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*Part of the World Bank Flagship*
***Green Horizon: East Asia's Sustainable Future***

# INDUSTRIAL DECARBONIZATION IN EAST ASIA

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The World Bank

# 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

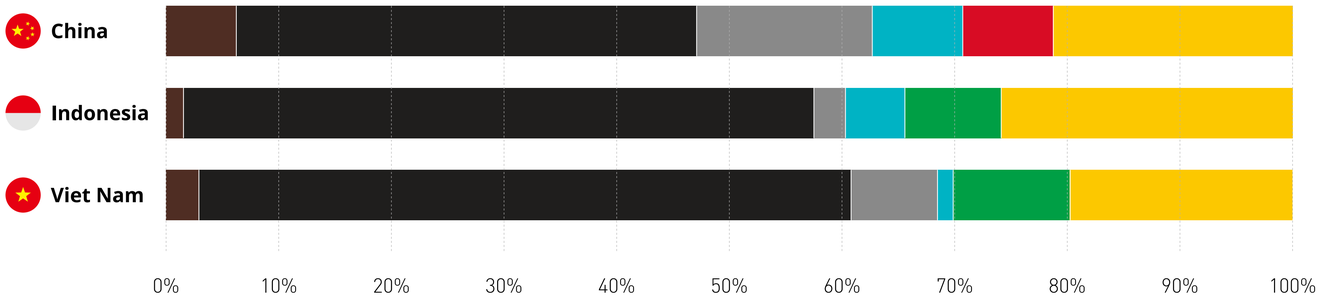
- **40 percent of the global industrial output is produced in East Asia**
- **Industry is the powerhouse for GDP (38%) and jobs (29%)**
- **Industry is the largest final energy user (including industrial electricity consumption):**
  - *47% in China*
  - *44% in Indonesia*
  - *51% in Viet Nam*
- **Most of the industrial energy use is fossil fuels (48-65%) like coal, coke, petroleum, and natural gas**

## 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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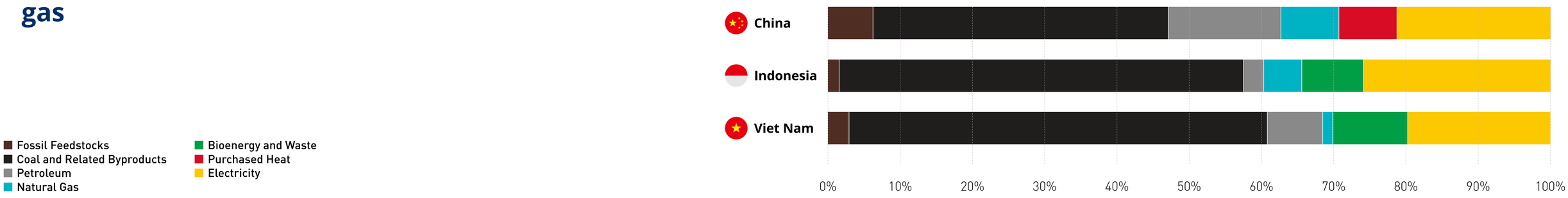

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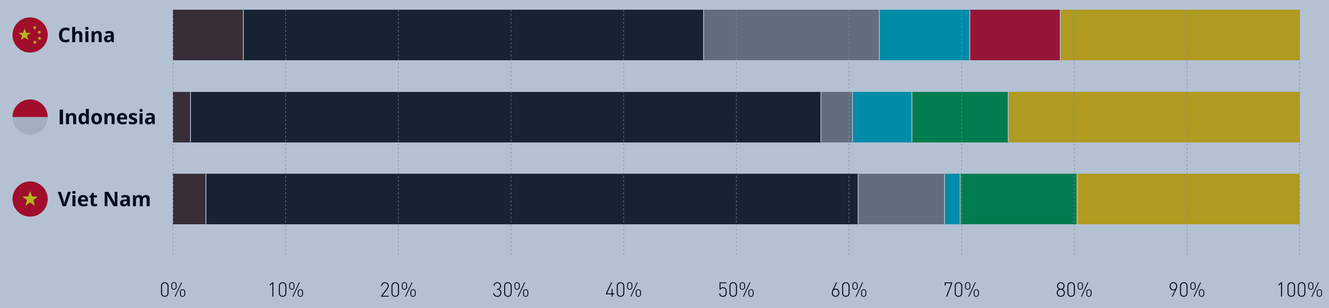

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INDUSTRIAL DECARBONIZATION IN EAST ASIA

# Opportunities and Benefits

ACHIEVE TECHNOLOGICAL LEADERSHIP

IMPROVE ENERGY SECURITY

ADDRESS CLIMATE CHANGE

PROTECT PUBLIC HEALTH


CREATE HIGH-QUALITY JOBS

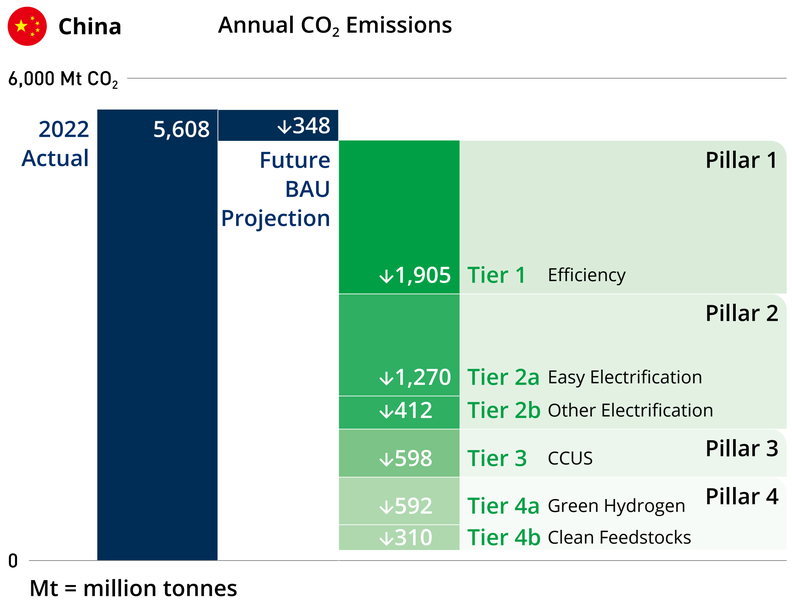
ENSURE LONG-TERM ECONOMIC SUCCESS*

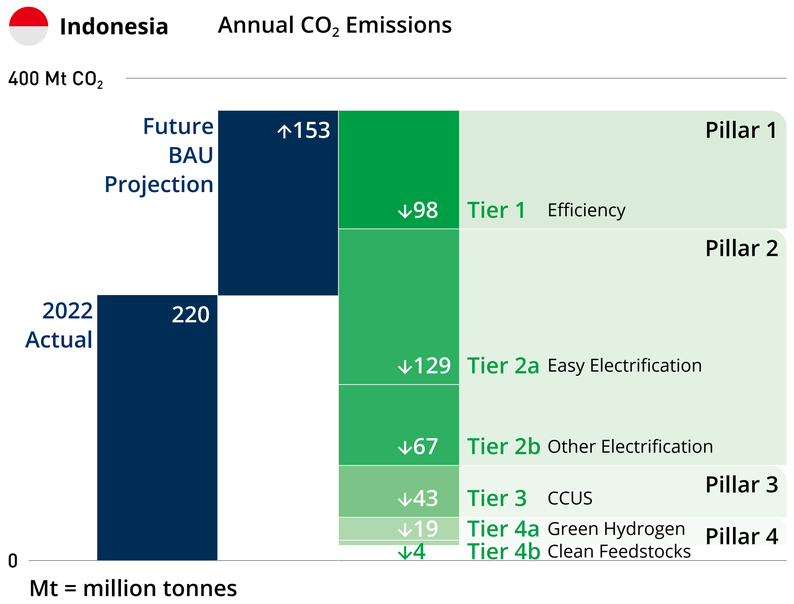
* as carbon-based tariffs and green supply chains emerge

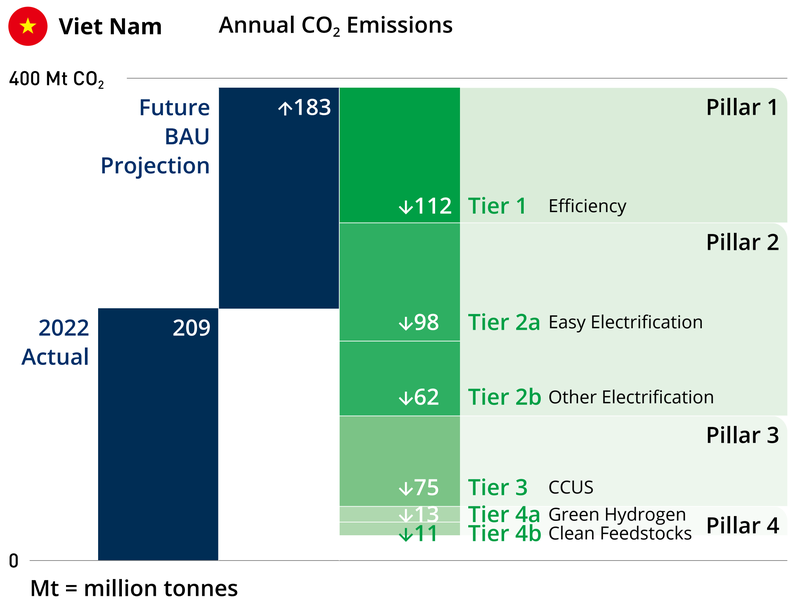
# Abatement Potential

» **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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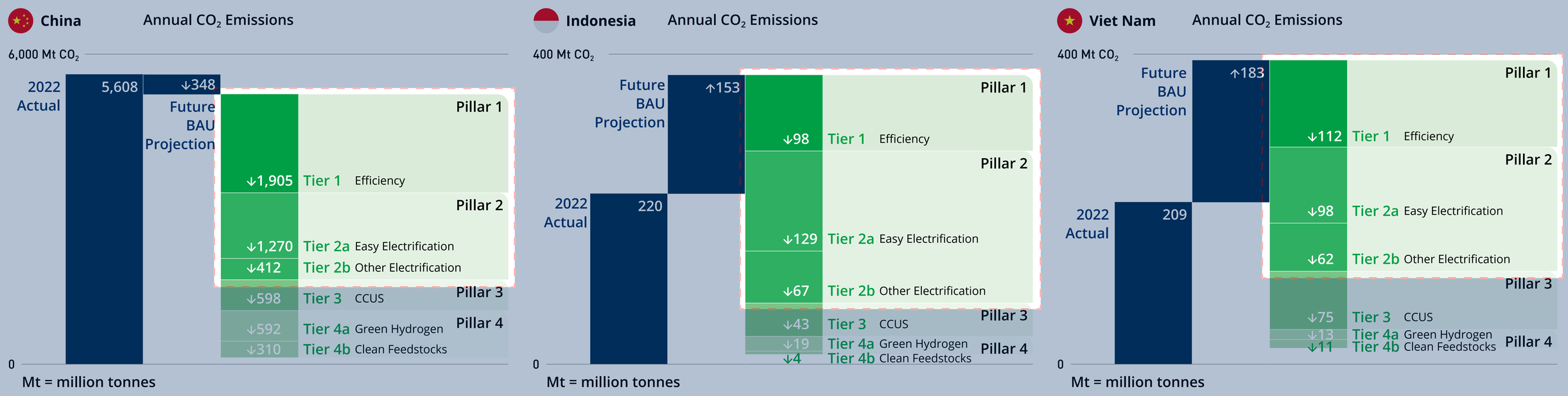

# Abatement Cost

- **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**

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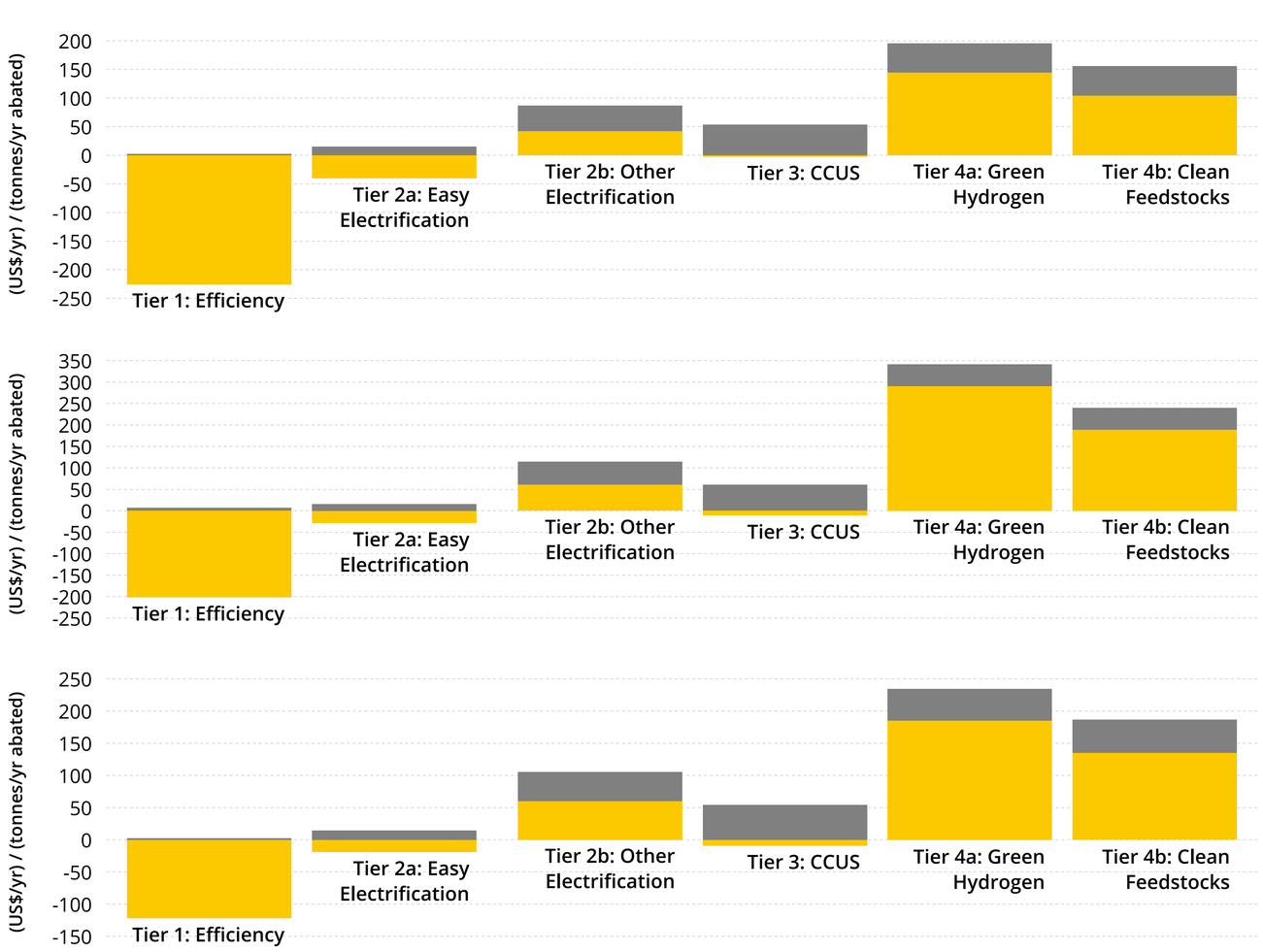

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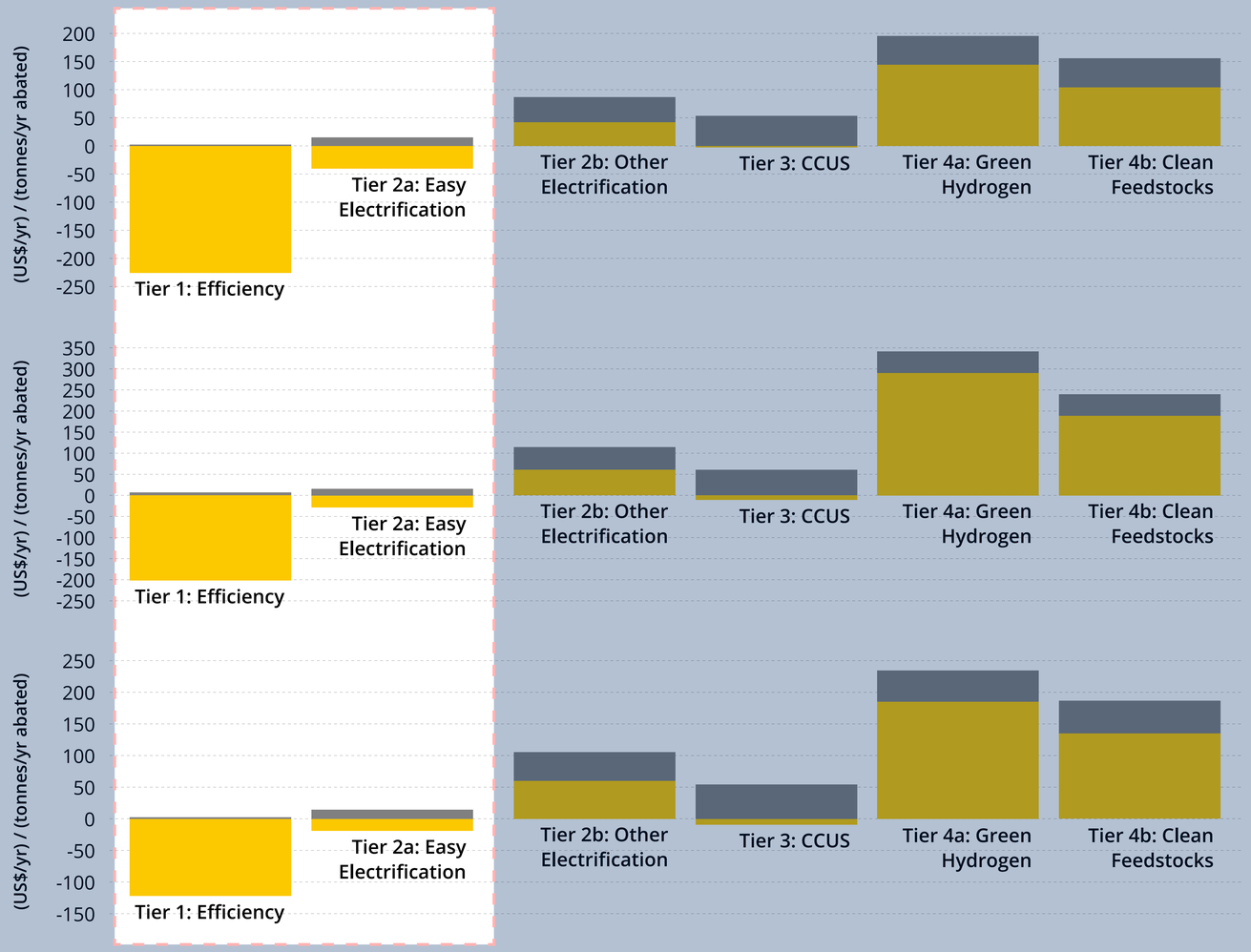

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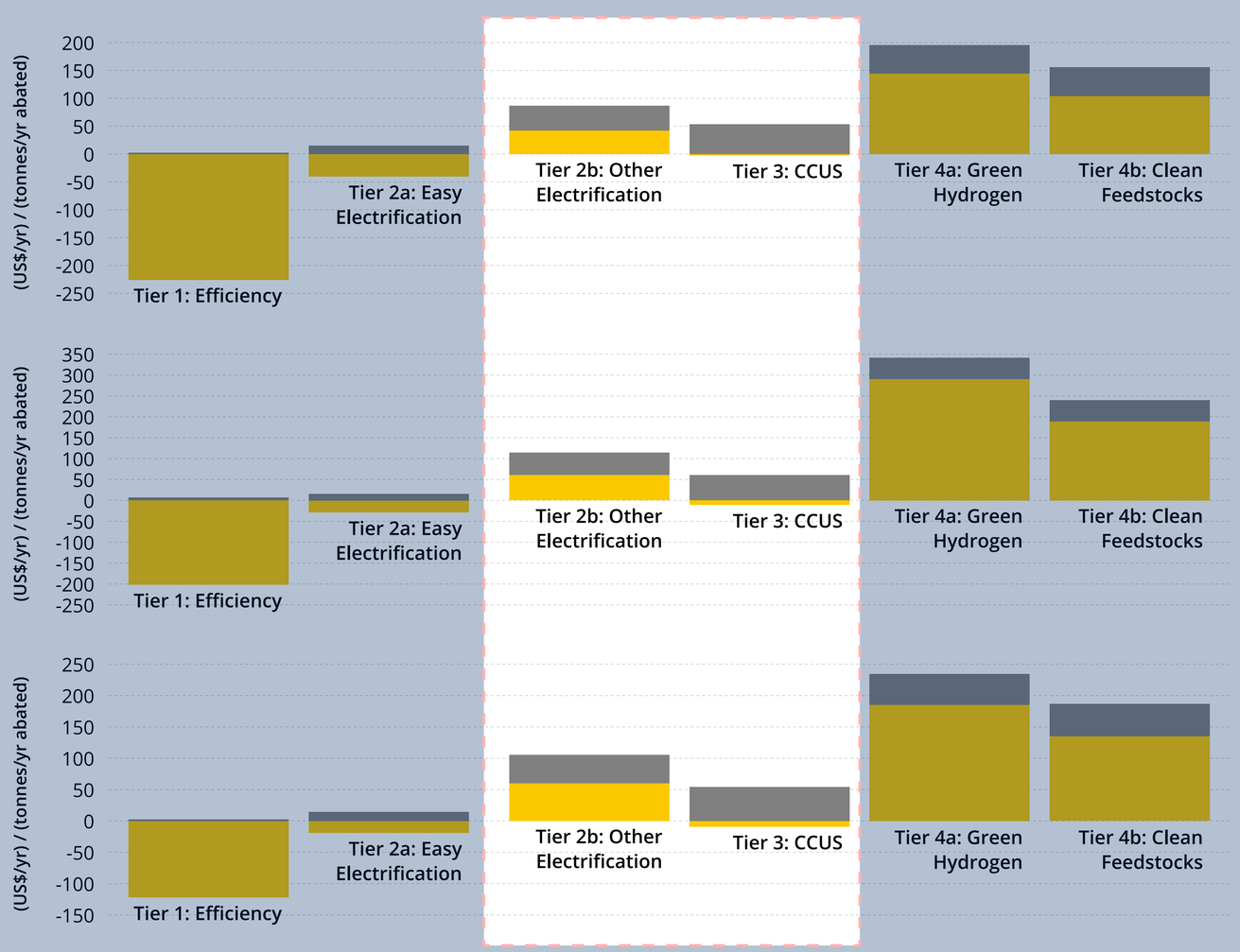

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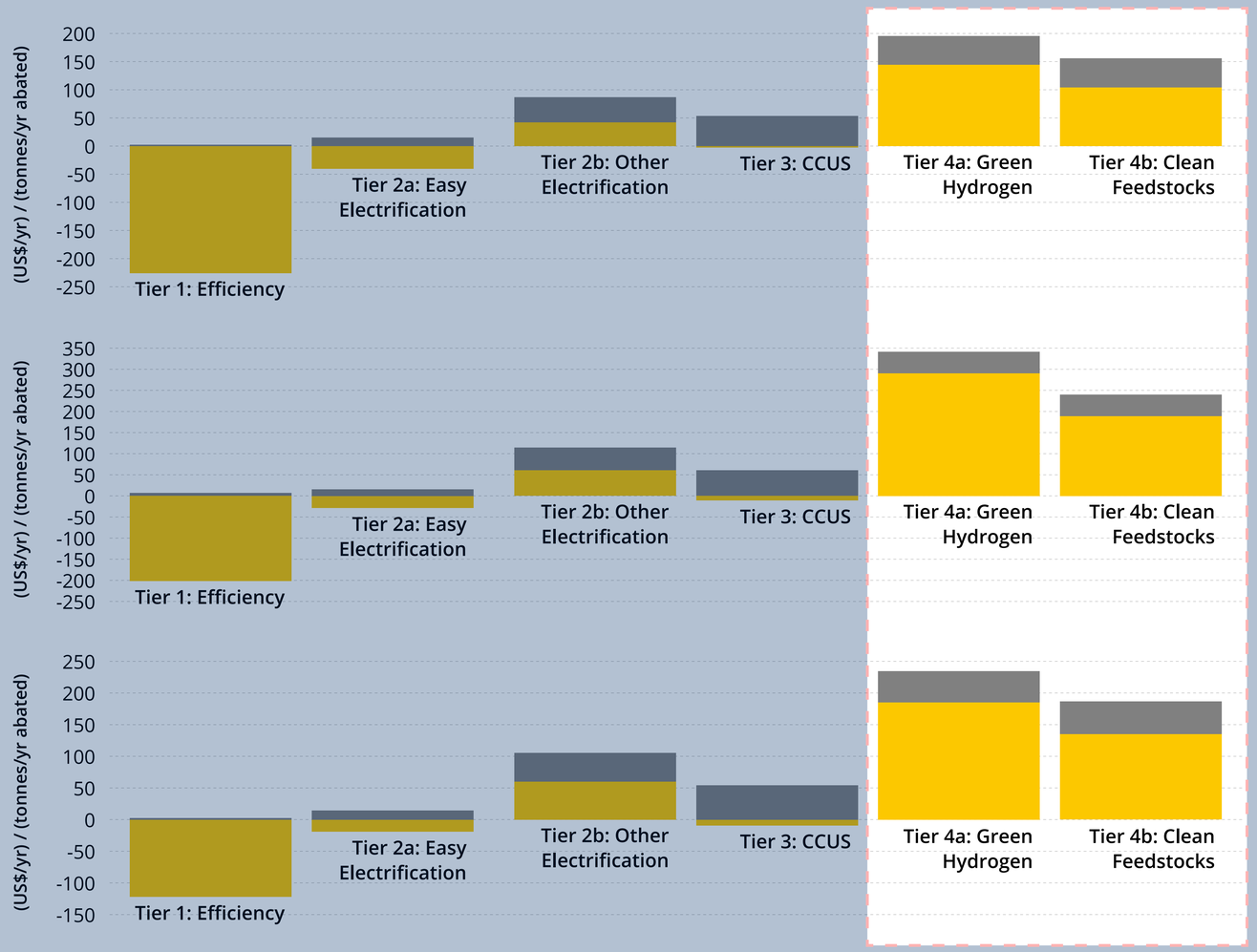

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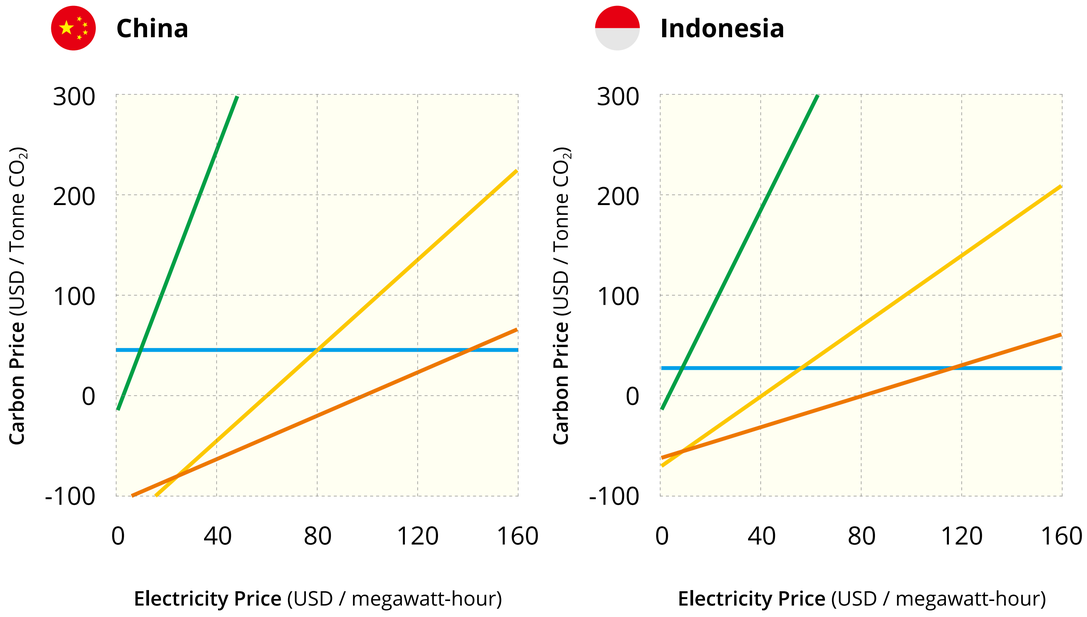


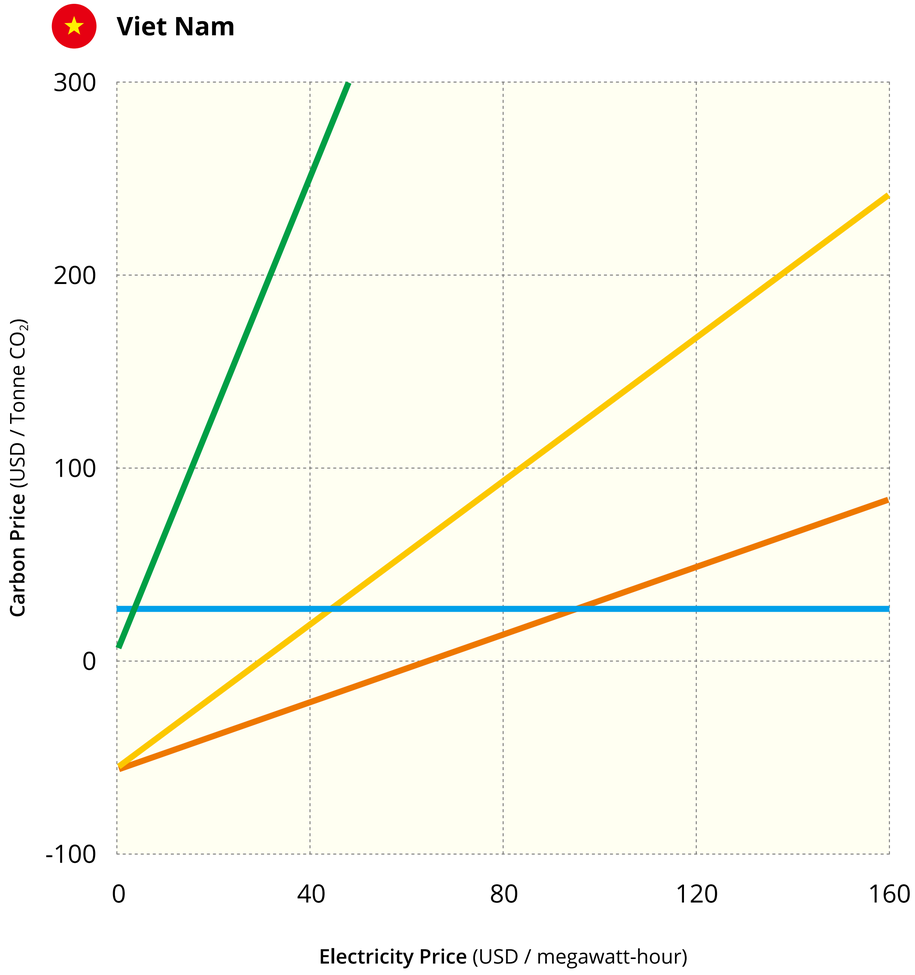

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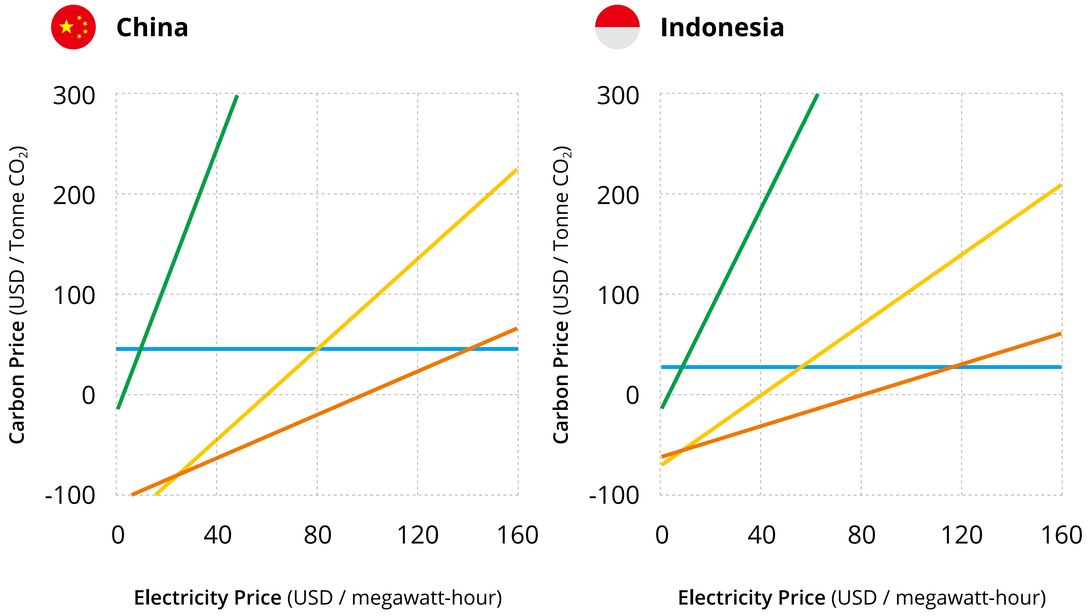


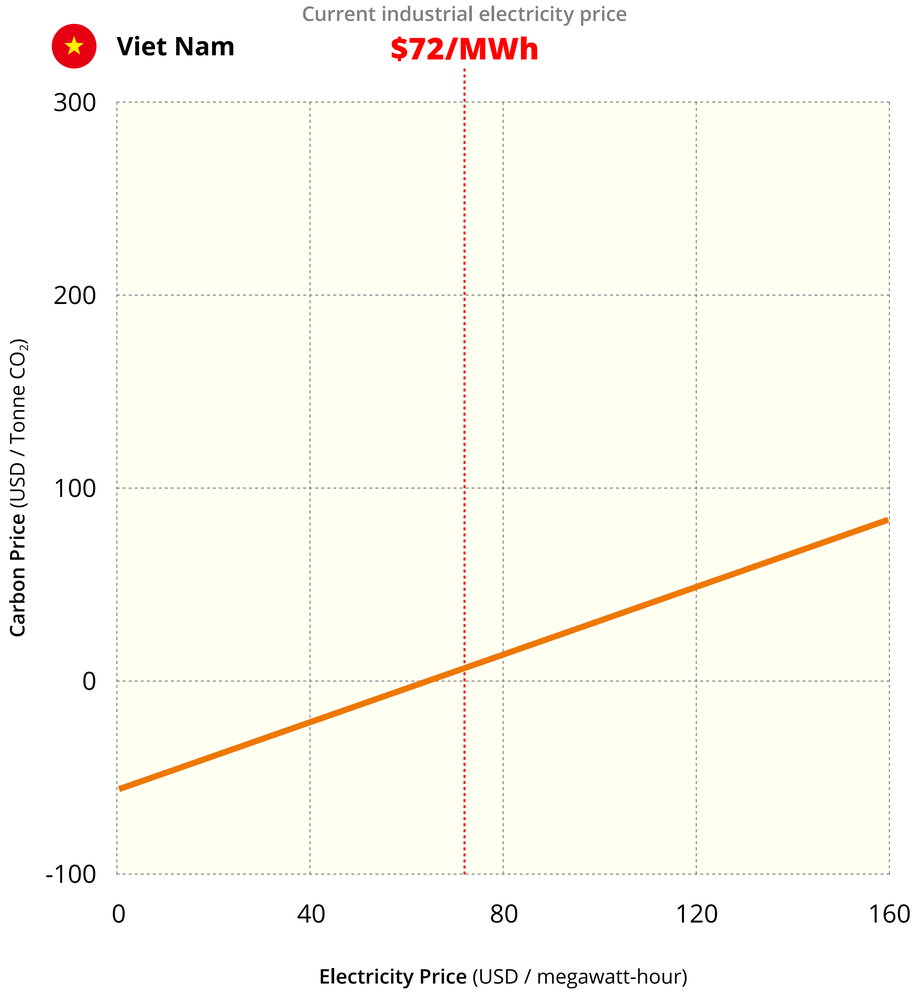


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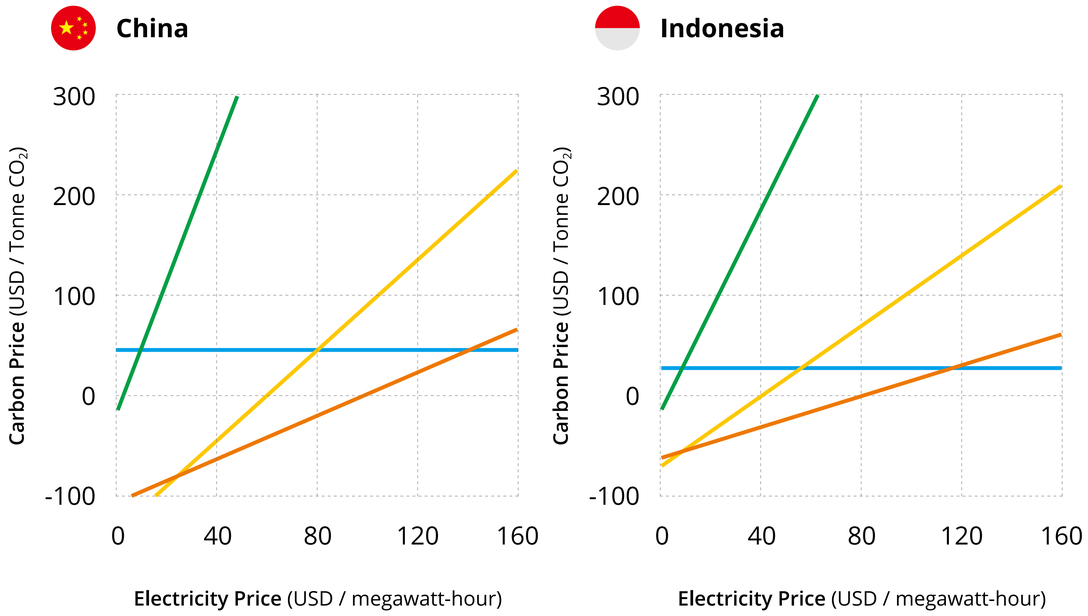


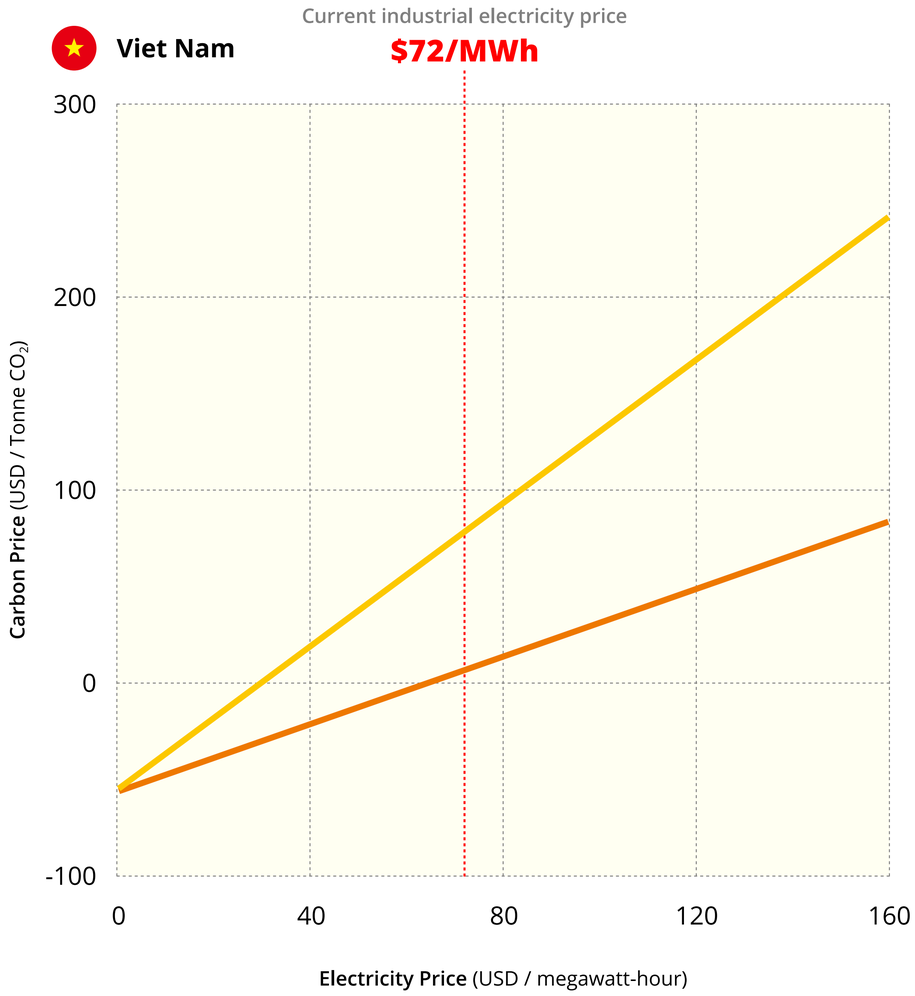


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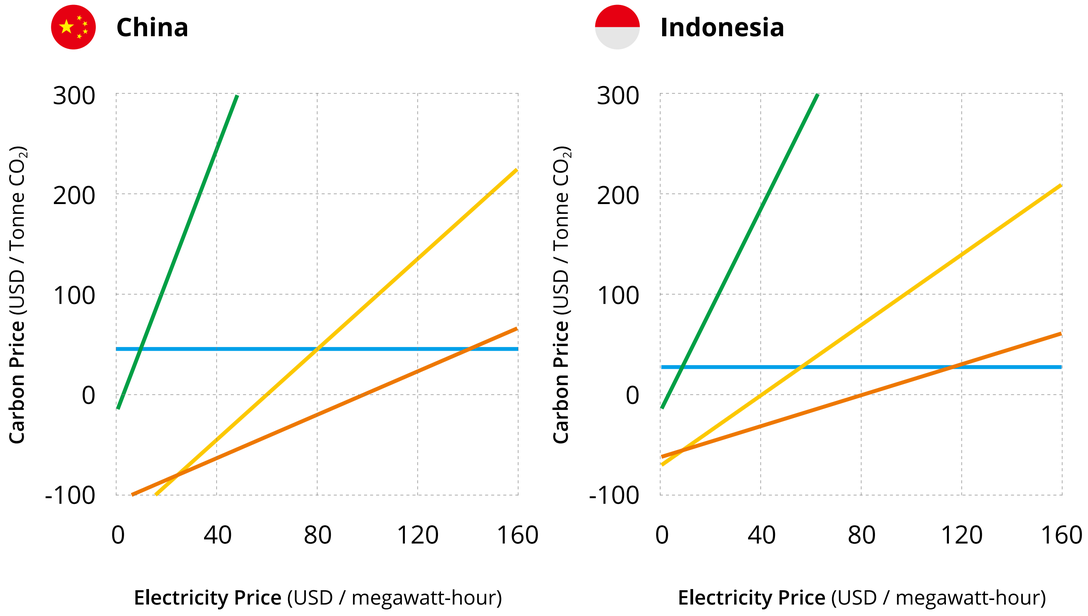


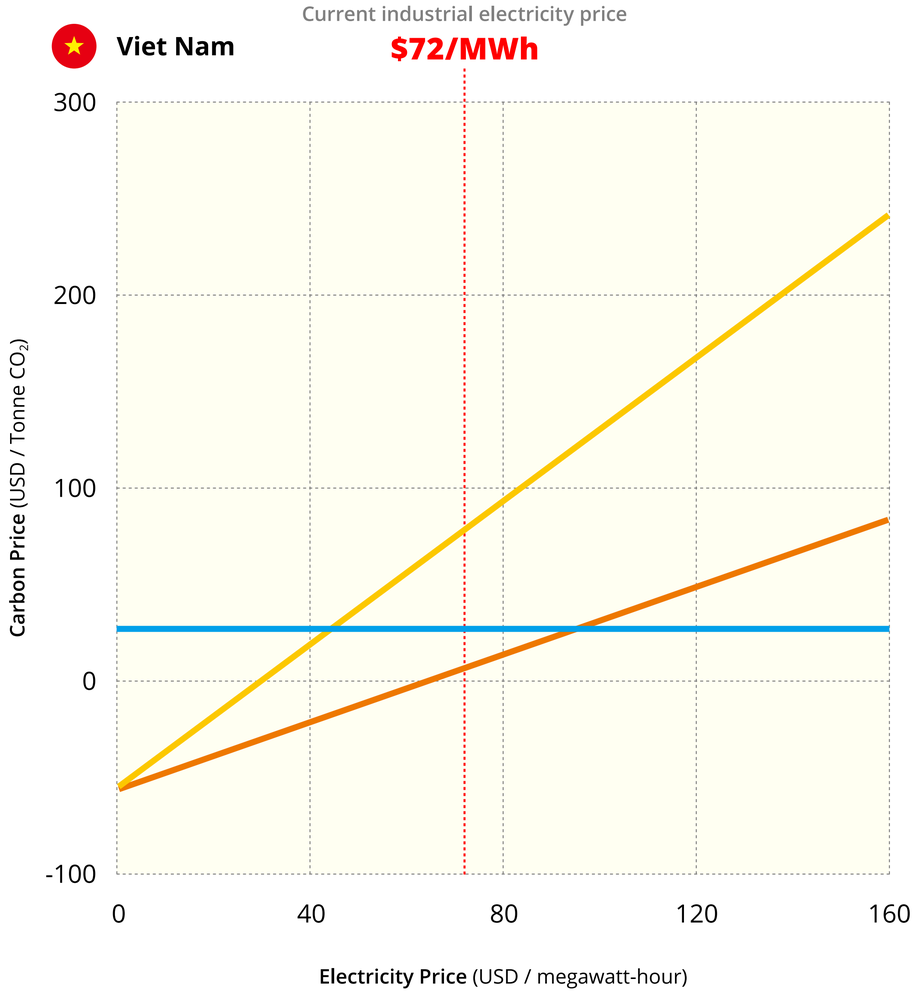


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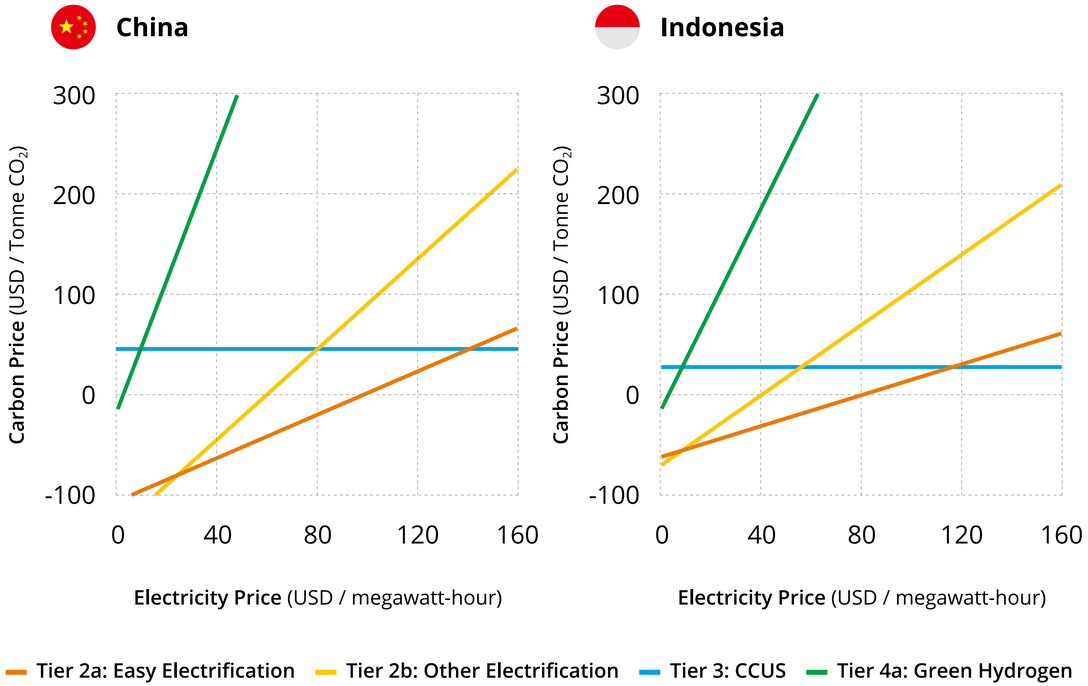



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CCUS can achieve breakeven at a carbon price of around **$25 per tonne of $CO_2$**

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

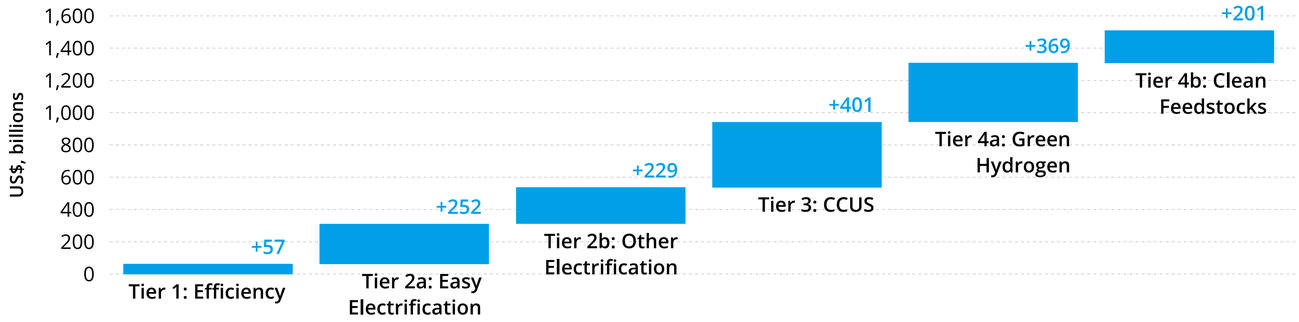
# The Financing Gap

- **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

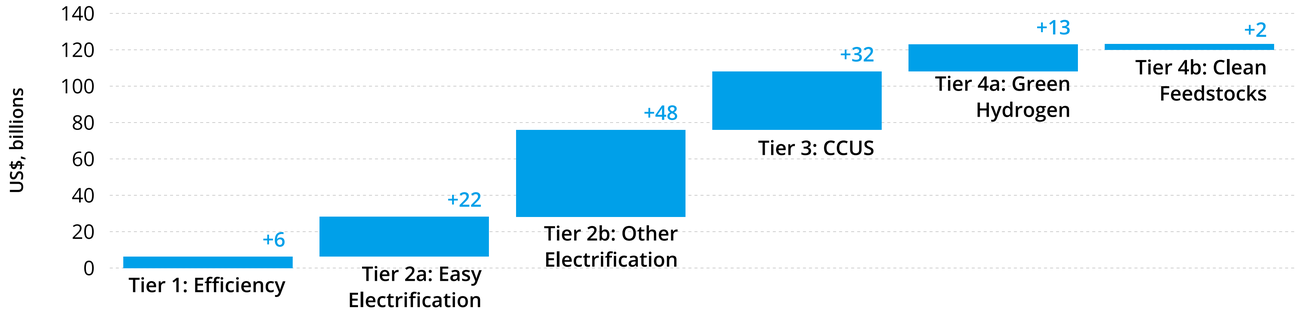
**China**

Total capital investment required is US$ 1.5 trillion



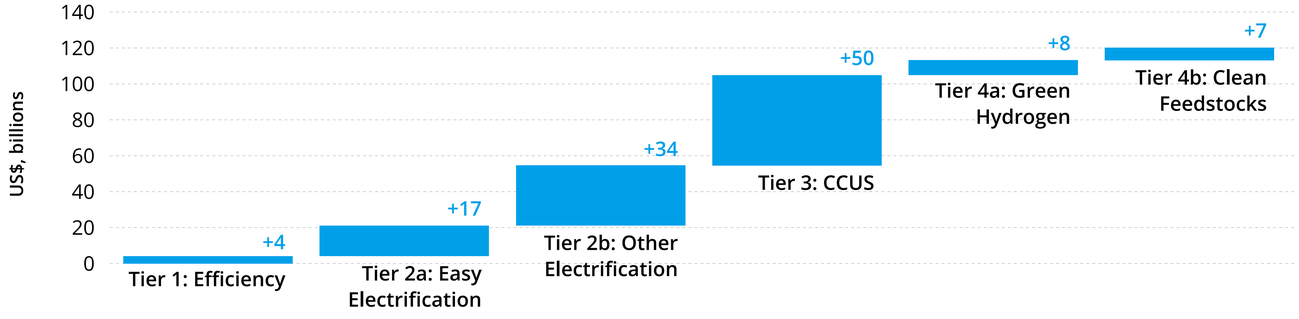

**Indonesia**

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**

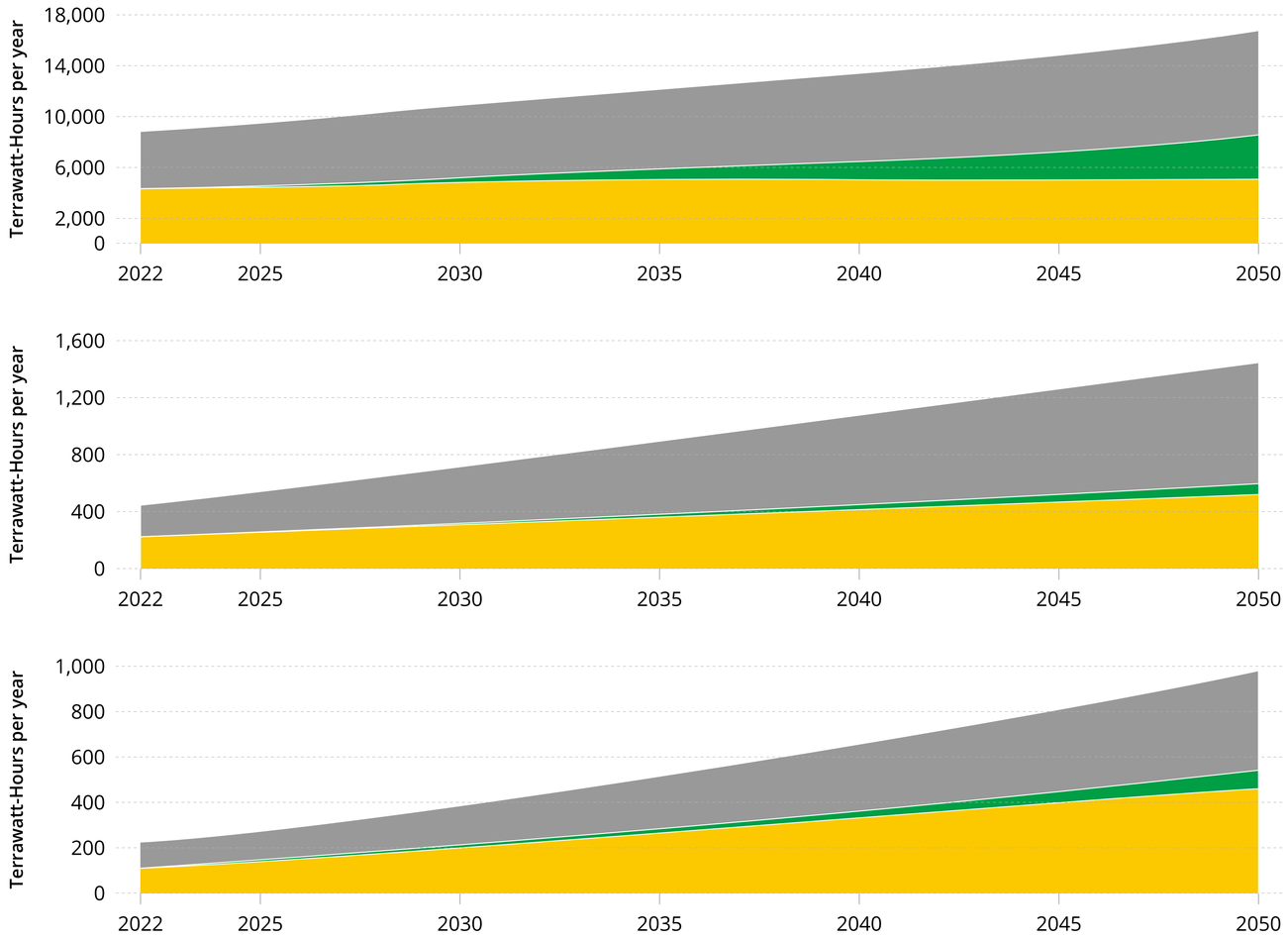
» **Compared to 2022 levels, decarbonizing industry will increase industrial electricity demand by:**

- *93% in China*
- *325% 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

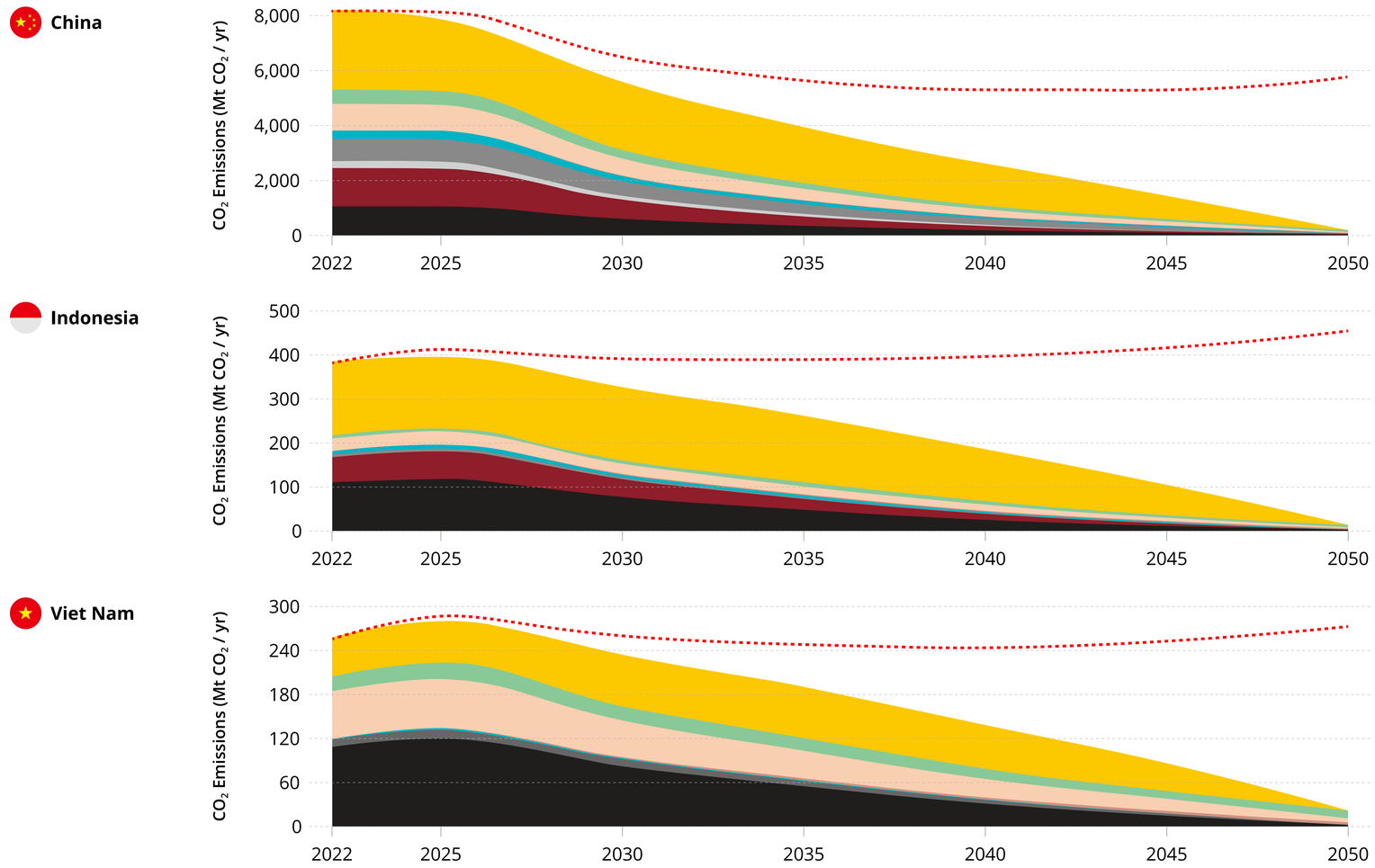
» **If the power sector decarbonizes by 2050:**

- *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

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- 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 |

### 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 |

### 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 |

### 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 |