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About ECECP

EU-China Energy Cooperation Platform was launched on 15 May 2019.

The overall objective of ECECP is to

'enhance EU-China cooperation on energy. In line with the EU's Energy Union, the Clean Energy for All European initiative, the Paris Agreement on Climate Change and the EU's Global Strategy, this enhanced cooperation will help increase mutual trust and understanding between EU and China and contribute to a global transition towards clean energy on the basis of a common vision of a sustainable, reliable and secure energy system.'

Phase I of ECECP (2018 – 2021) was implemented by a consortium led by ICF, with National Development and Reform Commission – Energy Research Institute and CECEP Consulting Company.

Phase II (2021 – 2023) was implemented by a consortium led by ICF, and with National Development and Reform Commission- Energy Research Institute.

Phase III (2024 – 2029) is implemented by a consortium led by GOPA Worldwide Consultants and with GIZ.

CONTENTS


ECEC

Dear All,

Welcome to the March 2025 issue of the EU-China Energy Magazine.

In this issue, we continue our in-depth exploration of EU energy legislation with 'Understanding EU Energy Law: Part Two - The Law in Practice'. In Part One of the article, published in our October 2024 issue, we delved into the development and design of energy law in the EU, tracing how rules are formulated centrally at the EU level. Building on that foundation, Part Two examines how individual EU Member States (looking in particular at the Netherlands, France, and Denmark) have found different ways to reconfigure their energy markets to align with EU directives and achieve their decarbonisation goals.

China is taking important steps to boost new energies, which are underpinned by ongoing market and price reforms as well as the continuous enhancement of its clean tech production. In this issue, we examine the potential of China's new Contract for Difference (CfD) renewable support scheme to accelerate power sector decarbonisation. We also feature a data-driven analysis from the Centre for Research on Energy and Clean Air (CREA), highlighting how clean technologies contributed a record 10% of China's GDP in 2024.

We are very sad to bid farewell to Enrui Zhang, our deputy team leader and senior policy expert. Enrui is returning to Paris for family reasons. He has been an invaluable member of our team. We wish him all the best in his new endeavours and look forward to future collaborations.

We wish you an early Happy Easter and look forward to your feedback.

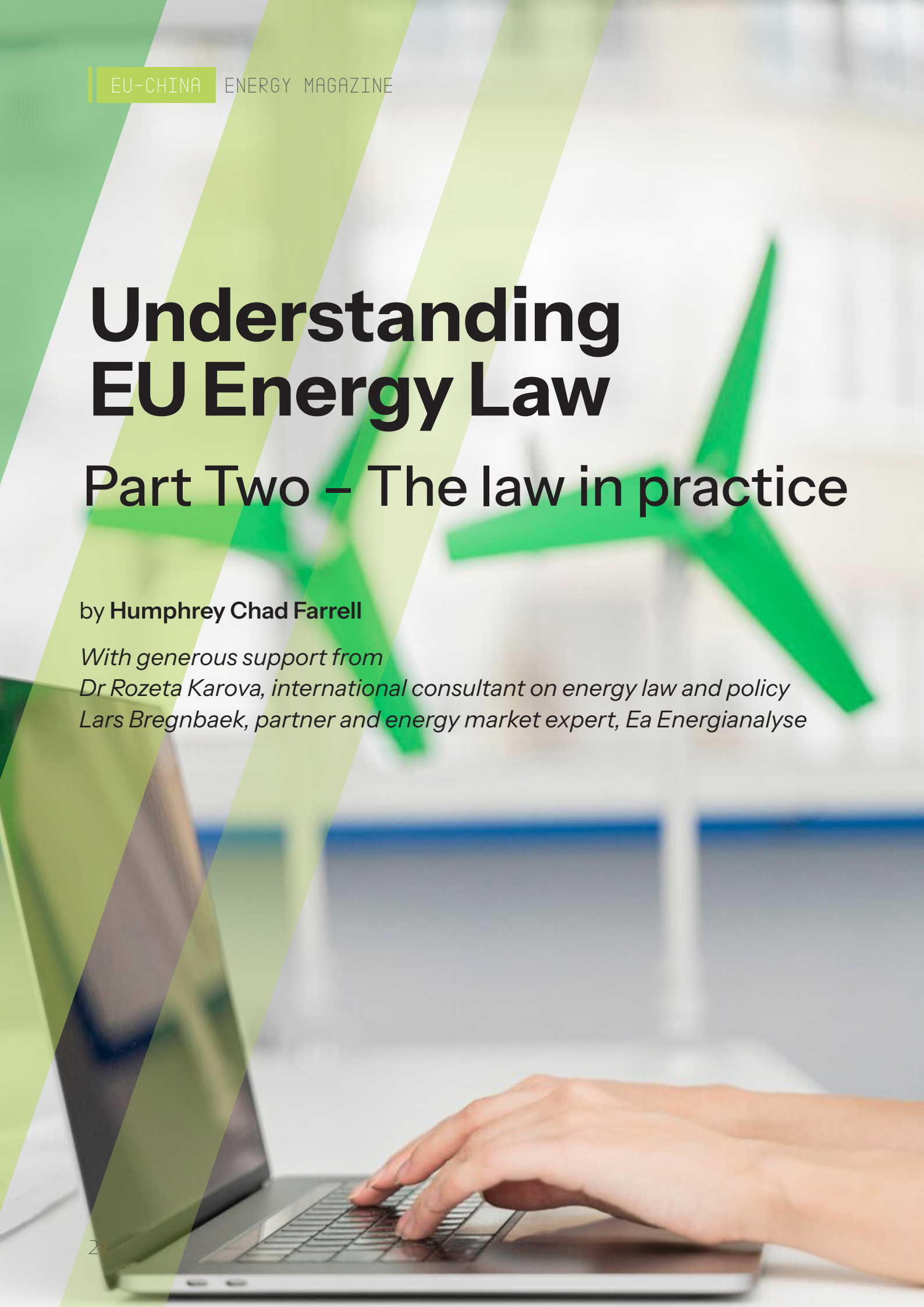
Dr. Flora Kan
ECECP Team Leader
31 March 2025

Understanding EU Energy Law

Part Two – The law in practice

by **Humphrey Chad Farrell**

With generous support from
Dr Rozeta Karova, international consultant on energy law and policy
Lars Bregnbaek, partner and energy market expert, Ea Energianalyse



In Part One of this article, published in the ECECP magazine in October 2024, energy law lawyer and consultant Rozeta Karova explored the dynamics, intent, implementation and incentives guiding EU energy law. When a state becomes a member of the European Union, it becomes subject to EU laws and courts, while maintaining a level of autonomy in how it chooses to implement policy, designing the laws and carrying out directives itself.

Karova introduced the topic of EU energy law with an exploration of the development and design of energy law in the EU, tracking how rules are developed centrally before being implemented into law by individual Member States. Karova's article focused on the development of short-term electricity markets and their integration, exploring how the EU principle of economic liberalisation drove the earlier energy policies of opening and unbundling energy markets across the EU[1], before creating a more unified market in the third 'package' of legislation - which created an association for cooperation between Transmission Systems Operators (TSOs) (ENTSO-E[2,3]) while establishing stronger principles for promoting energy trading across national borders. Karova also explained that the prioritisation of consumer protections has ensured an efficient market design: retail markets evolved alongside changing energy infrastructure, while national regulatory authorities have an important role in monitoring the functioning of the market[4].

To see how the law works in practice, this article will examine how the Netherlands, France and Denmark are reconfiguring their respective energy markets in response to key EU legislation (e.g. sector liberalisation through unbundling5, and the EU's ambitious green energy targets).

The case studies of these three countries will be investigated as examples of the legally binding EU targets being given form at a national level by individually determined national legislation.

In 2019, the EU adopted the 'Clean Package for All Europeans', a new package of legislation which created a legally-binding EU wide target to reduce emissions by 55% by 2030 (compared to 1990)[6], a binding target of at least 32% for renewable energy sources in the EU's energy mix by 2030 and an energy efficiency target of at least 32.5% by the same year (compared to a baseline scenario established in 2007)[7]. These targets[8] serve as key building blocks for the EU to become climate neutral by 2050[9]. While the Member States are able to negotiate the legislative provisions, the EU legal structure means that once the Council of the European Union and the European Parliament have made the law binding, each Member State retains their competence of how to implement the target. As we will see, this means that Member States have autonomy when it comes to choices between different green energy sources and managing energy consumption.

This article will highlight how these challenges have emerged from this major pivot towards green energy sources, as well as how Member States are able to confront those challenges with a combination of central planning and market-oriented solutions.

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1. EU Directive 96/92/EC https://eur-lex.europa.eu/eli/dir/1996/92/oj/eng establishing unbundling from the start of EU energy sector design in 1996, part of the first 'package' of legislation.
2. EU Directive 2009/72/EC https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009L0072 establishing common rules in the EU electricity market.
3. EU Regulation No 714/2009 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009R0714 establishing ENTSO-E to manage the electricity market.
4. Fact sheet on development of EU energy policy https://www.europarl.europa.eu/factsheets/en/sheet/45/internal- energy-market
5. EU Directive 96/92/EC https://eur-lex.europa.eu/eli/dir/1996/92/oj/eng establishing unbundling from the start of EU energy sector design in 1996. Unbundling rules have evolved and become stricter in legislation since then, but the principle of simplifying the market to encourage market participation remains a central pillar of EU energy policy design.
6. EU Regulation 2021/1119 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32021R1119, mandating climate targets of 55% emissions reduction by 2030 compared to 1990 levels, and climate neutrality by 2050 in all Member States.
7. EU Directive 2018/2002 https://eur-lex.europa.eu/eli/dir/2018/2002/oj/eng Updates energy efficiency target.
8. It is important to distinguish between EU-level targets and how those targets are implemented by individual member states. Here is a breakdown: EU-level targets: The EU sets overall, binding targets for the entire European Union. For example, the target of at least 32% for renewable energy sources in the EU's energy mix by 2030 is an EU-wide target. Also, the EU has a target of reducing emissions by 55% by 2030. This is an EU wide target. Member State contributions: While the EU sets the overarching goals, each member state is required to contribute to achieving those goals. Member states are required to create national energy and climate plans (NECPs) that outline how they will contribute to the EU-level targets. These plans take into account each country's specific circumstances. So in essence, the EU sets the overall goal, and the member states provide the plans on how they will contribute to that overall goal. Therefore the 55% reduction in emissions is an EU wide goal. In summary, the EU sets the overall emissions reduction target, and each member state contributes to achieving that target through its own national plans.
9. Factsheet on other aims of the 'fit for 55' energy package https://www.consilium.europa.eu/en/policies/fit-for-55/ including a 'social climate fund' to alleviate the impact of the energy transition on vulnerable individuals and businesses and increasing the use of sustainable aviation fuels

The Netherlands

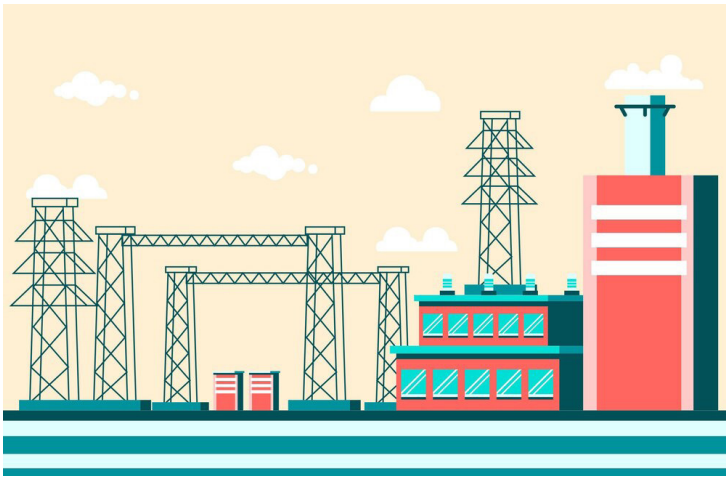
Although the Netherlands has achieved some key EU goals of high interconnection with other EU states and an unbundled sector, some infrastructural challenges are apparent.

As an EU Member State, the Netherlands has an unbundled electricity market, so that grid operators are separate from the companies that trade, produce and sell electricity. Seven grid operators manage the flow of electricity within and outside of the country. All bordering countries, as well as Norway, Denmark and the UK, are interconnected with the Dutch electricity grid via high-voltage transmission lines.

Dutch policy advisor Ermin Kloppenborg notes that the Netherlands has embraced unbundling more than other Member States, having unbundled the ownerships of both TSOs (Transmission

Systems Operators) and DSOs (Distribution Systems Operators). While unbundling is central to the EU model of a liberalised energy sector, the approach in the Netherlands has been criticised as potentially preventing a holistic approach to central planning.

In transitioning to renewable energy sources, the Netherlands faces the new challenge of grid congestion. For example, solar power has grown very strongly as a source of electricity, with installed capacity rising to 23.9 GW by 2023 - over 40 times that of 2013 - while annual production reached nearly 20 TW in 2023[10]. Because the Netherlands is such a small and densely-populated country, solar farms have been placed in low-density rural areas. However, because the infrastructure in these areas is designed primarily for small local populations, there is insufficient transmission capacity to efficiently transport the new volumes of electricity generated[11].



While a lack of sufficient infrastructure is the biggest obstacle to an efficient grid system, the high population density in the Netherlands makes the required finances and timeframe for the required development much more onerous; land is expensive and its use is highly regulated. This means that the current problems of insufficient transmission capacity relative to production may not be resolved for at least five years, according to Dutch/German TSO TenneT[12].

While the long-term solution to grid congestion is grid expansion, the time required for this scale of infrastructure investment means that more immediate solutions have been introduced in the short term to encourage more efficient use of the existing grid. These include incentivising lower consumption during peak times, and rewarding power generators to match supply and demand locally, rather than over-congesting grids. Grid operators may also encourage consumers to switch to off-peak usage using Time-of-Use network tariffs, and by applying capacity restriction contracts that require power generators to lower peak production in return for compensation.

10. CBS - Statistics Netherlands report on solar power and capacity, June 2024 https://www.cbs.nl/en- gb/news/2024/25/power-from-solar-panels-increased-slightly-in-2023
11. Report from Dutch and German TSO TenneT on 17/10/2024 - overproduction is causing capacity issues that may not be solved before 2029/32, https://www.tennet.eu/news/congestion-management-studies-yield-880-mw-infeed
12. ibid.

France

While many EU countries have embraced green energy derived from wind or solar sources in response to EU targets, France is unique in looking to nuclear power to replace fossil fuels.

The remarkable efficiency of nuclear energy can be attributed to the long lifespan of power plants, which is constantly being extended as technology improves. France's nuclear power generation can reliably meet national demand thanks to a generally stable annual consumption rate: it has decreased slowly from a peak of 472 KWh in 2010 (though sharper consumption decreases in recent years may have been driven by the energy crisis which meant other fuel sources were less available)[13]. The current cost of nuclear power is roughly EUR 60/MWh[14], and accounted for 65% of power consumed in France in 2023[15], though this cost may decrease as plants become more efficient.

Consumer needs have been prioritised throughout the liberalisation of France's energy market: the 'New Organisation of the Electricity Market Act 2010' – also known as the 'NOME Act – played a key role, states French energy law lecturer Guillaume Dezobry. The NOME Act reformed the organisation of the electricity market, allowing bidding for the right to supply electricity, and encouraging competition between suppliers to French consumers.

The price that suppliers pay is determined by the Energy Regulatory Commission (CRE), the French regulatory commission – for example the current CRE cost of nuclear energy production is EUR 60.7 MWh[16]. Suppliers can access the system through the 'Regulated Access to Incumbent Nuclear' or 'ARENH' mechanism.

A supplier will apply to CRE for access to nuclear energy based on demand forecasts, and then pay the CRE-determined price per energy unit to sell on to consumers[17]. ARENH access is capped at 100 TWh per year and the market is fully open to competition, ensuring best value for consumers.

France's example highlights the importance of investment in infrastructure. Before 2008, energy demand was increasing rapidly. Its long-term strategy of prioritising nuclear power investment in the face of rising energy demand has resulted in an improved grid design that is capable of delivering a stable power supply. France's efficient and very low cost nuclear fleet has enabled the country to become the world's largest net exporter of electricity - generating revenues of approximately EUR 3 billion a year[18].

Part of what makes France's nuclear energy so interesting is its unique character in EU

energy networks. In stark contrast to the French embrace of nuclear power is the German rejection of it. France's neighbour has embraced the 'prosumer'[19] - a consumer who is able both to produce and consume power by using locally sourced renewable energy from household solar panels or other sources. This push for more active producers and consumers of green energy contrasts with the French model of replacing older sources with green energy. The German EEG laws introduced between 2000 and 2017 reject nuclear as a transitionary technology and use its phase-out to promote connections with the electricity grid[20].

13. RTE (French TSO) annual electricity review 2023 https://assets.rte-france.com/analyse-et-donnees/2024- 11/RTE%20-%20Annual%20electricity%20review%202023%20-%20Key%20findings.pdf
14. Report from energy and climate research company Enerdata, Nov 2023 https://www.enerdata.net/publications/daily-energy-news/frances-cre-unveils-forecast-nuclear-power-costs-over- period-2026-2040.html#:~:text=The%20full%20cost%20of%20existing,2040%20(in%202022%20euros).
15. EU statistics report on Nuclear power energy production in 2023 across the EU, January 2025 https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Nuclear_energy_statistics
16. France's CRE unveils forecast on nuclear power costs over the period 2026-2040, https://www.enerdata.net/publications/daily-energy-news/frances-cre-unveils-forecast-nuclear-power-costs-over- period-2026-2040.html
17. RTE description of the ARENH mechanism and its benefits https://www.services-rte.com/en/learn-more-about-our-services/benefit-from-the-arenh-mechanism.html
18. Report on France's high level of exports, 2024 https://world-nuclear.org/information-library/country- profiles/countries-a-f/france#:~:text=In%20February%202022%20France%20announced,active%20in%20developing%20nuclear%20tec hnology
19. EU Publications Office explainer of 'prosumers' https://op.europa.eu/en/publication-detail/-/publication/496ccfd9- 3d4c-11ed-9c68-01aa75ed71a1
20. Report on EEG from 'Journalism for the Energy Transition', Peter Dinkloh, 2014. https://www.cleanenergywire.org/dossiers/eeg-20-new-legal-framework-german-energy-transition-0

The case of France highlights both the potential of renewable energy to meet demand, and, particularly in light of the starkly different experience of its neighbour Germany, demonstrates the level of autonomy exerted by Member States when implementing EU regulations.

Denmark

Denmark's energy reform has demonstrated the benefits of international interconnection and integrating different forms of green energy. Danish energy policy advisor Flemming Nielsen notes that EU energy targets have prompted the Danish government not only to exceed them, but also to become a green world leader, while the Nordic energy market is emulated by the EU as a whole in its implementation of regional energy markets.

In 1999, the Danish Electricity Supply Act implemented the EU electricity directives for the first time and has been amended every year since then, supplemented with new regulation in response to market conditions and the evolution of the EU acquis.

Denmark's electricity sector used to be vertically integrated, but legislation has unbundled transmission system operation (TSO) from production. The law established Energinet as a TSO for gas and electricity, while production and supply became competitive market sectors.

Ownership of Energinet is split 25%-75% between Vattenfall, the Swedish state energy company and Ørsted (formerly DONG Energy), the Danish oil and gas company. Nielsen stated that public ownership of these energy companies, as well as a political consensus in favour of green energy in Denmark, has allowed stable long-term planning.

Building on its historically close links with Norway, Finland and Sweden, Denmark has joined a group of countries specialising in different types of renewable energies. Norway generates a lot of hydro power, Sweden focuses on nuclear, and Denmark has homed in on combined heat and power, and especially wind power. Interconnection has benefited all three countries and is organised through The Nord Pool Energy Exchange[21], which has developed into an efficient energy market. ENTSO-E, established by the EU in 2009, facilitates regional cooperation with other EU TSOs, and has expanded interconnection to other north European countries such as Denmark and the Netherlands. Nielsen argues that the success of Nord Pool in facilitating regional energy trade inspired the EU to establish ENTSO-E and ENTSO-G.

Interconnection has done much to aid Denmark in achieving and outperforming the 55% carbon reduction target set by the EU[22] (the Danish government aims to be climate-neutral by 2045[23] and to be net negative after that point, though current Danish legislation mandates climate neutrality by 2050). However, the current market faces challenges when it comes to the variable power produced by renewable sources. This problem is particularly acute in wind energy, which forms an ever-growing proportion of Danish consumption (over 50% in 2022). Wind generation varies considerably based on weather conditions. This is partially balanced out by the integration of other renewable sources from neighbouring countries, and has been rendered more predictable by Energinet's sophisticated weather forecasting.

To ensure market functionality, market operators take turns operating the day ahead market algorithm 'EUPHEMIA'[24] which determines electricity pricing over different price zones. When markets are opened to auction a day in

21. Summary of NPEE https://www.nordpoolgroup.com/en/About-us/
22. EU Regulation 2021/1119 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32021R1119 , mandating climate targets of 55% emission reduction by 2030 compared to 1990 levels, and climate neutrality by 2050 by all Member States.
23. Summary of Danish climate policy design, Oct 2024 https://klimaraadet.dk/en/analysis/denmarks-climate-transition-towards-2050#:~:text=The%20government%20has%20proposed%20raising,to%20as%20net%2Dnegative%20emissions.
24. Nord Pool explainer of the Price Coupling of Regions algorithm https://www.nordpoolgroup.com/en/the-power- market/Day-ahead-market/Price-coupling-of-regions/

advance[25], prices will already have been determined between zones[26] and across the hours of the day[27].

The Danish adaptations through their green transition show the benefits of diversification when it comes to energy sources: wind power may not be as predictable as other forms of green energy. Diversification of power supply has, to a large extent, been possible due to the interconnection of Denmark with its neighbours, as well as the development of Nord Pool. In particular, the hourly-based market can factor in the variable effects of the weather and demand, while competition among producers for efficiency and market share ensure fair pricing for consumers.

Energy Storage

Throughout this paper issues of capacity and production variability from green sources have been apparent. The EU Commission has recognised the risk this poses to security of supply and has responded with moves to increase energy storage capacity. This is being done through increased investment in battery storage, with EU legislation promoting storage as part of supply infrastructure[28] as well an EU recommendation[29] in March 2023 for Member States to assess capacity needs, especially across areas with lower capacity or less stable grids. The EU also recommends market integration and transparency in market designs to encourage investment. The EU includes energy storage in its unbundled market model, and the Directive specifically states that storage ownership should be competitive and not owned by system operators, in order to ensure fair market access to storage and efficiency of energy use[30]. These recommendations should begin to address the variability of supply from green energy sources.

Conclusion

The case studies of the Netherlands, France and Denmark demonstrate key facets of EU energy law: the challenges of transitioning to green sources, and the diversity of approaches allowed for by EU legislation mean that net-zero targets are being achieved using a variety of green energy sources, while the continent is benefiting significantly from interconnection. These case studies are witness to the stabilising effect of local energy sourcing on pricing, as well as how market actors can adapt to a changing landscape of electricity production, while also demonstrating the weakness inherent in green energy: existing infrastructure was not built to support it, and green integration into energy supply requires huge investment.

Despite the fact that EU Member States have taken different paths towards the energy transition, have adopted different national market design features and have developed a different generation mix, the European electricity sector is increasingly converging under the harmonised framework provided by the EU's legislation and Electricity Market Design Target Model. This regulatory alignment has facilitated the integration of national markets into a pan-European day-ahead market, while efforts are ongoing to integrate the intra-day market – a crucial step that will allow absorption of a higher amount of renewable power and will enhance system flexibility. Meanwhile, long-term electricity markets are improving, and interconnectors are being utilised more efficiently, aiding cross-border balancing. The interplay between national policy autonomy and EU regulatory coherence will continue to balance local energy priorities with the continent's collective climate goals, supporting the energy transition.

25. EU Regulation setting out the rules on bidding zones https://eur-lex.europa.eu/eli/reg/2019/943/oj/eng
26. 'Price zones' are regions of market operation delineated by ACER. Production companies compete based on their capacity for production in the given time period before EUPHEMIA aggregates production bids as well as demand and determines electricity pricing from these factors. Prices end up being equal to the marginal cost of electricity. See also ACER report on bidding zones, explaining its regulatory powers. https://www.acer.europa.eu/electricity/market-rules/capacity-allocation-and-congestion-management/bidding-zone- review
27. Nord Pool explainer of the day-ahead market, https://www.nordpoolgroup.com/en/the-power-market/Day-ahead- market/
28. EU directive establishing rules for storage and other aspects of the internal energy market https://eur- lex.europa.eu/eli/dir/2019/944/oj/eng
29. EU Recommendation C/2023/1729.
30. Ibid, s (62)

Renewable energy: rural areas can be the EU's green powerhouse

The European Union aims to cut greenhouse gas emissions by at least 55% in 2030 compared to 1990 levels, and to become the first carbon-neutral economy by 2050. This ambitious goal requires a radical increase in the production of green energy within a relatively short timeframe. The untapped potential of rural areas in the union offers a way forward.

Rural areas could produce more energy than we need

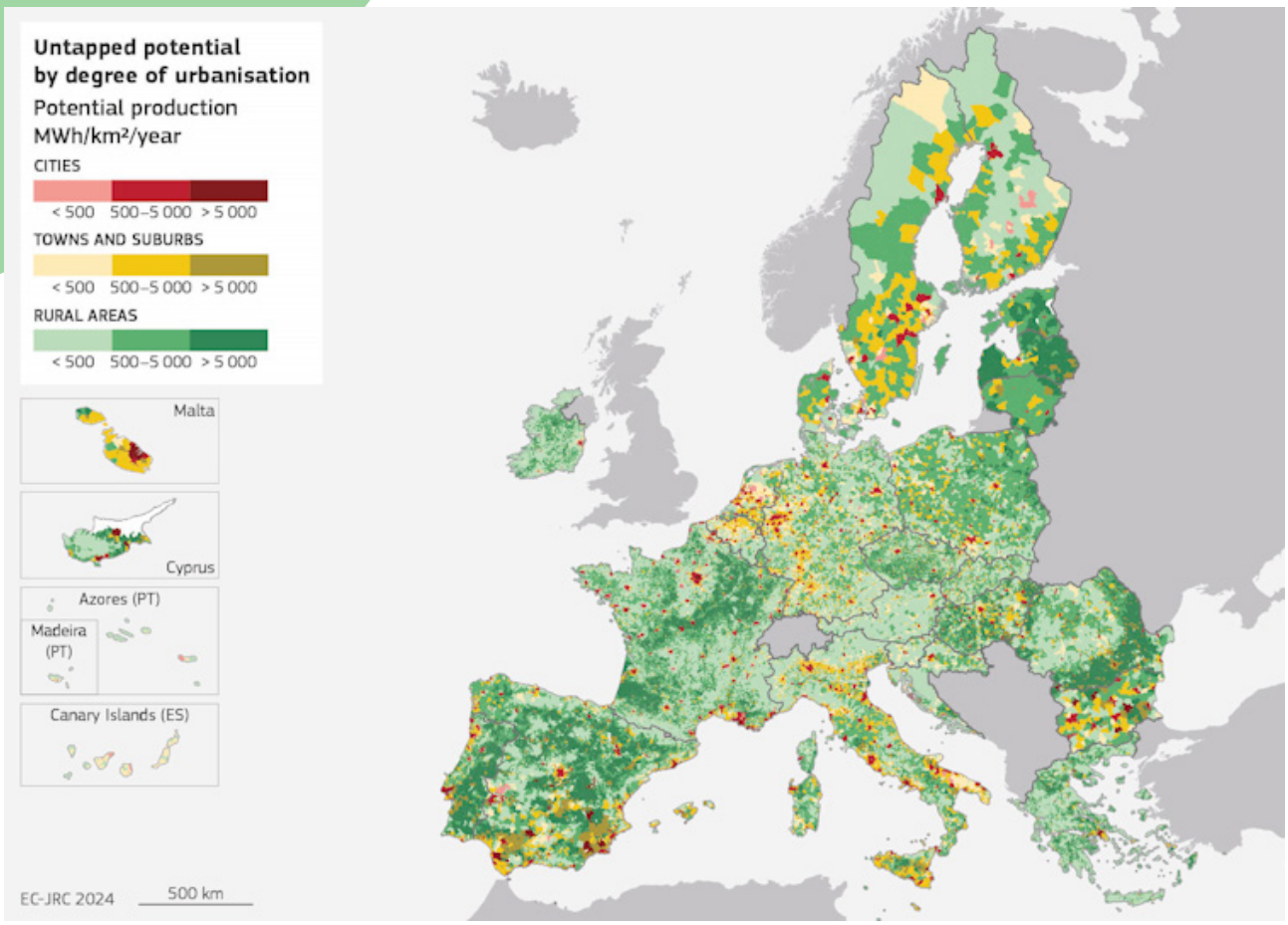
Rural areas cover more than 80% of the EU's territory and are host to around 30% of its population. Our work at the European Commission's Joint Research Centre (JRC) shows that rural territories already generate the largest share of green electricity (72%) from the three most prominent renewable technologies: solar photovoltaic, onshore wind and hydropower. The remaining share of renewable energy is produced in towns and suburbs (22%) and cities (6%). Germany, Spain, France, Italy and Sweden are the top five renewable energy producers in the union, accounting for 68% of its total production from solar, onshore wind and hydropower installations.

But there is more. According to our analyses, rural areas also possess the highest untapped potential of renewable energy production–nearly 80%. Theoretically, they could produce enough to meet the total energy demand of the EU. We estimate that the total potential of solar, onshore wind and hydropower energy production in rural areas nears 12,500 terawatt hours per year. That's more than five times the amount of electricity the union consumed in 2023, and it surpasses total energy consumption (which includes sources such as gas, oil and coal) for that year, too.

Technologies that suit the land

All this energy could be produced in rural areas without disrupting existing agricultural systems, landscapes and natural resources. Rural areas could produce up to 60 times more solar energy than what they currently deliver, quadruple their output from wind, and boost hydropower production by 25%. Spain, Romania, France, Portugal and Italy are the five EU countries with the highest combined (solar, wind and hydropower) untapped potential: together, they account for 67% of the EU's potential, with contributions from rural areas ranging from 92% in France to 49% in Italy.

Overall, solar panels installed on the ground can make the biggest contribution to green energy production in the EU. However, rural areas across the union are highly diverse, so choosing the right technology would depend on local characteristics. Mountainous areas with abundant water resources are a good fit for hydropower production, while rural municipalities with large areas of suitable land lend themselves to solar or wind energy, depending on sun irradiation and wind speed. In rural areas where wind and land are insufficient, rooftop photovoltaic systems are a good option.



A map of Europe shows the untapped potential for renewable energy production by degree of urbanisation in EU member states. European Commission -- Joint Research Centre, Author provided.

Boosting clean energy production can be a win-win

Rural areas are key to producing more renewable energy, as almost 80% of suitable, available land is located there. In addition, some of these areas are facing demographic and economic decline and are already the target of measures aimed at making them stronger, resilient and prosperous– as part of the EU's long-term vision for rural areas. In this context, ensuring that these areas benefit economically from hosting more renewable energy projects makes them even more enticing. It also aligns with political considerations, as energy independence is a key part of the EU's goal of strategic autonomy.

Addressing local concerns and fostering acceptance

While the potential offered by renewables is unquestionable, their production sites can face resistance from communities concerned about impacts on the local economy and quality of life. Seeing land used to produce energy with little local employment and seemingly for the benefit of large companies can also lead to resistance. Other concerns include competition for land use in areas where income is tied to other industries (such as agriculture or tourism), and the potential environmental impact of solar panels and wind or hydropower plants on rustic landscapes. With these concerns in mind, we

identified portions of land suitable to host renewable energy plants that comprise roughly 3.4% of the EU's surface. We excluded protected nature sites and biodiversity areas, forests and water bodies. We used strict limits on the use of agricultural land for energy production by only considering land that has been abandoned or has a very low productivity. Finally, we created buffer zones around infrastructure and settlements to minimise disturbance and safeguard natural beauty and cultural heritage.

Engaging local communities to find solutions

In our report, several case studies show the successful implementation of renewable energy projects in rural areas, driven by community engagement, collaboration and innovative financing models. From the first community-owned turbine in southern Europe in Catalonia, Spain, to a commercial energy company giving part of its profits to a local cause chosen with an energy community in the northern Netherlands, these cases highlight the potential for such projects to contribute to energy security, produce economic and social benefits and promote environmental sustainability.

These case studies show that active involvement of local communities from the early stages of renewable energy projects can foster acceptance. Citizens who are actively engaged or even share ownership in small- or medium-scale projects become more supportive. Beyond seeing profits stay local, engaged communities can mitigate negative effects of production by, for instance, choosing where to locate new energy plants.

Our report also offers an overview of renewable energy communities' role in ensuring a sustainable energy transition in which rural areas are not left behind. The number of renewable energy communities in the EU is rising and, although an exact count is unavailable, it is estimated that there were over 4,000 of them, with some 900,000 members, in 2023. These communities are mainly concentrated in northwest Europe, and a high proportion are rural. Beyond energy communities, place-based approaches, where local populations and administrations are engaged from the early stages and see clear benefits, can make an important contribution to our sustainable transition.

By **Lewis Dijkstra**
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Will China's new renewable energy pricing speed up coal's exit?

A shift to competitive auctions could accelerate the move to renewables, but much depends on how the policy is designed and implemented

Wind turbines in Dabancheng, also known "China's Wind Valley," in Xinjiang province (Image: Imaginechina /Alamy)

China's central government has announced a major reform in how renewable power is priced.

Until now, wind and solar farm operators have been guaranteed a fixed price (pegged to coal power rates) for a portion of the electricity they generate. Any output beyond that quota had to be sold at lower, more variable prices.

The new policy will see this coal-linked pricing system replaced by competitive auctions that determine the price for electricity from new wind and solar installations. Since coal power is relatively expensive to produce, this change is expected to considerably lower the price of renewable electricity specifically and electricity generally.

Local governments will draw up detailed plans and implement the auction-based system by the end of the year. The new pricing rules will apply to wind and solar projects completed after June this year, while earlier projects will continue to follow the older fixed-rate, coal-benchmarked model.

More than just a pricing adjustment, the policy may reshape China's entire power sector. However, with coal still dominating power generation, the policy must be carefully designed to ensure that renewables displace coal and cut emissions.

How does the new pricing mechanism work?

The new Chinese system is similar to the Contract for Difference (CfD) mechanism used in the UK and other markets. Renewable energy generators bid against each other to supply electricity to the grid at a fixed "strike price". When the market prices fall below the strike price, the government pays the generator the difference. When market prices exceed it, the generator must pay back the surplus. A dedicated fund, typically managed by the grid operator, handles these balancing payments to and from generators.

In countries like the UK, CfDs have successfully lowered renewable energy financing costs by providing stable revenues. But CfDs do have drawbacks. For instance, renewable generators might keep producing electricity even when prices drop below zero, delaying essential maintenance in order to maximise income. This has happened with wind power in Germany, where generators continued producing even when electricity prices turned negative.

Another challenge is choosing which market price to reference for payments. CfD payments are often based on day-ahead market prices, which could limit flexibility within the same day. Conversely, using real-time market pricing might discourage generators from planning their production efficiently.

CfDs can also complicate risk management, particularly for wind power. Because wind generation naturally fluctuates, operators might miss opportunities to sell power at peak market prices during calm weather. For example, wind operators in Spain have experienced huge fluctuations in revenue.

Limitations of implementation in China

China's power sector differs significantly from western markets, with coal still dominant and government intervention common. As of late 2024, coal accounted for about 60% of China's power generation, with prices and market share locked in through medium- and long-term contracts.

China's spot electricity market remains small and often provides distorted pricing signals. This raises questions about whether the CfD market reference price will accurately reflect the marginal cost of generating electricity. For instance, in Shandong province, which gets 70% of its electricity from coal, the marginal electricity price is largely determined by coal generation costs. Coal generation typically has significant fuel and maintenance costs that should, in theory, ensure positive market prices. However, the province has still experienced negative spot market prices for over ten hours at a time, forcing generators to pay to generate power.

Another challenge arises from the falling costs of wind and solar projects. The anticipated strike prices for renewables are already far below current coal-based benchmark prices (approximately RMB 0.38 per kilowatt-hour). Companies may bid even lower to secure contracts, resulting in a lower return on investment. Furthermore, if local governments strictly regulate bidding price ranges – as the recent reform suggests – competitive bidding could lose its effectiveness, clustering bids at the regulated minimum price and effectively reverting to government-controlled pricing.

Renewable dispatch in China is controlled by government policy and grid operators rather than market signals. Grid operators emphasise control, creating a disconnect between responsibilities and incentives. This centralised dispatch system, without self-correcting market mechanisms, limits renewables' ability to meaningfully replace coal, even when sufficient renewable generation is available.

CfDs may also unintentionally discourage companies from innovation and equipment upgrades, as new generation capacity bids must compete against older capacity that still benefits from higher subsidies or fixed reference prices.

What the future holds

The success of CfDs in China will depend on policy design and implementation. Three main scenarios can help illustrate this:

- **Scenario 1:**
  Priority for renewables and rapid coal phase-out

Renewables receive dispatch priority, minimising curtailment. CfDs stabilise renewable revenues, and efficient spot markets allow wind and solar to quickly displace coal. Coal operates mainly as backup and its market share falls quickly. Because market electricity prices remain higher than renewable strike prices, the CfD system generates a surplus. This surplus can fund energy storage, smarter dispatch systems, or lower industrial electricity for businesses. This scenario sees the biggest emissions cuts.

- **Scenario 2:**
  Gradual coal phase-out, competition slower to form

Coal's market share declines gradually through targeted policy interventions, with coal generators still competing in the market alongside steady renewables growth. Spot market prices hover near the strike price for wind and solar and remain lower than coal's average cost, keeping the surplus/deficit account balanced. Renewable dispatch remains heavily influenced by government interventions and emission reductions progress slowly.

- **Scenario 3:**
  Locked-in coal market share, limited renewable impact

China's substantial coal power capacity (around 1,300 gigawatts) remains dominant, running at high utilisation rates and maintaining elevated prices. The spot market is restricted, forcing renewable operators to compete fiercely for limited bilateral contracts. Spot market electricity prices frequently fall significantly below renewable strike prices, causing deficits in the CfD system. If these losses are distributed among business consumers, as currently occurs, the price of electricity will increase for them. Renewable capacity grows, but curtailment increases, failing to significantly replace coal or improve the energy mix.

Policy design is key

China's adoption of CfDs is an important reform in renewable energy pricing. Yet outcomes depend on detailed policy design and practical implementation. For CfDs to support meaningful emissions cuts, renewables must replace as much coal power as possible, not merely add new wind and solar capacity to coexist alongside it.

If CfDs consistently generate large deficits, it would indicate that renewables are relying too heavily on subsidies and surplus conditions. If CfDs remain consistently profitable, it signals that renewables are successfully challenging coal's market dominance.

The new CfD mechanism will need support both from policymakers and the market. Changes in the financial health of the CfD system – specifically the surplus/deficit account – will serve as an indicator of whether renewables are effectively displacing coal. Ultimately, clear, top-down market design and proactive policy improvements are essential for enabling CfDs to promote China's energy transition and rapidly decarbonise its power sector.

By **Zhang Shuwei**
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Clean energy contributed a record 10% of China's GDP in 2024

Clean-energy technologies made up more than 10% of China's economy in 2024 for the first time ever, with sales and investments worth 13.6tn yuan (USD 1.9tn).

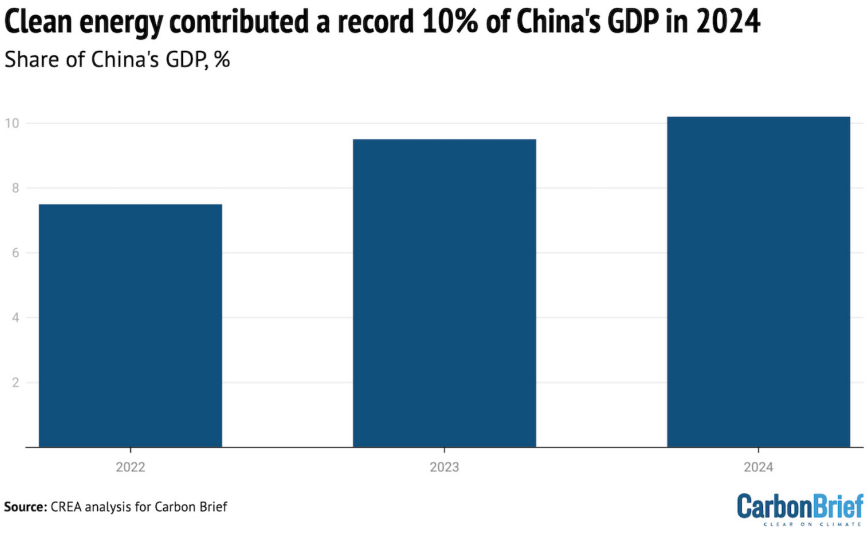
Clean energy reaches GDP milestone

In 2023, clean energy was behind an estimated 40% of economic growth in China, driven by a huge wave of investment in manufacturing capacity in the sector.

As noted in last year's analysis, it was inevitable that the extraordinary growth rates of investment would cool down in 2024 – and the new data bears this out.

Nevertheless, investment in the clean-energy sectors continued to grow in 2024. Moreover, growth in the production of goods and services in the sectors held up, at over 20%. As a result, clean-energy sectors made up more than 10% of China's GDP in 2024 for the first time ever, as shown in the figure below.

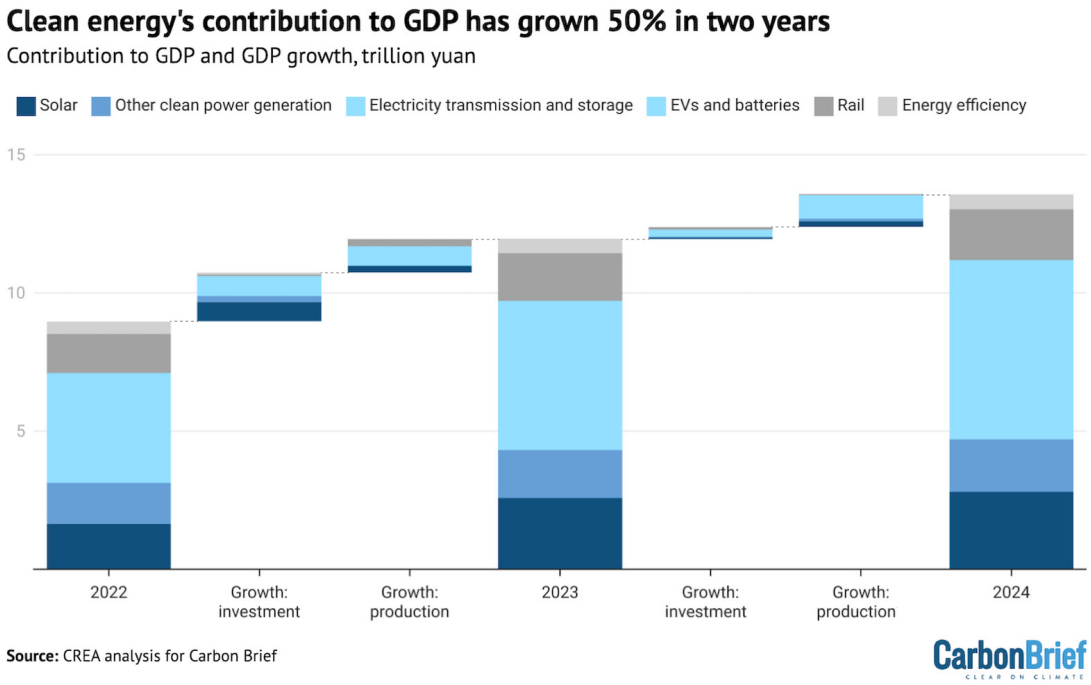
The overall economic contribution from clean-energy sectors, at 13.6tn yuan (USD 1.9tn), is of a similar scale to many major economies, such as Australia or Mexico. Equally, the sectors now make up a larger share of China's economy than real-estate sales, at 9.6tn yuan, or agriculture at 9.1tn yuan.



Share of China's GDP contributed by clean-energy sectors, %. Source: CREA analysis for Carbon Brief.

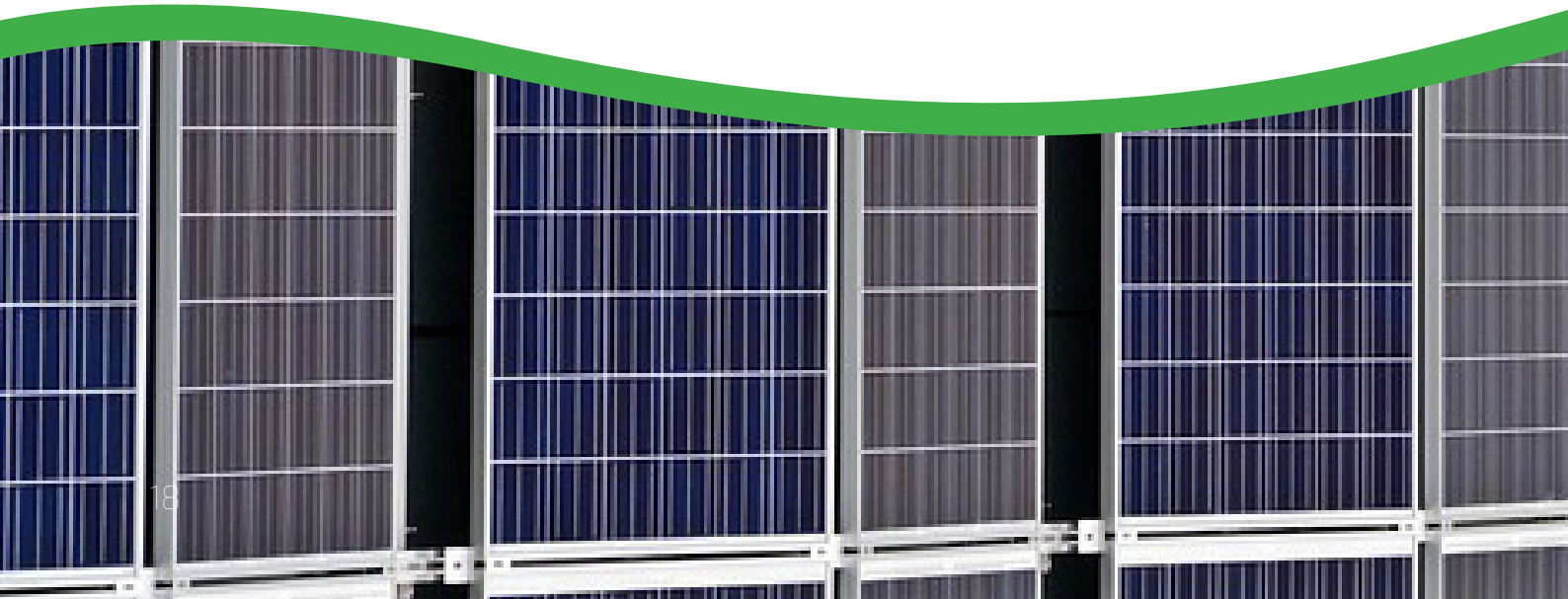
EVs and solar were the top growth drivers

The value of production and investments in clean-energy sectors grew an estimated 13% overall in 2024 – and has increased by 50% since 2022, as shown in the figure below.

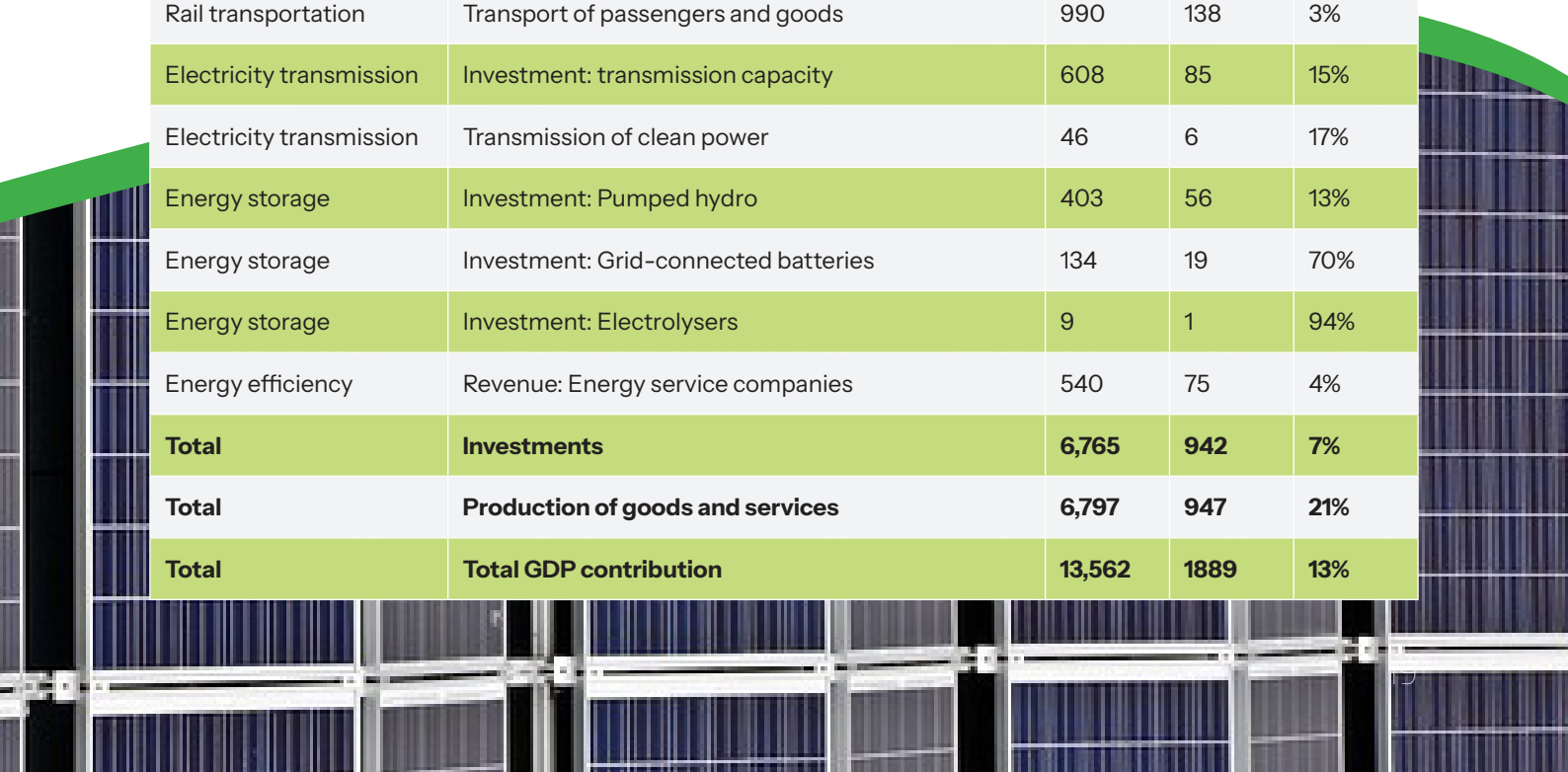


Contribution of clean-energy sectors to China's GDP and GDP growth, trillion yuan, 2022-2024. Source: CREA analysis for Carbon Brief.

Investments in clean-energy sectors reached an estimated 6.8tn yuan (USD 940bn), up 7% year-on-year, contributing almost half of all growth in fixed asset investments. The production of goods and services in the sectors grew by 21%, reaching 6.8tn yuan (USD 950bn). Electric-vehicle production was the most valuable sector overall, followed by clean-power production, rail transportation, electricity transmission and storage and energy efficiency.



Sector	Activity	Value in 2024, CNY bn	Value in 2024, USD bn	Year-on-year growth
EVs	Investment: manufacturing capacity	1,393	194	11%
EVs	Investment: charging infrastructure	122	17	20%
EVs	Production of vehicles	3,067	427	36%
Batteries	Investment: battery manufacturing	205	29	-35%
Batteries	Exports: batteries	494	69	8%
Solar power	Investment: power generation capacity	1,031	144	28%
Solar power	Investment: manufacturing capacity	779	109	-18%
Solar power	Electricity generation	386	54	41%
Solar power	Exports of components	607	85	14%
Wind power	Investment: power generation capacity, onshore	417	58	5%
Wind power	Investment: power generation capacity, offshore	48	7	-44%
Wind power	Electricity generation	440	51	14%
Nuclear power	Investment: power generation capacity	129	18	49%
Nuclear power	Electricity generation	200	28	3%
Hydropower	Investment: power generation capacity	95	13	19%
Hydropower	Electricity generation	567	79	11%
Rail transportation	Investment	851	118	11%
Rail transportation	Transport of passengers and goods	990	138	3%
Electricity transmission	Investment: transmission capacity	608	85	15%
Electricity transmission	Transmission of clean power	46	6	17%
Energy storage	Investment: Pumped hydro	403	56	13%
Energy storage	Investment: Grid-connected batteries	134	19	70%
Energy storage	Investment: Electrolysers	9	1	94%
Energy efficiency	Revenue: Energy service companies	540	75	4%
Total	**Investments**	**6,765**	**942**	**7%**
Total	**Production of goods and services**	**6,797**	**947**	**21%**
Total	**Total GDP contribution**	**13,562**	**1889**	**13%**



Electric vehicles and batteries

EVs and vehicle batteries were the largest contributors to China's clean-energy economy in 2024, making up an estimated 39% of value overall.

Of this total, the largest share was from the production of battery EVs and plug-in hybrids – which together make up the bulk of what China calls 'new energy vehicles' (NEVs) – worth more than 3tn yuan, followed by investment in NEV and battery manufacturing.

Investment in factories for making NEVs grew 11% to 1.4tn yuan, moderating from the high growth rates seen in 2023. The amount of money invested in new battery manufacturing facilities fell year-on-year, making a negative contribution to growth.

China produced 13m NEVs in 2024, rising 34% year-on-year. Some 22% of Chinese-made NEVs were exported, while the rest were sold domestically.

NEVs are the only growth sector for Chinese carmakers, as shown in the figure below. Moreover, NEVs made up 41% of total vehicle sales in 2024, up from 32% in 2023.

Production and sales of all vehicles and 'new energy vehicles' (NEVs) in China, from National Bureau of Statistics and China Association of Automobile Manufacturers data via Wind Financial Terminal. NEVs include battery electric vehicles and plug-in hybrids. The right-hand side shows the share of NEVs out of all new vehicles sold, and the cumulative share over the preceding 10 years, as an indicator of the share of NEVs out of vehicles on the road.

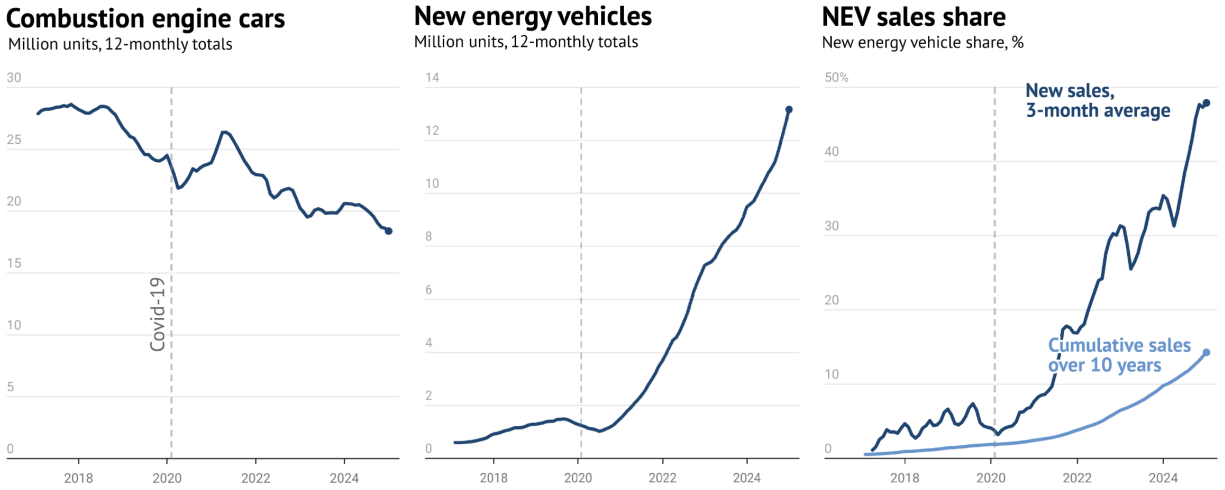
Domestic EV sales were supported by local government policies promoting vehicle replacement, but the strong sales also show that EVs have gained broad market acceptance.

New EV models have improved range and significantly shorter charging times – often under an hour – helping to ease consumer concerns. They also offer smart features such as 'navigate on autopilot' self-driving, that provide a better driving experience.

Much of the growth in EV production is now in plug-in hybrid vehicles. The extent to which these cut emissions depends on their being driven mostly on electricity.

Production and sales of 'new energy vehicles' are surging in China

Combustion engine cars (left), new energy vehicles (centre), million units. NEV share of sales (right), %



Source: CREA analysis for Carbon Brief

Real-world data suggests plug-in hybrids are rarely driven in electric mode in Europe. However, the electricity use of EV battery charging and swapping services in China rose by 51% in 2024, to levels consistent with a high level of electric driving from plug-in hybrids.

The growth in EV charging was supported by strong investment in charging infrastructure, with 4.2m charging points added in 2024, up 20% year-on-year. The total number of charging points reached 12.8m.

The average selling price of EVs in 2024 fell by just 8% year-on-year to 240,000 yuan (USD 33,000), despite intense competition in the sector.

While weaker than growth in domestic sales, EV exports still expanded 6.7% year-on-year, driven primarily by a 190% surge in the export of plug-in hybrids, while battery EV exports declined by 10.4%. This trend may be linked to EU tariffs targeting battery EVs, but excluding hybrids. The top growth markets were Brazil, Belgium, Mexico, the UAE and Indonesia, reflecting Chinese automakers' efforts to expand in markets where they do not face high tariffs or to accelerate exports before tariff increases take effect.

Investment in overseas production capacity is also supporting growth. For example, BYD's joint factory with BMW in Hungary is set to begin production in late 2025.

Solar

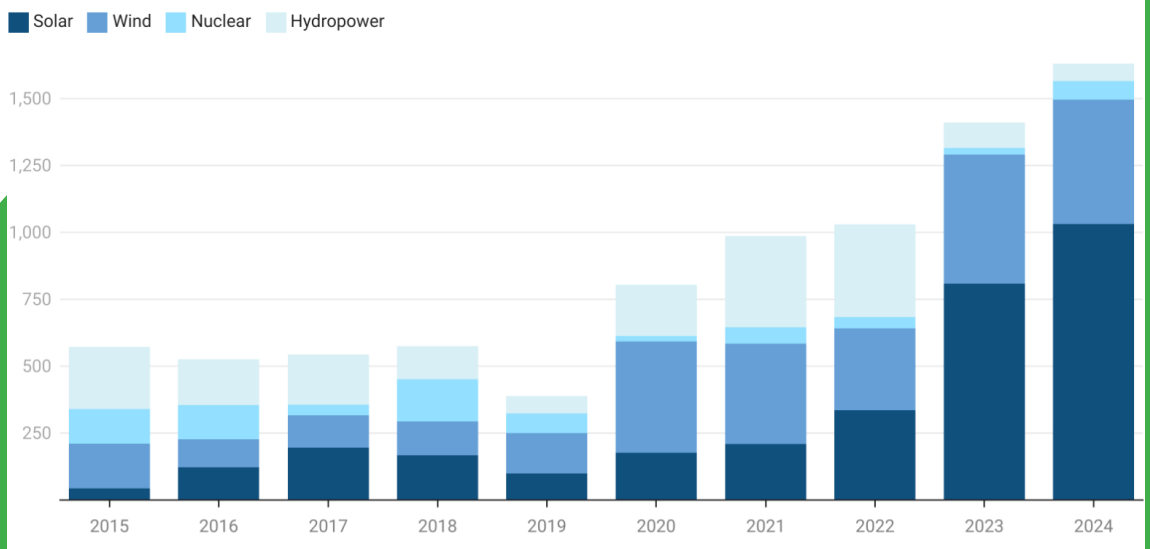
After EVs and batteries, the next-largest clean-tech contribution to China's GDP in 2024 came from solar power, which completes the 'new three' industries.

Solar generated 21% of the total value of the clean-energy industries in 2024, adding 2.8tn yuan (USD 390bn) to the national economy. Within this, investment in power generation projects, at 1tn yuan (USD 140bn), overtook manufacturing investment (0.8tn yuan, USD 109bn) as the largest contributor to the value of the sector. The value of solar power technology exports (0.6tn yuan, USD 85bn) was the third-largest, followed by the value of the power generated from solar (0.4tn yuan, USD 54bn).

The figure below shows the surge of Chinese investments in new solar power capacity – which has grown 10-fold in just five years – alongside spending on new wind, hydro and nuclear capacity (see next section).

China's investment in solar power capacity has risen 10-fold in five years

Value of investments in new clean power capacity, billion yuan



Source: CREA analysis for Carbon Brief

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Value of investments in new clean power capacity, billion yuan. The value of new capacity additions is calculated at constant 2023 capital cost levels to show the evolution of the real value of investment. Source: Capacity additions compiled from National Energy Administration annual electricity statistics releases and additional releases for solar PV and wind. Capital costs from China Electricity Council annual reports on power engineering costs.

China added some 277 gigawatts (GW) of new solar capacity in 2024, up 28% year-on-year from the previous year's 216GW, which was also a record. This increase included strong growth from both large-scale and distributed segments.

Centralised solar capacity grew the most in the western provinces of Xinjiang and Inner Mongolia, home to China's gigantic 'clean energy bases'. The relatively prosperous coastal provinces of Jiangsu, Zhejiang and Guangdong led the growth of distributed capacity.

As major manufacturing hubs, these coastal provinces have a large potential for distributed solar at industrial sites, where most of the power can be consumed locally.

Rising commercial electricity prices, along with pressure to meet energy-saving and carbon reduction targets, are further driving investment in industrial and commercial distributed solar.

Expansion of distributed solar in some other provinces is being limited by grid constraints. Henan, which topped the list of increases in distributed solar capacity in 2023, saw a slowdown in capacity additions, as residential solar-power producers have faced restrictions on selling power to the grid.

Solar manufacturing capacity additions slowed down sharply in 2024, reflecting falling product prices and a supply glut. Still, manufacturing capacity at the end of 2024 rose by 29% compared with a year earlier. The production of solar cells only increased by 16%, showing that manufacturing capacity additions are running ahead of demand and leading to weakened capacity utilisation at solar production lines. As a result, investments in solar manufacturing capacity are likely to slow down even further in the coming years.

Workers at a photovoltaic panel workshop in Jiangsu province, China. Credit: Sipa US / Alamy Stock Photo

A high-speed train in Shanghai, China. Credit: Markus Mainka / Alamy Stock Photo

Other clean power generation

Hydropower, wind and nuclear were responsible for 14% of the total value of the clean-energy sectors in 2024, adding some 1.9tn yuan (USD 264bn) to China's GDP in 2024. Nearly two-thirds of this (1.2tn yuan, USD 168bn) came from the value of power generation from hydropower, wind and nuclear, with investment in new power generation projects – shown in the chart above – contributing the rest.

Power generation grew 14% from wind, 11% from hydropower and 3% from nuclear. The rise in hydropower generation was mainly due to improved operating conditions as installed capacity only grew 1.2%.

Within investment, wind-power generation projects were the largest contributor to value, representing some 465bn yuan (USD 65bn) of spending in 2025. However, investment in nuclear projects, which increased by nearly half year-on-year, made the largest contribution to clean-energy spending growth. Investment in conventional hydropower declined slightly.

Wind-power investment was dragged down by a large drop in the commissioning of offshore wind capacity, which fell 44% year-on-year to just 4GW in 2024. This is expected to rebound strongly next year to 14-17GW. Newly added onshore wind power capacity increased 5% year-on-year, reaching 76GW, on top of the blistering 85% increase in 2023.

Nuclear saw strong growth, with 3.9GW completed in 2024, up from 1.4GW a year earlier. As a result of record approvals of new projects in 2022-2024, China now has more than 50 GW of new nuclear generation capacity permitted or under construction, implying a major uptick in capacity additions in the next five years, the typical construction timeline for new projects in China.

There is likely to be further strong growth in clean power investments in 2025, as large schemes race to complete before the end of the five-year plan period at the end of the year.

Railways

Rail transportation made up 14% of the value of the clean-energy sectors, with revenue from passenger rail transportation the largest source of value.

Growth rates moderated from the forceful post-Covid rebound in 2023, when 39% growth was recorded, to 3%. The number of rail passengers increased 11.9% year-on-year.

The largest source of growth was investment in rail infrastructure, increasing 11% year-on-year. China added 3,000km of new railway line in 2024, with the total length of operating railways reaching 162,000km. This includes the Shanghai-Suzhou-Huzhou high-speed rail line, which opened at the end of the year.

Another 12,000km of high-speed rail will be opened by 2030. The goal is to establish a nationwide '1-2-3-hour travel circle', where travel between cities within the same metropolitan area takes one hour, travel between adjacent cities takes two hours, and travel between major cities takes three hours.

Realising this vision involves connecting China's entire coastline through a 350km per hour route by 2028, and to create a grid of eight east-to-west and north-to-south high-speed trunk lines.

Electricity grids and storage

Electricity transmission and storage was responsible for 9% of the total value of the clean-energy sectors in 2024, with real growth of 19%.

The most valuable sub-segment was investment in power grids, followed by investment in energy storage. This includes spending on pumped hydropower, grid-connected battery storage and hydrogen production. The transmission of clean power also increased an estimated 17%, due to rapid growth in clean power generation.

China's installed electricity storage capacity growth rivaled the increase in coal- and gas-fired power generation capacity, for the first time on record. A total of approximately 50GW of battery storage, pumped hydro and hydrogen production capacity was added, while fossil fuel-based power generation capacity increased by 54GW.

This is significant, because a key rationale for building coal- and gas-fired power plants has been capacity adequacy, where electricity storage facilities can supplant the need for fossil fuel-based capacity.

Almost 40GW of battery storage was added, increasing 70% year-on-year and reaching 74GW total grid-connected capacity.

The operating capacity of pumped hydropower reached 59GW, with 8GW added during the year and 30GW entering construction. Capacity under construction increased to 189GW, up 13% on year, indicating that capacity additions will accelerate substantially in the next few years.

Investment in hydrogen electrolyser projects doubled year-on-year, from 1.8GW in 2023 to 3-4GW in 2024.

By the end of 2024, China had 42 operational long-distance, ultra-high voltage transmission lines, with a total length of over 40,000km and transmission capacity exceeding 300GW. Another 12 lines are under construction. One of the headline transmission projects completed during the year is an ultrahigh voltage transmission line connecting regions of Inner Mongolia and northern Hebei with large amounts of renewable and coal power, to demand centers in Beijing, Tianjin, Hebei, Shandong and Jiangsu provinces.

Investment in transmission and storage is bound to continue. China's top economic planner the National Development and Reform Commission (NDRC), published a new power system action plan that aims to integrate more than 200GW of new wind and solar onto the grid per year in 2025-27, requiring significant investments in storage and transmission.

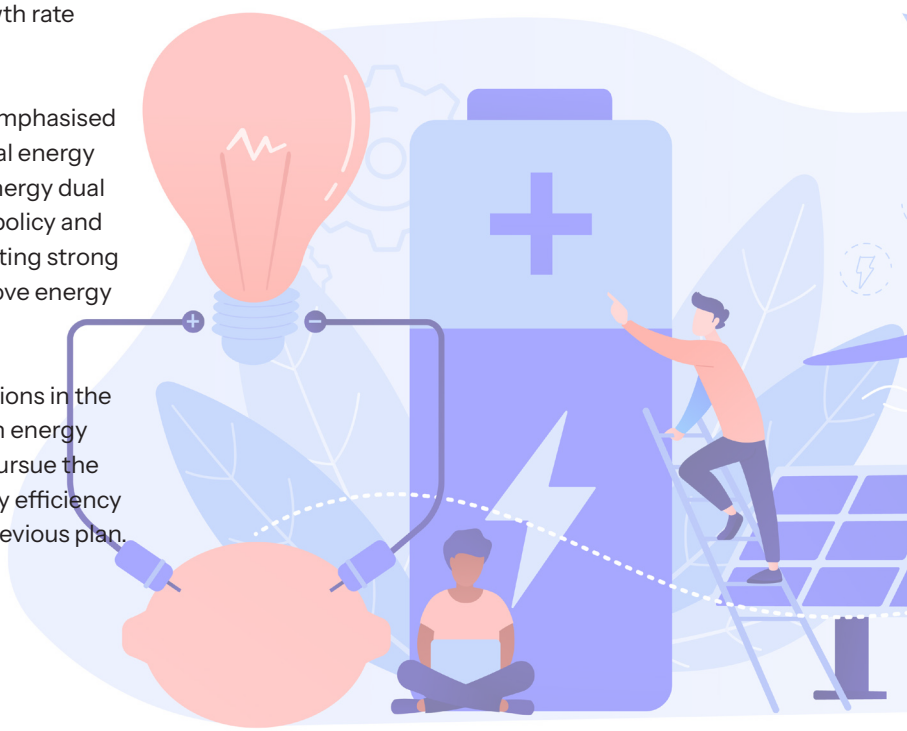
'Developing new forms of energy storage' was included in China's government work report for the first time in 2024, signaling a stronger policy push for energy storage deployment.

Energy efficiency

Investment in energy efficiency, as measured by the aggregate turnover of large energy service companies (ESCOs) grew 4% year-on-year, the slowest growth rate among the sectors we track.

China's energy and emissions policies have de-emphasised energy efficiency in recent years. Controlling total energy consumption and energy intensity – so-called energy dual control – was the centerpiece of China's energy policy and climate commitments until the early 2020s, creating strong incentives for provinces and enterprises to improve energy efficiency.

The policy was re-jigged in 2023 to target reductions in the fossil fuel intensity of the economy, making clean energy a more attractive way for local governments to pursue the targets. Five-year plan targets for building energy efficiency retrofits were also lowered compared with the previous plan.



Role of cleantech manufacturing in emissions growth

The clean-energy sectors include energy-intensive manufacturing industries, particularly the production of batteries and polysilicon, a key raw material for solar panels.

In addition, electric vehicles, solar panels and wind turbines need energy-intensive raw materials such as aluminum, steel and glass.

For this reason, and due to the high public profile of these industries, many commentators have suggested that the manufacturing of clean energy technologies is a major driver of China's energy demand growth and emissions.

In reality, however, their role in driving China's emissions is limited. The production of the 'new three' – EVs, batteries and solar – was responsible for an estimated 3.5% of China's CO_2 emissions and 0.9 percentage points of emissions growth in 2024

In addition, the analysis shows that these sectors contributed just 0.5 percentage points out of the overall 6.8% increase in China's electricity demand in 2024.

Electric vehicle charging used an additional 0.8% of China's total electricity consumption, making it responsible for approximately 0.3% of the country's total CO_2 emissions.

For a full accounting, these additional emissions from producing and fuelling clean energy technologies would need to be compared with the CO_2 savings from using them instead of fossil-fuelled alternatives, such as coal-fired power stations or combustion-engine cars.

Falling prices boost adoption, but challenge producers

While almost all other economies fret over high inflation, China is struggling with deflation, a product of aggressive expansion of manufacturing and weak domestic demand.

Several key clean-energy industries are facing this issue, with supply gluts leading to weak revenue and profits growth despite growing volumes. Attention on this issue has masked the contribution of the industries to real growth.

In the manufacturing of solar panels, for example, the nominal value of the industry's production fell by 41%, even as volumes showed strong growth.

Yet, the nominal value of investments in solar-power projects held steady as the volume of the projects increased strongly and the price of solar panels only makes up less than one third of the cost of solar-power generation projects.

The value of electricity generated from solar increased by 40%, pulling the overall contribution of the solar power industry to nominal GDP growth into positive territory.

In total, the value added of the clean energy industries grew an estimated 8.5% in nominal terms, slower than the 15% real growth rate but significantly faster than the growth rate of GDP, contributing 17% of nominal GDP growth.

In December 2024, a key annual economic policy meeting called for the creation of a 'healthy environment for the development of green and low-carbon industries' industries. This suggests the government may introduce measures to address excess clean manufacturing supply and address the weak profitability of the sector.

Implications of rapidly growing clean-energy economy

For the second year in a row, clean-energy sectors played an indispensable role in meeting China's key economic targets.

The combination of iIncreased supply and falling prices is leading to much faster deployment in China than practically anyone expected a few years ago and is also catalysing clean energy deployment in new overseas markets.

This growth is expected to continue into 2025, driven by major projects aiming to finish before the end of the current five-year plan.

Beyond 2025, development of China's clean-energy sectors hinges on new targets and policies in the next five-year plan, covering 2026-2030, which is being finalised this year.

After the lightning capacity expansion of the past few years, clean-energy manufacturing is plagued by weak profitability and oversupply.

Returning the sectors to profitability would require both maintaining strong domestic demand and measures to address overcapacity. Grid constraints, particularly affecting solar power, would need to be resolved to sustain demand.

Early indications of the targets proposed by China's key ministries for 2030 and 2035 fall short of maintaining the demand for key clean-energy technologies at the 2023–24 level.

Setting targets for the next five-year period that are below the current rate of deployment could turn the clean-energy sectors from a driver of GDP growth into a drag, as well as worsening the oversupply situation they are facing. In contrast, ambitious clean energy targets could maintain the sector's positive contribution to the economy.

The government's economic stimulus measures are likely to support investment in the clean-energy sectors, given their significant role in investment growth.

Moreover, the now critical role of clean-energy development in driving China's economic expansion creates incentives for policymakers to ensure the economic health of the sector.

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Qi Qin and **Chengcheng Qiu**, China analysts at CREA
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The battery industry has entered a new phase

Battery deployment continues to break records as prices fall

The global battery market is advancing rapidly as demand rises sharply and prices continue to decline. In 2024, as electric car sales rose by 25% to 17 million, annual battery demand surpassed 1 terawatt-hour (TWh) – a historic milestone. At the same time, the average price of a battery pack for a battery electric car dropped below USD 100 per kilowatt-hour, commonly thought of as a key threshold for competing on cost with conventional models.

Cheaper battery minerals have been an important driver. Lithium prices, in particular, have dropped by more than 85% from their peak in 2022. However, rapid advancements in the battery industry itself are also supporting price declines. After years of investments, global battery manufacturing capacity reached 3 TWh in 2024, and the next five years could see another tripling of production capacity if all announced projects are built.

These trends point to a battery industry entering a new phase of its development. While markets used to be regionalised and small, they are now global and very large, and a range of technological approaches is giving way to standardisation. Looking ahead, economies of scale, partnerships along the supply chain, manufacturing efficiency, and the capacity to bring innovations swiftly to market will be crucial to compete. This will likely result in greater consolidation across the sector, which is simultaneously being reshaped by government-driven efforts to geographically diversify battery supply chains.

China is set to remain the top producer, but consolidation could transform the market

Today, China produces over three-quarters of batteries sold globally, and in 2024 average prices dropped faster there than anywhere else in the world, falling by nearly 30%. Batteries in China were reported to be cheaper than in Europe and North America by over 30% and 20%, respectively. Declining battery prices in recent years are a major reason why many electric vehicles (EVs) in China are now cheaper than their conventional counterparts.

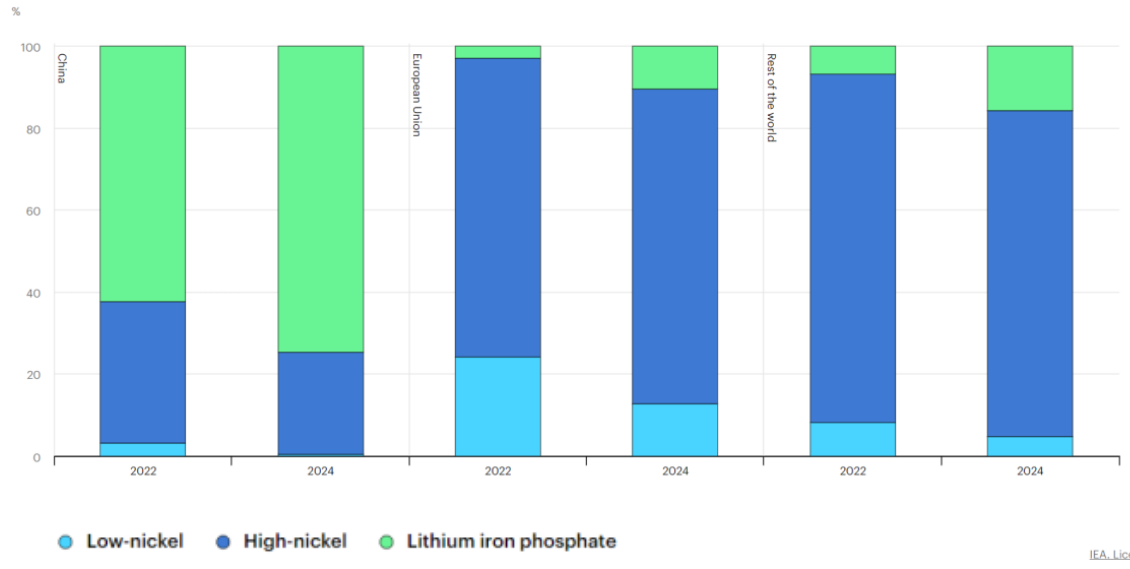
The price advantage of Chinese producers can be ascribed to four main factors:

- Over 70% of all EV batteries ever manufactured were produced in China, creating extensive manufacturing know-how. This has supported the rise of giant manufacturers such as CATL and BYD, which have centralised expertise in the battery sector and driven innovation. These companies have scaled up production faster and more efficiently than competitors and, crucially, achieved higher manufacturing yields.

- Supply chain integration, as the result of acquisitions by a single company as well as close cooperation among leading firms, has also supported faster innovation and a decline in manufacturing costs, with the latter additionally reported to be supported by access to below-market prices for critical minerals. The Chinese battery ecosystem covers all steps of the supply chain, from mineral mining and refining to the production of battery manufacturing equipment, precursors and other components, as well as the final production of batteries and EVs.
- Chinese producers have prioritised lithium-iron phosphate (LFP), a cheaper battery chemistry. Initially thought to be unsuitable for electric cars due to their lower energy density, years of research and development by Chinese producers have honed LFP batteries, which now cover nearly half the global EV market after more than tripling their share within the past five years. Today, they are about 30% less expensive than their main competitor, lithium nickel cobalt manganese oxide (NMC) batteries, while still offering competitive ranges for EVs.
- Fierce domestic competition has shaped the Chinese battery market, which is home to almost 100 producers. To maintain or gain market share, these firms have been cutting their profit margins to sell batteries at lower prices.

However, price declines could slow in the near future. Amid tough competition and shrinking margins, the number of companies producing batteries in China is likely to fall, and certain producers will acquire greater influence and pricing power. Even so, China is expected to remain the largest battery manufacturer by some distance in the medium-term.

Share of electric vehicle sales by battery chemistry in selected regions, 2022-2024



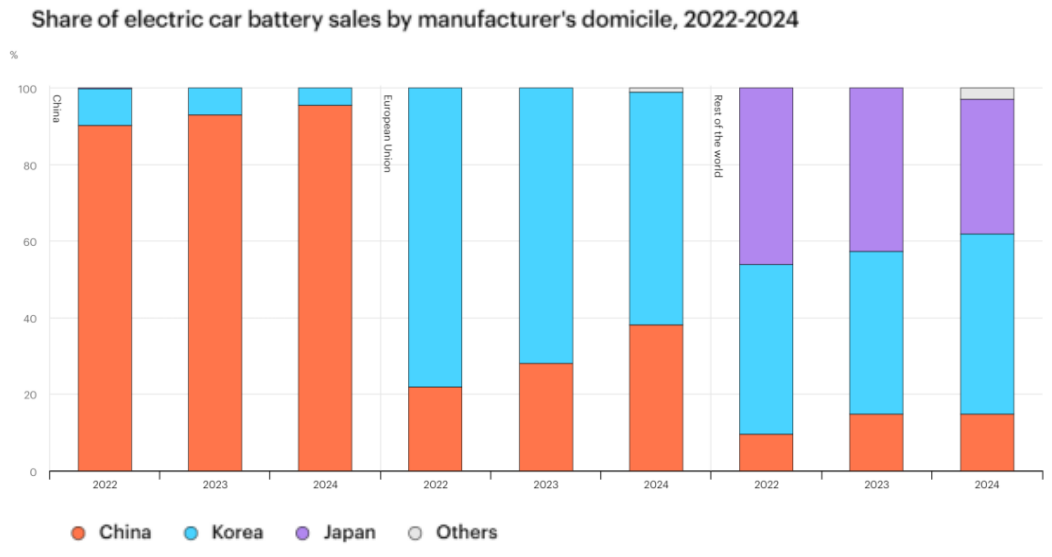
Battery production in Europe is going through a make-or-break moment

Elsewhere, the competitive edge of China's electric car and battery industry is presenting major challenges. Many battery producers in Europe are postponing or cancelling expansion plans because of uncertainty about future profitability. Production costs in the region are about 50% higher than in China; meanwhile, the battery supply chain ecosystem is still relatively weak and a lack of specialised workers persists. The bankruptcy of Northvolt – Europe's largest investment in a homegrown battery maker – underscores the difficulties of competing with Asian producers, with smaller manufacturers struggling to scale up production and reach sufficient yields.

Despite the challenges at hand, there are pathways for building a more competitive battery industry in Europe. All start with ensuring strong domestic demand, which gives manufacturers time to hone production processes and develop strong regional industrial ecosystems. On this front, clear policy that signals continued demand growth and reduces investment risks is essential.

Efforts to produce cheaper LFP batteries in the region are beginning to expand. Over the past two years, Korean manufacturers – traditionally the largest battery manufacturers in Europe – have lost almost one quarter of their market share in the European Union, which dropped from nearly 80% in 2022 to 60% in 2024 in part due to the increased success of LFP batteries made in China. However, some Korean companies have started investing in making LFP batteries in Europe, positioning themselves to better compete with Chinese producers.

In the meantime, Chinese battery makers are likely to keep expanding their European footprint, including through partnerships. Projects such the joint venture between Stellantis and CATL could speed up the uptake of LFP batteries in the region, improve Europe's battery ecosystem and potentially reduce the cost gap with China.



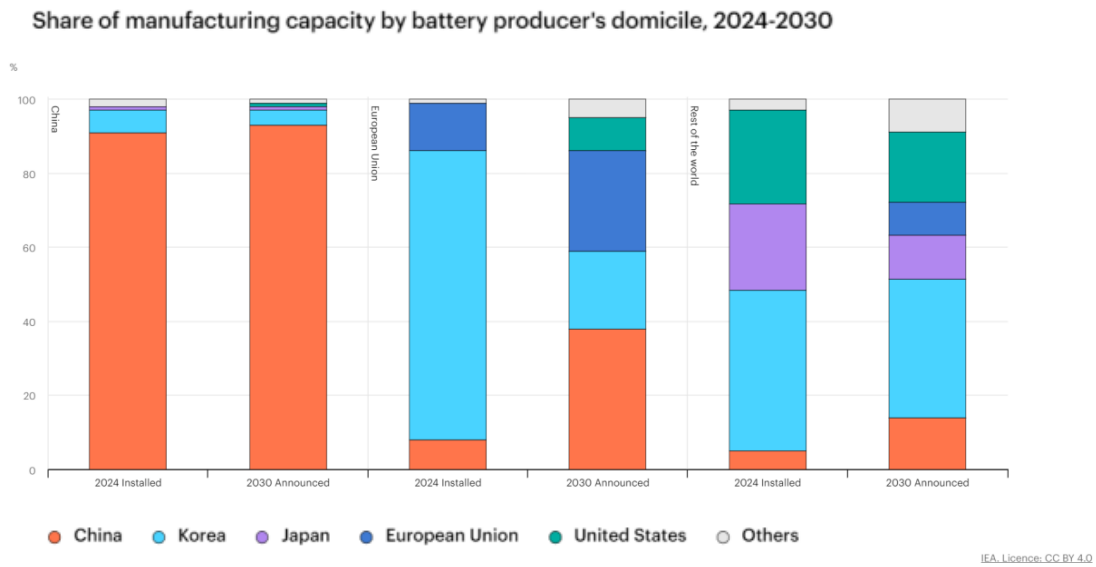
Though China leads, countries worldwide are racing to expand battery production

Despite China's current market dominance, the expansion of battery production is also moving fast elsewhere.

Korea and Japan are already major players in the global battery industry, home to key battery makers and specialised suppliers with strong expertise in NMC batteries. Both countries have limited domestic battery production but host established manufacturers with significant overseas investments. Korean companies lead in overseas manufacturing capacity, with nearly 400 gigawatt-hours (GWh), far surpassing Japan's 60 GWh and China's 30 GWh. Korean producers supplied over one-fifth of global electric car battery demand in 2024, while Japanese producers covered nearly 7%. As their overseas investments grow in major automotive markets, a key question is the extent to which they will embrace cheaper LFP designs. These producers also have strong innovation track records and are among those in the race to develop new technologies such as solid-state batteries.

In the United States, battery manufacturing capacity has doubled since 2022 following the implementation of tax credits for producers, reaching over 200 GWh in 2024. Nearly 700 GWh of additional manufacturing capacity is under construction. Around 40% of existing capacity is operated or developed by established battery makers in close collaboration with automakers. Developing domestic capacity for manufacturing battery components has progressed more slowly, so most anode and cathode demand is still satisfied by imports. Battery demand for stationary applications has increased by over 60% annually for the past two years, opening up a demand stream beyond EVs, albeit smaller in volume.

In the meantime, Southeast Asia and Morocco are emerging as potential production hubs for batteries and their components. Southeast Asia has attracted significant Chinese investment, which could speed up technology and innovation transfer. In Indonesia, home to half the world's mined nickel, the first EV battery manufacturing and graphite anode plants began production in 2024. Meanwhile, Morocco has the largest reserves of phosphate, a mineral essential for LFP batteries, as well as an established car manufacturing industry and free trade agreements with the European Union and the United States. These factors contributed to over USD 15 billion in announced investments in battery and components manufacturing in 2022.



Building a resilient battery industry while remaining competitive is difficult and may require trade-offs

Despite the rapid decrease in battery prices and continued innovation, the degree of concentration in battery supply chains has raised security concerns among governments in recent years. Announcements such as China's recently proposed export limitations on battery cathode and lithium processing technologies have amplified attention on this issue.

However, diversifying the production of batteries and their supply chain is a substantial undertaking and may require trade-offs. Any country interested in expanding output needs time and investment to bolster domestic manufacturing, build up their expertise and reduce production cost gaps relative to China. Such efforts require sufficient and sustained battery demand, and electric vehicle sales – which today account for 85% of the battery market - are the only driver that can create sufficient volume.

Strategically deploying automation, digitalisation and innovation also has an important role to play in reaching sufficient production yields to compete with Chinese production and facilitate the diversification of supplies. Meanwhile, collaboration with incumbent battery producers, through joint ventures or technology licensing agreements, can decrease the time and investments required to onshore battery production and develop domestic supply chains.

Another key lever is international collaboration. Many individual markets might not be sufficiently large to justify the necessary investments in the manufacturing of batteries and their components, and so may require closer collaboration with other EV and battery markets, as well as cooperation with resource-rich countries such as those in South America and Africa, Australia, Indonesia, to make the case.

The IEA will continue to monitor these trends in order to provide timely analysis and policy advice. Later this year, the Agency will also publish a special report focused on the car industry, which will include new analysis on battery supply chains.

By **Teo Lombardo**, Transport Modeller
Leonardo Paoli, Clean Transport Analyst
Araceli Fernandez Pales, Head of Technology Innovation Unit
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News in Brief

Click on the headlines to learn more.

ECECP highlight some recent key energy news headlines in the EU and China

Europe News

Policy Initiatives

EU: Flagship initiative to boost competitiveness and secure sustainable prosperity

The European Commission has unveiled the Competitiveness Compass, a major initiative that sets a strategic framework which will guide the Commission's work to enhance Europe's competitiveness and secure sustainable prosperity. Building on the recommendations contained in a 2023 report by former Italian Prime Minister Mario Draghi, it sets out a selection of flagship measures to support innovation, decarbonisation and security. These are complemented by five horizontal enablers, including simplification, enhancing the single market, financing, promoting skills and quality jobs, and better coordination at EU and national level. Together, these elements are intended to underpin competitiveness across all sectors.

EU: Commission unveils Clean Industrial Deal

This bold business plan positions decarbonisation as the key driver of growth in the European industrial sector. It promotes competitiveness, resilience, and decarbonisation, focusing primarily on energy-intensive industries and clean tech sectors, and introduces measures to lower energy costs for industrial producers and boost demand for EU-made clean products. The plan also prioritises circularity, a skilled workforce, mobilisation of financing, and safeguarding fair competition, all of which are crucial enablers for EU competitiveness. The measures are intended to create a clearer business case for industrial decarbonisation within Europe.

EU: Action Plan for Affordable Energy to save EUR 260 billion/yr by 2040

This Action Plan, released by the EU Commission as a key component of the Clean Industrial Deal, puts forward short-term measures to reduce energy bills, achieve deeper integration of the electricity market, attract investment and be better prepared for potential energy crises. The permitting times for renewables are also set to be reduced. The measures will bring relief not only to households facing high energy bills, but also to industries that struggle with high production costs, delivering estimated overall savings of EUR 45 billion in 2025, rising to EUR 130 billion by 2030 and EUR 260 billion by 2040.

EU launches Steel and Metals Industry Action Plan

On 19 March 2025, the European Commission launched the Steel and Metals Industry Action Plan which is intended to secure a competitive and decarbonised steel and metals industry in Europe. The plan consists of six main elements: ensuring abundant and affordable clean energy; preventing carbon leakage; promoting and protecting European industrial capacities; promoting circularity for metals; defending quality industrial jobs; and de-risking through lead markets and support to investments.

EU: Commission moves to ease regulatory burden on business

The European Commission has adopted a new package of proposals to ease the regulatory burden on EU companies, and so foster a more favourable business environment. The Omnibus packages propose amendments in key legislative fields that include far-reaching simplifications to sustainable finance reporting (CSRD), sustainability due diligence (CSDDD), EU Taxonomy, the Carbon Border Adjustment Mechanism (CBAM), and European investment programmes. If adopted, these changes are expected to reduce annual administrative costs by approximately EUR 6.3 billion and mobilise an additional EUR 50 billion in public and private investment to support policy priorities.

UK: Cap and floor scheme for Long Duration Electricity Storage (LDES)

A new scheme aims to encourage investment in LDES technologies, including pumped-storage hydro, liquid air energy storage, compressed air energy storage, and flow batteries, which can store surplus renewable energy and enhance energy security. The scheme is designed in two application routes: one for mature technologies (≥100 MW, with a technology readiness level (TRL) of 9) and one for new innovations (≥50 MW, TRL 8), with a minimum duration of eight hours. The first application window targets a capacity range of 2.7 to 7.7 GW by 2035. UK energy regulator Ofgem will oversee the first round of applications, which is set to open in April 2025.

Market & Business

EU: Europe establishes partnerships in PV and advanced materials

The Partnership for Innovation in Photovoltaics, established under Horizon Europe, aims to boost European PV manufacturing capacity and develop a resilient and green EU value chain, with EUR 240 million planned investment from the European Commission and private partners by 2030. Meanwhile, a new Partnership for Innovative Advanced Materials will enhance technology sovereignty and competitiveness in advanced materials, accelerating their sustainable development and industrial uptake as well as the construction of a circular economy. The plan is for this initiative to attract investments of EUR 250 million, from the European Commission and private partners, by 2030.

EU: European Hydrogen Bank's second auction is over-subscribed

The European Hydrogen Bank's second auction for the production of renewable hydrogen has attracted 61 bids from projects in 11 countries within the European Economic Area (EEA). The total grant support requested from the Innovation Fund is more than EUR 4.8 billion, four times the available budget of EUR 1.2 billion. These bids account for a total electrolyser capacity of around 6.3 GW, with a potential to produce more than 7.3 Mt of renewable H2 over ten years, meeting 7% of the EU's REPowerEU target for domestic renewable hydrogen production by 2030. The Grant Agreements are expected to be signed by November 2025 at the latest.

Eurostat: Electricity from renewable sources reaches 46.9% in 2024

New statistics from the EU's statistical office, Eurostat, show that wind and hydro power accounted for more than two-thirds of total renewable generation in 2024. Among EU countries, Denmark had the highest share of renewables in its net electricity generation with 88.4% (most came from wind), followed by Portugal (87.5%, mostly wind and hydro) and Croatia (73.7%, mostly hydro).

EU: New interactive tool maps Europe's energy storage data
A newly-launched open-access European Energy Storage Inventory represents the first European-level platform to show near real-time data on the deployment of all forms of clean energy storage solutions across Europe, from battery storage to pumped hydro, as well as emerging technologies like hydrogen storage and thermal storage. It features an interactive dashboard and map, which serves as a useful tool for energy system modelling and planning, and will help improve forecasting of storage deployment and capacity needs. The Inventory is part of the REPowerEU Plan and the EU's broader goal of achieving climate neutrality.

Germany: 40 GW offshore wind planned by 2034
Germany's Federal Maritime and Hydrographic Agency (BSH) has released its fourth area development plan for offshore wind expansion, targeting 40 GW capacity by 2034. The plan designates new wind energy areas in Germany's North Sea and Baltic Sea Exclusive Economic Zone (EEZ) through trilateral coordination with Denmark and the Netherlands. Germany will tender a total of 12 GW capacity over the next four years, and remains on track to achieve its 70 GW target by 2045.

UK: Carbon pricing causes GBP 2.9 billion in lost revenues over two years
New research from the Institute for Energy Economics and Financial Analysis (IEEFA) finds that the EU ETS has been trading almost 50% higher than the UK equivalent in the last two fiscal years. The UK's comparatively low carbon price cap is limiting the UK government's ability to fund climate change mitigation, while free allowances have reduced incentives to decarbonise.

Technology & Innovation

New project to tap tidal and river energy in NW Europe
The newly launched SHINES project (Showcasing Hydrokinetic energy Innovations for Northwest European Energy Sovereignty), which brings together partners from France, Ireland, Belgium, the Netherlands, Switzerland, and Germany, aims to unlock the potential of untapped tidal and river energy at the various gulfs, straits, islands, inlets, and locations along large rivers in the region by engaging various companies and working to overcome investment barriers hindering sector development. The EUR 10 million project will run from January 2025 to December 2028.

France: Underwater turbine farm to supply locals with clean electricity
A tidal farm featuring the world's most powerful underwater turbines is under construction off the coast of Normandy, France, after securing EUR 31.3 million in funding from the EU's Innovation Fund. The NH1 tidal project, one of France's first commercial-scale tidal energy pilot projects, led by Normandie Hydroliennes, will utilise four turbines to harness the Raz Blanchard tidal flow, Europe's strongest tidal stream, and convert it into renewable energy. Each turbine will have a rotor diameter of 24 meters and a 3 MW capacity, collectively generating 12 MW. This configuration will produce 34 GWh of energy annually, sufficient to power 15 000 local homes. Subsequent planned projects are set to deploy as many as 85 turbines a year.

Netherlands: New PVT-assisted heat pump using waste heat from PV
Dutch company Triple Solar has developed a residential PVT heat pump that uses waste heat from PV modules. The compact system consists of two modules installed in a building's boiler room, and does not require an outdoor unit. It is designed for family homes and can also be used in terraced housing or housing blocks as a gas heating replacement. The system uses rooftop sandwich PV modules that generate electricity on the front and features a heat exchanger on the back that can absorb ambient heat. It offers 1.2 kW to 5 kW heating output, with a maximum flow temperature of 70℃. The company claims that the system improves efficiency by 20% compared to conventional air-to-water heat pumps.

Germany: Europe's largest PEM electrolyser starts to decarbonise chemical production
Chemicals giant BASF has announced that Europe's largest green hydrogen project to reduce carbon emissions is now operational. Built together with Siemens Energy, the 54 MW proton exchange membrane (PEM) electrolyser will produce up to one metric ton of hydrogen every hour as feedstock for chemical products, helping to reduce BASF's carbon footprint. The machine, at BASF's main plant in Ludwigshafen, is capable of generating 8 000 tonnes of hydrogen per year.

Projects & Investments

EU: EV infrastructure gets EUR 45 million boost

E.ON, Eldrive, and ZSE have secured EUR 45 million in EU funding to expand Europe's electric vehicle infrastructure through the DRIVE-E project. By 2027, the three companies aim to install 1 400 charging points along major transport routes across 13 European countries, including 430 specifically for heavy-duty electric trucks. The new charging stations will be built along major transport routes to facilitate the switch to electric power for both passenger and freight transport. The project supports EU efforts to decarbonise transport, co-funded through the Alternative Fuels Infrastructure Facility (AFIF II).

EU: Funding announced to support cross-border energy infrastructure

The European Commission is to allocate nearly EUR 1.25 billion in grants from the Connecting Europe Facility (CEF) to 41 cross-border energy projects, including electricity grids, hydrogen infrastructure, and CO_2 infrastructure. This is the largest funding call under the current CEF Energy program and the first under the revised TEN-E Regulation, which now includes hydrogen and offshore electricity projects. The funding will support five works proposals and 36 studies, with nearly EUR 750 million allocated to electricity grid projects, EUR 250 million for 21 hydrogen development studies, and EUR 250 million for the construction of three CO_2 projects and the financing of nine preparatory studies for CO_2 infrastructure.

EU: New funding to support the green transition of the steel and coal sector

Collaborative research in the coal and steel sectors is to receive EUR 175 milion from the Research Fund for Coal and Steel (RFCS). This includes two main calls, launched in February 2025, of EUR 100 million for steel and EUR 35 million for coal, aimed at advancing near-zero-carbon steelmaking technologies and facilitating a just transition for coal mines. An additional EUR 40 million call for both sectors is scheduled for June 2025.

Baltic states join the European power grid

The three Baltic states of Estonia, Latvia, and Lithuania have cut all connections with Russia's power grid and successfully integrated into the EU internal energy market by joining the European continental network via Poland. This move marks the end of their energy dependence on Russia, further enhancing the region's energy security. The synchronisation project, supported by over EUR 1.23 billion in EU funding, was completed 10 months ahead of schedule. Construction work on the 700 MW Harmony Link Interconnector between Lithuania and Poland is set to finish in 2030.

Spain: CCS project launches in Valencia

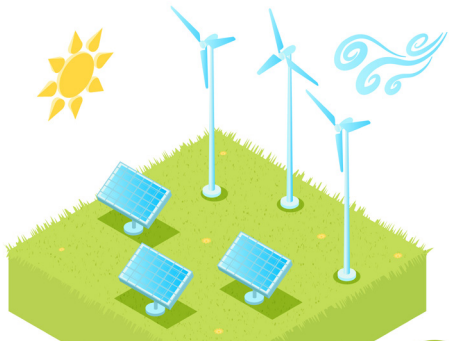
The CO_2necta project aims to support the decarbonisation of energy intensive industries and prevent the emission of more than 560 000 tonnes of CO_2 per year in the Sagunto community. A consortium comprised of Enagás, Holcim, and Saggas will build a carbon capture plant at Holcim's Sagunto factory. The captured CO_2 will be transported by Spanish TSO Enagás via a new pipeline to the Saggas LNG terminal in the port of Sagunto, where it will be liquefied and stored for shipment to a geological storage site. The project also plans to use the biogenic portion of captured CO_2 to produce e-methanol and other biofuels, supporting the local circular economy.

Netherlands: Large plant to generate heat, power from hydrogen

Dutch startup HyER Power is developing a hydrogen-powered plant to generate heat and electricity at Innovation Hub KAAP in Vlissingen. The HyER Power Plant, which is set to be operational by year-end, will combine a heat pump, fuel cell system, and energy storage technology, offering a decentralised solution for businesses. It aims to ease grid congestion in Zeeland province, where grid access delays are limiting business expansion. The project, funded with EUR 332 874 from the Zeeuwse Public Interests Foundation, will serve as a test case for hydrogen-based energy solutions in the built environment.

China News

Policy Initiatives



NEA issues energy work plan for 2025

This plan outlines the key targets for China's energy supply and consumption for the rest of the year. In 2025, China aims to add over 200 GW of renewable capacity, bringing total installed capacity to over 3 600 GW, and boosting annual power generation to 10 600 TWh. Renewables are expected to account for 60% of total installed capacity, with non-fossil energy sources accounting for 20% of total energy consumption. Major tasks for the year include improving trans-regional power transmission, promoting renewable substitutions in industrial, transportation and building sectors, facilitating renewable integration and consumption, and enhancing clean development of coal-fired power. China will continue to work towards a unified national power market which will help optimise resource allocation.

New guideline on promoting development of the green electricity certificate market

A new policy document published by NDRC specifies that China's green certificate (GEC) market trading system will be basically complete by 2027, with further improvements to be achieved by 2030. It contains detailed measures that aim to boost the GEC market: stabilising supply, stimulating consumption, improving trading mechanisms, and promoting international adoption of China's green certificates. The move will improve the market competitiveness of China's clean energy and significantly expand green power trading, which underpins the country's long-term green energy consumption and development.

China unveils plan to boost new energy storage manufacturing industry

This plan, jointly issued by eight departments including the Ministry of Industry and Information Technology, aims to enhance innovation and competitiveness, and achieve high-end, intelligent and green industry growth. By 2027, China plans to cultivate between three and five leading enterprises in the sector's ecosystem. It envisions a concentration of key industry players and the formation of regional clusters. The strategy also seeks to diversify new energy storage products and technologies to better meet the different needs of various sectors. The plan outlines measures to strengthen the security of mineral resources needed for power battery production, thereby boosting supply chain resilience.

China sets out plan for greening aluminum industry

Ten ministries in China have jointly issued a plan aiming for high-level development of the aluminum industry over the next three years, bolstering the resilience and security of the domestic value chain. It stipulates that by 2027, domestic bauxite resources should grow by 3%-5%, while recycled aluminum production is expected to surpass 15 million tons. To accelerate the green transformation of the sector, the plan outlines measures to promote energy efficiency and reduce emissions across the production lines. Moreover, enterprises are encouraged to increase their clean energy consumption through green power trading, purchasing green certificates, and directly investing in clean energy projects. The goal is to raise the share of clean energy used in the aluminum industry to over 30% by 2027.

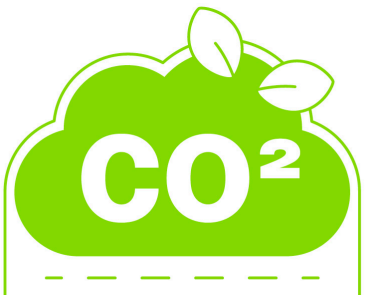
New guide for digitalising the energy and carbon management of industrial parks

China MIIT has issued a 'Construction Guide for Digitalised Energy and Carbon Management Centres for Industrial Enterprises and Parks', in a bid to enhance industrial energy saving and carbon reduction management and promote the green transition using digital technology. The guide details the functions, technical solutions, and support measures of digital energy and carbon management centres. These digital centres will enable industrial enterprises and parks to measure and manage their energy consumption and carbon emissions in a more intelligent manner, effectively supporting energy efficiency improvements and emission reductions, and facilitating an industrial low-carbon transformation.

China aims to scale up ocean energy development

China has launched an ambitious plan for large-scale deployment of ocean energy, targeting an installed generation capacity of 400 MW by 2030. The plan, jointly issued by six ministries, outlines major initiatives to unlock the potential of marine energy sources such as tidal, wave, and ocean thermal energy. Key elements of the plan include constructing multi-energy integrated power systems on islands and advancing large-scale demonstration projects for ocean energy. The goal is to further explore the application scenarios, fostering innovation and enhancing the sector's equipment manufacturing capability. Notably, the plan also promotes the co-development of wave energy with offshore wind, using shared infrastructure to reduce development costs.

Market & Business



China expands carbon trading market

Initially solely covering 2 200 power producers, China national ETS market will now include steel, cement, and aluminum smelting industries, according to a work plan issued by the Ministry of Ecology and Environment. These sectors account for over 20% of the country's total CO_2 emissions. The expansion will bring an additional 1 500 emitters into the scheme, increasing total covered emissions to 8 billion metric tonnes (over 60% of China's total emissions). Greenhouse gases such as CF4 and C2F6 will now be included.

China's installed non-fossil fuel power capacity reaches 2 TW

The latest data from the China Electricity Council (CEC) reveals that China's non-fossil fuel power generation capacity exceeded 2 TW for the first time by the end of February, up 103.1% since 2021. Non-fossil fuels now account for 58.8% of total installed power generation capacity. In particular, wind and solar power capacity reached 1.46 TW, accounting for 42.8% of the country's total. The surge reflects the power sector's continued drive to green its generation mix.

NEV market continues strong growth in early 2025

China's new energy vehicle (NEV) market continued to see robust growth in the first two months of 2025. According to the Ministry of Industry and Information Technology (MIIT), China's NEV production reached 1.903 million units and sales reached 1.835 million units, both up by 52% year-on-year. NEVs accounted for 40.3% of total new vehicle sales in the first two months of 2025. Exports of NEVs also surged by 54.5% to 282,000 units over the same period.

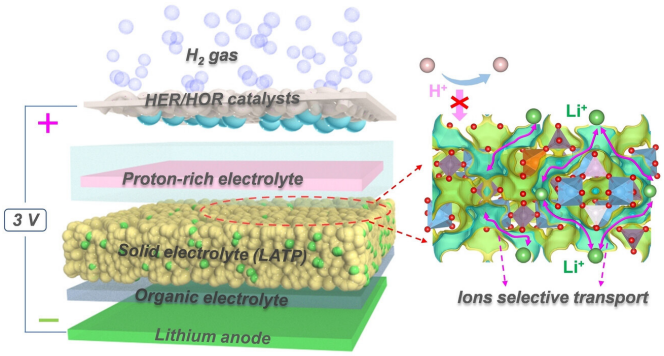
Technology & Innovation

High efficiency micronuclear battery among China's top ten scientific advances of 2024

The National Natural Science Foundation of China (NSFC) announced China's top ten scientific advances of 2024 at the opening ceremony of the 2025 Zhongguancun Forum. An innovative actinide-based radio photovoltaic micronuclear battery design is included in the list of breakthrough technologies. It harnesses the energy of radioactive decay to generate electricity. The design features a coalescent energy transducer, which is intricately coupled with radioactive nuclides at the molecular level. By integrating photovoltaic technology, the battery works efficiently to convert radiation decay energy into electrical energy, boosting energy conversion efficiency x 8 000 compared to traditional battery design. This technology not only sets a new record in energy conversion efficiency but also paves the way for new strategies in radioactive waste recovery. Click here to learn more about the technology.

First titanium-based solid state hydrogen storage module delivered

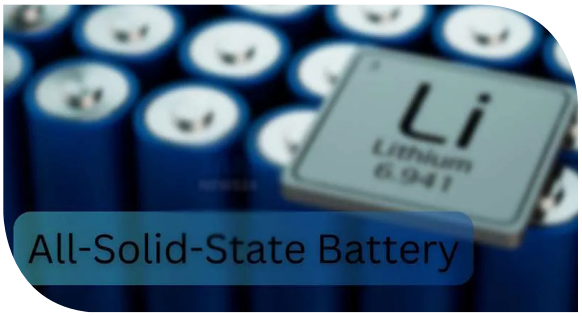
Zhongdian Electric Research Institute (Xuzhou) Hydrogen Energy Technology Co. Ltd has delivered a 48 000 Nm3 titanium-based solid-state hydrogen storage module to the CNY 6.3 billion Da'an PV+Wind+Hydrogen integrated demonstration project, the world's largest green hydrogen ammonia synthesis initiative. The module uses nano-porous titanium materials for hydrogen storage through physical adsorption, which achieves a 40% higher hydrogen storage density than traditional methods. It is the first of its kind to be applied at scale, offering enhanced safety and long cycle life for large-scale hydrogen storage and transportation.



Rechargeable Li-H battery

Chinese researchers unveil new Li-H battery system

A research team from the University of Science and Technology of China (USTC) has unveiled a new lithium-hydrogen (Li-H) battery system prototype with a theoretical energy density of 2 825 Wh/kg and a round-trip efficiency of 99.7%. Unlike conventional designs, this innovative battery system uses hydrogen gas as the anode to improve energy density and the battery's working voltage, allowing EVs to charge more quickly and extend their range. A rechargeable anode-free variant of the battery eliminates the need for pre-installed lithium metal.



All-solid-state batteries to be rolled out from 2027

All-solid-state batteries are expected to be installed in electric vehicles (EVs) in China starting in 2027 and will enter mass production by 2030, according to a senior official from the China EV100 (China Electric Vehicle Council). Development of these batteries, known for their long driving range and stability, is seen as a key factor in advancing EV performance. China has made significant progress in solid-state battery development. In the second half of 2024, China saw a surge in patent applications for all-solid-state batteries, nearly three times the number filed in Japan. Leading Chinese EV manufacturer BYD expects to launch EVs powered by all-solid-state batteries in 2027.

Projects & Investments

China outlines measures to manage Clean Energy Development Fund

China's Ministry of Finance has released the Clean Energy Development Special Fund Management Measures. The fund, effective from 2025 to 2029, will support the development of renewable energy, clean fossil fuels, as well as clean utilisation of fossil energy, and will be channeled through the central government budget. It will focus on five key areas, including demonstration and industrialisation of key technologies, large-scale development and capacity building, construction of public platforms, comprehensive application pilots, as well as other tasks assigned by the government. The fund will be distributed by means of competitive bidding, reward-based subsidies, and actual-cost settlements.

Subsidy plan for new energy city bus renewal

The plan, jointly issued by Ministry of Transport, NDRC, and the Ministry of Finance, aims to support the replacement of old city buses with new energy vehicles, with subsidies also available for battery upgrades. According to the plan, the replacement buses will receive an average subsidy of CNY 80 000 each, while battery upgrades will receive an average of CNY 42 000. The costs of the subsidies will be jointly borne by central and local governments at an overall ratio of 90:10.

China signs deal to develop 3.5 GW of solar capacity in Kuwait

The Chinese National Energy Administration and Kuwait's Ministry of Electricity and Water and Renewable Energy have signed a framework agreement that includes a commitment to cooperate in renewable energy and solar power plant technology. The agreement outlines a plan, overseen by the Chinese side, for the third and fourth zones of the Al-Shagaya and Al-Abdiliya solar projects. The projects will have a joint production capacity of 3.5 GW, with the potential to increase to 5 GW.

Construction starts on new West-East UHV power transmission corridor

The Datong-Huailai-Tianjin South 1000 kV Ultra-High-Voltage (UHV) AC transmission project, a new corridor for China's West-to-East power transmission, involves the construction of a 770 kilometre double-circuit transmission line, which is scheduled to become operational in June 2027. It will bring North China's UHV power transmission capacity to 21 GW, effectively meeting cross-provincial power transmission needs of coal-rich Shanxi Province and renewable-rich Hebei Province, as well as supporting the growth in power consumption in Tianjin. By the end of 2024, the State Grid Corporation of China had built 38 UHV projects, including 22 AC and 16 DC projects, forming the world's largest UHV power network.

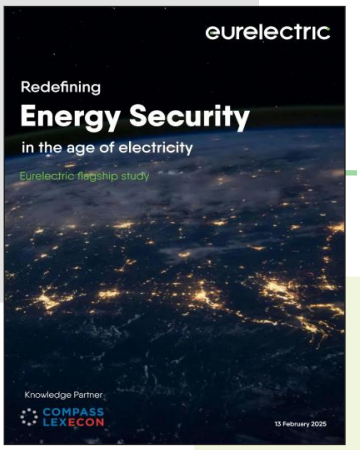
CATL partners with Ellen MacArthur Foundation on battery recycling

The world's largest battery manufacturer, CATL, is to work with an international charity, the Ellen MacArthur Foundation, to accelerate the development of a circular economy for batteries, with CATL becoming a strategic partner and the first renewable technology leader in the network. The collaboration aims to identify circular economy opportunities across the entire battery value chain and build a cross-industry ecosystem for battery circularity. CATL has adopted a zero-carbon strategy, prioritising reusable and renewable materials and facilitating recycling. In 2024, the company recycled about 130 000 tons of used batteries, producing 17 000 tons of lithium salt.

China completes its first integrated offshore project

Located five kilometers off the eastern coast of Yantai, Shandong Province, this landmark project represents the country's first full-chain demonstration project for offshore hydrogen production, storage, transportation, and utilisation. Jointly constructed by the National Energy Group, CIMC Raffles Group, and Guoneng Hydrogen Innovation Technology (Beijing) Co., the project can produce hydrogen from offshore renewable power and convert it into ammonia and methanol, both of which are clean fuels for ships and important industrial raw materials. The initative includes China's first semi-submersible hydrogen production platform, which will later operate as a refueling station for marine traffic.

FEATURED PUBLICATION



Redefining Energy Security in the age of electricity

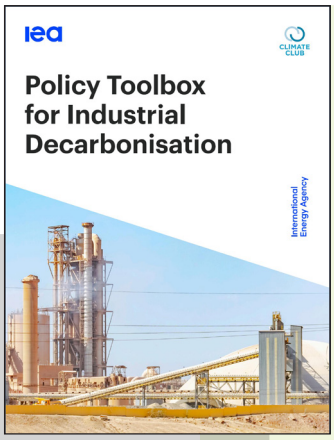
This report, published by eurelectric (the European electricity industry federation), redefines the concept of energy security in the context of an electrified EU energy system. It explores the benefits of a decarbonised, electricity-based energy system for the EU and how traditional energy security concerns have evolved due to geopolitical tensions, climate change, and supply chain and raw materials constraints. A new holistic approach called the 'Security of Supply 2.0' was introduced to address these challenges, emphasising the need of incorporating flexibility into security of supply, providing flexibility resources with clear signals for what is needed where and when. The study examines the three key pillars to ensure security of supply in the electricity sector, these include improving the framework to assess power system needs, enhancing the investment framework, and ensuring efficient markets and operations. Policy recommendations are provided to address these areas, offering a comprehensive roadmap for the EU to secure a resilient and sustainable future.

→ *More*

The EU Green Deal (2024 edition)

This latest edition focuses on the fundamentals of energy and climate policy as reformulated in the European Green Deal. Jointly developed in Italy by the Florence School of Regulation (FSR) and the Robert Schuman Centre for Advanced Studies, the report includes updates following the adoption of the Fit for 55 Package, the REPowerEU Plan, and the recent reforms of electricity and gas markets in Europe. It guides the reader through the landscape of EU policies aimed at achieving climate neutrality by 2050. The authors also provide a comprehensive overview of the foundations of EU energy and climate policy, security of energy supply, and energy networks, as well as energy wholesale and retail markets, energy innovation, sustainable finance and circular economy. Each chapter contains subsections that give the reader a broad overview of the policy areas impacted by the EU Green Deal, with references at the end of each section serving as suggestions for further reading.

→ *More*



Policy Toolbox for Industrial Decarbonisation

The IEA's Policy Toolbox is a repository of policy instruments available to governments as they design, develop and implement their strategies for industrial decarbonisation. It consists of multiple elements essential for an effective industrial decarbonisation strategy, grouped into three main pillars: 1) framework fundamentals, which include long-term policies and plans for decarbonisation and strategies to mobilise financing; 2) targeted actions for specific technologies and strategies, covering measures to develop low- and near-zero emissions technologies, create markets for these technologies, address high-emitting production, and optimise material demand; and 3) necessary enabling conditions, such as robust international co-operation frameworks, support for enabling infrastructure, and mechanisms for data collection and progress tracking. The report draws on comparative policy analysis to discuss the main considerations and best practices for a wide range of policy instruments, as well as opportunities for international collaboration.

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The Net-Zero manufacturing industry landscape across Member States

This report, led by international consultancy ECORYS, offers a comprehensive analysis of the development and recent trends in the net-zero technology manufacturing sector across EU Member States. It provides crucial insights for policymaking and industry development, supporting the implementation of the Net-Zero Industry Act. The report centres on eight key technology areas: solar PV and solar thermal, onshore wind and offshore renewables, batteries and energy storage, heat pumps and geothermal energy, electrolysers and fuel cells, sustainable biogas/biomethane, carbon capture and storage, and grid technologies. The authors discuss the industrial landscapes, policy support frameworks, and development challenges of these industries, and go on to offer policy recommendations.

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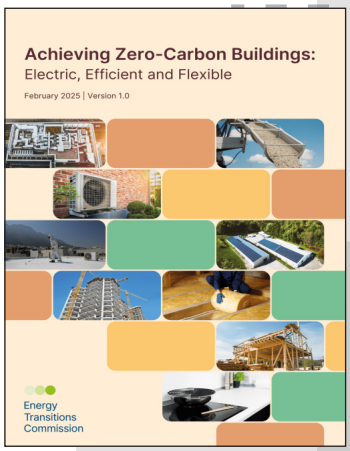

Achieving Zero-Carbon Buildings: Electric, Efficient and Flexible

This report from the Energy Transitions Commission offers a comprehensive analysis of the buildings sector's decarbonisation transition, highlighting how a combination of electric, efficient, and flexible solutions can reduce operational and embodied emissions from buildings, enhance living standards, and reduce energy bills. It identifies three key priorities for creating a building sector with zero emissions: electrification, dramatic improvements in energy efficiency, and the construction of efficient and low-carbon buildings. The report offers a detailed analysis of seven different, though overlapping, challenges: decarbonisation of heating, affordable cooling, clean cooking appliances, efficient lighting and appliances, decarbonisation of commercial buildings, the integration of electrified buildings within a clean energy system, and the decarbonising opportunities presented by the next generation of new buildings.

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