May 2022 | 59th edition

Renewable Energy Country Attractiveness Index

RECAI

Does the need for energy security challenge the quest for net zero?

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

EY

Building a better working world

Contents

In the global search for energy security, could diversifying to emerging green solutions be the answer?

The global energy market is in a state of chaos. In the past year, there has been unprecedented volatility in the natural gas market, with a handful of factors resulting in high demand and supply constraints. Meanwhile, the war in Ukraine has sent European nations racing to reduce their reliance on Russian gas. Sourcing gas from elsewhere will not happen overnight, of course. However, added impetus has been given to adding liquefied natural gas (LNG) import capacity, as well as boosting green gas production and the development of other alternative fuels, which appear to be regaining momentum at last.

In this edition of the RECAI, we take a deep dive into the case for floating technology. Currently, there are 11 floating offshore wind farms generating 79MW.

But major growth is in the pipeline, with close to 100 projects — with a combined capacity of more than 26,000MW — in the early-planning stages.[1] Given that wholesale electricity prices in Europe have fluctuated around the €200/MWh (US$217/MWh)[2] mark over the past year, floating wind power — the cost of which is expected to drop to US$70/MWh or lower by 2030[3] — looks primed to set sail.

Floating solar power has also garnered more interest as the cost of photovoltaic (PV) panels has plummeted, and global capacity jumped more than 100-fold in the five years to 2021. For smaller countries with little available land, it could be a key technology in generating carbon-free energy. As demand soars for new sources of renewable energy, research and innovation in this field could push floating solar from a niche area to mainstream.

Equally encouraging is that offshore floating power generation could be used to produce green hydrogen. Projects are already planned to combine electrolysis, desalination and green hydrogen production on floating wind platforms. Indeed, green hydrogen is expected to be a key substitute for natural gas in the coming years.

It is just one alternative fuel gaining in popularity as the conventional energy value chain undergoes an industrial revolution, shifting away from electrons to molecules. Companies are increasingly signing green gas purchase agreements[4] to supply industrial processing needs. Biomethane producers are also being looked upon to provide fuel for compressed natural gas engines in heavy goods transport fleets.[5]

So, while the divergence away from natural gas is creating an attractive investment climate for renewable energy, it is also helping to develop an increasingly lucrative market for green gases. This is a topic that the RECAI will be keeping a close eye on in the future.

From a regional perspective, the RECAI 59 puts Latin America under the microscope. With extensive renewables potential, the green energy sector in this region could experience major growth if barriers such as political uncertainty, a need for new regulatory frameworks, and financing issues can be overcome. As attention continues to be drawn toward green hydrogen, Chile, in particular, is a market to watch as it seeks to produce the world's cheapest green hydrogen. Research[6] used by the government, projects that Chile will be able to produce green hydrogen at US$1.05/kg by 2030.

The energy market is in a state of flux, and gas prices look likely to remain high in the short to medium term. But this presents an enormous opportunity for emerging green technologies to grow from niche markets to mainstream solutions in the global quest for energy security.

Key takeaways

- Geopolitical tensions, post-lockdown demand for gas, and environmental concerns have thrust energy security to the top of agendas.
- Emerging technologies and green fuels will be key to reducing the world's reliance on gas.
- Floating wind and solar have the potential to go mainstream as demand grows for new sources of renewable energy.
- Green hydrogen is expected to be a key substitute for natural gas in the coming years.
- Latin America is a green energy market to watch if it can overcome current barriers to growth.

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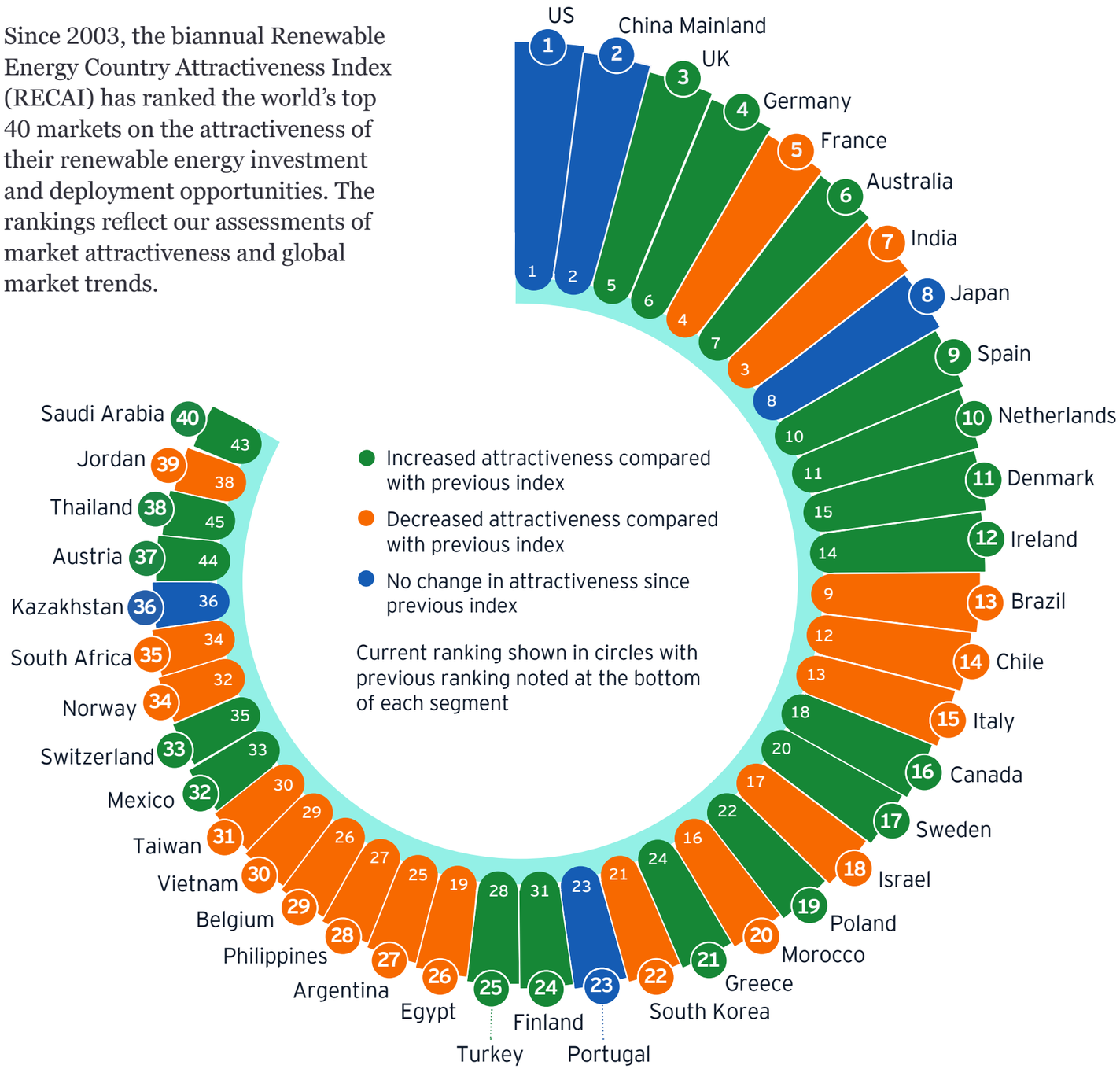
Strategy and Transactions Leader

Index

Since 2003, the biannual Renewable Energy Country Attractiveness Index (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.



+7 Austria

The Austrian government has committed to provide €250m (US$264m) to support the development of renewables, while Lower Austria has passed measures to ease the renewable project permitting process.

+2 Germany

Germany has brought forward its 100% green power target by 15 years, to 2035, and an 80% by 2030 goal has been set to increase energy security.

-2 Chile

Droughts in Chile demonstrated the market's continued reliance on hydropower, while solar tenders planned for June have been suspended indefinitely.

+3 Greece

Greece aims to double its installed renewables capacity to around 19GW by 2030 and recently energized a 204MW bifacial solar park, the largest of its kind in Europe.

+4 Denmark

Denmark has set a new target of producing up to 6GW of hydrogen annually by 2030, one of the highest targets in Europe.

-4 India

India's wind sector is struggling to match the explosive growth of the solar sector and is unlikely to hit its 60GW installation target by 2022.

+7 Finland

The Finnish government has approved the introduction of an auction model to lease out public waters for the development of offshore wind, starting in 2023–24.

+3 Poland

Poland launched tenders for three new offshore wind concessions. Capacity in the Polish Baltic Sea zone is expected to be 8GW to 11GW by 2040.

-1 France

Despite a slight decrease in ranking, France sets ambitious 2050 renewables targets, with plans for 100GW of solar and 40GW of offshore wind, while also announcing €5b (US$5.3b) spending for decarbonization of heavy industry.

Methodology

See page 40 for RECAI methodology.

Balance of power shifts as the power purchase agreement (PPA) market continues to grow

Since the PPA Index was introduced six months ago, the market for PPAs has continued to expand.

Exceptionally high and very volatile power market prices are pushing buyers to fix their price of electricity for as long as possible, while corporates are scrambling to make good on commitments made at COP26 to decarbonize their operations and supply chain. Demand for PPAs has increased significantly and shows no sign of slowing.

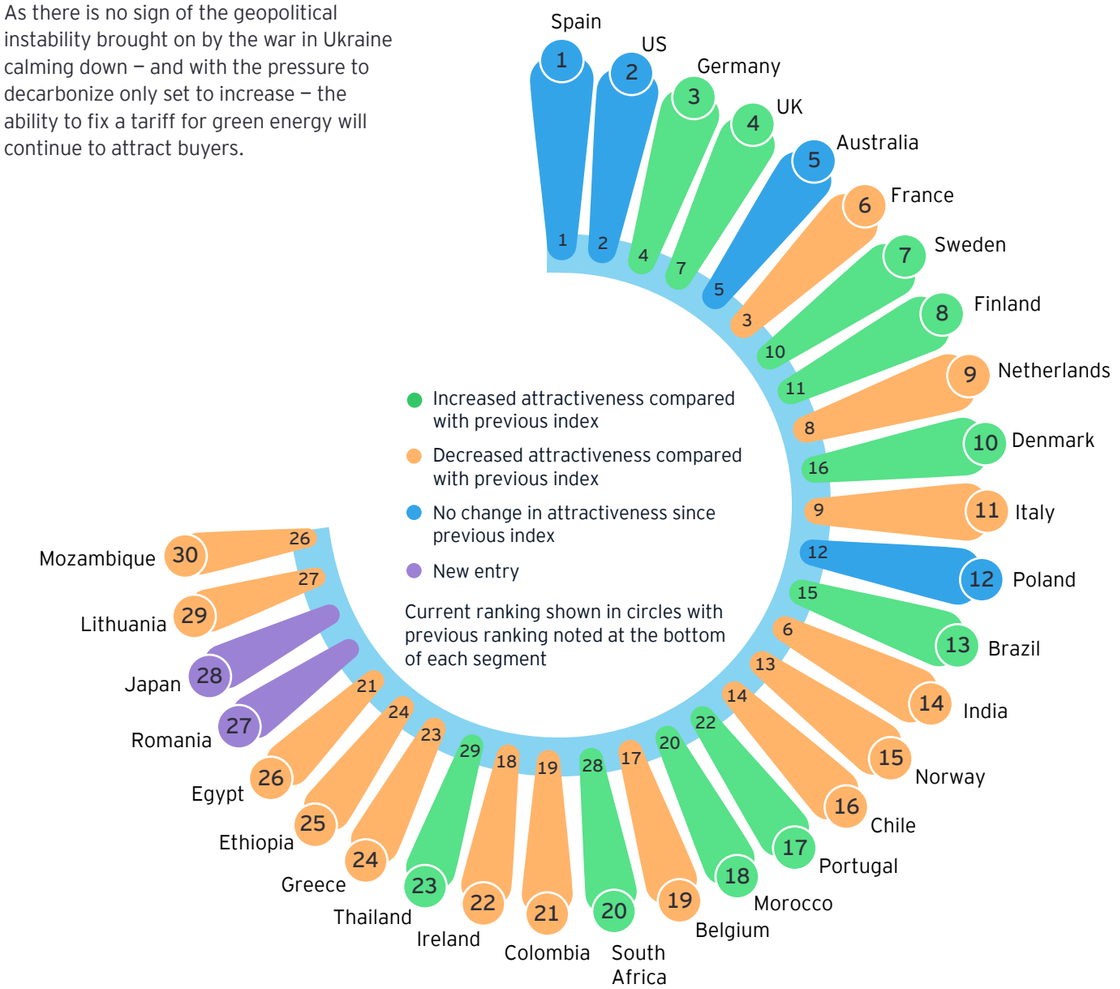
On the supply side, however, several bottlenecks are slowing progress. Backlogs in planning approval and grid connections, built up during the COVID-19 pandemic, have yet to ease. These procedural and regulatory holdups are being exacerbated by delays in the physical supply chain – in particular, China's periodic lockdowns of specific cities and districts are affecting manufacturing, with materials needed to create plant for new projects held up or unavailable.

These factors are tipping the balance from the buyers' market of last year to a more balanced picture, where sellers have some leverage in negotiating contracts and prices.

This is seen, for example, in a nascent trend for developers to try to transfer some inflation risk to the companies contracting to buy their electricity. For now, the market is balanced, so buyers can push back in these negotiations.

Despite this shift in the market, the economics are still strong in many locations with low, fixed PPA prices, which are attractive against high and unpredictable wholesale prices.

As there is no sign of the geopolitical instability brought on by the war in Ukraine calming down – and with the pressure to decarbonize only set to increase – the ability to fix a tariff for green energy will continue to attract buyers.



See page 44 for PPA methodology.

Spain and Portugal

The market is recovering well from a shock last September, after a decree – to curb presumed excess profits by suppliers during exceptional prices – was amended in November. Markets peaked in early March, but are still volatile, especially for solar, so PPAs may provide stability. Portugal is a much smaller PPA market, but growing, with the first deals made recently.

US

PPAs grew in 2021 by 11GW, 3% higher than in 2020, from 108 deals, with half of the 50 energy customers being new to PPAs. However, costs have increased by 30% due to supply chain constraints, with solar impacted by a Department of Commerce investigation into imports from East Asia. With more corporates chasing fewer shovel-ready projects, PPA prices have been rising.

UK

There has been a complex PPA market in recent months, as corporate processes run in parallel with the UK government's Round 4 auction. Auction awards were delayed until July. Despite the auction "competition," the corporate market has been buoyant, with many new buyers. High wholesale prices and increased capex costs have resulted in PPA prices rising.

Nordics

Traditionally an early mover in the European PPA market, the region continues to attract corporate deals. Denmark, Finland and Sweden have all risen up the index this issue, but – as in other markets – the availability of ready-to-build projects is scarcer than before. COVID-19-related delays to planning processes and grid enhancements are proving challenging, requiring patience from sellers and buyers.

Japan

A new entrant to the PPA Index, it is still early days. An active feed-in tariff market and policy barriers meant that PPAs were not attractive or suitable for renewable sourcing. However, with many corporates wanting green power, and a new feed-in premium scheme from April 2022, more PPAs are expected, as corporate users without electricity retail licenses can now participate.

Renewables highlights from around the world

Energy security has risen to the top of priority lists, as the war in Ukraine has led to increased geopolitical instability and spiraling gas prices and the world's ongoing recovery from the depths of the COVID-19 pandemic has boosted energy demand.

Governments around the world are looking to accelerate and broaden the scope of their renewables programs to help reduce their reliance on imported energy at this volatile and unpredictable time. Here, key developments within 10 markets that are taking interesting and varied approaches to trying to secure their energy supplies are explored – from the tripling of onshore wind and solar in Germany to green hydrogen investment in India.

1

No change

RECAI ranking

The US: breakthroughs sought in hydrogen and offshore wind

The U.S. Department of Energy is deploying US$10b in funding for the advancement of green and blue hydrogen[7] as part of the Infrastructure Investment and Jobs Act, which was passed in 2021. Development of regional clean hydrogen hubs will be allocated US$8b as the market takes initial steps forward in developing a national clean hydrogen network.

An additional US$1.5b will be allocated for research into, and development of, clean hydrogen manufacturing and recycling, and a clean hydrogen electrolysis program aimed at reducing the production cost. The US currently produces more than 11% of the 90m tonnes of hydrogen created globally each year; however, the majority is "gray" hydrogen, produced from natural gas.

On 11 May 2022, the Bureau of Ocean Energy Management held a wind energy auction for two lease areas offshore of North and South Carolina.[8] If developed, the areas could have a capacity of 1.3GW. In autumn 2021, the US identified up to seven potential offshore wind lease sales by 2025. Currently, the market has one operating offshore wind project, the 30MW Block Island Wind Farm off the coast of Rhode Island.

Renewable energy featured heavily in President Biden's US$5.8t budget request submitted to Congress in March, with US$2.1b sought for clean energy infrastructure.[9]

2

No change

RECAI ranking

China Mainland: prioritizing geothermal and hydrogen sectors, and rural areas

China Mainland has announced it will prioritize geothermal, hydrogen and tidal energy[10] as it seeks to develop new energy sources on a large scale. The market will adopt a region-specific approach, evaluating the presence of natural resources and industrial development in each district.

As China seeks to reach peak carbon emissions by 2030 and carbon neutrality by 2060, President Xi JinPing has highlighted that wind, solar and biomass will be relied upon heavily in its energy transition. He indicated that the government will seek to increase the development of large, integrated wind and solar project campuses.

China is also seeking to promote renewable energy in rural areas,[11] calling on developers to set up projects in grasslands and forested regions, and on land that is unsuitable for agricultural use. A budget is also being allocated to develop and upgrade transmission networks in underdeveloped regions. In particular, the central and western regions will be prioritized for the development of utility-scale solar and wind projects, as well as biomass and geothermal energy for district heating.

3

Up 2

RECAI ranking

The UK: battery storage and floating offshore big winners in recent auctions

Battery storage projects won record subsidies[12] in February's auction, with close to 1.1GW of projects receiving capacity subsidies. This marks a more than four-fold increase versus last year. In total, 107 projects, most of which are new builds, received capacity, while only about 10% failed to win subsidies. Most battery storage schemes have a duration of more than two hours and had their capacity contracted for 15 years. They are to be built by winter 2025. Despite the record auction of 1.1GW for battery projects, they still represent only a small proportion of subsidies won, as a total of 42.3GW of capacity was procured at the T-4 Capacity Market auction in February 2022. Experts warn that the nascent industry faces headwinds, given a lack of available grid connections.

In January's 2022 ScotWind tender,[13] floating offshore scored a victory, with the Scottish government awarding more than half of the 24.8GW to floating wind projects. In total, 17 projects were successful, with the winners of the round agreeing to pay close to £700m (US$912m) of option leasing fees.

After full agreements are signed, the projects will begin the consenting process and look toward financing options. The majority are forecast to reach financial close by 2028, with construction expected to be completed in 2030–31. Meanwhile, results of Round 4 of the UK's Contracts for Difference (CfD) auction[14] are expected to be announced in the early summer of 2022. Opened in December 2021 with a draft budget of £285m (US$371m), it is the biggest auction yet, aiming to secure up to 12GW of renewable energy generation for delivery between 2023 and 2027.

4

Up 2

RECAI ranking

Germany: all-green target moved forward to 2035, first biomethane auction held

Germany has announced ambitious renewable energy commitments, vowing to reach 100% green power by 2035,[15] moving forward its target date by 15 years. A near-term goal of 80% by 2030[16] has also been set, with the market promising to phase out Russian oil imports by the end of 2022. Currently, about 41% of its power comes from renewable energy.

New legislation, announced in late February, aims to triple annual additions of onshore wind from 3GW to 10GW in 2027. Offshore wind will be more than doubled, with cumulative capacity increasing to 70GW in 2045. And solar expansion will be nearly tripled, from 7GW to 20GW annually in 2028. This comes as Germany has decided to phase out nuclear power, with its last three reactors scheduled to go offline in 2022.

In January 2022, Germany's rooftop solar tender[17] was heavily oversubscribed, with 209 bids submitted, of which 136 were accepted for 156MW. The region of Saxony-Anhalt was awarded the most bids, with 25 successful applications for 34MW. Energy prices awarded spanned from €57/MWh (US$62/MWh) to €83/MWh (US$90/MWh), with a weighted average around €74/MWh (US$81/MWh).

The market also achieved a first when it awarded 148MW of biomethane plant capacity in a slightly undersubscribed auction. Bids were for plants with an installed capacity between 151kW and 20MW, and energy prices ranged from €169/MWh (US$184/MWh) to €190/MWh (US$207/MWh). Another biomethane auction is due to be held on 1 October 2022.

In its most recent onshore wind auction,[18] Germany awarded 1.33GW, of which 326MW was in the region of Lower Saxony. Energy prices awarded ranged from €48/MWh (US$52/MWh) to €59/MWh (US$64/MWh).

7

Down 4

RECAI ranking

India: green hydrogen policy unveiled

India unveiled its Green Hydrogen Policy[19] in February 2022, with a goal to produce a cumulative 5m tonnes of hydrogen by 2030. The policy will promote green hydrogen and green ammonia projects by providing a 25-year waiver for transmission charges. Producers will also be allocated land at ports for storing green ammonia for export.

By waiving transmission charges and increasing the size and scale of hydrogen manufacturing, India hopes to halve the price of clean hydrogen.[20] The government has set a target to bring down the cost of green hydrogen to US$2.50/kg by 2025 and to as low as US$1/kg by 2030. It is estimated that the market will need investments of around US$25b from the public and private sectors to form a domestic green hydrogen supply chain with a national installed electrolyzer capacity of 25GW, to reach its goal of producing 5m tonnes of green hydrogen by 2030.

The India Hydrogen Alliance has set a target of establishing five large GW-scale green hydrogen hubs for development within the next 18 months. And India also established a joint hydrogen task force[21] with the United Arab Emirates in February, as the two markets look to scale up technologies.

15

Down 2

RECAI ranking

Italy: eyeing floating offshore wind, but renewables undersubscribed

Italy is planning tenders over the next five years to award 3.5GW of floating offshore wind[22] projects. The auctions, between 2022 and 2026, will see developers bid for 20-year CfDs. The market has set a proposed tariff of €165/MWh (US$180/MWh) for the initial auction, with the price expected to be lowered for subsequent tenders.

Currently, only one small-scale (30MW)[23] fixed-bottom offshore wind project has been built in Italy. There has been tremendous interest in preliminary consultations, however, with 17GW of grid connection capacity for floating offshore wind projects having been presented to grid operator Terna.

State energy agency GSE's seventh renewables auction was heavily undersubscribed,[24] with a total of 975MW of an available 3.4GW of capacity awarded between 59 solar PV projects and 18 onshore wind projects.

So far, all seven rounds have been undersubscribed in Italy. In the eighth auction, which closed on 2 March 2022, GSE has made available 3.35GW of capacity that was not awarded in previous rounds,[25] with winners scheduled to be announced on 31 May 2022.

22

Down 1

RECAI ranking

South Korea: renewable standard raised as green energy ambitions grow

South Korea has raised its renewable portfolio standard policy[26] for independent power producers with more than 500MW of capacity to 12.5% for 2022. The market will keep building momentum by increasing the ratio to 14.5% in 2023, 17% in 2024, 20.5% in 2025 and 25% in 2026. Last year, the ratio was raised to 10%. The move is part of South Korea's plan to reach its 2030 greenhouse gas reduction target of 40% and its target of carbon neutrality by 2050.

Amid its announcement of more ambitious climate targets at COP26,[27] the market is expected to become a leader in offshore wind and clean hydrogen. Last year, plans were unveiled for the 8.2GW Shinan offshore wind project,[28] which will supply power to Seoul and the port city of Incheon and is expected to cost KRW48t (US$40.3b). A second megaproject was also announced, with a 6GW floating wind complex[29] to be developed off the coast of Ulsan. This would be the world's largest floating offshore wind project and is scheduled to be built by 2030.

South Korea has also announced that 624 hydrogen buses[30] will be put on the roads of the port cities of Busan and Ulsan by 2025. Subsidies for the world's largest-ever order of hydrogen buses amount to KRW187.2b (US$157m). The market currently has 112 hydrogen filling stations and is expected to add 38 more by the end of the year.

25

Up 3

RECAI ranking

Turkey: 2.8GW of grid capacity earmarked for renewables

Turkey has set a target to increase the share of renewable sources in its generation mix from 59% to 65% by the end of 2023.

Grid capacity will be allocated to 2.8GW of renewable power projects[31] in its €5b (US$5.4b) tender round in early 2022. Grid connection rights will be provided for 1.3GW of hybrid power plants combining solar and wind installations, while 784MW will be reserved for single-technology projects of solar parks or wind farms. An additional 680MW will be provided for small-scale unlicensed renewable plants. The projects are expected to be completed within two years of the awards.

The Turkish government is also developing an offshore wind energy road map[32] with international financial institutions, which it will publish later in 2022. It has indicated that offshore wind energy competitions with a capacity of 1.2GW are on the agenda for upcoming tenders.

As a result, Turkey was recently named as one of the top four countries[33] for offshore wind energy potential by the Global Wind Energy Council.

28

Down 1

RECAI ranking

The Philippines: seeking to add 2GW of renewables and reach 35% renewable energy by 2030

The Philippines is targeting the addition of 2GW of renewables capacity[34] in its next tender. It is seeking to add 1.4GW of solar, wind, hydro and biomass projects on the island of Luzon; 400MW of biomass, solar and wind power in the Visayas region; and 200MW of hydro, biomass and solar capacity on the island of Mindanao.

Once a ceiling rate is determined, the government will auction the projects over a two-month period. Privately held power distribution business Manila Electric Company is also accepting bids for 850MW of solar and battery supply projects.

This comes as the Philippines' proposed National Renewable Energy Program for 2020–40 has set a target of 35% green energy[35] in the power mix by 2030 and 50% by 2040. In recent years, the share of renewable energy in the generation mix has declined: it sat at 34% in 2008 and is currently at 21%.

In 2020, the market announced a ban on all new coal projects, leading to Philippines companies expanding their renewables portfolios.

35

Down 1

RECAI ranking

South Africa: renewables growth seen as the solution to load shedding

South Africa has awarded 25 contracts for renewable energy projects,[36] worth a combined ZAR50b (US$2.8b), as it seeks to combat load shedding and reduce its reliance on coal. The country has been struggling with load shedding since 2007 because of a failure to build new power plants, and it is estimated that blackouts cost the economy more than US$30m a day.

The latest awards are expected to boost South Africa's generation capacity by 2.6GW, roughly 4.5% more than at present, with the addition of 12 new wind farms and 14 PV plants. With South African electricity company Eskom in debt by several billion dollars,[37] a number of companies are harnessing solar power, with the aim of being 100% dependent on solar by 2025.

The city of Cape Town announced in February that it will seek to procure as much as 300MW of renewable energy[38] through upcoming tenders aimed at independent power producers. A first tender will be held for projects ranging in size from 5MW to 20MW, and a second tender, for projects of more than 20MW, will be held shortly afterward.

Divergence and diversification will help accelerate the renewables market and improve energy security

The natural gas market has faced unprecedented volatility over the past year, with prices rising rapidly even before the war in Ukraine. In the UK, for example, prices increased by 367%, from £0.47 (US$0.62) per therm on 1 April 2021 to £1.73 (US$2.27) per therm on 21 February 2022.

Anthony Tricot
EY UK&I Head of Generation and Power Markets, Economic Consulting

The drivers have been a combination of high demand and supply constraints across multiple markets. In Latin America, for example, there was high demand for gas throughout most of 2021 because of seasonal drought and reduced hydropower availability. Asia's high demand for gas was driven in large part by the region's recovery from the early days of the COVID-19 pandemic and the lockdowns that came with it. Additionally, a summer heatwave in 2021 drove strong demand for gas-fired generation. China struggled to meet its power requirements, while South Korea used LNG to compensate for nuclear power outages.

The situation was exacerbated by rising competition between Europe and Asia for LNG – especially as seasonal demand rose over the European winter – and by supply and transport constraints among gas producers. This included outages at Russian production facilities and in pipelines to Europe.

> "The current situation with energy across Europe brings what used to be called the energy 'trilemma' massively back into focus – the trilemma being making it low carbon, making it affordable and making it secure."
>
> **Alex Brierley**
> Co-head, Octopus Renewables

The war in Ukraine has resulted in further upheaval to the market, with new gas price spikes in March. UK short-term prices rose as high as £5.01 (US$6.58) per therm, from £1.73 per therm before the war, while prices on the Dutch Title Transfer Facility (TTF) hub had exceeded €6.33 (US$6.89) per therm by 7 March 2022, up from €2.60 (US$2.83) per therm on 22 February.

Illustrating how some markets have been more exposed than others to the impact of recent developments, the US Henry Hub benchmark's first-quarter peak came on 2 February, when it reached US$6.70 per million British thermal units (mmBtu).[39] Meanwhile, international natural gas spot prices such as the Japan Korea Marker (JKM) and Dutch TTF both peaked on 7 March before easing. European LNG prices reached US$42/mmBtu, their highest level in four years.

Natural gas prices are also always strongly influenced by the weather. On a weighted average basis, for example, heating degree days (a measure of how much colder a period is relative to average temperatures) in the US are 14% below normal in the first quarter of this year. Historically, that translates to a roughly 198 million cubic meters (mcm)-per-day reduction in gas demand from a base of about 2.8 billion cubic meters (bcm) per day. Meanwhile, production continues to come back from its pandemic lows, with US output at the end of the third quarter of 2021 up by 113mcm per day compared with the third quarter of 2020.

This has helped relieve some of the upward pressure on US natural gas prices. Europe, on the other hand, has had to contend with a colder-than-expected winter, inventory levels that are at, or close to, five-year lows, and tight Russian supplies. These factors have all contributed to skyrocketing European prices, which have subsequently been exacerbated by the war in Ukraine and the continent's response to it.

"The current situation with energy across Europe brings what used to be called the energy 'trilemma' massively back into focus – the trilemma being making it low carbon, making it affordable and making it secure," said Octopus Renewables' Co-head, Alex Brierley.

Forward curves for European prices remain elevated into 2023, supported by similarly high oil and coal prices as the entire energy complex continues to price in supply risk.

"Our expectation is that this current situation is going to be a massive accelerator for renewable energy rollout across Europe, and the globe, actually," said Brierley. "What I think we've always struggled with is a lack of global coordination. But I'm seeing evidence of more global coordination and that can only be good thing."

Information company Energy Intelligence has similar expectations of how current developments will shape the energy transition.

"The gas supply and price situations add impetus to stepping up renewables deployment," said Energy Intelligence's Director, Research and Advisory, Ian Nathan. "There is an energy security component, of course, which reduces exposure to a fuel with a volatile price that requires significant imports. But it helps meet emissions goals as well – something that was in the works long before European dependence on Russian gas became a crisis. So, while the transition may appear to be bumpy, the longer-term goal remains intact – and will gain even more policy momentum."

The extent of demand for Russian gas

Against this backdrop, the EU is proposing a fundamental rewriting of its energy policy. Through its proposed REPowerEU plan, it is aiming to reduce its dependence on Russian gas imports by two-thirds within a year[40] and phase them out altogether "well before" the end of this decade. The private sector is also stepping up with a wide range of moves aimed at expediting new energy projects.

"There has been a really positive industry reaction and governmental reaction to the current gas prices," said Lightsource bp's Director of Power Markets, Europe, Zosia Riesner. "And it's come at the time when there was already significant momentum toward renewables and low carbon, and that transition was happening. But the focus on trying to accelerate this transition more rapidly as we look to reduce reliance on gas is clearly helpful for that renewables transition."

At less than 4% of its supply, the UK's reliance on Russian gas is low relative to most European countries because of its North Sea gas production and LNG import infrastructure. But it has expressed an intention to further diversify away from Russian imports.[41]

The UK government unveiled a new energy strategy in April 2022, outlining steps to improve energy security and reduce dependence on imports. The plan entails expansion of domestic renewable, nuclear and, in the shorter term, fossil-fuel sources of energy.[42] The UK's strategy illustrates the diversified approach required to improve energy security.

"Options for displacing Russian gas in Europe more broadly include alternative gas supply and a trajectory toward lower gas consumption altogether, which includes renewables and other fuels over the longer term," said Nathan.

Across Europe, new LNG import capacity and pipelines would be necessary to source gas from elsewhere. Landlocked Central and Eastern European countries in particular are heavily exposed to Russian gas and would find it more challenging to pivot to an alternative source than those with coastlines and existing or planned regasification capacity, despite rising pipeline connectivity.

> "Options for displacing Russian gas in Europe more broadly include alternative gas supply and a trajectory toward lower gas consumption altogether, which includes renewables and other fuels over the longer term.
>
> **Ian Nathan**
> Director, Research and Advisory, Energy Intelligence

Increasing global gas prices

367% UK
April 2021–Feb 2022

Imports of gas from Russia 2021

EU 45%
Germany **55%**

Across Europe, new LNG import capacity and pipelines would be necessary to source gas from elsewhere – and while accelerating renewable deployment could help reduce the need for gas generation, other fuels and technologies would be required too.

"For those further inland, gas sourced from neighboring-country LNG imports represents one gas-replacement option, particularly where infrastructure expansion – including pipeline and import capacity – is already in the works," said Nathan. "Bulgaria is one example. But it will not be an easy task for all Central and Eastern European countries, which is why the response to pressure is clearly mixed."

Proposals under the REPowerEU plan also include making improvements to energy efficiency, as well as working to diversify energy sources and reduce overall demand for gas from heating and power generation. Actions to source gas from elsewhere and, simultaneously, reduce gas use by replacing it with alternative energy sources have a lead time of several years.

Moves to diversify the power generation mix include the acceleration of heat electrification, support for the commercialization of hydrogen as a replacement fuel and, potentially, a slowdown in the decommissioning of nuclear generation. In the short term, coal-fired generation has risen,[43] though countries will be keen to avoid treating this as a longer-term option, given how it undermines their decarbonization targets.

In 2021, the EU imported 155bcm of gas from Russia, accounting for around 45% of the bloc's gas imports.[44] The figure is even higher for some European countries, with Germany importing, on average, roughly 55% of its gas from Russia in recent years.[45]

At the time of writing, sanctions packages implemented by the EU and UK included some significant action against the Russian energy sector, such as the cancellation of the regulatory certification of the Nord Stream 2 gas pipeline from Russia to Germany and an EU ban on Russian coal imports.[46] Expectations that further energy sanctions could be brought in, or that Russia could halt supplies if relations between it and the EU deteriorate further, have accelerated the rise in gas prices.

In response to the sanctions, Russia has demanded payments for its gas in rubles. While there has been pushback against this from countries including Germany,[47] payments come due in May, and this will put Russia's threat of cutting off supplies to the test.

Europe looking at additional LNG imports

Additional LNG imports have been seen as an alternative source of gas for Europe for some time. In particular, the US and Qatar – both of which are global leaders in the industry and are in the process of expanding their gas liquefaction capacity – have been identified as potential suppliers of additional LNG.

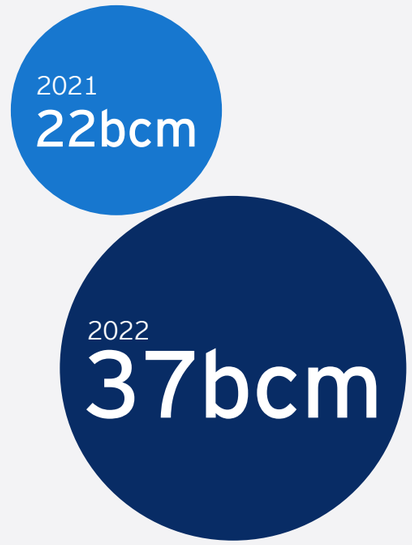
Imports from these producers could be increased through state-to-state facilitation of long-term supply agreements. US President Joe Biden announced in March that his administration would work with international partners to supply at least an additional 15bcm of LNG to the EU in 2022, with expected increases in supply over the subsequent years.[48] US LNG exports to the EU hit a record high of more than 22bcm in 2021.[49]

Ramping up EU LNG imports would require a significant expansion of regasification capacity on the continent, and momentum among developers is picking up. Rapid deployment of a floating storage and regasification unit (FSRU) is expected to take roughly two-and-a-half to three years. Italy, France and Germany are among those markets exploring opportunities to deploy FSRUs,[50] while companies in Germany are also taking steps to expedite development of new onshore regasification capacity.

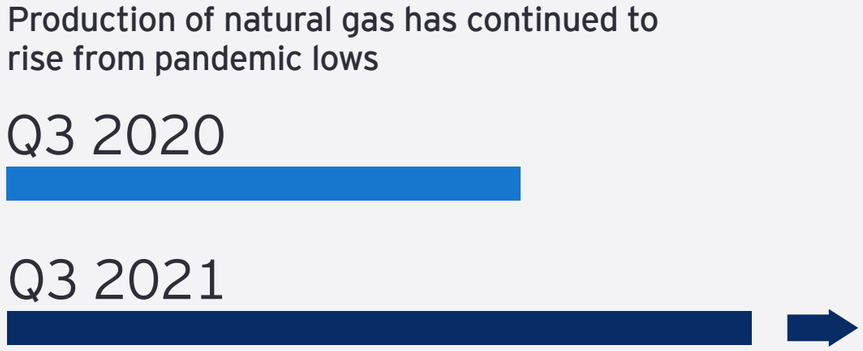
In the short term, national approaches to finding alternative sources of gas supply are starting to emerge. For example, Germany is in discussions with Qatar on LNG supplies,[51] while, in April, Italy agreed to boost gas imports from Algeria by around 40%.[52] Italy's Eni also signed a separate deal to increase gas production in Egypt, with a view to sending more Egyptian LNG to Europe.[53]

> "There has been a really positive industry reaction and governmental reaction to the current gas prices. And it's come at the time when there was already significant momentum toward renewables and low carbon, and that transition was happening."
>
> **Zosia Riesner**
> Director of Power Markets, Europe, Lightsource bp

US exports of liquified natural gas (LNG) to EU



Production of natural gas has continued to rise from pandemic lows



US output up 113mcm per day

The challenge of new pipeline options

New pipeline capacity is being considered to open fresh supply routes to Europe, while various countries are also exploring options for ramping up gas shipments on existing pipelines. In the short term, for example, Norway's Equinor will boost output by postponing some maintenance and making certain other adjustments, together with pipeline operator Gassco, in an effort to send more gas to Europe in the summer of 2022.[54] In the longer term, Norway would need to make additional gas discoveries to add more supply beyond projects it is already planning to develop.[55] Separately, the UK is also arranging to boost oil and gas exploration and production from the North Sea in the nearer term.[56]

Turkmenistan and Northern African gas producers, particularly Algeria, have been identified as potential supply sources that could be connected to Europe via new or existing pipelines. However, in terms of new projects, major pipelines are complex technically, commercially and in terms of regulation, especially if they cross multiple "third" (not the origin or destination) countries, as a pipeline from Turkmenistan would.

Turkmenistan's energy policy, however, has been focused largely on gas exports to China in recent years, while geopolitical challenges, among others, have hampered the proposed Trans-Caspian Gas Pipeline to Europe, which has been under discussion for more than 20 years and is still a distant prospect.

The Trans Adriatic Pipeline, connecting Italy to Azerbaijan, required four years of pre-construction activity and four years of construction before commissioning in 2020. New pipelines could expect similar timelines for construction, even where negotiation and pre-construction processes are accelerated.

In addition to intercontinental pipelines, better interconnection could be pursued in Europe to take advantage of the relatively secure position of markets such as Spain, which has a high penetration of LNG but currently lacks the infrastructure to shift significant volumes of imported gas to Northern Europe.

Seeking to reduce gas use

These challenges, and the likely lead times required to pursue any major infrastructure project, mean that supply will struggle to meet demand if Russian gas production is frozen out of global markets, so gas prices are likely to remain high in the short and medium term.

This is expected to help spur development of alternative sources of energy, including renewables and emerging fuels, such as blue and green hydrogen. However, this, too, will take time, especially in the case of blue and green hydrogen, which still needs to be commercialized. Steps to reduce the share of gas in power generation include the electrification of domestic heat, as well as the ramping up of wind, solar and other renewable energy sources.

There are various obstacles to be overcome as part of this process, including accelerating timescales required to deliver new projects.

"What we're looking for is a shorter development cycle. Why does it take seven years to get a wind farm fully permitted and construction-ready?" said Octopus's Brierley. "We're looking for policy and planning support, and we're looking for the whole grid connection process to become much easier and much quicker."

Efforts to remove or minimize regulatory and permitting hurdles are underway and have been welcomed by the private sector. However, not all government intervention is guaranteed to prove helpful, noted Lightsource bp's Riesner.

"Some of the initiatives that have been announced — for example, by the EU, around removing planning roadblocks — and boosting long-term PPAs [power purchase agreements] are really helpful," said Riesner. "The flip side is the uncertainty that's been created by some potential interventions in the market. Those are a real challenge."

She cited Italy as an example of a market where removing barriers to permitting would be helpful, and Spain as one where additional intervention in the wholesale market could shake investor confidence.

"There's positive intervention, such as removing blockers, and then there's more challenging intervention. It is all for the right reasons — they are trying to maintain affordability — but the intended consequence could be a slowdown in the renewables market," Riesner said.

While the renewable industry grapples with those issues, it has been suggested that current risks to gas supply could also force a rethink of various markets' plans to phase out nuclear power in the coming years. However, nuclear power is a polarized issue and heavily affected by local public sentiment, so some markets will be far more supportive of using it to bolster supply security than others.

New nuclear facilities would take years to build and have even longer lead times than LNG import terminals. However, some markets could opt to extend the lifespan of their existing nuclear power plants (NPPs). This is already happening in Finland, where, in March 2022, Fortum applied to extend the lifespan of both reactors at its Loviisa NPP by 20 years, to 2050.[57] And Belgium has unveiled plans to postpone its planned nuclear phase-out by 10 years, to 2035, while extending the lifespan of its two newest reactors.[58]

On the other hand, Germany considered, and then rejected, the possibility of extending the lifespan of its NPPs beyond what current plans allow.[59] In early March 2022, its Federal Ministry for Economic Affairs and Climate Action said that the costs and risks of keeping nuclear plants open for longer outweighed the benefits.

Nuclear policy could change if there is further disruption to gas supply, but, in Germany's case, there is not much time, given that its remaining nuclear capacity is due to go offline this year. This puts more pressure on renewables and battery storage to be developed as a viable alternative to natural gas in the power generation mix.

Greater diversification expected in the longer term

From the mid-2020s, greater diversification of gas sources is expected, with infrastructure build-out already underway. Additionally, a greater mix of other fuels and technologies is expected to be more readily available from the middle of the decade. As a result, prices are anticipated to normalize to near previous expectations.

A lower power price environment could be achieved through increased production or improved availability elsewhere — including expansion of LNG regasification capacity in Europe and a decline in Asian demand — or through a decoupling of gas and electricity prices. The latter would mean the replacement of gas generation as the marginal technology in markets such as the UK by alternatives — such as biomass or hydrogen-fired turbines — on an enduring basis.

This would require a substantial reduction in the costs of these technologies, which could be achieved through technological improvements because of subsidy-driven rollout or through a direct subsidy.

Power purchase agreements (PPAs)[60] could be a solution for consumers facing pricing pressures, as well as a way for developers to secure long-term price certainty. This assurance and the revenue certainty that comes with it could be sufficient to incentivize significant new renewable rollout. This would mean a reduction in overall power prices because of a greater proportion of generation being contributed by low marginal cost technologies.

If disruption to gas supply proves to be long term because of extended supply shortages or sanctions on Russian production, gas prices can be expected to remain high for the next few years. Given the role of gas generation in setting the power price in many European markets, this will mean an enduring environment of high power prices, which would make investment in new renewables more attractive for developers in the short term. It would also make programs of investment in renewables more attractive for governments, as the relative cost of those technologies decreases in relation to gas-fired generation.

Even beyond the explicit programs to increase renewable investment to reduce dependency on Russian gas, price levels for both gas and power could be expected to bring forward new investments.

This is already playing out. In addition to the UK, Germany was among the markets to unveil plans to accelerate the expansion of renewable energy in early April.[61] More broadly, the EU is considering adopting more ambitious renewable energy targets, even as it works to increase non-Russian gas exports.[62] Proposals for the bloc's energy strategy are expected in May and, in the meantime, more announcements on renewables could come from individual countries.

It will not be straightforward for Europe to reduce its dependence on Russian gas, and further upheaval in the natural gas market is expected. A diversified strategy will be necessary and will help to accelerate the deployment of renewables, and other fuels and technologies, over the coming years.

Latin America: seeking to bolster energy security by expanding renewables generation

Latin America has significant renewable potential and, as the energy transition accelerates, attention is turning increasingly to the question of how to harness it to enhance the region's energy security. Various markets in the region are taking different approaches to tackling this challenge.

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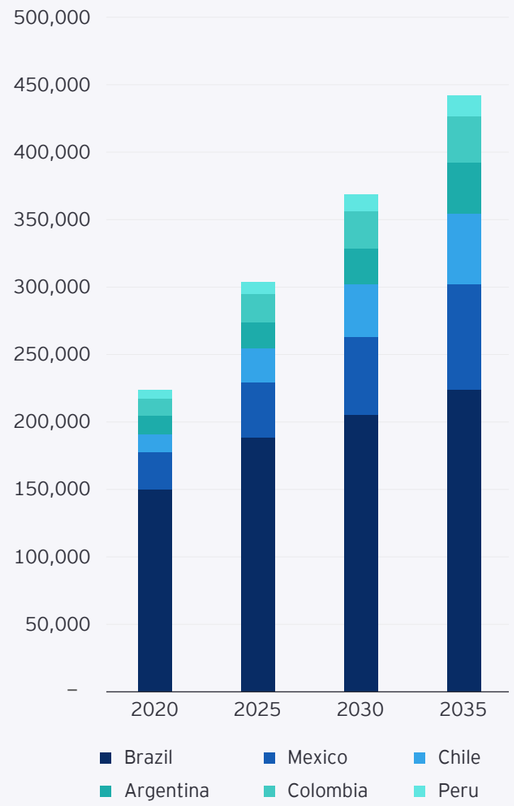
Brazil's renewable capacity and generation far outstrips that of other Latin American markets, but other nations are taking significant steps to advance their renewables industries. While they all face region-wide and global challenges – such as supply chain constraints created by the COVID-19 pandemic – there are also local and market-specific factors to consider.

"Latin American countries share several advantages, such as attractive resources and flexible power mixes reliant on hydropower and gas. Similarly, they suffer from the same illnesses," said Rystad Energy's Renewable Energy Analyst for the Americas, Marcelo Ortega. "On the technical side, countries need to revamp their aging transmission and distribution systems, as current infrastructure is not designed to connect renewable resource-rich areas, typically far away from cities, to load zones. On the other side, political support for renewable projects sways with changing governments, increasing the risk for developers willing to invest in these countries."

Colombia and Brazil are among the countries with elections later in 2022.

> Latin American countries share several advantages, such as attractive resources and flexible power mixes reliant on hydropower and gas. Similarly, they suffer from the same illnesses.
>
> **Marcelo Ortega**
> Renewable Analyst for the Americas,
> Rystad Energy

Cumulative installed renewables capacity (MW)

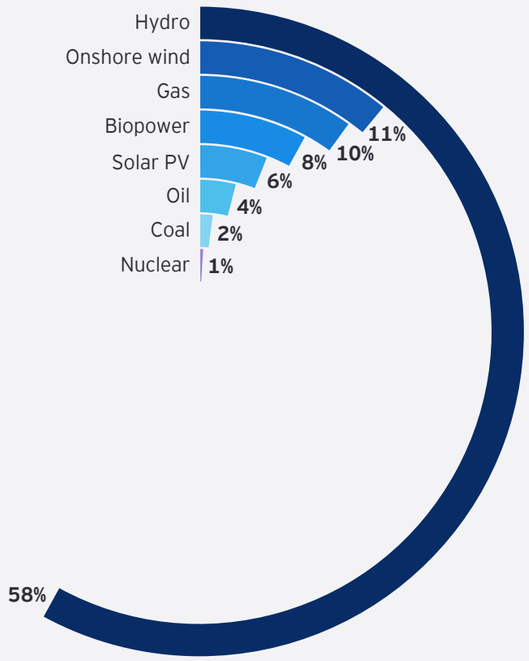


Source: GlobalData website, power.globaldata.com/, accessed 9 May 2022.

Brazil looks beyond hydropower

Brazil leads the way in renewable capacity and generation in Latin America. It had 158GW of renewable capacity in 2021, according to GlobalData.[63] And hydropower dominates this capacity, accounting for 110GW in 2021[64] and representing around 58% of Brazil's power generation mix.

Brazil installed capacity, by technology (MW)



Source: GlobalData website, power.globaldata.com/, accessed 9 May 2022.

Such a high level of dependence on hydropower, however, leaves Brazil vulnerable to the impacts of drought. Parts of the country were hit hard by drought in 2021 and, while this was followed by periods of heavy rainfall in early 2022, it illustrates concerns over the reliability of hydropower.

Against this backdrop, efforts to spur the development of wind and solar power are being stepped up. Wind is more advanced than solar in Brazil for a number of reasons, including that wind turbines can be partly produced and assembled locally. This allows developers to obtain financing from Brazilian development banks.

Solar panels are not yet manufactured locally and need to be imported, mainly from China. Local content requirements mean that solar developers have limited access to local long-term funding from development banks, and the exchange rate represents a further challenge for companies importing solar panels. Brazilian development banks, such as BNDES and BNB, require wind turbines and solar panels to be assembled or produced locally to receive a code that qualifies them for local financing. International players with local manufacturing operations can also qualify.

Certain developments are making things easier for the industry, however, including the recent introduction of US dollar-indexed PPAs and a move to allow project financing in US dollars. Atlas Renewable Energy is among the first companies to obtain financing in dollars,[65] and more renewable developers are expected to follow suit.

Meanwhile, recent reforms are opening up the electricity market, as distributed generation is increasingly commercialized, and residential customers are set to gain access to a wider variety of suppliers. Much still needs to be done, though, including a significant expansion of transmission lines to support new wind and solar farms. In addition, Brazil's offshore wind potential is extensive, but the country still needs to establish legal and regulatory frameworks for developing this resource.

Chile targets leading role in green hydrogen

Chile is among the markets with the largest solar potential in Latin America, along with Mexico. It has established a competitive renewables market with historically very low renewable auction prices, and now has ambitions to become a world leader in green hydrogen[66] – the cleanest form of hydrogen, which is produced using electrolysis and renewable energy.

"Chile has made impressive strides toward its energy transition, with continuous successful auctions and an ambitious green hydrogen target," said Rystad's Ortega. "The country is recognizing its exceptional renewable resources and, unlike some of its peers, Chile is integrating them into its long-term development plans."

Green hydrogen has yet to be commercialized, so developing an industry around it is a long-term project. However, Chile has a structured plan to pursue its development in three waves. The first involves developing green hydrogen for domestic use – in the mining sector and transportation, and for the production of ammonia – between now and 2028. Beyond 2028, in the second and third waves, it will aim to begin, and then scale up, green hydrogen and ammonia exports, and increase production.

Chile believes it has the potential to produce the world's cheapest green hydrogen. According to the Chilean government, it will be able to produce it at US$1.05 per kilogram by 2030.[67] The market can also expect to benefit from being relatively attractive for investment compared with other developing countries as it continues its green hydrogen plan.

Chile is heavily reliant on imports of fossil fuels and is currently pursuing a phase-out of coal. Moving away from fossil fuels is expected to be costly, and the country will have to take steps to ensure security of supply. Chile began taking coal-fired power plants offline in 2020 and is aiming to retire 65% of them by 2025.[68] The initial retirements of coal-fired plants came mid a lengthy drought, which led to energy shortages and highlighted the need to develop, or import, alternative sources of energy if the coal phase-out takes place as scheduled.

Chile is also an importer of liquefied natural gas (LNG) and faces increased competition in the LNG market as Europe ramps up imports of the super-chilled fuel. As a result, developing its renewables industry could become even more important to Chile. The major challenge will be transporting green power from the north, where renewable energy is produced, to the central part of the country, where it is consumed.

> "(Chile) is recognizing its exceptional renewable resources and, unlike some of its peers, is integrating them into its long-term development plans.
>
> **Marcelo Ortega**
> Renewable Analyst for the Americas, Rystad Energy

Argentina seeks to overcome market risk deterrent

Argentina has significant renewable potential but needs to overcome the deterrent that heightened market risk – related to a series of financial crises – poses to investors. Against this backdrop, and given a need to bring in US dollars for debt repayment, among other purposes, it is trying to attract more foreign direct investment and diversify its energy mix.

Despite economic volatility and foreign exchange controls, Argentina's previous government implemented a series of programs to champion the renewable sector. This included the RenovAr program, promoting the development of renewable generation in Argentina, particularly from large-scale wind and solar PV projects. Under the current government, however, priorities have changed, and these projects have lost momentum.

Argentina's financial challenges and efforts to attract investment have been seen as an opportunity by China. In recent years, 38 Chinese companies are estimated to have invested US$36b into Argentina,[69] including into renewable energy.

This trend is set to continue, with China expected to dominate investment, including broader power sector investments. In February 2022, China National Nuclear Corporation signed a contract to build the US$8b Atucha III NPP in Argentina, reviving a previously stalled deal.[70] Argentina has extensive expertise of its own in nuclear technology but, unlike other NPPs developed in the country, Atucha III will be built using Chinese technology and a Hualong One reactor.

Other notable foreign investors include Australia's Fortescue Future Industries, which announced plans to develop a US$8.4b green hydrogen project in Argentina in November 2021.

Other challenges for Argentina include a lack of grid infrastructure,[71] which has led to 2GW of capacity being awarded in renewable auctions but not yet built. Significant investment in new transmission lines will also be needed to overcome this challenge.

Hydropower is expected to play a significant role in Argentina's efforts to decarbonize – the country is aiming to raise the share of non-hydro renewables in its generation mix to 25% by 2030. While this could represent a relatively modest 5GW to 8GW of new capacity, the country's business environment could make it challenging to meet both hydro and non-hydro goals.

Argentina will also need to decide whether it wants to use its natural gas production domestically or push ahead with plans to export it amid high gas prices and rising demand for LNG. A bidding process is currently underway for construction of the Néstor Kirchner pipeline, which aims to increase production from the Vaca Muerta shale play and gas transportation capacity for local consumption.

In addition, Argentina has proposed the Law project for the Promotion of Sustainable Mobility, which will promote the use of technologies with less environmental impact for mobility. Given the high dependence on oil and gas in mobility, this law seeks to decrease consumption of hydrocarbons, among other objectives.

Hydropower is expected to play a significant role in Argentina's efforts to decarbonize – the country is aiming to raise the share of non-hydro renewables in its generation mix to 25% by 2030.

Constitutional reform threatens Mexican renewables

Like Chile, Mexico has some of the best potential for solar power — not just in Latin America, but in the world. It also has considerable wind potential. However, political and security concerns mean that, to date, renewable infrastructure development has been uneven, and some renewable-rich states have made more progress than others.

President Andrés Manuel López Obrador has been seeking to restore state dominance in the electricity sector, and his energy reforms represent a significant threat to the country's renewable industry,[72] despite their defeat in Congress in mid-April 2022.

Under his proposed constitutional amendment, control of the power sector would have been returned to state-run utility CFE, with independent energy regulators also brought back under state control. The proposal would have resulted in CFE having at least 54% of the power market.[73] On 18 April, however, the lower house of Congress voted 275–223 in favor of the reform, falling short of the two-thirds majority required for a constitutional change.[74] Following this setback, López Obrador pledged to submit legislation to nationalize the country's lithium sector.

Foreign investment in Mexico's energy sector has already slowed under López Obrador and will probably continue to decline, even though the reform failed. The extent of the proposals is expected to have a continued impact on perceptions of the market's attractiveness among investors, as it signals that López Obrador's administration will continue to favor CFE.

Parts of a separate law, passed in 2021, that was designed to give CFE priority access to the power grid for its power plants over privately owned renewable generation projects were rejected in Mexico's Supreme Court in early April. However, a majority of justices did not find the whole law to be unconstitutional.[75] Concerns have been raised, including by US Ambassador to Mexico Ken Salazar,[76] that further litigation could follow, adding to uncertainty for investors in the power sector.

Mexican wind and solar industry associations estimate that an additional US$10b of investment in renewables will be required by 2024 to meet the country's clean energy goals.[77] But with the proposed electricity sector reforms driving away investment, meeting this target will be harder.

Other markets to watch

Brazil, Chile, Argentina and Mexico are not the only markets in Latin America where notable developments are taking place. Others worth watching include Colombia, where the free market is expanding, and a mix of private and state-backed renewable energy auctions have attracted significant investment. La Guajira is also one of the best locations, globally, for onshore wind.

Colombia is under pressure to reduce its heavy reliance on hydropower after experiencing a lack of rainfall in recent years. This would have resulted in a power deficit had it not been for the shutdown of various industries because of the COVID-19 pandemic. Like Argentina, it still needs to invest in extensive expansion of its grid, and transmission bottlenecks could result in delays to new renewable capacity coming online.[78]

Another market where progress has been significant is Costa Rica, which sources around 98% of its electricity from renewables. To further minimize its greenhouse gas emissions, the country needs to turn its attention to the transport sector. Its plan for decarbonizing this sector includes an electric train project, though this has been struggling with delays,[79] and tax exemptions for electric vehicles (EVs).[80] Costa Rica became the first Central American country to establish a nationwide EV charging network in 2020.[81]

These examples illustrate the different approaches to decarbonization that Latin American markets are taking. There is still a long way to go, and obstacles such as political uncertainty, the need for new regulatory frameworks, and financing issues will need to be overcome if the region's renewables sector is to grow further.

Latin America has extensive potential, however, and progress on uptake of renewables can be expected across much of the region, this year and beyond.

Insight

The global search for energy security: the case for floating technology

The pressure to build capacity in renewable energy generation has risen high on to-do lists, as geopolitical events highlight concerns around energy security, the cost of power soars, and the need to decarbonize becomes ever more pressing.

Andrew Perkins
EY Partner, Corporate Finance,
Ernst & Young LLP

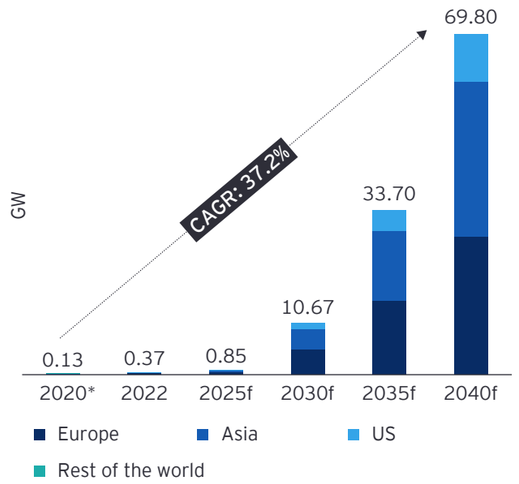
Renewable energy sources such as wind and solar are well established, but both require relatively large areas of land, a resource that is also under pressure. To mitigate this growth constraint, developers are looking for alternative locations, with offshore sites of particular interest.

The viability of floating wind

Offshore wind power is a relatively established source of renewable energy, but there are still significant constraints on the growth of offshore wind farms. The typical offshore wind farm requires expensive platforms in shallow waters with relatively light tidal currents. Deep water sites would expand the available options and are usually in places with more wind.

Increasingly, governments and energy companies are exploring the concept of floating offshore wind farms. Stronger and more consistent winds are usually found around deeper water, but the cost of fastening turbines to the seabed becomes prohibitively high beyond a certain depth. With 80% of Europe's potential offshore wind power – and 58% of the US's – in waters deeper than 60m,[82] however, the prize is worth pursuing.

Global floating offshore forecast



*Includes projects in operation and under construction.

CAGR: compound annual growth rate.
Source: EY Knowledge analysis of the Floating Wind Joint Industry Project – Phase 2 summary report, *Carbon Trust*, July 2020, https://www.carbontrust.com/resources/floating-wind-joint-industry-project-phase-2-summary-report.

There are currently 11 floating offshore wind energy projects installed around the world, representing 79MW of capacity, but significant growth is already in the pipeline. A further 15 projects, representing approximately 293MW, are under construction or have achieved financial close or regulatory approval. Almost 100 more – with a combined capacity of more than 26,000MW – are in the early planning stages.[83]

While the UK, Norway and South Korea have the highest capacity already operational, the US has one project in the pipeline and ambitions for more, as laid out in a 2021 executive order detailing plans for 30GW of wind power.

Wind power is currently the source of just 5% of the world's electricity, expected to rise to 33% by 2050. Floating offshore wind is expected to make up 2% of global electricity production – from close to zero today – but this will depend on industry development slashing the cost of installation and maintenance.

This is a major challenge, but not unprecedented. The cost of PV solar power plummeted from US$106.09 per watt in 1976 to US$2.04 by 2010 and stood at just US$0.38 in 2019.[84] This was achieved largely by economies of scale, which led to efficient mass production reducing prices. Although there may be some efficiencies in the production of kit for floating wind farms, it is more likely that improvements in technology will drive down prices.

Currently, the levelized cost of energy from floating wind stands at around US$200/MWh, and it is expected to drop to US$70/MWh or lower by 2030.[85] Given that wholesale electricity prices in Europe have fluctuated around the €200/MWh (US$217/MWh) mark over the past year,[86] briefly touching a peak of €400/MWh (US$435/MWh) in December, floating wind looks viable under current pricing conditions, even without further significant reductions in cost.

Getting wind farms to float

Wind turbines are extremely large and must be robust enough to withstand significant buffeting by wind, rain and salt water, so getting them to float in the right place, reliably, is a major engineering challenge. Several solutions are in use or on trial but, so far, there is no consensus on the best-performing or most cost-effective way to moor floating wind farms.

The main systems currently in use are the spar buoy, with a single, vertical buoyant column to moor the turbine, and the semi-submersible, which links multiple buoyant columns with pontoons. Although the former is the simplest, it has to be attached to the turbine in deep water, which presents a significant challenge. The semi-submersible can be attached to the turbine in relatively shallow water and towed into place, but having a shallower draft means it may be less stable. The tension-leg platform, which achieves greater stability with its vertically tensioned tendons, has not yet been tested fully in operation.

The first floating wind farm to come into operation was Equinor's 30MW project Hywind Scotland, which went online in 2017. The capital expenditure per MW was 70% lower than it had been in Equinor's initial experimental project, and the Norwegian power company says it expects a further 40% drop in cost for its 88MW Hywind Tampen project, which is due to start up in the third quarter of 2022.[87]

More recently, the 48MW Kincardine floating offshore wind farm has come into operation, while ScotWind's auction earlier this year was oversubscribed, with floating wind developers securing 11 of 17 leases, representing 15GW – 50% more than had initially been targeted.

According to Johan Sandberg, Head of Business Development for Norwegian conglomerate Aker, the industry is aiming to drive down the price of electricity from floating offshore to €50/MWh (US$54/MWh), roughly half the current price.

> "The challenge is to become really efficient and optimize design to get the cost compression we are aiming for."
>
> **Johan Sandberg**
> Head of Business Development, Aker Offshore Wind

"This is a stretch target given commodity prices at the moment," said Sandberg. "The challenge is to become really efficient and optimize design to get the cost compression we are aiming for."[88]

While mooring systems are the most obvious challenge for floating wind farms, getting the power from the turbine to the grid is another part of the cycle for which improving technology could lower costs.

Floating wind for green hydrogen production

Offshore floating wind generation would typically be used to feed electricity into national grids, but developers are starting to look at other possible outputs – including hydrogen.

Already widely used in industry, most hydrogen is produced using fossil fuels. This is known as brown hydrogen if made through the gasification of coal or lignite, and gray if it is made through steam methane reformation, which typically uses natural gas as the feedstock. The latter can also become blue hydrogen if emissions are cut by using carbon capture and storage. It will not be possible to capture at least 10% to 20% of the emissions, however, so blue hydrogen can be a transitional power source at best.

In recent years, there has been increasing interest in green hydrogen,[89] produced by using renewable energy to power the electrolysis of water.

One project in the Celtic Sea plans to combine electrolysis, desalination and green hydrogen production on a floating wind platform. Using Dolphyn technology from Environmental Resource Management (ERM), the project – a partnership between ERM and Source Energie – should come online in 2027.[90] ERM Dolphyn is also working with Simply Blue Energy, in partnership with Subsea 7, on the 200MW Salamander floating wind project off the coast of Scotland.

They are not the only players in the market. Norwegian group Aker has announced ambitions in this area, while Equinor and an alliance of TotalEnergies and Green Investment Group are also considering major developments off the Scottish coast.

While the ability to produce hydrogen without emissions is highly attractive, and the process would circumvent one of the main issues with wind power – that it is not necessarily produced at convenient times – there are challenges to be overcome. The technology is untested in conditions where it must withstand salt corrosion, strong winds and waves, while maintaining a major industrial plant, 100 kilometers or more out to sea.

Although floating offshore wind generation has a way to go before it is competitive with its fixed-bottom and onshore analogues, the industry is poised to accelerate in the immediate future. Niclas Boberg, Partner, Strategy & Transactions, Renewables, Ernst & Young Corporate Finance AB, says: "Most offshore players are taking the view that floating will happen, and are trying to position themselves around that."

> Although there may be some efficiencies in the production of kit for floating wind farms, it is more likely that improvements in technology will drive down prices.

Financing floating wind

The cost of capital for these innovative projects is another obstacle to be overcome, but, again, the omens are good. Borrowers can expect to pay around 3% over the risk-free rate to finance onshore wind farms, and about 3.5% for offshore fixed-bottom wind. Floating wind financing is likely to attract a spread of 8% over the risk-free rate. As risk management specialist DNV puts it in a recent report on the market[91]:

The business risks come from regulators who either do not understand what it takes to scale new industries by securing stable investment frameworks, or who set requirements for local production manufacturing that are too rigid and, therefore, restrict competition and economies of scale, leaving the full potential of offshore wind technology untapped.

So far, all floating wind projects have benefited from some level of derisking by government-backed institutions or structures, such as the European Investment Bank or the UK's CfD scheme. As the big players become comfortable with the technology and its implementation, we are likely to see them take on some of that risk themselves to achieve a lower cost of capital.

Once it has been established, other nonrecourse financing structures are likely to emerge, with no need for governmental subvention. Kinga Charpentier, Partner, Strategy & Transactions, Renewables, Ernst & Young Oy, estimates it will take another five to 10 years to make the cost of floating offshore power finance level with fixed-bottom offshore wind.

"Floatovoltaic" gains momentum

Wind is not the only renewable energy source taking to the water. Given how cheap PV panels have become, developers are looking for new areas in which to deploy the technology.

In places with calm, shallow waters and long hours of sunshine, floating solar farms are a real option and increasingly popular, with global capacity growing more than 100-fold in the five years to 2021.

It is attractive for markets such as Singapore, which has little available land but needs to find carbon-free energy sources. The island state recently opened a 60MW solar farm on its Tengeh Reservoir, in addition to the 5MW farm in the Johor Strait between Singapore and Indonesia.

Floating solar bypasses many of the objections to solar farms on land, where energy production has to compete with food production and amenity value, but it is not trouble-free. It is susceptible to capsizing, as in the case of the Ocean Sun Statkraft project in Albania, which suffered tornado damage within days of its commissioning in 2021. The floating platform has since been repaired and is now touted to be ready to withstand the weather for the next 50 years.

Placing a solar plant on bodies of water can also be controversial where those bodies are lakes in areas of outstanding natural beauty and, hence, a source of tourist revenue. In addition, there are questions around the impact on ecological systems. There is some evidence[92] that the cooling effect of solar farms may offset the damaging impact of heating, slowing algae overgrowth, but there is not yet sufficient data to know if this is meaningful.

So far, most "floatovoltaic" projects are on man-made, freshwater bodies, where the environment is relatively controlled, but there are plans to move further offshore to exploit the vastly larger resources of open sea.

Norwegian research institute SINTEF has been conducting a study[93] to examine the viability of offshore floating solar farms. A model in a marine basin has yielded sufficient information that researchers believe they can develop technology that will result in offshore solar farms competing with other power sources.

So far, however, the likely potential for floating solar is dwarfed by that of floating wind, where massive acceleration of the industry is already taking place.

Nevertheless, the soaring demand for new sources of renewable energy will drive research and innovation across all sectors. Floating wind is likely to become mainstream for investors in a few years, while engineers are working to establish whether floating solar will be more than a niche area. Even tidal power[94] and wave power,[95] often written off as unworkable in terms of efficiency, are receiving renewed interest (and research funding) in the hunt for oceanic energy.

While the ability to produce hydrogen without emissions is highly attractive, and the process would circumvent one of the main issues with wind power – that it is not necessarily produced at convenient times – there are challenges to be overcome.

RECAI 59 scores

					Technology-specific scores							
Rank	Previous rank	Movement on previous index	Market	Score	Onshore wind	Offfshore wind	Solar PV	Solar CSP	Biomass	Geothermal	Hydro	Marine
1	1	●	US	74.2	58.8	60.2	58.8	47.0	30.1	47.0	40.7	21.2
2	2	●	China Mainland	71.4	54.7	58.6	60.7	55.5	50.9	25.3	51.6	17.7
3	5	▲	UK	70.2	58.7	62.7	48.7	15.5	56.3	36.1	39.7	36.3
4	6	▲	Germany	69.6	54.3	52.0	53.4	17.5	50.9	38.6	35.1	20.7
5	4	▼	France	69.5	55.6	53.6	54.2	23.5	47.6	39.9	41.8	38.9
6	7	▲	Australia	69.1	54.3	33.5	57.8	49.0	40.9	17.8	26.7	26.1
7	3	▼	India	68.6	51.6	24.9	63.0	34.6	46.3	30.7	45.7	20.7
8	8	●	Japan	66.3	50.4	50.3	50.4	19.6	56.9	44.1	40.4	23.6
9	10	▲	Spain	64.4	49.2	34.4	51.5	29.0	39.8	15.6	25.2	23.5
10	11	▲	Netherlands	64.3	52.2	49.8	46.8	15.7	49.6	22.1	25.0	24.3
11	15	▲	Denmark	62.4	53.2	50.2	44.6	16.0	45.4	15.0	20.8	20.7
12	14	▲	Ireland	62.3	51.0	40.0	45.6	19.5	26.8	17.7	23.3	24.9
13	9	▼	Brazil	62.2	54.2	28.7	52.4	25.6	48.3	13.1	44.3	18.8
14	12	▼	Chile	62.0	51.7	20.5	49.2	53.5	43.0	45.5	45.6	27.8
15	13	▼	Italy	61.9	45.7	40.6	48.6	31.8	42.4	32.5	44.5	18.7
16	18	▲	Canada	61.2	54.2	35.0	45.4	18.9	32.6	25.7	47.0	27.1
17	20	▲	Sweden	59.4	49.5	40.9	42.1	15.2	43.9	17.7	32.8	26.7
18	17	▼	Israel	59.3	39.8	15.1	54.8	40.7	30.1	14.5	17.5	14.9
19	22	▲	Poland	59.3	44.6	40.1	48.0	13.4	44.7	17.4	32.5	14.2
20	16	▼	Morocco	59.2	45.4	17.8	50.4	51.2	26.3	14.3	32.9	14.3

					Technology-specific scores							
Rank	Previous rank	Movement on previous index	Market	Score	Onshore wind	Offfshore wind	Solar PV	Solar CSP	Biomass	Geothermal	Hydro	Marine
21	24	▲	Greece	58.9	49.2	23.5	46.4	35.2	45.5	28.0	41.0	14.2
22	21	▼	South Korea	58.3	39.6	32.2	50.5	18.4	48.8	14.3	34.0	33.9
23	23	●	Portugal	58.3	42.5	24.6	47.1	26.1	38.1	23.2	36.3	24.4
24	31	▲	Finland	58.2	59.8	31.9	34.0	15.4	50.5	15.4	22.8	15.4
25	28	▲	Turkey	58.2	48.1	22.1	48.8	29.9	39.3	43.2	43.4	20.7
26	19	▼	Egypt	57.5	46.0	16.2	54.4	48.8	25.4	12.0	23.6	12.0
27	25	▼	Argentina	57.5	49.6	23.7	49.2	32.0	37.4	15.6	31.7	19.6
28	27	▼	Philippines	57.1	42.2	22.8	48.1	20.2	43.1	42.8	40.8	20.7
29	26	▼	Belgium	56.7	48.4	27.7	41.5	18.0	42.3	20.0	21.4	14.8
30	29	▼	Vietnam	56.2	44.8	44.1	47.4	16.6	39.1	12.9	46.6	17.1
31	30	▼	Taiwan	55.1	39.3	45.5	45.0	17.4	34.7	27.6	32.7	19.3
32	33	▲	Mexico	54.8	42.8	19.4	47.5	24.2	36.0	42.0	29.6	19.2
33	35	▲	Switzerland	54.8	40.3	18.4	43.4	18.3	37.6	22.3	37.9	15.2
34	32	▼	Norway	54.6	48.8	39.9	37.6	13.8	31.7	16.3	45.3	31.9
35	34	▼	South Africa	54.3	46.4	17.7	47.1	44.6	31.6	12.0	25.1	20.3
36	36	●	Kazakhstan	53.3	46.0	13.5	44.8	17.4	29.2	14.3	39.1	13.0
37	44	▲	Austria	52.9	43.6	15.7	40.7	13.5	38.6	17.0	36.0	13.5
38	45	▲	Thailand	52.5	36.3	15.4	46.4	19.9	39.2	13.8	27.0	18.3
39	38	▼	Jordan	52.4	40.0	14.3	44.4	30.8	20.6	13.8	16.0	13.8
40	43	▲	Saudi Arabia	51.8	42.7	15.4	45.7	44.6	25.8	15.1	11.4	11.0

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 the EY RECAI analysis could help your business decisions or transactions, please contact the report's advisor Lavaanya Rekhi (lrekhi@uk.ey.com).

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	24,333,692	82.8	87.0	52.5	64.4
2	US	2	●	99.9	24,320,944	100.0	56.6	57.9	74.2
3	Germany	4	▲	95.2	23,173,497	72.2	85.7	53.9	69.6
4	UK	7	▲	83.1	20,222,447	68.1	78.0	54.3	70.2
5	Australia	5	●	73.5	17,890,097	82.9	53.7	58.1	69.1
6	France	3	▼	70.0	17,028,450	58.6	79.4	52.6	69.5
7	Sweden	10	▲	64.7	15,742,550	65.2	80.0	50.8	59.4
8	Finland	11	▲	57.2	13,930,131	67.5	66.9	53.0	58.2
9	Netherlands	8	▼	55.8	13,570,416	55.7	71.5	53.0	64.3
10	Denmark	16	▲	52.9	12,860,817	50.9	81.4	49.8	62.4
11	Italy	9	▼	48.7	11,853,238	44.6	81.0	53.1	61.9
12	Poland	12	●	45.3	11,027,156	56.7	57.0	57.6	59.3
13	Brazil	15	▲	44.0	10,699,624	72.8	54.6	43.2	62.2
14	India	6	▼	39.7	9,664,614	46.5	50.3	60.2	68.6
15	Norway	13	▼	36.4	8,852,661	58.3	56.5	49.3	54.6
16	Chile	14	▼	27.3	6,650,102	51.4	39.0	53.4	62.0
17	Portugal	22	▲	24.4	5,933,104	30.3	64.5	52.1	58.3
18	Morocco	20	▲	21.7	5,270,523	42.6	35.9	58.3	59.2
19	Belgium	17	▼	20.9	5,079,762	54.4	31.6	52.1	56.7
20	South Africa	28	▲	20.4	4,957,846	40.7	41.2	54.5	54.3
21	Colombia	19	▼	20.0	4,856,557	53.4	38.9	48.8	47.9
22	Ireland	18	▼	17.0	4,130,587	34.1	35.0	55.6	62.3
23	Thailand	29	▲	15.3	3,719,297	43.1	28.8	57.0	52.5
24	Greece	23	▼	12.0	2,910,371	28.3	34.5	50.5	58.9
25	Ethiopia	24	▼	10.6	2,578,693	38.3	33.7	48.8	41.0
26	Egypt	21	▼	9.8	2,394,253	20.5	38.4	52.8	57.5
27	Romania			9.2	2,232,690	29.0	30.4	52.7	48.0
28	Japan			8.9	2,176,651	12.7	47.8	53.9	66.3
29	Lithuania	27	▼	8.6	2,096,734	34.8	33.7	52.0	34.3
30	Mozambique	26	▼	6.3	1,539,919	36.7	31.5	56.8	23.4

PPA Index methodology

By analyzing the same 100 markets as in the full RECAI database, we have created a 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. The assessment 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 utilizes a multiplicative formula in order 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, in order 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 a more extensive discussion of the drivers and the barriers in the corporate PPA market or for more information on the services that EY teams provide corporates around renewable energy strategies and PPAs, please refer to our website: www.ey.com/uk/ppa or contact the report's senior advisor Phil Dominy (pdominy@uk.ey.com).

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

(Source: 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

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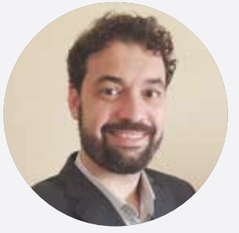

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