Energy Futures

Tomorrow's Vision

Foreword

Energy is one of the most critical systems on the planet. It powers every sector, from manufacturing and mobility to the world's digital economy. It is also under more pressure than ever. Leaders must deliver secure, affordable power while decarbonising at speed and navigating constant technological and regulatory change.

At Oracle NetSuite, we have the privilege of working alongside a wide range of businesses across the energy value chain. That vantage point gives us a close-up view of the dynamics redefining the sector: where capital is flowing, which business models are gaining traction, how data is unlocking agility and where the transition is creating both strain and opportunity.

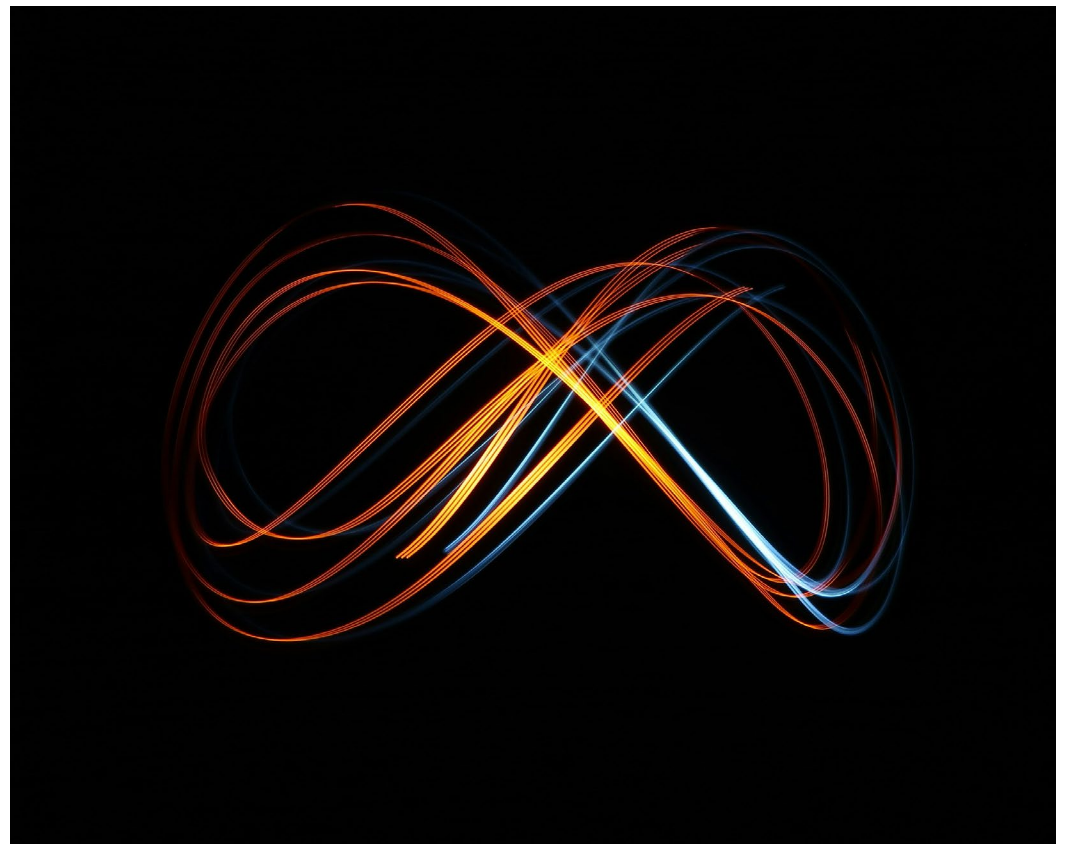
This report, produced in partnership with The Future Collective, brings together some of the strongest signals shaping the future landscape of energy.

It explores where new capacity will come from, how intelligent systems will manage growing complexity and how markets are being redesigned around flexibility, carbon and participation. It also highlights the capabilities that will determine advantage in the years ahead, as competitive positions evolve across the energy economy.

Our aim is simple: to help energy leaders see where opportunity lies and how to position for what comes next. The organisations that thrive will be those that can read what's emerging, explore new possibilities and question inherited assumptions. We are proud to support the energy community as it builds the resilient, low-carbon systems the world now depends on.

Thomas Sutter,
Infrastructure Services Industry Director,
Oracle NetSuite

Overview



Introduction

Energy is entering a decisive decade. Renewables are rapidly becoming central to power generation worldwide, yet demand from industry, digital infrastructure and electrified transport is surging, pushing deployment timelines into sharp focus. Progress must now accelerate to meet the ambitions of 2030.

The next phase is one of redesign. Rapid growth in renewables is outpacing the infrastructure built to support them. Power is shifting from centralised models to decentralised, digital networks, and markets are evolving around flexibility, participation and smarter use of data. The transition now depends on making clean energy not only abundant, but reliable, intelligent and affordable.

The context is complex, with national priorities diverging, climate pressures mounting and innovation accelerating faster than many strategies can absorb. Together, these pressures are redefining the energy landscape and opening new strategic pathways for the years ahead.

The Forces Shaping Energy

The forces shaping energy are systemic: rising demand, regulatory shifts and the race to scale clean power fast enough to deliver security, affordability and climate stability.

Energy Flux

> "Over the next three years, global electricity consumption is forecast to rise by an unprecedented 3 500 TWh. This corresponds to adding more than the equivalent of a Japan to the world's electricity consumption each year."
>
> IEA (2025) Electricity 2025: Analysis and Forecast to 2027.

Explosive demand collides with unstable supply.

Electrification is surging across every sector. The IEA describes this moment as an 'Age of Electricity', driven by rising demand from industry, cooling, electric mobility, data centres and artificial intelligence (IEA, 2025).

On the supply side, renewables dominate new generation and are set to meet 95 per cent of global demand growth to 2027 (IEA, 2025). Solar was the EU's fastest-growing power source in 2024, overtaking coal for the first time as power-sector emissions fell to below half their 2007 peak (Ember, 2025). Yet these sources remain tied to weather, water and seasonal cycles. Heatwaves, droughts and storms show how quickly conditions can shift. Europe's 2025 heatwave pushed daily electricity demand up 14 per cent while outages drove prices two to three times higher than normal (Ember, 2025).

This tension between rising demand and variable supply has ended the era of predictable baseload, replacing it with constant flux. Demand curves shift as new technologies scale, while supply can tighten unexpectedly. Businesses report growing concern about forecast accuracy, the risk of demand outstripping supply and the impact of volatility on planning and pricing. 92 per cent expect this to raise their product and service costs in the year ahead (PwC, 2025).

The grid is also being stretched in new ways. Interconnection queues, storage gaps and regional bottlenecks make it harder to match where power is generated with where it is used. Data centres are now exploring on-site generation and storage to secure power outside traditional networks, reflecting the strain many markets already face.

The system is now driven by overlapping surges and constraints, not steady patterns. Markets must navigate conditions that change quickly, and those able to balance variability and unlock new flexibility will be best placed to succeed.

> "In the race to stabilise the climate, net zero is the finish line. How quickly we get there determines the temperature we reach. But there's no escaping the race if we want a viable habitable and investible future. Net zero is non-negotiable."
>
> Dr. Sam Cornish, Transition Research Specialist, IIGCC, (2025).

Climate Contract

Net zero drives progress.

Climate risk used to be a long-term scenario; today it's a lived condition. The warmest year on record in 2024 and the fastest rise in CO_2 since modern measurements began show how quickly climate impacts are intensifying (WMO, 2025). Global energy demand is projected to double by 2050 (Northumbria University, 2025), which puts the energy sector at the centre of this challenge and also makes it the single biggest lever for change.

The transition is becoming time critical. The UK has committed to a 68 per cent reduction in emissions by 2030 with a fully clean power system the same decade. Across Europe, the Green Deal embeds climate neutrality by 2050 into law. These policies are reshaping energy markets, supply chains and investment priorities, not gradually but decisively.

In parallel, investors, regulators and customers now expect proof of real progress. Net zero is becoming a condition for access to capital, markets and talent. From carbon capture and storage to clean supply chains, the sector must demonstrate genuine decarbonisation, not just announce targets. The challenge is building business models that deliver and verify meaningful reduction.

Momentum is building. Corporate net zero commitments have almost doubled in a year, and more than four in five companies expect to increase investment in energy management (PwC, 2025). Wind and solar already supply nearly half of EU electricity (Ember, 2025). The Climate Contract reframes competitiveness for the decade ahead. Those who build transparent, intelligent systems of proof will lead.

Boundary Blur

The old lines of the energy system are dissolving.

Energy is no longer defined by fixed roles or clear boundaries. Oil and gas companies are scaling up renewables and low-carbon fuels. Utilities are moving into storage, flexibility and digital platforms. Tech giants are securing long-term power contracts and investing directly in generation as AI data centres drive unprecedented demand. Global spending on new data centre sites is projected to reach £2.3 trillion by 2030 (The Guardian, 2025). Start-ups are reinventing storage, EV charging and local markets, while households and communities become producers in their own right, with more than 1.5 million UK homes now fitted with rooftop solar (DESNZ, 2025).

This convergence is redefining the energy landscape. Traditional value chains, from generation to grid to consumer, are giving way to overlapping roles where companies generate, trade, store, manage and consume power at the same time. M&A activity reflects this trend, as energy, technology and industrial players combine capabilities into integrated hardware, software and service offerings. AI-driven load growth is accelerating parts of the transition, with hyperscale operators exploring on-site nuclear, gas and solar-plus-storage to bypass grid queues (Deloitte, 2025).

As these roles blur, competitiveness evolves. Consolidation is increasing at the centre as incumbents seek greater scale in renewables, grids and digital platforms, while fragmentation grows at the edges through community energy, plug-in solar and decentralised solutions. These forces pull in opposite directions – global and local, mega-scale and niche – but together they create a system that is more fluid, open and harder to define.

Boundary Blur is not just about who owns assets but who owns relationships, data and trust. As sectors and roles overlap, value moves to those who bridge worlds: connecting industrial demand with clean supply, linking households to markets, and turning system complexity into tangible value for customers.

Image Source: Tesla — Powerwall 3

> “The convergence of energy, technology and industrial sectors is rapidly reshaping the landscape.”
>
> PwC (2025) Global M&A Trends in Energy, Utilities and Resources, 24 June.

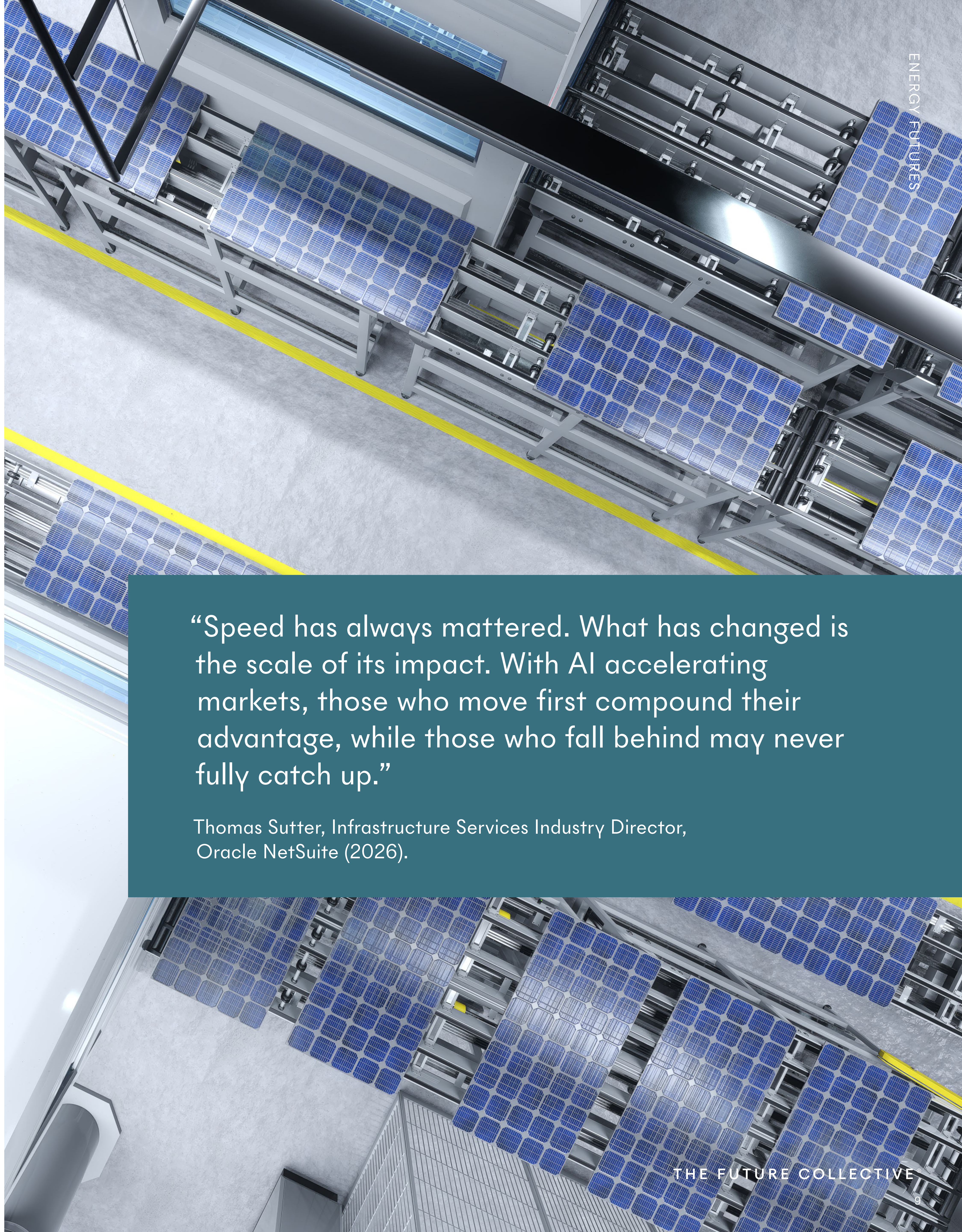
Velocity Advantage

In a disruptive energy landscape, speed and agility shape success.

The global energy system is evolving in ways that are increasingly difficult to predict. Policy shifts, international conflicts and new technologies can reconfigure markets with little warning. A subsidy in one region, a tariff in another or a sudden supply disruption can alter competitive positions overnight. Geopolitical tensions have elevated energy security concerns worldwide, shaping divergent national responses based on resources, dependencies and political realities. In this climate, sensing change early and being ready to act on it takes on new significance.

Global competition adds further pressure. China has become the dominant force in next-generation energy technologies, investing almost as much as the EU and US combined in renewables, storage and nuclear (WEF, 2025). Its industrial policies have built effective manufacturing and supply chains across solar, wind, batteries and electrolysers. India is moving with similar intent, surpassing its 2030 renewable target nearly a decade early and building some of the world's largest clean-energy manufacturing hubs (WEF, 2025). Meanwhile, AI is reshaping electricity demand in real time, outpacing the speed at which grids, storage and permitting systems can adapt.

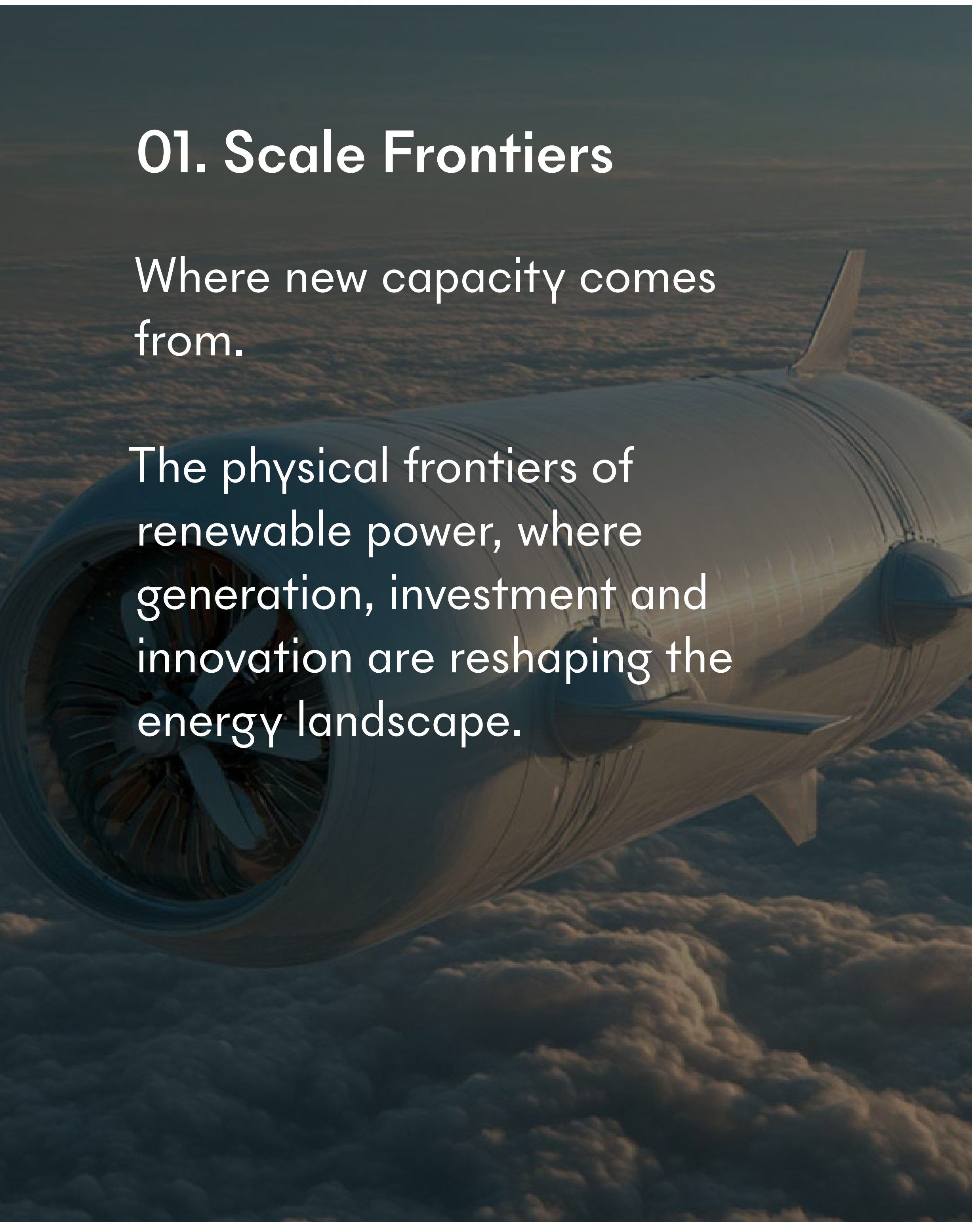
The operating environment is becoming narrower and less forgiving. Policy incentives now open and close within a budget cycle, and supply chains can tighten overnight as countries compete for the same components and talent. Add to this markets that move in years rather than decades, and the system becomes far more reactive than many organisations are used to. Those able to respond with clarity and pace will be best positioned to shape the opportunities that emerge.



> "Speed has always mattered. What has changed is the scale of its impact. With AI accelerating markets, those who move first compound their advantage, while those who fall behind may never fully catch up."
>
> Thomas Sutter, Infrastructure Services Industry Director, Oracle NetSuite (2026).

Energy Futures Framework

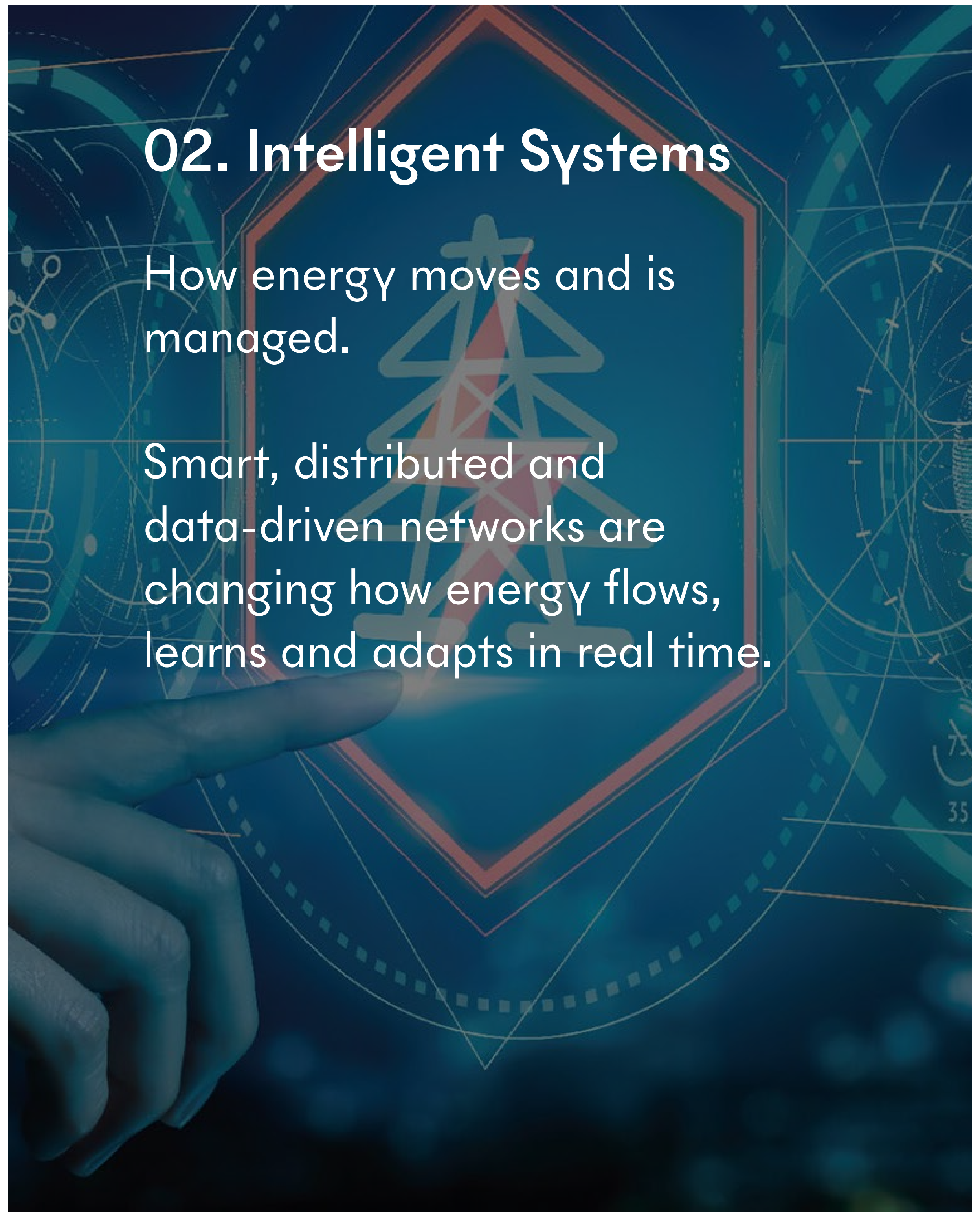
Four interconnected pillars transforming how energy is produced, managed, valued and competed for.



01. Scale Frontiers

Where new capacity comes from.

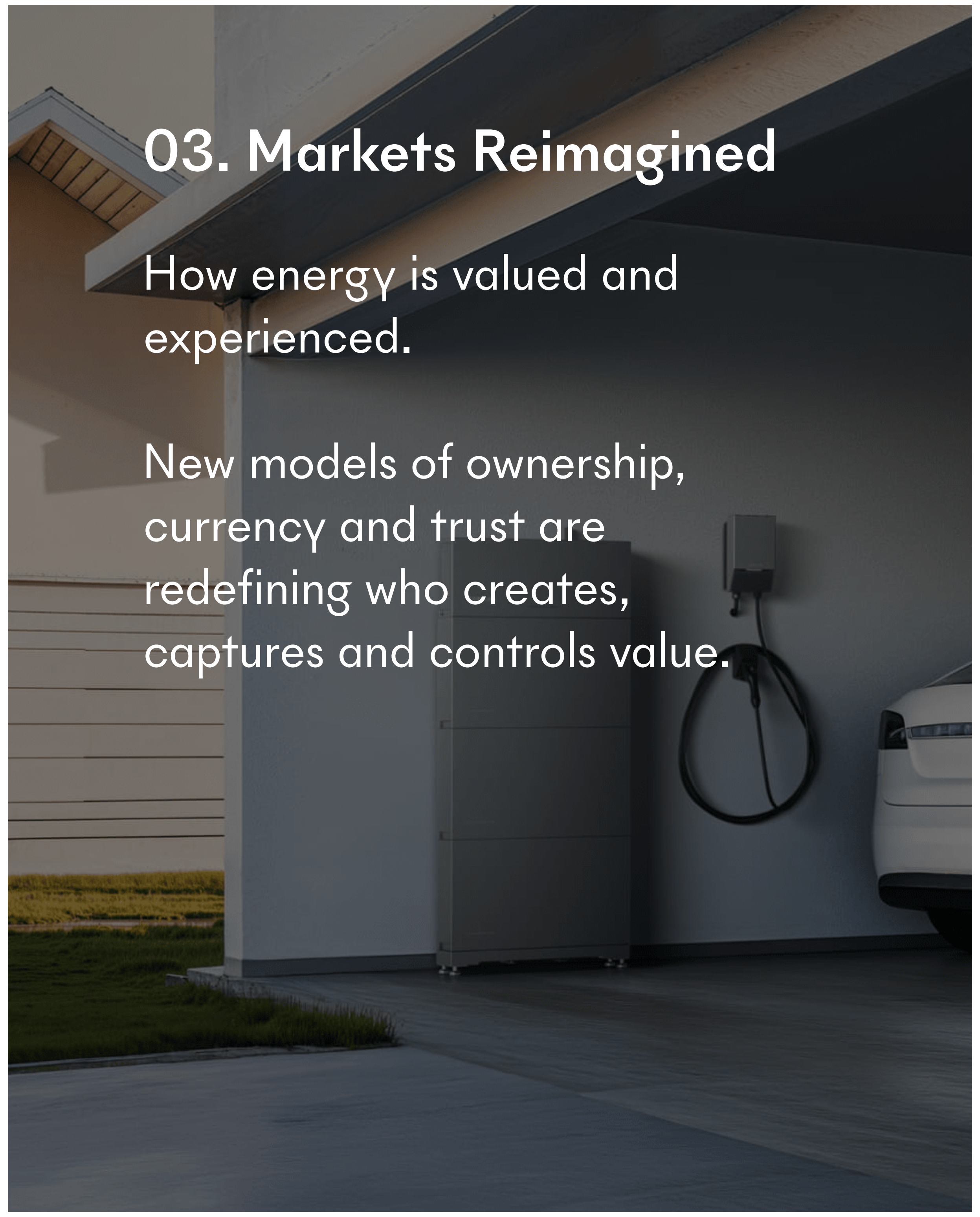
The physical frontiers of renewable power, where generation, investment and innovation are reshaping the energy landscape.



02. Intelligent Systems

How energy moves and is managed.

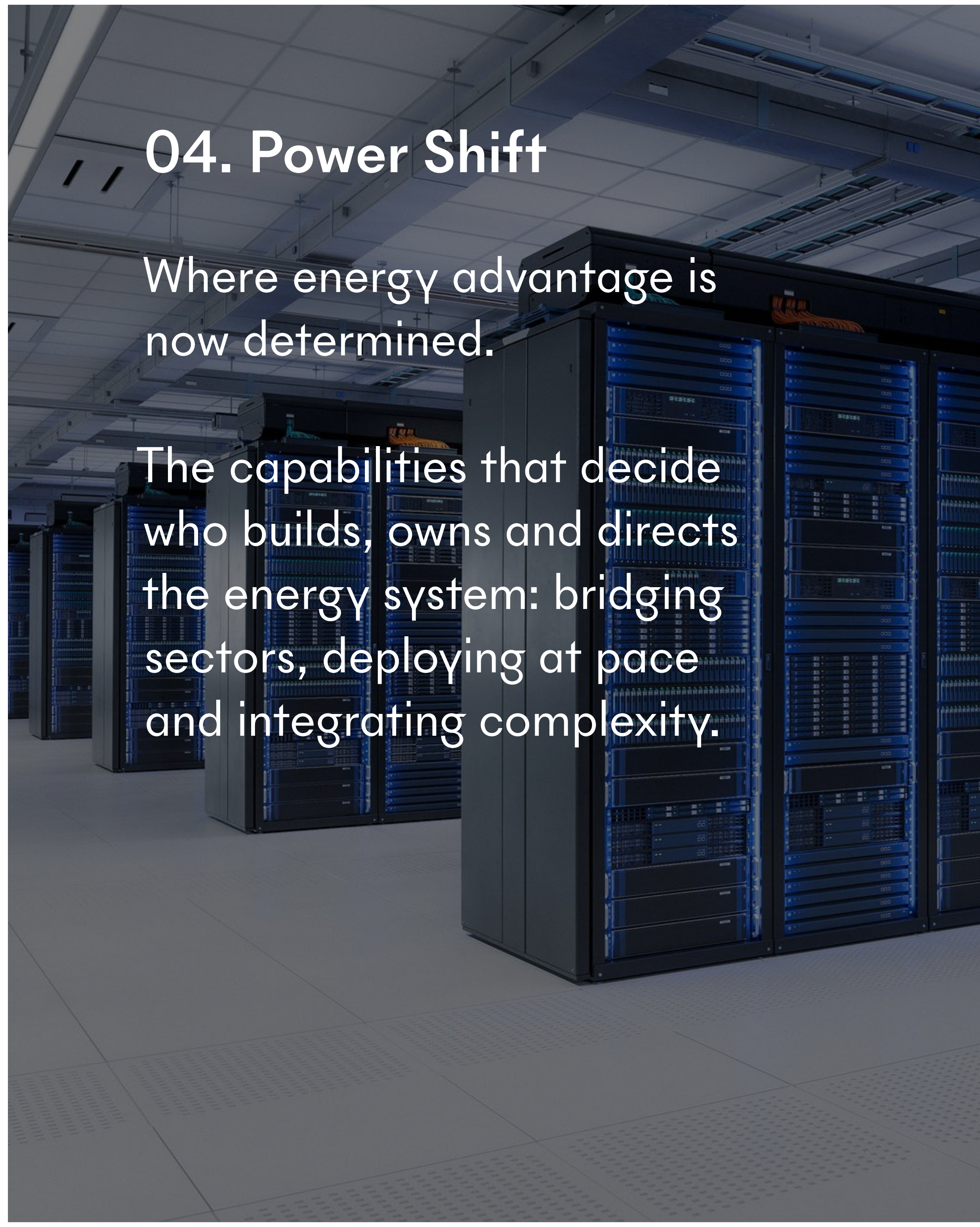
Smart, distributed and data-driven networks are changing how energy flows, learns and adapts in real time.



03. Markets Reimagined

How energy is valued and experienced.

New models of ownership, currency and trust are redefining who creates, captures and controls value.



04. Power Shift

Where energy advantage is now determined.

The capabilities that decide who builds, owns and directs the energy system: bridging sectors, deploying at pace and integrating complexity.

Image Source: (Left) Beijing SAWES Energy Technology — S1500 buoyant airborne turbine; (Right) EcoFlow

01 Scale Frontiers

- Above & Beyond
- Storage Supremacy
- Beyond Electrons
- Ambient Energy

Above & Beyond

How far can renewables go?

New energy frontiers.

The Future Forecast

The next generation of renewables is pushing into previously unreachable spaces beyond the limits of traditional infrastructure. With demand climbing at record pace and grids straining under pressure, high-altitude, deep-water environments and orbital platforms are emerging as viable territory for scalable clean power.

Advances in engineering and materials science are making these environments accessible. Floating and deep-water turbines extend generation into open seas where winds are stronger. High-altitude systems harness faster, more consistent air currents, and a doubling of wind speed can generate up to eight times more energy (Sustainability Times, 2025). Above them, space-based solar introduces a step change in potential, capturing uninterrupted sunlight without weather or daylight limits. Compact modular reactors bring reliable baseload closer to where it is needed most. Tidal, geothermal and osmotic energy are also gathering pace as feasibility improves.

Much of this expansion stems from pressure on land. Space is limited and communities are increasingly resistant to large installations that impact landscapes or compete with agriculture. As opposition grows, attention is turning to new frontier environments where capacity can scale without adding to land-use strain. Momentum is building through new partnerships, prototypes and early commercial pilots, but long-term progress will rely on investment models able to support infrastructure that takes time to deliver returns.

As these frontiers develop, the energy landscape becomes more varied, distributed and resilient. Instead of relying on a narrow set of land-based assets, future supply will draw from a wider ecosystem of environments to strengthen stability and expand possibility. These are no longer distant ideas, and early deployments backed by multi-trillion-dollar market projections (WEF, 2025) indicate what's possible. The future of energy will be shaped by imagination, ambition and a willingness to build beyond familiar boundaries. Above & Beyond frames where organisations should focus exploration and investment.

Pioneers in Action

- The largest airborne wind-power system ever built, China's SAWES S1500 completed its maiden flight in Hami, Xinjiang, where it demonstrated stable high-altitude operation and became the first turbine of its kind to generate 1 MW during testing. Its tower-free, airship-based design cuts material use by 40 per cent and could lower electricity costs by 30 per cent (South China Morning Post, 2025).

- Morven Offshore, Scotland is set to become one of the world's deepest fixed-bottom wind farms, installing turbines in 65–75 metre waters off Aberdeen, pushing seabed engineering into new territory (Enlit World, 2023).

- The UK-led £1.7 million Space Solar CASSiDi project (2024–25) advanced designs for orbital solar collection, showing potential for continuous clean power from orbit and signalling institutions and governments moving towards commercial pathways.

"Land-based renewable energy is irregular and weather-dependent, complicating reliable supply, and comes at varying costs."

The Guardian (2025) Solar Panels in Space 'Could Provide 80% of Europe's Renewable Energy by 2050', 21 August.

Strategic So What?

Renewables are moving into higher altitudes, deeper waters and orbital space, expanding where future capacity will come from.

Success requires:

- Integrating multi-environment generation into long-term planning and management, with grids and infrastructure designed to handle new resource profiles
- Shaping new partnerships and supply chains across aerospace, offshore engineering and advanced materials to accelerate deployment
- Reframing investment decisions around long-term resilience benefits rather than short-term returns, with financial models that can absorb upfront risk

These frontiers open new avenues for scalable clean power and long-term system security.

Image Source: Beijing SAWES Energy Technology — S1500 buoyant airborne turbine

> "Solar panels in space could cut Europe's terrestrial energy needs by 80% by 2050. They could also cut the cost of Europe's power system by 15% and battery usage by more than two-thirds."

The Guardian (2025) Solar Panels in Space 'Could Provide 80% of Europe's Renewable Energy by 2050', 21 August.

Image Source: iLexx

Storage Supremacy

Can storage finally close the gap?

Storage built for duration and scale.

The Future Forecast

The promise of renewables depends on solving storage. Solar and wind generate more clean power than ever, but their natural rhythms rarely match when people need it. Storage closes that gap, capturing energy when conditions allow and releasing it across hours or days to keep grids steady.

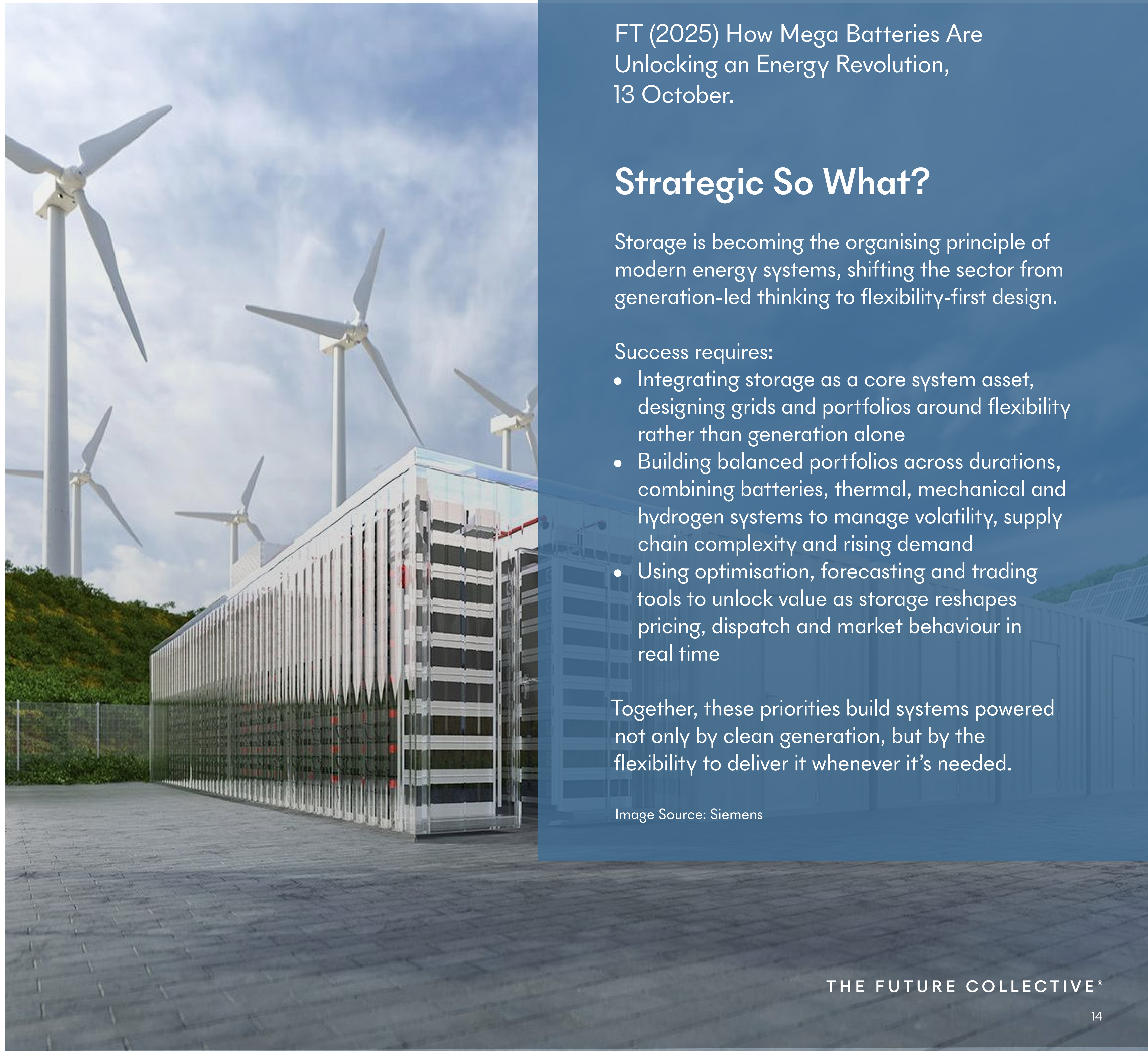
What is changing now is the speed and scale of deployment. Battery capacity is accelerating worldwide as costs fall, new chemistries emerge and grids adapt to heatwaves, electrification and rising demand from AI and industry. In leading markets, large battery fleets already shift surplus solar into evening peaks, reducing reliance on gas and proving storage can stabilise grids at scale. Global capacity is set to grow rapidly and could increase tenfold by 2035 (FT, 2025), with storage fast becoming central to power-system planning.

Storage is also diversifying. Lithium-ion remains dominant, but new solutions are emerging to extend duration, ease resource pressure and unlock greater flexibility. Flow batteries provide long discharge without degradation, while thermal systems bottle heat in salts, sand and industrial materials for use after sunset. Mechanical approaches such as compressed air caverns, gravity structures and high-rise storage turn geography and buildings into energy assets. Hydrogen offers seasonal potential, while even concrete is being reimagined as a structural supercapacitor. Each technology creates another way to bank renewable power and deliver it when needed most.

As storage scales, it starts to set the terms on which energy markets function. It affects how grids flex, how prices are set and how renewable power is dispatched. Solar-plus-storage is set to become the standard, while mega-batteries can provide services such as balancing, frequency control and system restart, opening new revenue streams and reducing reliance on fossil back-up. Storage Supremacy reflects a broader shift from generation-led thinking to flexibility-first design, where leaders in storage shape tomorrow's markets.

Pioneers in Action

- California has become ground zero for the battery storage revolution, expanding grid-scale capacity thirteen-fold in five years to reach 10 GW in April 2024. Batteries now shift surplus solar into the evening peak and, on one 2024 evening, supplied more power than any other source on the grid (Ember, 2024).
- The UAE has broken ground on the world's largest solar-plus-storage project, integrating 5.2 GW of PV with a 19 GWh battery to deliver 1 GW of round-the-clock baseload using AI-enhanced forecasting and intelligent dispatch (Masdar, 2025).
- Hyme Energy and Arla Foods are pursuing a 200 MWh molten-salt thermal storage system for Arla's Holstebro facility, set to become the world's largest industrial thermal storage project and cut both emissions and operating costs (Hyme Energy, 2024).
- Augwind Energy is planning to build the world's first commercial-scale 'air battery' in Germany, using underground salt caverns to store compressed air for electricity generation (MPS, 2025).



"These might look like shipping containers in the desert, but they are the key to unlocking a clean energy revolution."

FT (2025) How Mega Batteries Are Unlocking an Energy Revolution, 13 October.

Strategic So What?

Storage is becoming the organising principle of modern energy systems, shifting the sector from generation-led thinking to flexibility-first design.

Success requires:
- Integrating storage as a core system asset, designing grids and portfolios around flexibility rather than generation alone
- Building balanced portfolios across durations, combining batteries, thermal, mechanical and hydrogen systems to manage volatility, supply chain complexity and rising demand
- Using optimisation, forecasting and trading tools to unlock value as storage reshapes pricing, dispatch and market behaviour in real time

Together, these priorities build systems powered not only by clean generation, but by the flexibility to deliver it whenever it's needed.

Image Source: Siemens

"In 2022, there was only a single gigawatt-scale facility — defined as having a capacity of at least 1GWh, able to supply roughly 3mn UK households for an hour — in operation worldwide. Today there are 42 such sites. Five times as many giga-projects are set to come online in the next couple of years, including in the UK, the Netherlands, Chile and the Philippines."

FT (2025) How Mega Batteries Are Unlocking an Energy Revolution, 13 October.

Image Source: Arevon Energy / Los Angeles Department of Water and Power (LADWP) — Eland Solar-plus-Storage Center

Beyond Electrons

If electrons powered the last century, will molecules define the next?

Molecules and fuels for hard-to-electrify sectors.

The Future Forecast

The energy transition is not only electric. Hydrogen, green ammonia, e-fuels and advanced biofuels are advancing to decarbonise the industries electrons cannot reach, from aviation and shipping to steel, glass and chemicals. These sectors account for 37 per cent of global final energy use and roughly one-third of emissions (Sustainable Energy for All, 2025), making progress in these areas critical to climate goals. Molecular fuels provide the high temperatures and energy densities needed for the hardest-to-abate processes, forming a parallel clean-energy economy that grows alongside electrification.

Against this backdrop, momentum is building as costs fall and policy strengthens. Low-emissions hydrogen production, currently less than 1 per cent of total supply, is set to see robust growth, rising to roughly 4 per cent by 2030 (IEA, 2025). On the policy front, REPowerEU targets 10 million tonnes of domestic green hydrogen and 10 million tonnes of imports by 2030 (EY, 2025). Airlines are testing sustainable aviation fuels, shippers are commissioning methanol- and ammonia-ready vessels, and manufacturers are trialling hydrogen in furnaces and industrial heat. But scaling molecules requires far more than production: it needs pipelines, ports, certification frameworks, carbon-accounting systems and international trade routes designed to mirror traditional commodities.

At the same time, the economics are evolving. Green molecules remain expensive, but electrolyser costs are falling, materials are advancing and subsidies are expanding globally. Small pilots are becoming full supply chains with storage, logistics and cross-border flows. Companies entering this space face the complexities of a commodity market, including raw-material sourcing, multi-country operations, traceability and compliance, but also early-mover opportunities in fuel markets set to scale globally.

Molecular fuels bring new resilience to the transition, adding temperature, density and flexibility where electrons cannot compete. As these parallel systems mature, they broaden the energy mix, diversify risk and open new industrial pathways. The next phase will depend on the sector's ability to scale, certify and trade green molecules, turning them from experimental fuels into the backbone of clean heavy industry, long-distance transport and a more robust global energy system.

Pioneers in Action

- Stegra's green-steel project in Boden, Sweden will begin hydrogen-ready steel production in 2026, ramping up through 2027–28 towards full green-hydrogen iron and steelmaking at a planned scale of up to 5 million tonnes a year (Stegra, 2025).
- COSCO Shipping Bulk in China placed a 2025 order for four ammonia- and methanol-ready bulk carriers, preparing future fleet operations for emerging low-carbon shipping corridors (Offshore Energy, 2025).
- Moeve's Andalusian Green Hydrogen Valley in Spain is being developed with 2 GW of planned electrolyser capacity and an expected output of up to 300,000 tonnes of green hydrogen annually (Moeve, 2025).

"The future of energy hinges on integrating sustainable molecules with electrification."

ING (2025) The Energy Transition Isn't Just Electric, It's Molecular, 23 July.

Strategic So What?

Green molecules are rising as a pivotal part of decarbonisation, advancing into areas where electrification meets its limits.

Success requires:
- Building molecule-ready operations that integrate production, storage, certification and cross-border logistics into a coordinated system
- Investing in verification and carbon-tracking capabilities that prove origin, secure subsidies and meet emerging fuel-standard requirements across markets
- Developing bankable commercial structures for green molecules, from long-term offtake agreements to shared infrastructure, that reduce risk, lower costs and enable scale

The goal is to scale molecular energy as a viable industrial fuel, backed by systems that make production traceable, tradeable and investable.

"Green molecules may be tiny, but they represent a massive market opportunity. With the right investment, we could see multi-billion-euro turnover companies emerge in this space within a handful of years."

World Fund (2025) Green Molecules, Your Next Multi-Billion Dollar Investment? 28 August.

Image Source: Carlton Power Limited — Barrow Green Hydrogen, UK

Ambient Energy

What if every surface could generate power?

Microgeneration, embedded into everyday life.

The Future Forecast

What if power came not only from distant sites but from the surfaces we move through every day? Ambient energy reveals clean power hidden in plain sight, generated in small, continuous ways in the places we live, work and move.

It is about producing power where people already are, from offices and transit hubs to homes, capturing energy that would otherwise dissipate as waste heat, unused footfall or sunlight hitting glass. Building-integrated photovoltaics reached $18.7 billion in 2024 and are projected to almost triple by 2034 (Emergen Research, 2025).

Researchers are advancing microgeneration that blends into the built environment rather than sitting on top of it. Photovoltaic coatings are becoming flexible enough to wrap curved facades or tint semi-transparent glass, while thermoelectric panels draw power from temperature differences across HVAC systems and sun-exposed walls. Floors embedded with piezoelectric materials convert movement and vibration into usable electricity.

What sets ambient energy apart is that it adds capacity without adding infrastructure. Roads can illuminate themselves, warehouse facades can charge local storage and skyscraper glazing can function as a continuous solar surface. For dense cities running out of space, this introduces a new design logic that treats the urban fabric as a distributed generator.

The real change comes when thousands of micro-sources operate together. Ambient systems power sensors, feed building-level storage, reduce grid demand and support hyper-local networks. Rather than replacing large-scale renewables, they act as an always-on layer that smooths peaks, powers edge devices and turns the built environment into an active participant in clean generation.

Ambient Energy invites the industry to rethink where power comes from, not as a distant facility but as an urban fabric capable of producing its own electricity, one surface at a time.

Pioneers in Action

- Pavegen's kinetic floor systems are installed at more than 300 sites in 45 countries. In 2024, the company partnered with the $25 billion Sports Boulevard project in Saudi Arabia, UEFA, Ford and Uber in the UK, Merritt Park and Purina in the US and Dubai World Trade Centre in the UAE. The London-based firm converts footsteps into electricity and data, and is now rolling out hybrid "Solar + Kinetic" tiles that pair footfall generation with integrated solar films for higher output (Business Cloud, 2025).
- Fraunhofer FEP's Design-PV project (Germany, 2025) developed decorative photovoltaic films using roll-to-roll nanoimprint lithography that allow solar modules to blend seamlessly into building facades, achieving 80 per cent of standard module efficiency while appearing visually identical to conventional materials (pv magazine, 2025).

> "The possibility of producing energy from everyday actions represents a paradigm shift."

Noticias Ambientales (2025) Clean Energy Rising From the Ground, 30 September.

Strategic So What?

Ambient energy shifts generation to the micro scale, producing power through everyday surfaces that quietly feed the system.

Success requires:

- Integrating microgeneration into materials, from PV films to thermoelectric and kinetic systems in facades, floors and glass
- Managing distributed assets at scale, using unified platforms to monitor, optimise and maintain thousands of small generation points
- Building viable commercial models, capturing value through reduced peak demand, local generation, grid services and partnerships

The opportunity is to turn the built environment into a continuous source of clean power.

Image Source: Pavegen

> “As architects confront the climate crisis, integrating renewable energy into buildings has become a defining challenge.”

Foster + Partners (2025) Solar Power: Photovoltaics in Architectural and Urban Planning, 17 September.

Image Source: Foster + Partners — Masdar City, Abu Dhabi

02 Intelligent Systems

- Grid of Grids
- Virtual Power Platforms
- Autonomous Energy
- Energy Intimacy

Grid of Grids

What happens when one grid becomes many?

From centralised utilities to connected networks.

> "Grids will need to be decentralised, digitalised and more flexible to adapt to the intermittent nature of renewable energy sources and reduce the congestion management costs."
>
> European Parliament (2025)
> EU Electricity Grids.

The Future Forecast

The age of the single, centralised grid is giving way to a system of many. Europe's electricity demand is forecast to rise by up to 40 per cent by 2035 (IEA), and more than 1,700 GW of renewable and hybrid projects were waiting in connection queues across major markets as of 2024–25 (Beyond Fossil Fuels et al., 2025). With clean power increasingly stranded behind limited infrastructure, systems are moving towards networks that are modular, interconnected and capable of operating at multiple scales at once.

Microgrids show what this looks like in practice. They can run independently during disruption and reconnect once conditions stabilise, creating flexible capacity banks that help balance the wider European grid (Wärtsilä, 2025). Cross-border interconnectors strengthen this architecture, moving clean electricity to where it's needed most. The EU already saves up to €34 billion each year through market integration, and new links are expected to lower costs further as renewables expand (European Parliament, 2025).

Scaling this model requires major physical expansion. The IEA estimates more than 80 million kilometres of new grid will be needed by 2040, equivalent to rebuilding today's entire global network (European Parliament, 2025). Meanwhile, investment in digital grid technologies reached $81 billion in 2024, putting interoperability and system-wide visibility at the centre of planning.

Digital intelligence, from grid-forming controls and sensors to automation and AI forecasting, allows distributed systems to operate as one. Networks can communicate and adjust in real time, routing power efficiently and absorbing volatility from electrified transport, heating and industry. But a distributed system is harder to coordinate and the cost of misalignment is already visible. Seven European countries recorded €7.2 billion in renewable curtailment in 2024 because the grid could not absorb the power (Beyond Fossil Fuels et al., 2025).

A grid of grids is emerging: local systems, national backbones and cross-border corridors linked through shared intelligence. Rather than replacing the central grid, these networks reinforce it, adding resilience and more routes for clean power to flow. The priority is to integrate these layers quickly and coherently so clean energy can connect at pace and the system can meet rising demand, withstand climate extremes and support a fully electrified economy.

Pioneers in Action

- Denmark is establishing artificial energy islands in the North Sea to centralise offshore wind generation, enabling local use, storage and cross-border clean energy exports.
- The UK's Distributed ReStart programme showed that distributed renewables with grid-forming inverters can support black-start, creating temporary energy islands that later resynchronise with the wider grid (NESO).
- Belgium's Elia is trialling grid-forming inverters to provide voltage and inertia services, stabilising local sections of the network as renewables increase.

Strategic So What?

A single linear grid is no longer sufficient. The future lies in connected, multi-layered systems that can operate locally and coordinate globally.

Success requires:

- Building interoperable architectures that link microgrids, national networks and cross-border corridors into a coherent whole
- Digital control layers that use sensors, automation and AI forecasting to manage many interacting nodes in real time
- Prioritising investment based on curtailment, congestion and connection data, not just physical capacity, to modernise grids and accelerate clean-energy connections

This shifts planning from adding infrastructure to orchestrating a network of networks that can flex, stabilise and scale as electrification accelerates.

“The volume of renewable projects currently waiting in queues already outstrips the additional installation required to reach 2030 National Energy and Climate Plan targets (561 GW wind and solar combined between 2024 and 2030). More than €240 billion (£200 billion) worth of projects are stuck in a connectivity waiting list in the UK alone, that in some instances could last up to 15 years.”

Beyond Fossil Fuels et al. (2025) How Europe’s Grid Operators Are Preparing for the Energy Transition, May.

Virtual Power Platforms

What happens when the power plant becomes a platform?

Software-defined coordination of distributed assets.

> "The rise of virtual power plants marks the beginning of a new era in grid and power system modernisation."
>
> Ricardo Group (2025) Virtual Power Plants: Unlocking Flexibility in a Decentralised Energy Future, 2 October.

The Future Forecast

As generation and storage spread across millions of small devices, the power plant is being reimagined as a digital coordination layer. Instead of a single facility producing electricity, virtual power platforms connect rooftop solar, batteries, EVs and commercial loads into flexible capacity that can respond in real time. The focus shifts from where power is produced to how it is managed, unlocking capacity from distributed assets already connected to the system.

This model is scaling fast. The U.S. Department of Energy expects virtual power plant capacity to exceed 80 GW by 2030, and similar programmes are growing in Europe through flexibility markets, smart tariffs and grid-service incentives. Behind-the-meter assets that once sat idle now act as responsive resources that can help shape demand curves, relieve local constraints and provide firm services to the wider system.

Ultimately, it's how these assets work together that creates value. Algorithms forecast load and availability, optimise charge and discharge cycles, and bid aggregated capacity into wholesale and ancillary markets automatically. Thousands of devices acting together can deliver the kind of controllability once associated with large plants, but deployed faster and at lower cost. Instead of building new infrastructure, VPPs unlock value from distributed assets already in place.

There are still challenges to manage, as coordinating devices across different standards, regulations and market rules increases complexity, and many stakeholders including utilities, device manufacturers and regulators must align under shared incentives. But platform-based approaches are emerging to solve this, using unified data models and standardised market interfaces to treat millions of distributed assets as a single dispatchable resource rather than a fragmented set of devices.

Virtual power platforms signal a shift from owning generation to orchestrating portfolios. Homes, businesses and fleets become contributors rather than consumers, expanding who can take part in balancing the grid while unlocking value from existing assets.

The most challenging part is not the technology, but coordinating markets, assets and incentives at scale. Success now depends on how well power can be synchronised, dispatched and monetised through a unified digital platform.

Pioneers in Action

- Statkraft operates Europe's largest virtual power plant, aggregating more than 12 GW of wind, solar, storage and flexible gas across 1,400 units in Germany. In the UK, it has launched a 1 GW platform that optimises output and enables real-time wholesale trading through a common control centre, allowing distributed assets to participate in energy markets as a conventional power station would (Solar Power Portal, 2025).

- Next Kraftwerke runs one of Europe's biggest virtual power platforms, aggregating over 14,000 decentralised assets across 17 technologies to provide 12.7 GW of flexible capacity. In 2024, it traded more than 15 TWh of energy and helped cut grid-balancing costs by up to 25 per cent (Ricardo, 2025).

Strategic So What?

Virtual coordination turns distributed capacity into commercial capability.

Success requires:
- Standardising data from distributed assets, so rooftop solar, batteries, EVs and HVAC systems can be coordinated through one platform
- Automating dispatch and settlement, enabling aggregated flexibility to be traded like a single power plant
- Building market-ready interfaces, from forecasting and bidding engines to contract management and billing models that handle many small contributors at scale

Organisations that treat coordination as a product will unlock new revenue from existing assets and shape the next era of system reliability.

"While an autonomous power plant (APP) is a single, smartly controlled physical power plant, Virtual Power Plants (VPPs) aggregate multiple distributed energy resources into a unified, digital power-generating entity. VPPs coordinate assets like solar, wind, and battery storage to balance supply and demand in real time, participate in energy trading, and enhance grid reliability."

Siemens Energy (2025) Moving Towards Autonomous Power.

Image Source: Budderfly

Autonomous Energy

What if the grid could think faster than it breaks?

Predictive, self-managing systems and AI operations.

> "AI can help to balance electricity networks that are growing more complex, decentralised and digitalised. AI-based fault detection can help rapidly identify and precisely pinpoint grid faults, reducing outage durations by 30–50%."
>
> IEA (2025) Energy and AI.

The Future Forecast

The grid is entering a phase where speed, data and scale exceed human capacity. AI is becoming an operational partner rather than just an analytical tool, optimising output, balancing loads and improving efficiency in real time. Structural pressures are accelerating this advance as ageing workforces, extreme weather and increasingly distributed fleets make automated decision-making a strategic response, not just a technology choice.

Across the system, sensors, digital twins and machine-learning models are creating assets that understand their own condition, forecast failures and make adjustments without intervention. The IEA notes that AI-based fault detection can identify and pinpoint grid issues more quickly, cutting outage durations by 30–50 per cent. At plant level, autonomous controls modulate load, schedule maintenance and tune performance continuously, strengthening reliability and reducing routine performance risk.

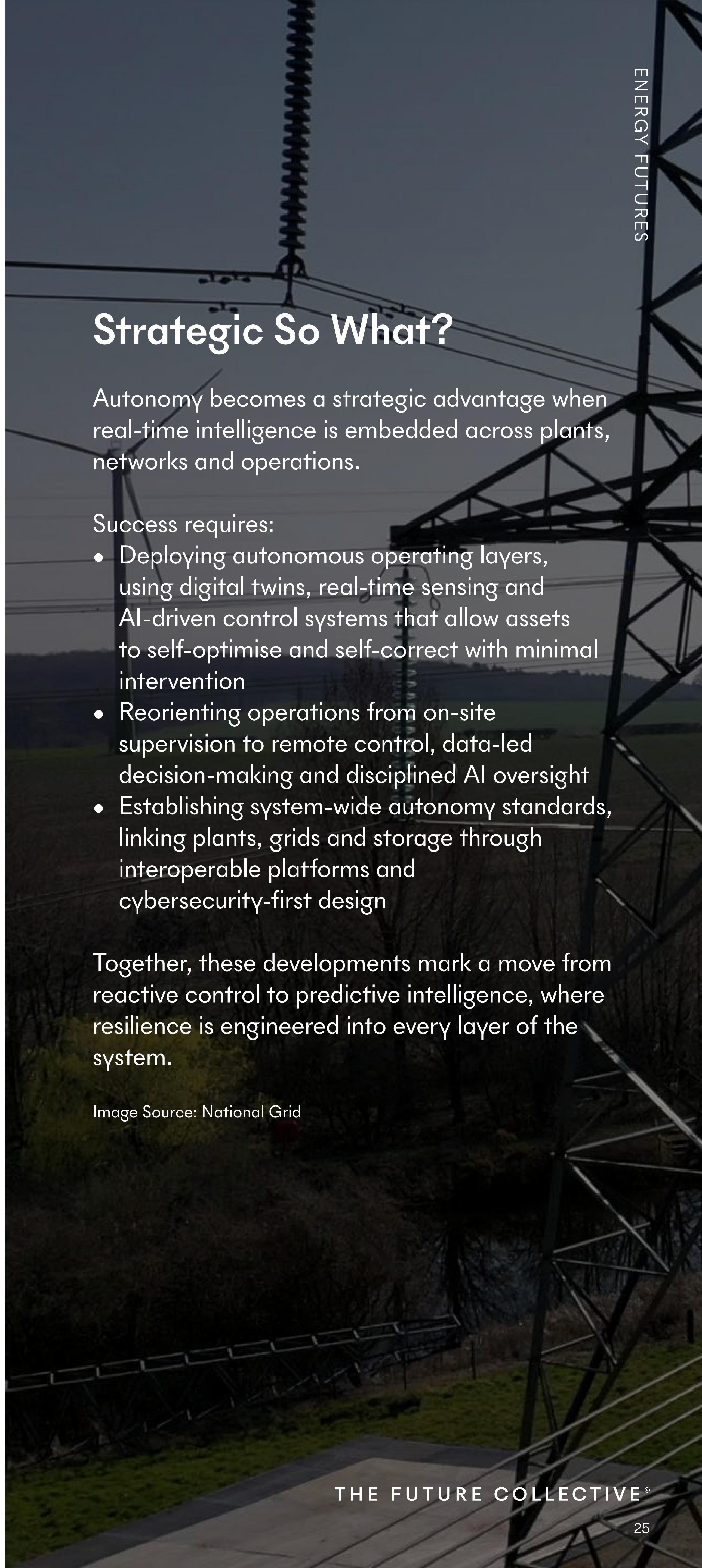
Autonomy is also altering economics. Predictive maintenance reduces downtime, remote operations cut staffing needs and digital optimisation unlocks value from existing infrastructure. The IEA estimates that AI-enabled management could free up 175 GW of transmission capacity globally without new lines, equivalent to absorbing projected data-centre load growth to 2030. Plants retrofitted with autonomous capabilities ramp faster, participate more flexibly in short-term markets and operate at lower cost.

Deployment is already underway. Utilities are testing autonomous fault response in distribution networks, while generators use AI to adjust output based on grid signals and weather forecasts. Humans remain essential for oversight, exception handling and strategic decisions, but routine operational control is shifting to software. The challenge is ensuring these systems fail safely when predictions are wrong or conditions fall outside expected parameters.

A more autonomous system does not operate in isolation. Plants, storage assets and networks still depend on each other, but increasingly manage their own behaviour within shared parameters. The result is a grid that reacts sooner, fails less and supports the volatility that comes with climate extremes and demand growth. Autonomy becomes the foundation for a power system built for speed, resilience and continuous optimisation.

Pioneers in Action

- Siemens Energy's Leipheim plant in Bavaria, built for LEAG, can be remotely ramped to 300 MW within 30 minutes, with operation, monitoring and servicing carried out through the Remote Monitoring Service Center in Erlangen using advanced AI and augmented-reality tools (Siemens, 2024).
- National Grid has rolled out autonomous drones that fly beyond visual line of sight to inspect high-voltage infrastructure, run from a central control room. The system uses AI and machine learning to capture and process condition data, informing maintenance programmes while freeing engineers for specialist tasks (National Grid, 2025).
- Researchers at the prominent UAE-based University of Sharjah developed a digital twin for compressed-air energy storage systems that uses sensors, statistical analysis and machine learning to detect early signs of faults, improving efficiency and reliability (Future Digital Twin, 2025).



Strategic So What?

Autonomy becomes a strategic advantage when real-time intelligence is embedded across plants, networks and operations.

Success requires:

- Deploying autonomous operating layers, using digital twins, real-time sensing and AI-driven control systems that allow assets to self-optimise and self-correct with minimal intervention
- Reorienting operations from on-site supervision to remote control, data-led decision-making and disciplined AI oversight
- Establishing system-wide autonomy standards, linking plants, grids and storage through interoperable platforms and cybersecurity-first design

Together, these developments mark a move from reactive control to predictive intelligence, where resilience is engineered into every layer of the system.

Image Source: National Grid

"Several technologies aimed at autonomous power generation are already in use. Leading among them is a smart monitoring system based on sensors that provide real-time data on temperature, pressure, vibration, emissions, and other key metrics across a plant's critical parts. These data flows can support a digital twin, improve performance, and enable predictive maintenance, boosting a plant's overall reliability with less human intervention."

Siemens Energy (2025) Moving Towards Autonomous Power.

Energy Intimacy

What if energy truly understood us?

Human-centred intelligence that adapts to how we live.

> "Utilities can shape the smart grid future by enabling the technical foundation for Advanced Metering Infrastructure (AMI) 2.0."
>
> EY (2025) How Utilities Can Prepare for the AMI 2.0 Era, 21 March.

The Future Forecast

Energy systems are starting to learn the rhythms of daily life. Sensors, smart devices, building-management platforms and predictive AI reveal how spaces are used, allowing systems to adjust lighting, heating, cooling and energy demand around occupancy, habits and comfort. These are systems that pay attention to context, not just consumption.

Evidence is emerging that this approach delivers material impact. New research by KPMG shows that strategic energy-management AI models can improve commercial building efficiency by up to 30 per cent, while a Schneider Electric study found occupancy-based controls in meeting rooms deliver average savings of around 22 per cent in energy use and emissions. These findings point towards a future where comfort and efficiency reinforce each other. That vision depends on real-time data, with AMI 2.0 – advanced metering infrastructure – providing the foundation for adaptive control.

The opportunity isn't more control, but control that fades into the background. Responsive buildings adapt without constant human input, featuring lighting that anticipates movement, HVAC that recognises when spaces empty and appliances aligned to behaviour. Complexity grows behind the scenes, while for the user, energy becomes simpler, seamless and personal.

This reflects a broader shift towards intimacy in technology, with systems that understand context, anticipate needs and adapt invisibly. As buildings, workplaces and districts become more autonomous, oversight shifts to ongoing adaptation. Energy quietly shapes itself around how people live, changing how it is used, billed and valued.

The next stage is depth rather than scale, with progress shaped by understanding behaviour instead of simply adding more devices. Intelligent systems will learn patterns over time, mapping how spaces change across seasons and how comfort varies between occupants. Instead of reacting to fixed schedules, energy will follow human rhythm. Energy Intimacy suggests a near-future where the most effective systems are not the largest or most powerful, but the ones that feel effortless.

Pioneers in Action

- Lenovo deployed an AI+IoT smart energy solution across its 350,000-square-metre headquarters in Beijing and a large manufacturing campus. The upgrade delivered around 30 per cent energy-cost reduction through automated HVAC optimisation, sensor-based control and real-time load management (Lenovo, 2025).
- Emrill Energy reported a 14 per cent verified reduction in electricity consumption over 18 months after retrofitting buildings with AI-controlled HVAC and building management systems (Emrill, 2025).
- Researchers in South Korea demonstrated the first continuous-variable, quantum-enhanced reinforcement learning system for residential HVAC and home power management. The system integrates occupancy detection, real-time environmental data and multi-zone cooling to cut energy use and costs by more than 60 per cent compared with classical control methods (Energy and AI, Vol. 21, 2025).

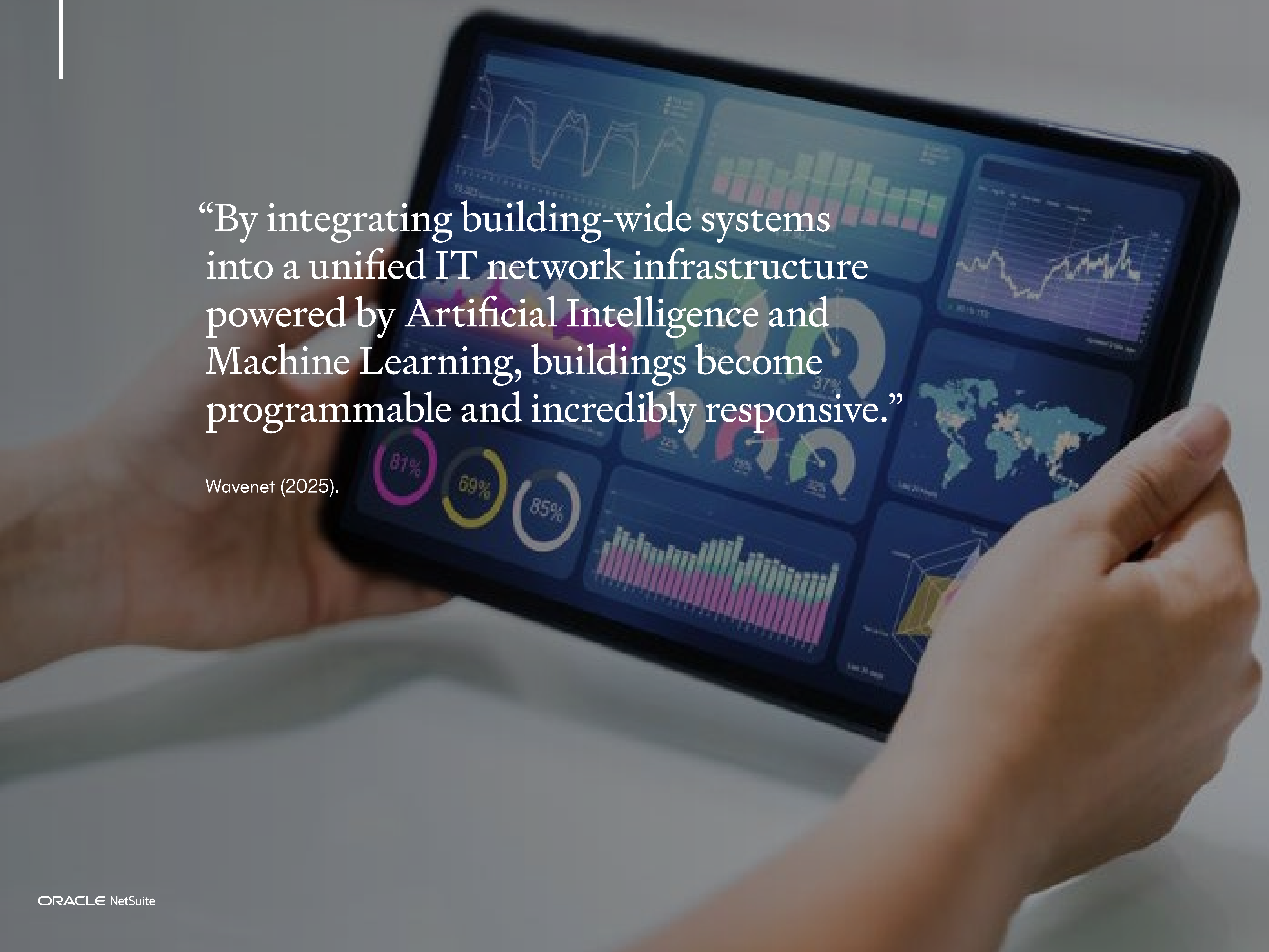
Strategic So What?

Energy intimacy becomes powerful when intelligence spans data, people and systems.

Success requires:

- Connecting building systems, IoT sensors and energy platforms through a single operational layer, enabling continuous monitoring, optimisation and reporting across portfolios
- Creating real-time data visibility across assets, billing, occupancy and loads to improve accuracy, reduce waste and identify opportunities automatically rather than quarterly
- Automating routine energy management, using AI to anticipate demand, adjust controls and trigger interventions autonomously

The organisations that benefit most will treat energy as a living dataset which is always tracked, continually optimised and seamlessly managed in the background.



“By integrating building-wide systems into a unified IT network infrastructure powered by Artificial Intelligence and Machine Learning, buildings become programmable and incredibly responsive.”

Wavenet (2025).

03 Markets Reimagined

- Energy Identity
- Carbon Commodities
- Flexibility Economy
- Energy Democracy
- Circular Energy Futures

Image Source: EcoFlow — STREAM Series Plug & Play Solar Plant

Energy Identity

What if every kilowatt came with a passport?

Traceability, provenance and digital proof.

The Future Forecast

Energy is acquiring identity. As systems decentralise and digitise, proving where power and equipment come from is becoming essential. What began with digital passports for batteries is evolving into traceable energy identities that certify renewable origin, carbon intensity and supply-chain integrity. Customers increasingly want to know not just what they consume, but how and where it was produced, creating a new layer of information that sits alongside pricing and metering.

From February 2027, every electric vehicle and industrial battery above 2 kWh sold in the EU must carry a digital passport accessible via QR code, detailing materials, lifecycle data and environmental impact (Circularise, 2025). This battery passport is just one example in a wave of product traceability requirements being introduced across Europe. In 2024, the Solar Stewardship Initiative published a supply-chain traceability standard for solar manufacturing, introducing chain-of-custody requirements for silicon, wafers and modules (Solar Power Portal, 2024). Similar verification models are being developed for green-hydrogen guarantees, certified renewable origin in power-purchase agreements and carbon-audited generation. As regulation evolves energy data is moving from static documents to digital records that can be tracked, queried and trusted.

This shift is bringing financial and sustainability data together. Blockchain registries, chain-of-custody systems and live emissions accounting allow operators to see a unified view of performance and impact, connecting data that once sat in separate systems across procurement, metering, ESG and compliance.

Traceability is also beginning to influence price. As disclosure obligations tighten, energy with a clear, credible identity can meet reporting requirements, reduce risk and strengthen commercial negotiations. Finance teams can link sustainability data to contracts and suppliers, making provenance a practical commercial tool.

Energy Identity points to a market where information becomes part of the product. Power comes with documented origin, contracts include evidence and environmental data is handled with the same discipline as financial reporting. Organisations that build traceability into routine operations will move faster and with more confidence as low-carbon markets mature.

Image Source: 3D AG

Pioneers in Action

- Lhyfe provides Digital Product Passports with every green hydrogen delivery, tracking carbon footprint, energy sourcing and production steps. Developed with compliance platform Atmen, the system enabled RFNBO certification in 2025, exceeding EU requirements (Lhyfe, 2025).
- EnerjiSA and Blok-Z have deployed a blockchain platform that matches corporate electricity consumption with renewable generation on an hourly basis. Over 313,000 MWh have been tokenised across 180 sites, giving customers verifiable origin data for sustainability reporting (Eurelectric, 2025).
- Good Energy introduced 'Good Green Supply' standards requiring suppliers to disclose the percentage of power actually matched to renewable generation hour by hour (Good Energy, 2025).

Strategic So What?

Energy Identity is a commercial capability that shapes contracts, pricing and market access. Energy businesses must prepare for a world where provenance is as important as price.

Success requires:

- Integrating origin and carbon data into procurement and trading systems, so environmental attributes flow through contracts and invoices
- Linking sustainability claims to verifiable records that can be tracked, audited and trusted in real time
- Applying financial-grade discipline to energy data, putting environmental performance next to cost and risk in strategic decisions
- Ensuring systems are interoperable, verifiable and cost-effective, so traceability strengthens trust without adding new complexity

Energy markets will reward clarity as much as capacity.

> "Customers are increasingly demanding comprehensive information about the source of origin of their energy. Year-on-year, an "electron pedigree" benchmark has become significant, highlighting the necessity for end-to-end traceability across the energy supply chain."

Smartest Energy (2025) Data-Driven Energy, 28 April.

"73% of consumers want stricter rules on energy suppliers making green claims, and 38% believe energy suppliers are more likely to greenwash than other businesses."

Good Energy (2025) New Standards Aim to Tackle Greenwash From Renewable Electricity Suppliers, 10 February.

Carbon Commodities

Who profits when carbon turns into currency?

Carbon as currency and tradeable asset.

The Future Forecast

Carbon is emerging as a parallel commodity system to energy. Renewable generators now produce units as well as power, and carbon capture earns revenue by storing emissions. Hydrogen projects and low-carbon fuels are beginning to be priced on carbon intensity, while nature-based offsets continue to expand the wider carbon ecosystem. Verified reductions, removals and carbon attributes are becoming monetisable in contracts, creating a commercial layer around energy production and use.

Regulation is catching up with the market. In late 2024, the EU approved a certification framework for carbon removals, and the UK confirmed engineered removals will enter its emissions trading system by 2029. As standards mature, carbon data is being built into power agreements, supply contracts and fuel pricing, giving verified projects a clear price advantage.

The market is expanding across borders, matching emissions challenges in one region with finance in another. Carbon transactions could reduce the cost of countries meeting their Nationally Determined Contributions by $250 billion in 2030, enabling 50 per cent more emissions to be removed at no additional cost (World Bank, 2022). These markets are already helping to fund infrastructure, jobs and local projects in the Global South – but the World Bank notes that carbon markets only deliver climate benefit when reductions are accurately tracked and verified.

Carbon markets only work if data is reliable, verifiable and comparable across projects. Investment is accelerating in digital MRV, from satellite tracking of forestry projects to sensor networks for industrial capture and AI tools that audit reporting. Together, these technologies help carbon be priced, insured and exchanged with greater confidence.

Carbon commodities open value pathways beyond generation. Energy producers, industrial operators, logistics networks and land stewards can all generate revenue from verified carbon outcomes. The advantage will lie with organisations able to measure impact accurately, manage data transparently and engage with emerging carbon commercial models.

Pioneers in Action

- Microsoft agreed to purchase 6.75 million metric tons of engineered carbon removal over 15 years from the AtmosClear bioenergy carbon capture and storage facility in Louisiana, the largest permanent carbon removal deal announced to date (ESG Today, 2025).

- In March 2025, a coalition of 30 organisations led by The Global Carbon Market Utility, Sylvera, RMI and S&P Global Commodity Insights launched the Carbon Data Open Protocol to standardise carbon credit data worldwide. By harmonising definitions and ensuring transparency, the protocol aims to turn fragmented voluntary markets into a trusted, scalable system (Sylvera, 2025).

Strategic So What?

Carbon becomes valuable when it is measurable, verifiable and commercial.

Success requires:

- Treating carbon data like financial data, with reliable measurement, audit trails and consistent reporting across projects, assets and partners
- Embedding verified carbon attributes into contracts and procurement, so value moves automatically through billing and commercial terms
- Creating unified data visibility across operations, finance and sustainability teams to identify monetisable carbon units

Organisations that build trusted carbon records today will be better positioned to sell, hedge and negotiate carbon value in the future.

> "Technology offers promising solutions to some of the challenges currently facing carbon markets."

Tony Blair Institute for Global Change (2025) International Carbon Markets, 9 September.

"Trading in carbon credits could reduce the cost of implementing countries' Nationally Determined Contributions (NDCs) by more than half – by as much as $250 billion in 2030."

World Bank Group (2022) What You Need to Know About Article 6 of the Paris Agreement, 17 May.

Flexibility Economy

What if energy's real value isn't power, but timing?

Flexibility, Energy-as-a-Service and dynamic value creation.

The Future Forecast

The way we use energy is becoming part of the resource mix. As renewable output rises and fluctuates throughout the day, the ability to shift, reduce or defer consumption is gaining greater commercial value. Households can earn by letting utilities manage batteries or EV charging during peak hours, and businesses subscribe to guaranteed energy outcomes without owning any infrastructure. Energy is adapting to users, not the other way around.

The commercial case is hard to ignore, with ENTSO-E estimating that tapping Europe's flexibility potential could avoid up to €5 billion a year in generation costs (Electron, 2025). Meanwhile, the Energy-as-a-Service (EaaS) market is projected to double from $52 billion in 2024 to over $100 billion by 2030 (MarketsandMarkets, 2025). Instead of financing and maintaining energy assets, companies subscribe to guaranteed resilience, optimisation and clean supply.

Timing becomes valuable as price volatility grows. Wholesale electricity prices dropped below zero for a record number of hours in several European markets in 2025, including over 500 hours in Spain (FT, 2025). Smart management is making flexibility invisible rather than disruptive. AI-powered platforms coordinate thousands of devices and schedule use when electricity is cheapest or cleanest, so consumers retain comfort while the grid gains stability. Flexible electricity use is growing fast, with the number of smart energy tariffs and services for European consumers almost tripling in the last three years, though fewer than 30 per cent of homes in ten EU countries have smart meters to access them (Ember, 2025).

This creates a new type of market participant, with aggregators increasingly treating distributed flexibility like a portfolio, booking home batteries, EV chargers and industrial load-shifting into dispatchable blocks that support peak balancing. Flexibility becomes a hedge against volatile conditions by shifting demand quietly in the background, storing solar during heatwaves to power cooling overnight, or reducing ventilation in commercial buildings during peak hours.

Tomorrow's flexibility isn't about asking people to change their behaviour. Instead, the focus is on systems absorbing volatility on their behalf, turning timing into revenue and converting what used to be a grid challenge into a business advantage.

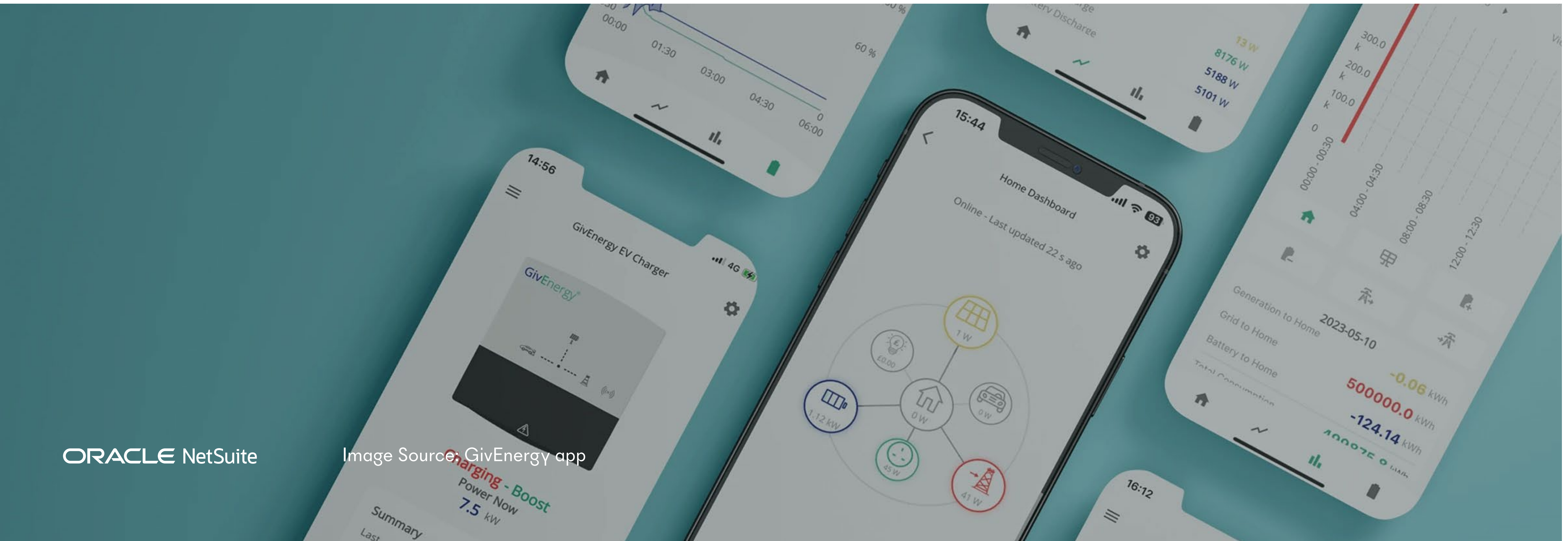


Image Source: GivEnergy app

Pioneers in Action

- E.ON Next launched Next Gen Home in July 2025, offering UK households £20,000 worth of solar panels, batteries, heat pumps and EV chargers through a fixed monthly subscription with no upfront cost. The 12-month pilot with 20 Midlands homes bundles equipment, installation, servicing and energy into one payment, with nationwide rollout planned for early 2026 (E.ON Energy, 2025).

- Sustainable Development Capital has partnered with Schneider Electric to deliver EaaS across the UK, targeting data centres, business parks, industrial sites and universities. The subscription model removes upfront financing while deploying energy efficiency technologies, digital tools and microgrid solutions. (The Energyst, 2025).

- Kraken has become a global leader in residential flexibility, managing over 2 GW of power from EVs, home batteries and heat pumps, balancing the grid and bringing down bills by charging cars and heating homes when energy is abundant, cheap and green (Octopus Energy Group, 2025).

Strategic So What?

Flexibility becomes valuable when timing is managed as deliberately as supply.

Success requires:

- Designing procurement and operations around when power is available and affordable, not just how much is needed
- Monetising demand-side capability through dynamic tariffs, aggregation services and price-signal contracts
- Choosing service-based models that shift capital risk to providers while unlocking optimisation technology and built-in reporting

Organisations that treat timing as a commercial capability will be better placed to reduce exposure to volatility and turn adaptability into advantage.

> "Energy supply is becoming more flexible, with regional models emerging that give consumers more choice over how and where they buy power."

Thomas Sutter, Infrastructure Services Industry Director, Oracle NetSuite (2026).

“Valued at $51.88 billion in 2024, EaaS is projected to reach $100.34 billion by 2030, growing at a CAGR of 11.6%.”

MarketsandMarkets (2025) Global Energy Perspective 2025: Energy as a Service Outlook, 14 July.

Image Source: GivEnergy

Energy Democracy

What if everyone could be an energy company?

Households, EVs and communities as market participants and investors.

The Future Forecast

A decentralised, citizen-led energy landscape is taking shape fast. Participation is shifting from passive consumption to active, shared ownership, with rooftop solar, home batteries and bidirectional EV charging turning households into producers who can generate, store and trade power. Energy no longer flows in a single direction from utility to user, but moves between neighbours, vehicles and the grid.

Prosumers will play an essential role in clean energy adoption, thanks to their ability to deliver much-needed scale. The IEA suggests that rooftop solar on half of the world's buildings could meet global residential electricity demand. In the UK alone, more than 1.5 million homes already have solar installed, with most new builds set to include solar and heat pumps under upcoming Future Homes Standard requirements.

The collective model is gathering momentum too. Communities are starting to behave like micro-utilities, pooling investment to build shared generation and storage. This local ownership protects communities from price spikes and strengthens resilience. Community Energy England reports around 398 MW of citizen-led renewable projects already in operation, powering roughly 280,000 homes, with hundreds of additional megawatts in development.

Beyond static assets, vehicles are joining the network as well. Smart charging and vehicle-to-grid services could store up to 10 per cent of Europe's power by 2040 (EY, 2025). As bidirectional chargers roll out, cars become mobile batteries that can generate income while parked, support local microgrids or feed energy back during peak demand.

Image Source: INDRA

Participation is also becoming virtual. One of the most dynamic developments is the rise of fractional energy ownership. Digital platforms now enable participation without a roof, a battery or planning permission, using blockchain tokenisation to let individuals buy small, verifiable shares in renewable projects. These models make energy ownership more accessible, bringing new voices and capital into the transition.

What makes this shift democratic is control: who owns the infrastructure, who benefits financially and who participates in future energy decisions. The aim isn't to make everyone a utility executive, but to distribute value among households, tenants, community groups and small businesses. Energy is evolving into participatory infrastructure, a network of shared assets and shared returns rather than a one-way commodity.

Pioneers in Action

- E.ON invested $4 million in Allume Energy's SolShare technology to bring shared solar to apartment buildings, giving residents access to clean energy by solving ownership and installation barriers (Sustainable Times, 2025).
- UK startup Cepro raised £600,000 to expand community microgrids that let neighbourhoods share solar and storage locally (Solar Power Portal, 2025).
- Enel's ebitts programme in Italy lets customers buy tokenised fractional shares of solar and wind projects via the Algorand blockchain, using their share of energy production to reduce electricity bills or sell oversupply (Algorand Foundation, 2025).

Strategic So What?

Energy democracy demands participation that is easy, visible and financially valuable.

Success requires:

- Making citizen energy data usable: connecting rooftop generation, EV charging and community assets into shared dashboards for production, revenue and carbon reporting
- Designing models that reward participation: tariffs, microgrid agreements and fractional ownership structures that allow households and businesses to earn, not just consume
- Integrating distributed assets into core planning: treating prosumer generation, community storage and vehicle-to-grid capacity as part of operational supply, not managed separately

Organisations that involve people directly in value creation will broaden their customer base, as well as unlock new capital, distributed resilience and local support for energy projects.

> "Smart charging and V2G can reduce costs, support grid stability, and store up to 10% of Europe's power by 2040."

EY (2025) How Smart Charging and V2G Solutions Can Drive Ireland's Renewable Future, 10 November.

> "The tokenization of real-world assets (RWAs) on blockchain makes it possible for ordinary people to invest in things that were once only available to big corporations. Blockchain's impact now extends to the energy sector, where tokenization is creating new models for renewable energy ownership and distribution."

Algorand Foundation (2025) Enel: Tokenizing Renewable Energy Assets on Algorand, 6 June.

Circular Energy Futures

Can we build a renewable future without creating a waste crisis?

From linear consumption to circular resource loops.

The Future Forecast

The clean-energy transition is accelerating, but so is its material footprint. Millions of solar panels, wind turbine blades and EV batteries will reach end of life over the next decade. The challenge is not just how fast renewables can be installed, but what happens when they retire. A circular approach keeps materials in play, extending life, reducing waste and closing supply loops.

That circular approach will need to operate at considerable scale. Industry expects over one million solar panels to need decommissioning in the UK by 2050, while Greenpeace estimates nearly 13 million tonnes of EV batteries will go offline globally between 2021 and 2030. Without systems that keep pace, we risk replacing a carbon crisis with a waste crisis – yet this volume also creates major opportunity for second-life storage and material recovery.

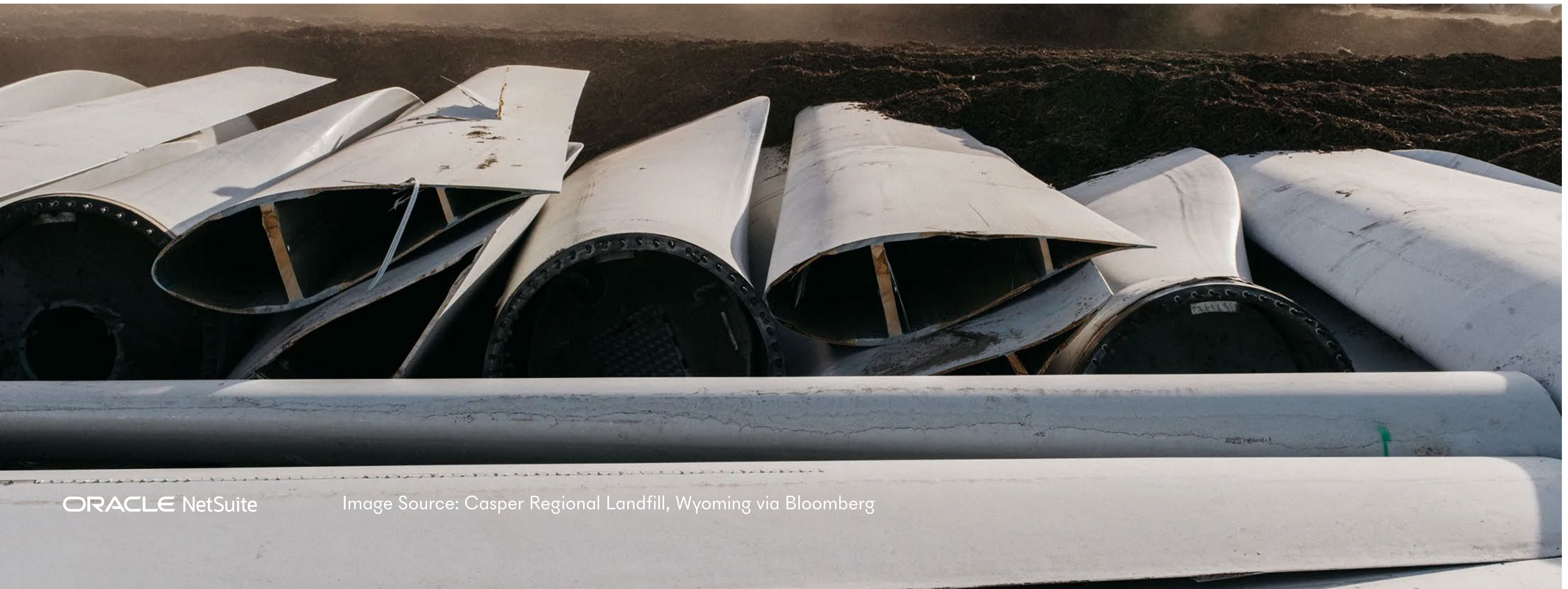


Image Source: Casper Regional Landfill, Wyoming via Bloomberg

A new generation of innovators is designing renewable assets with circularity in mind. Solar panels built for disassembly, turbine blades engineered for reuse and batteries designed for second lives are replacing the linear take–make–waste model. Retired EV batteries are being redeployed for residential and grid storage, extending their working life by a decade or more, while specialist recyclers recover high-value materials such as lithium, silver and rare earths.

Circularity also extends beyond materials into energy flows. Waste heat is being captured to warm district networks, CO_2 streams are being converted into synthetic fuels, and industrial by-products are feeding green hydrogen systems and other low-carbon processes. The idea remains the same, designing systems so outputs become inputs rather than waste.

Scaling these models depends on visibility. Lifecycle data, asset registries and traceable inventories allow operators to know what is installed, where it sits and when it will return, enabling components to be redeployed, refurbished or recycled efficiently rather than sent to landfill or lost.

The evolution from linear models to continual recovery and revaluation is both an environmental necessity and an economic opportunity. Circularity becomes powerful when information, infrastructure and incentives align, and success means building energy systems where materials circulate, value compounds over time and waste becomes a design failure rather than an inevitability.

Pioneers in Action

- Iberdrola's EnergyLOOP facility in Navarre is the first wind turbine blade recycling plant on the Iberian Peninsula, designed to process up to 10,000 tonnes of blade waste per year and recover glass fibres and resins for use in sectors including energy, aerospace, automotive, textiles, chemicals and construction (Iberdrola España, 2025).
- Palladio Partners and Voltfang will invest around €250 million in grid-scale battery storage across Germany by 2029, repurposing unused EV battery modules into second-life systems that support grid stability and balancing markets (Voltfang, 2025).
- Buckstop, a US-based "urban mining" startup founded in 2025, uses an AI asset appraisal platform to assess end-of-life solar panels and EV infrastructure, identifying the most cost-effective method to recover value via a network of resale or recycling partners (pv magazine USA, 2025).

Strategic So What?

Circular advantage comes from planning for renewal, not disposal.

Success requires:

- Tracing materials from day one with digital passports, asset registries and lifecycle data so operators know what's installed, where it is and when it returns
- Building commercial models for return and reuse that make second-life storage, repair networks and component harvesting financially viable
- Creating circular partnerships across manufacturers, recyclers, asset owners and digital platforms so materials can move seamlessly through recovery and back into production

Organisations that treat end-of-life as the start of new value will turn circularity into long-term competitive advantage.

> "The global economic opportunity associated with the circular economy and the value of recovered raw materials from solar PVs is expected to increase radically over the next 10–35 years."

University of Cambridge Institute for Sustainability Leadership (CISL), IfM Engage & E.ON Group Innovation (2025) Circular Solar.

"By 2030 Europe is expected to dismantle about 14,000 wind turbines, creating 40,000–60,000 tonnes of blade waste. Germany alone will account for approximately 23,300 tonnes, followed by Spain with 16,000 and Italy with 2,300."

WindEurope (2025) No Blade Left Behind: the Wind Sector's Commitment to Sustainable Blade Solutions, 3 July.

"With an average solar PV lifetime of 25–30 years, the amount of material contained in damaged and decommissioned solar PVs globally is projected to increase exponentially between 2021 and 2030, reaching more than 200 Mt by 2050."

University of Cambridge Institute for Sustainability Leadership (CISL), IfM Engage and E.ON Group Innovation (2025) Circular Solar.

Image Source: Casper Regional Landfill, Wyoming via Bloomberg

04 Power Shift

- Energy-Tech Convergence
- Scale Imperative
- Integration Edge

Energy-Tech Convergence

AI, hyperscalers and the new power dynamic.

AI is not just transforming how energy is managed but redefining who controls it. Hyperscale data centres are driving unprecedented electricity demand, while the intelligence needed to balance that demand and manage the grid is turning into critical infrastructure. Tech companies are no longer only buying power. Many are now investing in generation and storage, which dissolves the lines between utilities and technology firms. As long-term nuclear agreements, solar-plus-storage projects and even orbital data centre concepts emerge, one strategic question becomes clear: compete with Big Tech, collaborate, or risk being overtaken in a world where data and power are increasingly inseparable.

Signals to Watch:

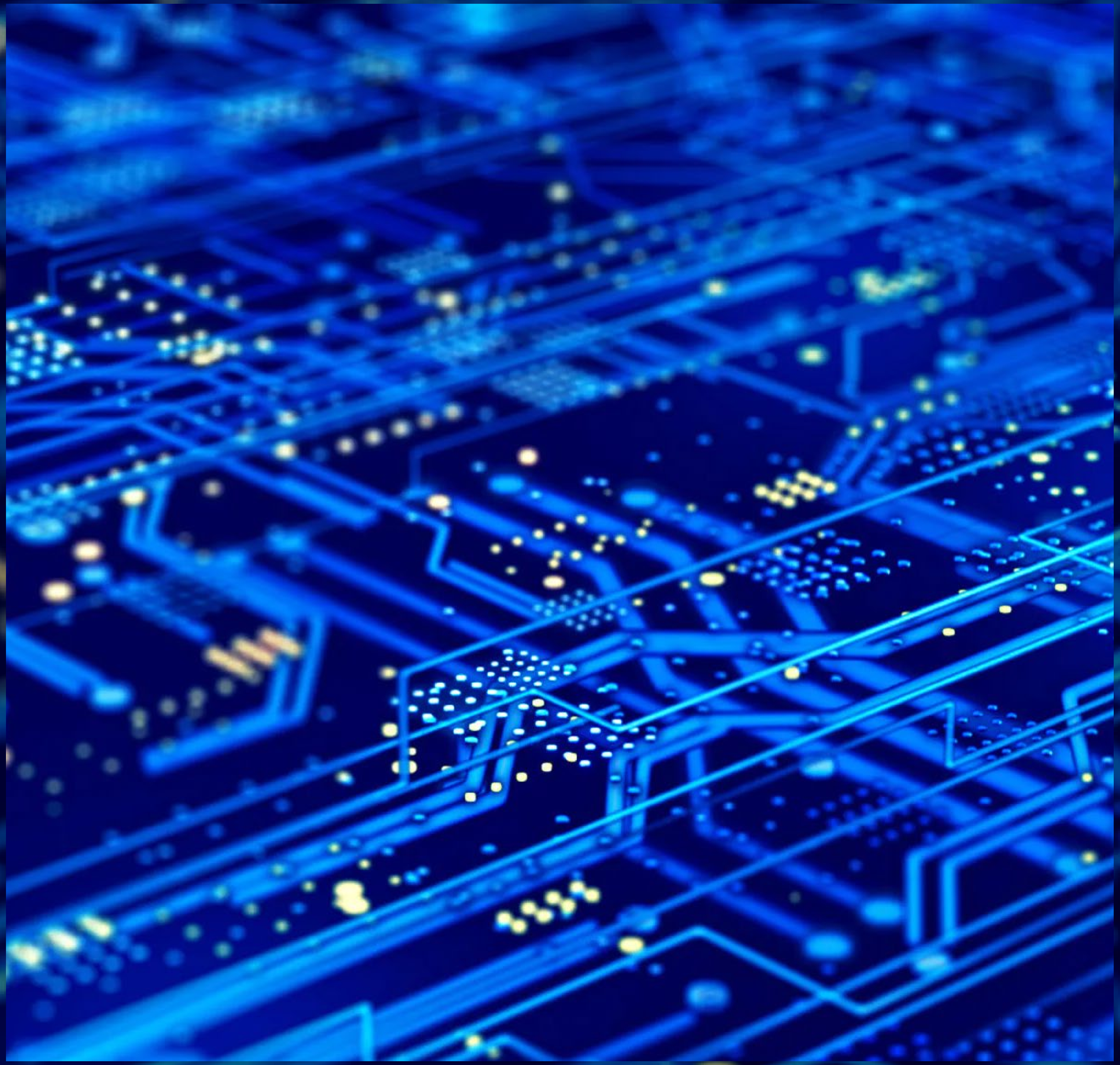
- Utilities reshaping grid investment strategies to prioritise AI data centre hubs
- Tech companies moving upstream into energy production through nuclear, storage and on-site generation deals
- Early experiments in off-planet power and space-based digital infrastructure, such as Google's Project Suncatcher

"Data centre electricity consumption is set to more than double to around 945 TWh by 2030. This is slightly more than Japan's total electricity consumption today."

IEA (2025) World Energy Outlook Special Report: Energy & AI, 10 April.

"There is no AI without energy; at the same time, AI has the potential to transform the energy sector."

IEA (2025) World Energy Outlook Special Report: Energy & AI, 10 April.



Scale Imperative

Execution, consolidation and the race to deploy.

Renewables have proven they can scale, and the challenge now is building them fast enough. Interconnection queues, skilled labour shortages and supply chain pressure are becoming defining constraints. Companies that control delivery are pulling ahead and consolidation is accelerating in response. Utilities are acquiring developers, infrastructure funds are creating integrated platforms and new multi-energy operators are emerging to coordinate projects end-to-end. Those who can build quickly are gaining ground, and delivery matters more than announcements.

Signals to Watch:

- Queue reform and faster permitting unlocking gigawatts of stalled capacity
- Vertical integration in construction and installation becoming a strategic advantage
- Regional manufacturing and supply chains cutting project timelines

"Renewable energy is estimated to make up 77% of the world's primary energy supply by 2050. To achieve this target, the deployment of renewable energy must triple from 2022 levels by 2030, which amounts to an annual addition of 1,200 gigawatts."

KPMG (2023) Turning the Tide in Scaling Renewables.

Image Source: Parkwind — Arcadis Ost 1 wind farm, Baltic Sea

Integration Edge

New structures for a fragmented yet connected system.

Energy systems are becoming more distributed yet more interdependent, neither fully centralised nor entirely decentralised, and this is creating new organisational complexity. Companies are managing multiple subsidiaries, revenue streams and assets across geographies through joint ventures, special-purpose vehicles and multi-entity structures. Financial and operational oversight has become just as important as generation and technology choices, and new models are forming to coordinate portfolios, integrate acquisitions and maintain real-time visibility across complex ownership. Those who can connect assets, data and governance across the whole system will be in the strongest position to succeed.

> "Energy companies are becoming multi-discipline businesses, acquiring across technologies and sectors to stay ahead."

Thomas Sutter, Infrastructure Services Industry Director, Oracle NetSuite (2026).

Signals to Watch:

- Consolidation of specialist developers into integrated multi-technology platforms
- Multi-entity governance and reporting becoming essential for investor confidence
- Real-time visibility across assets and contracts driving new digital operating models

Scaling with Confidence:

- Elements Green develops solar photovoltaic and battery energy storage systems in Europe, Australia and the US, currently managing 600 MWp of solar projects with more than 13 GW in the pipeline, offering energy services spanning development, finance and operations. As the business expanded, it required a system that could scale while providing strong data integrity and reporting. Using Oracle NetSuite to manage financials, purchasing, expenses and payments, with NetSuite OneWorld harmonising operations across the UK, Australia, Denmark, Germany, and Italy, Elements Green operates from a single, scalable ERP system that provides the insight needed to support continued growth. As the company continues to expand, its team plans to bring more operations into Oracle NetSuite.

Conclusion

A future shaped by energy

Energy is moving from a system built for stability to one designed for constant adaptation, as the architecture of power evolves around new pressures and possibilities. What unfolds now will redefine the systems that support every industry and every community. The decisions made in this decade will set the course for energy security, competitiveness and climate risk for a generation.

The evidence is everywhere. Renewables are expanding into new environments. Intelligent technologies are enabling grids and assets to sense, learn and respond. Markets are transforming from one-way supply to flexible participation, where carbon, timing and data influence value as much as volume. These forces mark a profound shift in how energy is produced, managed and shared.

The four pillars of energy's future – Scale Frontiers, Intelligent Systems, Markets Reimagined and Power Shift – outline how resilience and decarbonisation must advance together. The organisations that succeed will treat energy as an interconnected ecosystem, where generation, storage and demand work in unity, and progress depends on deeper integration across technologies, partners and communities.

This moment is also a generational agreement. Acting now unlocks cleaner power, stronger grids, new jobs and a more secure industrial base. Hesitation passes cost and constraint to those with fewer choices. The opportunity ahead is not only technological, but strategic, collaborative and deeply human.

So what comes next? Shape the way you participate in this emerging system, and build the capabilities that allow you to evolve with it. Leaders will need real-time insight, shared visibility across their organisations and portfolios, and the ability to turn diverse assets and data into a coherent view. Organisations able to connect these elements will be best placed to navigate uncertainty and turn the transition into lasting advantage.

At Oracle NetSuite, we see that leaders pair ambition with clarity. Ambition to help create a cleaner, smarter and more secure energy infrastructure. Clarity about where they create distinct value and how they execute with discipline.

The future of energy is being built now. It belongs to those who choose to step forward with intent and build systems that deliver today and define what comes next.

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