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Southeast Asia's Green Economy

Unlocking Systems for Growth and Impact

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“Bain & Company, GenZero, Google, Standard Chartered, and Temasek Southeast Asia’s Green Economy 2025 Report: Unlocking Systems for Growth and Impact”

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Terms and acronyms

#

1G biofuel	first generation biofuel
2G biofuel	second generation biofuel
4W	four-wheeler

A

ACCF	ASEAN Common Carbon Framework
ACFTA	ASEAN-China Free Trade Area
ADB	Asian Development Bank
Agri	agriculture
AI	artificial intelligence
AIF	ASEAN Infrastructure Fund
APAC	Asia-Pacific[1]
ASEAN	Association for Southeast Asian Nations
AT&C	aggregate, technical, and commercial
AWD	alternate wetting and drying
AZEC	Asia Zero Emission Community

B

BAU	business-as-usual
BESS	battery energy storage system
BEV	battery electric vehicle
BIMP	Brunei-Indonesia-Malaysia-Philippines

C

CAAS	Civil Aviation Authority of Singapore
CAGR	compounded annual growth rate
CBAM	Carbon Border Adjustment Mechanism
CFE	carbon-free energy
CLT	cross-laminated timber
CN	China[2]
CO_2e	carbon dioxide equivalent
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CPU	central processing unit

D

DC	data center
DFI	development finance institution

E

EEC	Eastern Economic Corridor
EMEA	Europe, Middle East, and Africa
ESCAP	Economic and Social Commission for Asia and the Pacific
ESG	environmental, social, and governance
ETS	Emissions Trading System
EU	European Union
EV	electric vehicle

F

FAO	Food and Agriculture Organization
FDI	foreign direct investment
FI	financial institution
FOLU	forestry and other land use

G

G2G	government-to-government
GHG	greenhouse gas
GIP	green investments partnership
GPU	graphics processing unit
GtCO2e	gigatons of carbon dioxide equivalent
GW	gigawatt

H

HEV	hybrid electric vehicle
HVO	hydrogenated vegetable oil

I

IBRD	International Bank for Reconstruction and Development
ICE	internal combustion engine
ICVCM	Integrity Council for the Voluntary Carbon Market
ID	Indonesia
IEAT	Industrial Estate Authority of Thailand
IFC	International Finance Corporation
Infra	infrastructure

J

JETP	Just Energy Transition Partnership
JP	Japan
JV	joint venture

K

KR	Korea[3]

L

LCOE	levelized cost of energy
LLM	large language model
LNG	liquified natural gas
LT-LEDS	long-term low-emission development strategy
LTMS	Laos-Thailand-Malaysia-Singapore Power Integration Project
LUCF	land-use change and forestry
LULUCF	land use, land-use change, and forestry

M

MAS	Monetary Authority of Singapore
MDB	multilateral development bank
MoC	memorandum of collaboration
MoU	memorandum of understanding
MRV	monitoring, reporting, and verification
MtCO2e	million tons of carbon dioxide equivalent
MY	Malaysia

Note: (1) In this report, Asia-Pacific does not include SEA or Australia; (2) China refers to Mainland China; (3) Korea refers to South Korea

Acronyms

N

NBS	nature-based solution
NDC	nationally determined contribution
NGO	non-governmental organization

O

OEM	original equipment manufacturer

P

PCI	Projects of Common Interest
PH	Philippines
PHEV	plug-in hybrid electric vehicle
POME	palm oil mill effluent
PPA	power purchase agreement
PPP	public-private partnership
PUE	power usage effectiveness

R

R&D	research and development
RCEP	Regional Comprehensive Economic Partnership
RE	renewable energy
READ-SI	Renewable Energy Accelerator for Decarbonizing Sustainable Industries
REC	renewable energy certificate
REDD	reducing emissions from deforestation and forest degradation
ROI	return on investment

S

SAF	sustainable aviation fuel
SEA	Southeast Asia
SEA-6	Consists of Thailand, Malaysia, Singapore, Indonesia, Philippines, Vietnam
SEZ	special economic zone
SG	Singapore
SGTraDex	Singapore Trade Data Exchange
SHF	smallholder farm(er)
SLB	sustainability-linked bond
SME	small and medium enterprise
Solar PV	solar photovoltaic
SRI	system of rice intensification
SWF	sovereign wealth fund

T

T&D	transmission and distribution
TBCB	tariff-based competitive bidding
TCAF	transformative carbon asset facility
TCO	total cost of ownership
tCO2e	ton of carbon dioxide equivalent
TH	Thailand
TWh	terawatt-hour

U

UCO	used cooking oil
UI/UX	user interface/user experience
UNFCCC	United Nations Framework Convention on Climate Change

V

VCMI	Voluntary Carbon Markets Integrity Initiative
VN	Vietnam
VPPA	virtual power purchase agreement
VSIP	Vietnam Singapore Industrial Parks

W

WUE	water usage efficiency

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Introduction

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Foreword by Bain & Company

BAIN & COMPANY

Dale Hardcastle

Partner
Asia-Pacific
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History moves in waves, each marked by shifting priorities, new challenges, and evolving aspirations. For generations, nations have grappled with the intricate challenge of balancing economic growth, energy security, and environmental sustainability. Today, as we navigate a period of renewed change and greater uncertainty, new models and ways of thinking have become essential.

Southeast Asia (SEA) stands at a pivotal juncture in its green transition. Over the past decade, the region has demonstrated growing ambition, heightened awareness, and early decisive steps toward sustainable development. Yet, progress has been uneven—and with only five years remaining to meet the critical 2030 climate targets, SEA is not yet on track to fulfill its climate pledges. The opportunity to alter this trajectory is narrowing rapidly, underscoring the urgency for bold, coordinated action at this moment of inflection.

This year's report explores pathways for SEA to enter the next phase of its green transition—one centered on value creation, where decarbonization must unlock economic competitiveness, job creation, and energy resilience. The central message is clear: Climate action must deliver tangible results, not merely aspirational targets. It has become a strategic growth lever rather than simply a cost.

Realizing this vision demands a fundamental shift. Single-sector or fragmented initiatives are insufficient in addressing the complexity of today's challenges. Instead, a systems-based strategy is required—one that comprehensively tackles interconnected issues across energy, transportation, and land use sectors. This report highlights three critical systems-level solutions: scaling up a sustainable bioeconomy to safeguard and regenerate natural resources, modernizing regional and domestic grids to enhance renewable energy integration, and rapidly developing an integrated electric vehicle (EV) ecosystem to decarbonize transportation and maintain regional competitiveness in automotive manufacturing. Each solution not only mitigates emissions but also generates economic value.

Crucially, the report also emphasizes the enabling solutions needed to support these comprehensive strategies. Expanding climate finance, scaling credible carbon markets, and leveraging green artificial intelligence (AI) to enhance energy efficiency and emissions reduction are vital to achieving scale and sustainability.

The report further introduces an important new catalyst: the significant potential for strategic collaboration between SE Asia and the broader Asia-Pacific region. By codeveloping infrastructure, harmonizing standards, and integrating green supply chains and digital platforms, regional partnerships and investment can amplify outcomes, delivering impacts greater than the sum of their parts.

We hope this report serves as a practical guide for leaders in both the public and private sectors, catalyzing the collaboration and innovation necessary to fully realize Southeast Asia's green economic potential.

Foreword by GenZero

Anshari Rahman

Director of Policy & Analytics
GenZero

Staying on course for net zero is increasingly difficult amid immediate challenges like inflation and energy security—but losing sight of the climate crisis risks far greater long-term consequences.

To refocus attention, the journey to net-zero needs to make business sense now.

Last year's report highlighted that Southeast Asia's green economy could generate an additional US $300 billion in revenue annually by 2030—a figure that matches the new finance target set at COP29. Crucial unlocks include the bioeconomy and carbon markets, which are underutilised yet high-potential levers for decarbonisation, job growth, and economic opportunities.

The global bioeconomy is projected to reach US $30 trillion by 2050. Southeast Asia, with its large forests, mangroves, and agricultural landscapes, can capture a significant share of this value while advancing net-zero goals. Nature-based solutions (NBS) and biofuels are both carbon sinks and economic drivers. For example, sustainable aviation fuel (SAF) developed from waste feedstock decarbonises air travel, while regenerative agriculture enhances food security. Therefore, to scale the sustainable bioeconomy, governments and businesses must de-risk investments, build robust value chains, and integrate advanced technologies to maximise both climate and economic benefits. A clear regulatory environment is essential to support this.

On top of nature-based solutions, we also need tech-based decarbonisation. Carbon markets can play a vital role in mobilising capital for both types of climate interventions, potentially growing to US $35 billion by 2030. However, this can only be achieved with improved credit integrity, stronger alignment with international standards, and clearer regulatory frameworks. Efforts such as the Integrity Council for the Voluntary Carbon Market (ICVCM) and the Voluntary Carbon Markets Integrity Initiative (VCMI) are helping to rebuild market confidence around quality supply and claims.

At GenZero, we are committed to catalysing Asia's green economy. We invest in a diversified range of nature-based and technological solutions to scale impact. For example, with rice cultivation being one of the largest methane emitters in Asia, we have invested in The Good Rice Alliance to advance sustainable rice farming practices in India, cutting approximately 100,000 tCO2e of methane emissions annually. The development of end-to-end technological solutions is also key to achieving a clean energy transition. On this front, we are collaborating with ACEN and Keppel Ltd to pioneer the use of transition credits to finance the early shutdown of a coal-fired power plant in Batangas, the Philippines, transforming it into a clean energy facility by 2030.

Charting a decarbonisation roadmap that is economically viable and environmentally sustainable is not just a vision. It is a reality we can build today.

Let us overcome climate paralysis together, starting now.

Sources: Nature Finance, The Global Bioeconomy; MSCI, "Frozen Carbon Credit Market May Thaw as 2030 Gets Closer"

Foreword by Google

Spencer Low

Head of Regional Sustainability, APAC
Google

Asia-Pacific generates more than half of the world's global greenhouse gas emissions, but it is also the region that is the most vulnerable to the effects of extreme weather events.

Southeast Asia sits at the heart of Asia-Pacific, with deep cultural, historical, trade, and investment ties with India, China, Japan, South Korea, and Oceania. SEA is also one of the fastest-growing regions in the world economy, with a young, digitally savvy population. For this reason, last year Google announced a $3 billion investment in data centers and cloud regions in Malaysia and Thailand as part of our efforts to boost cloud and AI capabilities in the region.

At Google, we believe we have a unique opportunity to contribute to SEA's transition to a more sustainable future by using AI for information, prediction, and optimization, and to drive innovation forward. AI has the potential to help mitigate 5%–10% of global greenhouse gas emissions by 2030, and we're already seeing the positive impact, with AI being deployed in sectors in Asia such as agriculture and disease detection.

At the same time, Google is committed to developing AI responsibly and working to address the environmental impact associated with it. We have a bold goal to reach net-zero emissions across all of our operations and value chain, which includes running on 24/7 carbon-free energy (CFE) on every grid where we operate. In Asia-Pacific, over the past year, Google announced long-term agreements for 275 megawatts of new clean energy generation capacity in Australia, India, Japan, and Singapore, in addition to supporting the development of a 1-gigawatt pipeline of new solar capacity as well as 10 megawatts of "always-on" geothermal energy in Taiwan. Google continues to work with partners to accelerate the deployment of CFE technologies and advocate for grid decarbonization policies in Asia-Pacific.

We believe that all of us—policymakers, industry leaders, and civil society—must work together to responsibly harness AI's potential to benefit everyone. Compared with other regions, people across Asia-Pacific view AI with greater optimism and believe it will have a positive impact on the way we work, learn, and access information. That's why Google.org, Google's philanthropic arm, has been supporting the APAC Sustainability Seed Fund, led by AVPN with ADB support, since 2022 with a total of $10 million to support social impact organizations and nonprofits in the region. As chair of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) Sustainable Business Network's Innovation task force, Google is committed to working with other corporations across SEA and the rest of Asia-Pacific to use AI to accelerate sustainable outcomes.

A sustainable future requires systems-level change, strong government policies, and new technologies. AI has the potential to help solve some of the biggest environmental challenges. Scaling AI and using it for environmentally positive outcomes will be just as crucial as addressing its environmental impact.

This report outlines pathways for SEA to decarbonize and identifies areas of investment and needs for policy change. Google is committed to collaborating with SEA governments and industry stakeholders to grow the region's green economy.

Foreword by Standard Chartered

Patrick Lee

CEO, Singapore and ASEAN
Standard Chartered

The opportunity to finance the transition to a low-carbon economy is more compelling and crucial than ever. For Standard Chartered and our clients, the commercial case continues to grow, with the green economy delivering total returns of 198% over the past 10 years. For the bank, sustainability remains an integral part of our business, and we recognise the scope for further sustainable finance growth, particularly as new technologies come online, and as renewable capacity growth continues to outpace that of fossil fuels.

At the same time, the urgency of the transition remains stark, as last year we breached the 1.5°C threshold for the first time, making 2024 the warmest year on record. The disproportionate impact of climate change on those least equipped to respond, notably across our markets in ASEAN, underscores the importance of our ongoing commitment to capital mobilisation at scale to deliver the sustainable outcomes we need to see, alongside inclusive growth.

ASEAN is the fourth largest energy consumer in the world and energy demand has increased by around 3% per year on average over the past two decades, according to the International Energy Agency. In response, most governments across ASEAN have set long-term net-zero emissions and carbon neutrality targets.

This is why Standard Chartered, along with our partners, decided to develop this year's edition of the Green Economy Report. Among other things, the report explores greater cross-border collaboration opportunities between Asia Pacific and ASEAN to scale decarbonisation impact and advocate for solutions.

As a global financial institution with a presence in over 53 of the world's most dynamic markets, including all 10 countries in ASEAN, we recognise that we have a role to play in supporting companies, governments, and stakeholders when it comes to the transition. We continue to scale finance to support sustainable and enduring growth, and our sustainable finance income growth speaks to this progress, with $982 million of sustainable finance income generated this year.

In Singapore, we continue to support the government's Green Plan 2030, actively contributing to multiple programmes in the country's sustainable finance ecosystem, including participating in the formation of the Singapore Green Finance Centre as well as the Singapore Sustainable Finance Association, and supporting the development of carbon markets as well as sustainable trade and data solutions through initiatives such as Climate Impact X, Transition Credits Coalition (TRACTION).

Together with Temasek, we have been a driving force behind the Just Energy Transition Partnerships (JETPs) in Indonesia and Vietnam, which combine public and private finance for investment in the early retirement of coal-fired power stations and expansion of renewable energy. We are also represented on the advisory board of Point Carbon Zero to drive the innovation, incubation and scaling of climate fintech solutions in Singapore and across Asia.

We know that transformation will not take place overnight, and more work remains to be done. Through this report, it is our collective hope that we can inspire confidence and empower greater action towards building a more sustainable future for the world.

Foreword by Temasek

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Franziska Zimmermann

Managing Director, Sustainability, Temasek

We are at a critical juncture in our global fight against climate change. With just five years until 2030, the window to avert the worst impacts of the climate crisis is closing rapidly. The past two years have been the hottest on record, with global temperatures breaching 1.5°C above pre-industrial levels for the first time. At the same time, the global sustainability movement is facing its strongest headwinds—political pushback, protectionist policies, growing anti-ESG sentiment, and corporations reassessing climate goals.

Maintaining momentum requires viable pathways that balance energy security, sustainability, and affordability. It also demands a shift in how we define climate leadership. Rather than relying on a few nations, leadership can emerge through public-private partnerships, ground-up efforts, and a "coalition of the willing." Southeast Asia has an opportunity to bring together diverse stakeholders to shape a clear, unified path forward.

This year's Southeast Asia's Green Economy Report offers a fresh perspective on how the region can close the emissions gap while creating economic growth and jobs. By exploring the interlinkages between essential economic systems, the report identifies high-impact, systems-level solutions. It also highlights how enabling forces—like climate and transition finance and carbon markets—can unlock a multiplier effect for decarbonization and economic growth.

Temasek recognizes that climate and transition finance is vital to catalyzing real outcomes. We have been working with global partners to scale capital deployment into green and transition solutions aligned with the systems-led pathways in this report.

Unlocking climate finance is key to scaling grid modernization and infrastructure. We are invested in Brookfield's Catalytic Transition Fund, which targets $5 billion in clean energy and transition assets in emerging markets. Through Pentagreen Capital, we are financing marginally bankable sustainable infrastructure projects in Southeast Asia, including an $80 million deal to accelerate the rollout of utility-scale solar and battery storage projects in the Philippines and Indonesia.

In addition, we partnered with Allied Climate Partners, the International Finance Corporation, and the Monetary Authority of Singapore (MAS) to establish the Green Investments Partnership (GIP). GIP is one of the programmes under the Financing Asia's Transition Partnership (FAST-P), a blended finance initiative by the MAS to mobilize up to $5 billion to de-risk and finance green and transition projects in Asia.

Scaling up sustainable aviation fuel (SAF) is essential for decarbonizing aviation, but its adoption is hindered by high costs. To boost demand signals for SAF and drive costs down, we joined Green Fuel Forward, an initiative of the World Economic Forum and GenZero, focused on building capacity and advocating for SAF and SAF certifications—ultimately to unlock more capital for this high-potential climate technology.

The impact of such systems-level solutions can be significant: Projections suggest they could raise SEA's GDP by 2%, create ~900,000 jobs, and potentially avoid 300 $MtCO_2e$ in emissions.

The path forward is not easy, but the potential rewards are immense. We hope this report serves as a roadmap for action, and a rallying call to all stakeholders to join us in accelerating Southeast Asia's green transformation.

Executive summary

02

The report in numbers

SEA's progress today

Rising commitments and investments

+40%($8B)

increase in private green investments in Southeast Asia (SEA) between 2023 and 2024

First steps towards a green transition, yet much potential

~9%

renewable energy (RE) penetration[1] in SEA

1.5%

deforestation rate vs. global average of 3% between 2013–23

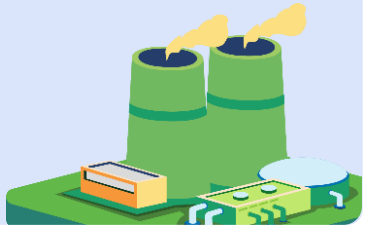
<15%

low battery electric vehicle (BEV) penetration vs. ~30%+ in other global markets (Europe, China)

However, reduction in emissions required to meet 2030 targets

600 MtCO2e

reduction required (13% reduction in current trajectory needed)



What accelerating systems-level solutions could achieve by 2030

Systems approach could yield strong impacts for the economy and the environment …

+$120B

increase in 2030 GDP projected for SEA-6 nations in 2030 (+2%)

~36 TWh

reduced T&D losses increases energy availability, potentially reducing import needs

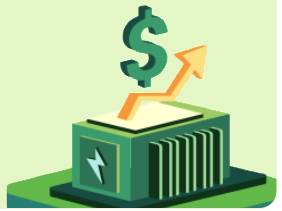
+900K

increase in jobs expected by using systems-level solutions to drive decarbonization

… offer new pathways for investment …

~$50B/year[2]

potential annual investment required by 2030 to activate systems-level solutions



… contribute to emissions targets[3] …

~300 MtCO2e

reduction in emissions (50% reduction in emissions gap needed to meet 2030 targets

… and help enable other aspirational goals within systems, including:

30%

increase in biofuel production

6M

annual EV adoption rate 2030

20%

RE penetration in electricity generation

Notes: (1) Hydropower excluded due to well-documented environmental and social impacts, including ecosystem disruption, methane emissions from reservoirs, and community displacement; (2) The $50B includes all types of fundings including private and public; (3) 2030 targets refer to the emissions level that needs to be achieved under APS scenario presented by IEA; this APS scenario assumes that governments' announced climate pledges and targets, including nationally determined contributions (NDCs) and longer-term commitments, such as net-zero targets, will be met in 2030

SEA's green economy can drive growth, energy security and climate impact

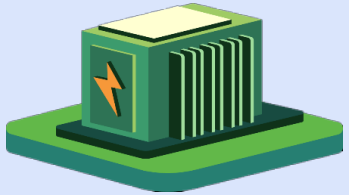
Economic growth will transform composition of regional systems …

~4%–5%

expected growth rate for real GDP in Southeast Asia[1]

~10%–20%

expected annual increase in EV penetration in new vehicle sales[2]



~10%

expected annual increase in power generation capacity until 2035[3]

… and offer the potential to build a greener, stronger SEA for the future

Economic growth: Spurring new industries

Leaders developing in-market plans for low-carbon production, driving new job growth and transition

+

Energy security: Promoting security and resilience

Build the green economy in ways that boost energy security and resilience through decarbonization

+

Climate benefits: Leveraging access to rest of APAC

Mutually beneficial relationships between APAC and SEA to expand and scale low carbon solutions

=

Targeting triple bottom line

Deliver desired economic growth + energy security + climate impact

Notes: (1) Projections from S&P, ADB (2) Projected annual increase in 4W BEV penetration rate (percentage of BEVs in new vehicle sales) from 2024–30 for SEA-6 nations; (2) Annual power generation capacity addition from 2023–35 under APS scenario from IEA for SEA; APS scenario refers to the scenario which assumes that all NDCs of SEA countries, as well as longer-term commitments (net-zero targets, etc.) will be met | Sources: IEA; Bain analysis

But approaching decarbonization through a sector lens has fallen short of delivering climate and growth outcomes

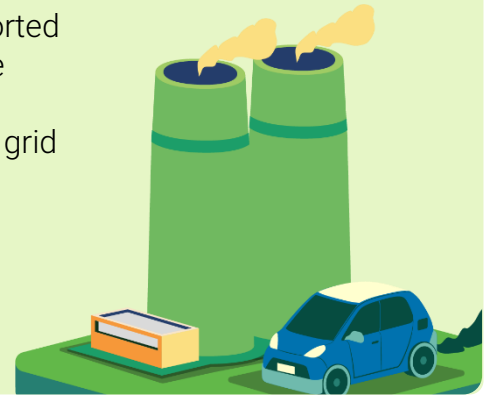
Lesson learned: A single sector approach limits resilience, economic outcomes, and climate impact

1 Systemic barriers limit pace of progress

e.g., investing in RE generation without upgrading grids results in curtailment, low return-on-investment (ROI), and slow rollout

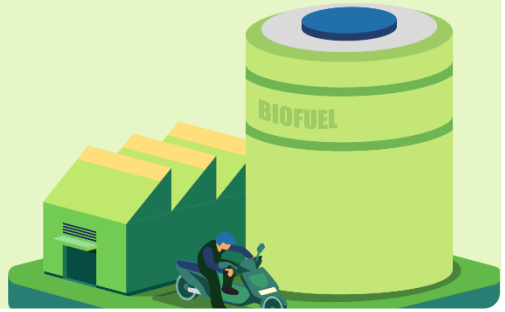
2 System interlinkages create unintended negative externalities

e.g., scaling electric vehicles (EVs) without greening power ecosystems increases emissions and retains reliance on imported fossil fuels while straining load management of grid



3 Missed opportunities to achieve cross-sectoral impact

e.g., scaling biofuels without prioritizing second generation (2G) feedstocks misses an opportunity to address crop burning and create value from agricultural waste



Over five years, SEA's Green Economy Report repeatedly identifies the same systemic barriers that limit scale and results

SEA Green Economy Report | Five years of insights

2020	2021	2022	2023	2024
				
Pathway to full potential	Opportunities on the road to net zero	Investing behind the new realities	Cracking the code	Moving the needle

Each year, the same systemic barriers reappear, consistently limiting scale and results

- Dual need to balance growth and transition
- Lack of carbon pricing
- Limited regional cooperation
- Economic incentives not well aligned
- Inadequate financing mechanisms

A **systems approach** is needed to overcome structural barriers

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Why adopt an integrated systems approach now?
To unlock value, ensure energy security, and drive lasting climate impact

What are systems?

A system is a set of interconnected elements, working together to produce a pattern of behavior; a system's function **arises from relationships** and not just individual components

What are systems-level solutions?

Systems-level solutions are high-impact interventions that address systemic barriers (e.g., patterns of behavior) across multiple systems to deliver transformative and amplified impact

What does it mean to take a systems-based approach?

1. Identify systemic barriers that reinforce detrimental patterns and perpetuate emissions cycles in SEA's green economy

2. Identify high-impact systems-level solutions and implementation levers that address systemic barriers across multiple systems

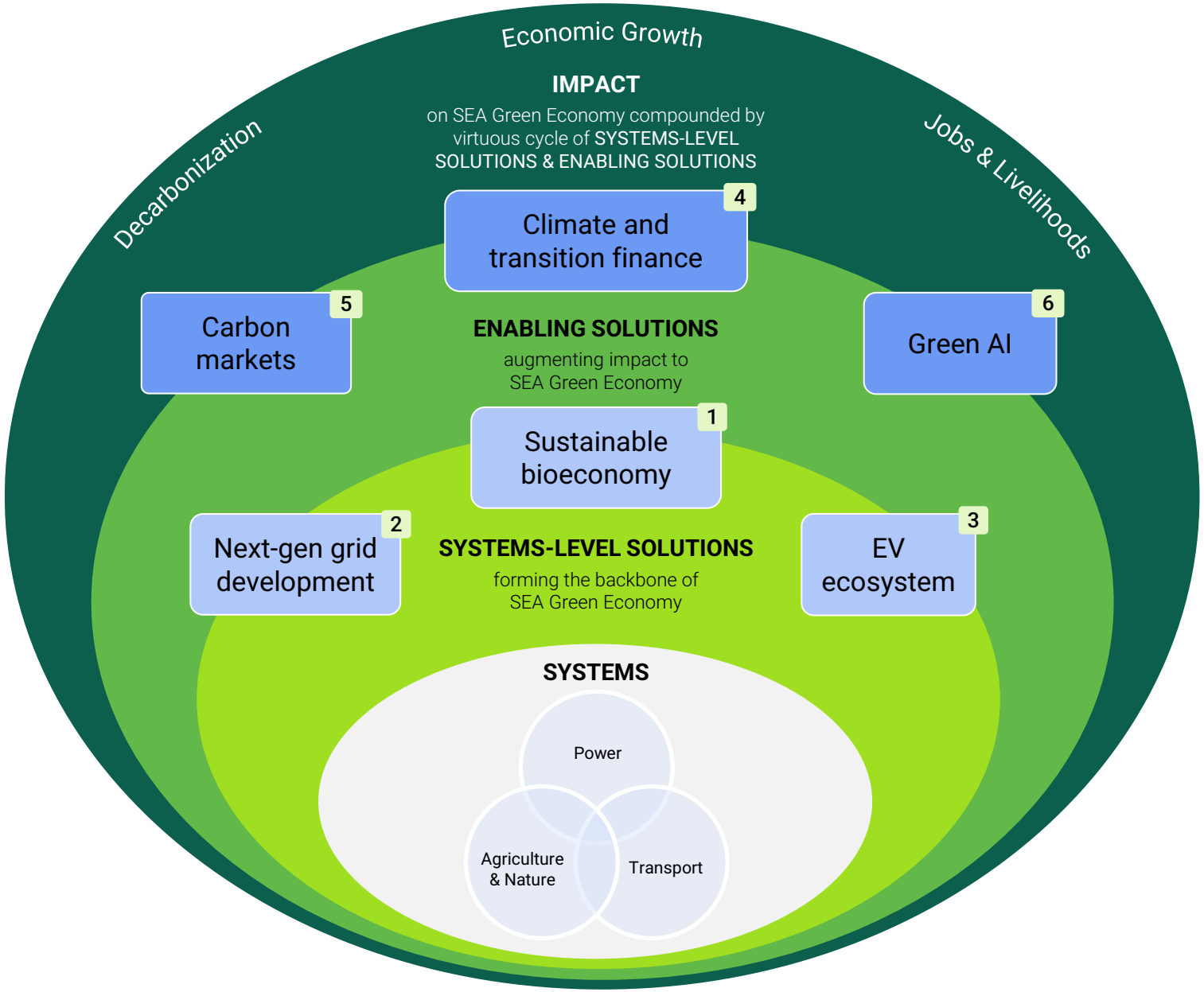
3. Prioritize levers with highest ability to drive lasting change

How will this lead to differentiated impact?

Addresses cross-cutting barriers

Maximizes return on investment and co-benefits

Prevents negative, unintended spillovers across systems



Analyzing interconnected systems is key to identifying systemic barriers and high-impact systems-level solutions to accelerate SEA decarbonization

Systems-level solutions

Enabling solutions

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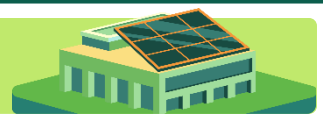
This report explores three core systems-level solutions important for SEA decarbonization, along with essential enabling solutions for their success

	Systems-level solutions		
	Sustainable bioeconomy 	**Next-gen grid development** 	**EV ecosystem** 
Associated System	Agriculture & Nature	Power	Transport
Solution description	Harness local biomass and nature-based solutions (NBS) to create new industries and jobs while reducing reliance on imported fossil fuels	Invest in grid infrastructure to scale renewable power and improve system reliability, with long-term positive impacts on regional energy security, affordability, and climate	Asia's EV transition presents an opportunity for manufacturing and innovation, driving the development of SEA supply chains to enhance competitiveness and reduce long-term emissions
Enabling solutions			
Climate and transition finance Expand access to commercial capital via regional funds, public-private partnerships, innovative approaches	**Unlocks capital to both innovate and de-risk investments** that can improve financial inclusion for smallholder farmers while also helping finance other large projects	**Catalyzes long-term financing that can balance the rewards and reduction of risks** needed to scale high capex green and transition infrastructure projects	**Mobilizes financing to accelerate adoption**, expand charging infrastructure, and advance technology
Carbon markets Creates price signals and incentives across systems to drive decarbonization	**Drives sustainable agriculture practices, biowaste utilization, and nature-based solutions with strong co-benefits** via increased monetization opportunities	**Accelerate and scale clean energy transition via increased** monetization opportunities	**Accelerates EV adoption** (especially for public transportation) **and infrastructure expansion** via monetization opportunities using carbon credits
Green AI Powers data-driven optimization across power, transportation, and agriculture	**Maximizes land productivity and nature-based solutions activities** with significant co-benefits (e.g., higher yields and smarter waste management) **Leverages AI-driven insights** to enhance carbon sequestration	**Optimizes energy demand and supply** with AI-driven grid balancing, predictive maintenance, and generation forecasting	**Optimize energy usage in EV infrastructure** via AI-driven congestion prevention and grid balancing tools

Leveraging systems-level solutions is projected to have significant impact in 2030 across GDP, employment, and emissions reduction

+2% [1]

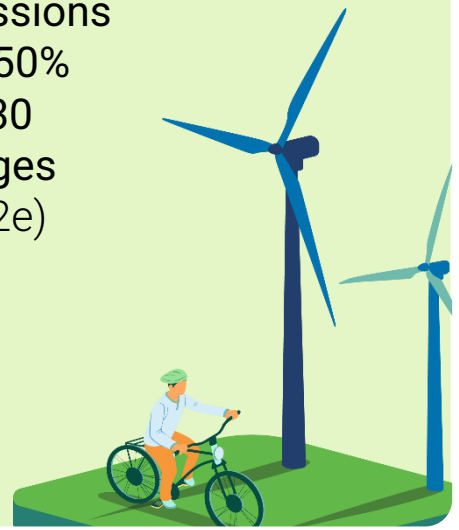
Prioritized systems-level solutions could deliver +2% uplift in SEA-6 nominal GDP by 2030 (~$120 billion/year) …

+900K [2]

… and increase green economy jobs in SEA-6 by 900K by 2030 (0.2% of 2030 labor force)

-50% [3]

Actions would also cut emissions materially; ~50% of gap to 2030 climate pledges (~300 MtCO2e)



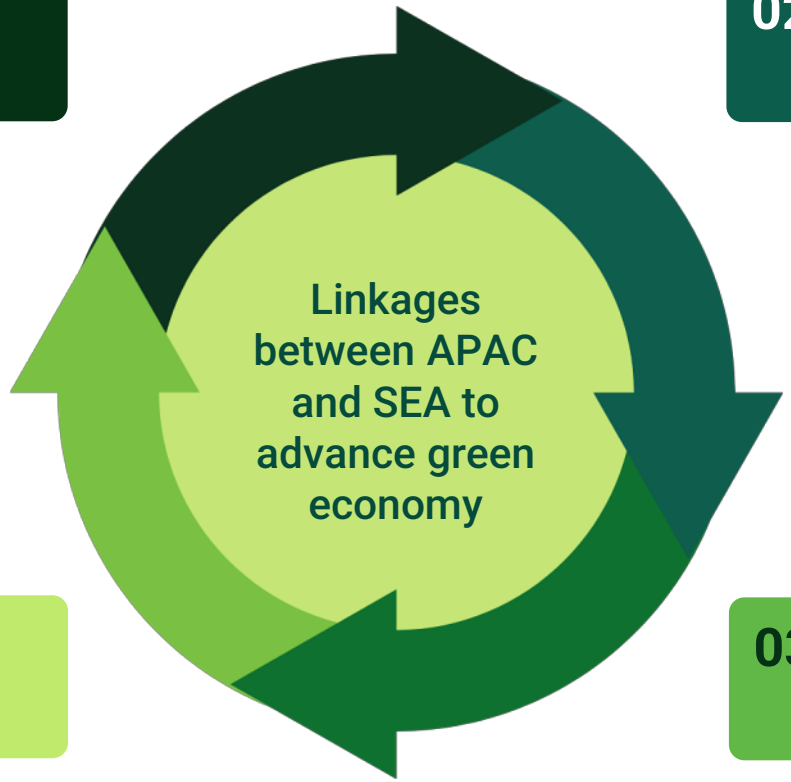
Notes: (1) Percentage uplift in SEA-6 2030 GDP derived using S&P projections (the projection is based on value of solutions, infrastructure growth, and efficiency gains from increased sales and related direct and relevant indirect investments); this uplift will amount to $120 billion annually in 2030; (2) Calculation for new jobs done based on GDP growth, job elasticity and employment forecasts in key industries in SEA-6 nations by 2030; (3) The emission reduction of ~300 MtCO2e has been calculated based on forecasted adoption of low-carbon solutions and their emissions impact from production, use, efficiency gains, fuel shifts, land-use changes, etc.; prioritized systems-level solutions have potential to close ~50% of emissions gap between SEA-6 emissions projected based on current policies scenario vs. what needs to be achieved to meet targets stated for 2030; the 2030 targets have been taken from IEA's APS scenario

SEA and wider APAC have common interests, benefits in building green economy

01 **Energy security a shared priority**
Incentive for strategic collaboration towards regional energy security

~$50B
SEA imported energy value

~$630B
APAC imported energy value



02 **Foreign direct investment inflows**
Shifting dynamics: APAC increasingly important to fund a transition in SEA

~40%
APAC contribution to SEA FDI since 2015

04 **Trade interlinkages**
Trade realignment creates opportunity: Nearly half of SEA's trade is with APAC

~45%
APAC contribution to trade flow of SEA in 2023

Heavy-emitting sectors
High volume trade between heavy-emission sectors like electronics, machinery, chemicals

03 **Green transition synergies**
Leverage each others' resources and strengths for shared green objectives

~45%
global nickel reserves in SEA

~30%
of China's global solar plant investments in SEA nations

Sources: UNCTAD; UN Comtrade; United States Geological Survey

BAIN & COMPANY GenZero Google standard chartered TEMASEK | ecosperity

Collaboration with SEA can bring direct and indirect benefits for wider APAC

Opportunities for wider APAC to benefit from SEA collaboration on systems-level solution implementation

	APAC and SEA collaboration opportunities	Potential direct benefits to APAC (immediate, tangible impact)	Potential indirect benefits to APAC (strategic, long-term impact)
Sustainable bioeconomy 	Secure biofuel/feedstock supply from SEA Co-invest in agritech innovation and deployment across SEA Funding NBS credit projects in SEA	Fulfilling domestic biofuel mandates Gaining access to high-quality carbon credits Creating new market for agritech innovation	Enhancing food and resource security (via climate-resilient agriculture in SEA)
Next-gen grid development 	Collaborating on SEA grid infrastructure planning and deployment Co-developing grid components and smart grid solutions	Increasing demand for APAC-made grid components and smart grid solutions	Improving regional energy stability Laying the groundwork for future energy integration and RE sharing
EV ecosystem 	Investing in end-to-end supply chains to leverage SEA production competitiveness Exchanging knowledge and tech through joint R&D in EV and related technologies	Accessing cost-efficient manufacturing hubs Tapping into new EV export markets	Strengthening supply chain resilience by reducing reliance on Western markets

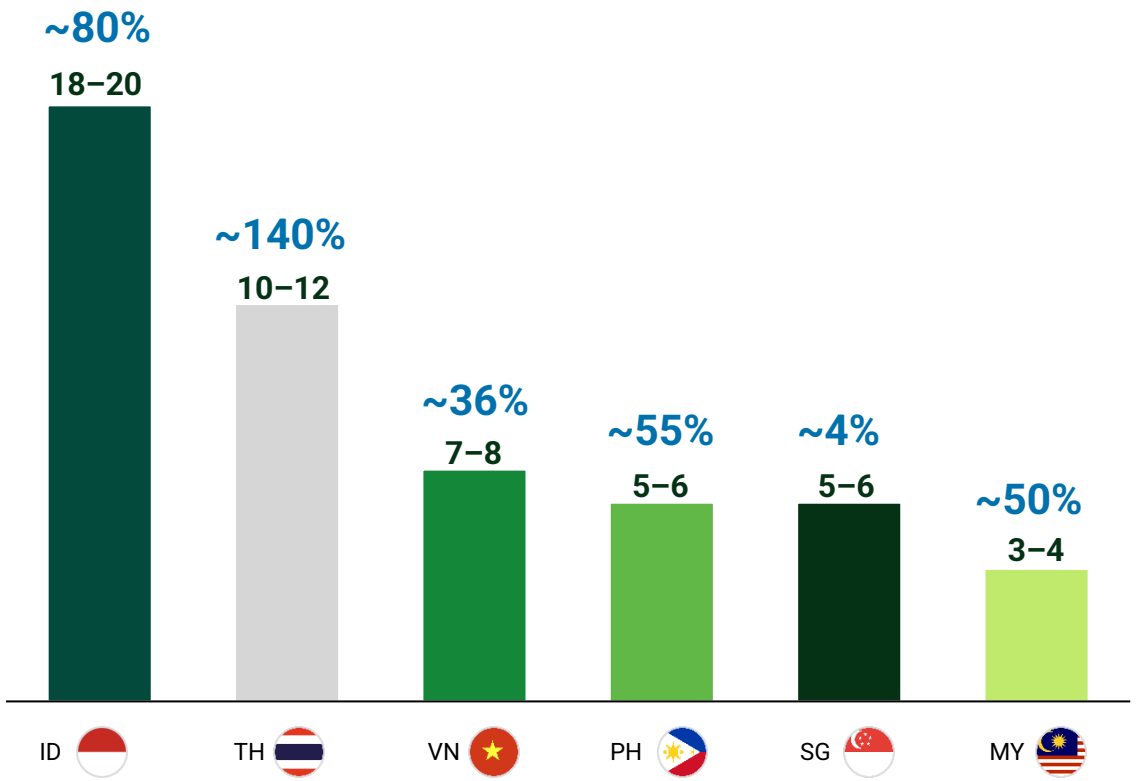
Three systems-level solutions could attract up to $55 billion annually by 2030 and potentially serve to shore up FDI during an economic slowdown

Green investment needs are material as a proportion of current FDI flows

Forecasted annual green investment needs for systems-level solutions in 2030 ($ billion)

Total: **$48–$55 billion**

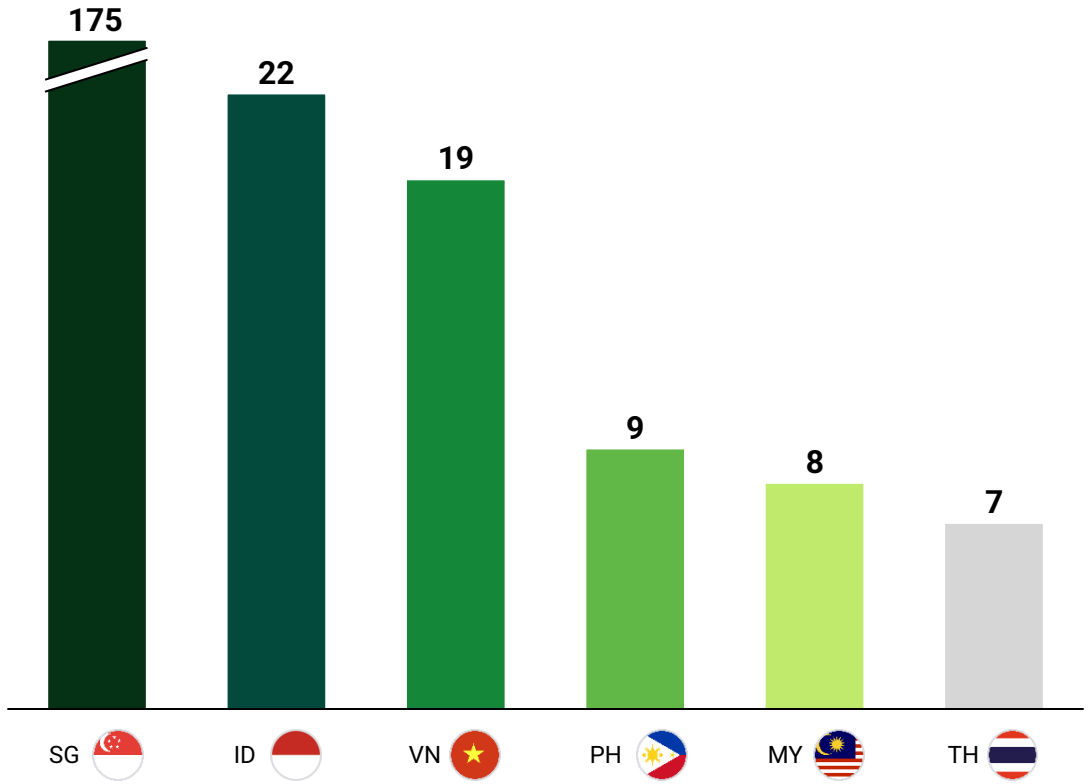
(percentage of country's 2023 FDI)



Current SEA-6 FDI flows into SEA -6

FDI inflow into SEA-6 nations in 2023 ($ billion)

Total: **$230 billion**



Sources: Reuters; The Guardian; Business Insider; ASEAN Investment report 2024; World Bank

CEOs, investors, and governments should seize the opportunity at hand

Call to action

Corporations/ private sector

Integrate sustainability into business models, focusing where near-term value aligns with decarbonization agenda

Collaborate with Asia-Pacific to create a win-win situation by leveraging Asia-Pacific's technology and SEA's resources to enhance resilience and sustainability

Identify and invest in green innovation and practices to deliver value long-term (e.g., 2G biofuels, precision faming, EV value-chain, battery storage, AI-driven solutions); leverage JVs and partnerships to expedite innovation.

Proactively shape sustainable markets by signaling strong demand for green solutions (e.g., long-term PPAs for RE, use of high-quality carbon credits to offset emissions, sustainability criteria for suppliers)

Private FIs and concessional investors

Build and scale high-impact financing tools like green, sustainability-linked, and transition bonds and loans to unlock capital for climate-aligned growth

Collaborate across commercial, concessional, and philanthropic capital providers to advance the design and standardization of blended finance mechanisms to de-risk early-stage projects and crowd-in private sector

Simplify and standardize impact reporting by harmonizing sustainability metrics, frameworks, and verification processes, reducing the burden, especially for those with limited technical capacity (e.g., smallholder farmers (SHFs))

Promote financial inclusion for underbanked groups such as smallholder farmers, who are critical to driving the region's green transition

Government and policymakers

Clarity and consistency in climate policies, roadmaps, and carbon pricing mechanisms, ensuring targets are both practically possible and actionable for investors and corporations

Harmonize regional standards and systems for carbon credit registration and integrity, PPAs, etc. to facilitate cross-border trade, investment, and cultivation of markets at scale

Deploy public funds strategically to catalyze private investment through blended finance structures

Ensure new green industries contribute to talent and workforce development and do not have negative environmental impacts for long-term sustainability to enable implementation of systems-level solutions at scale

By acting now, we can collectively ensure SEA's green economy will drive regional prosperity and sustainability for decades to come

Our recommendations will address systemic obstacles to accelerate decarbonization across the three system-level solutions

	Benefits of systems-level approach	Potential to help in decarbonization across the three systems-level solutions		
		Bioeconomy	EV ecosystem	Next-gen grid development
Need to balance economic growth with transition	Prioritizes creation of new green industries for long-term resilience		✓	
Lack of carbon pricing	Tackles carbon pricing head-on as a key unlock across sectors	✓		✓
Limited regional cooperation	Regional collaboration creates interoperability and cost savings across markets		✓	✓
Economic incentives not well aligned	Aims to realign incentives and taxes to favor low-carbon choices across sectors	✓	✓	✓
Inadequate financing mechanisms	Enables use of finance aligned with regional green and energy goals	✓		✓

State of decarbonization in Asia

03

Asia-Pacific and SEA have key roles to play in global decarbonization as both the source and the solution

Growth in APAC and SEA is a major driver of global emissions …

… while regions are at high risk from climate change

APAC and SEA are crucial to global decarbonization solutions

	Significant contributor to global emissions	Outsized reliance on fossil fuels	Rising energy demand	Impact on economic growth	Vulnerability to climate change-based disasters	High reserves of natural capital	Vast stores of critical minerals	Substantial manufacturing capacity
APAC (including SEA)	**50%** of global GHG emissions	**49%** of energy derived from coal	**5%** energy demand growth vs. ~3% globally[1]	**17%** potential reduction in GDP by 2070 due to climate change	**2x** rise in sea level in APAC vs. global average	**18%** of global forest cover	**55%** of global nickel reserves	**80%** of global solar module production in China
SEA	**7.5%** of global GHG emissions	**50%** of energy derived from coal		**11%** potential reduction in GDP by 2100 due to climate change	**3/20** SEA cities in top 20 coastal cities projected to have world's highest annual flood losses by 2050	**10%** of global forest cover	**45%** of global nickel reserves	**10%** of global solar cell manufacturing capacity

Notes: (1) Energy demand growth over 2010–23. The growing energy demand is also driven by growing population: As of 2023, APAC and SEA have a population of ~4.3 billion and ~0.7 billion, growing at ~0.9% and ~0.7% p.a. respectively; (2) Global Climate Risk Index published by Germanwatch
Sources: IEA reports; EIU; UNESCAP; Database Earth; Asia energy tracker; Asia-Pacific FSC; RECOFTC report; Statista; Borneo Bulletin

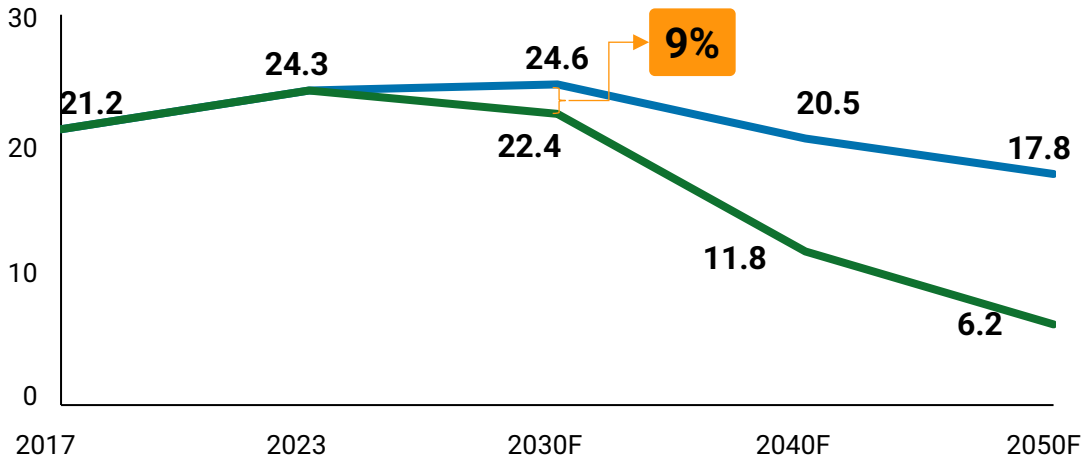
Asia-Pacific and SEA are working to meet 2030 targets with clear gaps to be closed; much work to be done to meet future 2040/2050 commitments

Widening gap between current policies vs. pledged targets for APAC and SEA; achieving pledged targets would bend emissions curve for both regions

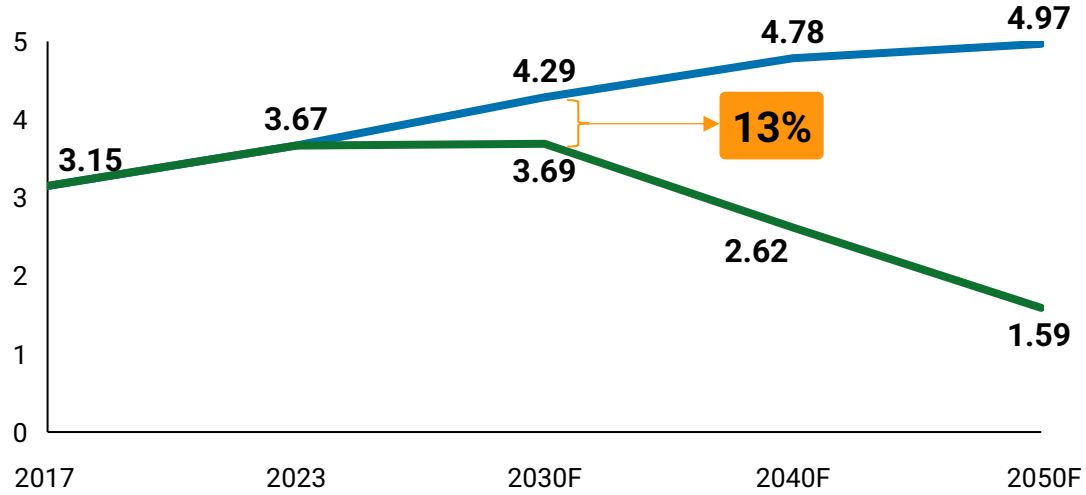
Trajectory based on current policy[1]
(expected temp. rise of 2°C globally by 2050)

Trajectory required to meet 2030 targets and accepted pledges[2]
(expected temp. rise of 1.8°C globally by 2050)

APAC (incl. SEA) GHG emissions (GtCO2e, 2017–50)[3] (including LULUCF[4])



SEA GHG emissions (GtCO2e, 2017–50)[3] (including LULUCF[4])



Notes: (1) Reflecting emission projections based on current policies as of Aug 2024; (2) Assumes that all pledges made by Aug 2024 will be met (incl. NDC, net zero, access to electricity, clean cooking, etc.); this scenario takes into account other factors alongside NDC; Both (1) and (2) are IEA-based scenarios, adjusted to include future projections for LULUCF emissions; global temperature rise (as per IEA's 50% confidence level) under STEPS and APS is 1.5°C by 2030 and 2°C and 1.8°C respectively by 2050; STEPS scenario assumes that all current policies, including those announced by governments, will be implemented as planned. The APS scenario assumes that all the climate-related pledges that countries have announced, including NDCs, will be fulfilled; (3) 2017–23 emissions taken from Climate Watch and 2030–50 emissions taken from IEA after adjusting for LULUCF and non-CO2 gases, assuming share of CO2 in total GHG to be 80% in APAC and 70% in SEA; (4) LULUCF refers to land use, land-use Change, and forestry; LULUCF historical emissions taken from Climate Watch and projected separately for STEPS and APS scenarios, assuming similar growth rate as emissions under the scenarios | Sources: IEA; Climate Watch

Based on current trajectories, most nations will fall short of 2030 targets

On track to meet NDC

May require more action to meet NDC

NDC implied emissions intensity of 0.1 indicates the country's NDC target corresponds to 0.1 % increase in emissions while growing 1% in GDP; negative figure indicates lowering emissions while growing GDP

All emission figures in GtCO2e except emissions per capita

Country	Emissions level (2023)	Emissions level per capita[1] (2023) in tons	Projected emissions (2030F) (base case)[2]	NDC target[3] (2030)	May require more effort to meet NDC?	NDC implied emissions intensity[4] (represents how ambitious the NDC target is)
China	13.4	9.5	16.38	14.00	✓	0.1
India	3.8	2.7	4.73	4.60	✓	0.3
Japan	0.9	7.6	0.73	0.76	?	-0.5 ★
Korea	0.5	11.3	0.52	0.73	?	0.7
Indonesia	1.6	5.9	1.97	1.95	✓	0.3
Vietnam	0.4	4.9	0.73	0.78	?	0.8
Thailand	0.4	6.4	0.50	0.28	✓	-1.3 ★
Malaysia	0.4	11.3	0.44	0.41	✓	0.1
Philippines	0.2	2.2	0.31	0.38	?	0.7
Singapore	0.07	11.9	0.08	0.06	✓	-0.4 ★

Key interventions needed to shift the trajectory today to meet the future targets

★ Denotes highly ambitious NDCs

Notes: (1) Calculated as emissions divided by population (2023); (2) Projected emissions for 2030 are calculated using historical emissions CAGR over the period 2016–23; data gathered from Climate Watch; (3) Target refers to 2030 unconditional NDCs as communicated to UNFCCC;
(4) Calculated as emissions CAGR needed to achieve NDC divided by GDP CAGR for the same period; the value reflects the emissions increase per 1% GDP growth
Sources: UNFCCC BTR; Climate Watch; S&P Global, Bain analysis

Historically, APAC (incl. SEA) and SEA-6 emissions have grown at ~2%–3% and ~3%–4% p.a. respectively; SEA-6 emissions intensity has been higher vs. APAC

GHG emissions (GtCO2e, 2016–23)

	2016	2019	2021	2023	CAGR (2016–23)	CAGR (2021–23)	Emissions intensity[2] (2016–23)	Emissions intensity[2] (2021–23)
APAC (including SEA)	**20.7**	**22.6**	**23.0**	**24.3**	**2.3%**	**2.8%**	**0.6**	**0.7**
China	11.0	11.9	12.8	13.4	2.9%	2.5%	0.5	0.6
India	3.1	3.4	3.4	3.8	3.0%	6.0%	0.6	0.8
Japan	1.2	1.1	1.0	0.9	-3.7%	-6.1%	-8.1	-4.3
Korea	0.6	0.6	0.6	0.6	-1.6%	-4.1%	-0.6	-1.9
Rest of APAC (excluding SEA-6)	1.9	2.0	2.0	2.2	2.1%	4.3%	0.7	1.6
SEA-6 (percentage of contribution in SEA emissions)	2.7 (89%)[1]	3.5 (91%)	3.0 (90%)	3.3 (90%)	2.6%	4.0%	0.7	0.8
Indonesia	1.4	1.9	1.5	1.7	2.5%	5.6%	0.6	1.1
Vietnam	0.3	0.4	0.4	0.5	5.9%	3.4%	1.0	0.5
Thailand	0.4	0.4	0.4	0.5	1.2%	1.3%	0.8	0.6
Malaysia	0.3	0.3	0.3	0.4	1.4%	4.2%	0.4	0.7
Philippines	0.2	0.2	0.2	0.3	3.0%	3.2%	0.8	0.5
Singapore	0.1	0.1	0.1	0.1	1.7%	2.4%	0.6	1.0

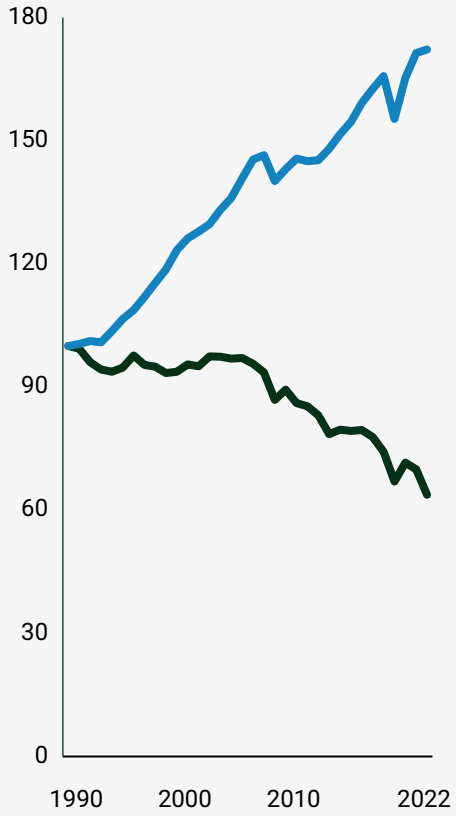
Notes: (1) The percentage refers to the contribution by SEA-6 to overall SEA emissions; (2) Emissions intensity calculated as emissions CAGR divided by GDP CAGR over the same time period; emissions for 2023 calculated by extrapolating Climate Watch's 2021 data using EDGAR's 2021–23 emissions CAGR | Sources: Climate Watch; EDGAR

SEA-6 have yet to start bending the emissions curve, unlike China or the EU

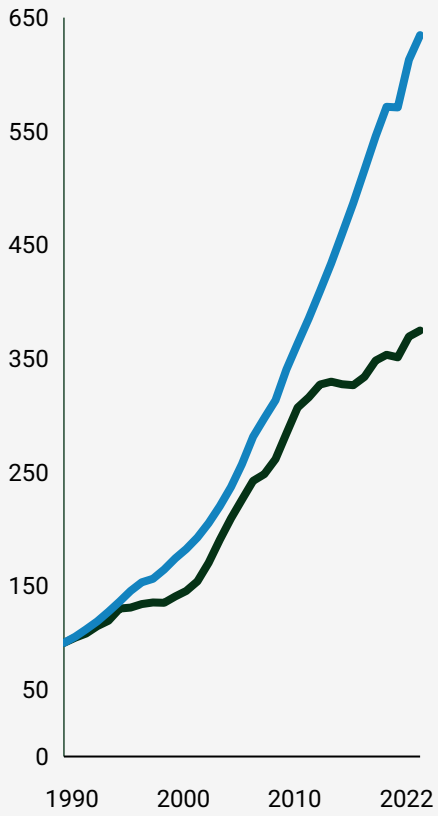
GDP[1] and GHG emissions[2] (1990–2022, indexed to 1990)

GHG emissions GDP

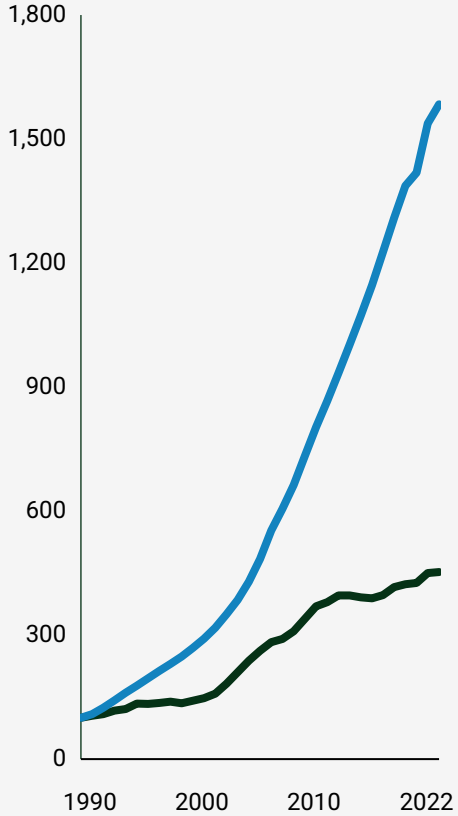
EU 27 + UK



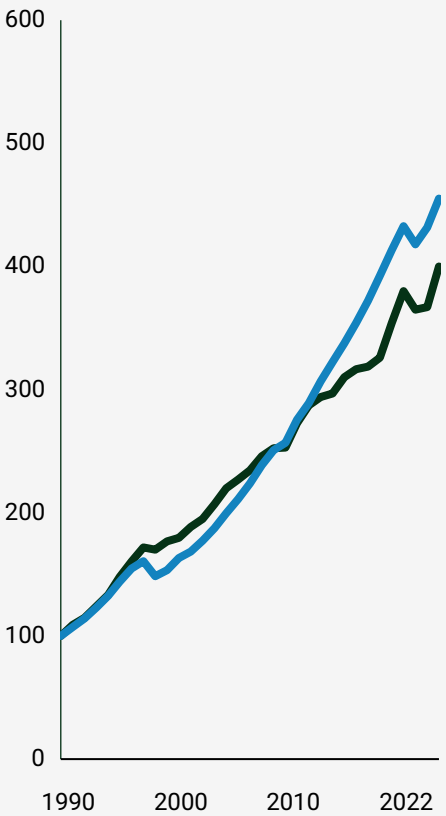
APAC



China



SEA-6



Notes: (1) GDP expressed in year-2015 dollars in purchasing power parity terms; (2) GHG emissions include emissions from energy related sectors, including emissions from fuel combustion; these emissions do not include LULUCF emissions | Source: IEA

New realities challenge and complicate any efforts to increase near-term actions

Shifting global trade order

Increasing restrictions and trade barriers and shifting relationships complicate business planning

4K Potentially harmful trade interventions introduced by G20 members every year from 2021–24[1]

Country climate pullback

Countries falling short of meeting their pledges; current US administration withdrawing from Paris Agreement

75% of climate pledges globally deemed insufficient (2020–23)

Decline in corporate ambitions

Reduced corporate investment in decarbonizing their operations (e.g., manufacturing, supply chain)

Only **4%** of 500 companies globally that pledged to achieve net zero by 2040 are on track to meet their goals

Inflationary pressures

Inflation, high capital costs, and slow global growth raise financing expenses, limiting green investment in emerging markets

2x increase in levelized cost of electricity[2] for renewable plants vs. cycle gas plant in case of 2% increase in risk-free interest rate

Rise of artificial intelligence and digitization

Increase in power demand and emissions from growing data centers and AI computing needs

160% growth in global data-center power demand by 2030; current consumption of 1%–2% global electricity vs. 3%–4% by 2030 (projected by Goldman Sachs research)

Macro uncertainties increase risks for green investments and hinder decarbonization progress

Notes: (1) Global Trade Alert; (2) Levelized cost of electricity (LCOE) is the average cost per unit of electricity generated by a particular energy source, accounting for all costs over its lifetime; a 2% increase in risk-free interest rates projected to push up LCOE by 20% for renewables vs. 11% for cycle gas turbine plant
Sources: Wood Mackenzie; WEF; FEU; Asia Financial; Eco-Business; Goldman Sachs research; Institute for Energy Research

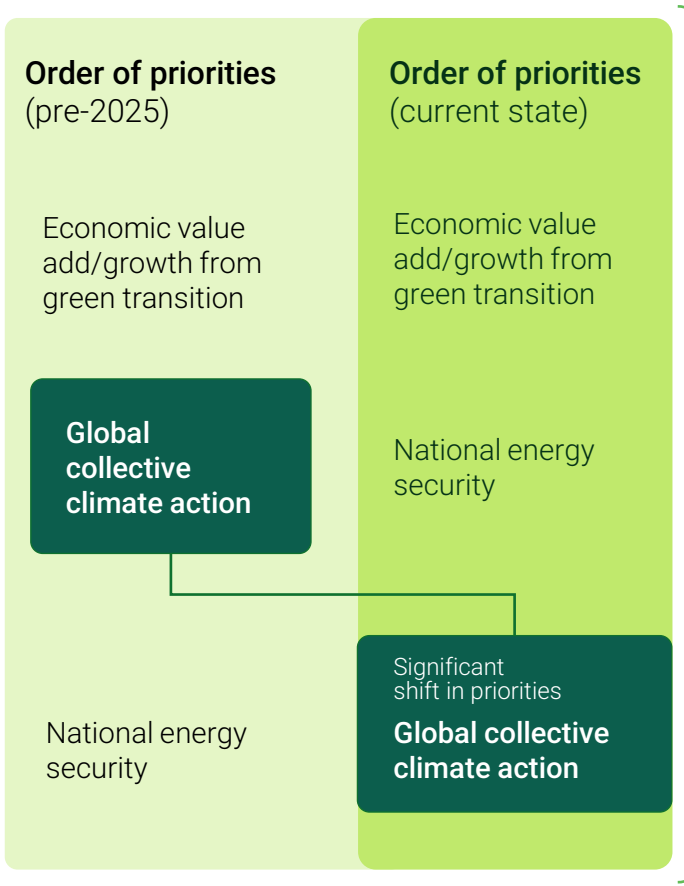
New headwinds cloud the climate outlook, but the stormy present could brighten the outlook for SEA's green transition

Headwinds	Tailwinds	Net results for SEA
Global trade wars hit investor confidence	Green economy as alternative growth lever	Green economy may fill investment gap
Lower Western demand impacts exports	APAC integration deepens	Stronger SEA and APAC green alignment
Legacy dependence on fossil fuels	Increasing cost competitiveness of RE	Renewables improve energy security
Potential reduction in overall FDI	Blended finance mechanisms maturing	New financing channels for green infra
Growing supply chain disruptions	Incentives for supply chain resilience	Growth/diversification of green industries

Convergence of tailwinds may help accelerate the green transition

Governments and corporations are reordering priorities in this new political and economic climate

For many countries, energy security is now a higher priority than global collective climate action or meeting targets



Economic growth from green transition continues to be a key priority for nations ...

> The European Green Deal is a growth strategy focused on economic transformation and security, prioritizing support for the most vulnerable
>
> European Commission President Ursula von der Leyen, 2019

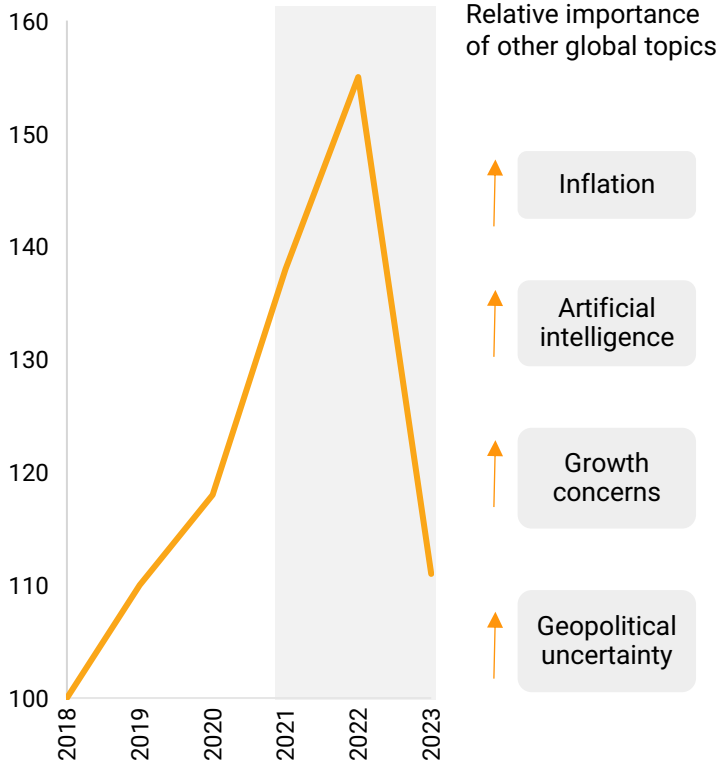
... however, increasingly, energy security is rising in priority over global collective climate action

> At a time of heightened geopolitical tensions, energy security and affordability remain top priorities for Southeast Asia
>
> IEA Southeast Asia Energy Outlook 2024

> We must maintain our baseload power that is delivered from fossil fuels, nuclear, and hydropower
>
> Chairman of the Subcommittee on Energy in the US, 2025

Sustainability concerns have decreased in priority for corporations

Importance of sustainability to CEOs
(indexed to 2018 levels)



Sources: Bain survey on visionary CEO's guide to sustainability 2024; Lit. review

Despite headwinds, the green economy can still drive SEA growth and competitiveness, as it has for neighbors

SEA lags APAC peers in green investment and growth of green industries ...

	APAC	SEA
Green investment[1]	**$659B** (4% of GDP)[2]	**$38B** (1% of GDP)[2]
	$81B (2% of GDP)[2]	
RE penetration generation of solar, wind, and bioenergy as percentage of total energy generation	**17%**	**9%**
	16%	
EV penetration EV sales out of total vehicle sales	**26%**	**<10%–15%**[5]

... which has potentially limited SEA's economic gains from green transition

9% ($1.6T) contribution to **China's GDP** from clean energy sectors[3] in 2023

VS.

~2%[4] ($90B) contribution to **SEA's GDP** from clean energy sectors in 2030

> Clean energy sectors were the largest driver of China's economic growth in 2023, accounting for 40% of GDP expansion in 2023. Without clean energy growth, China's GDP would have grown just 3.0%, instead of 5.2%
>
> Centre for Research on Energy and Clean Air (CREA)

SEA has significant headroom to grow

~$300B[6] potential economic gain from green transition by 2030

Notes: (1) Green investment figures sources from IEA; green investment includes investments across renewable energy power, grids & storage upgradation, nuclear energy, low-emission fuels, and improvements in energy efficiency; (2) Green investments as a percentage of 2024 nominal GDP (in $); (3) Clean energy sectors include solar power, EVs, and batteries; figure sourced from carbon briefing research; (4) SEA's economic contribution from clean energy is not available for 2024; for the purpose of comparison, we have estimated clean energy sector contribution using IEA's projected clean energy value add in 2030 as a percentage of 2030 GDP in SEA; (5) BEV penetration % for 2024; (6) Analysis done in SEA Green Economy 2024 Report | Sources: IEA; S&P Global; ADB; CREA; ET research; Carbon brief; Bain analysis

SEA will need to overcome structural constraints that have hindered past efforts

Dual need to balance growth and transition

GDP per capita is low at <$10K in 2023 (vs. $60K in North America)

Growing energy demand owing to population increase and rapid urbanization

Transition necessary to ensure access to clean and affordable energy for all

Legacy fossil fuel dependence

Economy is 25%–35% dependent on energy-intensive sectors

~150 million employed in energy-intensive industries[1]

Fossil fuels continue to support power generation (~80% dependency)

Uneven opportunities & limited cooperation

Mismatch between renewable energy potential and demand centers

Limited cross-regional grid connections and cooperative mechanisms

Natural commodity dependence

Rubber, palm oil, and wood are important export commodities for SEA-6 region, which has driven deforestation

For example, ~80% of global palm oil export from ID and MY, ~30% of global rubber export from ID, MY, TH

83% of tree cover loss in ID between 2019 and 2023 linked to commodity-driven farming

Inadequate access to financing

Insufficient returns on investments with higher perceived risks (e.g., currency fluctuation, regulatory risks)

Renewable projects, typically with higher leverage and upfront capital needs, face greater financing challenges amid rising structural inflation[2]

Notes: (1) Energy-intensive industries include mining, manufacturing, and construction; (2) Based on assessment by World Economic Forum |
Sources: IMF; Global Energy Monitor; UN Comtrade; Expert interview; Lit. search; Bain analysis

Leveraging a strong foundation in regional partnership can help SEA and wider APAC overcome constraints with innovative solutions for both regions' benefit

Regional trade agreements

Agreements between countries in a specific geographic area to enhance economic cooperation, knowledge sharing, trade, and development

Regional Comprehensive Economic Partnership (RCEP)

Description

Launched in 2022, RCEP targets elimination of 92% of import tariffs for participating countries

Impact

$186B addition of real income to world economy by 2030

2.8M jobs to be created for the member nations

ASEAN-China Free Trade Area (ACFTA)

Description

Launched in 2005, ACFTA aims to improve trade by eliminating tariffs (tariffs eliminated on 90% of imports by 2010)

Impact

10% YoY growth in China-ASEAN trade from 2014–23

9% YoY rise in Chinese investments from 2013–22

Special economic zones (SEZ)

Zones with distinct business and trade laws to attract investment or promote new industries; 10,000+ such SEZs exist across Asia

Johor-Singapore SEZ

Description

Launched in 2025, the Malaysia-Singapore SEZ aims to boost cross-border trade and investment with tax incentives

Impact

$38B economic boost expected by 2030

20K jobs to be created for both nations

Eastern Economic Corridor (EEC)

Description

Launched in 2018, EEC aims to boost economic development using tax incentives; received investment from nations including China, Japan

Investing nations

Impact

$14B expected global investments from 2024–29

0.5M skilled workers employed between 2019 and 2023

The APAC-SEA region rests on a strong foundation, but it must overcome emerging challenges and make deliberate policy choices to sustain and deepen regional connectivity

Sources: UNCTAD; RAND; Intereconomics; China briefing (news report); Asian Development Bank; Malaysian Investment Development Authority; Thailand EEC report

New pathways to accelerate decarbonization and the green economy may lie in often underappreciated connections between Asia-Pacific and SEA as partners

01 Common energy security concerns

Both SEA and Asia-Pacific's reliance on imported energy is set to grow, incentivizing both regions to reduce their growing import vulnerability through technology transfer and resource sharing

02 Strong trade relations

SEA is a key and growing trading partner for Asia-Pacific, with high interlinkages in multiple supply chains (e.g., production of electronics components in China and assembly in SEA)

03 High FDI inflow across regions

Key Asia-Pacific economies contribute ~40% to SEA's FDI, heavily shaping infrastructure, technology, and energy investments in SEA

04 Green transition synergy

Asia-Pacific markets are building foundations for a green transition, with China and Japan advancing green industries in SEA

Asia-Pacific and SEA both rely heavily on imported energy, which is a serious concern for energy security

Most Asia-Pacific and SEA countries are fossil fuel importers, underscoring need for self-sufficiency

High volume of coal and LNG being imported for fulfilling energy needs ...

Net importer Net exporter

Country	Net coal[1] imports[2] (million tons)			Net LNG[3] imports (billion cubic meters)		
	2019	2021	2023	2019	2021	2023
China	370	232	516	82	107	97
India	503	441	509	31	31	29
Japan	371	364	335	111	97	92
Korea	140	124	239	53	60	60
Indonesia	-911	-853	-1,023	-17	-16	-18
Malaysia	34	72	76	-33	-30	-27
Singapore	0.01	0.02	1.09	5	5	7
Thailand	44	9	24	7	9	12
Philippines[4]	32	41	57	-	-	2
Vietnam[4]	86	69	61	-	-	1

... causing huge cash outflow

Value ($ billion) of net imports[5]
2023
289
117
118
104
-34
12
30
32
7
4

Notes: (1) Coal includes lignite, briquettes, ovoids, coke, semi-coke; (2) Net imports = imports – exports; (3) Liquefied natural gas; (4) Philippines and Vietnam began importing LNG for the first time in 2023, emerging as newest LNG importers on world map; (5) Includes net coal and natural gas; coal includes lignite and natural gas includes crude petroleum; Imports for China and India are increasing due to increasing power needs which is outpacing growth of RE | Sources: Fitch; UN Comtrade; S&P Global; Helgi Library

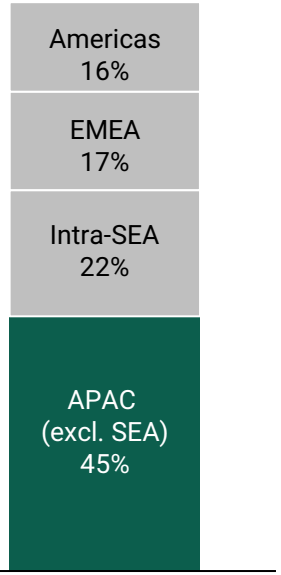
Asia-Pacific is a key trading partner for SEA (~45% of trade)

Trade flows between APAC and SEA-6: APAC contributes 45% to SEA's $3.2T global trade

$ billion, 2023 (percentage of total trade)

> 25% | 10%–25% | <10%

3,291



SEA trade with the world

Category	SEA-6 exports to APAC[2] (category as a percentage of total exports)	SEA-6 imports from APAC[2] (category as a percentage of total imports)
Electronics	228 (30%)	222 (31%)
Machinery	94 (13%)	64 (9%)
Chemicals	88 (12%)	64 (9%)
Metals	85 (11%)	56 (7%)
Minerals	69 (9%)	102 (14%)
Agriculture	60 (8%)	109 (15%)
Materials	25 (3%)	21 (3%)
Other[1]	100 (14%)	87 (12%)
Total	749 (100%)	725 (100%)

SEA-APAC trade expected to **grow at a 7% CAGR until 2030,** with imports rising faster than exports **(7.6% CAGR vs. 6.5%),** indicating continued dependence

Strong trade links seen in **multiple high-emissions** sectors (electronics, machinery, chemicals)

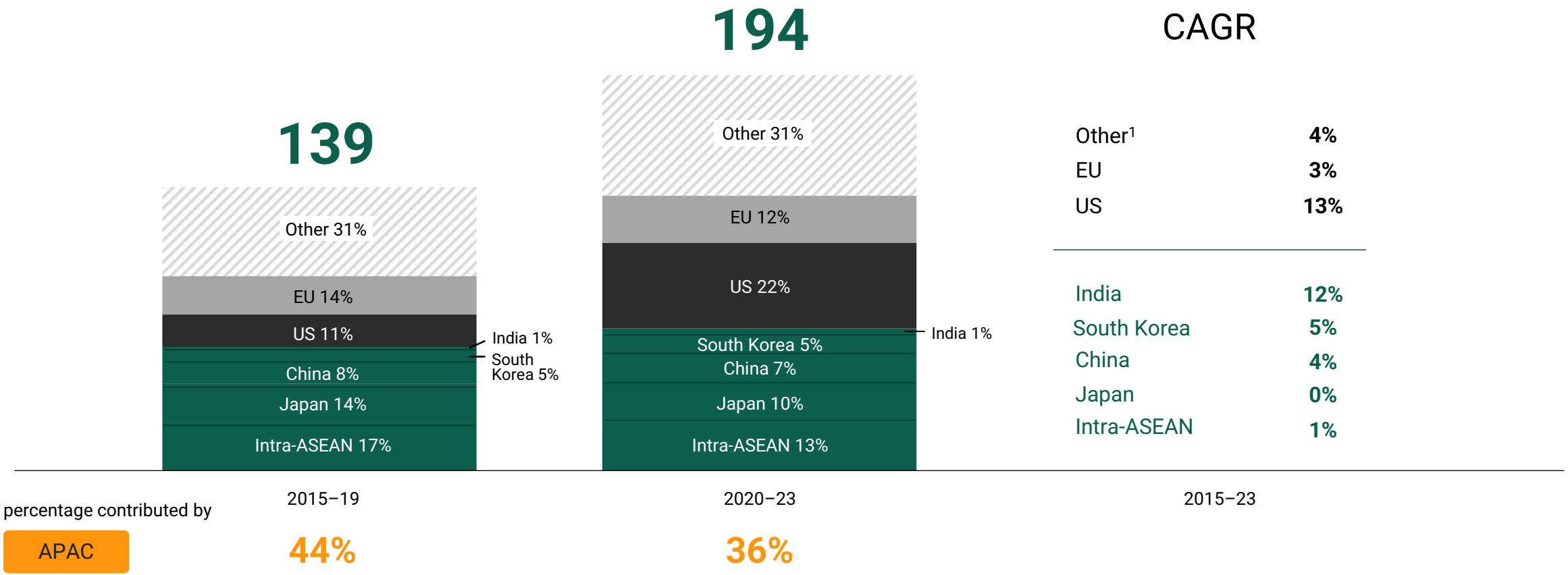
Interconnected electronics supply chain, with components from China and assembly in SEA, means green transition in one region affects all regions

Note: (1) Other includes textiles, automobiles, aircrafts; etc.; (2) APAC here excludes SEA-6 nations | Sources: UN Comtrade; Standard Chartered report on "Future of Trade"; Lit. search

Key Asia-Pacific economies contribute ~40% of SEA's FDI, shaping infrastructure, technology, and energy investments

Strong interdependence between SEA and Asia-Pacific, with Asia-Pacific consistently contributing ~40% of SEA's FDI

FDI inflows in SEA ($ billion)



Notes: Period refers to average for each period; FDI inflows refer to investments into ASEAN Member States; (1) Other refers to remaining nations contributing to FDI in SEA, such as middle-eastern nations, Australia, etc. | Sources: ASEAN statistics; UNCTAD

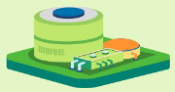
Strategic linkages to advance decarbonization already exist across SEA and Asia-Pacific

SEA provides minerals and green manufacturing vital for decarbonization

23% of global bauxite[1] reserves held by SEA

20% of global rare earth elements (e.g., cerium, europium, etc.) held by SEA

45% of global nickel reserves in SEA



63% of global refined nickel production being contributed by SEA

~4x projected increase in EV battery manufacturing in SEA by 2030

Asia-Pacific nations drive green tech collaboration with SEA through cross-country partnerships

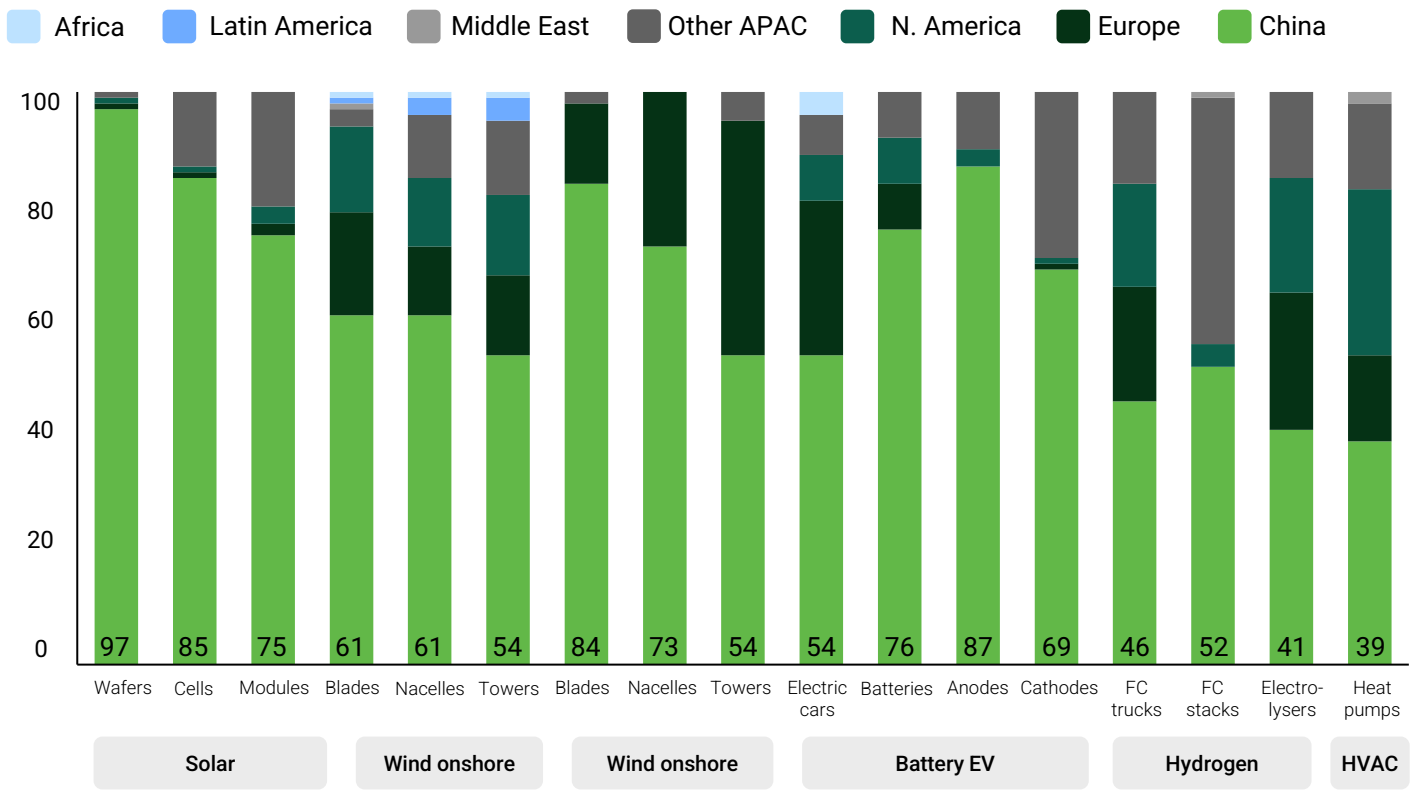
	Technology	Region	Description
	Solar PV Offshore wind development Energy storage systems	China	~$40 billion investment in power sector across SEA nations ~30% of China's global solar plant investment to SEA nations (totaling over 51 GW) Deep dive in following pages
	Carbon capture Ammonia & Hydrogen	Japan	150+ agreements signed under Asia Zero Emission Community (AZEC) for investments across non-coal fossil fuels and renewable sector Deep dive in following pages
	EV batteries capacity and plants	South Korea	Leveraging ASEAN-South Korea strategic partnership to invest in EV infrastructure and battery manufacturing in SEA

Notes: (1) Bauxite is used in green infrastructure due to its light weight, durability, and resistance to corrosion | Sources: UN Comtrade; IEA; Lit. review

China, as a leading global clean tech manufacturing player, is expanding green investments in SEA to tap into SEA's resources and markets

China is a strong global player in clean tech manufacturing and is the leading provider of clean tech solutions to the world

Regional share of manufacturing capacity (percentage)



China is also expanding green value chains in SEA, leveraging their improvements in manufacturing facilities

Nickel smelting and processing	EV manufacturing	Solar panel manufacturing
Indonesia 2024: JV between Chinese GEM Co. and PT Vale (ID) to build $1.4 billion nickel plant for EV battery manufacturing	**Indonesia** 2025: BYD (CN) completing buildout of a $1.3 billion EV manufacturing plant	**Vietnam** 2022: Jinko Solar set up a 7 GW plant for solar cells and modules
Vietnam 2013: JV between Tsinghan group (CN) and an Indonesian player to build upstream nickel industrial area[1]	**Indonesia** 2024: JV between Chinese and VN carmaker to build $800 million EV manufacturing plant	**Malaysia** 2017–24: Three Chinese firms committed funds to build solar PV facilities. However, the firms are scaling back investments considering US tariffs

Notes: (1) The area, called the Indonesia Morowali Industrial Park, houses 11 smelters within the park | Sources: Malaysia Investment Development Authority; World Resource Institute; The Edge Malaysia; The Investor Vietnam; The People's Map; The Star; Jakarta Globe; South China Morning Post; Tech in Asia; JV member web pages

Japan launched the Asia Zero Emission Community as a platform for green investment in SEA

Key nodes for engagement with SEA nations

Asia Zero Emission Community (AZEC)

Platform to drive strategy and collaboration between SEA and Japan for achieving net-zero emissions

150+ MoUs signed across SEA nations in non-coal energy sector since AZEC launch in 2023

Examples of investment from Japan into SEA

Thailand

Feasibility study by Mitsubishi for ammonia co-firing at a coal-fired BLCP power plant (Banpu)

Indonesia

JV by ITOCHU Corp. with Pupuk Indonesia to set up world's first hybrid green-ammonia facility

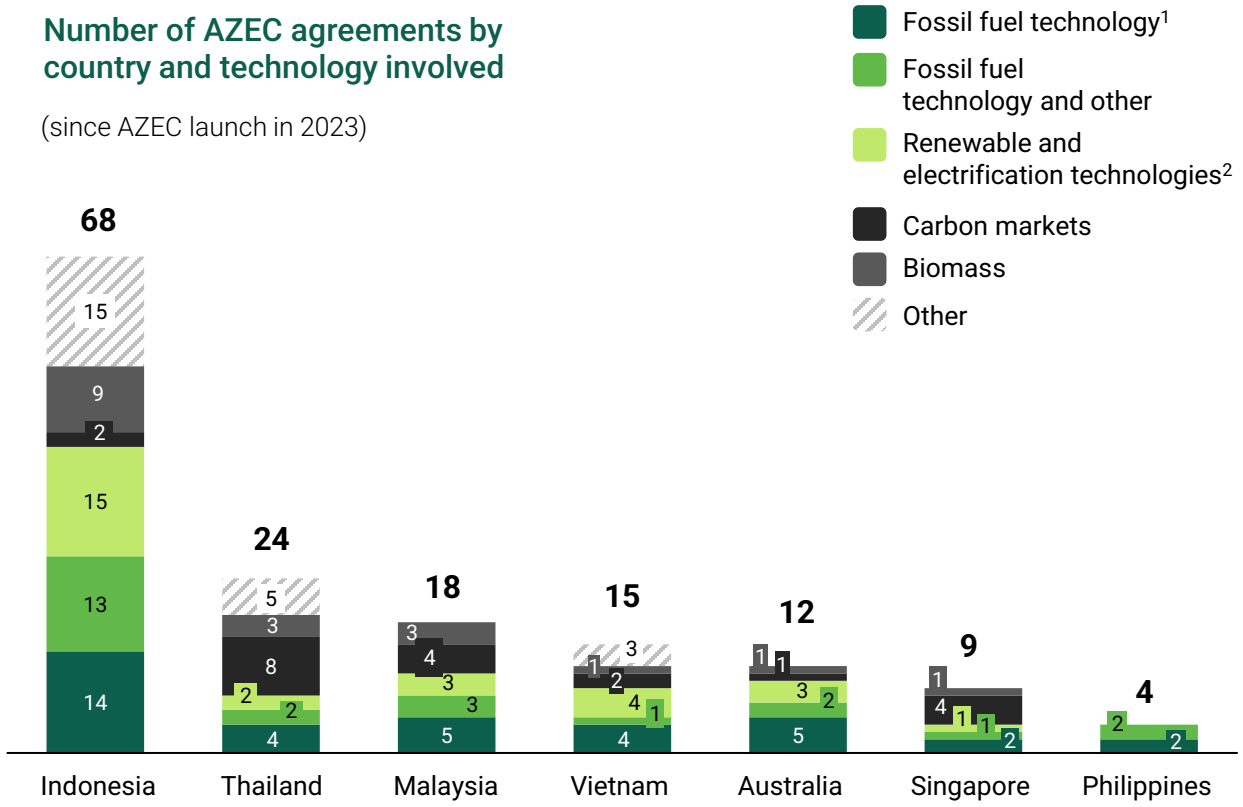
Malaysia

Investment by Euglena Co. to produce sustainable aviation fuel (SAF) and hydrogenated vegetable oil (HVO)

Most investments focus on non-coal fossil fuels and renewables

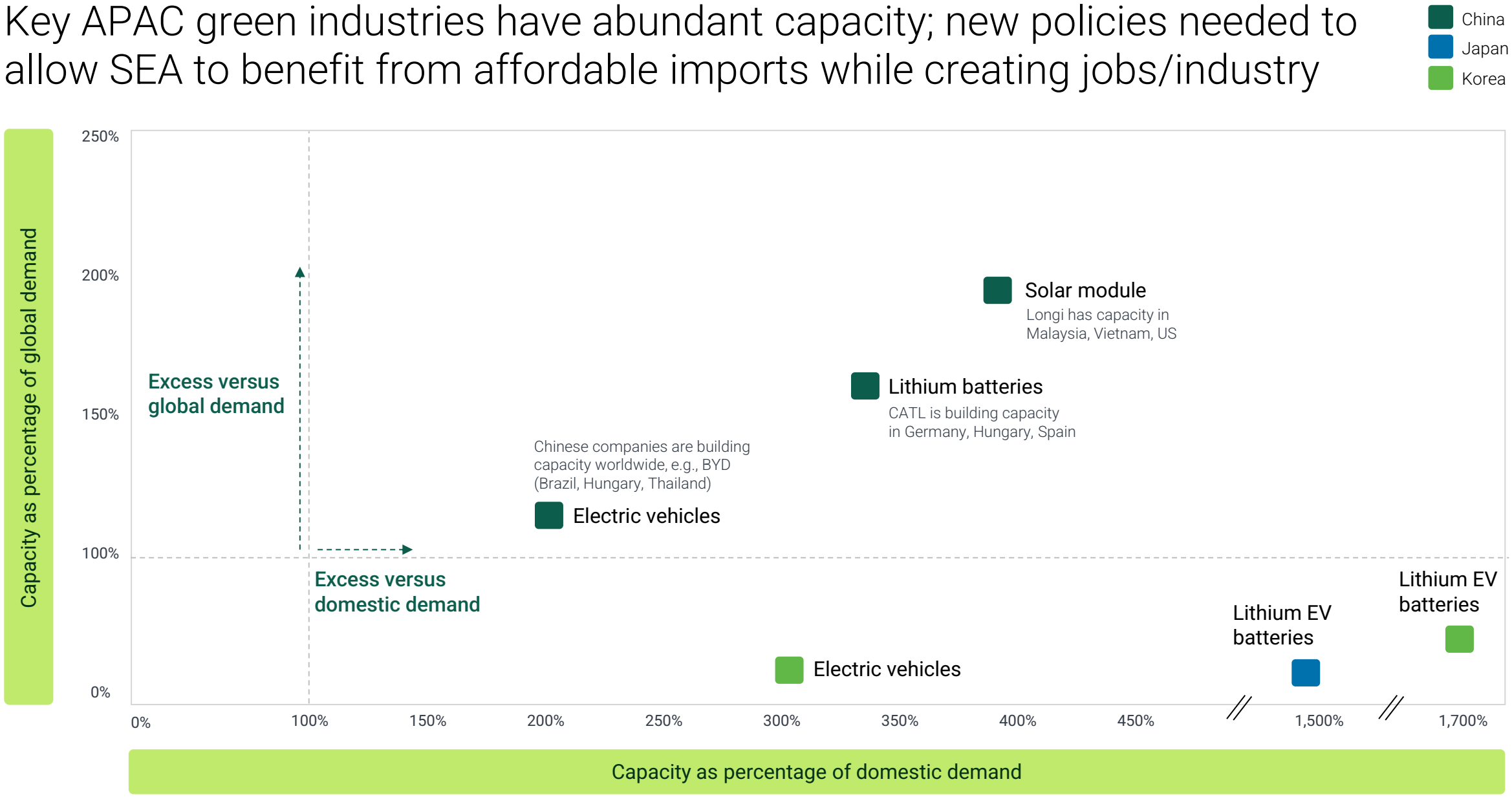
Number of AZEC agreements by country and technology involved

(since AZEC launch in 2023)



Notes: (1) Fossil fuel technologies are defined as: natural gas, LNG, ammonia co-firing, ammonia, carbon capture and storage (CCS), carbon capture utilization and storage (CCUS), hydrogen, and e-fuels; (2) Renewable and electrification technologies are defined as: solar photovoltaic (PV), wind, renewable power, green hydrogen, green ammonia, hydropower, geothermal, battery storage, electric vehicles, and waste management | Sources: Zero Carbon Analytics; Japan Ministry of Economy & Trade

Key APAC green industries have abundant capacity; new policies needed to allow SEA to benefit from affordable imports while creating jobs/industry



Sources: Lit. research; Goldman Sachs report 2024; IEA; IRENA; Bain analysis

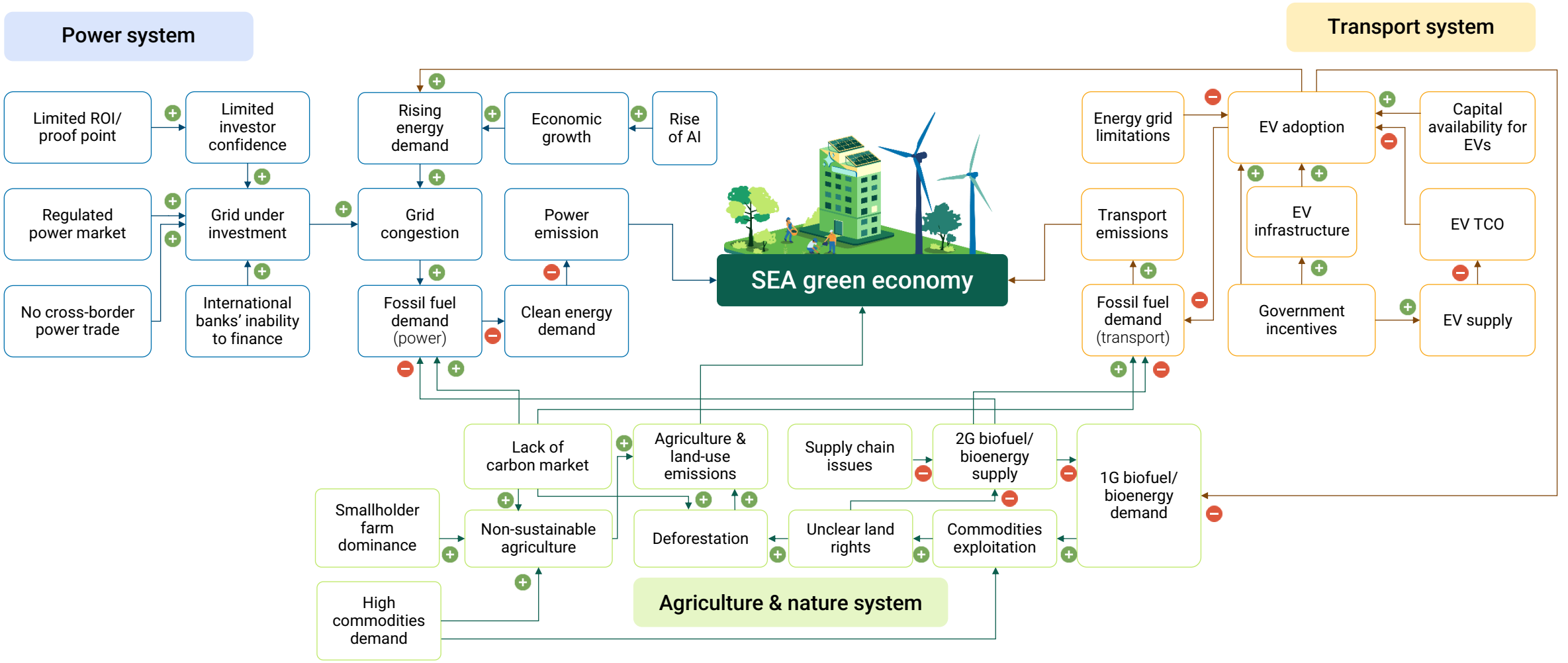
Introduction to systems thinking and solutions

04

Southeast Asia's green economy is a set of linked systems, where changes in one area can impact others

As-is state: Systemic behaviors perpetuating cycle of emissions in SEA

Illustrative and non-exhaustive



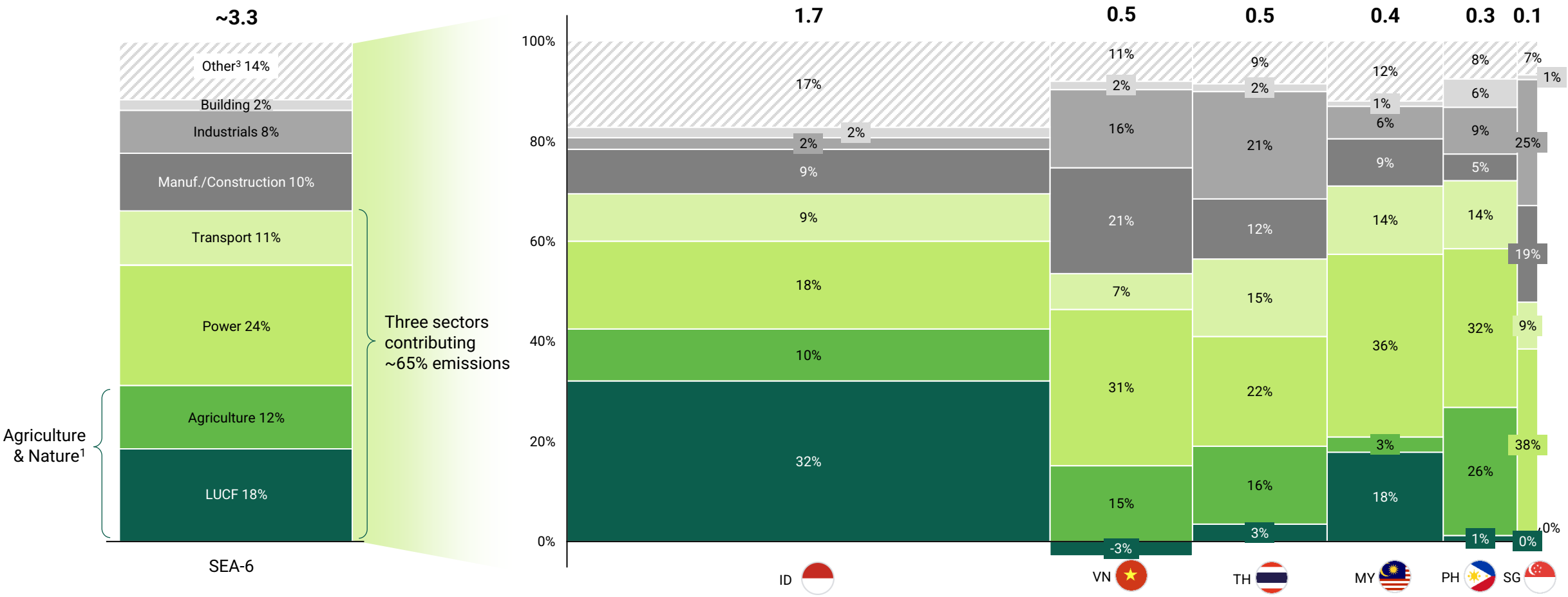
High-impact systems-level solutions should optimize across two key outcomes

Prioritizing the right systems-level solutions requires identifying systems with significant emission and economic impact

From an emissions lens, Agriculture & Nature, Power, and Transport are the biggest contributors to SEA emissions (~65%)

SEA-6 GHG emissions by sectors (GtCO2e, 2023)

Total = **~3.3GtCO2e**

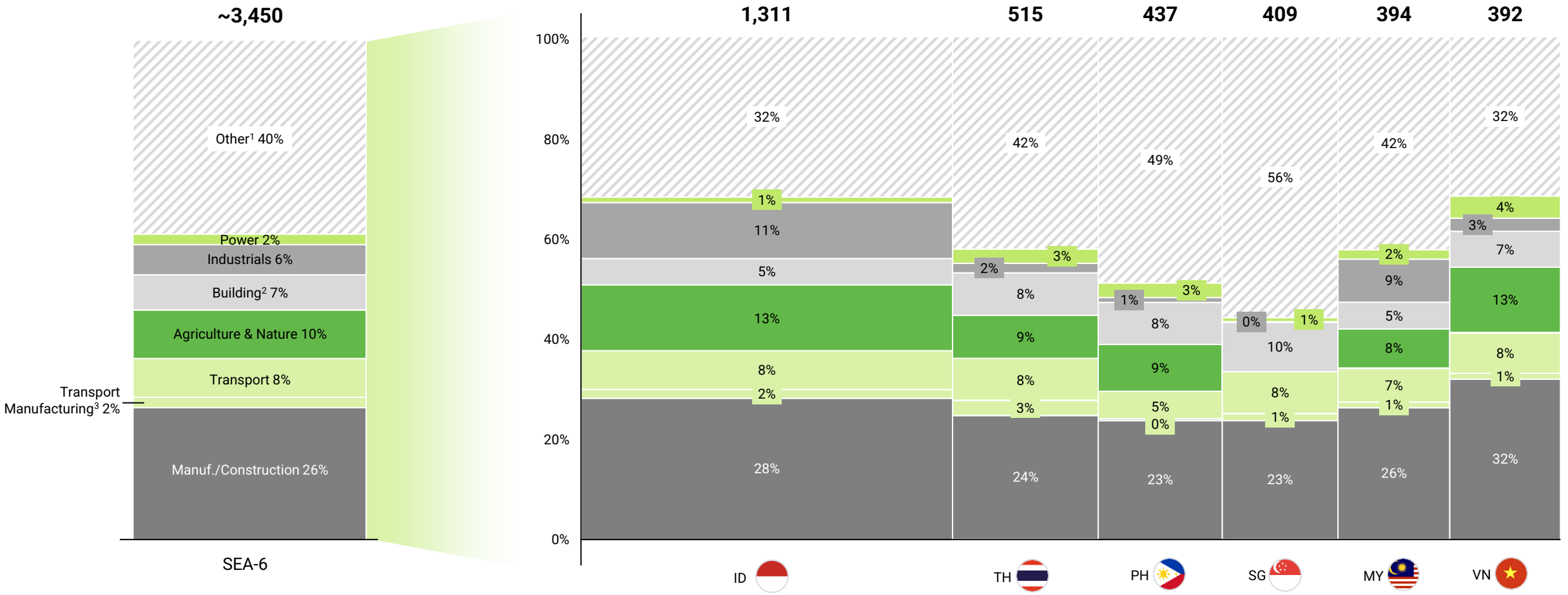


Notes: (1) Agriculture & Nature includes agriculture and LUCF; (3) Other includes waste, industrial processes, and bunker fuels | Source: Climate Watch

An alternative economic lens shows Agriculture & Nature, Transport, and Power directly contribute ~20% to SEA-6 GDP

SEA-6 GDP value-added by sectors ($ billion nominal, 2023)

Total GDP value-added = **~$3,450 billion**

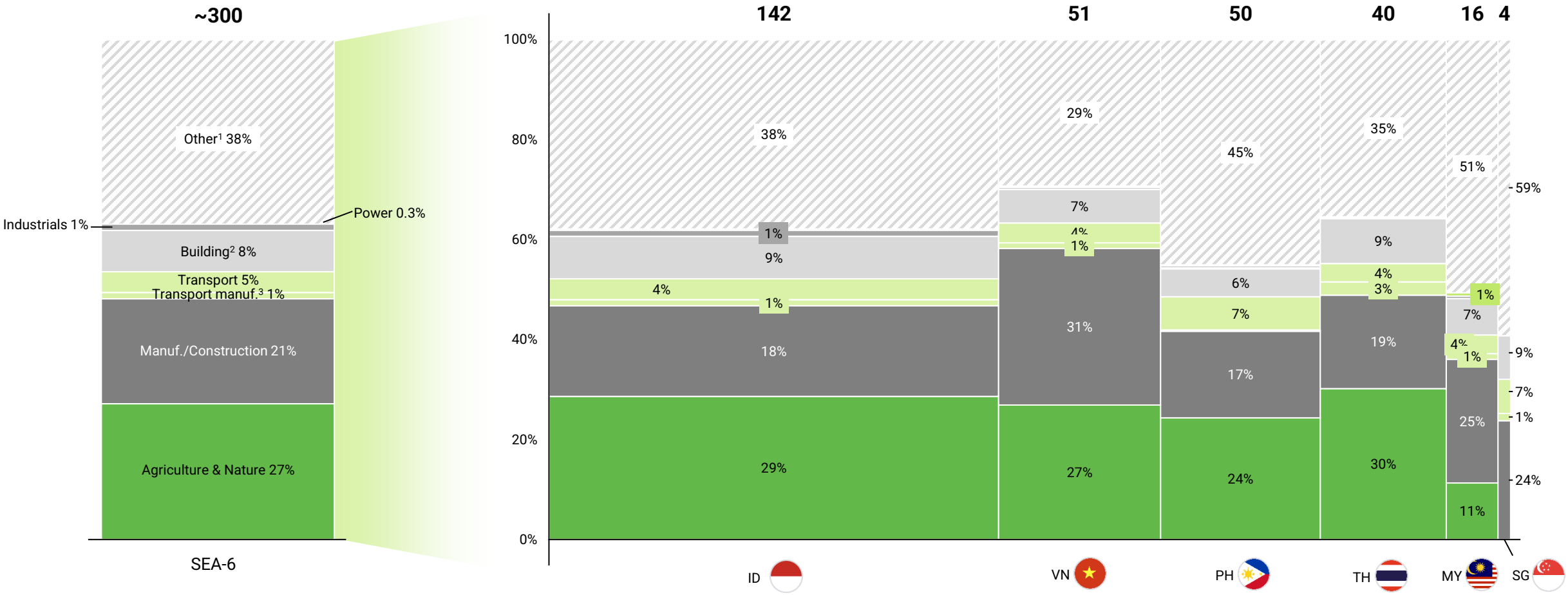


Notes: (1) Other includes insurance, financial services, I&C, arts, entertainment, etc.; (2) Building includes waste management, accommodation, and real estate activities; (3) Transport manufacturing includes manufacturing of motor vehicles, ships, aircrafts, etc. | Source: S&P Global

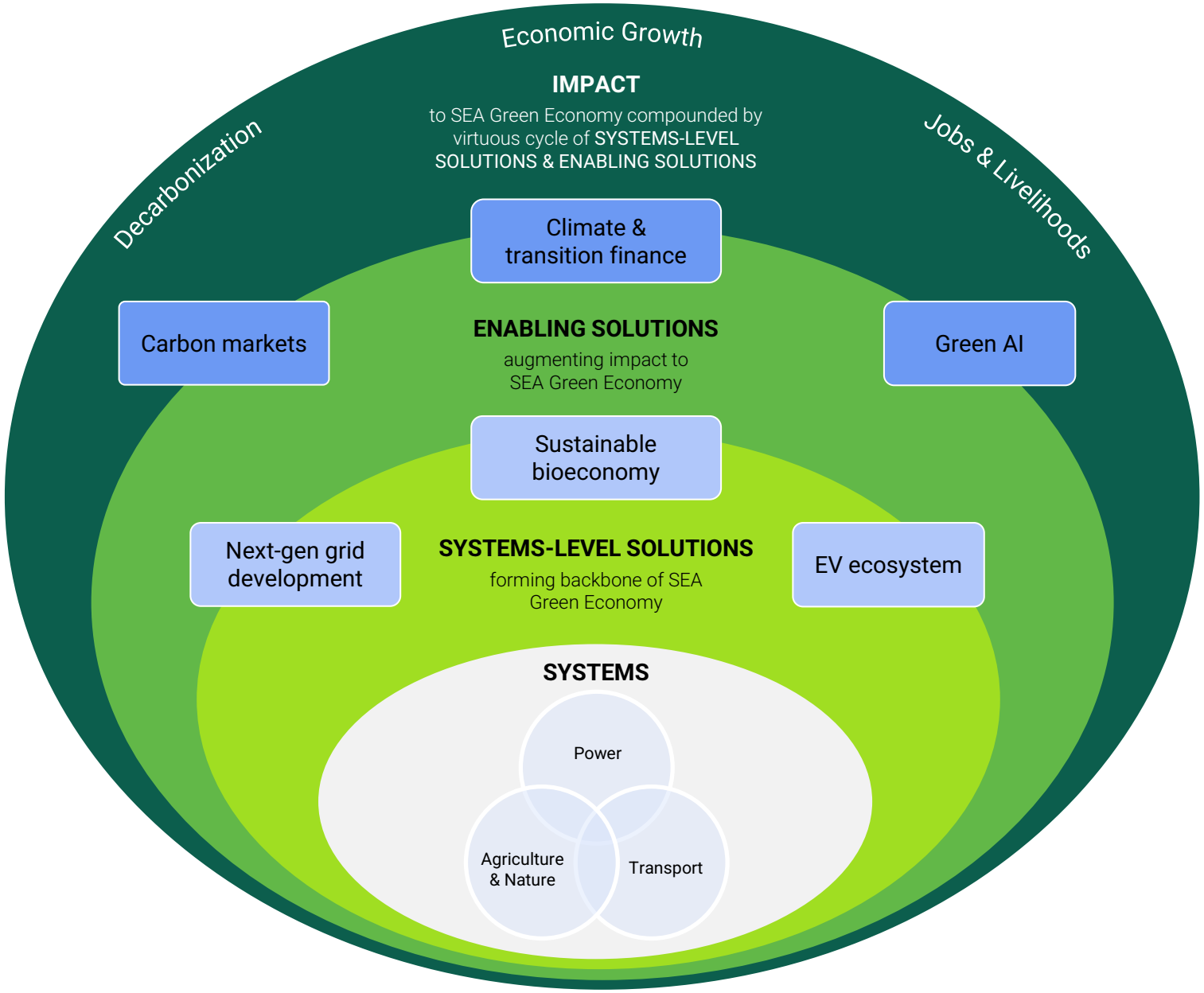
At the same time, Agriculture & Nature account for a large share of jobs and livelihoods in most economies; ~33% of SEA-6 employment comes from the sector

SEA-6 employment by sectors (millions, 2023)

Total number of people employed = **~300 million**



Notes: (1) Others includes insurance, financial services, I&C, arts, entertainment, etc.; (2) Building includes waste management, accommodation, and real estate activities; (3) Transport manufacturing includes manufacturing of motor vehicles, ships, aircrafts, etc. | Source: CEIC



Analyzing interconnected systems is key to identifying systemic barriers and high-impact systems-level solutions to accelerate SEA decarbonization

Systems-level solutions

Enabling solutions

This report dives deep into three systems-level solutions for SEA: sustainable bioeconomy, next-gen grid development, and EV ecosystem

Sustainable bioeconomy

Leveraging SEA's natural capital and assets for economic benefit and carbon reduction by promoting sustainable agriculture, expanding nature-based solutions, and scaling biowaste utilization

Next-gen grid development

Investing in grid infrastructure to eliminate a critical bottleneck to scale renewable power generation, with long-term positive impacts on regional energy security and affordability

EV ecosystem

Accelerating 2-wheeler (2W) and 4-wheeler (4W) EV adoption by implementing buyer incentives, triggering enabling infrastructure development, and developing regional EV supply chains

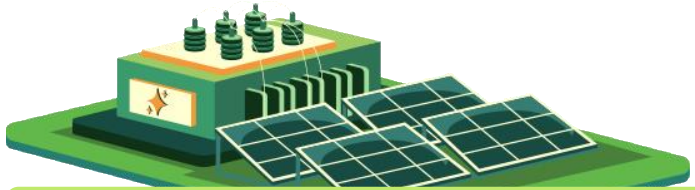
It further acknowledges the key enabling solutions: climate & transition finance, carbon markets, and green AI

Climate & transition finance

Expanding access to capital for decarbonization through innovative financing models, regional financing frameworks, strengthened policies, and enhanced risk-sharing mechanisms

Carbon markets

Further establishing domestic and regional connected carbon markets, driving demand through stronger carbon policies, increasing supply of large-scale verifiable credit projects, and strengthening enabling infrastructure

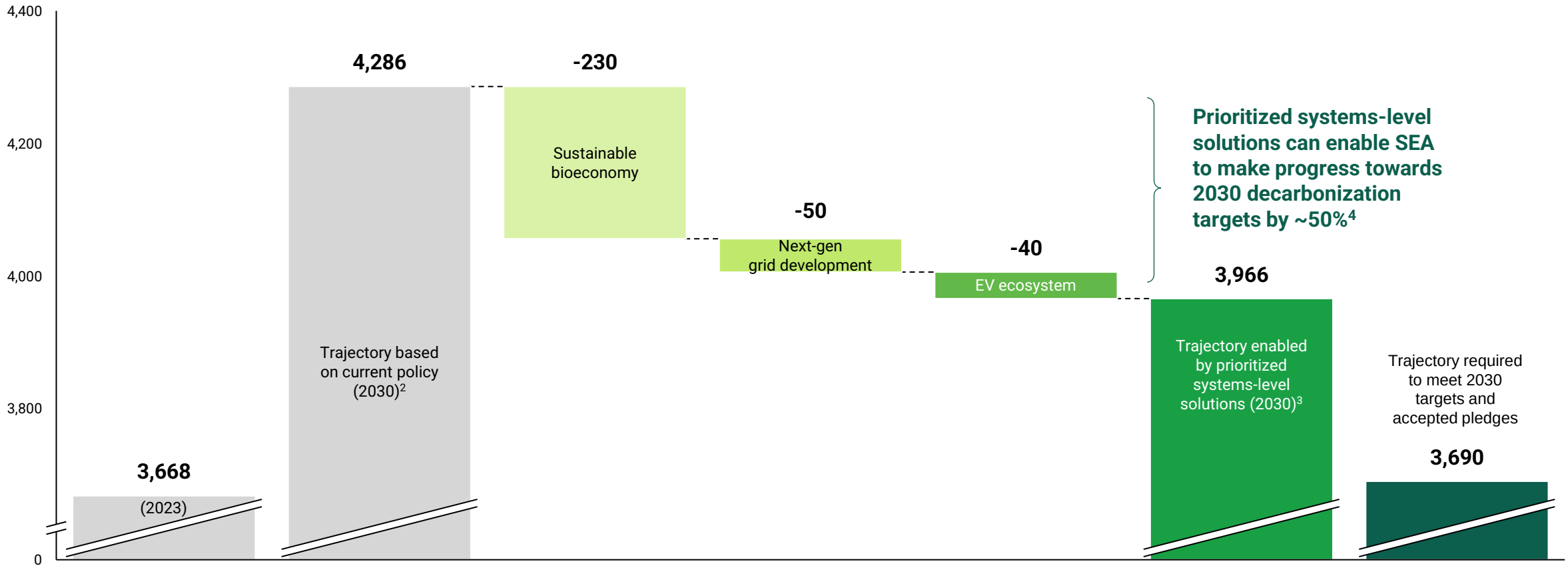


Green AI

Advancing AI-driven sustainability solutions while ensuring sustainable data center growth through domestic and regional mechanisms (e.g., regional clean energy trading)

Prioritized systems-level solutions can enable SEA to close ~50% of the gap to 2030 targets

SEA GHG emissions (in MtCO2e)[1]

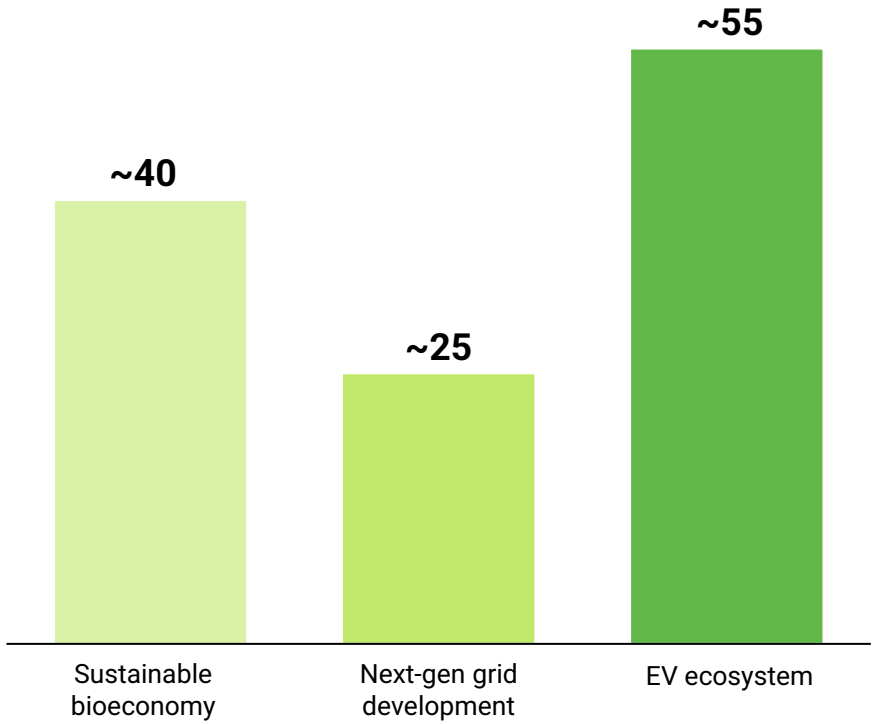


Notes: (1) 2023 emissions taken from Climate Watch and 2030 emissions taken from IEA after adjusting for LULUCF and non-CO2 gases, assuming share of CO2 in total GHG to be 70% in SEA; LULUCF historical emissions taken from Climate Watch and projected separately for STEPS and APS scenarios, assuming similar growth rate as emissions under the scenarios; (2) Reflecting emission projections based on STEPS as of Aug 2024; (3) Reflecting emission projections based on APS, assuming all pledges made by Aug 2024 will be met (incl. NDC, net zero, access to electricity, clean cooking, etc.); both (2) and (3) are IEA-based scenarios, adjusted to include projections for LUCF emissions (4) Based on forecasted adoption of low-carbon solutions and their emissions impact from production, use, efficiency gains, fuel shifts, land-use changes, etc. | Sources: IEA; Climate watch; IEA; US EPA; Euromonitor; Lit. Search; Bain analysis

Actioning prioritized solutions could create ~$120 billion in new value from green economy and generate ~900,000 jobs annually by 2030 for SEA

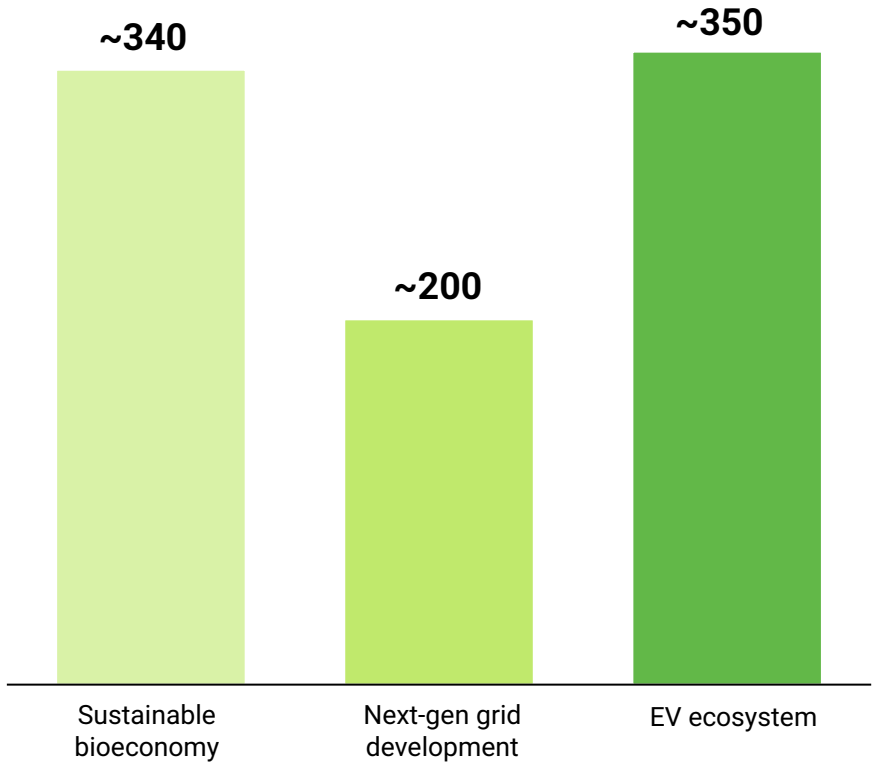
Estimated GDP contribution from systems-level solutions ($ billion, 2030)

Total GDP contribution[1]: ~$120 billion (2% of SEA-6 GDP)



Estimated job creation from Systems-level solutions (thousands, 2030)

Total job creation[2]: ~900,000



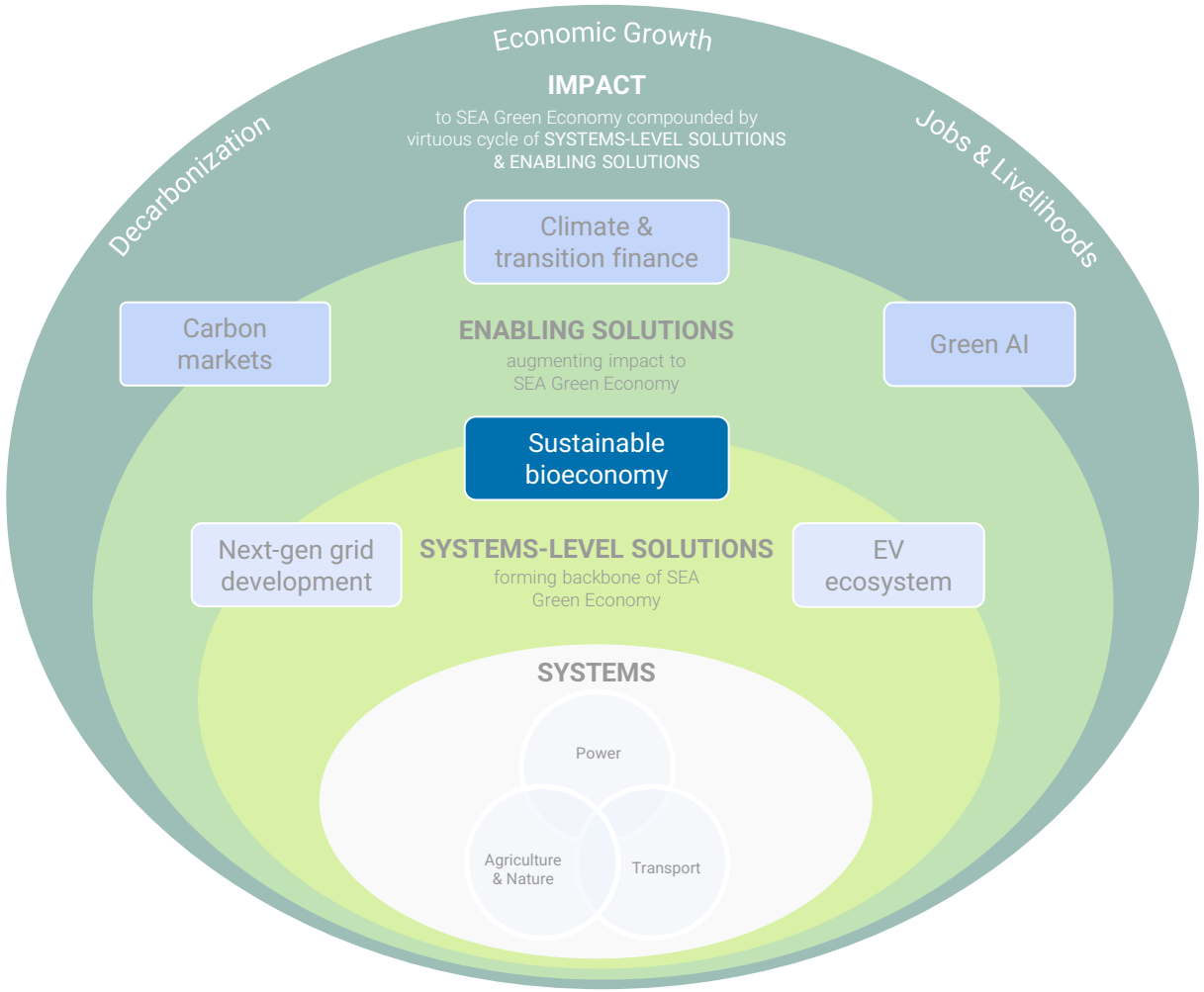
Notes: (1) GDP contribution based on projected 2030 value of solutions, infrastructure growth, and efficiency gains from increased sales, related direct investments and relevant indirect investments; (2) Job creation based on job elasticity and employment forecasts in key industries by 2030 | Sources: IEA; IRENA; World Bank; S&P; Euromonitor; Nature for Climate; Climate Trace; GlobalData; Lit. search; Bain analysis

Systems-level solution 1

Sustainable bioeconomy

05

Sustainable bioeconomy | Key takeaways



Potential results from the solution in 2030

~230 MtCO2e reduction	~340,000 jobs created	~$40 billion annual GDP contribution

01 **Bioeconomy is a critical part of the SEA-6 economy,** accounting for ~30% of the region's combined natural, human, and built capital, and ~25%–30% of jobs in key markets

02 **Current bioeconomy practices fuel emissions and deforestation,** contributing ~30% to total emissions in SEA-6 and ongoing forest loss

03 **SEA-6 bioeconomy faces major efficiency gaps across yields, waste utilization, and climate resilience—**addressing these is critical for growth

04 **Systemic barriers have stalled value unlock to date —**smallholder farm dominance, infrastructure gaps, unclear land rights, weak carbon markets

05 **Enhancing value from agriculture and land** (agri productivity, NBS)**, and value from waste** (2G biofuels[1]) and **implementing systems-wide reforms** (land rights, supply chain) have potential to unlock majority of value

06 **Regional APAC collaboration can accelerate bioeconomy growth** via offtake guarantees, investments, agricultural innovation, and tech sharing

Key initiative

Invest to **scale 2G biofuels** and NBS

Note: (1) 2G fuel, or second generation biofuel, is produced from non-food biomass like agricultural waste or forestry residues, making it a more sustainable alternative to first generation biofuels that use food crops

Bioeconomy is a critical part of the SEA economy

Bioeconomy is a large part of SEA's economy

Bioeconomy

Creating economic value from production and transformation of biological resources (from land and sea) while preserving vital ecosystems

~30%

of SEA's wealth[1] is estimated to come from natural capital

25%–35%

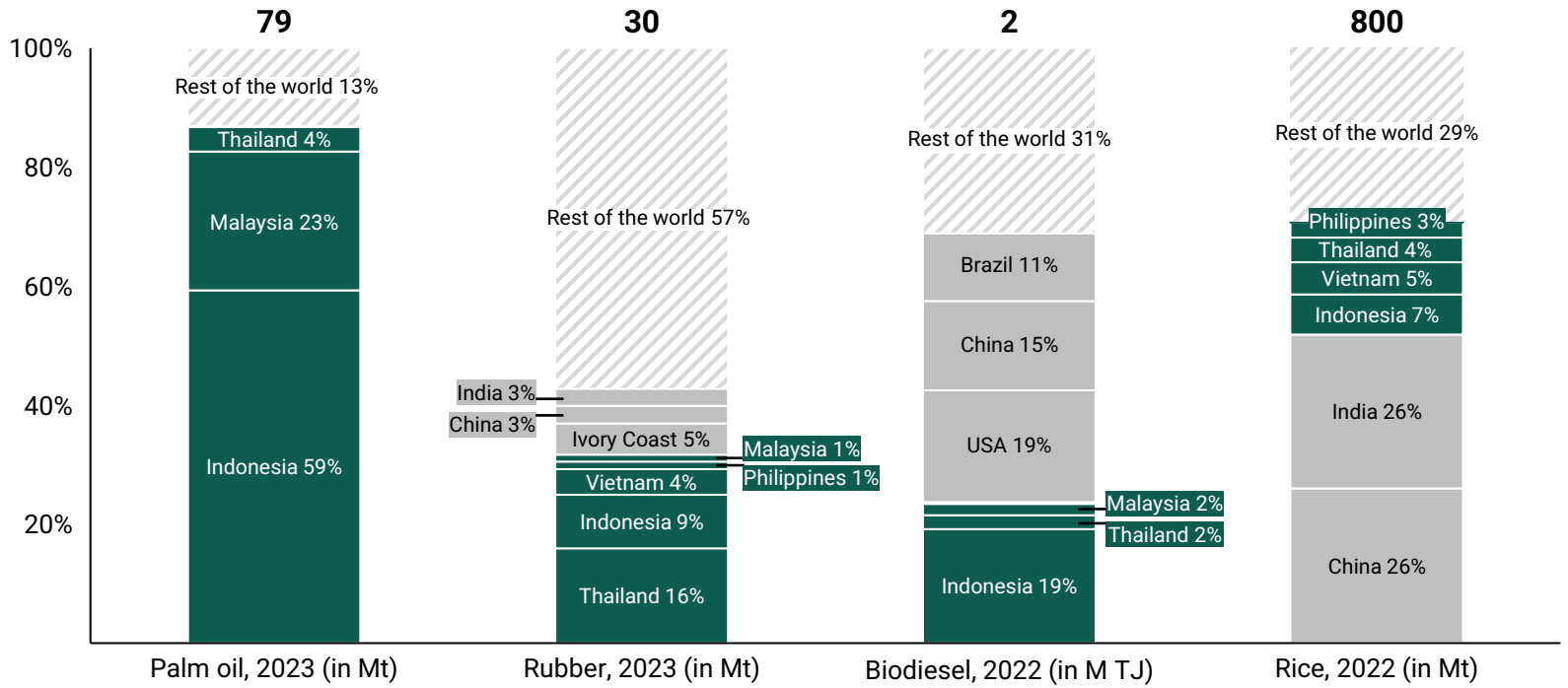
of overall labor force is employed by agriculture sector[2] across key SEA-6 export markets

~20%

of world's plant and animal species are located in SEA

SEA-6 is a key commodity producer leveraging rich natural assets

SEA-6 production volume of select commodities



SEA-6 share of global production	86%	31%	23%	19%

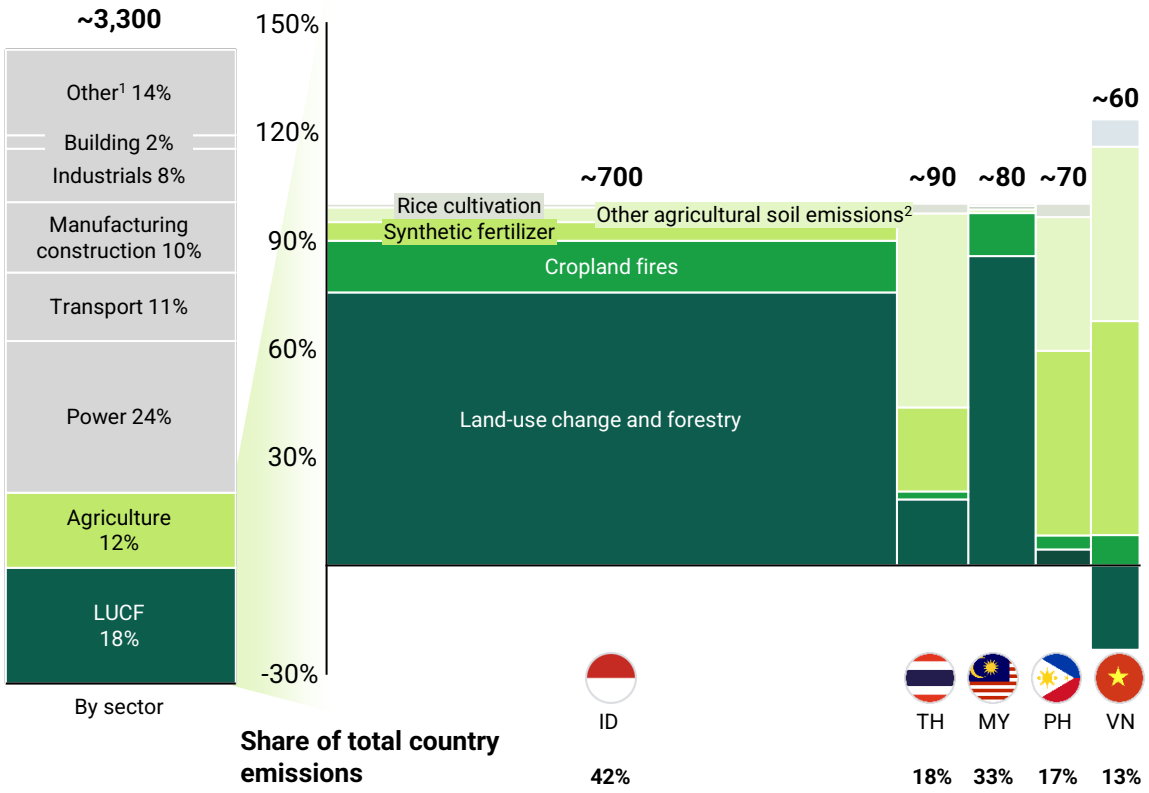
Notes: (1) Wealth is the aggregated sum of three types of capital: natural capital (present value of natural resource stock owned by a country, including forests, farmlands, protected areas, and subsoil assets such as energy and minerals), produced capital (value of assets manufactured or built, e.g., machinery or infrastructure), and human capital (share of labor earnings in country's GDP); (2) Share of labor force in agriculture sector by country – Vietnam: ~34%, Thailand and Indonesia: ~30%, Philippines: ~25% | Sources: ASEAN.org; FAO; The Global Economy

SEA's bioeconomy practices contribute heavily to emissions and deforestation

Bioeconomy contributes to ~30% of emissions, Indonesia's LUCF contributes ~50% of SEA's total bioeconomy emissions

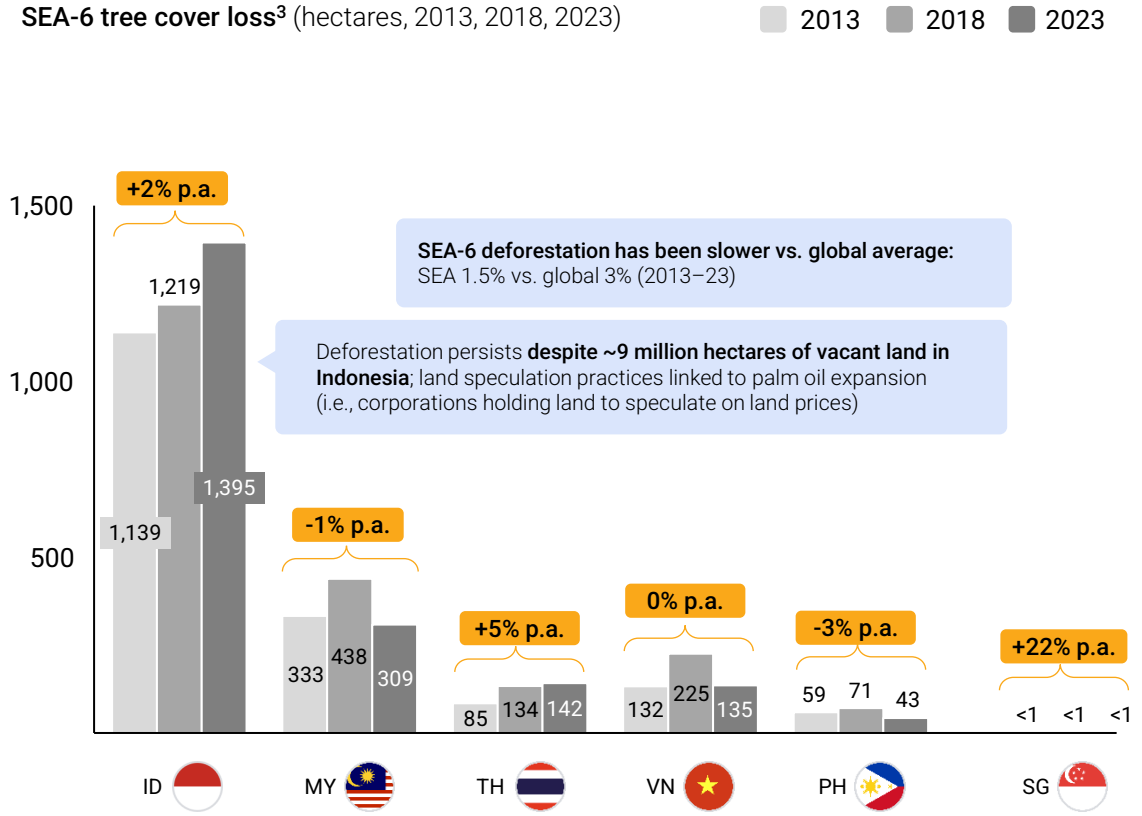
SEA-6 emissions (MtCO2e, 2023)

Total = ~1,000 MtCO2e



Deforestation slowed in SEA vs. global, but continues

SEA-6 tree cover loss[3] (hectares, 2013, 2018, 2023)

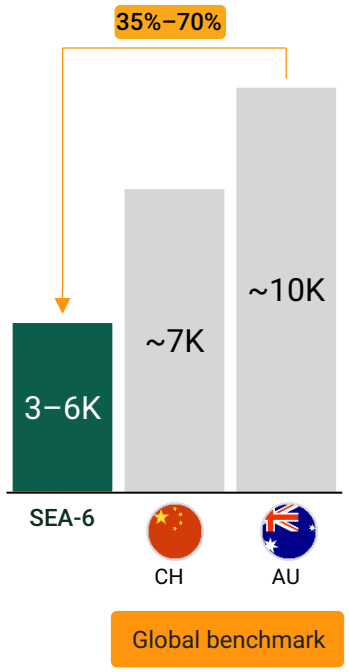


Notes: (1) Other includes bunker fuels, industrial processes, and waste; (2) Includes drained organic soils and manure left on pasture by non-cattle livestock; (3) Tree cover loss defined as complete removal of a tree canopy within a 30-meter pixel (when mapped at a 30-meter Landsat pixel scale, with a 30% threshold applied referring to areas that had at least 30% canopy density in the year 2000 | Sources: CDP; Climate Watch; Climate Trace; EU EDGAR; Global Forest Watch; Lit. search

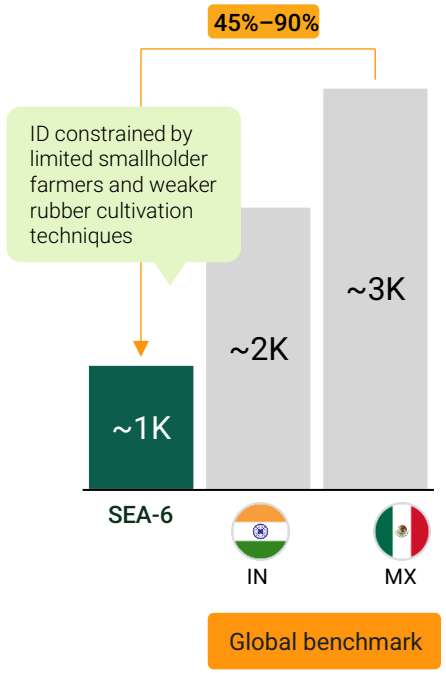
Significant room to improve efficiency across value chains in SEA's bioeconomy

SEA-6 lags in production efficiency

Rice yield
(in kg/ha, 2023)



Rubber yield
(in kg/ha, 2023)



Supply chain inefficiency leads to losses and waste underutilization

PH

~50%

of harvested crop is lost each year (vs. global average of ~13%)

VN

~80%

of rice straws in VN still burnt in fields after harvest

> SEA-6 lacks technology and infrastructure for agricultural waste management, with farmers opting to burn crop waste due to convenience, rather than processing it

Former Global Business Development Manager, Shell

Crop yield is likely to worsen due to climate change

MY

~31%

projected rice yield decline by 2050 due to rising temperatures

ID

~32%

projected agriculture production decrease due to intense dry seasons

> Climate change activity (droughts, floods, temperature increases) is projected to negatively affect agriculture production for rice, sugarcane, cassava, maize, and rubber in PH, TH, and VN

ASEAN State of Climate Change Report 8

Addressing inefficiency is critical to grow bioeconomy, especially with the worsening effects of climate change in the future

Sources: ASEAN.org; FAO; Industry Participant Interview; Lit. search

Key systemic barriers cause high emissions and prevent bioeconomy from reaching its full economic potential

Smallholder farm dominance

SEA's average farm size ranges from 0.6–4 hectares,[1] while the global average is ~7 hectares

Smallholder farmers lack adequate resources, incentives, and technical support to adopt lower emissions/high productivity practices (e.g., high-yield inputs)

Weak infrastructure and supply chains

SEA lacks adequate infrastructure to support production of biofuel (e.g., HVO, agri-based bioethanol) with poor rural connections, lack of storage, and no processing facilities for waste management

Unclear land rights and regulatory complexities

Insecure land rights, weak governance, and unclear boundaries tend to lead to land-use conflicts, increasing operational risks

The complex and fragmented regulatory environment across SEA increases operational costs and inhibits long-term investments

Nascent carbon pricing and carbon markets

Carbon markets in SEA are underdeveloped, only first launching in 2021[2]

Carbon pricing mechanisms are still in early stages across SEA-6: SG has introduced carbon tax, ID has implemented ETS; other nations still in consideration/ planning phase

Consequently, exploiting bioeconomy is more attractive than protecting it

For example, protection-focused NBS operating profit at $45–$80 per hectare,[3] compared to palm oil operating profit at $180–$300 per hectare[4]

Notes: (1) VN is lowest at 0.6 ha, while TH is highest at 4.04 ha; (2) SG launched CIX in 2021, TH launched FTIX and MY launched BCX in 2022, ID launched IDX carbon in 2023; (3) Operating margin representative of an NBS project at steady state, primary fixed OPEX are fees to project developers/managers, primary variable OPEX are community costs and carbon credit sharing with project developers/managers; (4) Based on estimates of commercial plantation operating margins of ~15% across both ID and MY | Sources: ASEAN.org; FAO; Philippine Statistics Authority

Systems-level solution | Scaling sustainable bioeconomy utilization to increase economic value and reduce emissions

Total expected impact on SEA-6 (2030)

~230 MtCO2e	~$40 billion	~340,000
Reduction in 2030, ~5% of reduction of emissions in 2030	Economic value add in 2030	Jobs created in 2030

Implications of systems-level solution across SEA decarb systems

Systemic challenges/patterns of behavior improved by systems-level solution

Potential for unintended consequences

Interventions through solution levers on systemic barriers

Agriculture & Nature system

Smallholder farm dominance

Fragmented land ownership → Limited land consolidation → Low adoption of sustainable farming practices at large scale

Weak supply chain and logistics infrastructure

Poor rural roads and transportation network → Lack of logistics and distribution network → Inefficiency in agricultural practice across value chain → Underutilization of agricultural waste

Unclear land rights and regulatory complexity

Complex regulatory environment → Unclear land rights and lack of formal ownership → Land-use and Land-grabbing conflicts → Discouragement of long-term investments

Nascent carbon markets

Lack of established carbon markets in SEA → Lack of financial incentive to create NBS projects → Low supply of high-quality NBS projects

Deforestation to secure biofuel feedstock

To be mitigated through (1) robust regulatory framework (e.g., sustainability criteria, zero tolerance for 1G biofuels), (2) enhanced monitoring and traceability (e.g., AI-driven land monitoring)

Lack of strong regulatory enforcement
Weak monitoring and traceability systems
→ (Inadvertent) increased demand for 1G feedstock → Deforestation and biodiversity loss

Sustainable bioeconomy

- SHF productivity
- NBS acceleration
- Sustainable biofuel
- Carbon markets scaling
- ASEAN bio trade framework
- Supply chains & infrastructure
- Revamped land use policies

Power system

High dependence on fossil fuels

Poor feedstock supply chain infrastructure for bioenergy → Higher ROI for fossil fuel-based energy vs. bioenergy → Higher usage of fossil fuel in power generation

Transportation system

High dependence on fossil fuels

Poor feedstock supply chain infrastructure for biofuels (e.g., SAF) → Higher ROI of fossil fuel vs. biofuel → Higher usage of fossil fuel in transport

Lack of strong enforcing biofuel mandates → Limited demand for biofuels

Deep dive on following pages

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Implementation levers | Key levers to turbocharge bioeconomy

Deep dive ahead

Ease of implementation: High | Moderate | Low

	Implementation levers	Expected economic value add[1] (2030)	Ease of implementation
Value from agriculture and land	**1 Enhance smallholder farm (SHF) productivity** • Facilitate access to high-value inputs such as climate-resilient seeds, biofertilizer, etc. • Enable financing (e.g., subsidized loans, target subsidies) for adopting sustainable high productivity • Scale up training on regenerative agriculture and precision farming techniques (e.g., Indonesia's rural empowerment and agriculture development scaling-up initiative [READ-SI]) • Drive innovation that boosts productivity of smallholder farms (e.g., low-cost irrigation solutions, mobile-based advisory services) • Connecting farmers to offtakers to gain fair pricing and economies of scale (e.g., marketplace through agritech)	**~$11B[2]**	**Moderate to high** Adoption of high-value inputs is growing; however, financing, training, and capability of smallholder farmers remain key barriers
Value from waste	**2 Expand NBS development** • Incentivize large-scale NBS projects (afforestation, reforestation, peatland and mangrove restoration, conservation, ocean-based carbon removal) through clear funding mechanisms and policy support • Develop centralized monitoring and verification systems to track NBS impact and allocate credits effectively	**~$2B[3]**	**Moderate to low** Long-term investments and policy alignments are needed, slowing large-scale adoption
	3 Accelerate sustainable biofuel production • Implement incentives to support production (e.g., Malaysia's National Biomass Strategy) • Implement mandatory sustainability standards for biofuel usage • Establish certification frameworks for sustainable biofuel sourcing for 2G feedstock (e.g., UCO, HVO, waste-derived biodiesel, rice husk-based bioethanol)	**~$27B[4]**	**Moderate** Certification systems and sustainable feedstock supply face regulatory and logistical challenges to ship waste across borders
System-wide reforms to value ecosystems	**Scaling carbon markets** to financially incentivize creation of NBS projects, introducing high-quality supply of NBS projects to increase sustainable agricultural practices at a large scale and conservation and enhancement of natural ecosystem	*Enables full potential implementation of sustainable bioeconomy systems-level solution*	**Moderate** Needs stronger regulations, verification systems, and financial incentives
	Embed the bioeconomy into SEA trade frameworks by harmonizing bio-product standards, tariff removal to boost intra-regional trade, etc.		**Moderate to low** Multilateral agreements and tariff eliminations, implementation politically complex
	Strengthen supply chains and logistics infrastructure to minimize post-harvest losses and establish efficient waste collection systems for 2G feedstock (e.g., UCO, rice husk and straw, palm oil mill effluent [POME], empty fruit bunches [EFB]) development		**High** Existing trade and agricultural networks make improvements feasible with strong investment interest
	Revamp land use policies to ensure formal ownership rights (including indigenous land rights) and expedite approvals and scalability of bioeconomy projects		**Moderate to high** Many SEA countries are reforming land policies, but unclear land tenure and bureaucracy slow progress

Notes: (1) Refers to estimated additional impact on GDP from implementation lever; (2) Calculated based on the anticipated GDP impact of various solutions (e.g., improved productivity in smallholder farms and plantations, carbon sequestration, sustainable aquaculture, indoor and vertical farming, supply chain traceability, optimized production, supply chain infrastructure, reduced consumption, and bioremediation processes); (3) Estimated based on projected nature-based solutions potential in Southeast Asia multiplied by forecasted price; (4) Estimated based on the future projection of biofuel production across the region | Source: Bain analysis

Enhance farmer productivity | Opportunities exist to enhance productivity of SHFs along end-to-end value chain via high-impact solutions

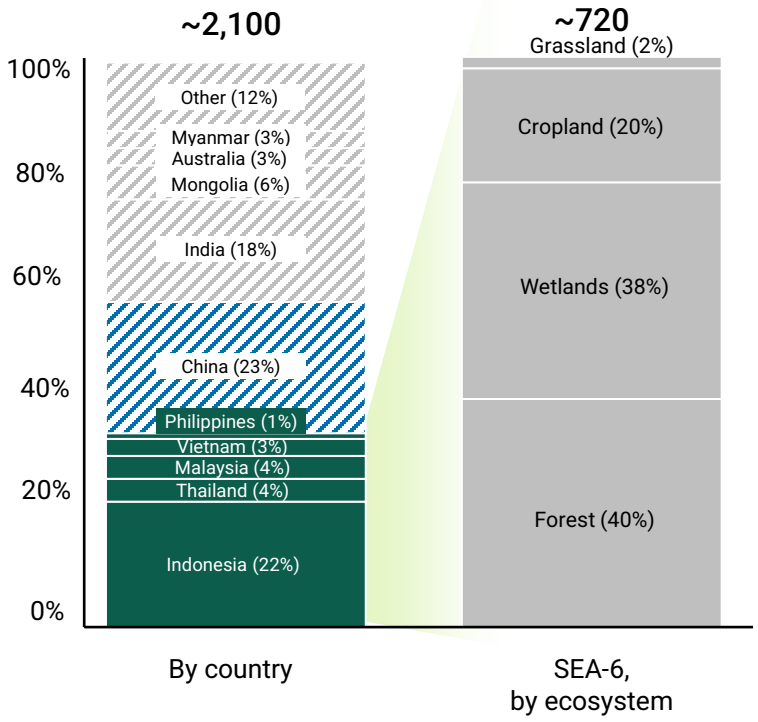
	Supply of inputs	Production and harvesting		Distribution
Key levers	**Higher yield input/higher value crops**	**Precision agriculture**	**Regenerative agriculture**	**Farmer service platforms**
	Input to generate greater output per unit of land or produce higher value crops	Tech-integrated farming to enhance productivity (drone imagery, data analysis, etc.) Deep dive in green AI chapter	Farming practice focused on soil health, conservation, and ecosystem restoration (e.g., cover crop plantation, integrated pest management, bio-input)	Digital marketplaces linking farmers with offtakers
Key success factors	Strong understanding of local community and presence of experts/trainers to bridge knowledge gap			
	Strengthened supply chain and infrastructure, formalized land rights			
	Specialization across **multiple crop types**	Innovative **business model** to drive adoption (e.g., leasing, pay-as-you-go)	Innovative **business model** to monetize farmer adoption (e.g., carbon credit sales)	**Innovative model** to drive adoption (e.g., subscription)
	Govt. policy to incentivize investment, strong **tech and R&D capabilities**	**Tech/knowledge transfer** from market leaders (e.g., China)	**Strong offtake potential** (both within SEA and across wider APAC region)	Easy-to-use user-interface/user-experience
	Strong offtake potential (both within SEA and across wider APAC region)			

Note: (1) Based on market studies (e.g., a four-year study done by German-Indonesian collaborative research center that observes stable yield result and higher profit due to reduced fertilizer costs) | Source: Lit. search

Expand nature-based solutions | SEA-6 NBS credit issuance represents 1% of estimated mitigation potential, indicating a vast untapped opportunity

~34% of NBS APAC potential from SEA-6, forest and wetlands ecosystem have the most potential

APAC estimated annual potential from NBS projects (MtCO2e, 2024)



Untapped potential of SEA-6 NBS carbon credits issuance

Annual carbon credit issuance (2020–24)

~5–10 MtCO2e[1]

vs

Annual mitigation potential[2]

720+ MtCO2e

~85% of total SEA-6 NBS issuance comes from Indonesia in the past five years

What is needed to scale NBS?

Catalyzing demand

Drive credit demand through claims guidance, pricing signals, aligned frameworks that ensure quality of credits, and cross-border market interoperability

Building supply

Scale high-integrity carbon credit generation by unlocking finance, enabling local capacity, and simplifying project pathways

Developing infrastructure

Build integrated regional markets with standardized regulations, clear MRV methodologies, alignment with international quality benchmark to ensure credit quality, and exportability

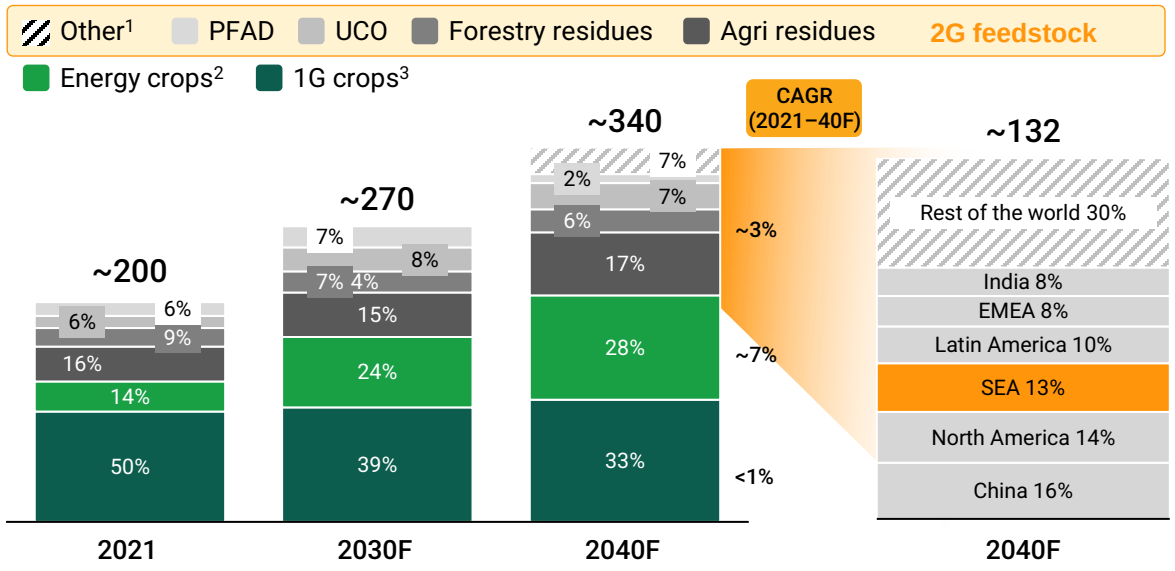
Deep dive in carbon market chapter

Notes: (1) Refers to SEA-6 nature-based solutions carbon credits issued between 2020 and 2024; (2) Naturebase total annual mitigation potential across four ecosystems (grass, wetlands, forest, and crop) and multiple NCS pathways, including protect, manage, and restore project types | Sources: Naturebase; Berkeley Carbon Database

Accelerating biofuels | SEA is positioned to be a leading 2G supplier on the back of global trend towards 2G; several factors need to align to realize full potential

SEA may become major 2G biofuel supplier by 2040F

Global biofuel supply by feedstock type and country (MtCOe)



SEA key competitive advantages in biofuel

- Abundant feedstock supply
- Growing refining capabilities
- Cost competitive manufacturing
- Proximity and good trade relationships with high-demand markets (e.g., KR, JP)

Actions by value chain player to realize full potential

Upstream suppliers	**Adopt latest tech to enhance traceability of feedstock** to minimize fraud **Government to create regulations around waste collection to create incentives** for F&B and other sectors to invest in waste collection infrastructure
Midstream producer	**Overseas importers:** Build localized assets close to feedstock source, consider JV with local refiners **Native SEA refiners:** Secure reliable cheap feedstock, convert existing assets and build capacity for export Incentivize demand **through mandates, credit schemes,** or other similar measures
Downstream users	**Airlines, mining, and other companies:** Secure volume via long-term agreements with upstream/midstream players, diversify intake sources, and invest in R&D/bio-refining for de-risking Scale production by **de-risking facility investments** through **offtakes** that lower market and volume risks
Overall demand incentives	**Blending mandates:** Mandating that certain percentage of biodiesel or bioethanol is mixed into regular fuel **Carbon taxes:** Companies using low-carbon fuels like biofuels can earn carbon credits or lower their carbon tax, making it financially attractive

Notes: (1) Other includes animal fat, municipal solid waste, and palm oil mill effluent; (2) Energy crops refers to cellulosic energy crops; examples include switchgrass, miscanthus, willow, poplar, etc.; (3) First generation (1G) crops are edible crops used directly to produce biofuels (e.g., sugarcane, corn, soybean, etc.) | Sources: FAO; BEFS; World Bank; WEF; ICCT; US DOE EERE; Market participant interviews; Secondary research; Bain analysis

Asia-Pacific and SEA | Collaborations across Asia-Pacific and SEA on bioeconomy

	Biofuel offtake and investments	Agricultural innovation and climate resilience	Regional carbon credits
Collaboration opportunity	**Securing offtake commitments with Asia-Pacific nations** for biofuels and feedstocks, along with **investments in integrated supply chain for the production and distribution of sustainable fuels**	**Investments in innovative solutions** (e.g., genetically modified crops, technology to increase productivity, etc.) leveraging SEA's rich agricultural inputs	**Investments in SEA's agroforestry and nature-based projects** with regionally focused green funds that manage forestry and nature-based assets
	Indonesia Ministry of Industry and Japan's energy and industrial technology organization signed MoU to establish a bioethanol plant	Agreement between PH govt. and XAG (CN agri-drone provider) to test drone tech on PH rice crops, aiming to boost rice yields, optimize resources, and reduce environmental impact	New Forests set up its Tropical Asia Forest Fund with a target of $300 million, a fund that focuses on sustainable plantation forestry investments in SEA
Impact to SEA	• **Accelerate SEA's supply chain and capabilities** development in biofuels • **Attract FDI inflows** to SEA • **Securing biofuel and feedstock offtake**	• **Accelerate tech advancements and production capabilities** in sustainable farming practices • **Strengthen SEA's** crop quality, yields, and dominance in global export market	• **Increase supply of high-quality** carbon credit projects (differentiating SEA-based credits from other NBS projects that are facing public scrutiny) • **Enable policy acceleration around** carbon credit as supply market matures
Impact to APAC	• **Access to large volume of biofuel feedstock supply** • **Fulfill national biofuel volume to meet targets**	• **Market expansion** for APAC companies to SEA and beyond	• **Access to carbon credits** from agroforestry and NBS projects to be used for offsetting emissions • **Financial return** from agroforestry and NBS projects

Sources: S&P; Lit. search

Investable ideas | Attractive options exist across multiple areas of bioeconomy

	Value from agriculture and land					Value from waste	
	Supply of input	Production and harvesting		Distribution	Nature-based solution	Biofuel	
	Higher-value/ yield crops	Precision agriculture	Regenerative agriculture	Farmer service platforms	Conservation, sequestration, etc.	Upstream (e.g., feedstock production)	Downstream (e.g., refining)
Opportunities							
Market size[1] ($ billion, 2030F)	**~$4–$6**	**~$2–$3**	**~$2–$4**	**~$3–$4**	**~$2–$3**	**~$10**	**~$30**
Indicative profit margin[2]	**5%–15%**	**~10%**	**~20%**	**15%–20%**	*Highly variable depending on projects*	**15%–20%**	**20%–30%**
Recent investments activity (M&A, JV, greenfield investments)	**AHSTI**[3] invested to develop hybrid corn seeds (PH, ID)	**Aerodyne raised** ~$100 million for technology, leveraging drones to boost yields (MY)	**Harmless Harvest** converts coconut farms to use regenerative practices (TH) **Rize, an agritech platform** for enabling sustainable rice decarbonization, raised ~$14 million in series A round	**Kita**, a B2B farmer-to-business platform, raised ~$2 million (PH)	**Green Carbon** co-develops SEA-based NBS projects[5] for carbon credits **New Forests funds** invests in SEA-based NBS projects	**Apeiron** raised $50 million green bond for improving collection points, pre-treatment for waste feedstocks (SG)	**Neste** invested ~$1.6 billion to expand biofuel refining plant (SG)

Notes: (1) Refers to potential revenue of the market in SEA by 2030; (2) Margins: EBIT for higher-value/yield crops, EBITDA for precision agriculture, and gross profit for regenerative agriculture, farmer service platforms, upstream, and midstream; (3) Asian Hybrid Seed Technologies, Inc.; (4) Crop biotechnology center of PhilRice Research Institute; (5) Projects are in reforestation, restoration, and rice paddy space | Source: ACN Newswire; AHSTI; Bioenergy News; Business Times SG; Corteva; Nikkei; Tracxn; US Embassy in PH; Unilever; Market participant interviews

Recommendations | Key steps for all stakeholders to accelerate SEA's bioeconomy

Policymakers and regulators

Establish clear land rights and strong regulatory environment to formalize ownership

Increase financial incentives for smallholder farmers to kick-start sustainable agricultural practices (e.g., through grants and tax breaks)

Develop and enforce regulatory frameworks that support sustainable biofuel sector (especially 2G biofuels)

- Biofuel blending mandates, sustainable biofuel certifications

Adopt mandatory sustainable production policies with financial support for transition (e.g., palm in Indonesia, rice in Thailand)

Promote regional production and trade of biofuels

- Support manufacturing cost competitiveness by providing supply-side incentives (e.g., capex subsidy)
- Regional alignment on sustainable production standards

Financial institutions and investors

Increase SHF/agribusiness access to sustainable financing

- Banks and DFIs to provide low-interest loans, green bonds, grants, etc.
- Creating differentiated credit scoring system to ensure higher approval rate for farmers

Invest directly in public-private partnerships to finance large scale bioeconomy projects

- Investments in refinery and waste management to support 2G adoption

De-risk investments by working with government to offer collaboration and guarantees that ensure long-term returns for NBS projects

Private sector (e.g., agribusiness)

Invest in sustainable agriculture technology

- **R&D and implementation** of scale precision agriculture, regenerative agriculture, sustainable biofuel production

Increase support for smallholder farmers

- Contract farming
- Fair pricing and supply programs

Strengthen supply chains to reduce post-harvest losses in both upstream and midstream production

Develop integrated waste collection system to increase adoption of 2G feedstock

Sign long-term offtake agreements for carbon credits generated through high-integrity NBS projects; including upfront financing for project development

NGOs

Facilitate training and knowledge transfer

- Capacity building and training programs to educate farmers and SMEs on best practices, technological advancements, financial literacy

Develop finance capabilities to support success and understanding across wide stakeholder base for sustainable agriculture financing initiatives

Advocate policy reforms on land rights and social equity for smallholder farmers

Farmers and local cooperatives

Look for opportunities to leverage financing through adopting sustainable practices and leverage transition programs to improve resilience

Adopt digital tools for farming and financial management

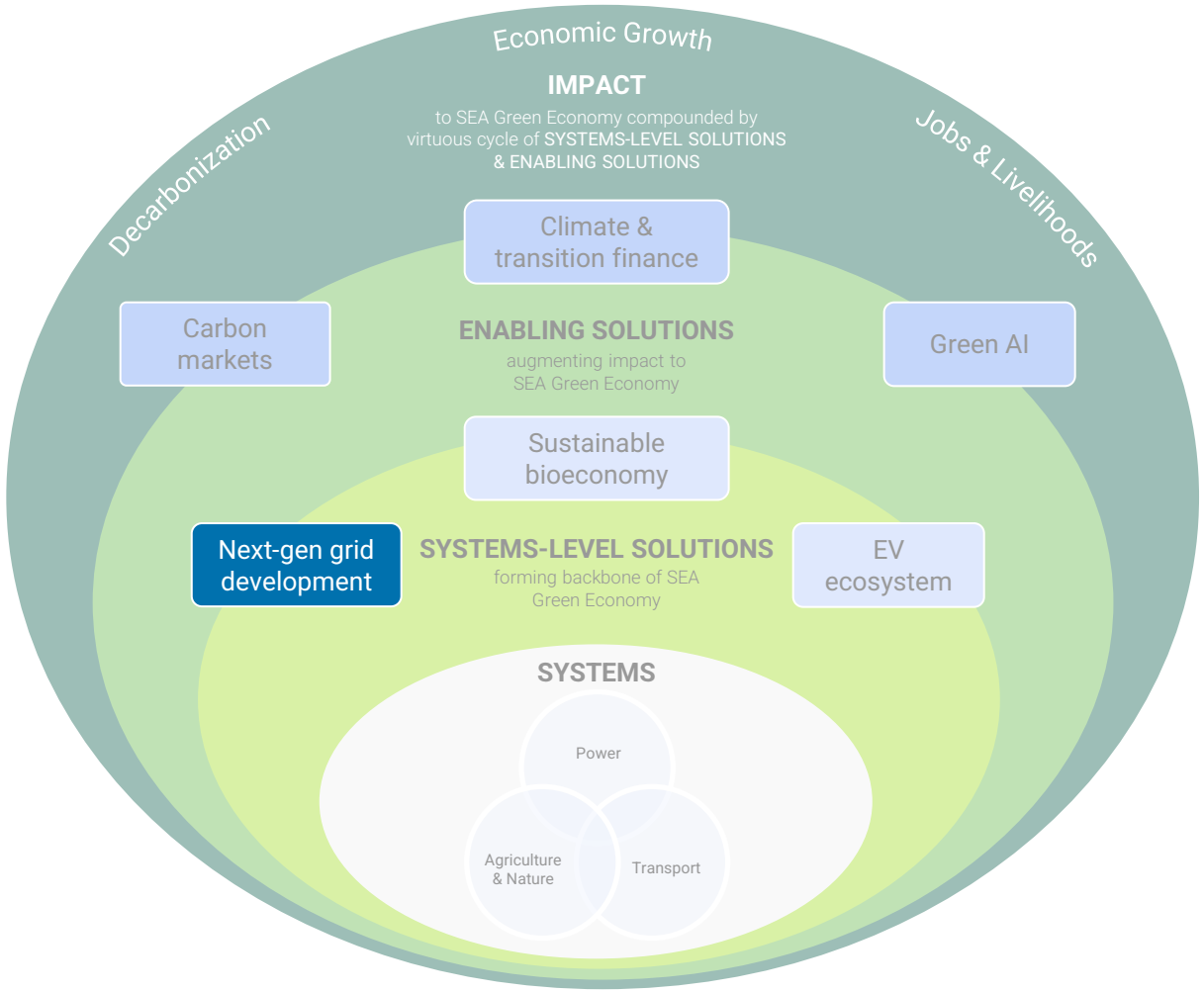
Collaborate across supply chains to create differentiated, fully traceable sustainable products to meet international demand

Systems-level solution 2

Next-gen grid development

06

Next-gen grid development | Key takeaways



Potential results from the solution in 2030

~50 MtCO2e reduction	~200,000 jobs created	~$25 billion annual GDP contribution

01 **SEA's grid was built for conventional thermal power plants with limited cross-border connections;** requires adjustments to the next generation of assets with fluctuating RE output and need to balance reliability

02 SEA's next-gen grid requires **expansion** and **modernization of domestic grids and expansion of cross-border connections** to accelerate green transition

03 **Governments play a crucial role in accelerating grid development;** critical unlocks include regulatory reforms to enable private investment, cross-border power trading, and potential subsidization of key infrastructure

04 **Green Industrial Clusters offers high-impact, near-term solutions** to attract private investment in RE generation, T&D infrastructure, and other green energy solutions

Key initiative

Build green industrial clusters ("sandboxes")
Accelerate bilateral grid connections

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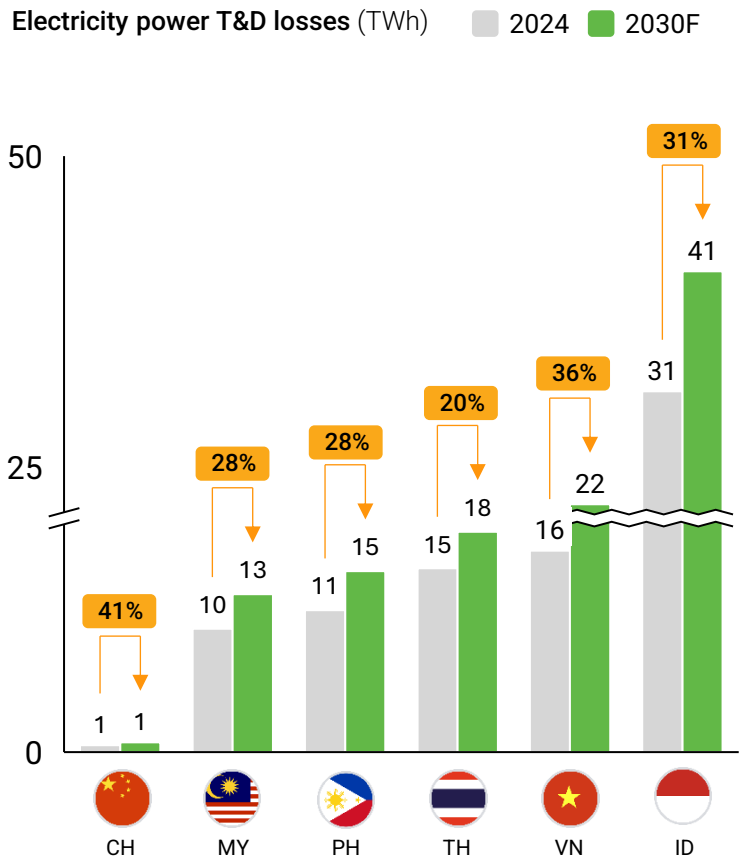
Across SEA, grids need upgrading and are not well equipped for renewable energy

Inefficiencies in power ecosystem create economic costs and a case for modernization



6.7%

T&D loss as a percentage of total electricity generation in SEA-6 by 2030F (vs. ~4% in China, Japan, and South Korea)

Meeting SEA's growing power demand through scaled RE generation cannot happen without upgrading and expanding grids

Mismatch between RE generation and demand centers

RE generation is concentrated in remote areas, far from major demand centers

Limited grid infrastructure exists for long-distance transmission

> SEA's diverse energy landscape, marked by uneven resource distribution, hinders sustainable progress and demands a coordinated effort from all stakeholders
>
> World Economic Forum, 2024

Infrastructure upgrade needed for RE integration

Current grid infrastructure primarily designed for conventional power generation; significant investment needed in grid upgrades (e.g., storage solutions) for RE integration

> Swift development of RE, combined with limited grid and storage infrastructure, led to congestion and curtailment issues in Vietnam *(reduction in Vietnam RE output by 1.3 billion kWh due to transmission constraints)*
>
> SEA Energy Transition Partnership, 2023

> Annual investments in grid expansion and modernization must nearly double to $30 billion by 2035 to support greater RE integration
>
> IEA Southeast Asia Energy Outlook, 2024

Sources: S&P Global; Global Data; IEA; WEF; Ember; Lit. search

A next-gen grid with cross-border connections would lower SEA's decarbonization costs and accelerate the green energy transition

Two pillars of developing a next-gen power grid in SEA

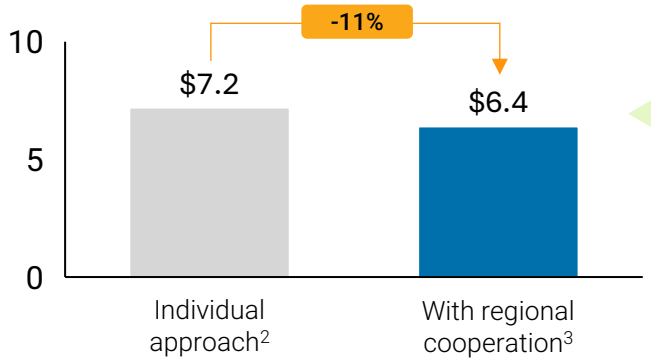
1. Expansion and modernization of domestic grids

Key initiatives include (non-exhaustive)

Dynamic load balancing	Optimization of power flow in real time **using AI, sensors, and automation**, preventing overloads	**20%–40%** improvement in RE utilization by adjusting power distribution to match output
Battery energy storage systems	**Strategic use of large-scale batteries** to store excess RE and balance supply/demand	**30%** improvement in RE penetration (reduction in RE curtailment rate) using battery systems
Microgrids	Installation of **small grids** that **operate independently** from the main grid, ensuring 24/7 power during blackouts and better RE integration	**18M** people with lack of electricity in SEA could be powered by renewables-based microgrids

2. Expansion of regional connectivity through bilateral/multilateral grids

Net present cost for decarbonizing grids in SEA by 2050 ($ trillion)[1]



Cost reduction of ~$0.8 trillion using a regional approach for decarbonization, involving unconstrained flow of power and hydrogen using interconnectors

Cost reduction driven by decreased capacity/storage requirements through cross-regional collaboration

600 GW
less solar capacity to be installed

13%
reduction in spatial footprint required

1.2 TWh
less electrical storage needed

Notes: (1) Net present cost includes values for renewables, storage, electrolyzer, interconnector, hydrogen network; (2) Regional cooperation allows for full resource sharing between countries without constraints; (3) Under individual approach, each country tries to fully decarbonize solely and independently from its own available resources | Sources: IEA; DNV; Lit. search

SEA's grids were designed for a different world; key systemic barriers must be addressed to modernize and scale for future

Restrictive and highly regulated power market structures

Heavily regulated state electricity markets and monopolies hinder private sector investment and innovation

- Most SEA nations have state-owned utilities that may deter investment and innovation
- In energy distribution sector, only SG and PH have allowed private investments

Heavy subsidies on fossil fuel-based energy generation further makes alternate forms of energy unprofitable

Limited cross-border electricity trading

Lack of harmonized technical and regulatory frameworks for cross-border electricity trading

- Cross-border electricity trading is complicated by a lack of common pricing, standard PPAs, grid codes, frequencies, etc.

Unclear policies and financing mechanisms on cross-border connections

Unclear wheeling tariffs[1] and **cost-sharing models** create barriers to regional power trade and grid expansion

Approval delays from multiple government bodies

Cross-border connections cover multiple jurisdictions and are often **politically sensitive**, making **approvals slow and complex**

- Undersea cable to Singapore to source renewables from Indonesia is highly complex, involving multiple sign-offs from multiple ministries in both countries

Supply chain bottlenecks and limited technical capabilities

Notable **dependence on foreign technology and expertise** for critical grid components; meanwhile, suppliers are already at or over capacity

- For example, MY relied on Japanese and Italian tech expertise to construct HVDC submarine cable under South China Sea to transmit electricity from Borneo to Peninsular MY

Note: (1) Fees for transmitting electricity through another country's grid | Source: Lit. search

Systems-level solution | Developing a next-gen grid ecosystem has potential to create ~$25B GDP impact, reducing emissions by ~50 MtCO2e for SEA-6 in 2030

Total expected impact on SEA-6 (2030)

~50 MtCO2e	~$25 billion	~200,000
Reduction in 2030, ~1.3% of reduction of emissions in 2030	Economic value add in 2030	Jobs created in 2030

Implications of systems-level solution across SEA decarbonization systems

Systemic challenges/patterns of behavior improved by systems-level solution

Potential for unintended consequences

Interventions through solution levers on systemic barriers

Power system (focus on grid)

Restrictive and highly regulated power market structures

Highly regulated power markets (limited private entry) → Lack of private investment in grid solutions → Limited grid expansion, modernization, and innovation

Limited cross-border electricity trading

Limited regional alignment and G2G[1] co-op to align regulatory and technical frameworks → Mismatched regulatory and technical frameworks → Limited cross-border power trade

Unclear financing mechanisms on grid interconnections

Lack of standardized financing mechanisms for transmitting cross-border power (e.g., wheeling tariffs) → Lack of financial incentives to invest in cross-border transmission

Limited evidence/proven business models

Limited govt. incentives to scale RE generation /transmission assets → Limited large-scale examples proving high ROI from RE generation/transmission assets → Limited investor confidence in RE generation/transmission

Limited technical capabilities

Limited regional expertise in advanced grid solutions
Limited manpower expertise in advanced grid solutions
→ High costs of implementing advanced grid solutions

Next-gen grid development

- Private investment in grid
- Regulatory/ technical reforms for cross-border trade
- Bilateral grid connections
- Mobilizing financing & investment
- Develop positive proof points/ green industrial cluster
- Advanced tech usage leveraging ties with Asia-Pacific peers

Transport system

Limited EV uptake

Insufficient grid capacity → Low buildout of charging infrastructure → Low EV adoption

High emissions from EV usage

Growing EV demand (due to govt. policies, lower TCO[2], etc.) → Growing power demand → Higher emissions from power

High RE curtailment rates → Higher ROI of fossil fuel-based power vs. RE power → Higher usage of fossil fuel in power generation

Agriculture system

Impact on biodiversity/deforestation

Complex regulatory environment → Unclear land rights
Deforestation
Discouragement of long-term investment
→ Land acquisition/grabbing to expand grid and associated RE (e.g., solar, wind)

To be mitigated through strengthened land ownership, land use, and environmental regulations (e.g., clear zoning laws, mandatory social impact assessment)

Notes: (1) Government to government; (2) Total cost of ownership

Implementation levers | Key levers to accelerate development of next-generation power grid (1/2)

Key implementation levers

Deep dive ahead

Ease of implementation: High | Moderate | Low

Implementation levers addressing systemic barriers

Implementation levers	Expected economic value add[1] (2030)	Ease of implementation
1 Unlock private investment in T&D infrastructure buildout and RE generation (which in turn increases investment in T&D) • For example, permit private players to invest in power ecosystem; implement mechanisms to encourage competition (e.g., tariff-based competitive bidding), establish clear frameworks to accelerate PPAs/VPPAs • Ensure clear long-term offtake agreements for better investor confidence	**$1–$2B[2]**	**Low** State utilities dominate SEA's electricity markets, resisting change and lacking standardized frameworks, while regulatory shifts heighten investment risks for private players
2 Implement regulatory and market reforms to harmonize frameworks and support cross-border electricity trade (e.g., standard wheeling tariffs) • Progress made on regional interconnection (LTMS/BIMP-PIP); **9 out of 18 cross-border power projects are operational** under SEA Interconnection Masterplan	**$3–$4B[3]**	**Low** Bilateral agreements exist, but a unified market is absent, and technical mismatches (voltages, frequencies) complicate cross-border trade
Identify high-priority bilateral cross-border grid connection opportunities, directing efforts and funding to key areas, which will then serve as proof points for further investment in multilateral/regional grid		**Moderate** High potential for bilateral agreement closure due to fewer stakeholders and streamlined collaboration
Mobilize financing and investment to secure long-term funds for grid buildout • **Establish collective funding mechanisms** pooling financing from governments, development banks (e.g., regional grid investment fund); issue green bonds • **Create innovative financing mechanism,** e.g., transition credits, which helps in early phase-out of coal plants and transition to clean energy	**$15–$20B[4]**	**Low** Securing long-term funds is difficult due to the absence of a regional investment fund, complicating domestic and regional grid financing

Notes: (1) Refers to estimated additional impact on GDP from implementation lever; (2) Private investments in SEA's T&D infrastructure assumed to follow a similar trajectory as in India, where private sector achieved 8% share in transmission line capacity over the last ~10 years; hence, privatization is expected to add ~8%–10% of incremental GDP of $25 billion; (3) Grid connections are projected to boost SEA's GDP by 1%–5%, factoring in GDP growth rate and assuming 50% of grid interconnection projects are operational by 2030, contributing half of the annual projected GDP increase; (4) SEA is expected to see inflow of investment worth $20–$25 billion for grid improvements as well as green-capacity addition; portion of this investment is expected to directly contribute to GDP through grid-related product manufacturing as well as greater employment | Sources: India Ministry of Power; Singapore International; Energy Week discussions; ASEAN review; IEA; Bain analysis

Implementation levers | Key levers to accelerate development of next-generation power grid (2/2)

Key implementation levers

Deep dive ahead

Ease of implementation: High | Moderate | Low

	Implementation levers	Expected economic value add[1] (2030)	Ease of implementation
Implementation levers addressing systemic barriers	**3 Develop/expand sandbox economic/industrial zones to demonstrate economic viability of scaled green power** • **Green industrial clusters/SEZs** as dedicated industrial zones powered by RE, offering low-carbon manufacturing, potential data center co-location	*Enables full potential implementation of next-gen grid development*	**High** Private capital can be attracted to green industrial clusters/SEZs with incentives like tax rebates for setting up new generation and transmission projects (e.g., Bangkok's clean energy and EV hub)
Additional indirect levers	**Leverage ties with Asia-Pacific nations to accelerate availability and usage of advanced tech for modernizing the SEA grid (e.g., smart meters, advanced conductors) through co-investment/local manufacturing** • e.g., potential collaboration with China on HVAC/HVDC transmission tech • Leverage **AI-driven innovative solutions,** e.g., smart grid maintenance, demand-side energy management, etc.		**Moderate** High potential to leverage Asia-Pacific relationships to import and use best solutions for grid modernization

Note: (1) Refers to estimated additional impact on GDP from implementation lever | Sources: Lit. search; Bain analysis

Case study: India | Reforming and deregulating power markets across generation, transmission, and distribution to attract private investment

Key steps taken to unlock market access across power value chain

Power supply value chain

Generation

Increase in generation and distribution through private investment further incentivizes transmission growth

- Electricity Laws (Amendment) Act, 1991, permitted **100% FDI** in power generation and allowed private generators to sell electricity to state utilities
- Government-backed long-term PPAs provided sovereign offtake guarantees to RE developers, reducing investment risk and cost of capital

Transmission

- **Tariff-based competitive bidding (TBCB)** opened transmission projects to private players in 2006, offering contract to the bid with lowest tariff, leading to cost reductions
- **Public-private partnerships (PPPs)** in transmission projects for high-risk locations

Distribution

Franchise model for distribution allowed private companies to operate distribution within a particular allotted area, while taking steps to ensure **low thefts and highest efficiency**

- Helped in reducing losses, improving collections, and upgrading infrastructure
- e.g., Tata power took control of four Odisha state DISCOMs under long-term franchise model in 2020

Key results

~90% transmission projects awarded under TBCB mechanism (2024)

~35% reduction in tariffs for projects awarded under TBCB vs. traditional regulated approach

~97% of the total installed RE capacity in India is contributed by private sector as of 2024

~8% Aggregate Technical & Commercial (AT&C) losses in Delhi in 2021 (vs. 55% in 2002)

Key learnings

Robust and holistic policy framework to build private sector interest in energy sector

Create incentives (e.g., fixed payback) for private players

Promote competition to accelerate innovation related gains

Sources: Expert interviews; Indian Ministry of Power; National Power Portal; Business Standard reporting; Economic Times; Times of India; PSR India (Power System Review)

Case study: European Union | Leveraging benefits of a regional connected grid for accelerating decarbonization targets

Key steps undertaken to enable regional connectivity

Harmonization of standards	• Adoption of eight legally binding network codes to harmonize grid technical standards, trading policies as well as guidelines for managing grid stability
Cross-border trade facilitation	• Development of **electricity exchanges** (e.g., Nord Pool) for electricity auctions, price discovery, and market coupling[1]
Grid stability and security coordination	• Establishment of regional coordination centers for **real-time balancing and congestion management** for safe and reliable energy flow across grids
Infrastructure development and funding	• Identification of strategic cross-border interconnectors that receive **priority support**[2] • **Funding of RE integration** through European Investment Bank and Green Deal funding[3]

Key results

10%	of each nation's electricity production is partially exportable, targeting 15% by 2030
€40B	annual savings from integrating EU energy market by 2030
32%	potential energy cost reduction from an EU-wide transmission system
33%	of a nation's monthly flexibility needs[4] to be fulfilled by EU grid via solar and wind by 2030

Key learnings

Align policies and regulations for seamless energy exchange

Boost **investment in regional transmission** networks to integrate renewables

Presence of a **dedicated, binding institution** to drive the regional grids

Notes: (1) Aligning prices and efficiently allocating transmission capacities, thereby reducing price disparities; (2) Under Projects of Common Interest (PCI); (3) Funding mechanisms to help EU achieve climate neutrality by 2050; (4) Monthly flexibility needs means ability to balance electricity supply and demand over a month by adjusting generation, storage, and consumption | Sources: Ember; Lit. search

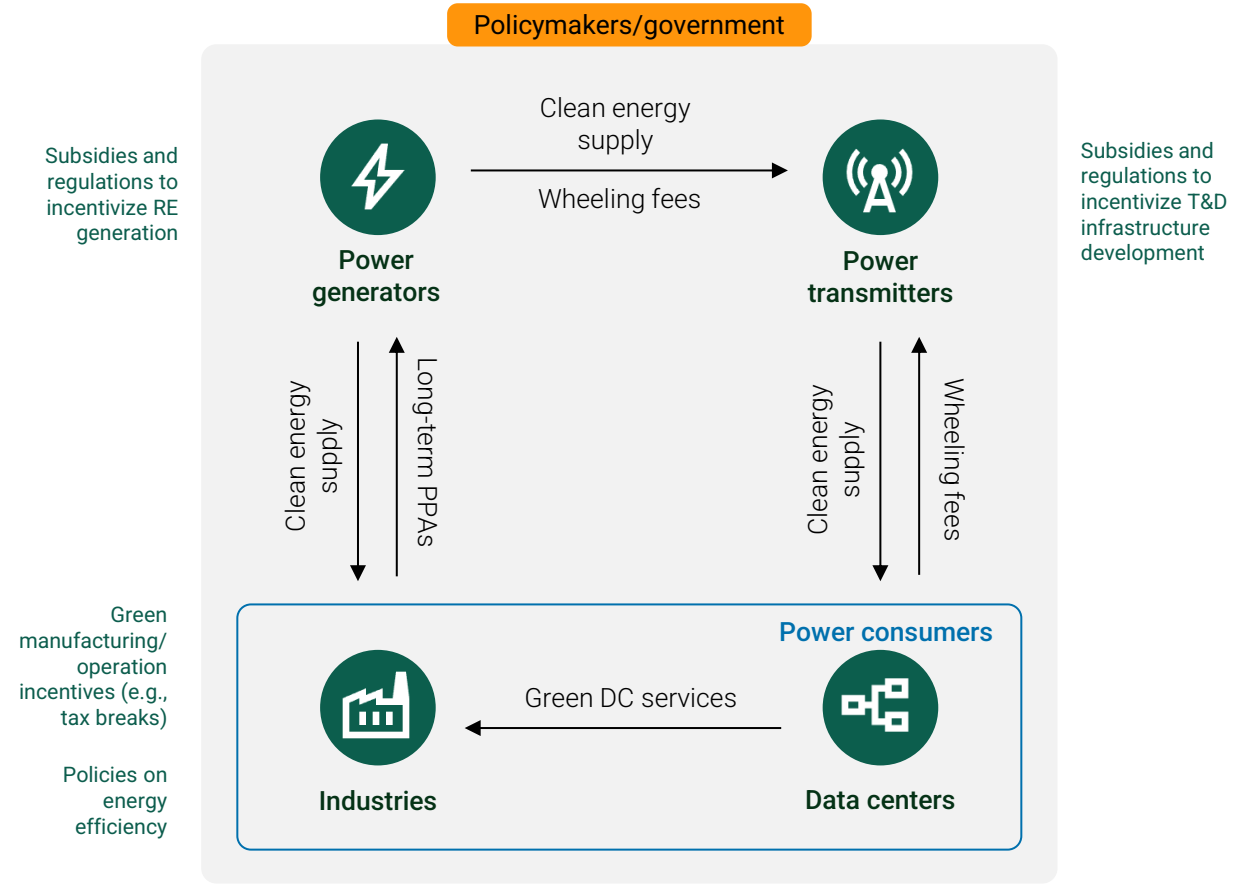
Green clusters create an ecosystem that accelerates private participation and provides proof points to demonstrate economic viability of green power investments

Creation of a green industrial cluster that incentivizes private investment into power ecosystem

Integrated ecosystem driving synergistic economic goals

- **Power generators** — Provide clean energy supply to the manufacturing players (e.g., through PPAs)
- **Power transmitters** — Create modernized transmission grids to flow from generation to industrial customers
- **Industries** — Set up operations within green industrial clusters (e.g., manufacturing factories, offices, etc.); sign up PPAs with RE generation firms for energy
- **Data center operators** — Leverage PPAs with the renewable energy producers to power the data centers
- **Policymaker** — Provide financial incentives to incentivize clean power generation and grid development through private sector participation

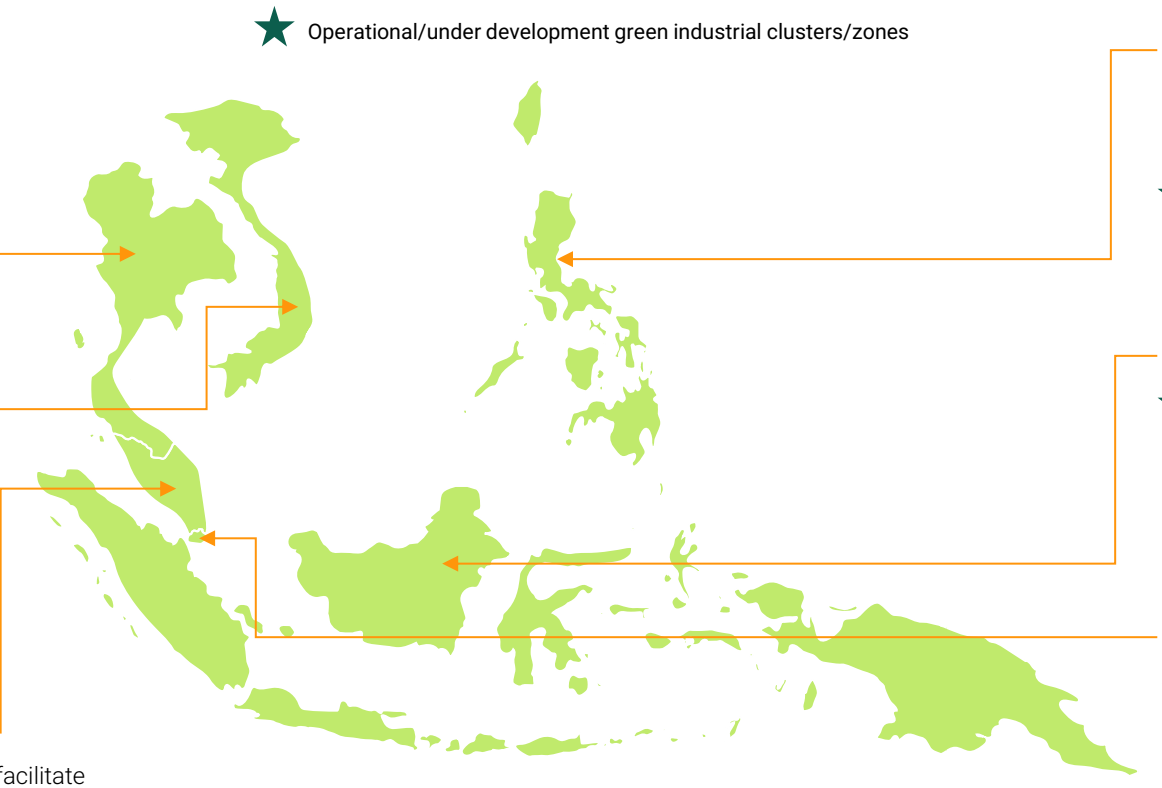
Functioning of a green industrial cluster (enabled by policymakers/government)



Source: Lit. search

New zones enabled by strong policy support are developing across multiple SEA countries

Growing momentum to establish green industrial clusters driven by government industrial policies and initiatives, private sector investment, and pull from MNCs and data center operators wanting green power at scale



Thailand

- Introduced new incentives under five-year investment promotion strategy (2023–27) to promote green industries
- ★ Key zones include Chachoengsao Green Industrial Cluster focusing on supporting electronics and logistics industries using RE

Vietnam

- State financial support of up to 30% of an industrial cluster infrastructure cost (2024)
- Receipt of ~$3.3 million foreign grant to promote transition to eco-industrial parks
- Developing VSIPs[1], a JV between Sembcorp (SG) and Becamex IDC (VN), to delivered sustainable industrial parks

Malaysia

- Launched New Industrial Master Plan 2030 to facilitate investments for development of eco-industrial parks
- ★ Key green zones include Sarawak Corridor of RE (SCORE)
  - Aims to create 1.5 million jobs by 2030
  - Launched SEA's first integrated hydrogen production plant

Philippines

- Collaboration with European, German agencies for encouraging various industrial sectors to adopt strategies for green modernization
- ★ Development of Palawan Eco-Industrial Park to attract industries such as renewable energy, electric vehicle production, and advanced manufacturing

Indonesia

- ★ Development of one of the world's largest green industrial zones in Kalimantan for catering to solar PV production, EV batteries
- Promotion of low-carbon manufacturing through carbon tax policy (incentivizing manufacturing firms to adopt energy efficient practices)

Singapore

- ★ Developing a green industrial park within Johor-Singapore SEZ
  - Includes a dedicated solar park
  - Positioned for high-value industries, e.g., logistics, clean tech, advanced manufacturing
- Development under Green Building Masterplan to advance environmental sustainability within industrial estates

Notes: (1) VSIPs = Vietnam Singapore Industrial Parks | Sources: Expert interview; Lit. search; Bain analysis

APAC and SEA | Opportunity to strengthen collaboration for mutual benefits in establishing next-gen power grid; clear economic and carbon incentive to accelerate

	Grid modernization and storage solutions	Grid expansion	Cross-border power trade	Tech transfer
Collaboration opportunity	**Deployment of smart grid technologies** such as AI-driven demand response and large-scale **battery energy storage systems** to support variable RE like solar and wind	**Investments in high-voltage transmission networks and RE integration** across SEA by leading energy firms from APAC nations	**Alignment of grid infrastructure standards across value chain** (transmission protocols, grid interconnection requirements, and energy trading mechanisms) to facilitate seamless cross-border trade	**Knowledge-sharing initiatives** between APAC nations and SEA for developing technical expertise in grid management
	$10 billion investment by Chinese firm CNGR in integrated battery production for precursor battery products in Indonesia in 2024	**Hitachi Energy** and **Samsung** C&T collab to explore **high voltage direct current (HVDC) projects in** SEA in 2024	India and SEA announced in 2023 their plan to **develop a connected regional grid for electricity trade**	**China-SEA collaboration** wherein China will share knowledge and facilitate clean energy transition and RE capacity development and integration to grid in SEA
Impact to SEA	• **Increase grid reliability** and **resilience** against outages • **Attract FDI flows** to SEA	• **Enhance energy security** • **Strengthen cross-border electricity trade,** allowing nations to export surplus RE	• **Enable FDI flows** to SEA in power transmission and distribution projects • **Accelerate RE adoption** through surplus energy trade across border	• **Strengthen local expertise** and increase **self-reliance** in maintaining and operating high-tech grid infrastructure
Impact to APAC	• **Market expansion** to SEA • Improve regional power trade efficiency through **smart grid interoperability**	• **Market expansion** to SEA	• **Strengthen regional energy resilience** by reducing dependence on single-country power supply chains	• **Market expansion** to SEA • Enhance **regional R&D collaboration**

Sources: The Jakarta Post; Renewable Energy Institute; EF China; Asia Society; Economic Times, Lit. search

Investable ideas | SEA offers diverse investment opportunities in grid development, with returns ranging from 10%–30%

Overall grid transmission infrastructure

	Grid expansion (e.g., power cables, towers)	**Grid modernization** (e.g., microgrids)	**Energy storage solutions** (e.g., BESS)
Market size[1] ($ billion, 2030F)	**$4–$6B**	**$2–$3B**	**$0.3–$0.5B**
Indicative profit margins (gross profit)	**10%–15%**	**20%–30%**	**20%–30%**
Recent investments activity (M&A, JV, greenfield investments)	**Japan's Hitachi Ltd.** and **Thailand's EGAT collab** to limit transmission losses by developing voltage control systems in Thailand JV between **China's XD group** and **Indonesia's CCM group** to manufacture power transformers	**TotalEnergies, BP, Shell,** and **Equinor** committed $500 million in regions including SEA to develop solar systems and microgrids[1] JV between **China's Narada Asia Pacific** and **Singapore's A*STAR** to develop an integrated microgrid system	**Japan's Marubeni Corp.** and **Vietnam's VinES collab,** where Japan is helping Vietnam develop battery energy storage solutions for better demand response and grid stabilization JV between **China's CATL** and **Indonesia Battery Corp.** to build a 15 GWh battery cell manuf. plant in Indonesia

Notes: (1) Microgrids are self-sufficient energy systems that integrate RE, storage, and smart grid technology, operating independently or in the main grid | Sources: Company websites; Reuters; Enerdata; Lit search; Expert interviews

Recommendations | Key steps to accelerate grid modernization and expansion

Policymakers and regulators (govt.)

Introduce regulatory reforms that enable private sector investment in grid modernization
- e.g., market-based pricing to attract private participation

Implement policies to facilitate cross-border electricity trade
- e.g., standardized wheeling tariffs, capacity-based transmission charges

Facilitate financing mechanisms for investment in grid (e.g., issuing green bonds, regional grid investment fund, transition credits)

Develop green industrial clusters/SEZs with incentives (e.g., tax rebates) for clean energy investments

Establish mechanisms to identify and prioritize high-impact projects
- e.g., EU identified strategic energy infrastructure projects and streamlined funding under Projects of Common Interest (PCI) initiative

Power consumers (e.g., industries, DC operators)

Purchase clean energy via high-impact instruments like corporate PPAs to drive demand for renewable energy integration into the grid

Invest in **energy-efficient technologies**, green solutions to help manage grid load and energy use
- e.g., leverage off-grid solutions such as solar, battery storage, and smart energy management to optimize power usage

Financial institutions

Provide **long-term financing solutions** (e.g., loans, green bonds, concessional funding) for large-scale grid infrastructure
- Support in solution execution through BDP sharing/knowledge transfer, when possible

Offer **guarantees and insurance** to de-risk private investment

Support governments and utilities in feasibility studies for **grid-related projects**
- e.g., provide funds to stakeholders for new solution exploration such as setting up subsea cables for regional energy trade

Power ecosystem players

Invest in AI-enabled smart grids (e.g., using Internet of Things for monitoring, predictive maintenance, load balancing, and RE integration)

Develop microgrids and energy storage solutions to enhance grid reliability and resilience

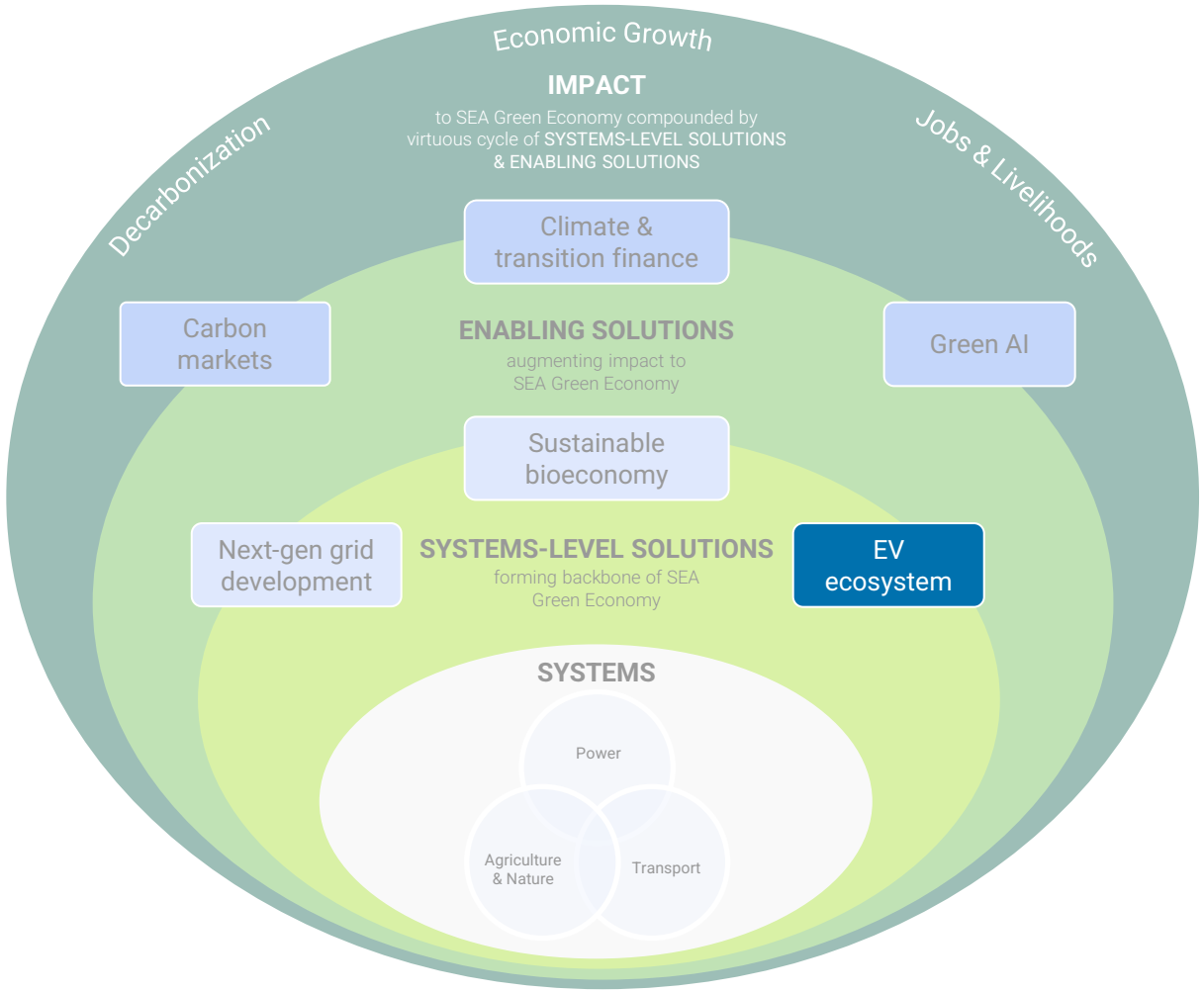
Invest in grid enhancing technologies (GETs) to maximize the transmission of electricity across existing power grids by increasing the capacity of existing lines **without the need for new infrastructure**

Systems-level solution 3

EV ecosystem

07

EV ecosystem | Key takeaways



Potential results from the solution in 2030

~40 MtCO2e reduction	~350,000 jobs created	~$55 billion annual GDP contribution

01 **EV adoption is rising, however BEV penetration remains low**, leaving much room to accelerate uptake

02 **SEA auto production is ~80% ICE, creating economic risks** as EV imports from global leaders increase competitive pressure, challenge markets

03 **Dual strategy required—scale EV demand and local production** to retain manufacturing edge and drive decarbonization in the most cost-effective way

04 **SEA is well-positioned as an EV hub,** with raw materials, manufacturing capabilities, and strong APAC investment momentum

05 **Green transport corridors can fast-track EV uptake in commercial fleets** by aligning key players—fleet operators, charging providers, clean energy suppliers—to enable fleet electrification

06 **Regional Asia-Pacific collaboration can unlock shared value** through joint investments and integrated supply chains across battery, EV manufacturing, and charging

Key initiative

Strengthen EV supply chains for resilience

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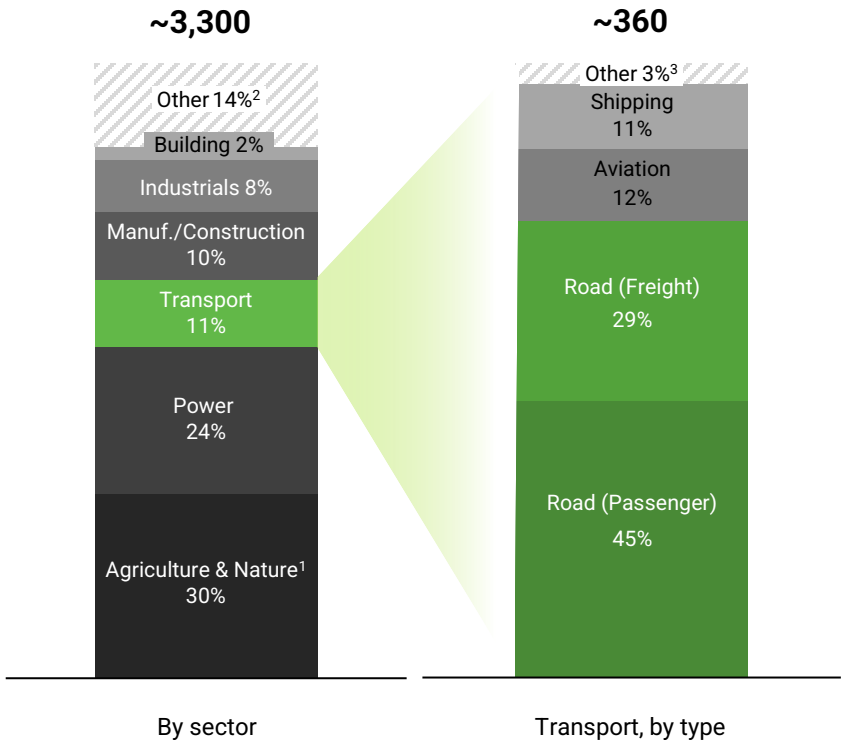
Road transport is a major source of SEA emissions, with emissions expected to rise due to underlying growing mobility demand

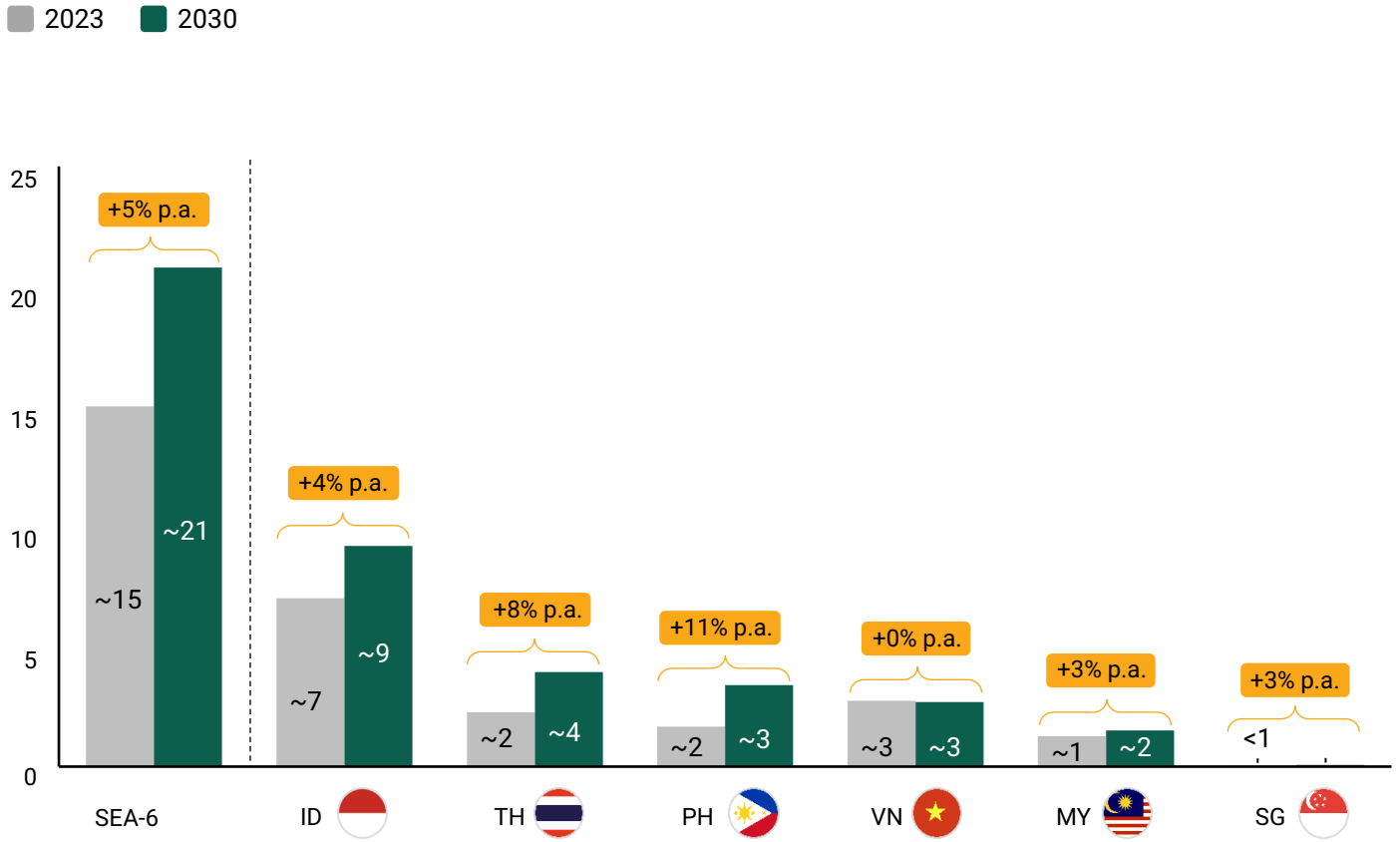
Road transport contributes ~75% of SEA's transport emissions

SEA-6 GHG emissions (MtCO2e, 2023)



Emissions expected to increase given rising demand in mobility across markets

Total annual vehicle sales[4] in SEA-6 (millions)

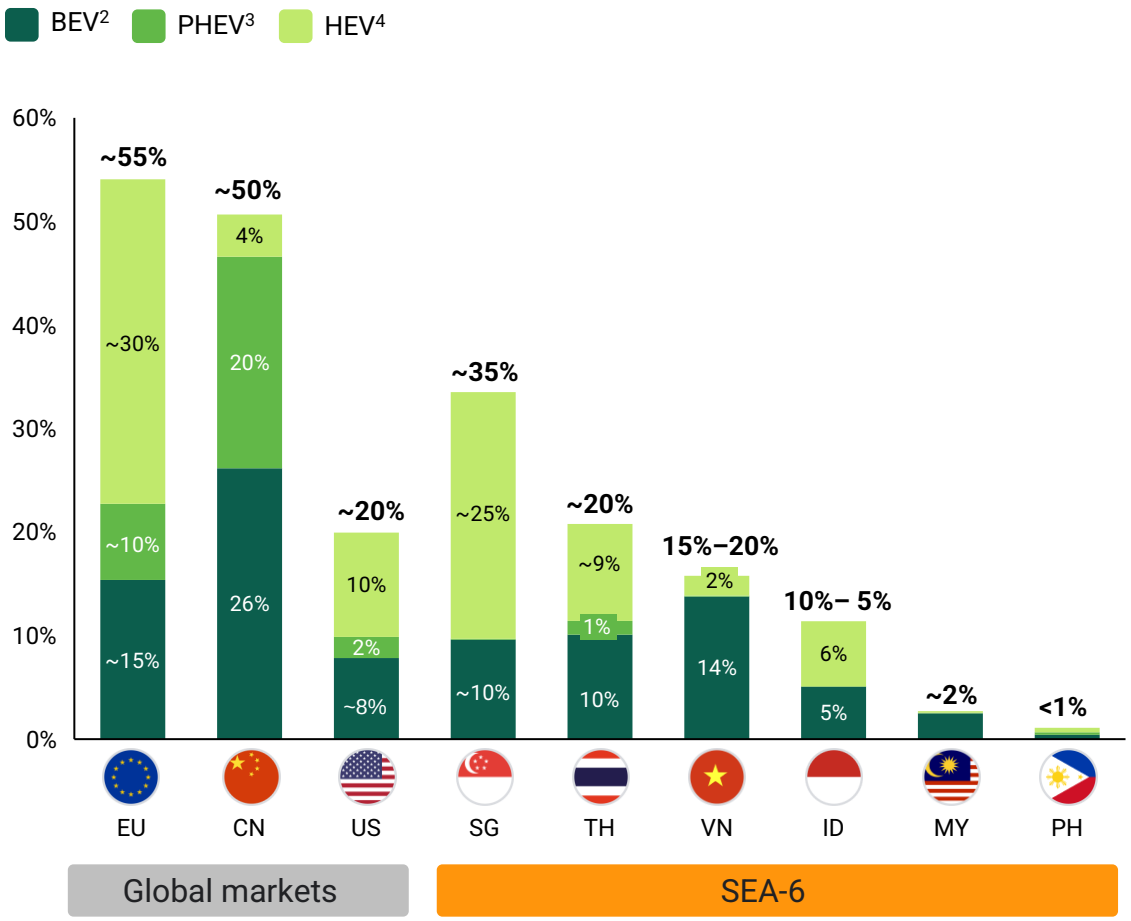


Notes: (1) Includes emissions from LUCF; (2) Includes bunker fuels, industrial processes, and waste; (3) Includes rail and transport of oil, gas, water, and steam; (4) Includes 4W passenger vehicles and 2W motorcycles and scooters | Sources: ASEAN Automotive Federation; Climate Watch; EU EDGAR; IEA; Fitch; Our World in Data

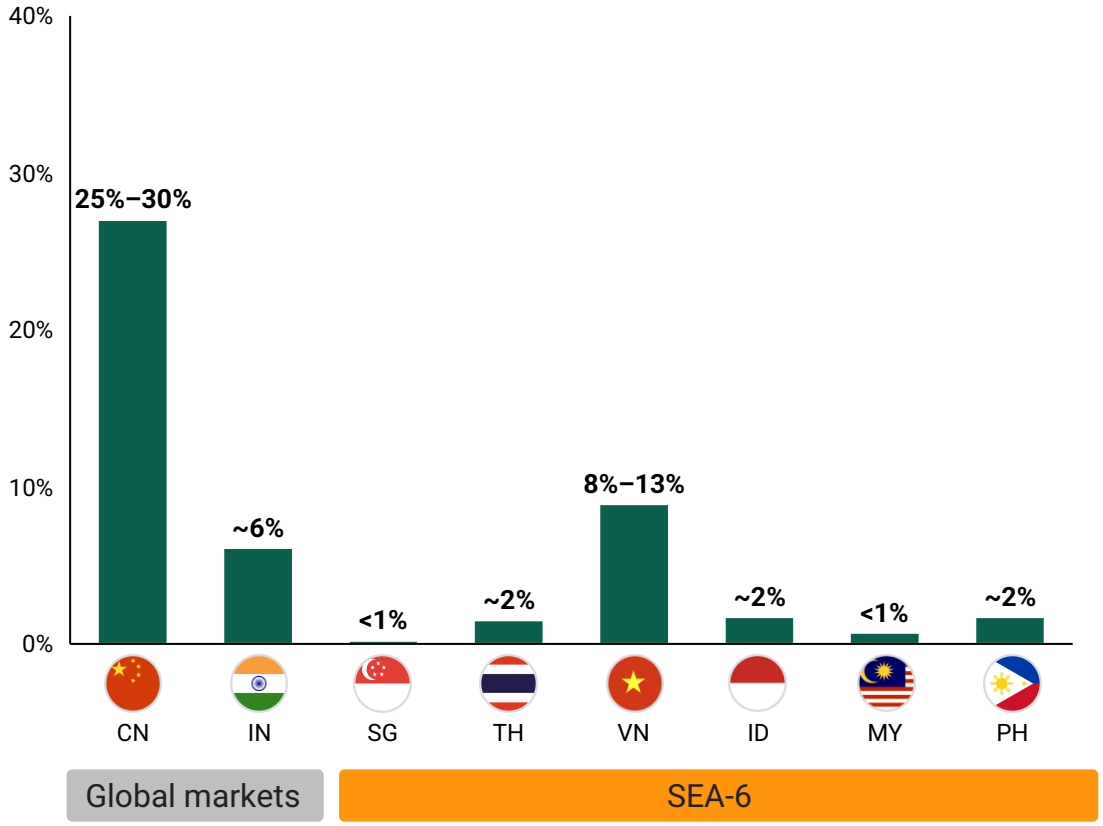
ICE vehicles dominate SEA; low EV adoption across markets

BEVs comprise <15%, while internal combustion engine (ICE) account for 65%–90% of 4W sales across SEA-6 nations

4W EV penetration[1] (percentage of new 4W sales, 2024)



2W BEV penetration (percentage of new 2W sales, 2024)

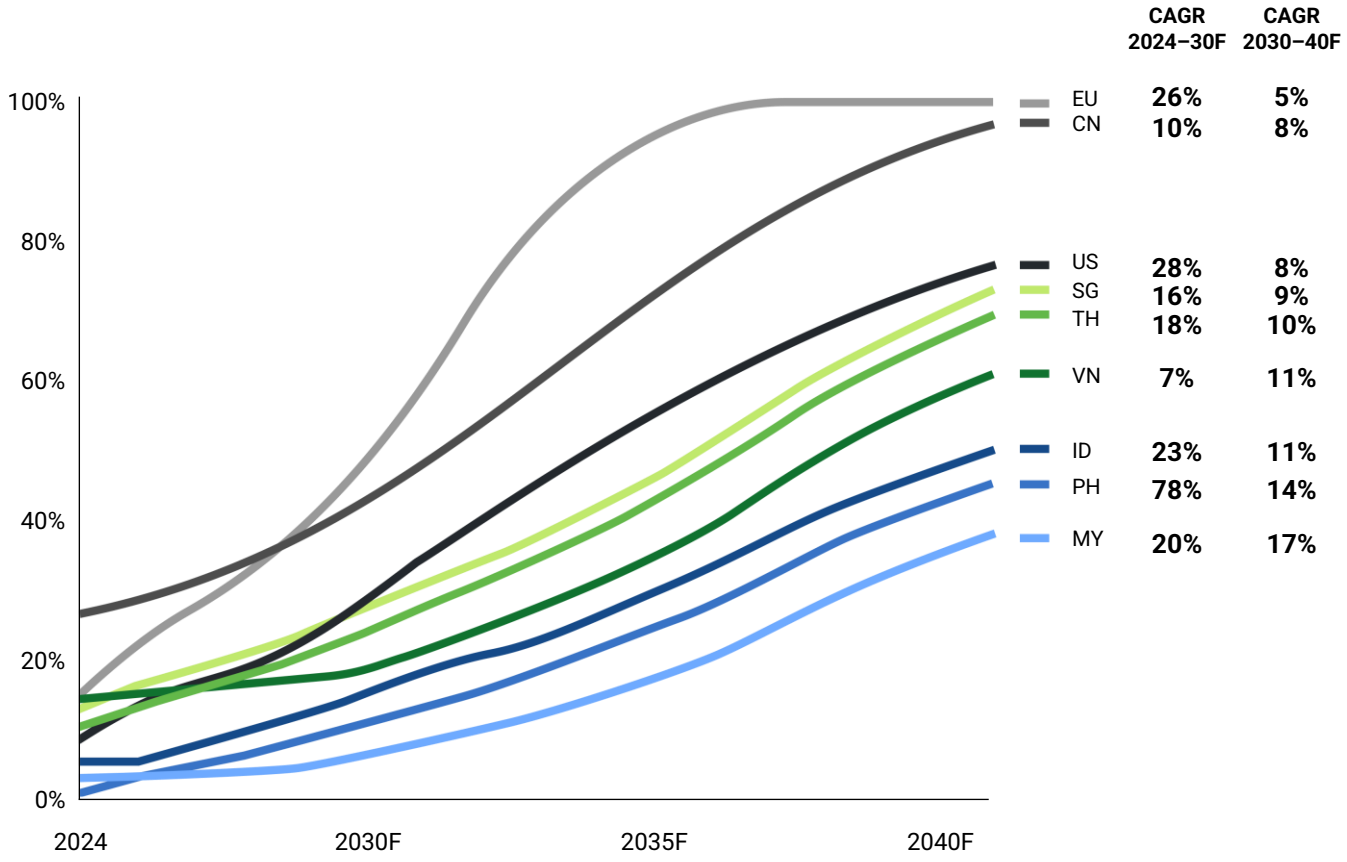


2W BEV penetration is low across markets; VN leads penetration in SEA-6

Notes: (1) 4W vehicles only includes light vehicles (passenger cars and commercial vehicles <3.5 trillion); (2) Battery electric vehicle; (3) Plug-in hybrid vehicle; (4) Hybrid electric vehicle | Sources: Euromonitor; IEA; Marklines

EV adoption in SEA is expected to accelerate over coming years, but currently still lags well behind global leaders

4W BEV penetration rate
(percentage of new vehicle sales), by country (percentage, 2024–40F)



4W BEV penetration rate
(percentage of new vehicle sales), by country

	Country	2024	2030F	2040F
Global markets	Europe	15%–20%	55%–60%	~100%
	China	25%–30%	45%–50%	95%–98%
	US	5%–10%	30%–35%	75%–80%
SEA-6	Singapore	10%–15%	30%–35%	70%–75%
	Thailand	10%–15%	25%–30%	65%–70%
	Vietnam	10%–15%	20%–25%	60%–65%
	Indonesia	5%–10%	15%–20%	45%–50%
	Philippines	<1%	8%–10%	45%–50%
	Malaysia	~2%	8%–10%	35%–40%

Note: 4W vehicles only includes light vehicles (passenger cars and commercial vehicles <3.5 trillion)
Sources: S&P Global; Fitch; EVAT; Philippines Department of Energy Association; Euromonitor; FTI; MAA; Desk research; Market participant interviews

SEA auto manufacturing is an important economic contributor that faces increasing competition from EV imports due to its high reliance on ICE

Auto manufacturing is important to SEA-6 economy

~$300B

contribution to total SEA-6 GDP is from auto manufacturing[1]

~10%

contribution[2] to GDP in both Indonesia and Thailand

~1M

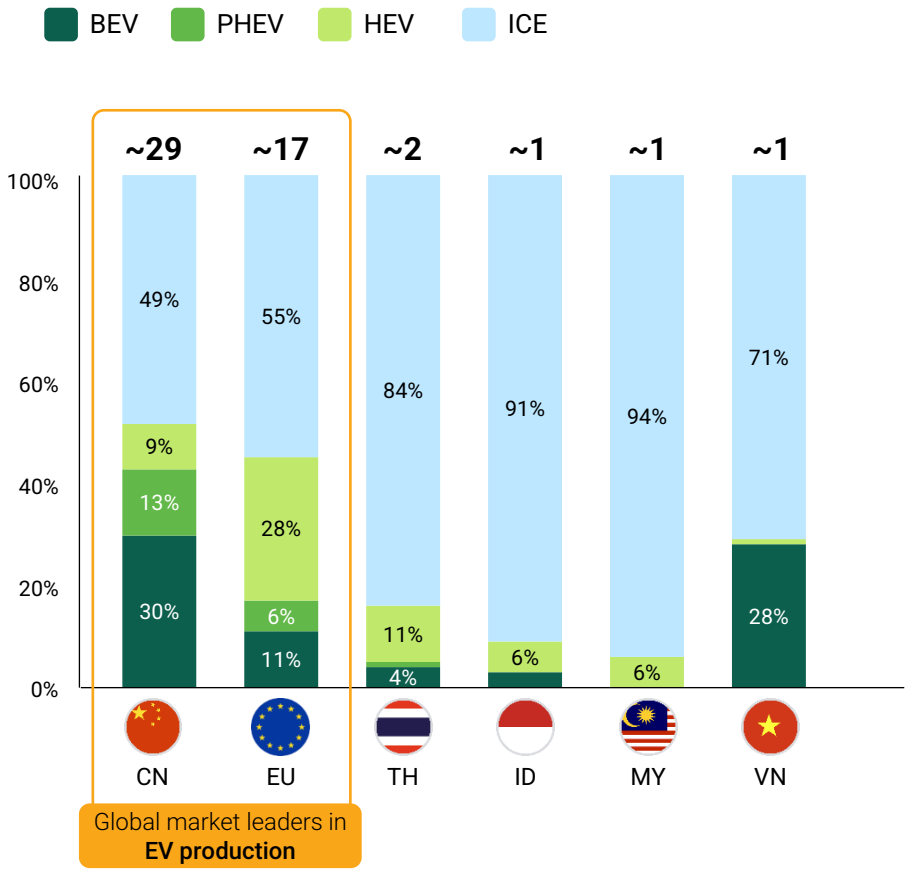
employment[3] in auto sector

~850K

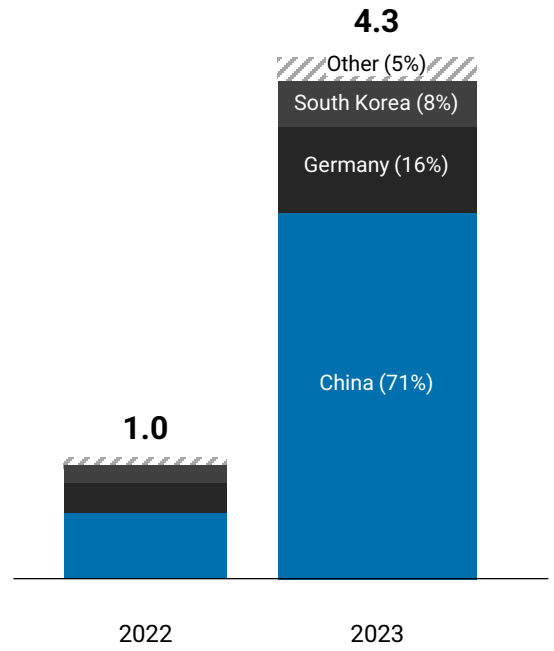
employment[4] in auto sector

ICE dominates SEA production; EV imports from global leaders (e.g., CN) are rapidly growing, posing competition risks to incumbent manufacturing hubs

4W production (million vehicles, 2024)



SEA-6 Import of EV ($ billion, 2022–23)



Notes: (1) Data from S&P Global; (2) Employment as of 2023; (3) Employment as of 2024; (4) Import of EV data excludes Vietnam as data is not available for 2023
Sources: EVAT; S&P Global; Thailand National Statistical Office; Bain analysis; UN Comtrade; Lit. search

SEA to implement dual strategy: Accelerate EV demand and strengthen regional EV production to sustain manufacturing competitiveness & advance decarb goals

01 Drive demand for EVs

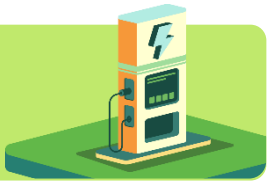
To reduce transport emissions

02 Enhance regional EV supply chains

To sustain auto manufacturing industry competitiveness and ensure ongoing value capture from auto industry in the region

Several systemic challenges are limiting acceleration of EV adoption and development of regional EV supply chains in SEA

Challenges to accelerating EV adoption



Limited incentive to increase EV affordability vs. ICE

- EV total cost of ownership (TCO) lower than ICE TCO in TH and at parity with ICE TCO in SG due to direct subsidies, fossil fuel subsidies, and fuel taxes; however, EV TCO higher than ICE in other (4 out of 6) SEA-6 nations

Nascent charging infrastructure buildout

- In TH, ratio of EV to charging points is ~12 (vs. ~6 in China)
- In PH, only ~340 charging stations built as of 2024 vs. government target of ~7,000 by 2025

Limited consumer financing options and high insurance premiums

- Residual value modelling is more complex for EVs vs. ICEs due to lack of viable method to assess expected battery degradation
- Higher insurance premium for EV cars due to higher vehicle repair cost

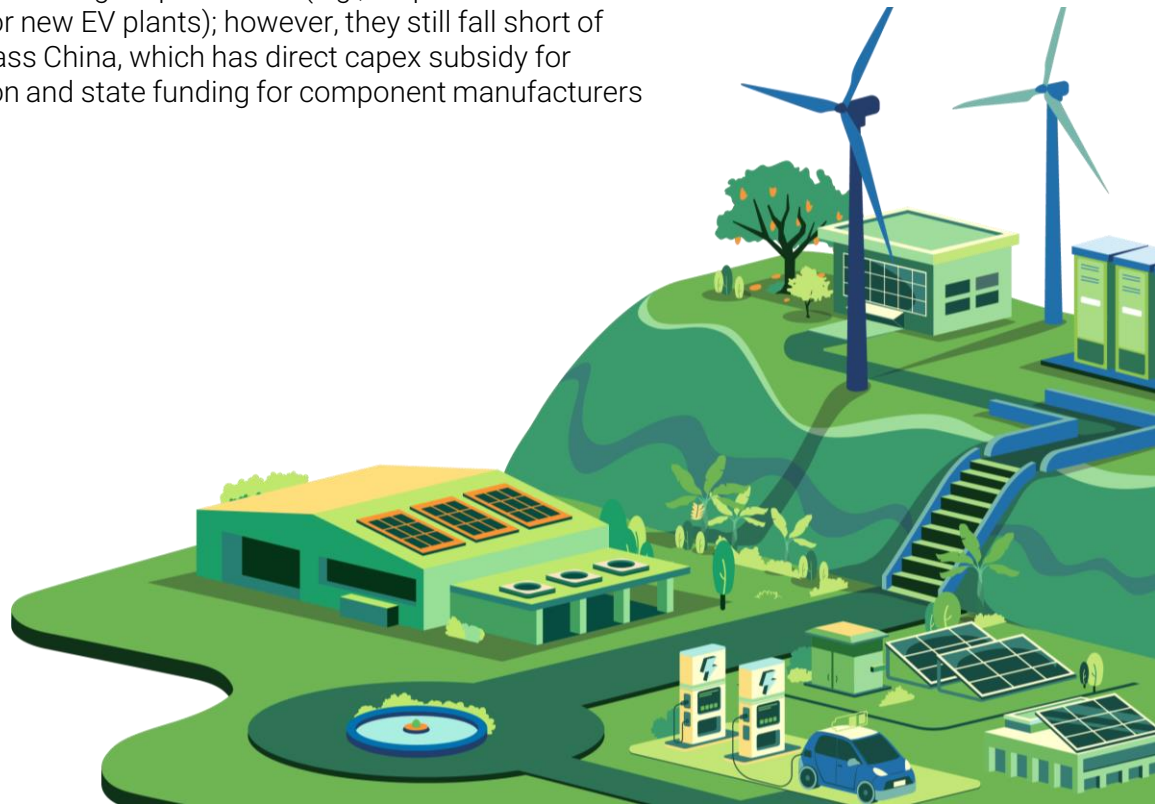
Lack of viable technological solutions for commercial vehicles (e.g., freight, public transport)

- Limited range and long charging time (resulting in higher downtime) makes EVs less viable for fleets needing high utilization rates (e.g., public buses)

Challenges to ramping up regional EV production

Lack of comprehensive incentives to develop regional EV supply chains

In SEA-6, only select countries (e.g., TH, ID) have strong regulations driving EV production (e.g., corporate income tax rebates for new EV plants); however, they still fall short of best-in-class China, which has direct capex subsidy for localization and state funding for component manufacturers



Sources: Daily Tribune PH; Kpler,;Krungsri; Market participant interviews; Bain analysis

Scaling EV ecosystem in SEA has potential to create ~$53 billion impact on GDP, reducing emissions by ~40 MtCO2e for SEA-6 in 2030

Total expected impact on SEA-6 (2030)

~40 MtCO2e	~$55 billion	~350,000
Reduction in 2030, ~10% of reduction of emissions in 2030	Economic value add in 2030	Jobs created in 2030

Implications of systems-level solution across SEA decarbonization systems

Systemic challenges/patterns of behavior improved by Systems-level solution

Potential for unintended consequences

Interventions through solution levers on systemic barriers

Transport system

Limited incentive to support EV affordability vs. ICE

High fossil fuel subsidies, limited incentives for EV adoption → High TCO of EVs vs. ICE → High ICE demand/ low EV demand

Limited charging infrastructure buildout

Low demand for EV infrastructure → Low supply of EV infrastructure

Limited consumer financing options and high insurance premium

Limited interest from FIs in financing/insuring EVs → Limited consumer financing options for EVs, high insurance premium

Technological limitations

Low investment in innovation → Range anxiety/long charging times

Limited technical expertise and capability → Range anxiety/long charging times

Limited incentives to localize EV production

Limited supply side incentive (e.g., tax break) → Limited ROI on EV production → Lack of localized production (i.e., ICE industry slow to transition)

High mobility demand

High demand for cars → High congestion

EV ecosystem

- Demand-side incentives
- Supply-side incentives, regional supply chain and trade
- Electrification of public transport fleet
- Green transportation corridor

Deep dive on following pages

Power system

Rising power demand

Higher demand for power → More generation of fossil fuel-based power

Lower ROI of RE vs. fossil fuel-based power → More generation of fossil fuel-based power

Agri & nature

Rising biofuel demand

Increasing demand from biofuel → (Inadvertent) increased demand for 1G feedstock

Lack of strong regulatory enforcement → (Inadvertent) increased demand for 1G feedstock

Weak monitoring & traceability systems → (Inadvertent) increased demand for 1G feedstock

(Inadvertent) increased demand for 1G feedstock → Deforestation and biodiversity loss

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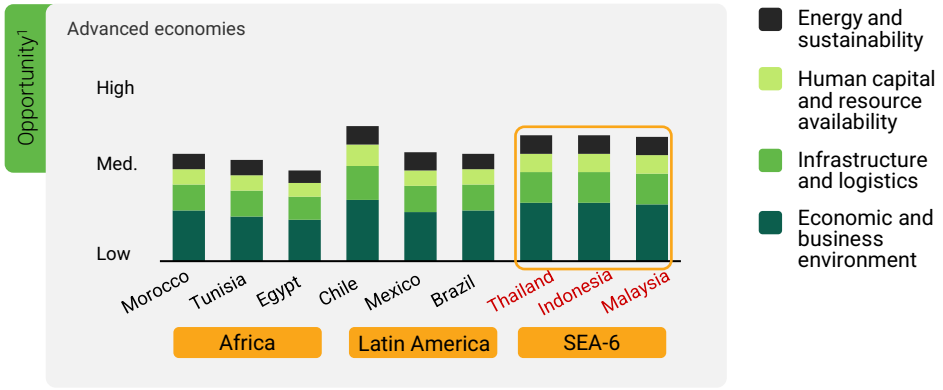
With the right policies and incentives, SEA can become an EV manufacturing hub

SEA-6 is a competitive manufacturing hub for EVs vs. other emerging economies ...

Batteries manufacturing opportunity assessment



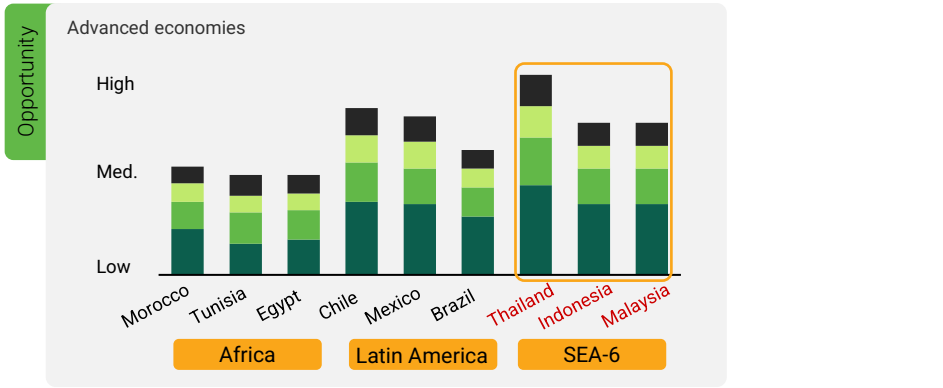
Energy and sustainability

Human capital and resource availability

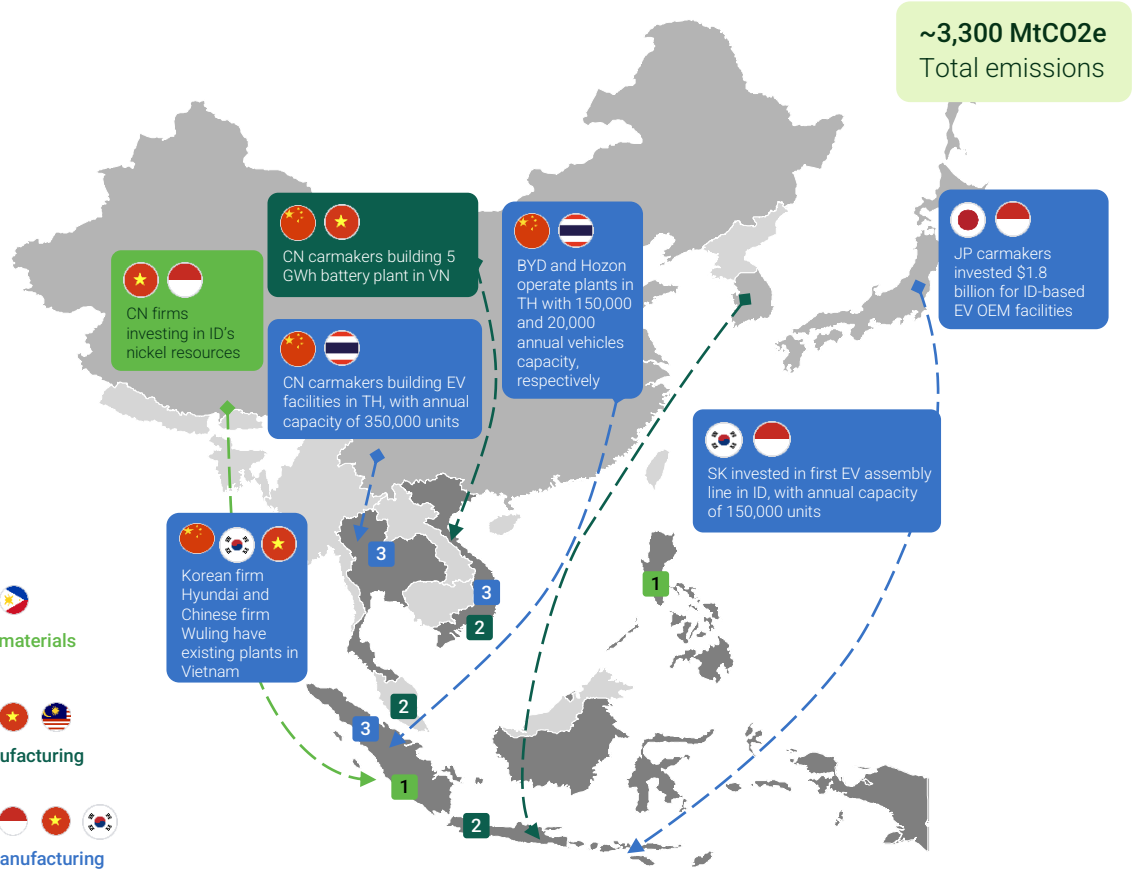
Infrastructure and logistics

Economic and business environment

EV cars manufacturing opportunity assessment



... and is benefitting from significant investments across the EV value chain from key Asia-Pacific nations (China, Japan, South Korea)



Note: (1) Based on IEA assessment of developing economies being location of manufacturing capacities | Sources: IEA; Bain analysis

Key implementation levers to scale EV ecosystems and increase regional production

Ease of implementation: High | Moderate | Low

	Implementation levers	Expected economic value add[1] (2030)	Ease of implementation
Implementation levers addressing systemic barriers	**Enhance demand-side enablers to drive EV purchase** (e.g., incentives, road tax deductions, phase out of ICE, regional alignment to facilitate import and export, etc.)	~$47–$48B	**High** Relatively quick implementation with government support, direct impact on consumer behavior by creating virtuous cycle of adoption
	Provide stronger supply-side subsidies to strengthen regional production (e.g., production-linked incentives that offer direct cash incentives or cash benefits for meeting domestic production targets)		
	Mandate EV manufacturers investing in region **to commit to tech transfer, local workforce upskilling, and local job creation,** fostering long-term industry growth and self-sufficiency		**Moderate to high** Requires government policy implementation but is attractive given SEA's position as automotive hub
	Coordinate regional trade policies to facilitate import/export of critical raw materials (e.g., easing Indonesia's nickel export ban)		
	Investments and regulatory push in charging infrastructure development via incentives or direct investments in buildout	~$2–$3B	**Moderate** Requires modernization of existing grid and substantial public/private investment
Additional levers	**Increasing and electrifying the public transport fleet** enhances public commute capacity and reduces need and reliance on private vehicles, reducing traffic congestion	~$0.7–$1B	**Moderate** While expensive, government backing and green financing make it feasible; several governments (e.g., SG, TH) already expanding EV bus fleets
	Establishing green transportation corridor for commercial vehicles, specifically within commercial logistics via fleet electrification, and collaboration on green infrastructure development Deep dive ahead	~$1.0–$1.1B	**Moderate** Private corporations are earmarking investments in the space, with several logistic firms piloting last mile fleet electrification

Note: (1) Refers to estimated additional impact on GDP from implementation lever; demand-side enablers and supply-side subsidies calculated using projected incremental value taken from producing EVs vs. ICE vehicles, in the four categories of 4W HDV, 4W LDV, 2W, and 3W; charging infrastructure calculated from projecting total number of chargers, and associated CAPEX/OPEX for buildout; electrifying public transport fleet calculated using difference between operating EV public vehicles and ICE public vehicles | Sources: IEA; Recessary; Global Petrol Prices; ASEAN projections; MJB&A; Lit. search; Bain analysis

Green transport corridors for light commercial transport | The next frontier for electrification

Convert corporate light commercial transport to EVs with scaled infrastructure

Why is this relevant now?

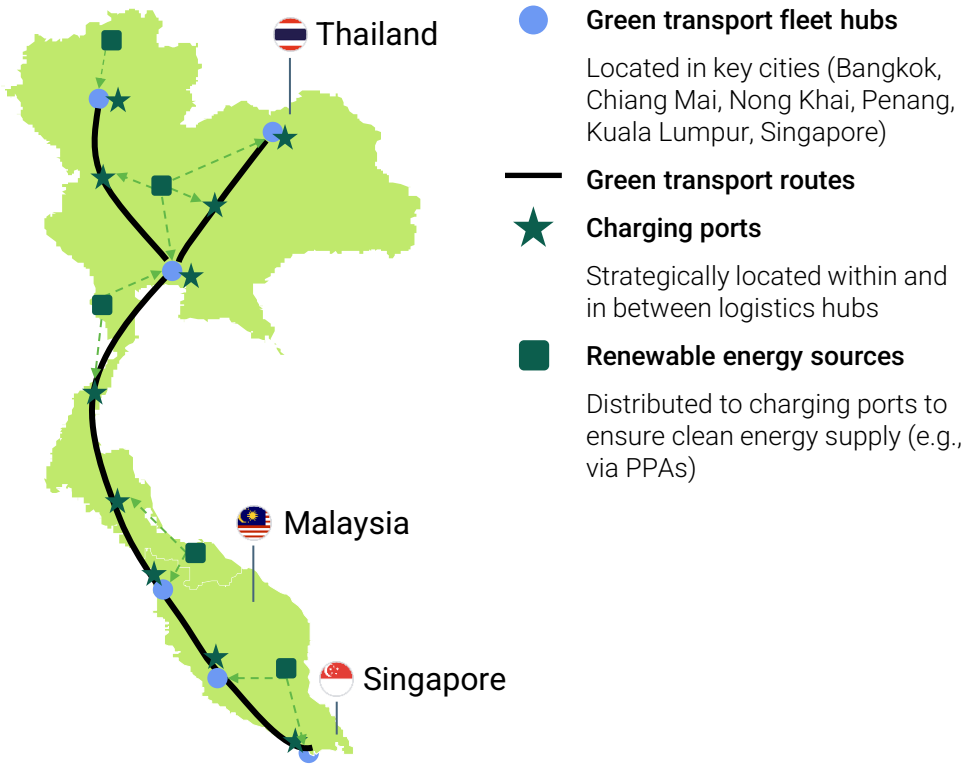
- **Light commercial transport represents 13%** of transport emissions in APAC
- **Total cost of ownership** for light EVs is becoming attractive

Players within the ecosystem have their own part to play

EV OEM company	**Invest in battery technology innovation** (to enhance range capabilities)
Logistics company	**Shift to EV fleets,** leveraging both local production and imports (e.g., low-cost EVs from China)
Charging infrastructure company	**Build out clean energy-based charging infrastructure**, in partnership with renewable energy provider
Renewable energy company	**Provide clean energy supply** to charging ports (e.g., through power purchase agreements)
Policymaker	**Provide financial incentives** to incentivize development

Players within ecosystem to test and scale solution is key success factor

Illustrative: Potential model and implementation in TH, MY, and SG



Source: Asian Transport Observatory

China and India are key success stories in accelerating EV adoption through strong government support and enhanced EV ecosystems

Global champion of EV adoption

25%–30%	**2W EV penetration rate**[1] in 2024
~50%	**4W EV penetration rate**[1] in 2024
~10%	**Lower BEV vs. ICE TCO**[2] by 2025F, parity reached in 2020
~30–35	**kW/EV for light duty vehicle (vs. ~20–25 globally)**

Fast-tracking EV adoption

55%–60%	**3W EV penetration rate**[3] in 2024
~40%	**Lower EV vs. ICE TCO**[4] for 3W model (auto-rickshaw)
~140%	**Public charging station growth** from 2021–25F

Key success factors

1. **Comprehensive demand-side government support provided** to kick-start EV adoption (e.g., dual-credit policy, EV purchase subsidies)
2. **Robust domestic end-market demand** key for value chain development; demand driven by domestic adoption vs. export
3. **Commercial fleet** (e.g., trucks, tractors) **adoption ahead of consumer adoption;** early adoption in commercial vehicles increases government's appetite to deploy more subsidies
4. **Localized EV production and supply chains** supported by government via state funding deployment, state-supported JV between players across the value chain, tax subsidies in certain provinces to increase domestic competitiveness across states
5. **Progressive government policies** driving initial adoption, boosting demand growth (e.g., ICE 3W registration restrictions, with recent initiative focused on battery-swapping policy)
6. **Strong collaboration across leading OEMs and component manufacturers** accelerates development of domestic EV ecosystem
7. **Growing start-up ecosystem** with >600 start-ups, fostering technological innovations across EV value chain
8. **Public transport electrification** driving expansion of battery swapping, which in turn supports broader adoption by technology advancement (e.g., increasing swapping stations for BEVs)

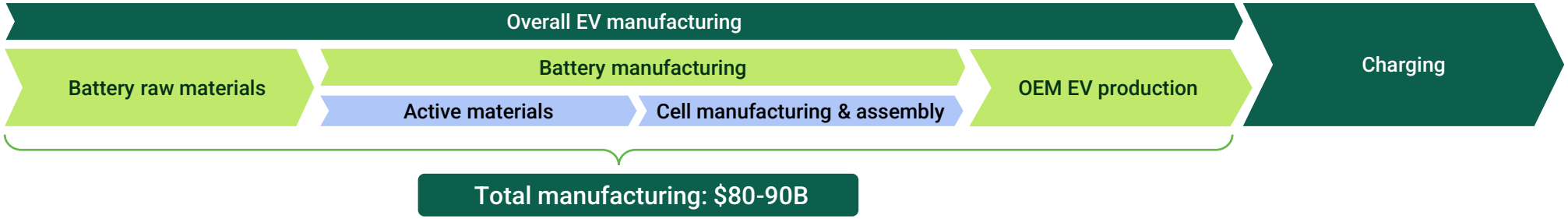
Notes: (1) Share of EV sales in new vehicle sales; (2) Total cost of ownership of 4W vehicles; (3) 3W EV share of new registrations; (4) Based on TCO at 8 years ownership using 2022 prices, based on IEA Global EV Outlook 2024 modelling | Sources: IEA; Lit. Search

APAC and SEA collaboration | Multiple economic opportunities for APAC and SEA to accelerate EV adoption through investment, infrastructure, and policy alignment

	Raw materials and battery production	EV manufacturing and assembly	Charging infrastructure	Alignment of standards
Collaboration opportunity	**Investments in raw materials and battery production in SEA nations** (e.g., Indonesia) by leading battery and refinery players from wider APAC nations (e.g., China, South Korea)	**Establishing regional EV manufacturing and assembly** in SEA, leveraging existing strong OEM production by regional players	**Investments in EV charging infrastructure** in SEA	**Investments in raw materials and battery production in SEA nations** (e.g., ID) by leading battery and refinery players from wider APAC nations (e.g., China, South Korea)
	$300 million in investments by GEM to expand ternary precursor factory in Indonesia to be export hub for overseas markets	**$490 million investments** in EV manufacturing facility by **BYD** for export hub to SEA and beyond in Thailand	**Kazam raised $8 million** in funding to enter SEA market	**ASEAN plus 3 initiative**, aligning international standards to ease cross-border EV trades
Impact to SEA	• **Creates high-value industries** beyond raw material extractions • **Accelerate SEA ability** to export EV components	• **Build regional expertise** in EV production • **Strengthen SEA position** as a strategic manufacturing hub	• **Increase charging** infrastructure to support adoption • **Attract FDI flows** to SEA	• **Improve access to EV components & batteries,** boosting regional production • **Ease FDI flows** to SEA on EV production
Impact to APAC	• **Access to cost-competitive** critical raw materials • **Cost efficiency** due to proximity to end EV market	• **Market expansion** to SEA and beyond • **Reduced production cost** through optimized supply chain	• **Market expansion** to SEA • **Additional revenues from charging fees** for owning and operating chargers	• **Stronger regional supply chain resilience** by reducing reliance on western markets

Sources: UNCTAD; RAND; Intereconomics; China briefing (news report); Asian Development Bank; Malaysian Investment Development Authority; Thailand EEC report

Investable ideas | Attractive investment opportunities exist, especially in high margin upstream part of the value chain



Market size (2030F)	**$1–$5B**	**$15–$20B**	**$60–$65B**	**$2–$3B**
Margin (EBIT)	**15%–30%**	**8%–11%**	**6%–8%**	**7%–9%**
Recent investment activity (M&A, JV, greenfield investments)	**Harita Nickel** invested $1.1 billion to build a HPAL plant in a JV with Lygend Resources (ID)	**GEM** invested in ternary precursor battery plant (ID)	JV between **Gotion and PTT Plc** to establish battery pack production with 8 GWh annual capacity (TH)	**BYD** invested $1.3 billion to construct production facilities with 150,000 units annual capacity (ID)	**Charge+** (EV charging operator) completed $8 million series A funding (SG)
	Indonesia Investment Authority JV with a Chinese auto supply company for 90 kT LFP production facility	JV between **EcoPro and GEM** to establish CAM production complex (ID)	**Sunwoda** plans to build a $275 million EV battery plant (VN)	**Chery Automobile** invested in $800 million EV factory (VN)	**Kazam** (India-based EV charging station) plans to expand into Malaysia, Thailand, and Indonesia
Key countries		Indonesia has proximity to low-cost raw materials supply			

Sources: Company websites; Euromonitor; Lit. search; Expert interviews; Bain analysis

Recommendations | Key steps to be taken by all stakeholders to support scaling EV ecosystem

Policymakers and regulators

Establish national targets to guide investment decisions of industry players

Locally manufactured EV targets; charging infrastructure targets

Phase out ICE vehicles

Implement regulations to limit and eventually ban ICE vehicle sales (e.g., petrol tax, traffic restrictions)

Introduce buyer incentives for EV adoption (e.g., subsidies)

Launch public awareness campaigns to educate consumers on EV benefits and available incentives

Support devt. of regional EV supply chains

Implement supply-side regulations[1] (e.g., tax rebates)
Coordinate policies to facilitate critical raw material trade

Develop policies and standards to facilitate charging infrastructure development

Mandate standardization of EV tech (e.g., charging connector types, charging speeds, pricing models)

Require commercial/residential buildings to include EV charging infrastructure

Corporations/ private sector

Strengthen regional production supply chain and technological capability

Establish JVs with regional firms to enter domestic market, localize supply chain and scale production

Invest in R&D (e.g., for range, battery, charging efficiency)

Expand and modernize EV charging infrastructure

Partner with energy utilities to develop smart, high-speed charging infrastructure powered by clean energy

Accelerate electrification of public transport fleets

Collaborate with governments to electrify public transport

Leverage innovative financial instruments (green bonds, SLLs) to reduce costs, (e.g., cycle and carriage automotive (partnered with Zhongtong Bus's green trade facilities for LTA's e-bus fleet)

Develop green transport corridors for commercial EVs

Identify key cross-border trade routes; develop EV charging infrastructure for commercial fleets along key routes

Conduct small-scale pilot programs to assess operational feasibility before scaling

Financial institutions and investors

Develop financing mechanisms to support EV manufacturing and infrastructure

For example, green, sustainability-linked, and transition instruments for EV manufacturing, infrastructure buildout, R&D

Develop financing mechanisms to reduce cost barriers for consumers and businesses

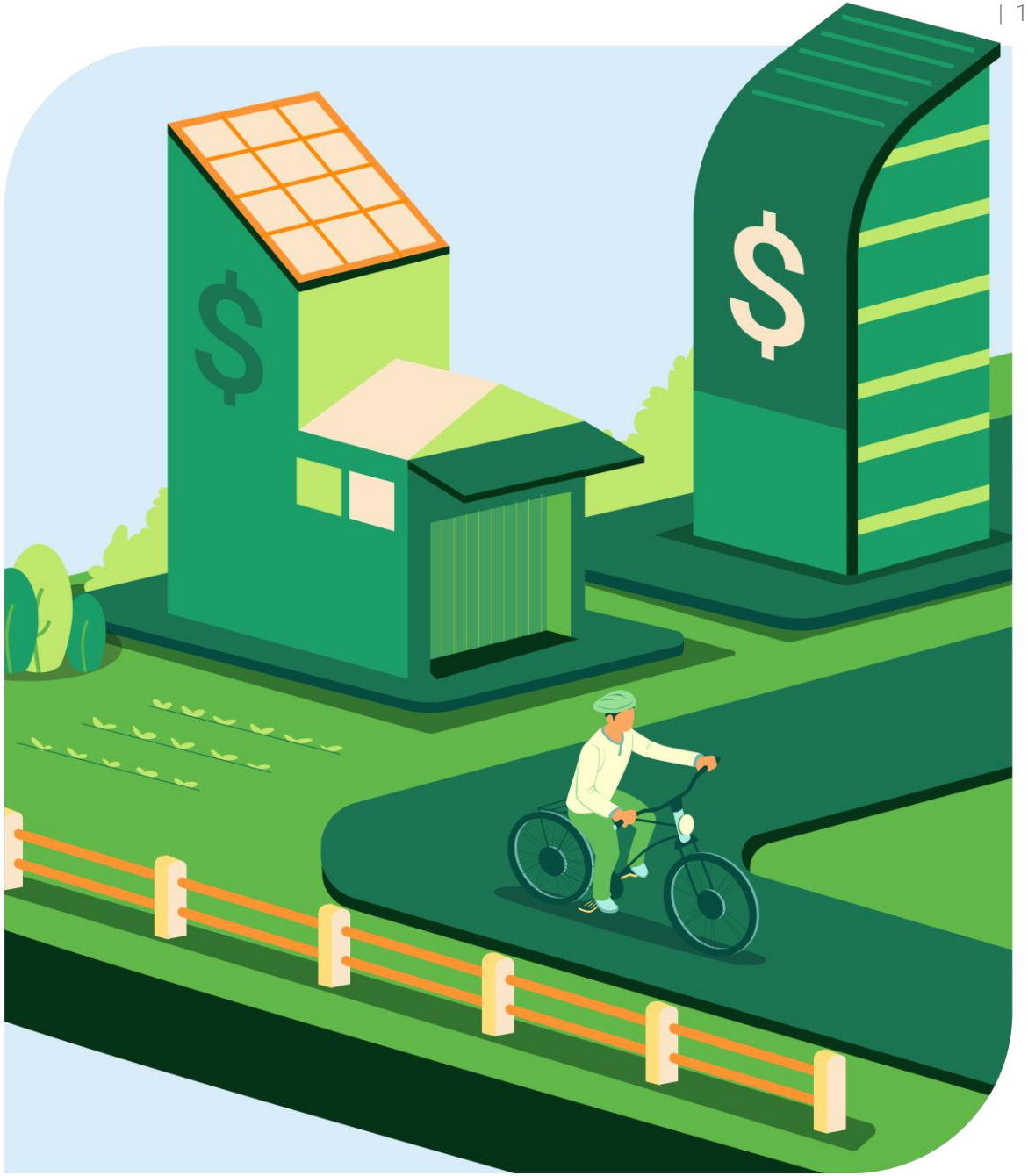
For example, concessional loans, zero-down payment loans, usage-based coverage for passenger EVs/commercial EV fleets

Note: (1) Supply-side includes EV producer along the value chain, infrastructure charging developer, public transport fleet provider, and green corridor transportation developer

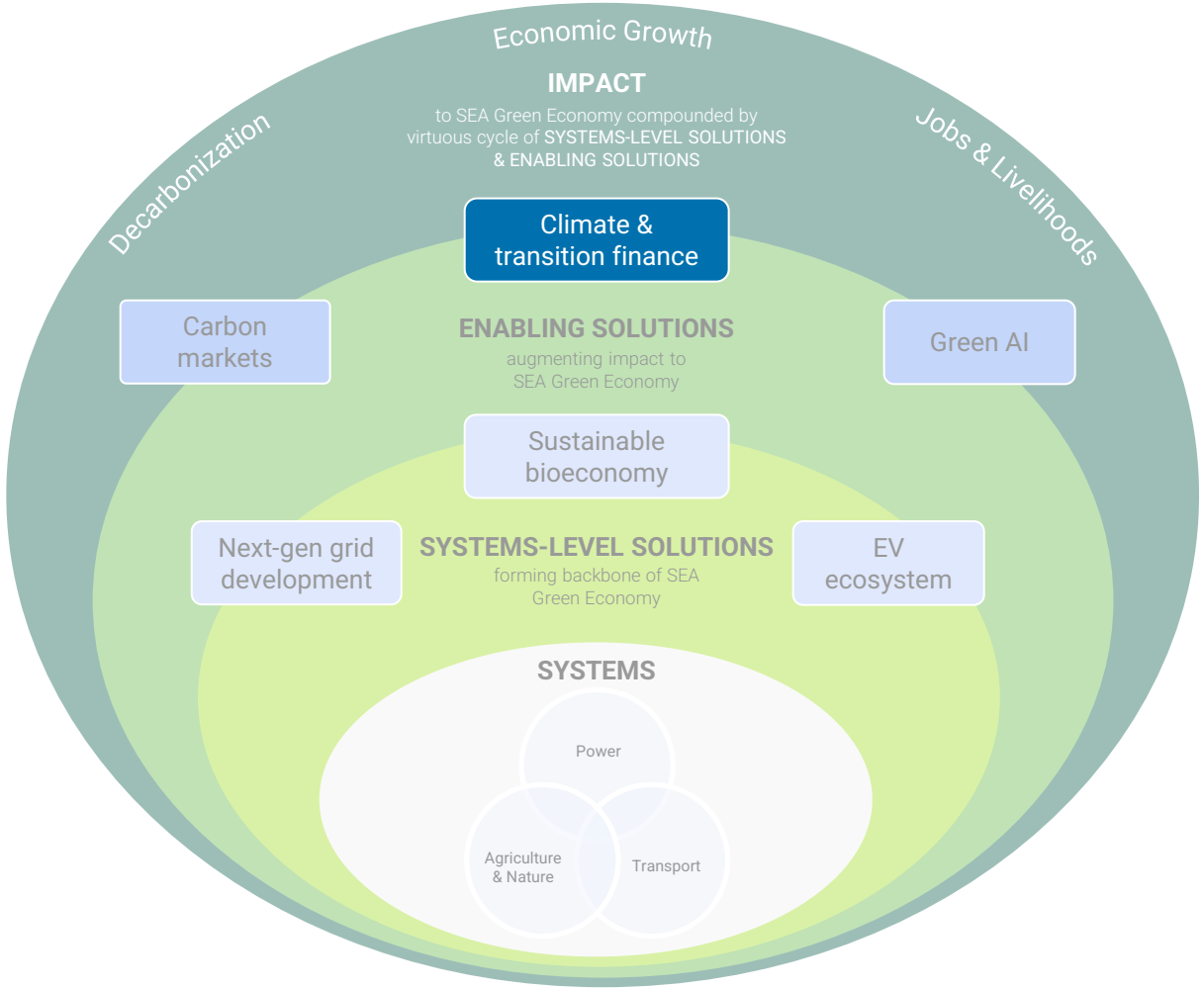
Enabling solution 1

Climate and transition finance

08



Climate and transition finance | Key takeaways



01 **Climate and transition finance is growing in SEA**, however, a gap remains and is set to widen given global pullback

02 **Blended finance is growing but requires additional policy navigation,** especially for harder-to-abate sectors

03 **Financing mechanisms** like offtake-based financing and infrastructure funds gaining traction; success depends on **developing standardized repeatable models to enable scale**

04 **Cross-stakeholder coordination is critical;** governments must standardize disclosures and taxonomies and expand co-financing while commercial investors scale up funding and concessional investors de-risk projects

Key initiatives

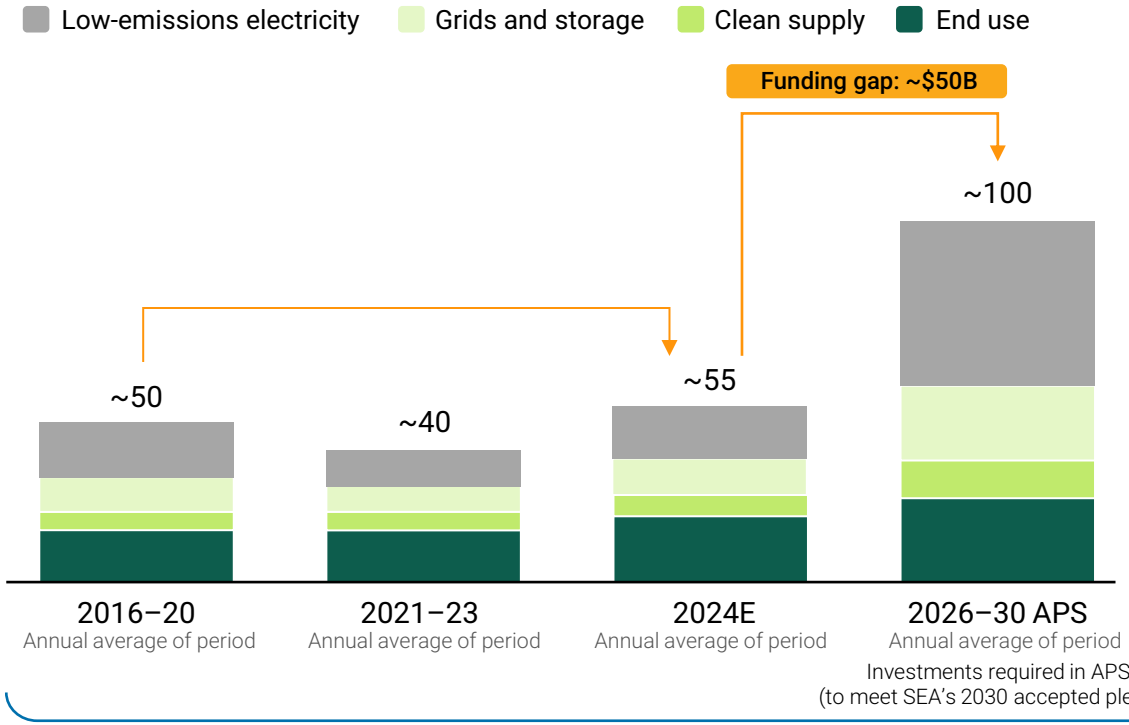
Engage commercial, concessional, and philanthropic capital providers to **develop enabling policies and standards**

BAIN & COMPANY GenZero Google standard chartered TEMASEK | ecosperity

Climate and transition finance is growing in SEA, but more is needed to meet accepted pledges

Investments have been growing since 2016 in SEA; however, a $50 billion gap exists to meet accepted pledges

Southeast Asia annual investments in clean energy ($ billion, 2016–30)[2]



Global climate investment momentum faces tightening with potential shifts in the funding landscape

> The financial aid provided to developing countries for climate change adaptation is significantly below the required $359 billion annually
>
> United Nations report, November 2024

> The US withdrawal from JETP creates a bigger financial gap in Southeast Asia's energy transition of the billions of dollars for Indonesia and Vietnam to transition to cleaner energy
>
> Institute of Energy Economics and Financial Analysis, US withdrawal from JETP

> The biggest thing about [climate and nature] finance is not actually aid. It's how to get private capital flowing on a large scale to Global South countries, which is not happening. That is the big, big problem
>
> Aniruddha Dasgupta, the chief executive of World Resources Institute (WRI)

> The 2024 COP29 agreement leaves SEA facing the same uphill battle—persistent funding gaps unmet by public sources, reinforcing need for strong private sector participation
>
> Article by Fulcrum SG

SEA needs innovative financing to close the funding gap and accelerate the green economy

Notes: (1) APS refers to Accepted Pledges Scenario as per IEA; assumes that all pledges made by August 2024 will be met; (2) Category details: low-emissions electricity includes RE, nuclear, and fossil fuel with CCUS; end-use refers to electrification, CCUS in industry, DAC, and direct use of renewables; clean supply includes low-emissions fuels, and emissions reduction in fossil fuel extraction | Sources: IEA World Energy Investments 2024; IEEFA; The Diplomat; Fulcrum SG

Each system requires multiple, tailored financing mechanisms to advance

/ Non-exhaustive

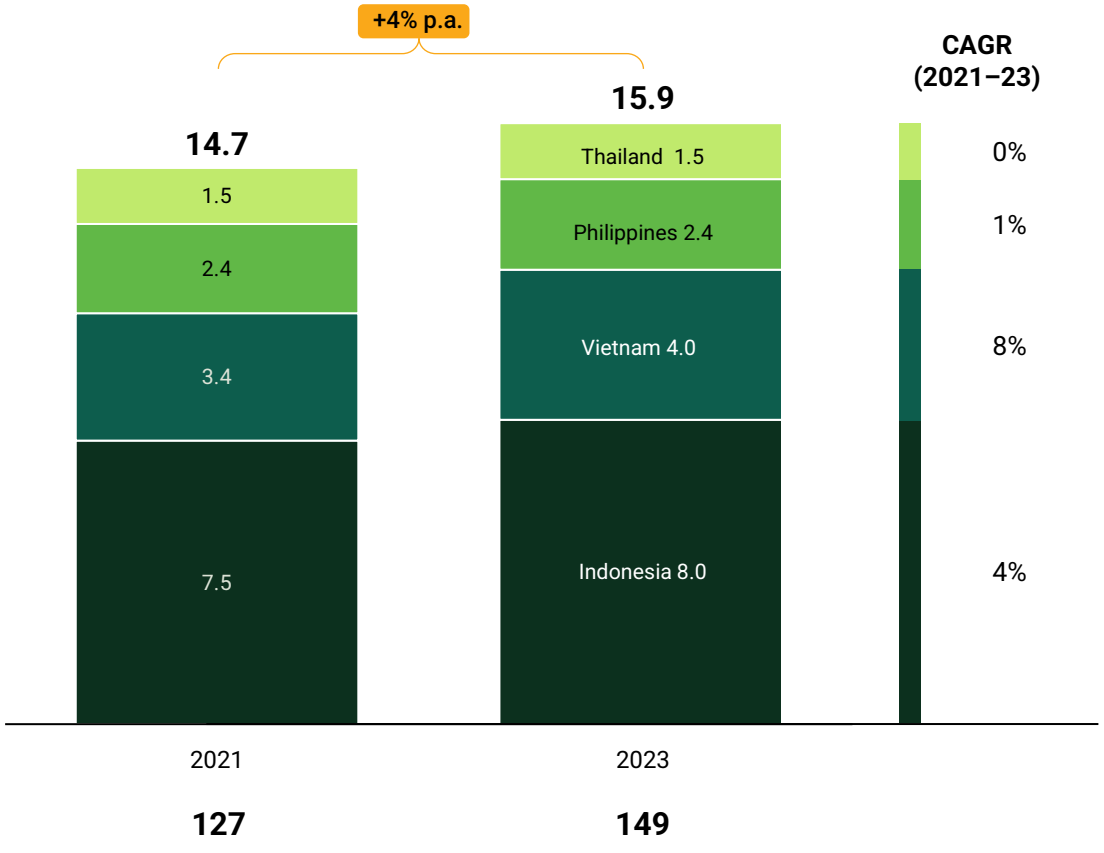
Deep dive ahead

	Sustainable bioeconomy	Next-gen grid development	EV ecosystem
Concessional and blended finance	1 **Blended finance** Investment structures that combine public or philanthropic capital with private sector funds to reduce risk and attract large-scale sustainable investments Investment use case: Capacity expansion of SAF facilities, upgrading grid powerlines, EV charging network expansion **Public grants and guarantees** Public good funding from governments and DFIs; grants are direct funding with no repayment expectation, and guarantees are coverage of non-payment or value loss, minimizing risk Investment use case: Biorefinery fuel plants, grid modernization, battery storage facilities, EV battery production and materials mining		
Revenue-backed financing	2 **Offtake-based financing** Project based financing where a lender provides funding based on a long-term offtake agreement Investment use case: Biofuel (e.g., SAF) production, regenerative agriculture		
Equity instruments	**Venture capital** Private investments in early-stage start-ups and technology-driven companies Investment use case: AI-based predictive grid monitoring, distributed energy management, microgrid solutions, OEM 2W start-ups, battery start-ups **Private equity** Growth stage investments into companies or projects approaching scale, with expectation of exiting the business and maximizing returns on initial stake Investment use case: Biofuel companies in growth stage, RE infrastructure (wind, solar, battery projects), late-stage EV start-ups	3 **Infrastructure funds** Funds that provide long-term equity investments or loans to finance critical infrastructure projects Investment use case: Grid expansion, transmission line, EV charging network expansion	
Debt instruments	**Green/sustainable/transition instruments** Debt instruments used to finance large-scale sustainability-focused projects across the systems; these can be used as refinancing instrument post commercial operations of the asset to reduce financing costs given operational status of the asset Investment use case: Construction of 2G plant, integrating RE sources into grid transmission, expansion of EV production facilities **Sustainability-linked instruments** Loans where interest rates and disbursements are tied to borrower's achievement of predefined sustainability performance target Investment use case: Biofuel production, upgrading grid, EV production (loan tied to production targets)		
Carbon finance	**Carbon credits** (further deep dive in carbon markets chapter)		

Blended finance in Southeast Asia has been growing since 2021, with energy and financial services attracting most significant investments

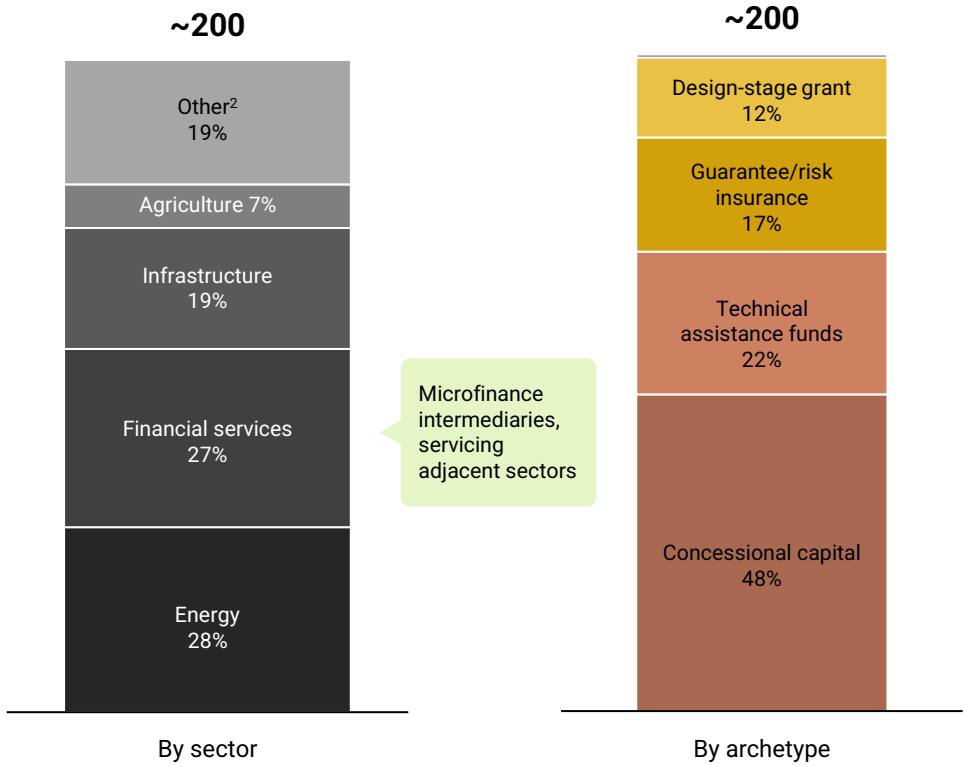
SEA accumulated blended finance capital invested

($ billion, 2021–23)



SEA accumulated deal[1] count, by sector and archetype

(2023)



Notes: (1) One deal can be classified under more than one sector and archetype; (2) Other includes general, health, education, marine life and biodiversity, industry and trade, housing and real estate | Source: Convergence

Sustainable agriculture | Mitigate investor risks through multiple solutions such as long-term offtake contracts to accelerate carbon market adoption

Leveraging carbon credits to fund diverse sustainable agricultural projects (e.g., AWD, regenerative agriculture, methane reduction in livestock, etc.)

Why is it needed in SEA-6?

Huge carbon sequestration potential

- Agriculture sector is the largest emitting sector in SEA-6 but holds high amount of **decarbonization potential** via practices like agroforestry, cover cropping, and no-till

Need for additional revenue stream for smallholder farmers

- **~100 million SHFs** in SEA, **with average farm size of 2 ha,** lack necessary funds for sustainable farming
  - Carbon credits can provide **vital income** for farmers adopting sustainable methods

Key challenges

Limited capability to monitor and validate credits

- Lack of standardized MRV frameworks to promote transparency and efficiency in the carbon crediting process

Knowledge and training gap among farmers

- Smallholder farmers may lack knowledge and training on sustainable practices

Uncertainty about credit offtake

- Uncertainty in credit sales discourages investment from developers into decarb projects

Key success factors

Fund feasibility studies

- Offer concessional funding for feasibility studies to ensure scalable, market-aligned carbon projects

Promote aggregation models

- Group smallholder farms into **carbon cooperatives** to share costs and benefits

Build regional carbon markets

- Enable cross-border trade & standards harmonization

De-risk via long-term offtakes

- Attract investments that might otherwise be deterred by uncertainty in carbon credit pricing

One-million-hectare high-quality and low-emissions rice project, Vietnam

Case study

Project overview	Project to enable farmers to transition to sustainable rice cultivation across **1 million hectares in Mekong Delta** by 2030 Helping farmers to adopt **climate-smart farming tech** (like alternate wetting and drying), providing **trainings and infrastructure support**
Results	**10 Mt** CO2e emissions to be mitigated cumulatively over a six-year period (2024–30) **30%** decrease in irrigation water usage compared to traditional methods
Key enabler	**World Bank financial support:** $360 million loan disbursed from IBRD[1] to scale the project and $40 million loan to be disbursed under TCAF[2] based on verified emissions reductions **Strong policy alignment:** Project's integration into VN's green growth strategy mandated local communities to adopt sustainable farming

Notes: (1) IBRD = International Bank for Reconstruction and Development; (2) TCAF = Transformative Carbon Asset Facility, a World Bank climate finance initiative that supports countries in reducing GHG emissions | Sources: Mitigation Action Facility; World Bank webpage; Carbon Herald; Business Times; Lit. search

Blended finance | Catalyzing a green transition through concessional capital requires clear policies, repeatable models, and skilled talent

Definition: Investment funds that combine public or philanthropic capital with private sector funds to reduce risk, used to fund marginally bankable sustainability projects

Why is it needed in SEA-6?

- **High perceived/real risk of green projects** (e.g., RE projects) given high upfront costs and long payback periods
- **Emerging markets attracting limited interest** from private investors given macro risks (policy uncertainty, currency, exchange rate volatility, etc.)

Key challenges

- **Limited large-scale, bankable projects** due to capacity and technical constraints in operating sustainability projects
- **Complex transactions and long negotiations** due to multiple stakeholders and policies within the region delays deals
- **Significant gap between investor (concessional and commercial) expectations and local realities:**
  - Commercial investors and lenders require regulatory certainty, bankability, and opportunities of size
  - Concessional lenders require additional reporting such as impact reporting, which adds cost burdens to projects

Key success factors

- **Set up supportive policies to implement and align financing frameworks, taxonomies** that encourage private sector participation
- **Develop proven, repeatable models** to enable scale
- **Secure regional talent pool** by investing in talent development and capacity building and build green finance expertise
- **Facilitate public-private communication and collaboration** to bridge trust and knowledge gaps for more effective partnerships

Mobilizing $5 billion blended financing fund for towards green and transition projects in Asia

Case study

Financier	**MAS**[1], in collaboration with public, private, and philanthropic sector partners, **is supporting FAST-P**[2]**, a $5 billion blended finance initiative;** Pentagreen (fund manager) announced plans to deploy ~$1 billion Singapore government will pledge up to $500 million as concessional capital, to match dollar-for-dollar, concessional capital from other partners
Beneficiary	Managed phase-out of coal-fired power plants and their replacement with renewable energy sources **Mature technologies such as renewable energy scaling**, grid modernization, and electric vehicle infrastructure **Emerging green technologies** like hydrogen and carbon capture, utilization, and storage
Key enabler	**De-risk green and transition projects**, thereby crowding in commercial capital **Building repeatable models with standardized investment structures** to attract large-scale private investment

Note: (1) MAS refers to Monetary Authority of Singapore; (2) FAST-P: Financing Asia's Transition Partnership | Sources: IFC; MAS

Blended finance | Southeast Asia's Green Economy 2024 Report outlined recommendations to scale blended finance; progress vs. recommendations

/ Non-exhaustive

Recommendation to scale blended finance (Southeast Asia's Green Economy 2024 Report)	Key examples of recent progress made
 Set up policies and incentives to boost low-carbon project attractiveness over high-emissions alternatives	**Policy development occurring on a country level, increasing attractiveness of low carbon projects** **Indonesia SAF targets:** ID mandating 1% SAF in international flights from 2027 **Singapore announces** Intention to import 6GW of low-carbon electricity by 2035 **Malaysia** rolled out its National Energy Transition Roadmap (NETR) and the new Industrial Master plan
 Develop repeatable standards and playbooks for catalytic capital usage	**Investment facilitation and integration with global standards through sustainable investments taxonomy** **ASEAN Taxonomy for Sustainable Finance:** framework for sustainable investments to mobilize catalytic capital and prioritize high-impact projects that align with global standards (April 2024) **Repeatable deal structures streamlining financing and de-risking investment and capital flow into nature-based solutions** **Tropical Asia Forest Fund:** SEA-focused fund aiming to generate competitive returns and long-term sustainability outcomes through replicable deals in commercial forestry investments (e.g., ecosystem restoration, reforestation, and community forestry)
 Invest in talent development, capacity building, and dedicated green finance teams to strengthen expertise	**Regional framework and collaborations to spearhead capacity building and develop regional talent** **Climate Finance Access and Mobilization Strategy (2022–30):** Framework for capacity building of ASEAN public officials and financial institution staff in sustainable finance and climate change-related institutional governance (December 2024) **GFANZ:** Helping financial institutions build capability is a key priority for the GFANZ APAC Network, co-founded by Standard Chartered, to drive a just and inclusive net-zero transition in the region
 Improved collaboration between public (e.g., government, DFIs) and private entities to bridge trust and knowledge gaps	**Developments marked by fund launches from public and private investors** **ADB:** $30 million loan to support 35 Philippines-based public-private partnership projects focused on sustainable infrastructure and transportation (December 2024) **Singapore Sustainable Finance Association:** Private cross-sectoral organization fostering collaboration and capacity building in SG's sustainable finance sector across financial institutions, corporations, academia, and government (November 2023)

Offtake-based financing | Unlocking market-driven capital through volume offtake guarantees, expanded offtake networks, and aggregated supply chains

Definition: Project-based financing relying on long-term purchase agreements with creditworthy buyers (offtakers), backed by banks and investors who are lending based on revenues, or offtakers providing pre-financing investing to secure supply

Why is it needed in SEA-6?

- **Undercapitalized and underbanked sectors** due to high operational and investment risks (e.g., renewables, biofuels, sustainable agriculture projects)
- **Reduces reliance on government subsidies,** replacing subsidies with market-driven mechanisms
- **Enables funding for high-risk projects with uncertain return** by providing upfront capital and validating market demand (e.g., carbon credit projects)

Key challenges

- **Limited bankability of offtake contracts** since they lack standardization, have short durations, or include volatile pricing, limiting viability as collateral
- **Policy and regulatory risks** disrupts offtake markets (e.g., frequently changing regulations), creating uncertainty for long-term contracts
- **Small-scale, fragmented supply chains** where SEA suppliers (e.g., farmers) often lack capacity to meet large-scale offtake commitments

Key success factors

- **Standardize offtake agreements** with transparent, long-term pricing benchmarks and contract standards to reduce investor risk while aligning with evolving regulatory requirements
- **Encourage cross-border offtakers to tap into large, international buyers** (e.g., global airlines, FMCGs, tech firms) to commit to multi-year, large-scale contracts, **providing bankability and project credibility**
- **Aggregate small suppliers** (e.g., smallholder farms, SMEs) through cooperatives and digital marketplaces for scalable contracts

$90 million financial package to build SAF facility on back of long-term offtake agreement

Case study

Financier	**ADB issued ~$90 million financial package[1] to SAFCO[2]** on back of SAFCO's long-term offtake agreement with Shell
Beneficiary	**SAFCO will set up 200 kt** p.a. capacity SAF plant in Pakistan using waste-based feedstock in production
Offtake agreement	**Shell signed a long-term offtake agreement** with SAFCO for volumes up to 145 kt p.a. once plant is completed

> Long-term offtake agreements leverage **Shell's trading network, operational capabilities, and technical expertise** to supply SAF
>
> General Manager at Shell

Notes: (1) ~$42 million ordinary capital resource loan from ADB and ~$45 million syndicated loans from PIDG; (2) SAFCO Venture Holdings Limited is a Pakistan-based sustainable aviation fuel facility | Sources: ADB; Shell; SAFCO

Infrastructure funds | Enhancing regional connectivity, sustainable development, and economic growth by funding infrastructure projects in key sectors

Definition: Funds that provide long-term loans or equity investments to finance critical infrastructure projects typically in transportation, energy, water and sanitation, and social infrastructure sectors

Why is it needed in SEA-6?

- **SEA-6 faces infrastructure investment gap** due to rapid economic development, urbanization, and population growth; **ADB estimates gap at ~$2.8 trillion**
- **High upfront costs and long payback periods** of infrastructure projects discourage investors
- **Funding needs** exceed capacity of public sector and individual investors or local banks; infrastructure funds improve liquidity and risk sharing by pooling assets

Key challenges

- **Long-term cost uncertainties, timeline risks, and difficulty forecasting revenues** lowers investor confidence
- **Regulatory and political risks** as long-term infrastructure projects are vulnerable to **policy changes and unstable regulatory environments** in SEA
- **Rigorous project preparation cycle** discourages developers, limiting viable projects

Key success factors

- **Strong government and financial institution backing** via co-funding, direct investments, tax incentives, or risk-sharing mechanisms
- **Stable regulatory environment** ensuring confidence and long-term predictability
- **Enhance financial structuring** (e.g., introducing infrastructure REITS, hybrid debt-equity structures) to attract institutional investors
- **Establish ASEAN-wide infrastructure funds** to strengthen project pipeline and increase cross-border investment flows

$272 million infrastructure fund loan for Vietnam's power grid development

Case study

Financier	**Disbursement of $100 million from ADB's ASEAN Infrastructure Fund (AIF)** to support energy, water, transport projects
Beneficiary	**Hanoi Power Corp. and Ho Chi Minh City Power Corp.** to fund grid modernization and expansion
Results	**Modernization and expansion of 330 kV** transmission lines in Hanoi and HCM to integrate RE sources and strengthen transmission
Key enabler	**AIF loans' interest rates are cost-effective,** having fixed maturity premium[1] **and long tenors** (up to 19 years)

Note: (1) Commercial loan interest rates may be either fixed or variable, with higher interest rates compensating lenders for riskier loans (due to higher credit risk or lower credit score), while ADB AIF loan interest rate premiums are priced solely on maturity period | Sources: ADB; World Bank

Leveraging climate finance to promote sustainable development: Standard Chartered leads Asia's first sovereign sustainability-linked bond issuance

Overview

Thailand's public debt office issued inaugural **sustainability-linked bond** in November, 2024

1st
sustainability-linked bond (SLB) in Asia, 3rd globally[1]

$865M
total issuance, with ~15-year tenor

>2.7x
Oversubscription, reflecting strong local and global demand

Key enablers

Collaborative structuring

Standard Chartered leads collaboration across four managers to pool financial expertise, market access, and distribution capabilities

- Standard Chartered acted as joint sustainability structuring bank, working on **framework construction process, and advising on key performance indicators (KPIs) and sustainability performance targets**

Sustainability-linked targets

Bond coupon tied to achievement of clearly defined sustainability goals, aligned with TH's climate roadmap

- **GHG reduction:** 30% reduction from the BAU baseline by 2030
- **Zero-emission vehicles:** Increase annual registrations of ZEV passenger cars and pick-up trucks by 476% by 2030, equivalent to 440,000 passenger cars and pick-up trucks

Technical assistance

Cross-sector collaboration with banks and relevant ministries, Global Green Growth Institute (GGGI), Asian Development Bank (ADB), and the Second Party Opinion (SPO) providers on the construction of KPIs

Alignment with international standards

Bond issuance aligned with international standards (International Capital Market Association), boosting credibility and appeal to international and regional investors

> Issuing Asia's first-ever SLB as we support Thailand's sustainable growth ambitions isn't just a milestone—it's a statement of intent. Standard Chartered is proud to lead the way in redefining how capital can drive meaningful change and shape a more sustainable future for generations to come
>
> Chow Wan Thonh, Head of Coverage, Singapore and ASEAN, Standard Chartered

> We hope that the issuance of the SLBs will serve as a good example for both state enterprises and the private sector in collaboratively promoting sustainable development in TH, while contributing to the development of sustainable capital markets
>
> Patchara Anuntasilpa, PDMO Director General

Note: (1) Following Chile, Uruguay | Sources: ESG News; ADB; Bangkok Post

Recommendations | Key actions by stakeholders to bridge climate financing gap

Policymakers and regulators

Strengthen and stabilize climate policy frameworks to boost investor confidence (clear targets, roadmaps, permitting reform)

Expand and standardize regional taxonomies and align them with global standards (e.g. ASEAN Taxonomy, ISSB)

Deploy public capital strategically through blended finance structures (first-loss guarantees, concessional loans, etc., to crowd in private investment)

Support development of regional project aggregation platforms to build investment-ready portfolios

Commercial investors and financial institutions

Deploy capital into blended structures with concessional partners to de-risk earlier stage and emerging projects

Scale up green financial instruments (e.g., green bonds, transition loans)

Aggregate small-scale projects into investment-grade portfolios to achieve scale and liquidity

Standardize impact-linked lending and ESG integration to reward long-term sustainability impact

Concessional investors (e.g., MDBs, DFIs)

Deploy first-loss capital to absorb early-stage risk and attract private investors

Broaden investment targets by focusing on diversified portfolios (e.g., multi-project or blended-sector funds) rather than isolated single projects

Channel philanthropic funding into early-stage project development, innovation support, and initiatives driving a fair energy transition

Enhance guarantee schemes to reduce perceived investment risks for emerging green infrastructure projects

Forge partnerships with local financial institutions to boost regional green finance expertise and improve the origination of viable projects

Project developers

Aggregate small projects into scalable investment vehicles

- Create regional project consortiums and cooperative models to attract investors

Engage investors early in project structuring

- Secure financial and technical commitments early to align projects with funding requirements

Leverage offtake agreements and blended finance mechanisms to improve project risk profile

Improve impact measurement and reporting

- Utilize digital MRV[1] tools to simplify sustainability reporting and improve credibility

Prioritize cross-border compliance to enhance international project marketability

Private sector (e.g., offtakers, agribusiness)

Secure long-term purchase agreements (e.g., renewable energy PPAs, carbon offsets, SAF certificate) to reduce project financing risks and stimulate market demand

Design and implement net-zero strategies, ensuring capital investments and supply chain operations are aligned with climate commitments

Collaborate early with financiers and policymakers to **create scalable projects that meet energy transition** objectives

Promote procurement policies tied to sustainability outcomes to drive widespread demand for low-carbon products and services

Support early-stage technology innovation (e.g., next-generation biofuels, AI-enabled grid technologies) to accelerate the development of new markets

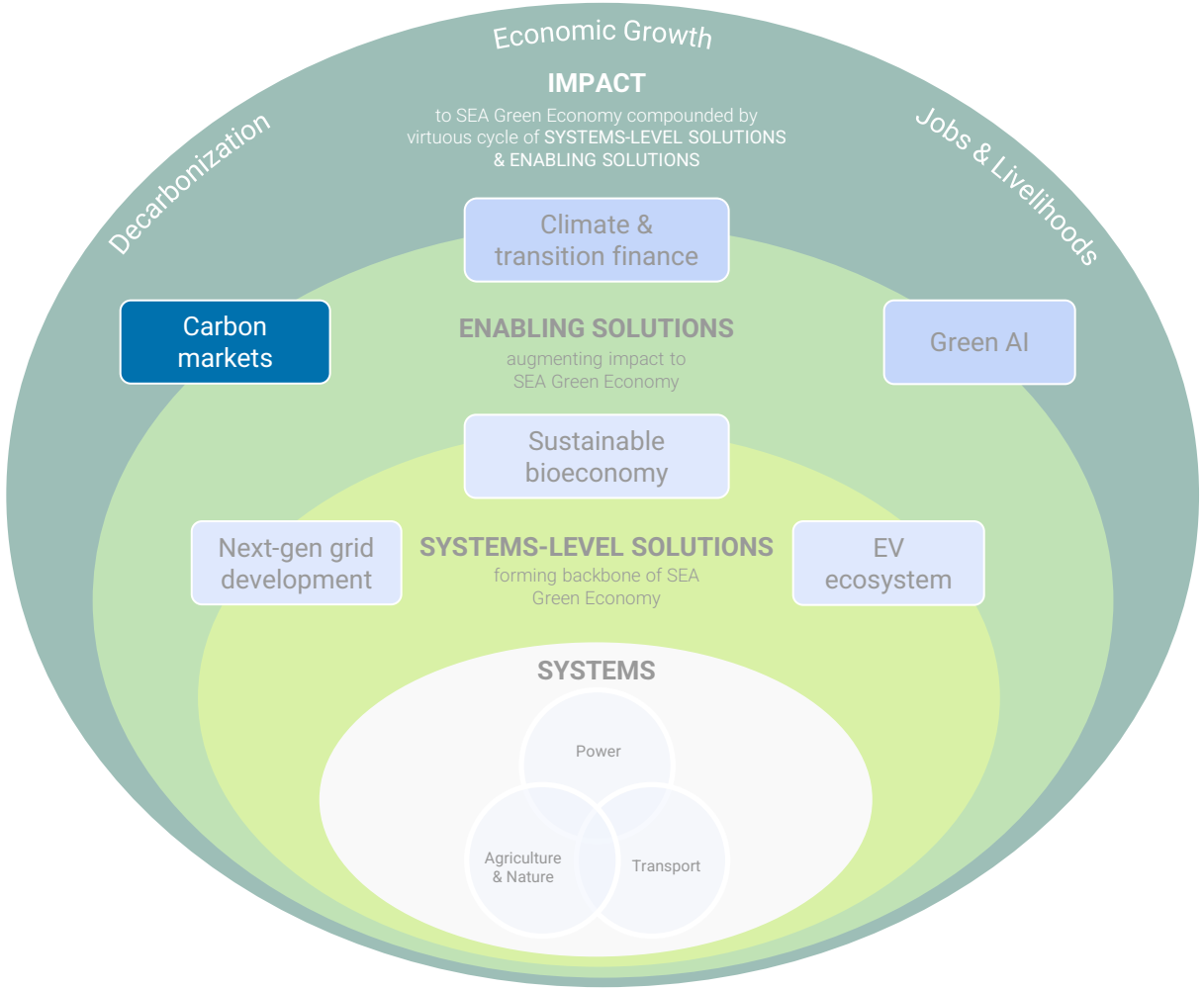
Notes: (1) Monitoring, reporting, and verification, used to track, document, and validate data; (2) Power purchase agreements, long-term contracts between electricity producer and buyer/offtaker | Sources: Lit search; Bain analysis

Enabling solution 2

Carbon markets

09

Carbon markets | Key takeaways



01 **Carbon pricing and carbon markets** are crucial for accelerating decarbonization and protecting SEA's natural assets

02 **SEA is making progress** with regulatory advancements and increasing carbon credit issuances; **however, acceleration is needed to reach full potential**

03 **Policy ambition remains nascent in region**; only select countries (e.g., Singapore) have implemented carbon pricing policies, with lower carbon price vs. more mature markets

04 Scaling carbon markets requires **catalyzing demand, building high-quality supply, and developing enabling infrastructure;** most urgent is to secure stable demand at prices that support project viability

05 To grow the market and ensure integrity, SEA should develop **compliance schemes** and enable streamlined authorization of projects while also establishing harmonizing regulations with international standards

Key initiatives

Harmonize **carbon market standards** to meet international demand

Carbon pricing and markets are key enablers of decarbonization and the green economy

Carbon pricing and carbon markets work synergistically, driving emissions reduction while providing flexibility to meet targets through offsets

Carbon price enables liquidity in carbon markets

Carbon price to incentivize firms to reduce emissions

Incentivize corporations to decarbonize though carbon tax/emission cap

Carbon markets to enable trade of carbon credits for reducing emissions

Provide corporations with a platform to get funding from selling credits/offset GHG emissions from buying credits

Carbon markets help determine price of carbon through supply & demand

Leaders back carbon pricing as key unlock for decarbonization

> International carbon markets—ones that put a price on carbon—are absolutely crucial if we're to have any chance of stabilizing global temperature rise and avoiding runaway climate change
>
> Patricia Espinosa,
> Former UN Climate Change Executive Secretary

> Carbon pricing can be one of the most powerful tools to help countries reduce emissions
>
> Axel van Trotsenburg,
> World Bank Senior Managing Director

Sources: UNFCCC; World Bank

SEA is making progress towards carbon pricing and market establishment; however, more efforts are needed towards complete development

Essential foundations for carbon markets

Increasing market maturity

Progress made by SEA-6 nations

SG's carbon tax rate at $18/tCO2e (2024) vs. other mature markets (e.g., $50 in Canada, $120 in Switzerland); SG carbon tax expected to rise to ~$50/tCO2e by 2030)

Implementation of ETS/carbon tax policies to put a price on carbon

- ETS under consideration; no carbon tax
- ETS under consideration; carbon tax expected by 2026
- ETS under consideration; carbon tax, set at THB 200, expected in 2025
- Functional ETS[1] since 2023 in power sector; carbon tax to be implemented
- Implemented SEA's first carbon tax in 2019

Alignment with global quality meta-standards (ICVCM/CORSIA)[4] to improve project quality, exportability, and investability

- Alignment with international standards in early stages
- TH signed MoU with Verra to align standards; MY & TH exploring CORSIA-eligible credit trading
- Opening to international standards, starting with forestry projects
- Aligned with international standards (e.g., Verra); enables trading of CORSIA-eligible credits

Enable trade of carbon credits to increase offtake opportunities for project developers and attract carbon finance (also establish robust MRV[5] for enabling trade)

- VCM credits generated domestically and sold to foreign buyers
- Enables auction-based international trading of VCM credits through BCX
- International trading of VCM credits started in 2025 on IDX Carbon; still in early phases
- International trading on Climate Impact X since 2023; signed Article 6[3] agreements with select nations
- Transacted first ITMO[2] with Switzerland in 2023 under a bilateral trade

Notes: (1) Cap-and-trade emissions trading system (ETS); started with power sector and is expanding over time; (2) ITM = Internationally Transferred Mitigation Outcome; (3) Article 6 of Paris Agreement establishes international carbon market mechanisms to enable carbon trading between countries; (4) ICVCM = Integrity Council for the Voluntary Carbon Market. CORSIA = Carbon Offsetting and Reduction Scheme for International Aviation; (5) Measurement reporting and verification | Sources: World Population Review; ICAP; MSCI Trove Research; Tropical Forest Alliance; UN; Reuters; SP Global; Carbon pulse; Bursa Malaysia; Business Today; Lit. search

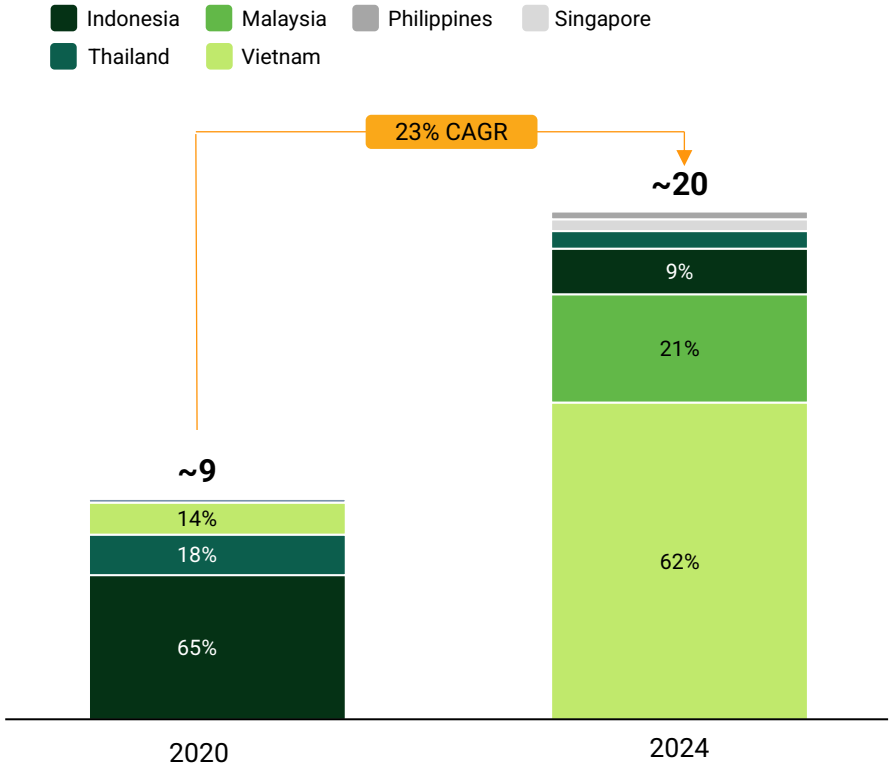
Carbon market in SEA-6 still in nascent stages; currently, carbon credit issuance in SEA-6 represents only 3% of mitigation potential across ecosystems

SEA-6 carbon credit issuance has traditionally grown at >20% CAGR …

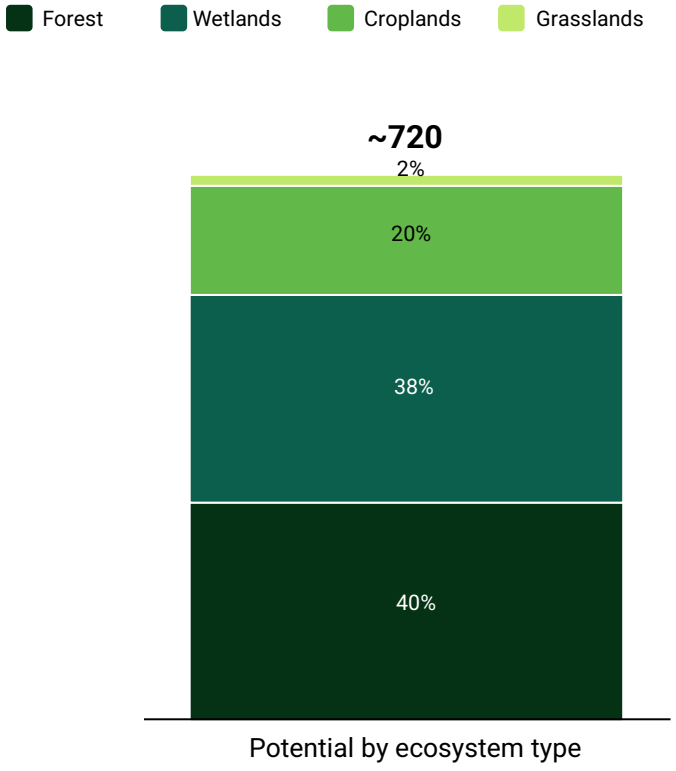
… but it is far below the full-abatement potential of SEA's ecosystems …

… reinforcing the huge untapped potential

SEA-6 VCM carbon credits issued by country[1] (MtCO2e, 2020–24)



SEA-6 estimated annual potential from NBS[2] (MtCO2e, 2024)



~3%

of SEA-6 **estimated annual carbon credit full potential[3]** captured currently (20 MtCO2e/720 MtCO2e)

Notes: (1) VCM Credit issuance data taken from Berkeley Carbon Trading Project, which covers credits issued from voluntary carbon offset projects only; (2) Estimated potential derived from Naturebase; note that the actual carbon credit generation potential could be lower due to buffer pool, OMGE; (3) Given data limitations, nature-based solutions issuances have been utilized as a proxy for the region's overall carbon credit potential; total potential has been derived using Naturebase | Sources: Naturebase; Berkeley Carbon Database; East Asia Forum; ASEAN Briefing

To attain full-potential usage of carbon markets, SEA needs to take key actions to increase demand, build carbon credits supply, and develop infrastructure

Key actions to enable carbon markets

Deep dive on following pages

Catalyze market demand for carbon credits

- **Raise effective carbon price through carbon tax/ETS mechanisms** (carbon price currently either non-existent or too low in SEA-6 nations to meaningfully incentivize credit purchases)
- **Clearly define credit usage guidelines** (e.g., regulatory frameworks on carbon credits claims against Scopes 1, 2, and 3)
- **Implement domestic and international buyer incentives** (e.g., tax deductions on purchasing verified carbon credits)

1 **Bilateral/multilateral agreements for international credit trading**

Build supply and safeguard integrity

- **Expand project bankability through long-term offtake agreements**
- **Accelerate issuance through streamlined project approvals**
- **Strengthen local community capacity for high-quality project delivery**
- **Increase financial access** (e.g., project aggregation, public-private financing, blended finance facilities)

Develop infrastructure

2 **Harmonize frameworks and standards regionally** (e.g., ACCF[1])

- **Strengthen MRV systems with tech and local capacity to increase project credibility**
- **Develop connected, high-integrity carbon registries**
- **Establish domestic/regional carbon trading platform/exchange**
- **Strengthen carbon market ecosystem** (e.g., brokers, insurance, legal)

Note: (1) ACCF = ASEAN Common Carbon Framework | Source: Bain analysis

Early signs of progress across SEA nations to accelerate development of harmonized, interoperable carbon credits markets

/ Non-exhaustive

1 Bilateral agreements for credits trading

Key initiative taken

Singapore signed **bilateral agreements under Article 6.2 of the Paris Agreement** with **other nations** to trade credits for meeting its Nationally Determined Contributions **(NDCs)**

Purpose and impact

Agreements signed with multiple nations for **carbon credits trading**

- Within ASEAN (e.g., Indonesia, Malaysia, Cambodia, and Laos)
- Within APAC nations (e.g., Bhutan, Papua New Guinea)
- Additionally, Singapore has signed MoUs with other countries, including **Chile, Fiji, Kenya, Mongolia, Morocco, and Peru**, aiming to establish similar agreements

Singapore's MoUs require carbon credit developers to **contribute 5% of proceeds** from Article 6-authorized credits **towards host countries' adaptation efforts** or the UNFCCC Adaptation Fund

2 ASEAN Common Carbon Framework (ACCF)

Proposed **ASEAN framework** for carbon projects to harmonize **carbon market** across SEA

- This initiative seeks to ensure the credibility and integrity of carbon credits generated within the region, facilitating cross-border carbon trading

ACCF aspires to **support carbon standards that align with international quality benchmarks** such as ICVCM and CORSIA to **strengthen the integrity and market acceptance of ASEAN carbon credits** supply

ACCF is expected to enhance ASEAN carbon **market's interoperability, liquidity, and pricing efficiency**

Carbon market associations across **Malaysia, Indonesia, Singapore, and Thailand** have **signed** a **Memorandum of Collaboration** (MoC) to support the ACCF

Sources: Financial Times, Eco-Business, ASEAN Briefing; Carbon Herald; Singapore Ministry of Trade and Industry

Three main drivers could accelerate carbon pricing and demand within the Asia-Pacific region

1. Advancing domestic carbon policies

Emerging mandatory carbon tax/ETS policies, with some Asian markets potentially allowing internationally sourced credits to be used for domestic carbon liabilities (e.g., SG, KR)

APAC progress on carbon pricing-related policies:

Pre-design: Philippines, Laos, Myanmar, Brunei, Cambodia

Developing carbon pricing scheme: Thailand, Vietnam, Malaysia

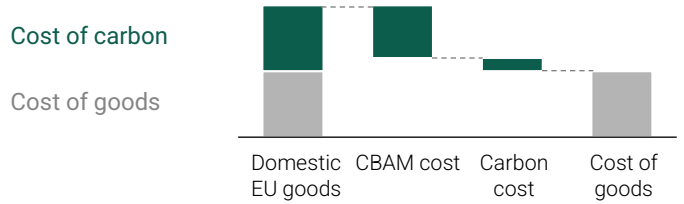
Carbon pricing linked to international markets: Indonesia, India, China

Bilateral agreements for international trade: Singapore, South Korea, Japan

2. Pressure from extra-regional policies

EU extra-regional **policies like CBAM incentivize carbon pricing in other markets** by pricing carbon in emissions-intensive imports. Developing carbon pricing can ensure emissions costs stays within country.

Equalizing cost of goods between EU & non-EU producers[1]:



APAC markets/sectors impacted by CBAM[2]:

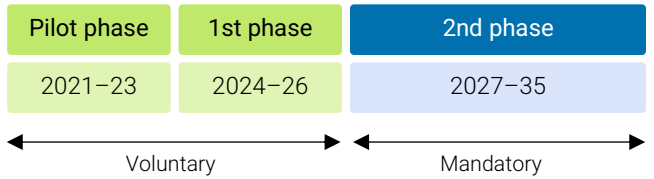
Aluminum, iron & steel, fertilizers: China, Malaysia, Vietnam, Indonesia, India

Cement, hydrogen: China, Malaysia, Vietnam, India

3. Opportunities from industry schemes

Industry schemes expected to drive up supply of and demand for quality credits for specific sectors (e.g., CORSIA eligibility for aviation). Countries can help advocate for their credits to be eligible with clear, aligned integrity standards

Planned timelines for implementation phases of CORSIA



Expected increase in demand driven by CORSIA

1.5B

Potential credit demand between 2024 and 2035

Positive demand trajectory; engagement needed to ensure SEA credit eligibility

Notes: (1) Adapted from UOB–How EU's CBAM affects Malaysia (2024) (2) Korea and Japan's steel and aluminum industries may also be impacted, as well as Thailand through it's supply chains for Cement and Fertilizer, though all potentially on a smaller scale | Source: ICAO

Developed carbon markets can accelerate decarbonization across all three systems-level solutions

High Medium Low

Deep dive on following pages

Carbon markets use cases to accelerate systems-level solutions

High priority

Sustainable bioeconomy

1

Sustainable agriculture
Credits are awarded to farmers for adopting regenerative agriculture practices like AWD[1]

Forestry and land use
Credits are awarded for REDD+[2], afforestation and reforestation, and improved forest management

Blue carbon projects
Credits are granted for coastal reforestation and mangrove protection

Biowaste utilization
Monetization of avoided emissions from waste, manure management, and crop burning through biogas plants and composting

Next-gen grid development

2

Fossil fuel phase-out using transition credits
Development of transition credits to finance early retirement of coal-fired plants and transition to renewables (emissions reductions post-2035)

Energy efficient technologies
Demand-side energy efficiency measures like smart grids and process upgrades can generate carbon credits

Carbon capture and storage (CCS) solutions[2]
Projects that capture carbon emissions from industrial facilities and store them underground

EV ecosystem

EV infrastructure buildout
Building EV charging stations and deploying infrastructure that enables the transition to clean energy vehicles

Vehicle electrification
Shifting from ICE vehicles to EVs (e.g., commercial fleets) and electric public transit systems

	Expected impact	
Size of prize		
Additionality		
Feasibility		

Notes: (1) AWD = alternate wetting and drying; (2) REDD+ refers to reducing emissions from deforestation and forest degradation plus additional forest-related activities; (2) CCS solutions to help scale RE within the grid | Source: Lit. search

Sustainable agriculture | Mitigate investor risks through multiple solutions such as long-term offtake contracts to accelerate carbon market adoption

Leveraging carbon credits to fund diverse sustainable agricultural projects (e.g., AWD, regenerative agriculture, methane reduction in livestock, etc.)

Why is it needed in SEA-6?

Huge carbon sequestration potential

- Agriculture sector is the largest emitting sector in SEA-6 but holds high amount of **decarbonization potential** via practices like agroforestry, cover cropping, and no-till

Need for additional revenue stream for smallholder farmers

- **~100 million SHFs** in SEA, **with average farm size of 2 ha,** lack necessary funds for sustainable farming
  - Carbon credits can provide **vital income** for farmers adopting sustainable methods

Key challenges

Limited capability to monitor and validate credits

- Lack of standardized MRV frameworks to promote transparency and efficiency in the carbon crediting process

Knowledge and training gap among farmers

- Smallholder farmers may lack knowledge and training on sustainable practices

Uncertainty about credit offtake

- Uncertainty in credit sales discourages investment from developers into decarb projects

Key success factors

Fund feasibility studies

- Offer concessional funding for feasibility studies to ensure scalable, market-aligned carbon projects

Promote aggregation models

- Group smallholder farms into **carbon cooperatives** to share costs and benefits

Build regional carbon markets

- Enable cross-border trade & standards harmonization

De-risk via long-term offtakes

- Attract investments that might otherwise be deterred by uncertainty in carbon credit pricing

One-million-hectare high-quality and low-emissions rice project, Vietnam

Case study

Project overview	Project to enable farmers to transition to sustainable rice cultivation across **1 million hectares in Mekong Delta** by 2030 Helping farmers to adopt **climate-smart farming tech** (like alternate wetting and drying), providing **trainings and infrastructure support**
Results	**10 Mt** CO2e emissions to be mitigated cumulatively over a six-year period (2024–30) **30%** decrease in irrigation water usage compared to traditional methods
Key enabler	**World Bank financial support:** $360 million loan disbursed from IBRD[1] to scale the project and $40 million loan to be disbursed under TCAF[2] based on verified emissions reductions **Strong policy alignment:** Project's integration into VN's green growth strategy mandated local communities to adopt sustainable farming

Notes: (1) IBRD = International Bank for Reconstruction and Development; (2) TCAF = Transformative Carbon Asset Facility, a World Bank climate finance initiative that supports countries in reducing GHG emissions | Sources: Mitigation Action Facility; World Bank webpage; Carbon Herald; Business Times; Lit. search

Sustainable aviation fuel certificate | Singapore Airlines, CAAS, and GenZero join forces to scale SAF demand for aviation decarbonization

Leveraging credit systems to harness demand from both airlines and corporations to accelerate the scaling of SAF production

Why is it needed in SEA-6?

SAF is widely recognized as a **key aviation decarbonization lever**

- Only viable and scalable decarbonization lever for medium- to long-haul flights

High potential to support SAF production and adoption

- **SEA is rich in biofuel feedstock** to support SAF production
- The Association of Asia Pacific Airlines (AAPA) has set an **aspirational target of using 5% SAF by 2030**

Key challenges

Persistent green premium of SAF vs. conventional jet fuel

- SAF is at **least 2x more expensive** than conventional, fossil-based jet fuel

Weak SAF demand in APAC

- Lack of certainty in SAF demand slows investment into SAF supply
- Globally, SAF accounted for only ~0.3% of global jet fuel consumption in 2024

Low awareness of SAF certificate (SAFc) as an innovative instrument to scale SAF demand

- SAF certificate is a financing mechanism bridge the SAF premium by harnessing corporate demand to facilitate scaling of SAF market

Key success factors

Global recognition of SAFc as a credible mitigation strategy for corporations' travel emissions
Availability of high-integrity SAFc supply
Globally accepted book and claim system

Systems approach towards scaling SAF demand in APAC

Case study

Project overview	A SAF pilot, supported by Singapore Airlines, a leading full-service passenger carrier, CAAS, and GenZero demonstrated the feasibility of SAF adoption at Singapore Changi Airport Launch of Green Fuel Forward, an initiative of the World Economic Forum in collaboration with GenZero, which aims to scale demand for SAF in APAC
Results	**1,000 t** SAFc generated from the pilot
Key enabler	Rising recognition of SAFc by voluntary standards: SBTi has recognised SAFc as an indirect mitigation lever for corporations' travel emissions in its latest consultation draft of the *Corporate Net Zero Standard Version 2.0* Collaboration to scale SAF production: MoU between SIA and Aether Fuel (portfolio company of Xora, a Temasek-backed early-stage venture builder and investor, to potentially source SAF from Aether Fuel plants which are being set up in SEA and the US

Note: CAAS = Civil Aviation Authority of Singapore

BAIN & COMPANY GenZero Google standard chartered TEMASEK | ecosperity

Transition credits | Opportunity to leverage innovative financing options using carbon credits (e.g., transition credits) to decarbonize high-emission industries

Leverage transition credits to generate additional financing towards managed phase-out of coal plants and switching to cleaner alternatives (e.g., developing RE infrastructure)

Why is it needed in SEA-6?

Necessary to phase out coal and fossil fuels

- SEA is still very heavy on coal usage, with **50% of energy derived from coal, many young plants**

Bridge the investment gap in clean energy

- SEA **invests ~1% of GDP in clean infrastructure** (~$38 billion) and requires huge funding to modernize
- Transition credits provide another financing mechanism to accelerate the shift from coal to clean
- Successful managed phase-out using transition credits can provide **opportunity to use similar approach** to decarbonize industries like **green cement**, steel

Key challenges

Entrenched fossil fuel infrastructure

- Many coal-fired power plants in SEA **backed by long-term PPAs,** making **early retirement financially complex and politically sensitive**

System-level cost of RE replacement

- Currently grid infrastructure is **built to support fossil fuel-**based energy, grid upgrades and batteries needed to replace fossil fuel base

Buyer uncertainty of carbon credit integrity, hindering interest

- Skepticism over whether transition credits yield additional emissions reductions
- Lack of harmonized green finance taxonomies/ exclusionary policies
- Concerns over just transition (ensuring energy security, affordability, etc.)

Key success factors

High-integrity credit methodologies

- Develop robust, transparent crediting methodologies to ensure credits are additional and verifiable

Tailored financing models and added incentives for early transition

- Pair transition credits with incentives (e.g., concessional loans, risk guarantees) to boost project economics

Offtakes and demand signaling

- Advocate for multi-year corporate offtake deals to boost developer confidence in transition credits

Accelerate the retirement of a 246 MW coal-fired power plant in Philippines by 10 years

Case study

Project overview	ACEN, GenZero, and Keppel signed an MoU to explore **transition credits** to accelerate retirement of coal plant in PH Focus is to **accelerate the retirement by 10 years** (2030 vs. previously estimated 2040) • Post-retirement, the coal plant's capacity will be substituted with a mid-merit integrated renewables and energy storage system
Results	**~19 Mt** CO_2 emissions can be avoided due to early retirement in 2030 (vs. 2040)
Key enabler	**New carbon mechanism:** Transition credits used to monetize decreased emissions from early coal plant retirement **Ensuring a fair transition:** Decommissioning plant in a manner that minimizes impact on communities and nature

Sources: Business Times; ADB; World Bank; Eco-Business

Recommendations | Key steps for all stakeholders to accelerate SEA's carbon markets

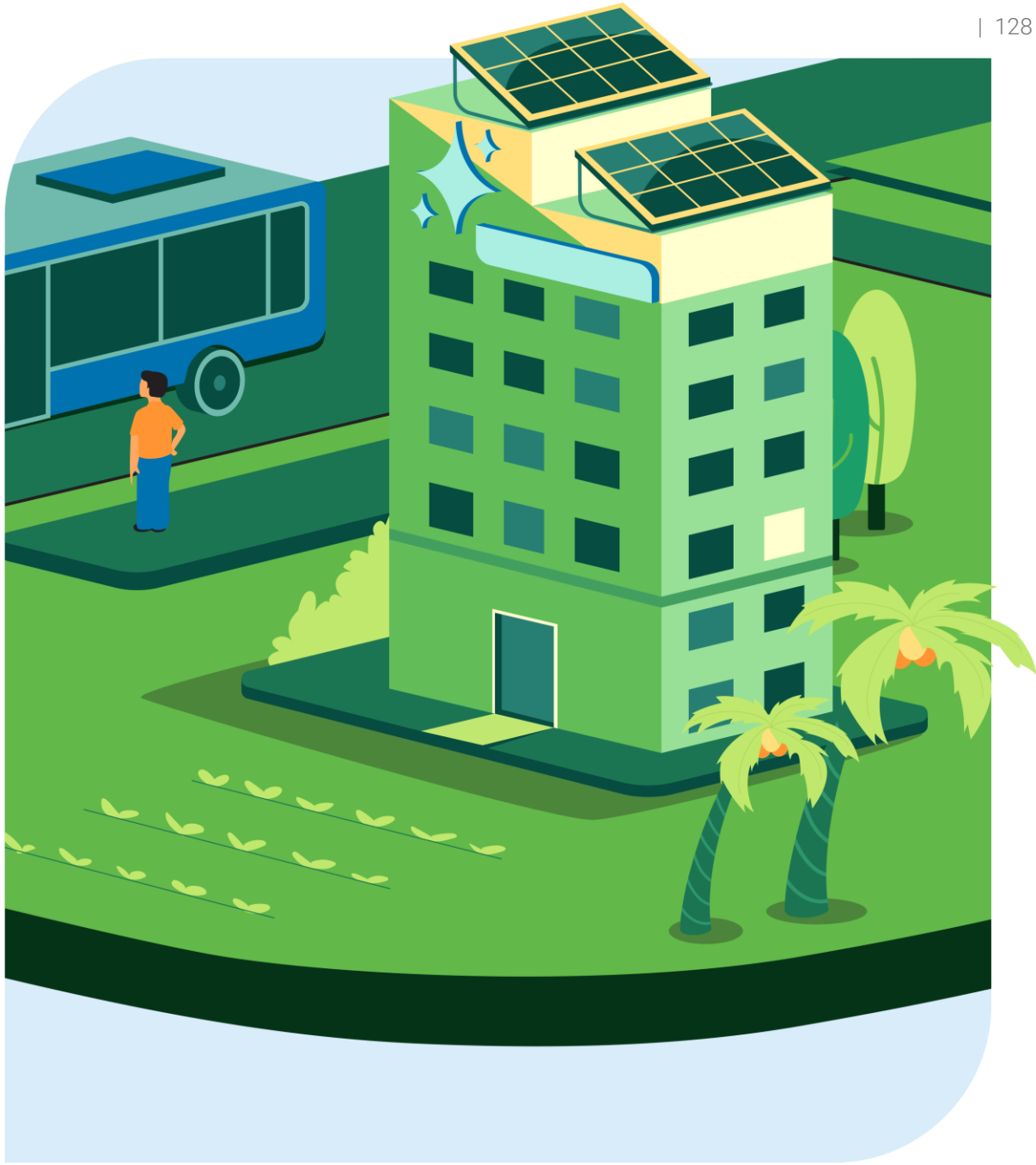
	Policymakers and regulators	Corporations	Carbon market ecosystem players	Investors and financial institutions
Demand	Develop **carbon pricing schemes** (ETS/carbon tax) • Collaborate with industry to set and phase up a carbon price to incentivize demand Establish **clear framework for eligible credits and claiming rules**	Leverage carbon credits to mitigate emissions in hard-to-abate areas • Leveraging **VCMI Claims Code of Practice** for using carbon credits and making emission reduction claims	Create **templates for long-term offtake** contracts • Contracts that **balance pricing and implementation risks**, with built-in insurance and **clear milestones** to ensure credible, accountable, and scalable climate impact	Enable **transition finance** by establishing clear transition **investment criteria** • Encourage FIs to **update exclusionary policies so they support transition finance**, not just avoidance or divestment
Supply	Develop regional frameworks to clarify integrity rules and requirements to avoid double-counting • IOSCO[1] and World Bank working together to help governments **design market rules to ensure project integrity** • Clarify project authorization processes as well as rules and procedures around project monitoring and revocation	**Engage in direct project financing** or **long-term offtake agreements** to support high-quality projects	**Train local communities and implementation partners** • Ensure project implementors adapt to **up-to-date methodologies on leakage and permanence** to enable high-integrity project supply • Rights and requirements for FPIC	Fund and **de-risk carbon credit generating projects** • Provide credit guarantees, **concessional loans, and revolving credit lines** to reduce financial exposure and build investor confidence
Infrastructure	Streamline **data sharing and transparency across registries** • Leverage **international platforms like Climate Action Data Trust for digitization, improved transparency as** credits move across registries	**Use market infrastructure solutions that enable integrity**, including MRV and ratings systems, trading infrastructure, and solutions to standardize and streamline project approvals	Implement robust MRV mechanisms • Leverage technologies like **drones, remote sensing, satellite monitoring** for accurate emissions monitoring Establish **strong carbon-market ecosystem**, boosting liquidity • e.g., **brokers, market researchers, exchange, insurance**	Enable market facilitation by acting as intermediaries and develop **insurance products to de-risk carbon projects** (e.g., covering loss due to policy changes/shortfall in credits)

Note: (1) IOSCO refers to International Organization of Securities Commissions; they have been working with World Bank on ensuring integrity, transparency, and standardization in voluntary and compliance carbon markets | Sources: GenZero; Lit. search

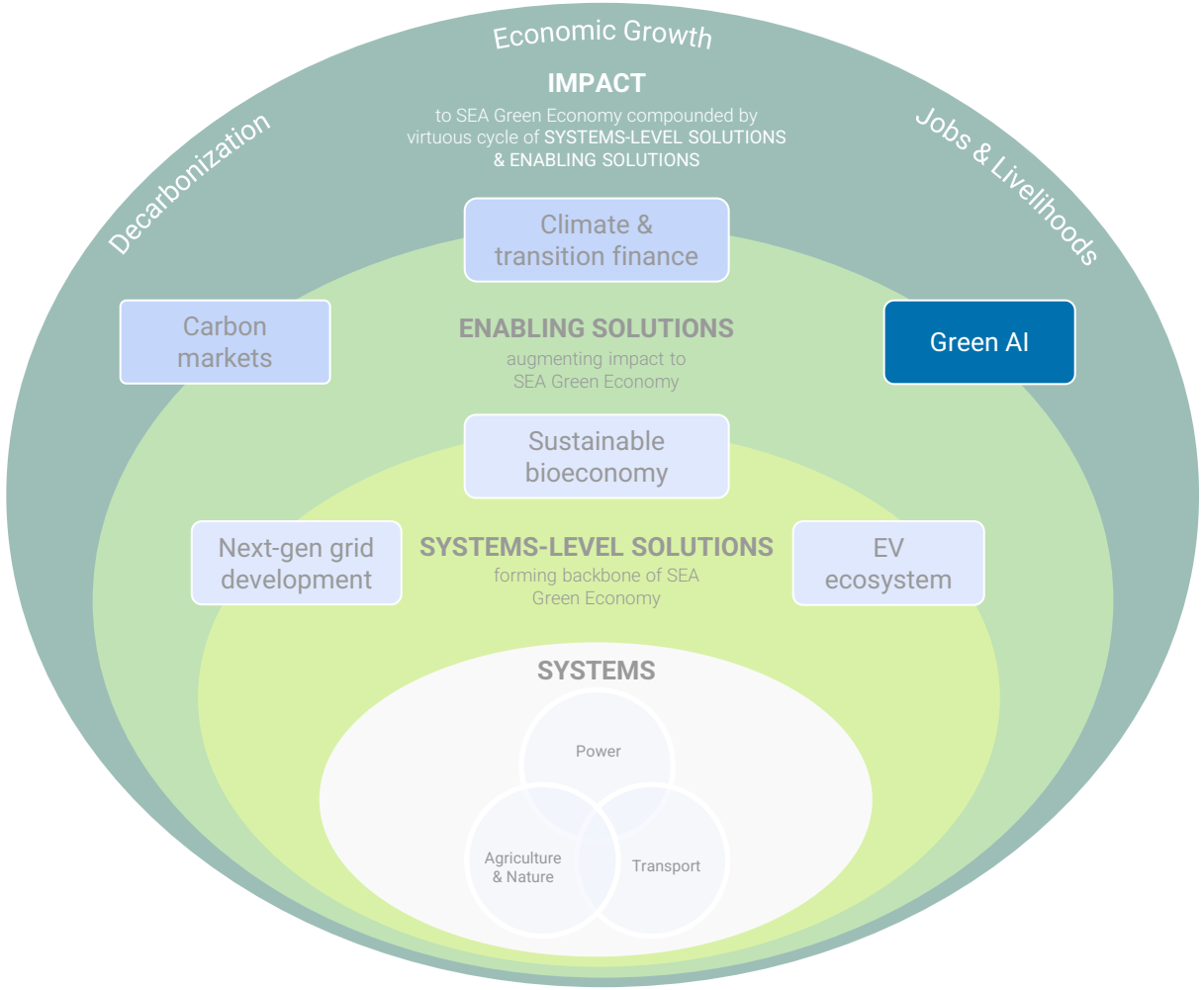
Enabling solution 3

Green AI

10



Green AI | Key takeaways



01 **SEA's data center (DC) demand is growing rapidly,** at a ~19% CAGR until 2030—driven by increase in both AI and non-AI workloads

02 **SEA is challenged to meet this demand sustainably,** given high reliance on fossil fuels and limited access to clean energy near major DC hubs

03 **DCs are estimated to contribute ~2% of SEA-6 emissions by 2030,** but this trajectory can shift with advances in hardware, software, and increased sourcing of clean energy

04 **Sustainable DCs can be a driving force of RE penetration out to 2030** if the right mechanisms and policies are in place, particularly to enable RE procurement through PPAs and vPPAs

05 **AI also offers a powerful opportunity to cut emissions, by 3%–5% across high-emitting sectors like power and transport;** unlocking this potential will require targeted investment, policy support, and scaled adoption

Key initiatives

Adopt and **scale AI use cases** for sustainability
Enable **cross-border VPPA** across regions

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Generative AI is emerging as a market disruptor as rapid adoption scales globally

Generative AI has emerged as a market disruptor …

Generative AI is a branch of AI that uses sophisticated machine learning models to generate original content based on existing data, replicating human-like thinking

Expected impact of generative AI across key functions

Manufacturing

~15% **productivity increase** in R&D

~20% **material cost reduction**

Sales and services

~25% of **outbound marketing messages** synthetically generated

~30% of potential reduction in **operational costs**

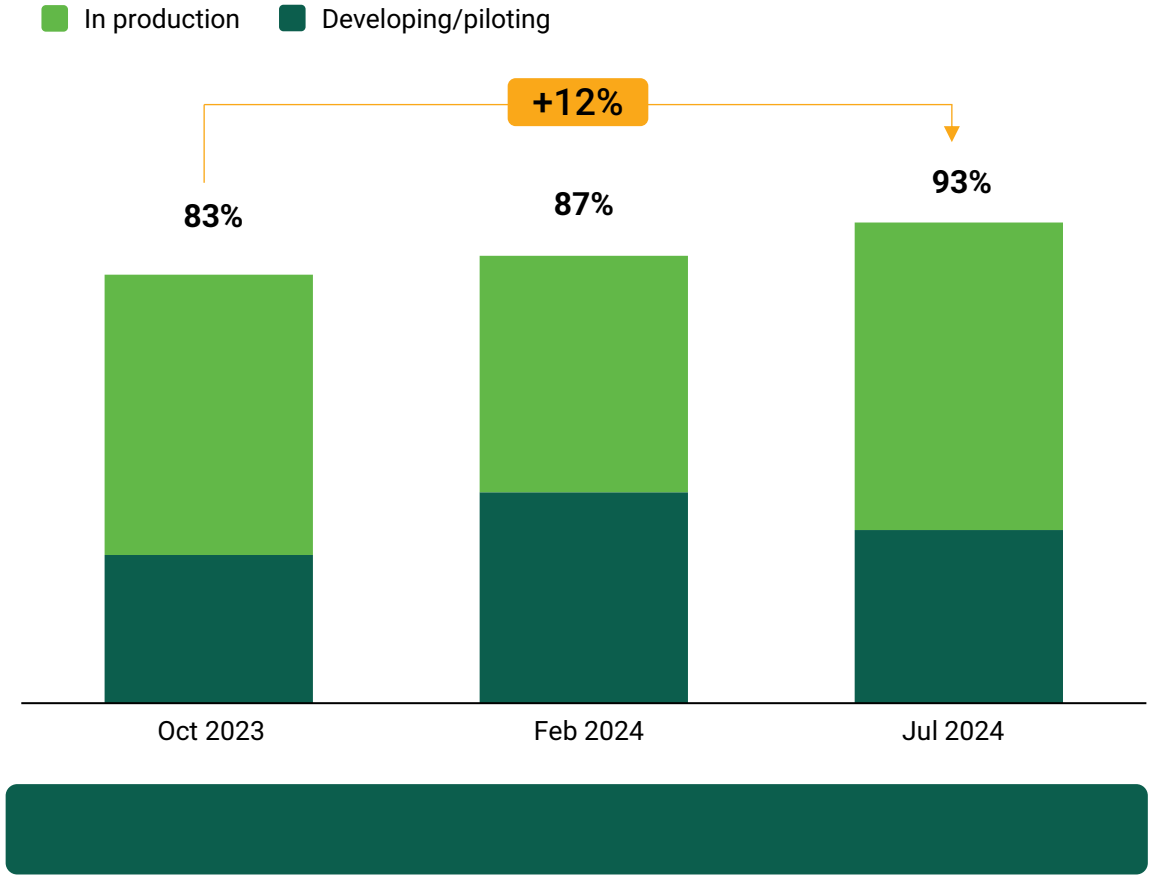
Employee productivity

50% of worker tasks[1] **could be accelerated** with access to software built on AI models

15% **productivity boost** across sales agents

… with high adoption rates across industries

Percentage of global companies adopting generative AI (based on Bain AI survey)
(n=198 Oct 2023; n=200 Feb 2024; n=184 Jul 2024)

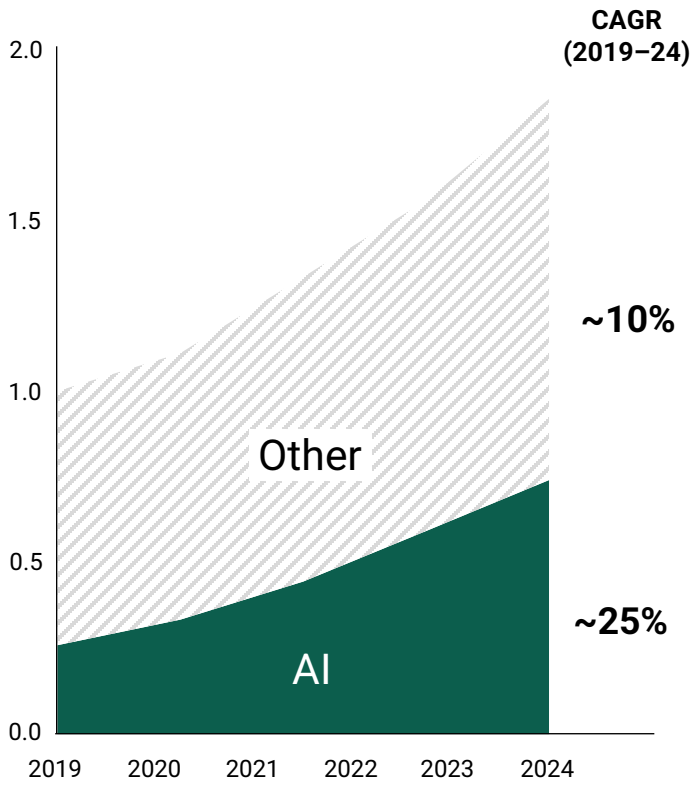


Note: (1) Clerical tasks | Sources: Bain Generative AI survey; GitHub; Microsoft

AI and generative AI workloads are accelerating driving data center demand, making it challenging for utilities to meet power needs sustainably

AI workload revenue outpacing other workloads, signaling rapid demand for AI

Revenue from DC chips by workload
(indexed to 2019)



With increase in workload, power demand from DCs accelerates …

Increase in power demand from DCs

~10x increase in power consumption in running AI models vs. traditional computing

~5x more energy per rack used by AI-powered DCs vs. traditional ones

5–7x consumption of power by AI GPUs per chip vs. traditional CPUs

… which is challenging for global utilities to meet sustainably

Surging power demand

AI-driven data centers are outpacing utilities' sustainable energy expansion

24/7 energy load

AI workloads demand constant high power, which is challenging for existing grids to meet, given limited energy storage infrastructure and limited integration of clean firm power (e.g., geothermal)

Outdated grid infrastructure

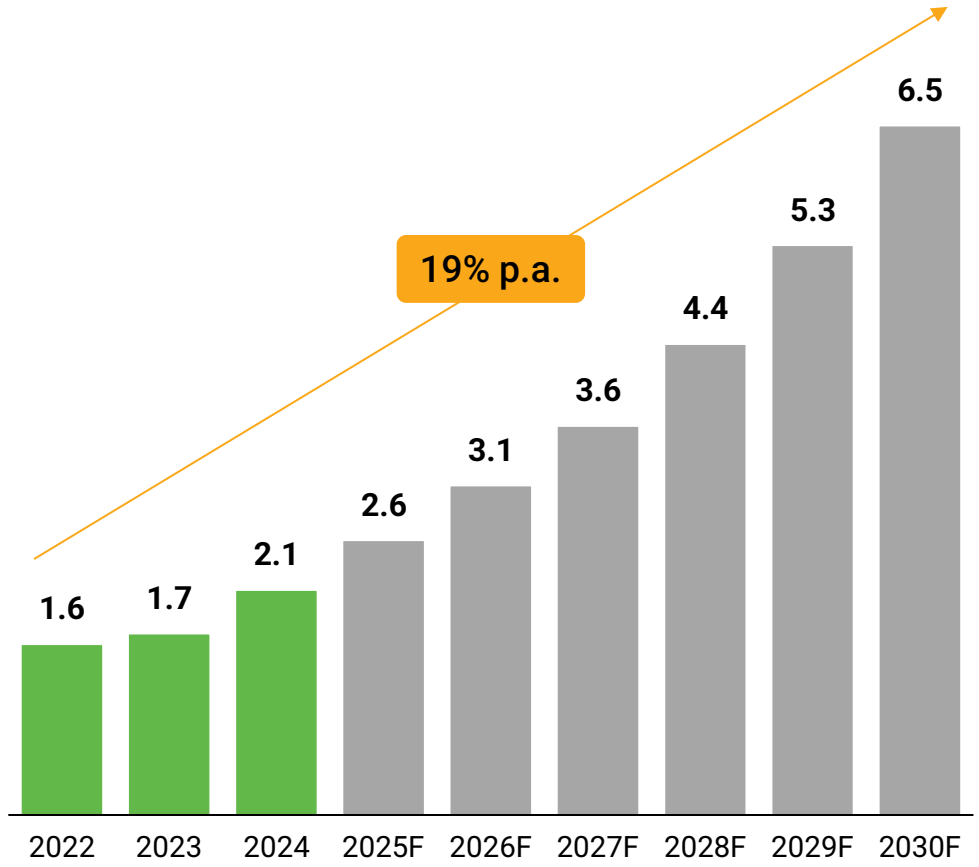
Traditional fossil-fuel grids lack modern tools to manage AI surges and integrate clean energy

Sources: Lit. search; Bain analysis

SEA is expected to see strong data center growth, including a shift in demand to markets outside Singapore

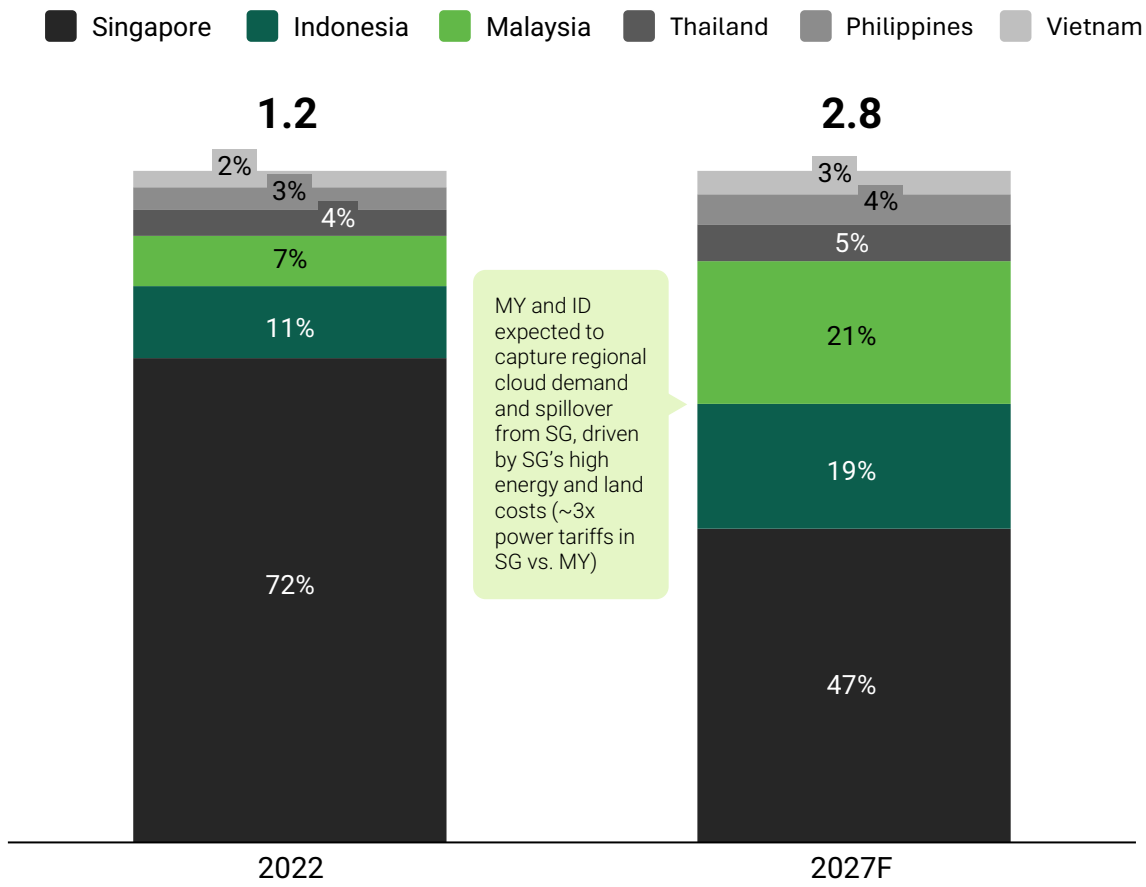
Growing demand for data centers in SEA

Data center energy demand in SEA nations (GW)[1]



DC demand mix likely to shift towards Malaysia and Indonesia

Data center energy demand share (GW)[1]

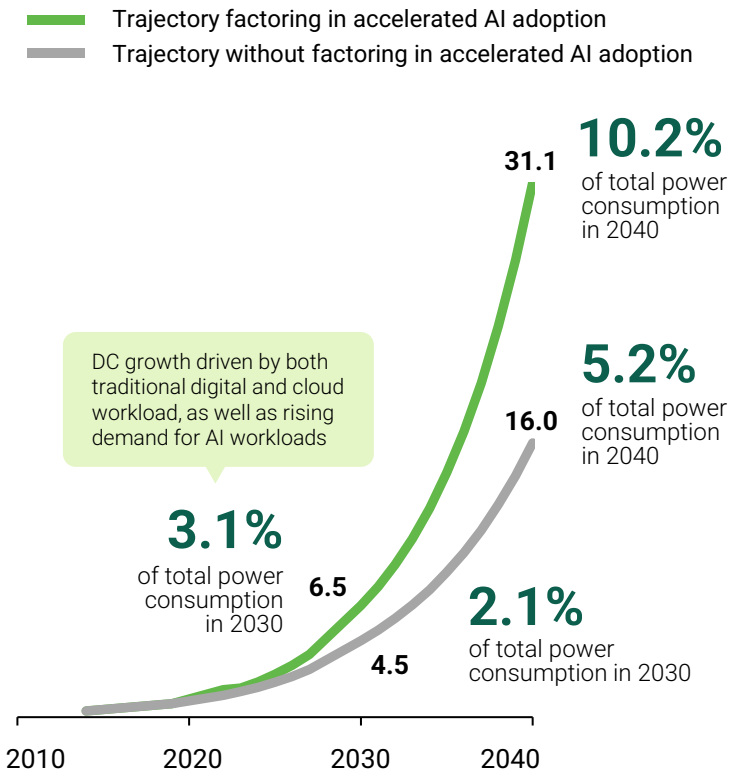


Notes: (1) Represents total power capacity; 2023–27 CAGR (~21%) used to extrapolate DC energy demand till 2030 | Sources: CGSI research; DC Byte; Maybank IBG research; Bloomberg

Data center power demand is currently small, but fast-growing

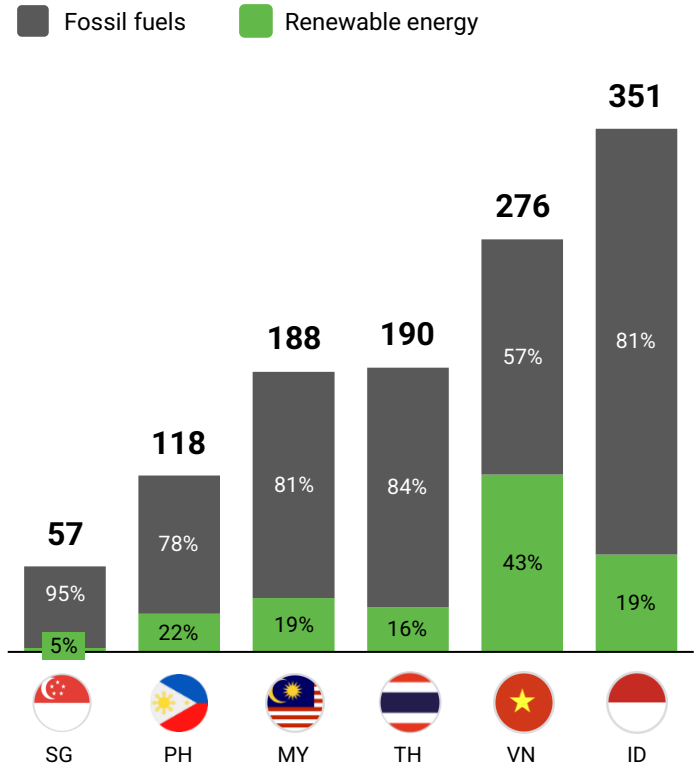
DC growth to use ~10% of total power demand in 2040 (vs. previous estimates of 5%)

DC capacity demand in SEA (GW)



Difficult for SEA to meet rising DC demands sustainably due to high fossil fuels mix …

Mix of RE and fossil fuels in electricity generation across SEA-6 in 2023 (TWh)



… and lack of easy access to renewable energy for DCs

Mismatch between clean energy locations and DC hubs

Clean/carbon-free energy sources tend to be in remote locations, while DCs are near cities, making energy transfer difficult

Need for uninterrupted baseload power

DCs need stable, round-the-clock power supply to minimize outages, which clean energy sources cannot guarantee

To fully rely on clean energy, DCs need energy storage systems or reliable access to clean firm power (e.g., geothermal), which can be expensive; however, the costs are decreasing as battery prices fall

Sources: EMBER; Global News Wire; DC Byte; Bain analysis

Data centers will make up 2%–3% of power demand and up to ~2% of SEA-6 emissions by 2030, subject to market developments

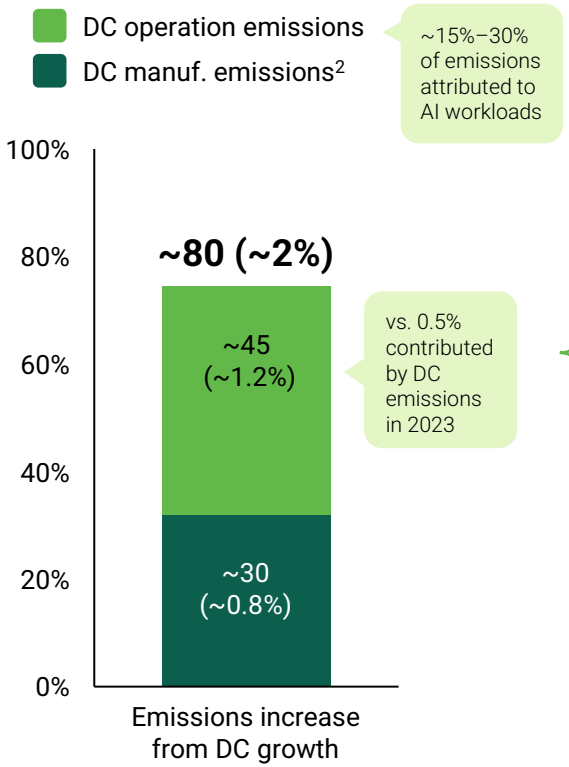
DC power demand expected to increase to 2%–3% of total power demand by 2030 for SEA

	IEA	Bain & Company
GW power demand by DCs in SEA in 2030	~5	6.5
Percentage of total power demand from DCs in SEA in 2030	2.3%	3.1%

> Although SEA today accounts for ~3% of global DC demand, its power demand for DCs is set to almost double by 2030
>
> IEA Southeast Asia Energy Outlook, 2024

DC growth could contribute up to ~2% of emissions by 2030; however, this could be lower depending on market developments[1]

GHG emissions (2030) in MtCO2e
(percentage of 2030 total emissions)



Market developments that could potentially reduce emissions	Impact assessment
1 **Significant improvements in hardware** (e.g., energy-efficient CPU/GPUs, application-specific circuits)	High
2 **Significant improvements in software** (e.g., energy-efficient LLMs, predictive scaling to cut power needs)	High
3 **Sourcing clean energy to decrease emissions** (e.g., direct sourcing from RE-heavy grid, on-site RE generation)	Moderate
4 **Improvements in PUE[3]** (e.g., advanced cooling systems, energy-efficient buildings)	Moderate

Notes: (1) Depending on market developments, smaller, high-performance models could enable more on-premise/VPC deployments and reduce reliance on GPU-heavy infrastructure, potentially moderating DC growth and encouraging a gradual shift toward commodity hardware, especially under ongoing geopolitical pressures; (2) Includes emissions from semiconductor manufacturing, growing e-waste, and deforestation linked with increase semiconductor manufacturing; (3) PUE = power usage effectiveness; current average PUE (2024) for Hyperscalers and other DCs is ~1.13 and ~1.6 respectively | Sources: IEA; Bain analysis; MayBank research

Meeting data center power demand sustainably will require innovation and a range of green energy solutions in the near term

Strategies for data center operators to reduce GHG emissions from energy use; a multi-solution approach is essential

DC infrastructure ← → DC operations

	Invest in green DCs	Leverage carbon offsetting	Green power procurement	Direct connection to clean energy heavy grid	On-site clean energy generation/sources
Description	Develop DCs using advanced cooling systems, optimized design, green construction materials (e.g., green cement), and energy-efficient hardware	Purchase carbon credits from third-party registries	Contract energy from renewable sources to match total energy consumption	Electricity sourced directly from high percentage of renewable grids	On-premise generation/use of RE, e.g., solar/wind farm or biofuel-powered backup generators connected to DC
Environmental impact	**High** High impact due to **lower energy consumption**	**Moderate** Dependent on **type of offset**, e.g., higher impact via **removal offset**[1] vs. lower impact via avoidance offset	**High** Buying RE to **match all energy usage, strong environmental impact**	**High** Lower impact vs. on-premise clean energy due to **transmission and distribution losses**	**High** Highest control over **RE use optimization** mitigates transmission losses
Required capabilities (investment)	• Expertise in advanced cooling systems • Upfront investment in energy-efficient infrastructure	• Team with understanding of carbon markets • Ability to negotiate with carbon traders • Appropriate budget allocation	• Negotiation capability • Understanding of RE market, types of RE projects (and their credibility), and available PPA suppliers	• Appropriate site selection/ proximity to RE sources • Relationship with local grid owner, agreement on RE sourcing network and cabling work	• Expertise in integration of on-site RE generation into distribution system • Infrastructure investment to construct on-site generation facility
Cost impact	**High** Key costs include energy-efficient hardware, sustainable cooling systems	**Moderate** Key costs include budget and purchasing team and potential reputation risk associated with offset credibility and quality	**Moderate to high** Key costs include cost of PPA, longer-term cost based on MGW volume negotiated	**High** Key costs include potential green PPA payments, network and cabling costs, new site selection for RE proximity	**High** Initial investments in design, infrastructure, and licensing; long-term cost savings depend on LCOE; dependency on favourable wind, sun conditions

Notes: (1) Removal offsets generated from activities that sequester carbon out of atmosphere; avoidance offsets generated from activities that reduce emissions by preventing their release into atmosphere | Sources: Market participant interviews; Lit. search

VPPAs (virtual power purchase agreements) offer an innovative mechanism for international collaboration on addressing rising power demand from AI

Critical transformations required in SEA to accelerate VPPA adoption

A VPPA is a financial agreement where the buyer supports a RE project by paying for renewable energy certificates (RECs) without directly consuming the energy or needing to be on the same grid or country, enabled by cross-border energy trading mechanisms

VPPAs are still nascent in SEA, but they are emerging as a significant tool for corporations to procure RE, with multiple nations (e.g., SG, MY) enabling VPPAs

What are the key transformations required to accelerate VPPA adoption?

Liberalize electricity markets and expand grid access

Allow corporate buyers to contract directly with renewable energy producers

Establish clear VPPA regulatory frameworks

Governments must formally recognize VPPAs, ensuring corporations can credibly claim renewable energy usage

Phase out fossil fuel subsidies and enable market-driven pricing

Gradually removing subsidies will make renewables more competitive and drive large-scale procurement

Ensure recognition of cross-border VPPAs by global standards

Global frameworks like GHG Protocol and initiatives like RE100 would need to allow corporations to claim cross-border VPPAs as RE sourcing

VPPAs can be further expanded via cross-regional collaboration

Case study: VPPA between three EU nations

Country	Stakeholder	Involvement
Czech Republic	T-Mobile	**Data center/telecom operators** across Czech Republic and Slovakia have signed VPPA with RE provider in Romania
Slovakia	CE-Colo	
		Buys RECs / Receives RECs
Romania	Rezolv Energy	**Wind farm operator in Romania,** supplying RE to the grid
		Supplies energy
Romania	End consumer	Wind farm will power ~270,000 homes and offset ~0.5 MtCO2e p.a.

Sources: Resolv Energy

AI potential to impact wider emissions reduction; 3%–5% annually in key systems

AI use cases to drive emissions reduction

★ Deep dive ahead ✓ High-impact solutions / Non-exhaustive

	 Agriculture & Nature	 Power	 Transport
Predictive modelling and optimization	• AI-driven **precision farming to identify soil** needs by using satellite imagery • AI-driven prediction of **wildfires** using satellite images and weather data	★ **AI-optimized RE generation**, leveraging weather forecast data ✓ AI-driven modelling to **forecast maintenance needs** of power plants	• AI-enabled **routing** to **optimize fuel** consumption by analyzing traffic conditions • **AI-driven ride-sharing** enabler that **forecasts demand** across area and time
Generative design	• AI-designed **farm layout** to maximize sunlight exposure, airflow for higher yields • AI-designed **planting patterns** to **enable** maximum tree growth and high GHG capture	• AI-designed smart grid layouts to optimize energy distribution and transmission • AI-generated **aerodynamic wind turbine blade designs** maximize energy capture	★ **AI-designed components** that use lighter, ✓ sustainable material, reducing fuel usage • AI-optimized **public transit layout** to improve passenger flow, weight distribution
Building sustainability capabilities	• AI-powered mobile apps to **boost smallholder farmers' awareness** of farming's best demonstrated practices	✓ AI-powered VR simulations to **bridge the renewable energy skills gap** in workers	• AI-powered **virtual labs** to train engineers in battery design and energy efficiency
Emissions reduction potential[1] (percentage of reduction within the sector/percentage of overall emissions reduction in 2030)	**~3%–5%/~0.9%**	**~4%–5%/~0.9%**	**~4%/~0.4%**

Notes: (1) Emission reductions have been forecasted for SEA-6 nations
Sources: Google maps-platform; Google environmental report 2024; Google blogs; Economic Times; Lit. search

Several proven AI and generative AI applications are already delivering measurable GHG emission reductions across corporations globally

	Airbus	Google DeepMind
	Airbus leveraged **generative design** to create a new partition for the A320 aircraft	Google collaborated with DeepMind to **forecast the quantum of wind-energy** that can be generated in the future
Overview	Leveraged AI algorithms to explore numerous design permutations based on specified weight, strength, and stress parameters Attained significantly quicker iterations of the partition's design, which helped speed up the aircraft's time-to-market	AI models forecast wind energy generation up to 36 hours ahead by analyzing historical weather data The forecast of wind energy allows for the grid to plan when to use renewable power vs. when to depend on fossil fuels
Benefits	• **Fuel savings**: Each partition is ~30 kg lighter than standard partition, resulting in fuel savings and lower emissions • **Low raw material costs**: 95% less raw materials required than the traditional process, reducing environmental impact	• **Increased grid stability**: Elimination of fluctuations in renewable energy generation, leading to better grid stability • **Cost efficiency**: Predicting wind energy output allows capture of the energy and prevents wastage
Impact	**166 Mt** reduction in CO2 emissions per aircraft per year due to lower fuel consumption **45%** lighter in weight vs. the traditional partition	**20%** greater volume of wind power captured, resulting in lower costs and lower reliance on fossil fuels

Sources: Autodesk; DeepMind; Airbus; Hannover Messe

AI use cases have the potential to accelerate and amplify impact of systems-level solutions for SEA

Sustainable bioeconomy

AI-driven levers to accelerate systems-level solutions

AI-driven land optimization
AI identifies most effective areas for nature-based sequestration

Precision agriculture
AI analyzes climate and soil data to optimize crop yields and reduce waste

Automated carbon modelling
AI models with high sequestration accuracy ensure reliable carbon credit valuation and verification

Expected impact

Moderate to high
AI enhances land-use efficiency and carbon sequestration; however, scaling depends on adoption by farmers and land rights clarity

Next-gen grid development

AI-driven demand-side management
AI adjusts power consumption dynamically, shifting nonessential loads to off-peak hours

AI-driven grid balancing
AI optimizes power distribution to prevent overload, improve efficiency, and minimize curtailment

Predictive maintenance
AI detects wear and tear in power lines, reducing outages and extending infrastructure lifespan

RE generation forecasting
AI enhances grid stability by predicting RE generation fluctuations

Moderate to high
AI can materially reduce energy needs by optimizing both energy demand and clean energy supply, but legacy infrastructure hinders full deployment

EV ecosystem

AI-enhanced charging infrastructure
AI predicts demand hotspots and optimally locates EV charging stations to prevent congestion

Dynamic load management
AI prevents grid overload by balancing charging demand with power supply

High
AI optimizes energy usage in EV infrastructure and benefits from strong policy and market momentum

Source: Lit. search

Governments will play a crucial role in ensuring that the DC expansion for AI aligns with environmental sustainability goals

Limited DC regulations in other SEA countries

	EU	US	China	Singapore	Malaysia
Key policies	**EU DC standard** (EN50600 by CENELEC) **EU's Climate Neutral Data Centre Pact**	**Federal Energy Management Program**	**National Action Plan** for Green DCs	**Green DC Standard** (modelled after ISO 50001 standard)	**Guidelines for sustainable DCs** by Malaysian Investment Development Authority
Policy scope	DC demand to be matched by 75% RE by end of 2025 and 100% by 2030	Efficiency evaluation of DCs every four years DCs in select states (e.g., Virginia) must source 90%+ energy from RE by 2027	Aims to increase utilization of RE in DCs by 10% yearly until 2025 end Cancellation of energy consumption permit if power utilization <80% after scaling	Recommended to build DCs as per the Green Mark certification[3] Recommended water-efficient cooling ways, e.g., immersion cooling	Mandatory declaration of PUE, CUE,[2] and WUE Recommended water intensity (WUE) of =<2.2
Power usage effectiveness (PUE) specifications	**1.3** for DCs in cool climate[1] **1.4** for DCs in warm climate[1]	**<1.2** recommended for availing tax exemptions	**<1.5** targeted by 2025	**<1.3** recommended levels DCs located in tropical weather likely to have higher PUEs	**<1.6** recommended levels
Strength of the regulation	High	Moderate	Moderate	Moderate to low	Moderate to low

Notes: (1) Target PUE starting 2025; (2) CUE = carbon usage effectiveness, calculated as the ratio of the data center annual CO2 emissions and IT equipment energy demand; (3) Green Mark certification comprises a comprehensive scoring system which evaluates power efficiency, water efficiency, natural ventilation etc.; a minimum score of 50 is needed for getting Green Mark certificate | Sources: EUDCA; ASEAN Energy; CENELEC; China State Council; EnergyStar; European Commission Joint Research Centre

Corporations must align technology and sustainability strategies to ensure sustainable AI growth

Guidelines for corporations to ensure sustainable AI growth

From Bain's The Visionary CEO's Guide to Sustainability 2024 report

Technology's power use and emissions can no longer be an afterthought

- Understand and track carbon footprint from IT infrastructure
- Monitor carbon footprint from consumer use of AI-enabled apps

Accelerate the decarbonization of the cloud

- Select cloud and data center providers with low carbon intensity
- Train procurement teams in incorporating carbon footprint in selection criteria

Integrate sustainable behavior from start

- Invest in green software development; optimize software design and function for energy efficiency
- Use tailored AI models for specific use cases (e.g., law-specific for legal tasks)
- Leverage prompt engineering to optimize AI usage
- Upskill teams on AI efficiency and sustainability

Google pioneers AI-driven sustainability across the organization

Case study

Innovations using AI

Using AI to **discover 700+ new materials, including lithium conductors**, for solar cells, battery

Enables accelerated discovery of material; 2.2 million prototypes undergoing feasibility checks

Using AI to **optimize flight paths, substantially reducing the warming effect of contrails**

Potential to identify areas with less contrail formation[1] and recommend flight paths through such areas

Ensuring sustainable AI growth

Leveraging AI to forecast future wind energy generation, leading to better **integration of RE into grid**

Using energy forecasts to schedule capture of wind energy, reducing dependency on fossil fuel for that period

Using AI to **shift computing loads to times with peak RE**

Enables software to adjust workload based on next day's carbon intensity, prioritizing heavier tasks during low-carbon periods

Notes: (1) Contrails (condensation trails) are ice clouds formed by aircraft exhaust at high altitudes; they contribute to global warming by trapping heat in the atmosphere | Sources: Google blogs; Google sustainability webpage; Google maps platform; Bain analysis

Investments across key green sectors, driven by AI, are expected to deliver a return on investment in the range of 15%–50%

← Managing AI growth sustainably → ← Accelerating AI-driven use cases to drive emissions reduction →

	Sustainable/ green DCs	Smart manufacturing	Waste collection	Precision agriculture	Regenerative agriculture solutions
Project description	Optimization of DCs to minimize power usage, leveraging **intelligent cooling systems, energy-efficient** workload mgmt., etc.	**AI-driven manufacturing**, improving accuracy, reducing waste, and optimizing machine operations for lower energy consumption	Leveraging AI to **optimize waste collection routes**, predict waste volumes, **automate sorting**, and enhance recycling processes	Leveraging AI to **optimize farming** by using sensors, data trends to identify and meet customized farm requirements	AI-driven regenerative farming solutions use sensors and machine learning to improve soil health and ecosystem resilience
SEA market size (2030F)	**$20B**	**$100B**	**$15B**	**$3B**	**$1–$5B**
ROI range	**15%–20%**	**30%–40%**	**30%–50%**	**15%–25%**	**20%–50%**
Risk level	**High**	**Low**	**Moderate**	**Moderate**	**High**
Key challenges	Significant time investment to realize ROIs Need reliable pipeline of potential customers	High degree of competition exists currently	Performance highly dependent on state of the waste collection system	Target audience is smallholder farmers with limited income to spend on AI products Cheaper labor cost vs. AI-based automation cost	Very early stage of carbon markets; lack of required regulations

Source: Expert interviews

BAIN & COMPANY GenZero Google standard chartered TEMASEK | ecosperity

Upcoming DC in Singapore shows how a consortium of financing providers can drive green outcomes

Overview

Singtel's regional DC arm, Nxera DCT, is developing DC Tuas, a high-efficiency DC in Singapore, set to begin operations in 2026

58 MW
capacity, making it Singtel's largest DC in Singapore

<1.25
PUE at full load (vs. average PUE of 1.47 in Singapore)

★
Achieved Green Mark Platinum certification for sustainability[1]

Key enablers

Consolidated green financing structure

~$470 million green loan secured through consortium led by five FIs, pooling both local and international financing expertise

Standard Chartered acted as a joint green loan coordinator. The loan proceeds will go toward funding the development and capital expenditure of DC Tuas, Singapore's most hyper-connected green data centre with the highest power density

Advanced technology for energy efficiency

High-density environment:
Facility supports high computing power of >30 kW; includes advanced real-time server monitoring platforms to ensure smooth operation of NVIDIA's graphic processor units

Advanced cooling systems:
Incorporates next-gen cooling capabilities, complemented by efficient chilled water systems and water recycling features

On-site clean energy integration:
On-site solar panels will supply up to 9% of the power required for common facilities, contributing to renewable energy usage

> DC Tuas will feature a green design and build, as well as next-generation liquid cooling systems, making it ideal for meeting the demand from enterprises for high-intensity compute and AI workloads. Sustainability is a core part of our data center business, and we are committed to developing and growing the industry's most sustainable next-generation digital assets. This loan will enable us to support Singapore's digital economy while reducing our carbon footprint in keeping with our net-zero goals
>
> Arthur Lang,
> Singtel Group Chief Financial Officer

Note: (1) Awarded by Singapore's Building and Construction Authority and Infocomm Media Development Authority | Sources: NXERA; The Straits Times; Singtel; ASEAN Briefing

Recommendations | Key steps to be taken by all stakeholders to ensure that AI adoption does not derail but accelerates the journey towards green transition

■ Managing AI growth sustainably ■ Accelerating AI-driven use cases to drive emissions reduction

Policymakers and regulators

- ■ Implement **mandates for DCs**
  Set strict eco standards for new and existing DCs (PUE, WUE)
- ■ Facilitate access to **cleaner energy** for DCs
  - **Incentivize generation of clean energy** (e.g., clean energy mandates, competitive auctions)
  - **Expand grid infrastructure** to enable clean energy integration
  - **Enable cost-effective clean energy procurement** between DCs and clean energy providers
- ■ **Incentivize development of AI-driven use cases** to mitigate emissions through tax credits, subsidies
- ■ Establish smart AI regulations that promote responsible AI usage while fostering innovation

Data center operators

- ■ **Invest in green, energy-efficient DCs**
  - Deploy energy-efficient tech to reduce energy usage
  - Build DCs with low-carbon materials, e.g., green cement, CLT
- ■ **Secure clean energy supply**
  - **Invest in sourcing clean energy from diversified sources** (e.g., PPAs with clean energy providers, high-impact utility green tariffs, on-site clean energy generation, and high-quality RECs)

DC operators'/hyperscalers' climate goals can be harnessed to drive growth in clean energy policy and infrastructure

Public and private organizations

- ■ **Track and manage emissions** from IT workloads
  - **Understand and track carbon footprint** from IT infrastructure
  - **Optimize workload scheduling** during periods of higher RE availability
- ■ Select **sustainable cloud/DC providers**
  - **Train procurement teams** in evaluating carbon footprint
- ■ **Integrate sustainable practices in AI usage**
  - **Optimize software design and function** for energy efficiency (green software development)
  - Leverage right-sized AI models
- ■ **Prioritize development of AI-driven use cases** to mitigate emissions

Financial institutions

- ■ **Establish sustainability criteria for financing DC projects**, channeling capital flows towards energy-efficient, low-carbon technologies
- ■ **Leverage innovative funding mechanisms (e.g., green bonds, green incubation hubs)** to support AI innovations in emissions mitigation (e.g., smart grid management, smart manufacturing)

Conclusion and call to action

11

Progress toward advancing green economy using a systems-based approach needs concerted effort from all stakeholders

01 Corporations/ private sector

02 Financial institutions/investors

03 Governments/ policymakers

Our recommendations will address systemic obstacles to across all three systems

	Benefits of systems approach	Potential to decarbonize across three systems-level solutions		
		Bioeconomy	EV ecosystem	Next-gen grid development
Need to balance economic growth with transition	Prioritizes creation of new green industries for long-term resilience		✓	
Lack of carbon pricing	Tackles carbon pricing head-on as a key unlock across sectors	✓		✓
Limited regional cooperation	Regional collaboration creates interoperability and cost-savings across markets		✓	✓
Economic incentives not well aligned	Aims to realign incentives and taxes to favor low-carbon choices across sectors	✓	✓	✓
Inadequate financing mechanisms	Enables use of finance aligned with regional green and energy goals	✓		✓

Roadmap to 2030 | Bioeconomy

Policymakers to lead
Corporations to lead
Investors to lead
★ High-potential, priority activity

What needs to be done to accelerate decarbonization journey and achieve targets set for 2030

2025	2026	2027	2028	2029	2030

- Adjust current biofuel demand incentives (e.g., biofuel blending mandates) to support 2G biofuels (e.g. INDO, TH, MY) ★
- Develop national bioeconomy strategies with ambitious targets for 2G biofuels; incentivize waste collection and recycling ★
- Build supply chains for collection, transport, and processing of waste feedstocks for biofuels
- Adopt/enhance policies and regional sustainability standards for regional trade of bio-based products
- Develop and scale closed-loop models to link sustainable agricultural production to offtakers in export markets
- Build and deploy blended funds to finance the transition to sustainable practices for smallholder farmers
- Adopt mandatory sustainable production policies with financial support for transition (e.g., palm in ID, rice in TH)
- Regional import markets to enforce sustainability standards on commodity imports
- Align regional standards for NBS credit quality and integrity
- Design carbon pricing policies to allow NBS credits to be used towards domestic carbon liabilities
- Develop clear policies around Article 6 and VCM for NBS projects ★
- Establish long-term offtake agreements for high-integrity NBS carbon credits, paired with upfront capital to support project development
- Develop/apply financial products to de-risk NBS investments (e.g., credit guarantees, insurance, permanence) ★

Aspiration by 2030

Scale sustainable biofuel production by at least 30%[1]

Expand sustainable production of commodities

Target ~80 MT of NBS credits generated annually[2]

Notes: Aspirational targets derived based on accelerated projections, leveraging data from multiple sources, including: (1) IEA Renewable Energy Progress Tracker projection for biofuels (Accelerated Scenario); (2) Bain data and analysis of NBS pipeline and expansion potential

Roadmap to 2030 | EV ecosystem

Policymakers to lead
Corporations to lead
Investors to lead
★ High-potential, priority activity

What needs to be done to accelerate decarbonization journey and achieve targets set for 2030

2025	2026	2027	2028	2029	2030

Provide financial incentives and streamline regulations for EV manufacturing and for automakers to localize EV supply chains ★

Build EV and battery supply chains within planned green industrial zones/cross-border clusters ★

Require JVs with regional players (e.g., BYD) to include tech and knowledge transfer, job creation targets

Offer incentives like feebate systems to influence adoption of EVs and phase-out of ICEs, especially for motorcycles and utility vans

Set zero-emission vehicle (ZEV) targets for public fleets and government procurement

Develop financing mechanisms to reduce cost barriers for consumers and businesses (e.g., low-interest rate loans, zero-down payment loans)

Explore range of financing mechanisms to incentivize charging infra (e.g., EACs, offtake guarantees)

Develop green transport corridors for commercial EVs

Enable interoperable charging standards and payment systems across ASEAN borders

Integrate smart charging and load management systems leveraging EVs to reduce grid stress

Aspiration by 2030

Scale EV production by at least 6x[1]

Increase annual EV adoption to ~6 million vehicles in 2030[2]

Scale charging infrastructure by 2x[3]

Notes: Aspirational targets derived based on accelerated projections, leveraging data from multiple sources, including: (1) forecasted sales using S&P E Propulsion Forecast, Asian Transport Observatory, ICCT, Thai Ministry of Energy, etc.; (2) Indonesia EV Outlook 2023 from Institute of Essential Services Reform; (3) Asian Automotive Analysis, Singapore Land Transport Authority (LTA)

Roadmap to 2030 | Next-gen grid development

Policymakers to lead
Corporations to lead
Investors to lead
★ High-potential, priority activity

What needs to be done to accelerate decarbonization journey and achieve targets set for 2030

2025	2026	2027	2028	2029	2030

- Encourage non-governmental sources of funding (e.g., PPP) to help accelerate large-scale transmission and smart grid initiatives
- Adopt cost-reflective tariffs and regulations to boost investor confidence in grid upgrades
- Facilitate innovative financing mechanisms for investment in grid (e.g., transition credits)
- Develop demand response systems to optimize load during peak hours and grid stress events
- Develop green industrial clusters/SEZs with incentives (e.g., tax rebates) for clean energy investments ★
- Develop AI-enabled smart grids/microgrids and energy storage solutions for better monitoring, maintenance, load balancing
- Facilitate access to cleaner energy for data centers; enable PPAs/VPPAs between DCs and clean energy providers
- Accelerate development of highest impact bilateral connections ★
- Introduce a coordinated regulatory regime to simplify and speed up the permitting and licensing of cross-border interconnectors
- Establish an ASEAN-wide green infrastructure fund to finance cross-border grid projects with concessional loans, guarantees, and blended finance options

Aspiration by 2030

Achieve ~$20 billion annual grid investment[1]

Achieve ~20% RE penetration in electricity generation[2]

Build next wave of connections in ASEAN grid

Notes: Aspirational targets derived based on accelerated projections, leveraging data from multiple sources, including: (1) IEA Grid and storage investment number in the APS Scenario and the NZE Scenario (2) IEA projections under APS Scenario

Appendix

Green investment refresh

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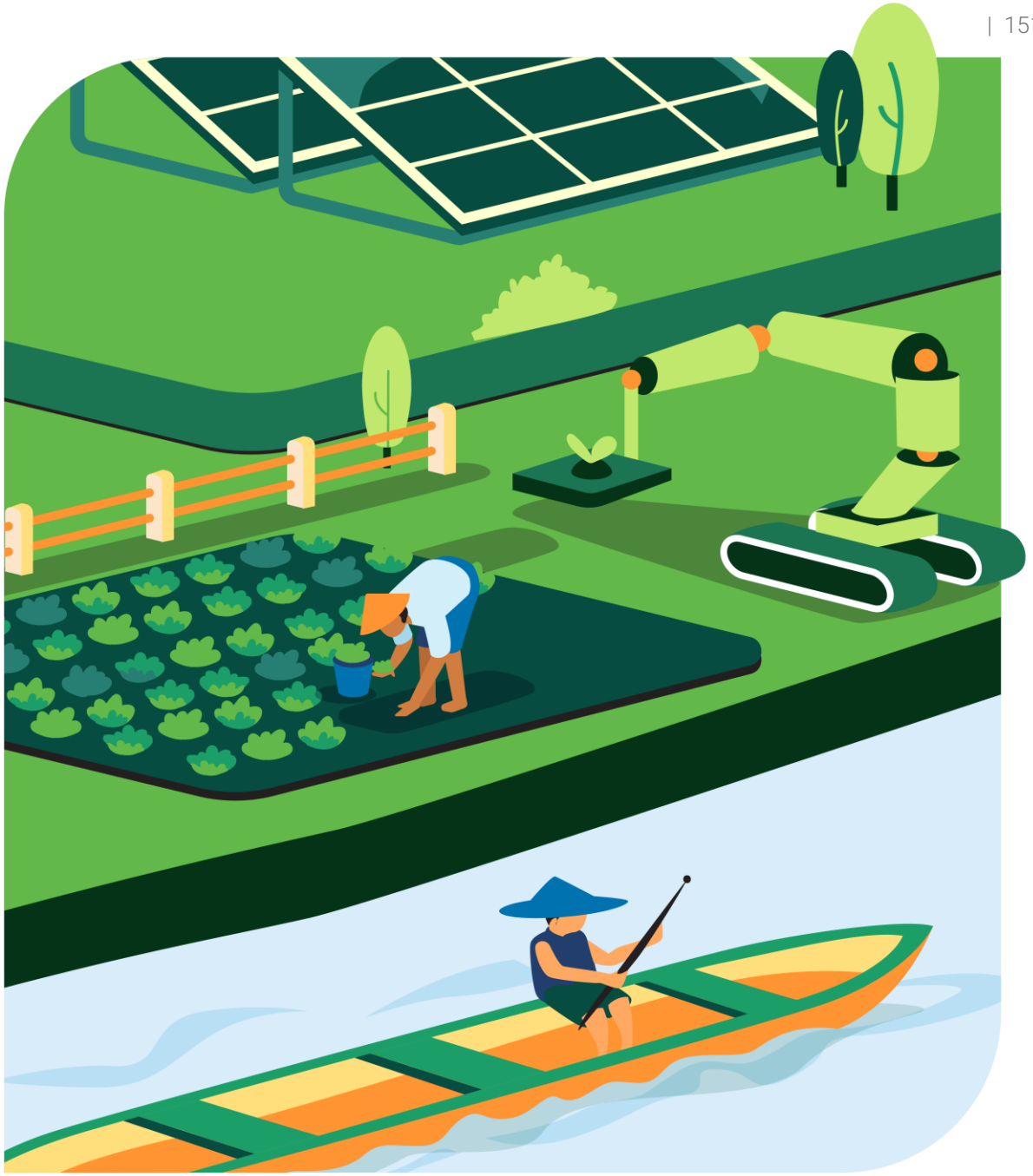


Section overview

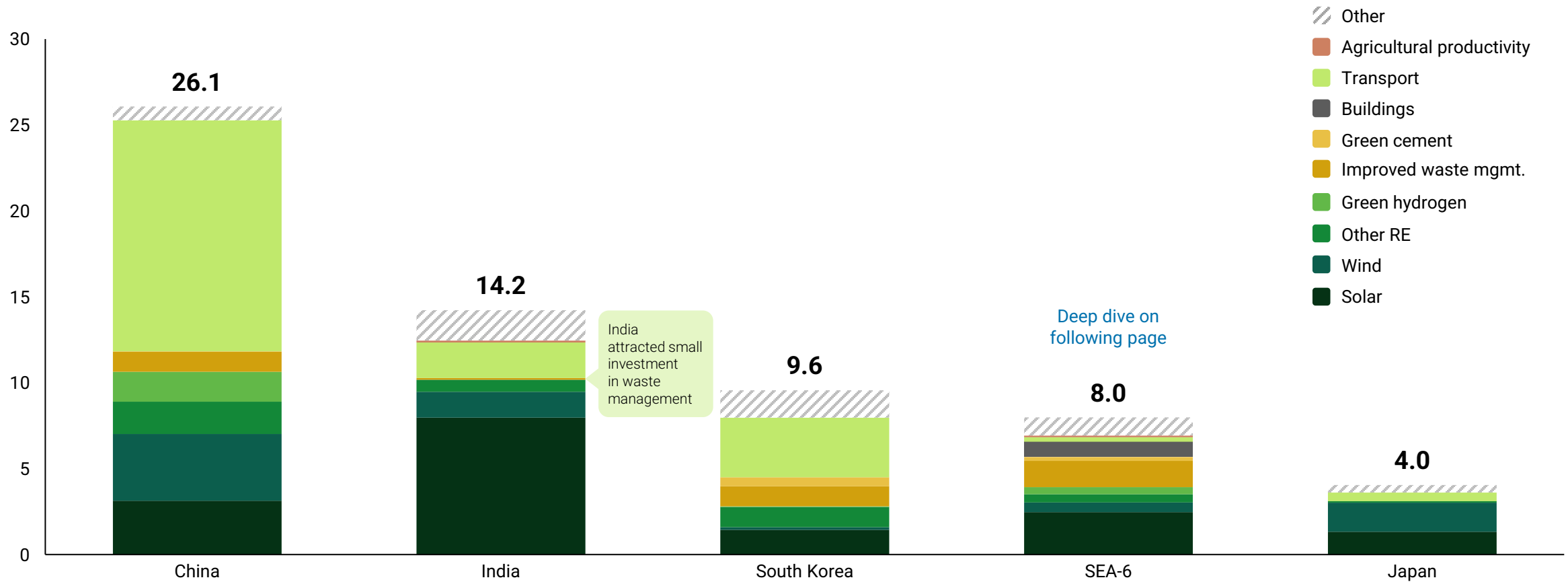
This section provides a **progress update on private green investments in SEA and key APAC nations**, offering insights into key market developments and sectoral shifts

This analysis represents a **selective view and includes private investments only**, excluding government investment, public markets investment, and debt financing

China, India, and South Korea lead private green investments in Asia-Pacific; transport, solar, and wind attract most green investments

APAC

APAC private[1] green investments by theme ($ billion, 2024)

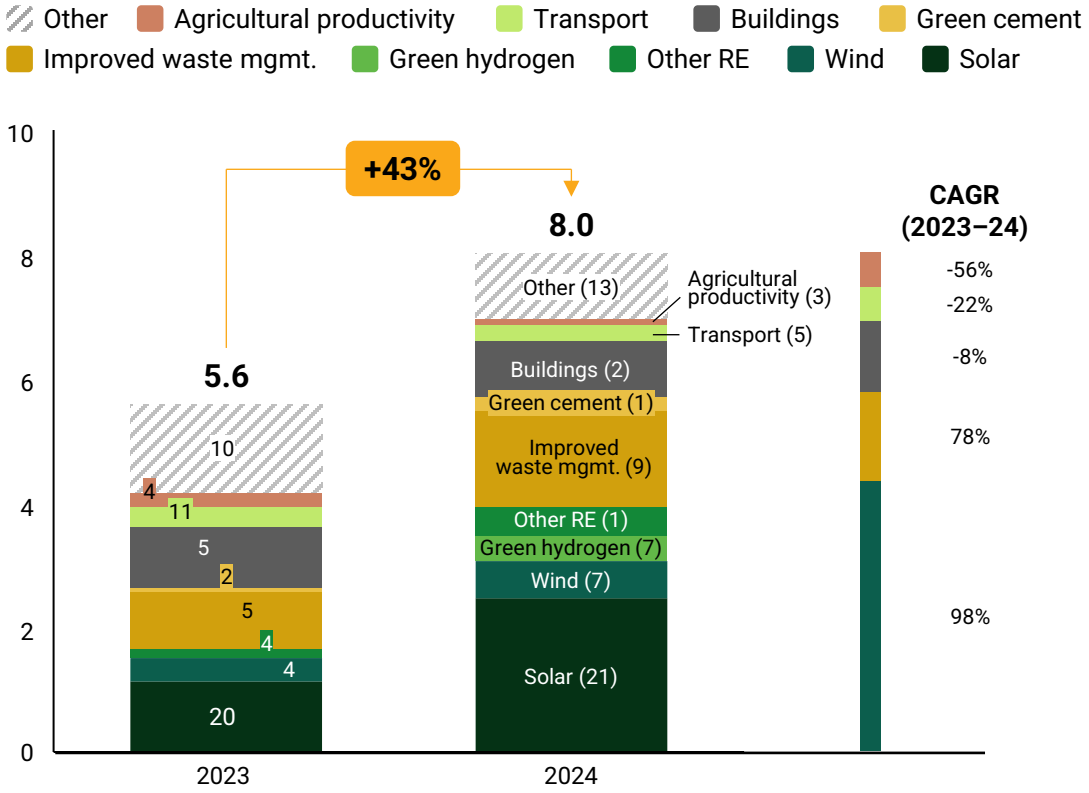


Notes: (1) Debt financing deals excluded and only private green investments are considered for this analysis | Sources: AVCJ; Preqin; CapIQ; PitchBook

Solar and waste management led green investment growth, with solar up by ~100% and waste management by ~60%

SEA DEEP DIVE

Private[1] green investments in SEA countries by theme ($ billion)
Number of deals indicated as (xx)



Power

Continues to hold about two-thirds share of green investments in the region with increase in deal sizes. **Solar** witnessed **the biggest jump** in investments **(~100%)**

Industrial waste

Investments in waste management increased, primarily driven by water treatment and recycling projects

Buildings

Total investment saw a slight decline, with contribution primarily coming from a **one-off deal in Malaysia**

e.g., investment in Johor Bahru data center project in Malaysia

Data center powered through green electricity

Transport

EVs experienced a dip, with low number of investments in the region (5 vs. 11 last year), with total investments declining by 22%

Agriculture & Nature

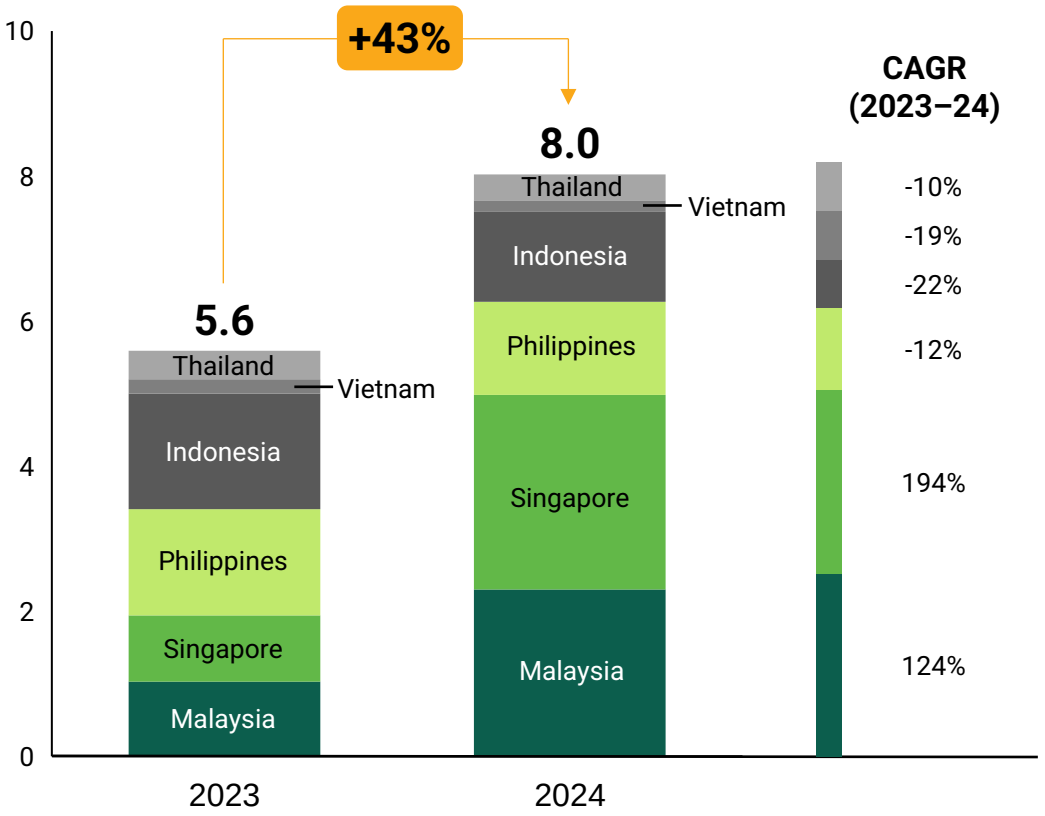
Agricultural productivity (e.g., agritech to decarbonize rice cultivation) saw a decline in investment **(~60%)**; no investments in Indonesia in agricultural productivity in 2024 vs. 6 deals in 2023

Notes: (1) Debt financing deals excluded and only private green investments are considered for this analysis; Themes covered in each of the sectors: Power = solar, wind, fuel substitution, sustainable biomass/biogas/biodiesel, efficient electricity generation, industrial electrification, green hydrogen, other renewable energy; Industrial waste = improved waste mgmt., alternative materials, green cement; Buildings = data centers; Transport = EV manufacturing, EV batteries; Agriculture & Nature = alternative proteins, agricultural productivity, minimal food loss and waste, forest protection, peatland protection, reforestation and afforestation | Sources: AVCJ; CIQ; PitchBook; Preqin; Lit. search; Bain analysis

~40% rise in private investment in green projects; solar investments lead, as do Singapore and Malaysia in terms of new growth

SEA DEEP DIVE

Private[1] green investments in SEA countries ($ billion)



Malaysia

Investments doubled, primarily driven by

- 100% rise in **building investments** (e.g., data centers) and ~4x increase in **solar** (solar power system)
- **~$400M new investments** (vs. none in 2023) in **green hydrogen**. Project focuses on green hydrogen production using solar power tech

Philippines

Investments remained stable compared to previous year

- **Solar investments grew 1.5x** (solar farmland) and **wind energy projects 6x**
- Investments in **waste management dropped significantly**, from ~$600M in 2023 to none in 2024

Vietnam

Investments decreased in comparison to the previous year

- **~95%** investments directed towards **renewable energy**

Singapore

Demonstrated **increase** by attracting **large solar energy, fuel substitution, and waste management investments**

- e.g., ~$320M investment in a solar panel manufacturer

Indonesia

Experienced **slowdown** due to **lack of investments in fuel substitution**[3]

- Lack of investment in fuel substitution (LNG plant in 2023) led to decrease in overall investments
- Wind (e.g., power plant) and solar (e.g., panels) attracted new investments vs. none in 2023

Thailand

Investments remained consistent with previous year

- **Green cement**[4] (~60% of overall investment) and **solar** (e.g., solar rooftop PV systems) attracted most investments in 2024

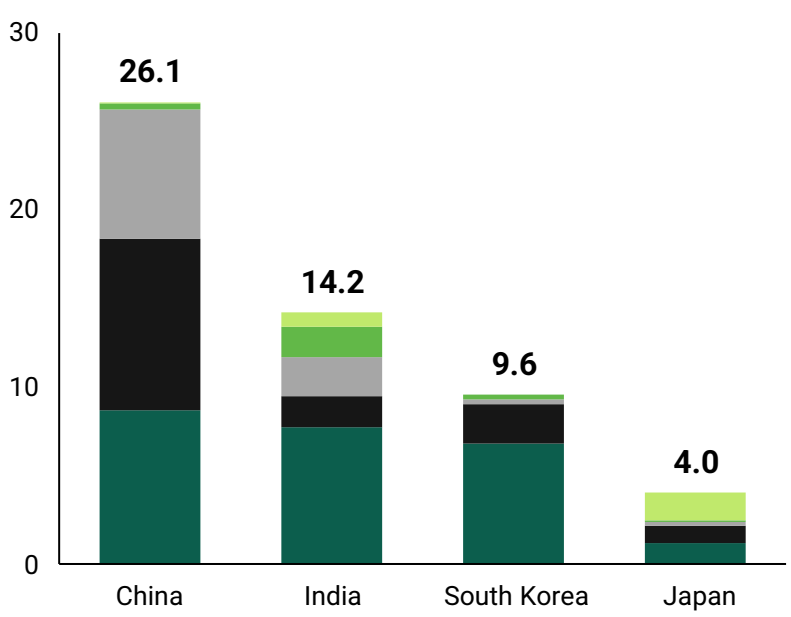
Notes: (1) Debt financing deals excluded and only private green investments are considered for this analysis; (2) Liquefied natural gas (LNG) transactions have been incorporated to ensure methodological consistency with the previous years; (3) Fuel substitution = replacement of fossil fuels with greener fuels like biodiesel, hydrogen and LNG; (4) Siam city cement green deal size ~$900M (focused on long term strategy and sustainability initiatives) – one-fourth of deal size taken as proxy towards sustainability initiatives | Sources: AVCJ; CIQ; PitchBook; Preqin; Lit. search; Bain analysis

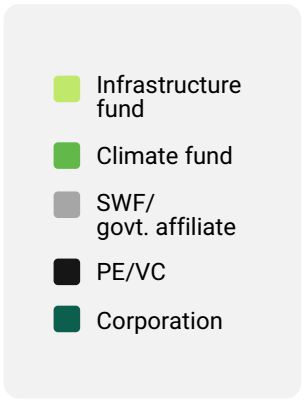
Corporate momentum drove green investments across SEA, India, and Korea; in SEA, climate and infrastructure fundings grew by ~4x and ~14x, respectively

APAC

Key APAC nations

Private[1] green investments by investor type ($ billion, 2024)

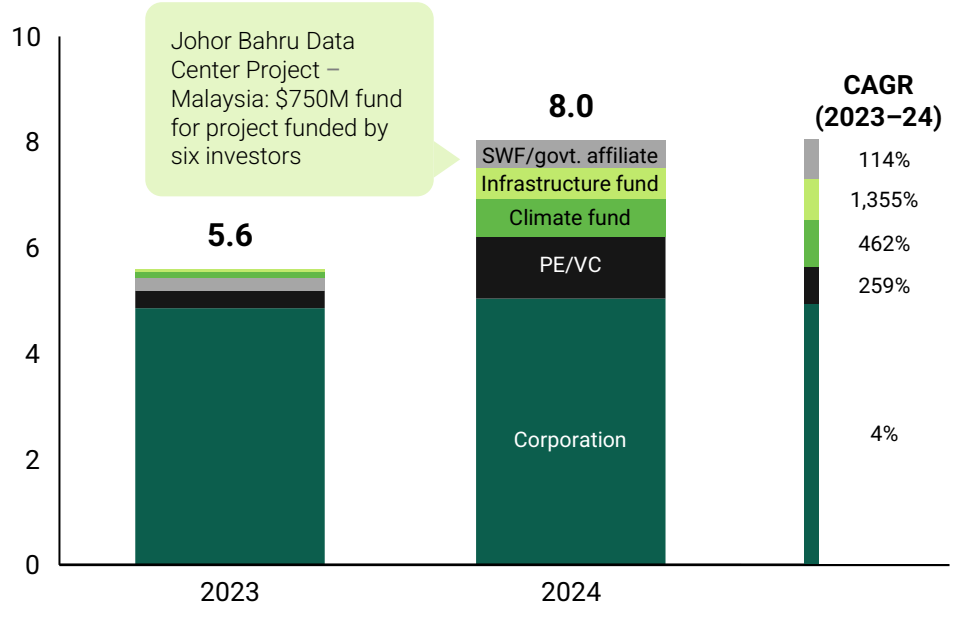




	China	India	South Korea	Japan
Corporation	**33%**	**54%**	**71%**	**29%**
Private[2]	**39%**	**30%**	**26%**	**65%**
SWF/govt. affil.	**28%**	**16%**	**3%**	**6%**

SEA

Private green investments by investor type ($ billion)



	2023	2024
Corporation	**87%**	**63%**
Private	**9%**	**31%**
SWF/govt. affil.	**4%**	**6%**

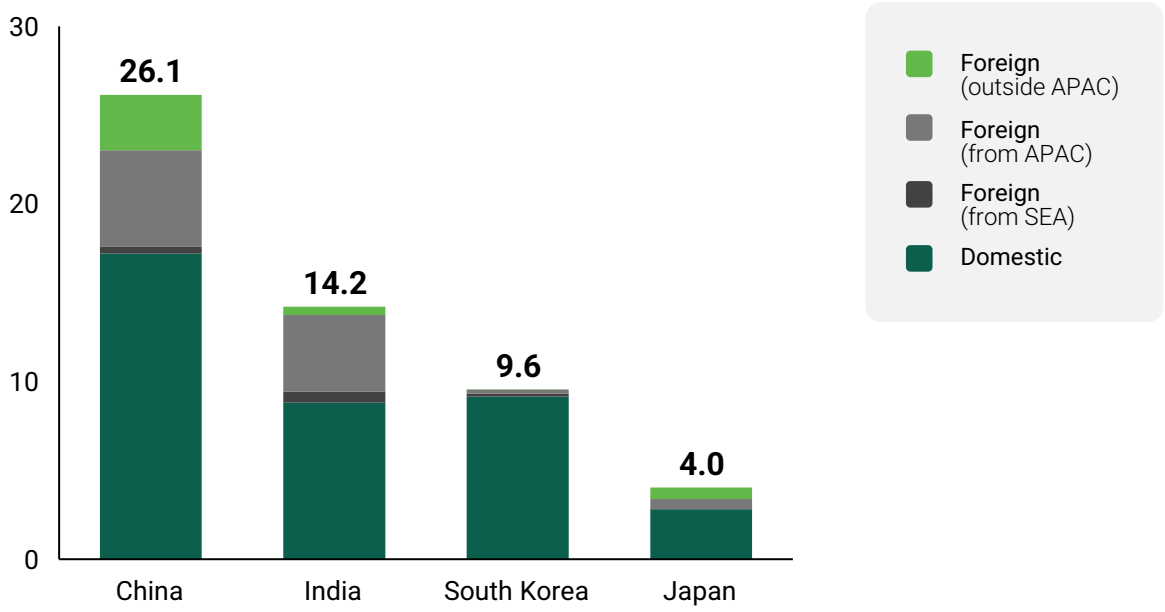
Notes: (1) Debt financing deals excluded and only private green investments are considered for this analysis; (2) Includes investments by PE/VC, infrastructure funds and climate funds | Sources: AVCJ; CIQ; PitchBook; Preqin; Lit. search; Bain analysis

Domestic capital drove 60%+ of green investments across APAC, but in SEA, foreign investment tripled as domestic funding fell by ~40%

APAC

Key APAC nations

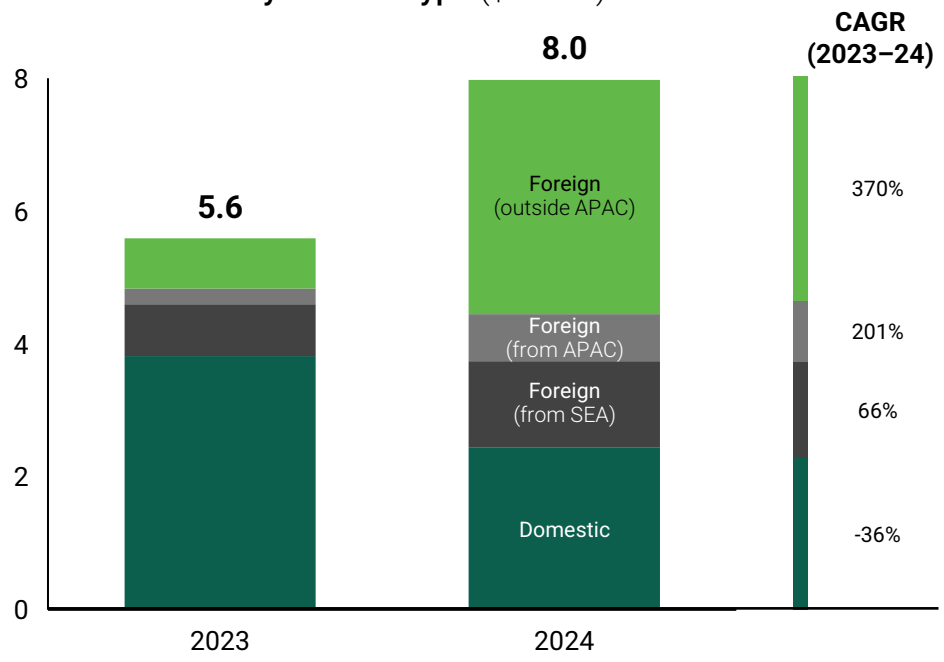
Private[1] green investments by investor type ($ billion, 2024)



	China	India	South Korea	Japan
Domestic	**66%**	**62%**	**96%**	**70%**

SEA

Private green investments by investor type ($ billion)



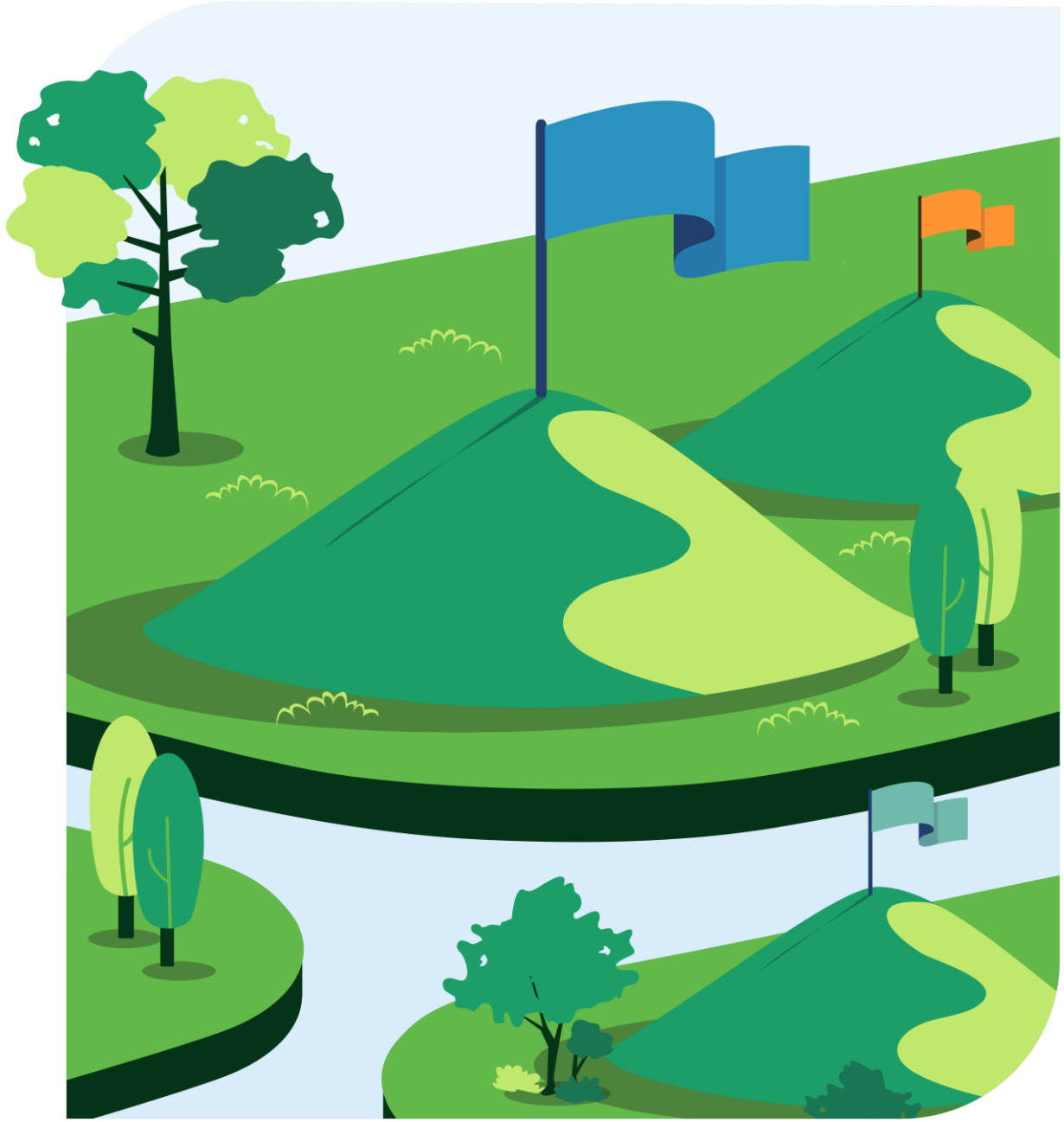
	2023	2024
Domestic	**68%**	**31%**

Note: (1) Debt financing deals excluded and only private green investments are considered for this analysis | Sources: AVCJ; CIQ; PitchBook; Preqin; Lit. search; Bain analysis

Appendix

Country insights

13



Section overview

This section provides an update on key SEA countries' progress using the SEA Green Economy Index methodology

This evaluates how countries are advancing across key decarbonization metrics—for example, ambition, policy roadmap, and investment—to assess their progress toward 2030 climate targets

SEA Green Economy Index Methodology: 2025*

Index (100%)

Ambition — 10% weightage

Target-setting and quality (50%)

Six binary questions asked on target-setting and quality

+

Target cascading (50%)

Sector level

One binary question on whether a country has sector-level targets

+

Corporate level

Count number of corporations with net-zero targets among top 10 (weighted average scores based on emissions level)

Progress — 25% weightage

GHG emissions per capita (33%)

Total country GHG emissions level/population

+

Sector progress (66%)

Energy

Percentage of RE in total power generation

+

Percentage of EVs in new car sales

+

Nature

Net percentage change in forest land

+

Agriculture

Nutrient efficiency

Roadmap — 15% weightage

Sector level roadmap (33%)

Energy | Nature | Agri.

Score based on existence and quality of sector-level roadmap

Quality evaluated on the level of detail and timeline of roadmap

+

Corporate-level roadmap (67%)

Count number of corporations with roadmap among top 10 (weighted average scores based on emissions level)

Accelerators — 25% weightage

Regulatory framework (33%)

Energy
Fraser index, permit/legal mandates on RE, etc.

Nature
Forest conservation, carbon markets, etc.

Agriculture
Inorganic fertilizer registry, sustainability certificate

+

Financial prerequisites (33%)

Energy
Carbon tax, incentives for RE/EV/green buildings

Nature
Carbon credits issued relative to forest area

Agriculture
Organic fertilizer incentives, SME loan/credit

+

Infra, tech, and human capital (33%)

Energy
National grid infrastructure, number of EV charging stations

Nature
Number of registered NBS projects

Agriculture
System of rice intensification (SRI) adoption

Investment — 25% weightage

Green investment size (100%)

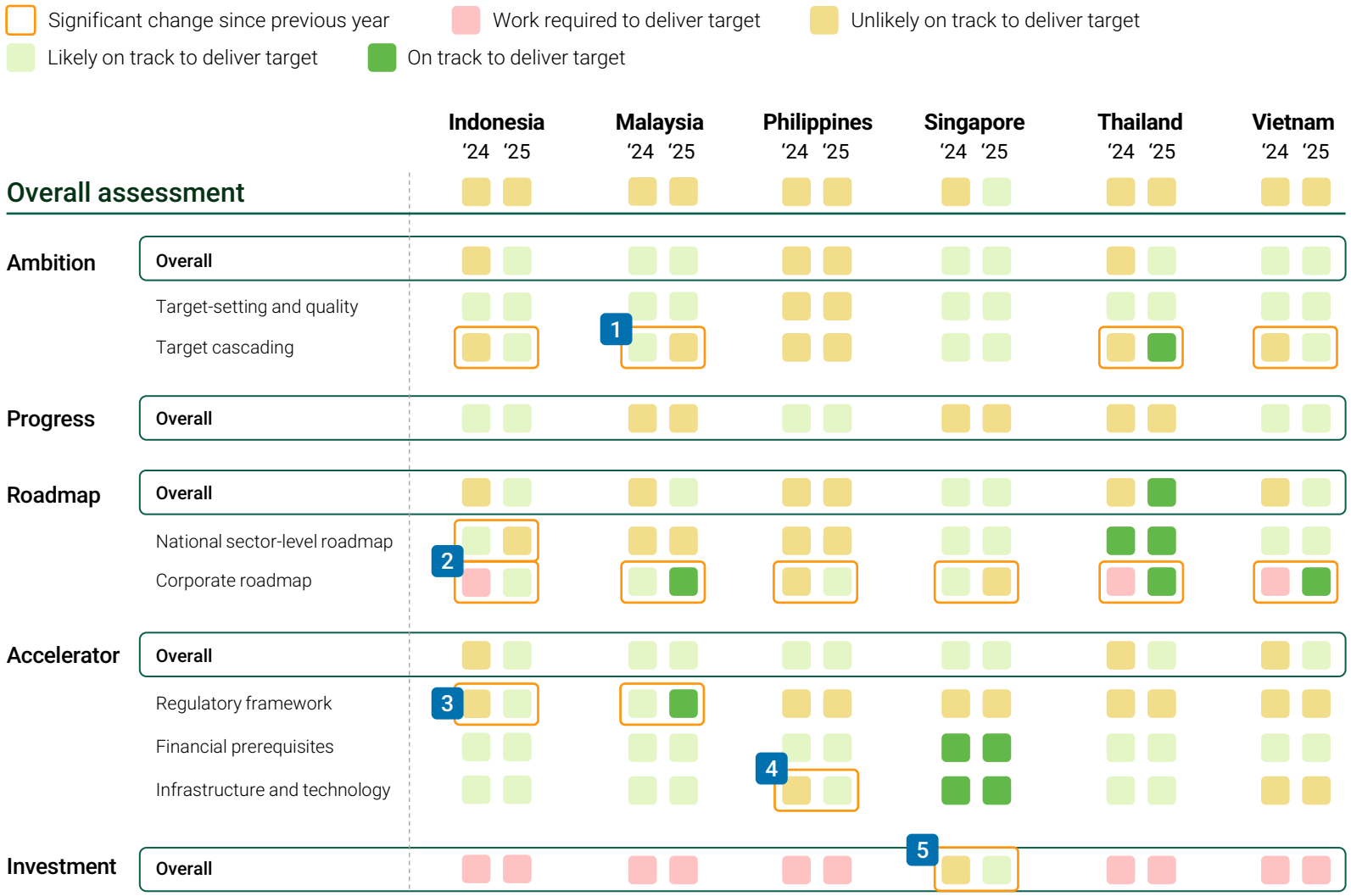
Percentage of actual private green investment against the required amount of investment

(Required amount of investment is proportional to the size of GHG emissions in each country)

Note: *Adjustments in weightages have been made in some categories to prioritize action-oriented themes like progress, accelerators, and investments over ambition and roadmaps. The changes are as follows: Ambition reduced from 20% to 10%, Roadmap decreased from 20% to 15%, and Investment increased from 10% to 25% | Source: Bain analysis

BAIN & COMPANY GenZero Google standard chartered TEMASEK | ecosperity

2025 SEA Green Economy Index: Corporations largely showing increase in setting targets and developing roadmaps; however, green investments still lag



Key observations

1. **New corporate targets** toward emissions reduction seen in 4/6 countries

2. Corporations in 5/6 countries have **shown progress in establishing roadmaps**

   Indonesia recently dialed back on its plan to phase out coal, which has negatively impacted its score

3. Minor **progress in regulatory framework,** such as improving mandatory emissions reporting, made in 2/6 countries

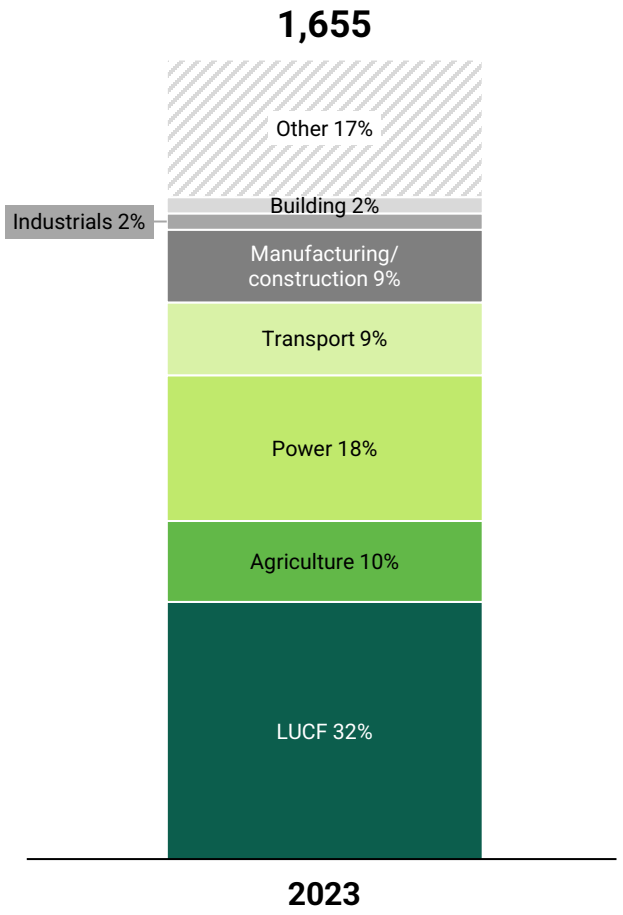
4. Philippines saw progress in **infrastructure and technology,** with better grid interconnectedness and EV charging stations

5. **Investment rose from ~$6B to ~$8B**
   All SEA countries continue to have a significant gap between required vs. actual investment

   Singapore has shown a 194% YoY increase in investment

Indonesia | Country insights

GHG emissions (MtCO2e)



Likely on track to deliver target | On track to deliver target | Work required to deliver target | Unlikely on track to deliver target | Key drivers influencing shifts in the overall theme score

'24 '25

Ambition

'24 '25

- **Net zero** by 2060
- **32% GHG reduction**[1] by 2030
- **Significant increase** in corporate targets[2]

Progress

'24 '25

- **Current per capita emission at 5.9 tCO2e** (+8% from 2022–23)
- **Renewable energy share at ~19%**
- **Share of 4W BEV sales in total 4W sales at ~5%**

Roadmap

'24 '25

- **FOLU**[3] **Net Sink 2030** plan sets sectoral targets to reduce deforestation
- **Corporate roadmaps** have shown a significant increase[4]
- **Coal-phase out commitment rephrased;** 2025 targets for RE generation will be missed[5]

Accelerators

'24 '25

- **Mandatory emission reporting** for public companies
- **Incentives for RE, EV, and green buildings**
- **High SRI**[6] **adoption** with five NBS projects in past year

Investments[7]

'24 '25

- **Green investments reduced** by ~22% in 2024

Notes: (1) GHG emissions reduction target is against 2030 business-as-usual; (2) Currently 60% of the top 10 polluting organizations have net-zero targets, while 90% have 2030 emissions reduction targets, compared to 0% and 70%, respectively, last year; (3) forestry and other land use; (4) Currently 40% of the top 10 polluting organizations have roadmaps compared to 10% last year; (5) Climate and Energy Envoy says coal phase-out target would be "economic suicide" and previous phase out commitment meant "After 2040, there will be no new coal plants"; (6) System of rice intensification; (7) This analysis represents a selective view and includes private investments only, excluding government and public market investments and debt financing | Sources: Country NDC; LT-LEDS; Climate Watch; IRENA; IEA; UNFCCC; Lit. search

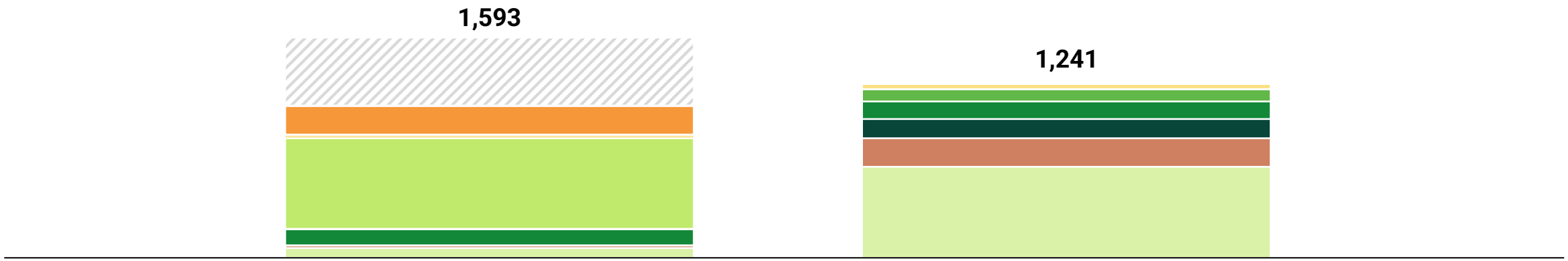
Indonesia | Investment landscape

This analysis represents a selective view and includes private investments only, excluding government investment, public markets investment, and debt financing

Private green investments in Indonesia (Unit: $ million)

Solar | Improved waste mgmt. | Other RE | Wind | Transport | Other | Fuel substitution | Sustainable biomass/biogas/biofuel | Agricultural productivity

2024 total = ~$1,241 million (~15% of SEA-6)

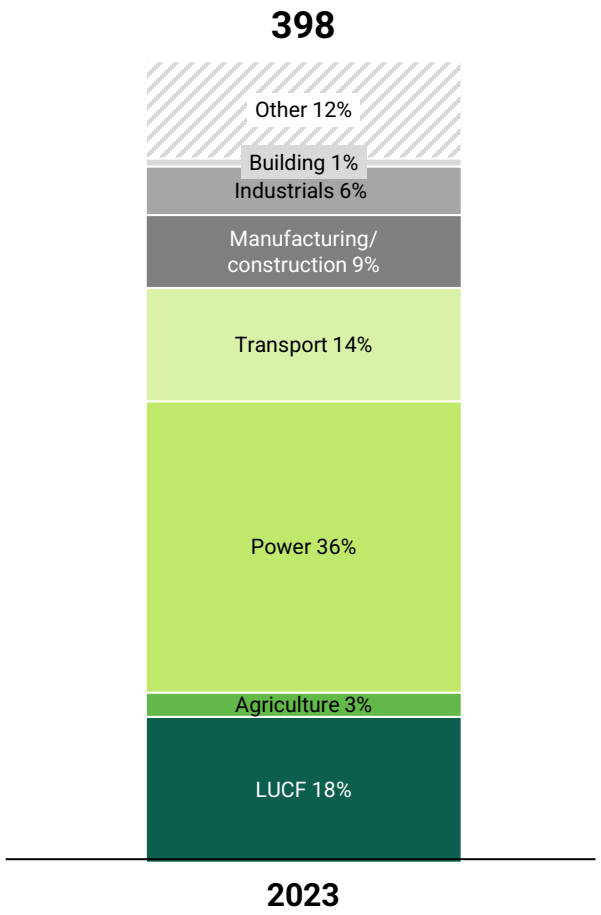


	2023	2024
Number of deals	11	10

Notes: Figures include private sector deal transactions, which are categorized as "closed" and "effective" and >$10 million in size, including private placements and excluding IPOs; used allocation methodology from the previous report, calculating the investment size of a country based on where the target company of the deal is operating; amount not representative of overall private sector investment | Sources: AVCJ; S&P Capital IQ; Preqin; PitchBook; Global Energy Monitor; Lit. search; Bain analysis

Malaysia | Country insights

GHG emissions (MtCO2e)



Likely on track to deliver target | On track to deliver target | Work required to deliver target | Unlikely on track to deliver target | Key drivers influencing shifts in the overall theme score

'24 '25

Ambition

'24 '25

- **Net zero** by 2050
- **45% GHG reduction**[1] by 2030
- **40% RE** in energy mix by 2035

Progress

'24 '25

- **Per capita emission at 11.3 tCO2e** (+5% from 2022–23)
- **RE share at 19%**
- **Share of 4W BEV sales in total 4W sales at ~2.5%**

Roadmap

'24 '25

- **NETP**[2] provides a long-term vision for energy transition
- **Corporate roadmaps** have shown a significant increase[3]
- **MyRER**[4] outlines initiatives to increase the RE share[5]

Accelerators

'24 '25

- **Mandatory sustainability reporting** expanded to large non-listed companies
- **Boosting RE and EV** through policies such as reducing fuel subsidies
- 8x increase from last year in **FOLU carbon credits issued**

Investments

'24 '25

- **Green investment increased** by ~124% in 2024

Notes: (1) Emissions reduction target is reduction in economy-wide carbon intensity (against GDP) vs. 2005 level; (2) National Energy Transition Plan; (3) Currently 100% of the top 10 polluting organizations have roadmaps, compared to 40% last year; (4) Malaysia Renewable Energy Roadmap; (5) Malaysia has other roadmaps as well, such as Twelfth Malaysia Plan, 2021–2025 and Social Forestry Strategic Plan of Malaysia 2021–2025 | Sources: Country NDC; LT-LEDS; Climate Watch;; IEA; UNFCCC; Lit. search

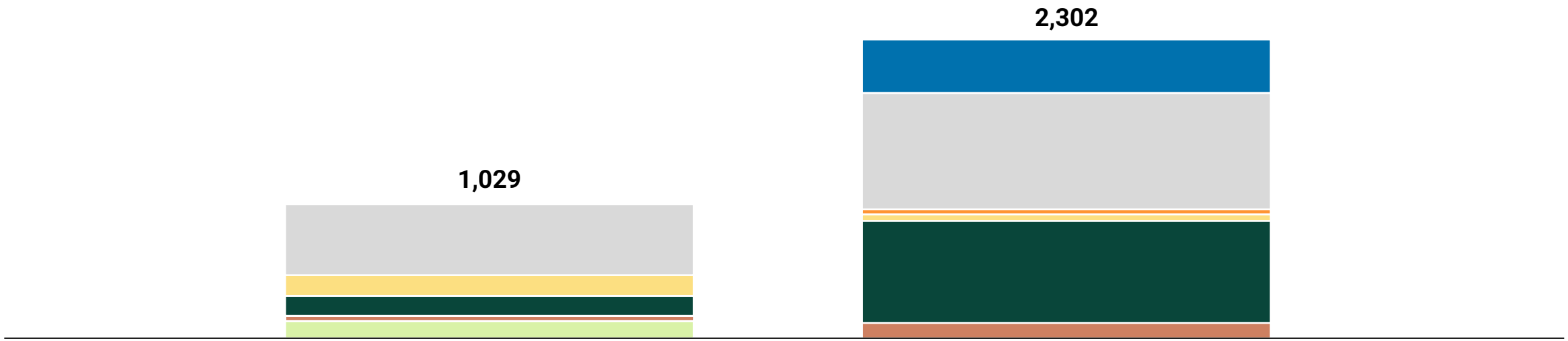
Malaysia | Investment landscape

This analysis represents a selective view and includes private investments only, excluding government investment, public markets investment, and debt financing

Private green investments in Malaysia (Unit: $ million)

Solar | Improved waste mgmt. | Other RE | Sustainable biomass/biogas/biofuel | Agricultural productivity | Buildings | Green hydrogen

2024 total = $2,302 million (~29% of SEA-6)

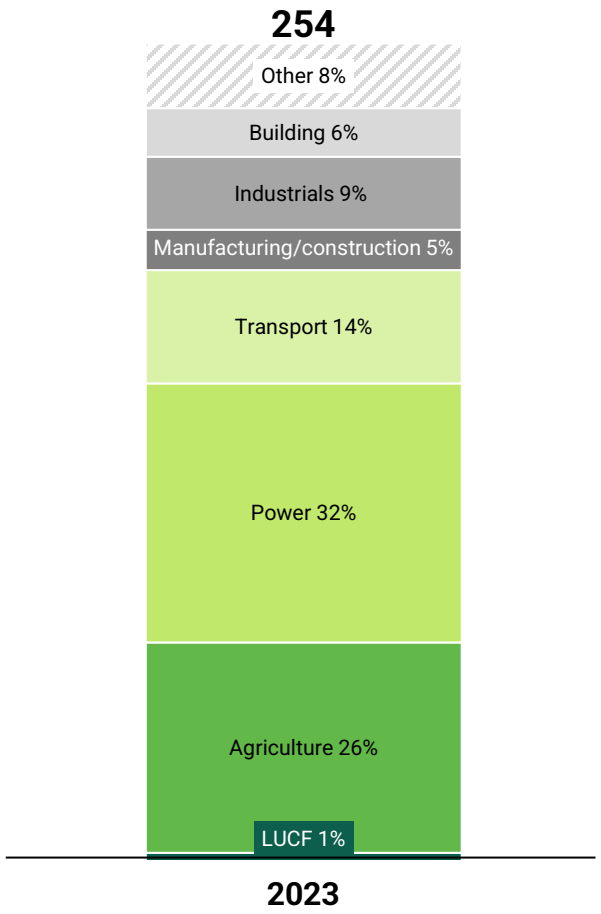


Number of deals	2023	2024
	9	12

Notes: Figures include private sector deal transactions, which are categorized as "closed" and "effective" and >USD10 million in size, including private placements and excluding IPOs; used allocation methodology from the previous report, calculating the investment size of a country based on where the target company of the deal is operating; amount not representative of overall private sector investment | Sources: AVCJ; S&P Capital IQ; Preqin; PitchBook; Global Energy Monitor; Lit. search; Bain analysis

Philippines | Country insights

GHG emissions (MtCO2e)



Likely on track to deliver target

On track to deliver target

Work required to deliver target

Unlikely on track to deliver target

Key drivers influencing shifts in the overall theme score

'24 '25

Ambition

'24 '25

No net-zero target

75% GHG reduction[1] by 2030

35% RE in energy mix by 2040

Progress

'24 '25

Per capita emission at 2.2 tCO2e (+9% from 2022–23)

RE share at 22%

Share of 4W BEV sales in total 4W sales at ~0.4%

Roadmap

'24 '25

Philippines Energy Plan sets a vision for energy transition

NREP[2] sets renewable energy targets

CEFIR[3] aims to mobilize capital for clean energy projects

Accelerators

'24 '25

Mandatory reporting for all publicly listed companies

Major regional grids unified in 2024

Incentives for RE but no carbon tax

Investments

'24 '25

Green investment decreased by ~12% in 2024

Notes: (1) Emissions reduction target is against 2000–30 business-as-usual levels, 2.71% of this target is unconditional while the rest is conditional; (2) National Renewable Energy Plan; (3) Clean Energy Finance and Investment Roadmap | Sources: Country NDC; LT-LEDS; Climate Watch; IRENA; IEA; UNFCCC; Lit. search

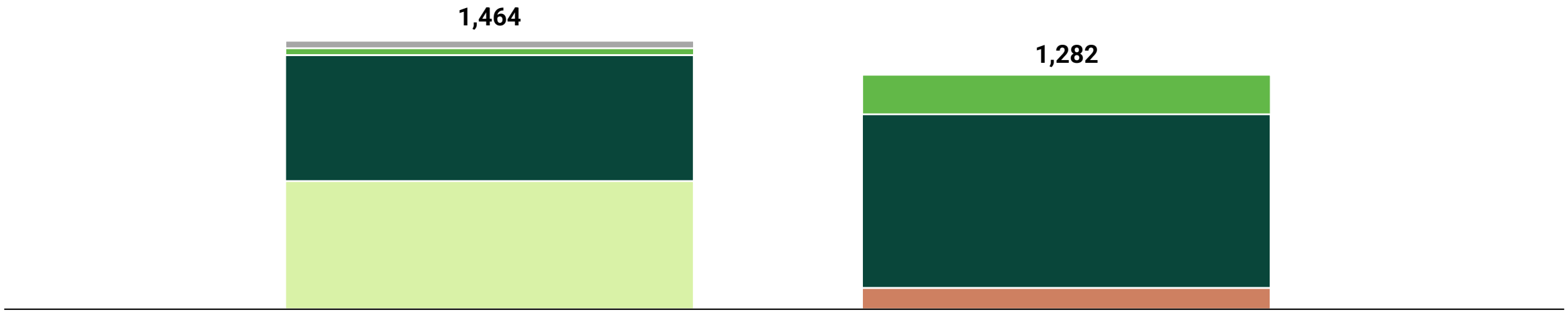
Philippines | Investment landscape

This analysis represents a selective view and includes private investments only, excluding government investment, public markets investment, and debt financing

Private green investments in Philippines (Unit: $ million)

Solar | Wind | Other RE | Improved waste mgmt. | Green cement

2024 total = $1,282 million (~16% of SEA-6)

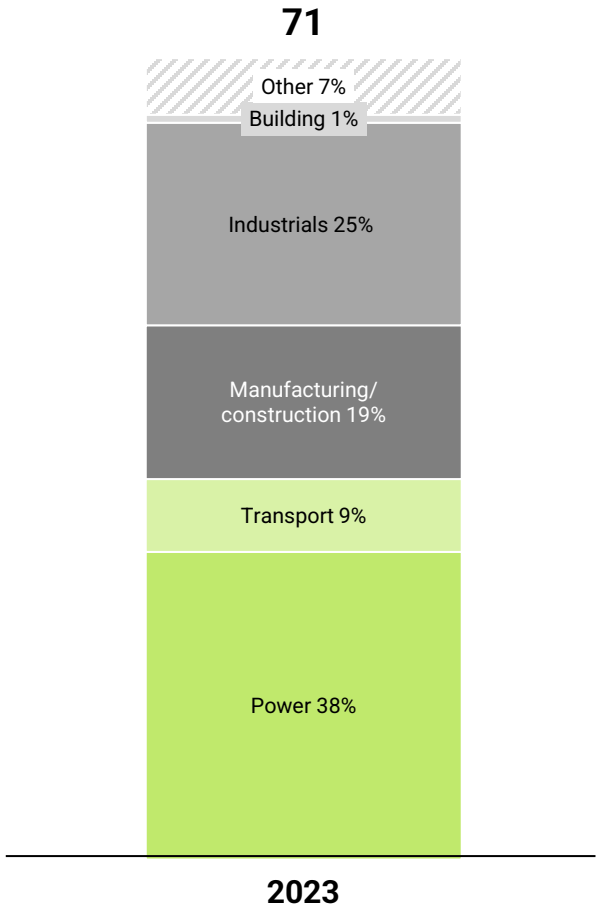


Number of deals	2023	2024
	15	11

Notes: Figures include private sector deal transactions, which are categorized as "closed" and "effective" and >$10 million in size, including private placements and excluding IPOs; used allocation methodology from the previous report, calculating the investment size of a country based on where the target company of the deal is operating; amount not representative of overall private sector investment | Sources: AVCJ; S&P Capital IQ; Preqin; PitchBook; Global Energy Monitor; Lit. search; Bain analysis

Singapore | Country insights

GHG emissions (MtCO2e)



Likely on track to deliver target

On track to deliver target

Work required to deliver target

Unlikely on track to deliver target

Key drivers influencing shifts in the overall theme score

'24 '25

Ambition

'24 '25

- **Net zero** by 2050
- **60 MtCO2e GHG** emissions by 2030
- **2 GWp[1] solar energy** deployment by 2030[2]

Progress

'24 '25

- **Per capita emission at 12 tCO2e** (+6% from 2022–23)
- **RE share at 5%**
- **Share of 4W BEV sales in total 4W sales at ~10%**

Roadmap

'24 '25

- **Green Plan 2030** sets targets for sustainable development
- **LT-LEDS[3]** in place, which outlines long-term climate commitments
- **Green Finance Action Plan** drives sustainable investments

Accelerators

'24 '25

- **Mandatory emission reporting** for PLCs
- **Incentives for RE, EV, and green buildings**
- **High infra for green spaces** but no SRI adoption

Investments

'24 '25

Green investment increased by ~194% in 2024

Notes: (1) Gigawatt-peak (the peak power a photovoltaic system can generate under standard test conditions); (2) Expected to meet around 3% of country's 2030 projected electricity demand; (3) long-term low-emission development strategy | Sources: Country NDC; LT-LEDS; Climate Watch; IRENA; IEA; UNFCCC; Lit. search

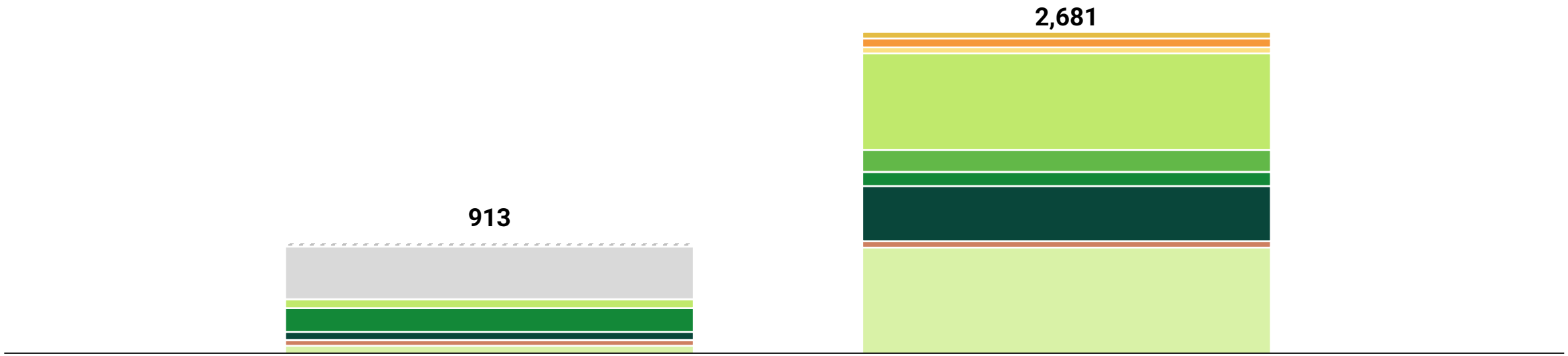
Singapore | Investment landscape

This analysis represents a selective view and includes private investments only, excluding government investment, public markets investment, and debt financing

Private green investments in Singapore (Unit: $ million)

Solar | Transport | Wind | Fuel substitution | Improved waste mgmt. | Other
Other RE | Efficient electricity generation | Agricultural productivity | Sustainable biomass/biogas/biofuel | Buildings

2024 total = $2,681 million (~33% of SEA-6)

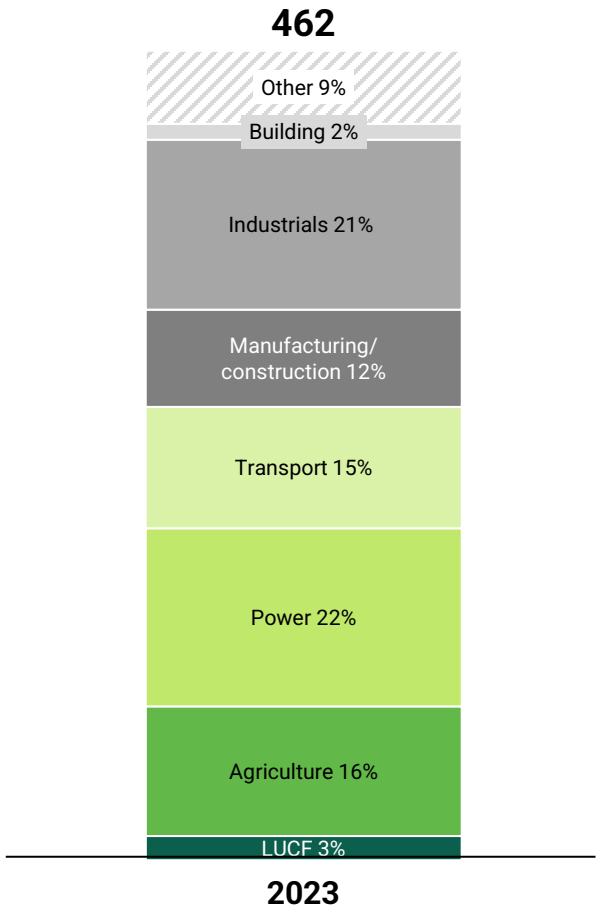


Number of deals	2023	2024
	22	27

Notes: Figures include private sector deal transactions, which are categorized as "closed" and "effective" and >$10 million in size, including private placements and excluding IPOs; used allocation methodology from the previous report, calculating the investment size of a country based on where the target company of the deal is operating; amount not representative of overall private sector investment | Sources: AVCJ; S&P Capital IQ; Preqin; PitchBook; Global Energy Monitor; Lit. search; Bain analysis

Thailand | Country insights

GHG emissions (MtCO2e)



Likely on track to deliver target | On track to deliver target | Work required to deliver target | Unlikely on track to deliver target | Key drivers influencing shifts in the overall theme score

'24 '25

Ambition

'24 '25

- **Net zero** by 2065
- **30% GHG reduction**[1] by 2030
- **Significant increase** in corporate targets[2]

Progress

'24 '25

- **Per capita emission at 6.4 tCO2e** (+2% from 2022–23)
- **RE share at 16%**
- **Share of 4W BEV sales in total 4W sales at ~10%**

Roadmap

'24 '25

- **National Energy Plan** sets an energy transition strategy
- **Corporate roadmaps** have shown a significant increase[3]
- **National Strategic Plan** sets long-term sustainability target

Accelerators

'24 '25

- **Mandatory emission reporting** for some sectors[4]
- **Carbon tax on petroleum products introduced**
- **Strong grid connectivity and ~2,600 EV charging stations**

Investments

'24 '25

Green investment decreased by ~10% in 2024

Notes: (1) Emissions reduction target is against 2030 business-as-usual; (2) Currently 90% of the top 10 polluting organizations have net-zero targets while 90% have a 2030 emissions reduction target, compared to 60% and 70%, respectively, last year; (3) Currently 80% of the top 10 polluting organizations have roadmaps, compared to 10% last year; (4) Sectors include cement, electricity, steel, fertilizers, aluminum, and hydrogen | Sources: Country NDC; LT-LEDS; Climate Watch; IRENA; IEA; UNFCCC; Lit. search

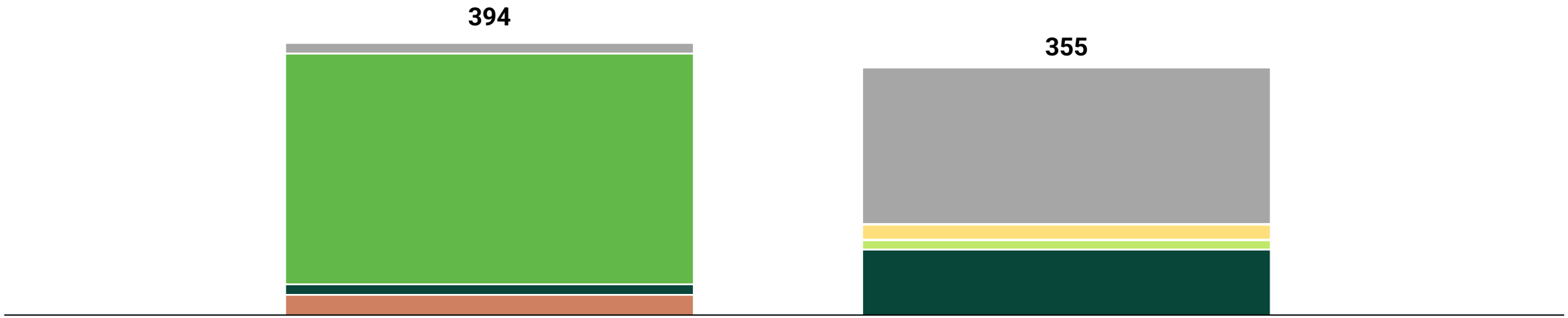
Thailand | Investment landscape

This analysis represents a selective view and includes private investments only, excluding government investment, public markets investment, and debt financing

Private green investments in Thailand (Unit: $M million

Solar | Wind | Other RE | Green cement | Fuel substitution | Sustainable biomass/biogas/biofuel

2024 total = $355 million (~4% of SEA-6)

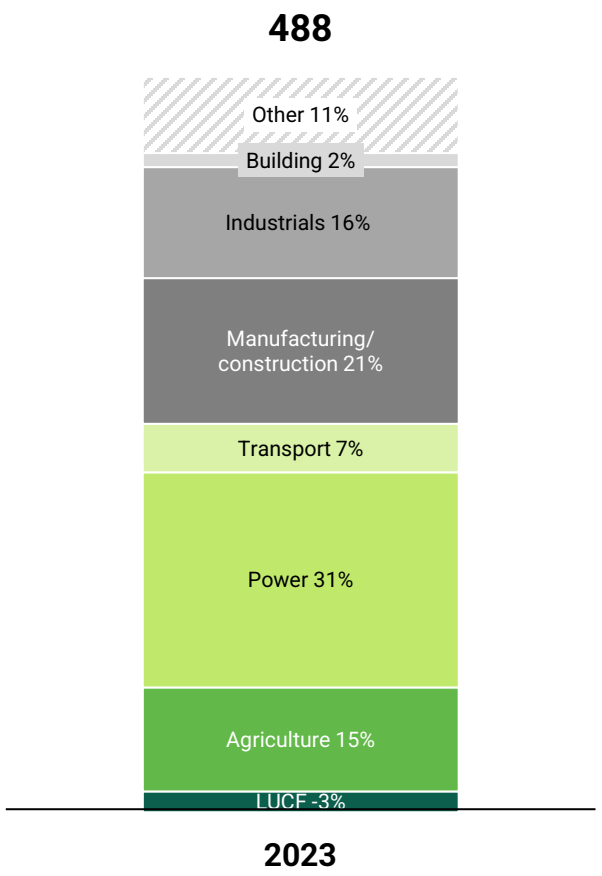


	2023	2024
Number of deals	5	5

Notes: Figures include private sector deal transactions, which are categorized as "closed" and "effective" and >$10 million in size, including private placements and excluding IPOs; used allocation methodology from the previous report, calculating the investment size of a country based on where the target company of the deal is operating; amount not representative of overall private sector investment | Sources: AVCJ; S&P Capital IQ; Preqin; PitchBook; Global Energy Monitor; Lit. search; Bain analysis

Vietnam | Country insights

GHG emissions (MtCO2e)



Likely on track to deliver target | On track to deliver target | Work required to deliver target | Unlikely on track to deliver target | Key drivers influencing shifts in the overall theme score

'24 '25

Ambition

'24 '25

- **Net zero** by 2050
- **16% GHG reduction**[1] by 2030
- **47% renewables** by 2030

Progress

'24 '25

- **Per capita emission at 4.9 tCO2e** (+3% from 2022–23)
- **Share of RE at 43%**
- **Share of 4W BEV sales in total 4W sales at ~14%**

Roadmap

'24 '25

- **PDP**[2] and National Energy Master Plan (2021-2030)
- **Corporate roadmaps** have shown a significant increase[3]
- **Grid infra push** and National Climate Change Strategy[4]

Accelerators

'24 '25

- **Mandatory emission reporting** across some sectors[5]
- **Nationwide grid connectivity; ~3,000 EV** charging stations
- **High SRI adoption** but limited NBS projects

Investments

'24 '25

Green investments reduced by ~19% in 2024

Notes: (1) Emissions reduction targets in the energy, agriculture, LULUCF, waste, and industrial processes by 2030 compared to business-as-usual; (2) Power development plan; (3) Currently 50% of the top 10 polluting organizations have roadmaps, compared to 0% last year; (4) Under the strategy, Vietnam aims to reduce emissions from land use, land-use change; (5) Sectors include steel production, cement production, and thermal power generation | Sources: Country NDC; LT-LEDS; Climate Watch; IRENA; IEA; UNFCCC; Lit. search

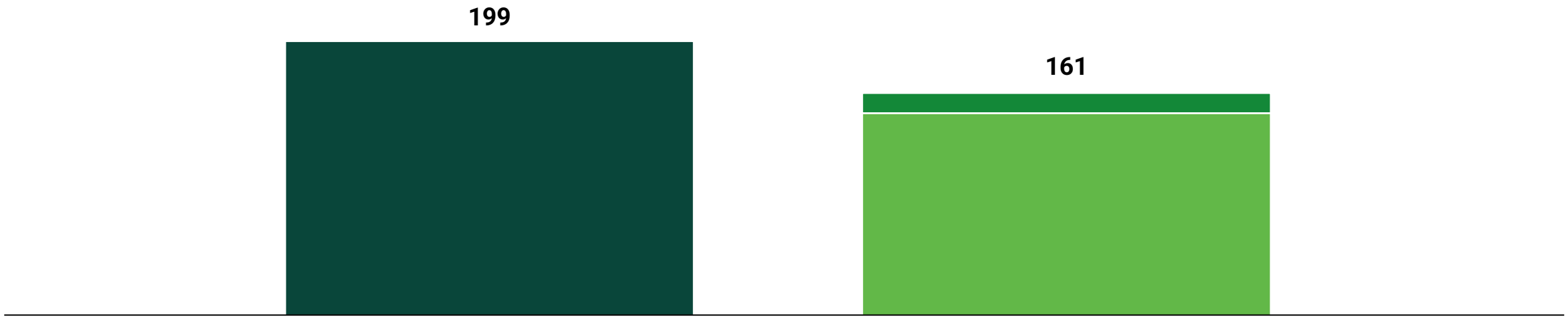
Vietnam | Investment landscape

This analysis represents a selective view and includes private investments only, excluding government investment, public markets investment, and debt financing

Private green investments in Vietnam (Unit: $ million)

Solar Transport Wind

2024 total = $161 million (~2% of SEA-6)



Number of deals	2023	2024
	3	4

Notes: Figures include private sector deal transactions, which are categorized as "closed" and "effective" and >$10 million in size, including private placements and excluding IPOs; used allocation methodology from the previous report, calculating the investment size of a country based on where the target company of the deal is operating.; amount not representative of overall private sector investment | Sources: AVCJ; S&P Capital IQ; Preqin; PitchBook; Global Energy Monitor; Lit. search; Bain analysis