November 2022 | 60 edition

Renewable Energy Country Attractiveness Index

RECAI

Start

Can decentralized energy get good enough, fast enough?

The better the question. The better the answer. The better the world works.

EY

Building a better working world

Contents

Can the renewables sector seize the power of decentralization to secure a resilient future?

The need for energy resilience has never been more urgent. Ramping up renewable generation, accelerating energy diversification and increasing energy storage are global priorities amid heightened geopolitical tensions, supply chain shortages, an increase in extreme weather events and soaring natural gas prices.

The collective need for resilience comes with another testing proposition: how to accelerate the integration of increasing amounts of renewable energy into grids. In this edition of RECAI, we focus on the key role distributed energy resources (DERs) and smart grids play in the energy transition.[1]

Decentralization has been talked about for decades but, as markets seek to rapidly integrate more renewables and improve grid flexibility, it is encouraging that now, with stronger regulatory support, we are beginning to see real progress.

Governments are increasingly mandating smart-grid installation, while growing policy support – notably, the European Commission's REPowerEU plan and the US Inflation Reduction Act – will provide subsidies and tax credits for DERs. Signals are being sent that an ideal climate is emerging for investment in DERs.[2]

There are good signs that such near-term energy policy intervention and acceleration of renewable energy sources will reduce some of the current risks in the system. Additionally, this should offer improved visibility over what a potential power price realization will be in the next few years and support continued growth, while potentially offsetting the implications of windfall taxes.

For countries to reach net zero, however, the integration of renewables must improve significantly. DERs have a vital role to play in allowing a range of green energy sources to be integrated into the grid, but delivering new and more efficient approaches to permitting, connecting and managing energy flows are particularly urgent.

Another pressing issue for the renewables industry is that of cybersecurity. Smart grid technologies, which help integrate, monitor, control and steer bidirectional flows of energy, significantly heighten the risk of cyber attacks. This edition of RECAI also explores how markets can strengthen their cybersecurity strategies in the face of such a rapidly expanding threat landscape.

On the ranking side, there is an important new feature in this edition: a new index, alongside the RECAI ranking, that has been normalized with gross domestic product (GDP) to control for economic size. The resulting ranking showcases which markets are performing above expectations for their GDP, creating attractive alternatives for potential investors.

Morocco (normalized RECAI ranking: 1, RECAI ranking: 19), for example, is making use of its topographical features to build flexibility into its power system, with wind expected to overtake solar in the coming decade and pumped storage hydropower being developed in its mountainous areas. Green hydrogen, meanwhile, is seen as a key aspect of decarbonization in Chile (normalized RECAI ranking: 5, RECAI ranking: 17), which hopes to become a top exporter of the fuel, and Portugal (normalized RECAI ranking: 8, RECAI ranking: 25) is a good example of the importance of government commitment to renewables.

Policy support for renewable energy sources is gathering momentum across the globe, and this is helping to reduce risk and expand opportunities. With a more energy-resilient future on the horizon, now is the time to seize the power of a more flexible energy system.

Arnaud de Giovanni
EY Global Renewables Leader

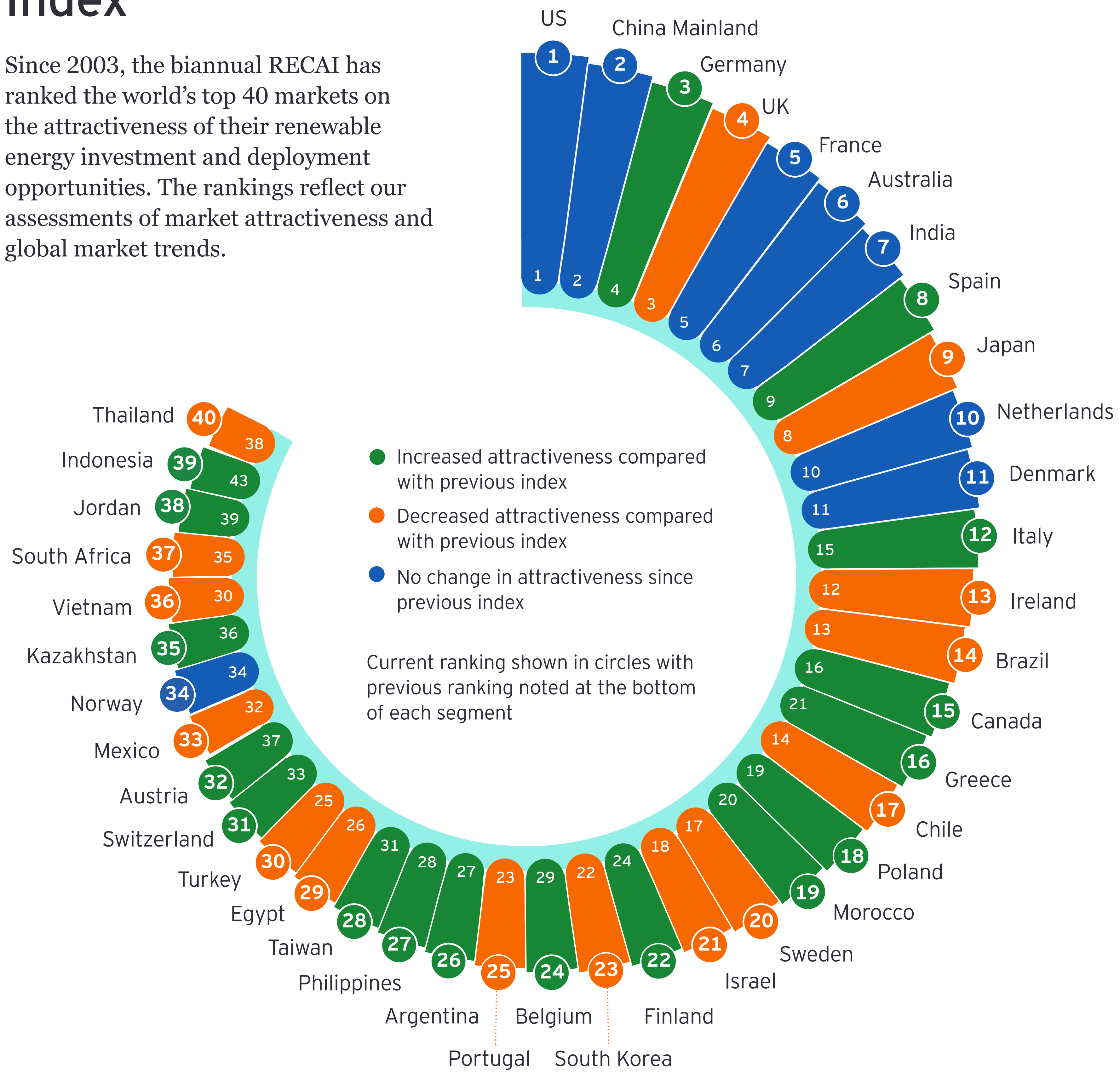
Ben Warren
RECAI Chief editor
EY Global Power & Utilities
Corporate Finance Leader

Key takeaways

- The transition to renewable energy has become even more urgent amid soaring gas prices, geopolitical tensions, supply chain shortages and extreme weather events.
- DERs and smart grids will be key to securing energy supplies and getting the world to net zero by 2050.
- Near-term policy interventions are helping reduce risks in the system, but more regulatory support is needed across the board.
- Cybersecurity will need to be prioritized as energy infrastructure incorporates greater levels of new technology that rely on connectivity to the Internet of Things.
- Some markets are spearheading the transition disproportionately to their actual size; our new ranking aims to underline which ones they are.

Index

Since 2003, the biannual RECAI has ranked the world's top 40 markets on the attractiveness of their renewable energy investment and deployment opportunities. The rankings reflect our assessments of market attractiveness and global market trends.



-1 Brazil

Averaging 1GW of new solar PV per month, Brazil now has 19GW of solar installed. Federal lawmakers are considering a draft bill to fill the regulatory gaps that investors believe have slowed the considerable renewables potential.

0 China Mainland

China Mainland is set to install a record 156GW of wind and solar capacity by the end of 2022, a 25% uplift on its previously record-breaking 2021 installations.

+5 Greece

Greece awarded 538MW of capacity in its most recent renewables tender.

+4 Indonesia

Indonesia has issued regulations, including fiscal incentives, to encourage renewable energy investment, and has plans to retire 15GW of coal-powered generation. The high capital cost of decarbonization efforts will be supported by donor countries, including the US and Japan.

+3 Italy

The government released a draft FER II Decree setting out new price support mechanisms, and announced 5GW of offshore wind power auctions to take place between 2023 and 2026. This follows the completion of its first utility-scale offshore wind farm.

+1 Kazakhstan

Set to launch 40 renewable energy projects by 2025 as part of its ambitious decarbonization targets, Kazakhstan has amended its renewable energy auction prices to protect investors from currency devaluation against the US dollar.

+1 Spain

When launching a 3.3GW renewable tender in November 2022, a budget of around €3B (US$2.99b) will be used to award up to 1.8GW of solar PV and 1.5GW of onshore wind. PV generation in the first five months of 2022 was 40% higher than in the same period of 2021.

-5 Turkey

The renewable energy market is struggling from the devaluation of the domestic currency. The market's feed-in tarrif scheme, which started in 2021, is denominated in Turkish lira, so has lost competitiveness for investors against other global schemes.

-1 UK

The fourth round of the Contracts for Difference scheme has allocated 11GW of new renewable capacity at record low prices. In efforts to limit consumer energy bills and decouple renewables pricing from the gas market, the government has considered introducing a voluntary CfD for operational renewables projects.

-6 Vietnam

Vietnam is attracting insufficient international finance to meet capacity targets due to factors such as difficult permitting procedures, price uncertainly and unbankable power purchase agreements (PPAs).

Methodology

See page 29 for RECAI methodology.

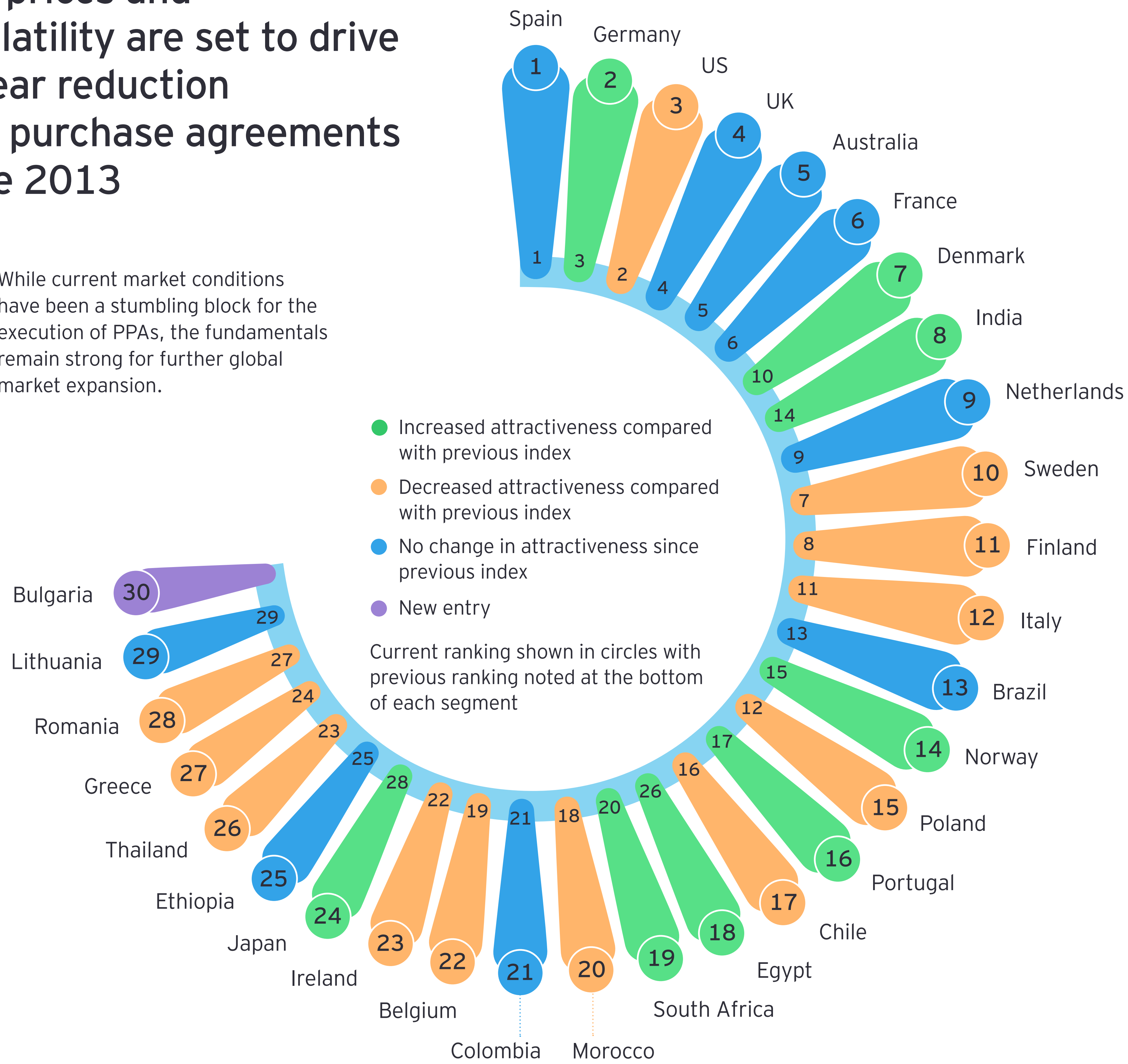
Record high power prices and extreme market volatility are set to drive the first year-on-year reduction in corporate power purchase agreements (PPAs) signed since 2013

Following an extended period of exponential growth, the volume of power generation committed through PPAs in 2022 is set to be less than 2021, although expected to be greater than 2020.

The market has shifted in favor of sellers, with high demand from corporates seeking to use PPAs as a long-term hedge against fluctuations in the wholesale power markets. However, uncertainty around government policy and rapidly changing cost profiles have left developers struggling to reach agreements on commercial terms.

PPAs are becoming increasingly viewed as a valuable financial tool and a strong green credential by companies that have already gained RE100 status. The large gap between low long-term PPA prices and high short-term market prices gives corporates an early financial benefit, and developers a long-term monetary boost and flexibility when compared with a state subsidy in many markets.

While current market conditions have been a stumbling block for the execution of PPAs, the fundamentals remain strong for further global market expansion.



Germany

The market is seeing a distinct increase in PPAs for operational and repowered post-EEG subsidy assets. The current high price environment is allowing larger PPA revenues to compensate for maintenance or repowering costs accrued by the generator.

India

Previous struggles in the PPA market have taken a positive turn with the Green Access Rules, issued in July, aiming to provide long-term clarity with respect to open access costs and relaxing the eligibility limit to allow a greater range of offtakers to access the market. It also allows greater offtaker flexibility with respect to purchasing and consuming energy.

Japan

The market has phased out full feed-in tariffs in favor of a feed-in premium that is sensitive to market price fluctuations, creating a consumption gap to be filled by PPAs. Following the first Japanese corporate PPA between Amazon and Mitsubishi in 2021, there has been steady growth in the market, with a number of corporates – including Seven-Eleven and NTT – entering into an array of off-site and on-site offtake arrangements.

South Africa

The first large-scale corporate virtual PPA in South Africa was signed recently between SOLA Group and mining and processing company Tronoz for a 200MW solar project. Other large industrial players in the market, including Sasol and Air Liquide, are in the process of procuring PPAs, reflecting the momentum building in the space.

Methodology

See page 31 for PPA methodology.

Foreword
RECAI 60
PPA Index
Key developments
Analysis
Regional focus
Insight
Data and methodology
Contacts

Renewables highlights from around the world

Governments around the world are accelerating their renewables programs to help reduce their reliance on imported energy, as geopolitical tensions and economic uncertainty continue to make this a volatile and unpredictable time.

Here, we look at key developments within 10 global markets – from the biggest change to German energy policy since 2017 to new US legislation that could be a game changer for its green hydrogen industry.

1
No change
RECAI ranking

2
No change
RECAI ranking

3
Up 1
RECAI ranking

4
Down 1
RECAI ranking

6
No change
RECAI ranking

7
No change
RECAI ranking

11
No change
RECAI ranking

14
Down 1
RECAI ranking

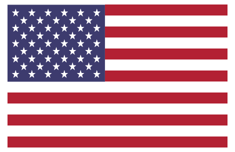
16
Up 5
RECAI ranking

19
Up 1
RECAI ranking

1

No change

RECAI ranking



The US: Green hydrogen set for breakthrough after passing of Inflation Reduction Act

The Inflation Reduction Act, passed in August 2022, is being viewed as a game changer for the US green hydrogen industry. Tax credits of up to US$3/kg for 10 years will make green hydrogen produced in the US the cheapest form of hydrogen in the world. Green hydrogen is currently being produced in the US Northwest at US$3.73/kg, so a US$3/kg tax credit would bring the cost of production for a developer to US$0.73/kg, cheaper than blue and gray hydrogen.[3]

Reaching this price would also make green steel cost competitive with steel made from fossil fuels, which would stimulate demand for green steel, and could spark demand for green cement and green glass made with green hydrogen.

The landmark Act, which includes US$369b in spending and green energy-related tax credits, will also be a major boon for the market's solar sector.[4] With a target to reach 50GW of domestic manufacturing capacity by 2030, the Act's tax credits, grants, low-cost loans and other support will play a key role in developing a full domestic solar supply chain. Last year, the US installed 23.6GW of solar capacity, a 19% increase versus 2020.[5]

2

No change

RECAI ranking

China: Record year expected for wind and solar

The China Renewable Energy Engineering Institute, a leading think tank, has projected that the market will install a record 156GW of wind and solar power this year, up 25% from 2021, which was also a record year. The forecast predicts that 100GW of solar, 50GW of onshore wind and 6GW of offshore wind will be added. In the first five months of 2022, China added 35GW of wind and solar, but installations are expected to accelerate toward the end of the year as developers and local governments push to meet annual targets.[6]

Despite challenges to global energy security, China remains committed to accelerating its renewable energy transition, and seeks to bring emissions to a peak by 2030. Its National Energy Administration says the market remains on target to increase the portion of nonfossil fuel energy in overall consumption by an average of one percentage point per year from 2022 to 2030. Last year, wind, solar, nuclear and hydropower supplied 16.6% of China's energy needs, an increase from 15.9% in 2020.[7]

As part of China's five-year plan for the renewable energy industry, it is aiming to generate one-third of its electricity from green sources by 2025. The market has also vowed to increase total wind and solar capacity to 1,200GW, nearly double the current rate, and is aiming to start cutting coal use from 2026.[8]

3

Up 1

RECAI ranking

Germany: Historic renewable energy package approved

Seeking to reform energy legislation to achieve climate neutrality and wean itself off Russian gas, the German government has approved the Easter Package, representing the greatest change to the market's energy policy since the introduction of competitive auctions in 2017.

It has set targets to raise the share of renewables in the power mix to 80% by 2030 and to nearly 100% by 2035. Last year, renewables comprised 42%.[9]

More ambitious annual auction volumes and wind energy installation targets have now been set. Beginning in 2025, Germany will aim to add 10GW of new onshore wind capacity each year, a huge commitment considering it added just 1.9GW last year. New offshore wind targets have also been set – 30GW by 2030, 40GW by 2035 and 70GW by 2045 – and permitting procedures shortened. Meanwhile, annual auction volumes for onshore wind will be raised to 12GW annually, which would put Germany on a path to 115GW of onshore wind capacity by 2030.

Solar power is expected to soar too, with a target set to reach 215GW of capacity by 2030, up from 59GW at the end of last year. This will require solar expansion to rise 22GW per year on average, up from 5.3GW last year.[10]

The expansion of renewables will be met with the addition of 36 new grid expansion and optimization projects. Renewable energies will also be classified as an "overriding matter of public interest and public security" in Germany's constitution. This will accelerate approval of new projects and cut delays caused by legal appeals, particularly against wind power.[11]

4

Down 1

RECAI ranking

The UK: Offshore wind gets boost from Made in Britain and Contracts for Difference

The UK lost its top ranking for installed offshore wind capacity this year to China, but does boast the largest pipeline.[12]

Offshore wind featured prominently in the government's Made in Britain energy strategy, which set an ambitious target of 50GW by 2030, a significant increase from its current capacity of 12GW. New planning reforms are expected to slash approval times from four years to one. Floating wind will also be accelerated, with a target of 5GW.[13]

Interest in the sector was on full display early this year when Crown Estate Scotland awarded option agreements to 11 floating wind projects with 15GW capacity.[14]

Meanwhile, the UK's fourth allocation round of its Contracts for Difference scheme saw many successful offshore wind projects, including Ørsted's 2.85GW Hornsea Three project, Red Rock and ESB's Inch Cape 1.8GW phase 1, and Scottish Power's East Anglia THREE 1.37GW phase 1. The strike price for offshore wind was the lowest of all technologies, at £37.35/MWh (US$42.04/MWh), which marks an almost 70% drop from the price in the first allocation round in 2015. A total of 93 green energy projects were given the go-ahead in the scheme, aiming to deliver nearly 11GW of renewable energy that will come online in 2023 and 2024.[15]

Investment flows have also been strong, with the UK Infrastructure Bank announcing a £22b (US$24.9b) investment plan in June. Renewable energy will be its largest investment sector, with funding earmarked for low-carbon hydrogen, energy storage and grid networks.[16] In July, the UK government also unveiled two hydrogen investment strategies – the Hydrogen Business Model and the Net Zero Hydrogen Fund – that will offer subsidy options and grant funding.[17]

6

No change

RECAI ranking

Australia: Eyeing renewable energy exports by 2030

Australia is undergoing a major shift in energy policy following the Labor Party's election victory in May. After years of general noncommitment, the Australian government passed legislation in September for a 2030 target of cutting greenhouse gas emissions by 43% below 2005 levels.[18] It also announced it will cut tariffs and taxes on electric vehicles, and introduce subsidies, as well as building charge points every 150km along the national road network. Additionally, it will convert 75% of the government's car fleet to zero emissions and establish a hydrogen refueling network for heavy vehicles.[19]

Australia now has its sights set on becoming a major exporter of renewable energy by 2030, through ramping up solar, onshore and offshore wind capacity, and generating export quantities of green hydrogen.

The market's Offshore Electricity Infrastructure Act 2021,[20] introduced in December 2021, has resulted in multiple offshore wind projects being proposed, with the federal government specifically identifying six regions that have world-class potential.[21]

Meanwhile, the Illawarra Renewable Energy Zone in New South Wales, located about 100km south of Sydney, issued a call for registration of interest in developing large-scale projects. It has attracted AU$43b (US$28.7b) worth of potential investments, with 44 proposals received for onshore and offshore wind, solar, energy storage, pumped storage hydroelectricity, green hydrogen and green steel projects, with a potential capacity of 17GW. Wind power generated the most interest, with 10 projects proposed, accounting for AU$35b (US$23.4b) of investment and 12.9GW of potential capacity.[22]

7

No change

RECAI ranking

India: Offshore wind potential gets a boost

Facing sluggish wind power growth compared with solar, the Indian government has set its sights on accelerating offshore wind generation, with a target of reaching 30GW by 2030.

It will put 4GW of capacity off the coast of Tamil Nadu, in the southeast of India, up for auction before the end of 2022. This will be the first of three years of 4GW of annual bidding invited for projects in this region, as well as Gujarat in the northwest. After this three-year process, a project capacity of 5GW will be bid out each year until 2030.

The high costs facing early offshore wind projects, combined with the low cost of onshore wind and solar power, have held back the offshore wind sector in India. To give it a boost, transmission from an offshore substation to the onshore grid will be provided by the government free of charge for all wind projects bid on before fiscal year 2029–30. Additionally, the first 8GW of projects will qualify for benefits such as carbon credits.[23]

Onshore wind has also lagged behind solar generation. From 2014 to 2021, wind capacity in India nearly doubled to 38.5GW, far behind the breakneck growth of solar during the same period, which grew more than tenfold to 39.2GW.[24] Given that the market boasts a 12GW manufacturing base in the wind power sector, several lawmakers have called for its acceleration to be prioritized.[25]

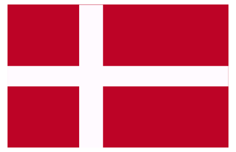
Currently, India's renewable energy generation capacity is 160GW, but it has an ambitious target of 500GW by 2030.[26] Consequently, it is looking to new emerging technologies, such as green hydrogen, to help it reach its goal.

The state government of Karnataka and Indian solar developer ACME Group have promised to spend INR520b (US$6.7b) on a plant that will produce 1.2 million tonnes of green hydrogen and green ammonia per year by 2027.[27]

11

No change

RECAI ranking



Denmark: Renewables soaring despite challenging conditions on the horizon

2022 saw a record first six months for green energy in Denmark, with the share of renewables for power consumption rising to a new high of 53.3%, sparked by significant growth in wind and solar generation. Total production from green energy reached 10.9TWh, rising from 9.7TWh a year ago.[28]

Despite the record growth, there could be difficult times ahead for the sector, with developers required to pay for grid connections from January 2023. Previously, they were only required to pay a small down payment when applying for a connection. Now, fees will range from €20,000 to €40,000 (US$19,700 to US$39,500) per megawatt, with discounts for larger projects.[29]

A new land tax is also planned, which will favor larger projects too. Given that solar projects need more land than wind, this will pose additional obstacles for solar developers and could spark more hybrid schemes with wind power in the future.

Denmark has ambitious plans to be a net exporter of green energy by 2030. It is seeking to increase total generation from solar and onshore wind fourfold by 2030, and will bring into force procedures to reduce administrative delays. The government is also aiming for tenders for an additional 1GW to 4GW of offshore wind before the end of 2030.[30]

14

Down 1

RECAI ranking

Brazil: Biomass beats wind and solar in tenders

Brazil has retained its position as the leading market in Latin America for investment in renewable energy sources in the RECAI rankings. However, a weak economy is slowing the pace of uptake of renewable energy sources and has resulted in low power demand.

Brazil's A-4 power tender in May saw a small tender size, with renewable energy supply contracts awarded for projects with a combined capacity of 947.9MW. Total investment is estimated at BRLR$7.9b (US$1.5b).

For the first time, biomass surpassed wind and solar, with 407MW of capacity awarded. Hydropower was allocated 189.7MW, wind 183.1MW and solar 166.1MW. Biomass projects sold power at BRL314.93/MWh (US$60.9/MWh), hydro earned a price of BRL281.65/MWh (US$54.5/MWh), while wind and solar sold power at BRL178.84/MWh (US$34.6/MWh). The average sale price of BRL268.16/MWh (US$51.8/MWh) marks a 50% increase on last year's auction. The biggest rise was for biomass projects, with the price up more than 60%.[31] The higher prices were largely attributed to national and global inflation.

For wind and solar, the contracts awarded mark a major drop from last year, when 581MW of new wind capacity and 518MW of solar were awarded. In May's auction, solar and wind technologies were placed together for the first time, as the cost of solar power had dropped significantly to make power delivery costs comparable for the two. The new wind and solar projects are required to come online by the beginning of 2026, with the start of 15-year power purchase agreements.

Brazil has also taken key steps forward in developing a green hydrogen economy. In August, it established a green hydrogen secretariat to accelerate growth.[32] Meanwhile, the state government of Ceará, in northeastern Brazil, has signed two memoranda of understanding (MoUs) for the development of a new green hydrogen hub at the Port of Pecém. In addition to the MoUs with Nexway and Energy Vault, the state government says it is preparing to sign MoUs with four other companies for the Pecém complex.[33]

Ports in Ceará are the closest to Europe within South America and, consequently, the green hydrogen hub will be structured around exports.

16

Up 5

RECAI ranking

Greece: Favorable legislation will accelerate renewable energy expansion

Greek lawmakers have given the green light to developers to accelerate renewables by passing legislation in June to expedite licensing for energy projects.

Currently, the average time for licensing green projects is five years, but the new legislation is expected to shorten that to 14 months, with firm deadlines established, and penalties and fines for delaying the permitting process. The new law also calls for the development of at least 3.5GW of energy storage by 2030 and increased grid connections for renewables.[34] The measures are expected to play a key role in helping the market reach its 2030 target of 25GW of non-hydropower renewable energy capacity.[35]

In addition, in July Greece kickstarted its offshore wind program by passing its first offshore wind law. It is now identifying offshore wind zones and auction criteria, and has set a target under the market's National Energy and Climate Plan (NECP) to add at least 2GW of offshore wind by 2030, most of which will be from floating offshore wind farms.[36] Transmission system operators are now in the process of identifying connection possibilities for future deployments.

In September, Greece awarded 538.4MW of capacity in its most recent renewables tender, with PV solar given 372MW for 14 farms at an average price of €47.98 (US$48.83)/MWh. Wind power projects secured 166MW at an average price of €57.66/MWh (US$56.9/MWh).[37]

Meanwhile, Greece continues to attract large investor interest, signing its first bilateral power purchase agreement with Axpo Group for a 100MW solar power project. The market also announced in July that private equity fund the Macquarie Green Investment Group's Cero Generation will seek to add 1GW of renewable energy projects to its portfolio by 2025, and only for corporate PPAs.[38]

19

Up 1

RECAI ranking

Morocco: Favorable legislation will accelerate renewable energy expansion

Morocco's renewable energy supplies soared by almost 10% last year – rising from 7.3TWh in 2020 to 7.9TWh in 2021 – as two solar power plants and a wind farm came online. Renewables now account for more than 19% of the market's energy, up from 18.5% in 2020.[39]

Installed renewable energy capacity surpassed 5GW, representing major growth over the past two decades given that capacity was at 1.2GW in 2000.[40] The government is seeking to more than double capacity by 2030 to reach 12GW, which would make up more than half of Morocco's energy capacity.

Currently, Morocco imports more than 90%[41] of its energy needs. The market is also heavily reliant on coal-fired power plants, which supply more than two-thirds of overall output. With high costs of coal because of sanctions on coal imports from Russia, pressure has mounted on Morocco to accelerate its green energy ambitions. As it seeks to ramp up its renewable energy generation, Morocco expects to meet its targets with the aid of technological developments in energy storage, green hydrogen and lower renewable energy costs.

Morocco has been ranked by the International Renewable Energy Agency in the top five globally for potential to produce competitive green hydrogen.[42] Last year, its National Hydrogen Commission unveiled a roadmap on green hydrogen and launched the Green H2 cluster, a five-hectare research and development pilot platform, with a focus on producing green ammonia. This is expected to begin in late 2023 and produce four tonnes of green ammonia daily.[43]

Decentralized energy markets: the future of distributed energy and the implications for energy resilience

As the world moves toward decentralized distributed energy systems, further steps will need to be taken to boost the resilience of energy infrastructure.

In brief

- The world is shifting away from centralized grid networks toward decentralized distributed energy systems.
- Centralized grid networks are most prevalent in developed economies, while developing economies have a different set of circumstances to consider.
- Regulatory integration is increasing as more markets coordinate their efforts to pursue energy security on the international level.

A global shift away from centralized energy generation toward decentralized distributed energy systems is underway. Decentralized energy takes various forms, including microgrids, small-scale renewables, and combined heat and power (CHP) facilities, as well as distributed energy storage and controllable loads. In contrast to conventional power-generation facilities connected to a centralized grid – with power often transmitted over long distances – decentralized energy is typically distributed locally.

There are a number of drivers behind decentralization, including the push to decarbonize and growing concerns over energy security. Indeed, these shifts have accelerated this year against the backdrop of the war in Ukraine, which has boosted the case for decentralization while dramatically improving the cost-effectiveness of renewables as wholesale power prices have risen.

DERs are being deployed rapidly, and this exposes network operators to multiple new challenges.

These include cyber threats, given the higher number of attack points available as DERs proliferate. Forecasting and optimizing DERs in real time is also made more difficult, as they generate power by following the availability of natural resources rather than consumer demand.

Additionally, unless properly managed, DERs can cause unstable network conditions, resulting in damage to grid assets, overuse and shortened useful asset lives. They can contribute to voltage instability and capacity constraints when low demand combines with high DER output. If they cause sudden spikes and drops in power supply, a grid's voltage and frequency level can be disrupted, leading to poorer power quality. And many DERs are not visible to system operators, which makes system planning difficult because the true load being met is unknown.

Lastly, network operators will come under pressure to find faster and cheaper ways to connect DERs or risk derailing the speed of the energy transition.

> “The challenge for grid operators is having the visibility and some control over the resources to stabilize the grid when necessary.
>
> **Paul DeCotis**
> Senior Partner, Energy and Utilities, West Monroe

Stephen Auton-Smith
Managing Director
EY Infrastructure Advisors, LLC

Contributors

Andrew Horstead
EY Global Power & Utilities Lead Analyst

Jeff Miller
EY Americas Power & Utilities Strategy Leader

Paul Micallef
EY Global Digital Grid Leader

Thomas J. Flaherty, III
EY-Parthenon Senior Advisor,
Strategy and Transactions, Ernst & Young LLP

Foreword
RECAI 60
PPA Index
Key developments
Analysis
Regional focus
Insight
Data and methodology
Contacts

DER growth drivers

Drivers	Description	Impact on DER growth
Falling technology costs	With technological advances, there has been a consistent decline in technology prices and related hardware costs.	
Corporate sustainability	Many companies are setting environmental, social and governance goals to improve sustainability by increasing the use of renewable energy.	
Increased electricity demand	As more sectors are electrified, such as transport, the demand for electricity will increase, which will drive growth of batteries.	
Policy/regulatory requirements	Close to 138 countries have committed to carbon neutrality by 2070 at the latest, including the US, India and China, which are leading carbon emitters.	
Decarbonization	Renewable generation such as wind and solar does not release harmful emissions and reduces the need for electricity generation from fossil fuels.	
Grid resiliency	Energy variability can be balanced using flexible automated grid operations, which simplifies balancing of energy supply and demand.	
Off-grid solutions	DERs have the capability to provide electricity access to rural and remote areas. They facilitate backup energy solutions for critical operation.	

Source: EY Knowledge analysis on news articles.
Note: the above projections can differ as the current geopolitical situation is unfolding.

"The interconnection of DERs on the grid is increasing, as are the types of resource being added and the locations where they are added. The challenge for grid operators is having the visibility and some control over the resources to stabilize the grid when necessary," says Paul DeCotis, Senior Partner, Energy and Utilities, at West Monroe. "The benefits include potentially lower overall system energy costs, greater grid flexibility and the ability to ramp resources up and down as necessary, to improve reliability and enhance resiliency."

The costs of these DERs have declined, and regulatory support has increased, as governments have focused more on decarbonization and energy security. These resources offer significant potential for increased grid flexibility and complement the integration of renewables. They help reduce demand for costly, large-scale utility infrastructure – such as high-voltage transmission lines – and lower the number of line losses experienced because of transmission of power across distances. Decentralization is therefore considered to give rise to greater energy resilience – that is, the ability to adapt to changing conditions and rapidly recover from disruptions.

While decentralization is a global trend, there are regional differences in how it is being implemented. The centralized grid network is most prevalent in developed economies, while there is more exploration and implementation of alternative means of accessing electricity in developing economies, given historical electricity access deficits. This has led to off-grid solar solutions being deployed in sub-Saharan Africa, for example. In Brazil, meanwhile, regulators started encouraging consumers to install small generation units in 2012, and a regulatory framework for distributed mini-generation and micro-generation was approved in 2021. China is also a global leader in DER deployment, and this is set to grow further still as the market pursues carbon neutrality by 2060.

More markets are also coordinating efforts to pursue energy security. However, major grid failures in parts of the US, extreme weather events and spiking energy prices all serve as reminders of the vulnerabilities that remain. Given this heightened concern, grid flexibility and energy security have become much more of a priority across large parts of the world. As more regions consider how to address these issues, they will need to take into account various regulatory and practical factors.

Spurs to greater investment

In the US, events such as the drought and heatwave in California in 2022, which put severe strain on the state's grid, have brought into sharp focus the need for grid decentralization and resilience. California has brought in legislation to expedite the development of battery storage, including financial support and mandates for the development of new storage capacity.[44] Even more significant were the extreme weather events of 2021, with the winter storm in Texas and Hurricane Ida making landfall in Louisiana later that year, both resulting in local grid failures.

In New Orleans, Louisiana, the desire to avoid future grid failures is spurring certain industries, municipal entities and other market participants to step up investment in decentralized energy systems. As power prices rise, additional grid flexibility also has the potential to offer some economic relief.

Extreme weather events and energy shortages are also putting centralized grids under pressure elsewhere in the world, bolstering the case for decentralization. Heatwaves have had a significant impact in South Asia this year, resulting in daily blackouts, while South Africa – which has long struggled with power shortages after years of underinvestment and mismanagement – has been hit by unprecedented levels of power outages in 2022. Isolated incidents, such as the accident at a power plant in Taiwan in March[45] that led to widespread power failures across major cities, are also highlighting grid vulnerabilities.

Against the backdrop of these events and pressures on grids globally, flexibility – that is, the ability of a power system to maintain stability in the face of swings in supply or demand – and enhanced reliability of power supply become increasingly important. Traditionally, flexibility was provided in power systems almost entirely by controlling the supply side at major power stations. As the share of intermittent renewable generation in the energy system increases, additional flexibility is required to maintain system reliability.

Customer-connected flexibility can help alleviate transmission and distribution constraints, and contribute to releasing additional capacity on both the transmission and distribution networks. Excess power generated by self-sustaining distributed systems can be stored and then used when centralized grids are hit by outages.

However, given the challenges that a higher penetration of DERs can present, network operators are also under increased pressure to ensure that decentralization improves flexibility, rather than detracts from it.

Why is it important to scale demand-side flexibility services?

There are multiple pilots running across Europe to demonstrate flexibility services. However, it is of paramount importance that we bring those pilots to a business-as-usual state in order to deliver a resilient power grid.

- **Catering to higher penetration of renewables**

  Carbon-intensive electricity generation is being replaced by renewables. By 2030,[1] the EU and the UK will install around 510GW of new renewables, 70% of which will be connected at distribution grid level. Scaling flexibility solutions are therefore needed to cancel the effects of uncertainty and variability in a system with high levels of renewables.

- **Reducing the cost to achieve net zero**

  Scaling flexibility services will help achieve net zero with significant cost savings. According to an analysis by the Carbon Trust and the Imperial College London, a fully flexible energy system in Great Britain has the potential to deliver material net savings of between[2] £9.6b and £16.7b per annum in 2050 compared across all scenarios.

- **Cater to expanding flexible electricity demand**

  Due to the electrification of heat, transport and industry global electricity demand is projected to increase from 23,230TWh in 2020 to ~60,000TWh in 2050, an average increase of[3] 3.2% per year. In addition, self-generation of electricity makes managing the power system and maintaining security of supply increasingly difficult. Hence, it is important to scale flexibility services to manage intermittent generation and peak demand.

- **Maintain system resiliency**

  Scaling flexibility services will enable the development of a secure net-zero energy system that can operate cost-effectively in diverse situations. Demand response and thermal storage reduce electricity demand peaks, while battery storage and interconnectors help to meet remaining demand, reducing requirements for backup generation. According to the IEA[4], to meet four times the amount of hour-to-hour flexibility needs, batteries and demand response should be used more extensively.

Source: [1] Why do electric systems need flexibility? – Eurelectric – Powering People, [2] Key findings – Flexibility in Great Britain – The Carbon Trust, [3] Net Zero by 2050 – A Roadmap for the Global Energy Sector (windows.net), [4] Net Zero by 2050 – A Roadmap for the Global Energy Sector (windows.net)

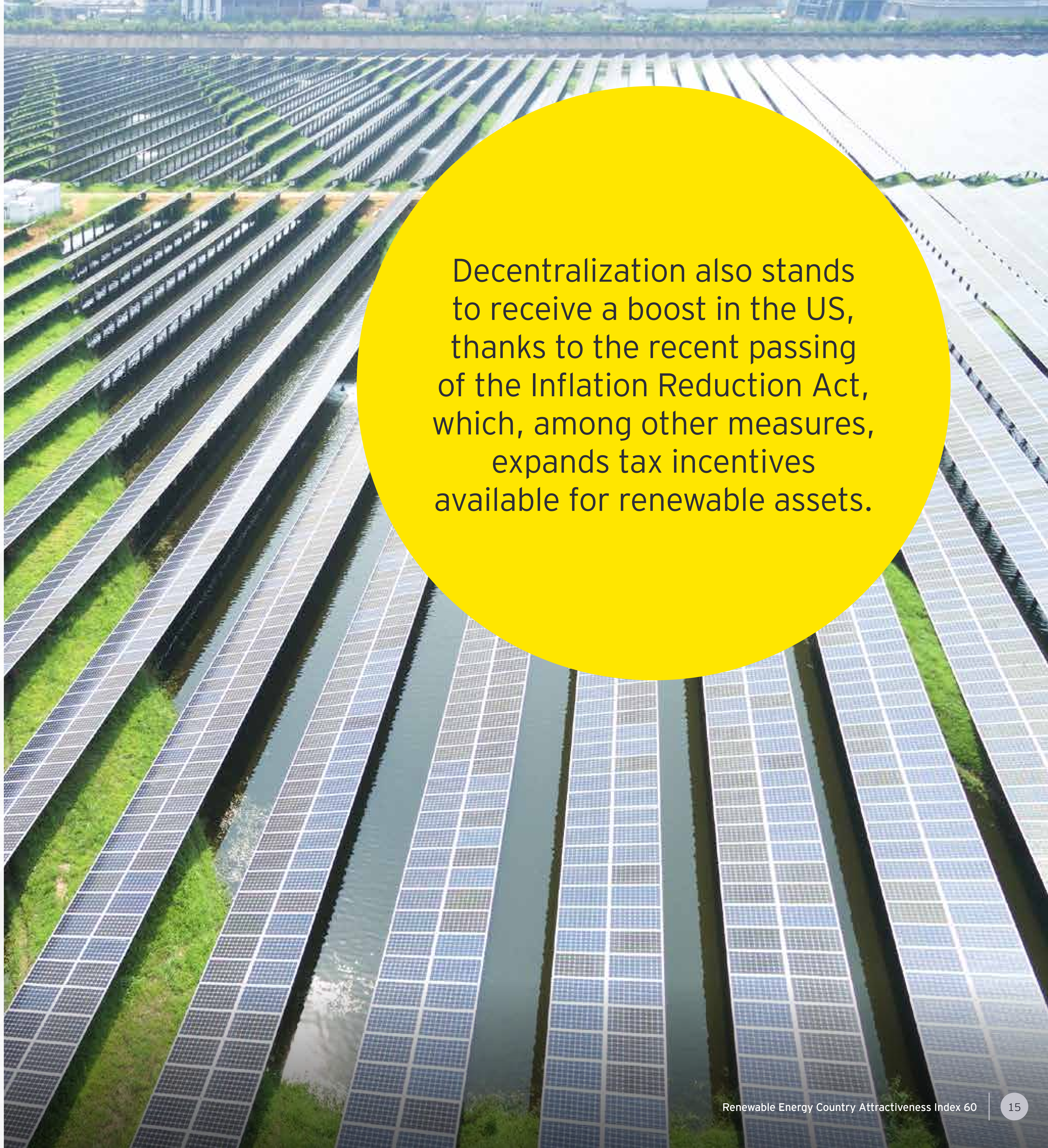
In Europe, attention has turned to energy resilience, given the scale of upheaval in energy markets and the speed with which the continent is aiming to change its power supply sources. The war in Ukraine, and Russia's response to sanctions, and the cessation of gas supplies have highlighted the risks associated with over-reliance on imports — in this case, of natural gas in particular — and shone a spotlight on other global markets where overreliance could become a challenge.

Concerns have been raised, for example, about the fact that China dominates the manufacturing of solar panels, accounting for more than 80% across all key solar panel manufacturing stages.[46] Indeed, by some estimates, it could account for between 70% and 98% of the world's production capacity of the silicon-based raw material and components in solar panels.[47] This could become a challenge for markets such as the US, which has seen its relations with China deteriorate.

The US is now working to boost its domestic production of solar panels and has approximately 1GW of PV module production capacity, according to Wood Mackenzie, out of a global capacity approaching 500GW as of 2021, according to the International Energy Agency. In an effort to become more competitive, the US extended tariffs on solar products containing crystalline silicon from China in February 2022. Through the Inflation Reduction Act, it has also brought in tax incentives for the development of a more robust solar industry.

In the longer term, decarbonization appears set to be a key driver of grid decentralization and modernization, especially as more entities adopt net-zero emissions targets. With that in mind, DERs are becoming increasingly popular, as they help accelerate the uptake and integration of renewables into the energy mix.

The war in Ukraine, and Russia's response to sanctions has shone a spotlight on other global markets where overreliance could become a challenge.



Decentralization also stands to receive a boost in the US, thanks to the recent passing of the Inflation Reduction Act, which, among other measures, expands tax incentives available for renewable assets.

Broadening the field for more players and approaches

As energy systems become decentralized, opportunities will be created for different types of players to participate beyond utilities alone. At the same time, DERs need to be enabled to participate in established markets – such as wholesale electricity, ancillary service or capacity markets – to be exposed to market prices.[48] In France, grid-connected storage can deliver cloud storage, ancillary and islanding services, as well as optimization of power. In Germany, it gives the option for rooftop PV systems to be included in tenders.

Around the world, the falling cost of solar generation is helping DERs to proliferate. In Africa, for example, Egypt, South Africa, Kenya, Namibia and Ghana are among the leaders when it comes to adding solar capacity.[49] More than 70 markets now have net metering policies in place to support distributed solar power. These include Spain, where net metering systems above 100kW in size are allowed to share surplus power with local consumers or inject it into the grid.

Some Caribbean markets have adopted hybrid net metering and feed-in policies, allowing residential consumers to offset power, while commercial consumers are required to feed 100% of the power they generate into the grid. In Turkey, legislation permitting consumers to install rooftop PVs without approval and sell excess power to distributors has been in place since 2019.

Battery storage regulations are also being rolled out or updated in various markets where regulators and system operators are seeking greater flexibility. Germany leads the European residential market, with up to 150,000 new battery storage systems installed in 2021, while Australia implemented changes in wholesale market trading rules for storage projects at the end of 2021.

While there are multiple applications for DER technologies operating at different levels and at varying scale, smaller players will need to proceed with caution if they are to avoid becoming subject to public utility regulations. In the US, for example, most utility regulations allow for customers to have behind-the-meter power-generating equipment. However, if some entities are supplying power, heating or cooling to other organizations, as well as meeting their own needs, this could fall within the scope of the regulations.

A further challenge in the US is the fact that much of the infrastructure involved in energy systems is regulated at state level, and approaches to these regulations can vary considerably. Given the relatively limited tenure of politicians and regulators, taking a more long-term approach to challenges such as decentralization is a struggle, even as long-term emissions and decarbonization targets are adopted. Utilities and other players are piloting new technology, but because there is no firm or unified view of what the future may look like, there is a lack of coordination that could prove detrimental to efforts to roll out DERs.

On the other hand, CHP and trigeneration – or combined cooling, heating and power (CCHP) – are emerging in the US as carbon-efficient and cost-effective options for decentralization. In many cases, there is demand for cooling rather than heating, and CCHP can provide a high volume of cooling capacity for major buildings or building clusters. The US also benefits from legacy infrastructure, built in the 1970s and 1980s, that is now being modernized and revitalized as decentralization is increasingly pursued.

Decentralization also stands to receive a boost in the US, thanks to the recent passing of the Inflation Reduction Act,[50] which, among other measures, expands tax incentives available for renewable assets. While the legislation is still being scrutinized and understood, it paves the way for rolling out the ownership of such assets to a broader base of players.

As the variety of players becoming involved in energy systems widens, a greater range of sources of capital is also emerging, including private and sovereign capital – and with the new tax benefits in the US, there is less need for tax equity partners than there has been previously.

The rollout of smart grids is a significant development in the push toward greater decentralization and energy resilience. Smart grids allow for the bidirectional flows of electricity and data using two-way communication and control capabilities to optimize the flow of energy along a network and enable real-time responses to changes in demand (see section, **"Why the world must get smart about energy grids"**).

Governments in markets such as the US are investing in strategic partnerships pursuing grid modernization, including smart grid solutions.[51]

Why the world must get smart about energy grids

For decades, developed regions have needed a national grid to maintain the transmission and distribution of their electricity. This was often an impressive piece of engineering, but not enormously responsive to waves of demand or localized problems.

As the energy transition intensifies and the world moves toward a decarbonized, mostly electrified economy, the demand for electricity from renewable resources will grow exponentially, as will the challenges faced by electricity network operators.

Renewable energy generation is very different from generation through traditional, fossil-fueled power plants. It's production is dictated by external factors – such as weather conditions – rather than in response to demand, and frequently in locations distant from the supply. As a result, efficient ways to store and transmit power are required.

The rapidly growing number of small – even domestic – producers of solar and wind power also creates a need for two-way electricity flow at the household level, which itself requires monitoring and recording.

With solar panels on every house roof, windmills on every offshore sandbank, and batteries in every electric vehicle (EV), the generation and storage of energy will look very different in the future. While such systems and technologies are a vital part of the move to decarbonize, they make managing the grid a more complex affair, because flows are less predictable. The grid must be intelligent enough to bring all these small generators together and control the flow of power so that it meets demand.

The technology to achieve this is largely still in development, but Paul Micallef, EY Global Digital Grid Leader, sees this as the most exciting area in the near future. "Making the grid smart enough to integrate DERs is the real game changer," he says.

The future grid will also have to deal with challenges to its stability. Spikes in production causing network constraints will place unprecedented strain on the grid's assets, leading to their earlier-than-expected degradation. In many regions, aging infrastructure is also facing growing strain from events fueled by climate change, as demonstrated by the Texas grid blackout.

To meet these challenges, transmission of electricity across the grid must be accompanied by data on generation, storage and demand, so stakeholders can respond to whatever the information is telling them. This is the basic concept of a "smart grid," which is expected to improve reliability, efficiency and flexibility.

Smart meters are the most familiar form of smart grid technology to consumers, allowing them to monitor their own electricity usage at a more granular level while helping suppliers work out where and when demand is likely to peak.

According to Micallef, the future grid "will always need some degree of intelligence, but there will be lots of versions."

Integration of renewable power generation is the most obvious aspect of DER management, but storage and supply management will probably be as important in the long run. One resource that is likely to grow exponentially is the available battery capacity of EVs; 130 million EVs are expected to be on Europe's roads alone by 2035.[52]

Micallef says: "As EVs scale, unmanaged charging could put a big strain on the system without the appropriate smart technologies and services in place, e.g., smart charging. But EVs will also have a big role to play in supporting the system via vehicle-to-grid technology."

Perhaps the biggest challenge of smart grids is that they open up a whole new set of problems for utilities in the form of data security, making them responsible for privacy issues and vulnerable to cyber attacks.

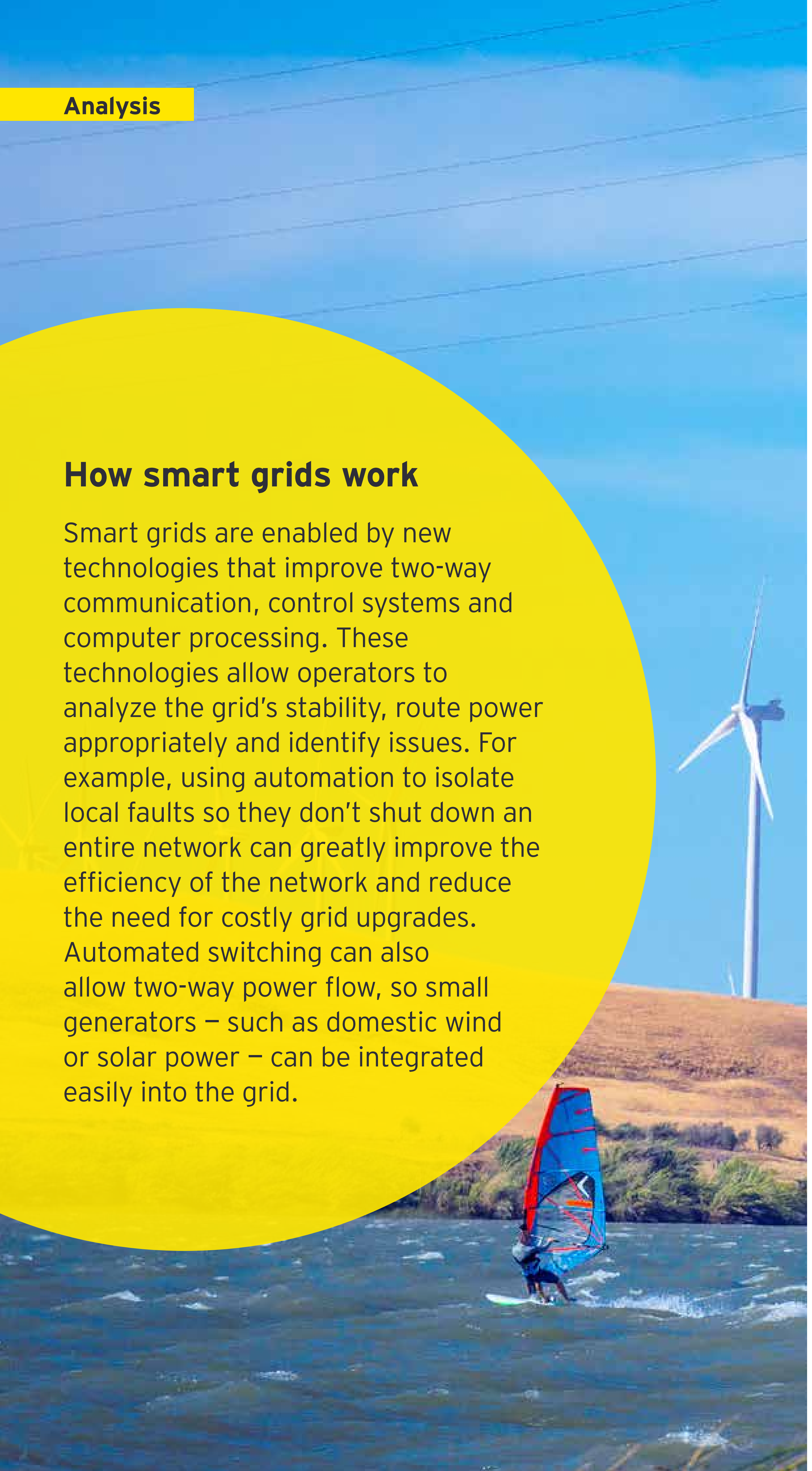
The assets and software created to support smart metering, network automation, EV charging and other applications will need to meet a number of criteria, including connectivity, interoperability (a common set of standards will be needed to allow all components to work with each other) and cybersecurity.

Each of these, plus the development of appropriate energy storage facilities, offers an opportunity for investors to support decarbonization and the transition to a more productive, lower-carbon economy.

"
As EVs scale, unmanaged charging could put a big strain on the system without the appropriate smart technologies and services in place, e.g., smart charging. But EVs will also have a big role to play in supporting the system via vehicle-to-grid technology.

Paul Micallef
EY Global Digital Grid Leader

Foreword
RECAI 60
PPA Index
Key developments
Analysis
Regional focus
Insight
Data and methodology
Contacts



How smart grids work

Smart grids are enabled by new technologies that improve two-way communication, control systems and computer processing. These technologies allow operators to analyze the grid's stability, route power appropriately and identify issues. For example, using automation to isolate local faults so they don't shut down an entire network can greatly improve the efficiency of the network and reduce the need for costly grid upgrades. Automated switching can also allow two-way power flow, so small generators – such as domestic wind or solar power – can be integrated easily into the grid.

Increasing the resilience of energy infrastructure

Further steps will need to be taken to boost the resiliency of energy infrastructure. This includes initiatives such as "weatherization" – weatherproofing to protect infrastructure from the elements, particularly extremely hot or cold weather – to ensure that there is enough capacity to accommodate the rollout of EVs. Indeed, the impact of electrification will need to be considered as it advances across numerous decarbonizing sectors and industries. With intermittency issues, the proliferation of renewables will need to be balanced by more sophisticated energy storage or conventional power generation capacity.

Given the interconnectedness of these ecosystems, cybersecurity concerns will increase as smart grids become more widespread. Addressing these will be a top priority for those involved in the development of smart grids, and artificial intelligence and blockchain technology could have a role to play here. See more insight on cybersecurity on page 24.

"To ensure the grid is more robust and resilient, more distributed generation, load management and fast-ramping resources must be added at strategic locations on the grid," says West Monroe's DeCotis. "This – combined with greater visibility and control of the resources in the hands of grid operators with the ability to 'island' sections of the grid to maintain voltage without service interruptions – is important. The grid is getting more complex, stronger and more resilient as more resources are added at strategic locations."

Successful decentralization efforts could depend on a combination of regulation, economics - with prices of power at a certain level for projects to be viable – and, in the case of renewables, favorable conditions. It will also be important to strike the right balance in providing sufficient backup generation to support critical infrastructure. Technological advances will play a significant role – for example, as storage becomes cheaper and more sophisticated.

Replicating successful efforts in different regions and markets could prove challenging, however, given how much regulatory, economic and weather conditions may vary. Regions with higher levels of regulatory integration, such as the EU, could have an advantage here. In the US, on the other hand, decentralization remains a more complex task because of the disjointed nature of rules, regulatory bodies and approaches across different states.

However, between the acceleration of the energy transition and the heightened energy security concerns that have emerged in 2022, the task of ensuring a smart and decentralized grid contributes to flexibility, and resilience has taken on a new urgency. As this urgency increases globally, market participants will see ever-growing incentives to act.

> With intermittency issues, the proliferation of renewables will need to be balanced by more sophisticated energy storage or conventional power generation capacity.

Different approaches to smart grids

In countries without an established national grid, the development of smart grid technology may enable a new form of infrastructure, where the overall grid is made up of microgrids – perhaps connecting solar power from individual houses or villages to provide greater stability for all.

This connectivity will obviously be most useful in areas with insufficient electrification, but it also has a role to play in developing resilience in more developed areas. Where service is unreliable – perhaps in an isolated rural area, or in a highly concentrated urban area where surges in demand can lead to brownouts or blackouts – a microgrid that can switch to operating independently of the wider grid will be a clear advantage.

In most cases, the development of a smart grid will require significant support from governments, but what that support will look like will depend on each government's long-term strategy.

China, for example, has made domestic energy security its focus,[53] so its policies have tended to look at improving transmission. This is because its vast quantity of wind and solar energy is produced miles from demand centers. In addition, the flow of power has historically been interrupted by local peaks in demand, causing frequent outages in overwhelmed distribution grids. China's push to build its renewable energy capacity has also outstripped its grid's ability to bring those new power sources online, so smart grid facilities that make it easier to bring distributed energy generation to consumers are highly desirable.

In Canada, the emphasis has been on smart meters, which help consumers understand their own energy use, thereby facilitating improved efficiency. Smart meters were installed in all homes and small businesses in Ontario in 2010, and the province had moved entirely to "time of use" billing by 2012. This has led to tangible reductions in peak demand of electricity consumption by residential consumers.[54]

Such a move is the first step toward bringing the Internet of Things into the smart grid. A fridge that tells you the milk is going off may be the advertising headline, but a freezer that knows it can turn itself off for an hour or two during peak times is a more useful development in the long term.

Developing a smart grid can also support national security. In the Baltic states, it has been an essential element of the project to disconnect from the Russian grid[55] and connect to the European Network of Transmission System Operators for Electricity, a broader power grid covering 39 European countries. Threats from Russia to cut the Baltic states off after they implemented EU sanctions against the country because of the war in Ukraine have turned this into a task of extreme urgency.

While the work is mostly focused on synchronizing networks and building links between the Baltic states and neighboring countries, the project has also improved the efficiency of networks – by, for example, installing battery capacity.

US$800b

the average annual global investment required in electricity networks up to 2030 to implement smart grid technologies and get on track for net zero by 2050, according to the International Energy Agency. Investments in digital assets must increase eightfold, at more than twice the speed of total investments in transmission and distribution.

Promising markets punching above their weight

The RECAI uses various criteria to compare the attractiveness of renewables markets, such as magnitude of development pipeline, that reflect the absolute size of the renewable investment opportunity. Hence, the index naturally benefits large economies. However, by normalizing with the gross domestic product (GDP) — that is, dividing the “raw” RECAI scores by the log of GDP — we can see which markets are performing above expectations for their economic size.

Market	Normalized ranking	RECAI ranking	Movement vs. RECAI ranking
Morocco	1	19	▲ 18
Greece	2	16	▲ 14
Denmark	3	11	▲ 08
Jordan	4	38	▲ 34
Chile	5	17	▲ 12
Ireland	6	13	▲ 07
Australia	7	6	▼ 01
Portugal	8	25	▲ 17
Finland	9	22	▲ 13
Germany	10	3	▼ 07
Netherlands	11	10	▼ 01
United Kingdom	12	4	▼ 08
France	13	5	▼ 08
Spain	14	8	▼ 06
India	15	7	▼ 08
Israel	16	21	▲ 05
Poland	17	18	▲ 01
Sweden	18	20	▲ 02
Philippines	19	27	▲ 08
Belgium	20	24	▲ 04

Market	Normalized ranking	RECAI ranking	Movement vs. RECAI ranking
Honduras	21	60	▲ 39
Kazakhstan	22	35	▲ 13
Tunisia	23	55	▲ 32
Italy	24	12	▼ 12
Argentina	25	26	▲ 01
Dominican Republic	26	45	▲ 19
Egypt	27	29	▲ 02
Kenya	28	46	▲ 18
China Mainland	29	2	▼ 27
Brazil	30	14	▼ 16
United States	31	1	▼ 30
Japan	32	9	▼ 23
Panama	33	53	▲ 20
Austria	34	32	▼ 02
Bulgaria	35	52	▲ 17
Canada	36	15	▼ 21
Sri Lanka	37	57	▲ 20
Taiwan	38	28	▼ 10
Vietnam	39	36	▼ 03
South Korea	40	23	▼ 17

Looking at the data in this way has uncovered some interesting examples of building a carbon-free economy in smaller markets, helping reveal ambitious plans for the energy transition. We explore three such markets that are creating some attractive alternatives for potential investors.

Arnaud de Giovanni
EY Global Renewables Leader

Contributors

Alexis Gazzo
EY & Associés France Climate Change and Sustainability Services Leader

Elanne Almeida
Sustainability Services Partner, EY Servicios Profesionales de Auditoría y Asesorías SpA.

Pedro Subtil
EY Portugal Energy & Resources Leader, Ernst & Young S. A.

Foreword
RECAI 60
PPA Index
Key developments
Analysis
Regional focus
Insight
Data and methodology
Contacts

Morocco

1 Normalized ranking

19 RECAI ranking

With very few fossil fuel resources of its own, Morocco has historically imported most of its energy. As the technology for renewable energy sources has developed, however, so has the North African market's aspiration to generate its own power. The government wants 52% of its energy to come from renewable sources by 2030, and 80% by 2050.[56]

In 2020, Morocco fell just short of an interim target of 42%, but it is now on track to meet its 2030 target, with ambitious plans for installation of more solar and wind power capacity.

With 3,000 hours of sunshine a year, Morocco is well placed for solar power[57] – currently its largest renewable energy source. However, wind is expected to overtake solar in the coming decade as large projects come online.

Topographical features such as the Atlas Mountains and access to the Sahara Desert have allowed Morocco to build flexibility into its power system, with pumped storage hydropower in the mountains and concentrated solar power plants (some with thermal storage) in areas with the most direct sunlight. This is particularly necessary for a system largely reliant on renewables, which cannot be switched on and off in response to demand.

Its geopolitical position is another positive factor in Morocco's journey to a low-carbon economy. Not only does it have two existing interconnectors with the Spanish power system, but a third is planned, as well as a fourth with Portugal. Morocco is also active in supporting other African markets with their clean energy transitions, drawing on its own experience.

According to Saïd Mouline, Director General of the Moroccan Agency for Energy Efficiency: "Morocco has shown that, when you have a strategy and political support, you can reach the lowest renewable prices in the world, less than three [US] cents per kilowatt-hour in the wind sector." Speaking to the Middle East Policy Council, he continued: "Morocco has shown the whole continent how to economically implement renewable energy policies, and we support our partners throughout the continent today in this pursuit."[58]

As well as targeting renewable energy to produce electricity, Morocco is looking at how to decarbonize other sectors, including transport, which will require new fuels such as green hydrogen, and agriculture, which needs a combination of solar power, to substitute for diesel generators, and innovative fertilizers. It hopes this will help spark a "green revolution" for Africa.

It is envisaged that all this development of renewable energy projects will be supported by foreign direct investment, through the institutional framework of the Moroccan Agency for Sustainable Energy (Masen). This is a "one-stop shop" for private project developers, bringing together permit processes, land acquisition and financing, and potentially providing a state guarantee for the investment.

MASEN tenders attract private developers and investors in renewable energy projects through a model of public debt, state guarantees and concessional loans. New financing models and the diversification of financing sources (e.g., green bonds) are critical to boosting private investment and commercial bank loans.

There is no doubt, however, that Morocco has the natural resources, regulatory support and government commitment to lead Africa's green revolution.

Topographical features such as the Atlas Mountains and access to the Sahara Desert have allowed Morocco to build flexibility into its power system, with pumped storage hydropower in the mountains and concentrated solar power plants in areas with the most direct sunlight.

Foreword
RECAI 60
PPA Index
Key developments
Analysis
Regional focus
Insight
Data and methodology
Contacts

Chile

5 Normalized ranking

17 RECAI ranking

Another market heavily reliant on fossil fuel imports, but blessed with enormous potential for renewable power generation, is Chile. The Atacama Desert, in the north, is one of the best solar resources in the world, with a theoretical potential of 1,800GW, while southern coasts and mountains have exceptional wind resources.[59]

With this in mind, Chile aims to achieve carbon neutrality by 2050. By the end of 2020, it was generating more than half its electricity from renewable sources, well on track for its interim target of 70% by 2030 and impressively beyond its original 2020 target of 20%. A year later, that proportion had risen to 54.1%, an acceleration in an already speedy growth rate.[60]

This progress has been helped by the development of an innovative auction process for electricity providers, allowing them to bid for contracts in four supply blocks: whole-year 24/7; quarterly; daylight; and nighttime. This is of particular value to solar producers, which no longer have to buy in power to cover the nighttime supply for which they were previously contracted.

A note of realism is struck by the President of the Chilean Association for Renewable Energies, ACERA AG, José Ignacio Escobar, in a recent newsletter. "They say that 'if the road is difficult, it is because you are going in the right direction'. And difficult it has been," he said. "But time has proved us right, and today, renewable energy and storage are the only technologies capable of responding to the innumerable energy challenges that the world faces. Sustainable development, balancing the economic, the social and the environmental, is the only viable form of coexistence between human beings with the rest of the species and our environment. A different way of looking at the world, some would say unconventional, but so necessary in a world that suffers the blows of the climatic urgency and the polarization of our society."[61]

The biggest challenge is getting the power from where it is produced, mostly in the north and the south of Chile, to the metropolitan center around Santiago. As Chile is 4,300 miles long – but only an average of 175 miles wide – this is a considerable obstacle. A major interconnector project linked the north and center in 2017, but the National Electric Coordinator estimates another US$3.2b needs to be spent on transmission projects by 2025.

Chile is taking on a considerable and multifaceted challenge, including phasing out its 28 coal-fired plants by 2040. Added to this, regulation of stand-alone storage systems to make up for the transmission deficit has taken longer than expected to be approved. Furthermore, price allocation mechanisms will have to be resolved if the market is to resume investing. The price fluctuations have been caused by, among other things, the persistent drought, which has required diesel-based thermal power plants to continue to operate, attracting higher costs to the system. If Chile is to meet its ambitious targets, integrated planning will be essential, as will a clear tariff scheme and a long-term commitment by the government to the energy transition, to convince investors there is no risk of the government's support suddenly dissipating. In line with this, the Chilean Senate recently approved the Storage Law, which it is hoped will clear up regulatory doubts about this type of technology.

Chile also views green hydrogen as a key part of its plan for carbon neutrality. It wants to become the top exporter of green hydrogen by 2050. The path toward this objective is set out in the National Green Hydrogen Strategy, but the mechanisms to implement such a strategy remain unclear. Deploying projects already in the pipeline is essential if Chile is to compete with other countries that also aspire to be the world's prominent supplier of green hydrogen. Nevertheless, such ambition is good news for the world. Decarbonizing Chile's mining industry – including lithium (used in batteries and energy storage) and copper (used in EVs, among other things) – would be a big step toward a global transition to a low-carbon economy,[62] and is already under way.

Portugal

8
Normalized ranking

25
RECAI ranking

Portugal may be geographically on the edge of Europe, but it is central to showing the value of government commitment to renewables.

The government strongly believes that a significant acceleration in the transition from fossil fuels to renewable energy sources this decade is the best way to achieve stable and lower electricity prices and, consequently, a more competitive industry. With a high level of production and consumption of electricity from renewable energy sources, Portugal aims to reduce its dependence on fossil fuel imports.[63]

While hydro and wind power have been the focus for the past decade, 2019 marked the tipping point for Portugal and solar PV. After several years of underinvestment in this technology, Portugal's 2019, 2020 and 2021 solar auctions, which allocated around 2.3GW of new solar power capacity, changed the paradigm in the market completely.

The tenders were a resounding success, with Portugal setting world records for the lowest solar tariff price. In a striking display of innovation in 2020, eight of the 12 blocks put up for auction were awarded in the storage option. This meant Portugal was one of the first markets to develop large-scale hybrid projects with renewable generation plus storage. In a further innovation, the 2021 auction allocated 263MW of floating PV at seven dams across Portugal.

Portugal is currently on track for 80% of its electricity production to come from renewables by 2030, according to the Portuguese Energy Services Regulatory Authority, including solar projects in the pipeline representing about 12GW.

The energy transition is not just about electrification. To accelerate decarbonization of the economy, Portugal also aims to invest in renewable gases, such as green hydrogen.

The war in Ukraine and subsequent energy shortages have prompted some markets to look at increasing energy consumption from alternative fossil fuel sources. Portugal has instead simplified procedures and reduced licensing deadlines for renewable energies and hydrogen, to continue decarbonizing its economy and reduce its dependence on energy from abroad more rapidly.

80%

the proportion of electricity production from renewables that Portugal is on track to achieve by 2030

Why the renewables sector must meet cybersecurity challenges head-on

The rise of distributed energy networks and smart grids is leading to more complex cybersecurity challenges as more devices are integrated into energy systems.

In brief

- The rise of smart grids and distributed energy networks is presenting increasingly complex cybersecurity challenges, while legacy technology continues to represent a different kind of obstacle.
- Several markets are developing or enhancing their regulatory environments for cybersecurity in an effort to protect critical energy assets.
- Organizations can take steps to bolster cybersecurity, but collaboration is required, internally and externally; external collaboration, in particular, presents additional challenges.

Cybersecurity is increasingly seen as a top priority for energy infrastructure, especially in the wake of significant events such as the cyber attack on the US Colonial Pipeline in 2021[64] and on Greece's largest natural gas distributor, DESFA, in August 2022.[65] This focus on cybersecurity is being amplified by current trends, including decentralization and the implementation of smart grid technologies.

Smart grids allow for the bidirectional flow of power and information, and use two-way communication and control capabilities to respond to changes in demand in real time. However, this increased connectivity of technologies leaves smart grids vulnerable to cyber attacks, and this will need to be addressed as they are rolled out further.

Among the critical infrastructure that could be vulnerable are power plants, electricity grids, pipelines, communication networks and cloud systems. Newer technology adds to the challenge, given its greater connectivity to the Internet of Things (IoT) and the Industrial Internet of Things (IIoT).

"The cybersecurity issue is not really new, I think it's just been overlooked in the past," says Jalal Bouhdada, DNV's Global Cyber Security Lead and founder and CEO of Applied Risk, a specialist industrial cybersecurity firm acquired by DNV last year. He points to a number of developments that have contributed to the growing seriousness and complexity of cybersecurity threats, including geopolitical tensions, a shortage of relevant skills, and the convergence of information technology (IT) and operational technology (OT).

"The other part is the threat actors," Bouhdada continues. "They are very active, very organized and very selective in terms of their target, and it depends on who you are dealing with."

Steps are already being taken to address cybersecurity challenges on a number of fronts, including regulation. Several markets are establishing, revising or enhancing their regulations relating to cybersecurity, with a focus on critical national infrastructure and OT environments.

Significant challenges are presented by the existence of legacy technology, however. A lot of legacy OT systems are part of billion-dollar infrastructure investments and cannot be upgraded, or even changed, without another large 20- to 40-year investment.

At the same time, the rise of smart grids and distributed energy networks is increasing the complexity of cybersecurity requirements, given the growing number of devices being integrated into energy systems. In many cases, cybersecurity breaches can go undetected for some time, or even indefinitely.

> Collaboration between public and private sector is very important. I think the relationship between companies and regulators does not always make this easy.
>
> **Jalal Bouhdada**
> Global Cyber Security Lead, DNV; and founder and CEO of Applied Risk

Clinton M. Firth
EY Global Cybersecurity Lead, Energy

Raising the focus on cybersecurity

The ransomware attack on the Colonial Pipeline, the largest fuel pipeline in the US, with a capacity of around 2.5 million barrels of refined products per day, illustrated just how serious a cyber attack on a major piece of energy infrastructure can be. This incident was pivotal because of the severity of the resulting outage and the strength of the US government's response.

Following the attack, the Colonial Pipeline Company shut down the pipeline and its IT systems for six days, leading to supply disruptions and spiking gasoline prices, which hit US$3 per gallon for the first time in nearly seven years. The pipeline carries nearly half the fuel consumed on the US East Coast and, though it was only offline for a few days, the outage prompted the US government to take action, issuing new regulations to critical pipeline companies.[66] The directives, the first of their kind for the US, have subsequently been updated after the government assessed how they were working in practice.[67]

A lot of the technology used in new distributed energy systems – for example, smart meters and solar controllers – is identical or similar in configuration and design. While this makes it easier to standardize components and bring down their costs, it can also lead to them being more exposed.

Other markets are also introducing or upgrading regulations relating to cybersecurity, and the US response to the Colonial Pipeline attack will have been watched closely by governments looking at how best to protect their critical energy infrastructure.

Even before the US attack, efforts to improve performance on energy cybersecurity through regulation were under way elsewhere in the world. However, the Colonial Pipeline incident and others – including the attack on DESFA in Greece, which caused a system outage and data exposure, and the distributed denial-of-service attack on Lithuanian state-owned energy provider Ignitis Group in July 2022[68] – have heightened concerns globally about the impact of cybercrime.

A number of markets, including Australia and China, are seeking to update their cybersecurity regulations, while, in September 2022, the European Commission published a proposal for a European Cyber Resilience Act. If implemented, this regulation would require any manufacturer of a "product with digital elements" to meet minimum cybersecurity requirements if it wants to place that product on the EU market. The proposal applies to software as well as hardware.

Also in September, a joint alert put out by government cybersecurity units in the US, the UK, Australia and Canada warned about advanced persistent threat actors that the partners believe to be affiliated with the Iranian government's Islamic Revolutionary Guard Corps.[69] The alert warned critical infrastructure companies in particular to step up their cybersecurity measures in the face of the threat posed.

Addressing the challenge of aging technology

Governments and companies seeking to improve their cybersecurity performance are faced with a two-fold challenge: aging legacy technology that would require billions of dollars to upgrade, and new technology that is increasingly connected via the IoT and IIoT.

Legacy technology cannot be easily upgraded or replaced without broader, more extensive and costly investment. There are also risks related to disrupting systems that are running around the clock if attempts are made to upgrade them. As a short-term fix, extra defenses and monitoring can be added. However, until companies are ready to make the significant investments required to completely overhaul assets with legacy technology components, little can be done to bring a meaningful solution to the problem of aging infrastructure. However, with the increasing focus on cybersecurity, companies may come under new pressure to invest more than previously planned in overhauling and upgrading legacy infrastructure.

Six days

the length of time the Colonial Pipeline and its IT systems were shut down after a cyber attack in 2021, forcing gasoline prices up to US$3 per gallon

Cybersecurity and smart grid implementation

The cybersecurity challenges presented by new technology and smart grids are different. Moving a city from traditional meters to smart meters increases the overall cyber exposure; the broader proliferation of IoT devices increases the potential attack surface area.

Often, such devices do not have a full operating system and are poorly configured – at times, with hard-coded passwords. They are generally cheap, and therefore prone to being forgotten, so they remain in their environment and connected to the IoT, but not managed. They also tend to be difficult to monitor because of the challenges of log generation.

Much of the technology used in new distributed energy systems – for example, smart meters and solar controllers – is identical or similar in configuration and design. While this makes it easier to standardize components and bring down their costs, it can also lead to them being more exposed – in particular, to accelerated lateral movement or attack vectors by threat actors. For example, a recent test of smart meters that had the same hard-coded password resulted in one successful attack, which then led to tens of thousands of devices being taken over within seconds.

Given their sheer number, it is difficult to manage IIoT devices, and it may not be possible to control them – in the case of home solar or battery technology, for instance. The situation stands to be further complicated over time by the proliferation of EVs, especially as the bulk of charging will happen at the home, creating additional cybersecurity concerns.

There are also risks associated with threat actors using the supply chain to get to their primary target, while the constant evolution of software means new configurations could introduce fresh vulnerabilities to energy systems.

Learning lessons from around the globe

Regions seeking to bolster their cybersecurity defenses can learn lessons from each other. South Korea, for example, has more than 30 years' experience in developing and implementing cyber resilience for its critical infrastructure. It is one of the world's most digitally connected markets, making it vulnerable to cyber attacks.

For geopolitical reasons, South Korea has been frequently targeted by cyber attacks suspected of originating in North Korea. In response to these threats, it has developed more comprehensive cybersecurity policies aimed at supporting the private and public sectors to prepare for, respond to and recover from cyber threats.[70] It has increased funding available for cybersecurity, invested in more personnel, enacted regulations to bolster the cybersecurity industry's competitiveness, and sought international cooperation.[71]

The US has also made significant strides, including over the past year when, among other changes, the government established the Office of the National Cyber Director.[72] This office will coordinate the overall federal cyber strategy, including broadening engagement and information sharing between the private sector and various federal agencies. The cyber incident disclosure requirements introduced after the Colonial Pipeline attack also represent a significant change in US policy, and the platform used for reporting such incidents continues to evolve.

In addition, the US and South Korea have worked to strengthen their bilateral cybersecurity cooperation, and these efforts could serve as a model for other markets to follow.

Organizations should equip themselves with new cybersecurity skills and engage on the topic at a senior level – with boards, for example. Increasing sector-wide collaboration on cybersecurity is another important step they can take.

Such steps are achievable, according to DNV's Bouhdada, but require commitment from senior management and a willingness to collaborate within and beyond an organization.

"Collaboration between public and private sector is very important," he says. "I think the relationship between companies and regulators does not always make this easy."

Given the vast and rapidly changing cybersecurity landscape – in which threat actors are increasingly more sophisticated – greater cooperation between countries could be essential to more effective cybersecurity strategies. The opportunities for new investment are both immense and critical.

RECAI 60 scores

Rank	Market	Previous rank	Movement on previous index	Score	Technology-specific scores: Onshore wind	Offshore wind	Solar PV	Solar CSP	Biomass	Geothermal	Hydro	Marine
1	US	1	●	73.3	58.1	59.3	58.5	46.4	28.9	46.7	40.9	20.5
2	China Mainland	2	●	72.2	56.2	56.8	61.1	54.9	50.6	24.0	50.6	17.6
3	Germany	4	▲	71.7	55.5	52.1	54.4	32.4	53.3	37.1	41.6	21.1
4	UK	3	▼	70.0	59.4	62.0	47.9	15.6	56.2	36.2	39.8	35.3
5	France	5	●	69.1	55.4	52.9	53.3	23.5	47.4	38.5	41.7	38.1
6	Australia	6	●	69.0	54.4	33.6	57.6	48.1	41.5	17.7	26.6	25.2
7	India	7	●	68.6	51.8	26.4	62.9	34.5	44.5	22.0	45.7	20.1
8	Spain	9	▲	65.8	52.8	36.5	51.5	29.3	39.7	15.6	23.4	23.2
9	Japan	8	▼	65.7	50.8	50.0	49.2	19.6	57.4	45.2	38.4	23.6
10	Netherlands	10	●	64.9	53.7	47.5	47.4	15.6	52.5	24.5	27.4	23.6
11	Denmark	11	●	64.0	53.3	50.2	46.3	16.4	43.2	15.5	21.3	21.1
12	Italy	15	▲	63.6	47.7	42.1	50.3	31.4	43.3	32.6	46.0	18.7
13	Ireland	12	▼	63.4	51.6	45.1	46.1	19.6	26.1	17.8	23.4	24.7
14	Brazil	13	▼	62.2	53.7	30.6	52.5	25.0	48.5	13.0	43.7	18.7
15	Canada	16	▲	62.0	54.9	35.6	46.2	19.0	33.3	23.0	45.8	26.1
16	Greece	21	▲	61.5	51.2	30.9	48.2	35.4	44.2	25.1	41.3	14.7
17	Chile	14	▼	61.4	51.5	20.6	48.1	54.7	41.9	45.8	44.9	27.8
18	Poland	19	▲	61.1	48.6	42.0	48.1	13.5	46.9	19.7	36.0	14.3
19	Morocco	20	▲	60.4	46.2	17.9	51.9	50.8	26.9	14.4	34.6	14.4
20	Sweden	17	▼	60.0	48.9	40.6	42.5	15.6	44.6	18.1	32.3	27.1

RECAI 60 scores

Rank	Market	Previous rank	Movement on previous index	Score	Technology-specific scores: Onshore wind	Offfshore wind	Solar PV	Solar CSP	Biomass	Geothermal	Hydro	Marine
21	Israel	18	▼	59.7	39.6	15.3	55.4	36.4	29.6	14.8	17.8	16.8
22	Finland	24	▲	59.4	59.7	43.4	34.6	15.3	50.9	15.3	27.7	15.3
23	South Korea	22	▼	59.3	39.5	41.9	49.2	18.8	49.5	17.2	29.9	33.0
24	Belgium	29	▲	59.1	51.4	36.6	41.7	18.2	45.1	22.6	21.6	20.1
25	Portugal	23	▼	59.0	43.9	23.0	48.6	25.1	40.8	23.0	36.7	23.7
26	Argentina	27	▲	58.1	51.7	23.1	49.1	31.9	41.4	15.6	38.2	19.5
27	Philippines	28	▲	57.9	42.7	21.3	48.8	20.5	44.1	43.5	42.4	20.7
28	Taiwan	31	▲	57.4	42.0	45.9	45.2	18.1	35.7	27.4	32.9	27.2
29	Egypt	26	▼	56.5	46.8	14.9	53.5	47.4	29.7	13.3	23.0	11.5
30	Turkey	25	▼	56.0	47.0	19.1	48.5	23.9	40.0	41.9	43.0	19.7
31	Switzerland	33	▲	55.7	41.3	18.0	43.9	18.5	38.2	22.9	37.5	15.4
32	Austria	37	▲	55.6	45.9	20.8	42.3	13.9	41.4	17.3	39.6	21.0
33	Mexico	32	▼	54.6	41.8	21.2	47.2	24.3	35.9	39.5	34.9	18.9
34	Norway	34	●	54.6	48.2	34.0	38.0	14.2	33.1	16.7	45.2	32.0
35	Kazakhstan	36	▲	53.8	45.5	13.8	45.1	17.6	30.1	14.5	41.6	13.3
36	Vietnam	30	▼	53.7	43.7	43.5	43.5	16.6	39.4	12.1	45.9	17.7
37	South Africa	35	▼	53.3	46.7	18.0	43.9	46.8	32.3	12.3	19.5	20.4
38	Jordan	39	▲	52.9	40.8	14.3	44.8	30.8	20.6	13.8	16.0	13.8
39	Indonesia	43	▲	52.7	38.6	18.5	46.7	17.3	43.5	56.9	47.3	20.2
40	Thailand	38	▼	51.9	38.3	15.0	44.0	21.2	41.8	16.2	31.3	18.2

RECAI methodology

The index rankings reflect our assessment of the factors driving market attractiveness in a world where renewable energy has gone beyond decarbonization and reliance on subsidies.

We have defined the questions being asked, based on what we see as global market trends affecting investment and deployment priorities, and the challenges and success factors impacting EY clients:

- Is there a long-term need for additional or replacement energy supply? If so, is there a strong case for energy from renewable resources in particular?
- Is policy hindering or helping the ability to exploit renewables opportunities?
- Are essential components in place to ensure project delivery, such as long-term contracts, grid infrastructure (including storage) and availability of finance?
- What does the strength of natural resource, track record and project pipeline reveal about the outlook for particular renewable technologies?
- Even if all other elements are in place, does the macro stability and investment climate enable or impede the ease of doing business?

These index pillars therefore put emphasis on fundamentals such as energy imperative, policy stability, project delivery (including capital availability) and diversity of natural resource – factors that will increasingly become key market differentiators as markets move toward grid parity, and "artificial" motivations, such as government targets or the ring-fencing of technologies, become less critical.

Determining the rankings

Each parameter within the five pillars comprises a series of data sets that are converted into a score, from one to five, and weighted to generate parameter scores. These are weighted again to produce pillar scores, then an overall RECAI score and ranking. Weightings are based on the EY assessment of the relative importance of each data set, parameter and pillar in driving investment and deployment decisions. Each technology is also allocated a weighting based on its share of historical and projected investment levels.

Separate from the main index, EY technology-specific indices rankings reflect a weighted average score across the technology-specific parameters and a combined score covering our other macro and energy market parameters. This is because some markets may be highly attractive for specific technologies but face other major barriers to entry.

Data sets are based on publicly available or purchased data, EY analysis or adjustments to third-party data. We are unable to publicly disclose the underlying data sets or weightings used to produce the indices.

If you would like to discuss how EY RECAI analysis could help your business decisions or transactions, please contact the RECAI Advisor Lavaanya Rekhi.

Foreword
RECAI 60
PPA Index
Key developments
Analysis
Regional focus
Insight
Data and methodology
Contacts

PPA Index scores

Rank	Market	Previous rank	Movement on previous index	Normalized score (0-100)	PPA Index score	PPA market maturity	PPA future market score	PPA policy score	RECAI score
1	Spain	1	●	100.0	25,119,946	83.2	87.8	52.3	65.8
2	Germany	3	▲	97.0	24,378,588	69.5	88.1	55.5	71.7
3	United States	2	▼	96.4	24,216,364	100.0	55.5	59.5	73.3
4	United Kingdom	4	●	79.9	20,058,321	67.5	78.4	54.1	70.0
5	Australia	5	●	68.6	17,237,139	78.5	54.4	58.6	69.0
6	France	6	●	62.0	15,578,263	56.5	77.9	51.3	69.1
7	Denmark	10	▲	61.8	15,519,832	57.1	81.8	52.0	64.0
8	India	14	▲	60.6	15,226,923	62.6	50.9	69.6	68.6
9	Netherlands	9	●	57.4	14,425,791	54.7	75.4	53.9	64.9
10	Sweden	7	▼	57.4	14,425,551	62.7	76.9	49.9	60.0
11	Finland	8	▼	56.5	14,183,087	66.0	68.1	53.1	59.4
12	Italy	11	▼	52.2	13,125,096	48.9	82.3	51.3	63.6
13	Brazil	13	●	43.0	10,810,439	72.3	54.5	44.1	62.2
14	Norway	15	▲	41.8	10,487,768	60.1	63.2	50.6	54.6
15	Poland	12	▼	35.2	8,852,111	54.5	46.6	57.1	61.1
16	Portugal	17	▲	28.4	7,131,284	35.8	64.9	52.0	59.0
17	Chile	16	▼	25.2	6,320,713	49.0	39.1	53.7	61.4
18	Egypt	26	▲	23.6	5,920,440	48.7	37.6	57.2	56.5
19	South Africa	20	▲	23.3	5,856,277	56.9	35.4	54.6	53.3
20	Morocco	18	▼	22.2	5,585,800	40.7	37.7	60.2	60.4
21	Colombia	21	●	21.2	5,312,874	54.4	40.0	50.5	48.3
22	Belgium	19	▼	20.6	5,183,799	52.7	32.0	52.0	59.1
23	Ireland	22	▼	17.0	4,282,555	33.1	36.0	56.7	63.4
24	Japan	28	▲	17.0	4,276,605	25.3	48.5	53.1	65.7
25	Ethiopia	25	●	13.4	3,360,595	37.1	35.2	61.5	41.8
26	Thailand	23	▼	13.2	3,315,303	43.8	23.2	63.0	51.9
27	Greece	24	▼	11.7	2,932,539	27.0	34.6	50.9	61.5
28	Romania	27	▼	10.3	2,593,960	27.7	34.1	53.9	51.1
29	Lithuania	29	●	8.1	2,034,230	33.4	33.5	51.6	35.3
30	Bulgaria			7.1	1,777,287	23.5	29.0	54.4	47.9

PPA Index methodology

By analyzing the same 100 markets as in the full RECAI database, the goal is to create a new ranking that focuses on the attractiveness of renewable power procurement — via offsite corporate PPAs — rather than the attractiveness of renewable project investment.

The final score for the top 30 markets is calculated from a weighted combination of 12 key parameters, which act as a proxy for corporate PPA potential. The PPA Index focuses on four pillars (three PPA-specific pillars together with a RECAI score pillar):

- **PPA market maturity** – this focuses on activities carried out within each market in the past decade. It concentrates on market maturity, looking at past PPA deal frequency and volume, as well as a quantitative analysis of more recent PPA deal growth.
- **PPA future market** – this forward-looking score assesses the forecast activity of each market. Forecast power capacity is a key driver of the magnitude of a market, so this has a significant weighting on the score as well as the wholesale power price relative to the levelized cost of energy (LCOE) or PPA price in each location. Forecast capacity installations and a weighted project pipeline score from the RECAI are used. The index has focused on wind and solar PPAs (together weighted at 93%) as these represent the vast majority of offsite corporate PPAs.
- **PPA policy score** – this focuses on the ease of operation in a given market. If a market is to have potential for corporate PPA growth, supporting government policy must be in place for efficient and large-scale expansion. This is considered in the core RECAI, but is also examined here, with a more nuanced focus on PPA supportive policy.
- **RECAI score** – the overall score yielded by the RECAI is also factored in as one of the fundamental pillars, because this provides a strong overview of the existing and potential strength of a market's renewable energy landscape.

The PPA Index uses a multiplicative formula to prioritize well-rounded markets with strengths in all aspects of corporate PPA development and integration. For example, this will mean that markets with zero PPA deals to date will score zero overall and will not yet be included.

However, with strong weighting on forward-looking parameters, even markets with just a few deals to date could score highly if significant growth is expected in the corporate PPA market within the next five years – the horizon of the RECAI.

The PPA Index score (which can be very large) has been normalized into a score from 0 to 100, to create a more manageable reference value. The leading market will score 100 – but this does not mean that the market is perfect for corporate PPAs. It means that, relatively speaking, it is the most attractive market for corporate PPAs across the coming five years.

Data sets are based on publicly available or purchased data, EY analysis or adjustments to third-party data. We are unable to publicly disclose the exact data sets or weightings used to produce the indices.

For more information on the services that EY teams provide to corporates around renewable energy strategies and PPAs, please refer to our website: www.ey.com/uk/ppa.

PPA market maturity

(Sources: Pexapark, DLA Piper and EY analysis)

1. Number of PPAs signed in the past five years
2. Total PPA volume in the past five years
3. Number of PPAs signed in the past year
4. Total PPA volume in the past year

PPA future market

(Sources: Wood Mackenzie, GlobalData, IRENA, IEA, Pexapark and EY analysis)

1. Pipeline of projects:
   a. Forecast power capacity
   b. Forecast installation growth
   c. Project pipeline
2. Wholesale power pricing:
   a. Wholesale power price relative to the historic LCOE
   b. Wholesale power price relative to the PPA price

PPA policy score

(Sources: World Bank, GlobalData, IEA and EY analysis)

1. Ease of doing business index (World Bank)
2. Renewable energy imperative:
   - Renewable energy percentage of total generation
   - Percentage of population with access to electricity
   - Forecast energy consumption growth
   - CO_2 emissions

RECAI score

(Source: EY analysis)

1. Macro fundamentals
2. Energy imperative
3. Policy
4. Project delivery
5. Technology

Special thanks to Pexapark for providing access to their data.

Normalized RECAI methodology

With the largest global markets tending to top the RECAI, there are many smaller markets where renewable energy is growing rapidly and becoming highly attractive. By dividing a market's RECAI score by logarithm of GDP to produce a "normalized score," the new index identifies those smaller renewable energy markets that perform the best on the core RECAI pillars of energy mix, government support, project delivery and natural resource. Removing a market's economic size showcases those that are efficient in terms of their size and the most attractive for investors. The normalized index also highlights larger markets that score well in the RECAI but could be doing more to support the green transition.

Arnaud de Giovanni
EY Global Renewables Leader
arnaud.de.giovanni@fr.ey.com

Ben Warren
RECAI Chief Editor
EY Global Power & Utilities
Corporate Finance Leader
bwarren@uk.ey.com

Stephen Auton-Smith
Managing Director
EY Infrastructure
Advisors LLC
stephen.autonsmith@ey.com

Clinton M. Firth
EY Global Cybersecurity Lead
Energy
clinton.firth@ae.ey.com

Andrew Horstead
EY Global Power & Utilities
Lead Analyst
ahorstead@uk.ey.com

Jeff Miller
EY Americas Power & Utilities
Strategy Leader
jeffrey.miller2@parthenon.ey.com

Paul Micallef
EY Global Digital Grid Leader
pmicallef@uk.ey.com

Thomas J. Flaherty, III
EY-Parthenon Senior Advisor
Strategy and Transactions
Ernst & Young LLP
tom.flaherty@parthenon.ey.com

Alexis Gazzo
EY Europe West
Sustainability Co-Leader
EY France Climate Change and
Sustainability Services Leader
EY & Associés
alexis.gazzo@fr.ey.com

Elanne Almeida
Sustainability Services Partner
EY Servicios Profesionales de
Auditoría y Asesorías SpA.
elanne.almeida@cl.ey.com

Pedro Subtil
EY Portugal
Energy & Resources Leader
Ernst & Young S.A.
pedro.subtil@pt.ey.com

Phil Dominy
Senior RECAI Advisor
Ernst & Young LLP
pdominy@uk.ey.com

Lavaanya Rekhi
RECAI Advisor
EY UK&I Energy and Infrastructure
Corporate Finance Senior Executive
Ernst & Young LLP
lrekhi@uk.ey.com

Nathan Docker
EY UK&I Energy and Infrastructure
Corporate Finance Senior Executive
Ernst & Young LLP
nathan.docker@uk.ey.com

References

[1] EY research, "The role of distributed energy resources in today's energy grid transition." Please contact us for more details.

[2] Bennett, Andy, "Renewable energy future includes DERs to support decarbonization," *Power*, 10 February 2022, www.powermag.com/renewable-energy-future-includes-ders-to-support-decarbonization

[3] Collins, Leigh, "Analysis: Why the US climate bill may be the single most important moment in the history of green hydrogen," *Recharge*, 9 August 2022, www.rechargenews.com/energy-transition/analysis-why-the-us-climate-bill-may-be-the-single-most-important-moment-in-the-history-of-green-hydrogen/2-1-1275143.

[4] Inflation Reduction Act of 2022, Congress.gov, www.congress.gov/bill/117th-congress/house-bill/5376/text

[5] Kessler, Richard, "New US climate law incentives can ramp solar manufacturing capacity to 50GW by 2030: SEIA," *Recharge*, 18 August 2022, www.rechargenews.com/energy-transition/new-us-climate-law-incentives-can-ramp-solar-manufacturing-capacity-to-50gw-by-2030-seia/2-1-1280805.

[6] "China's clean energy growth outlook for 2022 keeps getting bigger," *Bloomberg UK*, 24 June 2022, www.bloomberg.com/news/articles/2022-06-24/china-s-clean-energy-growth-outlook-for-2022-keeps-getting-bigger.

[7] Aizhu, Chen and Stanway, David, "China vows steady green energy growth as Europe returns to coal," *Reuters*, 27 July 2022, www.reuters.com/business/sustainable-business/china-vows-steady-green-energy-growth-europe-returns-coal-2022-07-27.

[8] Stanway, David, "China says a third of electricity will come from renewables by 2025," *Reuters*, 1 June 2022, www.reuters.com/business/sustainable-business/china-says-third-electricity-will-come-renewables-by-2025-2022-06-01.

[9] Biogradlija, Arnes, "German government approves historic renewable energy package," *Industry & Energy*, 7 April 2022, www.industryandenergy.eu/renewables/german-government-approves-historic-renewable-energy-package.

[10] Radowitz, Bernd, "Germany to triple renewables build-out by 2030, with new auction, permitting and legal rules," *Recharge*, 7 April 2022, www.rechargenews.com/energy-transition/germany-to-triple-renewables-build-out-by-2030-with-new-auction-permitting-and-legal-rules/2-1-1198442.

[11] Biogradlija, Arnes, "German government approves historic renewable energy package," *Industry & Energy*, 7 April 2022, www.industryandenergy.eu/renewables/german-government-approves-historic-renewable-energy-package.

[12] Ferris, Lee, "Weekly data: The number of countries generating offshore wind power is set to double," *Energy Monitor*, 18 April 2022, www.energymonitor.ai/sectors/power/weekly-data-the-number-of-countries-generating-offshore-wind-power-is-set-to-double.

[13] Lee, Andrew, "Made in Britain' energy strategy boosts offshore wind target to 50GW by end of decade," *Recharge*, 6 April 2022, www.rechargenews.com/energy-transition/made-in-britain-energy-strategy-boosts-offshore-wind-target-to-50gw-by-end-of-decade/2-1-1198015.

[14] "ScotWind result – 15GW of new floating wind projects in Scotland," *Vidi Energy*, vidi.energy/news/scotwind-result-15-gw-of-new-floating-wind-projects-in-scotland.

[15] Weitzman, Amelia, "UK signs 99 contracts under renewable CfD scheme," *Inframation*, 3 August 2022, www.inframationnews.com/news/12051701/uk-signs-99-contracts-under-renewable-cfd-scheme.thtml.

[16] MacLeod, Alexander, "UKIB outlines GBP22bn investment plan," *Inframation*, 23 June 2022, www.inframationnews.com/news/11707336/ukib-outlines-gbp-22bn-investment-plan.thtml.

[17] Puskas, Andras, "UK government to ramp up hydrogen projects," *Inframation*, 20 July 2022, www.inframationnews.com/news/11951336/uk-government-to-ramp-up-hydrogen-projects.thtml.

[18] AP, "Australian Senate passes law for 43% greenhouse gas reduction by 2030," *Business Standard*, 8 September 2022, www.business-standard.com/article/international/australian-senate-passes-law-for-43-greenhouse-gas-reduction-by-2030-122090800488_1.html.

[19] Drummond, Shaun, "Australian Government outlines renewables agenda," *Inframation*, 29 June 2022, www.inframationnews.com/news/11754371/australian-government-outlines-renewables-agenda.thtml.

[20] Federal Register of Legislation, Offshore Electricity Infrastructure Act 2021, Australian Government, www.legislation.gov.au/Details/C2021A00120.

[21] "Government announces six proposed offshore wind regions," *Energy Source & Distribution*, 8 August 2022, esdnews.com.au/bowen-announces-six-proposed-offshore-wind-regions.

[22] Petrova, Veselina, "NSW's Illawarra renewable energy zone draws 17GW of project proposals," *Renewables Now*, 29 August 2022, renewablesnow.com/news/nsws-illawarra-renewable-energy-zone-draws-17-gw-of-project-proposals-796212.

[23] Lee, Andrew, "Shock move as India hits offshore wind accelerator with gigawatt-scale auctions 'within months,'" *Recharge*, 9 June 2022, www.rechargenews.com/wind/shock-move-as-india-hits-offshore-wind-accelerator-with-gigawatt-scale-auctions-within-months/2-1-1235202.

[24] *Renewable energy statistics 2021*, International Renewable Energy Agency, August 2021, www.irena.org/publications/2021/Aug/Renewable-energy-statistics-2021.

[25] Lee, Andrew, "'Over-prioritised solar': Indian lawmakers say it's time to give wind its due," *Recharge*, 16 August 2022, www.rechargenews.com/energy-transition/over-prioritised-solar-indian-lawmakers-say-its-time-to-give-wind-its-due/2-1-1278822.

[26] Lee, Andrew, "Shock move as India hits offshore wind accelerator with gigwatt-scale auctions 'within months,'" *Recharge*, 9 June 2022, www.rechargenews.com/wind/shock-move-as-india-hits-offshore-wind-accelerator-with-gigawatt-scale-auctions-within-months/2-1-1235202.

[27] Collins, Leigh, "Indian state government and private developer pledge $6.7bn to build giant green hydrogen project," *Recharge*, www.rechargenews.com/energy-transition/indian-state-government-and-private-developer-pledge-6-7bn-to-build-giant-green-hydrogen-project/2-1-1234842.

[28] Vilnes, Olav, "Denmark sees record 53.3% share of renewables in H1," *Montel*, 9 August 2022, www.montelnews.com/news/1341151/denmark-sees-record-533-share-of-renewables-in-h1.

[29] Malkin, Brendan, "Infralogic Insight: Danish solar booming amidst challenges," *Inframation*, 14 July 2022, www.inframationnews.com/analysis/11920166/infralogic-insight-danish-solar-booming-amidst-challenges.thtml.

[30] Bech-Brun, "Danish government to accelerate investments in renewable energy," 27 April 2022, www.bechbruun.com/en/news/2022/danish-government-to-accelerate-investments-in-renewable-energy.

[31] Spatuzza, Alexandra, "Biomass beats wind and solar in Brazilian power bids for first time in low-energy tender," *Recharge*, 31 May 2022, rechargenews.com.

[32] Molina, Pilar Sánchez, "Brazil sets up secretariat to develop green hydrogen," *PV Magazine*, 9 August 2022, www.pv-magazine.com/2022/08/09/brazil-sets-up-secretariat-to-develop-green-hydrogen.

[33] Hames, George, "Brazilian state inks new green hydrogen MoUs," *I J Global*, 4 May 2022, www.ijglobal.com/articles/164047/brazilian-state-inks-new-green-hydrogen-mous.

[34] Buchsbaum, Michael, "Hellenic hope: Rapid solar build-out transforms Greece's coal-laden valley of tears," *Europe Beyond Coal*, 27 July 2022, beyond-coal.eu/2022/07/27/hellenic-hope-rapid-solar-build-out-transforms-greeces-coal-laden-valley-of-tears.

[35] "Updated NECP raises RES capacity target to 25GW by 2030," *Energy Press*, 6 April 2022, energypress.eu/updated-necp-raises-res-capacity-target-to-25-gw-by-2030.

[36] "First Greek offshore wind law seeks2GW by 2030," *Wind Europe*, 3 August 2022, windeurope.org/newsroom/news/first-greek-offshore-wind-law-seeks-2-gw-by-2030.

[37] Tsagas, Ilias, "Greece's renewables tender awards 372MW of PV at average of €47.98/MWh," *PV Magazine*, 13 September 2022, www.pv-magazine.com/2022/09/13/greeces-renewables-tender-awards-372-mw-of-pv-at-average-of-e47-98-mwh.

References

[38] Todorovic, Igor, "Cero signs Greece's first utility-scale corporate PPA for solar power," *Balkan Green Energy News*, 14 July 2022, balkangreenenergynews.com/cero-signs-greeces-first-utility-scale-corporate-ppa-for-solar-power.

[39] Benazizi, Aya, "Morocco's share of renewable energies continues to increase," *Morocco World News*, 20 July 2022, www.moroccoworldnews.com/2022/07/350370/moroccos-share-of-renewable-energies-continues-to-increase.

[40] Ibid.

[41] LB, "Morocco wants to double renewable energy capacity to 12GW by 2030," African Center for Competitive Intelligence, 17 May 2022, acci-cavie.org.

[42] Geopolitics of the Energy Transformation: The Hydrogen Factor, International Renewable Energy Agency, January 2022.

[43] Boutaleb, Hafid, "Morocco to ramp up green hydrogen production," *AL-Monitor*, 23 May 2022, www.al-monitor.com/originals/2022/05/morocco-ramp-green-hydrogen-production.

[44] Misbrener, Kelsey, "California Energy Commission mandates solar + storage on new commercial buildings," *Solar Power World*, 14 December 2021, www.solarpowerworldonline.com/2021/08/california-energy-commission-mandates-solar-storage-new-commercial-buildings.

[45] Cheng Ting-Fang and Lauly Li, Taiwan hit by widespread power outages, *Nikkei Asia*, 3 March 2022, asia.nikkei.com/Business/Energy/Taiwan-hit-by-widespread-power-outages.

[46] The world needs more diverse solar panel supply chains to ensure a secure transition to net zero emissions, International Energy Agency, 7 July 2022, www.iea.org/news/the-world-needs-more-diverse-solar-panel-supply-chains-to-ensure-a-secure-transition-to-net-zero-emissions.

[47] Copley, Michael, "A decade into tariffs, US solar manufacturing is still deep in Asia's shadow," *S&P Global Market Intelligence*, 23 May 2022, www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/a-decade-into-tariffs-us-solar-manufacturing-is-still-deep-in-asia-s-shadow-70236202.

[48] Market integration of distributed energy resources, International Renewable Energy Agency, 2019, www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Feb/IRENA_Market_integration_distributed_system_2019.pdf.

[49] Obonyo, Raphael, "Push for renewables: how Africa is building a different energy pathway," *Africa Renewal*, 6 January 2021, www.un.org/africarenewal/magazine/january-2021/push-renewables-how-africa-building-different-energy-pathway.

[50] Inflation Reduction Act of 2022, Congress.gov, www.congress.gov/bill/117th-congress/house-bill/5376/text

[51] Energy.Gov, Smart grid, www.energy.gov/science-innovation/electric-power/smart-grid.

[52] Cole, Serge, "As eMobility accelerates, can utilities move EVs into the fast lane?," *EY.com*, 8 February 2022, www.ey.com/en_sy/energy-resources/as-emobility-accelerates-can-utilities-move-evs-into-the-fast-lane.

[53] Brunekreeft, Gert et al (eds), Regulatory pathways for smart grid development in China (SpringerLink, 2015), link.springer.com/book/10.1007/978-3-658-08463-9.

[54] Stevens, David, "Report finds that Ontario's time-of-use pricing shifts electric consumption," *Energy Insider*, 28 February 2017, www.airdberlis.com/insights/blogs/energyinsider/post/ei-item/report-finds-that-ontarios-time-of-use-pricing-shifts-electricity-consumption.

[55] Sytas, Andrius and Strzelecki, Marek, "Europe ready for Baltics emergency switch-off from Russian gas," *Reuters*, 1 July 2022, www.reuters.com/business/energy/exclusive-europe-ready-baltics-emergency-switch-off-russian-grid-2022-06-30/.

[56] Energy policies beyond IEA countries: Morocco 2019, International Energy Agency, May 2019, www.iea.org/reports/energy-policies-beyond-iea-countries-morocco-2019.

[57] Ibid.

[58] Middle East Policy Council, Renewable energy in Morocco: interview with Said Mouline, Director General of Moroccan Agency for Energy Efficiency, mepc.org/commentary/renewable-energy-morocco.

[59] Bertram, Rebecca, "Good news from Chile," *Energy Transition*, 11 May 2021, energytransition.org/2021/05/good-news-from-chile.

[60] Renewable energy statistics 2022, International Renewable Energy Agency, July 2022, www.irena.org/publications/2022/Jul/Renewable-Energy-Statistics-2022.

[61] Asociación Chilena de Energías Renovables y Almacenamiento, Newsletter May 2022, acera.cl/wp-content/uploads/2022/06/Newsletter-ACERA-Mayo-2022.pdf.

[62] Horwath, Justin and Feliba, David, "Rich in renewable energy, Chile seeks to become global hydrogen powerhouse," S&P Global Market Intelligence, 30 August 2021, www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/rich-in-renewable-energy-chile-seeks-to-become-global-hydrogen-powerhouse-66012212.

[63] López-Dóriga, Elena, Portugal, a strong bet on renewables to reduce its energy dependency, 16 February 2022, Universidad de Navarra, www.unav.edu/web/global-affairs/portugal-a-strong-bet-on-renewables-to-reduce-its-energy-dependency.

[64] Marks, Joseph and Schaffer, Aaron, "One year ago, Colonial Pipeline changed the cyber landscape forever," *The Washington Post*, 6 May 2022, www.washingtonpost.com/politics/2022/05/06/one-year-ago-colonial-pipeline-changed-cyber-landscape-forever.

[65] Press release: announcement 20 August 2022, DESFA, www.desfa.gr/en/press-center/press-releases/anakoinwsh.

[66] "DHS announces new cybersecurity requirements for critical pipeline owners and operators," US Department of Homeland Security, 27 May 2021, www.dhs.gov/news/2021/05/27/dhs-announces-new-cybersecurity-requirements-critical-pipeline-owners-and-operators.

[67] Uberti, David, "TSA eases pipeline cybersecurity rules issued after Colonial hack," *Wall Street Journal*, 29 June 2022, www.wsj.com/articles/tsa-eases-pipeline-cybersecurity-rules-issued-after-colonial-hack-11656511031.

[68] "Lithuania's state-owned energy group hit by biggest cyber attack in a decade," *Lithuanian National Radio and Television*, 11 July 2022, www.lrt.lt/en/news-in-english/19/1736266/lithuania-s-state-owned-energy-group-hit-by-biggest-cyber-attack-in-a-decade.

[69] "Iranian Islamic Revolutionary Guard Corps-affiliated cyber actors exploiting vulnerabilities for data extortion and disk encryption for ransom operations," Joint Cybersecurity Advisory, 14 September 2022, www.cyber.gov.au/sites/default/files/2022-09/joint_advisory_iranian_islamic_revolutionary_guard_corps-affiliated_cyber_actors_exploiting_vulnerabilities_for_data_extortion_and_disk_encryption_for_ransom_operations.pdf.

[70] Kim, So Jeung and Bae, Sunha, "Korean policies of cybersecurity and data resilience," Carnegie Endowment for International Peace, 17 August 2021, carnegieendowment.org/2021/08/17/Korean-policies-of-cybersecurity-and-data-resilience-pub-85164.

[71] National Cybersecurity Strategy, South Korea Nation Security Office, April 2019, www.itu.int/en/ITU-D/Cybersecurity/Documents/National_Strategies_Repository/National%20Cybersecurity%20Strategy_South%20Korea.pdf.

[72] The White House, Office of the National Cyber Director, www.whitehouse.gov/oncd.

EY | Building a better working world

Back

EY exists to build a better working world, helping to create long-term value for clients, people and society and build trust in the capital markets.

Enabled by data and technology, diverse EY teams in over 150 countries provide trust through assurance and help clients grow, transform and operate.

Working across assurance, consulting, law, strategy, tax and transactions, EY teams ask better questions to find new answers for the complex issues facing our world today.

EYG no. 009888-22Gbl

BMC Agency
GA 2007362

ED None

ey.com