

Southeast Asia's Green Economy

Unlocking Systems for Growth and Impact



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Readers should not place reliance on, and are cautioned about relying on, any forward-looking statements.



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Terms and acronyms

# 1G biofuel first generation biofuel 2G biofuel second generation biofuel 4W four-wheeler	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 CO₂e carbon dioxide equivalent CORSIA Carbon Offsetting and Reduction Scheme for International Aviation CPU central processing unit	F FAO Food and Agriculture Organization FDI foreign direct investment FI financial institution FOLU forestry and other land use	J JETP Just Energy Transition Partnership JP Japan JV joint venture
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	D DC data center DFI development finance institution	G G2G government-to-government GHG greenhouse gas GIP green investments partnership GPU graphics processing unit GtCO₂e gigatons of carbon dioxide equivalent GW gigawatt	K KR Korea ³
B BAU business-as-usual BESS battery energy storage system BEV battery electric vehicle BIMP Brunei-Indonesia-Malaysia-Philippines	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	H HEV hybrid electric vehicle HVO hydrogenated vegetable oil	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
	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	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
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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
tCO ₂ e	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

01



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.



Foreword by Google



Spencer Low

Head of Regional
Sustainability, APAC
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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

TEMASEK | ecosperity



**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 MtCO₂e 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) penetration¹ 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/year²

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



... contribute to emissions targets³ ...

~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

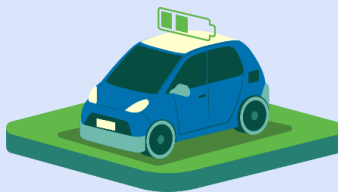
SEA's green economy can drive growth, energy security and climate impact

Economic growth will transform composition of regional systems ...



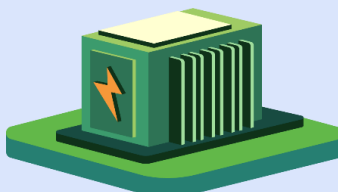
~4%–5%

expected growth rate for real GDP in Southeast Asia¹



~10%–20%

expected annual increase in EV penetration in new vehicle sales²



~10%

expected annual increase in power generation capacity until 2035³

... 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; (3) 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

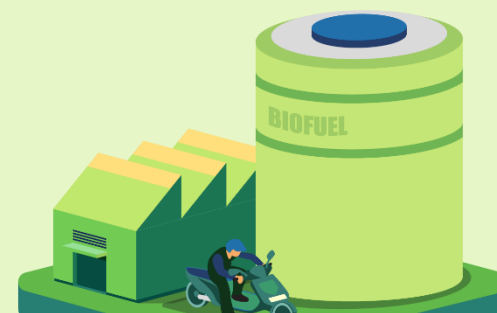
e.g., scaling electric vehicles (EVs) without greening power ecosystems increases emissions and retains reliance on imported fossil fuels while straining load management of grid



3

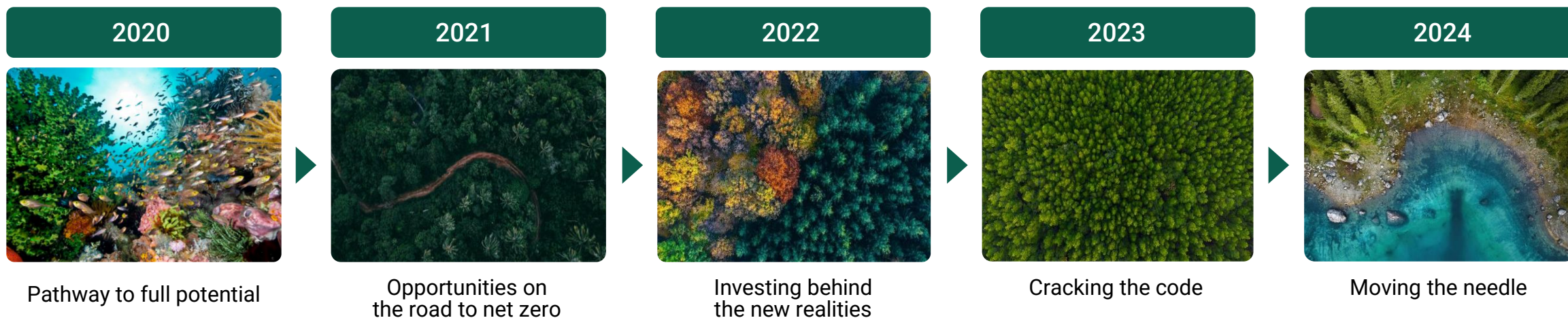
Missed opportunities to achieve cross-sectoral impact

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



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



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?



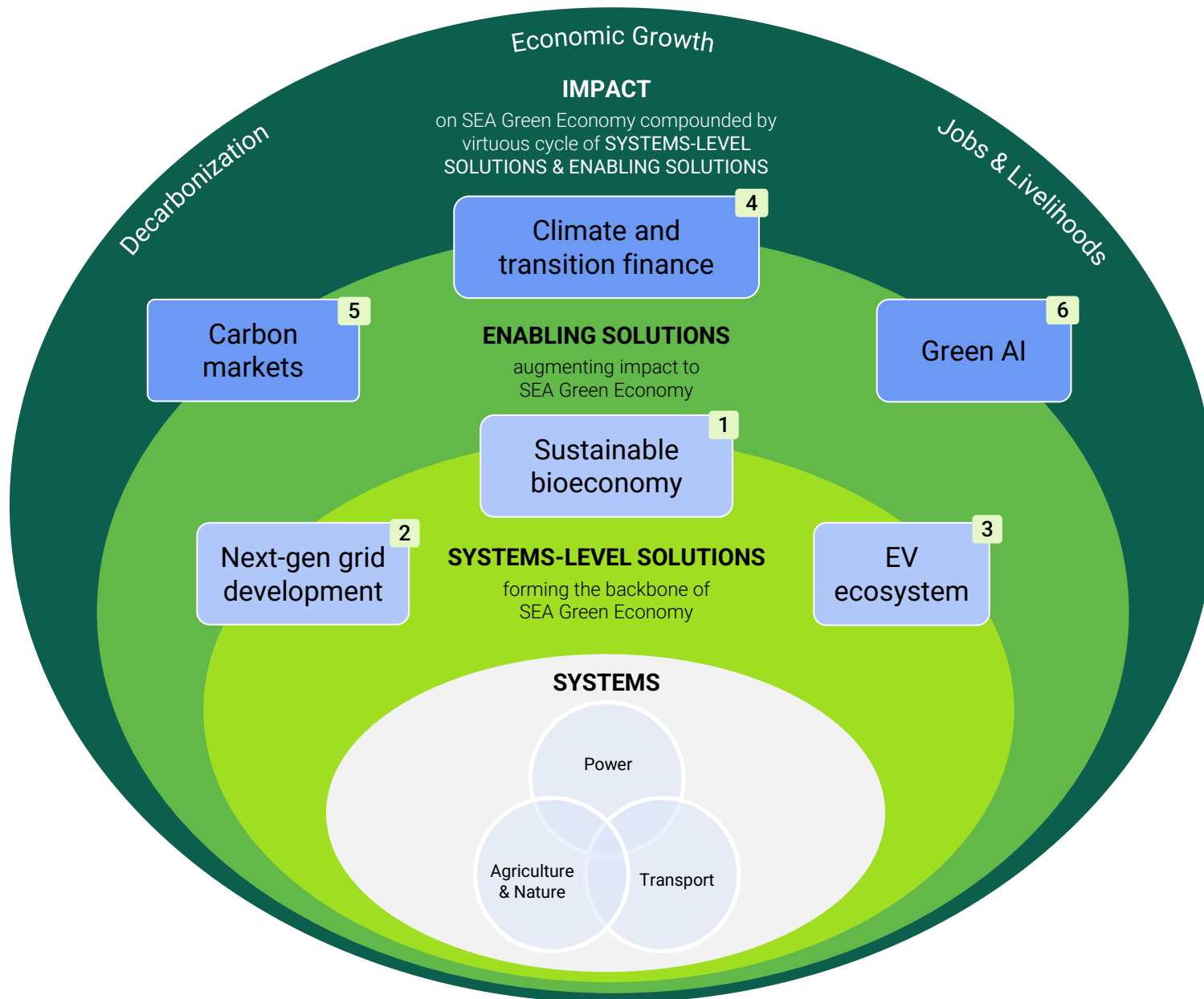
Addresses cross-cutting barriers



Maximizes return on investment and co-benefits



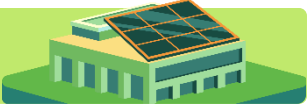
Prevents negative, unintended spillovers across systems



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

- Systems-level solutions
- Enabling solutions

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) ...



+900K²

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



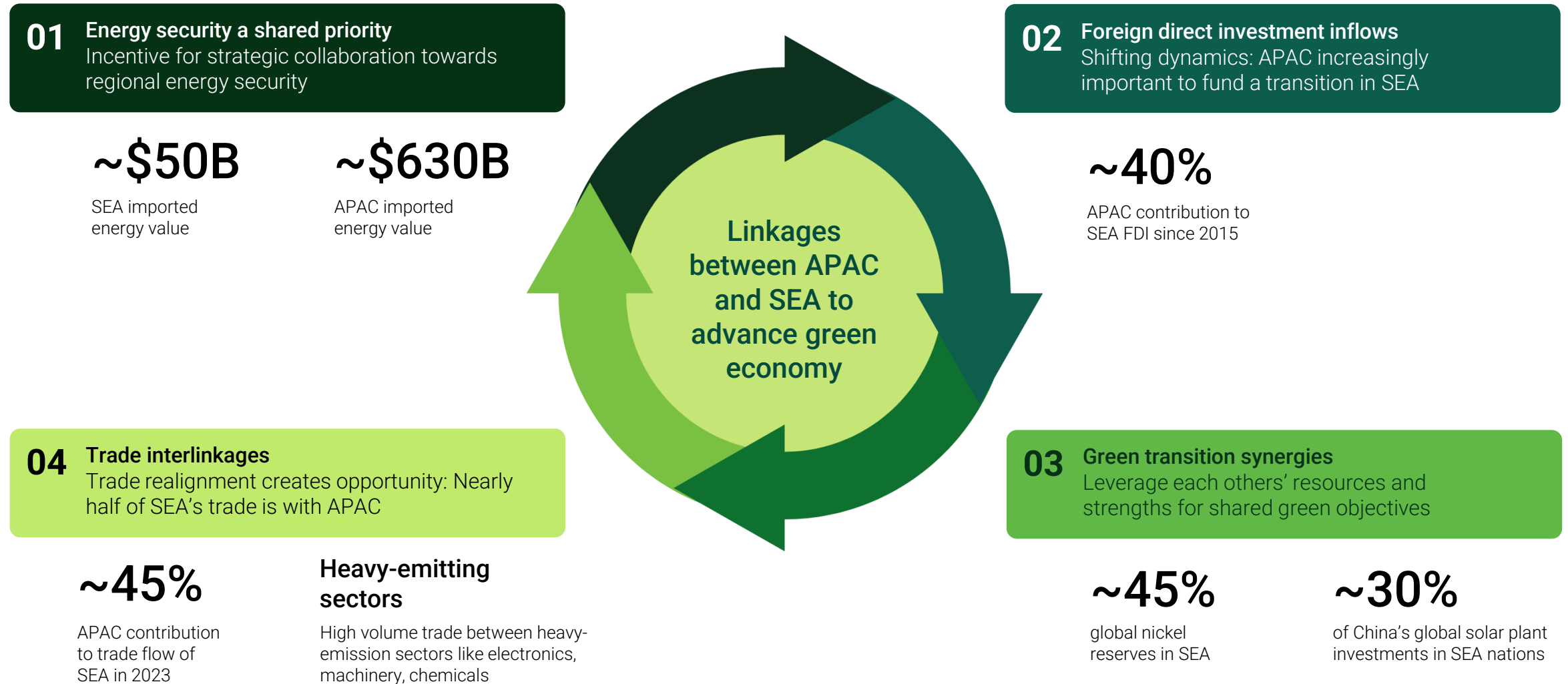
-50%³

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



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

Sustainable bioeconomy



Secure biofuel/feedstock supply from SEA

Co-invest in agritech innovation and deployment across SEA

Funding NBS credit projects in SEA

Next-gen grid development



Collaborating on SEA grid infrastructure planning and deployment

Co-developing grid components and smart grid solutions

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

Potential direct benefits to APAC (immediate, tangible impact)



Fulfilling domestic biofuel mandates

Gaining access to high-quality carbon credits

Creating new market for agritech innovation



Increasing demand for APAC-made grid components and smart grid solutions



Accessing cost-efficient manufacturing hubs

Tapping into new EV export markets

Potential indirect benefits to APAC (strategic, long-term impact)



Enhancing food and resource security (via climate-resilient agriculture in SEA)



Improving regional energy stability

Laying the groundwork for future energy integration and RE sharing



Strengthening supply chain resilience by reducing reliance on Western markets

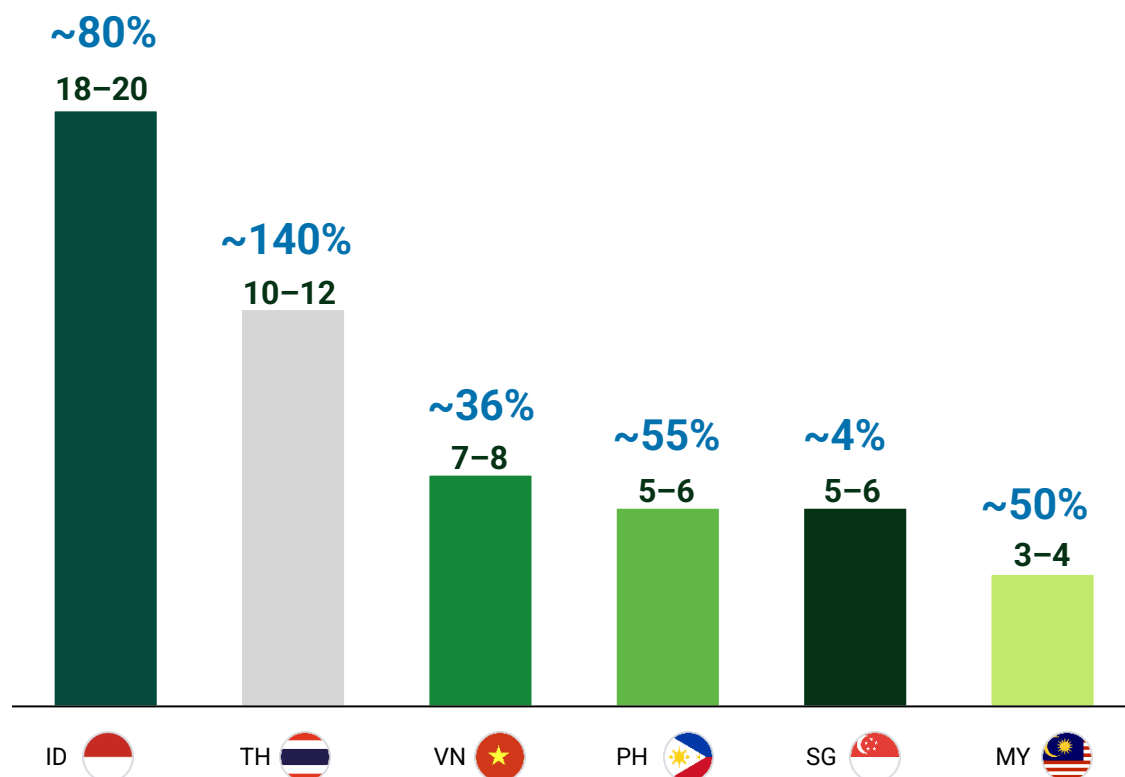
Three systems-level solutions could attract up to \$55 billion annually by 2030 and potentially serve to shore up FDI during an economic slowdown

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**

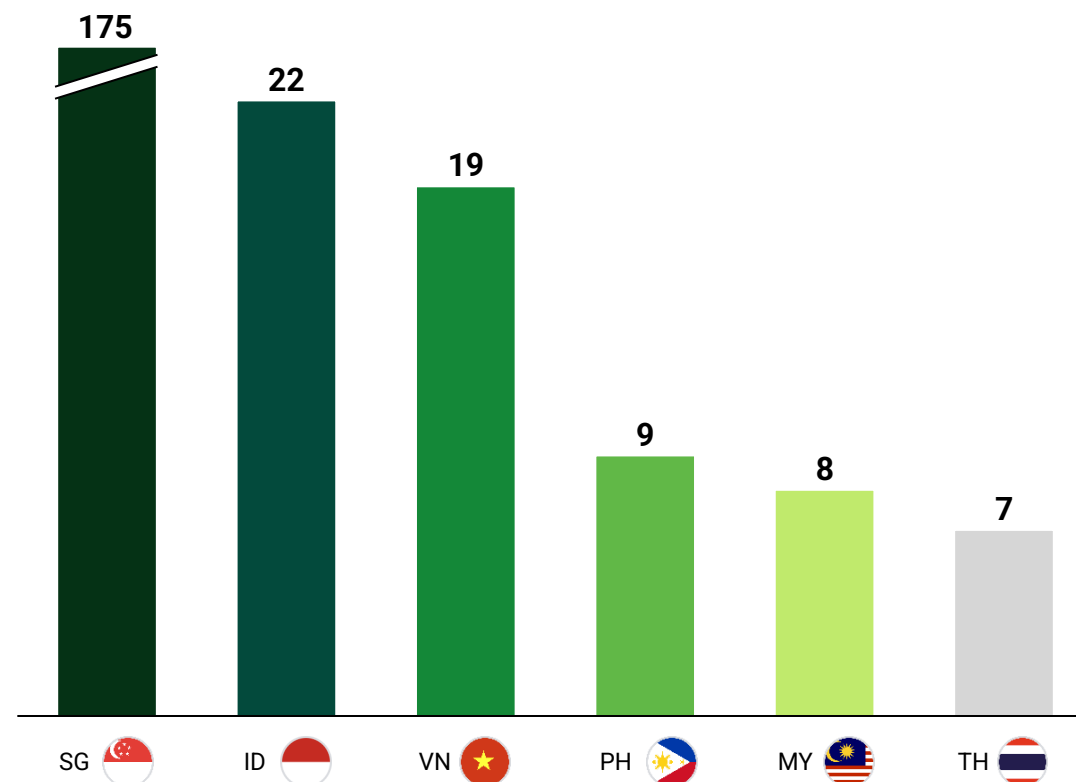
(percentage of country's 2023 FDI)



Current SEA-6 FDI flows into SEA -6

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

Total: **\$230 billion**



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 farming, 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 ...

Significant contributor to global emissions

50%

of global GHG emissions

Outsized reliance on fossil fuels

49%

of energy derived from coal

Rising energy demand

5%

energy demand growth vs. ~3% globally¹



... while regions are at high risk from climate change

Impact on economic growth

17%

potential reduction in GDP by 2070 due to climate change

Vulnerability to climate change-based disasters

2x

rise in sea level in APAC vs. global average



APAC and SEA are crucial to global decarbonization solutions

High reserves of natural capital

18%

of global forest cover

Vast stores of critical minerals

55%

of global nickel reserves

Substantial manufacturing capacity

80%

of global solar module production in China

APAC
(including SEA)

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

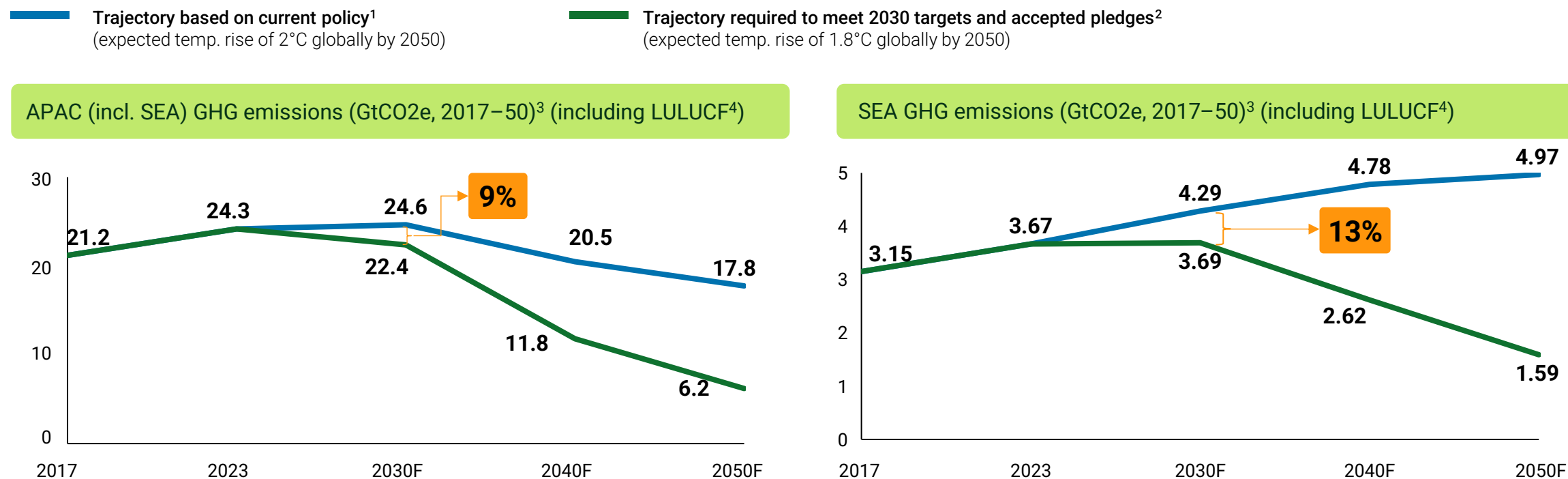
10%

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



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

All emission figures in GtCO₂e except emissions per capita

- ✓ 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

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)

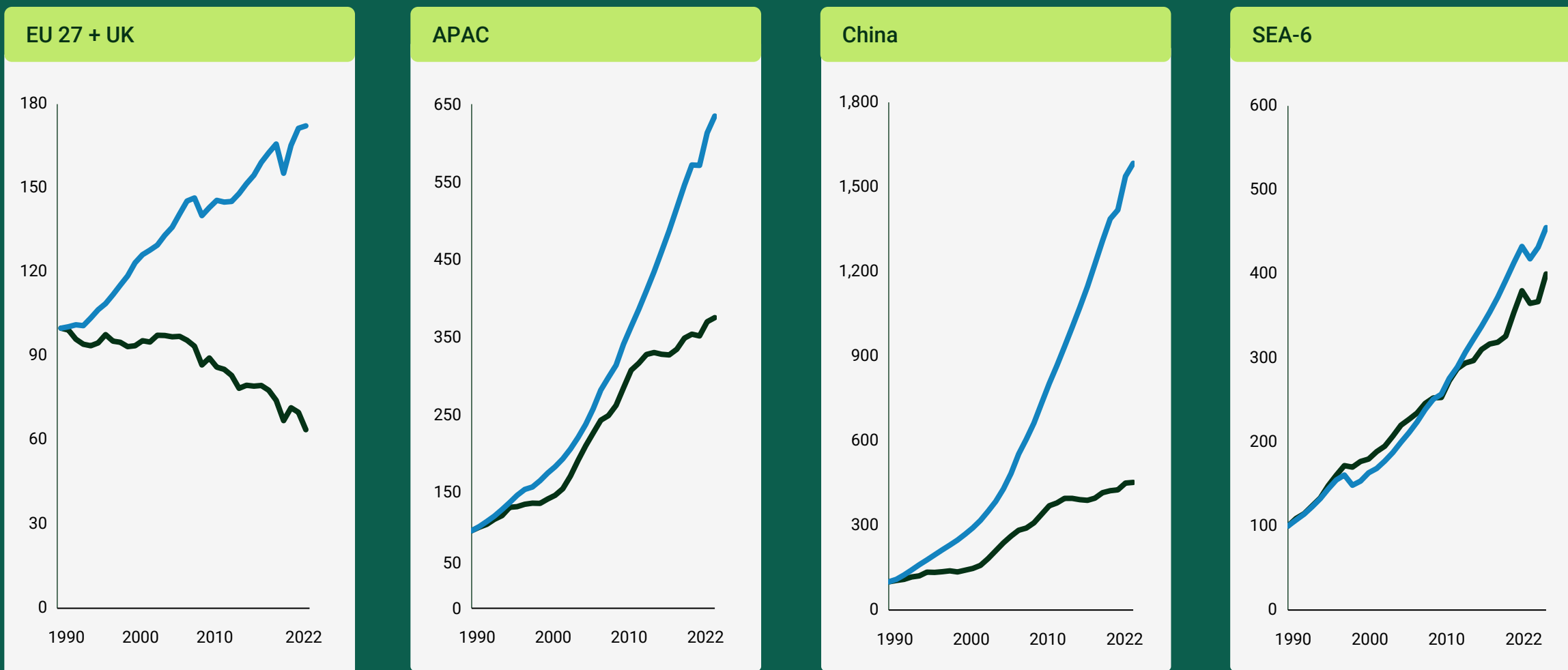
	2016	2019	2021	2023	CAGR (2016–23)	CAGR (2021–23)	Emissions intensity ² (2016–23)	Emissions intensity ² (2021–23)
APAC (including SEA)	20.7	22.6	23.0	24.3	2.3%	2.8%	0.6	0.7
China	11.0	11.9	12.8	13.4	2.9%	2.5%	0.5	0.6
India	3.1	3.4	3.4	3.8	3.0%	6.0%	0.6	0.8
Japan	1.2	1.1	1.0	0.9	-3.7%	-6.1%	-8.1	-4.3
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

GDP¹ and GHG emissions² (1990–2022, indexed to 1990)

GHG emissions GDP



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 2021–24¹



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 electricity² 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

Global trade wars hit investor confidence

Lower Western demand impacts exports

Legacy dependence on fossil fuels

Potential reduction in overall FDI

Growing supply chain disruptions



Tailwinds

Green economy as alternative growth lever

APAC integration deepens

Increasing cost competitiveness of RE

Blended finance mechanisms maturing

Incentives for supply chain resilience



Net results for SEA

Green economy may fill investment gap

Stronger SEA and APAC green alignment

Renewables improve energy security

New financing channels for green infra

Growth/diversification of green industries

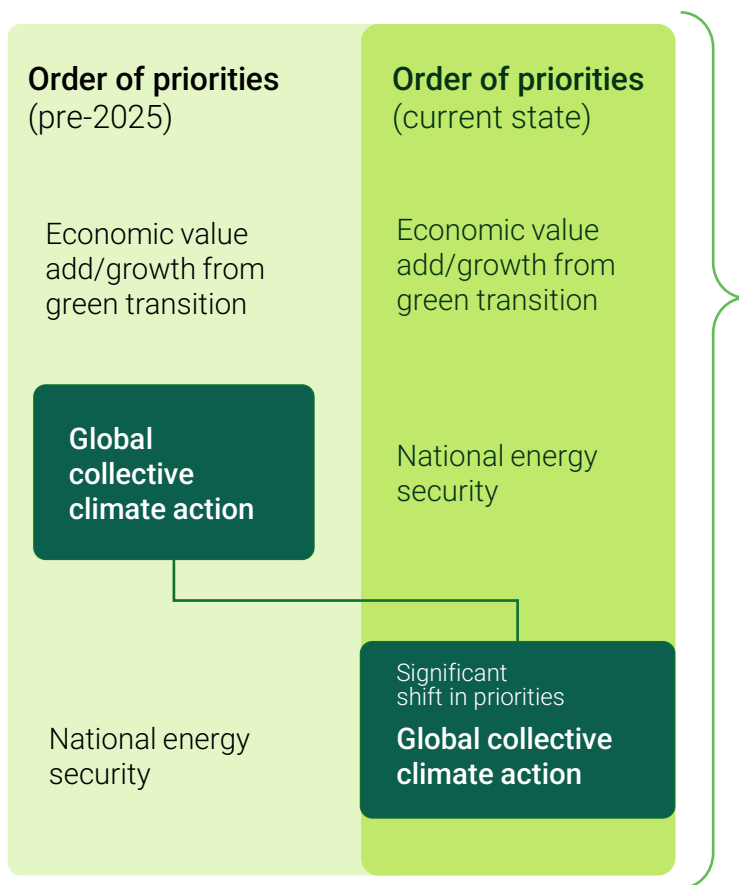


Convergence of tailwinds may help accelerate the green transition

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

Sustainability concerns have decreased in priority for corporations



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

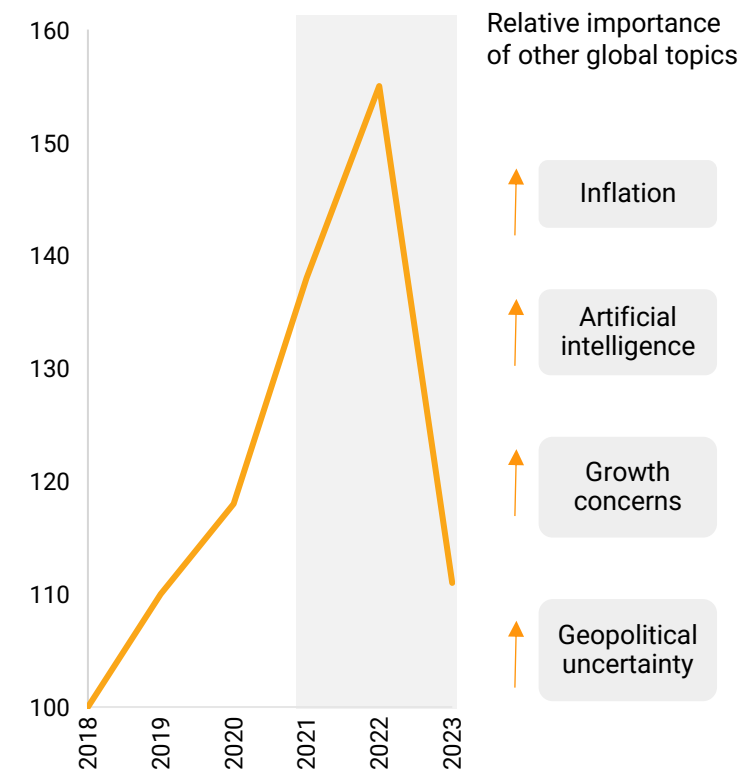
“The European Green Deal is a growth strategy focused on economic transformation and security, prioritizing support for the most vulnerable”
European Commission President Ursula von der Leyen, 2019

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

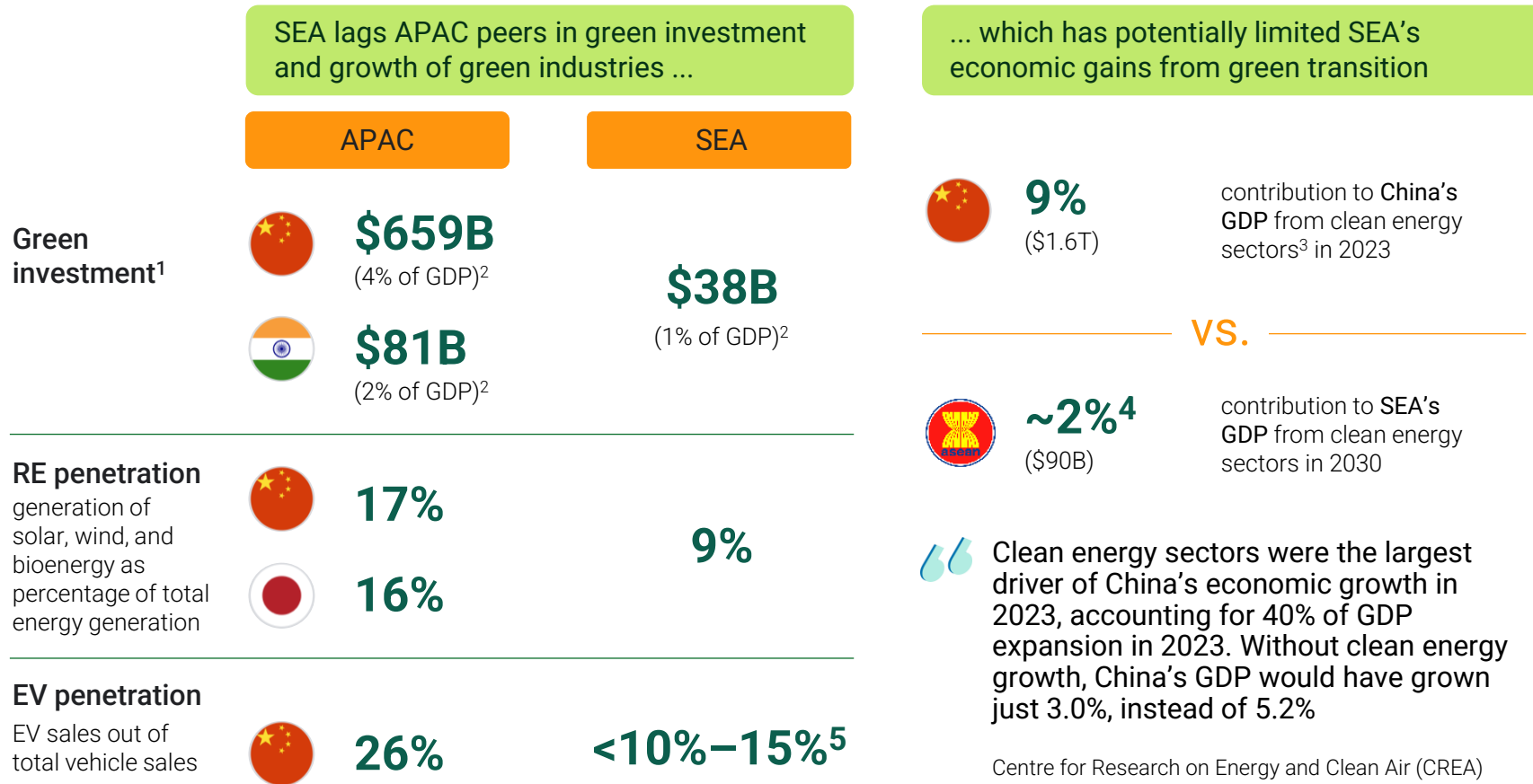
“At a time of heightened geopolitical tensions, energy security and affordability remain top priorities for Southeast Asia”
IEA Southeast Asia Energy Outlook 2024

“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

Importance of sustainability to CEOs (indexed to 2018 levels)



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



SEA has significant headroom to grow

~\$300B⁶
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 industries¹

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

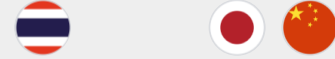


Inadequate access to financing

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 inflation²

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		Special economic zones (SEZ)	
	 Regional trade agreements Agreements between countries in a specific geographic area to enhance economic cooperation, knowledge sharing, trade, and development		 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	
Description	Regional Comprehensive Economic Partnership (RCEP)  Launched in 2022, RCEP targets elimination of 92% of import tariffs for participating countries		ASEAN-China Free Trade Area (ACFTA)  Launched in 2005, ACFTA aims to improve trade by eliminating tariffs (tariffs eliminated on 90% of imports by 2010)	
	\$186B addition of real income to world economy by 2030		2.8M jobs to be created for the member nations	
Impact	10% YoY growth in China-ASEAN trade from 2014–23		9% YoY rise in Chinese investments from 2013–22	
	\$38B economic boost expected by 2030		20K jobs to be created for both nations	
Description	Johor-Singapore SEZ  Launched in 2025, the Malaysia-Singapore SEZ aims to boost cross-border trade and investment with tax incentives		Eastern Economic Corridor (EEC) Investing nations  Launched in 2018, EEC aims to boost economic development using tax incentives; received investment from nations including China, Japan	
	\$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

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 ...

... causing huge cash outflow

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

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

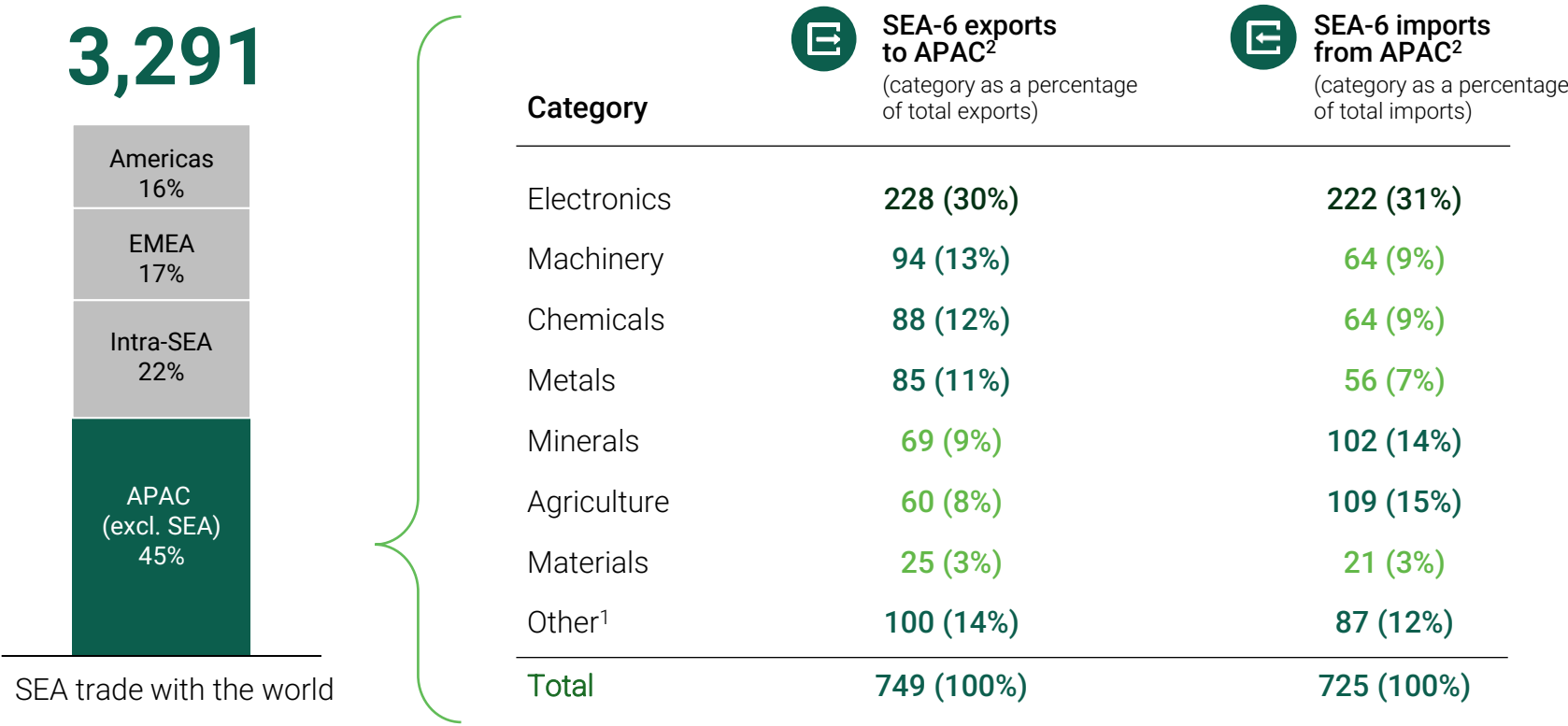
Asia-Pacific is a key trading partner for SEA (~45% of trade)



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%



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

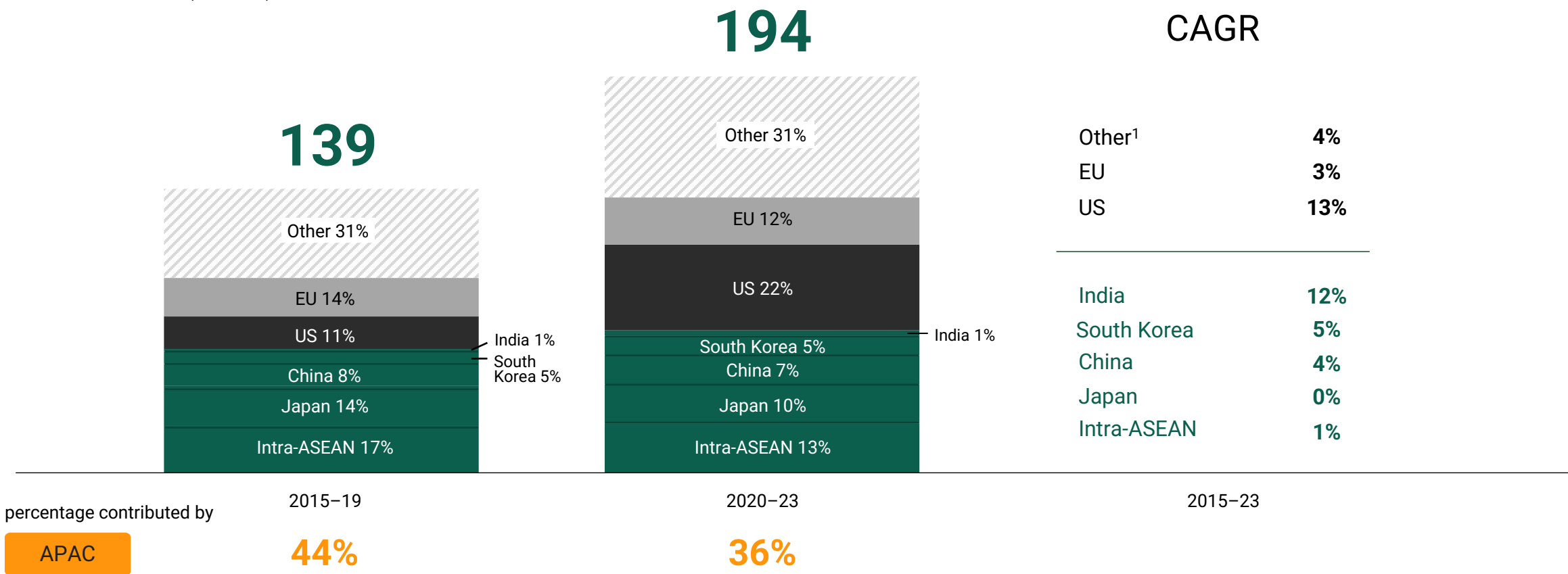
Note: (1) Other includes textiles, automobiles, aircrafts; etc.; (2) APAC here excludes SEA-6 nations | Sources: UN Comtrade; Standard Chartered report on "Future of Trade"; Lit. search

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 bauxite¹ 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

Solar PV

Offshore wind development

Energy storage systems



China

Description

~\$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



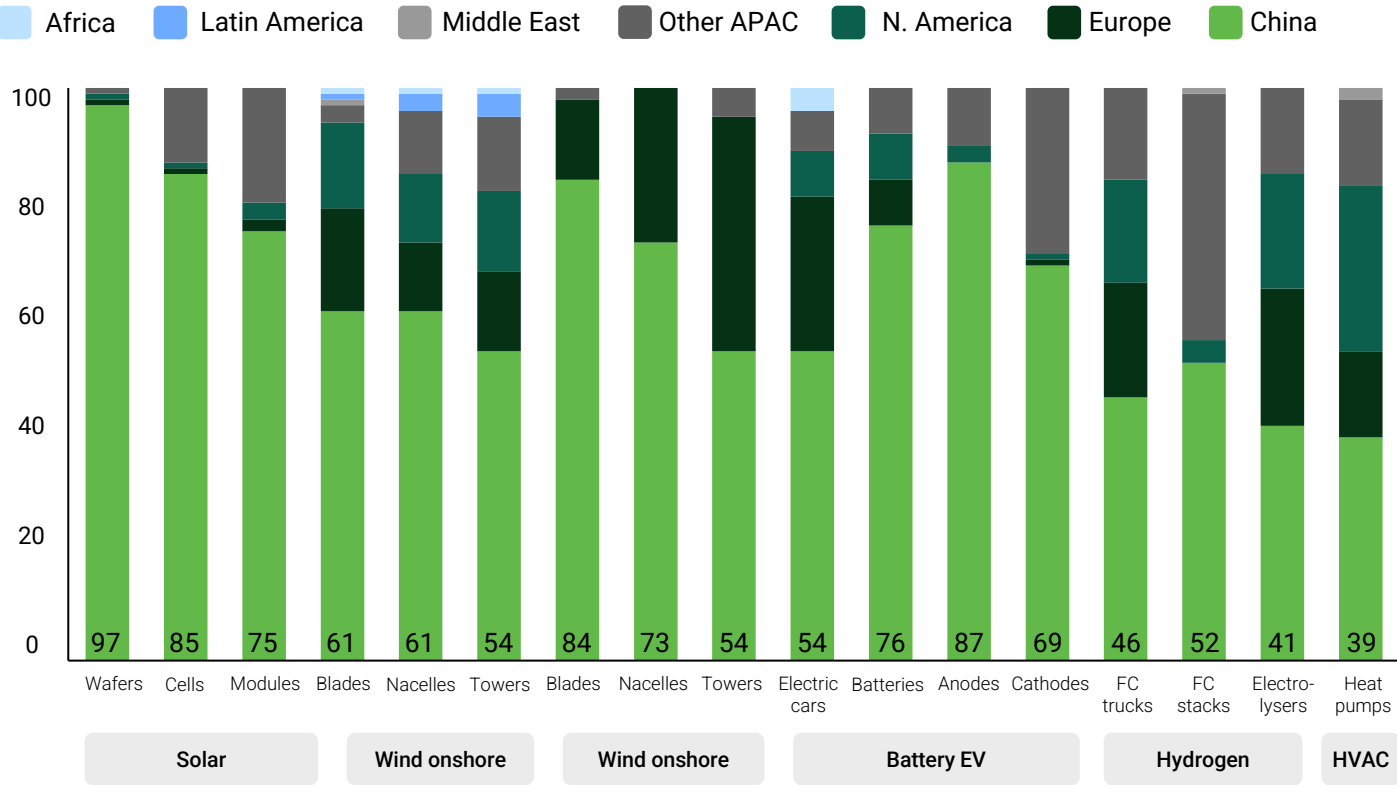
South Korea

Leveraging ASEAN-South Korea strategic partnership to invest in EV infrastructure and battery manufacturing in SEA

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 area¹	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 BCP power plant (Banpu)



Indonesia

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



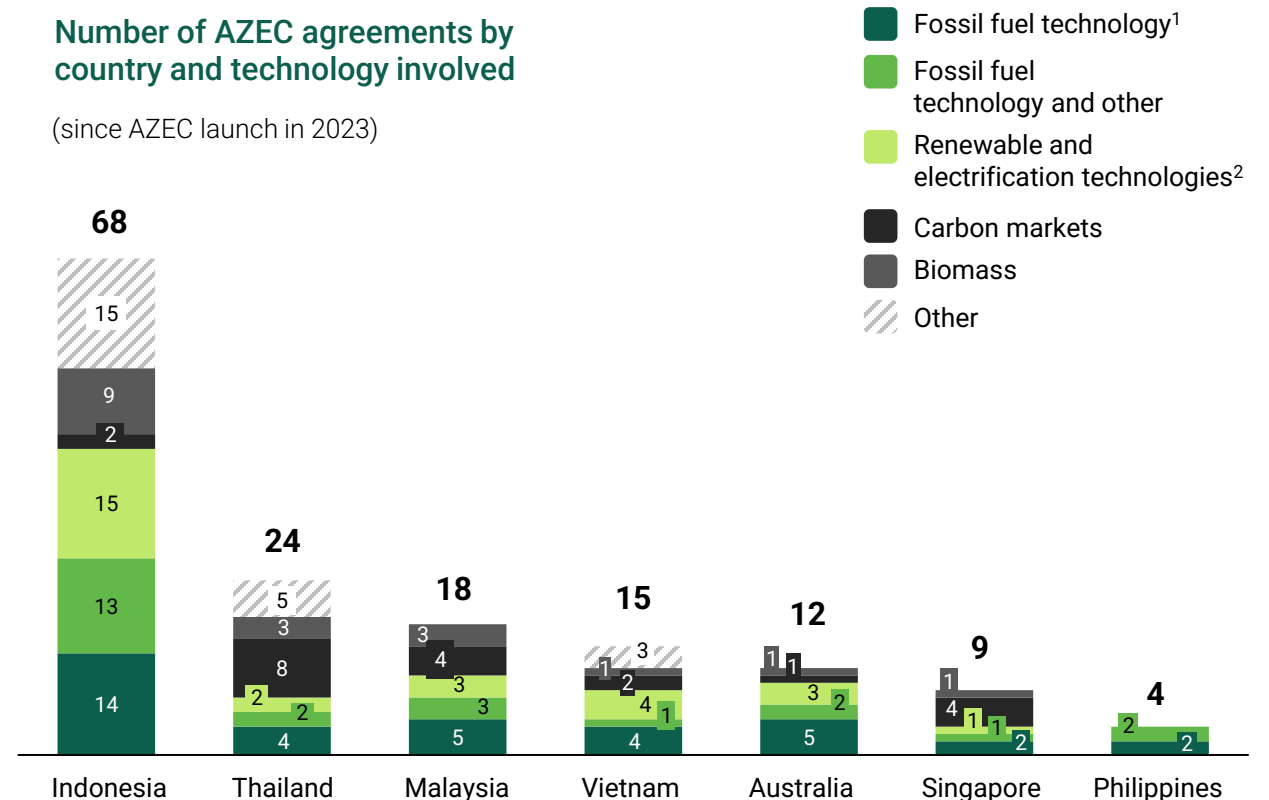
Malaysia

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

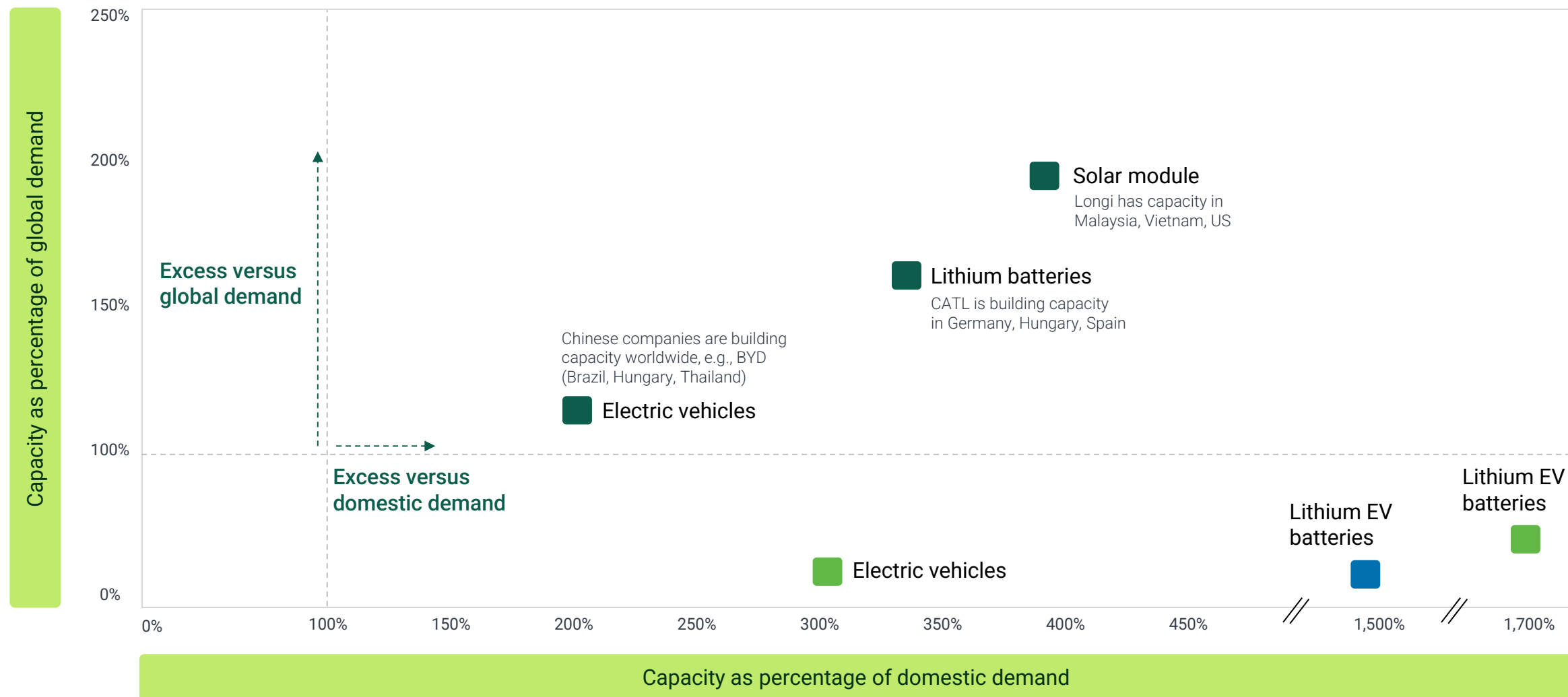
(since AZEC launch in 2023)



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

China
Japan
Korea



Introduction to systems thinking and solutions

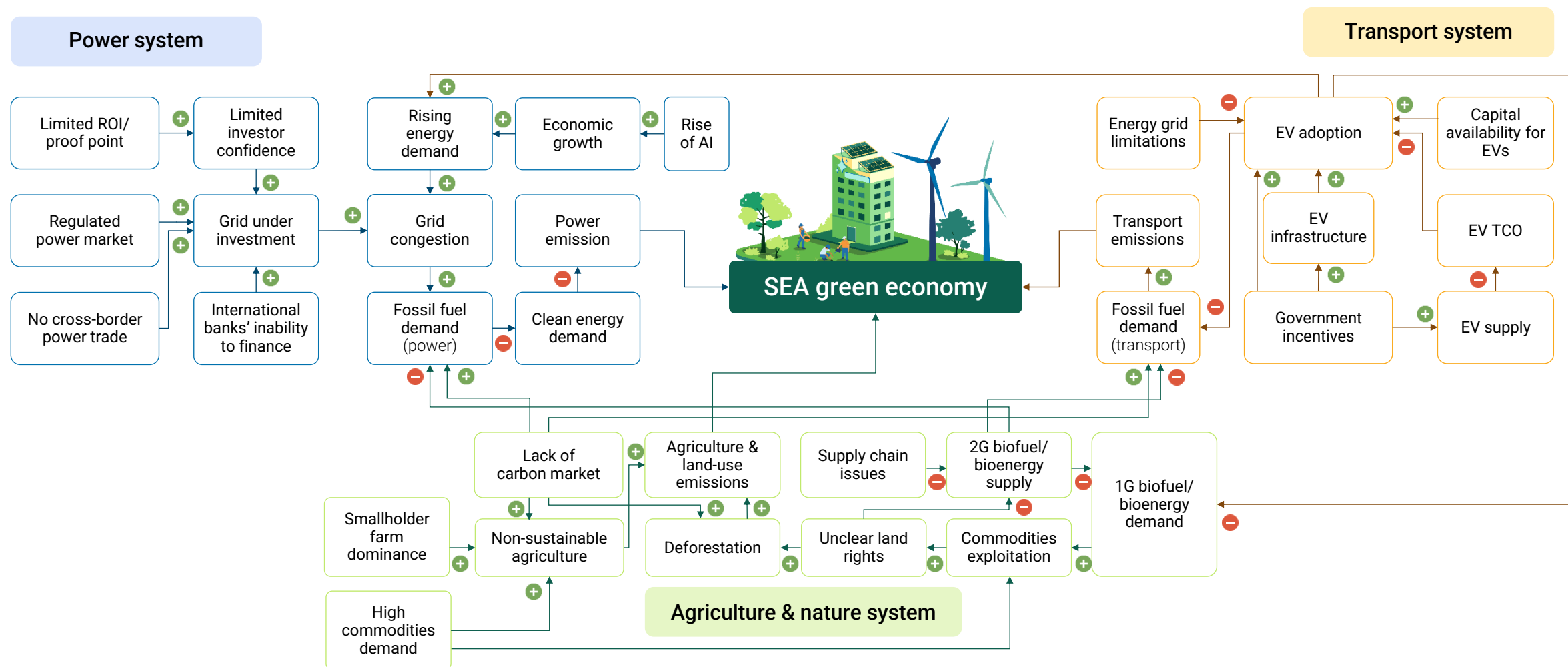
04



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

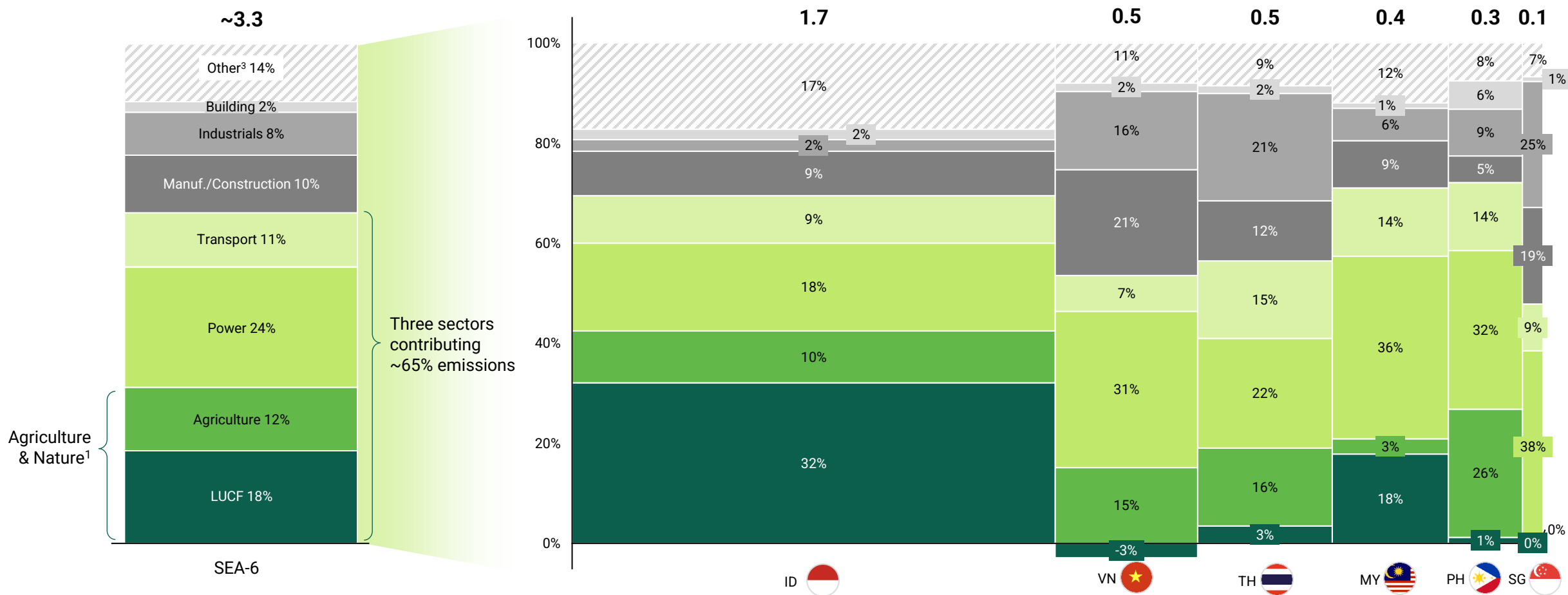


Prioritizing the right systems-level solutions requires identifying systems with significant emission and economic impact

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)

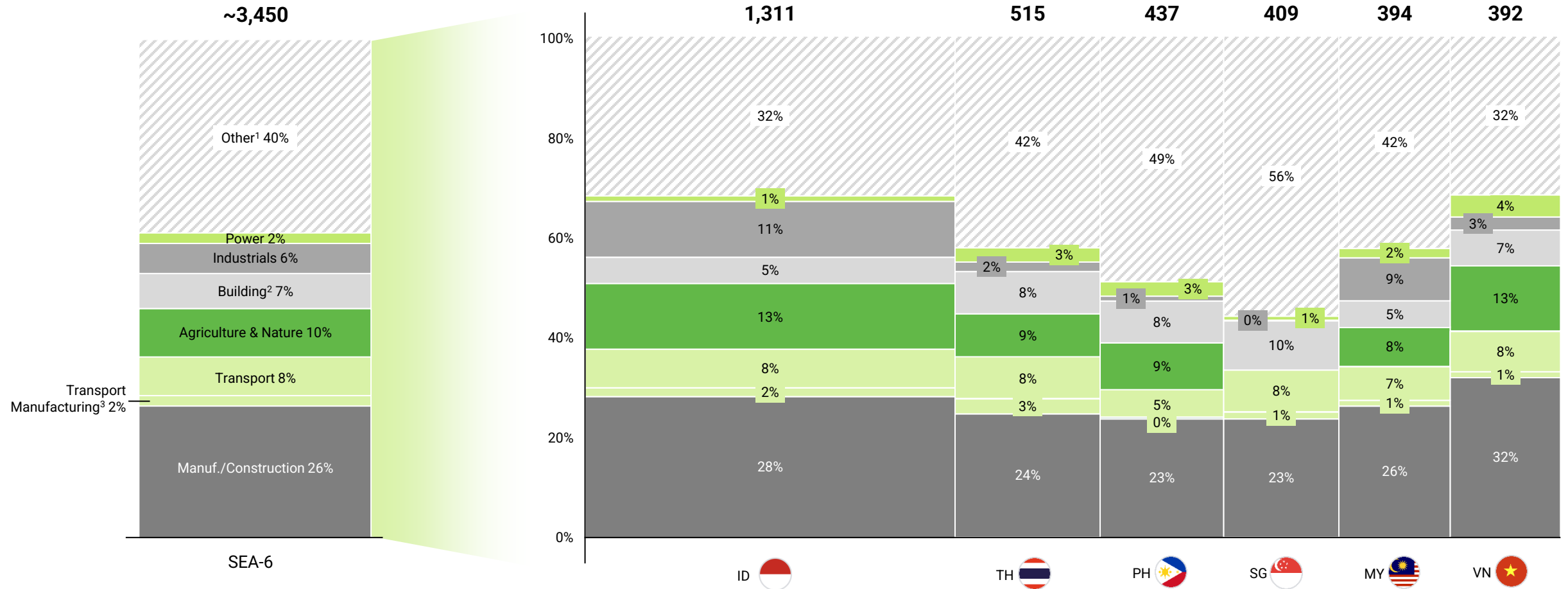
Total = ~3.3GtCO₂e



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

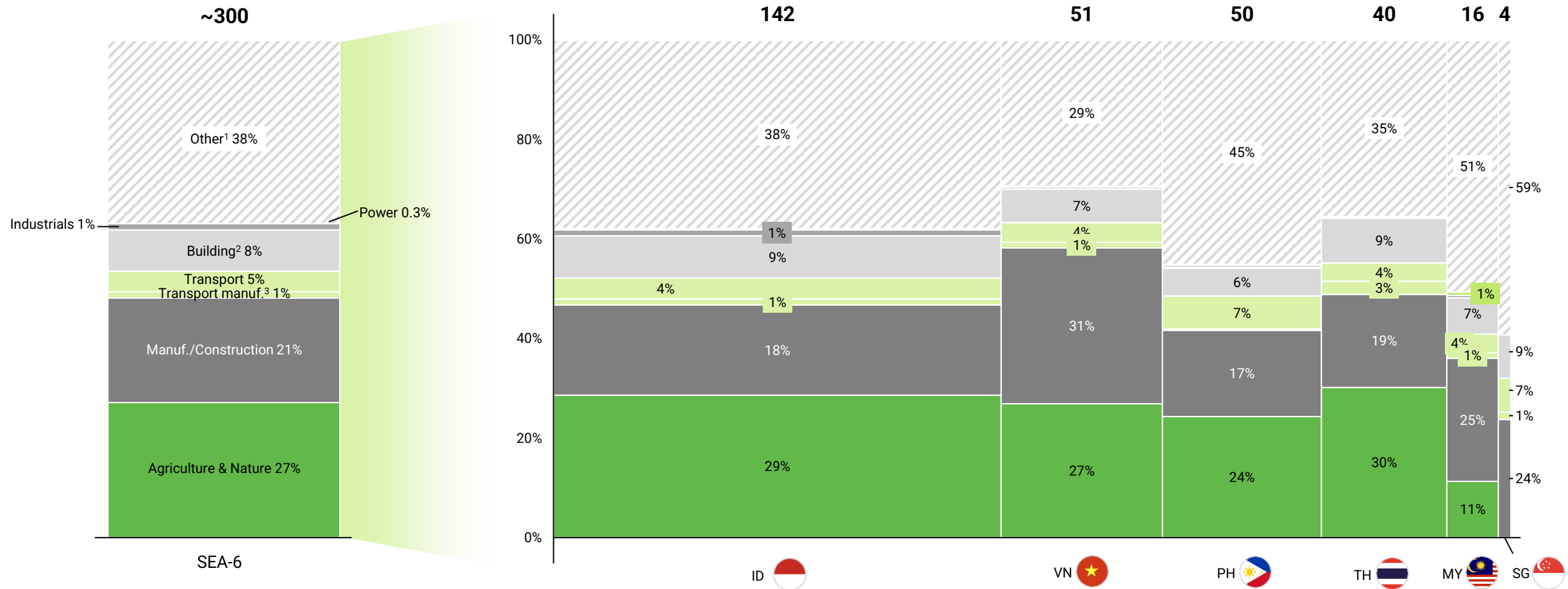


Notes: (1) Other includes insurance, financial services, I&C, arts, entertainment, etc.; (2) Building includes waste management, accommodation, and real estate activities; (3) Transport manufacturing includes manufacturing of motor vehicles, ships, aircrafts, etc. | Source: S&P Global

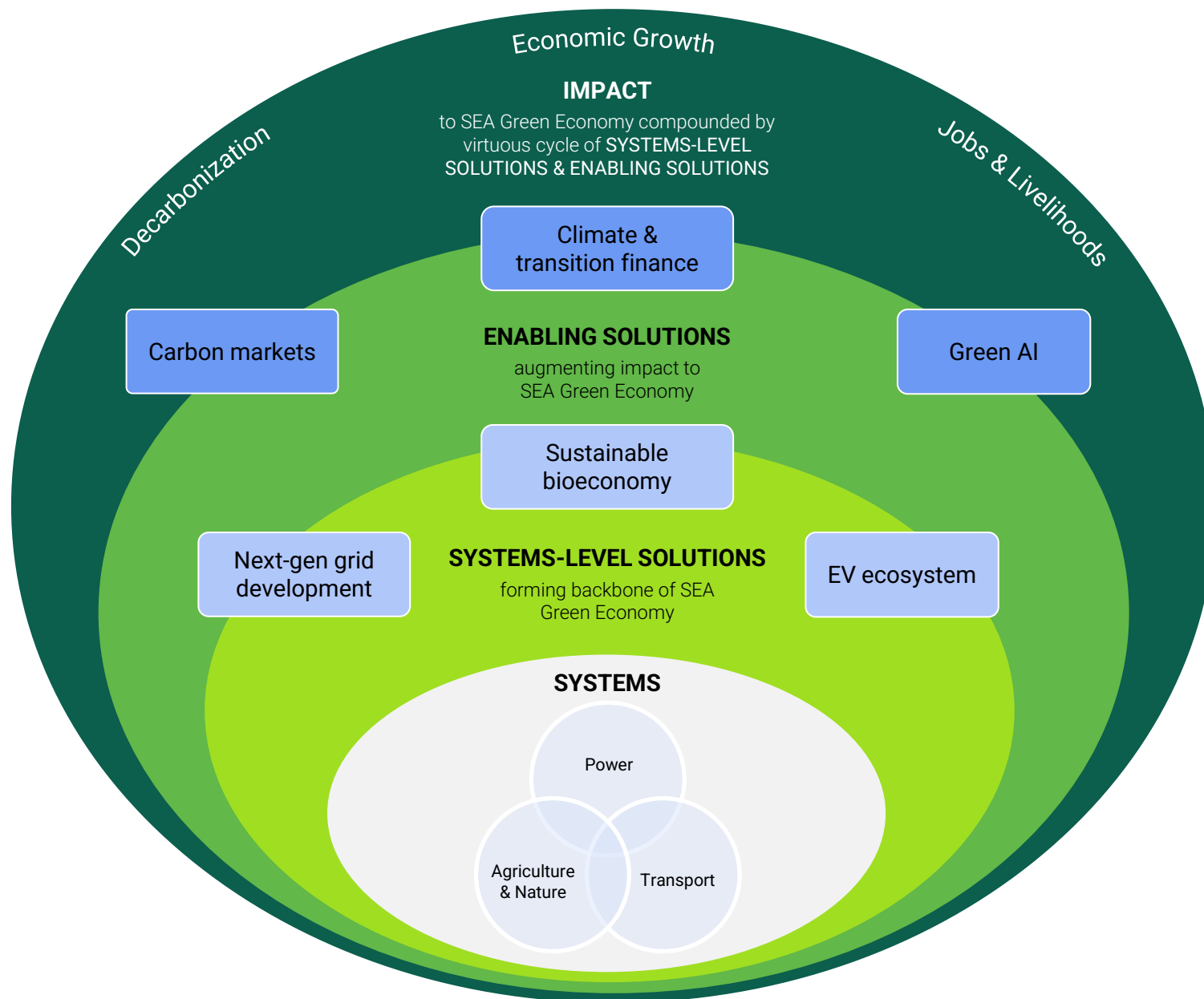
At the same time, Agriculture & Nature account for a large share of jobs and livelihoods in most economies; ~33% of SEA-6 employment comes from the sector

SEA-6 employment by sectors (millions, 2023)

Total number of people employed = ~300 million



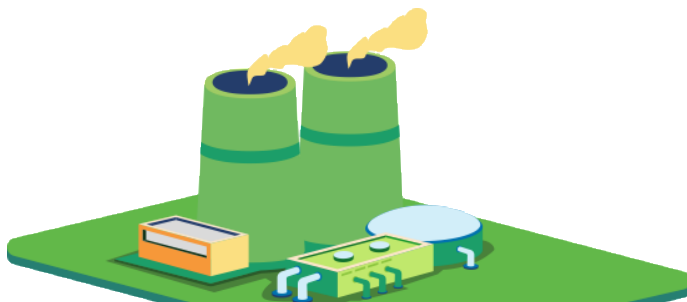
Notes: (1) Others includes insurance, financial services, I&C, arts, entertainment, etc.; (2) Building includes waste management, accommodation, and real estate activities; (3) Transport manufacturing includes manufacturing of motor vehicles, ships, aircrafts, etc. | Source: CEIC



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

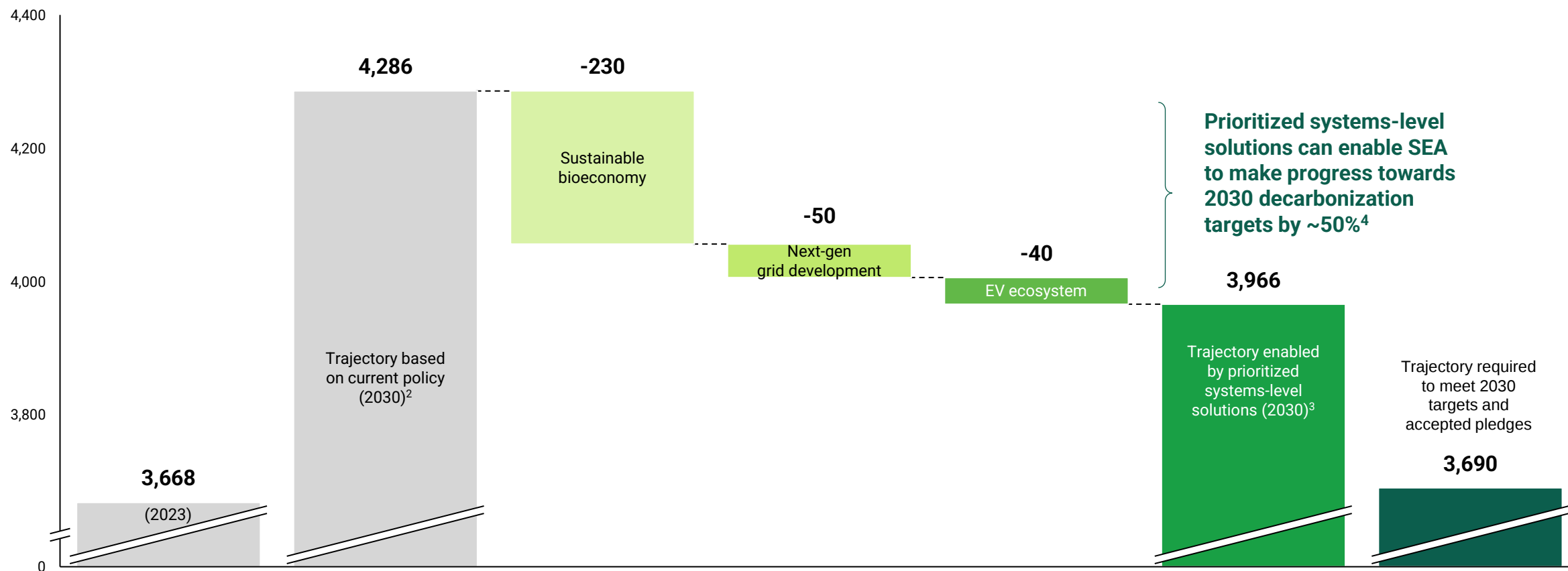


Green AI

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

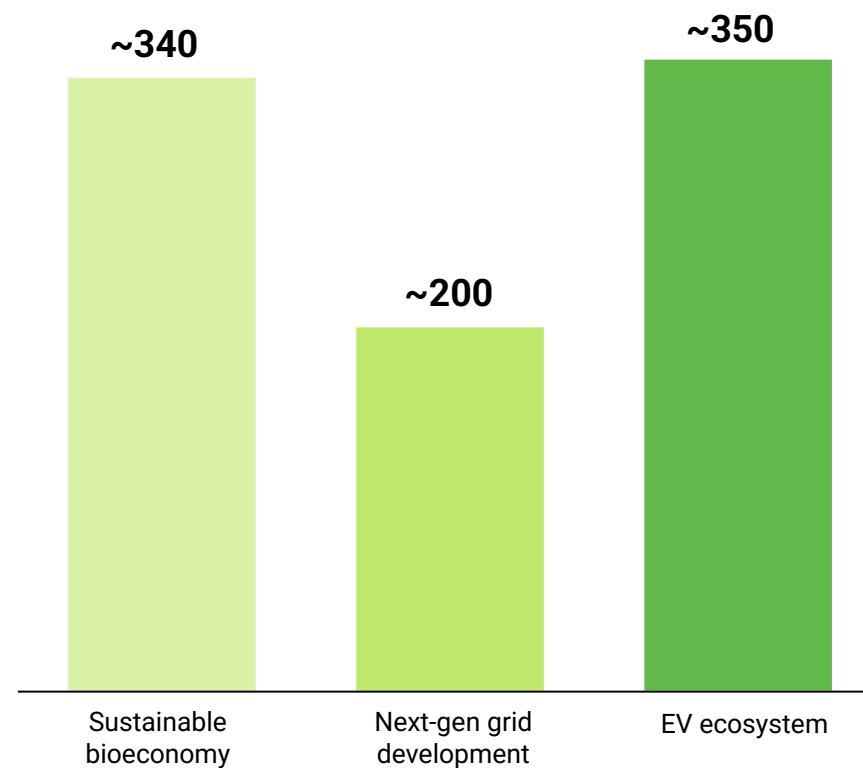
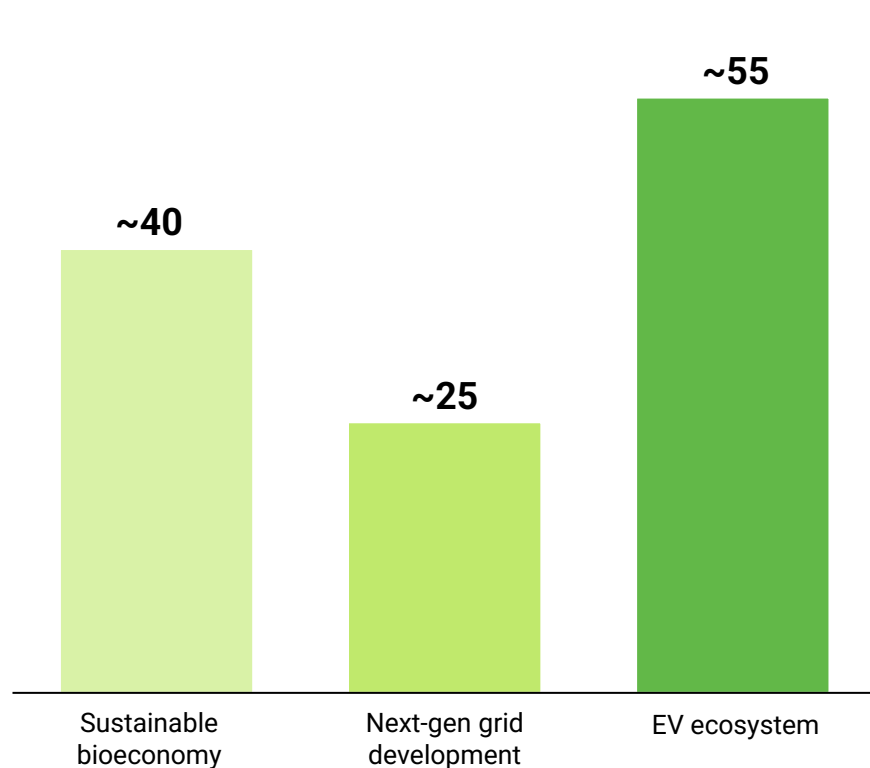
Estimated GDP contribution from systems-level solutions (\$ billion, 2030)

Total GDP contribution¹: ~\$120 billion (2% of SEA-6 GDP)



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

Total job creation²: ~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

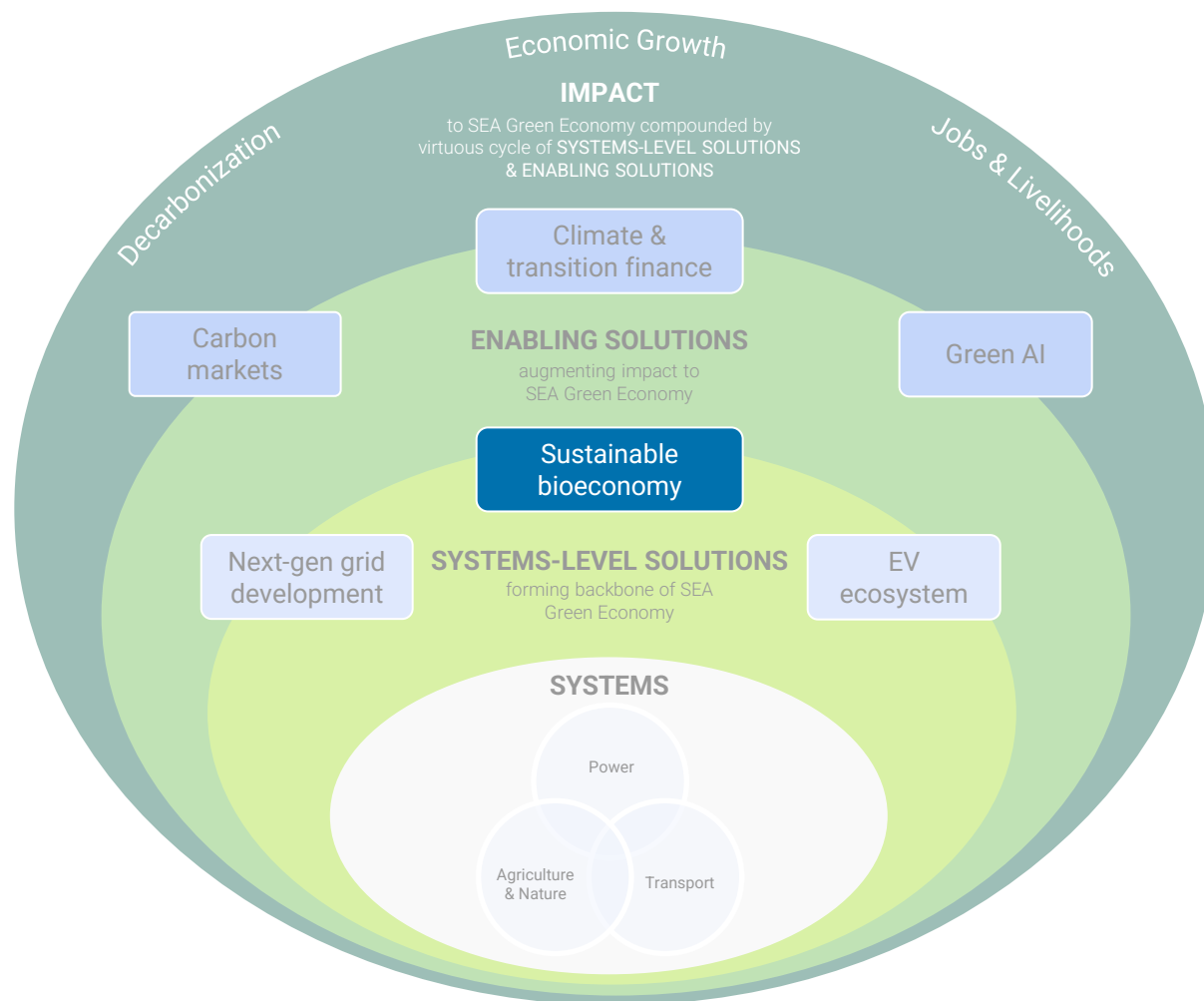
Systems-level solution 1

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 biofuels¹) 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 wealth¹ is estimated to come from natural capital



25%–35%

of overall labor force is employed by agriculture sector² across key SEA-6 export markets

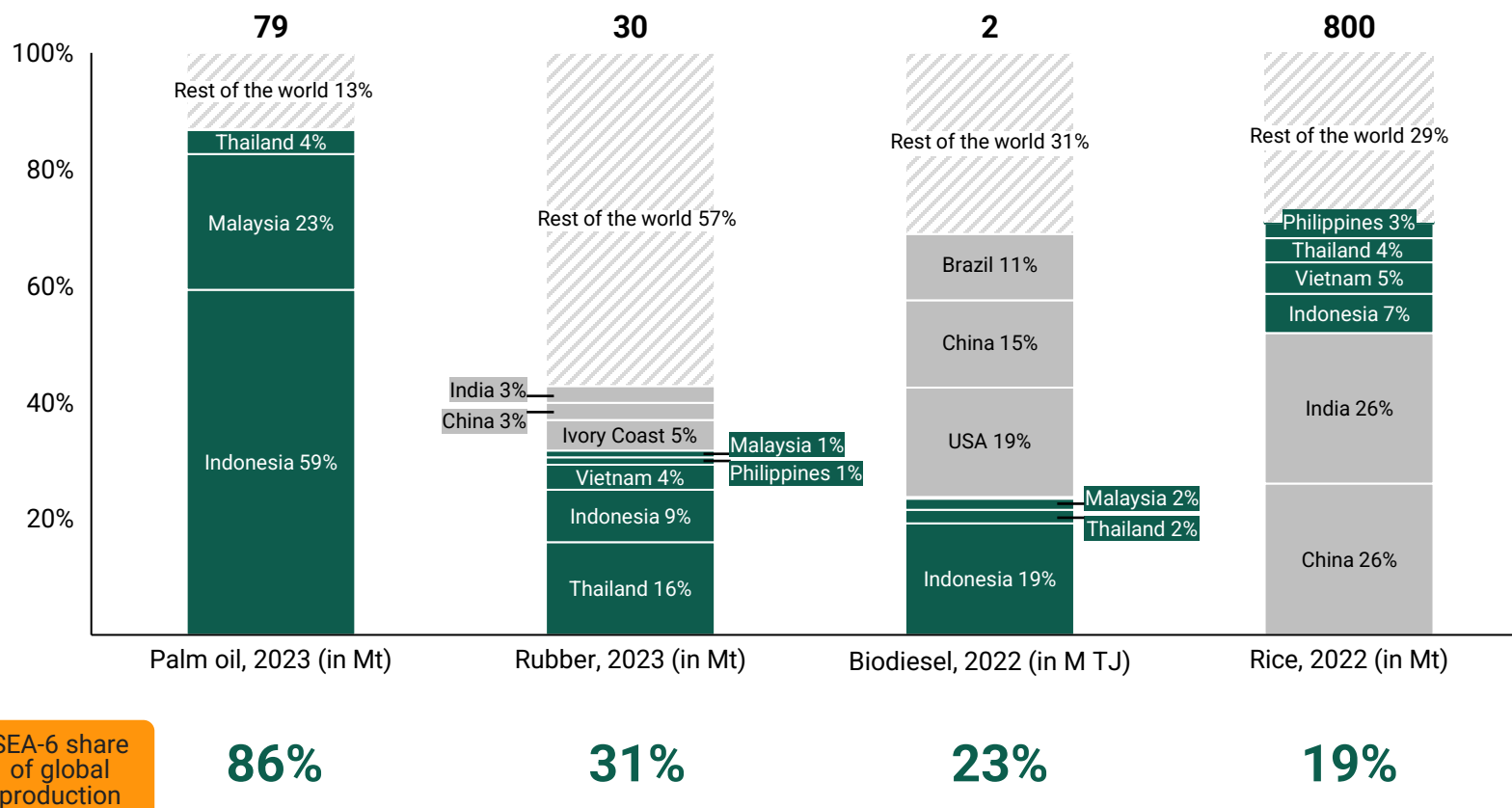


~20%

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



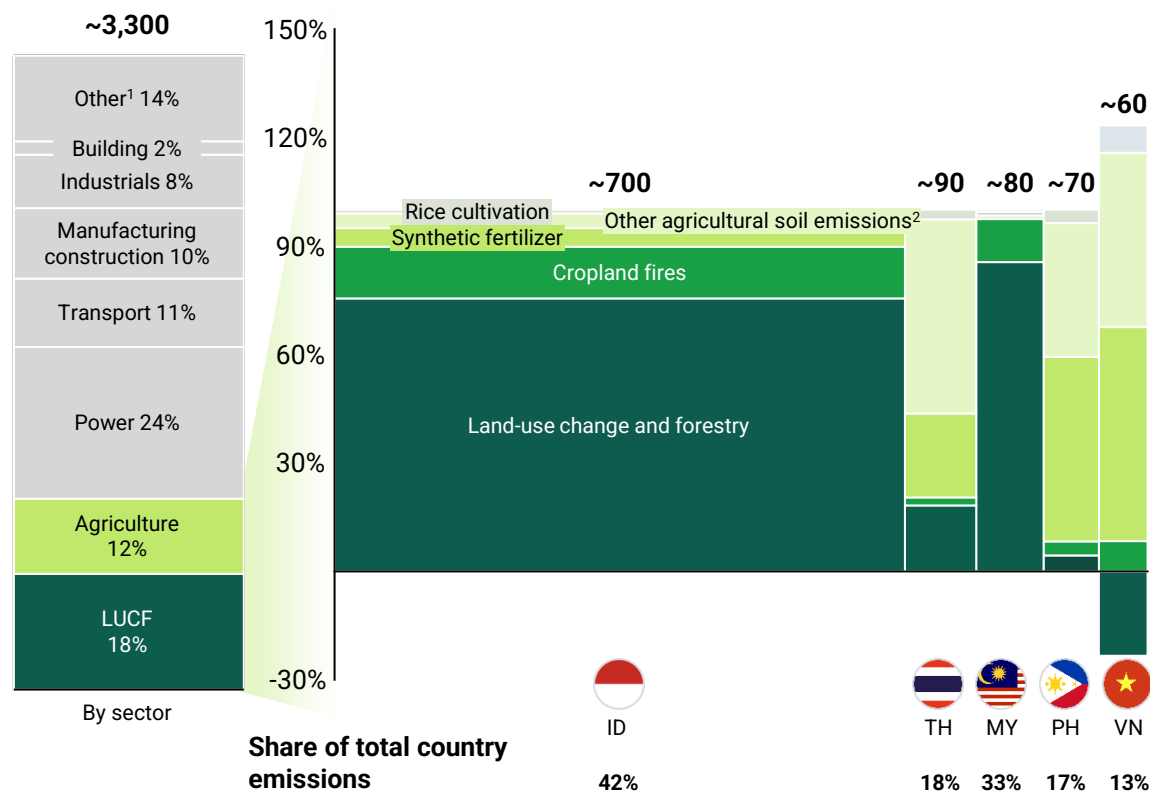
Notes: (1) Wealth is the aggregated sum of three types of capital: natural capital (present value of natural resource stock owned by a country, including forests, farmlands, protected areas, and subsoil assets such as energy and minerals), produced capital (value of assets manufactured or built, e.g., 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)

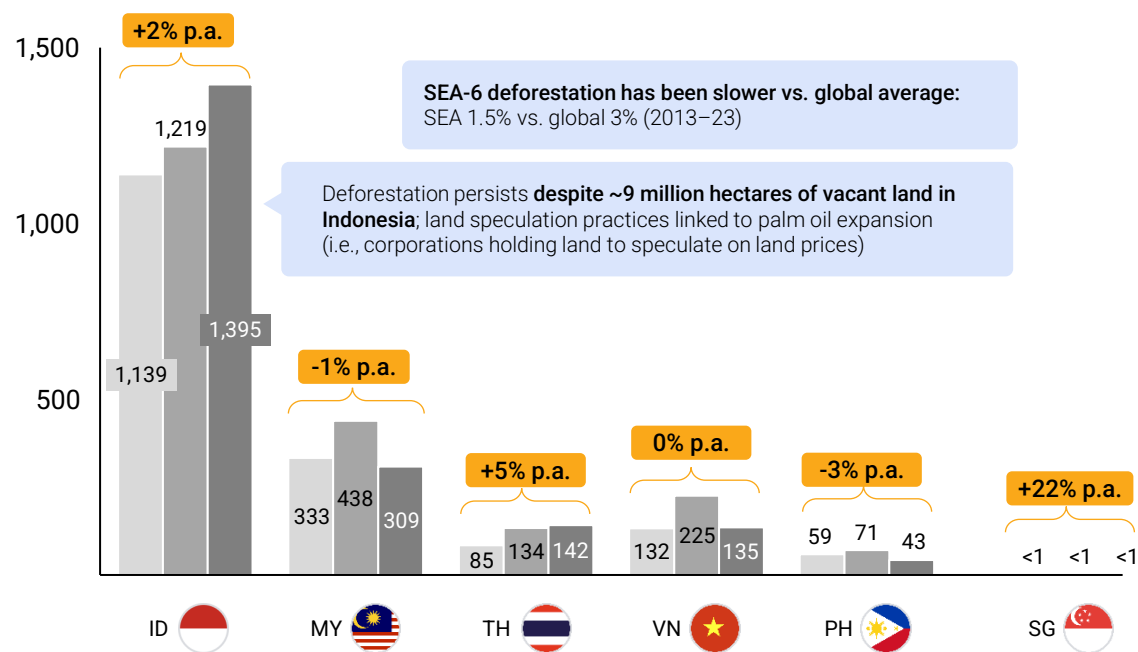
Total = ~1,000 MtCO₂e



Deforestation slowed in SEA vs. global, but continues

SEA-6 tree cover loss³ (hectares, 2013, 2018, 2023)

2013 2018 2023

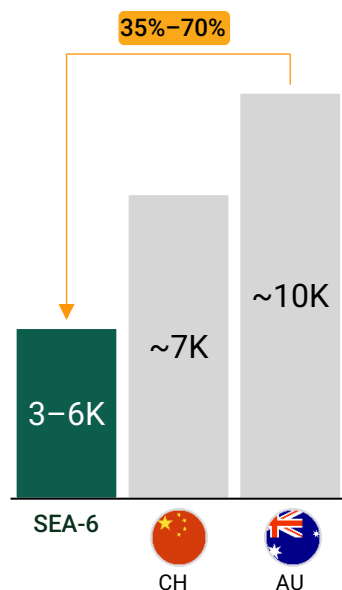


Notes: (1) Other includes bunker fuels, industrial processes, and waste; (2) Includes drained organic soils and manure left on pasture by non-cattle livestock; (3) Tree cover loss defined as complete removal of a tree canopy within a 30-meter pixel (when mapped at a 30-meter Landsat pixel scale, with 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

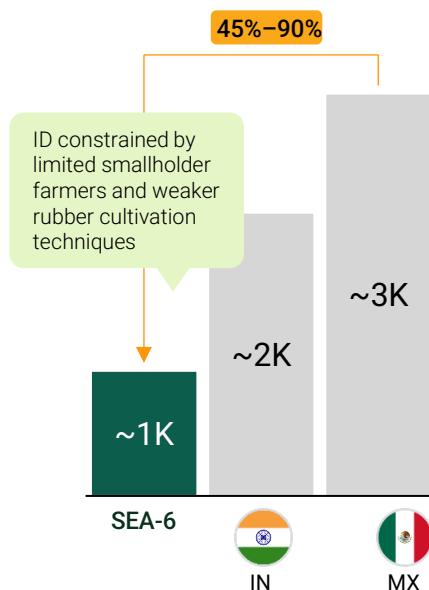
SEA-6 lags in production efficiency

Rice yield
(in kg/ha, 2023)



Global benchmark

Rubber yield
(in kg/ha, 2023)



Global benchmark

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

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 2021²

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 hectare⁴

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)

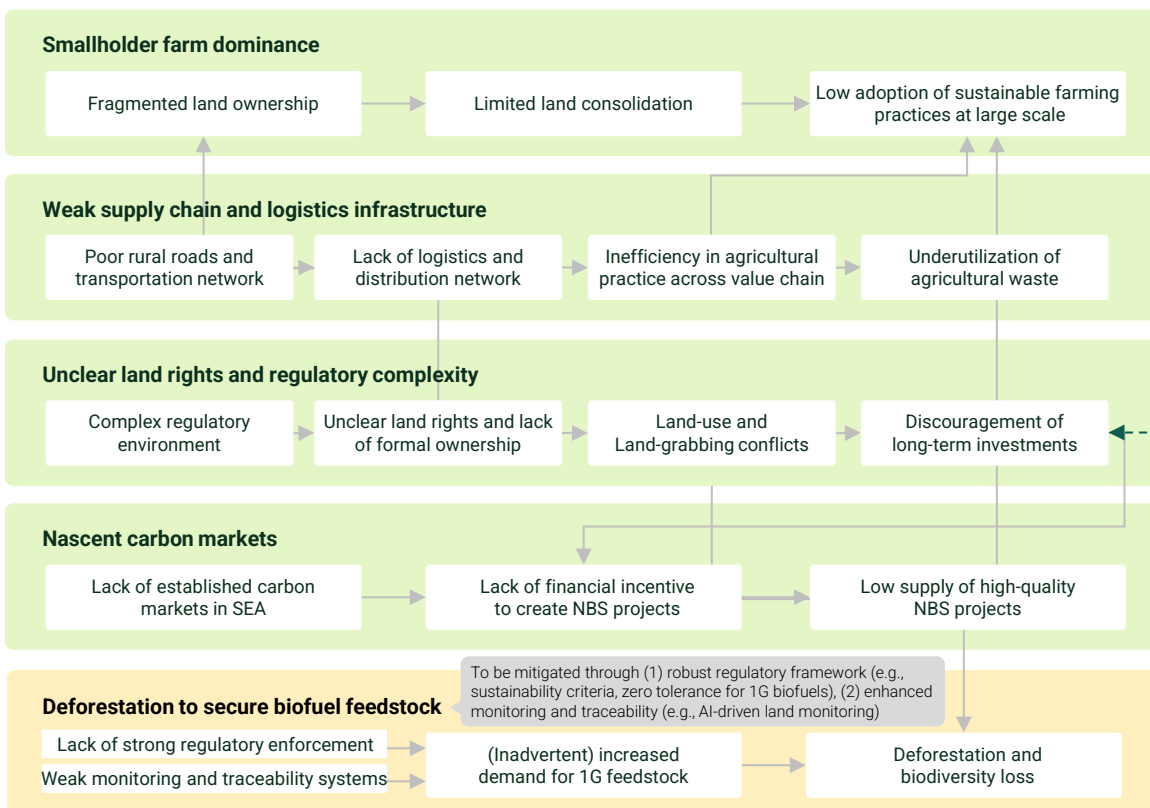
~230 MtCO₂e
Reduction in 2030, ~5% of reduction of emissions in 2030

~\$40 billion
Economic value add in 2030

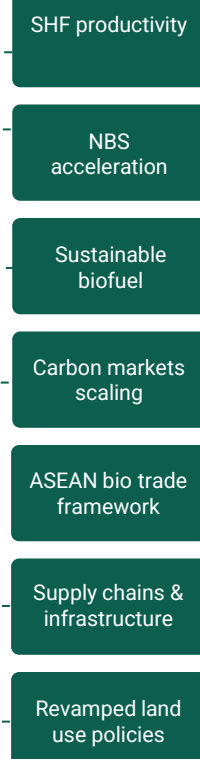
~340,000
Jobs created in 2030

Implications of systems-level solution across SEA decarb systems

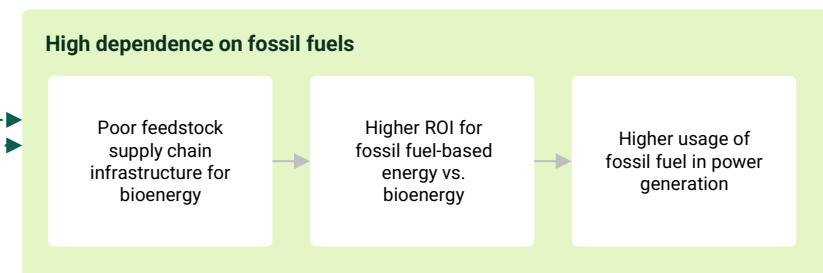
Agriculture & Nature system



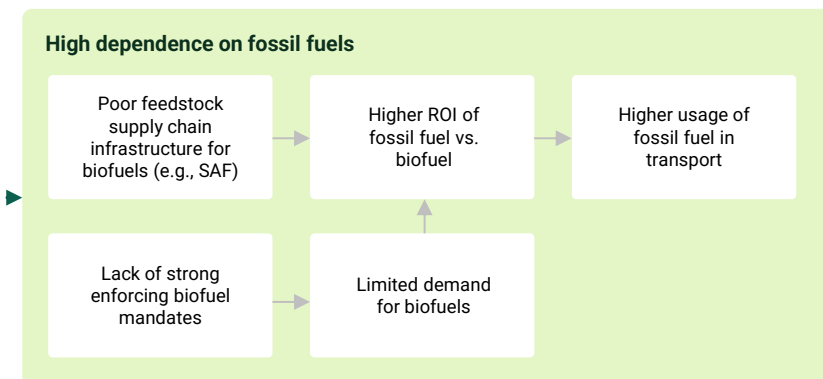
Sustainable bioeconomy



Power system



Transportation system



Deep dive on following pages

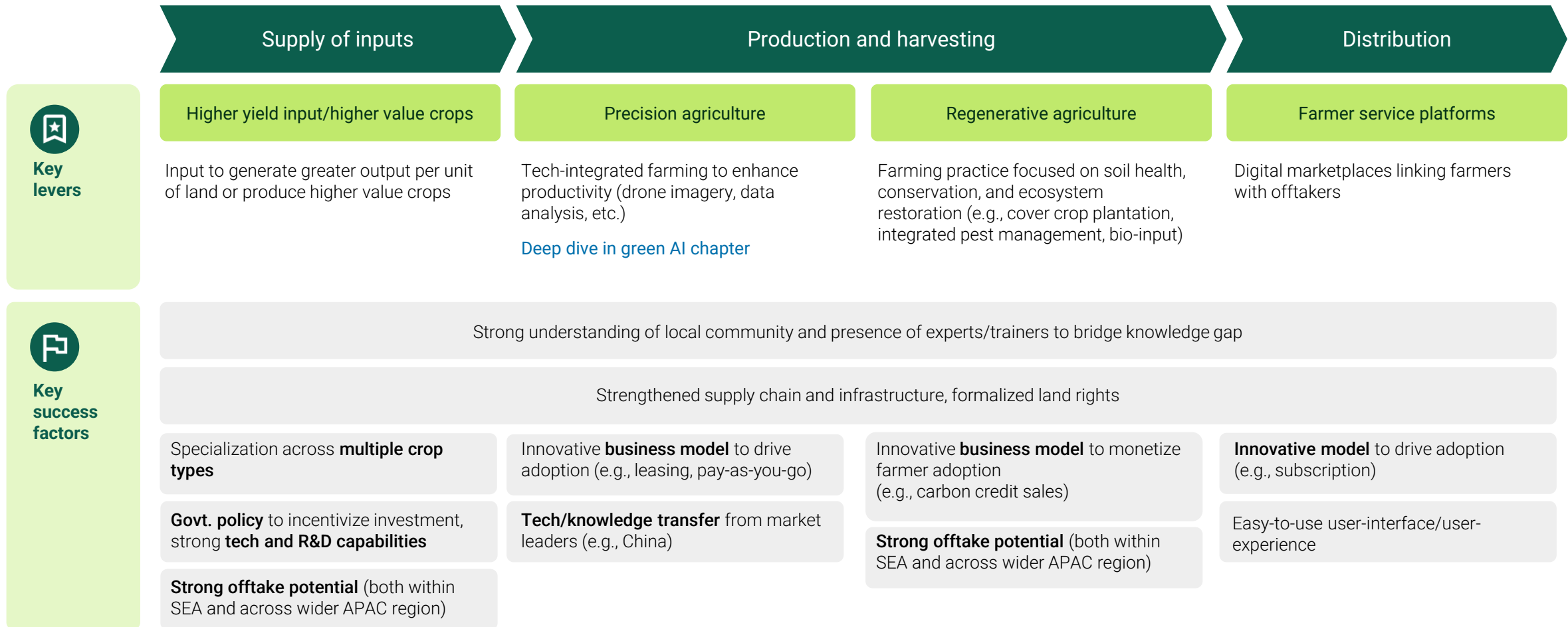
Systemic challenges/patterns of behavior improved by systems-level solution
Potential for unintended consequences
Interventions through solution levers on systemic barriers

Implementation levers | Key levers to turbocharge bioeconomy

		Ease of implementation		
		High	Moderate	Low
Value from agriculture and land	Implementation levers	Expected economic value add ¹ (2030)	Ease of implementation	
	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-SII]) - 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	
	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	
	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



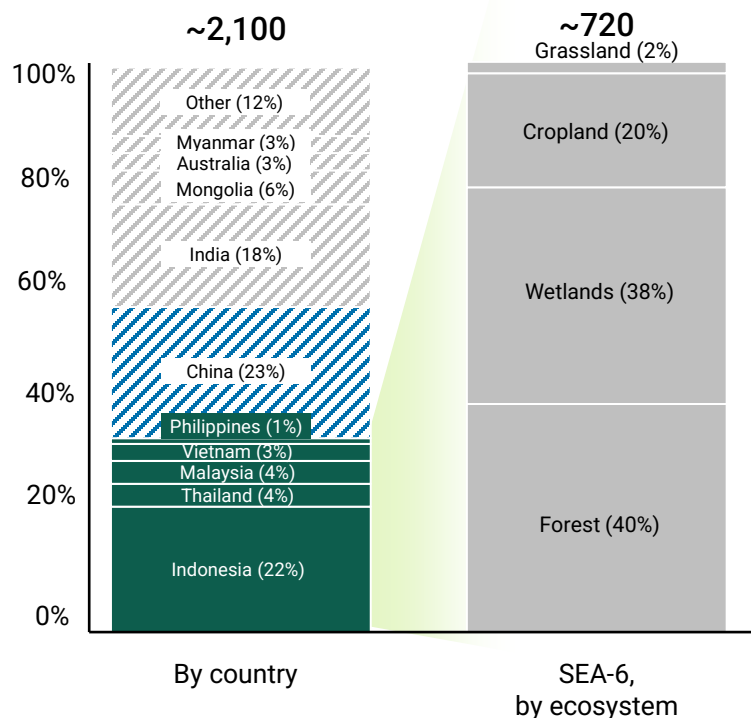
Note: (1) Based on market studies (e.g., a four-year study done by German-Indonesian collaborative research center that observes stable yield result and higher profit due to reduced fertilizer costs) | Source: Lit. search

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

Untapped potential of SEA-6 NBS carbon credits issuance

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



Annual carbon credit issuance (2020–24)

~5–10 MtCO₂e¹

vs

Annual mitigation potential²

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

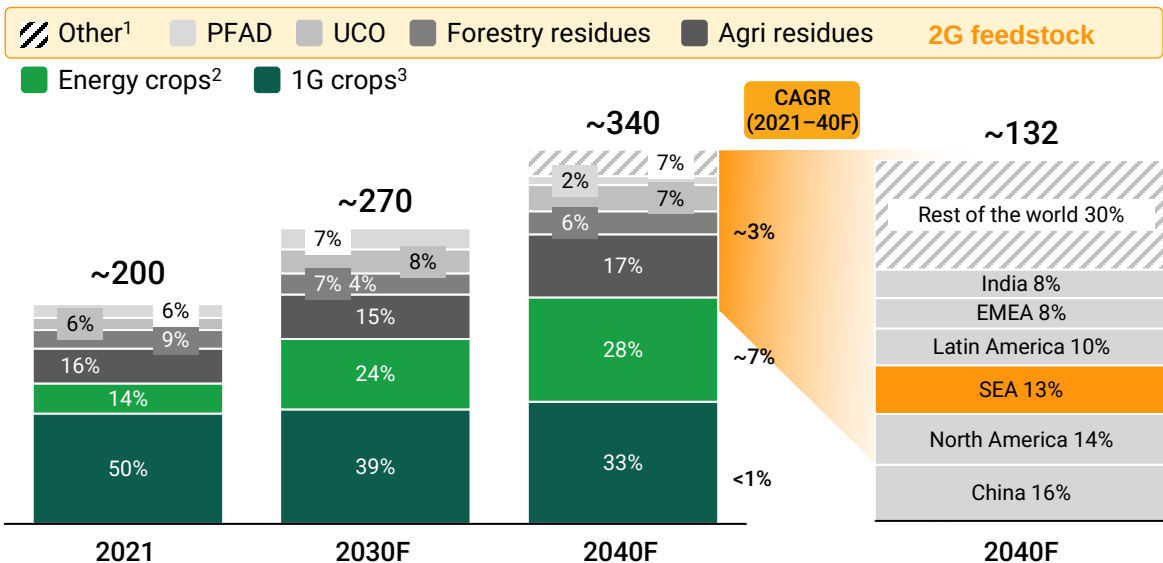
Build integrated regional markets with standardized regulations, clear MRV methodologies, alignment with international quality benchmark to ensure credit quality, and exportability

[Deep dive in carbon market chapter](#)

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



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

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

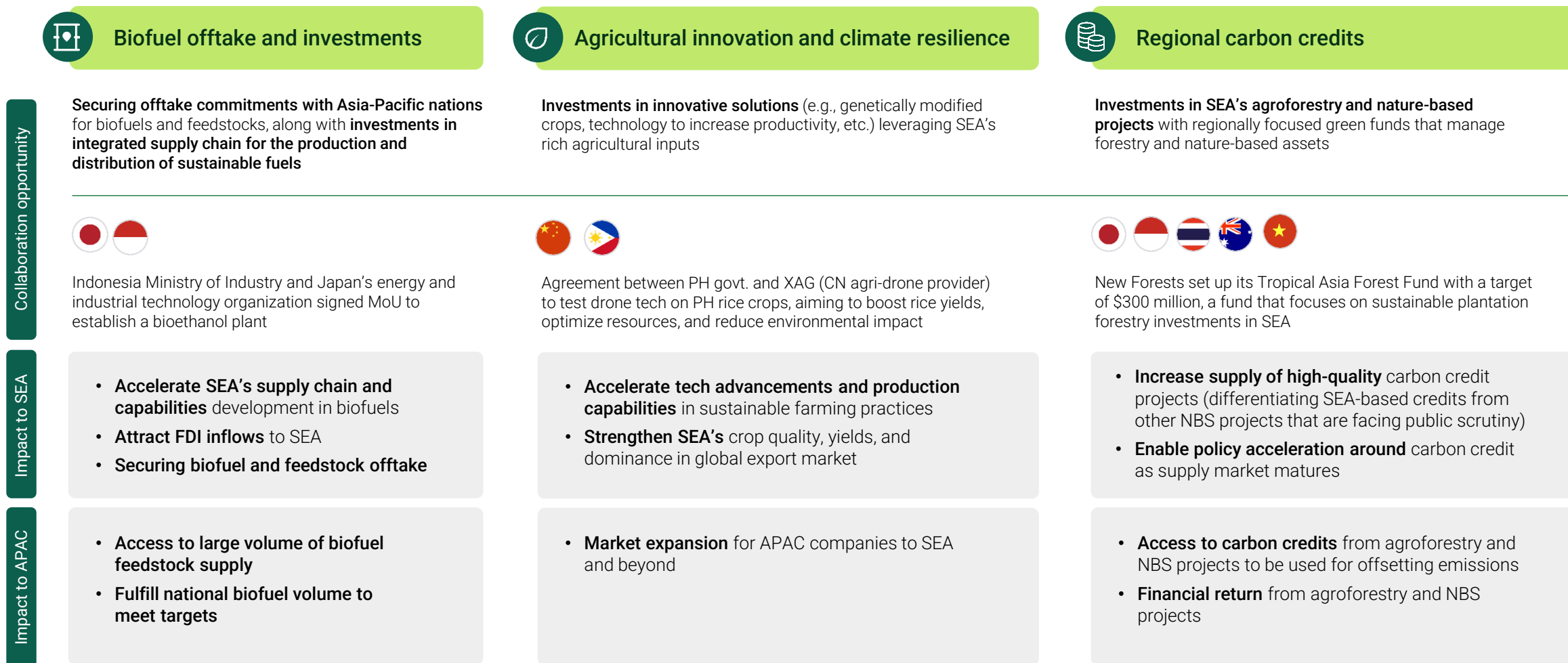
Scale production by **de-risking facility investments** through **offtakes** that lower market and volume risks

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

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



Investable ideas | Attractive options exist across multiple areas of bioeconomy

Opportunities	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)
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



Polymakers 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

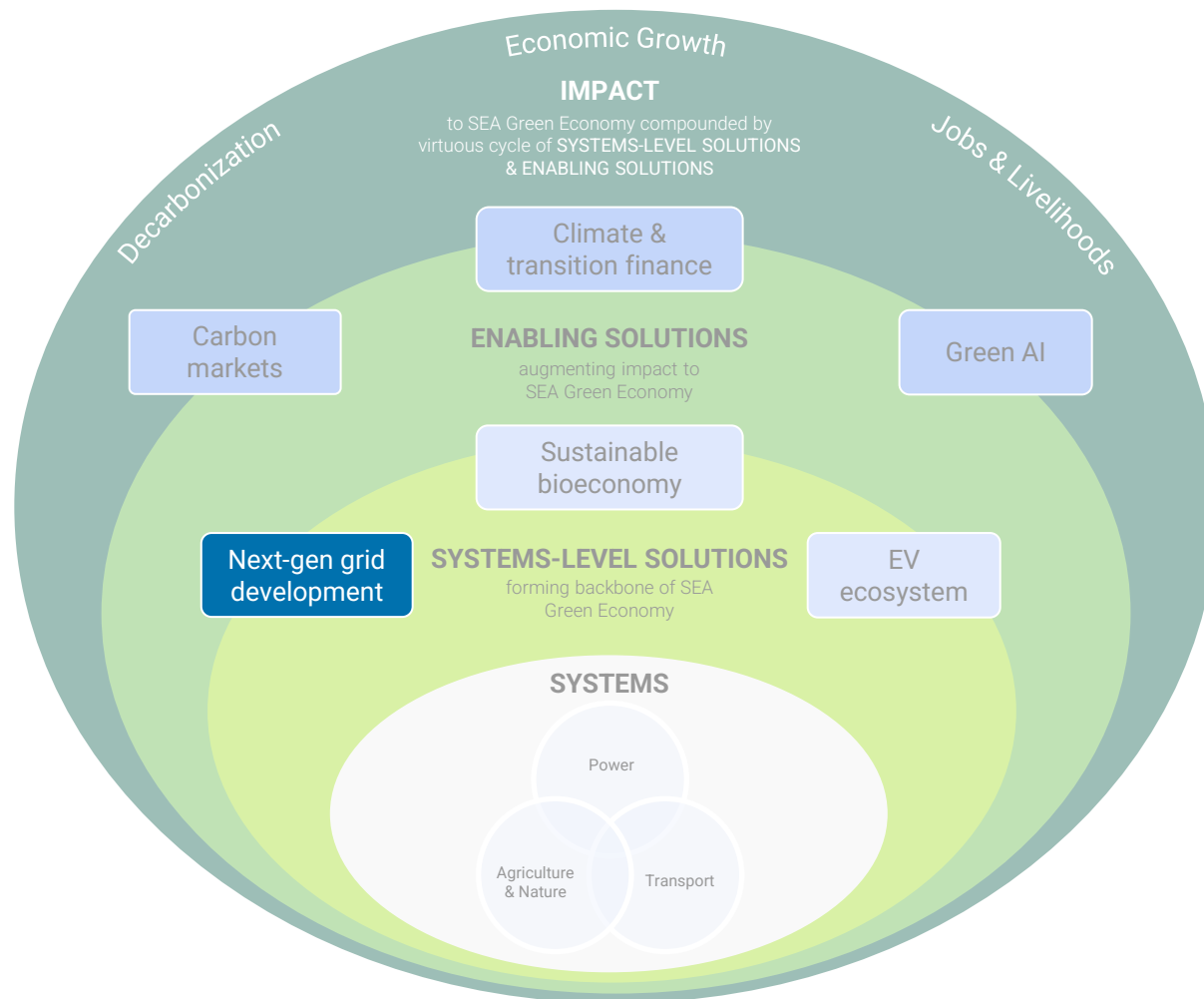
Systems-level solution 2

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

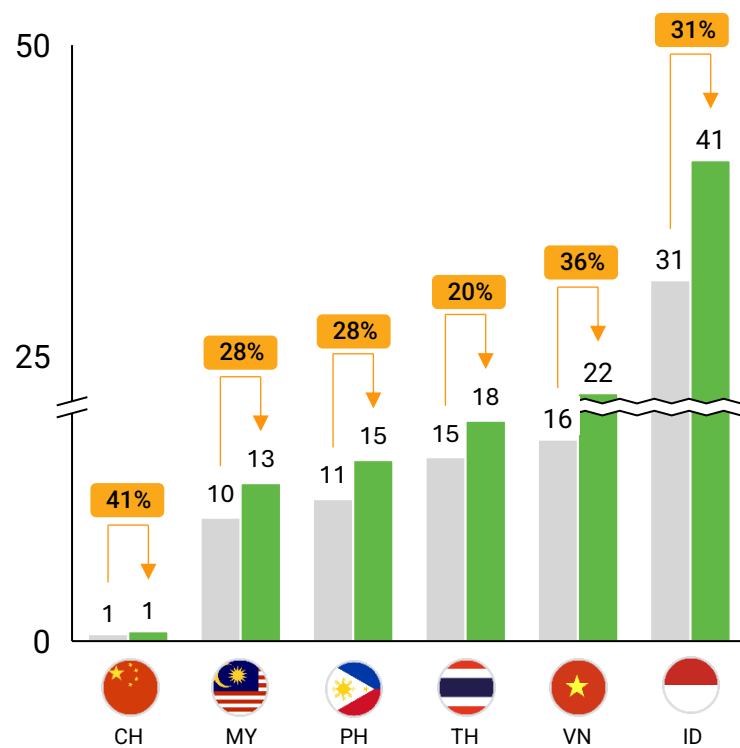
Build green industrial clusters ("sandboxes")
Accelerate bilateral grid connections



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

Electricity power T&D losses (TWh) 2024 2030F



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



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

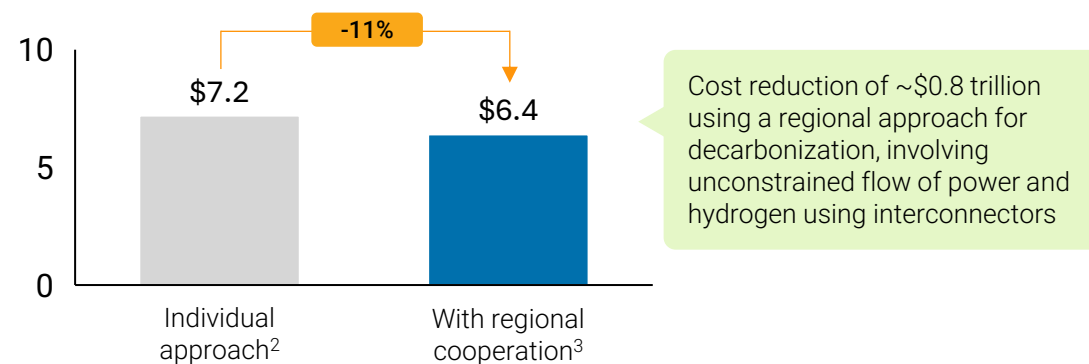
Installation of **small grids** that **operate independently** from the main grid, ensuring 24/7 power during blackouts and better RE integration

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 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 tariffs¹ 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

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)

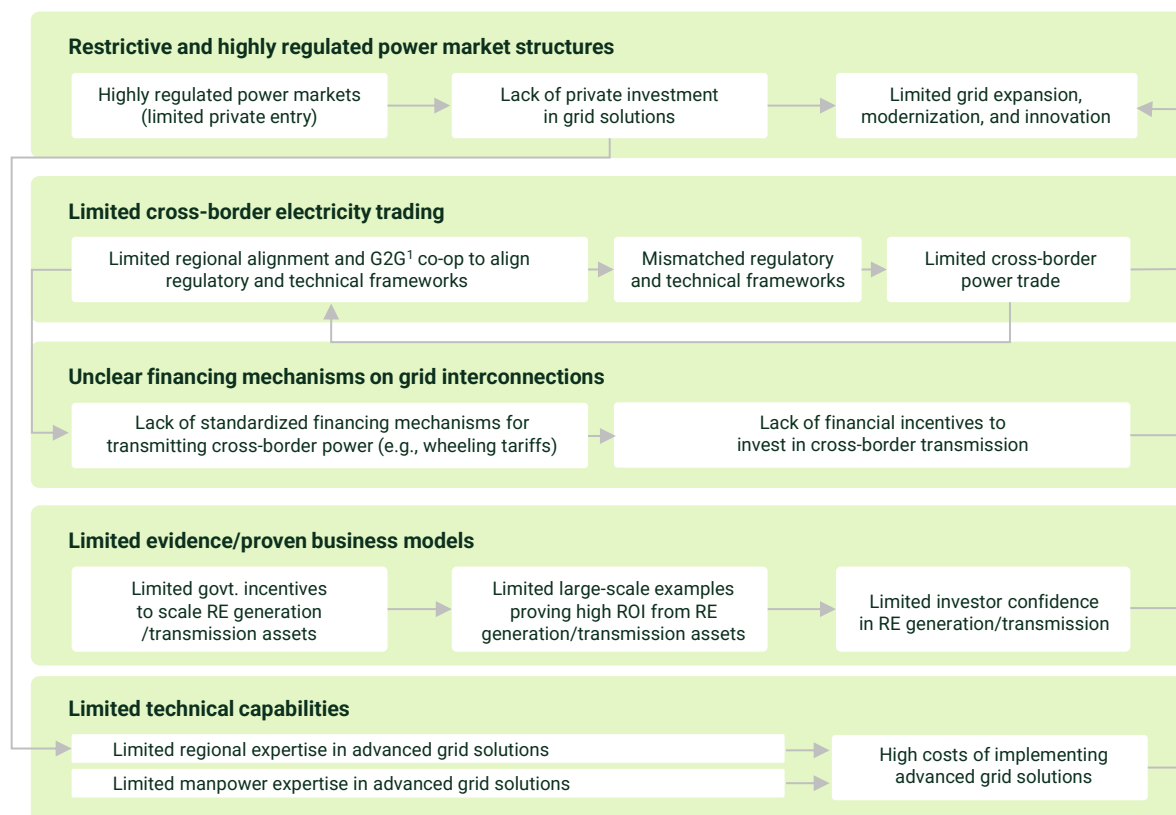
~50 MtCO₂e
Reduction in 2030, ~1.3% of reduction of emissions in 2030

~\$25 billion
Economic value add in 2030

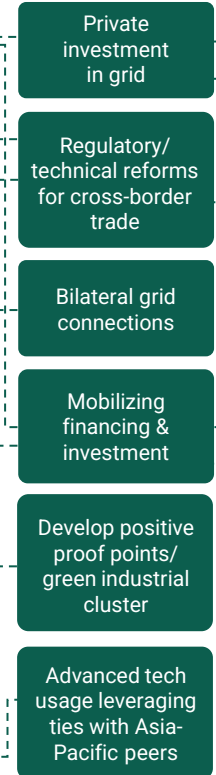
~200,000
Jobs created in 2030

Implications of systems-level solution across SEA decarbonization systems

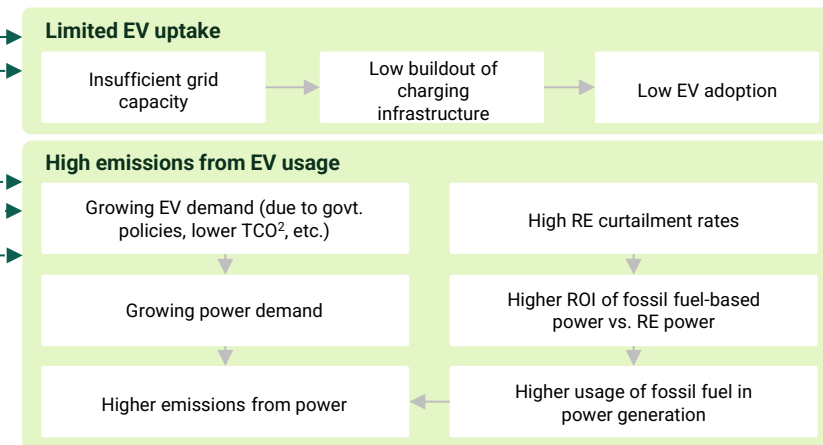
Power system (focus on grid)



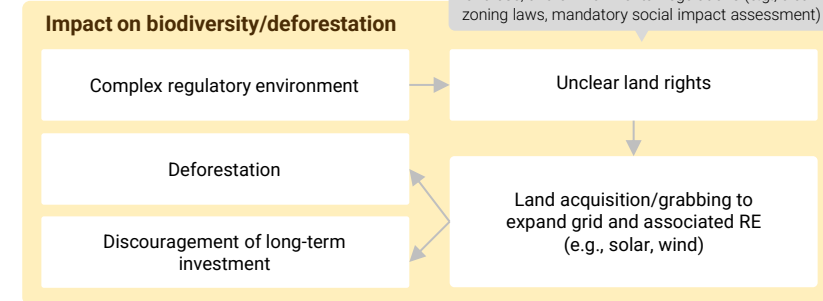
Next-gen grid development



Transport system



Agriculture system



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–\$2B²	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–\$4B³	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–\$20B⁴	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 - 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 Increase in generation and distribution through private investment further incentivizes transmission growth
	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

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 coupling¹

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 funding³

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 needs⁴ 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



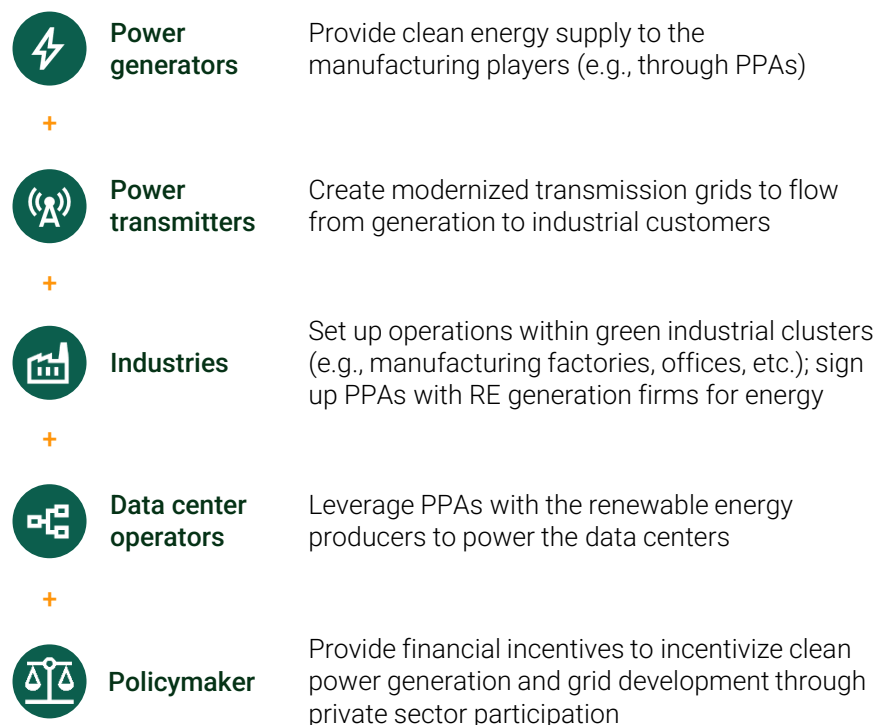
Presence of a **dedicated, binding institution** to drive the regional grids

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

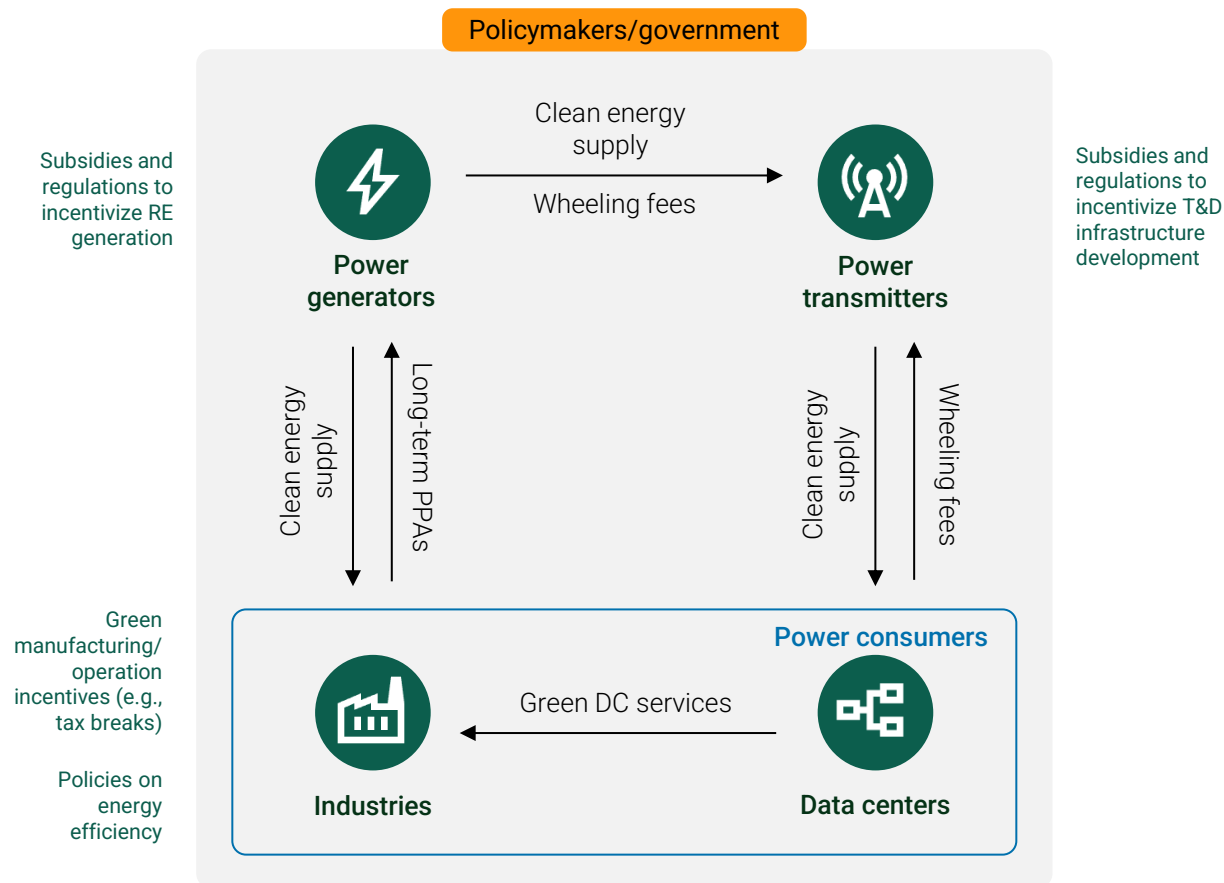
Green clusters create an ecosystem that accelerates private participation and provides proof points to demonstrate economic viability of green power investments

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

Integrated ecosystem driving synergistic economic goals

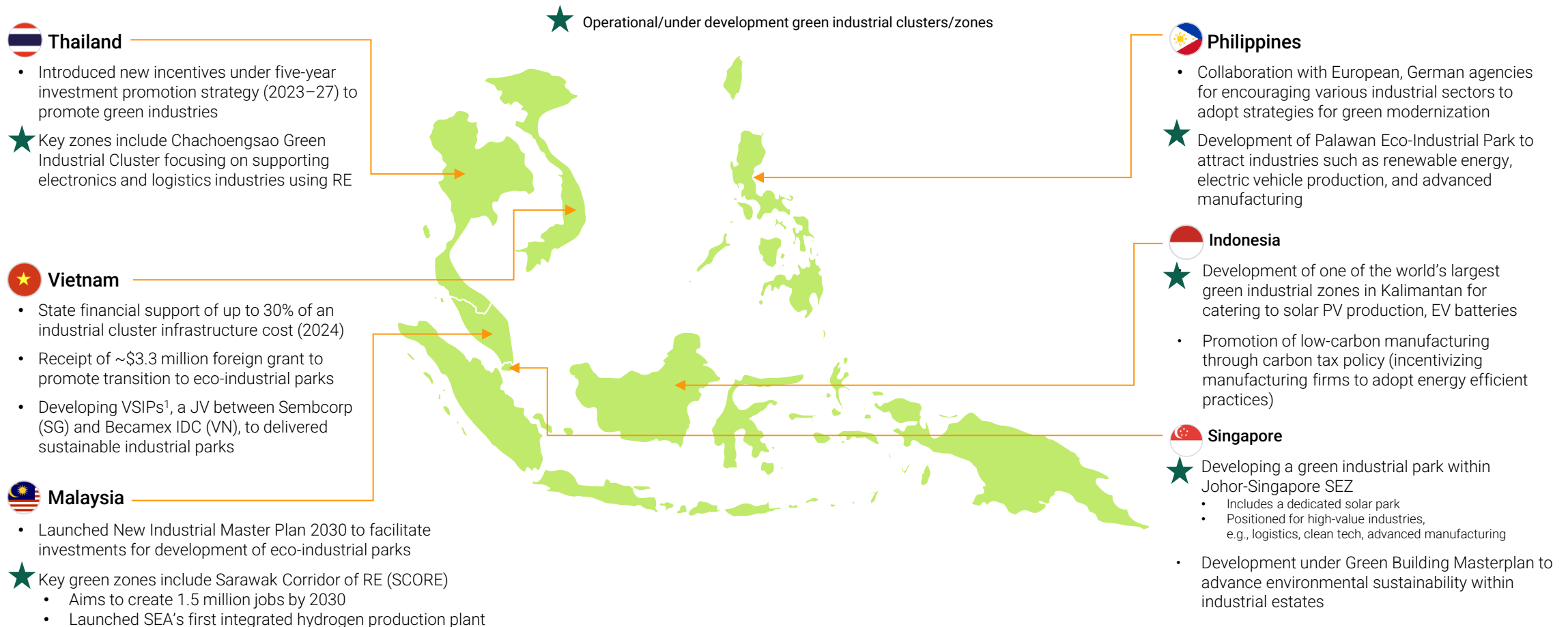


Functioning of a green industrial cluster (enabled by policymakers/government)



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



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

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 size¹ (\$ 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 microgrids¹ 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



Polymakers 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**

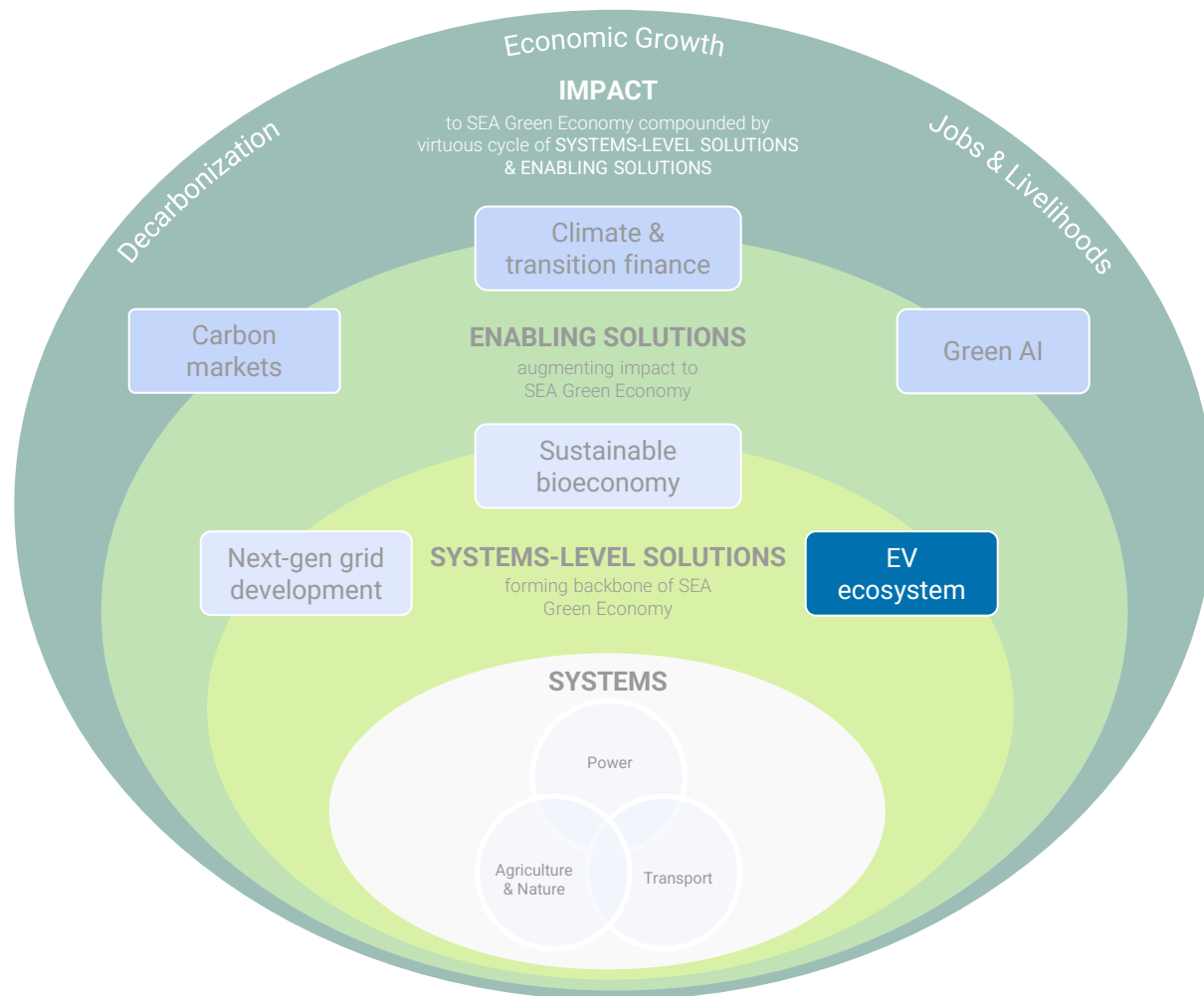
Systems-level solution 3

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



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

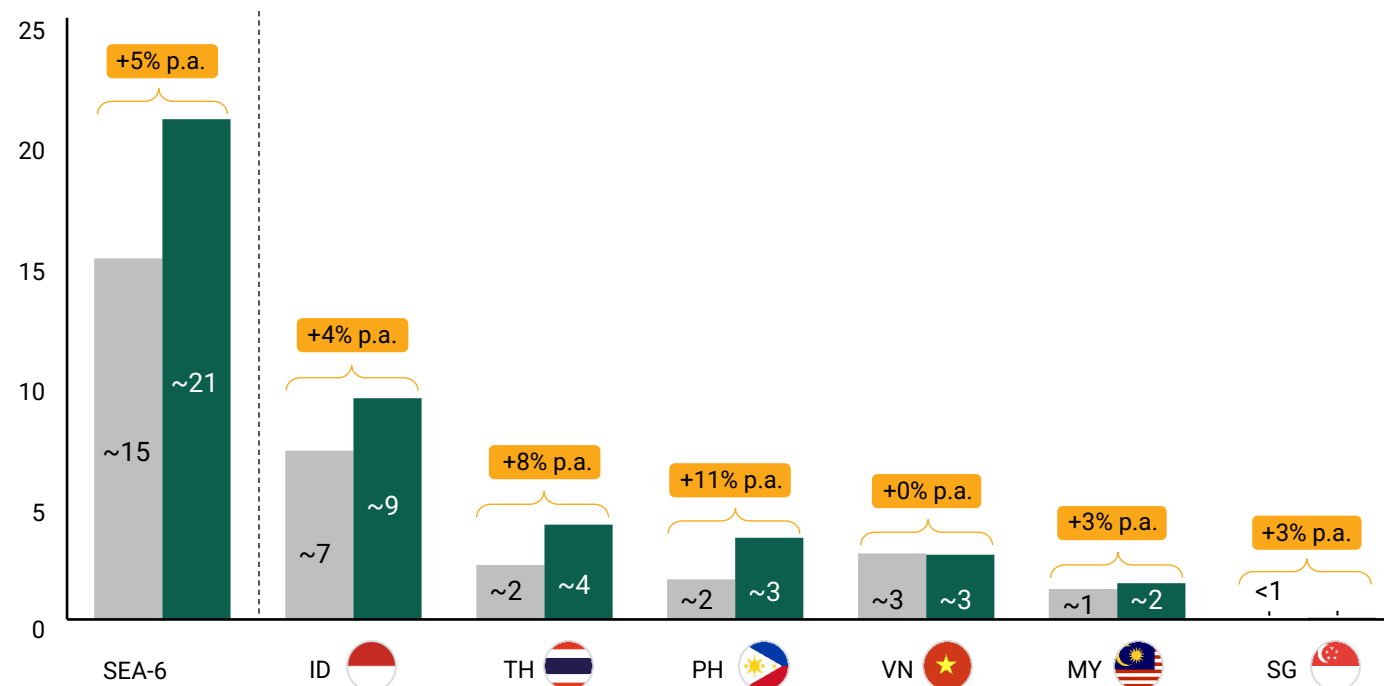
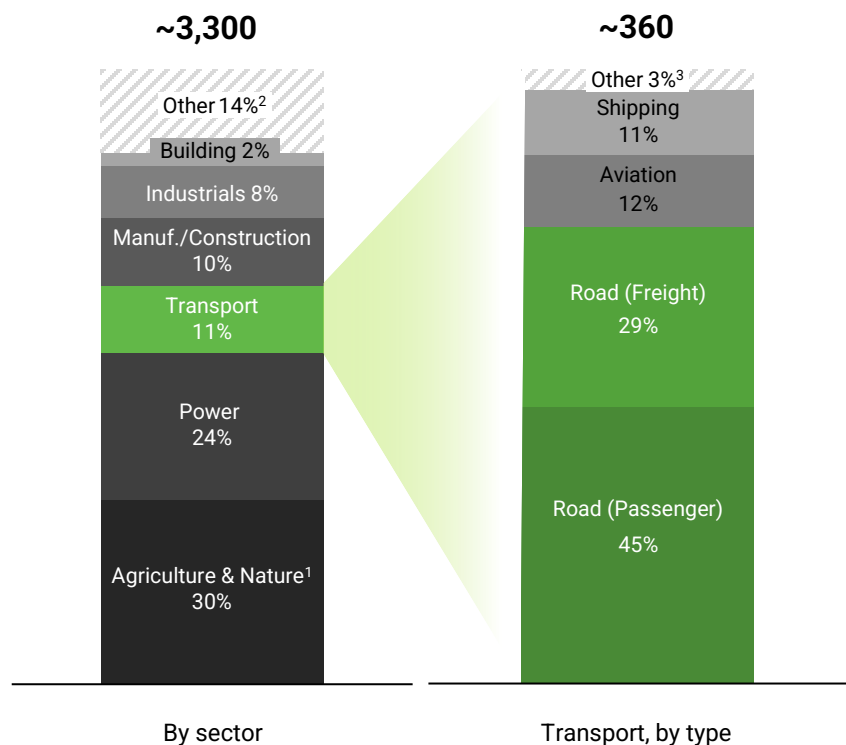
Road transport contributes ~75% of SEA's transport emissions

Emissions expected to increase given rising demand in mobility across markets

SEA-6 GHG emissions (MtCO₂e, 2023)

Total annual vehicle sales⁴ in SEA-6 (millions)

■ 2023 ■ 2030



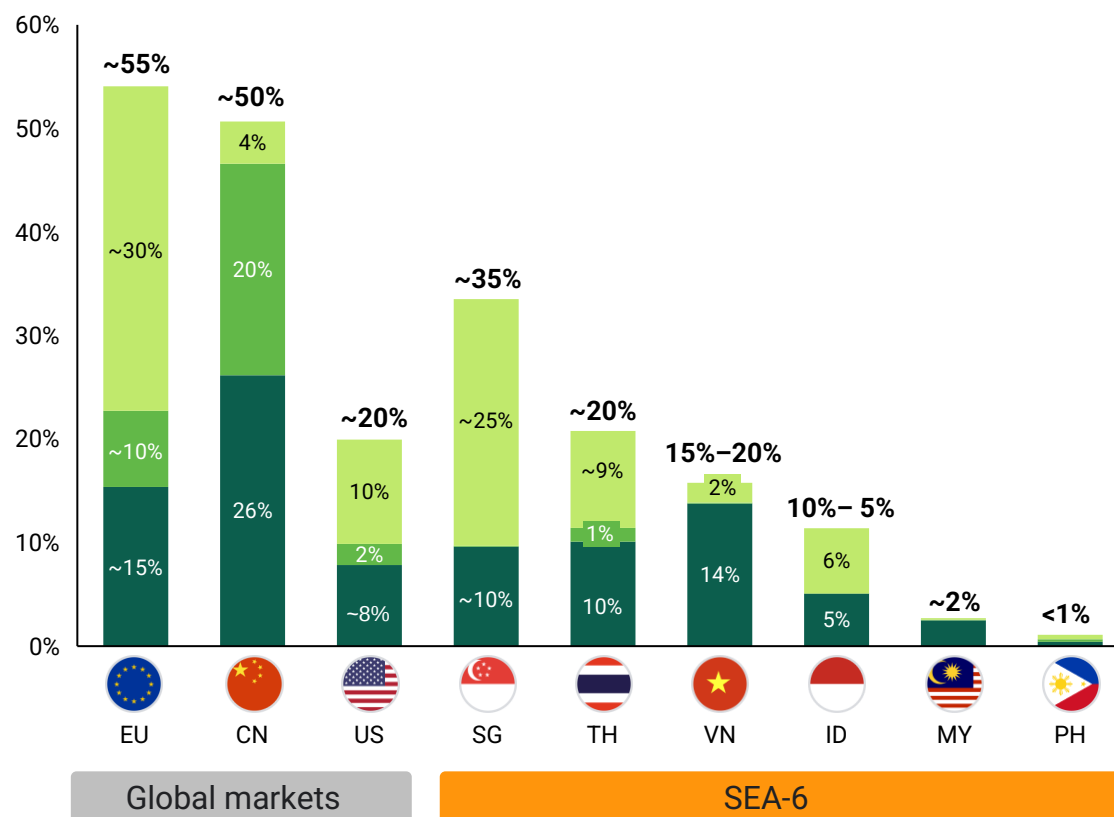
Notes: (1) Includes emissions from LUCF; (2) Includes bunker fuels, industrial processes, and waste; (3) Includes rail and transport of oil, gas, water, and steam; (4) Includes 4W passenger vehicles and 2W motorcycles and scooters | Sources: ASEAN Automotive Federation; Climate Watch; EU EDGAR; IEA;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

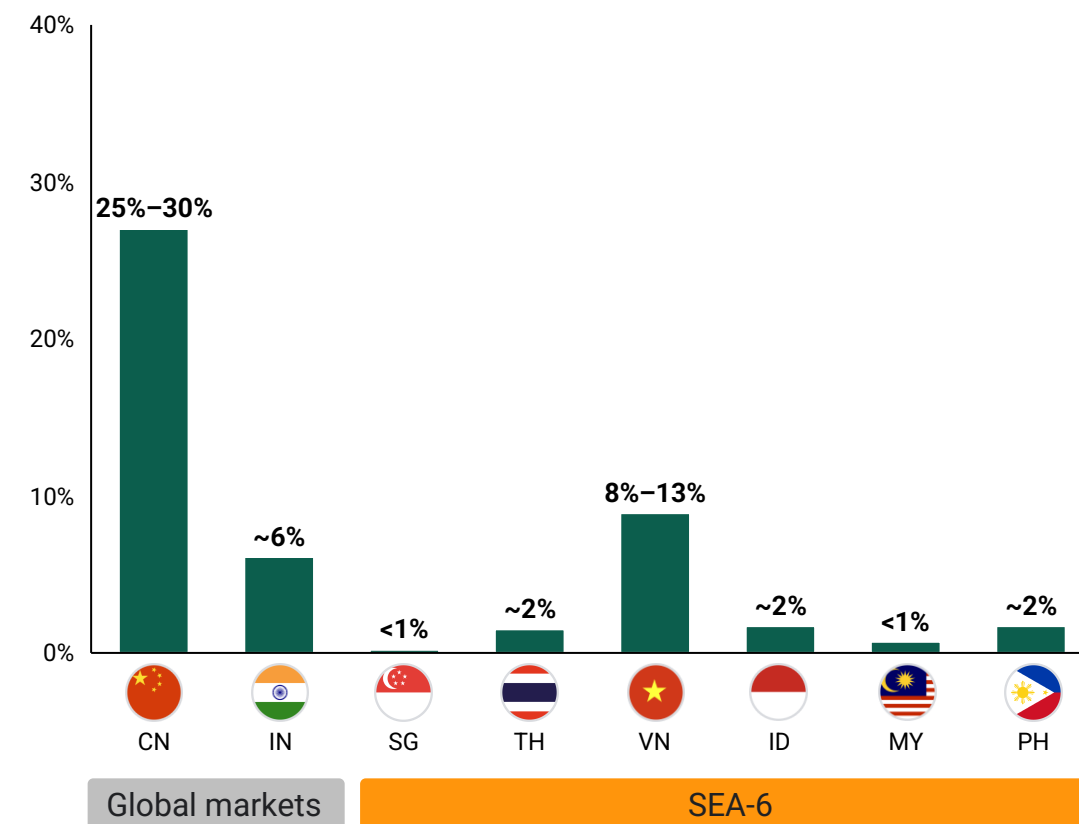
4W EV penetration¹ (percentage of new 4W sales, 2024)

BEV² PHEV³ HEV⁴



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

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

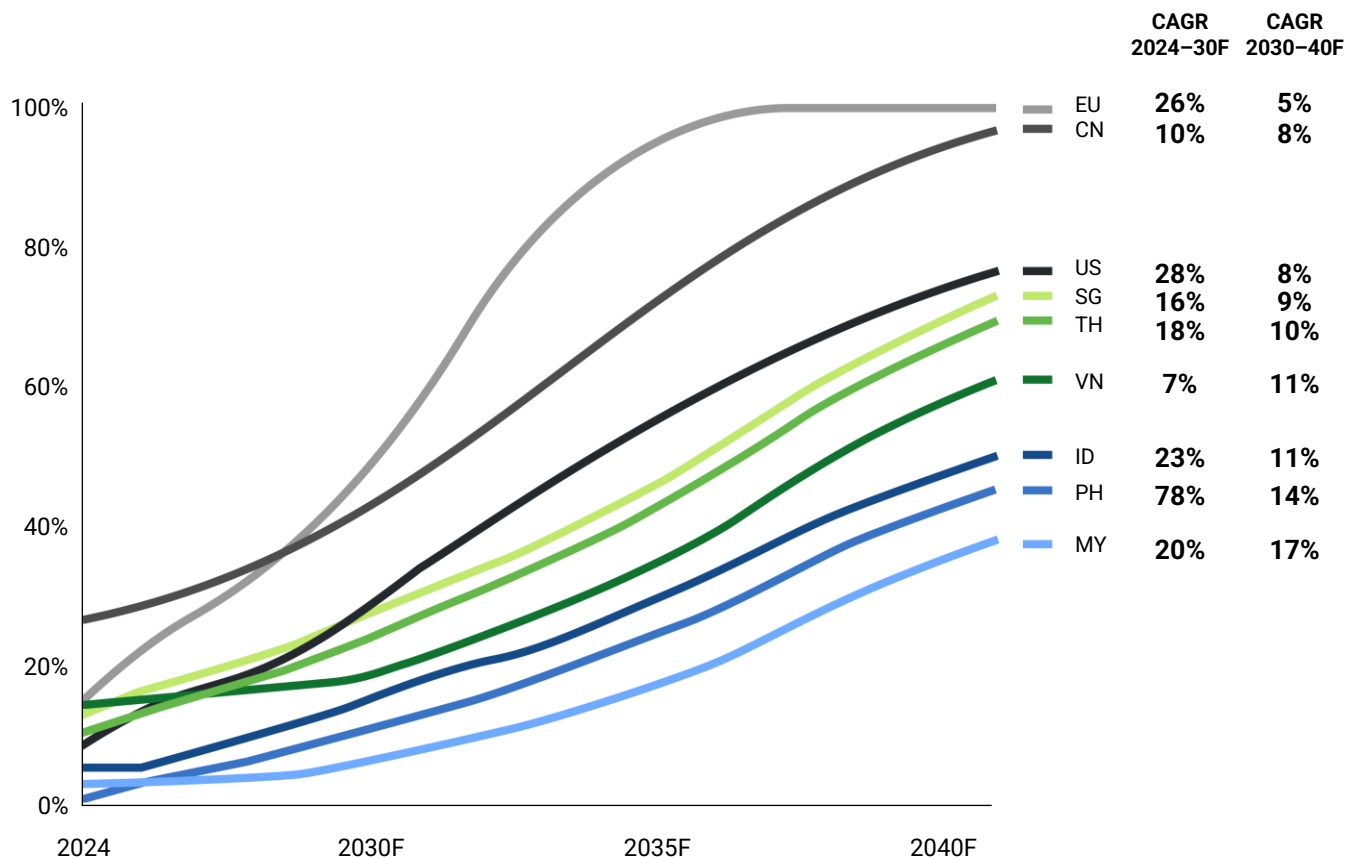


Notes: (1) 4W vehicles only includes light vehicles (passenger cars and commercial vehicles <3.5 trillion); (2) Battery electric vehicle; (3) Plug-in hybrid vehicle; (4) Hybrid electric vehicle | Sources: Euromonitor; IEA; Marklines

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

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



~\$300B

contribution to total SEA-6 GDP is from auto manufacturing¹



~10%

contribution² to GDP in both Indonesia and Thailand



~1M

employment³ in auto sector



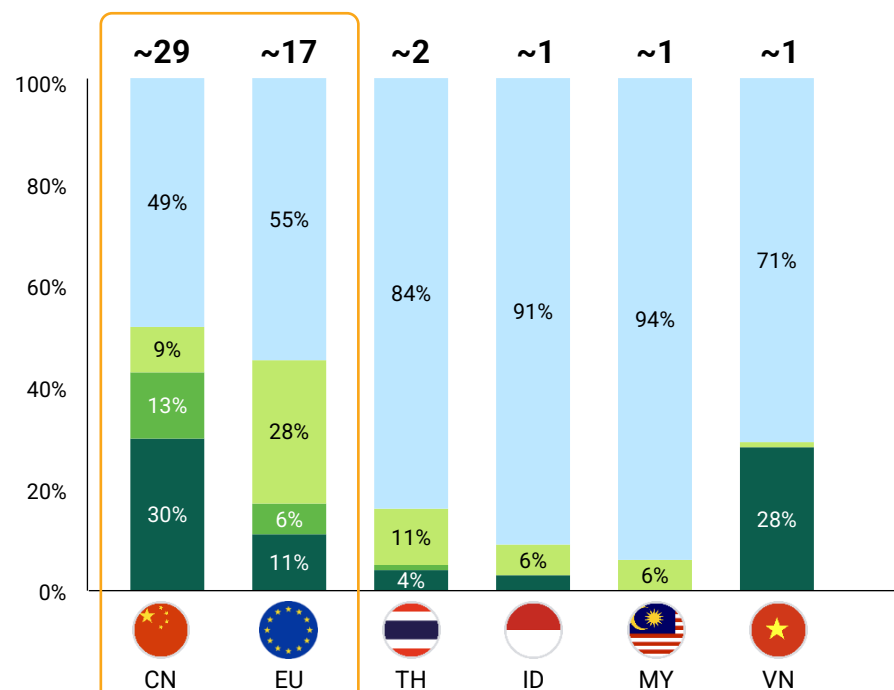
~850K

employment⁴ in auto sector



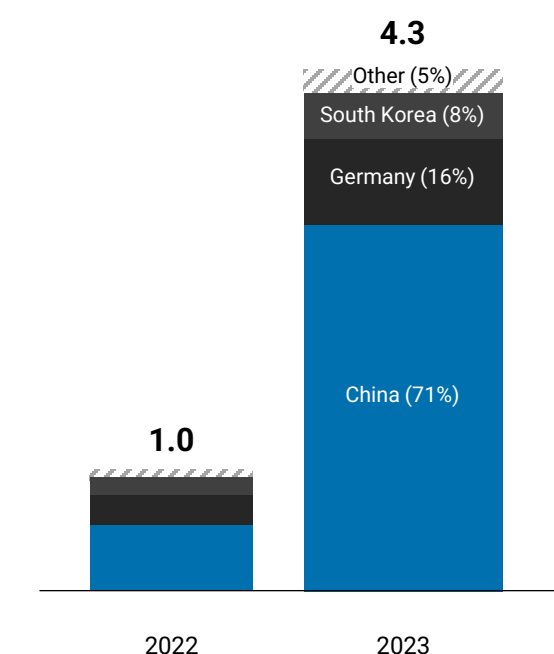
4W production (million vehicles, 2024)

BEV PHEV HEV ICE



Global market leaders in EV production

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



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



Validation of demand



Income and job creation



Infrastructure set-up



Tax revenues
(for reinvestment in incentives to drive demand)

SEA EV strategy

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)

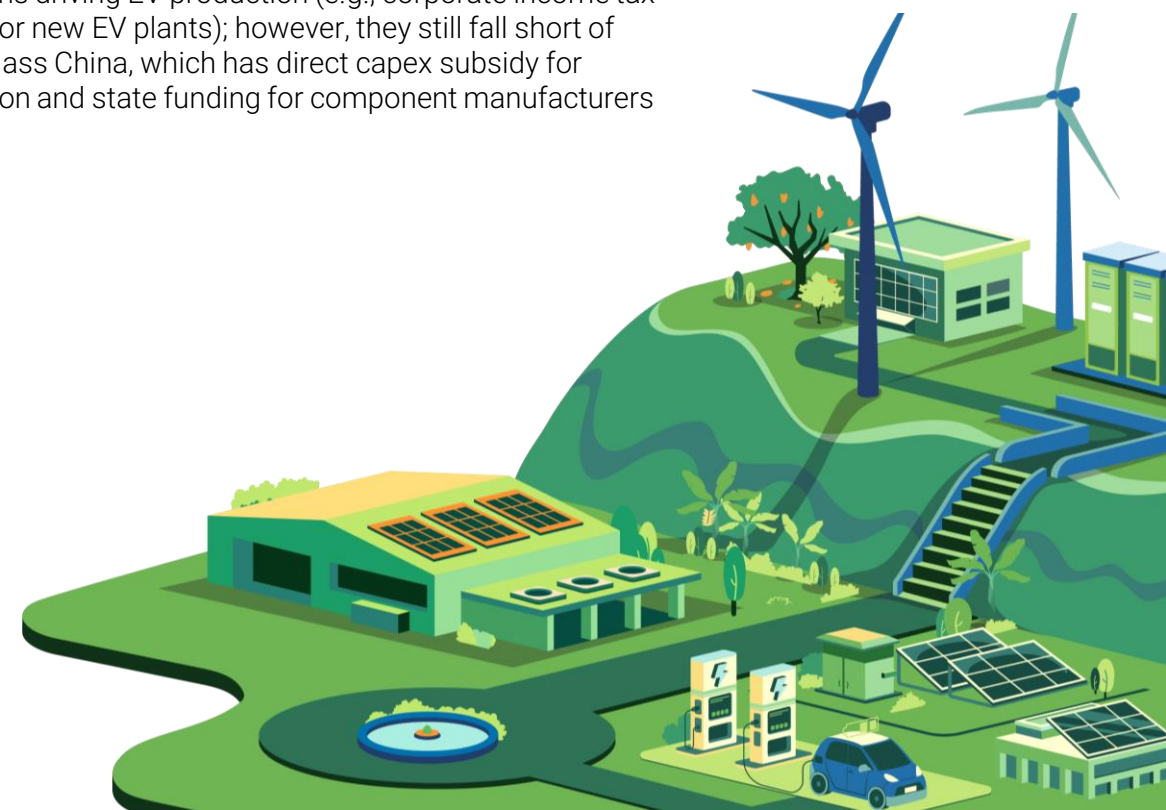
- Limited range and long charging time (resulting in higher downtime) makes EVs less viable for fleets needing high utilization rates (e.g., public buses)

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



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

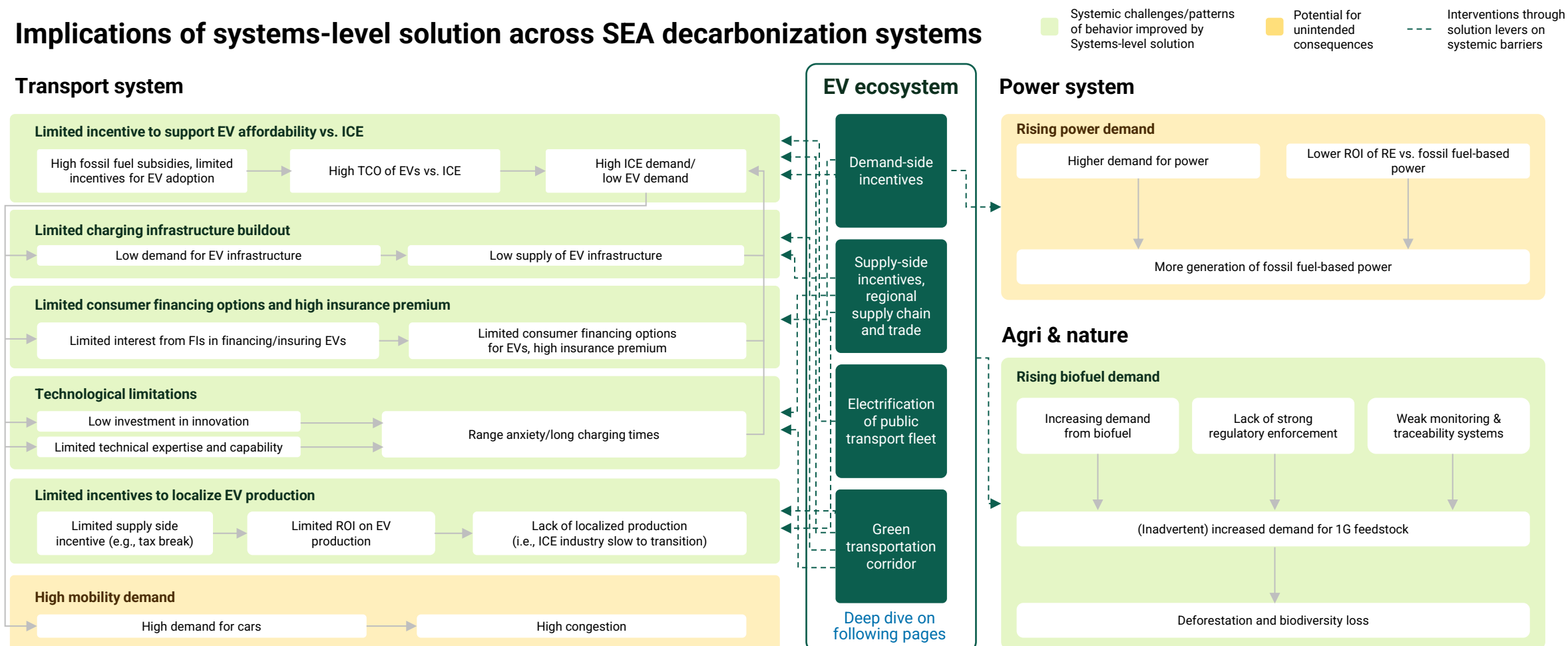
Total expected impact on SEA-6 (2030)

~40 MtCO₂e
Reduction in 2030, ~10% of reduction of emissions in 2030

~\$55 billion
Economic value add in 2030

~350,000
Jobs created in 2030

Implications of systems-level solution across SEA decarbonization systems

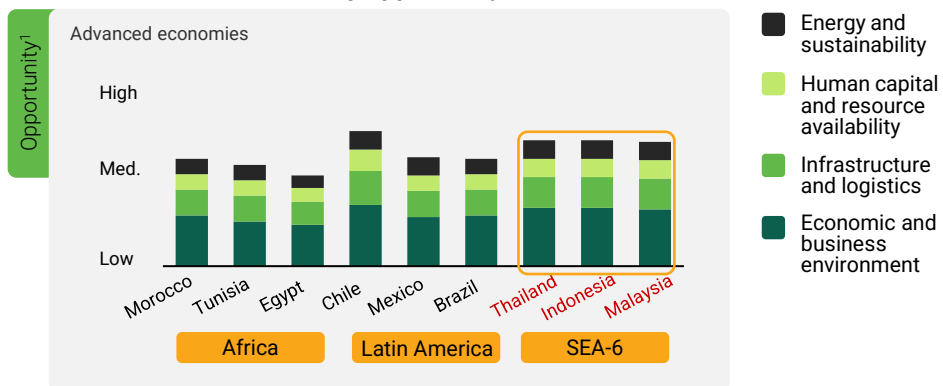


With the right policies and incentives, SEA can become an EV manufacturing hub

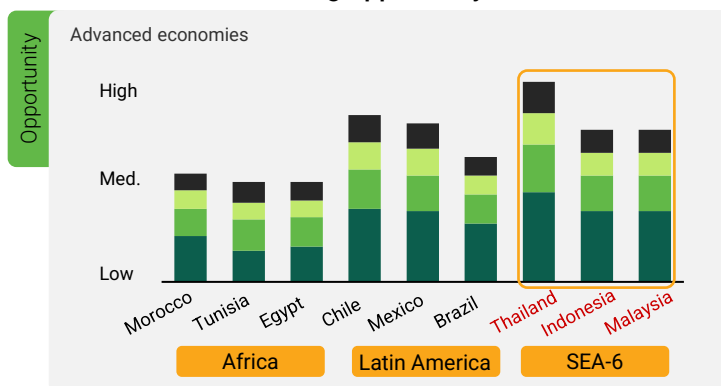
SEA-6 is a competitive manufacturing hub for EVs vs. other emerging economies ...

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

Batteries manufacturing opportunity assessment



EV cars manufacturing opportunity assessment



Key implementation levers to scale EV ecosystems and increase regional production

		Ease of implementation		High	Moderate	Low
Implementation levers addressing systemic barriers	Implementation levers	Expected economic value add ¹ (2030)	Ease of implementation			
	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	~\$1.0–\$1.1B	Moderate Private corporations are earmarking investments in the space, with several logistic firms piloting last mile fleet electrification			
	Deep dive ahead					

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; Necessary; 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?

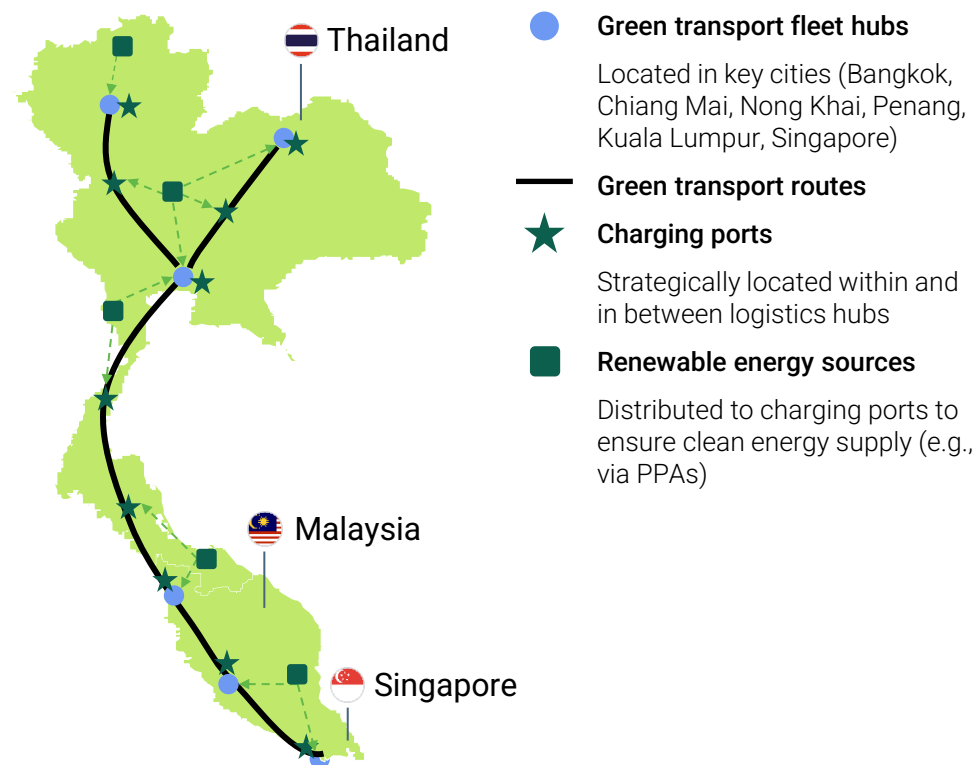
- **Light commercial transport represents 13%** of transport emissions in APAC
- **Total cost of ownership** for light EVs is becoming attractive

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



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)

Key success factors

- Comprehensive demand-side government support provided** to kick-start EV adoption (e.g., dual-credit policy, EV purchase subsidies)
- Robust domestic end-market demand** key for value chain development; demand driven by domestic adoption vs. export
- Commercial fleet** (e.g., trucks, tractors) **adoption ahead of consumer adoption**; early adoption in commercial vehicles increases government's appetite to deploy more subsidies
- 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



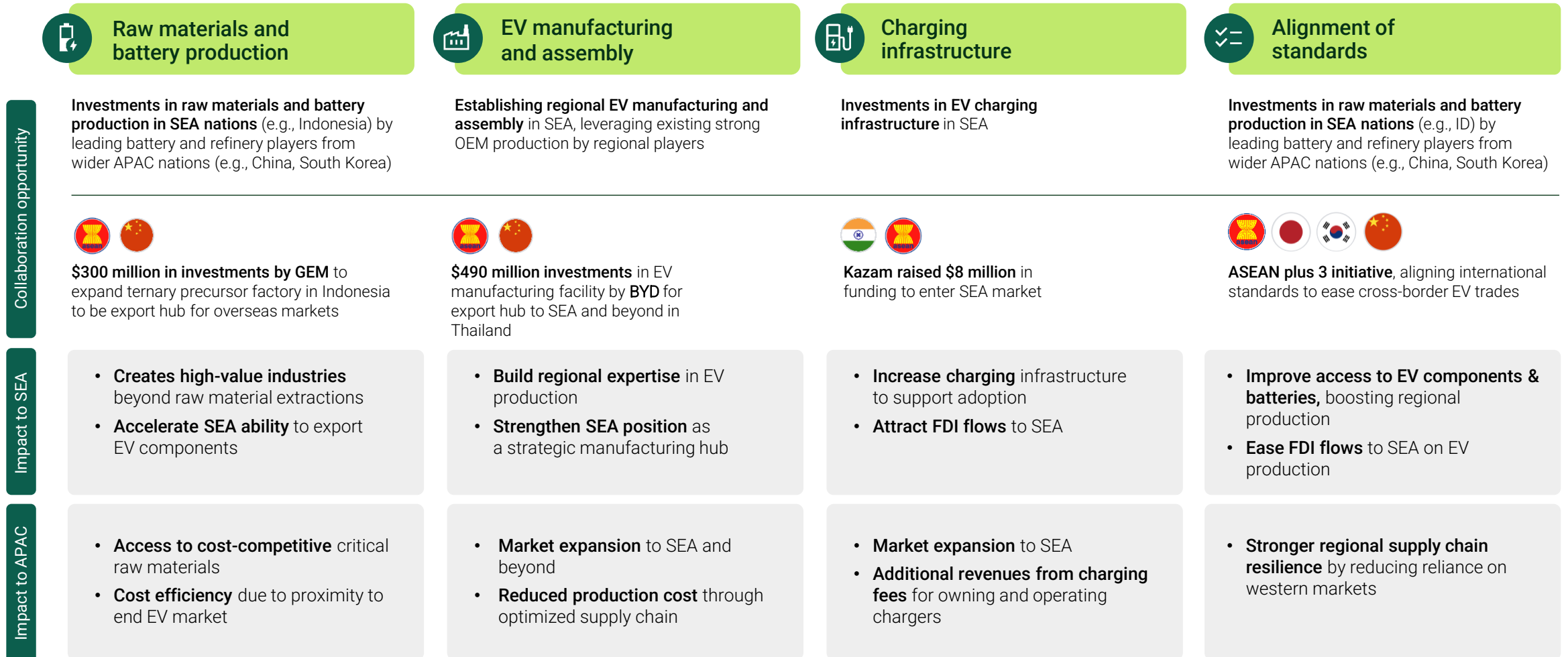
Fast-tracking EV adoption

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

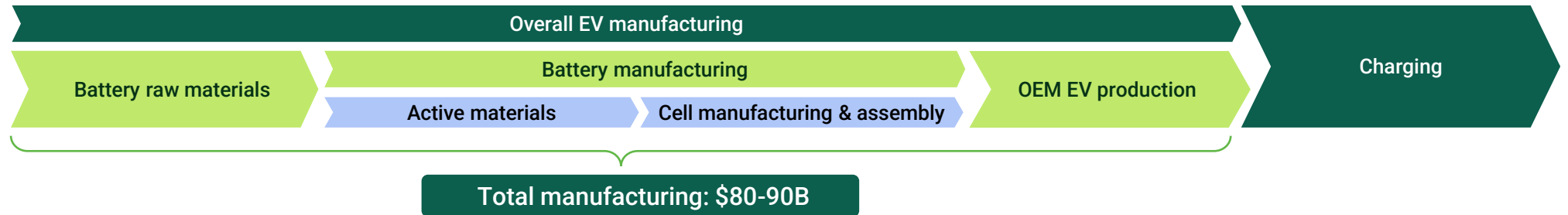
- Progressive government policies** driving initial adoption, boosting demand growth (e.g., ICE 3W registration restrictions, with recent initiative focused on battery-swapping policy)
- Strong collaboration across leading OEMs and component manufacturers** accelerates development of domestic EV ecosystem
- Growing start-up ecosystem** with >600 start-ups, fostering technological innovations across EV value chain
- 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



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	 	  	     

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 regulations¹ (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

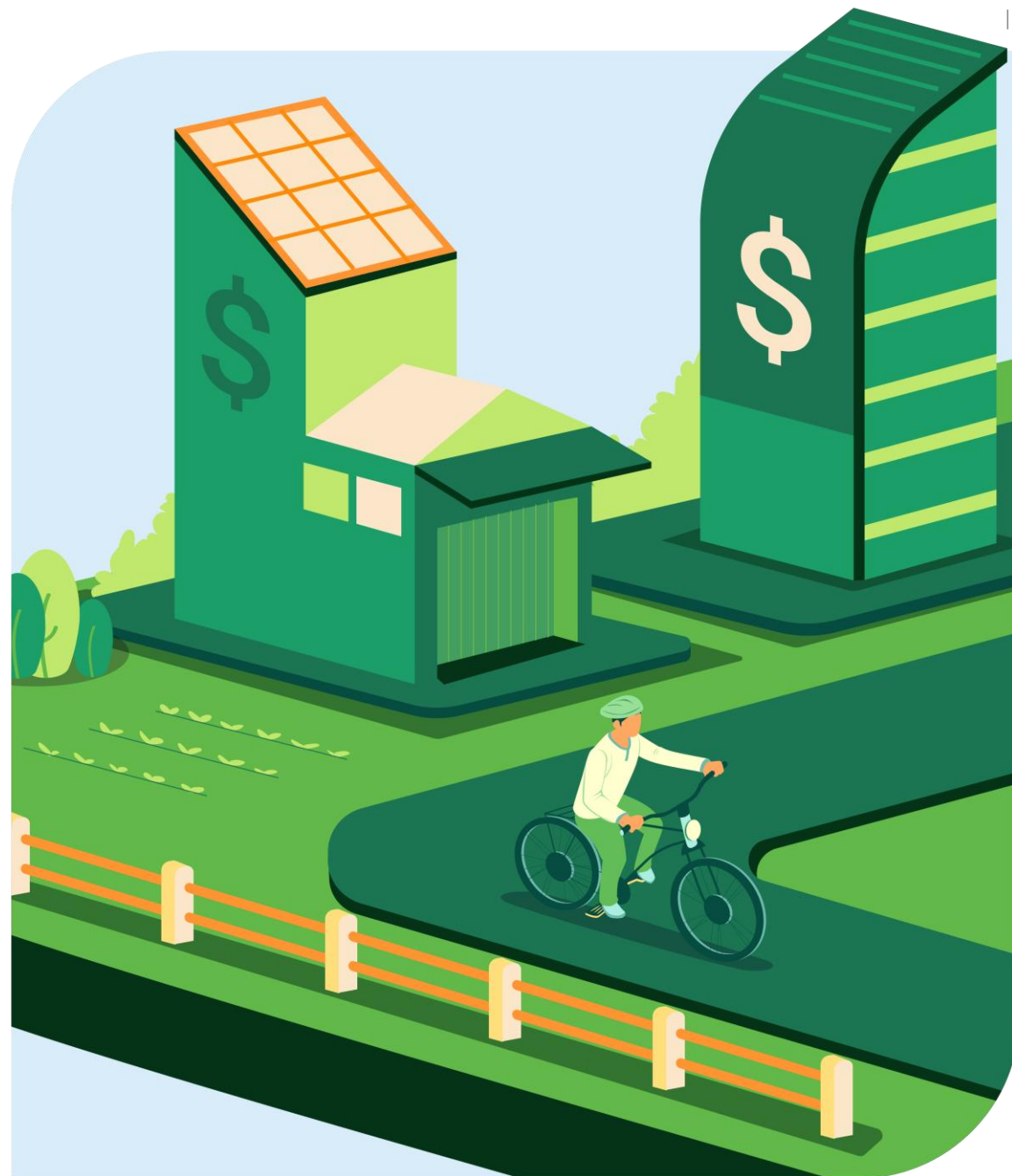
Develop financing mechanisms to reduce cost barriers for consumers and businesses

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

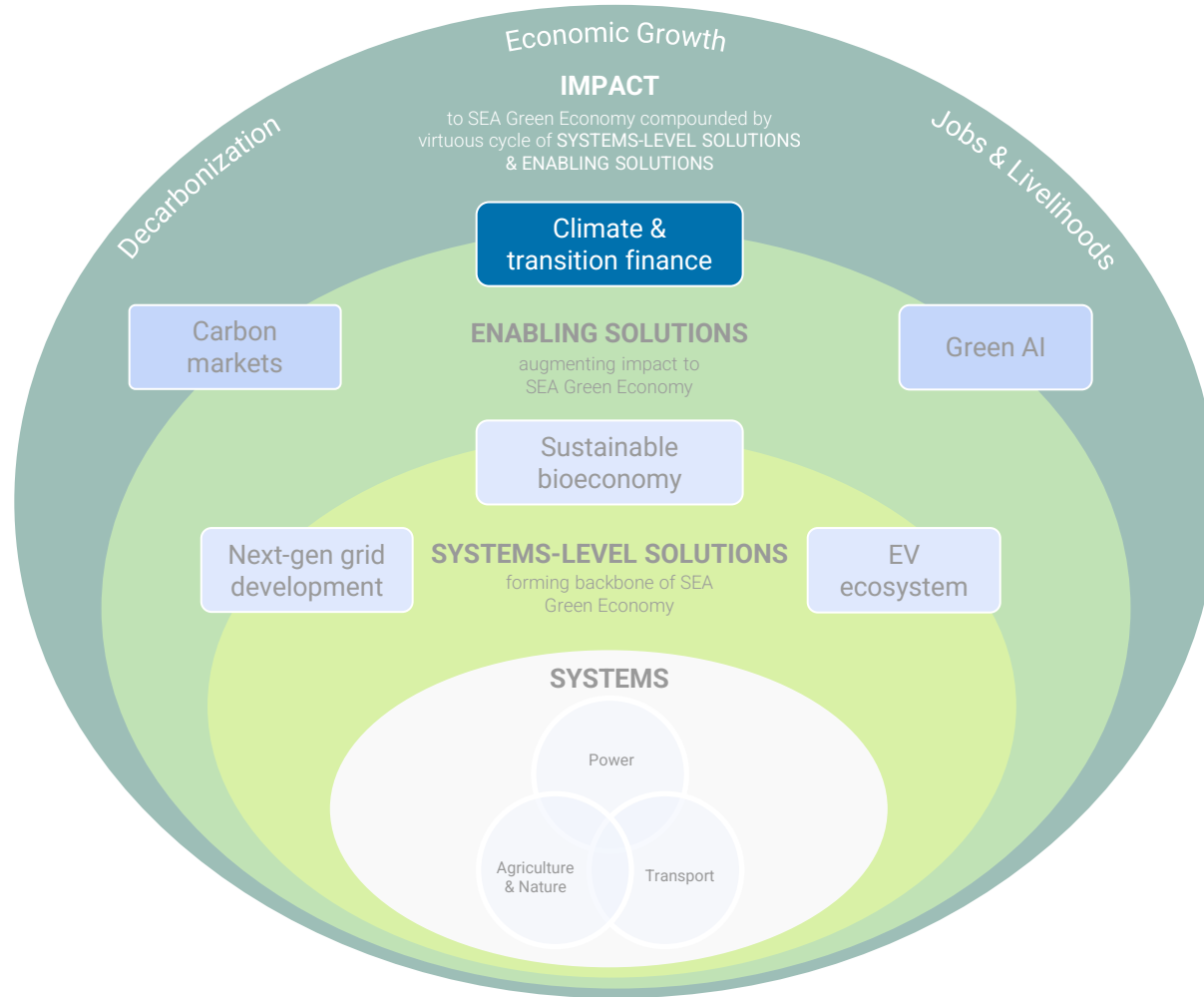
Enabling solution 1

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

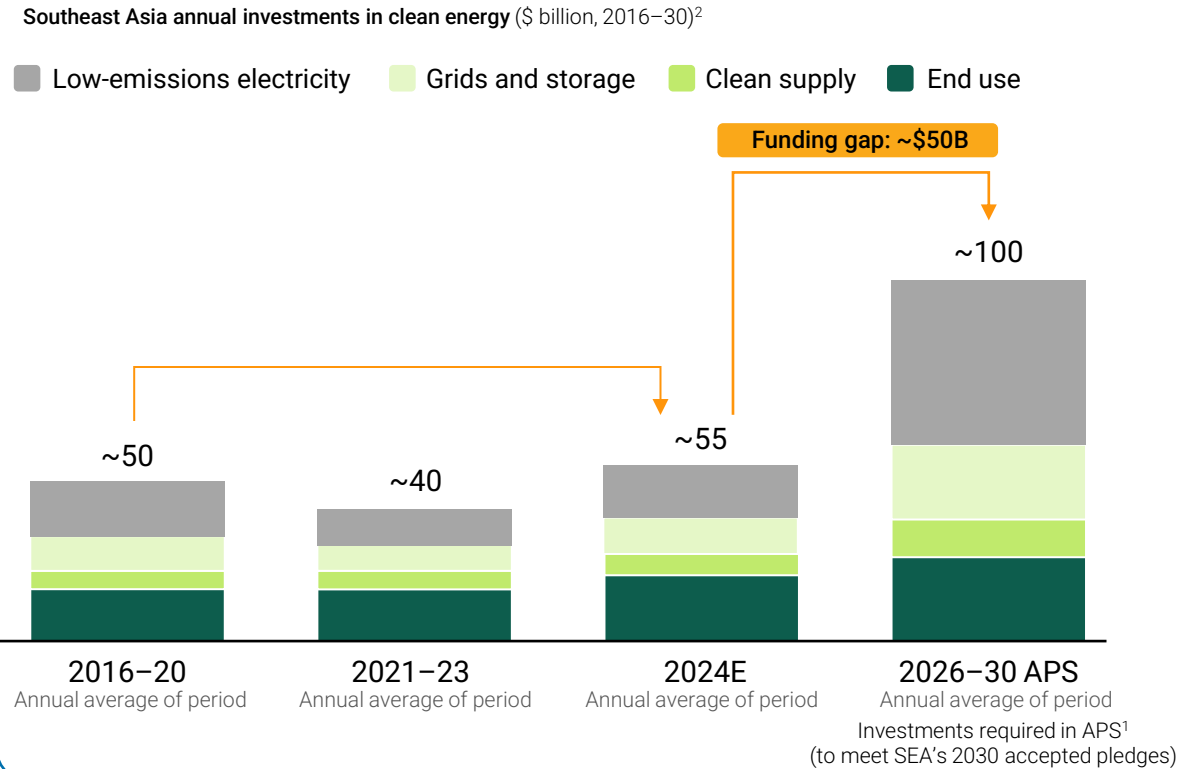
Key initiatives

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



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



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

Concessional and
blended finance

Revenue-backed
financing

Equity
instruments

Debt
instruments

Carbon
finance

Sustainable bioeconomy

Next-gen grid development

EV ecosystem

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

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

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

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

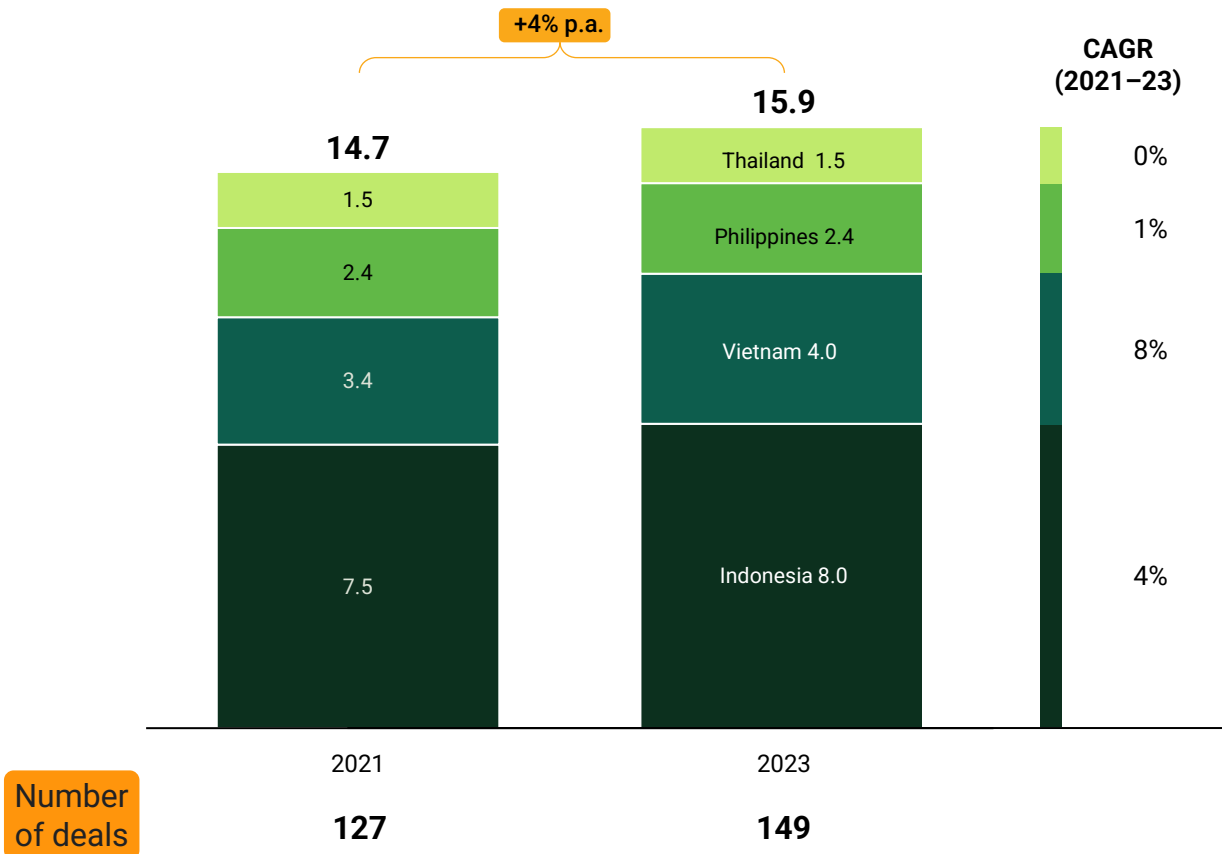
Investment use case: Biofuel production, upgrading grid, EV production (loan tied to production targets)

Carbon 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

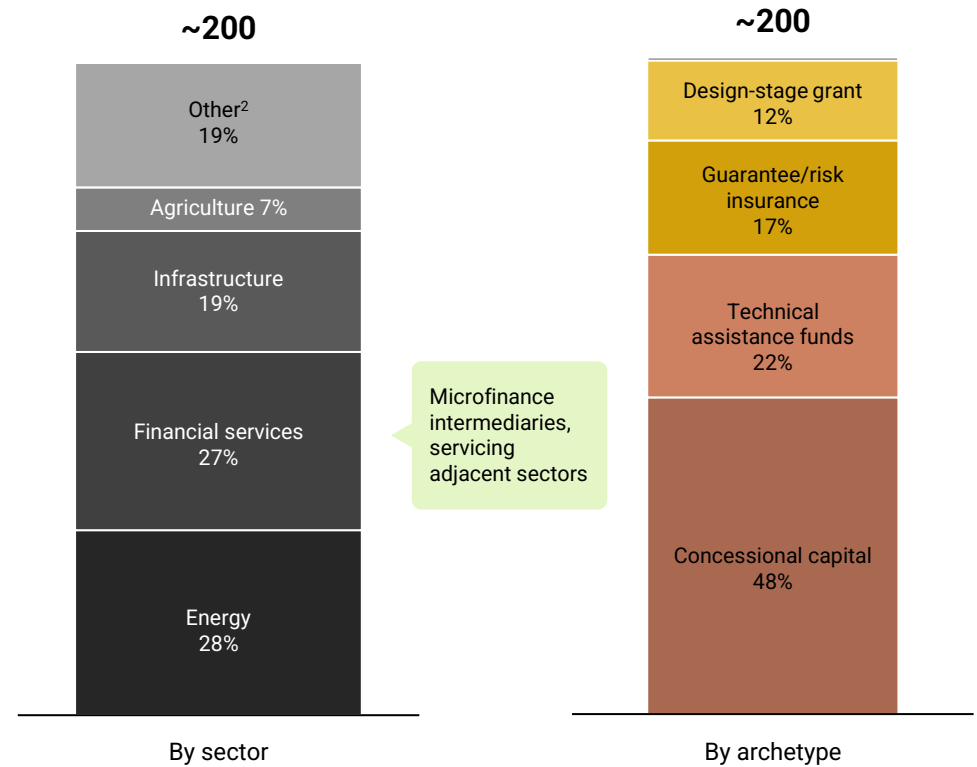
SEA accumulated blended finance capital invested

(\$ billion, 2021–23)



SEA accumulated deal¹ 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 IBRD¹ to scale the project and \$40 million loan to be disbursed under TCAF² based on verified emissions reductions

Strong policy alignment: Project's integration into VN's green growth strategy mandated local communities to adopt sustainable farming

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	MAS¹, in collaboration with public, private, and philanthropic sector partners, is supporting FAST-P², 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

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)

Set up supportive policies



Set up policies and incentives to boost low-carbon project attractiveness over high-emissions alternatives

Build proven repeatable models



Develop repeatable standards and playbooks for catalytic capital usage

Secure regional talent pool



Invest in talent development, capacity building, and dedicated green finance teams to strengthen expertise

Facilitate public-private cooperation



Improved collaboration between public (e.g., government, DFIs) and private entities to bridge trust and knowledge gaps

Key examples of recent progress made

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

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)

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

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

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

Case study



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

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

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 globally¹

\$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

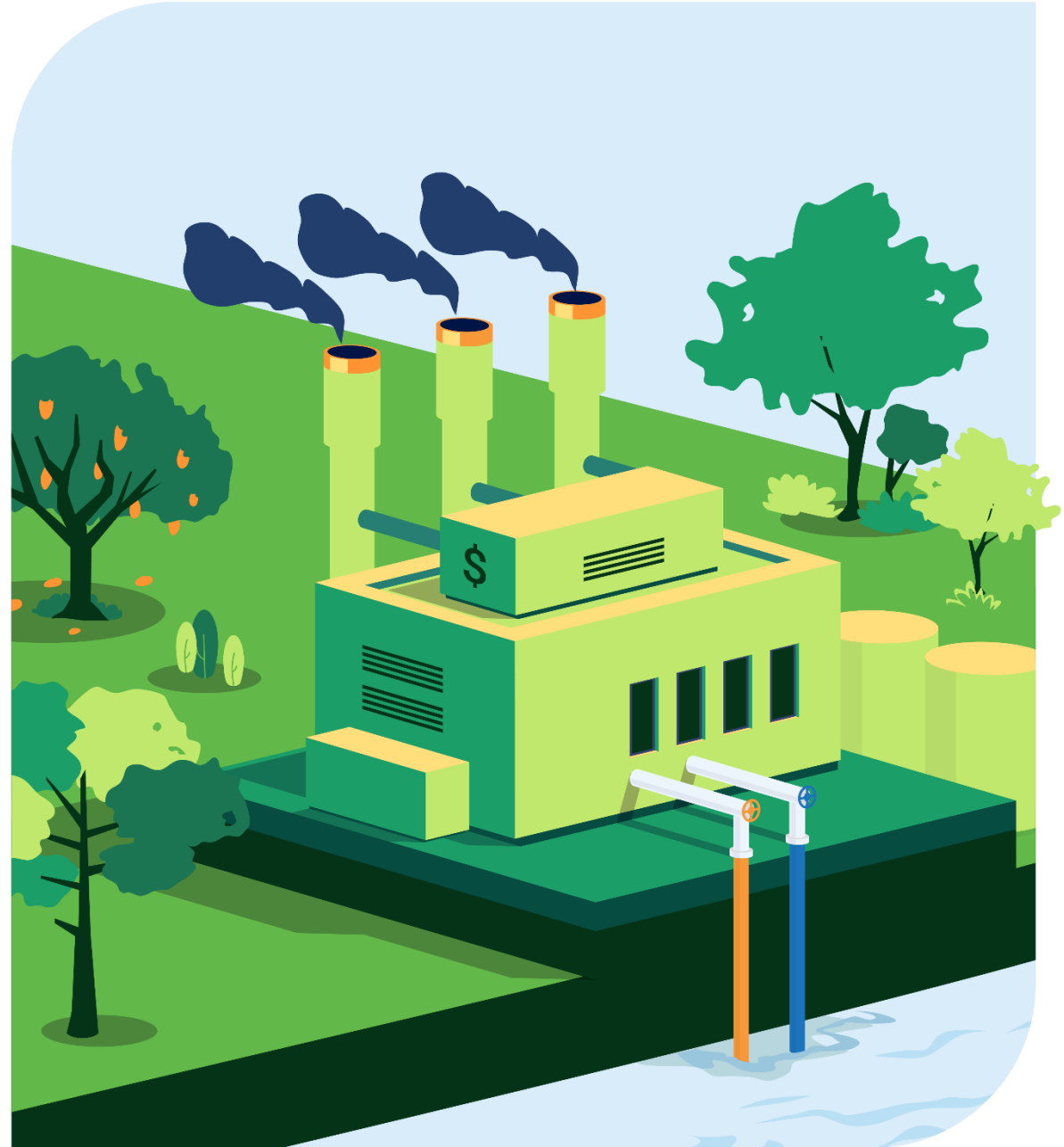
Recommendations | Key actions by stakeholders to bridge climate financing gap



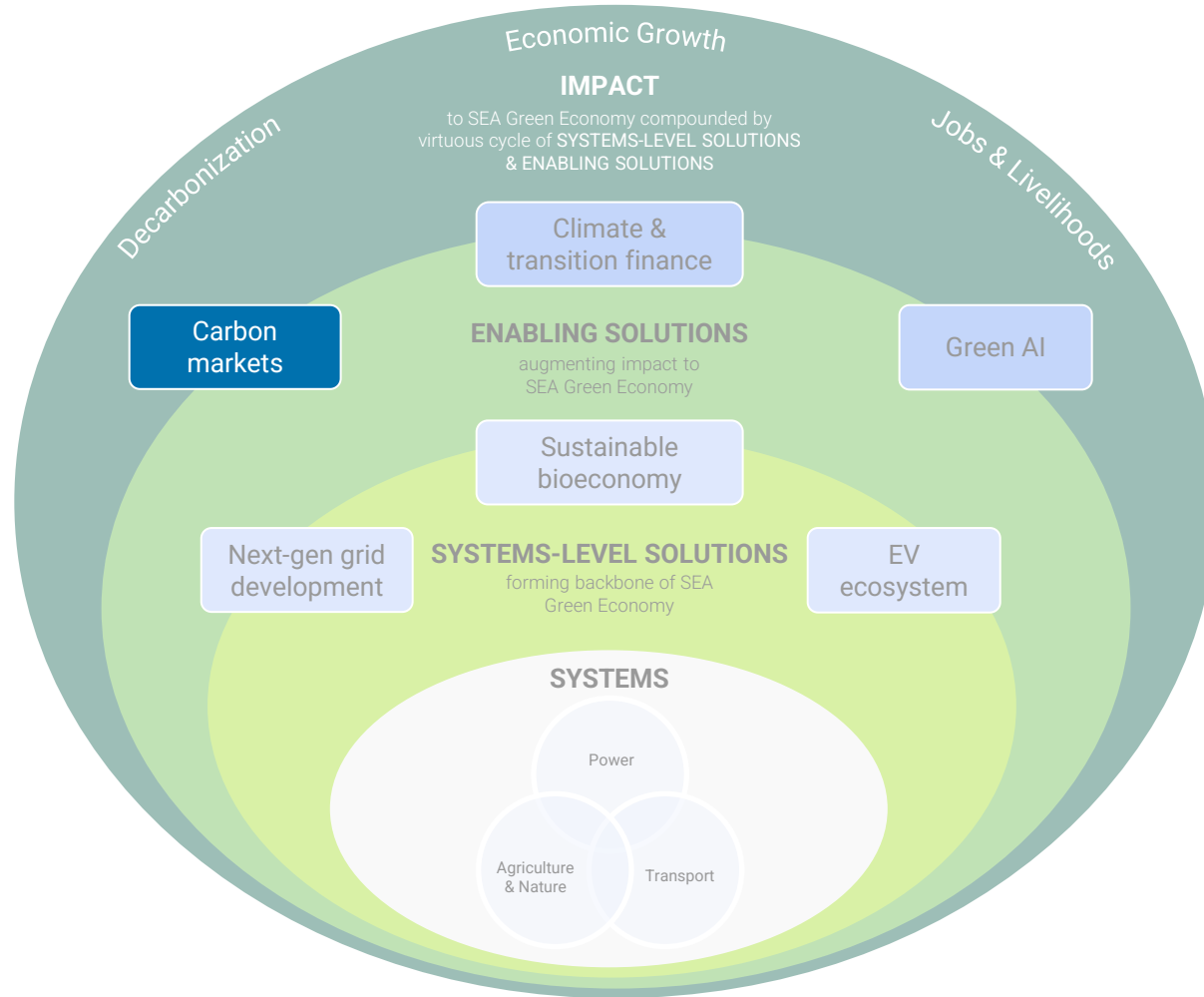
Enabling solution 2

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

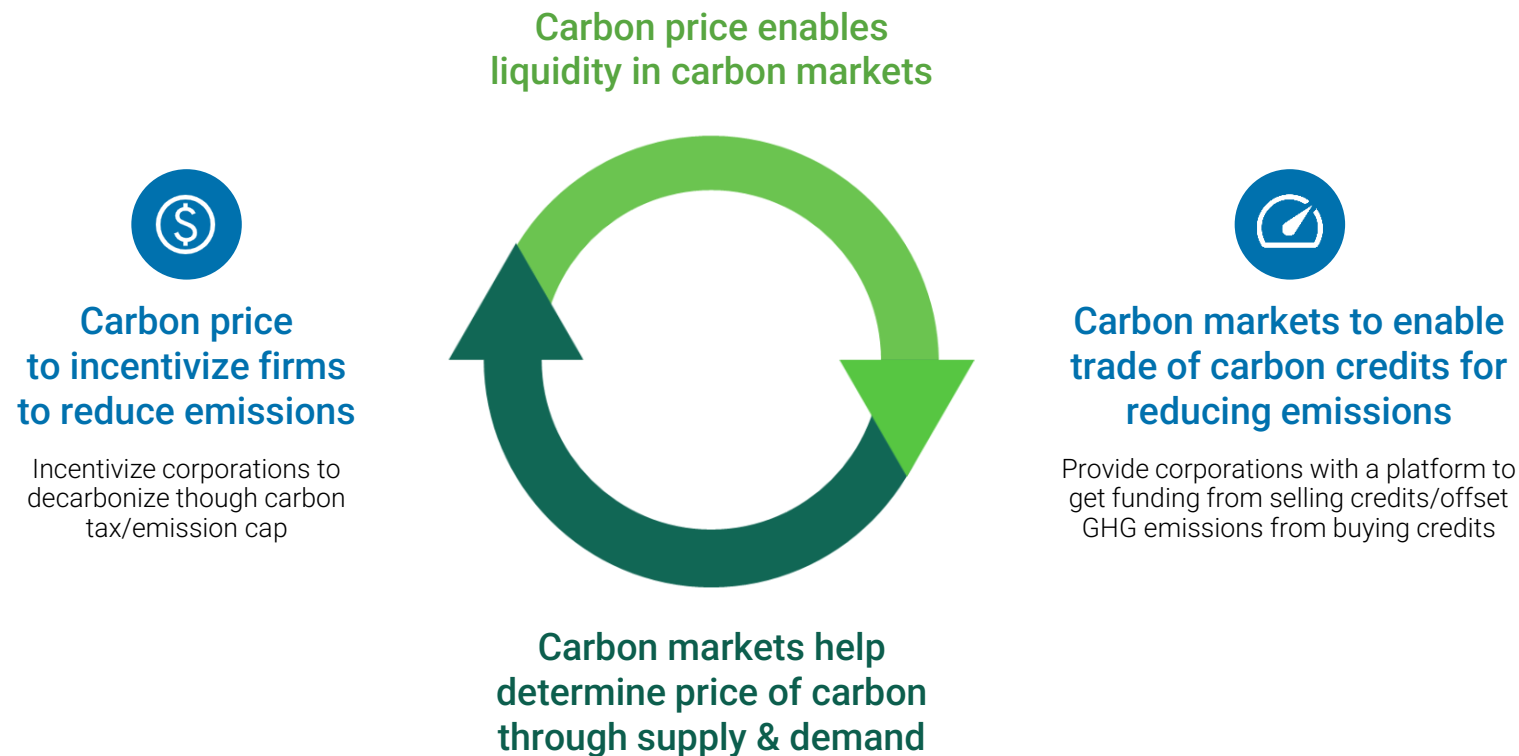
Harmonize **carbon market standards** to meet international demand



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

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

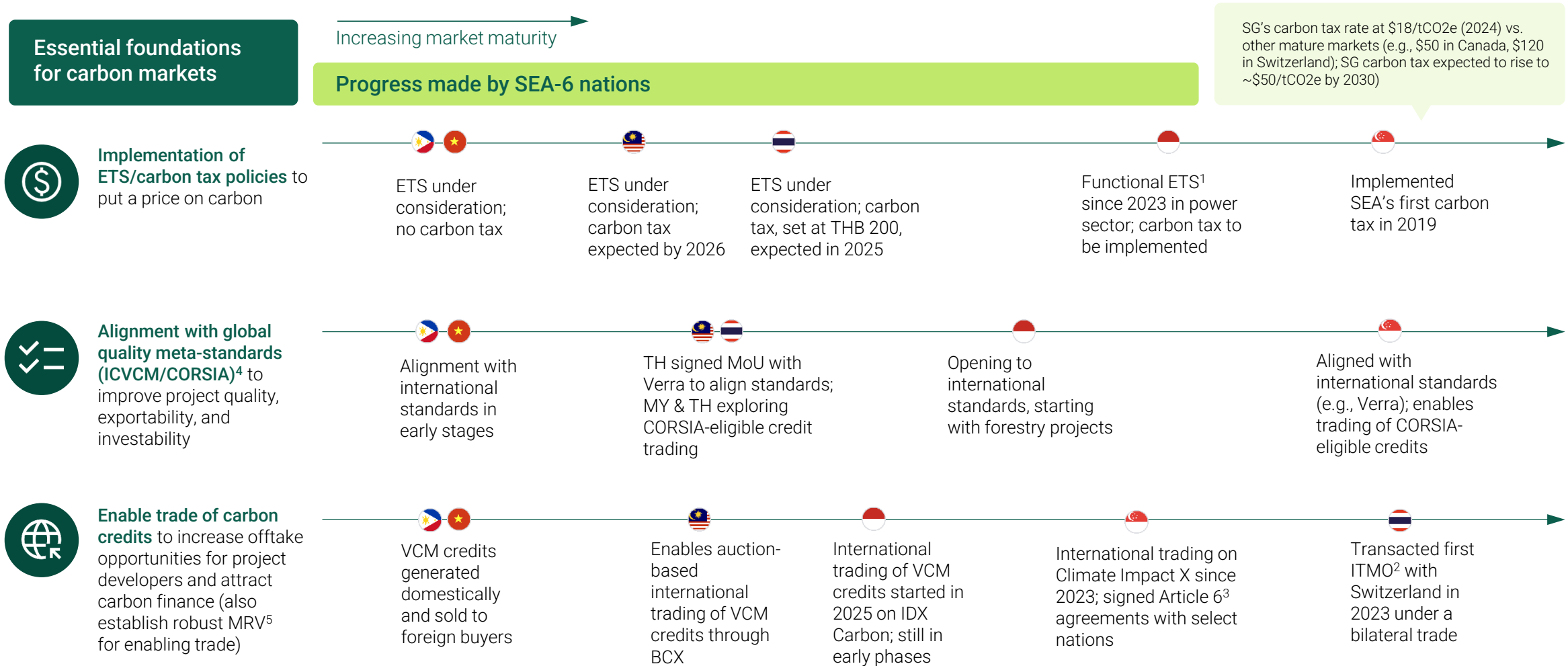
Patricia Espinosa,
Former UN Climate Change
Executive Secretary

“Carbon pricing can be one of the most powerful tools to help countries reduce emissions

Axel van Trotsenburg,
World Bank Senior Managing Director



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



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

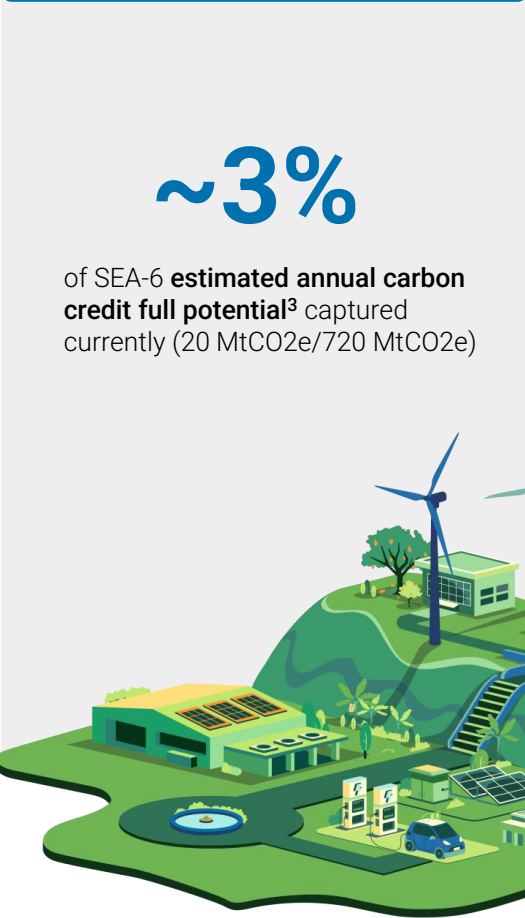
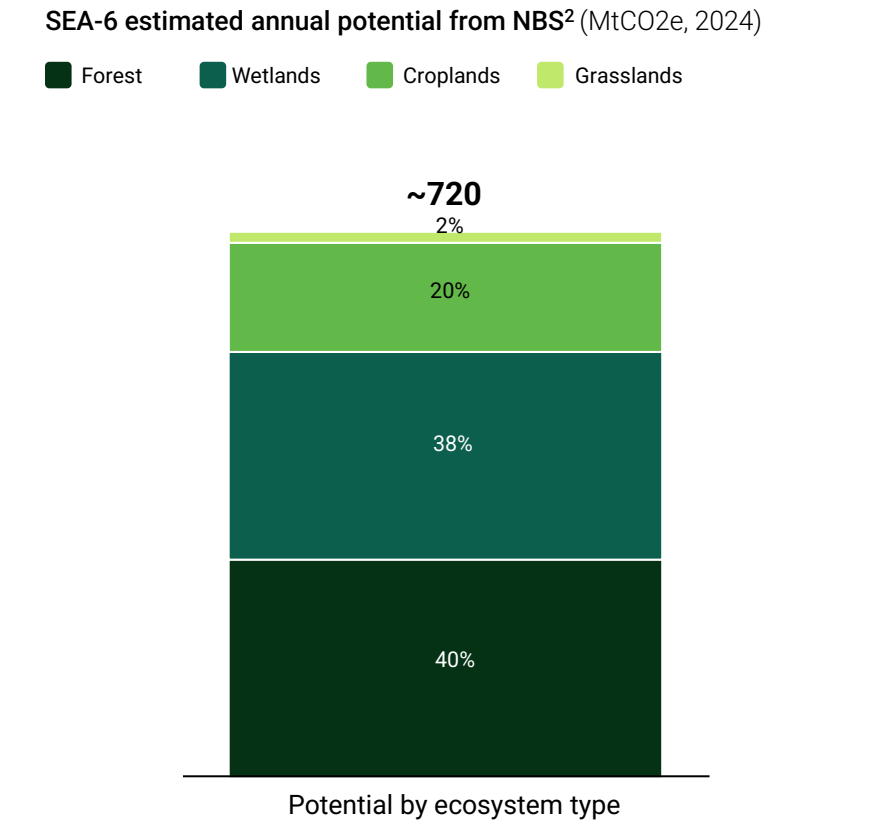
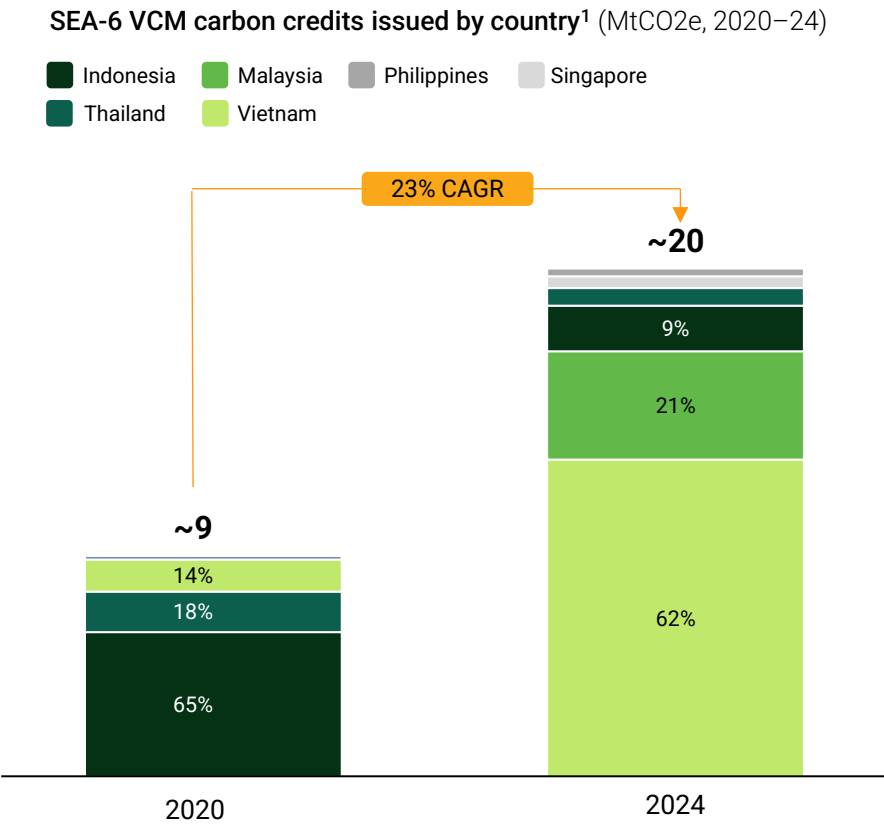
SEA-6 carbon credit issuance has traditionally grown at >20% CAGR ...



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



... reinforcing the huge untapped potential



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., ACCF¹)**
- **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)

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

/ Non-exhaustive

1

Bilateral agreements for credits trading

2

ASEAN Common Carbon Framework (ACCF)

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)



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

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

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

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

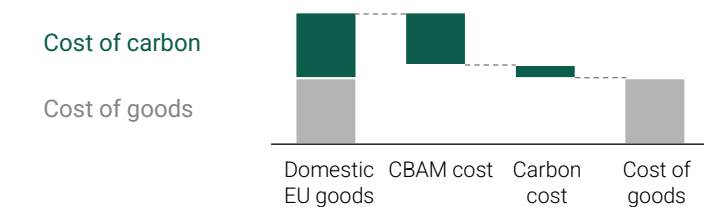
Bilateral agreements for international trade:

 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 producers¹:



APAC markets/sectors impacted by CBAM²:

Aluminum, iron & steel, fertilizers:

 China
  Malaysia
  Vietnam
  Indonesia
  India

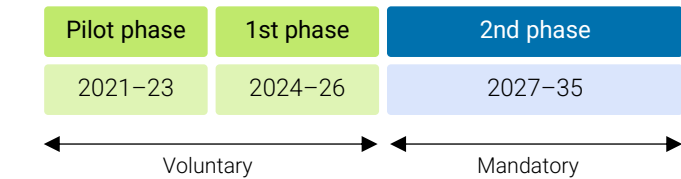
Cement, hydrogen:

 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



Positive demand trajectory; engagement needed to ensure SEA credit eligibility

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

Deep dive on following pages

Carbon markets use cases to accelerate systems-level solutions



Size of prize
 Additionality
 Feasibility

High priority		
Sustainable bioeconomy	Next-gen grid development	EV ecosystem
1 Sustainable agriculture Credits are awarded to farmers for adopting regenerative agriculture practices like AWD¹ 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	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) solutions² Projects that capture carbon emissions from industrial facilities and store them underground	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		
High Medium Low	High Medium Low	High Medium Low

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 IBRD¹ to scale the project and \$40 million loan to be disbursed under TCAF² based on verified emissions reductions

Strong policy alignment: Project's integration into VN's green growth strategy mandated local communities to adopt sustainable farming

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

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

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



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

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 CO2 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

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

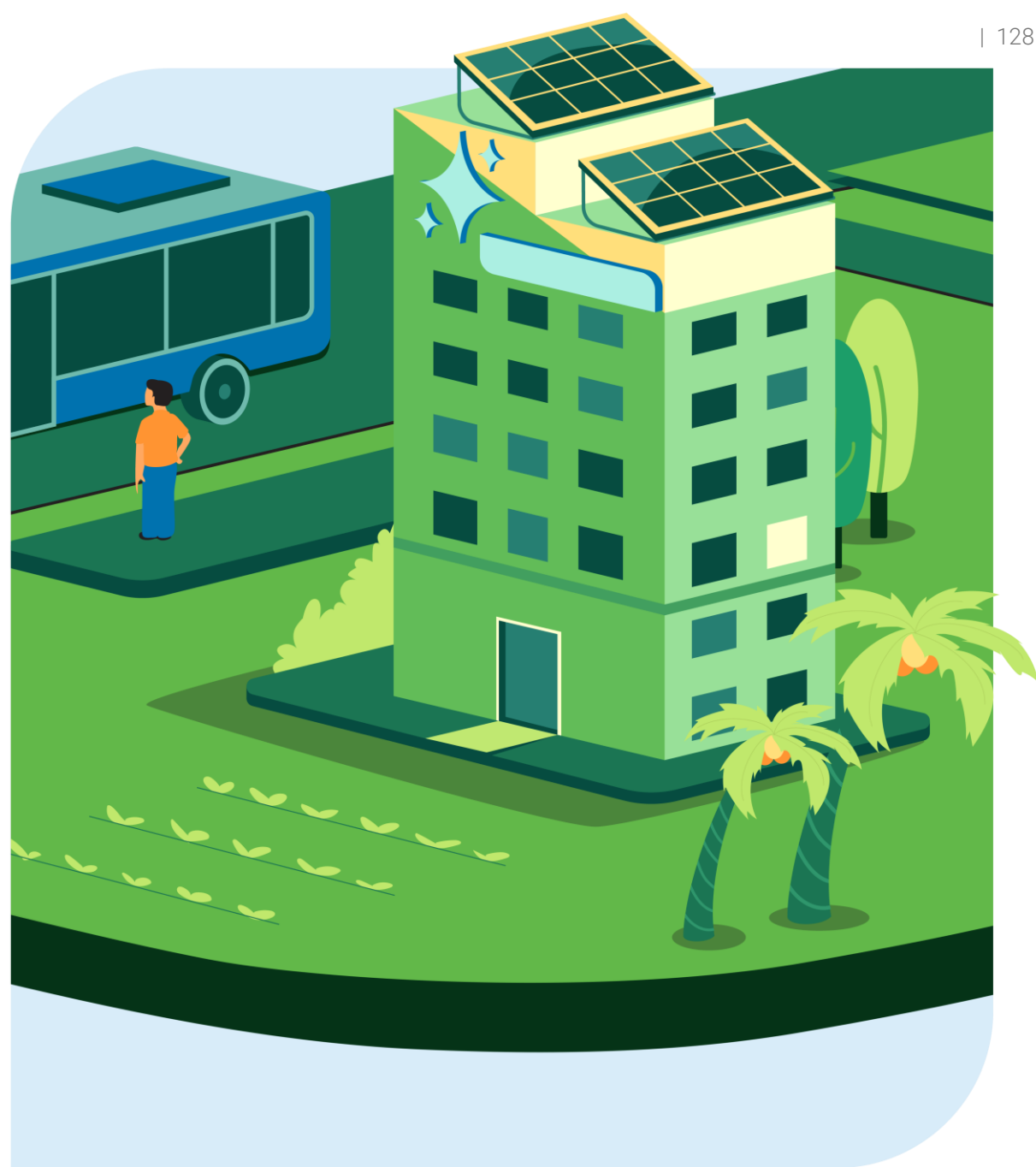
	 Policymakers and regulators	 Corporations	 Carbon market ecosystem players	 Investors and financial institutions
Demand	Develop carbon pricing schemes (ETS/carbon tax) Collaborate with industry to set and phase up a carbon price to incentivize demand Establish clear framework for eligible credits and claiming rules	Leverage carbon credits to mitigate emissions in hard-to-abate areas Leveraging VCM 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 - IOSCO¹ 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

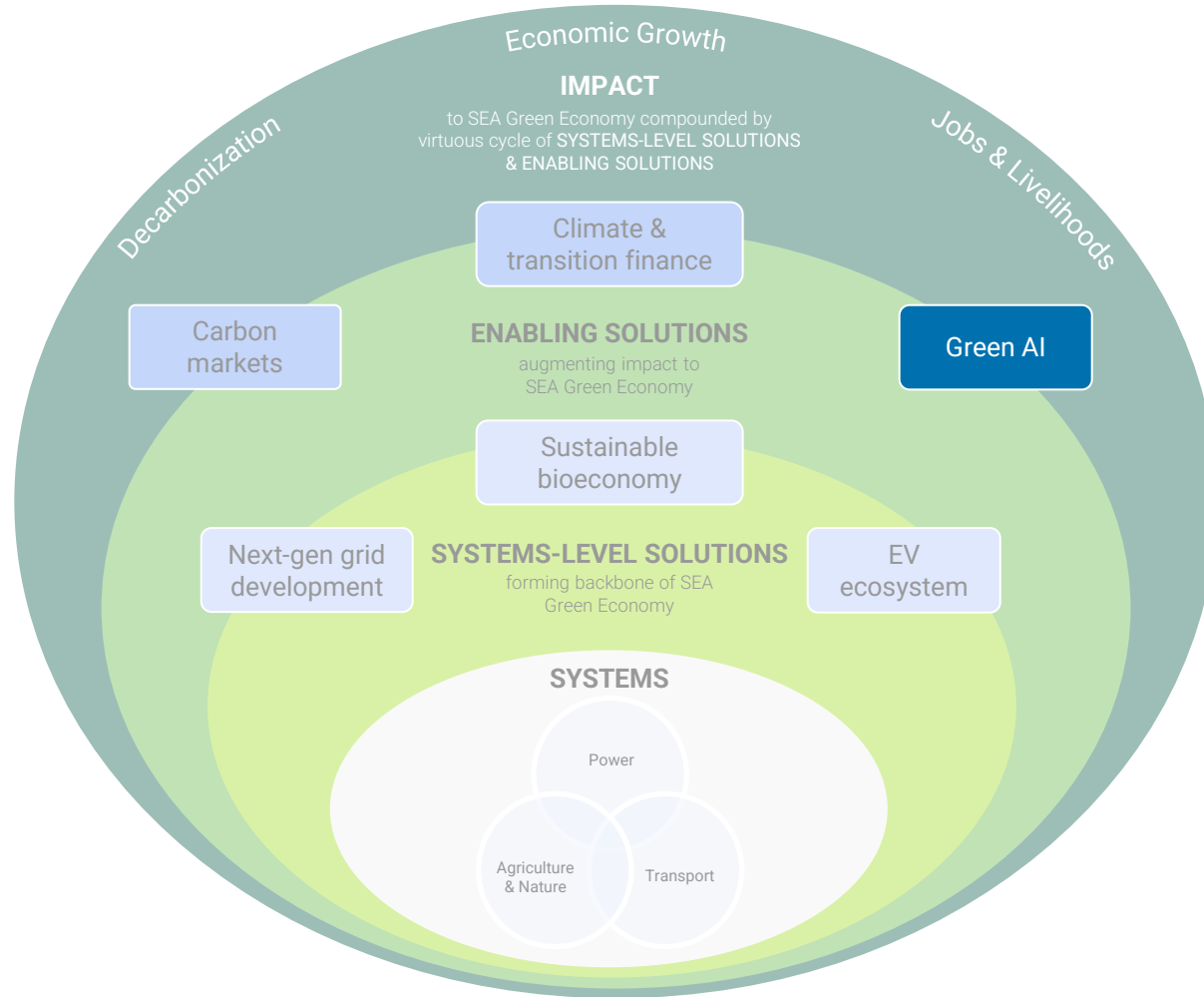
Enabling solution 3

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



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 tasks¹ could be
accelerated with access to
software built on AI models

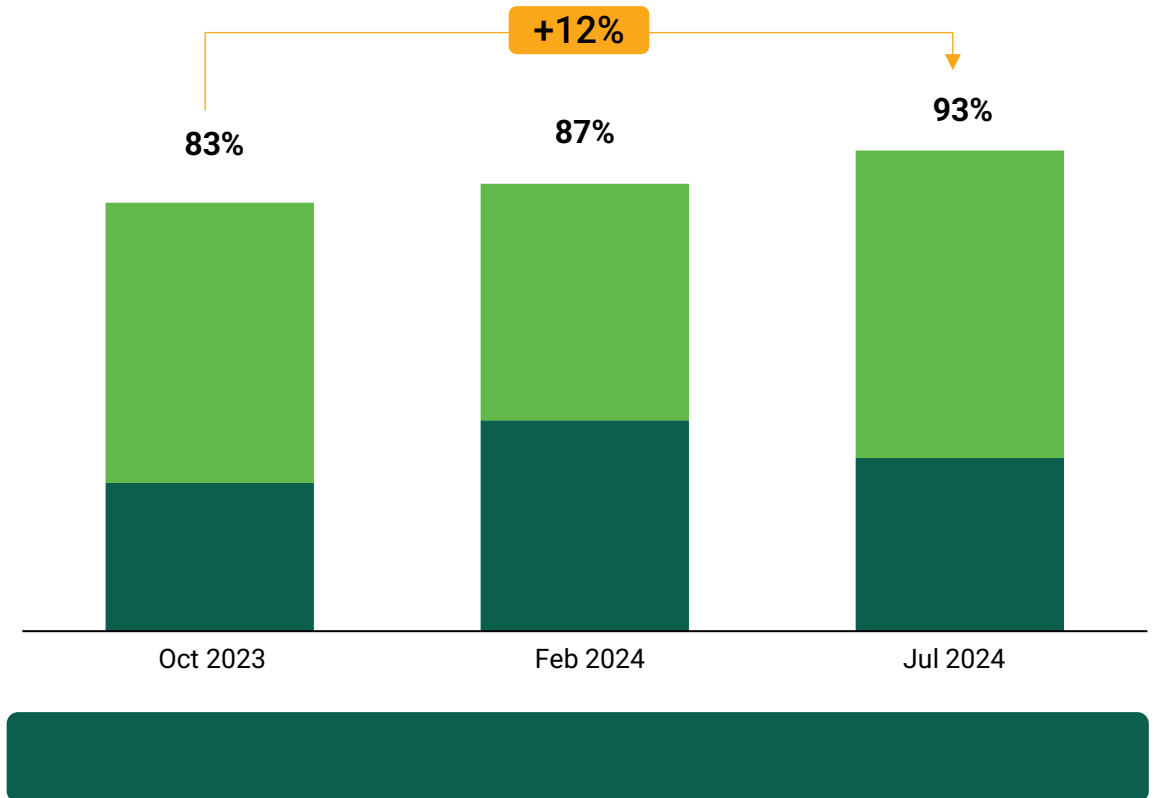
15%

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)

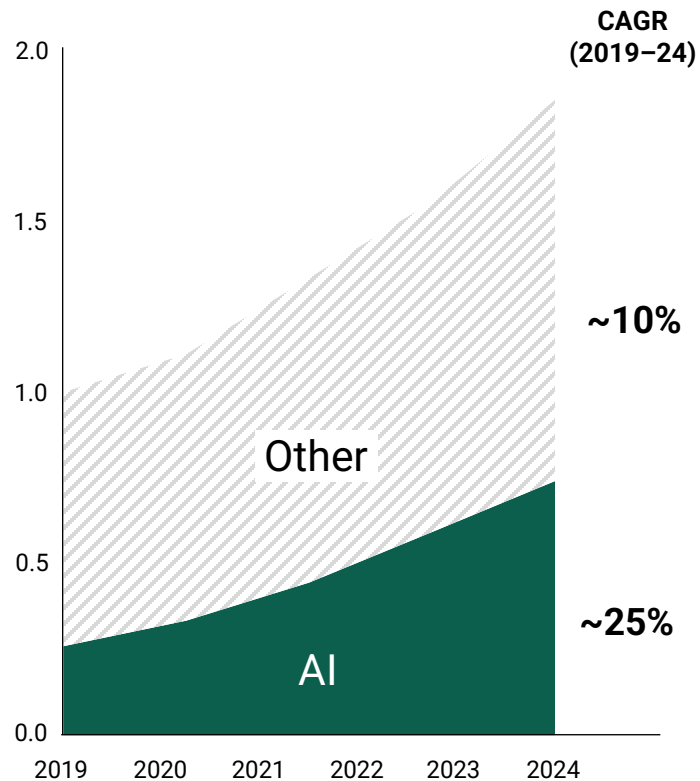
■ In production ■ Developing/piloting



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)

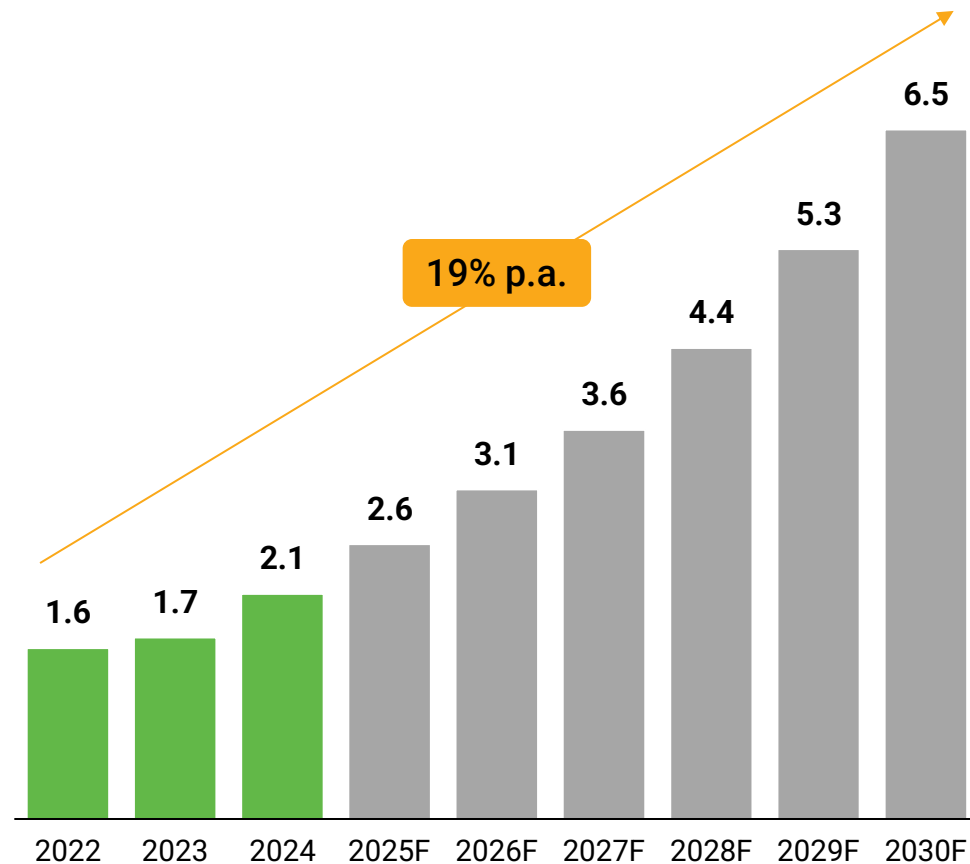
Outdated grid infrastructure

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

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

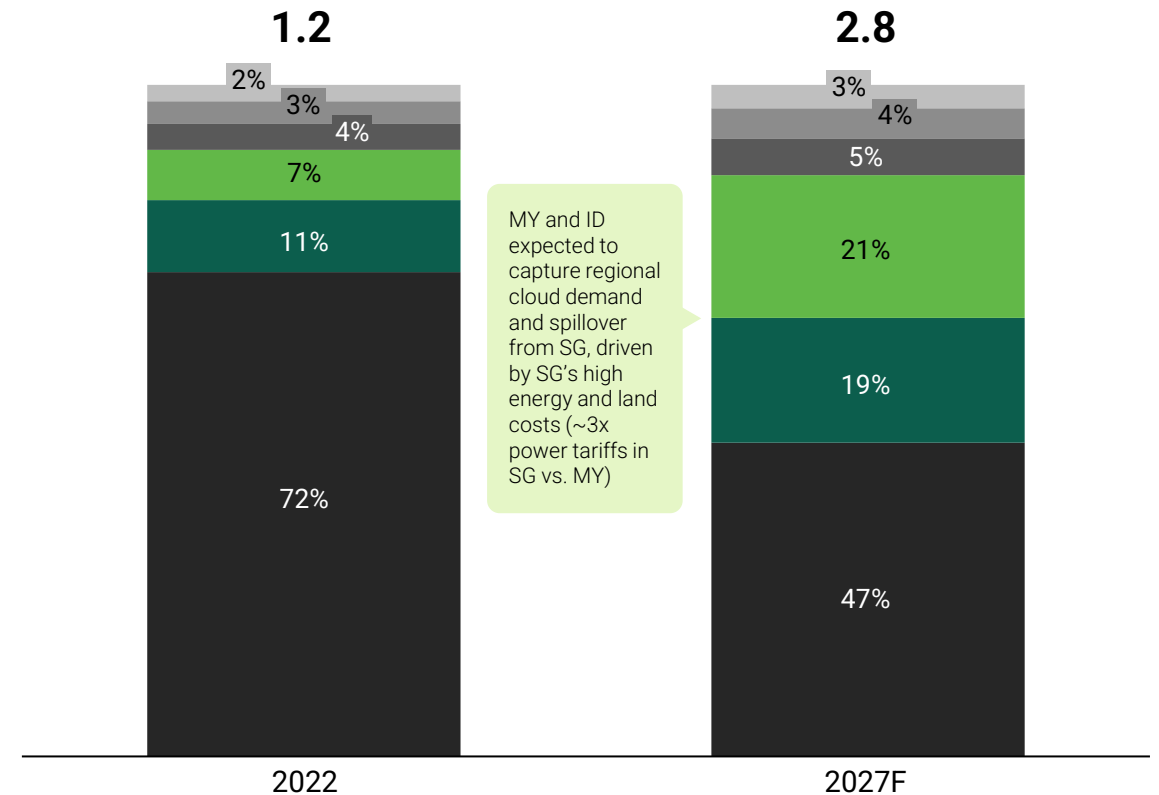
Data center energy demand in SEA nations (GW)¹



DC demand mix likely to shift towards Malaysia and Indonesia

Data center energy demand share (GW)¹

Singapore
 Indonesia
 Malaysia
 Thailand
 Philippines
 Vietnam

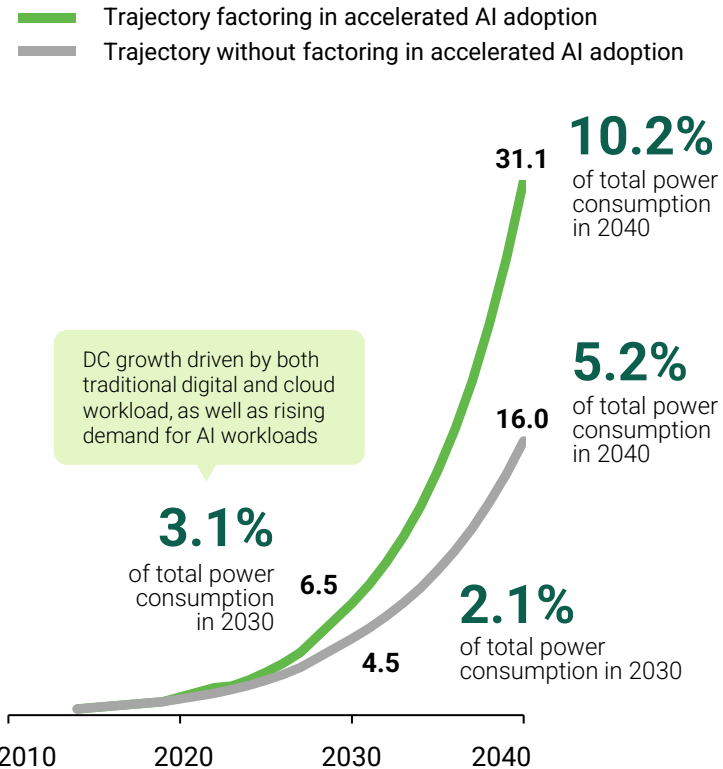


Notes: (1) Represents total power capacity; 2023–27 CAGR (~21%) used to extrapolate DC energy demand till 2030 | Sources: CGSI research; DC Byte; Maybank IBG research; Bloomberg

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

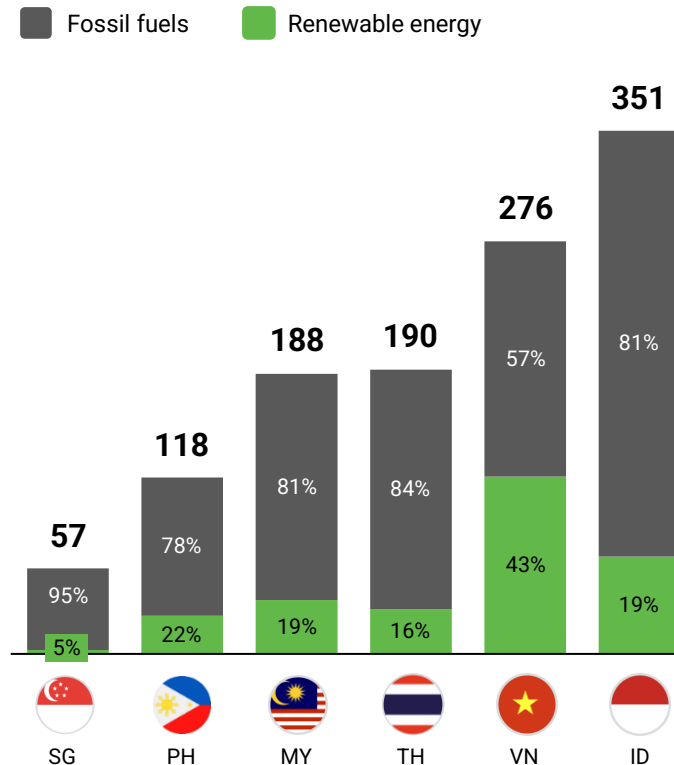
DC growth to use ~10% of total power demand in 2040 (vs. previous estimates of 5%)

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

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

DC growth could contribute up to ~2% of emissions by 2030; however, this could be lower depending on market developments¹

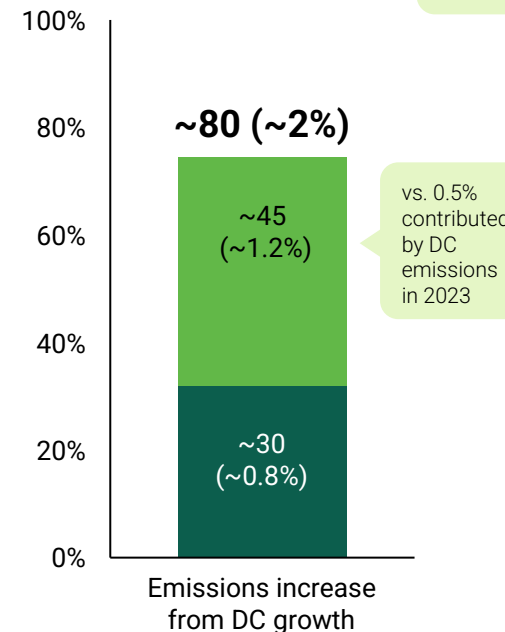
	IEA	Bain & Company
GW power demand by DCs in SEA in 2030	~5	6.5
Percentage of total power demand from DCs in SEA in 2030	2.3%	3.1%

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

GHG emissions (2030) in MtCO₂e (percentage of 2030 total emissions)

- DC operation emissions
 - DC manuf. emissions²
- ~15%–30% of emissions attributed to AI workloads



Market developments that could potentially reduce 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 PUE³
(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 MGV 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  Slovakia	T-Mobile CE-Colo	Data center/telecom operators across Czech Republic and Slovakia have signed VPPA with RE provider in Romania ↓ 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.

AI potential to impact wider emissions reduction; 3%–5% annually in key systems

AI use cases to drive emissions reduction

	 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	★ Deep dive ahead ★ AI-optimized RE generation, leveraging weather forecast data ✓ AI-driven modelling to forecast maintenance needs of power plants	✓ High-impact solutions / Non-exhaustive - 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 potential¹ (percentage of reduction within the sector/percentage of overall emissions reduction in 2030)	~3%–5%/~0.9%	~4%–5%/~0.9%	~4%/~0.4%

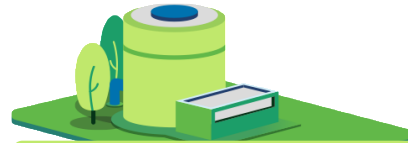
Several proven AI and generative AI applications are already delivering measurable GHG emission reductions across corporations globally

	Airbus	Google DeepMind
Overview 	Airbus leveraged generative design to create a new partition for the A320 aircraft 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	Google collaborated with DeepMind to forecast the quantum of wind-energy that can be generated in the future 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

AI use cases have the potential to accelerate and amplify impact of systems-level solutions for SEA



AI-driven levers to accelerate systems-level solutions



Sustainable bioeconomy

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



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



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



Expected impact

Moderate to high

AI enhances land-use efficiency and carbon sequestration; however, scaling depends on adoption by farmers and land rights clarity

Moderate to high

AI can materially reduce energy needs by optimizing both energy demand and clean energy supply, but legacy infrastructure hinders full deployment

High

AI optimizes energy usage in EV infrastructure and benefits from strong policy and market momentum

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

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 formation¹ 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

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 sustainability¹

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



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

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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

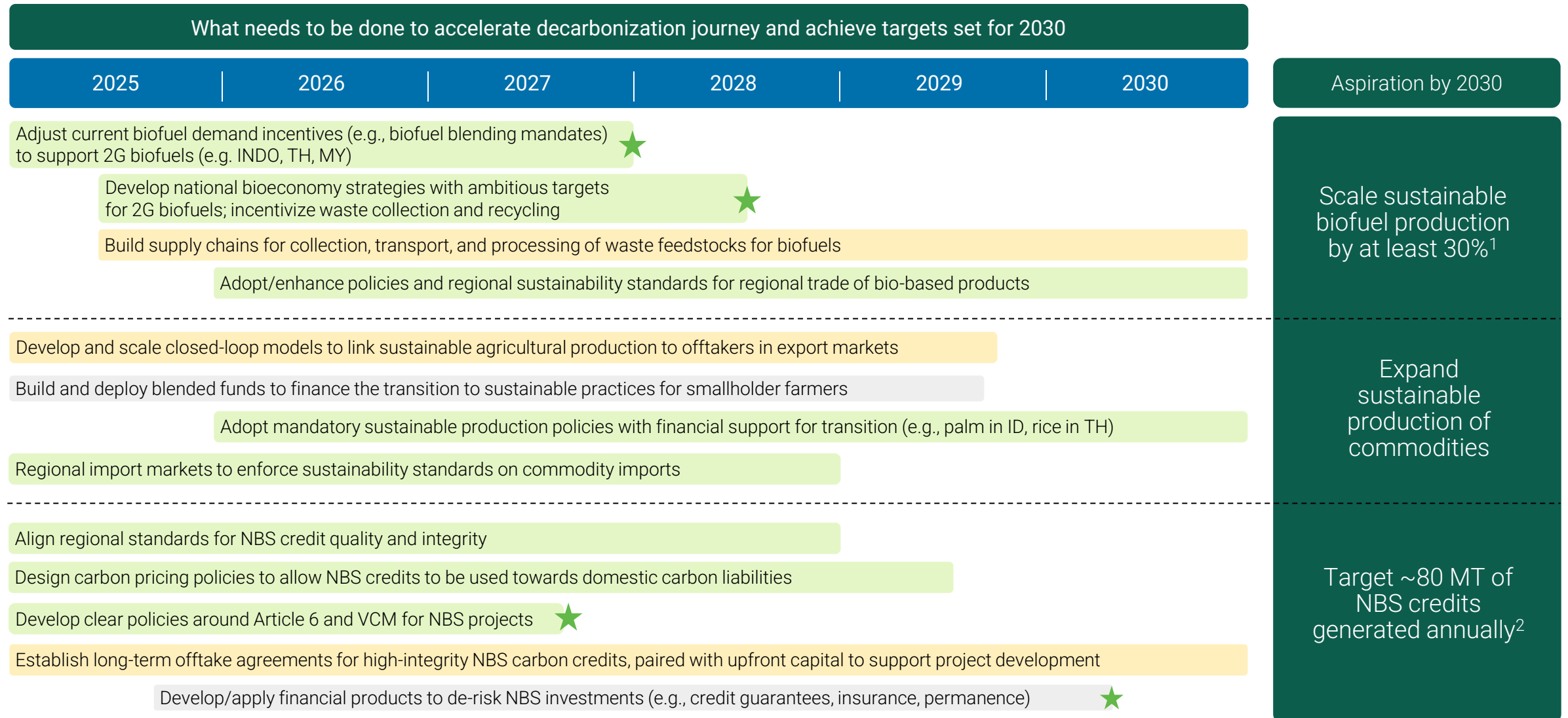


Our recommendations will address systemic obstacles to across all three systems

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

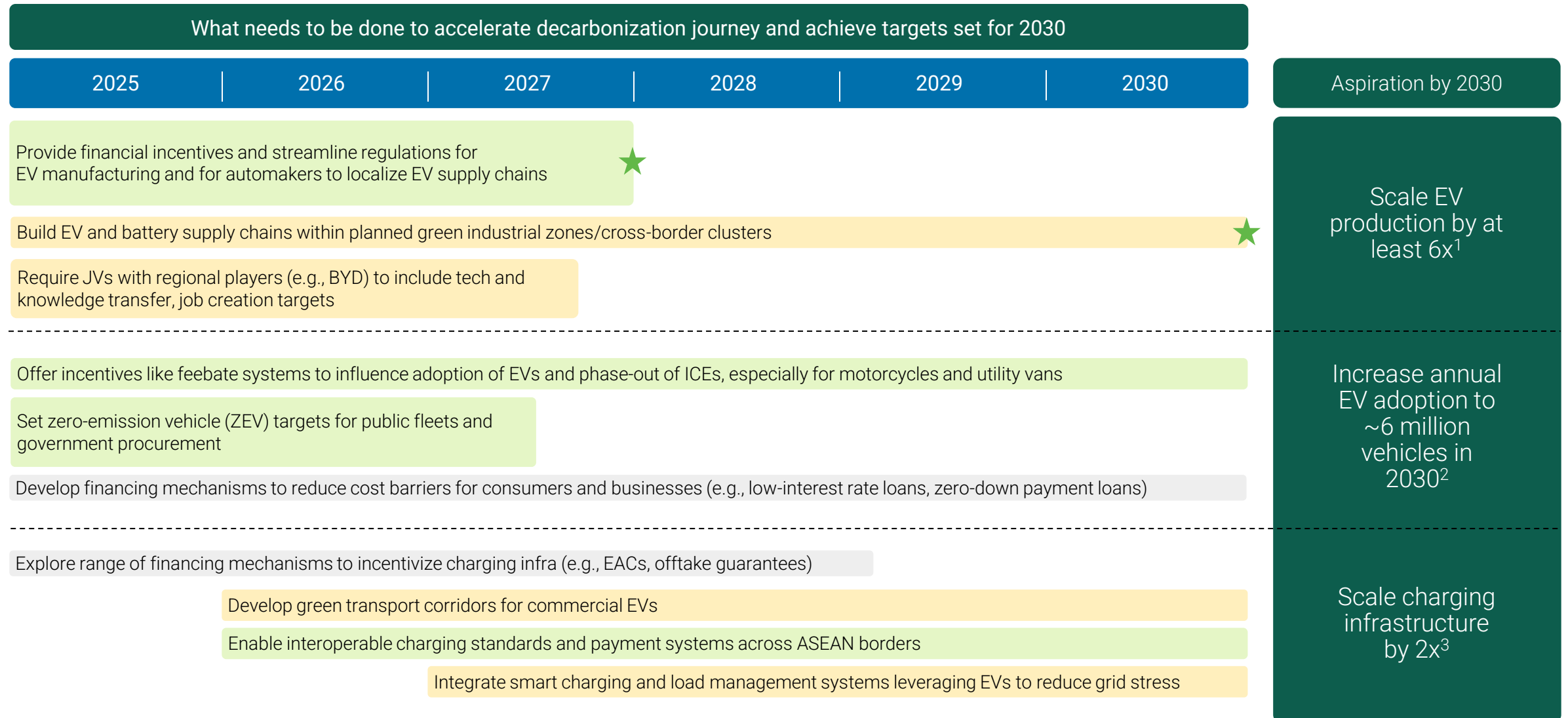
■ Policymakers to lead ■ Corporations to lead
■ Investors to lead ★ High-potential, priority activity



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



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

Aspiration by 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)

Achieve ~\$20 billion annual grid investment¹

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

Achieve ~20% RE penetration in electricity generation²

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

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

12



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

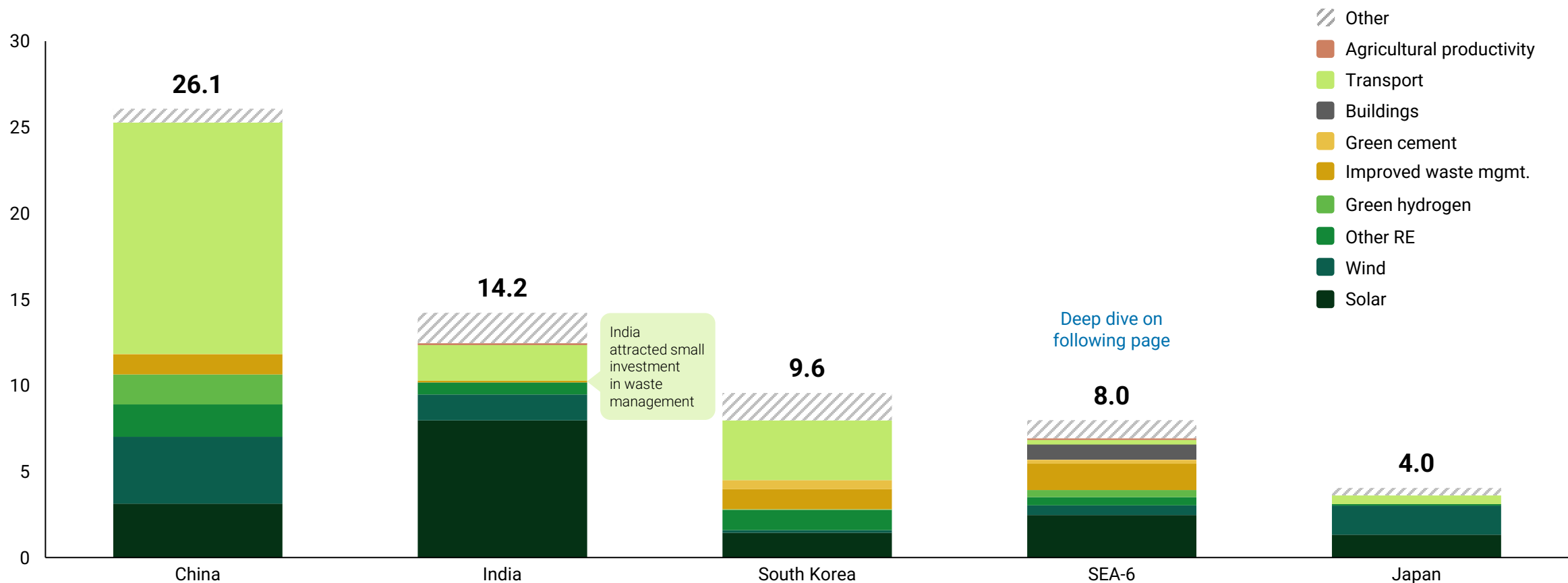


This analysis represents a **selective view and includes private investments only**, excluding government investment, public markets investment, and debt financing

China, India, and South Korea lead private green investments in Asia-Pacific; transport, solar, and wind attract most green investments

APAC

APAC private¹ 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

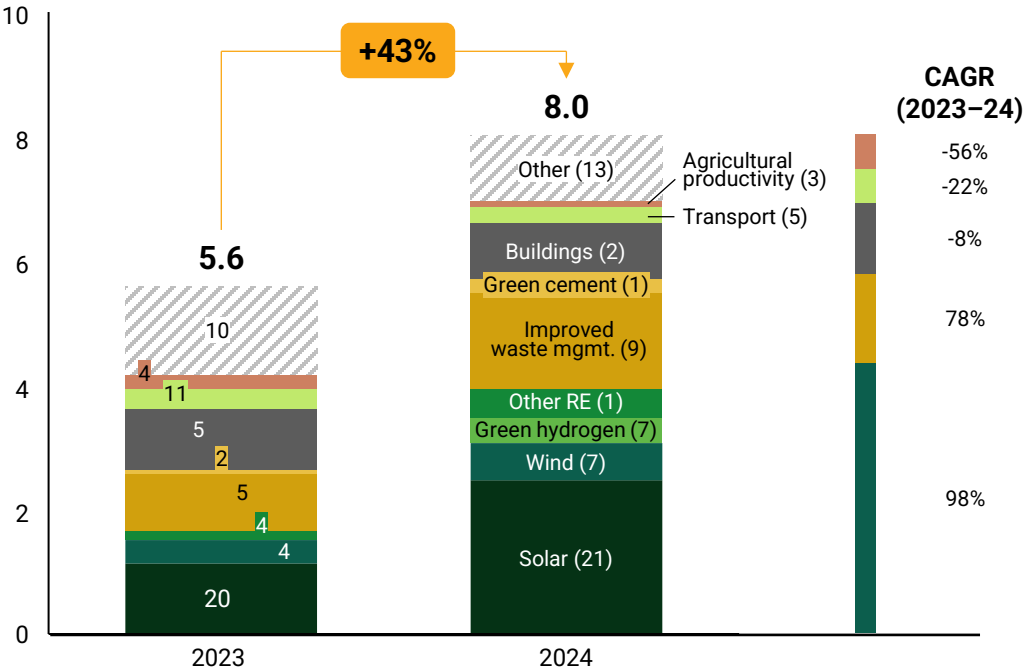
Solar and waste management led green investment growth, with solar up by ~100% and waste management by ~60%

SEA DEEP DIVE

Private¹ green investments in SEA countries by theme (\$ billion)

Number of deals indicated as (xx)

Other Agricultural productivity Transport Buildings Green cement
Improved waste mgmt. Green hydrogen Other RE Wind Solar



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%

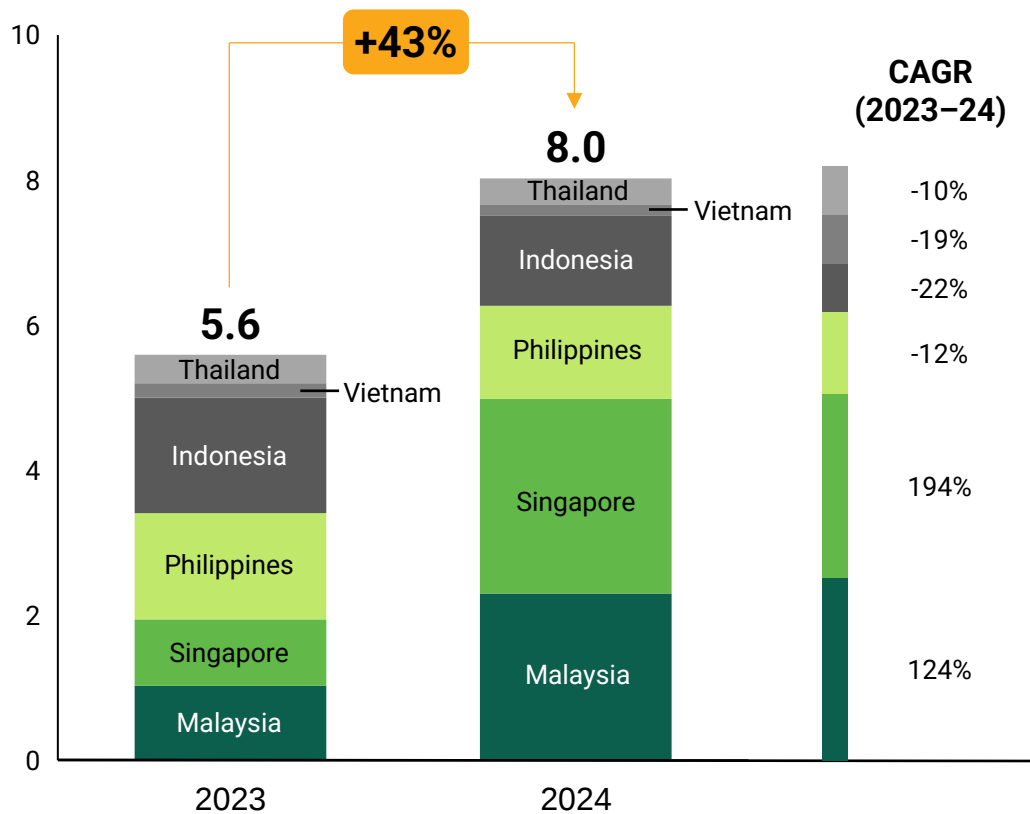
Agriculture & Nature
Agricultural productivity (e.g., agritech to decarbonize rice cultivation) saw a decline in investment (~60%); no investments in Indonesia in agricultural productivity in 2024 vs. 6 deals in 2023

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

Private¹ 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

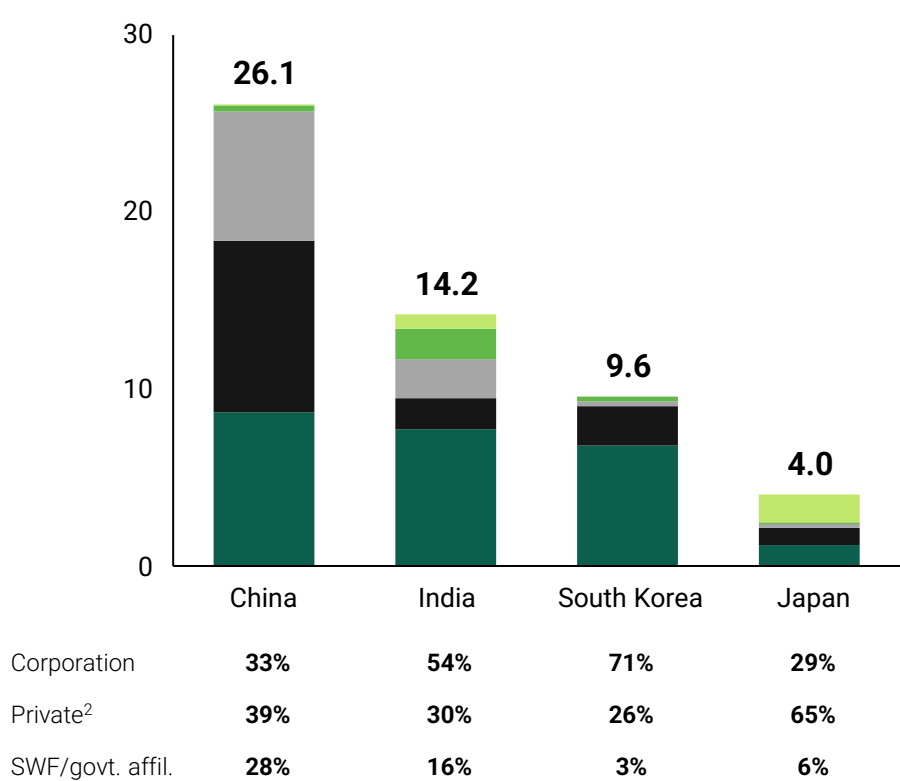
Corporate momentum drove green investments across SEA, India, and Korea; in SEA, climate and infrastructure fundings grew by ~4x and ~14x, respectively

APAC

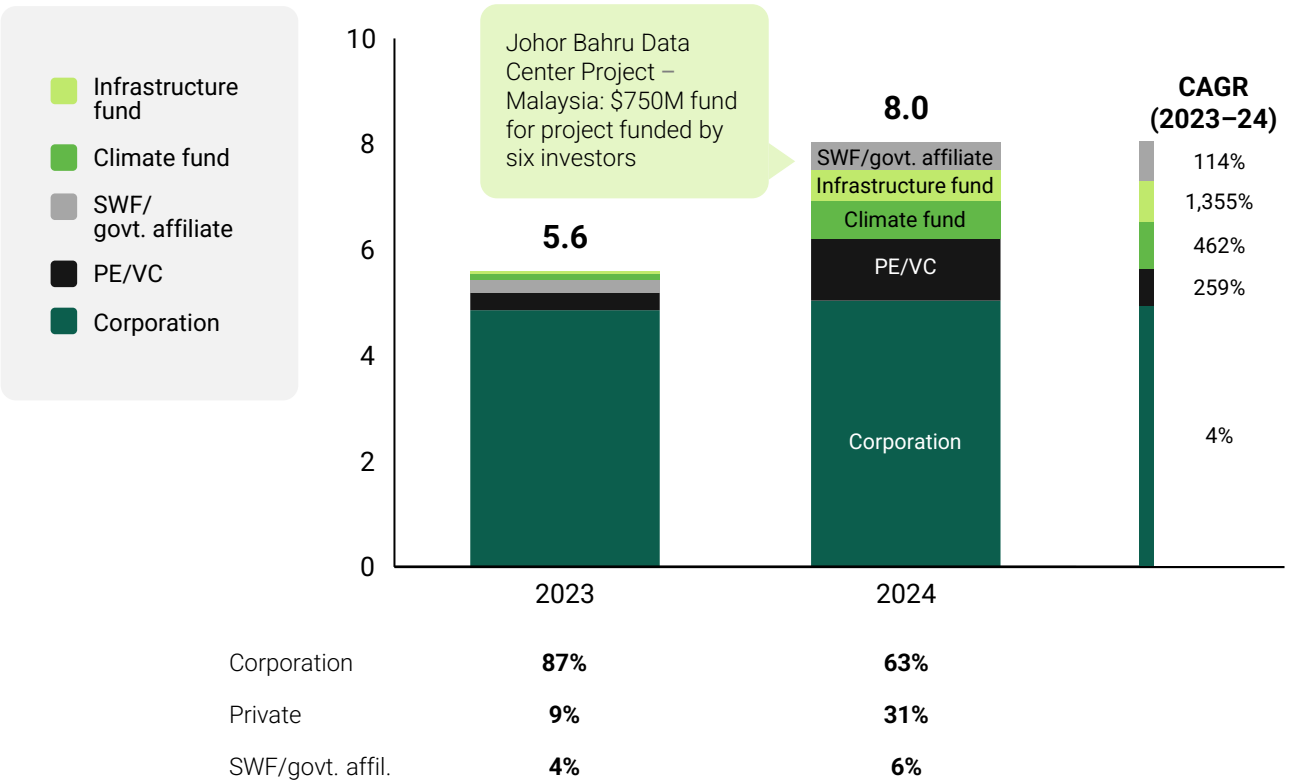
Key APAC nations

SEA

Private¹ green investments by investor type (\$ billion, 2024)



Private green investments by investor type (\$ billion)



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

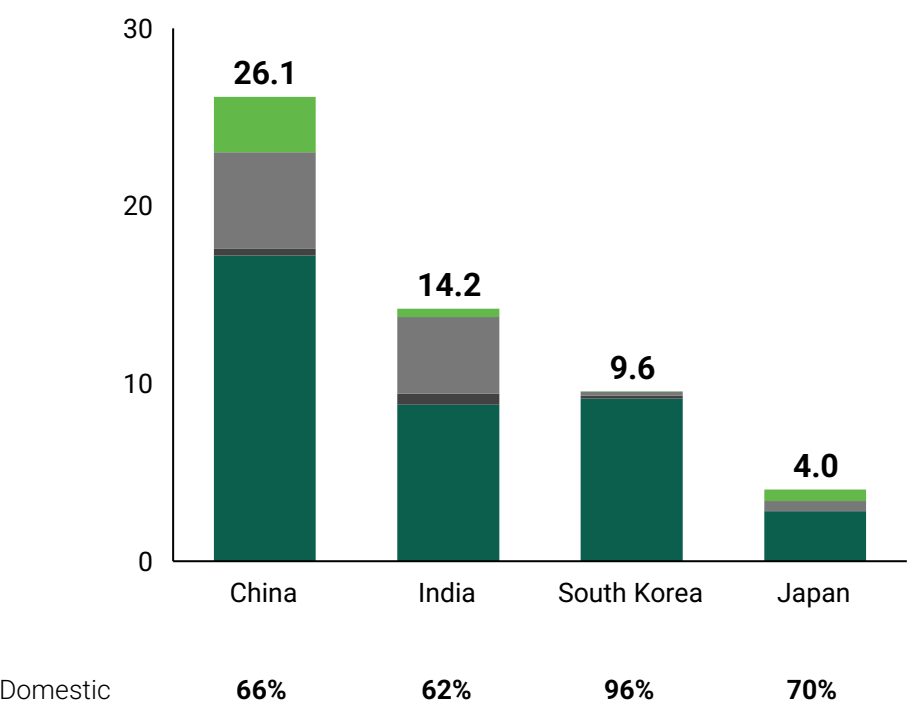
Domestic capital drove 60%+ of green investments across APAC, but in SEA, foreign investment tripled as domestic funding fell by ~40%

APAC

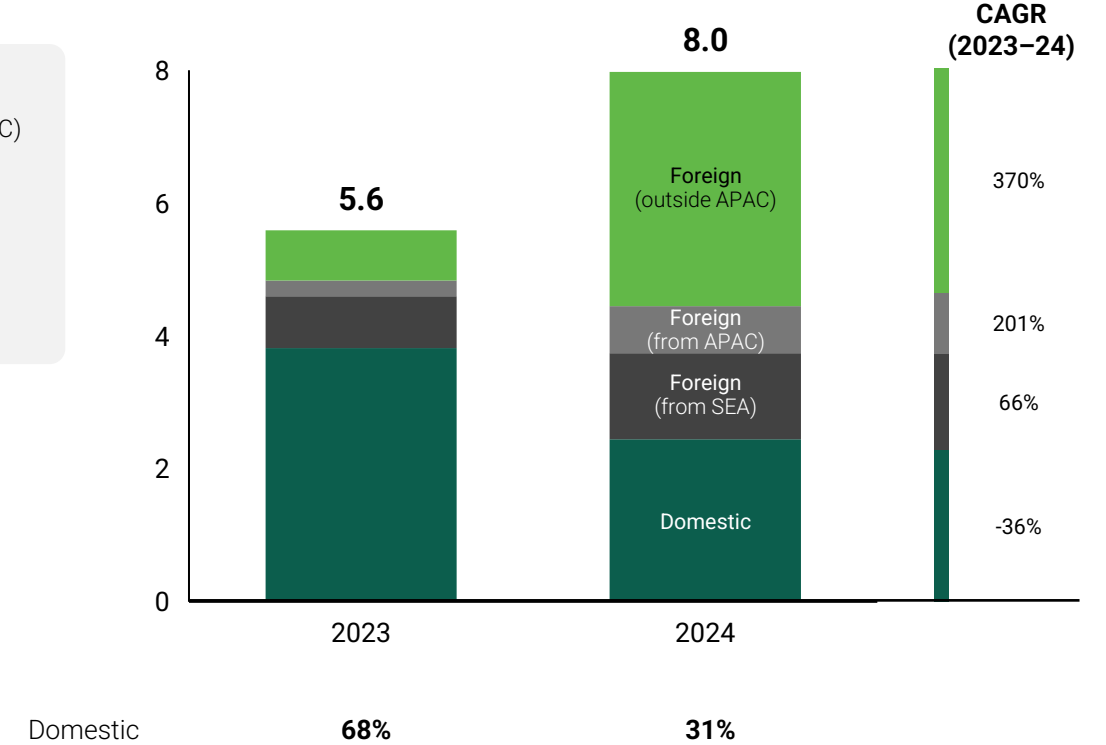
Key APAC nations

SEA

Private¹ green investments by investor type (\$ billion, 2024)



Private green investments by investor type (\$ billion)



Appendix

Country insights

13



Section overview



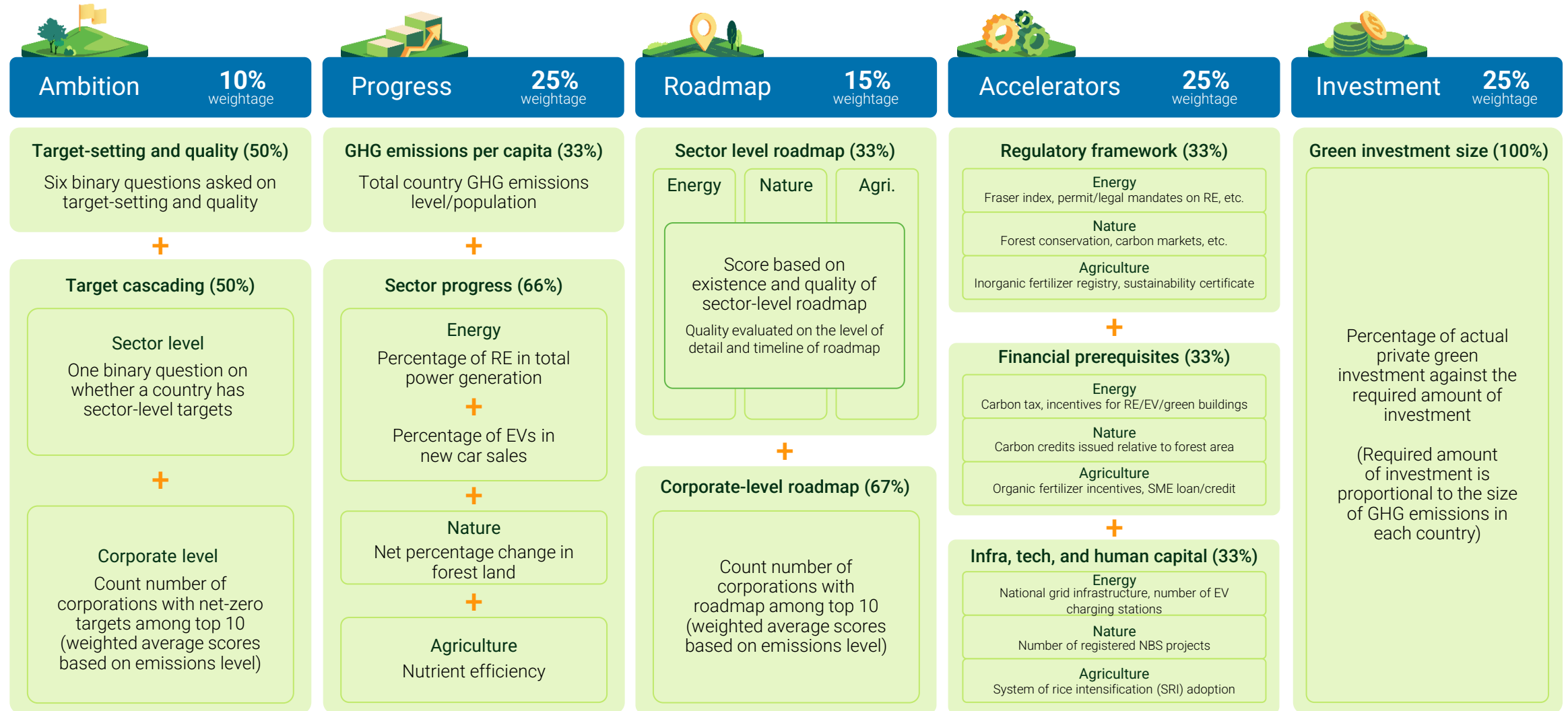
This section provides an update on key SEA countries' progress using the **SEA Green Economy Index methodology**



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%)



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

2025 SEA Green Economy Index: Corporations largely showing increase in setting targets and developing roadmaps; however, green investments still lag

 Significant change since previous year
 Work required to deliver target
 Unlikely on track to deliver target
 Likely on track to deliver target
 On track to deliver target

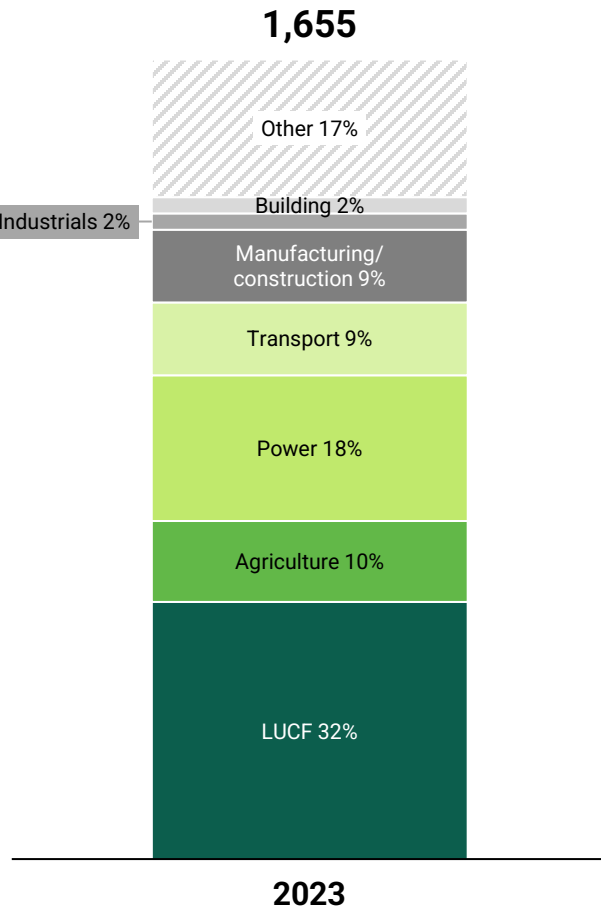
		Indonesia		Malaysia		Philippines		Singapore		Thailand		Vietnam	
		'24	'25	'24	'25	'24	'25	'24	'25	'24	'25	'24	'25
Overall assessment		 	 	 	 	 	 	 	 	 	 	 	
Ambition	Overall	 	 	 	 	 	 	 	 	 	 	 	
	Target-setting and quality	 	 	 	 	 	 	 	 	 	 	 	
	Target cascading	 	 	 	 	 	 	 	 	 	 	 	
Progress	Overall	 	 	 	 	 	 	 	 	 	 	 	
	Roadmap	 	 	 	 	 	 	 	 	 	 	 	
Roadmap	National sector-level roadmap	 	 	 	 	 	 	 	 	 	 	 	
	Corporate roadmap	 	 	 	 	 	 	 	 	 	 	 	
	Accelerator	 	 	 	 	 	 	 	 	 	 	 	
Accelerator	Regulatory framework	 	 	 	 	 	 	 	 	 	 	 	
	Financial prerequisites	 	 	 	 	 	 	 	 	 	 	 	
	Infrastructure and technology	 	 	 	 	 	 	 	 	 	 	 	
Investment	Overall	 	 	 	 	 	 	 	 	 	 	 	

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 reduction¹
by 2030

Significant increase
in corporate targets²

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 ■ ■

FOLU³ Net Sink
2030 plan sets sectoral targets to reduce deforestation

Corporate roadmaps have shown a significant increase⁴

Coal-phase out commitment rephrased; 2025 targets for RE generation will be missed⁵

Accelerators
'24 '25 ■ ■

Mandatory emission reporting for public companies

Incentives for RE, EV, and green buildings

High SRI⁶ adoption with five NBS projects in past year

Investments⁷
'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

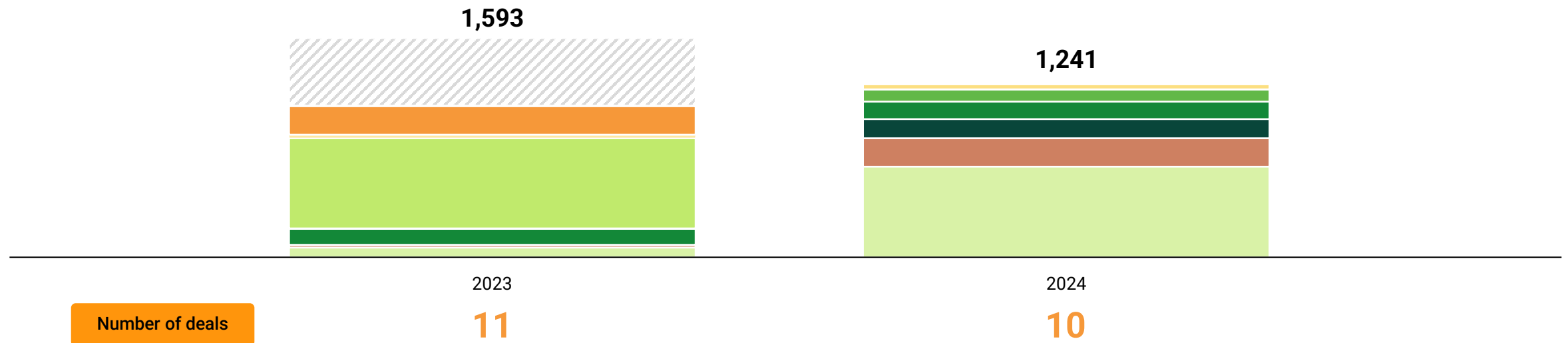
This analysis represents a selective view and includes private investments only, excluding government investment, public markets investment, and debt financing

Private green investments in Indonesia (Unit: \$ million)



Solar Improved waste mgmt. Other RE Wind Transport Other Fuel substitution
 Sustainable biomass/biogas/biofuel Agricultural productivity

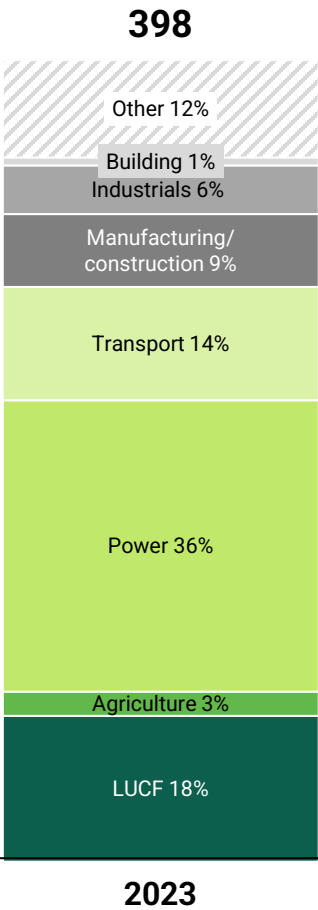
2024 total = ~\$1,241 million (~15% of SEA-6)



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; Prequin; 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 reduction¹ 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

NETP² provides a long-term vision for energy transition

Corporate roadmaps have shown a significant increase³

MyRER⁴ outlines initiatives to increase the RE share⁵

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

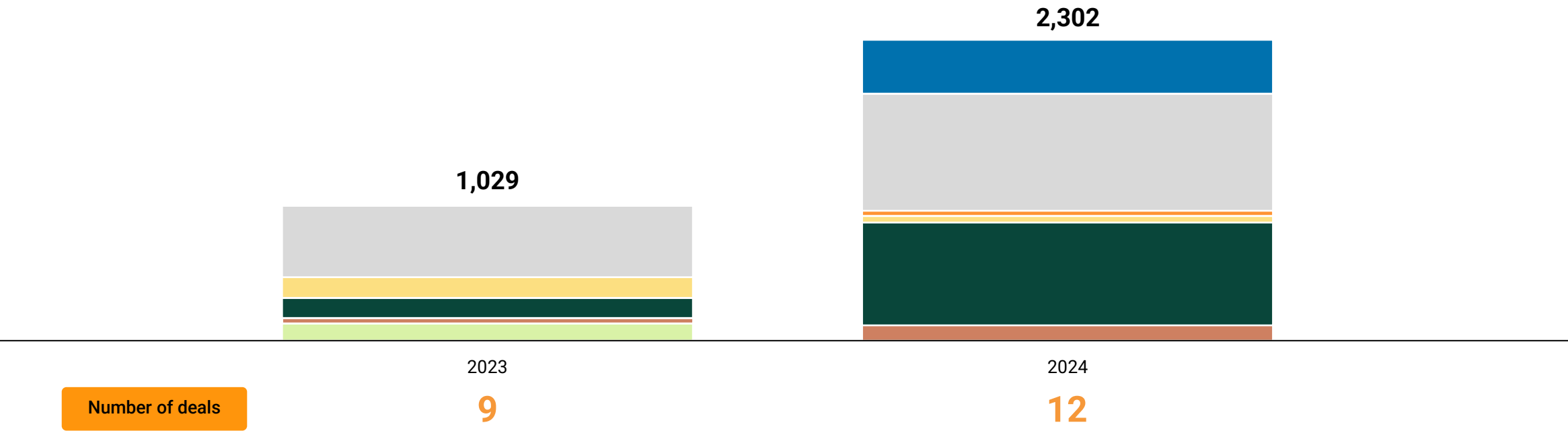
This analysis represents a selective view and includes private investments only, excluding government investment, public markets investment, and debt financing



Private green investments in Malaysia (Unit: \$ million)

- Solar
- Improved waste mgmt.
- Other RE
- Sustainable biomass/biogas/biofuel
- Agricultural productivity
- Buildings
- Green hydrogen

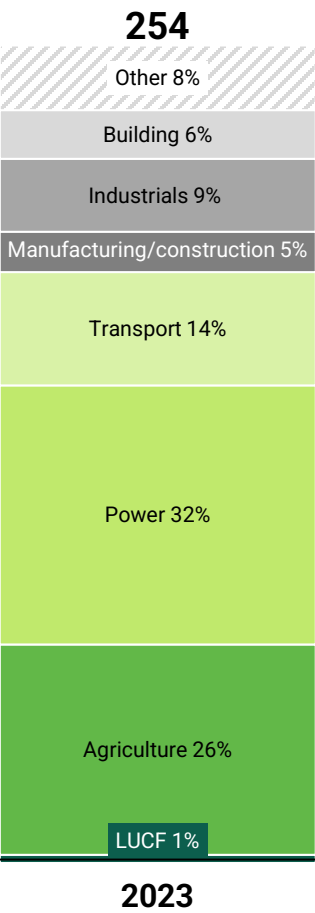
2024 total = \$2,302 million (~29% of SEA-6)



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 reduction¹ by 2030

35% RE in energy mix by 2040

Roadmap

'24 '25

Philippines Energy Plan sets a vision for energy transition

NREP² sets renewable energy targets

CEFIR³ aims to mobilize capital for clean energy projects

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%

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

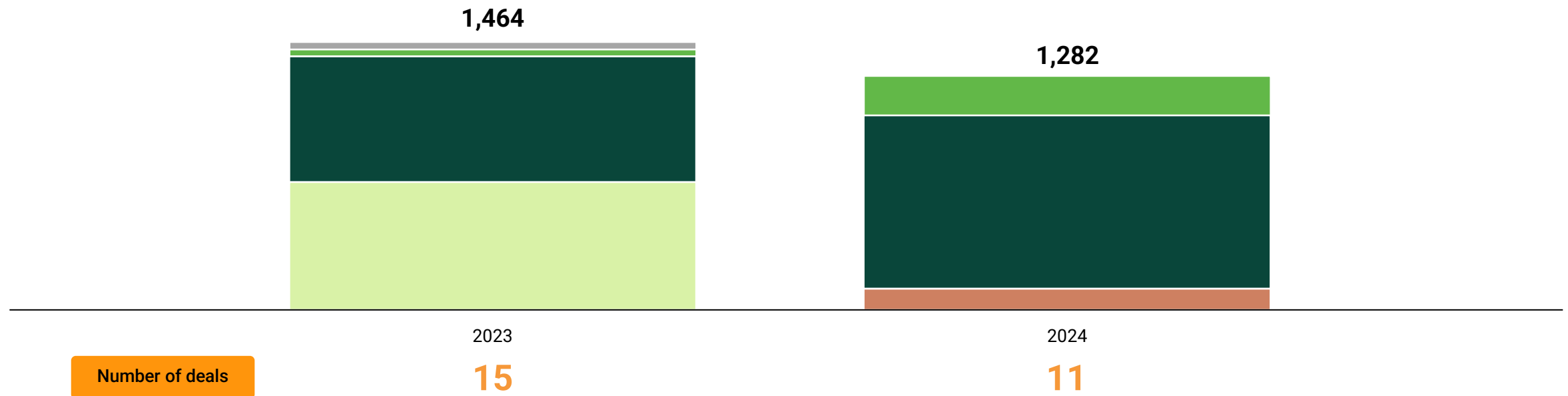
This analysis represents a selective view and includes private investments only, excluding government investment, public markets investment, and debt financing

Private green investments in Philippines (Unit: \$ million)



■ Solar
 ■ Wind
 ■ Other RE
 ■ Improved waste mgmt.
 ■ Green cement

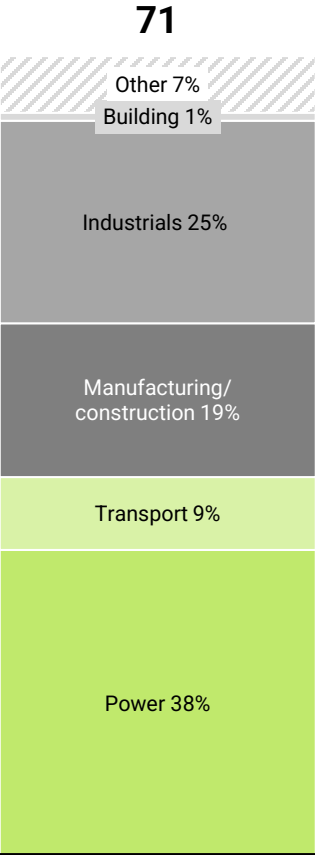
2024 total = \$1,282 million (~16% of SEA-6)



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; Prequin; PitchBook; Global Energy Monitor; Lit. search; Bain analysis

Singapore | Country insights

GHG emissions (MtCO₂e)



2023

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 GWp¹ solar energy
deployment by 2030²

Roadmap '24 '25

Green Plan 2030
sets targets for sustainable development

LT-LEDs³ in place, which outlines long-term climate commitments

Green Finance Action Plan
drives sustainable investments

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%

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

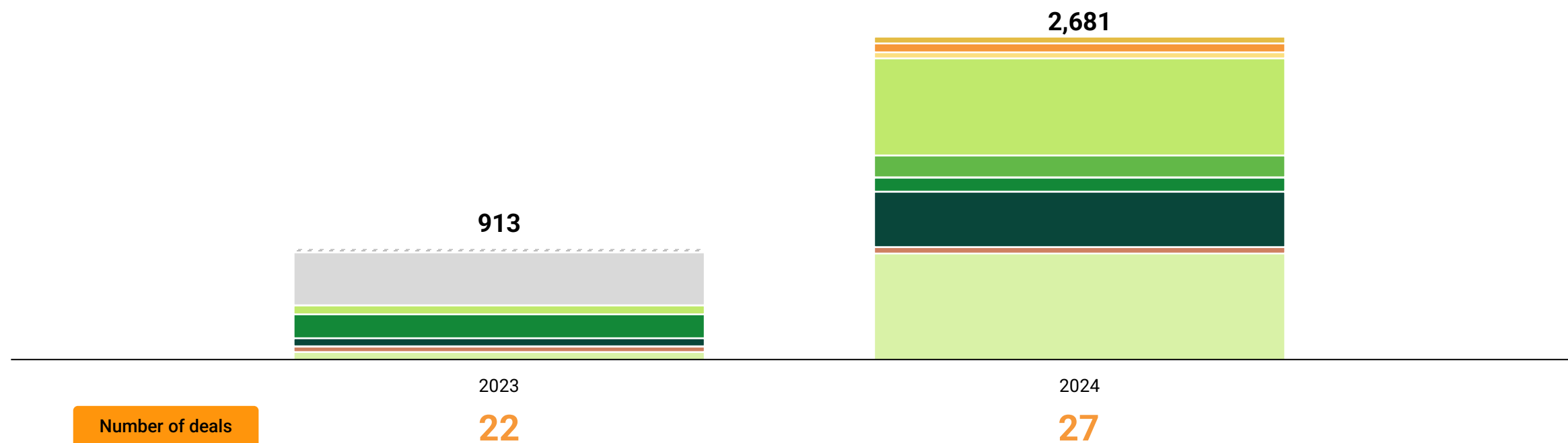
This analysis represents a selective view and includes private investments only, excluding government investment, public markets investment, and debt financing

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

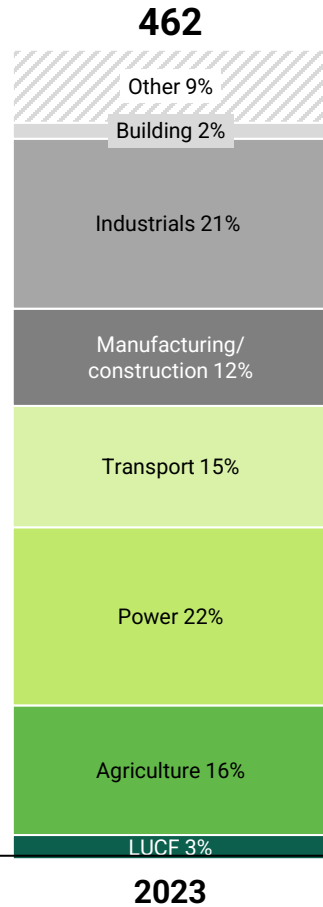
2024 total = \$2,681 million (~33% of SEA-6)



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

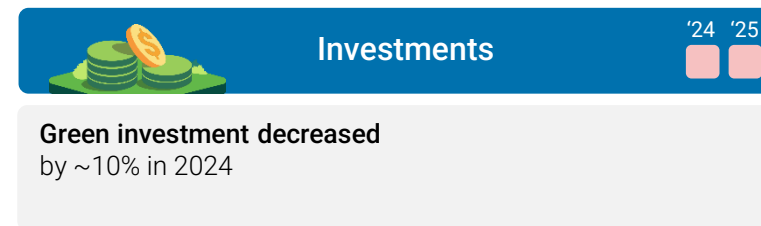
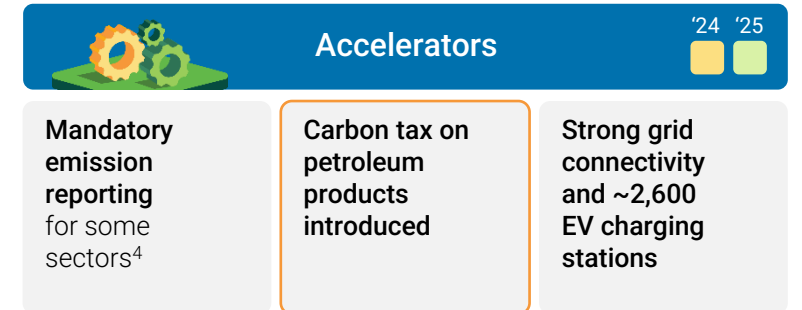
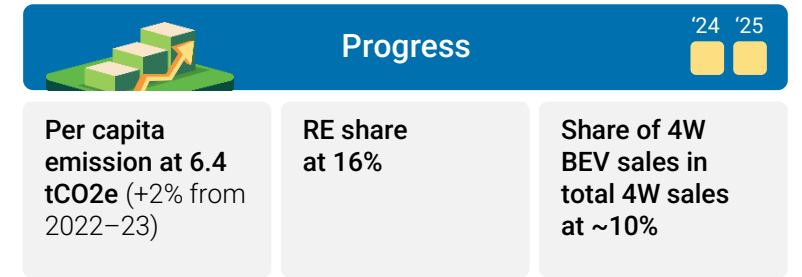
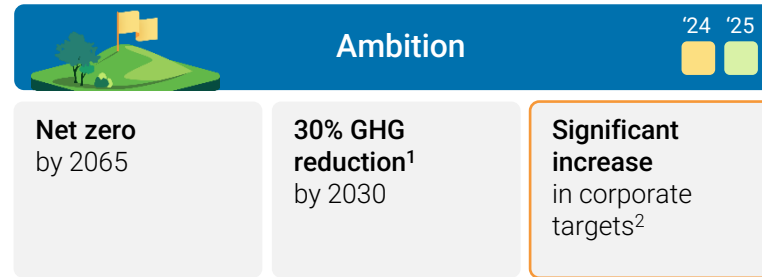
On track to deliver target

Work required to deliver target

Unlikely on track to deliver target

Key drivers influencing shifts in the overall theme score

'24 '25



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

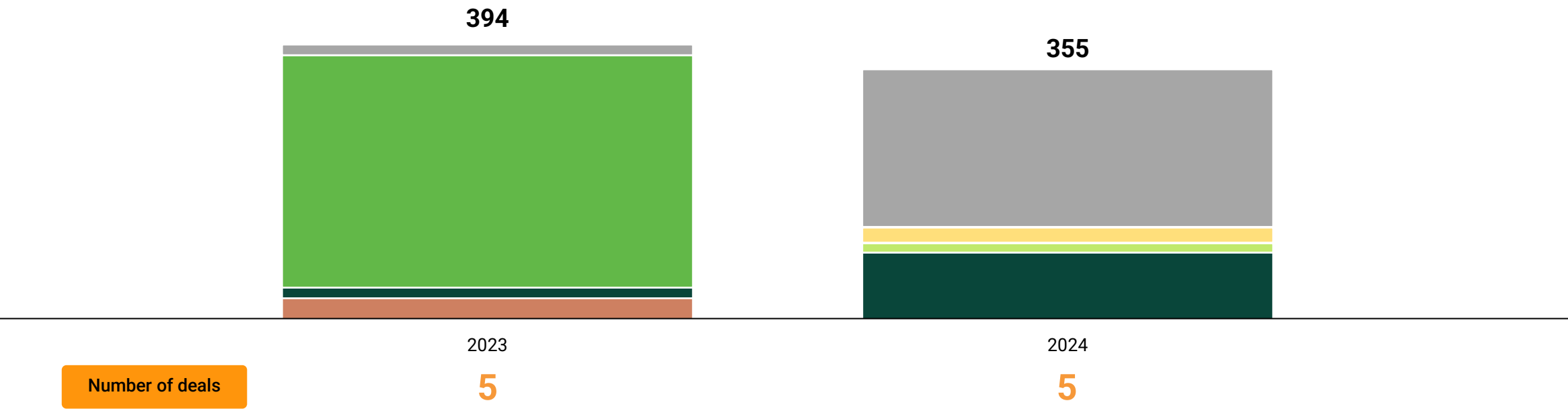
This analysis represents a selective view and includes private investments only, excluding government investment, public markets investment, and debt financing



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)



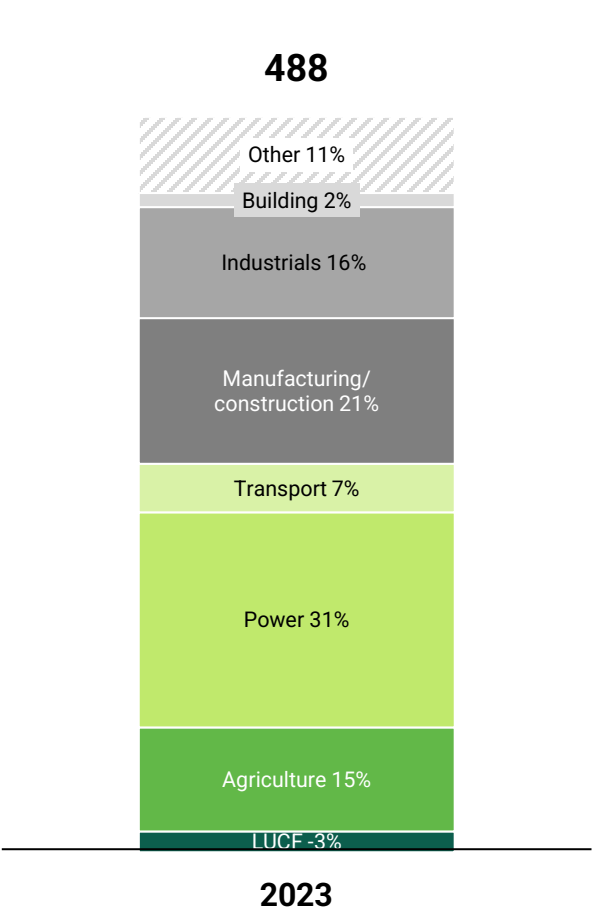
Notes: Figures include private sector deal transactions, which are categorized as “closed” and “effective” and >\$10 million in size, including private placements and excluding IPOs; used allocation methodology from the previous report, calculating the investment size of a country based on where the 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 reduction¹ 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 ■ ■

PDP² and National Energy Master Plan (2021–2030)

Corporate roadmaps have shown a significant increase³

Grid infra push and National Climate Change Strategy⁴

Accelerators
'24 '25 ■ ■

Mandatory emission reporting across some sectors⁵

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

 BAIN & COMPANY
 GenZero
 Google
 standard
 TEMASEK | ecosperity

Vietnam | Investment landscape

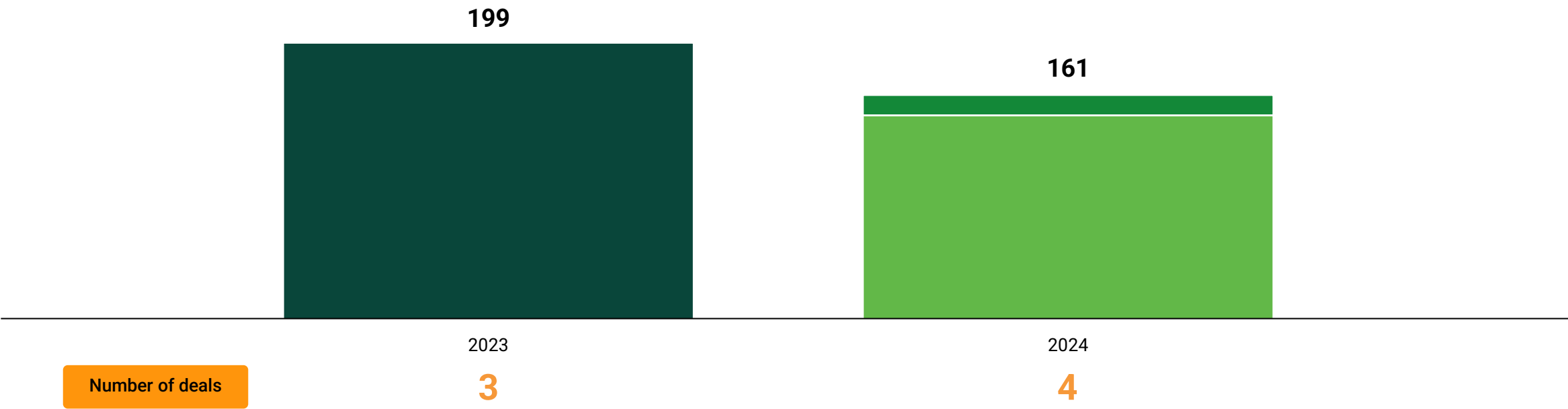
This analysis represents a selective view and includes private investments only, excluding government investment, public markets investment, and debt financing



Private green investments in Vietnam (Unit: \$ million)

■ Solar
 ■ Transport
 ■ Wind

2024 total = \$161 million (~2% of SEA-6)



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