

18 PREDICTIONS FOR THE NEXT 18 YEARS OF SOLAR

THE ROMANTIC PERIOD IS OVER.
THE GRID REVOLUTION IS NEXT.

Disclaimer

Purpose and perspective

This publication presents my personal views on how the solar industry and the wider energy system may evolve between 2026 and 2044. It is intended to encourage discussion and strategic thinking. Unless expressly stated otherwise, these views should not be attributed to any employer, affiliated company, business partner or other organization.

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The future rarely follows the forecast.

This July marked the beginning of my eighteenth year in solar. Looking back, the industry's most remarkable achievement has been making yesterday's audacious prediction sound like today's obvious conclusion. Looking ahead to 2044, I suspect we are about to repeat the exercise on a much larger stage.

The next chapter will concern more than cheaper panels. It will change who owns the grid, who finances electricity, how factories operate and what customers actually buy. The romantic period of proving solar that belongs in the energy system is giving way to the harder work of rebuilding that system around new possibilities.

These are deliberately bold predictions, not consensus forecasts. Their conditions and exceptions are part of the argument. The illustrations depict future concepts; they are not evidence of existing projects. Numbered references identify the evidence and its date; the 2044 outcomes remain my forecasts. Calculations are labelled separately. The evidence notes and source links are on page 22.

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Printing Solar Power



KEY INSIGHTS

✓ Scale delivery, not just factories.

- Fast permits and connections turn cheap panels into useful power.
- Prepare permitted sites and connection capacity before ordering equipment.
- Procure generation, storage and flexibility as a coordinated package.
- Track time to energisation and delivered energy, not announced gigawatts.

By 2044, governments will treat solar manufacturing capacity almost as seriously as central banks treat the money supply. When an economy needs more electricity, the answer will increasingly be to commission another production run, unlock prepared sites and connect standardised systems. **You cannot print sunshine, but you can industrialize almost everything that catches it.** Energy expansion will become a repeatable manufacturing operation rather than a procession of national megaprojects. The scale is no longer hypothetical: the IEA estimates that solar additions exceeded **600 GW in 2025**, lifting installed capacity to about **2,800 GW**; 30 countries added more than 1 GW that year. These include preliminary estimates and show manufacturing scale, not instantaneous delivery. [1]

The real printing press, however, will sit inside the permitting office. Cheap modules accomplish remarkably little while waiting for a connection agreement. Pre-approved development zones, published network capacity, standard contracts and predictable approval deadlines will matter as much as cell efficiency. Countries that digitise the paperwork without simplifying the decisions will merely discover how to deliver a bureaucratic headache in high resolution. The bottleneck is equally tangible: at end-2024, US transmission queues contained approximately **1,400 GW of generation and 890 GW of storage**. Only 13% of capacity entering the studied queues in 2000–2019 had reached operation by end-2024. A queue is not a construction forecast. [3]

This does not mean governments can manufacture reliable electricity by decree. Solar output still depends on daylight,

while dependable supply requires storage, transmission, flexible demand and reserves. My prediction is that these will increasingly be procured as one coordinated package. National energy planning will move from announcing impressive gigawatts to ordering useful megawatt-hours at the places and times the economy actually needs them.

The geopolitical consequence will be enormous. Industrial competitiveness and computing capacity will depend on how quickly countries can add dependable power. The winning energy ministries will behave less like ceremonial gatekeepers and more like production managers. **In the next industrial race, a fast grid connection may be worth more than a generous tax holiday.** Start before demand arrives, or watch the investment go somewhere that did.

Electricity Will Work More Like Mobile Networks



KEY INSIGHTS

✓ Sell service and flexibility.

- Digital access can evolve quickly; physical network limits remain.
- Prioritise interoperable platforms, transparent tariffs and easy switching.
- Pilot virtual power plants with clear customer benefits and consent.
- Treat wireless and space solar as options until costs and delivery are proven.

By 2044, buying electricity could feel more like subscribing to a mobile network than negotiating with a territorial monopoly. Customers will expect portable contracts, flexible tariffs, automatic switching and access to multiple energy services through one account. Buildings and vehicles will roam between suppliers commercially, even while the physical wires remain stubbornly local. **Your electricity provider may finally have to work as hard to keep you as your phone company does.** There is already a quantified version of this service model. A 2023 US Department of Energy scenario found that **80–160 GW of virtual power plants by 2030** could reduce annual grid costs by roughly **US\$10 billion**. That is modelled potential, not capacity already deployed. [4]

The analogy has limits worth respecting. Electricity cannot simply abandon cables because an app looks attractive. Wireless power will find useful niches in charging pads, industrial equipment and selected transport applications, but long-distance transmission must still overcome conversion losses, safety constraints and infrastructure costs. The revolution is more likely to begin with the commercial and control layers than with households receiving power through an invisible national Wi-Fi signal.

Space-based solar is the spectacular wildcard. Collecting sunlight in orbit and transmitting energy to a receiving station on Earth could eventually support demonstrations or specialized services. Yet launch economics, assembly,

maintenance, beam control and receiving land requirements make mass deployment a much harder proposition. AI may accelerate engineering, but it cannot negotiate a discount with the laws of physics. I would watch this frontier without building the national budget around it. Caltech's orbital demonstrator transmitted power wirelessly in 2023 and directed a detectable signal to Earth; its follow-up experiments continued for eight months. This establishes technical progress, not commercial-scale energy delivery or competitive cost. [5]

My stronger bet is an electricity system organised around intelligent access: distributed generation, aggregated batteries, responsive customers and interoperable markets. A user will buy comfort, mobility and uptime while software chooses the combination of resources. Whether the electrons originate on a neighbour's roof or at a distant solar farm will become less interesting than service quality. **The breakthrough will be electricity that behaves like a service, not necessarily like a radio wave.**

Factories Will Be Small Utilities



KEY INSIGHTS

✓ Make energy a core capability.

- Combine on-site assets, supply contracts and dispatch expertise.
- Audit hourly loads, outage costs and expansion plans before sizing assets.
- Combine rooftop solar with storage and diversified off-site procurement.
- Assign clear responsibility for dispatch, maintenance and energy risk.

By 2044, a serious manufacturer will also be an energy strategist. A factory that cannot control its electricity costs, reliability and emissions will be outsourcing part of its competitiveness to circumstances. Rooftop solar, batteries, flexible production schedules and long-term supply contracts will become part of industrial design. **The factory manager's new production line will manufacture certainty about power.** The finance department will care because downtime does not politely wait for a better tariff. Amazon reported **621 announced renewable projects representing 34 GW** as of January 2025, including 124 new announcements in 2024. This demonstrates corporate procurement at power-system scale; it does not mean every project was operating or owned outright. [6]

Land will remain inconveniently finite. An industrial roof cannot always supply an energy-intensive operation, and a battery shifts electricity rather than inventing it. Factories will therefore assemble portfolios of on-site generation, off-site contracts and shared infrastructure. Where regulation permits, industrial parks will aggregate demand and procure together. Cross-border contracting may expand too, but a financial renewable contract must never be confused with physically delivering power across a congested border.

The most ambitious manufacturers will invest directly in generation and storage platforms, sometimes supplying adjacent businesses or offering flexibility to the network. Their energy teams will resemble small utilities, with expertise in dispatch, hedging, maintenance and credit

risk. This will not make every factory an electricity trader. It will make energy management a core operating capability rather than a procurement exercise revisited when someone complains about the bill. The demand pressure is also measurable: the IEA estimated data-centre electricity use at **415 TWh in 2024**, with **945 TWh in 2030** in its 2025 base-case forecast. That projection reinforces the incentive to secure supply, without proving that every factory will become a licensed utility. [2]

The commercial prize is resilience as much as savings. A buyer choosing between two industrial locations will ask who can guarantee dependable, competitive electricity throughout the investment's life. Governments competing only on cheap labour will miss the larger conversation. **A discounted workforce is not much of a bargain if the production line spends the afternoon waiting for the grid.** Industrial policy and electricity policy will become the same meeting.

Grids Will Be Often Private and Localized



By 2044, the assumption that every useful electricity decision belongs to one central utility will look increasingly dated. Industrial parks, campuses, residential developments and municipalities will operate more of their own local energy infrastructure. Private capital will finance generation, batteries and selected distribution assets where rules allow. **The grid will become a federation of capable neighbourhoods, rather than a queue of helpless customers.** Local control will be bought for both efficiency and survival.

I do not expect national transmission networks to disappear. Long-distance interconnection remains valuable for sharing resources, smoothing geographic differences and accessing reserves. What changes is the relationship: local systems will manage more of their own demand and supply, while using the wider network as a strategic partner. Some will be able to island safely during outages. Others will remain tightly connected but much less passive. The IEA's 2023 grid assessment estimated that meeting national energy and climate goals requires **80 million kilometres of lines to be added or replaced by 2040**, alongside annual grid investment exceeding **US\$600 billion by 2030**. These are scenario requirements, not spending already committed. [7]

Ownership will be the easy argument; governance will be the difficult one. A privately owned wire can still behave like a monopoly, and a neighbourhood microgrid can still exclude customers who cannot afford entry. Regulators will need rules for access, tariffs, service quality and

KEY INSIGHTS

✓ Pair local control with a strong backbone.

- Microgrids need fair access, shared standards and sound governance.
- Define tariffs, access rights and emergency duties before financing.
- Test islanding, reconnection and cybersecurity where relevant.
- Compare local flexibility with network upgrades on total system cost.

emergency responsibilities. Cybersecurity and interoperability must be designed in from the beginning. Painting an old monopoly green does not make it innovative.

The winning architecture will combine local initiative with shared standards and a strong backbone. Software will optimise contracts and flows, although it cannot identify which particular panel supplied a particular appliance in a meshed grid. My bold prediction is institutional: **energy independence will mean having options, not pretending that every building is an island.** Utilities that help customers create those options will remain relevant; those that obstruct them will sponsor their own competition. The figures support a major network redesign and more local flexibility; they do not establish that private ownership is inherently superior. My ownership forecast is an institutional judgement, not a statistic in disguise.

Utility Solar CapEx Will Average US\$0.25/W



KEY INSIGHTS

✓ Standardize the whole delivery chain.

- US\$0.25/W is an ambitious selected-market target, excluding storage.
- Separate plant costs from storage and external grid upgrades.
- Standardise designs and procurement while retaining site-specific checks.
- Stress-test land, duties, delays and sale prices before setting return targets.

My 2044 bet is that utility solar capital expenditure can average around US\$0.25 per watt across mature, competitive markets, with exceptional projects below it. That is a deliberately aggressive forecast, not a current benchmark or a universal quotation. The comparison here is an installed solar plant before storage and major external network upgrades. **The module will become so inexpensive that everything surrounding it will have to explain itself.** IRENA puts the global weighted-average installed cost of utility solar commissioned in 2024 at **US\$691/kW**, or US\$0.691/W. [8] Reaching US\$250/kW would require another **63.8% reduction**, equivalent to about 5.0% annually over 2024–2044. These are my calculations; the target is interpreted in constant 2024 dollars for comparability.

Manufacturing advances will do part of the work: higher conversion efficiency, less material per watt, greater factory productivity and more consistent quality. The rest must happen in the field. Standard foundations, simpler electrical layouts, automated installation and designs adapted to local terrain can compress labour and construction costs. A cheap panel installed through an expensive sequence of avoidable complications is simply an expensive power plant wearing a bargain sticker.

Soft costs will decide whether the forecast travels beyond the easiest markets. Duties, costly land, financing delays, uncertain approvals and distant interconnection can overwhelm equipment savings. Some locations will remain well above the headline number. Reaching a broad

average near US\$0.25/W requires institutional learning alongside technical progress. It also requires manufacturers to earn sustainable returns; an industry cannot finance the next breakthrough indefinitely by losing money on the last one. That comparison also exposes the ambition: a selected-market forecast should not be presented as if it were already the observed global average.

Investors should read the forecast as a challenge to the whole delivery chain. The winners will standardise the ordinary and reserve engineering effort for what genuinely differs. Lower construction cost will open more markets, but will not automatically produce better project returns if electricity prices fall faster. **Solar's next cost revolution will be measured as much in eliminated meetings and avoided redesigns as in cheaper silicon.** The paperwork must learn to depreciate too.

No Solar Subsidies Will Exist, Anywhere



By 2044, I expect the ordinary solar project to arrive without a request for permanent financial life support. The provocative version is simple: no solar subsidies, anywhere. The more defensible meaning is that mature solar generation should no longer need technology-specific support to compete. **An industry cannot call itself the cheapest source of power forever and keep passing around the collection plate.** Commercial maturity should eventually come with commercial responsibilities. The economic foundation is substantial: IRENA found that **91% of new utility-scale renewable capacity** commissioned in 2024 had lower LCOE than the cheapest new fossil alternative. It put solar's global average LCOE **41% below** that comparator. [8] The first figure covers renewables collectively, not solar alone.

Policy support will not vanish from the energy system. Governments may still fund research, remote electrification, strategic manufacturing, network expansion or resilience. Competitive contracts can also allocate risks without necessarily providing an above-market subsidy. The distinction matters: removing a solar production incentive is not the same as abandoning public infrastructure. My prediction concerns routine support for conventional solar output, not a world in which governments stop having energy policies.

Investor returns could improve as technology matures, operating risks become easier to price and capital costs fall. But higher internal rates of return are not an automatic reward for cheaper modules. Competitive

KEY INSIGHTS

✓ Build projects that compete on fundamentals.

- Less subsidy dependence does not mean the end of energy policy.
- Underwrite projects without assuming permanent technology support.
- Distinguish generation incentives from network and resilience funding.
- Compete through location, contracts and operating discipline.

auctions and falling capture prices can transfer most of the benefit to consumers. Attractive returns will increasingly come from development discipline, useful locations, storage integration and sound contracts. The sun may be free; a durable commercial advantage is considerably less common.

The political test will be consistency. Fossil incumbents cannot demand a free market for solar while reserving preferential treatment for themselves. A credible transition would expose all technologies to transparent costs, obligations and competition. My wager is that solar will become strong enough to welcome that contest. **The industry's most convincing coming-of-age speech will be a project that closes financing without a subsidy consultant sitting at the head of the table.** These are generation-cost comparisons, not proof that subsidies were absent, that investor returns will rise, or that political support will disappear worldwide. The evidence backs declining economic dependence on support; the universal headline remains my deliberately provocative forecast.

No Solar Will Be Built Without Storage



KEY INSIGHTS

✓ Price electricity by its useful delivery time.

- Storage access matters; duration, losses and degradation still count.
- Size storage against hourly demand, capture prices and delivery obligations.
- Include losses, degradation, replacement and fire protection in the model.
- Compare co-location with shared storage and flexible customer demand.

By 2044, selling a large solar project without a strategy for storing or shifting its output will feel like opening a supermarket with no refrigerator. You can do it, but the most valuable inventory will spoil at the wrong time. **Solar will increasingly be sold with a clock attached.** Developers will be judged on when electricity is useful, not merely on how much the modules can produce at noon.

I expect storage access to become standard across most new commercial solar developments. That does not require a dedicated battery behind every panel. A project may use co-located batteries, shared storage, pumped hydro or a portfolio that coordinates flexible demand. The important pairing is functional and contractual. A physically separate storage asset can still help turn variable generation into a more dependable and commercially valuable supply profile. Berkeley Lab identified **359 operating US PV-plus-storage plants** at end-2024, pairing roughly **22 GW of PV with 11.9 GW / 35.7 GWh of storage**; their reported average storage duration was 3.0 hours. The dataset principally covers larger, transmission-connected projects. [9]

Batteries will not make seasonality disappear, and choosing the right duration will remain an economic decision. A system designed to move afternoon energy into the evening cannot automatically cover a long period of low sunlight. Degradation, round-trip losses, fire protection and replacement costs will have to be priced honestly. Calling every solar-plus-battery installation 'firm power' without specifying its delivery limits will become a

particularly expensive form of creative writing. IRENA's global installed-cost benchmark for utility batteries fell **93% between 2010 and 2024**, to US\$192/kWh. [8] Those numbers explain the attraction of pairing, but a three-hour battery is plainly not seasonal insurance.

The exceptions will be sites with naturally aligned daytime demand or markets where alternative flexibility is cheaper. Even there, developers will need to explain the decision. My prediction is therefore a new default rather than an engineering commandment: every project will be designed around the value of its output in time. **The industry's favourite question will move from 'How many megawatts?' to 'How many useful hours?'** Storage makes that question impossible to avoid.

EVs and Drones Will Join the Grid Ecosystem



By 2044, a parked electric vehicle will look less like an idle transport asset and more like an energy resource waiting for instructions. Fleets, workplace car parks and residential charging networks will help absorb solar output and reduce peak demand. **The car will finally find something productive to do during the hours it spends admiring the driveway.** Smart charging will be the foundation; bidirectional operation will add value where the economics justify it. The IEA reports that electric-car sales exceeded **20 million in 2025**, about **25% of new-car sales** globally. Its definition includes both battery electric and plug-in hybrid cars; these sales are not a count of vehicles capable of exporting electricity. [10]

Fleet operators will be the natural early winners because schedules are relatively predictable and many vehicles return to the same depot. Software will protect required departure charge, respect battery warranties and respond to electricity prices. Drivers will need compensation and a clear right to opt out. No energy platform will survive long if its brilliant evening trading strategy leaves the delivery fleet unable to leave in the morning. For scale, an illustrative fleet of one million cars with 50 kWh each contains 50 GWh of nominal battery energy; allowing just 10% for grid services gives **5 GWh before losses**. This is my arithmetic, not measured availability. Connection rates, charging power and departure needs determine what the system can actually use.

KEY INSIGHTS

✓ Start with smart charging and predictable fleets.

- Protect mobility needs before committing batteries to grid services.
- Map fleet schedules, charger limits and minimum departure charge.
- Begin with controlled charging before testing bidirectional exports.
- Agree customer compensation, opt-outs and warranty limits upfront.

Drones will participate differently. Their individual batteries are small, their operating requirements demanding and their aggregate grid value uncertain. The stronger opportunity is coordinated charging and battery swapping at logistics hubs, supported by stationary storage and solar canopies. I would not ask the nation's delivery drones to rescue the power system. I would ask their depots to stop charging every battery at precisely the most inconvenient moment.

The wider prediction is that mobility and electricity will stop pretending to be separate sectors. Charging infrastructure, grid planning and fleet procurement will be designed together. Some vehicles will export power; many more will provide flexibility simply by choosing when to consume it. **The most useful battery is not always the one you buy for the grid. Sometimes it is the one already waiting for its next journey.**

Equipment Makers Will Become Integrated Energy Companies



By 2044, the boundary between a solar manufacturer, battery supplier, charging operator, electricity retailer and finance company will be thoroughly inconvenient. Leading players will attempt to combine them into one offering, coordinated through an AI energy platform and virtual power plant. **The box will become the opening sale, not the entire business.** Recurring service revenue and access to customers will matter more than winning the next shipment through a slightly cheaper module. Tesla offers a concrete adjacent example: it reported **1,789,226 vehicle deliveries and 31.4 GWh of storage deployments in 2024**. [11] This demonstrates that mobility and stationary energy can share a large commercial platform, rather than proving that all seven activities must sit on one balance sheet.

The attraction is obvious. A company that designs the equipment can optimise the software, monitor performance, arrange maintenance and structure payments around customer savings. A household or factory may prefer one accountable provider to six suppliers exchanging blame. Financing can remove upfront cost, while aggregated assets can participate in electricity markets where permitted. The product becomes a long-term energy service with hardware inside it.

Integration also multiplies the ways to lose money. Manufacturing excellence does not automatically confer competence in lending, retail risk, consumer protection or

KEY INSIGHTS

✓ Connect hardware, finance and ongoing service.

- Integration succeeds only with risk controls and customer choice.
- Choose which capabilities to own and which to obtain through partners.
- Separate manufacturing, credit and trading risks in decision-making.
- Measure service retention and cash generation alongside equipment sales.

electricity trading. Balance sheets can become dangerously stretched when companies manufacture equipment, finance installations and guarantee future savings simultaneously. Some firms will partner rather than own every activity. Others will discover that a handsome platform diagram is not a substitute for risk controls or working capital. The prize extends beyond hardware: the US Department of Energy's 2023 VPP scenario put potential annual grid-cost savings at about **US\$10 billion** at 80–160 GW of deployment by 2030. [4] That is a potential system benefit, not revenue available to a single platform or evidence of guaranteed profit.

My prediction is not that every module company becomes a universal utility. It is that the strongest customer propositions will connect equipment, capital and ongoing operation seamlessly, whether through ownership or alliances. Open interfaces and credible warranties will matter because customers cannot afford technological captivity. **The successful supplier will sell confidence over twenty years; the unsuccessful one will sell seven business models in one brochure.** Integration must simplify the customer's life, not just enlarge the organization chart.

AI Will Manage Power Plants, Batteries and Grids



By 2044, manually scheduling a complex energy portfolio will seem as quaint as asking an airport controller to calculate every flight path with a pencil. AI will forecast demand, anticipate solar output, detect equipment problems and optimise dispatch continuously. **The electricity system will acquire a nervous system fast enough to keep up with its limbs.** The commercial value will come from better decisions repeated millions of times, not from a control room decorated with fashionable dashboards.

Plant operators will move from inspecting alarms to supervising exceptions. Predictive maintenance will target emerging faults, while batteries will balance trading opportunities against degradation and contractual commitments. At network level, software will coordinate flexible demand and distributed resources within physical limits. Reliable data and interoperable equipment will be prerequisites. An algorithm connected to inaccurate sensors is simply a very confident way to make the wrong decision faster. The IEA's 2025 assessment estimated that widespread use of remote sensors and AI management could unlock up to **175 GW of transmission capacity without new lines**. It also described AI-based fault detection reducing outage duration by **30–50%**. [2] These are potential/application-dependent gains, not a universal measured performance guarantee.

KEY INSIGHTS

✓ Use AI within tested operating boundaries.

- Reliable data, cybersecurity and fail-safe controls remain essential.
- Validate sensor quality and establish a baseline before automation.
- Retain deterministic protection, tested fallbacks and human accountability.
- Measure uptime and net value after degradation, fees and control costs.

Critical protection cannot depend on an unconstrained model improvising its way through an emergency. Fast protective devices, deterministic controls, tested fallbacks and human accountability will remain essential. Cybersecurity will become an operating discipline rather than an annual presentation. Owners will need audit trails, enforceable operating boundaries and the ability to recover from communication failures. Intelligent autonomy must be earned through performance, not granted because a vendor added 'AI' to the product name. The implication is disciplined deployment: benefits of that scale justify investment in digital control, but they do not justify handing every safety-critical decision to an unconstrained model.

The bold prediction is that AI will become ordinary infrastructure, embedded so deeply that nobody finds its presence remarkable. Operators will judge it by availability, losses, revenues and avoided failures. Human expertise will remain valuable precisely because someone must define the objectives and accept responsibility for trade-offs. **The best energy AI will not sound clever. It will keep the lights on, protect the assets and leave an unusually boring incident log.**

Renewables Will Become Bigger Than Fossil Fuels



By 2044, I expect renewables and the infrastructure around them to command more new energy investment than the fossil fuel system they are replacing. This is my chosen measure of 'bigger': the destination of new capital across generation, storage, networks and enabling services. Comparing revenues alone can mislead because volatile fuel prices inflate sales without improving usefulness. **The future belongs to the industry people are building, not necessarily the one sending the largest invoice this quarter.** The IEA's 2025 investment outlook projected **US\$2.2 trillion for clean energy**, compared with **US\$1.1 trillion for fossil fuels**, including US\$450 billion for solar. [12] Crucially, its clean-energy category includes nuclear, grids, efficiency and electrification as well as renewables. It cannot be quoted as renewables alone already being twice as large.

The structural difference is powerful. Fossil energy requires a continuing stream of purchased fuel; renewable energy shifts more expenditure into equipment and infrastructure upfront. Value creation will spread across manufacturing, construction, software, finance, maintenance and electricity-intensive industries. Abundant clean power may also encourage new production methods and locations. The economic footprint will extend well beyond the companies whose names appear on a solar panel or wind turbine.

KEY INSIGHTS

✓ Follow new capital and infrastructure demand.

- Distinguish renewables from the broader clean-energy category.
- Map opportunities across storage, networks, software and project delivery.
- Use consistent definitions when comparing capital flows and market size.
- Plan for uneven transition speeds across countries and end uses.

Fossil fuels will not disappear on a single ceremonial date. Aviation, shipping, industrial feedstocks and difficult high-temperature processes will move at different speeds. Some countries will transition more slowly because of financing or institutional constraints. The prediction is about direction and eventual scale, not a claim that every energy use will be electrified. A world can retain substantial fossil consumption while allocating most of its new energy capital elsewhere. A separate deployment measure strengthens the direction: the IEA estimates **800 GW of renewable capacity additions in 2025**, with solar accounting for more than three-quarters. [1] Capacity additions, annual investment and industry revenue are different measures and should not be quietly exchanged mid-argument.

For investors and governments, the relevant question is where learning, productivity and demand reinforce each other. Renewable systems offer a manufacturing pathway in which repetition can reduce costs and expand adoption. That compounding effect is the real challenger to the old order. **The energy transition will be won less by delivering a moving farewell speech to oil than by making the next clean investment too useful to ignore.** Capital has a limited attention span for nostalgia.

RECs and Carbon Credits Will Disappear Forever



KEY INSIGHTS

✓ Buy verifiable impact, not convenient claims.

- Hourly matching and credible removals favour reform over extinction.
- Prioritise operational reductions and credible clean-power procurement.
- Match energy claims to time and location where reliable data allow.
- Test credit additionality, durability and verification independently.

By 2044, I expect today's easy separation between buying clean-energy claims and changing real-world operations to become much harder to defend. The provocative headline is that renewable energy certificates and carbon credits disappear. More precisely, their weakest forms lose relevance as customers demand evidence of time, location and physical impact. **The atmosphere will remain magnificently unimpressed by a beautifully formatted certificate.** Corporate credibility will depend on what changed, not just on what was purchased.

For electricity, annual matching will increasingly face competition from more granular accounting. A company claiming clean operations may need to show how its consumption aligns with generation across hours and regions, supported by storage and credible delivery arrangements. Digital tracking can improve visibility, although it cannot make congested networks disappear. Buying a distant surplus at lunchtime should not automatically settle every question about a factory running overnight. Google reported **66% hourly carbon-free energy in 2024**, up from 64%, despite a 27% rise in data-centre electricity demand. [13] The distinction between an hourly score and an annual claim illustrates why procurement quality matters.

Carbon credits require a separate argument because they are not electricity certificates. Additionality, durability, leakage and verification remain fundamental tests.

Credible removals may retain an important role for residual emissions even as low-integrity offsetting loses acceptance. I would not predict the disappearance of every useful carbon instrument. I would predict a much smaller tolerance for using uncertain future benefits as a substitute for practical reductions today. There is also clear counter-evidence to literal extinction: the World Bank reports that **carbon-credit issuances rose 8% in 2025**. Separately, direct carbon pricing covered nearly 30% of global emissions across 87 policies in its 2026 assessment. [14] Taxes and emissions-trading allowances are not voluntary offsets or RECs. These data favour reform and differentiation, not a confident claim that every environmental instrument is disappearing.

The likely end state is evolution disguised as extinction: familiar labels fade while stronger accounting and procurement systems take their place. Companies will buy cleaner supply, verified flexibility and demonstrable removals rather than a convenient exemption from operational change. **The market for environmental ambition will survive; the market for environmental alibis should not.** If the certificate cannot explain its contribution in plain language, the customer will eventually stop paying for the frame.

China Will Still Be China



By 2044, I expect China to remain a central force in solar and battery manufacturing, even if a smaller share of the final equipment is assembled within its borders. Industrial capability is not a suitcase that moves when a tariff changes. Supplier density, production knowledge, engineering talent and speed reinforce one another. **You can relocate a factory faster than you can relocate the ecosystem that taught it how to compete.** The IEA's 2026 technology assessment puts China's share of production capacity at approximately **85% across solar supply chains and 80% in lithium-ion batteries**, rising to **95% for PV wafers**. The accompanying concentration analysis uses 2024 data. [15] These are capacity shares, not shares of every year's final sales.

Manufacturing will nevertheless spread. Governments will seek supply security, companies will manage trade barriers and customers will demand regional service and production. Chinese enterprises may participate through overseas factories, partnerships, licensing and local supply chains. The label on the shipping crate will reveal less than the ownership of the technology and the structure of the supplier network. Globalisation may change its paperwork without losing its industrial memory.

Dominance is not immunity. Overcapacity, weak margins, trade restrictions and technological shifts can destroy individual companies even inside a formidable national ecosystem. Competitors elsewhere can win in specialised equipment, advanced materials, software, project delivery and trusted local service. The useful question is not whether one country wins everything. It is which parts of

KEY INSIGHTS

✓ Diversify suppliers without ignoring industrial depth.

- Local assembly alone does not recreate a manufacturing ecosystem.
- Assess supplier quality, solvency and service support beyond price.
- Diversify critical components and maintain credible replacement options.
- Build defensible local capabilities rather than relying on tariffs alone.

the value chain remain defensible and where new capabilities can be built profitably.

My prediction is continued Chinese influence within a more geographically distributed industry, accompanied by fierce competition among Chinese firms themselves. Buyers will need diversification without confusing it with wishful thinking. Governments will need industrial strategies longer than an election slogan. **Declaring independence from a supply chain is easy; reproducing its cost, quality and speed is the examination.** China will still be China, but every other market will have to decide what it intends to become. Concentration on that scale gives the persistence argument a measurable starting point. It also explains why diversification is an industrial undertaking rather than a change of purchasing policy; the figures cannot guarantee any country's position eighteen years from now.

There Will Be a Couple of Bad Years



The next eighteen years will not resemble a smooth upward line in an investor presentation. There will be painful periods of oversupply, bankruptcies, stalled projects and disappointed capital. The timing is unknowable; the existence of setbacks is a much safer prediction. **Solar can win the energy transition while plenty of solar companies lose their shirts.** Confusing the success of a technology with the safety of every business built around it is an expensive category error.

Manufacturing will be vulnerable when capacity expands faster than demand, while developers will suffer when financing assumptions collide with connection delays or falling electricity prices. Storage can face its own crowding problem if too many projects pursue the same market revenues. A spreadsheet does not create demand merely because its cells have been filled to the right. Attractive historical margins often invite enough competition to make those margins historical. The IEA's Renewables 2024 report recorded module prices **more than halving since early 2023** and approximately **US\$25 billion of cancelled polysilicon and wafer capacity projects**. These were manufacturing projects, not cancellations of operating solar farms. [16]

The companies that survive will maintain liquidity, control counterparty exposure and avoid treating optimistic forecasts as contractual guarantees. Procurement discipline, realistic warranties and service capability will matter when weaker suppliers disappear. Investors will need to distinguish temporary industry distress from

KEY INSIGHTS

✓ Protect liquidity before the downturn arrives.

- Technology growth does not guarantee individual company survival.
- Stress-test lower prices, connection delays and supplier failures.
- Maintain liquidity reserves and monitor counterparty concentration.
- Use downturns selectively; price repair costs and inherited obligations.

permanently impaired assets. Buying cheaply can be intelligent; buying a problem whose repair costs exceed its discount is simply paying tuition in the language of opportunity. Berkeley Lab's historical US queue cohort provides another warning: **77% of capacity requesting interconnection in 2000–2019 had withdrawn by end-2024.** [3] Withdrawal is not synonymous with insolvency or investor loss, but it decisively disproves the idea that every announced gigawatt will become a generating asset.

The bad years will also clear space for better technology and stronger operators. Consolidation can remove duplication, improve standards and return attention to cash generation. My forecast is not pessimistic: it is an argument for preparing to benefit from turbulence. **The best time to build a resilient business is before the market starts charging emergency prices for resilience.** Keep enough financial oxygen to remain alive when the next attractive acquisition finally becomes affordable.

Utility Solar LCOE Will Fall to US\$5/MWh



By 2044, I expect the best utility solar projects to approach a levelised generation cost of US\$5/MWh. This is an aggressive frontier prediction for exceptional conditions, not a forecast of everyone's retail tariff. It describes solar generation before storage, delivery and the cost of guaranteeing supply at every hour. **Five-dollar solar would be revolutionary; pretending it means five-dollar electricity around the clock would be marketing malpractice.** The starting benchmark is **US\$43/MWh**, IRENA's global weighted-average utility solar LCOE for 2024. [8] Moving to US\$5/MWh means an **88.4% reduction**, or roughly 10.2% annually over 2024–2044, by my calculation. I use constant 2024 dollars; a frontier-project target is more ambitious than merely continuing today's global average.

The arithmetic requires several things to go right together. An illustrative US\$250/kW plant, a 35-year life, a 3% real discount rate and 2,500 kWh/kW of average annual output imply annualised capital cost of roughly US\$4.65/MWh. Add only US\$3/kW-year in operating costs and the result already approaches US\$5.85/MWh. Reaching five therefore requires still lower capital costs, cheaper funding, higher lifetime yield or some combination. This is a demanding destination, not a casual extrapolation.

Performance over decades will matter as much as the opening price. Degradation, inverter replacement, insurance, cleaning, curtailment and end-of-life obligations can erode an apparently spectacular result.

KEY INSIGHTS

✓ Optimise lifetime yield, financing and delivery value.

- US\$5/MWh is a frontier generation target, not an all-hours tariff.
- Model lifetime yield, degradation, curtailment and replacement honestly.
- Keep generation LCOE separate from storage and delivered supply costs.
- Test financing and capture-price sensitivities

Repowering may become routine where better modules can reuse valuable land and network access, but its costs and benefits must be accounted for separately. The winning projects will optimise lifetime output rather than compete exclusively for the cheapest first-day construction photograph. For the illustrative financing calculation above, US\$250/kW is an assumption, not an observed global cost; the average lifetime yield must already reflect degradation. The result is a sensitivity exercise, not a bankable tariff quotation.

Cheap generation will also make time and location more valuable. If every neighbouring plant produces at the same hour, low cost does not guarantee a useful selling price. Storage, flexible industry and network access will capture a larger share of the opportunity. **When sunshine becomes almost free, the premium business is making it useful.** The US\$5/MWh milestone would mark the end of one cost race and the beginning of a much more interesting systems race.

Coal Will Be Shut Down Earlier Than Projected



By 2044, I expect many coal retirement schedules to have been brought forward because the alternatives become cheaper, more flexible and easier to finance. Some plants will close before their technical lives expire. **A power station does not need to run out of useful steel before it runs out of economic purpose.** The decisive pressure will come from competing electricity systems, increasingly supported by storage and stronger networks. Great Britain provides an actual precedent: its final coal power station closed on **30 September 2024**, meeting a phase-out deadline brought forward by **one year** from the original 2025 target. Coal's share of its electricity supply fell from roughly one-third to zero over a decade. [17]

Retirement will depend on dependable replacement, not just attractive midday solar prices. Systems need sufficient energy, firm capacity, reserves and grid stability across difficult operating periods. Renewable overbuilding, batteries, interconnection, demand response and other dispatchable resources will contribute in different combinations. Countries unable to finance or implement that package may retain coal longer. Closing a plant before its essential services are replaced is not ambition; it is an avoidable reliability problem.

The politics will be local even when the economics are global. Coal regions need credible pathways for workers, municipal revenues and industrial redevelopment. Existing sites may offer valuable land, connections and infrastructure for storage or new industries. Well-designed transition finance can accelerate closure, but it

KEY INSIGHTS

✓ Replace coal's system services before retiring it.

- Reliability, transition finance and local jobs determine the pace.
- Identify the energy, capacity and stability services each plant provides.
- Finance and commission dependable replacement before closure.
- Plan worker transitions and reuse valuable land and grid connections.

should not simply reward owners for making promises they cannot verify. Communities deserve a future more substantial than a press release beside a silent chimney.

AI will help optimise replacement systems and identify retirement opportunities; rogue software is neither a credible transition plan nor an acceptable shortcut. The strongest disruption will be legal, financial and operational. My prediction is that investors will increasingly shorten coal's expected commercial life before policymakers revise their official timetables. **The coal plant's most dangerous opponent will not be a rebel algorithm. It will be a competing project with a better price and a more convincing reliability plan.** At global level, the IEA reports that **solar generation increased by 600 TWh in 2025**, while coal-fired generation declined. [18] This concerns electricity generation, not the disappearance of industrial coal demand; one year's decline cannot establish a universal retirement timetable.

BIPV, Flexible and Transparent Solar Will Make a Major Comeback



By 2044, buildings will increasingly generate electricity through the materials they already need: roofs, facades, shading and selected glazing. Building-integrated photovoltaics will return with a stronger proposition than simply making architecture look futuristic. **The breakthrough is not a solar panel pretending to be a building material; it is a building material that earns its keep twice.** Avoiding a separate conventional surface can change the economics in ways a module-only comparison misses. There is substantial room to grow: IEA PVPS estimates European BIPV installations at approximately **350 MW in 2024**, less than **1% of distributed PV added that year**. [19] This is an annual regional flow, not cumulative global BIPV capacity, and says little by itself about the separate transparent-cell niche.

Flexible products will serve curved roofs, lightweight structures and other surfaces unsuitable for conventional modules. Semi-transparent solar may work where shading, appearance and power production can be balanced intelligently. Fully transparent electricity-generating windows remain subject to difficult trade-offs between light transmission and energy capture. Architects will need honest performance data rather than renderings that imply every glass wall can become a high-output power station without affecting daylight.

KEY INSIGHTS

✓ Evaluate solar as part of the building envelope.

- Durability, compliance and avoided material costs drive adoption.
- Compare whole-building costs, including displaced conventional materials.
- Verify fire performance, weatherproofing, repairability and warranties.
- Pilot suitable surfaces before adopting integrated solar at scale.

The comeback will depend on less glamorous achievements: long life, fire compliance, watertight detailing, repairability and products that installers can fit consistently. A facade failure is a building problem before it becomes an energy problem. Warranties must reflect that reality, and replacement parts must remain available. The market will reward systems that survive weather and procurement committees, not just technologies that produce impressive laboratory efficiency announcements. The addressable built environment is economically important: UNEP's 2024/2025 report attributes **32% of global energy consumption and 34% of CO2 emissions** to buildings and construction. [20] Those totals include activities BIPV cannot directly decarbonise, so they indicate relevance rather than a solar-replaceable market size.

My prediction is selective mainstream adoption rather than universal coverage. Conventional rooftop solar will remain the sensible answer in many locations, while integrated products win where design and avoided material costs justify the premium. Building rules and procurement habits may accelerate that shift. **Eventually, installing a sun-exposed surface that does absolutely nothing could seem as old-fashioned as specifying a window that refuses to open.** Architecture will gain an energy budget alongside its aesthetic one.

Climate Disasters Will Accelerate Carbon Targets



By 2044, the pressure to decarbonise will increasingly arrive through insurance renewals, damaged infrastructure and interrupted business, rather than only through international summit declarations. As climate risks become harder to ignore, more governments and companies will bring forward action. **The atmosphere does not read policy roadmaps, but the insurance industry is very good at reading losses.** A risk that once seemed distant becomes politically immediate when assets cannot be insured or reliably operated. WMO measured 2024 at **1.55 degrees C above the 1850–1900 average**, with an uncertainty of 0.13 degrees C; a single year above 1.5 degrees C is not the Paris Agreement's long-term threshold. [21]

The response will combine mitigation with adaptation. Solar, storage and resilient microgrids can help maintain essential services, but they must themselves withstand local hazards. Flood elevation, drainage, wind loading, heat management and emergency access will become central design decisions. Clean infrastructure placed carelessly in a vulnerable location is not resilience. The transition will need better engineering, not just more ambitious capacity announcements. Swiss Re reports **US\$107 billion of insured natural-catastrophe losses in 2025**, with secondary perils accounting for **92%**. [22] These are insured losses, not total economic damage or losses attributable solely to climate change: asset exposure, reconstruction costs and natural variability also

KEY INSIGHTS

✓ Build resilience before urgency removes choices.

- Climate damage strengthens the case; delivery makes targets real.
- Screen sites for flood, wind, heat and access risks before investment.
- Budget resilient design and emergency procedures into the project.
- Prepare financeable projects early so rebuilding can accelerate progress.

matter. The numbers strengthen the resilience case; whether governments accelerate targets remains a political prediction.

Disasters will not automatically produce wiser policy. They can exhaust public budgets, disrupt supply chains and encourage emergency fossil investment when authorities need power quickly. The acceleration I predict depends on institutions translating damage into credible rebuilding standards, financing and delivery. A target without an implementation pathway remains a speech. The countries that prepare projects and resilient networks before disaster strikes will have more choices when urgency removes the luxury of delay.

The final irony is that climate disruption may make the economic case for change harder to dismiss while making the physical task of building harder to execute. That is a powerful argument for moving earlier. **The cheapest energy transition is the one completed before every construction project becomes a reconstruction project.** By 2044, the most successful countries will not be those that wrote the boldest target. They will be those that built enough of the future in time.

Evidence notes and source links

Researched 11 October 2026. Data years differ and are stated explicitly. Reported outcomes, company disclosures, modelled scenarios and author calculations are distinct. Figures support the mechanisms discussed; they do not validate every absolute 2044 headline. Costs in points 5 and 15 are compared in constant 2024 US dollars. GW measures power; GWh and TWh measure energy. Sources are numbered in the text.

[1] IEA – **Global Energy Review 2026 – Solar PV and wind.** 2026; 2025 actual and estimated capacity additions. Points 1 and 11. [Read source](#)

[2] IEA – **Energy and AI – Executive summary.** 2025; 2024 baseline, 2030 base case and digitalisation potential. Points 3 and 10. [Read source](#)

[3] Lawrence Berkeley National Laboratory – **Queued Up 2025 Edition.** 2025; US queues through end-2024; historical 2000–2019 cohort. Points 1 and 14. [Read source](#)

[4] US Department of Energy – **Pathways to Commercial Liftoff for Virtual Power Plants.** 2023; modelled 2030 deployment and savings. Points 2 and 9. [Read source](#)

[5] Caltech – **Space Solar Power Project Ends First In-Space Mission.** 2024; demonstrator experiments in 2023. Point 2. [Read source](#)

[6] Amazon – **2024 Sustainability Report.** 2025; announced project portfolio as of January 2025; company-reported. Point 3. [Read source](#)

[7] IEA – **Electricity Grids and Secure Energy Transitions.** 2023; national-goals scenario requirements for 2030 and 2040. Point 4. [Read source](#)

[8] IRENA – **Renewable Power Generation Costs in 2024.** 2025; 2024 commissioned projects; monetary values in 2024 US dollars. Points 5, 6, 7 and 15. [Read source](#)

[9] Lawrence Berkeley National Laboratory – **Hybrid Power Plants 2025 Data Update.** October 2025; end-2024 operating plants; slide 8. Point 7. [Read source](#)

[10] IEA – **Global EV Outlook 2026 – Trends in electric cars.** 2026; 2025 sales, including battery electric and plug-in hybrids. Point 8. [Read source](#)

[11] Tesla Investor Relations – **Fourth Quarter 2024 Production Deliveries and Deployments.** 2 January 2025; full-year 2024 company-reported figures. Point 9. [Read source](#)

[12] IEA – **World Energy Investment 2025 – Executive summary.** 2025; projected annual investment, broad clean-energy definition. Point 11. [Read source](#)

[13] Google – **2025 Environmental Report overview.** 2025; 2024 company-reported hourly carbon-free energy performance. Point 12. [Read source](#)

[14] World Bank – **State and Trends of Carbon Pricing 2026.** 2026; 2025 credit issuance and 2026 policy coverage. Point 12. [Read source](#)

[15] IEA – **Energy Technology Perspectives 2026 – Supply chain risks.** 2026; capacity concentration with 2024 comparison data. Point 13. [Read source](#)

[16] IEA – **Renewables 2024 – Executive summary.** 2024; price declines from early 2023 and manufacturing cancellations. Point 14. [Read source](#)

[17] UK Parliament – **Written answer 9066 on Coal Imports.** 22 October 2024; Great Britain coal-power closure and earlier deadline. Point 16. [Read source](#)

[18] IEA – **Global Energy Review 2026 – Global trends.** 2026; 2025 electricity generation changes. Point 16. [Read source](#)

[19] IEA PVPS – **Trends in Photovoltaic Applications 2025.** 2025; European BIPV market estimates for 2024, market-status discussion. Point 17. [Read source](#)

[20] UNEP and GlobalABC – **Global Status Report for Buildings and Construction 2024/2025.** 2025 edition; sector energy and emissions shares. Point 17. [Read source](#)

[21] World Meteorological Organization – **2024 confirmed as warmest year on record.** 10 January 2025; 2024 temperature relative to 1850–1900. Point 18. [Read source](#)

[22] Swiss Re Institute – **Wildfires storms floods contribute to record 92 percent of insured losses.** 19 March 2026; 2025 insured natural-catastrophe losses. Point 18. [Read source](#)