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Southeast Asia's Green Economy Report 2026

The New Calculus

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Authors and acknowledgments

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"Southeast Asia's Green Economy 2026 Report: The New Calculus" is jointly produced by Bain & Company and Standard Chartered. Contributing authors are as follows:

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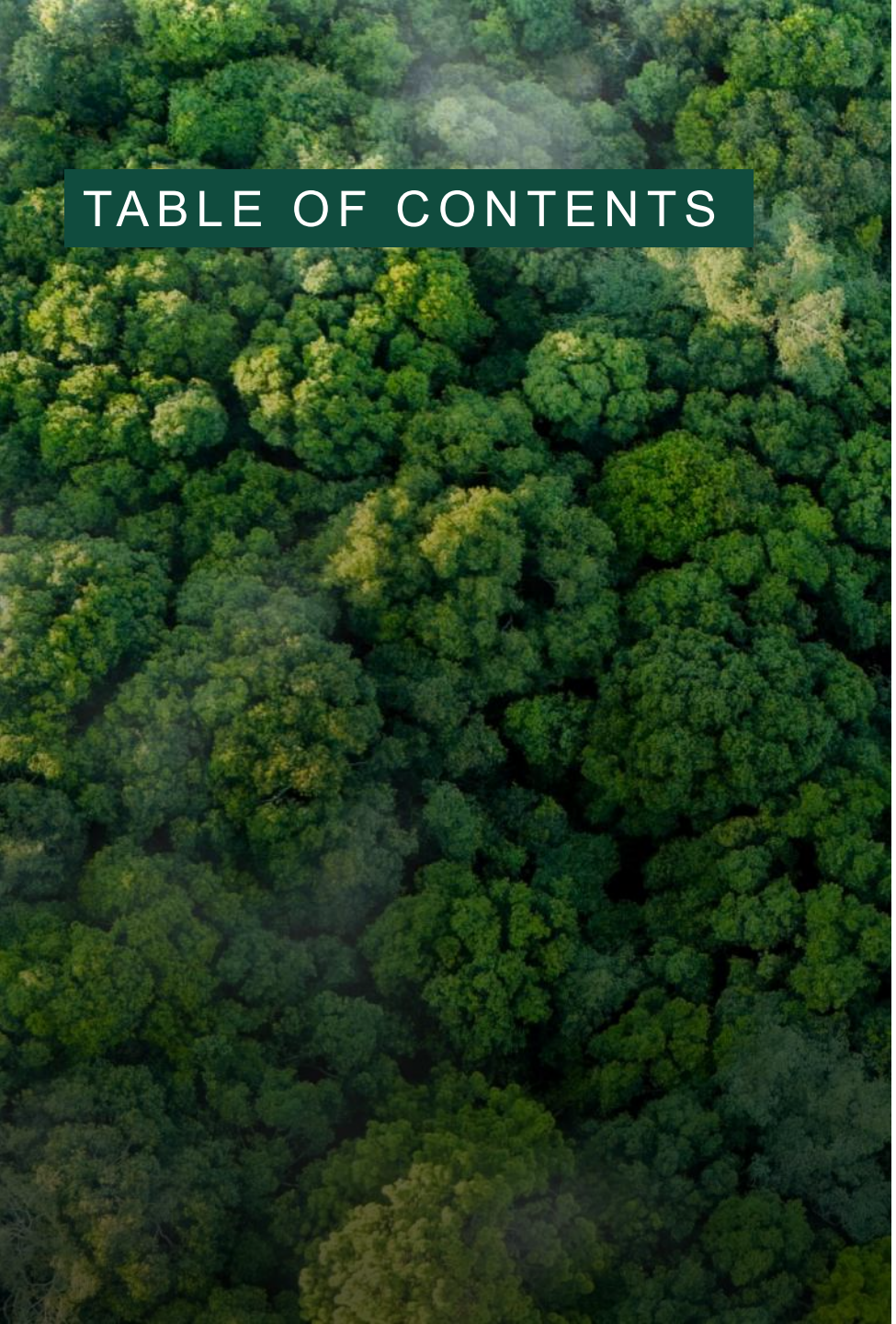

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FOREWORD

Dale Hardcastle
Partner
Bain & Company

At Singapore's Ecosperity Week in 2022, I spoke about the elephant in the room: that the real question of the energy transition was not which technologies to build, but who would pay for them. In 2023, I borrowed from a film about doing everything everywhere all at once, to argue the opposite—that attending to the reality in front of us was the only path that would actually work. In 2024, I named the gap directly: the distance between our targets and results we were delivering.

It's not about the targets we set. It's about the targets we deliver.

We have said versions of the same thing for five years. The markets have proven it faster and more comprehensively than any report could. Between 2021 and 2026, roughly $10 trillion was committed globally to clean energy. The returns accrued precisely where substance existed: grid infrastructure, battery systems, the unglamorous plays that served real buyers with real balance sheets on real timelines. They collapsed wherever policy ambition had been doing too much of the work that commercial demand should have delivered. Offshore wind developers wrote down billions. Hydrogen project returns went sharply negative. The gap between announcement and delivery was not a gap of ambition or capital. It was a gap of economic logic.

What the world has done in this period is reassert a hierarchy that was always true but briefly obscured. Think of Maslow's pyramid. After Paris, after Glasgow, climate seemed to be moving to the apex - the self-actualizing ambition of the age. And it was right that it did. But a pyramid requires foundations. Energy security. Affordable power. Economic growth. Industrial competitiveness for workers who cannot afford to wait. Geopolitical rupture, AI-driven power demand, and China's dominance of clean supply chains have collectively reminded every government in this region that the foundations were not yet secure. The reassertion is not a retreat from the green economy. It is the natural order making itself felt. And the green economy that operates within that order—that serves energy security, that delivers power people can actually afford - is scaling.

The scale is larger than the public conversation suggests. Southeast Asia's green economy is $290 billion today and on track for nearly $430 billion by 2030. Grid capex across the region's major utilities is running at levels that, five years ago, would have been considered aspirational. TNB has approved a 43-billion-ringgit program. EVN exceeded its 2024 target. Johor has gone from a planning conversation to 700 megawatts of data centers under construction. Thailand has become a serious EV manufacturing hub. Laos's Monsoon Wind is now delivering 600 megawatts of cross-border power into Vietnam—the first project of its kind in Asia. None of this is theoretical. It is being built because the economics work.

The harder truth sits alongside it. Vietnam’s 17-gigawatt offshore wind target has zero gigawatts under construction. Indonesia's solar program has achieved roughly 10% realization. Announced battery investment in Indonesia exceeds $14 billion; realized investment is closer to $5 billion. These are not failures of effort, but the predictable outcomes of market architectures that have not caught up to the ambition layered on top of them: single-buyer utilities, absent DPPA frameworks, grid access blocked to private capital. Consumers and corporations are desperate to buy green power and cannot find it to purchase. Fix the plumbing, and the investment follows.

Carbon markets, sustainable agriculture, biofuels, sustainable aviation fuel—all are real, all matter, all have made genuine progress. But they are scaling at a pace set by policy and pilot capital, not by the commercial demand that has pulled data centers and EVs through at speed. The buyer who must have the product, on a timeline that cannot slip, has not yet fully arrived. That is not a failure of the sectors. It is a description of where market architecture still needs to mature. The sectors scaling fastest are those serving energy security and economic growth with climate impact.

The sectors most directly tied to carbon abatement are scaling more slowly. That raises honest questions—whether the 2030 emissions targets most governments have committed to are achievable on current paths, and whether the gap between green economy growth and actual decarbonization is widening rather than closing. I do not have confident answers. I am not sure anyone does. Pretending they are not open questions does more harm than good.

Six years of this work has taught us that the most useful thing we can offer is not optimism or pessimism, but clarity about what is real and happening today.

FOREWORD

Patrick Lee
CEO, Singapore and CEO, ASEAN and South Asia, Standard Chartered

ASEAN's green economy is real and scaled, with expectations that it could be worth $430 billion by 2030—but the system is struggling to absorb the investment. Around 35% of announced green capex in the region remains unrealized, a gap that is wider than in most other markets globally.

At the same time, regional demand for electricity, digital infrastructure, and electric mobility is rising rapidly. Data centers, electric vehicle (EV) infrastructure, and green industrial parks are projected to absorb over 100 terawatt-hours of new energy demand by 2030 as ASEAN becomes the world's fourth largest economy, with a population of over 700 million.

On one hand, this vast new electricity load risks straining infrastructure, undermining competitiveness, and offsetting climate gains. On the other hand, this growing energy demand will be tied to nearly $200 billion in committed capex, raising the prospect that it could offer a demand-side anchor for renewables projects and financing.

Realizing that promise hinges on the development of a robust power grid.

More than 70% of ASEAN's data center demand is concentrated in two clusters, Singapore and Johor. This concentration of demand is placing significant strain on transmission networks that were not designed for such rapid, localized growth.

As a result, grid constraints are emerging as a binding bottleneck. According to Bain's Southeast Asia Data Center Operator and Hyperscaler survey done in February 2026, limited transmission capacity and connection delays risk constraining further data center investment in the region. In this report, we explore how investment in the ASEAN power grid can act as an important lever to unlock regional potential, aiming to connect ASEAN member states via cross-border electricity trade and interconnections—connecting renewables supply to demand centers. The prize is an additional $70 billion of clean energy and grid-related capital unlocked by 2030, materially expanding the addressable market for the SEA green economy.

The EV value chain also needs to scale across the ecosystem. Networks require synchronized, interdependent commitments to reach competitive scale, and as the region secures early investments by building capabilities, businesses will benefit through a coordinated ecosystem with shared standards.

Without coordinated investment in manufacturing, supply chains, and supporting infrastructure, ASEAN risks remaining an EV end market rather than becoming a production hub. As global manufacturers lock in production footprints, early decisions will shape the region's position in the value chain for years to come.

The coming 24 to 36 months will prove critical, with up to $50 billion in value at risk of being lost to advanced EV markets in 2030 if SEA does not scale its EV manufacturing capabilities. Enhanced integration across ASEAN's EV value chain has the potential to unlock a further $130–$160 billion by 2035.

Addressing these challenges will require stronger coordination across the ecosystem. Demand is already outpacing system readiness, and without faster alignment across infrastructure, policy, and execution, the conversion gap will widen.

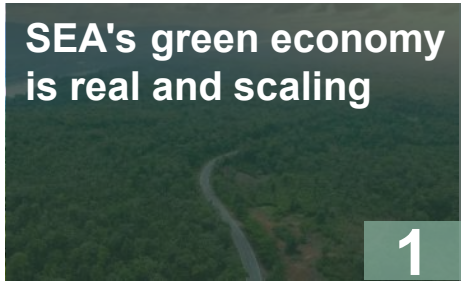
As an international bank with a strong presence across most ASEAN markets and a commitment to mobilizing $300 billion in sustainable finance by 2030, we are looking forward and stand ready to help ASEAN seize the opportunity. Our focus is on mobilizing capital, structuring solutions, and connecting clients to cross-border opportunities that help turn demand into delivery.

For instance, Standard Chartered has unlocked private capital for clean energy investment with Indonesia's first Just Energy Transition Partnership project, helping coal-dependent emerging economies transit to clean energy. Instead of a one-size-fits-all approach, we provide tailored, actionable, and monetizable advisory for clients, as well as solutions that help companies and green industrial clusters reap benefits.

If all else is true, ASEAN has the demand, the capital, and the momentum—what matters now is execution to catalyze meaningful progress.

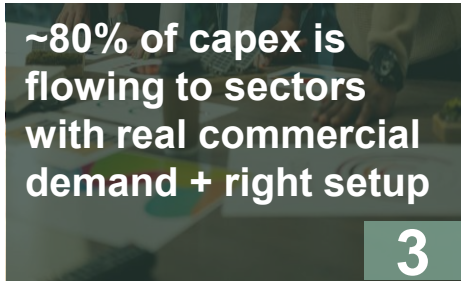
Notes: 1) According to IMF data: https://www.imf.org/external/datamapper/profile/SEQ; 2) WEF_From_Paradox_to_Progress_A_Net_Positive_AI_Energy_Framework_2025.pdf

The report at a glance

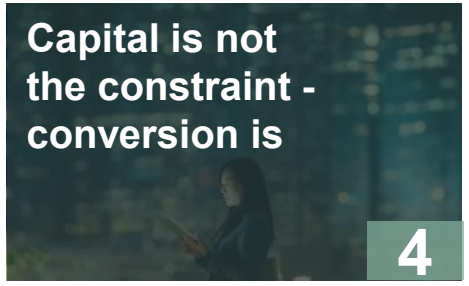


Value is $290 billion today and expected to reach $430 billion by 2030, growing 8%–9% p.a.

Security and growth are more prominent drivers in every investment decision



Where demand, policy and system readiness align, capital flowing; In SEA, majority of green capex is flow power, grid and EVs

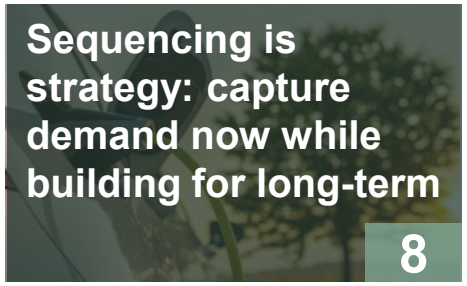


~35% gap exists between announced and realized capex - where real demand exists, capital converts; where mandates stand in, gaps appear

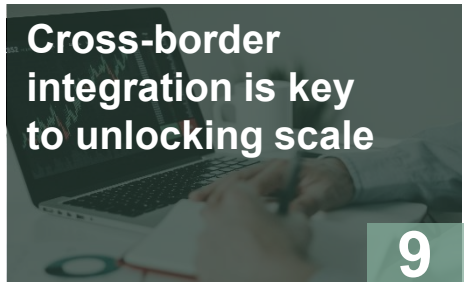
It’s shared by data centers, EVs, and industrial parks alike; fix the grid = unlock growth & green power

Large, concentrated loads are arriving on compressed timelines, relying on infra built for yesterday’s demand

4 of the world's top 15 EV markets are now in SEA, yet ~70% of EV value still flows outside the region



Near-term demand must be secured within current system constraints while building long-term infra



Linking SEA markets and broader Asia-Pacific capital is critical to unlock green economy scale

DC and OEM platform decisions made now will lock in positions; green prize in reach if SEA sequences correctly

Executive summary

The green economy is real; the question now is who captures it and how it scales

Asia-Pacific green economy

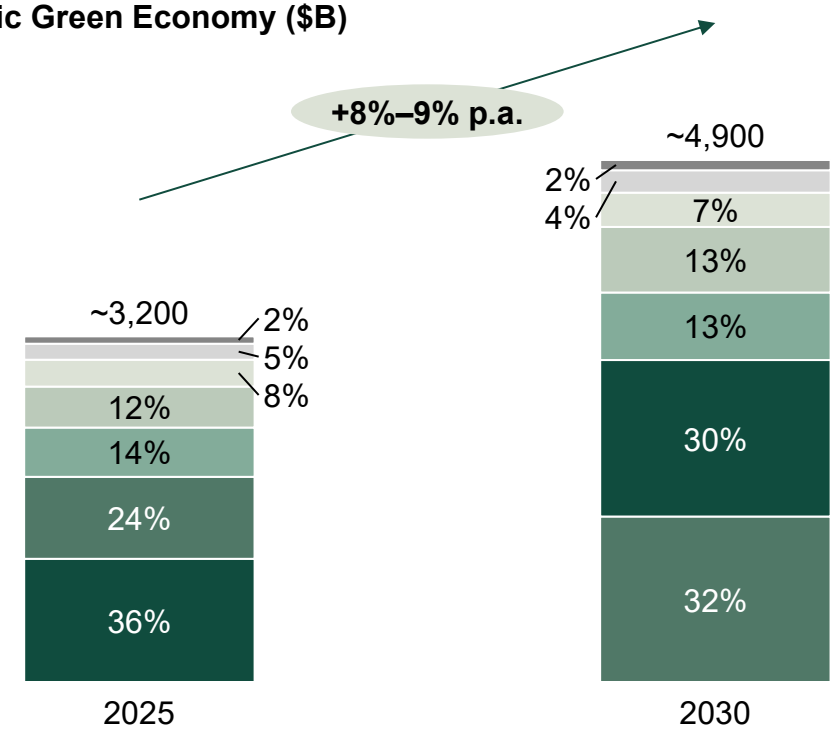
$3.2T 2025 → **$4.9T** 2030

SEA green economy

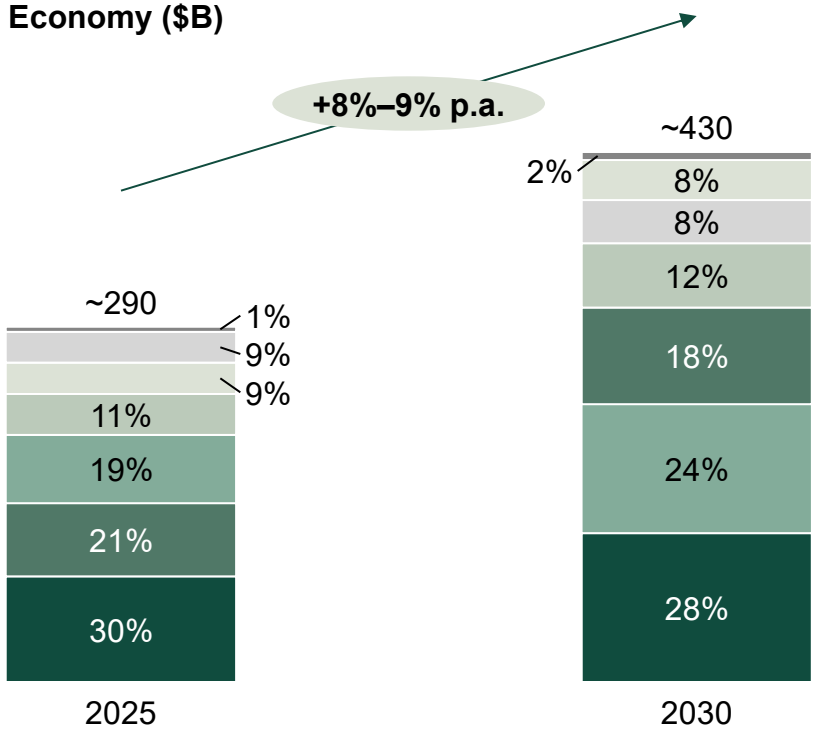
$290B 2025 → **$430B** 2030

Finance and Services | Nature and Agriculture | Climate Adaptation | Buildings | Industrial and Waste | Transport and Logistics | Power, Energy & Grid

Asia-Pacific Green Economy ($B)



SEA Green Economy ($B)



Source: Bain analysis

A new calculus is reshaping where capital is flowing in the green economy

Three structural shifts
Driving changing market dynamics

Then (pre-2025): *Climate-aligned, cooperation-driven calculus*	Now (2025–26): *Security- and growth-led calculus*
Policy convergence Global policy converged to net zero with regulation-driven investments	**Policy fragmentation** Global leaders pulling back from climate commitments, with focus shifting towards energy security and domestic growth
Rules-based order Western-led multilateral frameworks governed international trade and investment	**Geopolitical volatility** Tariffs and geopolitical tensions disrupt supply chains and raise fuel volatility
Ambition drives results Committed targets and investments would convert to construction	**Capital follows returns** Capital no longer follows policy alone but where the economics truly make sense

Implications
How the calculus is changing

Bankability is being recalibrated: Green investments are no longer backed on climate ambition alone, projects need standalone commercial returns to be funded

Execution is constrained by system complexity: Fragmentation and supply chain complexities are raising execution risk—capital favors projects with proven demand, ready infra and secure supply chains

Capital shifts to where systems work: Capital is reallocating toward ecosystems where demand, policy, and infrastructure are synchronized—creating “pockets of bankability” while others lag in attracting investment

Green investment now follows a stricter, market-based calculus - capital flows only where demand, policy and system readiness align

Sources: Expert interviews, Bain analysis

Capital flows where commercial demand exists and market & policy structures are aligned; when this breaks down, demand fails to convert into investment

Where system aligns, capital converts

Commercial demand, market design, and policy frameworks working in sync

1.5x–2x

EV adoption vs. previous forecasts

EV adoption

- SEA went from laggard to EV adoption leader in 3 years, driven by price parity and strong OEM-led demand
- BYD, CATL, VinFast driving EV production in SEA, supported by coordinated incentives and improving ecosystem readiness

3x

expected growth in SEA DC capacity

Data center driven power demand growth

- SEA DC capacity to grow 3x from 2024 to 2030 vs. 1.6x from 2019 to 2024 – and seeks green power for it
- Key clusters like MY and TH scaling rapidly, enabled by strong hyperscaler demand, targeted incentives, and fast-track power and permitting pathways

90

clusters in SEA today vs. 45 in 2021

Green industrial clusters development

- All SEA-6 governments now advancing green industrial policies, aligned to attract and anchor industrial demand
- Clusters like Jababeka (ID), Samalaju (MY), and VSIP[1] (VN) demonstrating viability, with integrated power, land, and permitting enabling faster execution

Where alignment breaks, investment stalls

Disconnects between demand, policy, and system readiness prevent conversion

50%–60%

RE project cancellation rate in VN/TH/ID

Renewable energy (RE) build-out

- ID achieved ~20%–30% of 2020–25 solar energy targets; VN added near-zero utility-scale solar or wind capacity in 2022–24, amid policy uncertainty and limited bankable procurement mechanisms

0 GW

of offshore wind farms under construction vs. 6 GW target

Offshore wind capacity

- VN's 6 GW target was set in 2023, but offshore wind regulations were only released in 2025—with no signed PPAs or FIDs in the interim despite the country's significant wind resource

40%–50%

cancellation rate on announced nickel/ battery investments

Nickel and battery manufacturing

- Nickel prices declined >70% in 2024 from 2022 peak, driven by oversupply
- Project cancellations triggered (e.g., BASF-Eramet's $2.6B nickel refinery, LG's $7.7B battery investment)

Note: 1) Vietnam-Singapore Industrial Park | Sources: ASEAN Centre for Energy; IEA; Ember; Reuters

The grid is a shared dependency for economic expansion + new demand sources

SEA will see ~100 TWh of new energy demand between 2025 and 2030, coming from:

~35–45 TWh

Estimated incremental DC electricity consumption (2025 vs. 2030) for ~6.0–6.5 GW DC build

~10–15 TWh

Estimated incremental EV electricity consumption (2025 vs. 2030)

~25–60 TWh

Estimated incremental green industrial park electricity consumption (2025 vs. 2030)

IF THE GRID IS NOT ABLE TO SUPPORT THIS...

DCs reallocate

Capital moves to markets with grid certainty; SEA loses the AI infra + renewables demand

EV factories build elsewhere

Unreliable industrial power raises costs and deters further OEM investment

Green clusters stall

Tenants cannot meet emissions standards without reliable, certifiable power supply

Source: Bain analysis

Data centers - while not directly part of green economy - are central to its future

Data centers - and AI demand - are material new electricity load

Offer potential demand-side anchors for renewables projects

SCALE POWER DEMAND	REAL CAPEX IN MOTION	GEOGRAPHIC FOCUS
≈ 2 GW	$3 to $4B a year	+420 MW
SEA data center demand	Committed capex—not aspiration	New construction in Johor alone

AI is creating the demand. The green economy outcome depends on how SEA chooses to meet it.

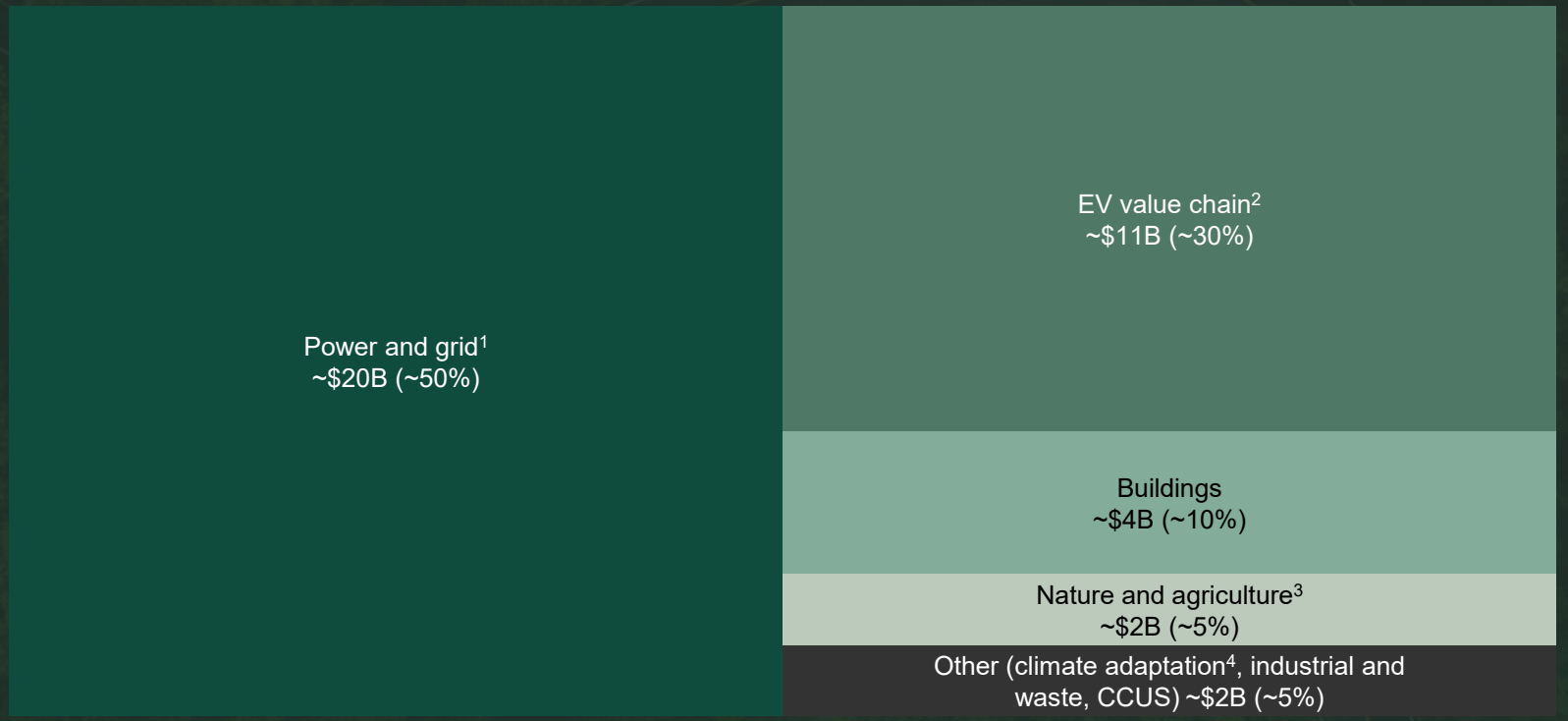
Sources: Bain analysis; IEA; expert interviews

Following the money reveals 80% of capital flows to the two sectors where commercial demand is real, creditworthy, and not wholly policy dependent

~$40 billion

of **annual green capex** deployed in SEA (2021–25)

Breakdown of SEA-6 green capex deployed, 2021–25 ($, percentage)



Notes: 1) Power and grid includes green power generation, grids, and storage; 2) EV value chain includes EV battery minerals, battery manufacturing, EV manufacturing, and EV infrastructure; 3) Nature and agriculture includes biomass and biofuels, agritech, nature-based carbon markets, credit platforms, and MRV; 4) Climate adaptation includes climate adaptation and water and wastewater
Sources: GlobalData; Wood Mackenzie; Berkeley Carbon Trading Project; Global Landscape of Climate Finance; Bain analysis

Money is available to invest; the system can’t absorb it

Power and grid

Underinvestment in clean energy

~0.5

Ratio of clean energy vs. overall energy investments (SEA, 2025)

vs.

~0.7

Ratio of clean energy vs. overall energy investments (global, 2025)

Underinvestment in grid infrastructure

3%

decrease in investment in T&D (2015–25)

vs.

5%

increase in energy demand (2015–25)

~90% of DCs indicate grid connection delays as a key factor constraining further DC investment in SEA[1]

EV value chain

High dependence on imported EVs

~70%

of 4W EV demand remains import-dependent

Small share of global EV and battery production captured

<2%

SEA’s share of global EV production

<2% SEA’s share of global EV battery production

Note: 1) Based on Bain SEA DC Operator and Hyperscaler Survey 2026 (n=10, covering ~50% of SEA capacity) | Sources: IEA; Bain analysis

Capital isn’t the problem; conversion is

Source: Bain analysis

POWER AND GRID | EV VALUE CHAIN

KEY CONSTRAINTS LIMITING INVESTMENT

Policy and tariff uncertainty

Changing subsidy structures and unclear offtake pathways weaken long-term cash flow visibility

Infrastructure and grid reliability gaps

Charging build-out, industrial power quality and grid reliability vary significantly, deterring investment

Market design rigidity

Single-buyer models, limited wheeling frameworks, and constrained private participation reduce bankability of assets

Fragmented value chains limiting cost competitiveness

Limited coordinated specialization across SEA, with gaps in battery, components, and material processing

Execution bottlenecks

Permitting delays, licensing backlogs, land access constraints, and supply chain shortages slow project realization

Lack of regional market architecture

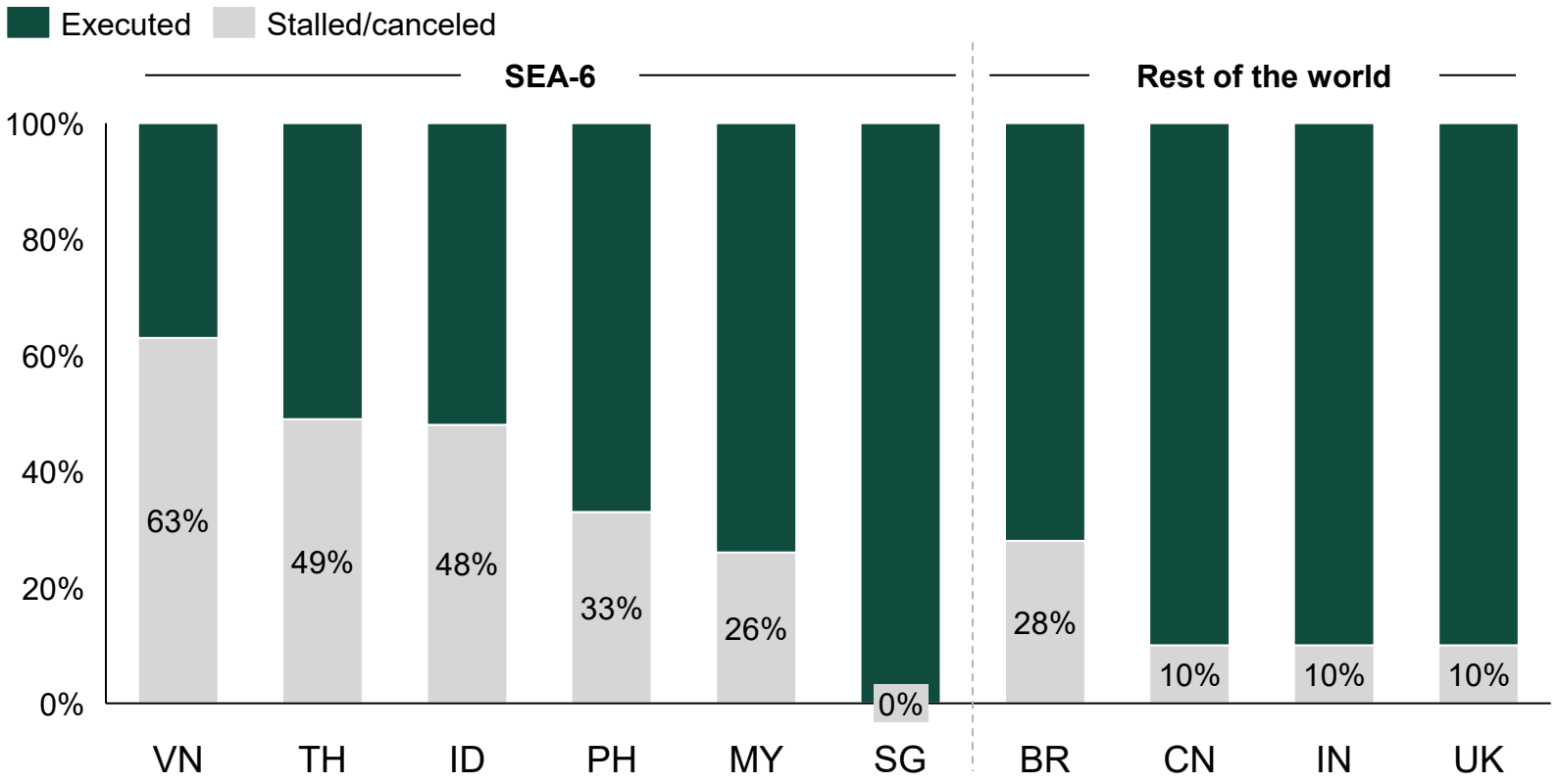
Fragmented EV standards and charging interoperability impede scaling across SEA as a single market

SEA turns less of what's announced into what's built than almost any peer market; closing this execution gap is critical for the region to gain ground

/ DIRECTIONAL ESTIMATES

SEA-6 countries have seen a higher share of clean energy generation projects stalled or canceled vs. other mature markets

Historical clean generation capex (cumulative): executed vs. stalled/canceled, 2021–25 ($ billion)



Several announced projects stalled or canceled due to system constraints

Vietnam: Offshore wind canceled

- Ørsted **canceled two major projects** (~5 GW) in Ninh Thuan
- Attributed to **unclear PPA structures, permitting, and grid connection rules**

Thailand: RE projects delayed

- Key projects including South Khao Yai Thiang **wind farm** (50 MW) and SAMART's **waste-to-energy plants** (10 MW each) **delayed**
- Attributed to **land use constraints and approval bottlenecks**

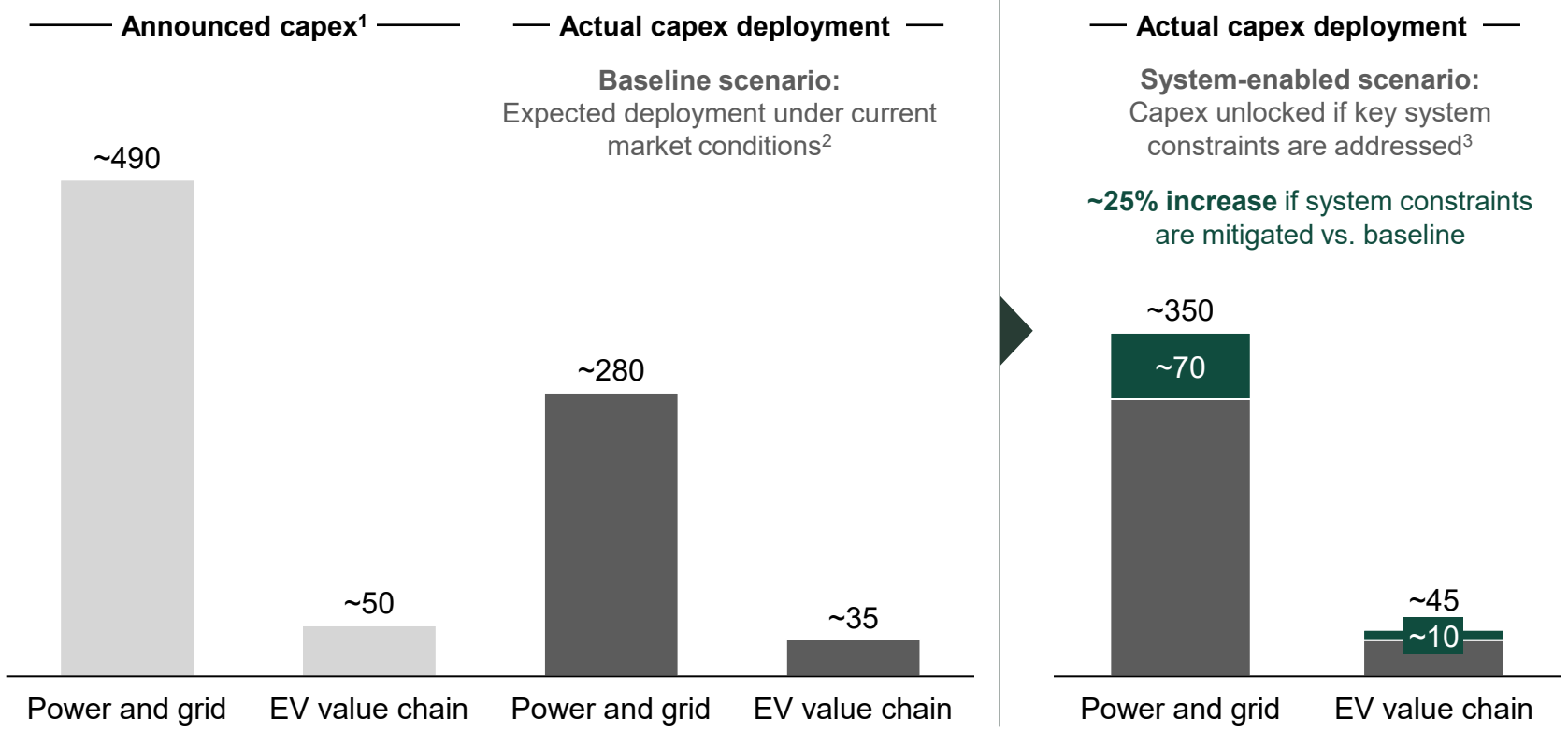
Sources: GlobalData; Wood Mackenzie; Berkeley Carbon Trading Project; Expert interviews; Bain analysis

Fixing roadblocks in SEA could unlock additional ~$80 billion of investment by 2030

While ~$540 billion in capex has been announced in power and EV value chains in SEA, only ~$315 billion is likely to be deployed under current market conditions

Mitigating system constraints could unlock an additional $80 billion in capex (~25% uplift)

SEA-6 capex deployment, 2026–30 ($ billion)



Notes: 1) Total capex announced to be deployed based on projects announced as of February 2026; 2) Represents the expected conversion likelihood, acknowledging that a portion of announced investments may not be realized; derived using a weighted average of Aspirational, Likely, and Locked-in classifications; 3) Represents the total investment flow if grid readiness is resolved and stronger EV regional integration happens, improving the overall deployment rate to SEA's average
Sources: GlobalData; Wood Mackenzie; Berkeley Carbon Trading Project

The window for scaling investment is open, but it may not stay open

Timing is critical; next 24–36 months will determine whether investment can scale and be supported by green power

Large-scale power demand is committing on compressed timelines

Hyperscalers, DCOs, and industrial parks are making investment decisions today; large loads (~100–500 MW) require power access in 24–36 months

EV manufacturing platforms are being allocated for the next decade

Global OEMs are locking in production footprints between 2025–28, after which supply chains, suppliers, and export corridors follow

Battery and midstream investments follow anchor OEM decisions

Cell plants cluster around early manufacturing hubs, reinforcing scale advantages and penalizing late entrants

Which will determine whether ...

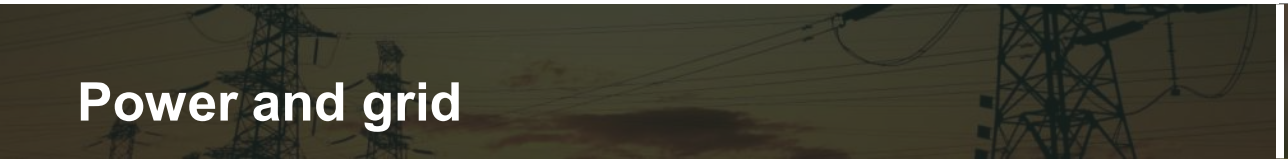
DC expansion compounds in SEA or reallocates

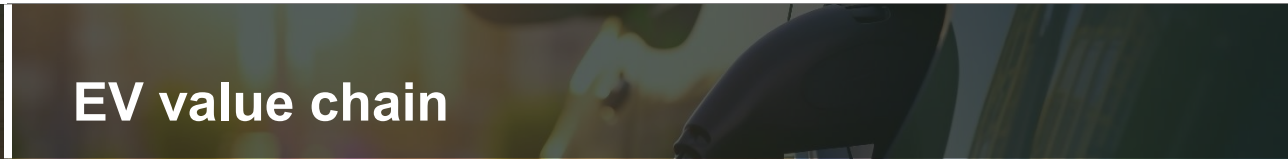
EV production anchors regionally or locks elsewhere

Battery ecosystems cluster in SEA or consolidate outside

Sources: IEA; Industry participant interviews; Bain analysis

Sequencing is strategy - capture now or lose the foundations for 2030





COMPETING TENSIONS IN ECOSYSTEM

Demand is committing before delivery capacity is expandable

Large, time-sensitive power loads are committed on timelines that move faster than regulated grid infrastructure can be expanded

Different actors are optimizing for different objectives

Utilities, corporations, and consumers each pursue rational but divergent priorities—reliability, speed, affordability

Grid investment is reactive, not anticipatory

Regulatory frameworks incentivize expanding transmission only once demand is contracted, causing infrastructure to lag growth

The value chain is regional, but policy remains national

EV production economics reward cross-border specialization and clustering, yet incentives and standards remain nationally structured

Scale is interdependent across the ecosystem

Battery plants, OEM platforms, and supplier networks require synchronized, interdependent commitments to reach competitive scale

WHAT SEQUENCING STRATEGY LOOKS LIKE

Capture near-term demand within existing system limits while accelerating grid depth so investment compounds in region rather than reallocating

Leverage growing demand to secure anchor OEM and battery commitments now while progressively aligning regional integration to translate demand into durable industrial depth

Sources: Expert interviews; Bain analysis

Unlocking regional potential requires sequencing the 2026–28 window correctly

Secure early demand and investment through pragmatic deployment pathways

POWER AND GRID

Capture emerging demand; keep loads grid-connected via interim solutions and near-term clean procurement

EV VALUE CHAIN

Anchor early EV investment by building initial value chain capabilities

Convert initial momentum into scaled capabilities and shared infrastructure

POWER AND GRID

Convert anchor demand into durable system capacity by expanding T&D infrastructure, enabling cross-border trade, and opening grid asset participation

EV VALUE CHAIN

Deepen regional EV value chains by scaling manufacturing clusters and charging infrastructure and by supporting industry capabilities

Scale integrated, regionally coordinated ecosystem

POWER AND GRID

Scale regional power system through integrated grids, coordinated market operations, and expanded cross-border electricity flows

EV VALUE CHAIN

Connect specialized national hubs through trade, supply chains, and shared standards

Sources: Expert interviews; Bain analysis

What then needs to happen? SEA's green economy will be won by execution

CALL TO ACTION

Government and policymakers

Reduce time-to-power for strategic demand, especially for DCs, EVs, and industrial clusters

Reform market design to improve bankability, including DPPAs/VPPAs, wheeling, and selective private-grid participation

Coordinate infrastructure around high-demand clusters to accelerate execution and attract first movers

Advance regional integration pragmatically through bilateral corridors and harmonized systems

Investors and financial institutions

Prioritize demand-backed investments where commercial demand is already visible and creditworthy

Fund the enabling systems, not just end assets—especially grids, storage, charging, and interconnections

Deploy blended and catalytic capital to unlock first-of-a-kind and early-stage resilience projects

Standardize structures and pool projects to create investable scale across SEA

Private corporations

Signal long-term demand clearly to unlock faster grid, renewable, and EV ecosystem build-out

Use flexible procurement pathways to secure reliable and cleaner power while infrastructure catches up

Commit early to local and regional value chains before supply chain positions harden

Embed resilience into operations and investment choices as a core competitiveness requirement

Source: Expert interviews, Bain analysis

Wider collaboration between APAC and SEA can unlock and scale regional potential

What SEA has to offer

Creditworthy demand

Growing energy needs from DCs, EVs, and industrial clusters deploying committed capital

100+ TWh of new energy demand to come from DCs, EVs and green industrial clusters, 2025–30

Resource endowments

Transition-critical minerals[1] and renewables for the energy transition

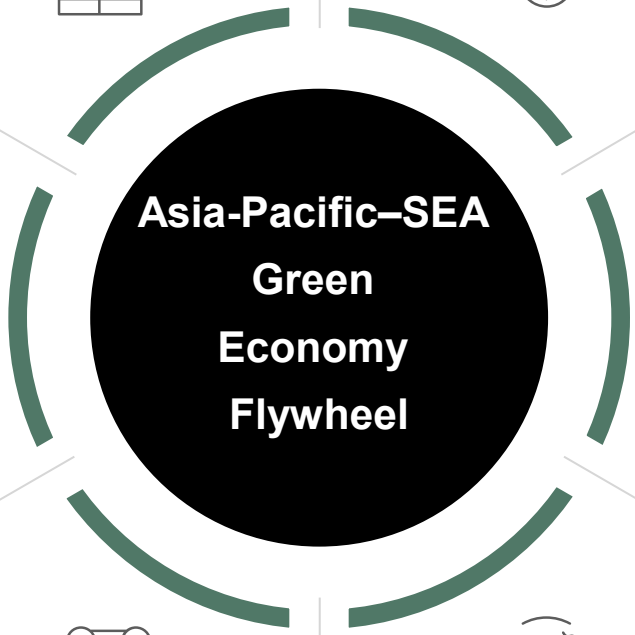
1st in global nickel reserves (Indonesia)

2nd in global nickel output (Philippines)

Manufacturing hubs

Automotive and industrial hubs ready to repurpose into green economy clusters

10th largest automotive producer globally in 2025 (Thailand)



What Asia-Pacific has to offer

Capital at scale

Deep industrial and project capital across China, Japan, Korea, and regional DFIs

$68B in FDI flowed from East Asian economies into SEA in 2024

Technology and know-how

Proven capabilities in batteries, grid systems, and manufacturing at scale

65% of global battery production in 2025 (China)

20% of global battery production in 2025 (Korea)

Ecosystem depth

Proven models for coordinated system build-out, resulting in stronger cost competitiveness

>30% lower cost of EV production in China vs. advanced economies

Note: 1) SEA's mineral endowment is a strategic advantage, but long-term value creation depends on developing the mining and processing base sustainably and responsibly
Sources: Expert interviews; Bain analysis

Wider cross-border collaboration has clear local and regional economic rationale

/ NON-EXHAUSTIVE

What SEA has to offer

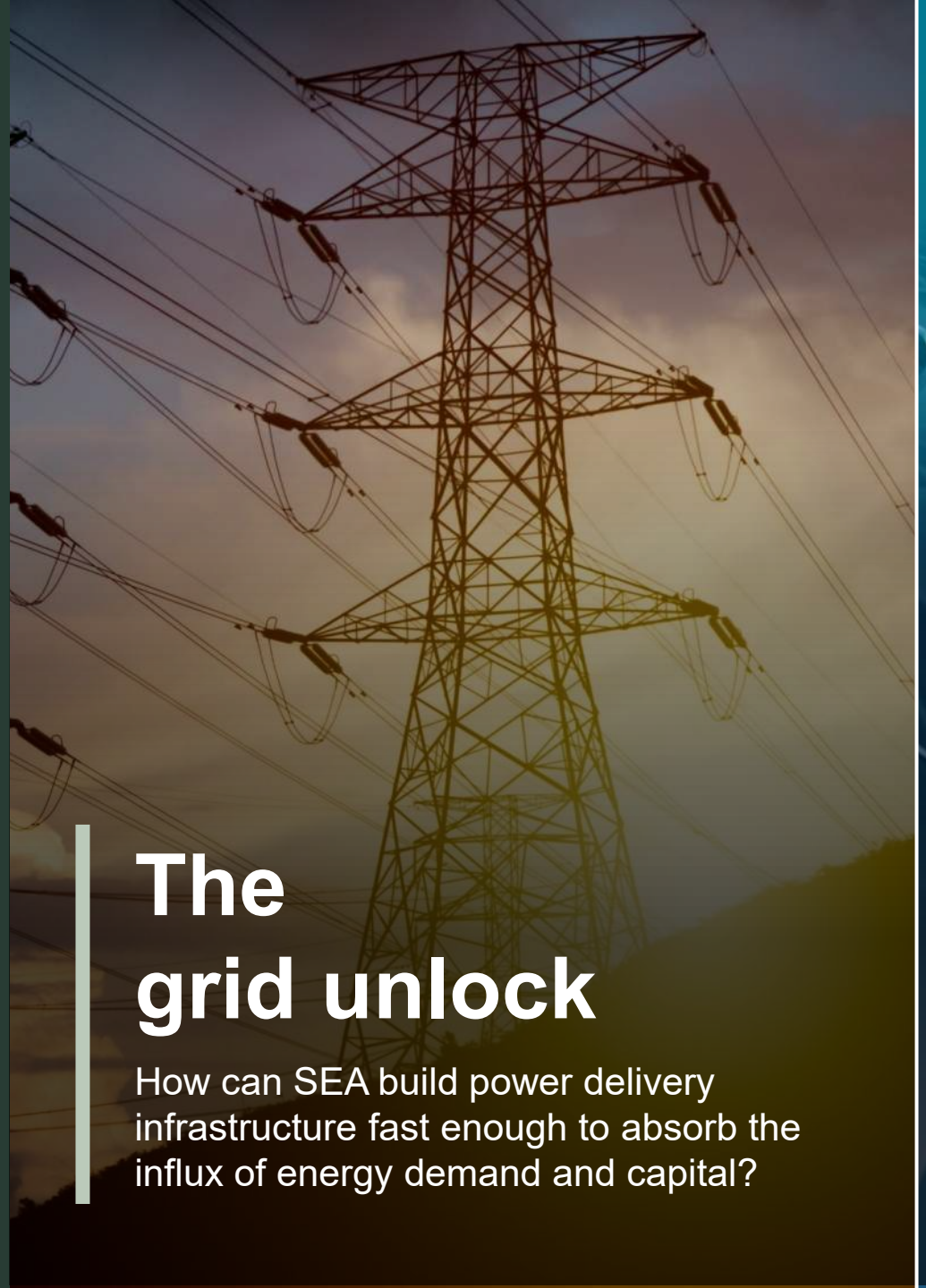
What Asia-Pacific has to offer

Indonesia	Malaysia	Philippines	Singapore	Thailand	Vietnam	Wider Asia-Pacific
Capital and market access						
Large **domestic demand**	Large, **creditworthy demand** for green power	Growing **investment and power demand**	**Financing** and **standards setting**	**Investment-ready base** for EV and industrial build-out	Domestic **EV demand**	Deep **industrial and project capital** across China, Japan, Korea, and regional DFIs
Power and grid system						
Export potential for green power	**Strong grid policies** and **DC corridor** (Johor)	Untapped **geothermal potential**	**Anchor demand** for cross-border power	Strong **grid reserve** margins	Strong **renewable energy base**	**Grid technology and equipment depth**, **proven market and operating models**, and **execution know-how** at scale
EV/industrial manufacturing						
Major **nickel and cobalt reserves**	**Electronics** and **advanced manufacturing** base	Large **nickel and cobalt reserves**	Regional **headquarters** and **coordination node**	**Automotive manufacturing** scale	Domestic **EV manufacturing** capabilities	**Battery technology**, **advanced materials and quality systems**, and **OEM ties**

Cross-border contribution of strengths could result in an Asia-Pacific–SEA green economy flywheel

Source: Expert interviews, Bain analysis

This report explores two key questions; each is a test of the new calculus in practice



The grid unlock

How can SEA build power delivery infrastructure fast enough to absorb the influx of energy demand and capital?

The EV value chain race

How can SEA convert EV demand into integrated battery and EV manufacturing ecosystems?

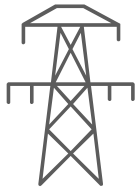
CHAPTER 1

The grid unlock

Emerging demand is real, creditworthy, and ready to commit … yet the regional infrastructure is not ready to serve it

The grid was built for yesterday's demand; today's capital won't wait

TENSION EXISTS AS INVESTMENT DEPLOYMENT OUTPACES GRID READINESS



~5–15 vs. ~1–3 years

Legacy grid development cycles

New demand patterns from DC/EV infrastructure

~100+ TWh

Estimated incremental demand from DC/EV infrastructure and green industrial parks (2025 vs. 2030) vs. ~30+ TWh (2020 vs. 2025)

~$18 billion/year

Gap in SEA grid investment to 2035[1] (~$29 billion required vs. ~$11 billion in 2024)

THIS CHAPTER COVERS

THE CONSTRAINT

Grid investment has lagged demand growth, even under moderate expansion

THE MISMATCH

Grid readiness is likely to fall short of accelerating investment timelines

THE UNLOCK

SEA must reduce time-to-power to capture new investment and growth

Note: 1) Required grid investment to meet Announced Pledges Scenario target as per the International Energy Agency | Sources: IEA; Global Energy Alliance for People and Planet

The grid “system” connects power supply and demand - the key determinant of the timely, scalable delivery of power to existing and growing major demand sources

Power generation

- Solar
- Wind
- Hydro
- Gas
- Geothermal

… and others

The grid system

Physical T&D network

- Transmission
- Substation
- Distribution

System operations

- Dispatch, balancing, and flexibility
- Congestion management

Market and access layer

- Permitting and approvals
- Market design (e.g., single buyer, tariffs, wheeling rules)
- Contracting mechanisms (e.g., DPPA, VPPA)
- Planning and investment signals (e.g., capacity planning)

End-use demand

- Data centers
- Electric vehicles
- Industrial parks

… and others

Source: Bain analysis

~100+ TWh of power demand lands in SEA over the next 3–4 years

DATA CENTERS	ELECTRIC VEHICLES	GREEN INDUSTRIAL PARKS
~100+ TWh of new demand (2025 vs. 2030) vs. **~30+ TWh** (2020 vs. 2025)		
~35–45 TWh Estimated incremental data center electricity consumption (2025 vs. 2030) for ~6.0–6.5 GW DC build	**~10–15 TWh** Estimated incremental EV electricity consumption (2025 vs. 2030)	**~25–60 TWh** Estimated incremental green industrial park electricity consumption (2025 vs. 2030)
~1–3 years Estimated deployment timeline	**~1–2 years** Estimated deployment timeline	**~2–3 years** Estimated deployment timeline
~$120–$130 billion Announced capex (2026–30)	**~$50–$60 billion** Announced capex (2026–30)	**>$40 billion** Announced capex (2026–2030)

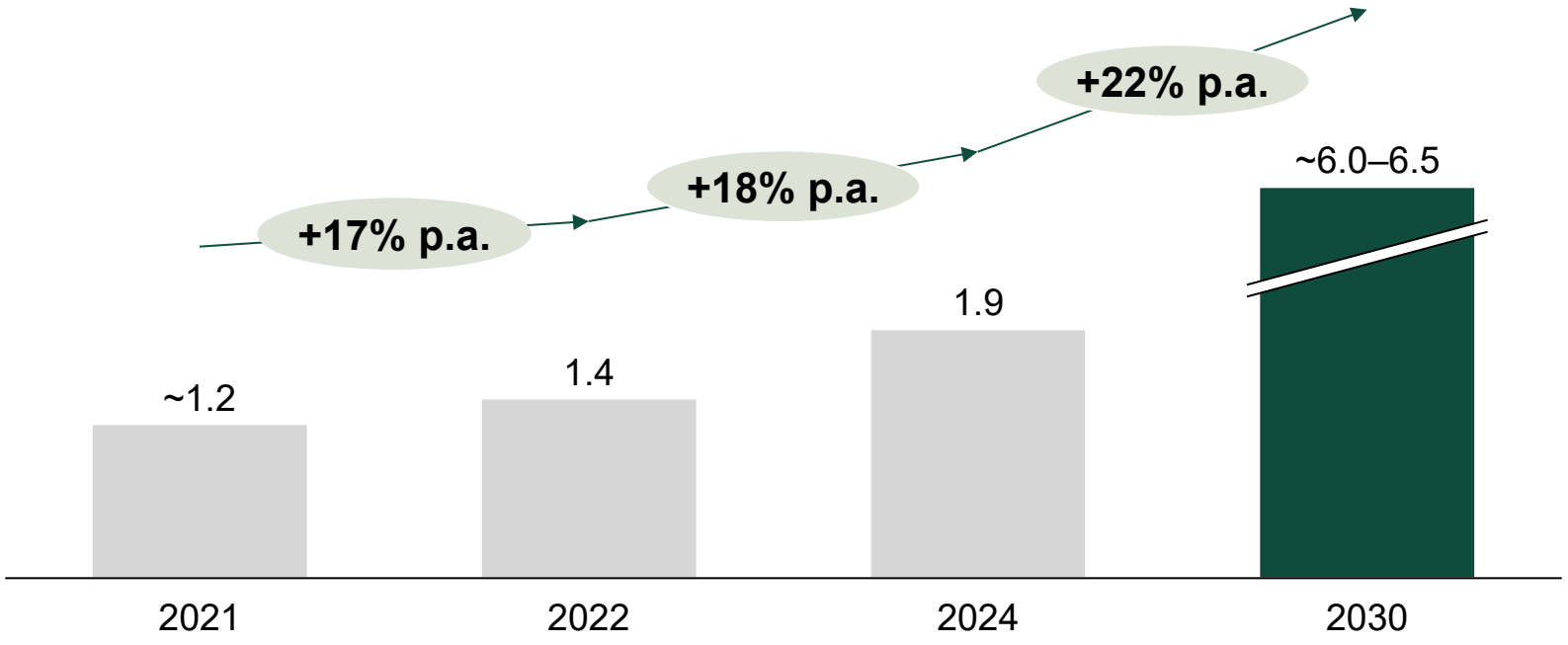
~100+ TWh of demand will arrive in the next 3–4 years from creditworthy sources, tied to ~$200+ billion of capex

Source: Bain analysis

DC load triples by 2030 - a new baseload category has arrived

Rapid regional data center expansion is driving sustained growth in electricity demand

DC IT load in SEA, 2021–30 (GW)



DC power consumption

FROM

~0.9%

of estimated total SEA electricity consumption in 2024

TO

~3.2%–3.5%

of estimated total SEA electricity consumption in 2030

DC IT load is estimated to grow ~3x by 2030, materially increasing baseload power requirement

Sources: ASEAN Centre for Energy; IEA; Ember; Bain analysis

DC load is not incremental; it demands large volumes of high-quality, reliable power, delivered on accelerated timelines

Structural characteristics of DC power demand

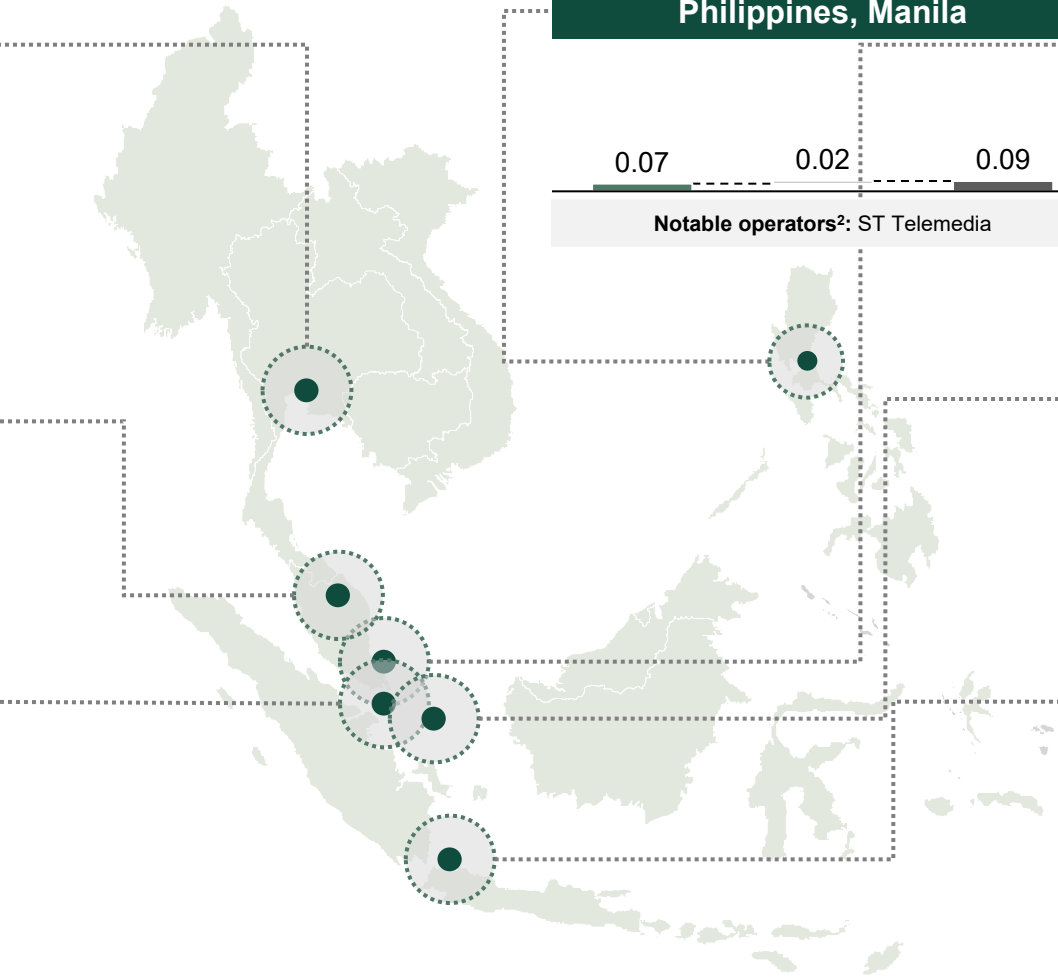
1	**Backed by large, creditworthy buyers with bargaining power**	• Hyperscalers have strong balance sheets and **long-term visibility on load,** making them attractive counterparties for developers and giving them leverage in **contract terms**
2	**Arrives as large, discrete blocks of load**	• Load arrives in **large, step-change increments**, unlike the gradual rise from homes or EVs • For example, Thai DC projects approved at 84–200 MW contributed to the tightening power reserve margins at ~26% in 2024 (vs. ~50% in 2022)
3	**Pays a premium for clean, high-quality power**	• Hyperscalers have public 24/7, net-zero, and “carbon-free” commitments and reputational exposure • DCs require **uninterrupted, high-quality power** to meet uptime guarantees (often 99.999%)
4	**Geographically concentrated in a few hubs**	• DC demand is **localized**, not spread evenly across national grids, resulting in sharp load imbalances • For example, ~70% of SEA’s existing capacity is clustered in **Singapore (~1 GW), Johor (~0.6 GW)**
5	**Moves on faster timelines than grid expansion**	• DCs can be built in **1–3 years**, often faster than utility grid reinforcements or generation additions • This timing mismatch puts pressure on grid operators and regulators to **accelerate approvals and upgrades**

Sources: Cushman & Wakefield; JLL; Bain analysis

>70% of SEA's DC load sits in two clusters - and it's arriving in 100–200 MW blocks

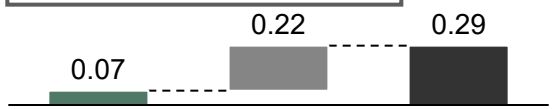
/ NON-EXHAUSTIVE

Key DC hubs | IT capacity—operational (GW) | IT capacity—under construction (GW) | IT capacity—operational and under construction (GW) | IT capacity—total, including planned (GW)



Thailand, Bangkok and EEC[1]

EEC is rapidly expanding, with **~0.64 GW of additional capacity planned**, competing closely with Johor as SEA's DC hub

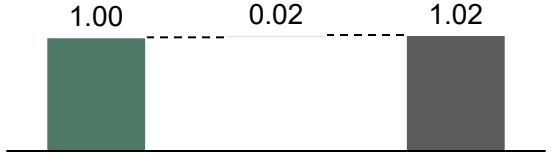


Notable operators[2]: Google, Amazon Web Services, Equinix, DayOne

Malaysia, Kuala Lumpur

Notable operators[2]: Equinix, Bridge Data Centres, AirTrunk

Singapore

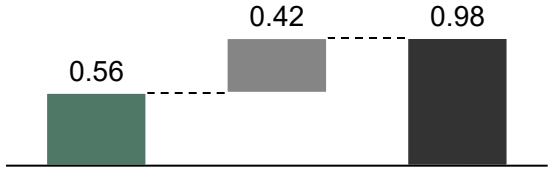


Notable operators[2]: Google, Amazon Web Services, Microsoft, Equinix

Philippines, Manila

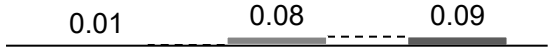
Notable operators[2]: ST Telemedia

Malaysia, Johor



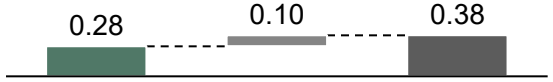
Notable operators[2]: Microsoft, DayOne

Indonesia, Batam



Notable operators[2]: DayOne

Indonesia, Greater Jakarta



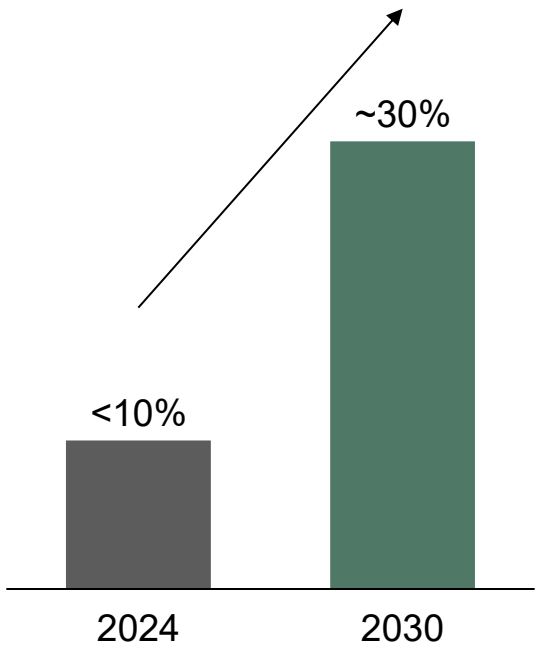
Notable operators[2]: Google, Amazon Web Services, Microsoft

Notes: IT capacity data as of H1 2025 from Cushman & Wakefield and JLL, with additional post-Q2 2025 planned capacity updates based on lit. search; 1) Bangkok and EEC data here refers only to Bangkok and East Economic Corridor (EEC) capacity; neighboring regions such as Nonthaburi and Samut Prakan are excluded; 2) Includes operators with planned or announced investments; facilities may not yet be operational | Sources: Cushman & Wakefield; JLL; Bain analysis

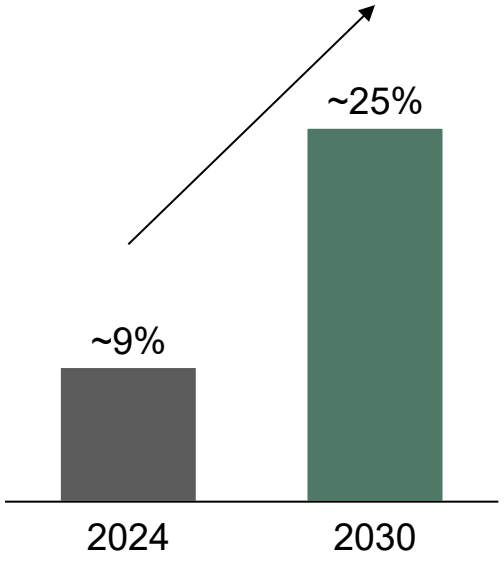
Additionally, EV adoption is expected to grow sharply through 2030, creating a parallel, long-term source of power demand

EV adoption is set to grow sharply through 2030 across all segments, contributing to ~1% of overall electricity demand

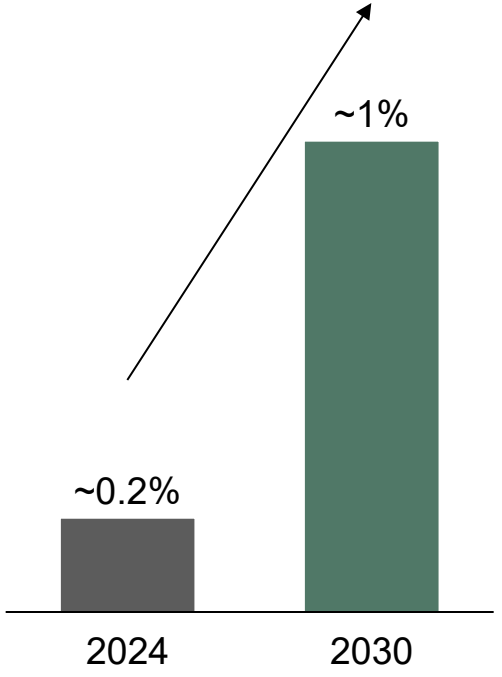
Electric 2W/3W SEA annual sales volume share, 2024 and 2030 (%)



Electric car (BEV & PHEV) SEA annual sales volume share, 2024 and 2030 (%)



Share of electricity consumption from EV[1] in SEA, 2024 and 2030 (%)



Key characteristics of EV-led demand

Reliable, market-led growing demand

Sustained EV adoption growth driven by declining battery costs, competitive Chinese OEM pricing, and local manufacturing scale, which structurally improves EV affordability and availability

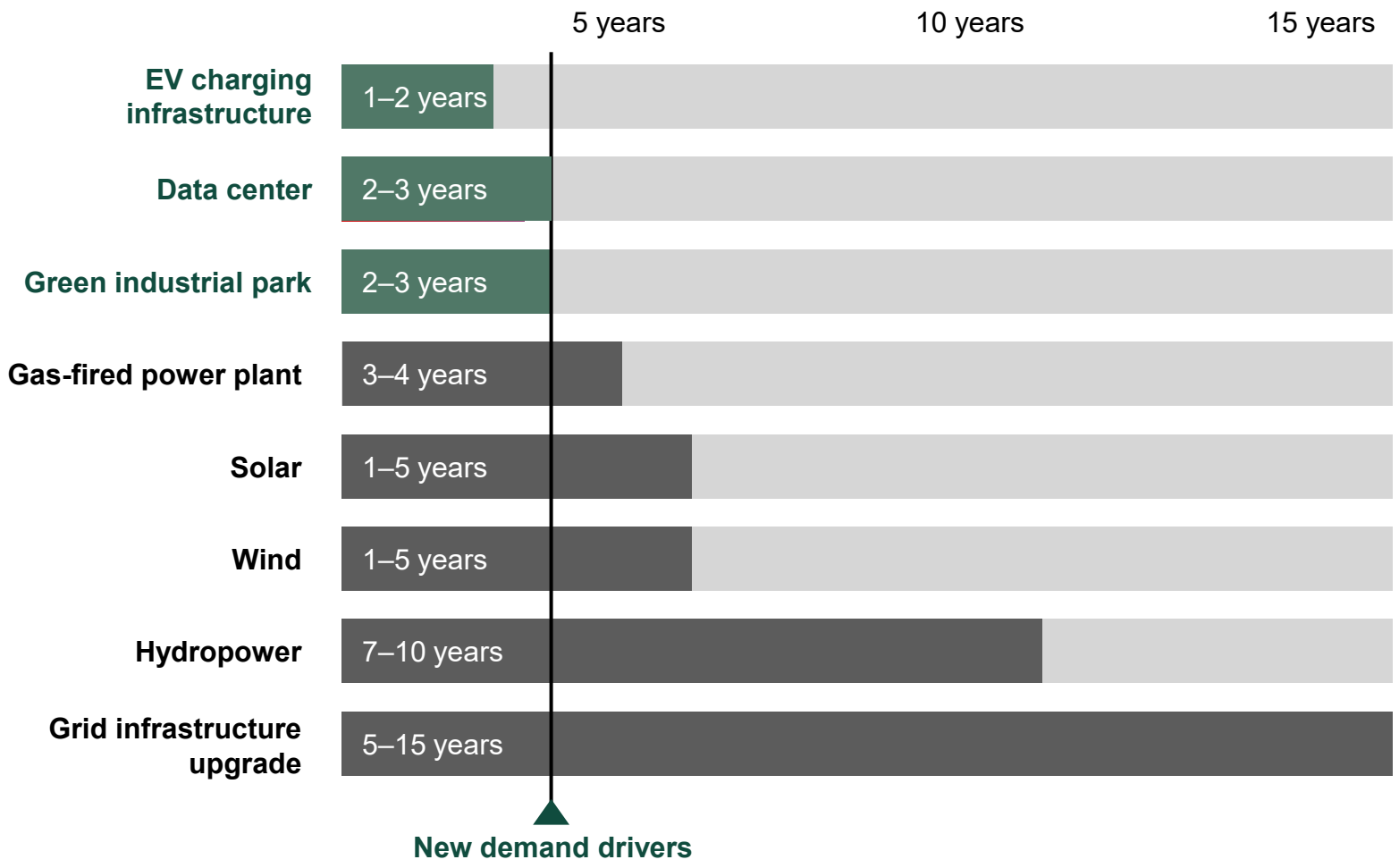
Long-term load profile

EV fleets typically operate over 10–15 years, which supports long-term revenue visibility for charging and power infrastructure

Note: 1) Refers to all electric vehicle types | Sources: IEA; Bain analysis

These large, concentrated loads deploy in 1–3 years, while the grid required to serve them takes 5+ years - creating a structural time-to-power gap and infra challenge

New demand comes online far faster than the grid can be upgraded



~2x–5x

Longer to upgrade T&D grid vs. deploy new demand

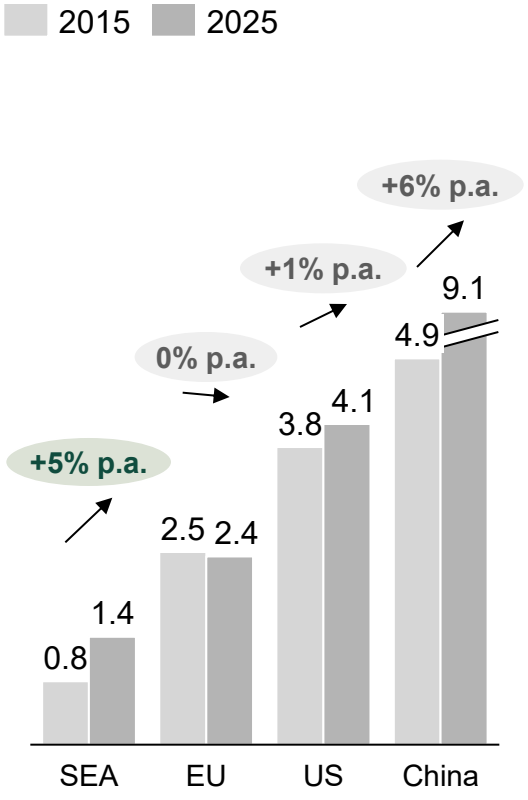
Only **modular, behind-the-meter solutions** (e.g., solar with storage) can meet near-term demand, leading buyers to design **around** the grid, not **for** it

Sources: IEA; Industry participant interviews; Bain analysis

Generation is not the constraint - transmission is, with an $18B annual shortfall

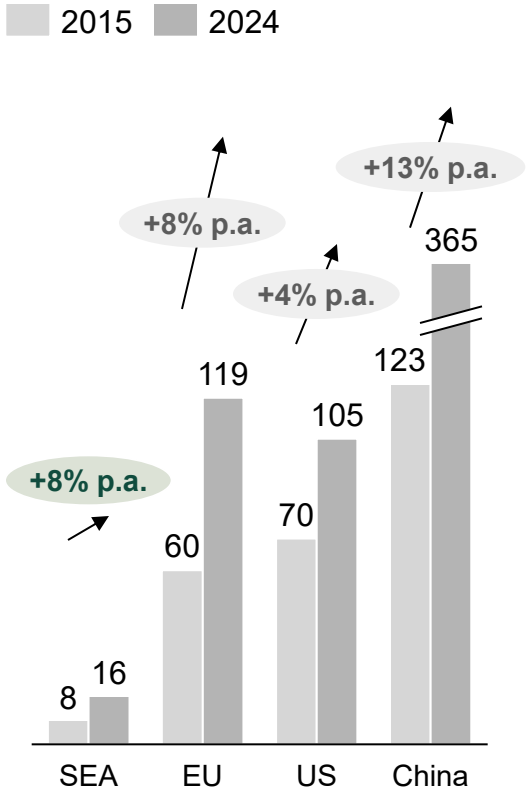
SEA's demand has been growing rapidly

Electricity demand, 2015–25 (TWh thousands)



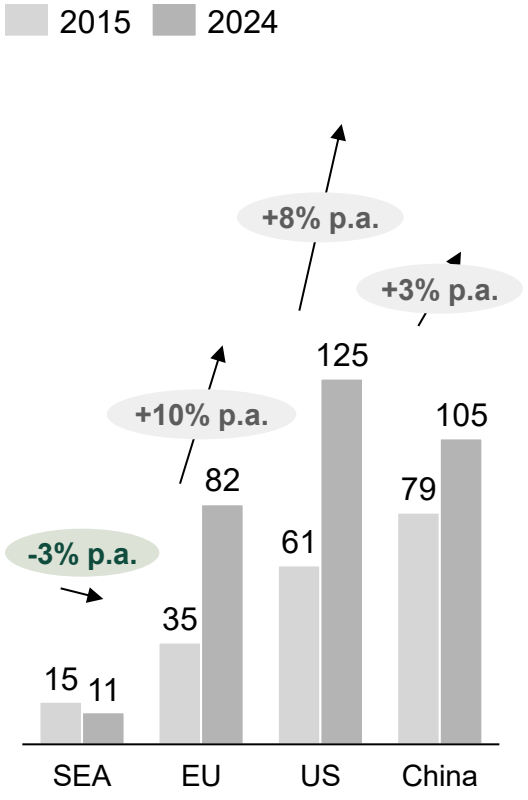
While investment in generation is on par ...

Investment in low-emissions generation, 2015–24 (USD billion)



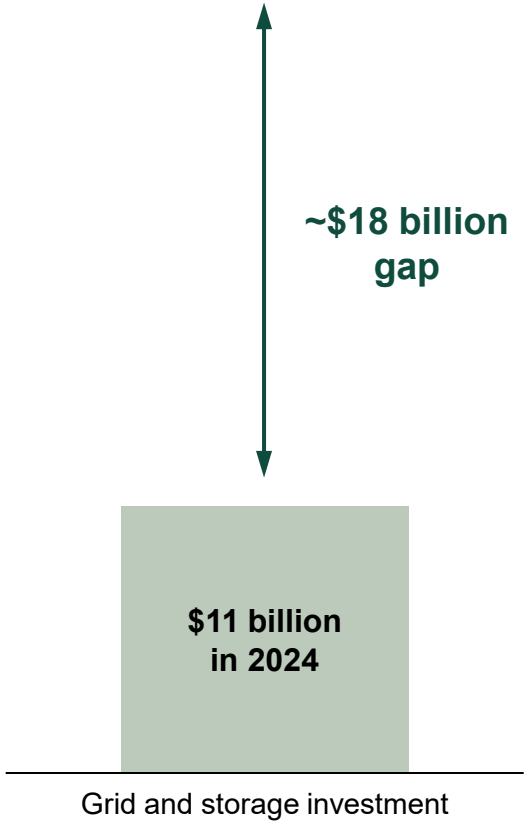
... grid investment is not keeping pace

Investment in grid and storage, 2015–24 (USD billion)



~$18 billion/year gap in SEA grid investments

$29 billion/year required by 2035



Source: IEA

The grid investment gap is already leading to a “grid breakpoint” in many markets across SEA; existing “headroom” is being absorbed faster than new capacity

Grid capacity is maxed out in markets where it matters most

Malaysia

- Grid constraints remain key bottleneck, with DC power **supply applications already exceeding 11 GW** (~40% of Peninsular Malaysia’s current installed capacity)
- TNB has **committed ~$10 billion** to upgrade and expand national grid

Grid Expectations: Can Malaysia's Power Grid Cope with Rise of Data Centres?
Bernama Garasi

Johor data centres hit ‘time to power’ bottleneck
The Business Times

Thailand

- **Power shortages** emerging in key provinces such as **Chon Buri** and **Rayong,** with substation expansion failing to keep up with rising demand
- Electricity Generating Authority of Thailand is investing **~$1 billion to upgrade the EEC grid** and relieve supply bottlenecks for DC development

EGAT to invest 3bn baht to upgrade power grid for Thailand’s data-centre push
The Nation Thailand

Egat makes B31bn investment to upgrade EEC power system
Bangkok Post

Indonesia

- Power capacity in Jakarta’s DC clusters increasingly constrained, with **most supply already committed**
- Securing **new grid connections** can take **up to three years**, extending time-to-power for new developments

Lack of grid investment stalls progress on clean energy
The Jakarta Post

Gearing up for a major grid transition, investment in Indonesia
The Star

Vietnam

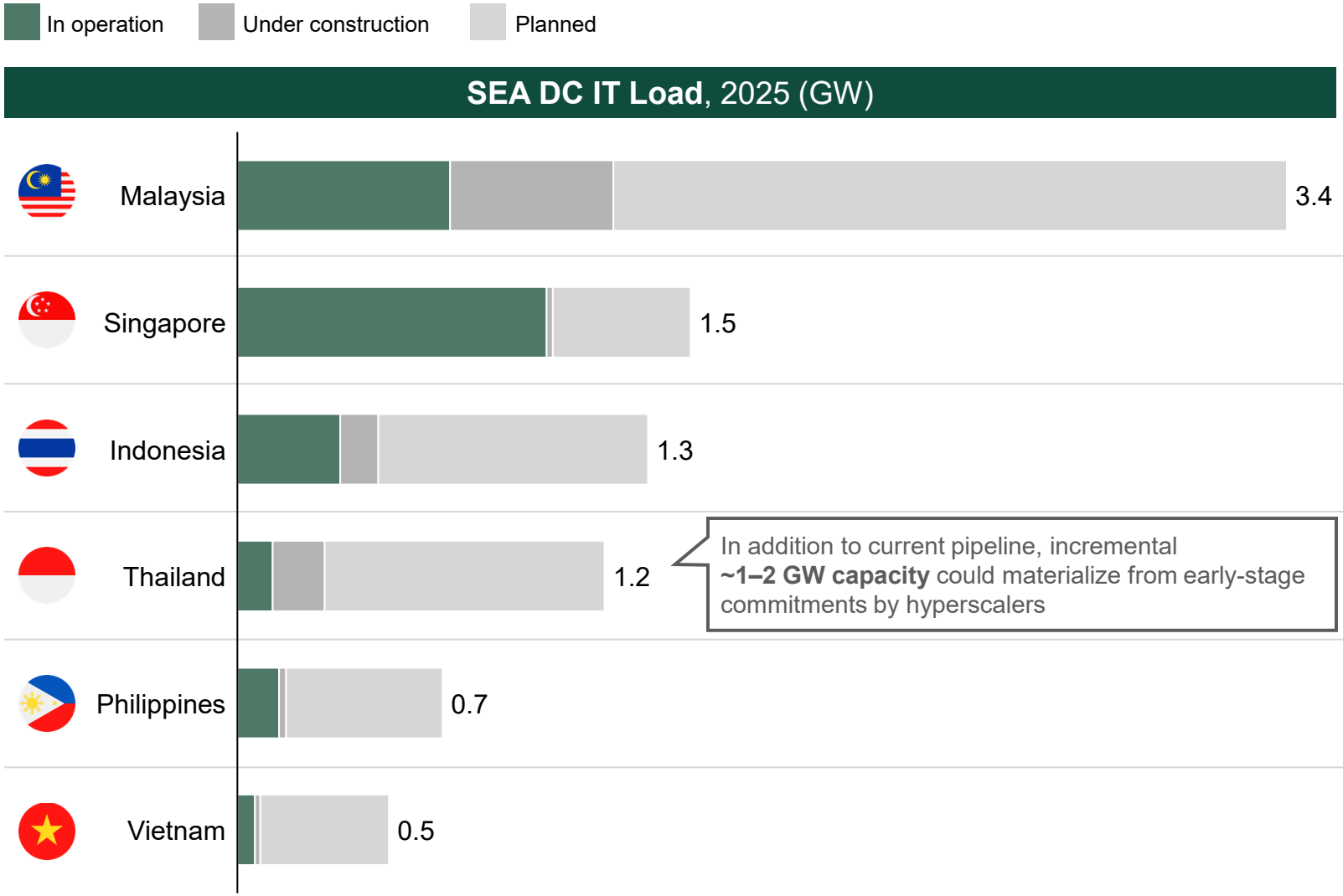
- Vietnam’s grid reliability constrained—**frequent outages** are common as the **national grid struggles to keep up with peak demand,** raising “time-to-power” and reliability risk for DC rollouts

Vietnam’s AI push hits hiccups amid power constraints
VnExpress

The cost of cloud: Vietnam’s data center push comes with a price tag
Mekong Eye

Sources: Cushman & Wakefield; International Trade Administration; Bain analysis

Grid readiness is now a defining factor in DC capital allocation today



Grid readiness and capital trajectory

↑ Capturing: Grid expansion underway with TNB's ~$10 billion commitment; improved RE purchase with CRESS (1.3 GW secured in first 9 months)

→ Holding: Highly reliable grid with 0% T&D losses, but DC approvals tightly controlled and land/energy imports limit scale

↗ Capturing/Holding: Utility's financials are constrained and need MDBs support (e.g., World Bank $500 million grid upgrade loan), but selective local DC builds observed

↑ Capturing: EEC is well positioned with dedicated industrial power infrastructure; EGAT continues reinforcing grid with ~$85 million investment in 2025

↓ Stalling: Facing delays for transmission projects across Luzon, Visayas, and Mindanao

↓ Stalling: Frequent power outages disrupt operations; ~$3–$4 billion investment annually needed to improve country's transmission

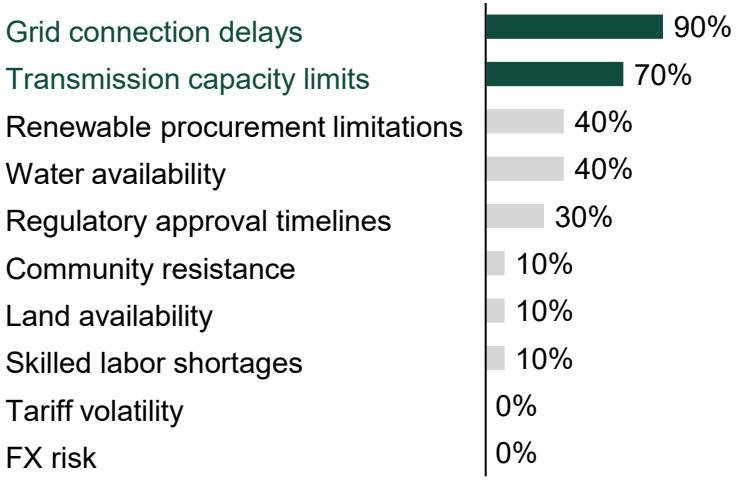
Notes: IT capacity data as of H1 2025 from Cushman & Wakefield and JLL, with additional post-Q2 2025 capacity updates based on literature search | Sources: Cushman & Wakefield; JLL; GlobalData; Bain analysis

DC capital is ready to deploy more investment - it's waiting on the grid

Insights from Bain SEA DC Operator and Hyperscaler Survey Q1 2026

Grid connection delays and T&D capacity issues are the biggest constraints to DC investment

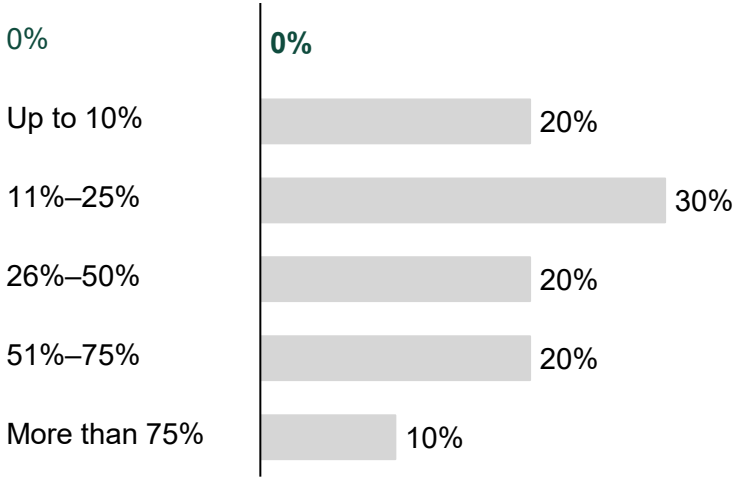
Q: What are the top three factors constraining further DC investment in SEA?



percentage of respondents ranking the factor among their top three constraints

The **exposure is structural** as majority of DC players have >25% of projects relying on future grid updates

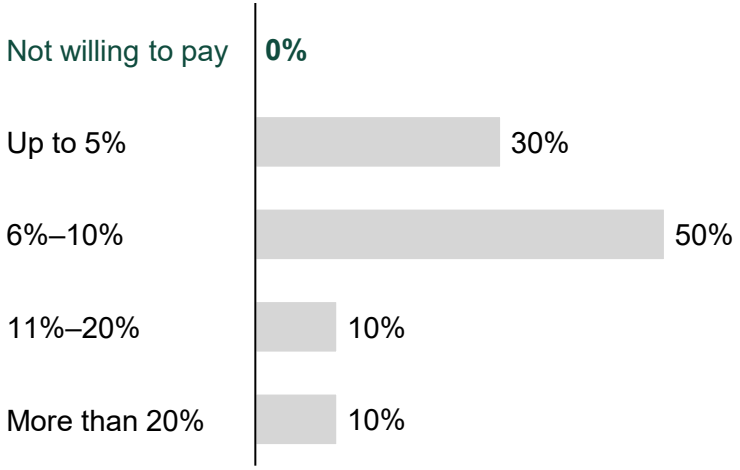
Q: What percentage of your planned SEA projects depend on grid upgrades not yet funded or constructed?



percentage of respondents with SEA projects dependent on grid updates

DC players show **clear willingness to pay a premium** for guaranteed grid connection timelines

Q: Would you be willing to pay a premium tariff for guaranteed grid connection within a fixed delivery timeline?



percentage of respondents willing to pay a premium tariff for guaranteed grid connection

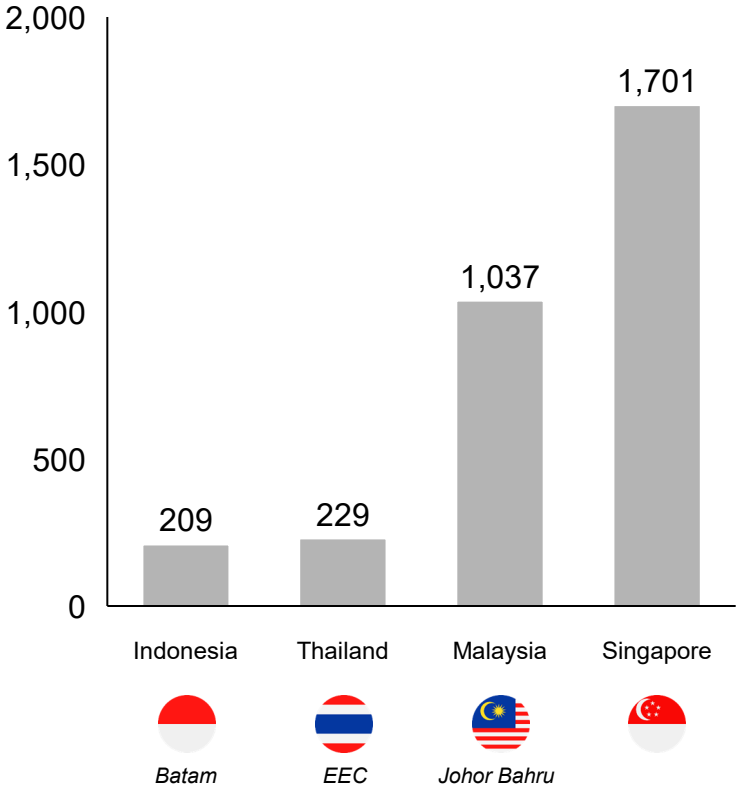
If grid constraints were mitigated, DC players would, on average, commit ~0.3GW[1] of additional capacity per player in SEA over the next three years

Note: 1) Survey responses were provided in capacity ranges; midpoints of each range were used to calculate the average | Source: Bain SEA DC Operator and Hyperscaler Survey 2026 (n=10, covering ~50% of SEA capacity)

Relative to SEA peers, Malaysia and Thailand currently offer strongest delivery fundamentals to capture DC demand

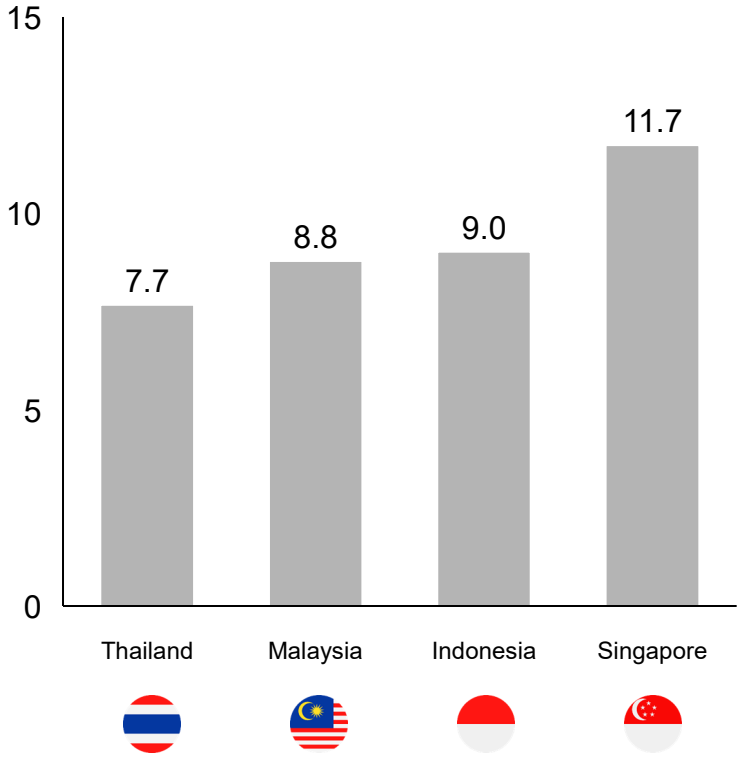
Land

Land cost, 2024
(USD per m^2)



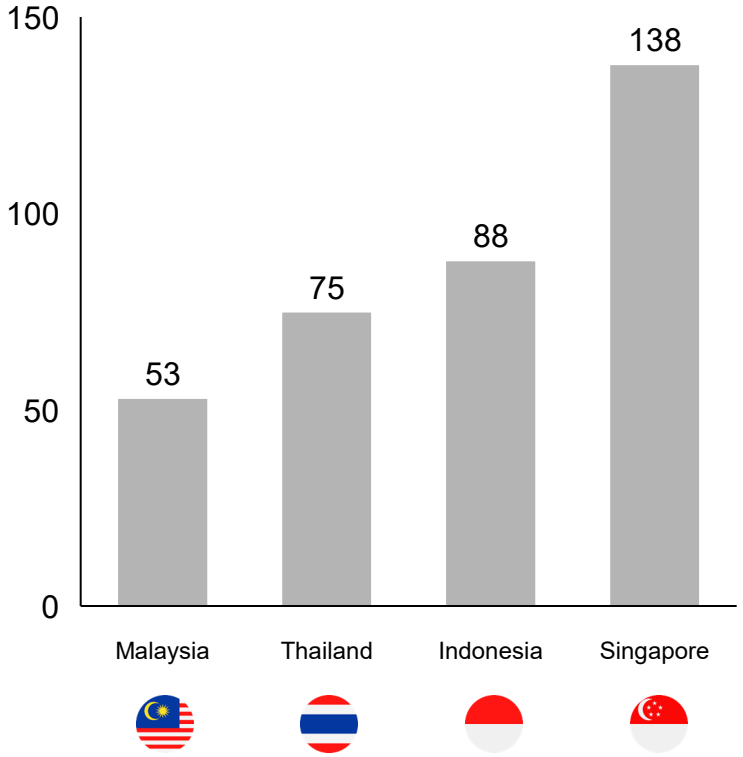
Construction

Construction cost,[1] 2024
(USD million per MW)



Power

Monthly power cost,[2] 2024
(USD per kW)



Notes: 1) Construction cost index calculated from benchmarking key cost data, including shell and core, architectural fit-out and finishes, mechanical and electrical fit-out, labor costs, mechanical and electrical equipment, etc., and standardizing cost data to represent a hyperscale DC in the average range of 5–20 acres of 50 MW capacity; 2) Power cost is assumed to be the cost of a 20 MW data center with power usage effectiveness (PUE) of 1.3 running at 60% occupancy and steady workload; cost includes all recurring costs (base tariff, metering costs, network charges, distribution charges, etc.)
Sources: Cushman & Wakefield; Asia Pacific Data Centre Construction Cost Guide 2025; UN-Water; Bain analysis

Johor (Malaysia): The DC boom is real, but power & water may prove a constraint

Johor saw rapid DC expansion in the past five years ...

- **2020:** Johor's **first DC** was completed
- **2022:** **First hyperscale campus announced**, ~0.2 GW capacity
- **2023:** TNB launches **Green Lane Pathway to fast-track energization** to 12 months (3x faster)
- **2024:** **Two hyperscale sites energized** in Sedenak (total ~0.535 GW)
- **2025:** RP4 approved at +**$800 million annual T&D investment** for Johor within wider TNB envelope (~30% more than RP3), **~0.56 GW DC capacity** operational[1]
- **2026:** **~0.42 GW DC** capacity under construction, additional **~1.4 GW** planned
- **2029:** Projected to reach **~5 GW DC capacity**

0.2 GW
DC capacity in 2022

↓ 3x

0.56 GW
DC capacity in 2025[1]

1.82 GW
DC capacity under construction/planning

4%–5%
of Malaysia's total power capacity (if all planned capacity comes online)

... however, committed DC capacity is now outpacing delivered grid and water infrastructure

Power: New demand outpaces delivered grid capacity

- RP4 investments are conditional and phased; grid upgrades and interconnections only deployed when demand is certain
- Transmission upgrades still face multiyear lag vs. FID timelines

Water: A second binding constraint

- Tightening approvals for new high-intensity DC projects (Tier 1 and 2) given 200x higher water usage than lower tiers
- New DC-specific water tariff (up 50%) from August 2025
- Community pushback rising; Johor's first protest observed

Malaysia draws first data centre protest over pollution, water
The Gelang Patah project is unusually close to a residential area
The Business Times, Feb 2026

Johor data centres drive revenue but strain resources, says Amanah leader
New Straits Times, May 2025

> People are too hyped about data centers nowadays, but the **issue in Johor is water and power.**
>
> DATUK MOHD NOORAZAM OSMAN, FORMER MAYOR, JOHOR BAHRU CITY COUNCIL

Note: 1) Data as of H1 2025 | Sources: Cushman & Wakefield; JLL; Bain analysis

The EEC (Thailand) is an emerging contender for future DC demand; however, accelerated growth is tightening reserve margins and challenges momentum

EEC scaled from first build to national leader within three years

- **1H 2023:** Rayong's **first DC completed** (~1.4 MW)
- **2H 2023:** **First hyperscale DC campus** completed in Chon Buri**,** ~0.15 GW
- **2024:** **Google announced ~$1 billion investment commitment** in Chon Buri
- **2025:** **Regional developers scale up,** ~0.28 GW build
- **2025:** **~0.204 GW** DC capacity under construction, additional **~0.640 GW** planned
- **2030:** Could reach **~0.882 GW DC capacity**

0.001 GW
DC capacity in 2023

0.038 GW
DC capacity[1] in 2025

~0.844 GW
Under construction and planned capacity —more than rest of Thailand combined

~1.2%
of Thailand's 2030 total power capacity[2] (if all planned capacity comes online in 2030)

~26%
Thailand's reserve margin in 2024 (vs. ~50% in 2022)

Backed by structural advantages and supportive regulations

Power: Structural supply provides reliable scale

- Existing industrial grid surplus with available connection capacity reduces time-to-power
- LNG infrastructure from Rayong terminal provides relatively scalable, dispatchable capacity to ensure stability for large 24/7 hyperscale loads
- Ongoing grid modernization investment (~$85 million in 2025) strengthens grid reliability and future scalability

Regulations: Execution certainty and speed

- EEC positioned as a national high-tech corridor under Thailand 4.0, signaling long-term state commitment
- Board of Investment's targeted incentives (e.g., 3- to 5-year corporate tax exemption) improved DC investment returns
- Pre-zoned and precleared industrial land for digital infrastructure lowered site preparation risk

BOI moves to unlock zoning and land rules to ease EEC investment bottlenecks

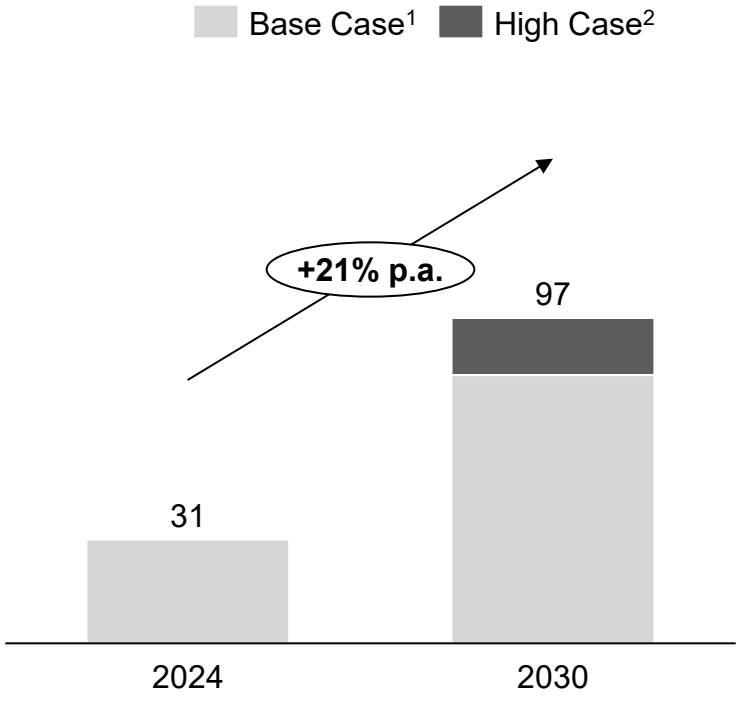
The Nation Thailand, Jan 2026

Notes: 1) Data as of Q1 2025; 2) Based on estimated total 2030 power capacity for Thailand | Sources: Cushman & Wakefield; Bain analysis

When the grid fails to deliver, capital engineers around it - as the US today shows

DC growth is increasing the need for power …

Cumulative data center capacity in the US, 2024–30 (GW)



… however, issues with grid persist …

Grid delivery lags project timelines

- Utilities' power delivery timelines are typically 1–2 years longer than hyperscaler and colocation developers' expectations

Aging grid infrastructure hinders interconnections

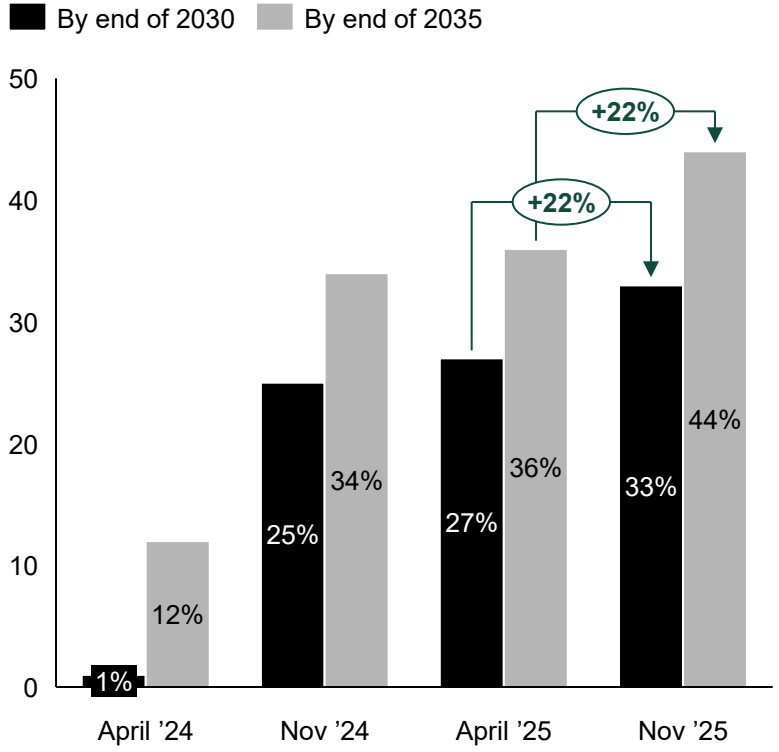
- T&D bottlenecks slow grid interconnections despite utilities generating enough power
- Congestion increases, which raises power delivery costs

*"**If I can get grid power, I would choose it every time. Nobody building data centers wants to be in the business of operating generation assets.** … But because of grid interconnection lead time, **it's almost impossible to access the grid when we need it,** so we look to SOFCs and other forms of power."*

—Senior executive, DC operator

… prompting DCs to shift toward BTM solutions

Percentage of developers expecting 100% on-site generation at data centers,[3] 2024–25



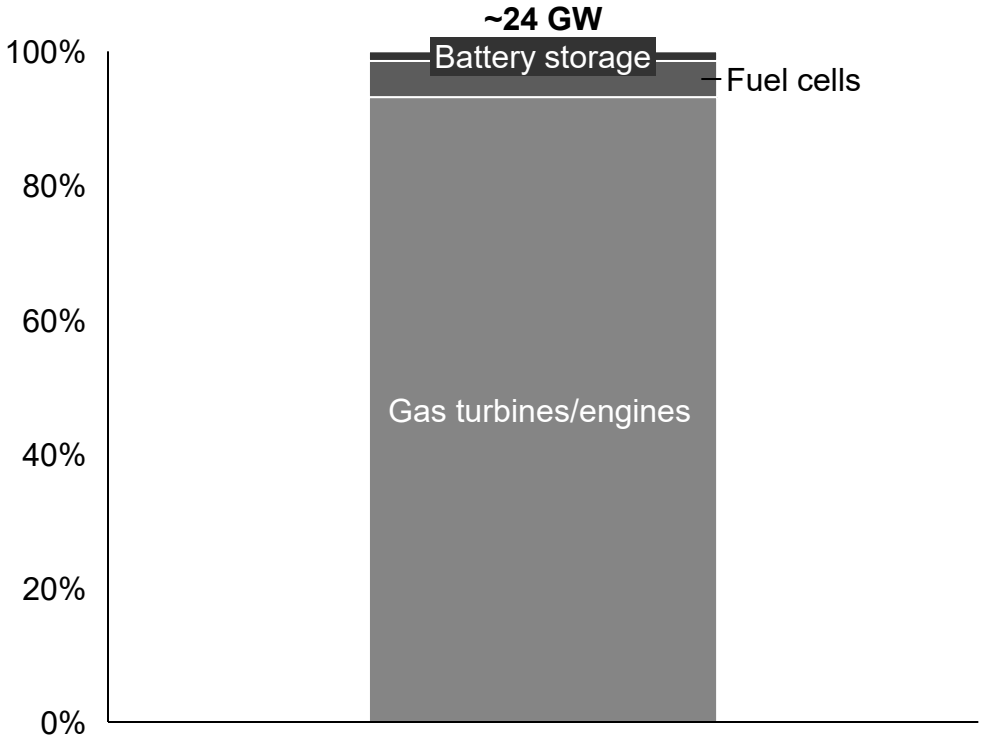
Notes: 1) Base case represents strong AI demand growth continues while ongoing power/component constraints continue to bind in key regions like the US; 2) High case represents maximum AI growth, X Processing Unit allowed, through rapid GenAI adoption across sectors and requires breakthroughs in power generation & build locations optimized for power; 3) Survey of DC decision makers (n=30 in April 2024, n=100 in April 2025); survey question: What percentage of data center sites do you think will have 100% on-site power generation in 2030? | Source: Bloom Energy's Survey of data center decision makers

The absence of readily available and connectable power has led to a structural pivot to on-site generation - with 20+ GW of behind-the-meter power committed

DIRECTIONAL – NON-EXHAUSTIVE – AS OF JAN 2026

Natural gas accounts for ~90% of all on-site generation BTM equipment committed in the US

Share of committed BTM on-site power capacity by technology[1]
(percentage)



On-site distributed generation technology	2025 committed volume	Commentary
Gas turbines	~22.8 GW	• Natural gas turbines driving majority of 2025 committed volume • 10–50 MW natural gas turbines contribute majority of volume
Gas engines		• Large arrays of small gas engines (<5 MW) for small DC applications • Limited large-format (>15 MW) committed in 2025
Fuel cells	~1.3 GW	• Bloom Energy is the main fuel-cell provider serving DC at scale
Battery storage	~0.3 GW	• Primarily deployed alongside on-site renewables, e.g., solar or wind

Note: 1) Capacity represents generation deals and transactions that were able to be identified and verified through permit documents, SEC filings, and press releases; this represents what was publicly discoverable, not necessarily all generation | Source: Cleanview data center tracker

BTM works in the US because three things align; they are not present in SEA today

	Fuel infrastructure and access	Market structure permitting private generation	Commercial bankability of private generation
US	✓ **Mature and competitive gas markets** provide operators direct, long-term fuel contracting access ✓ Industrial-grade **infrastructure typically reaches DC campus**	✓ Private microgrid **participation is widely permitted** in many ISO/RTO wholesale markets (e.g., PJM[1], NYISO[2], ISO-NE[3], CAISO[4]) ✓ Clear **interconnection and aggregation frameworks** for captive generation	✓ **Multiple routes to monetize** beyond self-consumption (e.g., demand response, capacity/ancillary services) ✓ **Available tariff and wheeling frameworks** (e.g., net-metering rules support surplus sale through retail credits or wholesale participation via aggregation where permitted)
SEA	✗ **State-owned gatekeepers** sit between DC operators and fuel/gas access ✗ Current gas infrastructure built for centralized plants; **site-level access is limited in most DC clusters**	✗ **Strong utility or single-buyer structures** dominate most markets, limiting private participation (except PH, SG) – e.g., in MY and ID, all private generators must sell power to TNB, PLN respectively, as the primary grid offtakers	✗ **Weak economics for export of surplus power** (e.g., MY's CRESS sets ~RM0.08/kWh sale price vs. ~RM0.20/kWh wheeling charge) ✗ Long-term **project finance viability constrained** (e.g., MY's wheeling charges reset every three years, with up to ~15% increase per reset)

"We're starting to see progress in BTM, but it's not about replacing the utility. In most cases the **utility will still supply the majority of the power**. **Behind-the-meter generation** is really there to **fill the gaps when the utility can't meet the full requirement** so projects can move forward." — DC Operator, Southeast Asia

Given these constraints, BTM will only complement SEA's grid at a margin

Notes: 1) Pennsylvania-New Jersey-Maryland Interconnection; 2) New York Independent System Operator; 3) Independent System Operator New England; 4) California Independent System Operator
Sources: Industry interviews; Bain analysis

BTM likely to evolve incrementally in SEA - reinforcing urgency to upgrade grids

Common → Niche/pilot | Growing | Stable

	1 Diesel generators as backup	2 Renewables with battery storage	3 Natural gas turbines (on-site)	4 Industrial microgrids
Description	**Fastest to deploy with minimal regulatory friction**; proven backstop for grid delays **Misaligned with net-zero** commitment targets	ESG-aligned and relatively **quick to deploy** **Higher LCOE and limited storage duration** limit 24/7 replacement capability, positioning it as grid support rather than substitution	**Closest to baseload-capable** on-site supply; like US BTM model Constrained by **underdeveloped site-level gas infrastructure and multi-party** regulatory coordination requirement across utility and fuel supplier	**Long-term resilience model** with potential cost/reliability benefits **Unclear regulatory frameworks** (across licensing, third-party supply, and wheeling) limit private players' ability to operate at scale
What we hear from industry	*"We use backup generators as core resiliency infrastructure."* —DC operator	*"We could be faster to market, but there will be no takers at the current price point."* —DC operator	*"PLN is very separated from Pertamina, same with PETRONAS and TNB, if collaboration does not happen, BTM will be challenging."* —DC operator	*"Microgrids are attractive, but high initial capital cost and regulatory structures oriented for centralized grid models create complexity."* —Industrial energy developer
SEA adoption	Deployed today as preferred solution for backup	Several deployments across data centers	Selective deployment, primarily in Thailand's EEC and green zones	Limited to government-supported industrial zones
SEA outlook	Quietly increasing despite ESG commitment clashes	Near-term solution for corporations seeking ESG alignment	Scalability limited by multi-party coordination requirement	Scalability dependent on supportive regulatory frameworks

Sources: Industry interviews; Bain analysis

First deliver power reliably. Then make it green - so say data center participants

Power sourcing decision criteria for SEA DC players

Decision criteria	Description	DC decision criteria ranked	Commentary
Cost	Total **delivered cost of electricity** (effective $/kWh), including energy price, capex recovery, and O&M	**1** *(tied)*	*"Malaysia's new tariff structure will see operators of large DCs paying a larger share of grid costs, and **many had been looking into alternative energy providers** in anticipation of rising tariffs."* —Managing director, global DC operator
Time to power	End-to-end **elapsed time for delivering on-site capacity** (from contracting to interconnectivity/commissioning)	**1** *(tied)*	*"If the grid connection queue is extremely long, **customers will immediately explore on-site generation as a faster path to electricity** and will do what they can to get there."* —Senior vice president, global DC operator
Reliability *(e.g., uptime, MTBF)*	Ability to **deliver continuous power** and meet reliability expectations	**3**	*"The **ability to provide high reliability and uptime is crucial for power source options.** Secondly, **if a provider can give service guarantees or SLAs,** they can stand out."* —Principal engineer, global DC operator
Environmental/ ESG impact	**Emissions profile** (criteria pollutants and CO_2), noise pollution, alignment to customer clean energy requirements	**4**	*"We are always looking at the opportunities to grow in Singapore in whatever ways make sense, but then we also want to make sure that **we can do it in alignment with our sustainability goals.**"* —Vice president, global DC operator
Modularity	Ability to **customize and scale** solutions based on specific requirements	**5**	*"The **ability to customize power solutions, tailor them to the end customer's industry, and scale them up and down depending on changing needs** is helpful with deciding which type of energy source to use."* —Principal engineer, regional DC operator
Power density *(e.g., space efficiency)*	**Footprint required to deliver a target MWh** (e.g., space/land constraints)	**6**	*"**Space and real estate matter, but they typically come after** cost, time-to-power, reliability, and ESG in the decision stack."* —Former senior director, global DC operator

If SEA cannot build grid delivery infrastructure fast enough to serve DCs, it will not be able to capture this demand

Sources: Industry participant interviews; Bain analysis

Options for private players to secure RE in SEA limited, unlike Asia-Pacific peers

✔ Available ▪▪▪ Under development/in pilot ✖ Not Available

Country	DPPAs	VPPAs	RECs
India	✔	✔	✔
Japan	✔	✔	✔
Australia	✔	✔	✔
China	✔	▪▪▪	✔
Singapore	✔ (via retail market)	✔ (via retail market)	✔
Malaysia	✔ (via CRESS)	✔ (via CGPP, which is fully subscribed since November 2023)	✔
Indonesia	✖ (PLN as sole seller)	✖ (PLN as sole seller)	✔
Vietnam	✔ (via Decree 57, announced in March 2025)	✔ (via Decree 57, announced in March 2025)	✔
Philippines	✔ (via GEOP)	▪▪▪ (draft DOE circular)	✔
Thailand	▪▪▪ (policy in draft)	▪▪▪ (in pilot phase under ERC[1] sandbox program)	✔

Generally have lower additionality compared to DPPAs/VPPAs

SEA must move from fragmented, utility-led models to scalable, direct procurement mechanisms (DPPA, VPPA)

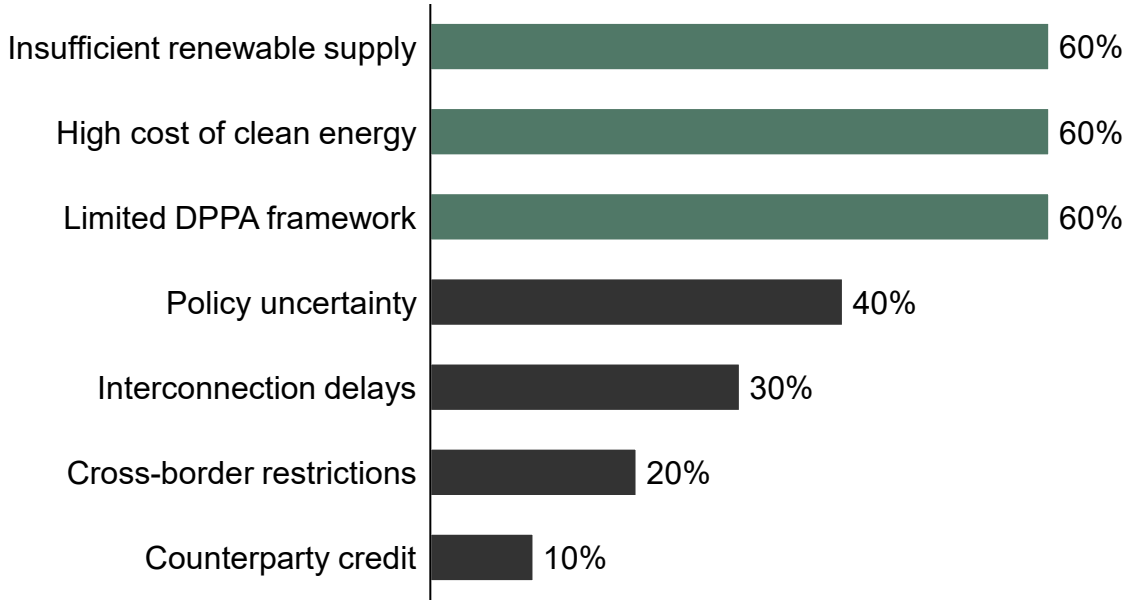
Note: High additionality procurement (e.g., DPPAs/VPPAs) supports the development of new renewable capacity through long-term project contracts, unlike unbundled RECs, which primarily provide accounting claims; 1) Energy Regulatory Commission
Sources: Asia Clean Energy Coalition; Bain analysis

Data center demand for renewable power clear but uptake is limited by market design

DC demand for green power is strong but constrained by supply, cost, and limited DPPA access

Insights from Bain SEA DC Operator and Hyperscaler Survey, Q1 2026

Q: What are the biggest challenges to scaling green power procurement by your company in SEA?



Percentage of respondents ranking the factor among their top three challenges

SEA governments are introducing new mechanisms, but impact remains early stage

RECENT EXAMPLE IN SEA

CRESS enables direct RE procurement by corporations

- Announced in July 2024, CRESS allows corporations to **procure RE directly from developers** through third-party access to the grid
- Within 12 months, **total take-up under CRESS is at ~1.3 GW** with announced deals—for example, TNB–Bridge Data Centre (400 MW) and DayOne–TNB (up to 500 MW)
- Challenges remain around wheeling charges, which add a material **RM0.20–0.40/kWh** to the underlying PPA price and **may increase by ~15% at each three-year reset**

*"Frameworks like Malaysia's CRESS are **a step in the right direction, but cost and scalability** will determine whether they can meaningfully support large-scale renewable procurement."*

—DC operator

Sources: Bain SEA DC Operator and Hyperscaler Survey 2026 (n=10, covering ~50% of SEA capacity); Bain analysis

Even global DC leaders fall short of high-additionality renewables in SEA today… and are challenged to source (even with intent) given supply and market design

	GLOBAL LENS				ASIA-PACIFIC/SEA LENS					
	Global Scope 2 emissions footprint			Global 100% RE match	Total PPAs/VPPAs signed (GW)		PPAs/VPPAs as share of IT load in 2025[4] (%)		PPAs/VPPAs as share of IT load in 2030 (%)	
	Location-based[1] ($MMTCO_2e$)	Market-based[2] ($MMTCO_2e$)	Residual emissions share[3] (%)	Status to date	Asia-Pacific	SEA	Asia-Pacific	SEA	Asia-Pacific	SEA
Amazon	15.7	2.8	18%	**Achieved** since 2023 via local + cross-border purchase	~3.1	~0.4	**>100%**	**>100%**	**80%–85%**	**70%–75%**
Microsoft	10.0	0.3	3%	**Achieved** since 2025 mainly via local purchase	~1.5	~0.5	**>100%**	**>100%**	**50%–55%**	**60%–65%**
Google	11.3	3.1	27%	**Achieved** since 2017 via local + cross-border purchase	~1.3	~0.1	**74%–76%[5]**	**24%–32%[5]**	**35%–40%[5]**	**10%–20%[5]**
Equinix	2.6	0.3	10%	**In progress** 96% in 2024	~0.5	~0.1	**>100%**	**>100%**	**90%–95%**	**>100%**
ST Telemedia Global Data Centres	0.9	0.3	34%	**In progress** 78.5% in 2024	~0.2	~0.1	**34%**	**55%**	**10%–15%**	**10%–15%**
AirTrunk	0.2	0.2	100%	**In progress** 74% in 2024	~0.1	~0.03	**5%**	**10%**	**3%–5%**	**5%–10%**
DayOne	Data unavailable	Data unavailable	Data unavailable	Limited information available	~1.0	~1.0	**>100%**	**>100%**	**55%–60%**	**60%–65%**

Notes: PPA signed numbers are based on publicly available, announced signed capacity as of end of January 2026; 1) Scope 2 emissions calculated using the average emissions intensity of the local electricity grid where consumption occurs; 2) Scope 2 emissions calculated based on contractual instruments (e.g., PPAs, RECs, I-RECs) reflecting purchased electricity attributes; 3) Portion of emissions remaining after accounting for renewable procurement and market-based instruments; 4) Based on H1 2025 capacity; 5) Proxy for Sembcorp Housing & Development Board (HDB) solar project has been taken to be 30–80 kWp per block for total 500 HDB blocks
Sources: Omdia; company sustainability reports; Bain analysis

CASE STUDY: MICROSOFT

Microsoft navigates diverse power market structures to procure ~0.46 GW of clean energy across SEA

~0.46 GW
of RE PPAs signed across SEA

>100%
renewable procurement vs. current SEA DC capacity[2]

"Microsoft's experience building our clean energy portfolio has served as an important catalyst in driving commercial demand for infrastructure and innovation across the power sector."

- Melanie Nakagawa, Chief Sustainability Officer, Microsoft

Microsoft has invested more than $3.9 billion in DCs across Malaysia and Indonesia, with additional commitments in Singapore and Thailand.

Microsoft's current regional footprint represents **~0.28 GW of IT load**, positioning SEA as a core AI and DC growth corridor.

However, SEA's fossil-heavy grids with high carbon intensity (~0.55 tCO_2e/MWh[1]) conflict with Microsoft's **global commitment to have 100% RE coverage by 2025.** To align its regional expansion with global climate commitments, Microsoft has **deployed differentiated renewable strategies** across SEA, calibrated to each market's regulatory context.

Mature markets (e.g., Singapore): Direct contracting with RE developers	Transitional markets (e.g., Malaysia): Utility-mediated procurement	Traditional markets (e.g., Indonesia): Direct negotiation with integrated state utility
Direct contracting via PPA/VPPA structures in liberalized markets where PPAs/attribute-based mechanisms are recognized and developers can enter into bankable contracts with offtakers	Leveraging utility-mediated procurement in markets where direct bilateral PPAs and power wheeling are restricted and renewable access must be routed through the incumbent grid operator	Securing renewable supply through direct negotiation with vertically integrated state utilities in systems where corporate PPAs remain nascent
For example, 20-year PPA with EDP Renewables for ~200 MWp SolarNova 8 program in Singapore	For example, Microsoft's $2.2 billion DC investment in Malaysia to leverage CRESS and CGPP to contract RE via TNB's grid	For example, 10-year PPA signed with PT PLN for ~200 MW of RE within Indonesia's grid

Notes: 1) Average grid emission factors for nine SEA countries; 2) Based on contracted renewable capacity relative to estimated current SEA DC IT load
Sources: Omdia; Ember; Company website; Bain analysis

CASE STUDY: EQUINIX

Equinix navigates Asia-Pacific's fragmented RE landscape via market-calibrated procurement across DPPAs/VPPAs

~0.5 GW
of RE PPAs signed across Asia-Pacific

>100%
renewable procurement vs. current Asia-Pacific DC capacity[1]

Equinix operates as a **retail co-location provider across urban campuses in central business districts** and select hyperscale facilities on city outskirts, procuring RE at facility level on behalf of the tenant base.

Equinix's current Asia-Pacific regional footprint represents **~0.5 GW of IT load** and is one of the fastest-growing subregions in its global portfolio.

"We know that energy consumption is central to our environmental footprint, so our team works to scale our renewable energy procurement and leverage our purchasing power to raise standards and support the development of new or additional renewable generation capacity."

Vinit Chitkara, Director of Energy Operations & CleanTech, APAC, Equinix

To achieve its 100% renewable target by 2030, Equinix prioritizes **long-term PPAs sourced within the same grid as consumption,** where possible, and supplements it with GHG Protocol-compliant RECs only where direct procurement remains structurally challenged.

Key RE procurement initiatives deployed by Equinix across Asia-Pacific markets

SINGAPORE

- Signed **three solar PPA agreements** during 2024–25, totaling 143.5 MWp
  - 75 MWp (Sembcorp/Housing & Development Board SolarNova 7), 58.5 MWp (Sembcorp/Jurong Island JTC), and 10 MWp VPPA (ESR–TEPCO rooftop portfolio)
- Leveraged **government-backed solar programs** to reduce developer risk and support long-term bankable offtake in supply-constrained market

INDIA

- Signed first India PPA with CleanMax for 33 MW **dedicated captive solar and wind plant** in Maharashtra, structured to serve Equinix's Mumbai DC consumption
- Leveraged captive designation under India Electricity Act to **unlock grid charge waivers and cross-subsidy surcharge exemptions**, reducing effective energy cost vs. standard PPA structures

JAPAN

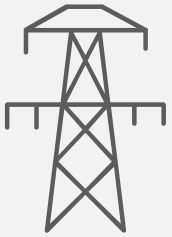
- **Signed two solar PPA** agreements during 2025–26 totaling ~151 MWp
  - 30 MW (Trina Solar) and 121 MW VPPA (ENEOS Renewable Energy)
- Leveraged liberalized retail electricity market to contract directly with generator via **both DPPAs and VPPAs**

Note: 1) Based on contracted renewable capacity relative to estimated current Asia-Pacific DC IT load | Sources: Omdia; Company website; Bain analysis

New, creditworthy demand is outpacing grid readiness and T&D build-out in SEA

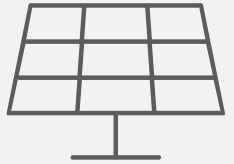
WHAT THE DATA IS TELLING US

A wave of creditworthy power demand scaling faster than the grid can absorb



Grid investment is lagging generation; the bottleneck has shifted decisively to T&D

Grid readiness is reallocating capital, with investors clustering where delivery certainty is strongest



BTM solutions cannot replace the grid in SEA; under current structures, they remain incremental

Time-to-power is a critical variable—without grid build-out, SEA risks losing the next wave of capital

SEA's power ecosystem faces structural tensions from competing priorities

Grid reliability and system stability

Ensuring stable, secure power supply with sufficient flexibility to maintain high uptime while integrating renewables

Top priority for: Utilities/SOEs

Time-to-power requirements

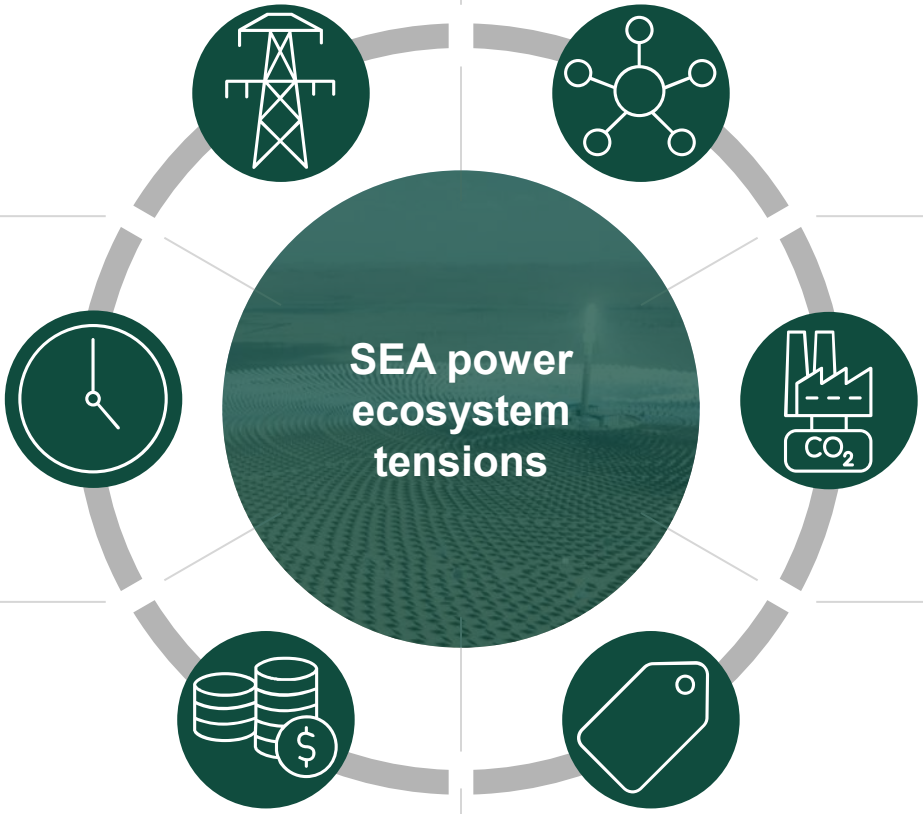
Providing predictable power-access timelines aligned with large buyers' investment decision cycles

Top priority for: Power buyers (DC, EV)

Utility balance sheet and cost recovery

Maintaining financially sustainable power utility providers through adequate cost recovery, enabling continued investment in grid expansion

Top priority for: Utilities/SOEs



Long-term system efficiency

Achieving least-cost decarbonization over time through shared infrastructure and efficient investment sequencing

Top priority for: Utilities/SOEs

Emissions accounting and credibility

Delivering clean power solutions that meet audit-ready emissions accounting and disclosure standards

Top priority for: Hyperscalers, green ind. parks

Power affordability and access

Ensuring competitively priced clean power and access to electricity

Top priority for: Power buyers (DC, EV)

Source: Bain analysis

Overly rigid market design and compliance rules are slowing decarbonization and pushing buyers toward suboptimal outcomes

Structural rigidity in RE procurement	Short-term casualty
Attribute-based procurement pathways (e.g., RECs, VPPAs) not permitted or not recognized as credible	• Corporations lose the ability to **credibly claim clean energy use** before physical supply is available • Procurement is delayed until new grid-connected capacity is built (multiyear lead times) • Buyers either accept higher-emissions grid power in the near term or **defer/resize investments**
DPPAs not permitted or highly restricted	• **Utilities remain the dominant** procurement channel even where expansion pace is constrained • Buyers lean harder into **on-site/captive supply** to protect timelines and uptime • Grid-connected renewable projects scale more slowly without anchor offtake
Clean energy sourcing restricted to in-country supply only	• Few near-term options qualify; **buyers can't meet decarbonization standards and timelines** simultaneously • **Decarbonization commitments get delayed** or narrowed
Strict compliance and additionality standards	• **Clean energy procurement stalls** as corporations cannot meet strict additionality requirements • **Capital and demand are delayed or diverted** to interim or fossil-based solutions to ensure reliability
Private capital excluded from grid investment/ownership	• Grid **expansion pace is capped** by public funding cycles and utility balance sheets • Network **upgrades lag demand** and generation growth; interconnection timelines extend • **Congestion/curtailment risks rise**, weakening confidence in grid-connected investment

Overly rigid standards can lead energy buyers to rely on higher-emissions grid, bypass grid infrastructure, or delay investment decisions

Source: Bain analysis

SEA's grid was built for a different era - the future requires a fundamental shift

	WHERE THE SYSTEM IS TODAY	WHERE WE WANT IT TO BE
Regulatory and policy	• Transmission largely controlled by state utilities, e.g., **private grid participation restricted in Indonesia and Thailand** • Corporate procurement limited, with **DPPA/VPPA frameworks nascent** or legally constrained	• **Open-access transmission frameworks** enable third-party private grid participation • **Corporate procurement mechanisms normalized,** allowing direct contracting with independent RE developers
Execution	• **Permitting fragmented across agencies;** long development timelines common • **Grid expansion lags** RE build-out, causing curtailment • **Future demand uncertain—**large load announcements might not materialize, making planning challenging	• **Single-window permitting** with predictable timelines and priority connection rights • Integrated generation-transmission planning **anchored on RE zones and demand clusters** • **Transparent demand signaling** from strategic loads to enable proactive grid planning
Capital and financing	• **Limited financial instruments** and risk-sharing structures for emerging assets • **Green investments typically country-led,** limiting project scale and investor appetite	• **SEA green capital markets** deploying blended finance, guarantees, and innovative instruments • **Regional investment platforms pooling projects** across SEA to create investable scale

Source: Bain analysis

Sequencing action to capture demand across today's grid while building tomorrow's

What should SEA power and grid ecosystem focus on?

0–2 YEARS — Capture
Capture demand and keep demand system-connected

- **Enable interim clean power solutions**
  - Allow near-term procurement mechanisms (e.g., PPAs) to secure clean power claims ahead of full grid upgrades

★ **Scale green industrial zones**
- Designate industrial areas where land use, power access, permitting, and RE supply are coordinated up front

- **Scale EV and DC hubs**
  - Aggregate demand in designated zones

★ **Deploy VPPs to optimize DER and demand**
- Coordinate on-site generation, storage, and flexible loads

- **Fast-track interconnection pathways for strategic loads**
  - Define maximum connection timelines and priority lanes

★ **Scale long-term financing solutions for large-scale grid and clean energy infrastructure**
- For example, blended finance via concessional funding with DFIs, loans, green bonds; combine with support in solution execution through best practice sharing and knowledge transfer

2–5 YEARS — Bridge
Convert anchor demand to shared grid infrastructure

- **Implement cross-border electricity market mechanisms**
  - Establish standardized rules for cross-border power flows (e.g., wheeling tariffs, cost allocation, settlement)
- **Realign T&D economics and revenue models**
  - Restructure tariff, allowing grid operators' returns to be tied to demand growth and network modernization
- **Enable private participation in T&D infra**
  - Permit private developers and investors to finance, build, own, or operate selected T&D/grid-support assets

- **Develop clean power priority corridors**
  - Build dedicated transmission and substation infrastructure to link RE generation zones to major data centers/industrial clusters

★ **Advance bilateral APG connections**
- Develop priority bilateral cross-border interconnections

- **Pool regional investment vehicles**
  - Leverage co-investment platforms from governments and development banks to de-risk power and grid projects

5–10 YEARS — Destination
Operate an integrated regional shared power system

- **Establish regional power markets and system operations**
  - Develop regionally coordinated market and operational frameworks (e.g., dispatch coordination, balancing and reserve sharing, cross-border settlement)

★ **Strengthen APG interconnection**
- Scale the APG as a sequenced portfolio of cross-border interconnections

ASEAN markets are progressively enhancing private participation; for example, the Vietnam DPPA decree (July 2024) allows private project ownership, transmission, sale, and purchase of RE

Regulatory and policy reforms | Delivery and execution enhancements | Capital and financing enablement | ★ Deep dive in following pages

Source: Bain analysis

CASE STUDY: STANDARD CHARTERED

In 2025, Standard Chartered partnered with DFIs to finance Indonesia's first JETP solar project, demonstrating how blended finance can mobilize capital needed for the energy transition

Launched at COP26, the **Just Energy Transition Partnership (JETP)** is a multilateral financing platform that pairs **public concessional capital** from the International Partners Group (IPG) with **private sector finance coordinated by Glasgow Financial Alliance for Net Zero (GFANZ)**, helping coal-dependent emerging economies transition to clean energy.

As a **GFANZ member**, Standard Chartered is working with the Indonesian government, the IPG, and development finance institutions (DFIs) to move projects from proposal to financing. The bank partnered with Germany's and France's DFIs, **DEG and Proparco,** respectively, to finance the **Saguling Floating Solar PV Plant, which has secured a 60 MW PPA with Indonesia's state-owned utility, PLN.** Financing was done through a blended structure in which funding from DEG and Proparco de-risks the project and mobilizes Standard Chartered's commercial capital.

> "Our participation in the financing of the Saguling Floating Solar PV Plant is testament to our dedication to mobilizing private capital for clean energy investment, particularly through partnerships like JETP.
>
> DONNY DONOSEPOETRO, CEO, STANDARD CHARTERED INDONESIA

JETP: HEADLINE FIGURES

- Indonesia's JETP has currently achieved **~$20 billion in total pledges** (~$10 billion public and ~$10 billion private)
- Of this, **~$3.1 billion has already been mobilized** to support clean energy projects in Indonesia
- Standard Chartered cofinanced the **first JETP solar project**, mobilizing **$60 million** alongside DEG and Proparco
- The Saguling plant will offset **63,100 tonnes of CO_2 per year** and boost Indonesia's solar output by **~13%**

Sources: Expert interviews; company website

Green industrial clusters: Pragmatic work-around to grid constraints, bringing forward green investments at a quicker pace

Green industrial clusters bring clear benefits …

Ring-fenced RE deployment
Dedicated generation integration aligned to required load profile

Anchor aggregated demand
Co-located tenants create scale with clear offtake commitments

Structured capital platform
Defined governance and phased build-out framework helps attract private investments

Embedded carbon architecture
Traceable electricity attributes tied to production output improve ability to be CBAM[2] compliant

… with success observed across SEA markets

	Indonesia: Jababeka Net-Zero Industrial Cluster	Malaysia: Samalaju Industrial Park in Bintulu
Context	**Largest industrial estate in** SEA, with more than 2,000 firms from 30 countries, in Java	Part of Sarawak Corridor of Renewable Energy that is **mainly hydro powered**
Focus	Partners include **energy players and multinational corporations** that focus on **system efficiency and electrification**	Focus on **energy-intensive industries** like aluminum that contribute greatly to economy
Results[1]	**~9%** reduction in emissions **~1.7 million** jobs protected	**~72%** reduction in Sarawak's grid emissions **~$28 billion** total investment attracted
Why cluster worked	✓ **Location:** Co-located global firms with rich expertise ✓ **Government:** Implemented carbon pricing (however, this continues to be low at $1–4/$tCO_2e$)	✓ **Location:** Energy-intensive industry players co-located ✓ **Government:** Investment-friendly policies for foreign capital

Green clusters are a strong capture-to-bridge mechanism where ring-fenced RE can deliver clean supply ahead of full T&D build-out

Notes: 1) Based on latest information available; 2) CBAM refers to Carbon Border Adjustment Mechanism, a carbon pricing tool that sets import levies to disincentivize high-emission imports | Sources: Euromonitor; lit. search; Bain analysis

Green industrial clusters: Green industrial clusters are becoming essential to SEA's competitiveness with impending CBAM regulation

Low to high likelihood / NON-EXHAUSTIVE

CBAM being gradually phased in to allow industry adjustment

EU's CBAM is a carbon pricing tool that sets **import levies to disincentivize high-emission imports**

2023

Gradual phasing-in; importers of affected products obliged to report embedded GHG emissions

2026

Importers to start paying CBAM financial adjustment

2026–34

Phasing out of free allocations under EU ETS and phasing-in of CBAM

From 2026, embedded carbon becomes a direct export cost, accelerating the shift toward certifiable green manufacturing

Competitive divergence is emerging across industrial zones

Industrial parks (Selective list based on those most exposed to CBAM)	Sector	Corporate access to RE	Scalable RE supply	Grid readiness	Likelihood to be CBAM compliant
MY: Samalaju Industrial Park	Steel, aluminum	CRESS allows DPPA, ~1.3 GW approved to date	Total ~20% RE supply (2025)	TNB's ~$10 billion commitment in grid upgrade	
MY: Pengerang	Petrochem				
MY: Iskandar Puteri	Biopharma				
TH: Map Ta Phut Industrial Estate	Petrochem	DPPAs still in pilot	Total ~20% RE supply	EEC grid investments progressing	
TH: Saraburi Sandbox	Cement				
PH: Leyte Ecological Industrial Zone	Copper	Corporate PPAs limited	Total ~20% RE supply	Fragmented grid; delayed upgrades	
ID: INBC	Nickel	Corporate PPA mechanism still difficult to scale	Coal dominated at ~70%	Utility financials remain constrained	
ID: Kalimantan Green Park	Aluminum				

SEA CBAM exposure is concentrated in **steel, aluminum, cement, copper, nickel, petrochemical, and biopharma**

Sources: European Commission website; IEA; Bain analysis

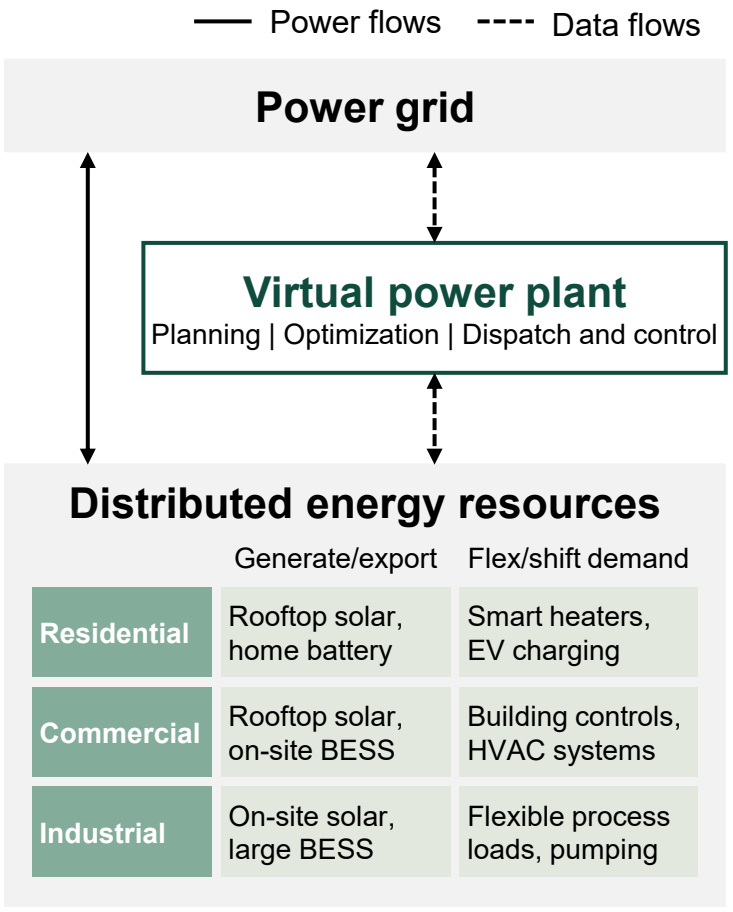
Virtual power plants: T&D constraints will catalyze demand for distributed energy and non-wire solutions to enhance grid flexibility and peak management

VPPs unlock capacity from distributed energy resources without new infra …

HOW VPPS SUPPORT THE GRID

- **Aggregate and manage DERs** (e.g., rooftop solar, batteries, EVs, flexible C&I loads) through centralized control platforms
- **Absorb surplus power through storage and demand-shifting** to stabilize the grid and minimize curtailment
- **Reduce peak demand by dispatching stored energy** to alleviate grid congestion and lower system costs
- **Enhance system reliability and asset utilization,** reducing need for additional generation capacity and T&D upgrade investments

… serving as central platform that optimizes power flows across DERs



	Generate/export	Flex/shift demand
Residential	Rooftop solar, home battery	Smart heaters, EV charging
Commercial	Rooftop solar, on-site BESS	Building controls, HVAC systems
Industrial	On-site solar, large BESS	Flexible process loads, pumping

Case study: VPPs are proven at scale in Australia

South Australia VPP

- Tesla-led VPP to **aggregate rooftop solar and residential batteries** into dispatchable, grid-scale capacity
- Scaled through government-backed **subsidies and low-interest loan for home battery installation,** particularly in social housing
- Delivers **grid stability and peak shaving** in a system with high rooftop solar penetration

Impact

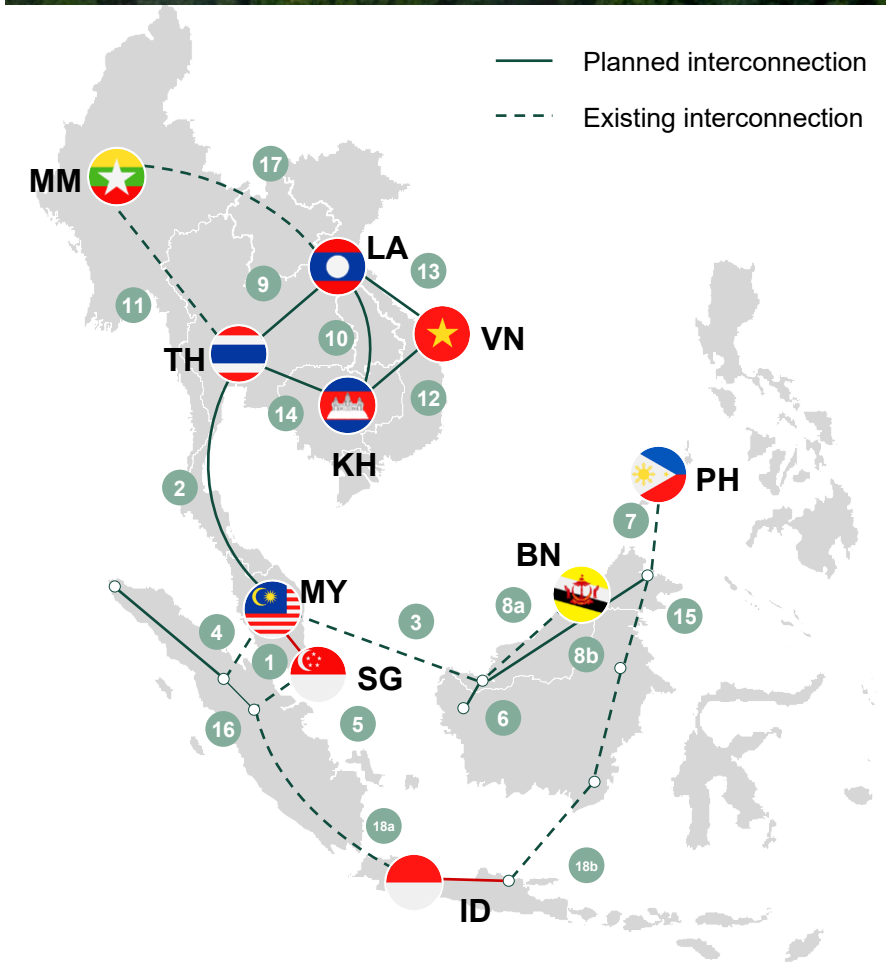
~7,000
Households with battery system installed

~25%
Lower retail electricity price vs. default market price

Source: Bain analysis

ASEAN power grid: An important lever to unlock regional potential, likely to be a strong contributor over the medium to long term - post 2030

APG interconnection map



Project overview and current status

Overview

APG is an ambitious **regional initiative** that aims to connect ASEAN member states via **cross-border electricity trade and interconnections—**connecting renewables supply to demand centers

13.7 GW
planned interconnection capacity by 2040

$0.8 trillion
saved economic cost of decarbonization by 2050

1.45 million
jobs expected to be created by APG (75% as direct lifetime jobs)

Current status

8/18
operational interconnections vs. identified projects

2.8 GW
operational grid-to-grid capacity (as of 2024)

7.5 GW
operational generation-to-grid capacity (as of 2024)

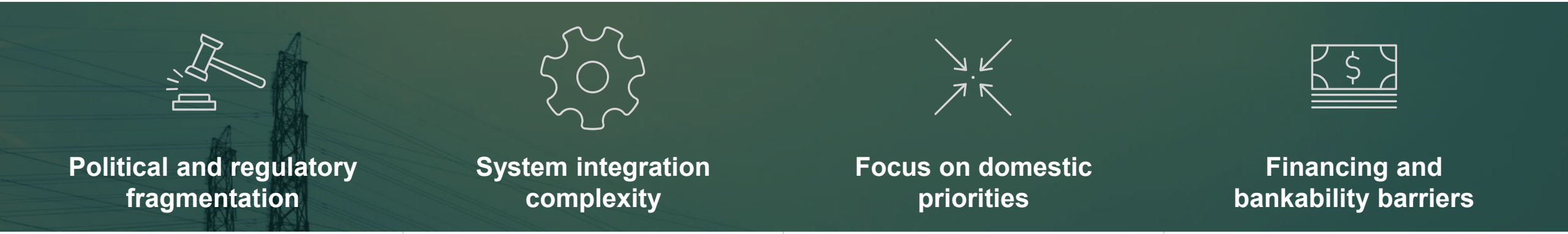
13.7 GW
planned interconnection capacity by 2040

While the APG has made incremental progress since its launch in 1999, significant work remains to deepen regional interconnections:

- Cross-border electricity trade remains **predominantly bilateral**, with multilateral trading still nascent
- LTMS-PIP, the first multilateral cross-border electricity trade project, illustrates long lead times: Feasibility studies began in **2019**, but multilateral operations only began in June **2022**

Source: ASEAN Centre for Energy

ASEAN power grid: Fundamental structural constraints will limit pace of progress



Political and regulatory fragmentation

Fragmented regulations, tariffs, and market rules slow cross-border power trade and decision making.

Indonesia–Singapore power trade: Mismatch in licensing frameworks stalling progress; Singapore allows electricity import licenses of 25 years, whereas Indonesia's regulations cap export licenses at 5 years.

Sarawak–Singapore power trade: Project delivery depends on Indonesia's approval, given that the cable route would cross Indonesian waters.

System integration complexity

Diverse grid maturity and design create technical hurdles, particularly for new subsea interconnections. Additionally, tight global supply of high-voltage subsea cables—driven by rising offshore wind demand—is extending lead times and increasing delivery risk.

Singapore–Sarawak undersea power cables: Singapore–Sarawak (~1 GW) import hinges on >700-km high-voltage subsea cable, materially increasing technical and execution complexity. The project also faced delays in 2025 due to a shortage of submarine cables.

Focus on domestic priorities

Countries focus on domestic considerations (growth, employment, energy security) over regional interconnections.

Indonesia green electricity exports: Indonesia is restricting electricity export permits to Singapore in lieu of stronger reciprocal benefits.

*"We have established a policy that requires **domestic energy needs to be fulfilled before that energy is exported.**"*[1]
—Deputy Energy Transition and Water Transformation Minister, Malaysia, 2025

Financing and bankability barriers

Large capital needs and the absence of bankable remuneration models increase project risk and preparation costs

*"The benefits of an ASEAN power grid are clear; **what is needed now is a new generation of financing solutions**—well designed and implemented with urgency."*
—Secretary General, ASEAN, 2025

The establishment of platforms like the ASEAN Power Grid Financing Initiative and the Partnership for ASEAN Connectivity on Energy are key steps to addressing this barrier by facilitating and mobilizing financing for the APG

Note: 1) Translated from the original Malay quote
Sources: IEA; Asian Development Bank; industry participant interviews; Bain analysis

ASEAN power grid: Pragmatic bilateral corridors are likely to provide the most immediate pathway to scaling APG, with some first steps likely in 2027

Bilateral corridors that are actionable in the near term are key to unlocking APG; Singapore has potential to be an anchor buyer

ASEAN corridor	Why it is actionable now	Key unlocks to be solved next
Indonesia (Bintan, Batam, Karimun)–Singapore	• **Shortest route,** with only ~42 km cable required; lowest capex and complexity • **Advanced commercial setup** with conditional licenses[1] approved for ~2 GW of low-carbon electricity from Indonesia to Singapore	• **Regulatory alignment** to harmonize export license tenor terms (5 vs. 25 years), clarification of PLN's commercial role • **Regulatory clarity** on export licenses for green energy exports to Singapore, which will accelerate project progress • **Emphasize mutual benefits** to monetize RE export without losing sovereignty
Malaysia (Sarawak)–Singapore	• **Large-scale operating hydropower** capacity of ~3,558 MW • **Bilateral momentum** observed with conditional approvals[1] to import ~1 GW from Sarawak to Singapore	• **Diplomatic and regulatory clearance:** Subsea cables crossing Indonesian waters require trilateral cooperation

Singapore has potential to be an anchor buyer

- As of October 2025, the Energy Market Authority has issued **Conditional Approvals**[1] to **11 projects** to import low-carbon electricity from **Australia** (1.75 GW), **Cambodia** (1 GW)**, Indonesia** (3.4 GW), **Sarawak** (1 GW), and **Vietnam** (1.2 GW)
- **Six projects** have been awarded **Conditional Licenses**[1]

Singapore aims to **import around 6 GW of low-carbon electricity from the region** by 2035

Prioritize closing 1–2 bilateral anchors to unlock APG at scale

1 Scale new bankable corridors
Establish commercial precedent and political will for cross-border imports

↓

2 Standardize templates
Develop a repeatable set of PPA terms, wheeling rules, and bilateral approvals

↓

3 De-risk financing
Lower perceived risk through broader participation from private players

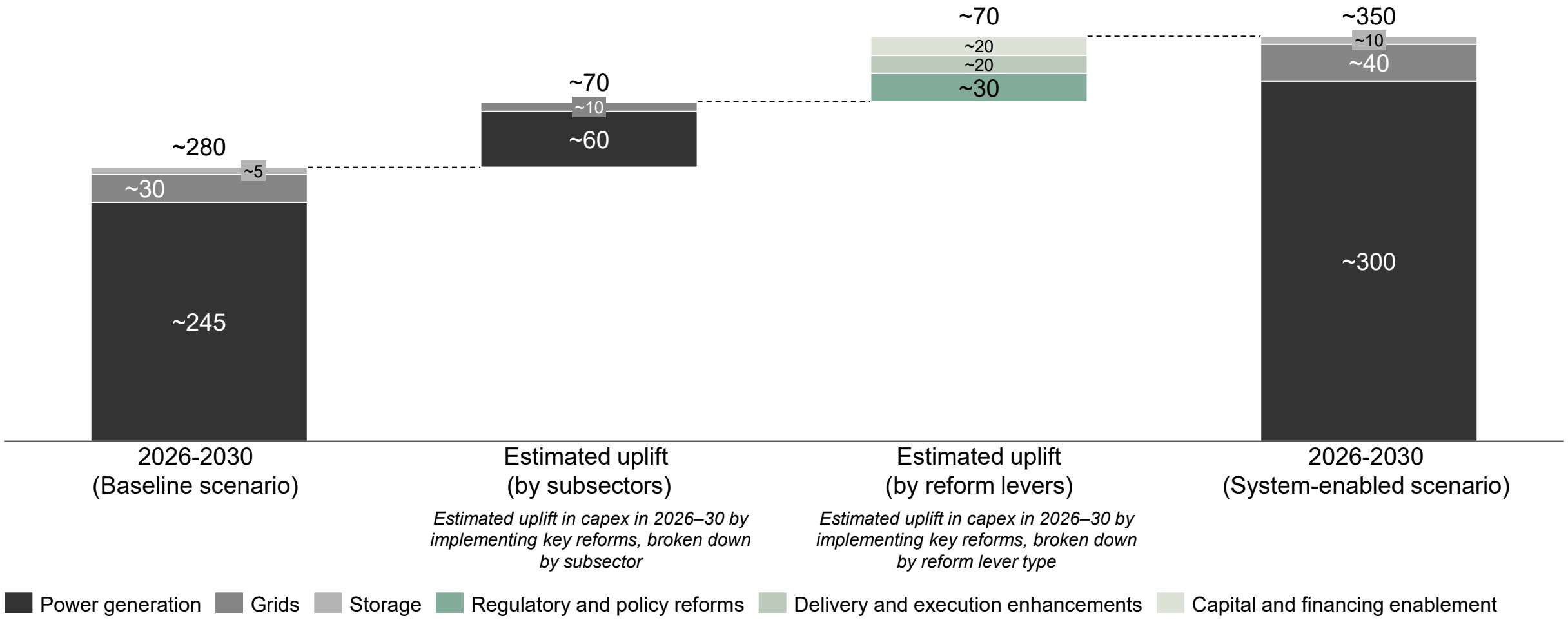
↓

4 Scale to next corridors
Accelerate APG delivery with less uncertainty given proven model

Note: 1) Conditional approval refers to Energy Market Authority's early-stage green light to continue development, while a Conditional License is a later-stage signal that the project has made substantive progress and is closer to execution
Source: Energy Market Authority

Near-term solutions to mitigate constraints (beyond APG) could unlock an additional ~25% of capex in the next five years to invest in the power and grid ecosystem

Estimated capex deployment into power and grid ecosystem ($ billion)



Source: Bain analysis

APAC & SEA: Opportunity for SEA to tap APAC capabilities to accelerate grid unlock

/ NON-EXHAUSTIVE

Concessional and strategic financing

Leverage lower-cost, long-term capital **from Asia-Pacific DFIs and government agencies** to fund T&D build-out

Grid infra tech and manufacturing depth

Import proven grid engineering capability and manufacturing scale **from North Asia corporations**

Smart grid and modernization

Adopt proven grid digitalization and flexibility solutions to optimize existing grid capacity **from Asia-Pacific leaders**

Bankable cross-border trading corridors

Anchor RE generation and T&D investment through contracted bilateral flows **with neighboring markets**

Market reform framework transfer

Learn from proven T&D procurement and market models to improve grid **from Asia-Pacific markets**

Selected examples

Asian Development Bank: APG financing

~$10 billion capital mobilization target for cross-border and national grid expansion

LS Cable (Korea): HVDC and subsea cable expertise

Strong cable manufacturing capability to enable long-distance interconnections

KEPCO[1] (Korea): Demand response platform

National DR program deployed to manage peak load and improve grid flexibility

China–Laos RE export corridor

Hydro surplus in Laos exported to China via dedicated 500 kV interconnection (~$2 billion invested), with long-term contracted power flows improving T&D bankability and cross-border grid integration

India: Tariff-based competitive bidding for T&D

Nationwide implementation by 2024 with ~90% of new T&D projects competitively awarded, successfully reducing tariffs by ~35% (vs. regulated model) and doubling foreign T&D investment to ~$5 billion by 2023 (vs. 2019)

Japan International Cooperation Agency: Vietnam T&D upgrades

~$200 million loan for Vietnam's 500 kV T&D upgrade

Mitsubishi (Japan): High-voltage grid hardware

Advanced transformer and substation systems to support large-scale T&D grid upgrades

Hitachi (Japan): Digital substations and analytics

Advanced grid automation analytical software deployed to improve reliability and reduce outage time

Note: 1) Korea Electric Power Corporation | Source: Bain analysis

Private capital can invest across the grid build-out lifecycle, starting with near-term opportunities to optimize and stabilize the grid

Opportunities | Asia-Pacific examples / ILLUSTRATIVE

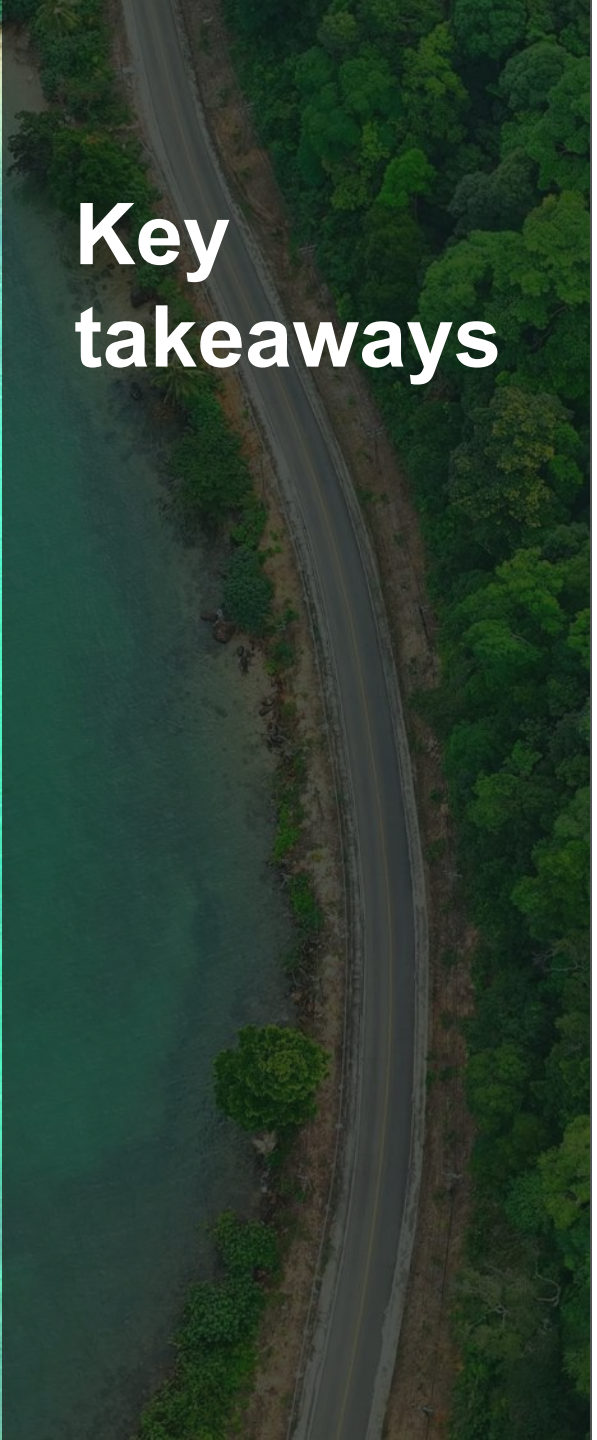
Investable opportunities across grid build-out lifecycle—with proven Asia-Pacific models

Optimize grid operations		Enable system flexibility		Scale grid-connected capacity		Reinforce transmission and interconnection	
Advanced metering infrastructure	• Smart meter and grid digitalization – TNB, MY	**DER**	• Industrial microgrid and distributed solar platforms – Tata Power, IN • Integrated DER for C&I use – SP Group, SG	**System-ready clean generation**	• Large-scale solar and wind generation platform – ReNew, IN • Integrated utility-scale renewable generation platform – Sembcorp, SG	**Transmission infrastructure**	• High-voltage transformers and grid equipment – Mitsubishi, JP • Substation and grid equipment – Hyosung Heavy Industries, KR
Demand response and load management platforms	• National platform to shift or reduce electricity demand during peak hours – KEPCO[1], KR	**Utility-scale battery storage system**	• Utility-scale lithium-ion battery storage platforms – CATL, CN; LG Energy Solution, KR			**Inter-connection lines**	• High-voltage direct current system and submarine cable – LS Cable & System, KR
Grid analytics and forecasting	• Real-time grid model for forecasting and simulation – SP Group, SG						

Improve market access and liquidity

Market access and contracting platforms	REC standards-setting and governance body – I-TRACK Foundation	Digital registry and REC tracking platform – AsiaREC Registry	Marketplace for REC trading – SP Group, SG

Note: 1) Korea Electric Power Corporation | Sources: Industry participant interviews; Bain analysis



Key takeaways

1 **Data centers are the proof case:** Bankable, concentrated, and urgent demand can pull forward grid and RE investment if sequenced correctly

2 **Grid is the binding constraint, as demand is arriving faster than delivery:** Credible large loads can commit in 1–3 years, but grid upgrades take at least 5 years

3 **Capture → Bridge → Destination** is a phased path to unlock the grid; capture near-term quick wins before full interconnections and T&D network build-out

4 The **prize is an additional ~$70 billion** of clean energy and grid-related capital unlocked by 2030, materially expanding addressable market for SEA's green economy

CHAPTER 2

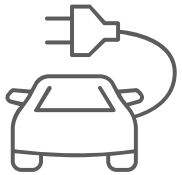
The EV value chain race

SEA's 4W EV penetration has inflected sharply—from laggard to global front-runner in three years

The next three to five years determine whether it converts this momentum into an additional $130–$160 billion in value by 2035

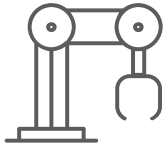
SEA is scaling EV adoption, but risks losing the profit pool and economic value

DEMAND IS ACCELERATING, BUT VALUE CAPTURE IS NOT FOLLOWING



4 out of top 15

Global EV penetration markets are now in SEA: Singapore, Vietnam, Thailand, Indonesia (outpacing the US)



~2%

of global EV manufacturing (by units) **is in SEA**—demand is still largely import-fed

$130–$160 billion gap

Value capture gap in 2035 if SEA doesn't expand participation in EV value chain

THIS CHAPTER COVERS

THE SURPRISE

SEA has emerged as one of the world's fastest-growing EV markets, outpacing every major forecast

THE RISKS

~70% of EV value flows outside the region, and platform decisions locking in now will set the next 20 years

THE OPPORTUNITY

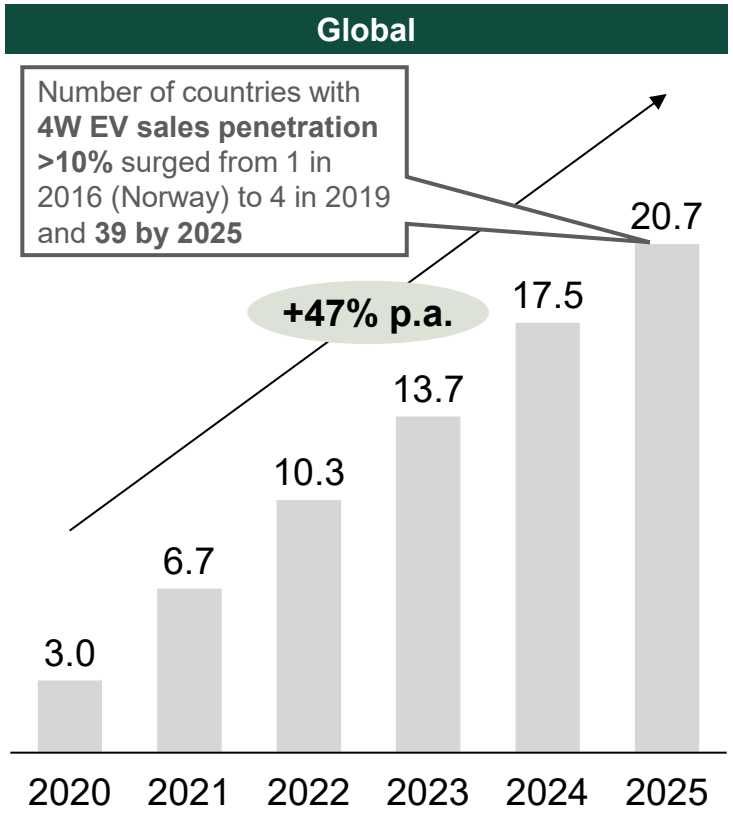
Regional integration could capture extra $130–$160 billion per year by 2035—if SEA acts in time

Sources: Ember; IEA; Bain analysis

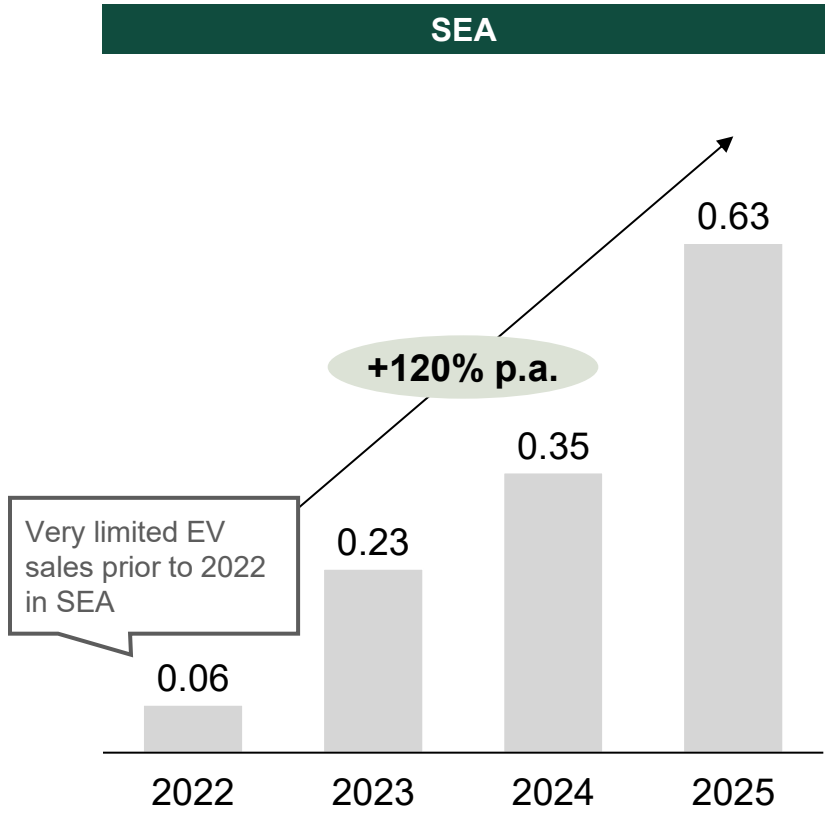
Global 4W EV demand is now structural - demand & capital make a decisive shift

Global EV sales are growing at over 45% annually, with adoption accelerating even faster in SEA

Global 4W EV sales, 2020–25, million units

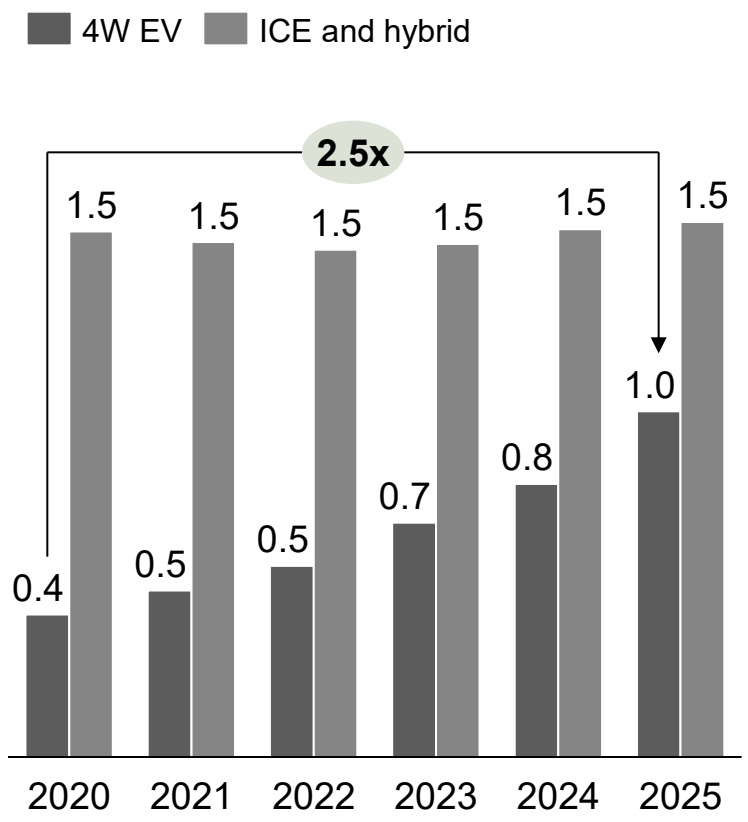


SEA 4W EV sales, 2020–25, million units



OEMs are decisively shifting capital toward 4W EVs

Car model availability, 2020–25, thousand units

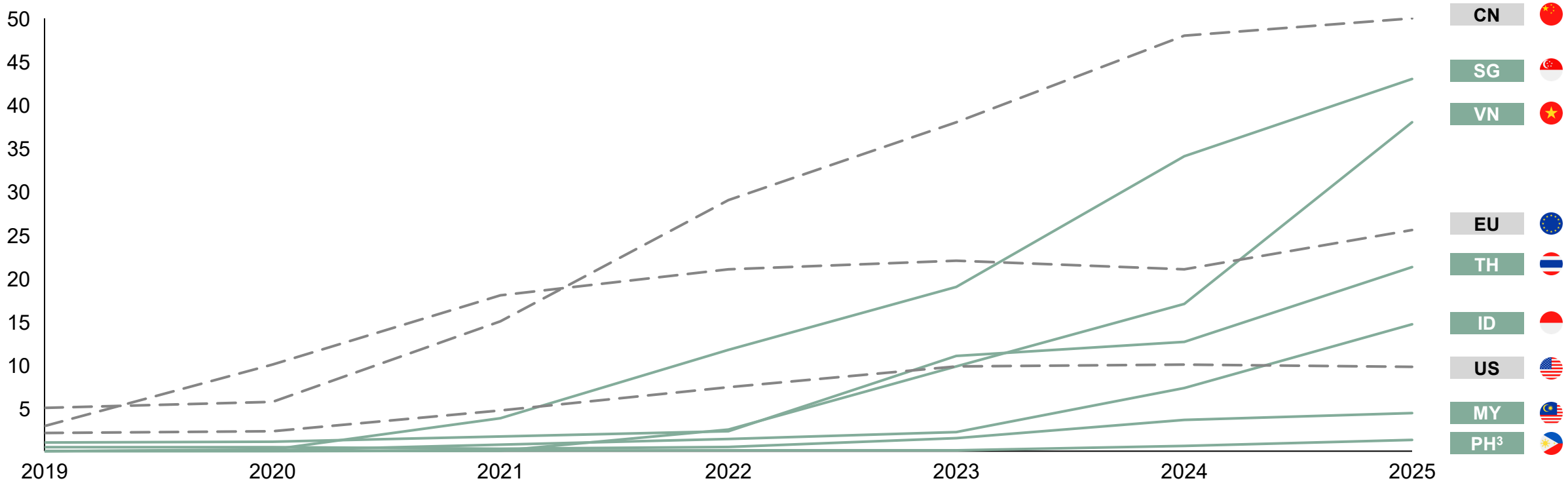


Sources: IEA; BNEF; Ember; MarkLines

SEA's 4W EV transition has strong momentum; multiple markets now outpacing US

SEA markets have leapfrogged mature markets like US in 4W adoption

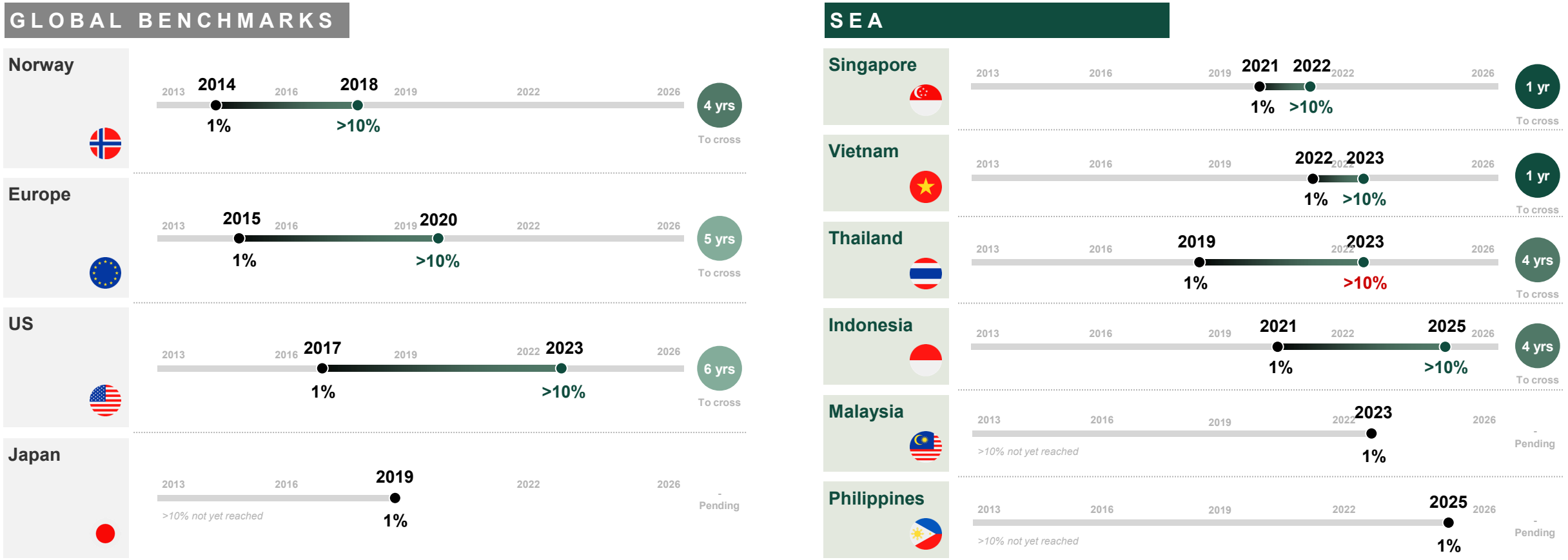
EV share[1] of new passenger car sales, 2019–25[2] (percentage)



Notes: 1) EV penetration includes BEV and PHEV; 2) National data available for January–October 2025 except for China (full year 2025); 3) Philippines data includes passenger and commercial vehicles
Sources: S&P Global; MarkLines; IEA; Ember

Several SEA markets match or beat mature global peers in scaling 4W EV penetration

Number of years taken to go from 1% to 10% EV penetration across countries



● Reached 1% EV penetration ● Reached >10% EV penetration ● Not yet reached >10% EV penetration

Note: EV penetration refers to number of EV passenger car sales as a percentage of total passenger car sales | Sources: BNEF/APEC; Bain analysis

Major forecasts underestimated SEA; 2025 4W EV penetration 1.5x–2.5x projections

Pace of 4W EV adoption is materially outperforming forecasts and national targets

Country	Forecast year	Forecast source[1]	4W EV pen. (forecast)	4W EV pen. (actual, 2025)	Overshot 2025 forecast?	Actual 4W EV penetration (2025) over forecast
SEA	**2025**	**BNEF[2]/APEC**	**~5–6%**	**>9%**	✓	**1.8x**
Singapore	2030	National target	~100%	~46%	✗	**0.5x**
	2025	Analyst reports	~30%		✓	**1.5x**
Vietnam	2030	National target	~30%	~38%	✓	**1.2x**
	2025	Analyst reports	~20%		✓	**1.9x**
Thailand	2030	National target	~30%	~21%	✗	**0.7x**
	2025	Analyst reports	~13%		✓	**1.6x**
Indonesia	2030	National target	~30%	~15%	✗	**0.5x**
	2025	Analyst reports	~6%		✓	**2.5x**
Malaysia	2030	National target	~15%	~4%	✗	**0.3x**
	2025	Analyst reports	~3%		✓	**1.3x**
Philippines	2030	National target	~25%	~1–2%	✗	**0.04x**
	2025	Analyst reports	~3%		✗	**0.4x**

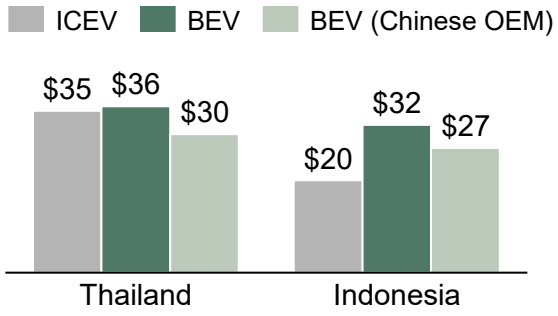
Note: 1) Analyst reports are based on reports published in 2021–23; 2) BloombergNEF | Sources: BNEF/APEC; Bain analysis

SEA's 4W EV surge is driven by a combination of structural market and policy forces

1 Chinese OEM price shocks hit SEA's affordability sweet spot

- **Strong discounts from Chinese OEMs** drove consumer take-up in SEA
- Average EV prices in key markets (e.g., ID, TH) **comparable or even lower vs. ICEVs**

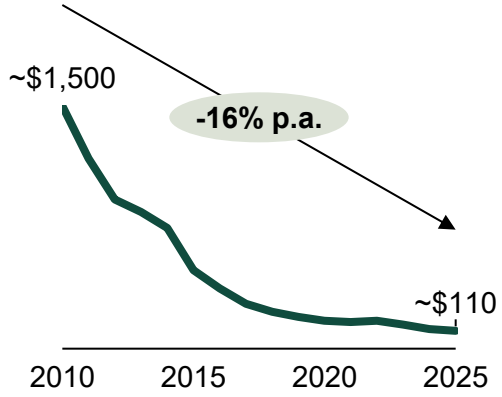
Average prices by power train in 2024 ($ thousands)



2 Battery cost declines unlocked real price parity

- **Battery packs (which make up 30%–40% of EV costs) saw sharp declines**, falling at ~16% p.a. in the past 15 years

Lithium-ion battery pack prices ($/kWh)



3 Local manufacturing is scaling up to meet domestic needs

- **Growing investments in local manufacturing** to meet domestic EV needs at scale

SEA local manufacturing capabilities

~15% **EV manufacturing capacity** (>1M) as a % of ICEV capacity (~7–8M) in SEA, signaling structural build-out

VinFast: Local manufacturing at scale

200K vehicles produced at **VinFast Hai Phong plant** in **2025** alone

10%–15% **price discount** observed between VinFast's VF6 vs. BYD's Atto 3 (imported competitor)

4 Favorable policies amplified momentum

- **Countries introduced targeted incentives for EV adoption**; for example:

- **Indonesia:** 1% VAT (instead of 11%) on locally made EVs
- **Thailand:** Subsidies for EVs and reduced import duties
- **Malaysia:** Import and excise duty exemptions for EVs
- **Singapore:** EV rebates provided until end of 2026
- **Philippines:** Tariff exemptions on EVs and parts
- **Vietnam:** Exemption of registration fee for EVs

Sources: IEA; BNEF; Bain analysis

Investor confidence and consumer demand have inflected sharply past 18 months

INFLEXION #1
SEA has reached top-tier EV penetration globally

- EV sales in Singapore, Vietnam, Indonesia, and Thailand have **exceeded legacy automotive markets** like the US, Europe, and the UK
  - SG and VN reached ~40% EV sales share in 2025—surpassing the UK and EU
  - Indonesia reached 15% penetration in 2025, surpassing the US
  - Thailand sold more EVs in Q1–Q3 2025 than Denmark
- This contrasts with **three years ago**, when SEA was considered a **laggard**


Southeast Asia lags in electric vehicles. Can it catch up?

By Michael Taylor

February 28, 2023 5:29 PM GMT+8 · Updated February 28, 2023

Reuters, 2023

INFLEXION #2
Global OEMs are committing to manufacturing in SEA

Indonesia
- **BYD** invested **$1 billion** to develop a manufacturing plant, with annual production capacity of 150,000 units from 2026
- **Toyota** confirmed its first SEA EV production in Indonesia in 2025

Malaysia
- **Stellantis and Leapmotor** began local EV assembly at its Gurun, Kedah, plant in 2025

Vietnam
- **BYD** is establishing local EV production in Vietnam

Thailand
- **BYD** opened its **Rayong plant** in 2024 with 150,000-unit annual capacity, mandated to export across SEA

INFLEXION #3
First battery investments are landing in SEA

Indonesia
- **CATL** broke ground on its **$6 billion battery integration plant investment** in 2025
- **HLI Green Power**[1] HLI Green Power's battery cell plant (10 GWh) went live in 2024

Malaysia
- China's **Eve Energy** invested **$422 million** to build a lithium battery manufacturing plant; first batteries were produced in 2025

Thailand
- Thailand approved **China's Sunwoda Electronic's $1 billion investment** to build an EV battery plant in 2025

Note: 1) Hyundai LG Indonesia Green Power (JV between Hyundai and LG) | Sources: Reuters; Nikkei Asia; company websites

CASE STUDY: GRAB

Grab's 50,000- and 20,000-vehicle deals with BYD and GAC, respectively, mark a turning point—commercial EV deployment in SEA has crossed from pilot to viable at scale

In January 2025, Grab announced a **partnership with BYD to expand access to up to 50,000 EVs** across SEA-6 markets, followed by a January 2026 **partnership with GAC to deploy an initial 20,000 Aion EVs**—together representing one of the largest platform-led EV fleet commitments in the region.

Grab gives drivers the option of **renting the EVs from Grab's fleet partners** or **opting for financing support** through Grab's car ownership schemes—**which lowers the financial barriers associated with EVs**.

Both partnerships feature deep IoT integration to improve the overall ride experience, with the Grab driver app embedded into vehicle cockpits for navigation and trip management, while real-time vehicle data feeds back into Grab's platform to improve dispatch efficiency and route optimization.

WHAT THIS PARTNERSHIP SIGNIFIES

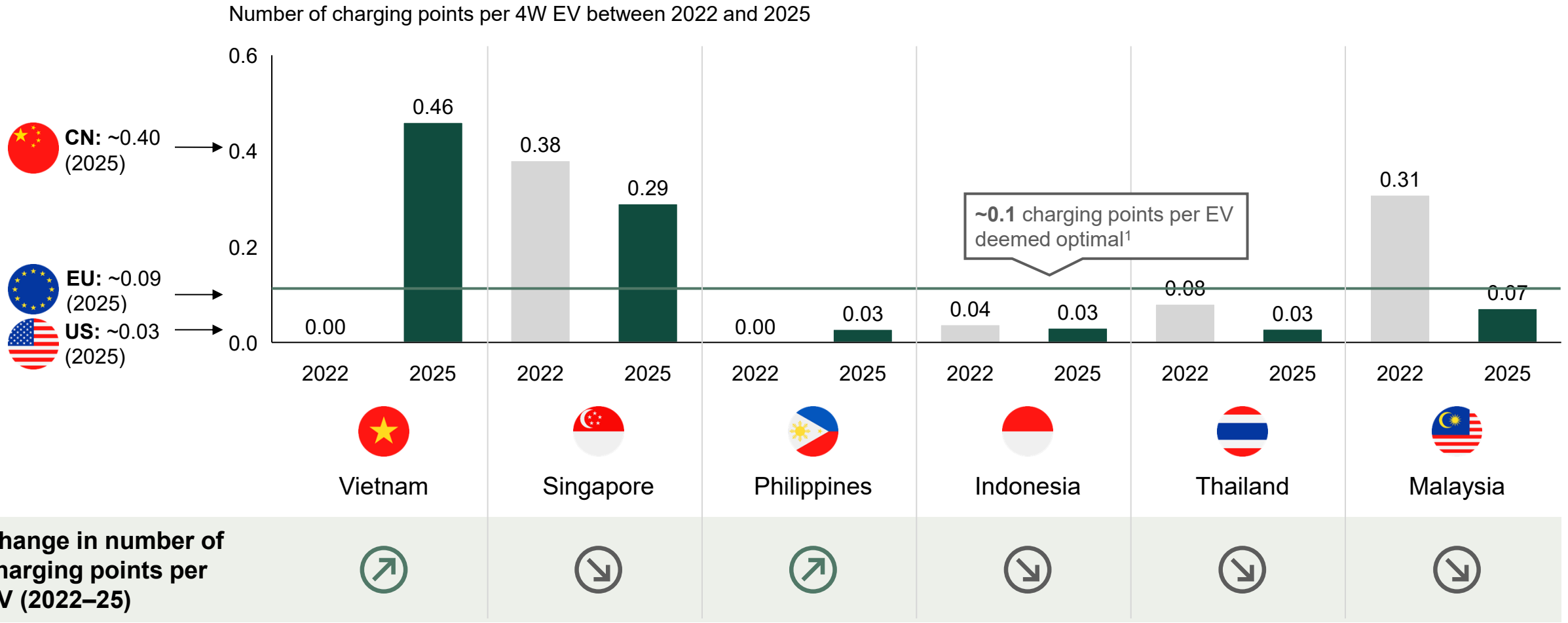
- Commercial EV TCO has crossed the viability threshold (EVs offer better economics in high-mileage use cases)
- There is an increasing shift from pure hardware to full ecosystem build-out with deep-tech integration
- Six-market simultaneous deployment confirms region-wide readiness
- Mass market participation is being enabled through innovative financing models

> "Our strategic collaborations with BYD and GAC underscore our belief that Southeast Asia's EV ecosystem has reached a stage where electric fleets are now a strong contender for high-mileage use cases. By exploring these large-scale deployments alongside innovative financing, we aim to lower barriers to entry and help shape a more diverse, sustainable mobility landscape across the region.
>
> CHUCK KIM, MANAGING DIRECTOR, GROUP BUSINESS DEVELOPMENT & CAPITAL MARKETS, GRAB

Sources: Expert interviews; company website

Charging build-out is accelerating across SEA, but EV adoption is outpacing infrastructure in most markets

Vietnam and Singapore are leading in charging infrastructure build-out, with other SEA markets lagging

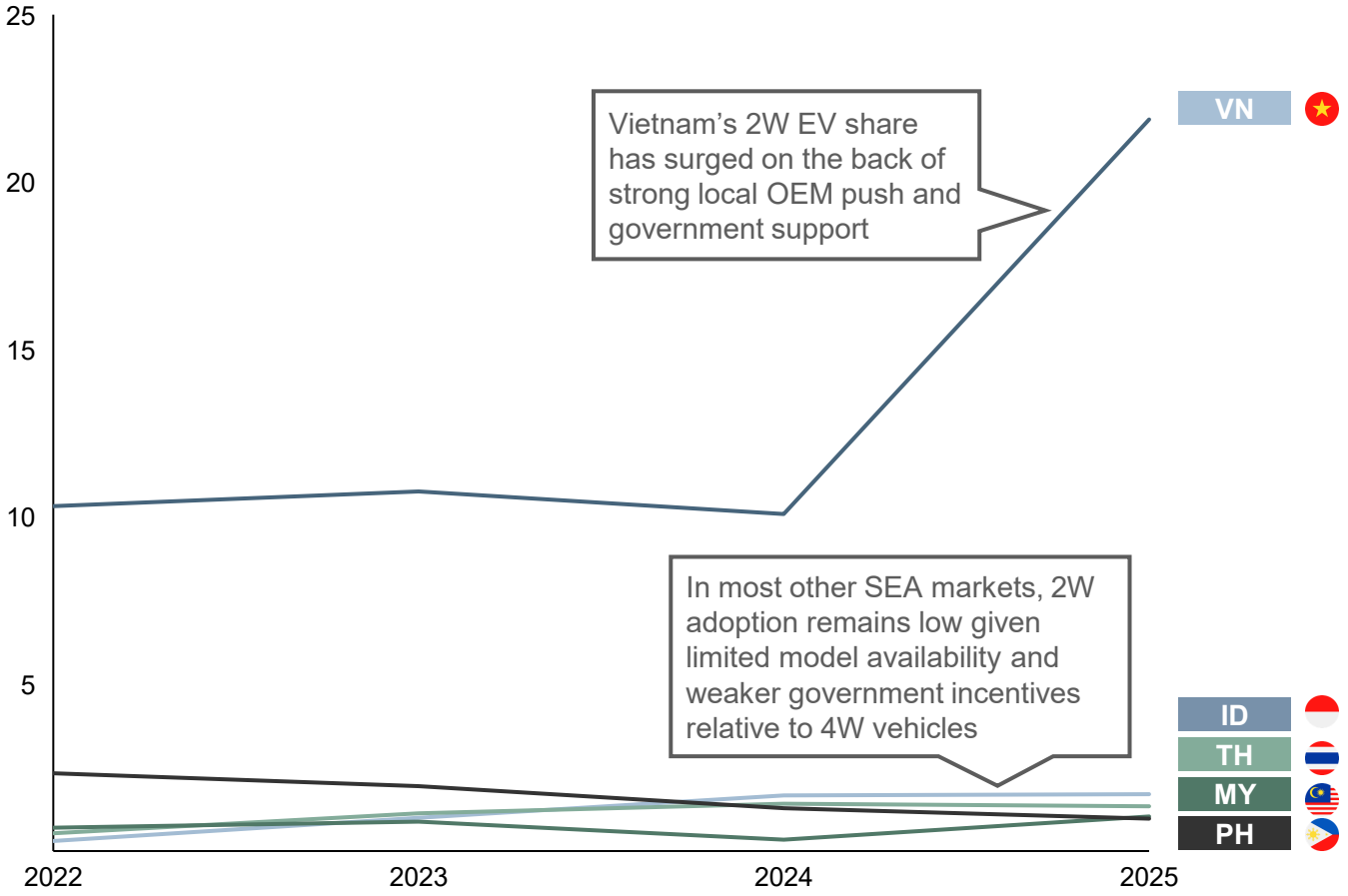


Note: 1) Based on recommendations by IEA and regional targets for number of EV chargers in relation to number of EVs | Sources: MarkLines; IEA; Bain analysis

For 2Ws, adoption has not yet reached a breakout phase for most SEA markets—except in Vietnam

Most SEA markets show muted growth for 2Ws except Vietnam

2W EV share of sales, 2022–25[1] (percentage)



Government incentives aim to bolster 2W adoption

Vietnam: mandate + subsidy

- Issued directive **banning all gasoline-powered mopeds and motorcycles** from Hanoi's inner city from July 2026
- Ho Chi Minh City targets **elimination of 400,000 gas ride-hailing/delivery bikes** from city center by early 2026
- Up to **~$800 subsidy** per 2W EV
- 2030 target: **22%** of all **2W to be electric**

Indonesia: direct purchase subsidy

- **~$420 subsidy** per 2W EV[2]
- 2030 target: **13 million 2W EVs** on the road

Thailand: direct purchase subsidy

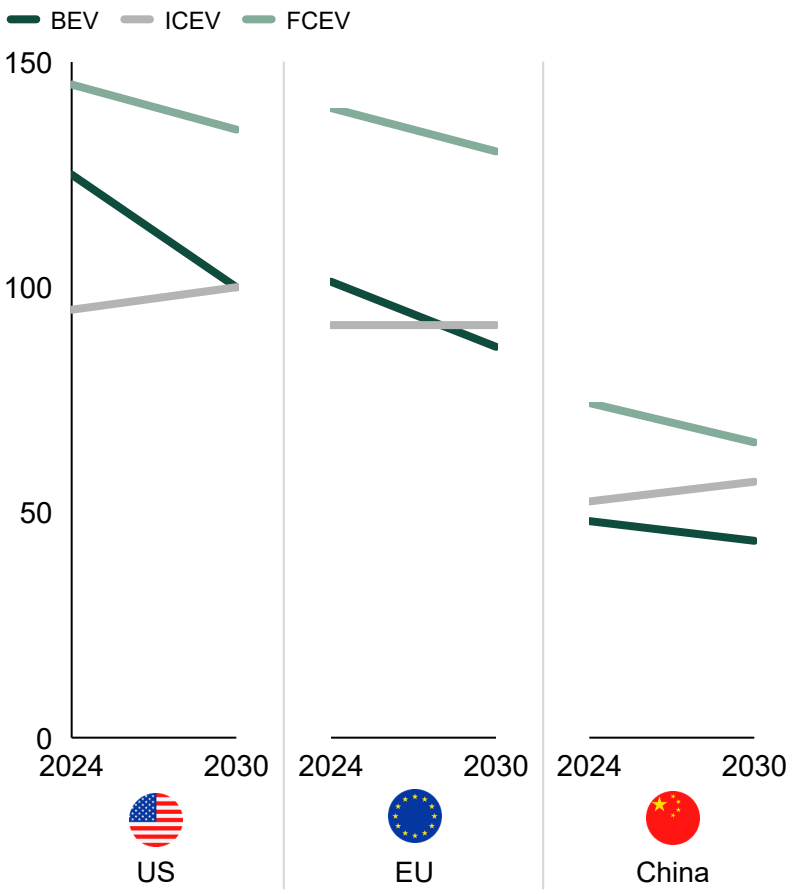
- **$160–$320 subsidy** per 2W EV priced under ~$4,800 with battery > 3kWh
- 2030 target: **675,000 2W EVs** produced domestically

Note: 1) January–November 2025 data for VN, TH; 2025 January–September data for ID, PH, MY; 2) Only for selected groups of people (e.g., those on wage subsidy assistance)
Sources: S&P Global; MarkLines; IEA; Ember

And while commercial heavy vehicle fleets are next electrification frontier globally...

BEV trucks to reach cost parity with ICEV by 2030—and already outcompeting FCEV

Total cost of ownership (2024–30)[1]



BEV trucks to become the fastest-growing segment by 2030

Annual growth rate across types of trucks (2024–30)

	Region		
Type of truck	**US**	**EU**	**China**
BEV	11%	11%	8%
ICEV	1%	-1%	-1%
FCEV	10%	10%	9%

HEADLINE FIGURES
HEAVY COMMERCIAL EVs[2]

~20%–25%
Annual growth rate of heavy commercial EVs (2024–30)

3.8M
Estimated heavy commercial EV stock in 2030

~40%
Asia-Pacific's share of global heavy commercial EV stock in 2030

Note: 1) Indexed to US 2024 value of diesel heavy-duty trucks; 2) Includes electric buses and trucks | Sources: IEA; Bain analysis

... SEA's commercial-heavy EV market is still in nascent stages but showing progress

While nascent, momentum is building through real-world fleet progress and commitments in SEA

	Kargo Technologies EV program, ID	FedEx regional EV fleet, SG/MY/TH	Banpu NEXT–DHL EV fleet partnership, TH
Overview	Focus on platform electrification of trucking through **partnerships with EV OEMs**	Focus on a **phased rollout of electric trucks and vans** across SG, MY, and TH	Focus on EV fleet solutions to meet **rising demand for sustainable transportation**
Progress to date	Secured **EV OEMs supply partnerships** with Foton, Indomobil JAC, Wuling, and VKTR **SPX, Astro, and Teleport** as potential first clients	**>25% of FedEx SG** pickup and delivery fleet is electric Pioneered MY's **first cross-border EV delivery** to SG	DHL has **installed Banpu's chargers** at six key locations
Commitment	**2,500** Target EV deployment within its network by 2026 (>5% of its total fleet)	**100%** of new vehicle purchases to be electric by 2030	**21 to >120** Target expansion of EV chargers by 2030 at DHL's hubs nationwide in TH

However, challenges remain in scaling up commercial EVs in SEA

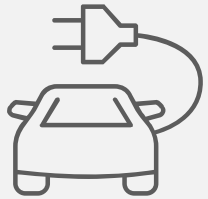
KEY LEARNINGS FROM BANPU NEXT

- **Upfront capex, not TCO, is the real barrier**
  - EV prime movers remain 20%–30% more expensive up front than ICE equivalents
  - Operating costs are competitive, but payback periods remain too long
  - Operating lease structures are still nascent
- **Commercial fleet charging is a distinct infrastructure challenge**
  - Only 30–50 commercial-grade chargers in Thailand today
  - Large footprints and highway locations are required for commercial-grade chargers
- **Model choice is limited**
  - Vans, pickups, and prime movers have far fewer EV options than passenger cars
  - After-sales and dealer networks are also limited

Sources: Kargo Technologies; FedEx; Banpu NEXT

SEA's EV adoption rate has well exceeded even the most ambitious forecasts - the question is no longer if it will happen but who captures the value

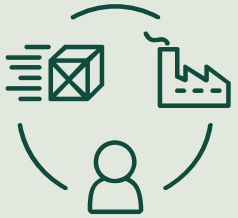
WHAT THE DATA IS TELLING US



The 4W market has structurally inflected, with adoption surpassing the most optimistic projections

Momentum is underpinned by both policy- and market-driven forces, making the shift durable

The next frontiers—2Ws and heavy commercial vehicles—are early but moving



SEA's demand can anchor a regional value chain—if supply-side investment moves now

Battery manufacturing and EV production dominate the EV value pool, accounting for ~95% of total market value

EV value chain

	Battery raw materials mining and refining	Battery manufacturing	EV production (OEM)
	Mining and processing key minerals (e.g., lithium, cobalt, nickel) for battery-grade use	Producing cell components and assembling them into finished battery cells	Building and assembling EV components into finished vehicle products
Global market size (2025)	**$55–$65 billion** (~5% of overall EV manufacturing value chain)	**$190–$200 billion** (~15% of overall EV manufacturing value chain)	**$1,100–$1,200 billion**[1] (~80% of overall EV manufacturing value chain)
Margin (EBITDA)	**~10%–40%**	**~5%–20%**	**~3%–8%**
Potential for durable value capture	**Medium** • **High capex** but value dependent on **volatile and cyclical commodity prices** • **Limited differentiation in core refining processes**—tech advances exist but are less defensible over time • **Geological endowment**, not process or tech IP, is primary moat	**High** • **High capex and tech/IP complexity** create durable barriers and competitive advantages • **Steep learning curves**—yield, process stability, and cost improve with cumulative production • **Switching costs rise** as platforms are optimized around specific suppliers	**Low** • **Fragmented competition**, **cost pressures**, and **limited pricing power** dilute margins • **High capex requirements** with structurally constrained margins

Note: 1) OEM market size and growth includes only selling of components and finished units and excludes all other activities like after sales, maintenance, software and services, financing, etc. | Sources: Bain analysis

However, while SEA has the raw materials and auto manufacturing base, it has yet to establish a durable position in either battery manufacturing or EV production

SEA has built a strong presence in raw materials, specifically mining, but is nascent in battery and EV production

EV value chain

	Battery raw materials mining and refining[1]	Battery manufacturing	EV production (OEM)
SEA share (2025)	✓ Strong  **>60%** of global nickel output  **~12%** of global cobalt output	✕ Largely absent  **~2%** of global battery production	• • • Emerging  **~2%** of global EV output Small share today but set to rise rapidly with committed capacity expansions across SEA
Key strengths and challenges for SEA	✓ **Dominance in raw material availability and processing** • ID holds ~40% of **global nickel reserves** and commands >60% of global nickel output; PH is the **second-largest nickel producer** in the world • ID is also a **significant cobalt producer**, accounting for ~12% of global production	✓ **Landmark investments arriving** • Anchor investments (e.g., $6 billion from CATL in ID) signal SEA as an emerging manufacturing location ✕ **Lack of supply chain depth** • Cathode/anode clusters largely absent; difficult to compete with China, which controls ~65% of global battery production ✕ **Talent shortage** • Local expertise in cell process is limited vs. competitors in China, Korea, Japan	✓ **Established automotive base** • SEA countries (e.g., TH, ID) offer world-class auto manufacturing infrastructure, logistics, and supplier networks ✓ **Growing OEM investment momentum** • Chinese and Korean OEMs have committed more than $20 billion in SEA manufacturing ✓ **Strong local players emerging** • Gov't industrial policy is catalyzing domestic OEM champions

Strong foothold established in SEA ◄---► *Still nascent in SEA today*

Note: 1) SEA's mineral endowment is a strategic advantage, but long-term value creation depends on developing the mining and processing base sustainably and responsibly | Sources: S&P Global; Bain analysis

While Indonesia is a leader in nickel, it is currently grappling with a structural market reset as it finds a foothold in battery manufacturing

The peak
2021–23

$48,000/ton

Nickel reached peak price

- EV boom triggered a global nickel rush
- ID became the nickel expansion center, fueled by ban on raw ore exports[1]
- ~$28 billion announced in battery and processing investments in ID

ID positioned as anchor of global nickel supply

The reversal
2024–25

-70%

Nickel prices fell 70% from peak

- Prices slumped due to supply flood from ID
- Rise in LFP[2] battery options dented nickel demand
- EV demand did not grow fast enough to absorb oversupply

Battery ecosystem investments canceled or delayed as prices fell

What has held (vs. not)
2026

~25–30 GWh

Battery capacity committed in ID

- ID's nickel stronghold persists: ~40% of reserves and >60% of global output
- Committed projects continue (e.g., HLI[3] and CATL's battery plants in Karawang) despite investment pullbacks by LG and BASF

Committed projects proceeding; new investments slowing sharply

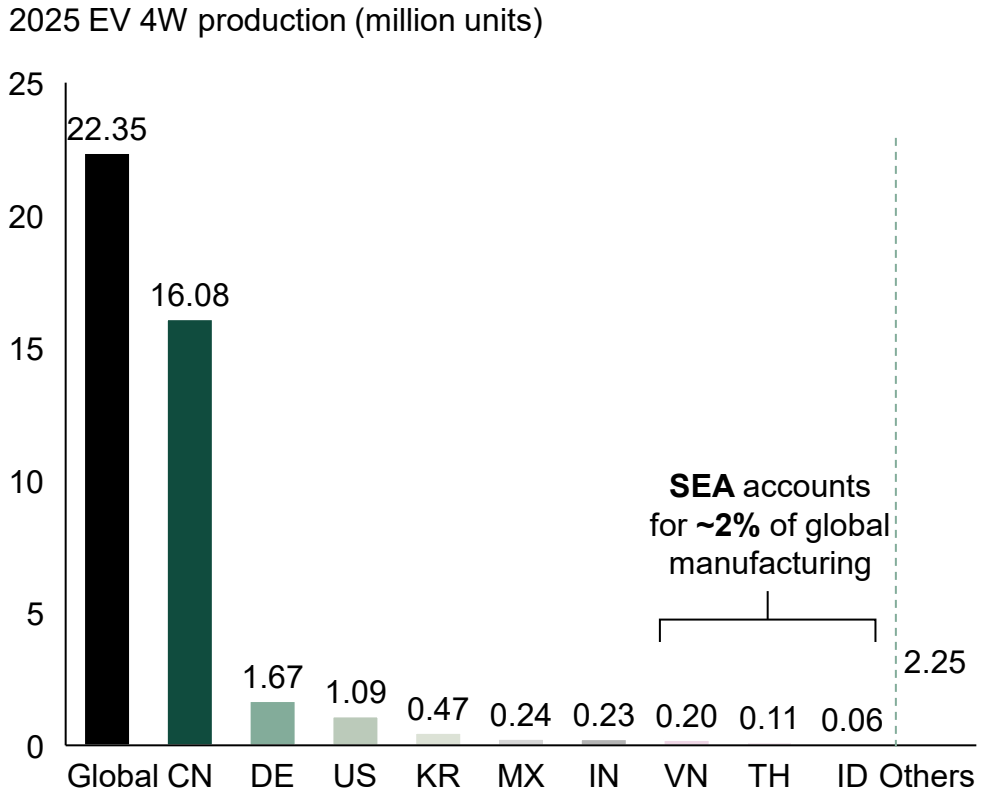
What comes next

- ID has **secured global leadership** in nickel
- Nickel processing **retains its competitive advantage**
- Future integrated value chain and battery investments **hinge on offtake certainty and cost competitiveness**
- ID should **accelerate shift** from ore exporter to integrated battery manufacturer **before supply chains lock in elsewhere**

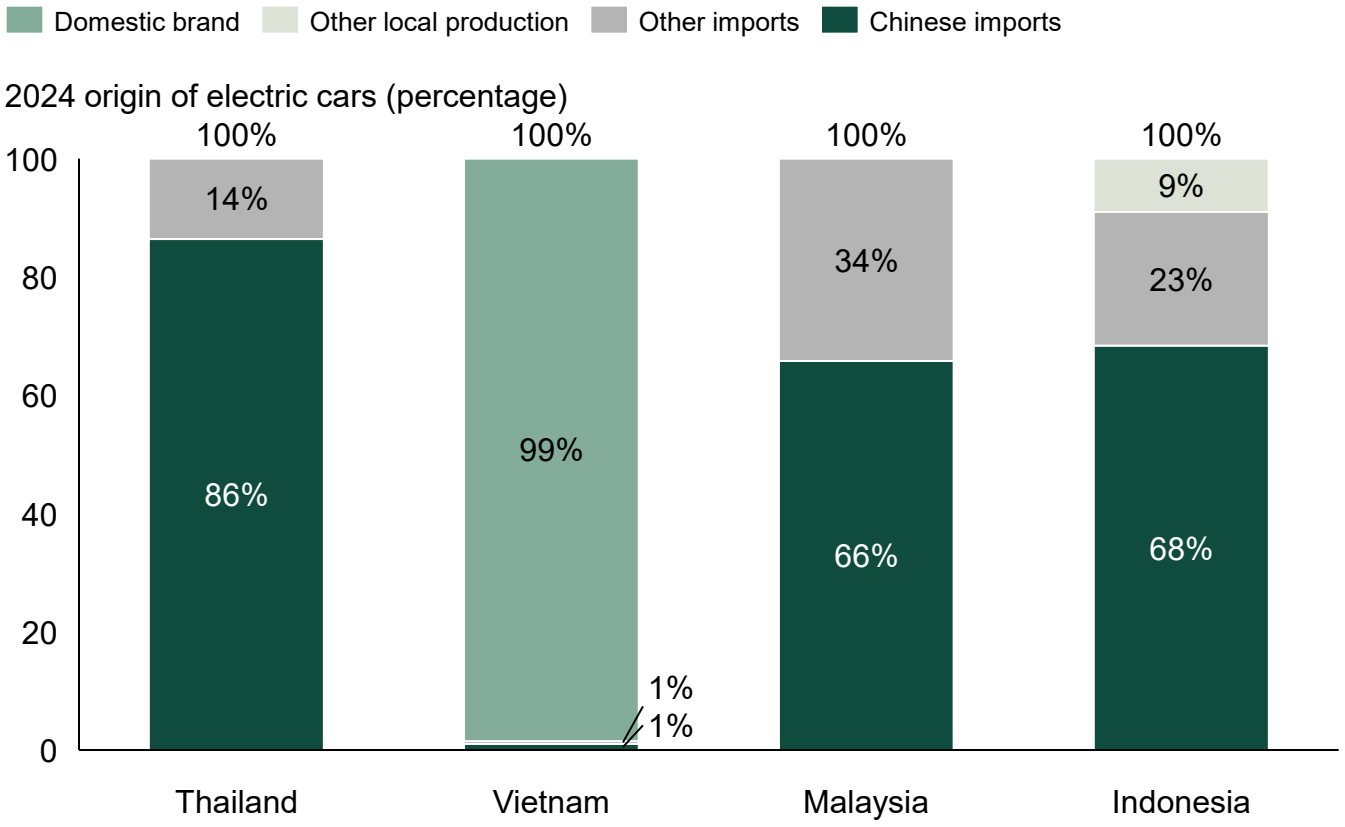
Note: ID's mineral endowment is a strategic advantage, but long-term value creation depends on developing the mining and processing base sustainably and responsibly; 1) The ban drove global battery and processing investment into ID, as companies could no longer just buy cheap ID nickel ore and process it elsewhere; 2) Lithium iron phosphate; 3) Hyundai LG Indonesia | Sources: U.S. Geological Survey; S&P Global Commodity Insights; Bain analysis

SEA captures just ~2% of global EV manufacturing - demand is import-led, with Vietnam as the sole exception

SEA is relatively nascent in EV manufacturing, accounting for ~2% of global manufacturing



SEA's EV demand is mostly met through Chinese imports, with Vietnam as a notable exception



Sources: S&P Global Mobility; IEA; Bain analysis

SEA's $150+ billion auto economy, one of the region's largest employers, at risk

SEA has a significant automotive industry …

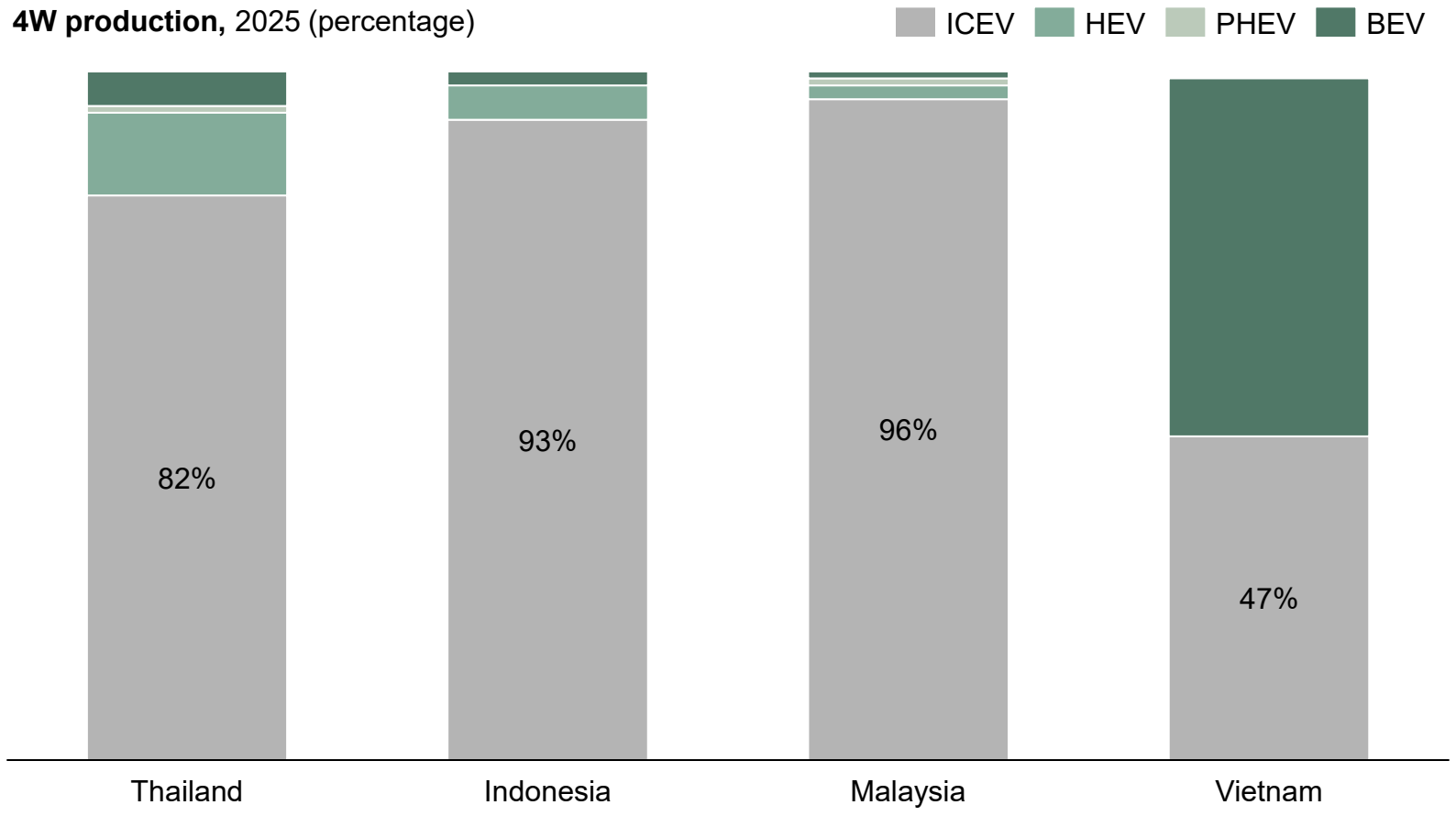
… ~50%–90% of which is reliant on ICEVs, exposing the region to erosion risks

~10%–11%
GDP contribution from the automotive industry in Thailand and Indonesia

~5%
GDP contribution from the automotive industry in Malaysia

>5.2M[1]
people employed in automotive industry in SEA-6 (excl. Singapore)

10th
largest automotive producer globally in 2025: Thailand

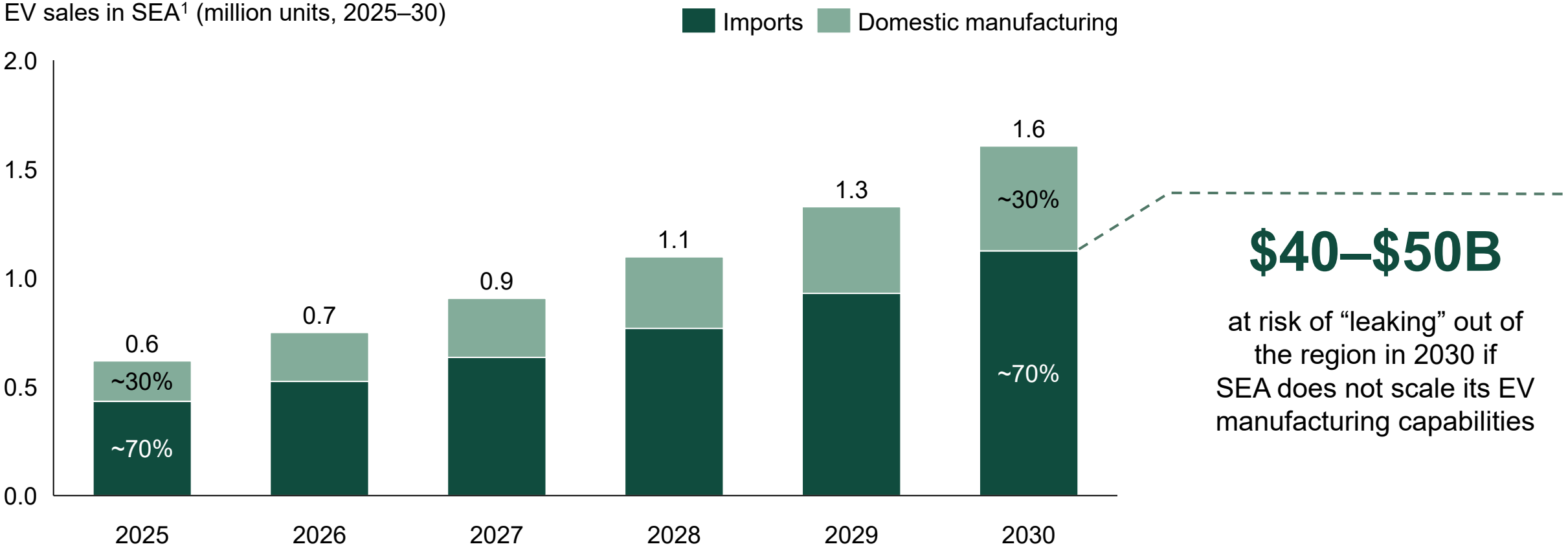


Note: 1) Including direct and indirect jobs | Sources: EVAT; S&P Global; Thailand National Statistical Office; Bain analysis

Inaction has a price: $40–$50 billion in value risks permanently leaking to advanced EV markets like China, Korea, and Japan

If SEA continues importing ~70% of its EV demand, it risks losing economic value to markets supplying EVs to region

EV sales in SEA[1] (million units, 2025–30)



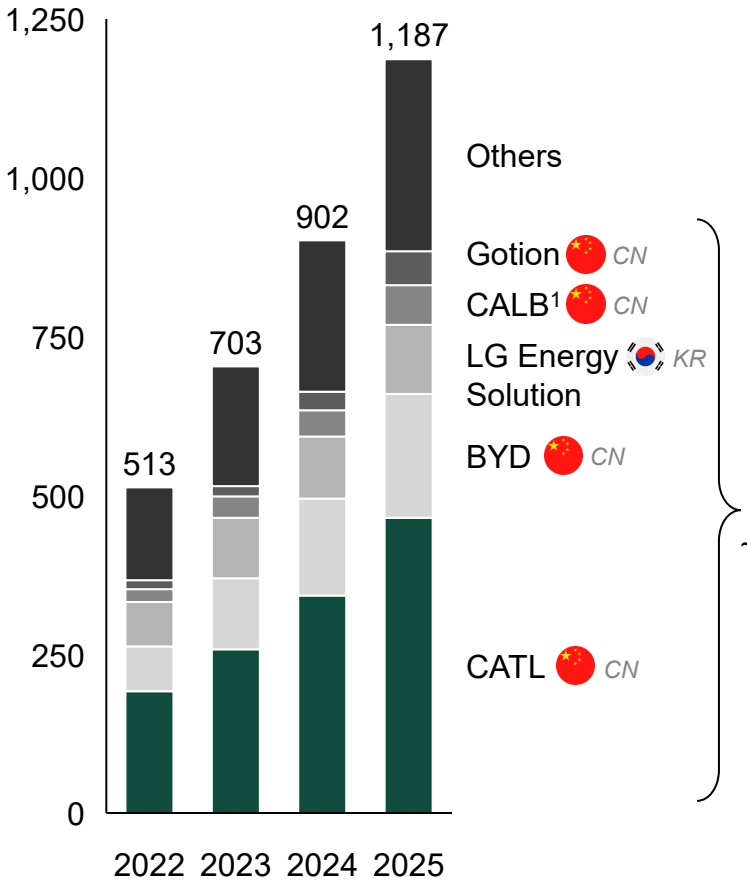
$40–$50B

at risk of "leaking" out of the region in 2030 if SEA does not scale its EV manufacturing capabilities

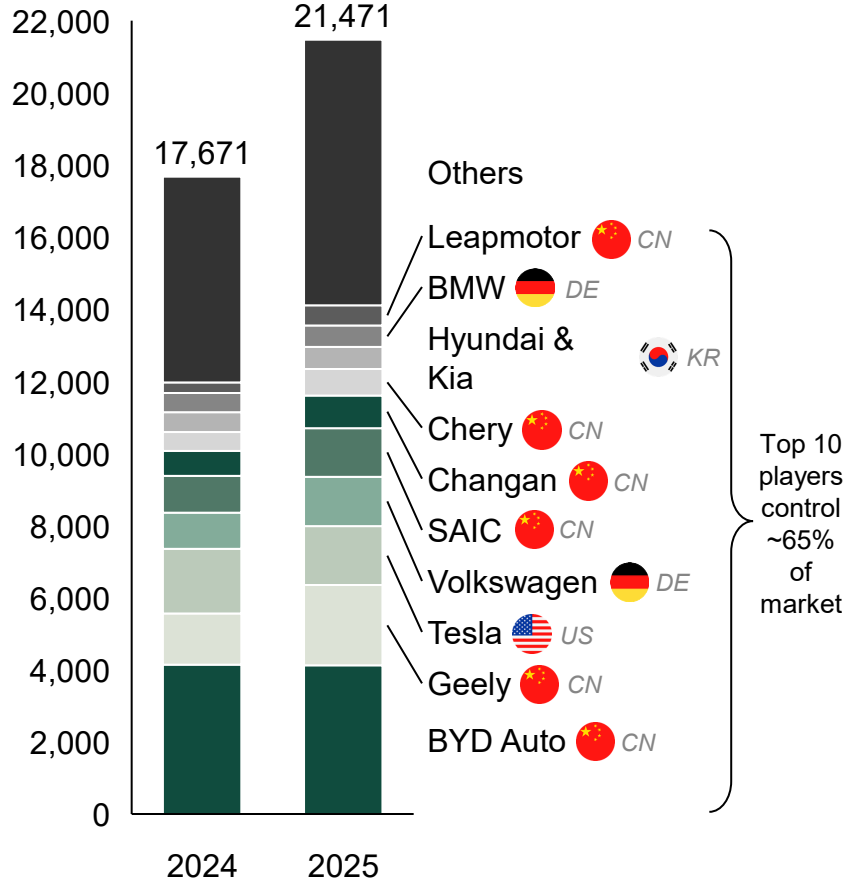
Note: 1) Serves as a proxy to indicate ratio of imported vs. domestically manufactured EVs for the overall EV market in SEA, including 2W, 3W, 4W, buses, trucks, and vans | Sources: S&P Global Mobility; Bain analysis

The EV market remains contested but is rapidly consolidating around early movers - especially in battery manufacturing

Global EV battery market share by player



Global EV market share by player



Key takeaways

Battery manufacturing—highly concentrated and scale driven

~75% controlled by top five players

~65% controlled by Chinese manufacturers

EV manufacturing—comparatively more fragmented at OEM level but increasingly concentrated geographically

~65% of sales by top 10 players, with BYD, Geely, Tesla maintaining market position

6 out of the top 10 players are from China, capturing ~45% of market

Note: 1) China Aviation Lithium Battery | Sources: SNE Research; MarkLines; Bain analysis

China’s 65%–70% control across every stage - from minerals to finished vehicles - reflects deep system-wide integration

China has built integrated champions across the end-to-end EV value chain

EV Value Chain

	Battery raw materials mining and refining	Battery manufacturing	EV Production (OEM)
China’s share	**~70%** of global EV raw materials refining output[1] (2024)	**~65%** of global battery production (2025)	**>70%** of global EV car output (2025)
China’s key achieve-ments	World leader in processing **manganese and graphite** — ~90% *market share* World’s largest refining hub for **lithium, cobalt, and phosphate** — ~70% *market share*	Home to world’s **largest lithium-ion battery producer** (CATL) — ~38% *market share* Home to world’s **second-largest EV battery producer** (BYD) — ~17% *market share*	Home to world’s **top EV seller in 2025** (BYD) **2.3** *million units sold, vs. 1.6 million units sold by Tesla (2025)*

Note: 1) Data aggregated across six key EV battery raw materials: lithium, cobalt, phosphate, manganese, graphite, and nickel
Sources: Aranca Research; IEA; Global Critical Minerals Outlook 2025; BNEF; company financial reports

China built a self-reinforcing flywheel of demand, supply chain, and capital… SEA needs to conceive its own version before the window closes

Large, growing domestic demand

Volume certainty justifies capacity build-out across the value chain

~60%
of global EV car sales in 2025 (~16 million units)

~50%
of total car sales were EV in China in 2025

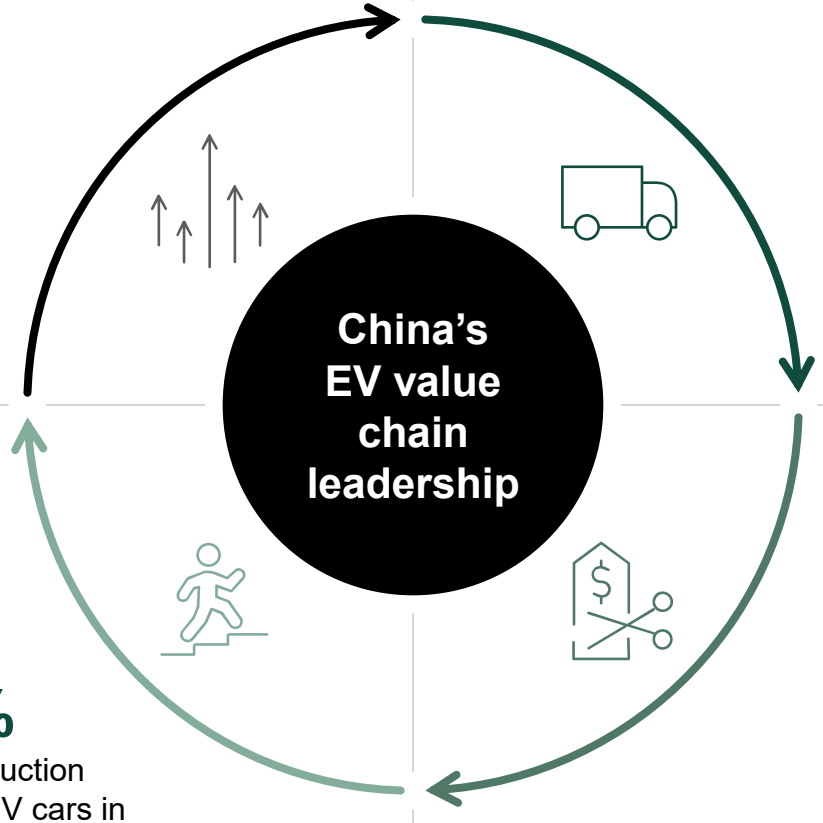
Scaled, integrated supply chains

Scale and coordination reduced cost, shortened lead time, and accelerated ramp-up

~70%
of global EV raw materials refining output in 2024[2]

~65%
of global battery production in 2025

>70%
of global EV car manufacturing output in 2025



Accelerated EV innovation

Lower production costs enabled rapid reinvestment into R&D

>40%
lower direct manufacturing cost for batteries[1] in China vs. US

10%–15%
lower production costs for EV cars in China vs. SEA

>30%
lower production costs for EV cars in China vs. advanced economies

Lower cost of capital

Cheaper capital, as repeatable delivery reduced risk premium

1.7%
ultra-low interest rate on ~$700 million tranche of "green science and technology innovation" bonds issued by CATL in 2026

Notes: 1) Batteries used in BEV and FCEV; 2) Data aggregated across six key EV battery raw materials: lithium, cobalt, phosphate, manganese, graphite, and nickel | Sources: IEA; Bain analysis

The clock is ticking for SEA: OEM platform decisions made in 2025–28 will lock in supply chain positions for the foreseeable future

Thailand's ICE origin story is a proof point of early platform allocation creating decades of advantage

1984–96

Japanese OEMs expand local assembly/CKD operations and build a manufacturing foothold in Thailand

2000–17

Thailand formalizes an ambition to be **"the Detroit of Asia"** alongside large production growth through the 2000–17 period

2018

Thailand widely described as a regional manufacturing hub with a deep domestic supply chain **(>2,000 auto parts suppliers** operating in Thailand)

10th	**~11%**	**~500,000**
largest automotive producer in the world (2025)	of GDP contributed by the automotive industry (2025)	jobs added as part of the automotive industry (2025)

For EVs, the same locking-in dynamic is being observed today—manufacturers are moving quickly

TH	**BYD**	Began manufacturing operations in Rayong in **2024** Production capacity of **150,000 vehicles annually**
ID	**CATL**	Began construction on battery plant in **2025** **Capacity output of 15 GWh**
VN	**VinFast**	Began EV manufacturing operations in **2021** Production capacity of **200,000 vehicles annually**

Sources: CNBC; CNA; BYD; CATL; VinFast

The 4W manufacturing battle is already underway - Thailand leads on capacity, Indonesia on resources, Vietnam on integration

Overview

Thailand
Scale through manuf. base

- Leveraged its top 10 global **ICE manufacturing base** to transition into a regional EV production hub
- Secured **early platform allocation** from Chinese OEMs
- Incentivized local production through tax incentives for imported EVs, on condition that importers **must produce EVs locally in Thailand** within a specified time frame

Indonesia
Resource-led integration

- Enforced **local content** requirements to deepen localization
- Scaled EV manufacturing through **incentives** (VAT cuts, luxury tax exemptions, import duty relief)
- Attracted **early investments** from Korean and Chinese OEMs (Hyundai, Wuling)
- Push for participation **across EV value chain**, leveraging its upstream nickel advantage—**resource availability** makes it an attractive spot for **E2E value chain**

Vietnam
Champion-led expansion

- Built industry around **single national champion**, VinFast
- Rapidly scaled and became Vietnam's **largest OEM in ~24 months** with manufacturing plant in Hai Phong
- **Vertically integrated** across assembly, battery pack, and charging
- Push to **expand production** into Indonesia and India

4W EV production in 2025
(million vehicles)

Note: 1) Estimated based on publicly reported production capacities of major EV manufacturers in each respective country | Sources: S&P Global Mobility; IEA; Bain analysis

CASE STUDY: VINFAST

How VinFast built SEA's first homegrown EV brand—mitigating legacy ICE transition cost and positioning as Vietnam's default EV brand

Established in 2017, VinFast delivered its first vehicle in 2019 and **committed fully to EVs by 2022—earlier than most competitors in the region had committed to local EV production.**

By building at scale and targeting 80% local content by 2026, **VinFast sought to bring production costs below imported alternatives**. Its entry-level VF3 was priced to undercut the total cost of ownership of ICEVs—increasing affordability for the masses.

VinFast **operates a vertically integrated ecosystem extending beyond vehicle manufacturing**, with subsidiaries/sister companies supplying battery cells, building charging infrastructure, and operating electric ride-hailing and bus platforms. This end-to-end integration is a key differentiator linking manufacturing, charging infrastructure, and fleet operations, **enabling VinFast to support EV adoption across ownership and ride-hailing segments in Vietnam.**

VINFAST'S PERFORMANCE IN SEA

- **~25%–30% share** of total EV sales in SEA in 2025
- **Largest automotive brand in Vietnam** with ~95% EV market share
- **~100% year-over-year sales** growth in 2025
- **200,000 vehicles produced** at Hai Phong factory in 2025—a record for Vietnam's automotive history
- Planned **~$40 billion investment** to scale Vietnam's renewable energy capacity to **40 GW by 2030**

> "VinFast's core mission is to make electric mobility and sustainable journey accessible to everyone. Every strategic decision we make is anchored to that objective, including investing in technology, industrial capabilities, and global expansion.
>
> THUY LE, CHAIRWOMAN, VINFAST

Source: Expert interviews, Company website, Bain analysis

No single SEA country can anchor the full EV value chain, but the full EV puzzle, distributed across the region, adds up to a formidable whole

What SEA could build: A cross-border ecosystem to replicate advantages of China's flywheel model

Battery raw materials mining and refining[1]		Battery manufacturing	EV production (OEM)	
Mining	Refining	Batteries	Components	Assembly
Indonesia • Has largest nickel and third-largest cobalt reserves globally • Also has existing large-scale mining ecosystem **Philippines** • World's second-largest nickel producer • Has fifth-largest cobalt reserves globally • Also has existing large-scale mining ecosystem	**Indonesia** • World's largest nickel refining hub (~40%) • Nickel refineries are largely co-located with mines for logistical efficiencies • Policy push to restrict raw nickel exports; aim is to produce higher-value nickel outputs used in EV batteries	**Indonesia** • Has SEA's first EV battery plant with 10 GWh capacity • Introduced policy incentives for cell production (tax reduction, local content requirements) **Vietnam** • VinFast provides large domestic demand for EV batteries, with four battery manufacturing facilities established in Vietnam	**Indonesia** • Nickel-rich; supports downstream components manufacturing **Thailand** • Has large car-making hub with base of component suppliers already present **Vietnam** • VinFast provides large domestic demand that pulls in battery and component suppliers	**Indonesia** **Thailand** **Vietnam** **Malaysia** **Philippines** • Cost-competitive assembly vs. developed markets • Have existing auto clusters for vehicle assembly, enabling fast ramp-up for EVs • Batteries and components can be sourced easily, either locally or regionally

Note: 1) SEA's mineral endowment is a strategic advantage, but long-term value creation depends on developing the mining and processing base sustainably and responsibly | Sources: S&P Global; Bloomberg; VinFast

SEA has multiple pathways to build a regional value chain - the “contested integration” model offers the highest collective payoff

ARCHETYPES OF MARKET PATHWAYS FOR SEA

	1 **Current trajectory** Growth largely reliant on market forces	2 **Solo trajectory** Country-level market capture and protection	3 **Contested integration** Interregional competition and collaboration
Government policies and incentives	• **Limited push to localize manufacturing** • Domestic projects are **scattered and uncoordinated**	• Strong incentives **tied to local content** • Preferential procurement for **domestically manufactured or assembled EVs**	• Incentives are designed to **reward SEA-wide sourcing** (not just domestic) • Joint financing available for **cross-border projects**
Standards and regulations	• **Fragmented standards** by country (e.g., different safety test requirements, charging connector rules) • Approval and certification are **repeated in each market**	• Countries keep national technical requirements but **also accept international certifications**	• Harmonized **SEA-wide standards** • Local product certification is **valid across SEA markets**
Supply chain and logistics	• Supply chains are **import-heavy** • **Inconsistent hazardous-goods-handling practices**	• Supply chains are **domestic-heavy** • **More standardized controls and licensing for strategic inputs** (e.g., battery materials, cells)	• **ASEAN “green lanes” established for EV components** to speed up clearance • **Consistent hazardous-goods-handling practices** to reduce shipment delays
Regional strategy and specialization	• **No deliberate specialization**; each country pursues opportunistic investments	• Each country picks its own lane and **tries to own full value locally**	• Planned **“distributed specialization”**; countries own different parts of the value chain but still maintain competition for projects and investments

Stronger regional integration could help SEA unlock 2x–3x more value across the EV value chain compared to status quo

	SEA market size ($ billion)			
	2025	**2035 (current trajectory)** Growth largely reliant on market forces	**2035 (solo trajectory)** Country-level market capture and protection	**2035 (contested integration)** Interregional competition and collaboration
Mining and refining	$4–$6	$10–$12	$12–$14	$12–$14[1]
Battery cells	$5–$7	$18–$20	$24–$28	$34–$38
Components	$4–$6	$16–$18	$20–$22	$34–$38
Assembly	$4–$6	$16–$18	$55–$65	$120–$130
Total	**$17–$25**	**$60–$70** (1%–2% of global market)	**$110–$130** (2%–3% of global market)	**$200–$220** (4%–5% of global market)
Additional market value captured in contested integration vs. current trajectory				**$130–$160** (3%–4% of global market)

Achieving "contested integration" could unlock ~$130–$160 billion in incremental value by 2035 vs. "current trajectory"

Note: 1) As SEA already controls a sizable share of mining and refining, it is assumed that in the "contested integration" scenario this share will likely not increase significantly | Sources: IEA; S&P Global; Bain analysis

SEA's semiconductor industry - which constitutes ~20% of the global market - proves that regional cooperation creates outcomes no single country could achieve alone

Semiconductor industry—an analogous model for SEA's EV ecosystem

Country	Role in regional collaboration model	Contribution to SEA's semiconductor industry
Singapore	Anchors **integrated circuit design and wafer fabrication**	• Strong IP protection framework • Trusted regulatory environment • Access to global capital markets • Advanced R&D ecosystem and talent pipeline
Malaysia	Leads **backend manufacturing and packaging**	• Mature backend manufacturing ecosystem • Deep supplier networks and industrial infrastructure • Established government-industry coordination mechanisms
Vietnam	Absorbs **overflow demand from other SEA markets**	• Competitive manufacturing cost base • Rapidly improving technical capabilities • Pro-investment government policy environment
Thailand	Provides **automotive grade ATP capacity**	• Dominant assembly, testing and packaging (ATP) base • Strong automotive-grade manufacturing infrastructure

What SEA did to achieve a regional "flywheel"

- **Regional policy coordination**
  - AFISS (2025) was established as the first ASEAN framework to align member states around complementary semiconductor roles
- **Frictionless intra-regional trade**
  - RCEP/AFTA tariff rules enable low tariffs on semiconductor components
- **Role-specialized talent programs**
  - National initiatives help each country secure talent in their value chain position: SG TechPass (design talent), MY ETSI (backend manufacturing engineers), and VN NIC (assembly/testing workforce)
- **SEA-wide technical expertise sharing**
  - Regional workshops (e.g., ERIA[1]–UKM[2]) and university partnerships (e.g., Thailand–ASU[3] regional training hub) are building a shared tech knowledge base across the value chain

Notes: 1) Economic Research Institute for ASEAN and East Asia; 2) Universiti Kebangsaan Malaysia; 3) Arizona State University
Sources: ERIA; ASEAN Main Portal; ASU; Singapore Economic Development Board; CREST Malaysia; NIC Vietnam

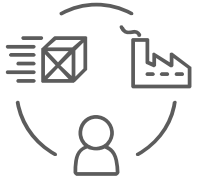
Four moves to turn SEA's EV potential into a self-reinforcing "flywheel"

1 Lock in anchor OEM commitments before platform decisions close

- Use import duties and local content requirements to incentivize in-country production
- Structure offtake agreements alongside manufacturing commitment, especially during the 2026–28 window
- Deploy public land, grid access, and fast-track permitting to reduce OEM first-mover costs

2 Build midstream scale through regional specialization

- Formalize value chain specialization through ASEAN-level coordination frameworks
- Repurpose existing auto clusters toward EV manufacturing
- Develop cross-border logistics corridors and fast customs procedures



3 Harmonize policy standards and market architecture

- Adopt common SEA EV component certification and safety standards
- Mandate open telematics and charging interoperability standards across SEA charging point networks

4 Mobilize Asia-Pacific capital and technology

- Attract innovative financing instruments from Asia-Pacific to de-risk first-mover investments
- Mandate technology transfer and R&D as a condition of market access

SEA's EV ecosystem is fragmented and nascent - capturing its full potential requires coordinated, region-wide transformation

	WHERE THE SYSTEM IS TODAY	WHERE WE WANT IT TO BE
Regulatory and policy	• **EV targets set country by country** with limited ASEAN-level harmonization on incentives, timelines, or phase-out schedules • **Charging standards fragmented—**no common connector or interoperability protocol across SEA-6 • **Technology transfer and R&D obligations weak,** limiting local capability building	• **Coordinated national roadmaps** with aligned phase-out timelines and trade policies • **Harmonized cross-border standards and certification frameworks,** enabling seamless regional supply chain • **Technology transfer mandated** as condition of market access, ensuring deeper value capture
Execution	• **Midstream battery manufacturing nascent—**SEA's first cell plant only opened in 2024 • **Charging infrastructure urban-concentrated—**highway corridors and rural areas underserved	• **Scaled midstream battery manufacturing** anchored in Indonesia (nickel-to-cell) and Thailand (pack assembly), linked by regional offtake agreements • **National charging backbone** with mandated highway corridor coverage
Capital and financing	• **EV ecosystem financing nascent—**capital is concentrated around Chinese OEMs bringing their own balance sheets, with limited local debt financing and financing infrastructure for demand side (consumer auto loans, fleet financing, etc.)	• **Deep, locally anchored capital stacks across the full value chain**—blended finance for battery and charging infrastructure, green loans for domestic OEMs, and consumer financing products • **SEA capital markets anchoring large-scale project finance** for regional EV champions

Across the EV value chain, sequencing is key for the region to capture full potential

What should SEA EV ecosystem focus on?

0–2 YEARS

Capture
Attract investment and build EV value chain capabilities

- **Provide clear EV transition and localization roadmaps**
  - Time-bound incentives, phased local content requirements for OEM, battery, and charging investments
- **Seed commercial and fleet EV demand**
  - Use public transport, logistics, and ride-hailing as anchor demand to crowd in private adoption

- **Anchor OEM and battery catalysts in industrial clusters**
  - Convert ICE lines where viable, attract battery partners, and co-locate Tier 1/2 suppliers in designated zones
- **Fast-track approvals for EV and battery plants**
  - Reduce permitting and interagency delays for strategic projects

- **De-risk first-of-a-kind EV manufacturing and battery assets**
  - Use FDI incentives and structured financing to unlock large-scale projects

2–5 YEARS

Bridge
Deepen value chains and scale enabling systems

- **Align cross-border standards and certification networks**
  - Harmonize EV safety, charging, and testing standards to enable regional supply chains
- **Mandate technology transfer and R&D as a condition of market access**
  - Link incentives to capability building so value capture increases over time

- **Scale component and battery manufacturing depth**
  - Expand cells, modules, power electronics, and drivetrain production linked to anchor OEM ecosystems
- **Scale SEA EV export corridors**
  - Fast-track customs clearance and logistics infrastructure to support competitive regional exports

- **Expand EV financing ecosystems**
  - Scale innovative fleet financing tools that make EV adoption viable at scale

5–10 YEARS

Destination
Establish a regional, integrated EV ecosystem with specialized hubs

- **Build SEA-aligned export frameworks**
  - Embed common regulatory and data-sharing models to enable seamless regional trade

- **Specialize by hubs to cover full EV value chain across SEA**
  - Thailand as EV export hub, Indonesia as minerals and battery hub, Malaysia as EV electronics and software hub, Singapore as standards and capital hub

- **Anchor SEA EV capital markets ecosystem**
  - Expand large-scale project finance, infrastructure fund, and public listings for regional EV champions

Regulatory and policy reforms | Delivery and execution enhancements | Capital and financing enablement

Each SEA country has a distinct role to play… and the steps and sequence to get there will differ by market (1/2)

What should each SEA market focus on?

	0–2 YEARS **Capture** Attract investment and build EV value chain capabilities	2–5 YEARS **Bridge** Deepen value chains and scale enabling systems	5–10 YEARS **Destination** Establish a regional, integrated EV ecosystem with specialized hubs
Thailand Regional manufacturing and export powerhouse	• **Convert ICE lines to BEV production** – Attract OEM commitments via incentives • **Seed commercial EV demand via incentives** – Priority focus on fleet and logistics operators as early adopters	• **Develop SEA EV export corridors** – Fast-track customs clearance and logistics infrastructure • **Scale commercial fleet charging infrastructure** – Prioritize highway and industrial zone coverage to meet fleet operator SLAs	• **Become SEA's primary EV export hub** – Target high EV share of total vehicles produced, with integrated OEM-to-export supply chain • **Lead regional EV after-sales and servicing** – Lead in power train maintenance and parts distribution
Indonesia End-to-end industrial anchor	• **Expand domestic battery-grade nickel refining** – Lock in offtake with major battery players to anchor downstream gigafactory investment • **Mandate local content** – Drive in-country manufacturing commitments from OEMs seeking market access	• **Commission gigafactories with KR/CN partners** – Co-locate in industrial zones with renewables and grid infrastructure • **Launch domestic EV financing schemes** – Stimulate market demand to bolster local manufacturing	• **Operate full E2E EV supply chain** – From nickel mining and refining to vehicle assembly • **Become SEA's main battery production hub** – Supply cells and modules across SEA OEM assembly operations
Vietnam Integrated OEM-led ecosystem builder	• **Continue scaling domestic EV production** – Attract Tier 1–2 component suppliers to co-locate, using existing EV OEMs as anchor demand • **Secure KR battery manufacturing investment** – Target KR battery manufacturers via existing FDI relationships and coinvestment incentives	• **Build OEM-linked component manufacturing clusters** – Develop depth across power train, electronics, and battery modules around VinFast ecosystem • **Deploy national charging network** – Scale infrastructure with roaming interoperability	• **Move up value chain toward connected vehicle software** – Transition from hardware assembly to mobility tech and software-driven vehicle capabilities

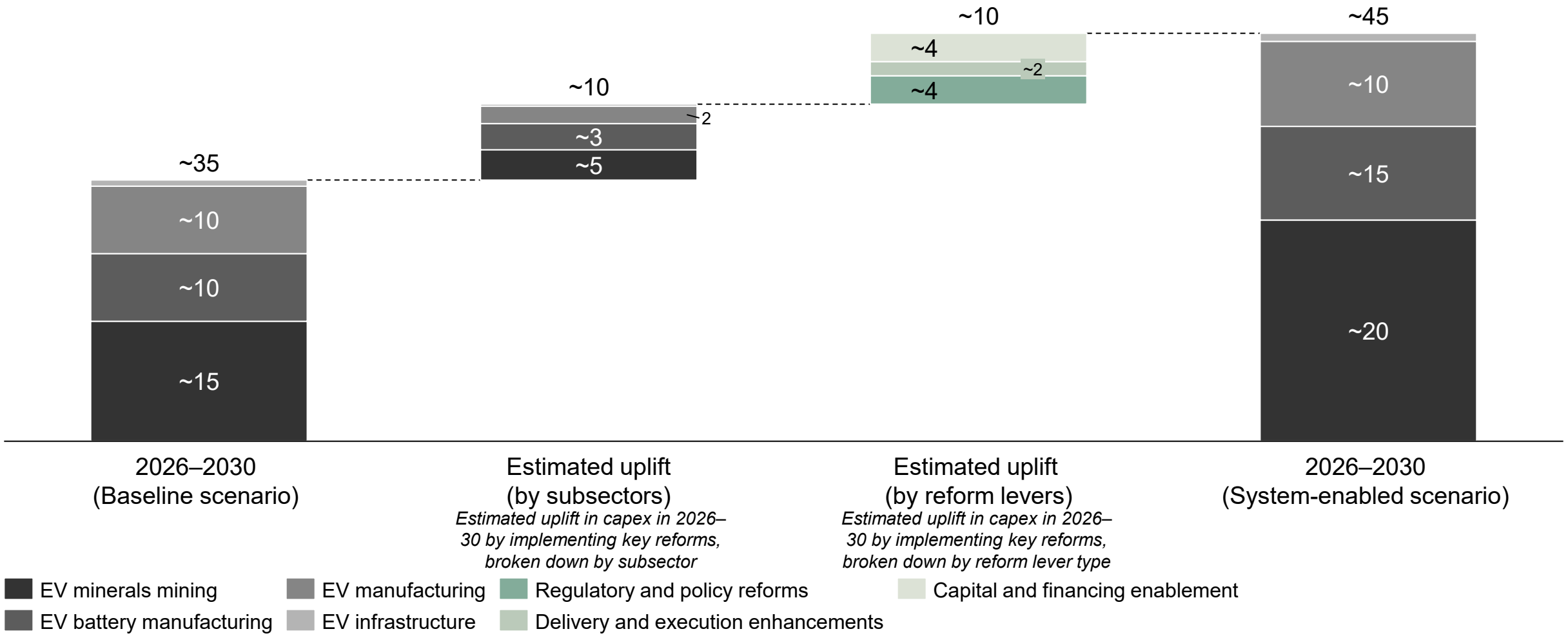
Each SEA country has a distinct role to play… and the steps and sequence to get there will differ by market (2/2)

What should each SEA market focus on?

	0–2 YEARS **Capture** Attract investment and build EV value chain capabilities	2–5 YEARS **Bridge** Deepen value chains and scale enabling systems	5–10 YEARS **Destination** Establish a regional, integrated EV ecosystem with specialized hubs
Malaysia Targeted value chain participant	• **Transition local OEMs (e.g., Proton, Perodua) to EV platforms** – Provide incentives/subsidies to accelerate affordable BEV model development • **Leverage electronics base to expand EV component manufacturing** – Direct semiconductor and electronics manufacturing capacity toward regional power train supply chains	• **Develop EV electronics manufacturing at scale** – Link production into Thai and Indonesian OEM supply chains as a mid-chain node • **Establish Johor-Singapore as EV testing corridor** – Codevelop cross-border standards, certification, and logistics infrastructure with Singapore	• **Become SEA hub for EV electronics and software** – Specialize in power management, connected vehicle components, and control systems • **Attract regional EV company headquarters** – Leverage Singapore proximity and business environment to host mobility technology firms
Philippines Targeted value chain participant	• **Upgrade nickel refining to battery-grade output** – Attract CN, KR, and JP processing investment to capture more upstream value • **Seed domestic demand** – Use public transport electrification as demand anchor for locally assembled vehicles	• **Develop copper and electronics EV component exports** – Build wire harness and electronics manufacturing capacity for regional supply chains • **Incentivize 2W EV assembly** – Tailor fiscal incentives to vehicle segments suited to Philippine urban transport needs	• **Supply battery-grade nickel to SEA gigafactories** – Establish Philippines as the region's key upstream critical mineral processing node • **Secure durable mid-chain role in SEA** – Anchor position in copper and electronics component exports to regional OEM assemblers
Singapore Regional standards and capital orchestrator	• **Establish Singapore as EV investment hub** – Structure government-backed blended finance vehicles to de-risk first-mover infrastructure investment • **Co-convene SEA EV standards body** – Work with JP and KR to develop common protocols for charging, safety, and software across the region	• **Operate as regional EV certification and financing hub** – Provide testing, green bond structuring, and sustainability-linked lending for SEA EV assets • **Build vehicle telematics standards for SEA** – Drive data-sharing agreements across charging operators and fleet managers region-wide	• **Anchor SEA EV capital markets ecosystem** – Enable project finance, infrastructure fund, and public listings for regional EV champions • **Export Singapore-developed frameworks as SEA standard** – Embed regulatory and data-sharing models as the default regional governance architecture

Through mitigation of constraints, ~25% additional capex can be unlocked over the next five years within EV value chain ecosystem

Estimated capex deployment into EV value chain ecosystem ($ billion)



Source: Bain analysis

SEA cannot build this alone: Japan, Korea, and China each hold expertise and capital that are essential to accelerating the regional supply chain

Country specialization Regional enablers

AVENUES FOR ASIA-PACIFIC–SEA COLLABORATION TO UNLOCK SEA EV VALUE CHAIN

Japan
Quality, safety systems, advanced materials IP, OEM ties

South Korea
High-performance batteries, process control, OEM ties

China
Scale, manufacturing expertise, OEM ties

Investment and expertise

Investment and expertise

SEA EV SUPPLY CHAIN

Battery raw materials mining and refining	Battery and component manufacturing	EV production (OEM)
Indonesia, Philippines	**Indonesia, Thailand, Vietnam**	**Indonesia, Thailand, Vietnam, Malaysia, Philippines**
Raw materials supply, mining and refining infrastructure	Battery and component manufacturing facilities, anchor demand	Electronics and power train manufacturing facilities, vehicle assembly hubs

Common standards | Fast customs | High traceability | Predictable policies | Industrial-ready grid

Wider Asia-Pacific collaboration across three pillars is essential to achieve this vision

/ NON-EXHAUSTIVE

Technology and IP transfer partnerships	Capital investments and anchor demand	Institutional enablers and policy alignment
Absorb Asia-Pacific's process know-how, engineering depth, and proprietary battery chemistry through structured JVs and codevelopment agreements	Mobilize Asia-Pacific capital and offtake commitments to de-risk first-mover investments across refining, manufacturing, and infrastructure	Adopt and codesign Asia-Pacific's mature EV regulatory frameworks, standards, and financing architecture to allow capital, components, and vehicles to move efficiently across borders

Selected examples

LG Energy Solution (ID)—Battery expertise transfer

Transfer of battery cell manufacturing process technology through the HLI Green Power[1] JV alongside commitments to train Indonesian engineers in cell chemistry and quality management

BTR New Material Group (ID)—Graphite anode processing technology transfer

Project brings Chinese graphite anode processing know-how into SEA and trains local engineers in anode production processes

CATL (ID)—EV battery plant investment

A $6 billion battery plant investment—the largest single EV battery capital commitment in SEA—providing both manufacturing capacity and a demand anchor for Indonesian battery-grade nickel supply

Ford, Huayou Cobalt, PT Vale, Standard Chartered, HSBC, Morgan Stanley—Nickel processing project

Construction of a battery-grade nickel processing project via a JV that combines OEM offtake agreement, Chinese processing capital, and Indonesian resource access

ASEAN Plus Three mechanism (SEA-wide)

Partnership between SEA and China, Japan, and South Korea to encourage harmonization of regional EV regulations and standards (e.g., types of charging plugs, battery safety standards) to facilitate trade

Commitment to EV ecosystem development (ID)

MOU between Indonesia and South Korea for cooperation on EV development, including ramping up EV exports from South Korea to Indonesia and securing core minerals from Indonesia for battery production

Note: 1) Hyundai LG Indonesia Green Power (JV between Hyundai and LG) | Sources: Company websites; Bain analysis

CASE STUDY: 3-PARTY NICKEL PROCESSING JV IN INDONESIA

How a three-party nickel processing JV is advancing sustainable EV battery supply chains in Indonesia

In March 2023, **PT Vale, Huayou Cobalt, and Ford signed a definitive agreement to jointly invest in the Pomalaa Block high-pressure acid leaching (HPAL) Project** in Southeast Sulawesi – a ~$3.8 billion national strategic project to produce battery-grade nickel for EVs.

Standard Chartered served as Huayou Cobalt's financial advisor in the JV transaction, helping to structure the three-party equity framework. Standard Chartered subsequently co-arranged ~$2.7 billion in debt financing alongside HSBC for the HPAL facility—one of Indonesia's largest project finance deals in the EV supply chain.

The HPAL plant can **produce up to 120 ktpa of processed nickel** and combines PT Vale's ore resources in Indonesia, Huayou Cobalt's HPAL technology, and Ford's downstream EV demand to create an integrated mine-to-battery value chain.

ROLES ACROSS THE JV / TRANSACTION

- **Huayou Cobalt:** Lead investor, project developer, and HPAL technology provider
- **PT Vale:** Ore supplier from Pomalaa Block; brings extensive nickel mining expertise
- **Ford:** Offtaker of processed nickel output for its EV batteries
- **Standard Chartered:** Financial advisor to Huayou; co-arranged (with HSBC) ~$2.7 billion debt financing
- **Morgan Stanley:** Financial advisor to Ford

> "This framework gives Ford direct control to source the nickel we need—in one of the industry's lowest-cost ways—and allows us to ensure the nickel is mined in line with our company's sustainability targets, setting the right ESG standards as we scale.
>
> LISA DRAKE, PRESIDENT, FORD ENERGY

Source: PT Vale press release (March 2023); Bloomberg (November 2024); company websites; Bain analysis

Capital is needed across value chain to build SEA's EV ecosystem to full potential

Opportunities | Asia-Pacific examples / ILLUSTRATIVE

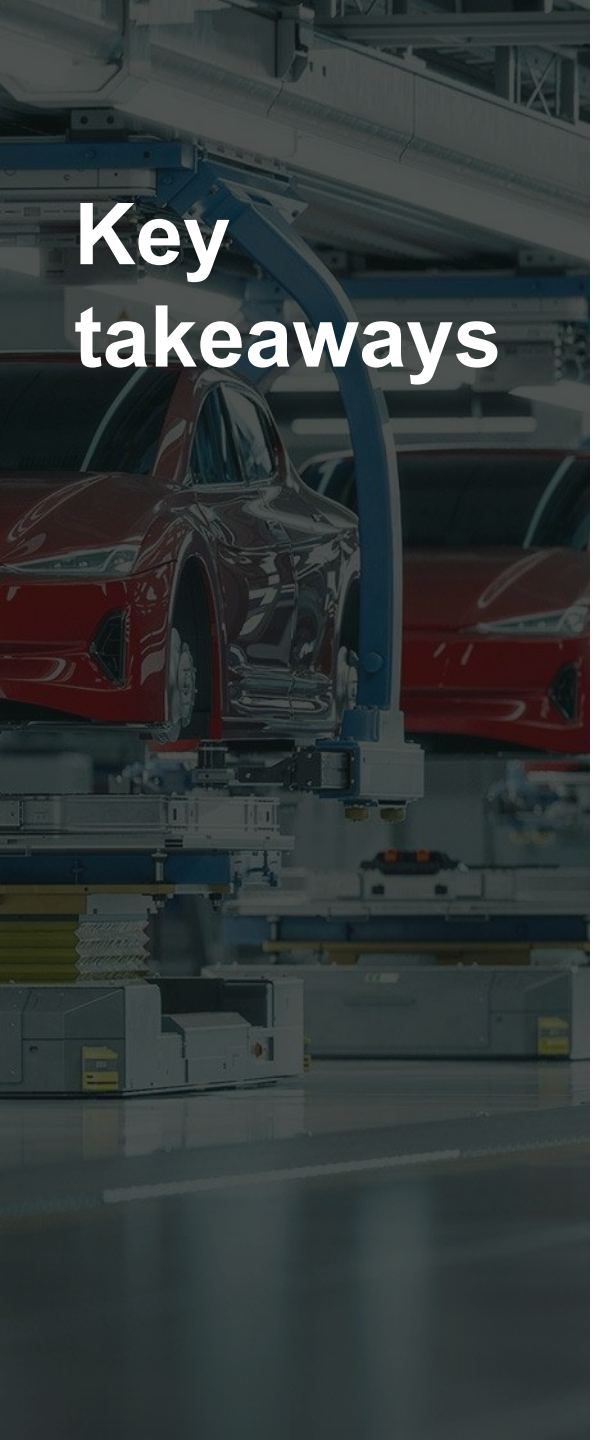
Investable opportunities across EV value chain

Battery raw materials refining		Battery manufacturing		EV production (OEM)		Charging infrastructure/ EV operations	
Battery-grade nickel and cobalt production	• Nickel processing plants—Ford, Vale Indo, and Zhejiang Huayou Cobalt, ID	**Battery pack/ module manufacturing**	• Battery assembly factory—BMW, TH • Battery cell plant—HLI Green Power[2], ID	**Contract manufacturing/ CKD assembly platforms**	• CKD plant—Great Wall Motors, TH • CKD plant—BYD, TH	**Commercial fleet charging points**	• Highway corridor and warehouse charging infra—Banpu NEXT, TH
Nickel sulfate and pCAM[1] refining facilities	• Nickel sulfate smelters—LG, ID	**Battery materials mfg.** *(e.g., anode processing, electrolyte production)*	• Lithium battery anode plant—BTR, ID			**Data exchange infrastructure**	• Integrated vehicle telematics platform—Grab and GAC, SEA-wide
Critical mineral traceability platforms	• *No precedent today in SEA*	**Battery testing and certification infrastructure**	• Battery testing center—TÜV SÜD, TH				

Improve market access and liquidity

EV fleet financing and operating lease platforms	"Drive-to-own" payment model for EVs, which offers five-year leases with no down payment (payments are deducted directly from driver earnings)—Grab, SEA-wide

Note: 1) Both nickel sulfate and pCAM (Precursor Cathode Active Material) are critical, high-value materials used for EV lithium-ion batteries, with production currently concentrated in China;
2) Hyundai LG Indonesia Green Power (JV between Hyundai and LG) | Sources: Company websites; Bain analysis



Key takeaways

1. **SEA's EV demand has structurally inflected** faster and more durably than anyone predicted

2. **Strong demand is necessary - but not sufficient - to capture the full value on offer**; SEA risks becoming a large and growing market that primarily benefits manufacturers headquartered elsewhere

3. **The window to act is narrow and closing, with $40–$50 billion in value at stake** - supply decisions made between 2025 ~ 2028 lock in positions for next two decades

4. **The solution is regional, not national, and the blueprint already exists**; better integration across value chain could unlock an additional $130–$160 billion by 2035

CHAPTER 3

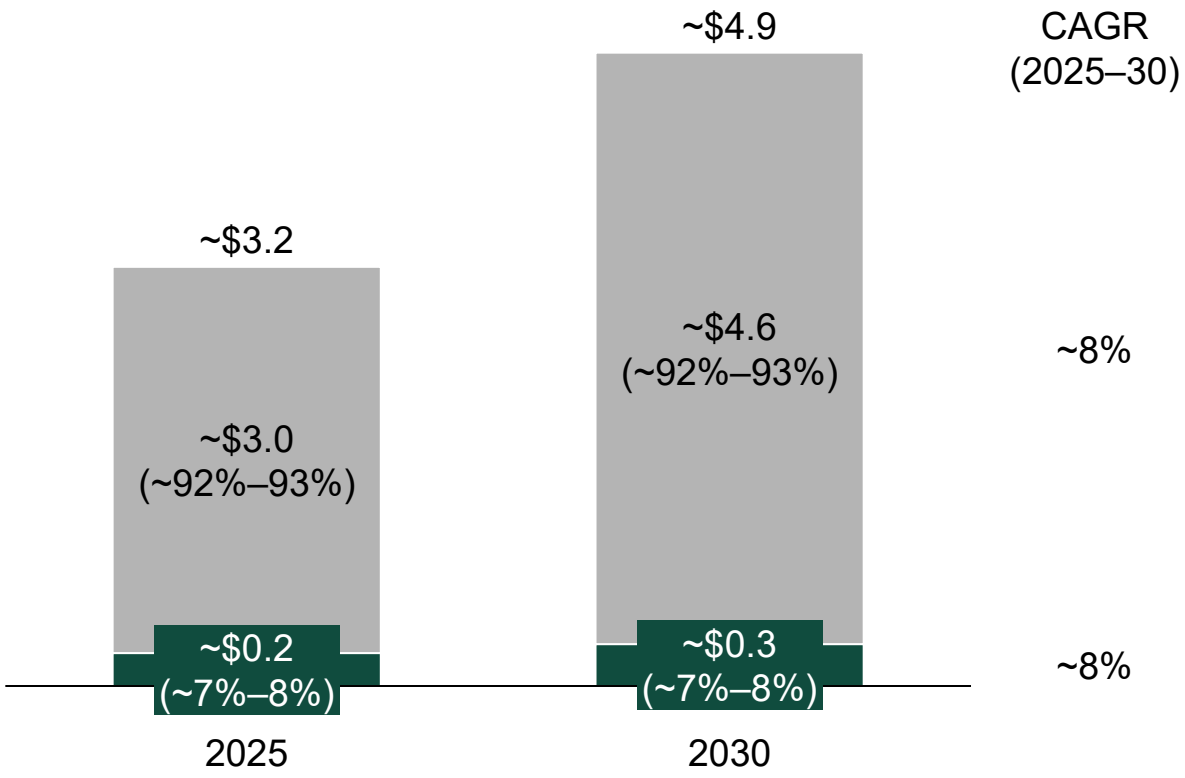
The adaptation economy

Adaptation is a relatively small share (<10%) of Asia-Pacific's green economy today.

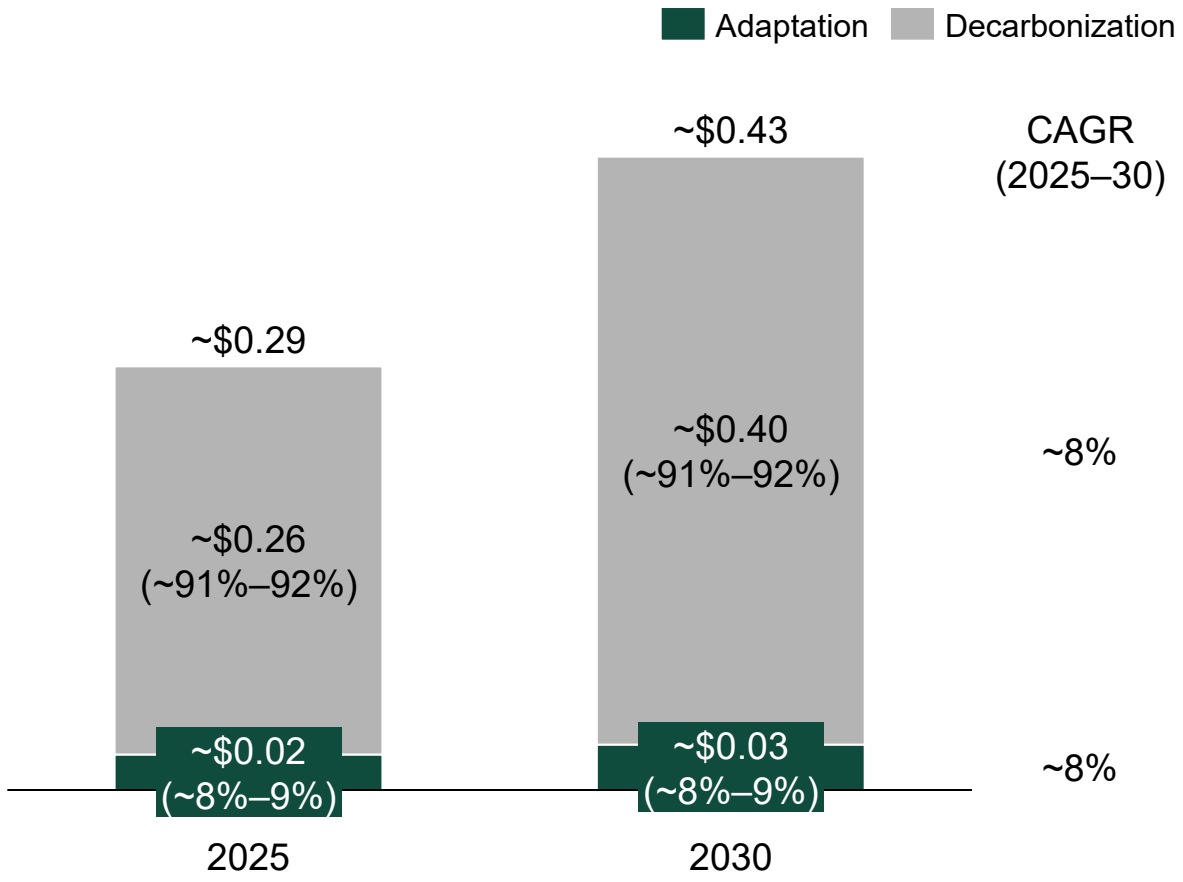
The relevance of adaptation will expand steadily over the next decade—with rising climate vulnerability across Asia-Pacific, the market is expected to mature gradually, especially post-2030

Adaptation contributes to <10% of Asia-Pacific's green economy today and is expected to grow as climate impacts become more acute

Asia-Pacific green economy market size ($ trillion)



SEA green economy market size ($ trillion)



Source: Bain analysis

With climate vulnerability and economic losses growing, the adaptation economy is expected to grow in size and significance over the next decade

Relative economic impact High Mid Low

Climate-related hazards have already imposed >$1 trillion in economic losses across Asia-Pacific since 2000

Cumulative economic losses, 2000–24 ($ billion)

	SEA-6	CN	IN	JP	KR	AU
Storms	$20–$30	$150–$160	$40–$50	$100–$110	$10–$20	$20–$30
Floods	$70–$80	$280–$290	$100–$110	$40–$50	$5–$10	$30–$40
Wildfires	<$5	<$5	<$5	<$5	<$5	$5–$10
Water stress	$5–$10	$40–$50	$5–$10	<$5	<$5	$5–$10
Heat stress	<$5	<$5	<$5	<$5	<$5	<$5

Climate risk is expected to escalate into material macroeconomic drag for Asia-Pacific and SEA

$160B+ **annual economic losses in Asia-Pacific** from climate-related hazards by 2030

~$1.2T of **physical capital stock in Asia-Pacific** is at risk from flooding damage alone by 2050

$6B+ **annual economic losses in SEA** from climate-related hazards by 2030

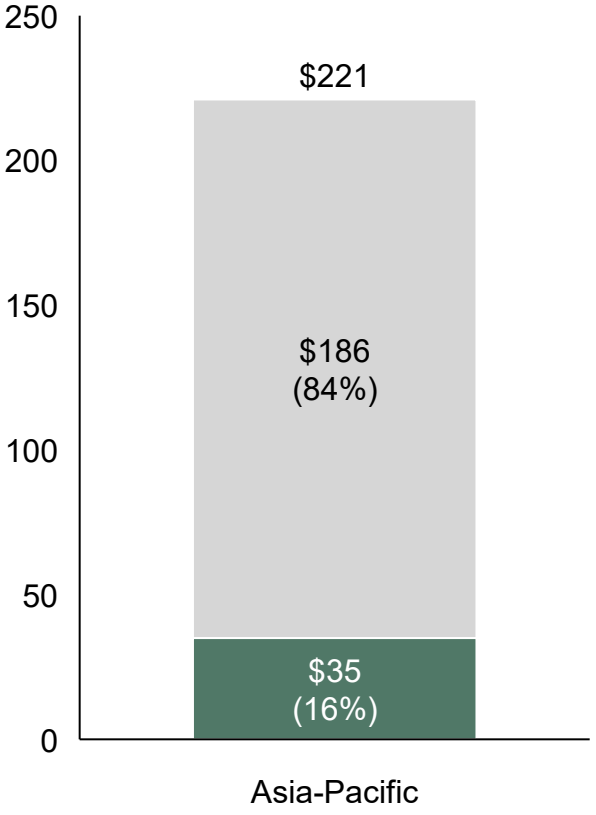
~11% of **SEA GDP** is at risk by 2100 due to climate-related hazards (e.g., storms, floods, water stress)

Sources: EM-DAT database (The International Disaster Database); Bain analysis

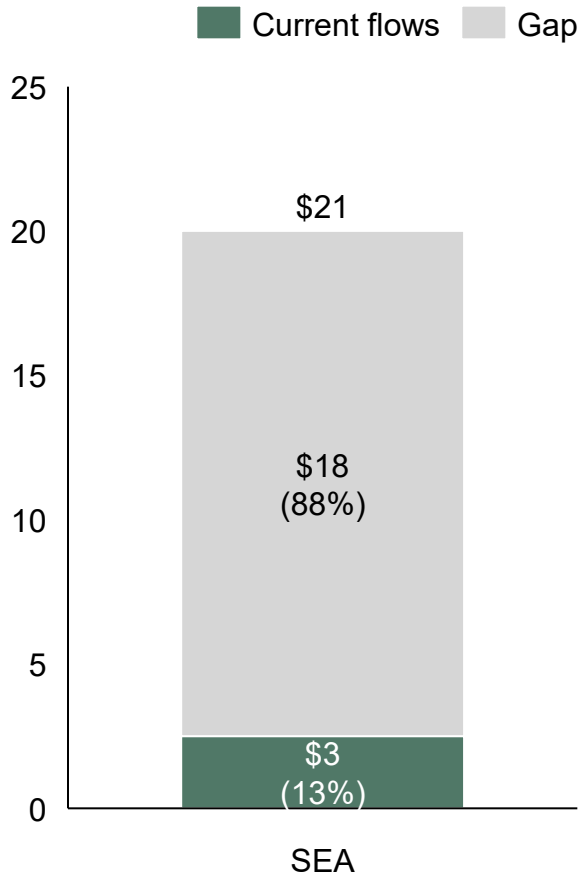
Asia-Pacific has an annual adaptation funding gap of ~$186 billion, with most financing coming from the public sector

Adaptation finance flows and gaps in Asia-Pacific

Annual average of adaptation flows and gaps ($ billion)



Adaptation finance flows and gaps in SEA



Key takeaways

- **Asia-Pacific faces a $186 billion annual adaptation funding gap, with current flows meeting only 16% of total needs.** SEA alone sees an $18 billion gap per year, with just $3 billion in actual flows
- **Private capital remains negligible (<8% of adaptation spend)** due to lack of bankable projects, weak returns, and unclear policy frameworks
- **Project pipelines are underdeveloped.** Most proposals are early stage, with limited bankability or implementation readiness
- **Heavy reliance on loans (85% of flows) misaligns with adaptation needs,** which often lack immediate revenue streams and require more concessional instruments

Sources: Climate Policy Initiative; Eco-Business; Bain analysis

Five structural barriers make it challenging to channel both public and private capital into adaptation today

1 Investments may be hard to monetize

Adaptation projects often **reduce losses rather than generate revenues**—hence, **financial upside may not be clear or immediate** (e.g., seawalls prevent flood damage but do not generate direct cashflow)

2 Risk metrics and data are immature

Physical climate risk modeling remains nascent—**granular, localized data on flood, heat, and storm exposure is lacking across SEA,** while information disparities impede accurate pricing of natural hazard risks at the asset level

3 No standardized asset class; few pure plays

Adaptation **lacks taxonomies/frameworks that have made green bonds scalable**—additionally, **pure-play adaptation companies in SEA are scarce** (e.g., flood-resilient construction materials and water conservation products are usually a product line within a larger, diversified conglomerate)

4 Public finance is lacking and fragmented

Most SEA governments **lack ability to fund adaptation at the required scale;** multilateral climate finance remains fragmented and **predominantly directed toward mitigation rather than adaptation**

5 Impact is challenging to quantify

Cascading and systemic benefits are hard to model—an adaptation investment may have multiple simultaneous impacts, making it **hard to attribute or capture the value accruing specifically to a private investor's balance sheet**

Source: Bain analysis

The adaptation economy is expected to scale in phases—near-term focus will be on defensive measures, while longer-term capital will shift toward ecosystem solutions

What are the key adaptation and resilience priorities for Asia-Pacific?

0–2 YEARS

Adaptation as risk mitigation
Embed climate resilience into near-term asset and operational decisions

- **Retrofitting critical infrastructure for climate risk**
  - Upgrading data centers, ports, and industrial parks with flood and heat protection
- **Deploying localized protection and redundancy**
  - Installing asset-level resilience (e.g., backup power, passive cooling) for high-value sites
  - Prioritizing facilities exposed to compound risk (coastal, floodplain, heat zone)
- **Expanding climate risk intelligence**
  - Using weather analytics, flood maps, and early warning data to guide investment and O&M

2–5 YEARS

Adaptation as infrastructure build-out
Scale resilience infrastructure and integrate into broader development

- **Build-out of district and city-level protection systems**
  - Flood basins, drainage networks, coastal embankments to protect industrial corridors and urban zones
- **Integration of resilience into urban planning**
  - Codevelopment of transport, utilities, and zoning alongside adaptation infrastructure
- **Mobilization of blended finance and pipeline development**
  - Coordinated planning and financing for scalable adaptation programs (e.g., resilient industrial estates, regional protection schemes)

5–10 YEARS

Adaptation as competitive advantage
Position climate resilience as a strategic growth and location advantage

- **Resilience as a baseline for capital investment**
  - Site selection for manufacturing, logistics, and digital infrastructure considers resilience as a precondition
- **Differentiation of cities and corridors by climate resilience**
  - Resilient regions attract investment and talent; they offer uptime, continuity, and climate-adjusted cost competitiveness
- **Institutionalization of resilience in systems and governance**
  - Resilience standards are codified into infrastructure design, land use planning, and permitting

As Asia-Pacific's adaptation economy approaches $300–$350 billion by 2030, the window to establish early positions in key adaptation solutions is opening now

XX Projected Asia-Pacific market size (2030F) | Top solutions contributing to ~90% of overall market size / NON-EXHAUSTIVE

KEY NEAR-TERM ADAPTATION OPPORTUNITIES

Infrastructure and built environment

Long-duration, asset-heavy investments tied to physical resilience of structures and systems

- **~$64B** — **Flood-resistant construction materials**: Waterproof membranes, elevated foundations, sealed wall systems
- **~$19B** — **Flood protection infrastructure**: Seawalls, levees, floodgates, temporary barrier systems
- **~$16B** — **Wind-resistant building materials**: Reinforced roofing, impact-resistant windows, storm-rated facades
- **~$4B** — **Pumping stations**: Stormwater pumps, drainage networks, flood diversion infrastructure
- **~$0.3B** — **Reflecting and cooling building materials**: Cool roofs, reflective paint coatings, heat-deflecting facade panels

Resource resilience

Essential services with utility-like demand characteristics and recurring revenue

- **~$116B** — **Water treatment**: Desalination plants, filtration systems, wastewater recycling technologies
- **~$37B** — **Water conservation**: Smart irrigation, leak detection systems, low-flow fixtures
- **~$10B** — **Backup power systems**: Battery storage, diesel generators, distributed solar microgrids
- **~$8B** — **Indoor cooling solutions**: Cooling fans, air conditioners
- **~$7B** — **Water storage**: Reservoirs, rainwater-harvesting tanks, aquifer recharge systems

Climate risk intelligence

Asset-light, data- and balance-sheet-driven solutions with scalable economics

- **~$40B** — **Climate-related insurance**: Fast-payout insurance linked to heat, flood, or storm triggers
- **~$1B** — **Climate risk intelligence platforms**: Hazard mapping, flood forecasting, early warning systems

Sources: EM-DAT database (The International Disaster Database); Bain analysis

CASE STUDY: STANDARD CHARTERED

Standard Chartered completed an adaptation financing deal with JinkoSolar in 2025, demonstrating the potential for resilience infrastructure to be an investable asset class

Standard Chartered announced an **adaptation deal with Chinese firm JinkoSolar in March 2025**, providing bank guarantees to facilitate trade of **storm- and extreme weather-resistant Tiger Neo solar modules** to solar photovoltaic farms in Florida, the United Arab Emirates, and Saudi Arabia. These modules are resistant to tornadoes, storms, and sandstorms, building **resilience in critical energy infrastructure.**

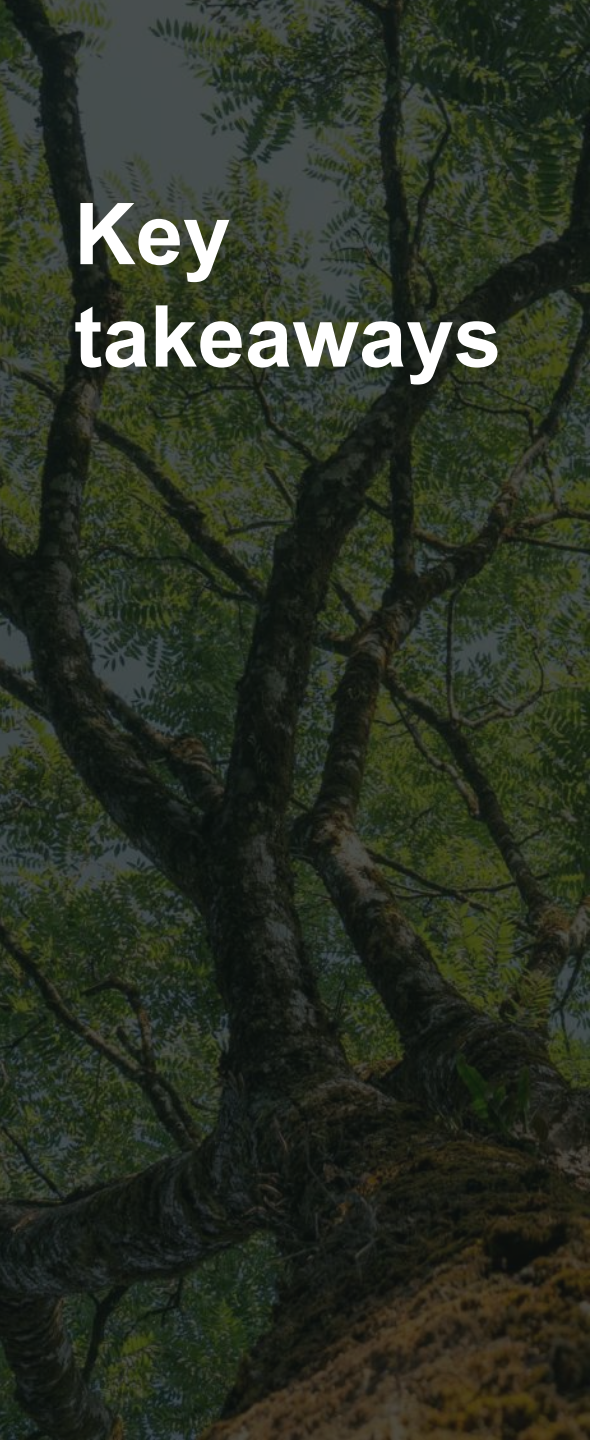
Standard Chartered highlights that the deal reflects the potential of **adaptation and resilience as an emerging investable asset class**—building on its **2024 Guide for Adaptation and Resilience Finance**, which maps **100+ financeable activities and highlights the economic benefits of investing in adaptation.**

> "Today, we're putting the Guide into action ourselves through our first labeled deal with a corporate client (JinkoSolar), demonstrating the commercial opportunity alongside the economic benefits of financing resilient infrastructure in markets that are acutely vulnerable to the negative effects of extreme weather
>
> MARISA DREW, CHIEF SUSTAINABILITY OFFICER, STANDARD CHARTERED

STANDARD CHARTERED'S 2024 ADAPTATION GUIDE: HEADLINE FIGURES

- **<10% of all climate finance** is allocated for adaptation
- Total global cost of inaction estimated to be **$1.266 trillion** over the period 2025–2100
- Every **$1 invested** in adaptation generates **$12 in economic benefits** globally
- Private capital providers supply just **2% of the tracked finance for climate adaptation**

Sources: Expert interviews; company website



Key takeaways

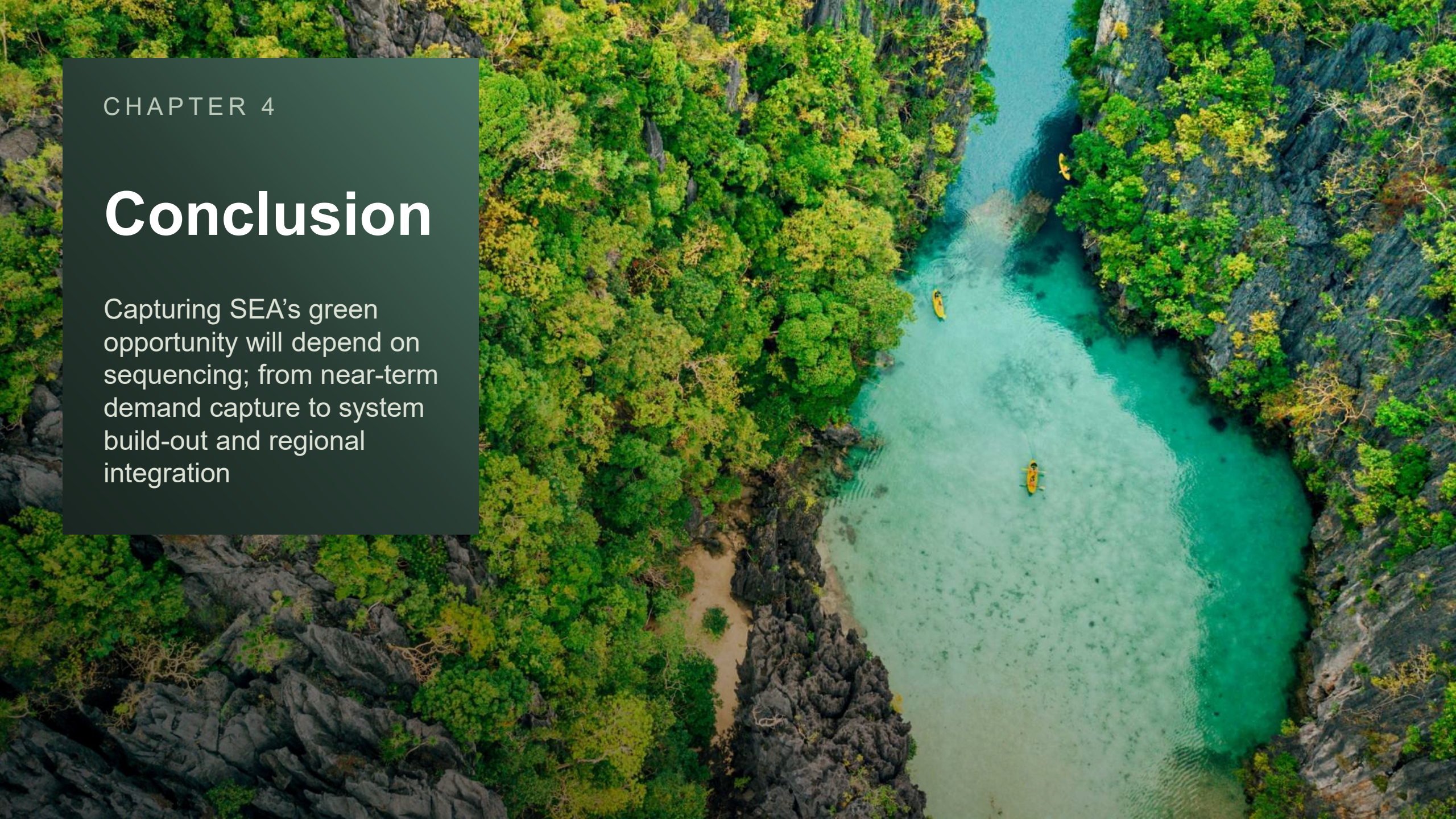
1. Climate adaptation is a relatively **small part (<10%) of Asia's green economy today** but is **expected to grow more rapidly as climate hazards become more severe**

2. **More than 80% of Asia-Pacific's climate adaptation financing needs remain unmet,** equals annual financing gap of $186 billion in APAC and $18 billion in SEA

3. There remain **structural challenges to channeling capital into adaptation,** including lack of clear financial upside for investors and limited climate risk data, standardized adaptation taxonomies, and public funding in SEA

4. Consequently, the adaptation market will **evolve in a few distinct phases -** near-term investment will likely prioritize solutions for immediate protection, while longer-term capital will focus on building a competitive edge through adaptation

5. **The adaptation market will continue to build into a competitive growth market in the long term (post-2030),** driven by increasing frequency and severity of impacts



CHAPTER 4

Conclusion

Capturing SEA's green opportunity will depend on sequencing; from near-term demand capture to system build-out and regional integration

Policymakers and regulators
Accelerate move from ambition-setting to system-enabling reform

0–2 YEARS — Capture

1. **Fast-track permitting and grid connection approvals** with clear time-to-power SLAs for priority loads like DCs, EVs, and industrial parks
2. **Operationalize clean procurement mechanisms** like DPPAs/VPPAs with clear pricing, bankability, and third-party grid access
3. **Designate green industrial zones and EV/DC hubs** with pre-coordinated power and targeted incentives to anchor first movers
4. **Mandate large-load disclosures** to create transparent demand visibility, which supports proactive grid and system planning
5. **Seed EV demand** through fleet mandates and incentives to create bankable offtake
6. **Incentivize locally integrated ecosystems build** via phased localization roadmaps, local content rules, and supply chain-linked incentives

2–5 YEARS — Bridge

7. **Reform T&D market design and utility incentives** to shift from reactive expansion to anticipatory, demand-led investment
8. **Enable private sector participation** in transmission, storage, and grid-support assets to accelerate infrastructure build-out
9. **Advance bilateral APG** through coordinated regional infrastructure build-out across priority corridors
10. **Establish electricity market mechanisms,** including wheeling, settlement, and trading frameworks, to enable cross-border flows
11. **Harmonize EV standards** and certification frameworks (e.g., charging, safety, interoperability) to unlock regional scale

5–10 YEARS — Destination

12. **Mandate convergence of regional technical, regulatory**, and market standards across power and EV systems
13. **Operate an integrated ASEAN power market** with coordinated dispatch, balancing, and cross-border electricity trade
14. **Enable a regionally integrated EV value chain** with coordinated supply chains, standards, and cross-border specialization
15. **Embed climate resilience and adaptation** as a core requirement in infrastructure planning and system design

Source: Bain analysis

Investors and financial institutions
Move beyond funding projects to enabling systems

0–2 YEARS	2–5 YEARS	5–10 YEARS
Capture	**Bridge**	**Destination**
1 **Scale long-term financing for grid, storage, and interconnections** to address system bottleneck and unlock near-term demand	**6** **Pool regional investment vehicles** and platforms to aggregate projects and create regional scale	**10** **Scale deep, liquid SEA capital market ecosystem** across project finance, infrastructure funds, green bonds, and public equity
2 **De-risk first-of-a-kind EV and battery projects** to unlock early ecosystem investments	**7** **Mobilize blended finance at scale** to crowd in private capital across grid, EV value chains, and adaptation systems	**11** **Institutionalize blended and transition finance** as standardized capital stacks embedded across sectors rather than bespoke transactions
3 **Allocate capital toward conversion enablers** like industrial clusters, charging infrastructure, and grid technologies to improve project realization rates	**8** **Standardize financing structures and risk-sharing mechanisms** to enable replication across markets, particularly for cross-border and first-of-a-kind assets	**12** **Establish adaptation and resilience as a recognized, investable asset class** supported by standardized frameworks and financing instruments
4 **Prioritize demand-backed investments** anchored in DCs, OEM-led EV ecosystems, and large industrial clusters with visible offtake	**9** **Leverage carbon, REC, and flexibility markets** to unlock additional revenue streams and improve bankability of green assets	
5 **Deploy concessional and blended capital to unlock early-stage adaptation and resilience projects** where commercial returns are not yet fully bankable		

Source: Bain analysis

Corporations (power and grid)
Aggregate demand, coinvest in infrastructure, and enable system build-out

0–2 YEARS	2–5 YEARS	5–10 YEARS
Capture	**Bridge**	**Destination**
1 **Secure clean, reliable power access** via a portfolio of mechanisms like DPPAs, VPPAs, RECs, and BTM solutions to bridge grid delays	**5** **Coinvest in transmission, substations, storage, and grid-support infrastructure** through long-term offtake and partnership models	**8** **Operate across integrated regional power markets** to optimize for cost, reliability, and clean energy access
2 **Aggregate and co-locate demand within priority clusters** to create bankable load and accelerate grid and infrastructure build-out	**6** **Optimize clean procurement across markets and instruments** by diversifying across DPPAs, VPPAs, and RECs	
3 **Provide forward demand visibility** through long-term commitments to enable proactive grid planning and investment	**7** **Integrate flexibility solutions** like storage and demand response to improve system reliability and efficiency	
4 **Commit to long-term, multi-market procurement agreements** to enable system-scale renewable and grid investments		

Source: Bain analysis

Corporations (EV value chain)
Anchor demand, localize supply chains, and coordinate production

0–2 YEARS	2–5 YEARS	5–10 YEARS
Capture	**Bridge**	**Destination**
1 **Commit early to priority EV value chain segments,** including assembly, batteries, and components, to secure advantaged ecosystem positions	**4** **Scale manufacturing depth** across battery, component, and assembly ecosystems by localizing critical supply chains	**7** **Operate within a fully integrated regional EV ecosystem** with coordinated supply chains, production, and market access
2 **Anchor demand through fleets, logistics, and public transport** deployments to crowd in broader EV adoption	**5** **Expand charging and supporting infrastructure** in line with fleet and commercial demand growth	**8** **Scale vertically integrated or tightly orchestrated ecosystems** spanning vehicles, batteries, charging, and services
3 **Build regional partnerships and shared platforms** to scale production, sourcing, and distribution	**6** **Optimize production and sourcing footprints** across markets to align with emerging regional specialization	

Source: Bain analysis

CHAPTER 5

SEA Green Economy Index 2026

SEA-6 markets are making progress in the green transition, but more effort is needed to stay on track to deliver national targets

The SEA Green Economy Index 2026

What is the SEA Green Economy Index?

The SEA Green Economy Index evaluates how countries are **advancing across key decarbonization metrics—for example, ambition, policy roadmap, and investment—**to assess their progress toward 2030 climate targets

The key evaluation metrics are:

Ambition 01
- Target setting and quality
- Target cascading

Progress 02
- Emissions level and decarbonization levers

Roadmap 03
- National sector-level roadmap
- Corporate roadmap

Accelerators 04
- Regulatory framework
- Financial prerequisites
- Infrastructure and technology

Investment 05
- Size of green investment

Key enhancements in 2026 (vs. 2025)

1. Revised investment assessment to **incorporate capex deployed**, reflecting a broader view of capital deployment
2. Rebalanced weightings toward **ambition (15%) and roadmap (20%)** to prioritize forward-looking strategic intent and execution clarity over other backward-looking measures
3. **Raised the threshold for "likely on track" assessment** to better capture sustained, meaningful progress instead of early-stage momentum
4. Added the **transport sector** to roadmap component to reflect its growing role in the energy transition

SEA Green Economy Index 2026 Methodology

Index (100%)

Ambition — 15% weightage

Target setting and quality (50%)

Six binary questions on target setting and quality

+

Target cascading (50%)

Sector level

Binary question on whether a country has sector-level targets

+

Corporate level

Count number of corporations with net-zero targets among top 10

(weighted average scores based on emissions level)

Progress — 25% weightage

GHG emissions per capita (33%)

Total country GHG emissions level/population

+

Sector progress (66%)

Power

Percentage of RE in total power generation

+

Transport

Percentage of EVs in new passenger car sales

+

Nature

Net percentage change in tree cover

+

Agriculture

Nutrient efficiency

Roadmap — 20% weightage

Sector-level roadmap (33%)

Power | Nature | Agri. | Transport

Score based on existence and quality of sector-level roadmap

+

Corporate-level roadmap (67%)

Count number of corporations with roadmap among top 10 (weighted average scores based on emissions level)

Accelerators — 25% weightage

Regulatory framework (33%)

Energy
Fraser index, permit/legal mandates on RE, etc.

Nature
Forest conservation, carbon markets, etc.

Agriculture
Inorganic fertilizer registry, sustainability certificate

+

Financial prerequisites (33%)

Energy
Carbon tax, incentives for RE/EV/green buildings

Nature
Carbon credits issued relative to forest area

Agriculture
Organic fertilizer incentives, SME loan/credit

+

Infra, tech, and human capital (33%)

Energy
National grid infrastructure, number of EV charging stations

Nature
Number of NBS projects (registered or beyond)

Agriculture
SRI adoption

Investment — 15% weightage

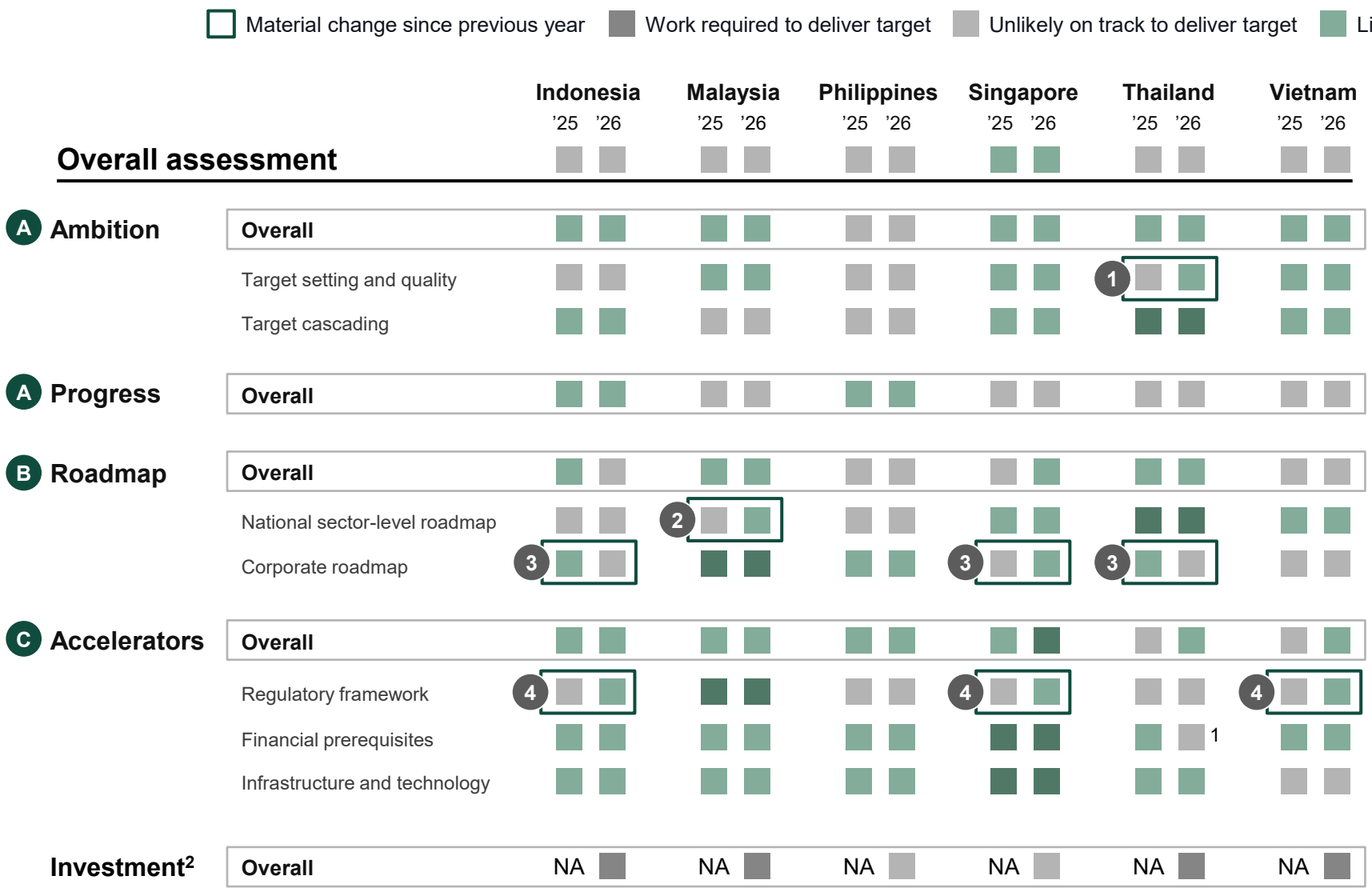
Green investment size (100%)

Percentage of actual capex investment (average of 2023–25) against the required amount of investment

(Required amount of investment is proportional to the size of GHG emissions in each country)

Source: Bain analysis

SEA Green Economy Index 2026 | Countries maintain national ambitions and roadmaps, but progress is stalling - especially in investment and corporate action



Key observations

A **Ambition and Progress scores remain stable** across most markets

B **Roadmap score is diverging**, with national roadmaps remaining steady while corporate roadmaps show signs of weakening

C Progress in **Accelerators score,** primarily through strengthening regulatory frameworks

1 Thailand's latest NDC 3.0 advanced its **net-zero target to 2050** from 2065

2 **Malaysia advanced implementation of its energy transition plan** through LT-LEDS, the Thirteenth Malaysia Plan, and CRESS scale-up

3 **Singapore advanced; Indonesia and Thailand slowed**, with fewer high emitters publishing transition roadmaps

4 **Singapore, Indonesia, and Vietnam** advanced frameworks for mandatory emission reporting and RE contracting

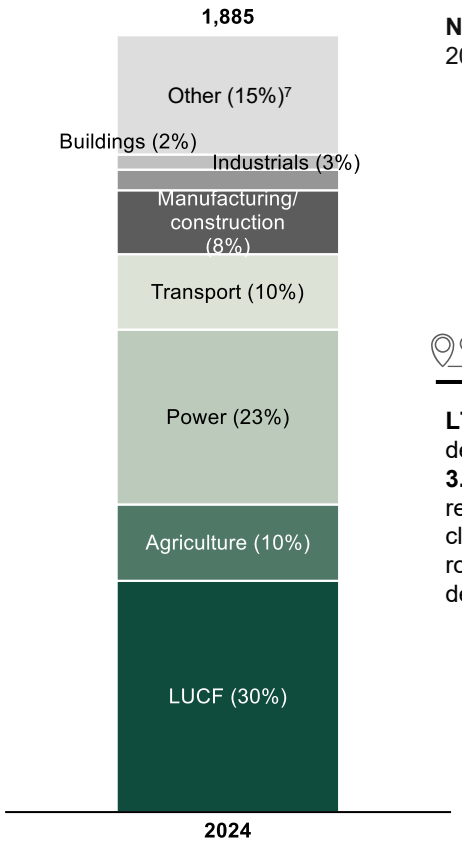
Notes: Methodology updated: Threshold for "likely on track to deliver target" increased to reflect enhanced assessment criteria; 2025 scorecard ratings have been updated accordingly; 1) The weightage of Thailand's emission in nature increased from 6% in 2023 to 16% in 2024 despite limited improvement in the number of registered NBS projects; 2) Methodology updated to include total capex deployed, prior analysis was limited to private investments | Source: Bain analysis

Indonesia | Country insights

'25 '26

Key areas for improvement | Work required to deliver target | Unlikely on track to deliver target | Likely on track to deliver target | On track to deliver target

GHG emissions[1] (MtCO2e)



Ambition

'25 '26

Net zero by 2060	**32% GHG reduction** by 2030[2]	**Slight decline** in corporate decarbonization targets[3]

Progress

'25 '26

Per capita emissions at 4.6 tCO2e in 2024–25 (-21% from 2023–24)	Share of **RE** is stable at **~18%** in 2024, vs. **~19%** in 2023 (low vs. global peers)	Share of **4W EV** sales increased to **~15%** in 2025, vs. **~7%** in 2024

Roadmap

'25 '26

LT-LEDS (2022) defined and **NDC 3.0 (2025)** released, but no clear sector roadmaps defined	**FOLU Net Sink 2030 plan** sets sectoral targets to reduce deforestation	**Fewer** top emitters have published **transition roadmaps**[4]

Accelerators

'25 '26

MEMR[5] updated (2025) with refinement to RE contracting and coal phase-out planning framework	**Fossil-fuel subsidies** persist, while **EV incentives lapsed** in December 2025	**Carbon credit issuance declined** due to a trading moratorium (since 2021), with a reversal only in 2025

Investment

'25 '26
NA

Green capex invested in 2025 is **~12%–15% of required green investment**[6]

Recommendations

- Reinstate lapsed **EV incentives** to protect 15% penetration momentum and OEM investment
- **Open T&D to private capital participation** to break PLN's financing constraint—the structural cause of RE under-realization
- Strengthen requirements for top manufacturing/industrial emitters to **publish and implement transition roadmaps** connecting targets to action
- Leverage the reversal of the carbon trading moratorium to **reactivate carbon markets** and streamline issuance processes

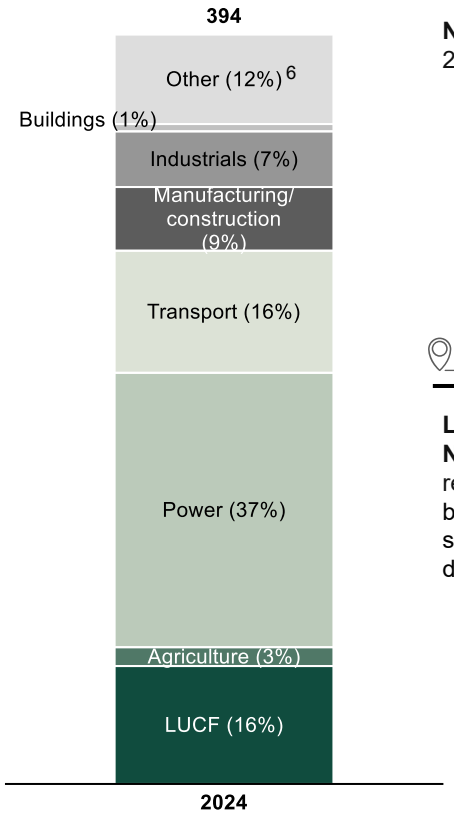
Notes: 1) Methodology—Calculate 2024 non-LUCF emissions (EDGAR), derive sectoral splits (including LUCF) using 2023 Climate Watch data (with 2023 non-LUCF totals as denominator), and project 2024 sector-wise emissions by applying the splits to 2024 non-LUCF emissions (EDGAR); 2) Emissions reduction target is against 2030 BAU; 3) In 2025, 50% have net-zero and 80% have 2030 targets vs. 60% and 90% in 2024; analysis based on top 10 emitting (headquartered) public companies in Indonesia as per Refinitiv; 4) Emissions-weighted average of top emitters based on the presence of corporate roadmaps; 5) Ministry of Energy and Mineral Resources; 6) Total investment needed for SEA to meet its 2030 decarbonization targets, split across countries according to their share of emissions; 7) Other emissions include other fuel combustion, unspecified fugitive emissions, other product use, or minor industrial activities | Sources: Country NDC; LT-LEDS; Climate Watch; IRENA; IEA; UNFCCC; EDGAR; literature search

Malaysia | Country insights

'25 '26

Key areas for improvement | Work required to deliver target | Unlikely on track to deliver target | Likely on track to deliver target | On track to deliver target

GHG emissions [1] (MtCO2e)



Ambition

'25 '26

Net zero by 2050	**45% GHG reduction** by 2030[2]	**Slight improvement** in corporate decarbonization targets[3]

Progress

'25 '26

Per capita emissions at 9.6 tCO2e in 2024–25 (-19% from 2023–24)	Share of **RE** is stable at **~20%** in 2024, vs. **~19%** in 2023 (low vs. global peers)	Share of **4W EV** sales is very low and flat at **~4.4%** in 2025, vs. **~3.6%** in 2024 (very low vs. SEA-6 peers)

Roadmap

'25 '26

LT-LEDS and **NDC 3.0** released in 2025, but no clear sector roadmap defined	**Thirteenth Malaysia Plan (2025) sets 2026–30** goals across key sectors (e.g., energy, agriculture)	**Fewer** top emitters have published **transition roadmaps**[4]

Accelerators

'25 '26

LTMS-PIP power export expanded in 2024–25, **supporting regional grid trading**	**CRESS** scaled in 2025 (~1.3GW DPPA signed), but **high wheeling charges** limit further uptake	**REDD+ engagement,** with NBS projects being consistently registered

Investment

'25 '26
NA

Green capex invested in 2025 is **~14%–17% of required green investment**[5]

Recommendations

- **Cap the CRESS wheeling charge reset:** The 15% increase per three-year cycle destroys long-term PPA bankability more than the headline charge level itself
- **Promote GLC and government fleet electrification** by 2027—the fastest available lever to move Malaysia's 4.4% EV penetration, one of the lowest in SEA-6
- **Convert** TNB RP4's contingent **grid investment allocation** into annual delivery milestones rather than demand-triggered release to ensure grid investment leads demand; publish plans

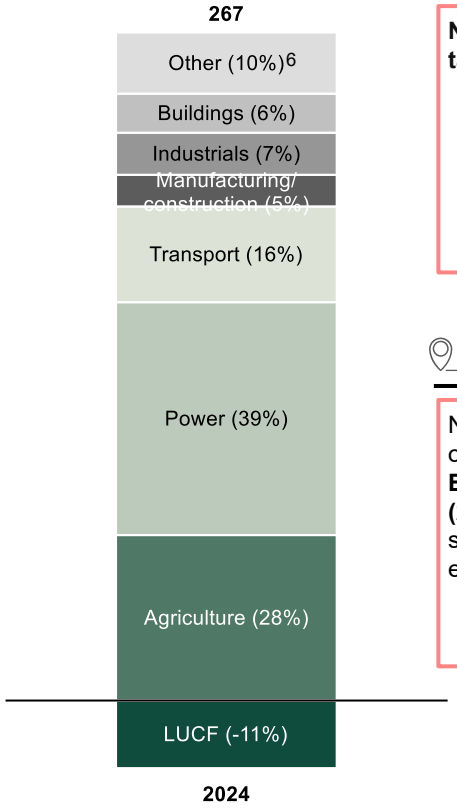
Notes: 1) Methodology—Calculate 2024 non-LUCF emissions (EDGAR), derive sectoral splits (including LUCF) using 2023 Climate Watch data (with 2023 non-LUCF totals as denominator), and project 2024 sector-wise emissions by applying the splits to 2024 non-LUCF emissions (EDGAR); 2) Emissions reduction target is reduction in economy-wide carbon intensity (against GDP) vs. 2005 level; 3) In 2025, 90% have NZ and 70% have 2030 targets vs. 80% and 80% in 2024; analysis based on top 10 emitting (headquartered) public companies in Malaysia as per Refinitiv; 4) Emissions-weighted average of top emitters based on the presence of corporate roadmaps; 5) Total investment needed for SEA to meet its 2030 decarbonization targets, split across countries according to their share of emissions; 6) Other emissions include other fuel combustion, unspecified fugitive emissions, other product use, or minor industrial activities | Sources: Country NDC; LT-LEDS; Climate Watch; IRENA; IEA; UNFCCC; EDGAR; literature search

Philippines | Country insights

'25 '26

Key areas for improvement | Work required to deliver target | Unlikely on track to deliver target | Likely on track to deliver target | On track to deliver target

GHG emissions[1] (MtCO2e)



Ambition

'25 '26

No net zero target	**75% GHG reduction** by 2030[2]	**Slight improvement** in corporate decarbonization targets[3]

Progress

'25 '26

Per capita emissions at 2.3 tCO2e in 2024–25 (+3.7% from 2023–24)	Share of **RE is** stable at **~21%** in 2024, vs. **~22%** in 2023 (low vs. global peers)	Share of **4W EV** sales stable at **~1.3%** in 2025, vs. **~0.6%** in 2024 (very low vs. SEA-6 peers)

Roadmap

'25 '26

No LT-LEDS, only **Philippine Energy Plan (2023–50),** which sets a vision for energy transition	**Philippine Development Plan (2023–28)** sets direction for energy and agriculture sectors	**More** top emitters have published **transition roadmaps**[4]

Accelerators

'25 '26

Mandatory emission reporting for all publicly listed companies	**Incentives for RE and EVs** via VAT zero-rating for RE projects and reduced import tariffs for EVs	Adoption of **SRI in multiple regions;** however, limited NBS projects

Investment

'25 '26

NA

Green capex invested in 2025 is **~40%–45% of required green investment**[5]

Recommendations

- **Publish LT-LEDS** with a net-zero target to unlock DFI and institutional capital currently flowing to peers with clearer long-term frameworks
- **Prioritize Luzon inter-island T&D backbone,** where DC investment is concentrated and RE integration constraints are most acute and in need of investment
- **Increase geothermal development** as an under-tapped renewables resource
- **Promote select public fleet electrification** as demand anchor for nascent local EV assembly investment

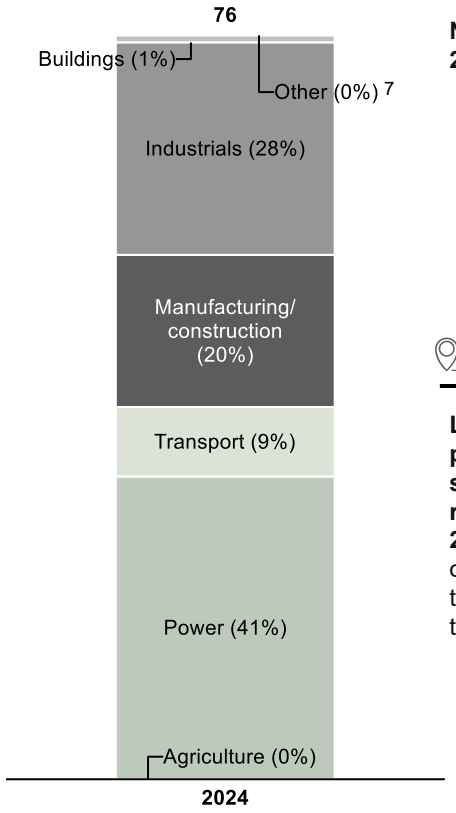
Notes: 1) Methodology—Calculate 2024 non-LUCF emissions (EDGAR), derive sectoral splits (including LUCF) using 2023 Climate Watch data (with 2023 non-LUCF totals as denominator), and project 2024 sector-wise emissions by applying the splits to 2024 non-LUCF emissions (EDGAR); 2) Emissions reduction target is set below a cumulative 2020–30 BAU trajectory; 72% of this target is conditional on international support while the rest is unconditional; 3) In 2025, 30% have NZ and 30% have 2030 targets vs. 40% and 20% in 2024; analysis based on top 10 emitting (headquartered) public companies in Philippines as per Refinitiv; 4) Emissions-weighted average of top emitters based on the presence of corporate roadmaps; 5) Total investment needed for SEA to meet its 2030 decarbonization targets, split across countries according to their share of emissions; 6) Other emissions include other fuel combustion, unspecified fugitive emissions, other product use or minor industrial activities | Sources: Country NDC; LT-LEDS; Climate Watch; IRENA; IEA; UNFCCC; EDGAR; literature search

Singapore | Country insights

'25 '26

Key areas for improvement | Work required to deliver target | Unlikely on track to deliver target | Likely on track to deliver target | On track to deliver target

GHG emissions [1] (MtCO2e)



Ambition

'25 '26

- **Net zero by 2050**
- **60 MtCO2e GHG** emissions by 2030
- **Slight improvement** in corporate decarb targets[2]

Progress

'25 '26

- **Per capita emissions at 12.5 tCO2e in 2024–25** (+3.9% from 2023–24)
- Share of **RE is** stable at **~5%** in 2024, vs. **~5%** in 2023 (very low vs. global peers)
- Share of **4W EV** sales increased to **~46%** in 2025, vs. **~34%** in 2024 (among the highest in SEA-6)

Roadmap

'25 '26

- **LT-LEDS in place and second NDC released in 2025,** which outlines long-term climate targets
- **Green Plan 2030** outlines targets and roadmaps across key sectors such as energy and nature
- **More top emitters** have published transition roadmaps[3]

Accelerators

'25 '26

- **Mandatory emission reporting** for all publicly listed companies
- **Carbon tax** in place with **progress to access Article 6 credits** via international agreements
- **SAFCo[4] established** to purchase SAF using a levy on departing flights[5]

Investment

'25 '26
NA

Green capex invested in 2025 is **~23%–27% of required green investment[6]**

Recommendations

- Reduce per capita emissions by ensuring **continued carbon tax progress** (S$50–S$80 by 2030) and **phasing down EITE transitory carbon tax allowances**
- Close the **Indonesia-Singapore bilateral power corridor** as a first step toward cross-border imports, which is key to achieving the 6GW 2035 RE import target
- **Mandate Singapore-Asia Taxonomy** across SGX-listed companies to enhance growing corporate roadmap momentum in this year's assessment.

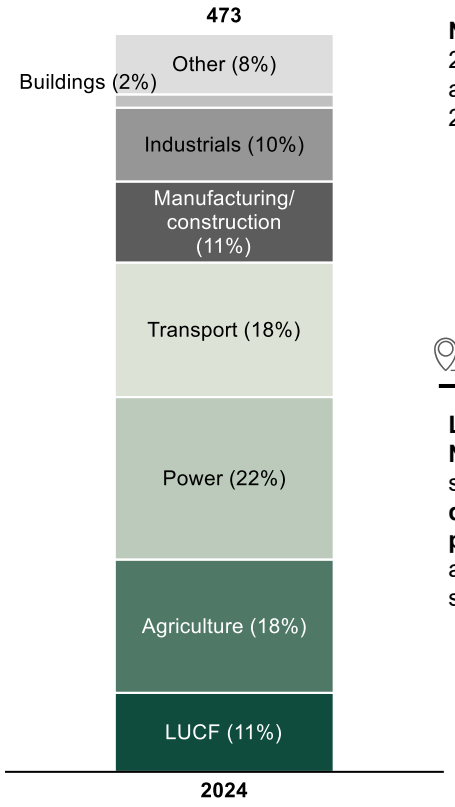
Notes: 1) Methodology—Calculate 2024 non-LUCF emissions (EDGAR), derive sectoral splits (including LUCF) using 2023 Climate Watch data (with 2023 non-LUCF totals as denominator), and project 2024 sector-wise emissions by applying the splits to 2024 non-LUCF emissions (EDGAR); 2) In 2025, 80% have NZ and 60% have 2030 targets vs. 80% and 50% in 2024; analysis based on top 10 emitting (headquartered) public companies in Singapore as per Refinitiv; 3) Emissions-weighted average of top emitters based on the presence of corporate roadmaps; 4) Sustainable Aviation Fuel Company; 5) Implementation of levy delayed from October 2026 to January 2027; 6) Total investment needed for SEA to meet its 2030 decarbonization targets, split across countries according to their share of emissions; 7) Other emissions include other fuel combustion, unspecified fugitive emissions, other product use, or minor industrial activities | Sources: Country NDC; LT-LEDS; Climate Watch; IRENA; IEA; UNFCCC; EDGAR; literature search

Thailand | Country insights

'25 '26

Key areas for improvement | Work required to deliver target | Unlikely on track to deliver target | Likely on track to deliver target | On track to deliver target

GHG emissions[1] (MtCO2e)



Ambition

'25 '26

Net zero by 2050 (deadline advanced from 2065)	**30% GHG reduction** by 2030[2]	**Slight decline** in corporate decarbonization targets[3]

Progress

'25 '26

Per capita emissions at 5.9 tCO2e in 2024–25 (-8.3% from 2023–24)	Share of **RE** is stable at **~15%** in 2024, vs. **~16%** in 2023 (low vs. global peers)	Share of **4W EV** sales increased to **~21%** in 2025, vs. **~13%** in 2024

Roadmap

'25 '26

LT-LEDS and **NDC 3.0** (2025) strengthened **decarbonization pathways** across key sectors	**Thailand Power Development Plan (2024)** sets targets/ pathways for energy and transport sector	**Fewer** top emitters have published **transition roadmaps**[4]

Accelerators

'25 '26

LTMS-PIP power export expanded in 2024–25, **supporting regional grid trading**	**Climate Change Act** supports RE, EV, and green buildings **via grants and low-interest loans**	RE PPA frameworks still nascent; **DPPA policy in draft,** and **VPPA in pilot phase** under ERC[5] sandbox

Investment

'25 '26
NA

Green capex invested in 2025 is **~10%–13% of required green investment**[6]

Recommendations

- **Guarantee EEC power delivery** for committed industrial loads in face of declining reserve margins—key for DC and EV manufacturing investment
- **Move DPPA from pilot to full implementation by the end of 2026** to unlock DC procurement and RE deployment
- **Lock in EV incentives through 2028** to further attract global OEM platform investments
- **Reframe green industrial zones** around CBAM (e.g., Map Ta Phut and Saraburi face EU carbon pricing liability from 2026)

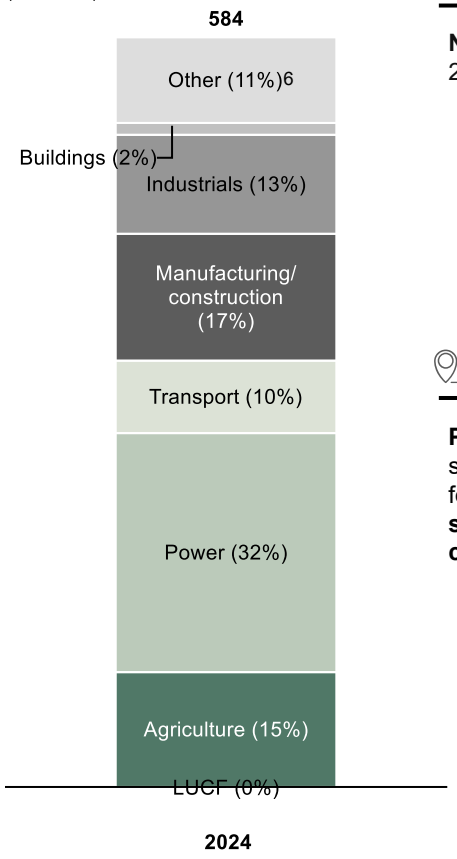
Notes: 1) Methodology—Calculate 2024 non-LUCF emissions (EDGAR), derive sectoral splits (including LUCF) using 2023 Climate Watch data (with 2023 non-LUCF totals as denominator), and project 2024 sector-wise emissions by applying the splits to 2024 non-LUCF emissions (EDGAR); 2) GHG emissions reduction target is against 2030 business-as-usual; 3) In 2025, 80% have both NZ and 2030 targets vs. 90% in 2024; analysis based on top 10 emitting (headquartered) public companies in Thailand as per Refinitiv; 4) Emissions-weighted average of top emitters based on the presence of corporate roadmaps; 5) Energy Regulatory Commission; 6) Total investment needed for SEA to meet its 2030 decarbonization targets, split across countries according to their share of emissions; 7) Other emissions include other fuel combustion, unspecified fugitive emissions, other product use, or minor industrial activities | Sources: Country NDC; LT-LEDS; Climate Watch; IRENA; IEA; UNFCCC; EDGAR; literature search

Vietnam | Country insights

'25 '26

Key areas for improvement | Work required to deliver target | Unlikely on track to deliver target | Likely on track to deliver target | On track to deliver target

GHG emissions[1] (MtCO2e)



Ambition

'25 '26

Net zero by 2050	**16% GHG** reduction by 2030[2]	**Slight decline** in corporate decarbonization targets[3]

Progress

'25 '26

Per capita emissions at 5.8 tCO2e in 2024–25 (+18% from 2023–24)	Share of **RE at ~42% in 2024;** but **unresolved feed-in-tariff disputes** erode investor confidence	Share of **4W EV** sales increased to **~38%** in 2025, vs. **~17%** in 2024 (among the highest in SEA-6)

Roadmap

'25 '26

PDP-8 (2023) sets pathways focusing on **RE scale-up, grid connectivity**	**NFP (2024)** targets an increase of **43% in forest cover and 20% in carbon sequestration** by 2030	**More** top emitters have published **transition roadmaps**[4]

Accelerators

'25 '26

Decree 57 (2025) DPPA framework introduced	**Incentives for RE, EV** via import duty exemptions, preferential tax rates and loans	**Pilot ETS (2025)** introduced for power, steel, and cement sectors

Investment

'25 '26
NA

Green capex invested in 2025 is **~11%–14% of required green investment**[5]

Recommendations

- **Resolve legacy FIT disputes** in next 12 months to unlock stalled renewables investment
- **Accelerate northern transmission build-out,** as generation exists but often cannot reach load centers
- **Implement Decree 57 DPPA** at pace, as execution speed will impact whether institutional capital returns as before
- Sustain EV uptake by **expanding charging infra with continued domestic support**
- **Set a carbon price floor** within the pilot ETS to convert compliance infrastructure into investment signal for market

Notes: 1) Methodology—Calculate 2024 non-LUCF emissions (EDGAR), derive sectoral splits (including LUCF) using 2023 Climate Watch data (with 2023 non-LUCF totals as denominator), and project 2024 sector-wise emissions by applying the splits to 2024 non-LUCF emissions (EDGAR); 2) Emissions targets in energy, agriculture, LULUCF, waste, and industrial processes by 2030 vs. BAU; 3) Emissions-weighted average of top 10 emitting (headquartered) public companies in Vietnam as per Refinitiv; 4) Emissions-weighted average of top emitters based on the presence of corporate roadmaps; 5) Total investment needed for SEA to meet its 2030 decarbonization targets, split across countries according to their share of emissions; 6) Other emissions include other fuel combustion, unspecified fugitive emissions, other product use, or minor industrial activities | Sources: Country NDC; LT-LEDS; Climate Watch; IRENA; IEA; UNFCCC; EDGAR; literature search

Appendix

Appendix: Underlying solutions behind key sectors of the green economy

Power & Grid	Nature & Agriculture	Industrial & Waste	Buildings	Transport & Logistics	Finance & Services	Climate Adaptation
Solar energy infrastructure	Agritech	Green steel	Smart urban planning	Electric/hybrid vehicles	Green financing and investments	Weather-related insurance
Wind energy infrastructure	Indoor and vertical farming	Green cement	Low-carbon building materials	EV battery manufacturing	Climate analytics and consulting	Weather intelligence
Low-carbon hydrogen infrastructure	Sustainable aquaculture	Green chemicals	District heating and cooling systems	EV charging infrastructure	Carbon services and trading	Backup power systems
Other renewables infrastructure	Alternative proteins	Critical minerals	Building optimization systems	Hydrogen refueling infrastructure		Wind-resistant building components
Biofuels infrastructure	Food supply chain traceability solutions	Robotics and automation (for energy efficiency)	Green data center services	Ride-sharing services		Flood-resistant construction materials and components
Solar energy	Carbon markets	Waste heat recovery	Energy-efficient DC cooling solutions	Vehicle telematics		Pumping stations
Wind energy	MRV solutions	Carbon capture utilization and storage	Heat pumps	Digital platforms for supply chain traceability (non-food)		Flood protection infrastructure
Low-carbon hydrogen	Sustainable forest products	Methane abatement technologies	Low-carbon refrigerants	Supply chain footprint optimization solutions		Water conservation
Other renewables		Bioremeditation process				Water treatment
Biofuels/biomass		Sustainable packaging				Water storage
Waste-to-energy		Resource recycling				Reflecting and cooling building materials
Grid modernization and upgrades						Indoor cooling solutions
Smart connected systems						
Energy storage						

Source: Bain analysis

Appendix: Proprietary evidence-based approach to assess the realizable share of announced capex, based on execution trajectory and country/sector risk

/ ILLUSTRATIVE

Overall methodology

- Two-tier evidence-based approach to **track where capital is actually flowing**
- Designed to separate delivered and bankable capex from aspirational targets to **gauge true green economy momentum in SEA-6**

1 Classification of future potential capex into stages

Tiers	Description
Locked-in	Projects **under construction or fully committed**, with FID taken and/or financing closed
Likely	Projects with **clear development progress** (e.g., permits secured, Board of Investment approval, PPA pathway, credible sponsors) but **not yet at FID**
Aspirational	**Targets, MOUs, and early-stage announcements** without binding commitments, financing, or execution readiness

2 Assessment of probability of deployment based on sector x country risk profile

Criteria	Description
Policy stability	Risk of project economics deterioration due to policy reversal or regulatory uncertainty
Execution capacity	Risk of project delays due to lack of relevant permits, skilled labor, and supply chain readiness
Revenue certainty	Likelihood of cashflow visibility through contracted offtakes
Capital accessibility	Depth of capital market and availability of private or public financing
Technical maturity	Readiness of technology for commercial deployment at scale

Source: Bain analysis

Appendix: Terms and acronyms

#–C

2W Two-wheeler (motorcycles/scooters)

4W Four-wheeler (passenger vehicles)

AI Artificial intelligence

APEC Asia-Pacific Economic Cooperation

APG ASEAN Power Grid

ASEAN Association of Southeast Asian Nations

AFISS ASEAN Framework for Integrated Semiconductor Supply Chain

AFTA ASEAN Free Trade Area

BEV Battery electric vehicle

BAU Business-as-Usual

BESS Battery energy storage system

BTM Behind the meter

C&I Commercial and industrial

CAGR Compound annual growth rate

CAISO California Independent System Operator

CALB China Aviation Lithium Battery

CAPEX Capital expenditure

CBAM Carbon Border Adjustment Mechanism

CCUS Carbon capture, utilization, and storage

CKD Completely Knocked Down

CRESS Corporate Renewable Energy Supply Scheme

CGPP Corporate Green Power Programme

COP26 26th UN Climate Change Conference

Appendix: Terms and acronyms (cont.)

D–G

DC Data center

DCO Data Center Operator

DER Distributed energy resources

DFI Development finance institution

DOE Department of Energy

DPPA Direct power purchase agreement

DR Demand response

E2E End-to-end

EBITDA Earnings before interest, taxes, depreciation, and amortization

EDGAR Emissions Database for Global Atmospheric Research

EEC Eastern Economic Corridor (Thailand)

EGAT Electricity Generating Authority of Thailand

EITE Emissions-intensive, trade-exposed

ERC Energy Regulatory Commission

ERIA Economic Research Institute for ASEAN and East Asia

ESG Environmental, social, and governance

ETS Emissions Trading System

EU European Union

EV Electric vehicle

FCEV Fuel cell electric vehicle

FDI Foreign direct investment

FID Final Investment Decision

FIT Feed-in tariff

FOLU Forestry and other land use

FX Foreign exchange

GDP Gross Domestic Product

GFANZ Glasgow Financial Alliance for Net Zero

GHG Greenhouse gas

GLC Government-linked company

GW Gigawatt

GWh Gigawatt-hour

GEOP Green Energy Option Program

Appendix: Terms and acronyms (cont.)

H–O

HDB Housing & Development Board (Singapore)

HEV Hybrid electric vehicle

HLI Hyundai LG Indonesia

HPAL High-pressure acid leaching

HVAC Heating, ventilation, and air conditioning

HVDC High-voltage direct current

ICE Internal combustion engine

ICEVs Internal combustion engine vehicles

IEA International Energy Agency

INBC Indo-Pacific Net-Zero Battery-Materials

IPG International Partners Group

IRENA International Renewable Energy Agency

I-RECs International Renewable Energy Certificates (I-RECs)

ISO Independent system operator

IoT Internet of Things

IP Intellectual property

IT Information technology

JETP Just Energy Transition Partnership

JICA Japan International Cooperation Agency

JV Joint venture

KTPA Kilo tonnes per annum

LCOE Levelized cost of energy

LNG Liquefied natural gas

LT-LEDS Long-Term Low Emissions Development Strategy

LTMS-PIP Laos-Thailand-Malaysia-Singapore Power Integration Project

LUCF Land use change and forestry

MDB Multilateral development bank

MEMR Ministry of Energy and Mineral Resources

MOU Memorandum of understanding

MTBF Mean time between failures

MRV Measurement, reporting, and verification

MW Megawatt

NBS Nature-based solutions

NDC Nationally determined contribution

NFP National Forestry Program

NIC National Innovation Center

NYISO New York Independent System Operator

O&M Operations and maintenance

OEM Original equipment manufacturer

Appendix: Terms and acronyms (cont.)

P–S

PDP Power Development Plan

pCAM Precursor cathode active material

PHEV Plug-in hybrid electric vehicle

PJM Pennsylvania-New Jersey-Maryland (US power grid)

PLN Perusahaan Listrik Negara

PPA Power purchase agreement

PUE Power usage effectiveness

PV Photovoltaic

R&D Research and development

RCEP Regional Comprehensive Economic Partnership

RE Renewable energy

REC Renewable energy certificate

REDD+ Reducing Emissions from Deforestation and Forest Degradation, plus conservation, sustainable management of forests, and enhancement of forest carbon stocks

RP3 Regulatory Period 3 (Malaysia)

RP4 Regulatory Period 4 (Malaysia)

RTO Regional transmission organization

SAF Sustainable aviation fuel

SEA Southeast Asia

SEA-6 Six core SEA economies (ID, MY, PH, SG, TH, VN)

SME Small and medium-sized enterprise

SGX Singapore Exchange

SLA Service-level agreement

SOFC Solid oxide fuel cell

SOE State-owned enterprise

SRI System of Rice Intensification

Appendix: Terms and acronyms (cont.)

T–V

T&D Transmission and distribution

TCO Total cost of ownership

TEPCO Tokyo Electric Power Company

TNB Tenaga Nasional Berhad

TWh Terawatt-hour

UNFCCC United Nations Framework Convention on Climate Change

USD US dollar

VAT Value-added tax

VKTR PT VKTR Teknologi Mobilitas Tbk

VPP Virtual power plant

VPPA Virtual power purchase agreement

Country/Region Codes

AU Australia

BN Brunei

BR Brazil

CN China

DE Germany

ID Indonesia

IN India

JP Japan

KH Cambodia

KR South Korea

LA Laos

MM Myanmar

MX Mexico

MY Malaysia

PH Philippines

SG Singapore

TH Thailand

UAE United Arab Emirates

UK United Kingdom

US United States

VN Vietnam