APEC POLICY SUPPORT UNIT
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Using AI to Power Up Efficient and Resilient Energy Systems

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KEY MESSAGES

- **Artificial intelligence (AI) can be a transformative tool for advancing more resilient, efficient and smarter energy systems.** AI can enhance grid forecasting, optimisation and situational awareness while improving demand management. It strengthens energy security by boosting efficiency in energy-intensive sectors and supporting the development of secure supply chains. Integrating AI into energy and infrastructure planning and policy can bolster energy reliability, affordability and system flexibility.

- **AI must be human-centred, explainable and premised on the goal of providing universal, affordable, clean and reliable power.** Responsible AI integration calls for regional capacity building at both technical and decision-making levels. Economies need to ensure that AI tools reflect diverse system realities and avoid 'techno-solutionism'. Coordinated policies through standard-setting, innovation funding and cross-sector collaboration can support accessible deployment for all.

- **Develop regional governance standards for trustworthy AI.** Harmonised AI policy frameworks across APEC will ensure scalability, interoperability and trust. Shared benchmarks for transparency, explainability and accountability are vital to safeguard system reliability and build confidence in AI deployment across critical energy infrastructure. APEC economies could jointly develop regional standards or adopt existing international standards for trustworthy AI in energy to avoid fragmented governance.

- **Cooperate on data governance and interoperability.** As energy systems become increasingly digital, high-quality, real-time data is foundational. Addressing gaps in data infrastructure, interoperability and cybersecurity could enable scalable AI deployment. A coordinated regional approach to digital governance and open data frameworks may offer significant benefits.

- **Start small, learn fast through pilot programs and sandboxes.** Economies can initiate regulatory sandboxes and joint pilot programs to safely encourage innovation and experimentation. A progressive approach starting with low-risk AI applications can help build confidence, test solutions in real-world conditions and promote regional knowledge exchange.

- **Coordinate on workforce development and capacity building.** Given current cross-sectoral skills gaps, economies need to ensure human capacity development across working and policy levels. Enhancing energy-AI literacy can support more informed and context-appropriate applications of AI in complex decision-making environments. Training programs could focus on developing 'AI translators' who combine knowledge of AI, energy systems, and policy.

Introduction

APEC economies are navigating a period of rapid transformation in their energy systems. Rising electricity demand (Figure 1), greater system complexity and growing reliance on variable energy sources are reshaping the way energy is generated, managed and consumed across the region. At the same time, increased exposure to extreme weather events and infrastructure constraints are putting pressure on energy reliability, resilience and planning capacity.[1]

Simultaneously, APEC's collective energy targets to double the share of modern renewables in the energy mix by 2030 (relative to 2010 levels)[2] are reshaping energy systems across the region. The increasing integration of renewable energy supply (Figure 2), distributed generation and decentralised storage is making energy supply more variable and complex to manage.[3]

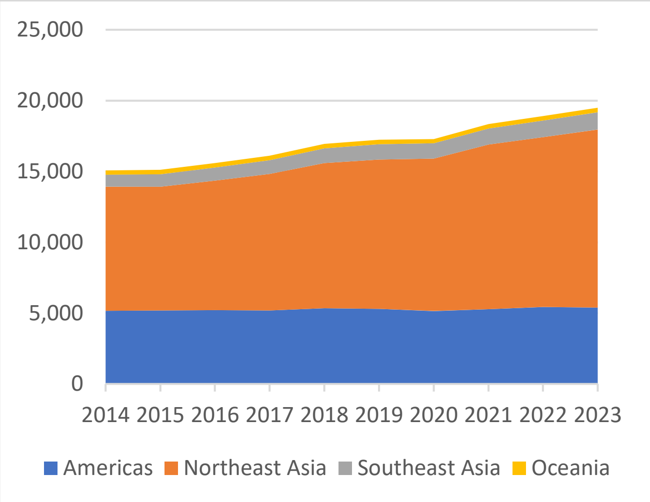

Figure 1. Electricity demand in APEC in terawatt hours (TWh), 2014–2023

Note: Americas = Canada; Chile; Mexico; Peru; and the United States; Northeast Asia = China; Hong Kong, China; Japan; Korea; Russia; and Chinese Taipei; Southeast Asia = Brunei Darussalam; Indonesia; Malaysia; the Philippines; Singapore; Thailand; and Viet Nam; Oceania = Australia; New Zealand; and Papua New Guinea. Source: Data from Ember's Electricity Data Explorer; APEC Policy Support Unit (PSU) calculations.

Artificial intelligence (AI) presents a timely opportunity to help APEC economies modernise energy systems and enhance operational effectiveness. This policy brief explores how AI can be applied across the energy system value chain (Figure 3). It also identifies key enablers to ensure AI is deployed in a responsible, accessible and effective manner across APEC's diverse energy systems.

This policy brief leverages insights gathered from interviews with experts and practitioners in the power sector, AI development and policy research as well as published studies on the topic. These insights provide practically grounded and regionally relevant perspectives to guide policy recommendations for APEC economies navigating digital transitions in their energy sectors.

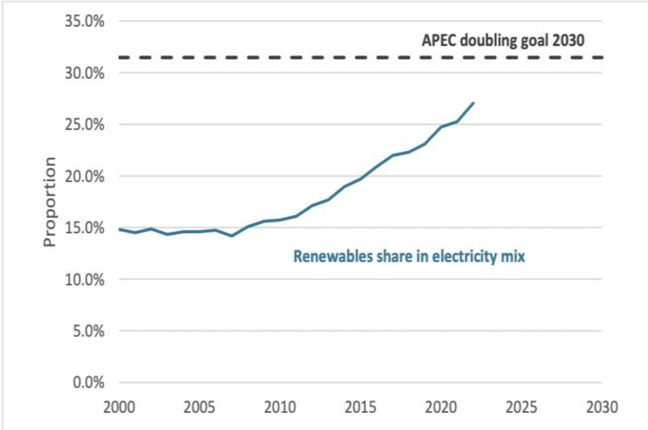

Figure 2. APEC's modern renewable energy share in the electricity mix, 2000 to 2030

Source: APEC, "APEC Energy Overview 2025" (APEC Secretariat, 2025), https://www.apec.org/publications/2025/07/apec-energy-overview-2025

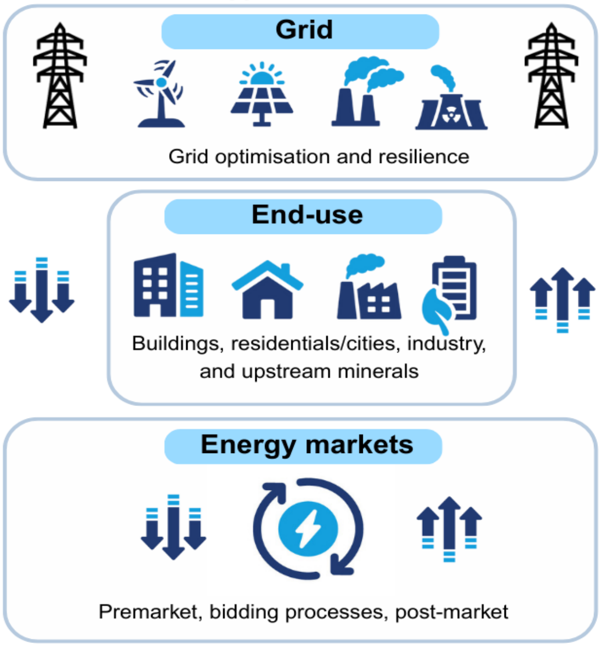

Figure 3. Energy value chain

Note: Grid and end-use cases (e.g., building systems) extend to vertical power systems, while energy markets refer to competitive markets. Source: Authors.

Making the grid more efficient and resilient

Most existing electricity grids are built upon outdated, centralised infrastructure designed for a one-way power flow from large power stations to distant consumers. These systems often lack the ability to share real-time information, which limits the ability of operators to monitor and respond to real-time grid conditions.[4]

In APEC economies, rising electricity demand is still predominantly met by this conventional, inefficient grid infrastructure,[5] which frequently results in supply interruptions (Figure 4) and, notably, contributes to the region's 68 to 70 percent share of global power sector emissions as of 2023 (Figure 5).

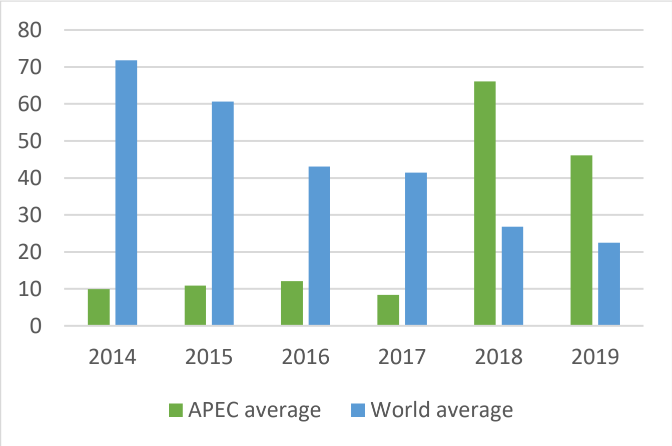

Figure 4. End-use power supply interruptions (hours/year)

Note: (1) Higher values indicate worse performance, i.e., longer and more frequent electricity interruptions. (2) The increase in APEC's average interruption duration in 2018 and 2019 is primarily due to one economy reporting unusually high interruption values (1,356 hours in 2018 and 940 hours in 2019). Source: System average interruption duration index (SAIDI) from World Bank DataBank's Doing Business data; APEC PSU calculations.

Incidents of large-scale blackouts in APEC economies[6] show how extreme weather events, systemic imbalances and failures in one part of the power grid can rapidly cascade into widespread disruptions. These events jeopardise economic activity, costing as much as USD 1.6 billion in economic impact,[7] and compromise public safety. This shows that electric grid efficiency and resilience remain critical priorities for economies, and AI can help meet these challenges (Figure 6).

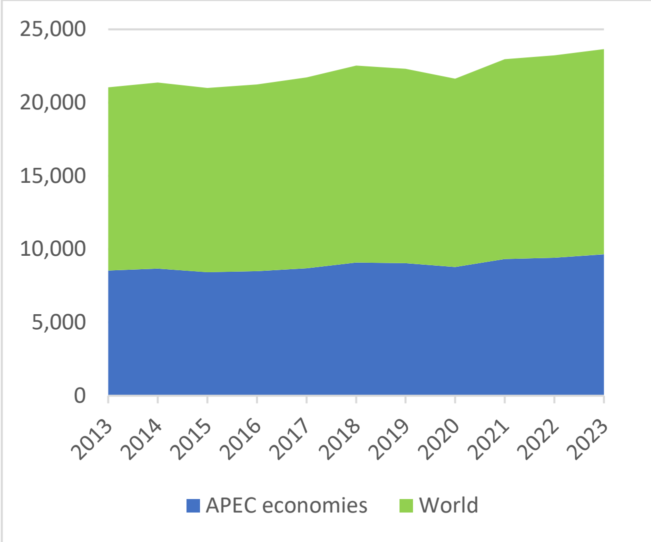

Figure 5. Power sector emissions from fossil fuels (MtCO2)

$MtCO_2$=megatonnes of carbon dioxide
Source: Data from Ember's Electricity Data Explorer; APEC PSU calculations.

How AI can optimise the grid

Electricity must be consumed the moment it is generated and injected to the grid. If too much electricity is produced, it can overload equipment; if too little, it can trigger blackouts. Though grid-scale storage investment has grown in some economies, storing electricity at scale can be financially and technically burdensome under certain market and regulatory conditions.[8] AI can help balance supply and demand in real time, making the grid more efficient, adaptive and reliable at lower cost.

Forecasting and planning

AI uses large amounts of data to predict electricity demand and supply faster and more accurately than traditional methods.[9] These forecasts help system operators make better decisions, reduce waste and avoid curtailing use of clean energy.[10]

One example is optimal power flow (OPF), a model that is used to find the best way to deliver electricity across the grid. AI can solve OPF problems faster, which is especially important in energy systems with high shares of renewable energy like wind and solar that can make the grid less stable and more challenging to manage in real time.[11] Faster solutions mean improved real-time situational awareness and help system operators and planners maintain grid stability.

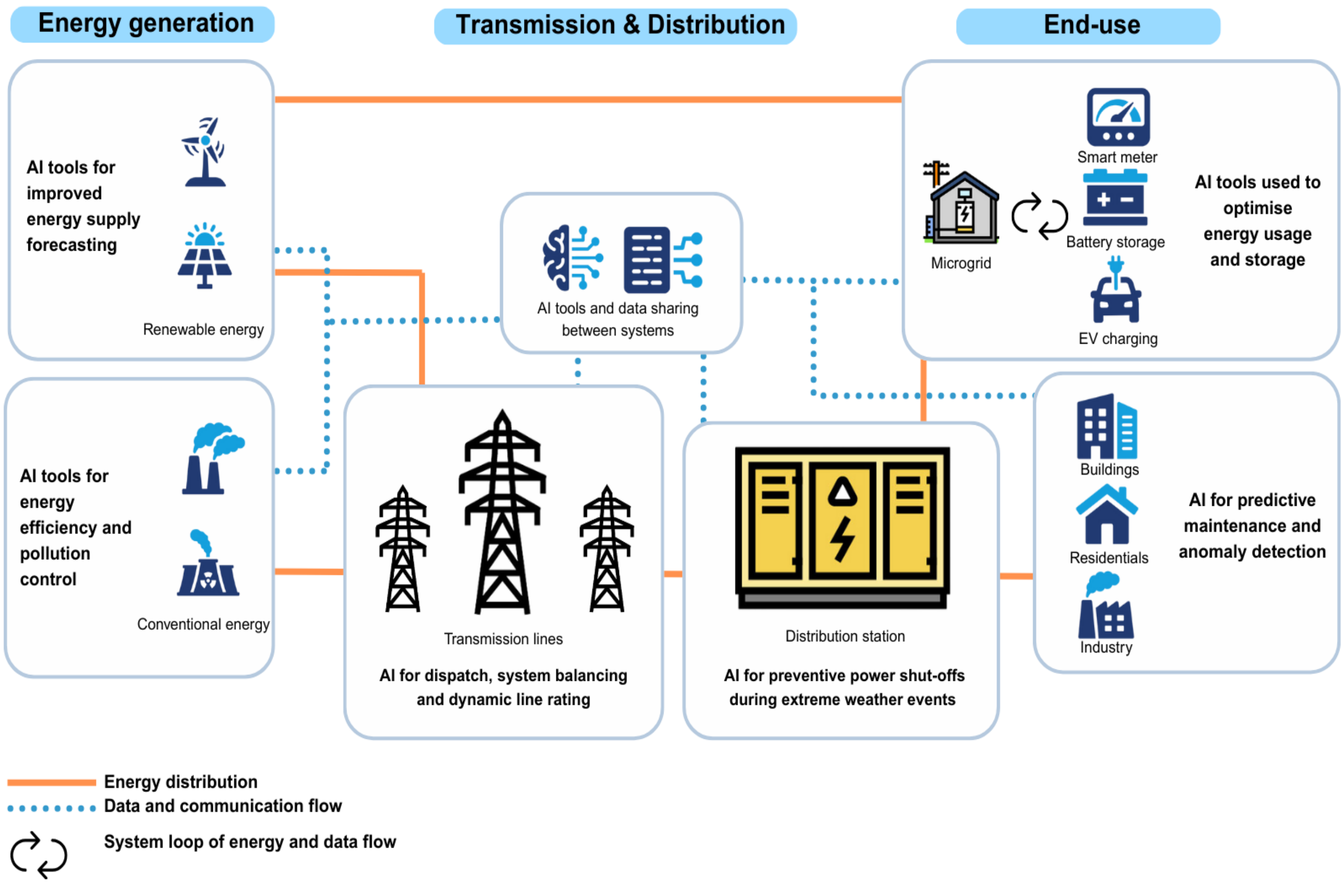

Figure 6. AI applications in the grid system
AI=artificial intelligence; EV=electric vehicle
Source: Authors.

Infrastructure optimisation

AI helps make better use of the grid infrastructure and can unlock additional transmission capacity using existing power lines.

One example is the use of AI in dynamic line rating (DLR) – a process for regulating power line capacity based on weather conditions – as a low-risk, ready-to-deploy tool for grid optimisation.[12] DLR can use AI for real-time monitoring and enable more electricity flows through the system when physical conditions allow.

According to the International Energy Agency (IEA), AI could unlock up to 175 gigawatts of additional transmission capacity worldwide without the need for new transmission lines.[13] This additional capacity is especially crucial in developing economies where rising power flows due to growing demand can result in costly bottlenecks in the grid system.

Smart coordination and control

The grid system and its operators are increasingly required to manage decentralised electricity production, weather-related volatility and complex grid flows.[14]

AI enables real-time control and coordination across the grid. It can automatically adjust how much electricity is produced or consumed based on inputs like prices, weather and grid conditions.[15] This improves coordination between big utilities and smaller players such as households with rooftop solar panels.

In wind farms, AI-enabled wake steering (adjusting turbine angles to minimise turbulence) can improve energy output and density by an average of 22 percent,[16] enhancing efficiency without adding new turbines. Separately, trials across 700 megawatts of wind generation in the US show machine learning (ML) boosting wind energy value by 20 percent.[17]

How AI can improve grid resilience

Traditional grid models struggle with rapidly changing load behaviours and extreme events, leading to inaccurate predictions and operational challenges. For example, during a record peak in demand in Quebec in early 2023, traditional models incorrectly predicted a dip in demand between the morning and evening peaks. Instead, demand rose steadily throughout the afternoon, forcing operators to make significant manual corrections.[18] AI models could quickly adapt to new load behaviours and can even simulate novel, extreme weather or electrical scenarios by generating synthetic data for testing.

Early warnings and predictive maintenance

AI can help energy systems respond faster to problems by detecting unusual activity before it escalates. ML tools can spot anomalies in grid operations and alert operators to take action early.[19] This allows for proactive responses to faults and disruptions. AI also plays a key role in predictive maintenance. Instead of relying on traditional run-to-failure models, AI can forecast when equipment is likely to fail, helping avoid costly breakdowns.[20]

Disaster prevention

AI tools can be deployed to predict the impacts of extreme weather events on electricity grids, enabling grid operators to take proactive measures, including targeted power shutoffs.

Utilities like Pacific Gas and Electric Company (PG&E) in California have been using advanced meteorological models, sensor data and AI/ML to predict high-risk wildfire conditions.[21] This allows them to implement Public Safety Power Shutoffs in vulnerable areas to prevent their equipment from potentially sparking wildfires during high winds and dry conditions.

Another example is Vector, an electricity distributor in New Zealand, which uses Tapestry's AI-powered GridAware tool to identify potentially defective assets and prioritise repairs.[22]

Unlocking energy efficiency in buildings and cities

The building and construction sector is the largest sectoral emitter of greenhouse gases, contributing a substantial 37 percent of total emissions.[23] This carbon footprint stems from both operational energy use (e.g., heating, cooling and lighting) as well as the carbon-intensive production of materials such as cement, steel and aluminium. AI offers substantial potential to reduce pollution across a building's entire lifecycle,[24] through enhancing energy efficiency initiatives and supporting renewable energy production.[25]

Projections indicate AI applications could reduce energy consumption and carbon dioxide (CO_2) emissions in commercial buildings by 8 to 19 percent by 2050 compared to the business-as-usual (BAU) scenarios without AI adoption.[26] These reductions happen even in BAU scenarios that assume continued technology improvement and increased numbers of high-energy efficiency buildings and net-zero energy buildings without the influence of AI.

In early design planning, AI enables optimised site layouts and low-carbon material choices.[27] Tools like image sensors and drones enhance data collection, improving solar generation forecasting and spatial energy performance.[28] Furthermore, AI helps mitigate urban heat island (UHI) effects by predicting UHI intensity and analysing the impact of cooling interventions, such as green roofs or shade trees, based on local climate conditions.[29]

Beyond the design phase, AI enables real-time monitoring and adaptive control systems to optimise energy use based on occupancy patterns, weather shifts and user requirements, improving overall efficiency.[30] AI can also enhance demand response capabilities by enabling automated responses such as demand reduction or shift of energy use to off-peak hours.[31]

Examples include Project Faraday by the Centre for Net Zero,[32] which uses synthetic smart meter data for residential demand forecasting, and AI Singapore's NetZero Building Energy Management System (BEMS), which reduces HVAC energy use through predictive maintenance and adaptive control.[33]

Empowering industry through AI-driven energy optimisation

Energy-intensive industries like steel, cement, chemicals, aluminium and paper account for over two-thirds of global industrial energy demand.[34] Applying AI across these industries can lead to 2 to 6 percent savings in energy demand.[35]

In steelmaking, AI enables real-time production adjustments, reducing energy waste and boosting yields.[36] Broader deployment of such AI applications could cut sector-wide emissions by 200 to 400 megatonnes of CO_2 each year.[37] In cement, Holcim's 'Plants of Tomorrow' initiative uses AI for predictive maintenance and smart control, enhancing efficiency and resilience across planned global sites.[38]

Upstream industries are also being reshaped by AI, particularly in mineral exploration. AI can help identify critical mineral deposits like lithium and nickel more efficiently and safely,[39] supporting APEC's broader goals for energy transition and digitalisation.[40]

Developing smarter energy markets

Energy markets are platforms where electricity is competitively bought and sold either through long-term contracts or in shorter timeframes, such as forward, day-ahead or spot markets.[41] In competitive electricity markets, multiple producers such as power plants or renewable energy generators bid to supply electricity, while retailers or large consumers bid to purchase it. The energy market operator matches these bids to determine a market-clearing price, which balances supply and demand in real time to manage congestion and optimise electricity dispatch.[42]

Figure 7. AI applications in the energy market

Source: Adapted from I. Niet et al., "Societal Impacts of AI Integration in the EU Electricity Market: The Dutch Case," *Technological Forecasting and Social Change* 192 (2023), https://doi.org/10.1016/j.techfore.2023.122554

Competitive electricity markets enhance system efficiency by providing transparent price signals, lowering operational costs, and incentivising investment in least-cost and innovative technologies. When paired with sound policy, these markets can also accelerate low-carbon transition and offer greater consumer choice.[43]

However, APEC economies are in varying stages of developing competitive electricity markets. Power systems are vertically integrated and centrally managed in some economies, with limited capacity for market-based pricing. Other economies, particularly those integrating more renewable energy, are exploring more flexible, dynamic market mechanisms to make their power systems more future-ready.[44]

As energy systems become more complex and decentralised, the ability to efficiently forecast demand, price fluctuations or system imbalances becomes increasingly important. This is where AI offers immense value: improving forecasting, enabling faster and smarter bidding, managing volatility and even automating participation for new market participants like battery operators or flexible consumers (Figure 7).

Institutional enablers of AI adoption

As AI's benefits in power, industry, buildings and energy markets grow clearer, enabling its adoption becomes critical. Strengthening institutional enablers ensures efficient integration and prevents fragmented or uncoordinated AI governance.

Ensuring a trustworthy AI

Stakeholder confidence is essential to deploy AI in energy systems.[45] A trustworthy AI system must be reliable, explainable, transparent and accountable especially when applied to critical infrastructure where errors can impact public safety, service reliability and system resilience.

Reliability refers to the system's ability to ensure consistent and dependable performance, particularly in critical operations. It involves maintaining the integrity of equipment, ensuring service continuity and adhering to regulatory standards.[46] Simultaneously, explainability ensures that AI decisions are understandable across diverse users, from engineers and coders to regulators and policymakers.[47]

Accountability requires answering, 'Who is responsible if AI makes a wrong call?' This is especially important in critical cases, like preventing wildfires, keeping medical equipment running during outages[48] or disaster management.[49] It is vital to keep records of human–AI interactions so mistakes can be reviewed, and responsibility assigned appropriately.[50]

A major concern is the lack of transparency in AI decision-making especially with deep learning models that often function as 'black boxes'.[51] Technically correct outcomes of AI can still raise regulatory and equity concerns when the reasoning is opaque.[52] In high-stakes contexts like grid management, unclear decisions can undermine trust, fairness and accountability.[53]

Trustworthiness initiatives help ensure AI systems are human-centred, uphold stakeholders' concerns, and minimise risk while maximising societal benefit. It is important to avoid overreliance on AI: while AI can provide powerful insights, it should remain a tool to support – not replace – human judgment. Final decisions, particularly in high-stakes situations, must ultimately rest with people.

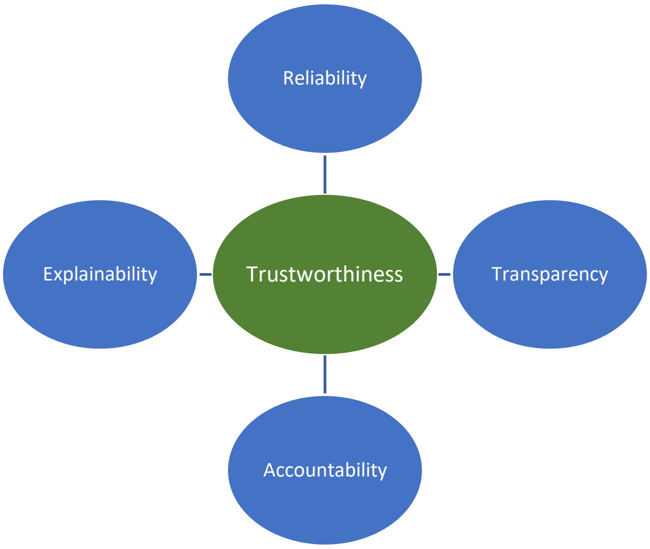

Figure 8. Trustworthy AI in the energy sector

Source: Adapted from D. Slate et al., "Adoption of Artificial Intelligence by Electric Utilities," *45 Energy Law Journal 1* (2024), http://dx.doi.org/10.2139/ssrn.4847872

Bodies like Organisation for Economic Co-operation and Development (OECD) have introduced three categories of tools for implementing trustworthy AI: technical (bias detection, explainability), procedural (governance, ethical guidelines), and educational (training, awareness).[54] Similarly, the report from the Global Partnership on AI (GPAI) on responsible AI offers practical models for embedding trustworthy AI practices, including in energy applications. [55]

Clear, harmonised regulatory frameworks and standards

AI policy frameworks are rapidly evolving across the Asia-Pacific, with at least 16 economies in the region having introduced or actively exploring their own approaches to AI governance.[56] These approaches span a wide spectrum, from government-led binding models to market-oriented and risk-based strategies.[57] While this diversity reflects the region's dynamic regulatory landscape and differing priorities, it also presents challenges for policy alignment.

Existing international standards – such as those by the International Organization for Standardization (ISO), International Electrotechnical Commission (IEC) or International Telecommunication Union (ITU) – remain underutilised despite their availability and potential to ensure interoperability if widely adopted.[58] The need for global coordination in AI governance is also emphasised by international organisations like the OECD and the United Nations, which play pivotal roles in developing harmonised principles.[59]

Furthermore, the lack of standardised metrics for measuring the energy use and environmental impact of AI models discourages transparency, as organisations fear their disclosures may be misinterpreted. Without a consistent framework, reporting often relies on varying assumptions, resulting in speculative or incomparable findings.[60] Development of common, transparent metrics to measure the energy impact of AI models is therefore essential for accountability,[61] especially as AI's environmental impacts – both positive and negative – grow in relevance.[62]

Conflicting legal and technical standards also hinder the safe operation of AI systems like smart grids, especially across borders. Without common standards, interoperability suffers, reliability declines, and regional coordination weakens.[63] As energy systems become more interconnected, harmonised policies are essential to attract investment and support innovation.[64]

International and domestic frameworks can provide inspiration to address this issue. At the domestic level, examples such as Japan's AI governance guidelines,[65] Singapore's Model AI Governance Framework,[66] and the Philippines' integration of AI[67] into sectoral strategies demonstrate how tailored policies can promote safe, accountable and cooperative approaches to AI in energy systems.

Meanwhile, international frameworks such as the ISO/IEC 42001 standard for an AI management system provides structured guidance to help organisations develop, deploy or use AI in a responsible, trustworthy and effective manner, helping manage risks and opportunities associated with AI.[68]

Collaboration to ensure AI benefits all

Many AI solutions are premised on the goal of providing universal, affordable, clean and reliable power to all people.[69] Strengthening energy system resilience should not come at the cost of reinforcing digital divides in terms of digital infrastructure, technical capacity and data access.[70]

Some AI tools demonstrate how solutions can be deployed effectively by leveraging existing geospatial data, such as satellite and street imagery, reducing the need for new infrastructure. Transferable models enable rapid rollout in communities that are underserved and vulnerable to extreme weather, helping keep them at parity with more advanced regions.[71]

Without targeted support, centralised or commercial AI development risks prioritising well-resourced communities, leaving smaller utilities or poorer communities behind.[72] To avoid this, AI tools must be designed with input from a broad and diverse group of stakeholders, including those with limited resources.[73] Beyond technical design, collaboration is essential to ensure equitable AI adoption.

A practical example is Hydro-Québec's CASTOR Lab, which brings together a multidisciplinary team of internal and external collaborators. It is a computing facility designed to test and validate AI models under real-world conditions before deployment in critical grid operations. By closely replicating secure production environments, it ensures models are reliable and compliant, while accelerating development.[74]

Technical enablers of AI adoption

AI's adoption and effectiveness depend on the people who use it and the data with which it is fed. However, many energy companies have identified that the primary barriers to AI adoption in the energy sector are a lack of quality data and a shortage of skilled personnel.[75] Without addressing these foundational needs, AI's potential to improve energy efficiency, optimise grid management and support resilient energy systems cannot be fully realised.

Digital infrastructure and data requirements

AI models in the energy sector depend on granular, high-quality datasets to train and operate effectively, sourced from smart meters, sensors and other data-gathering devices (i.e., the Internet-of-things or IoT).[76]

While it is often assumed that ML applications always require extremely large volumes of data to be effective, newer approaches such as physics-informed ML combine engineering knowledge with data-driven models to reduce data requirements.[77] This could make AI more accessible in lower-data environments, provided the available data is clean (free of errors and inconsistencies), reliable (reflective of real system behaviour) and relevant to real-world conditions.

Therefore, the priority is not scale alone but the quality, interoperability and contextual relevance of the data. This includes improving consistency across sources, addressing gaps or noise in datasets and ensuring alignment with operational realities. Importantly, data is not a solution on its own; it must be applied with an understanding of the physical properties and causal mechanisms of the energy system to ensure its effective use.[78]

In various economies, strategies such as prioritising data centre development and introducing data localisation policies reflect the growing recognition of data as a strategic production factor for competitiveness and resilience.[79] However, these approaches involve trade-offs that merit careful consideration.

While data localisation policies can support various legitimate public policy objectives such as law enforcement and security, they can also increase operational costs and limit cross-border data collaboration essential for robust AI applications. Constrained data mobility can limit the ability to aggregate datasets across borders, which is crucial for developing robust AI models and conducting large-scale data analysis.[80] These constraints affect the efficiency of international operations, including trade and digital services.

Workforce development and capacity building

A skilled, AI-literate workforce is critical for effective AI deployment in the energy sector, yet significant skills gaps remain, especially in developing economies.[81] Key gaps include data engineering, machine learning and systems integration.[82] In addition to these technical roles, decision-makers also need foundational literacy to critically assess AI capabilities, limitations and risks when applied to energy planning and operations.[83]

AI is changing the roles of system operators by significantly reducing their manual tasks and increasingly directing them toward strategic functions such as managing big data, supervising a multitude of AI models and producing hundreds of geolocated forecasts.[84] Successful AI adoption requires cross-disciplinary knowledge that combines AI technical skills with energy system expertise. Without this, implementation risks bias, poor performance, and safety issues.

Policy options

AI offers significant opportunities for the overall improvement of energy systems, but its deployment must be carefully managed to ensure it is responsible and effective. APEC economies, with their diverse stages of development, must balance the urgency of innovation with caution, to enable deployment while safeguarding system integrity, privacy and fairness. Policymakers could consider a range of coordinated policy options – ranging from regional cooperation for joint learning to domestic promotion of innovation – to unlock AI's full potential in the energy sector.

Develop regional governance standards for trustworthy AI. Harmonisation of AI-related policy frameworks and technical standards is crucial to avoid fragmentation and ensure scalability across the APEC region. Shared benchmarks for transparency, explainability and accountability can provide the foundational trust needed for safe AI deployment across grids, energy markets and industrial applications.

The adoption of international standards can help establish a common regulatory language and improve interoperability, preventing the emergence of isolated or fragmented AI ecosystems. For instance, ISO 42001 on AI management systems provides a good basis for APEC economies to build their domestic AI standards, avoiding divergent frameworks and standards that would add friction to AI deployment across grids, energy markets and industrial applications. APEC can leverage existing fora to lead these harmonisation efforts, drawing on international best practices while tailoring them to regional needs.

Establish regulatory sandboxes and joint pilot programs. These sandboxes can begin domestically, before expanding across multiple economies where they could initially focus on lower-risk, ready-to-deploy solutions – such as AI-powered DLR or weather forecasting for renewable power generation – to build regulatory capacity and confidence with minimal operational risk.[85]

Hydro-Québec's 'hare and tortoise' approach to AI integration, progressively deploying simpler to more complex neural networks after rigorous testing in secure environments, exemplifies how cautious, continuous validation can ensure reliability and foster operator confidence.[86] By focusing on such ready-to-deploy solutions, regulators can provide tangible benefits and valuable lessons for scaling up.[87]

Beyond their immediate benefits, these sandboxes and pilot programs can serve as vital platforms for knowledge transfer, allowing emerging economies to learn from more technologically advanced members and facilitating the sharing of anonymised data and best practices to accelerate research, scalability and replicability across the region.

Establish a regional AI data taskforce for the energy sector. In Chile, the deployment of Tapestry, an AI-driven grid planning tool for electricity transmission, was made possible by open access to Chilean grid data.[88] Gaining access to grid data in a timely and facilitative manner, along with data cleaning and restructuring, enabled Tapestry to start work more quickly. This illustrates that data is the bedrock of AI, and lack of access could be a stumbling block to deployment. Access to high-quality, interoperable and secure energy datasets with robust cybersecurity and privacy protocols is essential to running AI systems.[89] Hence, ensuring data quality, consistency and reliability across diverse sources is the key for effective AI deployment.

Good regulatory practices and investments in infrastructure and processes to ensure data is open, interoperable and secure from collection to utilisation will be needed. Recognising varying levels of readiness, APEC economies could explore tiered data-sharing models where highly sensitive data is subject to strict controls, while anonymised or aggregated data can be shared more openly for research and public benefit. APEC economies could establish a regional energy data taskforce to promote open data standards, protocols and accessibility across public and private stakeholders. Open data can foster innovation by ensuring fair access, preventing monopolies and enabling smaller firms and innovators to adopt and develop AI solutions.[90]

Investments in digital infrastructure must be designed to enable seamless data flow, both within economies and across borders. Common guidelines for data collection and access can improve dataset coherence and usability.[91] This includes setting interoperability standards for end-use devices and distributed energy resources to respond dynamically to real-time signals such as carbon intensity, peak demand, and pricing. At the same time, policies must address growing risks around data privacy and cybersecurity. Given the criticality of energy infrastructure, cybersecurity frameworks for data ecosystems must be built in from the outset, not as an afterthought.[92]

Coordinate on capacity building programs. Upskilling programs for the energy sector need to focus on multi-disciplinary skills, emphasising the intersection of AI technical knowledge with energy systems, policy, economics and ethics to foster 'AI translators' who can bridge these gaps. APEC economies could develop regionally coordinated training strategies focused on both technical implementation and strategic oversight. This includes training partnerships with universities and international energy institutions, as well as mid-career upskilling programs to enable professionals to evaluate, adapt and govern AI tools responsibly.

APEC could also support the establishment of regional hubs for AI development in energy, potentially hosted by leading universities or research institutions, to facilitate training, research and collaborative projects. Shared learning platforms between advanced, emerging and developing economies will further help disseminate expertise more equitably across the region, alongside promoting public–private sector rotations to foster mutual understanding and practical skills. Governments can encourage energy utilities and industry leaders to establish internal AI labs to build domestic capabilities, develop tailored solutions and securely integrate AI into critical infrastructure.

Furthermore, economies could support initiatives that create a seamless pathway from university research to industry deployment. This lab-to-operations continuum will accelerate the adoption of AI innovations, enhancing grid efficiency, resilience and reliability. This approach facilitates acceptance of change by giving operators the means to directly participate in building their new or future work tools, allowing them to objectively assess their advantages and limitations at their own pace. [93]

Ensure AI access and deployment for all. AI must not reinforce or exacerbate existing digital divides. To ensure accessible AI deployment in critical infrastructure, economies need to facilitate collaboration and dialogue between various stakeholders such as power sector utilities, energy industry firms, policymakers and local communities. These collaborations can produce AI tools that are grounded in real-world conditions and local needs.

Initiatives that address specific energy challenges and data realities of developing economies are also crucial as there is no one-size-fits-all solution for AI adaptation. Input from grid operators, energy actors and local communities, particularly those most impacted by energy transitions or climate change, should be prioritised to ensure solutions are tailored to the needs of the communities they are meant to serve.

Supporting local AI development and research in developing economies can also contribute to closing digital divides. The development and sharing of open-source AI models, tools and data, particularly those tailored for energy applications in data-constrained or resource-limited environments, could be helpful in this regard. Such multisectoral and stakeholder-grounded approaches, accompanied by social and environmental impact assessments for AI energy projects in vulnerable communities, are critical for ensuring that AI supports broader development goals.

Invest in AI innovation for energy efficiency and resilience. The use cases for AI in the energy sector are just a start, and economies are only beginning to understand how AI can contribute to energy resilience and efficiency. More research and innovation are needed to integrate AI into broader energy infrastructure planning, simulating stress scenarios (e.g., typhoons or heatwaves), and informing resilience and resource allocation.

AI can even enhance long-term resilience by enabling large-scale simulations that model future changes in weather patterns.[94] Methodologies need to be developed to systematically measure and report the direct and indirect benefits of AI deployment in the energy sector,[95] such as emissions reductions from optimised operations or avoided infrastructure costs from enhanced resilience.

But this will all require funding, and economies need to create a supportive environment for investments in AI innovation for the energy sector. Investment will also be needed to accelerate the uptake of AI tools and services, leading to optimisation and cost savings in energy systems. Setting up and co-funding public–private partnerships to jointly invest in AI energy startups could be one way forward. Directly supporting and incentivising research and development in this field is another.

Conclusion

AI enables APEC economies to modernise energy systems, improve operational efficiency and strengthen resilience across the energy value chain. From enhancing grid stability and managing variable renewables to optimising energy use in buildings and industry, AI is already delivering tangible benefits. However, its transformative potential will only be fully realised if economies address its foundational requirements: robust data infrastructure, skilled human capital, clear governance frameworks and accessible innovation ecosystems.

To ensure AI supports equitable and future-ready energy transitions, coordinated action at both domestic and regional levels is essential. This includes harmonising technical standards, fostering cross-border collaboration and enabling knowledge sharing through platforms like APEC. With the right policy choices and enabling conditions, APEC economies can lead in demonstrating how AI can be responsibly scaled to support smarter, more secure and resilient energy systems across the region.

Notes

[1] F. Li, "Supersession C: Resilience and Reliability in Multi-energy System Planning," in IEEE, *2023 IEEE PES GTD International Conference and Exposition (GTD)*, (IEEE, 2023), https://doi.org/10.1109/GTD49768.2023.00014
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