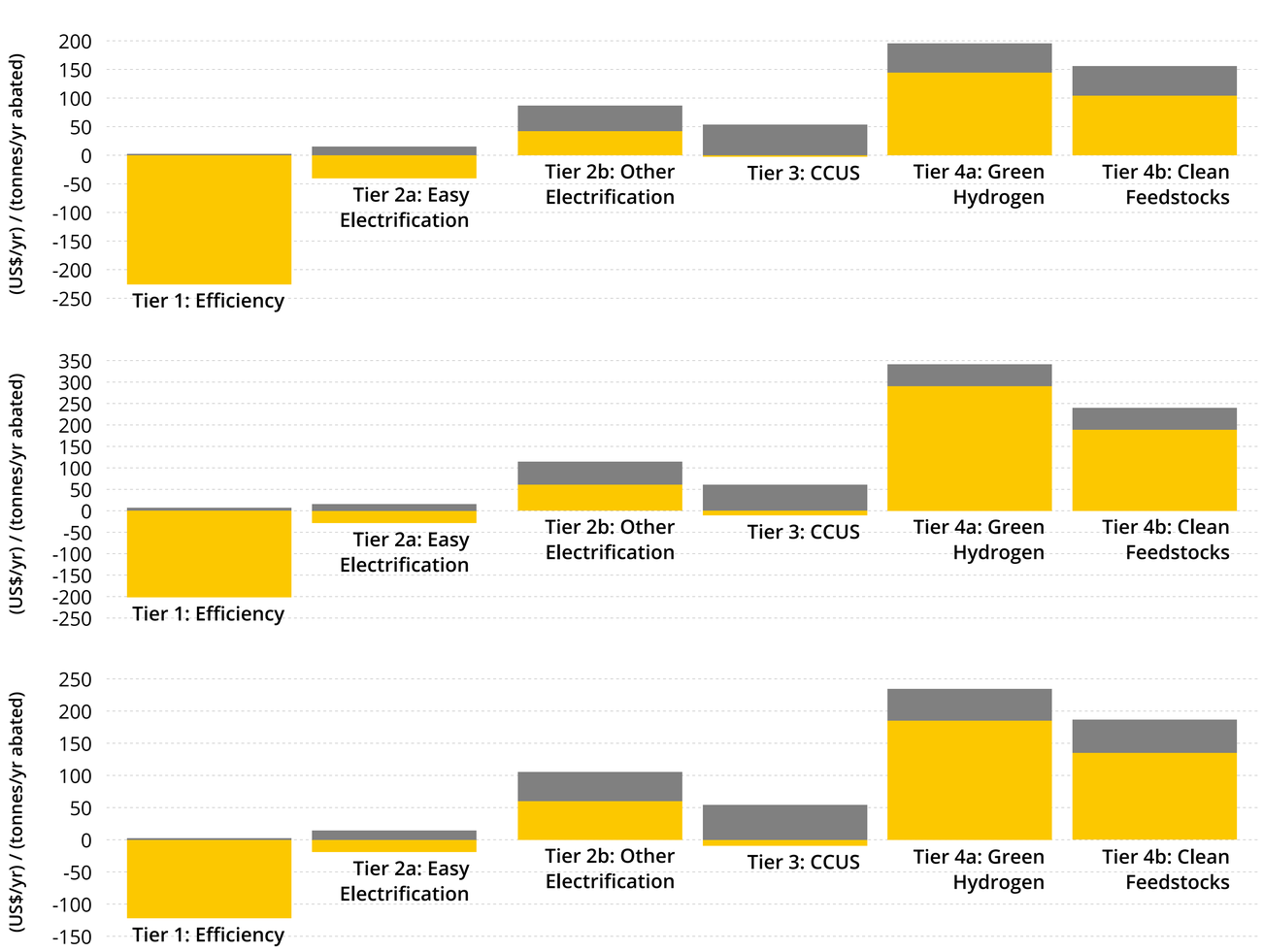


Abatement Cost

- **Efficiency and "Easy" Electrification offer significant overall cost savings**
- **Other Electrification and CCUS moderately increase costs**
- **Green Hydrogen and Clean Feedstocks significantly increase costs (mainly energy costs)**
- **Carbon pricing of $50/tCO$_2$ by 2050 was incorporated**

Energy costs and annualized capital investment needs per unit of annual abatement



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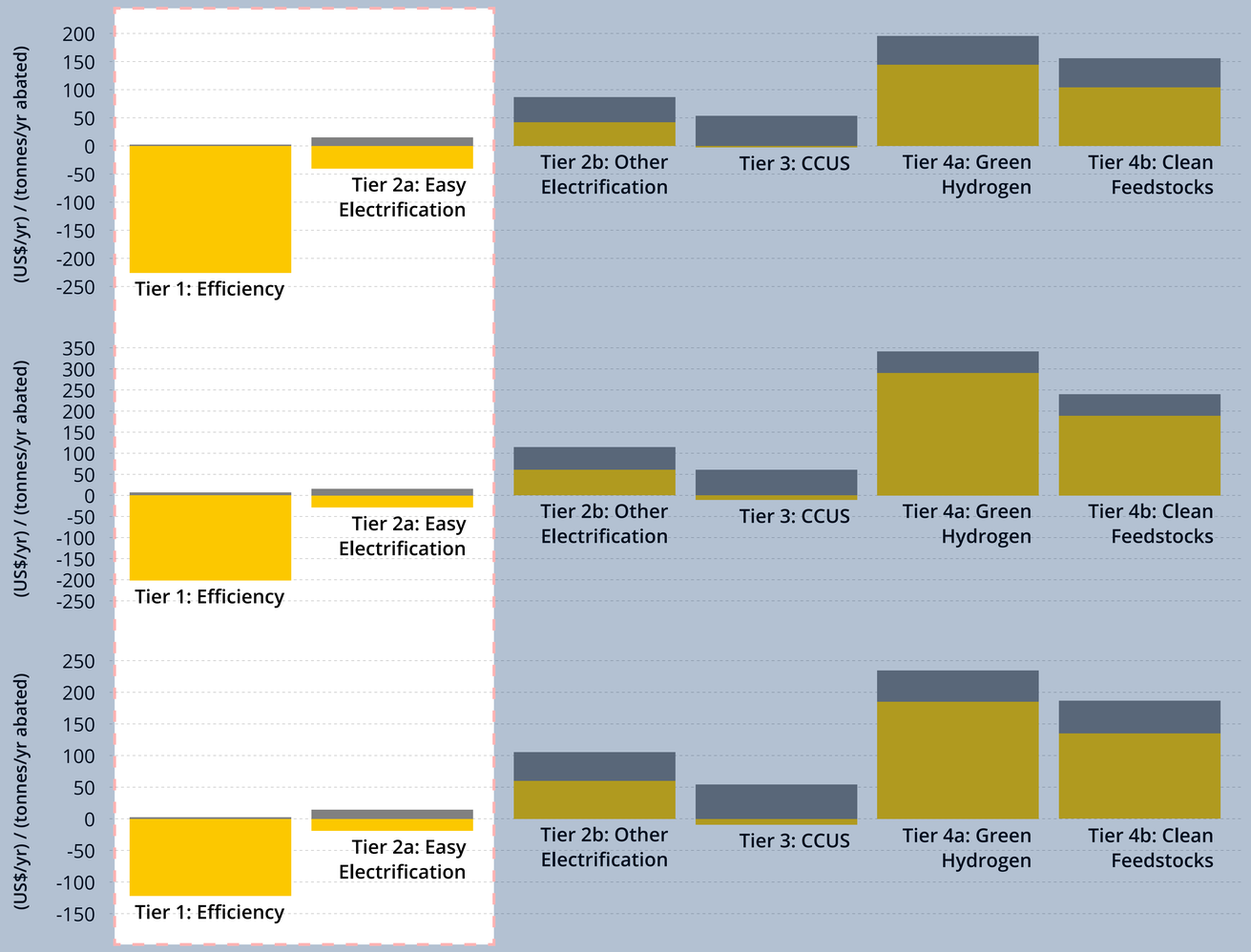

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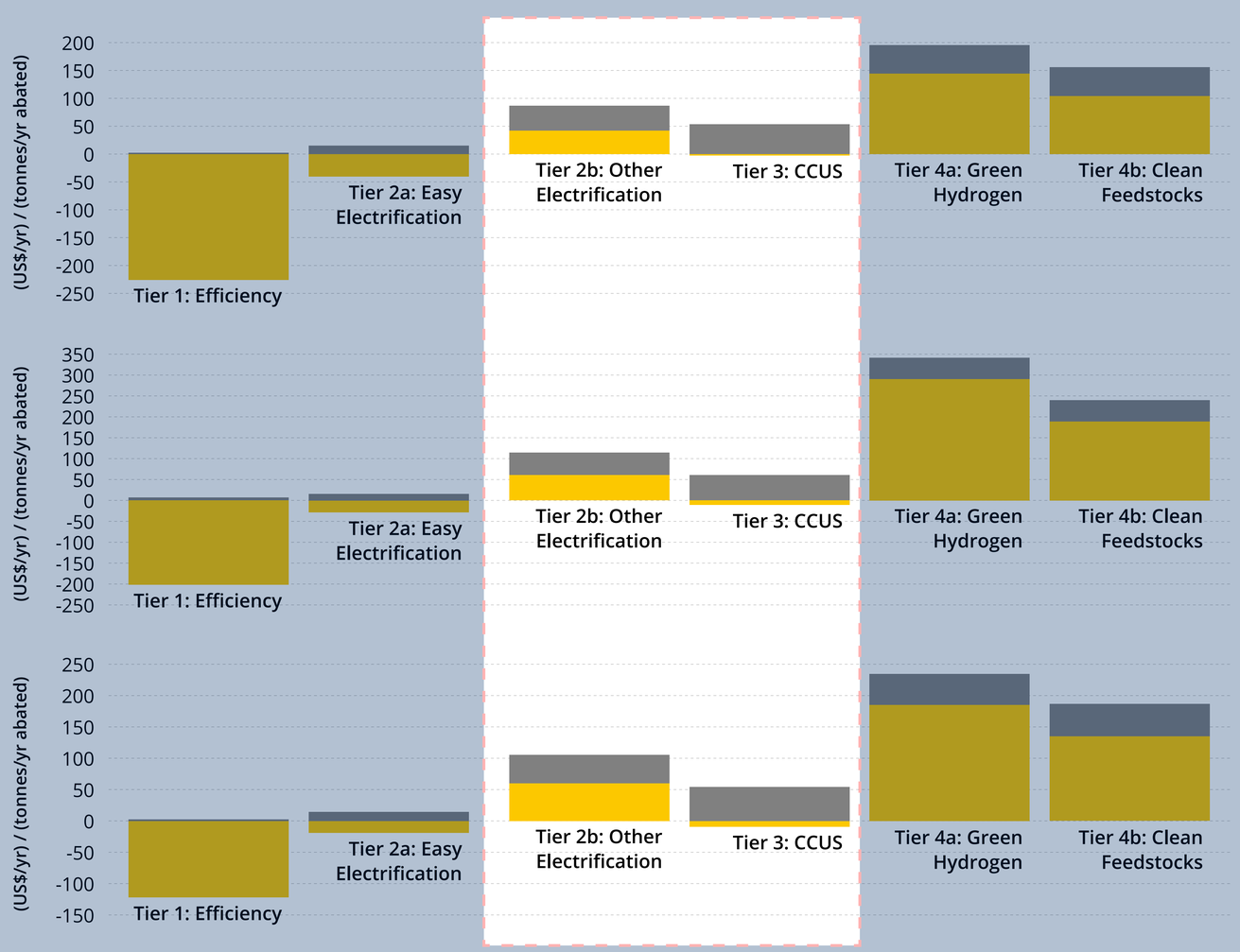

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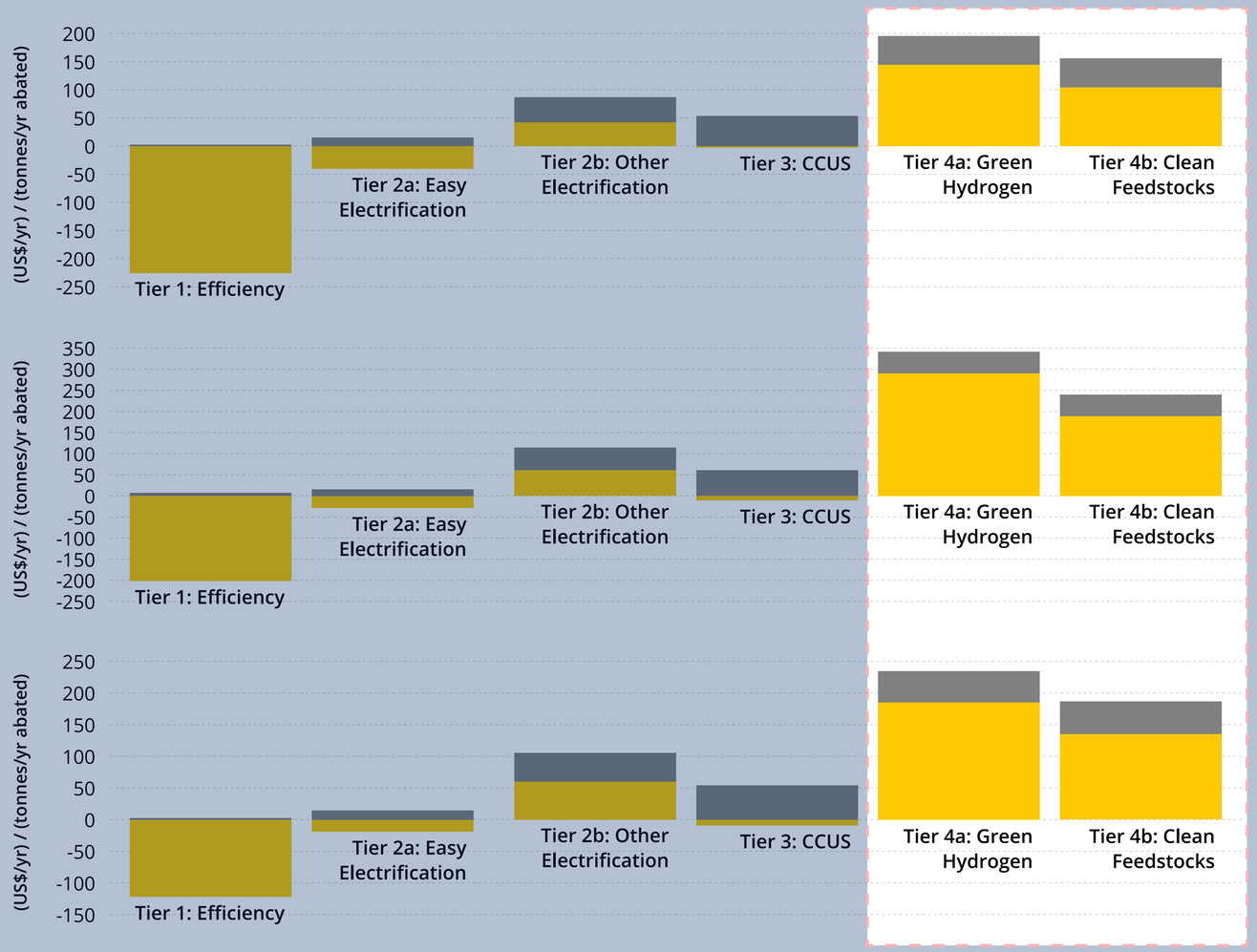
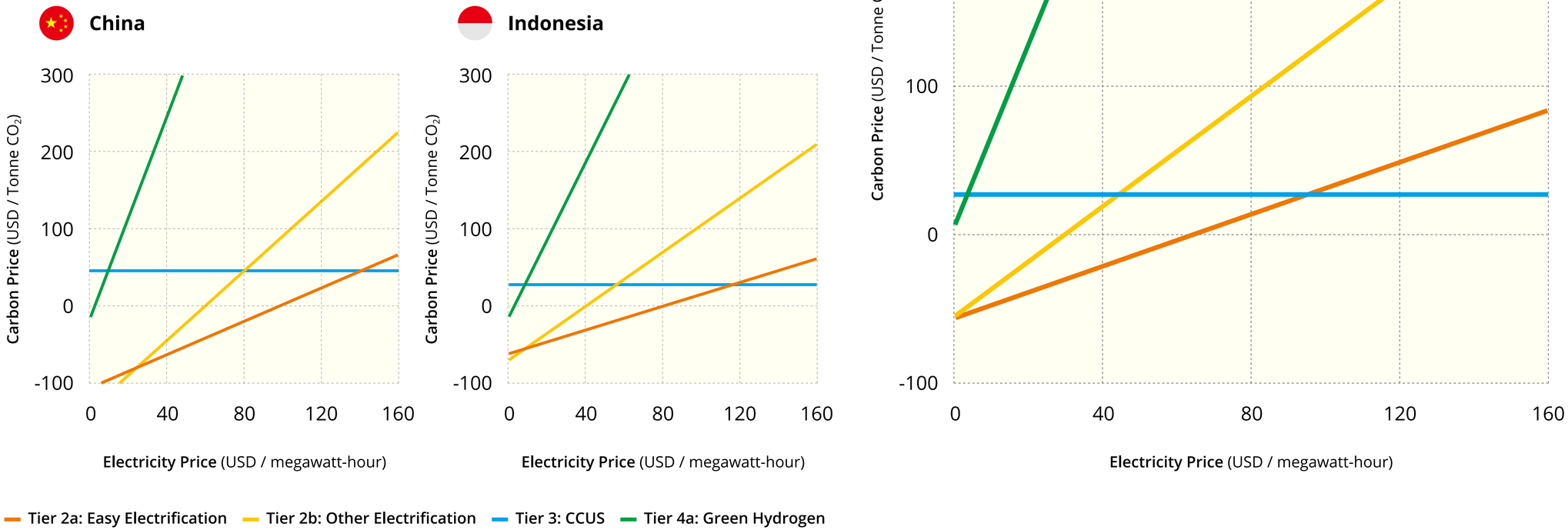


Carbon Price & Electricity Price Trade-offs

» **Low operating costs (i.e. cheaper electricity) and higher revenues (i.e. carbon pricing) can make clean industrial projects bankable**

» **Yet the cost gap is significant especially for innovative technologies**



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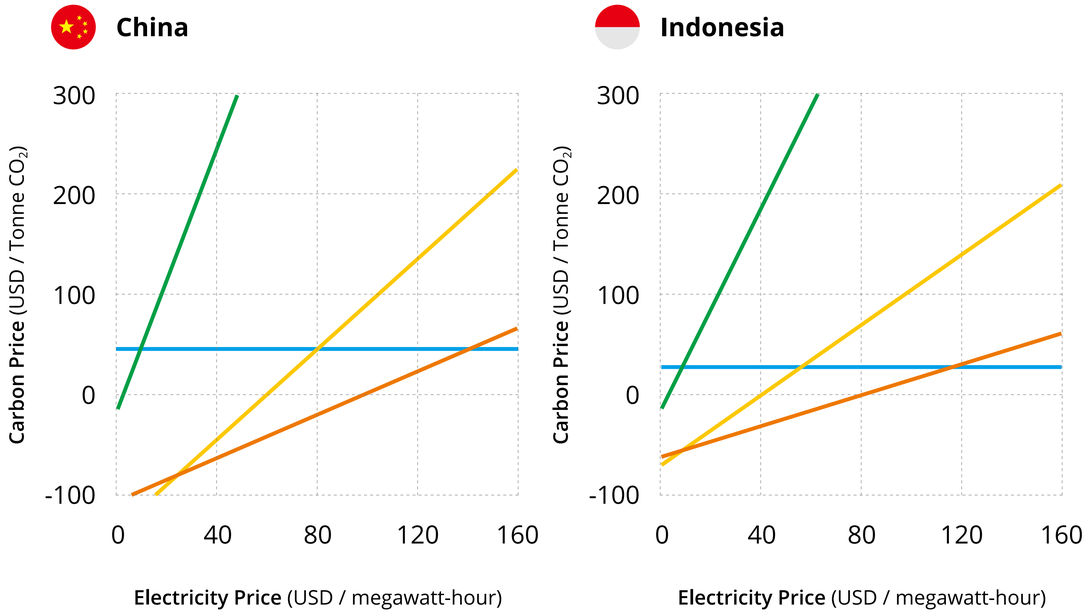

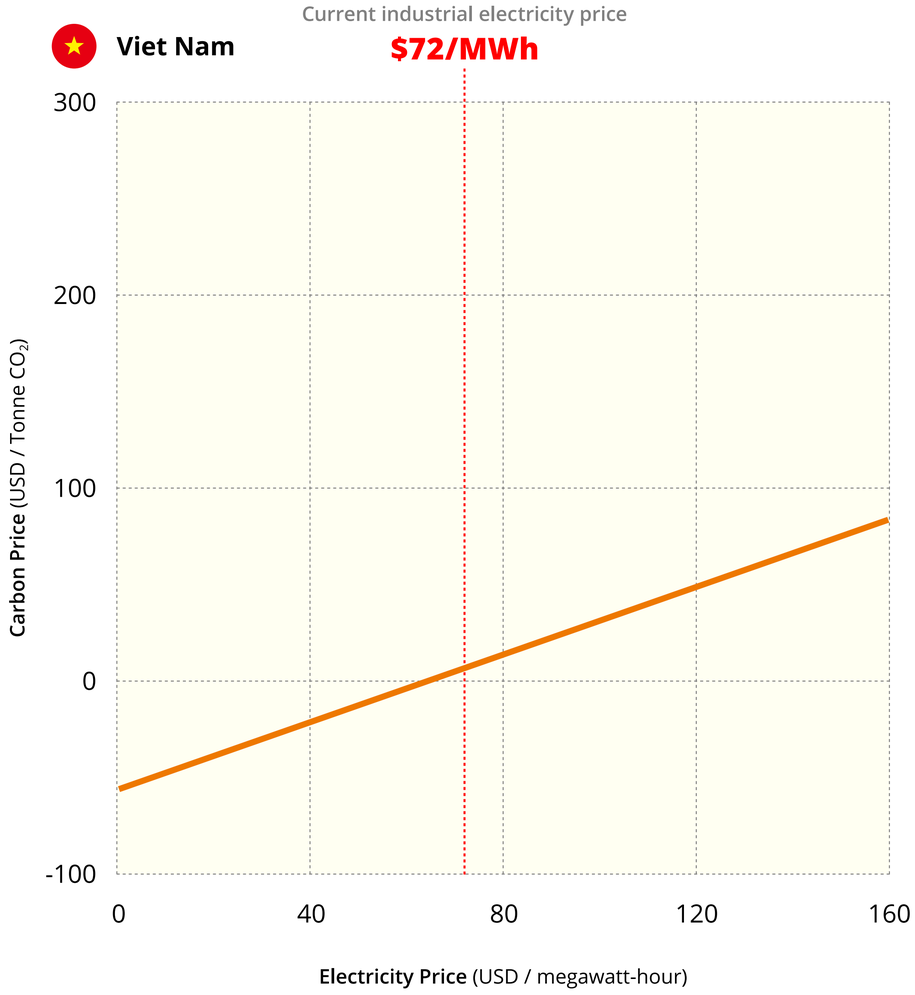

Easy electrification is already cost-competitive at current electricity prices of **$72/MWh** for industrial buyers, even with minimal carbon pricing

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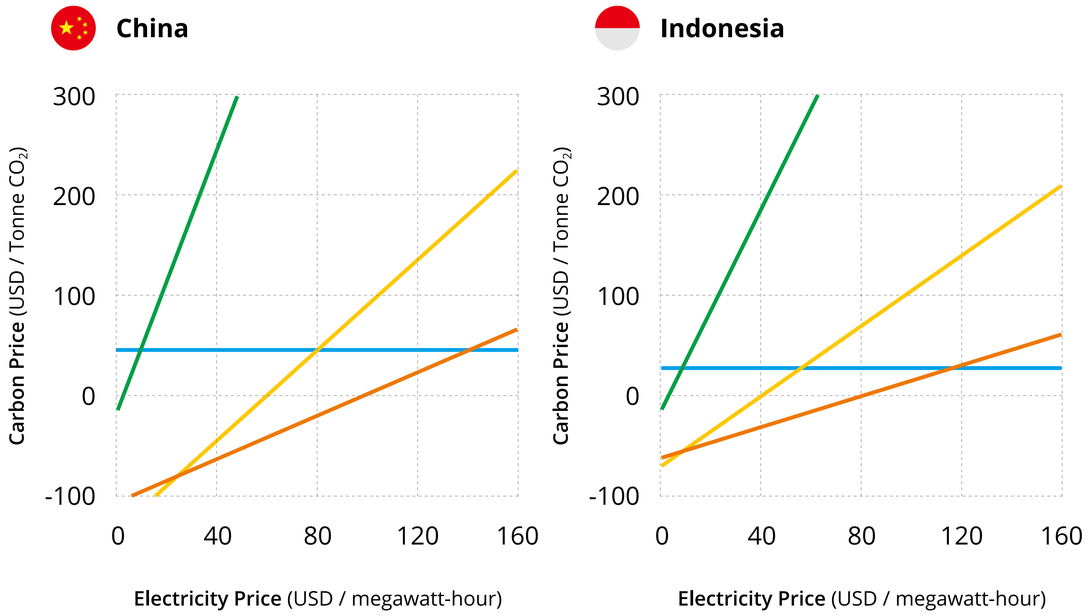

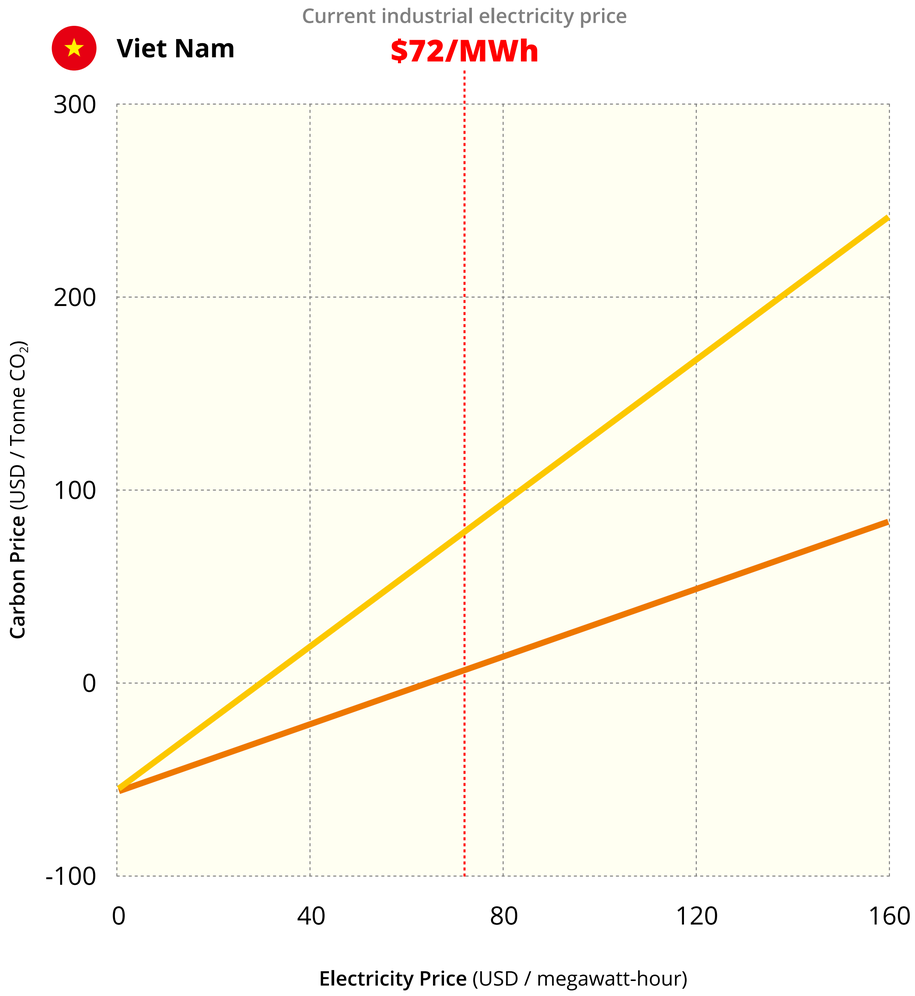

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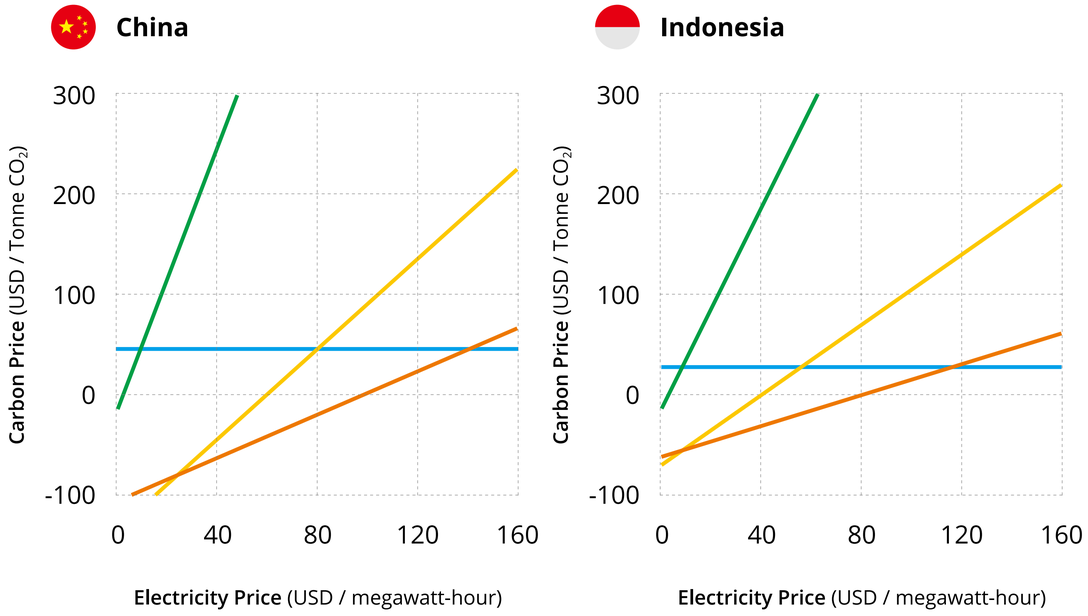

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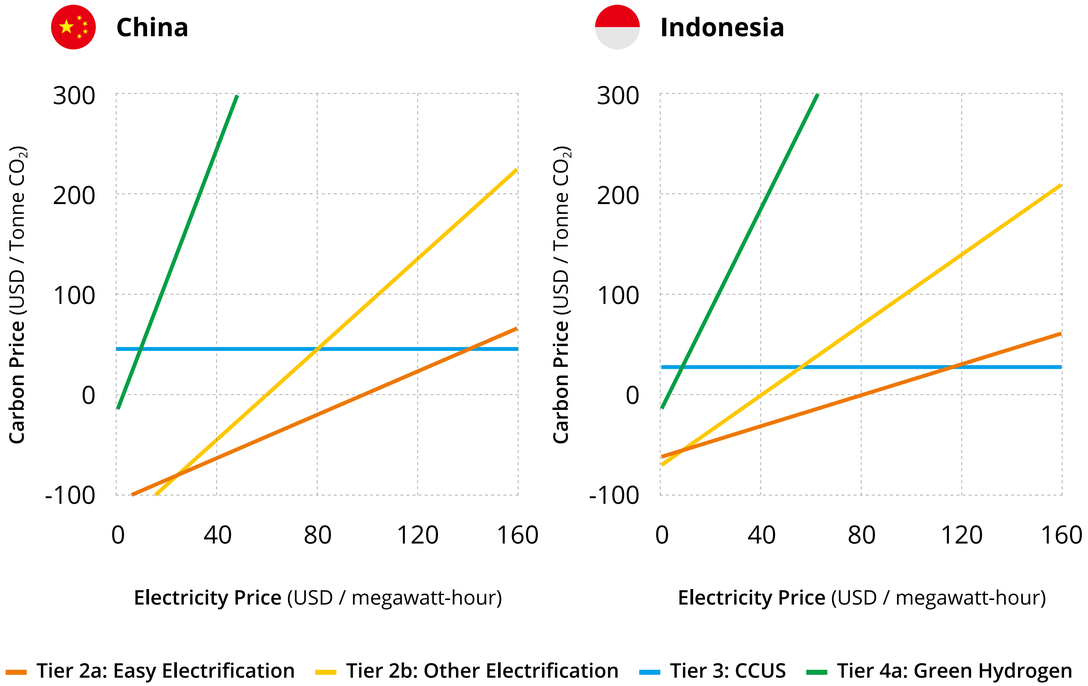

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CCUS can achieve breakeven at a carbon price of around **$25 per tonne of CO_2**

GH would require electricity prices of around **$40/MWh** and carbon prices of **$250 per tonne of CO_2** to break even.

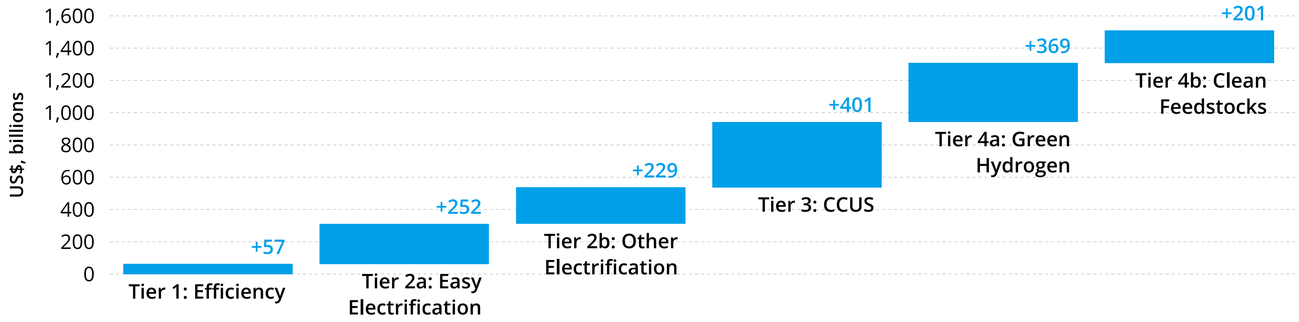
The Financing Gap

- **Total capital costs of industrial decarbonization (now-2050)**
  - *$1.5T in China ($60 billion per year)*
  - *$122B in Indonesia ($5 billion per year)*
  - *$120B in Viet Nam ($5 billion per year)*
- **Capital costs are concentrated in heavy industries**
  - *Most of these costs are for CCUS, green H_2 and clean feedstocks*
- **Only 1.4% of international climate finance went to industry in 2022 ($52 billion)**
- **Capital cost estimations include facility-level equipment and hydrogen electrolyzers, not grid infrastructure upgrades**

Capital investment needed in China, Indonesia, and Viet Nam to reach net-zero

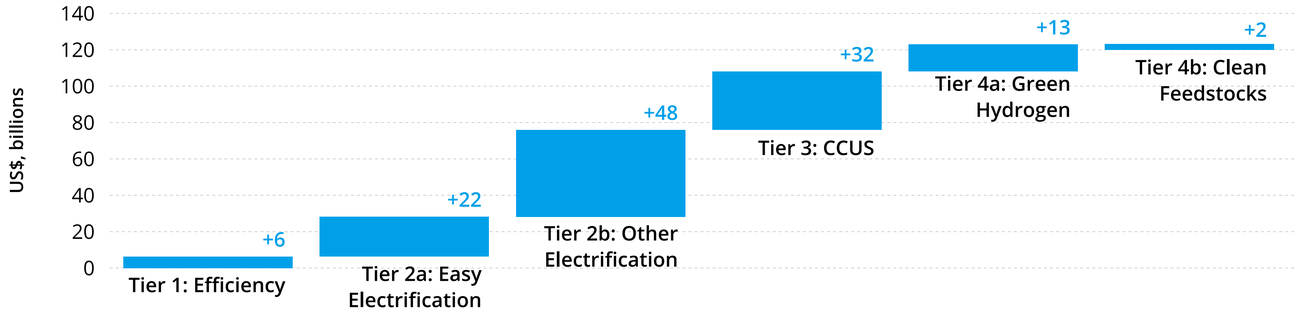
China

Total capital investment required is US$ 1.5 trillion



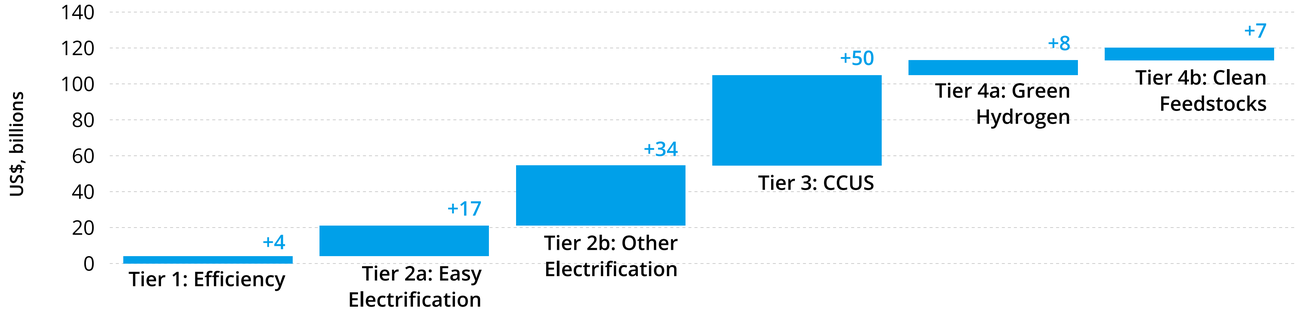
Indonesia

Total capital investment required is US$ 122 billion



Viet Nam

Total capital investment required is US$ 120 billion



The Energy Gap

» **Clean industry relies on electricity for direct electrification and green hydrogen production**

» **Compared to 2022 levels, decarbonizing industry will increase industrial electricity demand by:**

- *93% in China*
- *165% in Indonesia*
- *380% in Viet Nam*

» **In 2050, electricity for green hydrogen production represents:**

- *41% of industrial electricity demand in China*
- *13% in Indonesia*
- *15% in Viet Nam*

Industrial sector electricity demand in China, Indonesia, and Viet Nam

Direct Use of Electricity by Industry
Electricity for Green Hydrogen for Industry
Electricity for Rest of Economy (BAU Projection)

Power sector must decarbonize in parallel

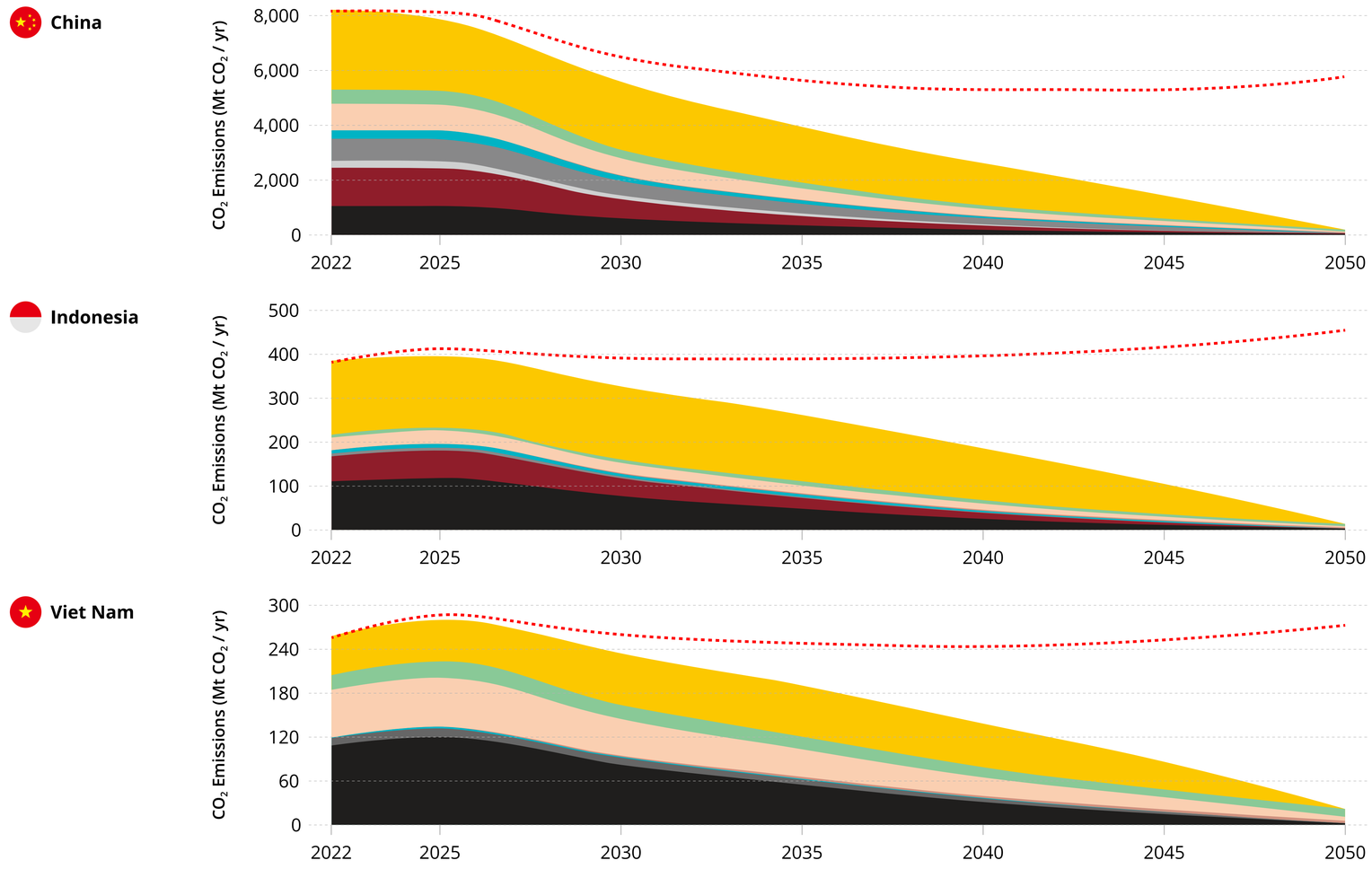
» **If the power sector decarbonizes by 2050:**

- *Industry can reach net-zero in all three countries by 2050*
- *Each year between 2025 and 2050, emissions decrease by an average of 15% in China, 2.8% in Indonesia, and 3% in Viet Nam*

» **If power sector decarbonization is off-track:**

- *By 2050, direct and indirect emissions from industry will only be 32% less than 2022 levels in China, and they will increase by 18% in Indonesia and 5% in Viet Nam*

CO_2 emissions from the industrial sector and from electricity purchased by industry



Barriers to Decarbonizing Industry in East Asia

Energy

- **High Cost:** Electricity prices > fossil fuel prices, due in part to cross-subsidy and fossil fuel subsidies
- **Insufficient Supply:** lack of clean energy, especially in industry-heavy regions

Finance

- **Inadequate volume:** Only 1.4% of international climate finance went to industry in 2022 ($52 billion)
- **Not fit-for-purpose:** Higher risks, longer paybacks, and complex processes

Technology

- **Commercial viability:** Nascent technologies, low market awareness
- **Local availability:** Lack of reliable information about technology performance, costs and ecosystem

Jobs

- **Limited workforce:** STEM-trained workers are essential for decarbonization
- **Skill mismatch:** Students are typically trained in conventional energy and industrial systems

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Four Enabling Foundation

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Enabling the Energy Foundation: Abundant, Cost-Competitive Clean Power

Reliable, affordable clean electricity is critical for making electrification of medium- and high-temperature heat, green hydrogen combustion, and clean feedstocks cost-competitive.

1 Co-optimize the industry and power sectors

Goal **Meet rising industrial electricity demand**

- Coordinated planning of electricity supply, industrial load, and H_2 production
- Targeted grid expansion (via RE mandates, procurement, incentives, etc.)
- Support grid-enhancing technologies to optimize existing infrastructure

2 Support industrial demand-side resources

Goal **Reduce grid burdens and industrial energy costs**

- Fund advanced digital tools like sensors and controls for real-time grid management
- Offer dynamic electricity pricing like time-of-use or real-time pricing

3 Industrial RE procurement & Open access policy

Goal **Expand industry's access to competitive clean energy**

- Pursue open-access policies that allow corporate RE procurement and onsite RE
- Improve China's Green Electricity Certificate (GEC) scheme to include off-grid RE, integrate with carbon markets, and ensure price transparency

Enabling the Finance Foundation: Adequate and Fit-for-Purpose

Innovative financial models can accelerate needed investment in clean industrial projects, tailoring support to industry's unique challenges - complex processes, high upfront costs + long paybacks, low technological maturity, and reliance on enabling infrastructure.

4 Cluster-based approach finance & PPP

Goal **Reduce cost of energy, materials, and infrastructure while spreading investment risk**

- Create regulatory frameworks that facilitate joint infrastructure investment
- Provide long-term offtake agreements for anchor projects
- Offer blended finance tools like concessional loans

5 Carbon pricing and carbon finance

Goal **Level the playing field of clean power and fossil fuels**

- Use explicit tools (e.g., carbon taxes, ETS) and implicit tools (e.g., removal of fossil fuel subsidies)
- Pair carbon price with carbon-based tariffs to protect industry
- Establish internationally aligned MRV frameworks

6 De-risking instruments

Goal **Unlock financing for SMEs and in credit-constrained regions**

- Offer investment guarantees, pooled investment vehicles, subsidized interest rates, etc.
- Boost demand for clean industrial products with public procurement and government-led emissions accounting systems

Enabling the Technology Foundation: Commercially viable and locally available

Many industrial decarbonization technologies are in pre-commercial and early commercial stages, creating performance and safety risks that hinder investment.

7 Clean industrial technology standards

Goal **Scale mature techs and reduce investment risk of early-stage techs**

- Energy efficiency and emissions standards for more mature technologies
- Standardized use protocols for earlier-stage technologies
- Robust MRV frameworks for effective implementation of standards

8 Strategic pilot projects

Goal **Reduce technology risk through real-world validation and learning**

- Offer grants and loans to large-scale demonstrations of newer technologies
- Pilot innovative business models, like heat as a service (for heat pumps) and partial-chain ownership models (for CCUS)

9 Targeted technical assistance

Goal **Fill research gaps and foster knowledge transfer**

- Offer training & certification programs for policy implementation
- Fund research, development, and demonstration of newer technologies

Enabling the Jobs Foundation: A Robust Workforce Trained in Clean Industrial Production

A successful industrial transition requires more workers trained in the science, technology, engineering, and math skills necessary to install and operate clean industrial technologies.

10 Enhanced vocational training

Goal **Expand vocational programs to include clean industrial competencies**

- Train workers in energy management, carbon accounting, etc.
- Create national certification frameworks to standardize vocational credentials
- Foster industry–academia training partnerships

11 Digital and interdisciplinary skills

Goal **Help workers navigate energy systems, energy/carbon markets, and supply chains**

- Embed data science, systems thinking, and sustainability in training
- Integrate digital and interdisciplinary skills into national skills frameworks
- Promote continuous learning ecosystems

12 Workforce transition program

Goal **Reduce social inequities and grow the clean industrial workforce**

- Support mid-career training and mobile learning platforms in key regions, tailored to displaced workers
- Offer retraining subsidies linked to clean industrial investments

Recap: Key Findings

» Good news: Industrial Decarbonization is technically achievable, and some technologies are already cost-effective!

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» However, decarbonizing heavy industries are still very costly:

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- Good news: Industrial Decarbonization is technically achievable, and some technologies are already cost-effective!
- However, decarbonizing heavy industries are still very costly:
  - *Lower electricity prices and higher carbon prices can help to bridge the breakeven gap*
  - *Commercialization of new technologies can help to narrow the capital investment gap*

Recap: Key Findings

- Good news: Industrial Decarbonization is technically achievable, and some technologies are already cost-effective!
- However, decarbonizing heavy industries are still very costly:
  - *Lower electricity prices and higher carbon prices can help to bridge the breakeven gap*
  - *Commercialization of new technologies can help to narrow the capital investment gap*
- **A comprehensive policy package** is essential to strengthen the energy, finance, technology, and Jobs foundations needed to realize the region's net-zero industry ambition.

The Policy Package

THE WORLD BANK PLAYBOOK FOR REGIONAL AND COUNTRY ACTIONS

- *Concessional Finance*
- *Technical Assistance*
- *Policy Support*

Energy

Sufficient and Cost-competitive Clean Power

Recommendation	Technical Pillar	Prioritization
1 Industry-Power Co-optimization	Energy & Material Efficiency	1 2 3
2 Industrial Demand-Side Resources	Electrification with Renewable Energy	1 2 3
3 Direct RE Procurement, Open Access	Carbon Capture Utilization & Storage	1 2 3
	Green Hydrogen & Clean Feedstocks	1 2 3

Finance

Adequate and Fit-for-purpose

Recommendation	Technical Pillar	Prioritization
4 Cluster-Based Approach via Concessional Finance & PPP	Energy & Material Efficiency	4 5 6
5 Carbon Pricing & Carbon Finance	Electrification with Renewable Energy	4 5 6
6 Derisking Instruments	Carbon Capture Utilization & Storage	4 5 6
	Green Hydrogen & Clean Feedstocks	4 5 6

Technology

Commercially Viable and Locally Available

Recommendation	Technical Pillar	Prioritization
7 Industrial Standards & MRV	Energy & Material Efficiency	7 8 9
8 Pilot Emerging Technologies & Business Models	Electrification with Renewable Energy	7 8 9
9 Technical Assistance	Carbon Capture Utilization & Storage	7 8 9
	Green Hydrogen & Clean Feedstocks	7 8 9

Jobs

Skilled and Robust Workforce

Recommendation	Technical Pillar	Prioritization
10 Vocational Training	Energy & Material Efficiency	10 11 12
11 Digital & Interdisciplinary Competence	Electrification with Renewable Energy	10 11 12
12 Workforce Transition Program	Carbon Capture Utilization & Storage	10 11 12
	Green Hydrogen & Clean Feedstocks	10 11 12

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Let today's actions create tomorrow's abundance

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