

# IAEE ENERGY FORUM

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Editor: IAEE Headquarters

## PRESIDENT'S MESSAGE

Dear IAEE Members,  
Recent geopolitical developments, notably the conflict in the Middle East, have once again underscored how closely energy markets are intertwined with global security and economic stability. These events remind us how sensitive energy systems remain to geopolitical tensions, with far-reaching implications for markets, policy, and investment.

At the same time, the global energy landscape continues to undergo profound transformation. Decarbonization, technological innovation, and shifting demand are reshaping the sector, while energy security has again moved to the forefront of policy discussions. These dynamics unfold at different speeds across regions, underscoring the importance of addressing energy poverty and ensuring a just transition.

In this increasingly complex environment, informed international exchange in energy economics is more important than ever. As a global association, IAEE fosters dialogue across academia, industry, and policy, bringing together diverse perspectives to navigate these challenges. We look forward to continuing these discussions across our global activities, including our upcoming International IAEE Conference in Santiago.

To reflect this diversity, we have decided to dedicate the 2026 editions of the Energy Forum to regional perspectives. This first issue, developed with our Asia-Oceania affiliates, brings together contributions from across this dynamic and strategically important region.

By amplifying these perspectives, we aim to deepen our understanding of global energy developments and strengthen exchange across our community.



Yours sincerely,  
Aaron Praktijnjo  
President, IAEE

Published By:

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## *Editor's Notes*

This issue of *Energy Forum* brings together a set of contributions that examine energy transition and energy security across Asia and the Gulf at a time of heightened geopolitical tension, rapid technological change, and rising pressure on electricity systems. Several articles focus on how strategic rivalry, war, and supply-chain risks are reshaping global energy markets, while others explore the structural challenges of decarbonization in economies facing fast-growing demand, limited domestic resources, or new technological disruption. Taken together, these contributions show that energy policy can no longer be understood in isolation from trade, industrial strategy, regional cooperation, and security considerations.

**Hessa Al Fadhel** and **Latifa Al Fadhel** examine the growing vulnerability of Gulf energy trade in the context of recent military escalation involving the United States, Israel, and Iran. They argue that energy security in the GCC now depends not only on production capacity, but also on the resilience of shipping routes, insurance systems, and export infrastructure. Their article highlights how disruptions in the Strait of Hormuz quickly reverberate through Asian oil and LNG markets, underscoring the strategic interdependence between Gulf producers and Asian consumers.

**Hongyan Zhang, Jiyuan Li, and Peng Zhou** trace the rise of China's new energy technologies over the past two decades. They show how sustained planning and industrial coordination have enabled China to build a highly competitive clean energy supply chain, particularly in wind, solar, and energy storage. The authors argue that this transformation is not simply changing the energy mix, but is also redefining industrial competitiveness under increasingly protectionist global conditions.

**Jihyo Kim** and **Eunbyeong Heo** turn to the rapid expansion of artificial intelligence and data centers in Korea and the strain this may place on the electricity system. They estimate that electricity demand from data centers could rise dramatically by 2030 and warn that the concentration and timing of these loads may create serious system challenges. Their analysis points to the need for policies that can support digital innovation while managing broader impacts on the power sector.

**Qiang Li, Junyan Tang, and Lin Zhang** address one of the most difficult questions facing Hong Kong and the Greater Bay Area: how a densely built, resource-constrained city can decarbonize its electricity system. They assess Hong Kong's strategy of importing large volumes of zero-emission electricity from the mainland, especially nuclear power, and argue that while such imports are necessary, they are unlikely to be sufficient on their own. The article makes the case for a broader transition strategy that includes demand-side reform, credible carbon pricing, and a more realistic discussion of the trade-offs involved.

**Sheng Zhong** and **Bin Su** review modelling studies of ASEAN's long-term electricity transition and show that there is no single pathway to deep decarbonization. Some scenarios rely on rapid renewable deployment supported by battery storage, while others assign a larger role to carbon capture and hydrogen where renewable constraints are tighter. Across these pathways, regional grid integration emerges as a central theme, with cross-border electricity trade offering an important means of reducing costs and supporting a lower-carbon power system.

**Xuan-Hoa Nghiem** considers Vietnam at a particularly important moment, as the country faces both political transition and strong economic growth ambitions. The article explores whether Vietnam can meet rapidly rising energy demand while also addressing environmental concerns and long-standing weaknesses in the energy sector. In doing so, it presents Vietnam as a case where the success of economic strategy will depend heavily on the ability to resolve power shortages, pollution, and vulnerability to uncertainty.

**Yu Song, Qiang Ji, Xunpeng Shi, and Ying Fan** explore the expanding role of artificial intelligence in the energy transition across the Asia-Pacific region. They survey AI applications ranging from renewable forecasting and grid dispatch to energy efficiency and infrastructure management, while also showing how these uses vary across countries with different resource endowments and development stages. Their article suggests that advances such as large language models and digital twins may further strengthen the role of AI in building more resilient and sustainable energy systems.

**Noha Razek** and **Valentina Galvani** examine the economic consequences of geopolitical tension in oil markets. Drawing on data analysis, they argue that the 2022 sanctions on Russia did not benefit the Saudi economy, but instead increased the valuations of U.S. shale firms. They place this finding in a broader context shaped by the repercussions of the 2026 U.S.-Israel-Iran war and renewed disruption around the Strait of Hormuz, raising wider questions about the governance of strategic commodity markets.

# GCC Energy Security Under Conflict: Strait of Hormuz Disruptions and Implications for Asian Energy Markets

BY HESSA AL FADHEL  AND LATIFA AL FADHEL 

## Abstract

*The recent escalation of military tensions in the Gulf involving major actors, including the United States, Israel, and Iran, has transformed a long-recognized vulnerability in global energy trade into an immediate and measurable market shock. This article argues that energy security in the Gulf Cooperation Council (GCC) can no longer be understood solely through traditional indicators such as production capacity or resource endowment. Instead, it increasingly depends on the resilience of maritime transport corridors, the stability of commercial insurance systems, and the operational security of export infrastructure amid geopolitical stress. The Strait of Hormuz remains the central artery of this system, facilitating approximately 20-23% of global crude oil shipments and nearly one-fifth of worldwide Liquefied Natural Gas (LNG) trade. Recent disruptions associated with the regional conflict have slowed tanker traffic, sharply increased freight and war-risk insurance costs, and contributed to the temporary shutdown of major LNG production capacity in Qatar. Because Asian economies are the primary destination for GCC hydrocarbons, instability in the Gulf is rapidly transmitted to Asian oil and gas markets through supply disruptions, logistical constraints, and price volatility. By examining the evolving structure of GCC Asia energy interdependence, this article highlights how geopolitical conflict in a critical maritime chokepoint can reshape global energy security dynamics. The analysis concludes by outlining policy implications for maritime security governance, supply-chain resilience, and deeper strategic cooperation between Gulf energy producers and Asian customers.*

## Keywords

GCC, Energy security, Strait of Hormuz, LNG Markets, Asian Energy Demand

## 1. Introduction

Few regions influence global energy markets as directly as the Gulf. When instability emerges in this region, its effects are transmitted rapidly across international oil and gas systems, particularly to Asia, the world's largest energy-importing region.

The recent escalation of regional military tensions in the Gulf, involving major actors including the United States, Israel, and Iran, demonstrates how quickly geopolitical tensions can disrupt global energy supply chains. What has long been understood as a structural vulnerability in the concentration of energy flows through the Strait of Hormuz has now become an

active, measurable risk. Tanker movements have slowed, shipping costs have risen, and markets have responded with increased volatility (LSEG, 2026a).

For the GCC, this crisis highlights a shift in how energy security must be understood. It is no longer sufficient to focus on production capacity or resource endowment. Instead, energy security depends on the ability to move energy reliably through contested maritime routes and under conditions of geopolitical stress. As the implications are immediate for the Asian economies, as the primary destination for GCC oil and LNG exports, Asia remains highly exposed to disruptions in Gulf supply. This article examines the structure of GCC-Asia energy interdependence, analyzes the role of the Strait of Hormuz as a systematic chokepoint, and assesses the implications of recent disruption for Asian energy markets.

## 2. GCC – Asia Energy Interdependence

The strategic importance of the GCC in the global energy system derives not only from the scale of its hydrocarbon reserves but also from its central role in supplying the rapidly expanding energy demand of Asian economies. Over the past two decades, Asia has emerged as the principal engine of global energy consumption growth, driven by industrialization, urbanization, and rising transportation demand in major economies such as China, India, Japan and South Korea. As energy demand in these economies has expanded, dependence on imported hydrocarbons has intensified, strengthening trade and strategic linkage between Asian energy consumers and Gulf exporters. (Intriligator, 2015).

This shift has created a deep and structural interdependence between Gulf producers and Asian markets. GCC countries, in particular Saudi Arabia, the United Arab Emirates, Kuwait and Qatar, have become indispensable suppliers of oil and LNG to Asia. In turn, Asia's rapid economic growth has reinforced the strategic importance of the Gulf as a central hub in global energy trade (Yergin, 2006). The scale of this relationship is reflected in trade flows through the Strait of Hormuz. As a substantial share of Oil and LNG exports passing through this corridor is directed toward Asian markets. In the LNG sector, Asia accounts for most of Qatar's and the UAE's exports, making it particularly sensitive to disruptions in Gulf supply. Recent market data indicate that Qatar and the UAE exported approximately 10.5 billion cubic meters (bcm) of LNG in March 2025, of which around 4.4 (bcm) were delivered to Northeast

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Asia and a further 4 (bcm) to other Asian markets, while Europe received only about 1.4 (bcm) (LSEG, 2026a).

The structure of Asian energy demand further reinforces this dependence. Despite diversification efforts and growing investment in renewable energy, hydrocarbons remain essential for transportation, electricity generation, and industrial production. As Asian economies continue to expand, their demand for imported hydrocarbons is expected to increase, deepening reliance on external supply (Intriligator, 2015). From a geopolitical perspective, this concentration of supply and demand reflects broader dynamics of energy geopolitics. The distribution of oil and gas reserves, combined with the infrastructure required to transport their resources, creates strategic interdependence between producing and consuming regions (Sun et al., 2011).

### 3. The Strait of Hormuz as a Systemic Chokepoint

The Strait of Hormuz is the most critical maritime chokepoint in the global energy system. Approximately 20-23% of global crude oil and nearly 20% of LNG flows pass through this narrow corridor, making its stability essential for global energy security (LSEG, 2026b). Recent developments demonstrate how this vulnerability can materialize. Following the recent escalation of regional tensions in the Gulf, tanker movements through the Strait slowed sharply. More than 100 vessels are reportedly anchored outside the corridor rather than risk transit, due to concerns about the flow of oil and LNG shipments (LSEG, 2026a).

The consequences were immediate. Freight rates increased as shipping capacity tightened and war-risk premiums rose. Oil prices responded to supply uncertainty, reflecting market expectations of potential disruption. These effects occurred even without a full closure of the Strait, highlighting how the energy

market reacts not only to physical constraints but also to perceived risk. The disruption also exposed the financial dimension of energy security. Maritime insurance plays a critical role in sustaining global energy trade, particularly in conflict-prone regions. As tensions escalated, war risk insurance premiums rose sharply, prompting some insurers to reduce or withdraw coverage and prompting tanker operators to delay transit. Vessel tracking data showed significant volumes of crude temporarily stranded as ships avoided the corridor (LSEG, 2026c). In response, the United States announced plans to provide up to \$20 billion reinsurance coverage to support maritime energy trade (Reuters, 2026a). These developments illustrate that energy security now depends not only on physical infrastructure but also on the stability of financial risk mechanisms.

### 4. LNG Disruption and the Repricing of Asian Energy Risk

The natural gas market has revealed the consequences of Gulf instability even more starkly than oil markets. LSEG’s LNG market analysis estimates that the conflict initially removed nearly 18% of global LNG supply from the market. The principal driver was the shutdown of Qatar’s Ras Laffan liquefaction complex, a 105 bcm per year facility and the single most important LNG export hub in the Gulf. According to LSEG, production halted on 2 March following drone-related security threats, after which QatarEnergy declared force majeure on several supply contracts (LSEG, 2026d). Reuters likewise reported that Qatar accounts for roughly 20% of global LNG supply and that a return to normal production levels could take at least a month (Reuters, 2026b).

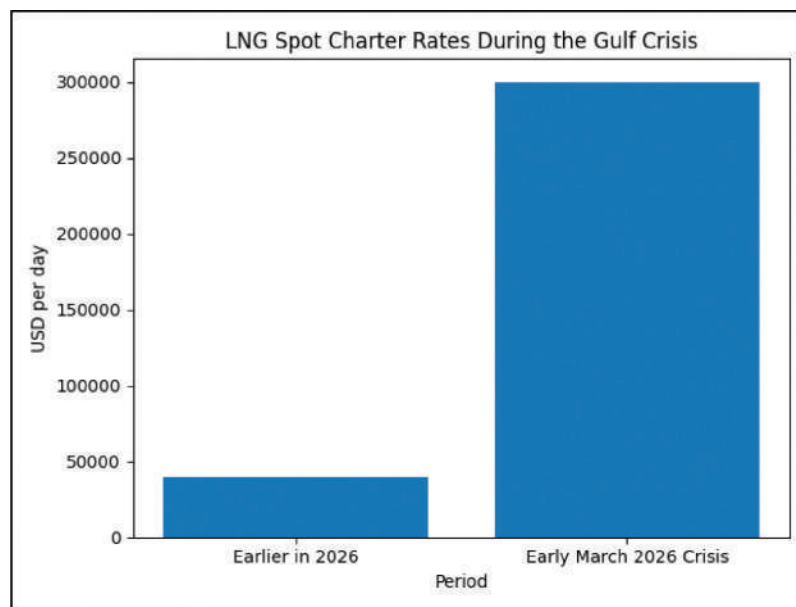


Figure 1: LNG Spot Charter Rates During the Gulf Crisis (Source: Author's illustration based on LSEG Commodities Research (2026))

The disruption matters most for Asia because Asian buyers constitute the primary destination for Gulf LNG exports. LSEG analysis indicates that several Asian economies were immediate losers following the interruption of Qatari and Emirati LNG flows, forcing importers to seek replacement cargoes from the United States, West Africa, and other suppliers (LSEG, 2026d). This shift intensified inter-basin competition and sharply increased freight demand because Atlantic Basin cargoes must travel significantly longer distances to reach Asian markets.

As a result, spot charter rates reportedly surged to around \$300,000 per day for modern LNG carriers, up from less than \$40,000 per day earlier in the year. The market effect was therefore twofold: a reduction in physical supply and a sharp rise in the delivered cost of replacement cargoes.

The crisis also highlights that Asian exposure to Gulf disruptions is not uniform. Zero Carbon Analytics identifies Japan and South Korea as among the most vulnerable countries to potential disruptions in the Strait of Hormuz due to their heavy reliance on imported fossil fuels (Zero Carbon Analytics, 2026). By contrast, analysis from the Atlantic Council suggests that China, while highly exposed to Gulf oil price shocks, may be somewhat more resilient than its Northeast Asian peers due to greater domestic production, more diversified gas import routes, and a large strategic reserve (Atlantic Council, 2024). These differences do not alter the broader regional conclusion: instability in the Gulf imposes immediate and asymmetric economic risks on Asian economies, particularly through LNG supply disruptions and the transmission of energy prices.

## 5. Policy Implications for GCC Energy Security

The recent disruption in the Strait of Hormuz highlights a fundamental shift in how energy security must be understood in the GCC. While the region continues to possess abundant hydrocarbon resources, its ability to deliver them to global markets is increasingly constrained by geopolitical risk and infrastructure vulnerabilities.

First, the crisis underscores the extent to which GCC energy exports remain dependent on a single maritime chokepoint. The concentration of oil and LNG flows through the Strait of Hormuz exposes Gulf producers to systemic risks that lie beyond their direct control (LSEG, 2026a). Reducing this dependency will require long-term investments in alternative export routes, including expanding pipeline networks and storage infrastructure to bypass critical maritime corridors. Second, the events highlight the growing importance of maritime security as a core component of energy policy. Ensuring the safe and continuous flow of energy through key shipping routes has become as critical as maintaining production capacity itself (Yergin, 2006). Strengthening regional and international cooperation including joint naval cooperation and partnerships with major global powers, will be essential to safeguarding these critical energy corridors.

Third, the crisis demonstrates the need for greater supply chain resilience. Improving coordination between producers, shipping companies, and buyers can help manage disruptions more effectively. Expanding strategic storage capacity both within the GCC and in key Asian markets can also provide a buffer against short-term supply shocks and reduce market volatility. Fourth, the disruptions of maritime insurance markets highlight the growing financial dimension of energy security. The temporary withdrawal or repricing of insurance coverage during the crisis illustrates how financial constraints can disrupt energy flows even in the absence of physical damage. Strengthening risk-sharing mechanisms and ensuring the continuity of insurance coverage during periods of conflict will therefore be critical for maintaining stable energy trade.

Finally, strengthening the long-term cooperation between GCC producers and Asian consumers will be essential. This includes deeper strategic partnerships, joint infrastructure investments, and coordinated contingency planning. Given the scale of interdependence, energy security can no longer be addressed unilaterally but requires coordinated approaches that enhance resilience across the entire supply chain. Taken together, these developments suggest that GCC energy security must evolve from a narrow focus on production capacity toward a broader strategy centered on resilience, diversification, and coordinated risk management. In an increasingly uncertain geopolitical environment, the ability to sustain reliable energy flow will be as important as the availability of resources themselves.

## 6. Conclusion

Recent tensions in the Gulf have demonstrated how quickly energy security risks can shift from structural concerns to immediate market disruptions. The Strait of Hormuz remains a critical chokepoint, and even partial instability has been sufficient to slow tanker movements, raise freight and insurance costs, and disrupt LNG supply. These developments highlight that energy markets respond not only to physical outages but also to perceived risk and uncertainty.

For the GCC, the implications are clear: energy security can no longer be viewed solely in terms of production capacity. It increasingly depends on the reliability of transport corridors, the functioning of maritime insurance markets, and the resilience of export systems under geopolitical stress.

The impact is most visible in Asia, where strong dependence on Gulf hydrocarbons exposes economies to rapid transmission of supply disruptions and price volatility. The recent LNG shock illustrates how quickly regional disturbances can reshape global trade flows and increase costs for end users.

Looking forward, strengthening energy security will require a more integrated approach, diversifying export routes, reinforcing maritime security, supporting insurance mechanisms, and deepening cooperation

between Gulf producers and Asian consumers. In this evolving landscape, the central challenge is not resource availability but ensuring that energy can be delivered reliably in an increasingly uncertain geopolitical environment.

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# The Rise of China's New Energy Technologies: Powering a Global Green Transition

BY HONGYAN ZHANG, JIYUAN LI, AND PENG ZHOU\*

IAEE Energy Forum 2026 Q1: Showcasing Hot Topics in Energy Economics in Asia-Oceania

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## Abstract

The development of new energy technologies has become a key engine driving energy transition and economic upgrading. Through two decades of strategic resolve and systematic planning, China has built the world's most complete clean energy industrial chain. The meteoric rise of China's new energy sector—particularly in wind power, photovoltaics, and energy storage—has attracted worldwide attention. This paper aims to trace the development path of China's new energy technologies, while delving into the underlying logic behind this transformation. This paper further analyzes the competitive advantages of China's new energy technologies and multidimensional systemic strength, alongside the emerging challenges. We argue that the advancement of China's new energy technologies represents not only a physical restructuring of the energy mix, but also a profound transformation in the competitiveness of an industrial system. Amid rising trade protectionism and technological barriers, China's new energy industry is prioritizing long-term value and demonstrating a commitment to global leadership.

## 1. The Rapid Scaling of China's New Energy Industry

According to data from the International Renewable Energy Agency (IRENA), solar PV and wind power together accounted for over 90% of global renewable energy capacity additions in 2024, solidifying their

position as the mainstay of the energy transition (IRENA, 2025a). In this context, as the world's largest renewable energy installer and equipment manufacturer, China's industrial development path holds significant reference value for the global energy transition process.

In developing its new energy industries, China has consistently adhered to addressing climate change as a strategic choice, embedding the energy transition into the broader framework of high-quality development and industrial upgrading (Yang et al., 2022). This demonstrates China's strategic autonomy and sense of responsibility on the path toward sustainable development. Driven by the synergy between market mechanisms and industrial policies, China has continued to expand its solar PV, wind power, and energy storage sectors. IEA data show that from 2020 to 2024, China's cumulative installed capacity of wind and solar PV increased from approximately 559 GW to 1,526 GW, a growth of nearly 1.7 times (Figure 1).

Structurally, solar PV has become the main engine driving new energy growth. In 2024, utility-scale and distributed PV together accounted for 65.8% of total installations across the four technology categories, with the share of distributed PV rising from less than 30% to nearly 40%, rapidly broadening application scenarios. Cumulative onshore wind capacity surged from 271 GW to 480 GW, providing steady support to the power supply. While offshore wind currently represents a smaller

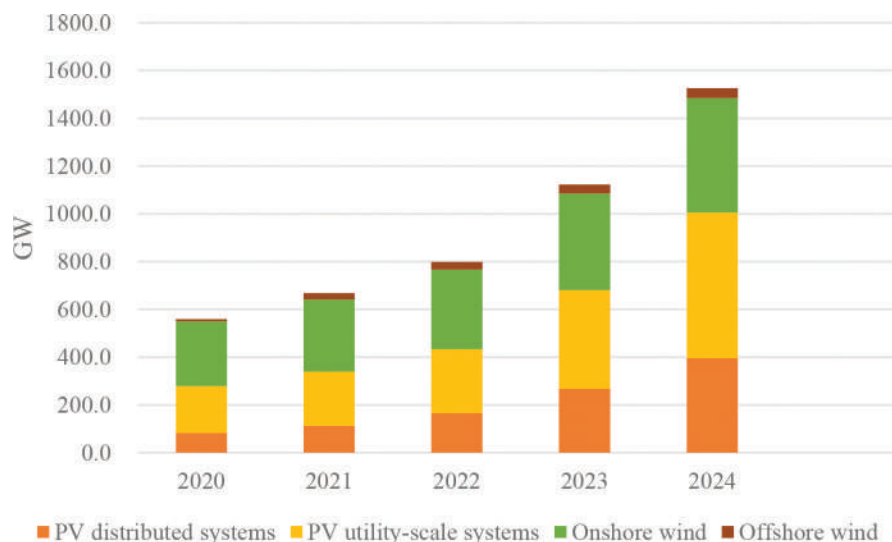


Figure 1: Cumulative Installed Capacity of Wind and Solar Power in China, 2020-2024

share of the mix, its development potential continues to be unleashed driven by technology breakthrough. The IEA projects that China will account for nearly half of all global offshore wind additions between 2025 and 2030 (IEA, 2025a).

Energy storage has also entered a phase of rapid development. By the end of 2024, China's new energy storage installations accounted for over 40% of the global total (IRENA, 2025b). In 2025, the average utilization rates of wind and solar PV reached 94% and 95%, respectively, highlighting the increasingly prominent role of energy storage in supporting renewable energy integration (NEA, 2026).

## 2. Technological Evolution in New Energy

The rapid scale expansion of China's new energy industry has been made possible by the strategic choice to address climate change, together with the coordinated advancement of market mechanisms and technological innovation (Wang et al., 2023). Policy has played more of a guiding role in this process, creating a predictable market environment that enables enterprises to achieve technological breakthroughs and large-scale deployment. From the perspective of the global energy transition: how does policy, in combination with market forces, drive continuous technological iteration? And how does China's approach differ from that of other countries? The following analysis explores these questions across three sectors—solar PV, wind power, and energy storage.

### 2.1 Solar PV

Over the past decade, global PV installation costs have cumulatively decreased by over 80%, an achievement closely tied to the continuous technological advancements in China's photovoltaic industry. According to IEA-PVPS statistics, China's new PV installations reached 357.3 GW in 2024, accounting for approximately 60% of the global total (IEA-PVPS, 2025). This leadership stems not only from scale expansion but also from policy design. The "Top Runner" Program launched in 2015 did not focus primarily on feed-in tariffs; instead, it established industrial bases and set technology benchmarks above industry averages, creating large-scale application scenarios for new-generation battery technologies such as Passivated Emitter and Rear Cell (PERC) and Tunnel Oxide Passivated Contact (TOPCon).

Despite the gradual phase-out of subsidies, Chinese firms have sustained their global edge through rigorous technological upgrades and disciplined cost management. By aggressively ramping up R&D, these companies have institutionalized innovation as a core competitive advantage—a move that has secured the Chinese PV industry's long-term global leadership. Furthermore, China's model of utilizing large-scale application scenarios to accelerate technological maturity has established a proven blueprint for cost reduction, offering a scalable roadmap for emerging economies.

### 2.2 Wind Power

Offshore wind power involves high technological barriers and a relatively complex industrial chain. According to GWEC data, global cumulative installed offshore wind capacity has approached 100 GW. Although China started late in this sector, it has developed rapidly in recent years, accounting for over half of cumulative global installations (GWEC, 2025). This rapid progression was fueled by economies of scale and a market environment that incentivized continuous iteration. A prime example is the installation surge prior to the 2020 subsidy phase-out; the firm deadline for subsidy withdrawal acted as a catalyst, forcing enterprises to fast-track the transition from demonstration to utility-scale deployment. This effectively compressed the innovation lifecycle, turning a multi-year development process into a rapid-response industrial shift.

By 2025, the transition toward full market-based competitive bidding for renewable feed-in tariffs signaled a pivotal policy shift. The focus moved away from traditional generation-based subsidies toward incentivizing multi-sector integration. This new framework prioritizes pilot projects that pair offshore wind with marine ranching and green hydrogen production, fostering a landscape of cross-scenario technological synergy. Rather than relying on high feed-in tariffs and projects led primarily by traditional energy giants, China has adopted a path combining competitive bidding with comprehensive development. It not only forces enterprises to reduce LCOE but also requires them to develop cross-industry technology integration capabilities. Over recent years, China has markedly accelerated the expansion of its offshore wind power sector into deep-water and far-offshore waters. As the advantages of a full industrial chain materialize, this integrated progress is providing proven technical benchmarks for wind power development in high-cost offshore waters.

### 2.3 Energy Storage

Energy storage is regarded as a critical link in unlocking the full potential of renewable energy applications. According to BloombergNEF data, China accounted for more than half of global new energy storage deployments in 2025, with China and the United States continuing to dominate as the world's two largest energy storage markets over the next decade (Kikuma, 2025).

The Chinese government has addressed inefficiencies, such as low utilization rates, stemming from new energy storage allocation policy. In a decisive policy shift in 2025, the central government decoupled energy storage requirements from the approval and grid-connection process for new renewable energy projects, thereby reinstating market-driven decision-making (NDRC & NEA, 2025a). This was further reinforced by the Action Plan for Large-Scale Construction of New Energy Storage (2025–2027), which incentivizes storage facilities to participate in electricity markets as independent, market-oriented entities (NDRC & NEA, 2025b). Policy frameworks are increasingly

emphasizing the diversification of energy storage technological pathways such as sodium-ion batteries, flow batteries, and compressed air energy storage. They also facilitate the expansion of multi-scenario applications from grid-side storage to diverse settings such as industrial and commercial energy storage and shared energy storage. Consequently, enterprises are broadening their market presence through continuous technological and business model innovation, leading to a sustained surge in market vitality. Moreover, the emerging synergy between energy storage and digitalization is enabling storage resources to facilitate cross-regional power balancing. This integration offers novel technological pathways to enhance grid flexibility (Zhang et al., 2023).

### 3. Global Impact and International Comparison

Technological evolution has not only catalyzed China's own energy transition but has also profoundly influenced the global renewable energy landscape. According to IRENA data, the global weighted average total installed cost of utility-scale solar PV projects fell to USD 691/kW in 2024, a cumulative decrease of 87% compared to 2010 (IRENA, 2025c). China's large-scale manufacturing and technological iteration have been key drivers of this cost reduction. BloombergNEF estimates that the global benchmark cost of four-hour battery energy storage systems fell to USD 78/MWh in 2025. The continuous decline in China's lithium battery costs has enabled electrochemical energy storage to reach commercial viability earlier than expected in multiple markets (Oktavia, 2026). In the wind power sector, China's large-capacity offshore wind turbines continue to mature, offering more cost-effective solutions for global projects. Overall, the scale expansion and technological upgrading of China's new energy industry have become the critical driving force behind the global transition of clean energy technologies from high-cost to widespread affordability.

Based on global trends in clean energy research and development (R&D) investment, there are notable differences in the structure and trajectory of spending across countries. According to the latest statistics from the International Energy Agency (IEA), total government energy R&D expenditure reached USD 54 billion in 2024, representing a 4% increase in real terms compared with 2023. Europe's share of investment in clean energy R&D continues to rise, with a focus on areas such as hydrogen, and integrated offshore wind technologies. In North America, the share of clean energy R&D remains relatively stable, with emphasis on next-generation batteries, nuclear energy, and carbon capture. Meanwhile, underpinned by substantial investment in basic R&D (Zhang and Zhang, 2023), China's enterprise-led industrial R&D continues to scale. This expansion is most prominent in grid digitalization, advanced photovoltaics, high-capacity wind turbines, and next-generation energy storage—sectors where China's R&D intensity now leads the world across both large-scale manufacturing and engineering applications (IEA, 2025b).

Compared with Europe and the United States, the policy mix of China's new energy industry has distinctly different emphases. In its early stages, Europe relied primarily on high feed-in tariffs and consumer-side incentives to initiate technological development. Its highly market-oriented electricity system has created multiple revenue streams for flexible resources such as energy storage. In recent years, European countries have gradually adjusted their subsidy approaches. For example, starting in 2025, France eliminated fixed feed-in tariffs for some distributed PV projects, instead encouraging self-consumption and introducing market-based bidding mechanisms (CRE, 2025). The United States has placed greater reliance on federal tax credits and venture capital-driven technological innovation. One Big Beautiful Bill Act, passed in July 2025, tightened eligibility criteria for tax credits for wind and solar projects, requiring that projects become operational by the end of 2027—approximately five years earlier than originally planned (U.S. Congress, 2025). In contrast, China's policy mix places a stronger emphasis on balancing supply-side incentives with application-side drivers. When technologies were still immature, mechanisms such as the "Top Runner" bases created predictable demand to accelerate technological iteration. As the industry matured and achieved scale, market-oriented tools—such as competitive bidding—were phased in to foster merit-based competition and efficiency. This strategic evolution has endowed China with a formidable advantage in large-scale manufacturing and cost control. The formation of these different pathways is closely related to each country's market size, industrial base, and institutional environment, making simple replication difficult. Nevertheless, the experiences of each offer valuable lessons for exploring diverse pathways to energy transition.

### 4. Conclusion

From the perspective of global energy transition, the significance of China's practice lies not in providing a directly replicable model, but in illustrating a universal proposition: in the process of clean energy technologies moving from high cost to widespread affordability, policies need to play different roles at different stages—avoiding excessive intervention that distorts markets while providing necessary impetus when market failures occur. This remains a pivotal challenge that any economy striving to accelerate its energy transition must perpetually navigate and explore.

Despite its rapid development, China's new energy industry faces formidable practical challenges. While significant breakthroughs have been made in next-generation photovoltaics—notably perovskite photovoltaics—these technologies remain far from utility-scale commercialization. Similarly, long-duration energy storage (LDES) and deep-water, far-offshore wind power remain pivotal frontiers requiring critical technical milestones. By the end of 2025, the cumulative installed capacity of wind and solar historically eclipsed that of coal. However, as renewables become the predominant power source, grid flexibility pres-

asures have intensified, exposing an immature coordination mechanism between energy storage and the grid (Reuters, 2025). On the external front, trade policy uncertainties, coupled with the trend toward supply chain localization, are continuously reshaping the global division of labor in the industry. These challenges are not only inevitable hurdles as the industry matures, but also provide direction for subsequent policy optimization and technological breakthroughs.

From a global perspective, China's breakthroughs in technological innovation and market mechanisms are poised to offer a proven valuable experience for other developing nations and provide practical benchmarks for the diversified deployment of clean energy. By systematically addressing these multifaceted challenges, China is pivoting from a global supplier of clean energy hardware to a strategic architect of energy transition solutions. This evolution underscores China's commitment to advancing global climate governance and sustainable development.

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# Future Electricity Demand Driven by AI and Data Centers in Korea: Challenges for Net-Zero Power Systems

BY JIHYO KIM AND EUNNYEONG HEO

## Abstract

*The global boom in artificial intelligence (AI) and data centers is rapidly increasing electricity demand in Korea. Based on planned data center developments, this study estimates that electricity demand from data centers could grow about 3.7 times by 2030 compared to current levels. Such rapid expansion is likely to impose significant challenges on the energy system, particularly in terms of spatial concentration and temporal load characteristics. Addressing these challenges requires a careful policy balance between sustaining AI-driven innovation and mitigating system-level impacts.*

## 1. Introduction: AI and a New Phase of Electricity Demand

The rapid expansion of artificial intelligence (AI) is emerging as a new driver of electricity demand through the growth of data centers. As AI models become increasingly computationally intensive, the scale, density, and energy consumption of computing infrastructure are rising quickly. While there is broad consensus that AI-driven data center expansion will increase global electricity demand (LBNL, 2025), a key concern is that this demand may place significant pressure on electricity systems – both spatially, by requiring additional generation and transmission infrastructure—and temporally, by intensifying peak loads (Kim et al., 2026; EPRI, 2026).

These issues are particularly relevant in Korea. The government is actively promoting AI-driven innovation, supported by the country's advanced ICT infrastructure. Reflecting these trends, Korea's 11th Basic Plan for Long-term Electricity Supply and Demand (MOTIE, 2025) incorporates projections of rising electricity demand associated with data center expansion. At the same time, a growing number of large-scale data center projects have been announced, suggesting that the pace of demand growth may accelerate further.

In this article, we examine the potential growth and spatial distribution of data center electricity demand in Korea based on publicly announced projects. We address two key questions: how much electricity demand from data centers could increase in the near term, and where this demand is likely to emerge.

More importantly, we argue that the key challenges arise not only from the scale of demand growth, but from its spatial concentration and temporal load characteristics. The location of data centers will shape transmission constraints and regional imbalances, while their load profiles—often concentrated during daytime and peak hours—may intensify system stress. These challenges may become more pronounced as

Korea expands the share of variable renewable energy.

## 2. Data Center Electricity Demand in Korea: Current Status and Near-Term Outlook

There are no comprehensive official statistics on data center electricity demand in Korea. To address this gap, we draw on recent estimates by the BAI (2025), complemented by our own estimation on contracted capacity and electricity consumption from 1990 to 2025.

As of 2023, Korea had 314 data centers with a combined contracted capacity of 2.2 GW, accounting for only about 1.5% of total installed capacity. Assuming an average utilization rate of 30%, this corresponds to approximately 5.8 TWh of electricity consumption—just over 1% of total national demand. At present, data center electricity demand remains relatively modest and does not pose a significant burden on the power system.

However, this situation is likely to change rapidly. Based on publicly announced projects identified through news sources, an additional 6.0 GW of capacity is expected to come online by 2030. If fully realized, total contracted capacity would increase to 8.2 GW—roughly 3.7 times the current level. Under the same utilization assumption, electricity demand from data centers could reach approximately 21.6 TWh by 2030.

This represents a clear departure from historical trends, as seen in Figure 1. While improvements in efficiency and technological progress have moderated demand growth in recent years (LBNL, 2024), the projected expansion implies an average annual growth rate of around 27% in contracted capacity between 2025 and 2030. This growth rate exceeds that assumed in the IEA (2025) “lift-off” scenario. Moreover, given that additional projects may not yet be publicly disclosed, actual demand could increase even more rapidly.

## 3. Structural Constraint in Korea's Power System

The rapid growth of AI and data center electricity demand poses several critical challenges for Korea's power system.

First, data center expansion is likely to exacerbate regional imbalances in electricity supply and demand, increasing grid investment requirements. Our analysis shows that more than 70% of data center electricity demand is concentrated in the capital area, which accounts for approximately 40% of national electricity

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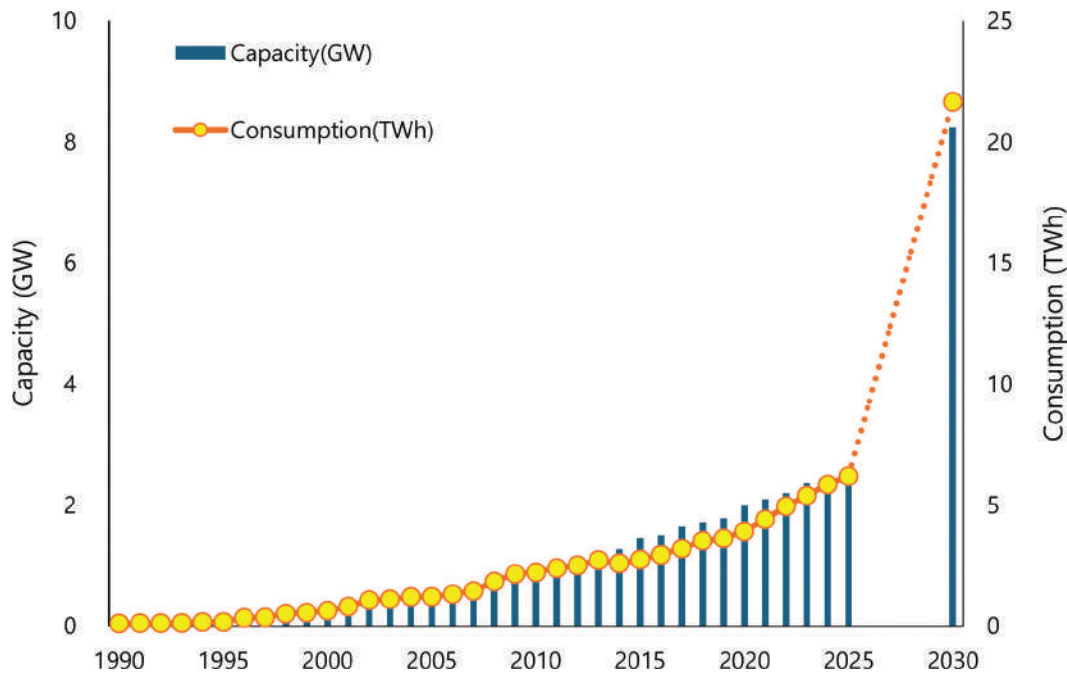


Figure 1: Korea's data center electricity demand, 1990–2030.

consumption but only about 25% of generation capacity. To address this imbalance, the Korean government has introduced the Distributed Energy Act to promote the decentralization of both demand and new generation capacity. As a result, only around 15% of electricity demand from newly announced data center projects is expected to be located in the capital area. However, data center operators continue to prefer capital-region locations due to service quality considerations (KDCC, 2024; IDC, 2025), creating a persistent gap between policy objectives and market preferences. Even if new facilities are partially distributed across regions, the marginal increase in network costs associated with serving demand in the capital area is likely to remain substantial. This highlights the need to more explicitly account for the grid cost implications of data center expansion, particularly in the post-2030 period.

Second, the interaction between data center load profiles and renewable energy expansion may amplify system stress. Korea's renewable capacity—primarily solar and wind—is projected to triple to around 100 GW by 2030, leading to a shift in system peak demand toward the late afternoon and evening hours. Our analysis suggests that data center demand is likely to peak between 16:00 and 19:00, coinciding with the decline in solar generation. This temporal mismatch implies that data center expansion may increase reliance on flexible or peaking resources, raising system costs beyond the effect of demand growth alone.

Lastly, efficiency and cooling technologies represent an additional, though secondary, consideration. Korea's average power usage effectiveness (PUE) improved from 2.66 in 2015 to around 2.2 in 2024 (BAI, 2025), but remains above leading international benchmarks (Xiao et al., 2025). Further improvements will require

stronger efficiency standards and accelerated retrofits, alongside attention to emerging water-use constraints from high-performance computing.

#### 4. Conclusion and Implications

The rapid expansion of AI and data centers is ushering in a new phase of electricity demand growth in Korea. While the increase in demand is a global phenomenon, its implications are highly country-specific, shaped by the structure of national energy systems.

In Korea, two structural features are particularly important: the persistent imbalance between the capital and non-capital regions, and the rapid expansion of variable renewable energy. These factors amplify the spatial and temporal challenges associated with data center growth. A key policy challenge is therefore to support AI-driven innovation while minimizing additional burdens on the power system. This requires not only expanding supply, but also addressing the spatial distribution and temporal characteristics of demand.

More broadly, while existing discussions have focused on major AI-leading countries such as the United States and China, the system-level implications of AI-driven electricity demand vary significantly across countries. Expanding the evidence base through diverse country case studies will be essential for developing more robust and policy-relevant insights.

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# The Electricity Import Dilemma: Hong Kong's Path to Net-Zero in the Greater Bay Area

BY QIANG LI, JUNYAN TANG, AND LIN ZHANG<sup>1</sup>

Contribution to IAEE Energy Forum — Showcasing Hot Topics in Energy Economics in Asia-Oceania

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## Abstract

This contribution discusses what has become a central question in energy economics for both Hong Kong and the Guangdong–Hong Kong–Macao Greater Bay Area (GBA): how can one of the world's most densely developed and renewable-resource-constrained cities decarbonise its electricity system? Hong Kong's current response—an explicit strategy of importing 60–70% of its electricity from zero-emission sources on the mainland by 2035, primarily nuclear power—is pragmatic but raises profound concerns regarding energy security, governance, cost, and long-run credibility. This article examines the structural drivers of Hong Kong's energy challenge, the economic logic and risks of the electricity import strategy, the constraints on local renewable deployment, and what the GBA regional context means for the transition. It argues that the import strategy is necessary but not sufficient: durable decarbonisation also requires deeper demand-side reform in buildings and transport, a credible regional carbon pricing architecture, and a more honest public reckoning with the trade-offs involved in outsourcing clean power generation to the mainland. The GBA, taken as a whole, offers one of the most instructive case studies of city-cluster energy transition in the world—and one that deserves far more attention from energy economists.

## Introduction: Revisiting Hong Kong's Climate Challenge

In the third quarter of 2022, this newsletter published a short overview of Hong Kong's climate situation (Zhang, 2022). At the time, the city had just released its Climate Action Plan 2050, committing to achieve carbon neutrality before 2050 and to reduce greenhouse gas (GHG) emissions by 50% from 2005 levels by 2035. The plan was ambitious, but its central mechanism—transforming the electricity mix—remained only partially specified. Three years on, that mechanism has come into sharper focus, and the questions it raises are, if anything, more pressing.

Hong Kong's total GHG emissions in 2023 were approximately 34.5 million tonnes of CO<sub>2</sub>-equivalent, implying a reduction of about 20% relative to 2005 levels (HKSAR Government, 2024). Figure 1 places this trajectory against the city's official decarbonisation targets. The downward trend since the 2014 peak is real, but the pace of reduction must accelerate substantially if the 2035 interim target is to be met. The bulk of reductions to date have come from the coal-to-gas shift in power generation—a transition now largely complete. The next phase is structurally far more demanding: it requires eliminating fossil fuels from the electricity system almost entirely, transforming transport and buildings,

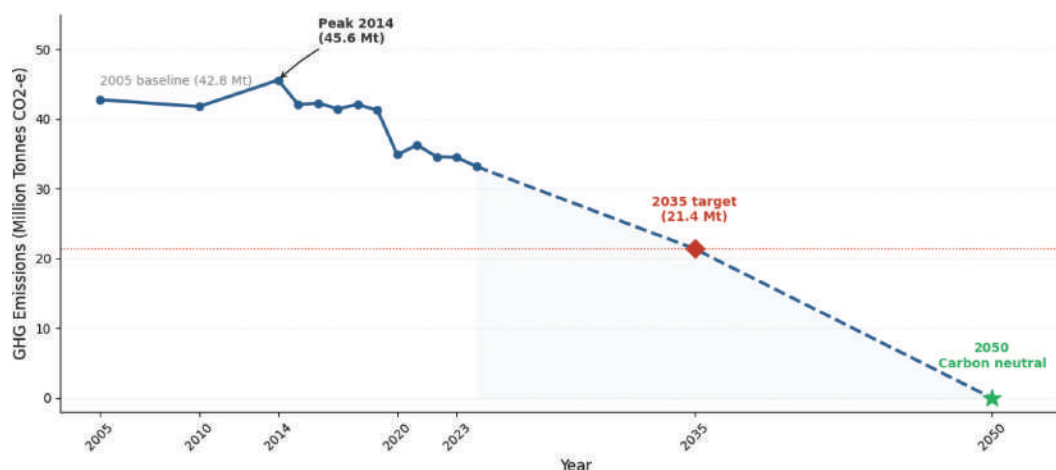


Figure 1: Hong Kong's GHG Emissions Trajectory and Decarbonisation Targets (2005–2050). Sources: HKSAR Government (2024); CNSD (2025). Historical data based on official GHG inventories (AR5 GWP basis). The dashed line illustrates the linear abatement pathway implied by official targets.

and doing so in a city that generates virtually no usable renewable energy of its own.

### A Structural Energy Problem

Hong Kong's energy challenge is fundamentally shaped by geography. The territory covers about 1,110 square kilometres, of which nearly 80% is hilly, forested country park. The dense urban core leaves negligible space for utility-scale solar or wind farms. Offshore wind is theoretically feasible, but marine traffic density, typhoon risk, and costly subsea cabling make it far less competitive than in, say, the North Sea or even the Taiwan Strait. As a result, local renewable generation today accounts for well under 1% of electricity supply—a fraction of rooftop solar, a single wind turbine on Lamma Island, and some small-scale building-integrated systems (HKSAR Government, 2024).

Hong Kong's electricity mix remains correspondingly dominated by fossil fuels. Natural gas accounts for approximately 48% of generation and coal for around 27%, while the remaining quarter is supplied through imports from the Daya Bay nuclear plant in adjacent Guangdong province, under a long-standing agreement with China General Nuclear Power Group (Energy Connects, 2024). This mix is the product of decades of franchise-based utility governance: the city's two power companies, CLP Holdings (serving Kowloon and the New Territories) and HK Electric (serving Hong Kong Island and Lantau), operate under a scheme of control agreements that have historically guaranteed rates of return on capital, with limited pressure to accelerate decarbonisation beyond what government mandates require.

The buildings sector, which accounts for around 60% of Hong Kong's total carbon emissions, sits almost entirely on the electricity system—meaning that decarbonising electricity is the single most impactful lever available to policymakers (Dong & Zhang, 2023). Transport constitutes the second-largest source of emissions, but progress toward vehicle electrification remains constrained by the city's dense urban form and the limited availability of charging infrastructure, particularly in older residential developments. The upshot is that the electricity transition is not merely

one piece of a broader decarbonisation puzzle; it is the puzzle's load-bearing corner.

### The Import Strategy: Logic, Scale, and Risks

Given these structural constraints, the Hong Kong government has adopted electricity imports as the principal mechanism for power-sector decarbonisation. The Climate Action Plan 2050 targets a fuel mix of 60–70% zero-emission electricity by 2035, with the bulk of this to come from the mainland. In practice, this strategy rests primarily on nuclear power, supplemented by large-scale renewable generation transmitted through China's west-to-east grid (HKSAR Government, 2021). CLP Holdings has made clear that nuclear power will form the backbone of this strategy, given its dispatchability advantages: unlike solar or wind, nuclear provides firm, round-the-clock power that can anchor a grid without requiring costly storage or backup capacity (Energy Connects, 2024).

Table 1 illustrates the implied transformation of Hong Kong's electricity fuel mix over three time horizons. The scale of change is substantial. Moving from roughly 28% zero-emission supply today to 60–70% by 2035 requires a near-tripling of the zero-carbon share within a decade. The economics of this arrangement are, in principle, attractive: mainland nuclear power is significantly cheaper per kilowatt-hour than domestically generated gas-fired electricity, and the cost of long-distance high-voltage direct current (HVDC) transmission has fallen sharply over the past decade.

But the strategy carries three categories of risk that deserve more rigorous economic attention than they have so far received.

The first is *energy security*. 60–70% of Hong Kong's electricity is supplied by China Southern Power Grid, introducing a structural dependency with no easy domestic backstop. As Hong Kong retires gas-fired units to hit emission targets, its capacity for self-supply during disruptions dwindles. This is not merely a theoretical concern: climate change is increasing the frequency of extreme weather events that affect transmission infrastructure, and geopolitical dynamics—while currently stable—introduce long-horizon uncertainty. A rigorous treatment of this risk

**Table 1: Hong Kong Electricity Fuel Mix: Current Status and Decarbonisation Targets**

Energy Source	2023 Actual	2030 Interim	2035 Target	Notes
Natural gas	~48%	>50%	~20–30%	Transition fuel; phase-down after 2030
Coal	~24%	Phase-down	0%	Full phase-out by 2035; no new coal capacity since 1997
Mainland Zero-emission energy (imported)	~27%	—	60–70%	Daya Bay plant; Wind and hydro via west-to-east grid; contingent on cross-boundary transmission build-out
Local renewables	<1%	3–4%	7.5–10%	Rooftop solar, waste-to-energy; constrained by geography and building stock
Zero-emission subtotal	~28%	—	60–70%	Government target range for 2035 (HKSAR Government, 2021)

Sources: HKSAR Government (2021, 2024); Energy Connects (2024); HK2050isNow (2023). Figures for 2030 and 2035 reflect government policy targets; actual outcomes will depend on infrastructure build-out and bilateral agreements with mainland suppliers.

would involve explicit modelling of supply disruption scenarios and their welfare costs, of the kind applied to European gas dependency on Russia in the years before 2022 (Jin et al., 2024).

The second risk is *governance and regulatory opacity*. With most power generated outside its borders, Hong Kong faces significant challenges in monitoring production safety and environmental performance. The existing Daya Bay agreement has operated without incident, but it was negotiated under very different political and energy market conditions than those of the mid-2020s. To ensure long-term stability, an expanded partnership requires a more robust, transparent framework that guarantees legislative oversight of the underlying costs and contingency arrangements.

The third risk is *cost and distributional impact*. Transitioning to a high-import, zero-emission electricity system will change the cost structure of the two utilities significantly, with implications for retail electricity tariffs. Hong Kong households and businesses already face high electricity prices by regional standards. Research on the relationship between Chinese energy costs, household welfare, and energy poverty suggests that tariff increases can have regressive distributional effects if not accompanied by targeted relief mechanisms (Li et al., 2025). A city-level equivalent of this analysis for Hong Kong has yet to be conducted systematically, and its absence represents a gap in the policy evidence base.

### The Local Renewables Question

One of the more controversial aspects of Hong Kong's Climate Action Plan is its relatively modest ambition for local renewable deployment. The government's official scenario assigns local renewables a 3–4% share of the 2035 electricity mix, rising perhaps to 7–10% under an optimistic case (HK2050isNow, 2023). Environmental advocates argue this underestimates what is technically achievable. Studies of Hong Kong's solar potential suggest that full deployment of rooftop solar on suitable buildings could supply a meaningful fraction of residential electricity demand, particularly given the city's roughly 1,800 annual hours of sunshine.

The honest answer is that both sides of this debate are partly right. The physical potential for local renewables in Hong Kong is real but genuinely constrained—not by political will alone, but by the economics of high-density urban deployment. For instance, it is very difficult to integrate photovoltaics into Hong Kong's aging public housing. Research on buildings' carbon footprint using machine learning forecasting indicates that without decisive intervention, building-sector emissions will remain stubbornly high through mid-century, underscoring the urgency of both supply-side decarbonisation and demand-side efficiency improvement (Dong & Zhang, 2023). Getting rooftop solar right in this context requires building-specific analysis, not city-level aggregates.

There is also a question of where local renewable deployment adds value beyond its direct generation

contribution. Even if rooftop solar supplies only 5% of total demand, its role in shaping consumer behaviour, building an installer and maintenance workforce, demonstrating public commitment, and generating political legitimacy for the broader transition may be disproportionately large. Following the insights of Bretschger et al. (2017), we must view energy transitions not just as engineering challenges, but as essential tools for forging social and political consensus around a sustainable future.

### The GBA Context: Regional Interdependence and Carbon Pricing

Hong Kong's energy challenge cannot be understood in isolation from the wider GBA. The nine Guangdong cities, together with Hong Kong and Macao, constitute one of the world's most economically productive urban agglomerations, with deep energy system interdependencies. Guangdong province hosts much of the manufacturing and industrial base that HK's service economy interfaces with; the China Southern Power Grid connects all eleven GBA jurisdictions; and the emissions trajectories of the GBA's industrial cities directly affect the regional air quality and carbon accounting that HK's targets reference.

From an energy economics standpoint, the most consequential unresolved question for the GBA is carbon pricing. Hong Kong currently operates only a voluntary carbon market through HKEX's Core Climate platform, launched in 2022. In contrast to Hong Kong's voluntary approach, Guangdong has mandated carbon trading since 2013, alongside a maturing national ETS in Mainland China. Research using dynamic computable general equilibrium (CGE) modelling suggests that linking Hong Kong's nascent carbon market with Shenzhen's ETS could reduce Hong Kong's abatement costs by up to 23%, while a tripartite integration including Guangdong could reduce them by as much as 38% (Zheng et al., 2025). A September 2025 MoU between HKEX and the carbon exchanges of Guangzhou, Shenzhen, and Macao signals institutional movement toward regional integration, but translating this into an operational linked market remains a major governance challenge.

The relationship between electricity import pricing and carbon pricing also deserves closer attention. Because mainland nuclear power is zero-carbon and priced via bilateral negotiations rather than market competition, it inherently excludes carbon costs. This effectively sidesteps the carbon market's ability to incentivize decarbonization within Hong Kong's electricity sector. This matters because carbon pricing is supposed to drive not just the current transition but the long-run structure of the energy system, including investment in storage, demand flexibility, and distributed generation. A system in which carbon is priced in industry and transport but not in electricity supply risks creating a fragmented and ultimately less efficient decarbonisation pathway.

## Demand-Side Challenges: Buildings, Transport, and Behavioural Change

Even the most ambitious electricity import strategy cannot achieve carbon neutrality on its own. Decarbonising supply while demand continues to grow—or fails to become more efficient—is a treadmill, not a transition. Hong Kong's buildings sector presents the starkest version of this challenge. With approximately 60% of the city's carbon emissions attributed to building energy use, and with a building stock that includes many structures built before any meaningful energy code was in place, the retrofit challenge is formidable (Dong & Zhang, 2023).

The economic incentives for building energy efficiency in Hong Kong are further complicated by the city's property market structure. Due to highly fragmented ownership, the split incentive between landlords and tenants is severe. Landlords are shielded from electricity costs, leaving them with little reason to invest in retrofits. Landlords who pay neither the electricity bills nor the maintenance costs of common areas have limited motivation to invest in upgrades; tenants who pay bills but do not own the building cannot capture the capital value of improvements. Standard economic theory suggests that addressing split incentives requires either regulatory mandates (minimum energy performance standards for rental properties), financial instruments (on-bill financing, green mortgages), or a combination of both.

The transport sector offers somewhat more tractable challenges, given the city's exceptional public transit system. Hong Kong's MTR network already runs on grid electricity and, as the grid decarbonises, will automatically reduce its emissions intensity. The remaining challenge is the private vehicle fleet and, crucially, the commercial vehicle sector—goods vehicles, buses, and taxis—which account for a disproportionate share of transport emissions and are harder to electrify quickly given charging infrastructure requirements and vehicle replacement cycles.

## Conclusion: Necessary but Not Sufficient

Hong Kong's electricity import strategy is an economically rational response to a binding structural constraint. A city of approximately 7.5 million people packed into 1,110 square kilometres cannot realistically produce the volume of low-carbon electricity it requires within its own territory, at least not at remotely competitive cost. The pragmatic embrace of mainland zero-emission power, including nuclear, reflects an honest reckoning with physical geography that some other cities, with more land and sun and wind, can afford to avoid.

Yet necessity should not be conflated with sufficiency. Three things need to happen alongside the import strategy if Hong Kong is to achieve genuine, durable carbon neutrality. First, the energy security and governance risks of deep import dependence need to be taken seriously and managed proactively—with transparent bilateral frameworks, domestic backup capacity plans, and strategic reserve arrangements. Second, demand-side decarbonisation in buildings and transport needs to accelerate

beyond its current pace, including through regulatory instruments that address split incentives and through tariff structures that send correct long-run price signals. Third, the city's integration into the GBA carbon market architecture needs to move from aspiration to operational reality, so that carbon pricing plays its proper role in shaping investment across the full economy.

The GBA's energy transition is, in aggregate, one of the most consequential and least-studied experiments in city-cluster decarbonisation underway anywhere in the world. Hong Kong, as the region's financial hub, legal anchor, and international interface, has a unique role to play in that experiment—not just as a policy subject but as a contributor of analytical capacity, governance expertise, and financial innovation. Whether it rises to that role will depend, in no small part, on whether its energy economics community—and the international community it connects to—keeps this region firmly on the research agenda.

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## Footnote

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# ASEAN Power Sector Decarbonization: Technology Options and Regional Grid Integration

BY SHENG ZHONG AND BIN SU

## Abstract

*ASEAN faces the dual challenge of meeting rapidly growing electricity demand while transitioning to a low-carbon power system. This paper synthesizes energy system modelling studies on ASEAN's pathways to deep decarbonization and net-zero by 2050. Results show that no single pathway dominates: one relies on rapid renewable expansion with battery storage, while another emphasizes CCS and low-carbon hydrogen, particularly under renewable constraints. Regional power grid integration emerges as a key enabler, reducing system costs and supporting renewable integration through cross-border electricity trade. Achieving these pathways requires coordinated transmission planning, market development, and strengthened regional cooperation.*

## 1. Introduction

The coming decades will be critical for the energy landscape of the Association of Southeast Asian Nations (ASEAN). In particular, the electricity demand of this region is projected to more than double by 2050 from the 2024 level (IEA, 2025). ASEAN countries are facing challenges in expanding their energy systems to meet energy and climate targets, such as the 2030/2035 Nationally Determined Contributions (NDCs) and long-term net-zero targets. The challenge is not only about decarbonising the energy system but also about maintaining affordability, reliability, and energy security.

This complicates the energy transition of ASEAN's power sector. ASEAN's current power generation mix remains heavily reliant on fossil fuels, accounting for about 74.4% as of 2023 (IEA, 2026), particularly coal and natural gas. Although renewable energy has expanded in recent years, particularly in countries such as Singapore and Vietnam, its contribution to ASEAN's aggregate electricity generation has remained quite stable over the past decade. Transitioning to a low-carbon power system will require not only scaling up low-carbon energy technologies but also rethinking system design, energy infrastructure, regional cooperation and benefit-sharing.

Recent energy systems modelling studies (Zhong et al., 2025, 2026) on ASEAN's power sector provide valuable insights into what such a transition would look like. Instead of relying on a single pathway, these studies highlight a range of possible pathways, each combining different technology options. In addition, implementing ASEAN's decarbonization pathway will require effective integration and coordination of

electricity markets. Regional power system integration emerges as a critical enabler of a cost-effective and reliable transition.

## 2. Options for Multiple Net-Zero Pathways in ASEAN

In addition to the 2030 NDCs, ASEAN countries have been developing the 2035 energy and climate targets. Beyond the NDCs, all ASEAN countries plan to achieve net-zero emissions (or carbon neutrality) by 2050 or later. Key energy transition strategies, particularly in the power sector, include renewable energy, regional power grids, emerging low-carbon technologies such as Carbon Capture and Storage (CCS) and hydrogen.

A key insight from recent modelling studies is that there is no single definite pathway to achieving net-zero emissions in ASEAN's power sector. Instead, different combinations of those technology options can deliver substantial emissions reductions, depending on country-specific circumstances and assumptions. The issue here lies in the costs and benefits associated with those pathways.

Each technology option faces critical barriers and challenges. Renewable energy resources are unevenly distributed across the region. With increasing adoption of variable renewable energy (e.g., solar and wind), large-scale energy storage and grid flexibility management are required. Regional power grids, e.g., the ASEAN Power Grid (APG), have been an important initiative in ASEAN, but their growth has been slow due to barriers such as cross-border coordination and information and benefit-sharing. ASEAN has significant potential for CCS, but its implementation is constrained by carbon transport and storage infrastructure, supportive regulatory frameworks, and cross-border governance (Zhong et al., 2025). Recent international conflicts in the Middle East and ongoing geopolitical uncertainties have constrained the supply of natural gas to ASEAN, with significant implications for natural gas-based CCS in the region. Hydrogen faces challenges similar to those for CCS and is associated with high costs.

For ASEAN policymakers, it is critical to design the transition pathways by considering the trade-offs of various technology options. The implication here is that flexibility and diversification can be robust strategies that enhance energy security, compared with a technology pathway that relies on a single technology. Research using energy systems modelling can provide valuable reference benchmarks.

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### 3. Net-Zero Pathways: CCS and Hydrogen vs. Renewables and Storage

At the ASEAN-wide system level, a recent study by [Zhong et al. \(2026\)](#) identifies two types of net-zero pathways, depending on the availability of renewable resources, as shown in [Figure 1](#). The first relies more heavily on CCS technologies (applied to both fossil-fuel-based generation and biomass) and on low-carbon fuels such as hydrogen. The second requires rapid deployment of renewable energy, particularly solar and wind, supported by battery energy storage systems. There are also variations of these two types of scenarios, depending on the status of regional power grids.

In the scenarios where renewable expansion is constrained, natural gas becomes the transition fuel, reducing the share of coal-fired power in the generation mix, CCS and hydrogen offer potential net-zero pathways. Natural gas with CCS can account for up to 33% in the 2050 electricity supply. Biomass with CCS further expands the range of options by enabling negative emissions, which can help offset residual emissions from those fossil fuel-based generation. In the long run, hydrogen, including low-carbon hydrogen imports from Australia, will be necessary for countries such as Brunei and Singapore, where renewable resources are limited.

Meanwhile, electricity imports could account for about 21% of ASEAN's electricity supply in 2050. Enhanced cross-border transmission can further

reduce the shares of coal-fired power and hydrogen and facilitate the development of gas-based CCS. However, given recent geopolitical conflicts in the Middle East, constraints on natural gas supply chains and fuel price volatility may pose significant challenges to such pathways.

If higher levels of renewable resources are available, the large-scale expansion of renewable energy can be a central feature of ASEAN's net-zero pathways. Solar is expected to play a dominant role (up to 55% in 2050), due to the region's favourable geographic conditions and rapidly declining technology costs. Wind power can also contribute to suitable locations (e.g., the Philippines and Vietnam).

However, the integration of variable renewable energy introduces important intermittency challenges to the system. This requires significant improvements in system flexibility. Battery storage enables excess renewable electricity to be stored and dispatched when needed. Ensuring reliability under high renewable penetration will require large-scale deployment of batteries (e.g., battery charging reaching up to 28% in 2050).

In such scenarios, electricity imports could play a larger role (reaching up to 29% in 2050). Enhanced cross-border transmission can facilitate the substitution of solar with offshore wind (e.g., in Vietnam) and reduce the need for battery storage. Similar findings have been observed in the EU system ([Zachmann, Carlos Batlle, Beude, Maurer, Morawiecka, & Roques,](#)

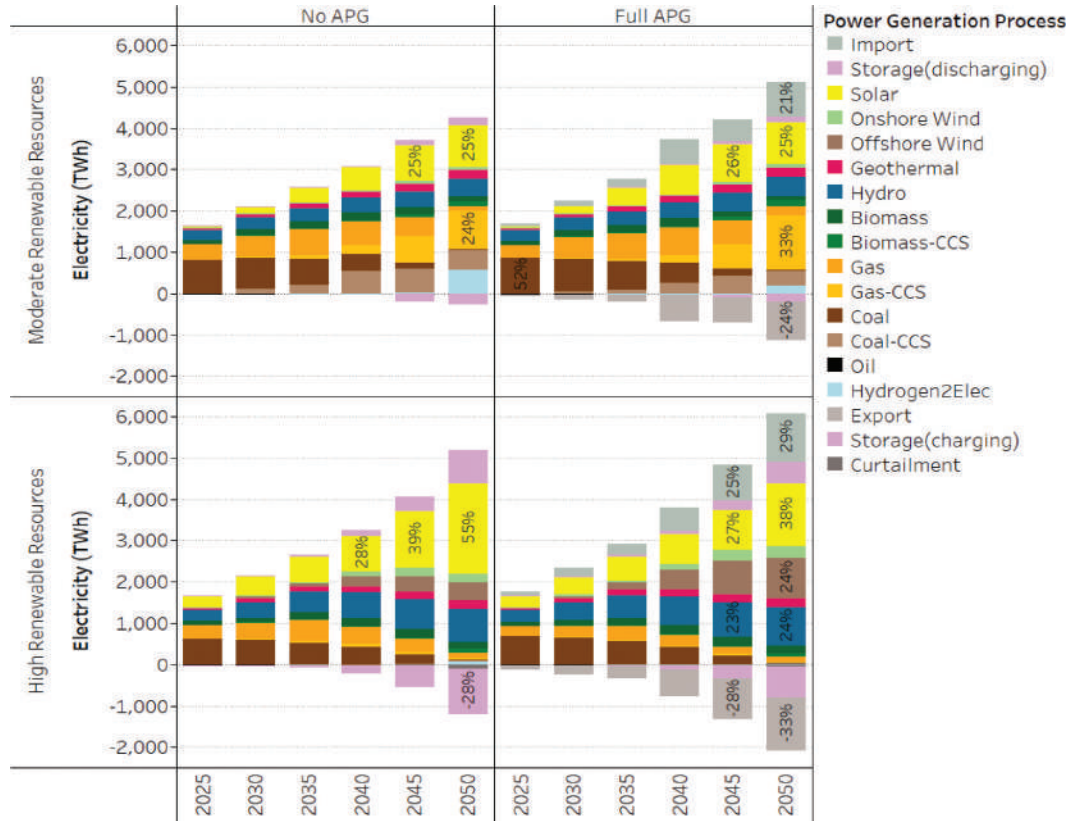


Figure 1: Electricity generation mix in ASEAN's net-zero pathways  
Source: Adapted from [Zhong et al. \(2026\)](#).

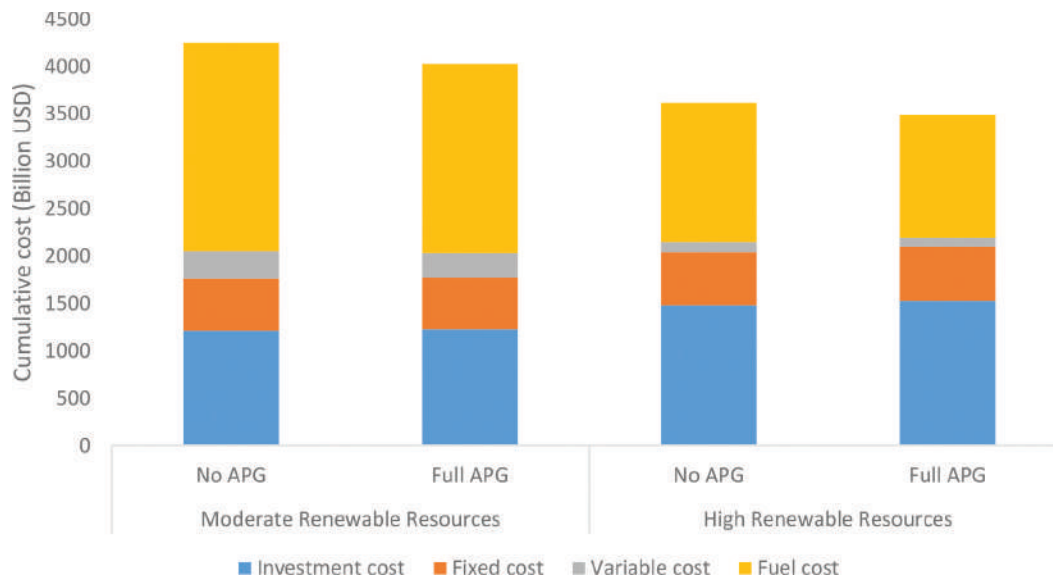


Figure 2: Cumulative energy system costs under ASEAN power sector net-zero pathways  
Source: Adapted from Zhong et al. (2026).

2024). For ASEAN, a diversified portfolio of those decarbonization options can enhance system resilience and provide greater flexibility in managing risks and uncertainties.

#### 4. The Role of Regional Power System Integration

Beyond technology choices, integrating regional power systems through the ASEAN Power Grid will play an important role in shaping ASEAN's energy transition. In this regard, regional power grids stand out as one of the most powerful enablers of a cost-effective decarbonization pathway.

The primary economic rationale is that regional integration enables a more efficient allocation of generation capacity, allowing electricity to flow from low-cost to high-cost regions (IRENA, 2022). This improves the balance between electricity supply and demand across the region. Instead of maintaining excess generation capacity to ensure reliability, enhanced electricity connectivity can enable the sharing of power system reserves across countries. Given the uneven distribution of renewable energy resources, greater electricity interconnection also allows countries to utilise these resources more efficiently. Thus, renewable generation in one country can be exported to other countries. Enhanced cross-border transmission can smooth the variability of renewable generation and serve as a form of virtual energy storage.

The figure below shows the cumulative energy system costs through 2050 for the four net-zero pathways presented in Figure 1. It highlights the effects of renewable resource availability and APG. Higher levels of renewable resources significantly reduce total system costs, primarily by lowering fuel expenditures, though they require more infrastructure investment.

Regional integration through APG can play a complementary role in achieving cost-effective decarbon-

ization. It reduces cumulative costs in both renewable scenarios by promoting cross-border electricity trade, enabling better utilisation of renewable generation and lowering fuel costs. The cost reduction from APG becomes more pronounced in the high-renewable case, with reductions of up to 18% relative to those moderate-renewable cases.

However, expanding cross-border transmission requires significant capital investment and long-term planning, while the infrastructure investment is not evenly distributed across ASEAN countries (Zhong et al., 2025). It also depends on the development of harmonized regulatory frameworks, transparent market mechanisms, and effective coordination among national grid operators. Higher levels of system flexibility and operational capabilities will be essential to ensure the stable and secure operation of the APG (Zhong et al., 2026).

#### 5. Policy Implications for ASEAN's Energy Transition

The findings from recent modelling studies on ASEAN's net-zero pathways highlight several implications for policymakers in ASEAN. First, different pathways rely on distinct technology portfolios, including renewables, storage, CCS, and hydrogen. It is therefore essential to carefully assess the trade-offs among these options.

Second, regional power system integration should remain a central part of ASEAN's energy transition strategy. Accelerating the development of the ASEAN Power Grid and enhancing cross-border market integration can unlock significant cost savings and operational benefits.

Third, supporting policy and market frameworks are critical for enabling investment and facilitating cross-border electricity trade. Clear policy signals, transparent electricity pricing mechanisms, and stable regulatory environments can facilitate the large-scale investment required for infrastructure development and long-term operation.

Finally, stronger regional cooperation is needed. Energy transition is a challenge for the whole region, requiring coordination across national boundaries. By aligning policies and technical standards, sharing information and resources, and jointly developing energy infrastructure, ASEAN countries can move toward a power system that is low-carbon, affordable, and resilient.

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# Ensuring energy security and facilitating energy transition in Vietnam: mission impossible or possible?

BY XUAN-HOA NGHIEM

IAEE Energy Forum 2026 Q1: Showcasing Hot Topics in Energy Economics in Asia-Oceania

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The Vietnamese economy is at a critical juncture in 2026 as it is undergoing the most comprehensive leadership transition while struggling to meet its double-digit growth. An indispensable component in Vietnam’s efforts to realize this goal is to meet its burgeoning energy demand without compromising the environment. Yet, Vietnam’s energy sector is riddled with shortcomings including power shortage, environmental pollution and exposure to uncertainty. This article analyzes Vietnam’s potential to achieve its ambitious goals, opportunities and challenges in the avenue to success.

## 1. Introduction

Since its Renovation (Doi Moi) in 1986, the Vietnamese economy has made significant progress, rising from a low-income to a lower-middle income economy. The 5<sup>th</sup> Vietnam’s National Party Congress set the objective of becoming an industrialized economy by 2030. Consequently, Vietnam has been shifting from an agriculture-based economy to a manufacturing-dominant and service-oriented economy, resulting in its burgeoning energy market especially huge electricity generation/consumption.

Figure 1 clearly demonstrates that no matter what the economic development/situation in Vietnam is (whether it is the AFC, GFC, COVID-19 pandemic or WTO accession in 2006), its electricity generation (and consequently, consumption) always displays an increasing trend, thus emphasizing the critical role played by energy in general and electricity in particular in the Vietnamese economy. However, as the old saying “every coin has its two sides” goes, high electricity/energy generation and consumption as well as impressive economic growth are also

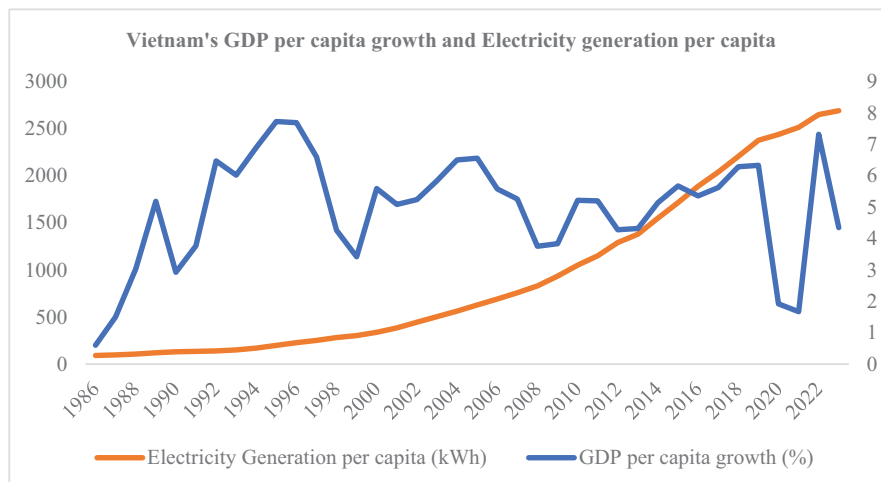
associated with certain problems such as environmental pollution, burgeoning energy demand which carry important (and probably negative) implications. Figure 1 also indicates that electricity generation growth exceeds GDP growth – which is in contrast to most major emerging economies and developed economies. Normally, advanced emerging economies (such as China) and other developed nations tend to put in place policies to reduce the electricity growth to less than GDP growth. However, Vietnam’s conservation policies have not been effective and hampered by low power prices (Dapice et al., 2022<sup>1</sup>). Dapice et al. (2022) also pointed out the paradox that even China has higher urbanization and industrialization rates than Vietnam, the growth pace of electricity consumption in Vietnam is far higher than that of China which goes against conventional thinking.

In response to these challenges, in 2018, the Vietnamese government approved the Power Development Plan 8 (PDPVIII or PDP8) setting important objectives for the 2021-2030. Yet, the implementation of this plan and the achievements of overall energy objectives are called into questions owing to recent leadership changes in Vietnam as well as geopolitical tensions in the world.

## 2. Contemporary sources of electricity production in Vietnam

### 2.1. Coal

According to official statistics, coal remains the largest single source of electricity generation in Vietnam.



Source: World Bank's World Development Indicators and Our World in Data

Although the proportion of coal-generated electricity dropped significantly in the late 1980s and early 1990s (which is probably owing to the rise in hydroelectric power), coal has re-gained its significance recently. This trend is particularly worrying especially given the emissions discharged by coal during the electricity generation process.

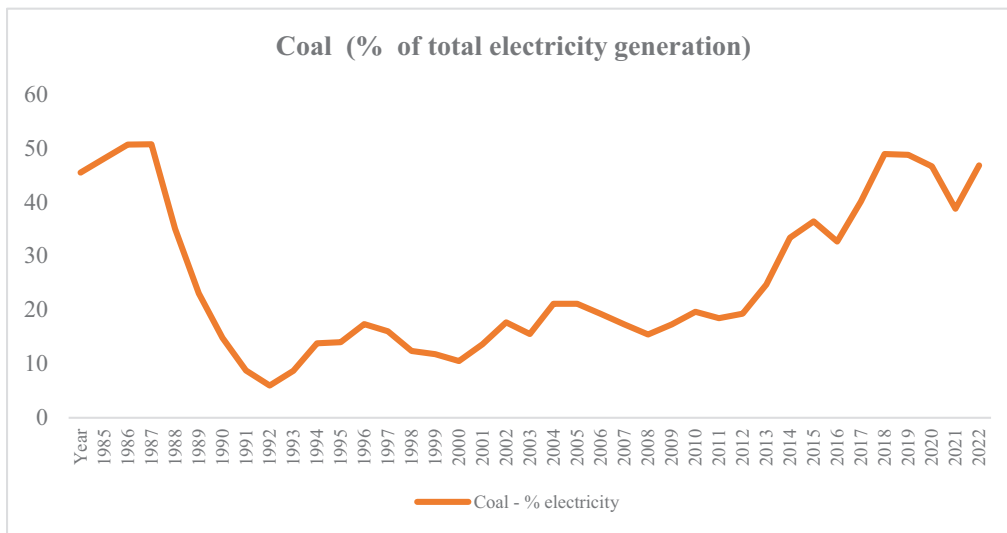
### 2.2. Hydroelectric power

Hydroelectric power has been a foundation of Vietnam's generation mix for decades, supporting low-cost power driving economic growth. Overall development in the market is relatively tapped out, and PDP VIII proj-

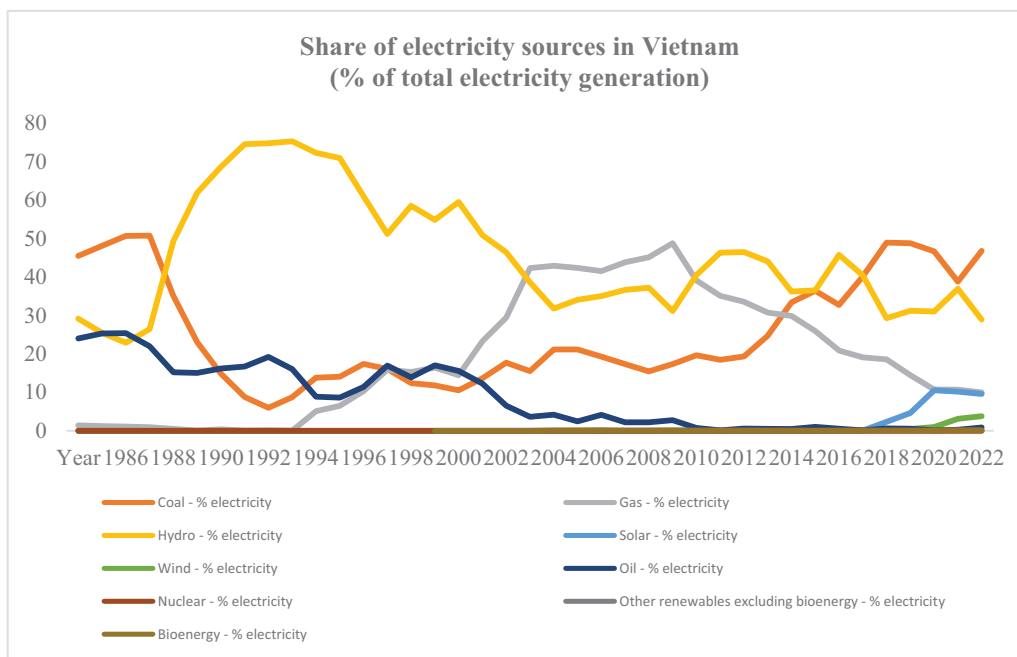
ects slow the growth to 2050, adding only 6-7 GW. As a result, hydropower is projected to reduce from 25% of total installed capacity today to less than 10% by 2050.

### 2.3. Nuclear source

In 2009, the Vietnamese National Assembly approved the construction of 2 nuclear power plants in Ninh Thuan province. However, after 7 years of preparation, this option has been temporarily ruled out due to concerns over the safety of these plants as well as lack of expertise. The use of nuclear power has also been criticized by experts. Instead, Vietnam has made the bold decision to strengthen the use of other renewable



Source: Our World in Data



Source: Our World in Data

energy sources such as wind, solar as well as enhance the energy efficiency.

#### 2.4. Photovoltaics (PV)

PV (also called solar power) has been undergoing strong growth in Vietnam. The ADB (2023) estimates that currently, Vietnam is the leading supplier of photovoltaic in ASEAN, accounting for nearly 5% of global supply. Solar power enjoyed rapid growth from 2015 to 2021, with a first wave of large, ground-mounted project development giving way to the rooftop solar boom, totaling nearly 20 GW of installed solar power.

The Power Development Plan VIII (PDP8), approved May 2023, put a strong focus on photovoltaics, specifically rooftop solar, aiming for a tepid 2.6 GW increase by 2030. Furthermore, around 50% of all buildings will be required to be equipped with rooftop solar. The Vietnam Photovoltaics market is projected to reach USD 2.86 billion by 2030 from USD 1.51 billion in 2022 growing at a CAGR of 8.30% for the forecast period between 2023 and 2030 driven by a continuously growing demand for electricity, a steep rise in investments towards the manufacturing of solar panels by the Vietnamese government, strict environmental protection regulations and reduced cost of conventional PV modules.

#### 2.5. Wind power

Wind power has grown as well to nearly 10 GW over the past eight years (in terms of electricity generation). This is expected to grow to roughly 30 GW by 2030, and over 130 GW by 2050. An ambitious element of PDP VIII is the capacity target for wind, both onshore and offshore. The PDP also mentions the establishment of two interregional renewable energy service centers. These clusters may drive renewable generation, manufacturing of equipment, and provision of related services. Yet, the plan also offers limited guidance on how or where these may be established.

Higher priority will be given to offshore wind power generation (together with other renewable energy sources). It is estimated that till 2050, Vietnam can fully meet its energy demand by utilizing wind and solar power without tapping other sources. Therefore, nuclear power, is temporarily removed from the list. However, due to the inherent uncertainties associated with wind and solar, Vietnam will also employ other energy sources such as hydrogen, LNG (Dr. Ngo Duc Lam, former Deputy Head of the Institute of Energy, former Head of the Industrial Safety Techniques and Environment Agency, Ministry of Industry and Trade).

### 3. Challenges

#### 3.1. Internal/domestic problems

Clearly, the Vietnamese electricity/energy market is riddled with several serious problems that may hinder its growth ambitions.

First, mismatch between demand and supply. Vietnam's energy demand is expected to rise by 12-15%

over the next 5 years, presenting it with significant challenges especially given that its new electricity-generation capacity still struggles to keep up with its growing demand. Northern provinces were only able to develop 3,160 MW of new generation capacity – a meager in comparison with the 10,800 MW objective stated Vietnam's PDP8. The mismatch between Vietnam's current generation capacity and its expanding demand is likely to make a bad situation even worse: the blackout risks in Vietnam. As people and businesses may still be obsessed with the severe blackouts occurring in the mid-2023 (which is estimated to cost Vietnam 0.3% of its GDP) which inflicted severe consequences on foreign corporations especially those involved in semiconductor and manufacturing<sup>2</sup>.

Second, regulatory and transmission vacuum. There exists significant bottlenecks that can seriously hamper Vietnam's progress, including regulatory/institutional bottlenecks and transmissions bottlenecks. In terms of regulatory/institutional barriers, although being priorities under the PDP8, development of offshore wind energy and battery energy storage systems has been constrained owing to lack of regulatory framework. Even when these issues are resolved and new electricity/power is generated, the delivery of electricity power to places in need is confronted with another serious threat: the insufficient, inadequate grid and transmission infrastructures. With the distance from the North to the South estimated to be 1,650 km (1,025 miles), the transmission of electricity (especially solar and wind power) from Southern provinces (those have surpluses of these energy sources) to the North is naturally difficult. Worse still, the dilapidated national grid has been depreciating which makes it unable to take on additional electricity power generated by wind and solar energy plants, thus hurting all relevant stakeholders: individuals, firms, operators and the State.

#### 3.2. External/international threats: exposure to uncertainty

The aforementioned internal problems are exacerbated by external threats, especially the current geopolitical tensions and/or conflicts occurring in the world. Clearly, the US- and Israel-led attacks on Iran and Iran's counter-measures (including its strikes on its neighbouring countries) have resulted in huge oil price volatility and supply chain disruptions. Consequently, the Vietnamese authorities were forced to frequently adjust its fuel prices as well as oil refinery products. These frequent adjustments are likely to feed into inflation and business costs.

Another threat comes from nature: as nearly 29% of Vietnam's installed power capacity is still generated by hydropower plants (as discussed in [Section 2](#) above), this reliance may pose serious threats to its energy security especially during cyclical droughts and intense dry seasons (usually happen in the middle of the year) when reservoir levels decline substantially, stripping the grid of its primary baseline power source.

## 4. Opportunities

Vietnam's desirable growth target (more than 10% annually from 2026 to 2030) is certainly accompanied by the satisfaction of its growing energy demand. Pessimistic people may argue that the ongoing geopolitical tensions and conflicts in the Middle East (and other parts of the world) would render these objectives infeasible (even an impossible mission). Yet, optimists have their own arguments to place greater trust in Vietnam's ability to attain its ambitious double-digit growth target: the desires and determination of its new generation of leaders (expected to take office in April 2026).

### 4.1. Leadership transitions

Challenges (internal and external alike) discussed above may threaten Vietnam's energy security as well as call its energy transition and zero-carbon objective into question. Corruption and bribery inherited in Vietnam's public projects may even imply a bleak scenario for Vietnam's energy security and transition, especially given the corruption scandals related to wind power and solar power projects at Vietnam's Ministry of Industry and Trade (MoIT) – the State agency responsible for electricity/energy issues.

However, recent developments in Vietnam's political arena have revived one's hopes and even investors' confidence into its electricity/energy markets outlook. The Communist Party of Vietnam (CPV) – the only ruling party in the fastest-growing economy – just wrapped up its 14<sup>th</sup> Congress in early February in which a new generation of leaders emerged. While some members of the Politburo and the Central Committee – the most powerful bodies responsible for crafting strategy and directions – are re-elected, there are new, younger leaders that are well-educated and risk-taking. Vietnam's current top leader – General Secretary To Lam – is expected to stay in power – a move carrying important implications. Originating from the Ministry of Public Security, To Lam successfully rose to the highest level in his career ladder in late 2024. At that time, as then (now late-) General Secretary Nguyen Phu Trong passed away, Mr. To Lam was elected to be CVP's No.1 leader. Since taking office, Mr. To Lam has proved to be a determined, decisive leader and even reformist. Together with the out-going Prime Minister Pham Minh Chinh, these two top leaders have adopted drastic economic measures especially in the electricity/energy market reforms.

With Mr. To Lam remains in power, it is highly likely that Vietnam will put in place stronger, more comprehensive reforms. While some businesses may feel uneasy, the upcoming new generation of leaders is expected to be technocrats with proven expertise and skills. According to their public profiles, a significant portion of newly-elected Politburo and Central Committee members have (at least) one of their degrees (either undergraduate or postgraduate) obtained from abroad, arousing expectations among the public and investors that these new leaders are more open-minded, well-educated, less prone to corruption and more

risk-taking and willing to take bolder reforms. More importantly, the likely candidate for the post of Prime Minister has experiences in handling economic issues – which bode well for the Vietnamese economy in general and its electricity/energy markets in particular.

The new Prime Minister and other ministers will officially be voted/confirmed/approved by the Vietnam's National Assembly in early April. However, recent personnel developments/rotations/reshuffling do bode well for a promising outlook in Vietnam. The determination of the top leaders, together with knowledge, experiences and skills of other high-ranking officials can help accelerate the Vietnamese economy and its electricity/energy.

### 4.2. Strong attractiveness to investors

In spite of formidable challenges, the expectations on the upcoming generation of leaders may present lucrative opportunities in the Vietnamese economy in general and electricity/energy market in particular, thus arousing interests from foreign investors. For example, in response to its potential, a number of foreign power corporations have been heavily investing in the Vietnamese photovoltaic market. They are, to name but a few, the U.S.'s First Solar (has been operating since 2011), Canada-invested Vina Solar (has been operating since 2014), China-invested HT Solar (newly established in 2024), China-invested Trina Solar (established in 2016 and ended in 2023), China-invested Ja Solar (has been operating since 2016), local firm Irex Solar (has been operating since 2012), and a few others. The products and services provided by these companies are offered both for local use and exports. However, the shares of each component are unavailable to the public.

In August 2023, Boway, a leading Chinese business signed an agreement to lease 20 hectares of land in Hai Duong's Cong Hoa Industrial Park for project development to build a factory for manufacturing photovoltaic panels, solar energy conversion modules, high-tech alloy strip plates. This project is projected to be worth \$350 million. In June 2023, Vietnamese private conglomerate Damsan's AD Green launched a \$45 million, 3-gigawatt 8 hectares factory in Ninh industrial complex, Thai Binh province, northern Vietnam, manufacturing solar panels for domestic and overseas markets.

In November 2022, Phu Tho province awarded an investment certificate for a \$200-million solar cell factory to Japanese-invested Vietnam Sunergy JSC that will be built in 2023. The 13-hectare project at the Cam Khe industrial park will employ 700 people and use eco-friendly technology.

JinkoSolar, one of the world's top makers of solar modules, has 12 production facilities globally, including two in Vietnam. Both are located in northern Quang Ninh province's Song Khoai Industrial Park (IP), developed by Thailand's Amata Corp. U.S. major First Solar operates three production sites globally, including one in Ho Chi Minh City. The corporation has invested \$830 million in two manufacturing facilities in Dong Nam Industrial Park of Cu Chi district, home to the Tunnels

of Cu Chi, a very popular destination among international tourists.

### 5. Some final thoughts

The above discussions point out the fact that Vietnam is being confronted with significant challenges in ensuring energy security and facilitating energy transition, especially given external threats and internal weaknesses. Yet, the emergence of new leaders in April 2026 is expected to create more momentum for the Vietnamese economy in general and its energy market in particular. New leaders are recommended to tackle regulatory/institutional bottlenecks as well as improve electricity/energy market infrastructure to attract new investors. More importantly, to successfully develop and implement sustainable electricity/energy strategies, high-quality human capital is a must. Given the complexity in the electricity/energy market, it is strongly recommended

that relevant authorities adopt different measures to encourage talented students to pursue majors their majors and careers related to electricity/energy.

To sum up, in spite of certain drawbacks and/or challenges (internal and external alike), expectations are running high on the Vietnamese economy in general and the Vietnamese electricity/energy market. Provided that the relevant authorities and leaders take appropriate, decisive actions, the energy security issue can be guaranteed and energy transition can be resolved successfully.

### Footnotes

<sup>1</sup> Dapice, D., Le, P. V. & Le, T.-H. 2022. Phase change: getting to a sustainable energy future in Vietnam. Handbook of Energy and Environmental Security. Elsevier.

<sup>2</sup> World Bank's estimates which can be accessed at <https://www.asiafinancial.com/vietnam-asks-foxconn-others-to-cut-power-use-to-avert-blackouts>

# AI-Driven Energy Transition: Development Trends and Future Prospects in the Asia-Pacific Region

BY YU SONG, QIANG JI, XUNPENG SHI, AND YING FAN

## Abstract

*Against the dual backdrop of global climate change mitigation and digital-intelligent transformation, artificial intelligence (AI) has deeply penetrated the entire chain of energy transition. It has demonstrated remarkable strengths in renewable energy power forecasting and integration, intelligent dispatch and safety management and control of new power systems, end-use energy efficiency optimization and demand-side response, and full-life-cycle intelligent operation and maintenance of energy infrastructure. From the perspective of regional practices, countries in the Asia-Pacific region have significant differences in energy endowments, development stages, power grid fundamentals, and transition targets, which have given rise to four typical application paradigms of AI-enabled energy transition: resource-rich, resource-scarce, transition-leading, and emerging market-oriented. Looking ahead, with the increasing maturity of cutting-edge technologies such as large language models and digital twins, AI is expected to inject new momentum into advancing a more resilient and sustainable energy transition in the Asia-Pacific region.*

## 1. AI Has Fully Penetrated the Entire Process of Energy Transition

The global energy transition is at a critical stage of leaping from traditional fossil fuels to a clean, low-carbon, safe, and efficient new energy system. Driven by the dual goals of addressing climate change and ensuring energy security, AI has emerged as a core enabling technology for advancing the energy transition. It has deeply penetrated all links of the full life cycle of the energy system, becoming an irreplaceable core driving force for the energy transition.

AI has achieved full coverage across the entire chain of the energy transition. In the upstream link, AI facilitates refined assessment of wind and solar resources and intelligent exploration of oil and gas resources, drastically improving the efficiency of energy development. In the midstream link, AI supports intelligent regulation of power production, optimization of power grid transmission and distribution, and fault early warning, ensuring the safe and efficient transmission of energy. In the downstream link, AI enables end-use energy optimization and collaborative dispatch of virtual power plants, unlocking the transition potential on the demand side. In addition, AI supports intelligent accounting and verification of carbon emissions throughout the entire chain, providing technical support for quantifying the effectiveness of the transition.

In April 2025, the International Energy Agency (IEA) stated in its Energy and Artificial Intelligence report that

“energy companies have begun to use artificial intelligence to transform and optimize energy and mineral supply, power generation and transmission, and energy consumption” (IEA, 2025). These initiatives can deliver huge efficiency and operational benefits to the energy industry and significantly reduce the technical and economic costs of the energy transition. At present, all major global economies have incorporated “AI + Energy” into the core strategic layout of their energy transition. The deep integration of AI technology iteration and energy scenarios is continuously reshaping the operating logic of the energy system, providing core support for the efficient, safe, and low-cost advancement of the global energy transition.

## 2. Core Application Scenarios and Remarkable Advantages of AI-Driven Energy Transition

The deep integration of AI and energy scenarios has formed a multi-dimensional, widely covered mature application system, demonstrating unparalleled advantages over traditional technologies in the core links of the energy transition. The core application scenarios are concentrated in four major directions, providing all-round support for the implementation of the energy transition.

First, renewable energy power forecasting and integration. Based on dynamic artificial neural network forecasting methods, it is possible to accurately predict the power generation of renewable energy such as solar energy under variable weather conditions (Bozkurt et al., 2022; Gul et al., 2025). This greatly mitigates the impact of the intermittency and volatility of wind and solar power output on the power grid, significantly improves the grid integration and consumption capacity of renewable energy, and addresses the core pain point of large-scale application of clean energy.

Second, intelligent dispatch and safety management and control of new power systems. AI can realize collaborative and optimized dispatch of multiple entities including generation, grid, load, and energy storage, providing new methods and tools for intelligent safety management of power systems with a high proportion of grid-connected renewable energy (Luo et al., 2025). Meanwhile, real-time big data monitoring enables equipment health inspection, extreme weather

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forecasting, and cybersecurity protection, ensuring the safe and stable operation of the power system during the transition process.

Third, end-use energy efficiency optimization and demand-side response. By integrating machine learning, the Internet of Things, and big data technologies, AI conducts real-time data collection and intelligent analysis of end-use energy scenarios such as buildings, transportation, and commerce, to realize collaborative dispatch of multiple energy sources. It achieves an energy demand forecasting error rate of less than 10% and an improvement in comprehensive energy efficiency of over 20%, facilitating the low-carbon transition of end-use energy (Mehmood et al., 2019; Runge & Saloux, 2023; Yan et al., 2024; Fu et al., 2025; Ghosh et al., 2025). At the same time, it supports the implementation of new models such as virtual power plants and demand-side response, unlocking the potential of demand-side resources to participate in the transition.

Fourth, full-life-cycle intelligent operation and maintenance of energy infrastructure. Through technologies such as machine vision and digital twins, AI realizes intelligent inspection and fault prediction of facilities such as oil and gas pipelines, wind turbine towers, and photovoltaic modules. It greatly improves the accuracy of defect detection (Zheng et al., 2022; Liu et al., 2022; Lu & Cheng, 2025), extends the service life of equipment, and reduces the infrastructure investment cost of the energy transition.

Overall, the core advantage of AI-driven energy transition lies in its ability to solve the uncertainty and complexity challenges in the energy transition through data-driven intelligent decision-making, while balancing the triple goals of low-carbon transition, secure energy supply, and cost control. It provides solid technical support for the large-scale and sustainable advancement of the energy transition.

### 3. Progress and Application Characteristics of AI-Driven Energy Transition in the Asia-Pacific Region

The Asia-Pacific region is the core growth pole of the global energy transition, accounting for more than half of the world's newly installed renewable energy capacity. It is also one of the most active regions in the world for AI technology R&D and scenario implementation. Driven by the dual needs of addressing climate change and ensuring regional energy security, major economies in the Asia-Pacific region have taken AI technology as the core means for promoting the low-carbon energy transition, and formed a differentiated development pattern of AI-enabled energy transition based on their own energy resource endowments, industrial foundations, and carbon neutrality targets.

#### 3.1 Resource-Rich Paradigm

Representative countries include Australia, Malaysia, Indonesia, and others. These countries boast world-leading solar and wind energy resources, providing superior natural conditions for the large-scale development of wind-solar power generation and green hydro-

gen industry. The core focus of AI applications is the deep integration of renewable resources and intelligent dispatch. The Nullagine Wind Power Project in Australia uses EN182-7.8MW Galileo AI wind turbines equipped with the Envision Tianshu Energy Large Model and Envision Tianji Meteorological Large Model, which can coordinate renewable energy power generation, energy storage, grid dispatch, and energy demand in real time to achieve efficient grid integration and consumption of wind power. China's Tianneng Group, in cooperation with VCI Global Limited (VCI), is building a 1GWh photovoltaic energy storage power station in Malacca, Malaysia, which uses AI technology for energy dispatch to provide stable, efficient, zero-carbon power exclusively for AI data centers (AIDCs), realizing on-site consumption of green electricity.

#### 3.2 Resource-Scarce Paradigm

Representative countries include Japan, Singapore, and others. These countries have an extremely high external dependence on fossil energy. Under the hard constraint of inherent insufficient resource endowments, they use AI technology to simultaneously achieve "throttling" (energy efficiency improvement) and "source expansion" (distributed collaboration). They use the digital-intelligent transformation of the energy system to hedge against geopolitical risks, and ultimately advance the low-carbon transition while ensuring energy security. In March 2026, Japan's Ministry of Economy, Trade and Industry (METI) released the Guidelines for Energy Conservation and Productivity Improvement through Digital and AI Technologies, which systematically encourages the manufacturing industry to introduce AI technology to replace traditional energy conservation measures. In November 2025, Univers and Singapore's SP Group announced a partnership to advance a virtual power plant (VPP) pilot project under the regulatory sandbox framework of the Energy Market Authority (EMA) of Singapore. The VPP platform will aggregate distributed energy assets and use AI to provide grid services such as frequency regulation, reserve capacity, and energy balancing.

#### 3.3 Transition-Leading Paradigm

Representative countries include China, South Korea, and others. These countries are the core forces of manufacturing and technological innovation in the Asia-Pacific region, and are undergoing a systematic and structural transition from a high-carbon energy structure to a low-carbon and green energy system. AI applications cover the entire industrial chain of the energy sector, focusing on the construction of new power systems and decarbonization of all links. China is currently the country with the richest application scenarios and the largest data scale for AI+Energy in the world. China Energy Investment Corporation has built Qingyuan, the world's first hundred-billion-parameter large model for the power generation industry, which has established an intelligent decision-making system

covering the entire chain of power trading, production and dispatch hub, equipment maintenance, and safety management. It has driven the transformation of the energy industry from “experience-driven” to “data-driven”, injecting strong intelligent momentum into the safe, efficient, and green development of the energy and power industry. Relying on its advantages in the semiconductor industry, South Korea promotes the systematic integration of AI, hydrogen energy, and robotics technologies to build a next-generation energy industrial ecosystem.

### 3.4 Emerging Market-Oriented Paradigm

Representative countries include Vietnam, India, the Philippines, and others. These countries are in a period of rapid economic growth and the initial stage of energy transition, with relatively weak power grid infrastructure, widespread uneven power access quality, and high line loss rates. AI applications focus on improving power grid stability and optimizing the efficiency of basic operation and maintenance. Tata Consulting Engineers has commissioned India's first 400kV dynamic line rating project for India's power grid transmission lines, which adopts a real-time AI-driven approach to improve the integration of renewable energy, optimize existing grid assets, and enhance operational reliability. Vietnam has partnered with CapitalLand Group to use digital technology, AI, and machine learning to enable real-time remote monitoring and optimization of energy supply, refrigeration, decarbonization, and intelligent energy management, allowing enterprises to enjoy significant energy savings without large upfront investments.

## 4. Future Expansion Directions and Risk Challenges of AI-Supported Energy Transition

The Asia-Pacific region has become the world's largest and fastest-growing region for clean energy development, leading the global energy transition process. As the core technology for digital empowerment, AI is deeply penetrating from single-point pilots to the entire industrial chain of the energy sector, providing core driving force for the low-carbon energy transition in the Asia-Pacific region. At the same time, it is accompanied by regional and systematic risk challenges.

In terms of technology expansion directions, AI applications present three core evolutionary trends. First, solving the challenge of high-proportion renewable energy integration. Aiming at the pain points of uneven spatial and temporal distribution of wind and solar resources and large differences in grid interconnection levels in the Asia-Pacific region, AI can realize ultra-short-term accurate forecasting of wind and solar power, collaborative intelligent dispatch of generation, grid, load, and energy storage, and support large-scale aggregation of distributed energy virtual power plants, to suppress the volatility and intermittency of renewable energy. Second, enabling full-chain energy efficiency improvement and low-carbon management and control. Relying on the huge manufacturing volume in

the Asia-Pacific region, AI can realize dynamic optimization of energy efficiency and full-process carbon footprint traceability in high energy-consuming fields such as industry and buildings, while accelerating the process iteration and cost reduction of emerging low-carbon technologies such as hydrogen energy and Carbon Capture, Utilization and Storage (CCUS). Third, strengthening regional energy security early warning. In response to the intensifying energy geopolitical games and prominent supply chain vulnerabilities in the Asia-Pacific region, AI can realize fault prediction of energy infrastructure and advanced early warning of energy price and supply chain risks.

In terms of risk challenges, the first is data governance and sovereignty risks. There are significant differences in data regulations among countries in the Asia-Pacific region, core energy data is highly classified, and barriers to cross-border flow coexist with data silos. Most developing economies have a weak digital foundation, which cannot support the large-scale implementation of AI. Second is system security and algorithm risks. As critical infrastructure, the energy system faces potential systemic safety accidents caused by the black-box characteristics of AI algorithms, insufficient robustness in extreme scenarios, superimposed with cyber attack risks. Finally, the risk of unbalanced regional development. There is a significant digital divide within the Asia-Pacific region. Core AI computing power and algorithms are highly concentrated in a few developed economies, and developing countries are prone to fall into technological dependence. Meanwhile, the replacement of traditional jobs by AI may trigger regional employment structure imbalances.

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# Tectonic changes in the global oil market? A tale of three wars

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**Summary:** Our data analysis reveals that the 2022 oil sanctions on Russia failed to reward Saudi Arabia's economy, but boosted the valuations of U.S. shale energy companies. The 2022 novelty versus the early 1990s is the winner of geopolitical risk being the sanction-imposing country, a scenario that highlights the need to reform the global governance of strategic markets. The need for this reform has been further exacerbated by the repercussions of the 2026 US-Israel-Iran war that are choking the global economy, as Iran responds by halting shipments through the Strait of Hormuz. *This note focuses on the economic implications of geopolitical tension pertaining to oil markets. Political considerations are beyond the scope of our research.*

## 1. The 1990s Gulf and 2022 Russia-Ukraine wars

### 1.1. Context

Saudi Arabia, Russia, and the United States (U.S.) are currently the three largest crude oil producers worldwide. Given that Russia has been under sanctions, a natural question is: which major oil producer, if any, was the ultimate winner of the geopolitical events associated with the 2022 Russia-Ukraine conflict?

To address this question, this section juxtaposes oil market conditions in the early 1990s and 2022 to highlight the geopolitical implications of the expansion of the U.S. shale energy sector, and of the Russia-Ukraine war, on the relative positioning of the major crude oil-producing countries. We contextualize our discussion around Saudi Arabia's evolving relationships with Russia and the U.S.

### 1.2. Evolving relationships

The U.S.-Saudi relationship dates back to the 1930s and is based on mutual interests: energy security, military cooperation, and regional stability (Miller, 2017). Although this relationship continued through the Cold War and its aftermath, the balance of power has changed in recent years for several reasons. First, the expansion of the U.S. shale oil industry impacted Saudi Arabia's preeminence in the global oil market. Second, geopolitical tensions—including the decline in U.S. strategic engagement with the Middle East—contributed to global oil market instability and incentivized new alliances. Specifically, OPEC, led by Saudi Arabia, formed a strategic partnership with Russia and issued the 2016 Declaration of Cooperation. With Saudi Arabia building closer economic ties with Russia (and China), its foreign policy has become more independent from the U.S. It can be expected that the Kingdom of Saudi Arabia (KSA) will be unwilling to let the U.S.'s political aspirations influence its economic decisions in future years.

The 2022 geopolitical events brought to the forefront these new dynamics in the U.S.-Saudi relationship. When oil prices spiked, causing severe gasoline inflation, the U.S. administration attempted to exert its influence on the Kingdom to increase oil output. However, in July 2022, Biden's diplomatic visit to the KSA did not result in a sustained commitment to increase production. In fact, OPEC+ countries adjusted production based on their assessment of global demand, recessionary fears, tight monetary policies, rising inflation, and increased uncertainty. Naturally, the OPEC stance was a disappointment for the U.S. administration, which described OPEC's decisions as short-sighted and as an act of support for Russia.

**The litmus test of whether the U.S. administration was justified in finding political ill will in Saudi Arabia's decision not to increase production is whether the Kingdom was a winner of the 2022 geopolitical events, as it had been in the early 1990s.**

### 1.3. Saudi Arabia

In the early 1990s, the KSA ascended to the influential role of the lone swing producer in the global oil market by filling the output gap left by competitors displaced by sanctions and war (Iraq) or internal collapse (Soviet Union). Successive crises (e.g., the invasion of Iraq in 2003) solidified Saudi Arabia's reputation as the "guardian of global oil markets" and the lone winner of geopolitical instability. As a result, oil market investors grew accustomed to expecting that OPEC would answer the markets' "call on OPEC" with stabilizing production decisions.

Given these historical precedents, it could have been reasonable to expect that the 2022 Russia-Ukraine conflict and the associated sanctions on Russian oil exports would benefit Saudi Arabia. However, the 2022 crisis resulted in a new regime in which extreme oil backwardation failed to reward Saudi competitiveness. The underlying causes for the emergence of this new regime can be understood by comparing the Saudi position and global oil market conditions in the early 1990s to those in 2022.

In the late 1980s, Saudi Arabia had invested heavily in boosting oil production capacity and was therefore ready, when the crisis struck in the early 1990s, to acquire displaced competitors' market share. In contrast, since the pandemic, a global acceleration toward energy transition has incentivized the Kingdom to diversify its investments from expanding oil production capacity to the development of strong renewable

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energy and finance sectors. For instance, renewables, utilities, metals, and mining are among the 13 strategic sectors of the Saudi Arabia Public Investment Fund (PIF). Apparently, the Kingdom's current strategy is to hedge both long-term challenges associated with energy transition and short-term disruptions such as those brought about by the recent pandemic. Consistently, in January 2024, Saudi Arabia shelved the previously pledged crude oil production capacity expansion plan to devote funds to finance economic and energy-mix diversification. These diversification efforts have been successful, as Saudi competitiveness is no longer driven primarily by oil exports.

The U.S. monetary policy in 1990 was accommodative in response to early signs of economic weakness in 1989. Expansionary policies extended to the early 1990s, with the policy rate stabilizing at low levels. A weakened U.S. dollar positively affected Saudi Arabia's international competitiveness through the peg. In contrast, in 2022, the Federal Reserve held elevated rates to stave off post-pandemic inflation, which was exacerbated by the impact of the sanctions on Russian oil exports. The implied increase in global capital rates negatively affected the Kingdom's competitiveness, as Saudi Arabia's diversification strategy takes the form of capital-intensive mega-projects. In this sense, the 2022 oil crisis may have exposed a new vulnerability of the KSA to the dynamics of the global capital market.

Additionally, in 2022, Saudi Arabia was understandably unwilling to take a stance against Russia, as the Kingdom had to be careful not to be seen as betraying the spirit of the 2016 Declaration of Cooperation. In this context, Saudi Arabia might have opted against major production increases during the extreme backwardation regime in 2022 to protect the integrity of a diplomatic mechanism designed to ensure stability in the global oil market.

In addition to diplomatic considerations, Saudi Arabia's ability to pacify the hyper-backwardation of 2022 might have been constrained by strained spare capacity driven by untamed global demand, coupled with global supply uncertainty amid the war and sanctions. By early August 2022, OPEC+ warned that strained spare capacity levels were to be utilized with caution.

#### 1.4. U.S. Shale energy sector

In 2025, the U.S. administration founded the Energy Dominance Council and announced a national energy emergency, while emphasizing the importance of cooperation with international allies and domestic investors to achieve energy independence and national security. Naturally, a well-functioning shale energy sector is pivotal to this strategy. From an international perspective, the U.S. shale sector has become vital to the global oil market, as domestic policies and global geopolitical risks affecting it have repercussions beyond the U.S. economy.<sup>1</sup> Therefore, understanding which market forces sustain the expansion of the U.S. shale industry becomes crucial to devising appropriate domestic energy policies in the context of global oil market dynamics.

[Galvani and Razek \(2026\)](#) examines the impact of domestic industry conditions, market risk, monetary policy, and global geopolitical tensions on the profitability of the U.S. shale sector. We focus our discussion, in this note, on the latter.

[Galvani and Razek \(2026\)](#) documents that the U.S. shale sector, unlike Saudi Arabia, benefited from the 2022 geopolitical events and the associated sanctions on Russian crude exports. Specifically, the valuations of U.S. shale energy companies surged amid the extreme oil backwardation regime caused by the Russia-Ukraine conflict. These findings are robust to the use of a variety of geopolitical risk measures, including news-based indicators from [Caldara and Iacoviello \(2018\)](#), such as the threat-based geopolitical risk index (GPRT), which responds to threats rather than actions on a global level, and the GPR combined index of threats and actions for each of Russia, Saudi Arabia, Israel, Egypt, and Turkey, as well as the Strait of Hormuz and Mediterranean regions. To capture different aspects of geopolitical risk, Galvani and Razek also rely on the drawdown of the U.S. Strategic Petroleum Reserve (SPR) and on global arms trade as policy-based and trade-based indicators of geopolitical risk, respectively. Furthermore, following [Razek et al. \(2025\)](#), they also employ a price-based measure, namely the Brent-Urals percentage spread, which captures the oil risk premium for Russia's oil exports, as a proxy for the 2022 sanctions. Additionally, they account for a global oil risk measure that reflects European investors' hedging activities amid the war. All the results consistently point to U.S. shale investors benefiting from the Russia-Ukraine conflict.<sup>2</sup>

Contrasting the findings in [Razek and McQuinn \(2021\)](#), [Razek et al. \(2025, 2023\)](#), and [Galvani and Razek \(2026\)](#), we conclude that **although the 2022 geopolitical events were detrimental or, at best, neutral to Saudi Arabia, they were advantageous to the U.S. shale energy stakeholders.**

#### 1.5. A reconfiguration of the global oil market

An unexpected immediate impact of the Russia-Ukraine war was the pervasive sense of panic among oil traders as **the U.S. and the KSA seemed unable to manage the sanctions' fallout and counter the impact of the geopolitical shock on oil trade flows and prices.** For instance, the U.S. enacted aggressive policies, such as the massive SPR draw-down, to control the inflationary pressure associated with the 2022 oil price spike. Not only did these interventions fail to calm the global oil market, but they may even have backfired, stoking fears of depleting oil supply buffers. Further, the Russia-Ukraine war may have ushered a new regime in which markets' "call on OPEC" might go unanswered, as the KSA couldn't, due to strategic reasons or to depleted spare capacity, increase oil production when the market entered an extreme backwardation regime. **Put differently, the analysis of the 2022 events suggests that extreme backwardation regimes might become more frequent in the coming years, due to depleted oil buffers, diversification efforts, and changes in political alliances and power dynamics**

among major oil producers. Only the years to come will reveal how the global oil market will reconfigure (Razek et al. 2023).

## 2. The 2026 U.S.-Israel-Iran war

From another perspective, the 2022 geopolitical tensions triggered a rise in Saudi Arabia's military expenditure, as shown in Razek et al. (2025). This study argues that this reaction of the KSA could be explained by perceived risks associated with a likely deepening of military cooperation between Iran and Russia, a threatening scenario for the region. While Razek et al. (2025) did not foresee the 2026 U.S.-Israel-Iran war, the authors cautioned that the 2022 events could feed into the geopolitical tensions in the Middle East, with detrimental repercussions for the global economy.

Galvani and Razek's (2026) results may suggest that the U.S. shale oil sector might be once more one of the winners of the 2026 geopolitical shocks in the Middle East. However, Russia's Urals oil has been sold at a premium since early March 2026, for the first time since 2022. The extent to which Russia is going to capitalize on the oil price increase will depend on the modifications to the sanction regime that the global crude oil shortfall will impose, should the U.S.-Israel-Iran war continue for an extended period of time. The U.S. shale energy sector's long-term gains and, in general, the future of global energy markets will likely be influenced by the acceleration, magnitude, and direction of the global economic fragmentation and multi-polarization in the aftermath of this 2026 war.

While Galvani and Razek (2026) did not foresee the 2026 war, the authors raised a concern that the 2022 U.S. sanctions on Russia were imposed outside the UN framework, thus setting a precedent for the violation of international laws by others. Fast forward to 2026, and this scenario appears to have been realized. On the one hand, D'Alessandra (2026) and Kawser (2026) consider the U.S.-Israeli attack on Iran as a violation of the UN's Charter's Article 2(4). On the other hand, Iran's closure of the Strait of Hormuz could be considered a violation of the United Nations Convention on the Law of the Sea (UNCLOS) (United Nation, 1982).<sup>3</sup>

**Regardless of who wins the 2026 war, the global economy stands to further lose from the weakening of the governance framework that previously allowed strategic markets to grow and from the resulting energy crisis.**

## 3. Concluding remarks

While the geopolitical events of 2022 and the associated sanctions identified winners and losers, with the U.S. shale sector increasing in value, Russia losing the European market, and Saudi Arabia's competitiveness deteriorating, the ultimate effect was a negative shock to the global economy.

Empirically examining the dynamics underpinning these paradigm shifts yields two policy-oriented considerations. These considerations apply to all strategic markets, as governments face challenges related to climate change and energy security.

The first consideration comes from comparing the political frameworks for sanctions on oil exports in the early 1990s and in 2022. The earlier sanctions were imposed within the U.N. framework, with the U.S. being a large importer of crude oil. In contrast, the 2022 sanctions on Russia were enacted outside the U.N. framework due to Russia's veto power, with the U.S.'s interests being those of a large exporter. That a war involving a major oil-producing country may benefit its competitors is not unprecedented, as evidenced by Saudi Arabia's evolution into a global market power. However, it is unusual for a country that imposes international oil sanctions to be a major global crude exporter. From this perspective, **the 2022 sanctions could appear as economic penalties against a major U.S. competitor in the global oil market. This intervention sets a precedent that could be exploited by other countries, highlighting the need for a discussion on global governance to stabilize globally strategic markets.**

The second consideration is based on the recognition that even powerful and rich countries struggle to counter the adverse impact of geopolitical shocks affecting energy markets in the absence of cooperation. Therefore, **the prosperity of the global economy requires the development of solid agreements among major energy producers to ensure global energy security.**

The coming months will reveal the real winners and losers of the 2026 U.S.-Israel-Iran war. What is clear already is that the war is a massive shock to the global oil supply which is detrimental for the global economy at least in the short run. Hence, **the 2026 scenario makes the case for reforming the global governance of strategic resource markets and for the necessity of robust supply agreements even more compelling.**

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## Footnotes

<sup>1</sup> Prior to the expansion of the U.S. shale sector, geopolitical events affecting the KSA and the Strait of Hormuz raised concerns about

potential supply disruptions that could trigger oil price spikes. The expansion of the U.S. shale sector may have alleviated those concerns in recent years, as record production highs grounded traders' consensus of a well-supplied market. These expectations explain the short-lived oil price spikes following geopolitical tensions in the Middle East in 2017-2019 and 2025.

<sup>2</sup> That the geopolitical events increasing the valuations of shale energy companies are indeed those associated with the Russia-Ukraine conflict is demonstrated by the irrelevance of the measures of geopolitical tensions of the other countries, and by subsample analysis. Galvani and Razek (2026) studied a sample that ended in 2025.

<sup>3</sup> Although Iran signed the 1982 UNCLOS, Tehran has never ratified it (United Nations Treaty Collection, n.d.) due to the country's concerns over the passage of warships (Bagheri, 2015).