November 2023 | 62 edition
Renewable Energy Country Attractiveness Index
RECAI

Start

Are the global winds of change sending offshore in a new direction?

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

EY
Building a better working world

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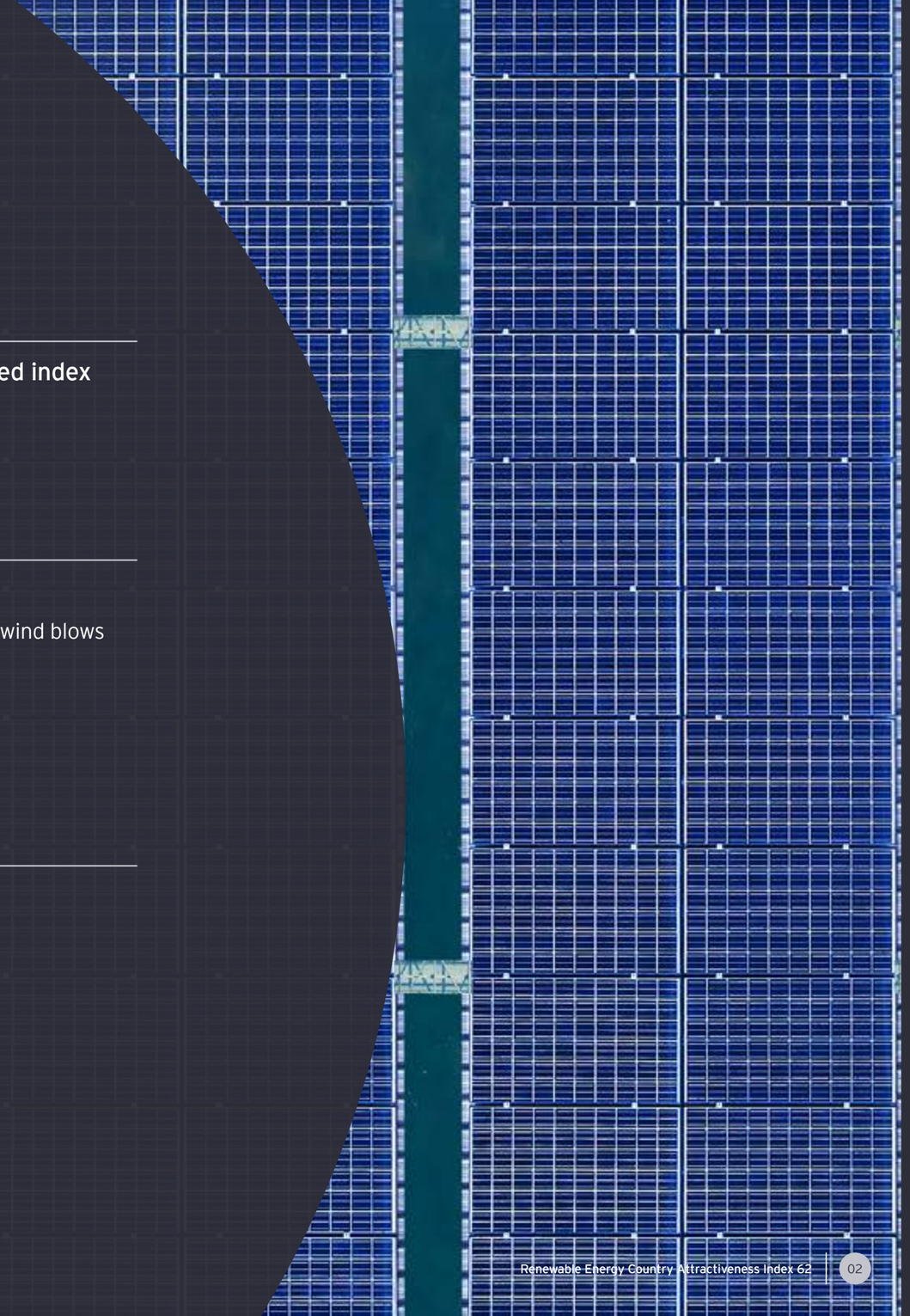

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There is no time to waste in the global race to decarbonize our entire way of life. The rewards for doing so will be bountiful, and the consequences of not doing so unthinkable.

The technology we employ to achieve this and the way we finance transitional projects are among the topics to be discussed at the UN Climate Change Conference (COP28) in the United Arab Emirates from 30 November to 12 December.

COP28 will also be the end date for the first-ever global stocktake – a five-yearly process by which, collectively, markets and stakeholders can see where they are making progress, or not, toward the goals of the Paris Climate Change Agreement.

The stocktake looks at where the world stands on climate action and support – but, as UN Climate Change Executive Secretary Simon Stiell points out, it is not just a routine checkup. It is a "moment for course correction"; an opportunity to ramp up ambition.[1]

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EY Global Renewables Leader

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Ambition such as that of the 3xRenewables campaign, which is led by the Global Renewables Alliance (GRA) and of which EY is a signatory. It is urging global leaders to triple the world's renewable energy capacity to 11,000GW by 2030.

Such growth in renewable energy is not linear, however, but instead follows an "S" curve typical of such new technologies. We are now approaching the inflection point in this curve, where we will see rapid, exponential growth that will enable us to decarbonize faster and achieve the GRA members' ambitions – but only if the right accelerators are in place first.

Can we scale fast enough? Can we connect to the grid quickly enough? Can we streamline the permitting process, and are the right funding mechanisms in place? Do we have the right infrastructure and supply chains? We need to be prepared to act swiftly if we are to capitalize on the opportunity that's just around the corner.

To find out which markets are best prepared to move fast, we need only look at the RECAI 62 rankings. The top three spots remain unchanged, with the US, Germany and China out in the lead. And the Nordic markets are showing their renewable energy intent, with Denmark, Sweden and Norway climbing two, three and five places respectively.

Offshore wind – often cited as the closest thing we currently have to a sustainable form of baseload energy generation – will be essential to global decarbonization. So, in this edition of RECAI, we take a detailed look at the sector, which has experienced a difficult 12 months because of challenging economic headwinds. This is reflected most clearly in the performance of the UK in the RECAI 62 scores: down three places, to seventh, because of its high dependence on offshore wind in its energy mix.

What went so wrong for the UK, where zero bidders expressed an interest in the 2023 AR5 offshore wind auction? In our deep dive, we look at how escalating raw materials costs weren't properly reflected in the strike prices of the auction, and how a squeezed supply chain is struggling to cope with the pressure of looming 2030 net-zero targets.

These problems are not limited to one market, however. Supply chain difficulties have resulted in global project costs rising by 39% since 2019,[2] and the sector is operating in a post-COVID-19 economy that is feeling the effects of an energy-price spike caused by the war in Ukraine and macroeconomic tensions.

Crucially, we ask whether this is a temporary blip, or if such factors are here to stay. Is offshore wind entering a new chapter, and is it still a good place for investors to put their money?

To answer this last point right away: emphatically, yes. There are some real winners in offshore wind right now, such as Germany, which awarded nearly 9GW over two auctions this year, and the Nordics, with Sweden approving two west coast offshore wind farms this year, and Finland having awarded 1.3GW in late 2022 and announcing an ambitious 6GW auction program by 2024. China is also set to continue its growth in offshore wind, despite ceasing national-level subsidies.

In many ways, offshore wind is a microcosm of the larger renewable energy industry as a whole. It's maturing and has been immensely successful in reducing costs via stringent competition.

The sector has the opportunity to modulate the pace of technology progress to take advantage of economies of scale; governments can end the "race to the bottom" on cost and start thinking about security of supply and value to society instead. Crucially, they can also join up energy policy with industrial policy. Governments, developers and investors that get this right will be winners in the long term.

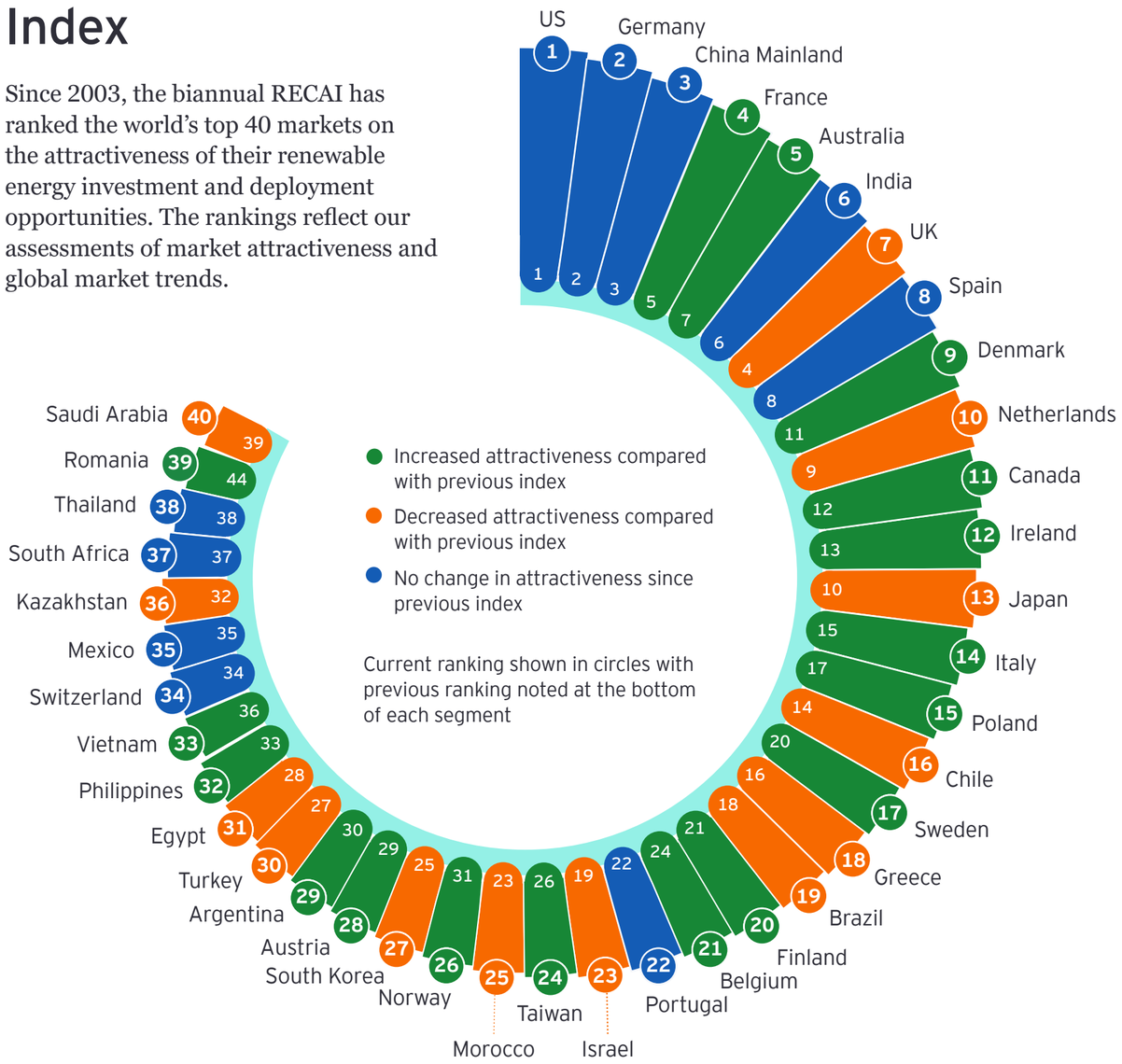
We must move quickly to meet our climate responsibilities. Key players the world over need to hold their nerve and keep their foot on the accelerator. It's never been more important.

Key takeaways

- We need to move faster to meet our net-zero ambitions. EY is calling on governments to triple global renewable energy capacity to 11,000GW by 2030.
- Highest climbers in RECAI 62 include the Nordic countries, Belgium and Romania. Markets dropping down the rankings include the UK, Japan and Chile.
- The UK loses its status as the world's No. 1 place for offshore wind, as a government auction fails to attract any bidders because of increased costs, which weren't fully reflected in target strike prices.
- Offshore wind is crucial to achieving net zero, but the sector is facing challenging times from a squeezed supply chain and escalating costs.
- Tensions in the offshore supply chain could be eased by standardizing technologies and giving more certainty to manufacturers and developers.
- When auctioning contracts for offshore wind generation, governments should reflect economic conditions in the design of the auction.
- Considering moving away from cost-only auction formats and incorporating non-price factors would boost the supply chain, improve deliverability and benefit wider society.

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.



0 US

The US retains the top spot amid significant solar growth driven by Inflation Reduction Act incentives. Market players are putting pressure on the government regarding offshore wind requirements.

+2 Denmark

A policy allowing issuance of guarantees of origin for green hydrogen supports Denmark's role in the energy transition and is a key decarbonization factor for hard-to-abate sectors.

0 Germany

There has been significant growth in Germany's onshore wind sector, with the volume of new capacity installed by the end of September exceeding the total installed in 2022.

+1 Italy

Italy aims to increase the amount of renewables in its energy mix to 65% by 2030. New renewable capacity in H1 2023 of 2.5GW represents a 120% increase on 2022's rate.

-3 UK

The failure of Contracts for Difference (CfD) Round 5 to attract new offshore wind capacity, plus the diminishing of green policies, has left investors with reduced confidence in UK renewables.

-2 Chile

Despite lofty new battery storage targets, Chile continues to struggle with intermittency issues driven by solar curtailment throughout the country.

-3 Japan

Despite significant natural resources and a commitment to reduce fossil fuels, Japan is falling behind other leading economies in terms of solar and wind deployment.

+5 Romania

Romania is set to tender 1GW of onshore wind and 1GW of solar as the first steps in its multiyear plan to award 20GW of CfD-backed capacity.

See page 22 for RECAI methodology.

The RECAI model's energy imperative pillar has been slightly adjusted to ensure that markets with a strong and demonstrable commitment to deploying green energy are scored positively.

Normalized index

RECAI uses various criteria to compare the attractiveness of renewables markets, such as the magnitude of the 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) we can see which markets are performing above expectations for their economic size.

In this way, the normalized index helps reveal ambitious plans for energy transition in smaller economies, creating some attractive alternatives for potential investors.

Normalized ranking	Market	Previous ranking	Movement vs. previous	RECAI ranking
1	Denmark	3	▲	9
2	Morocco	2	●	25
3	Greece	1	▼	18
4	Australia	6	▲	5
5	Chile	5	●	16
6	Ireland	7	▲	12
7	Portugal	10	▲	22
8	Netherlands	14	▲	10
9	Finland	9	●	20
10	France	11	▲	4
11	Spain	13	▲	8
12	Jordan	4	▼	45
13	Germany	8	▼	2
14	Poland	17	▲	15
15	Sweden	19	▲	17
16	India	16	●	6
17	UK	12	▼	7
18	Israel	15	▼	23
19	Kazakhstan	18	▼	36
20	Belgium	22	▲	21

Normalized ranking	Market	Previous ranking	Movement vs. previous	RECAI ranking
21	Canada	21	●	11
22	Honduras	23	▲	58
23	Norway	25	▲	26
24	Austria	26	▲	28
25	Taiwan	28	▲	24
26	Egypt	20	▼	31
27	Italy	31	▲	14
28	Vietnam	36	▲	33
29	Philippines	24	▼	32
30	US	30	●	1
31	Tunisia	29	▼	55
32	Dominican Republic	35	▲	46
33	Argentina	33	●	29
34	China Mainland	34	●	3
35	Romania	47	▲	39
36	Kenya	27	▼	48
37	Bulgaria	41	▲	50
38	Panama	39	▲	54
39	Peru	40	▲	41
40	South Africa	32	▼	37

0 Morocco

Morocco is forecast to bring more than 1GW of renewables capacity online every year between 2023 and 2027, while the US$20b Xlinks Morocco-UK Power Project interconnector is on track for commissioning during 2030.

-2 Greece

Greece is showing good progress toward 2030 and 2050 targets. It has recently surpassed 11GW of installed renewables capacity, with 1.7GW of green hydrogen electrolyzers in planning.

+1 Ireland

A new memorandum of understanding with the UK to support offshore renewable energy and increase interconnectivity is expected to improve Irish energy security and reduce intermittency risk.

+3 Portugal

Portugal's new 2030 target of 85% renewables generation has led to huge growth in forecast capacity in solar, wind and hydrogen electrolyzers, reducing reliance on gas.

See page 23 for normalized RECAI methodology.

Calmer wholesale markets, but PPA landscape may yet be ruffled by rising costs of generation and geopolitical unrest

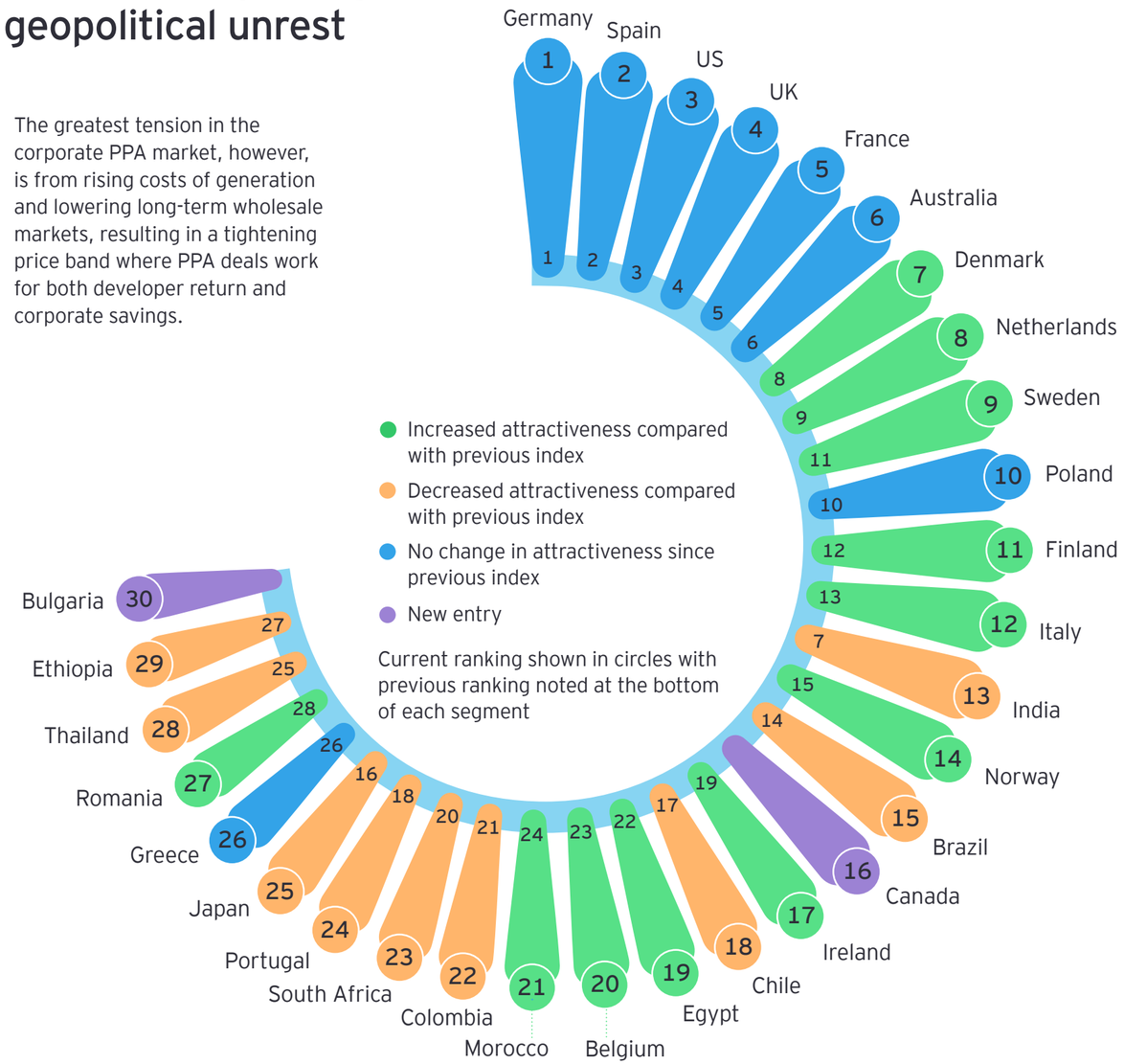
It has been a challenging year for power purchase agreements (PPAs) in 2023, as more and more corporates target new deals, while supply chain, grid and permitting delays continue to hamper progress in many markets.

Having said that, in Europe, 7.1GW of PPAs had been signed by the end of September (more than the total 6.6GW in 2022) and the 2021 record of 7.6GW is likely to be exceeded.[3]

After the extreme prices and volatility of 2022, wholesale markets calmed in the first nine months of 2023. However, unrest in the Middle East has already started to impact markets globally, through greater volatility and an uptick in pricing.

Thankfully, high inflation rates that were affecting many PPA markets have been easing in recent months, helping PPA prices to level off, or even decline, in some markets. Other helpful drivers in Europe include the revision of the Renewable Energy Directive (REDIII), to target 42.5% renewables for all EU energy consumption by 2030, and speeding up the permit-granting process.

The greatest tension in the corporate PPA market, however, is from rising costs of generation and lowering long-term wholesale markets, resulting in a tightening price band where PPA deals work for both developer return and corporate savings.



Spain

Although it was knocked off the top spot by Germany in June 2023, Spain continues to be a strong market for corporate PPAs, with more than 800MW in more than eight deals during Q3 2023.[4] Spain also leads all markets (except the US) in terms of total capacity of corporate PPAs to date: an impressive 7.4GW.[5] This huge supply of projects, 59% of which are solar, has led to bottlenecks in grid connection queues, however, and some summertime cannibalization of prices – showing the importance of negotiating liquidated damages for delay and fully understanding profile risk.

UK

Staying at number four in our index, the UK has experienced quite a shift in the PPA market in the past few months, because of some surprising results in the government's latest Contracts for Difference auction: No offshore wind projects bid in because recent increases in offshore costs made the low clearing price unviable, so 1.5GW of onshore wind, and 1.9MW of solar photovoltaic (PV), won awards instead. Consequently, a large number of onshore wind and solar projects were taken away from potential corporate PPAs, thinning liquidity in the market and placing some upward pressure on prices.

Sweden

Sweden has jumped up two ranks into the top 10, as it continues to see appetite from corporates in the region. Although predominantly a wind market, historically, 7% of Sweden's 4.2GW PPAs to date have been solar PV.[6] This proportion is expected to rise because of the scarcity of solar-shaped generation in the Nordic mix and much higher prices in the sunnier southern grid regions of SE3, and especially SE4, compared with the windy north – SE1 and SE2 – with much lower prices.

Canada

Canada has entered the index for the first time as the number of corporate PPAs build in the Alberta market. There have been at least five deals in the past year covering 500MW, four from onshore wind projects and one from solar PV. Typical tenors are 15 years in length. It is hoped that other provinces may follow Alberta's direction in terms of opening up for corporate PPAs, further extending the growth across the rest of Canada.

See page 25 for PPA methodology.

Renewables highlights from around the world

Amid a backdrop of subdued economic activity and rising geopolitical tensions — and with 2030 on the horizon — markets are assessing their progress toward achieving their net-zero targets. Here, we look at key developments within 10 global markets — from Australia's plan to build one of the world's largest batteries to Poland's first offshore wind project.

1
No change
RECAI ranking

3
No change
RECAI ranking

4
Up 1
RECAI ranking

5
Up 2
RECAI ranking

7
Down 3
RECAI ranking

15
Up 2
RECAI ranking

19
Down 1
RECAI ranking

31
Down 3
RECAI ranking

32
Up 1
RECAI ranking

40
Down 1
RECAI ranking

1

No change

RECAI ranking

US: Solar surge to add record production capacity

The US solar sector is booming, with the market expected to add a record 32GW of production capacity in 2023,[7] up 53% from the new capacity added in 2022. Financial incentives from the Inflation Reduction Act (IRA) have been cited as the key driver for this growth.

With increased investment in domestic manufacturing, the US could see production of solar photovoltaic (PV) components expand tenfold by 2026 if all the planned factories are built. With the expansion of domestic module manufacturing, the market's solar module supply looks to be stable for the years ahead.[8] Moreover, as the policies outlined in the Inflation Reduction Act (IRA) come into play, Wood Mackenzie projects a remarkable growth trajectory for the sector. It anticipates that the total operating solar capacity will surge from the current 153GW to a staggering 375GW by 2028.[9]

Offshore wind has stumbled, however. A combination of inflation, higher financing costs and supply bottlenecks have contributed to low developer interest, and a number of projects being reassessed, with some developers canceling offtake agreements and others attempting to renegotiate terms. Wind power costs have risen by as much as 30% since the start of 2022, and pressure is now mounting on the government to ease requirements for subsidies provided in the Inflation Reduction Act (IRA).

The US has ambitious plans for its fledgling offshore wind sector and is seeking to add 30GW of capacity by 2030. Currently, it has no large-scale commercial wind farms in operation; however, Vineyard Wind 1 and South Fork are expected to deliver their first power before the end of the year, and a couple of dozen projects are in development. If the US can reach its 2030 goal, it will have enough energy to power 10 million homes. Without reforms to tax credits, however, current headwinds are starting to make its lofty goal appear unreachable.[10]

3

No change

RECAI ranking

China: Solar and wind lead charge to smash 2030 targets

China's transition to net zero is accelerating rapidly, with the market on target to easily reach its renewable installation targets by 2030. By the end of this decade, its utility-scale solar and wind power capacity is expected to double from its current level and surpass its 2030 target of 1.2TW of wind and solar capacity in 2025, five years early.

At the end of the first quarter of 2023, 228GW of utility-scale solar was online, representing more than 50% of the global utility-scale solar capacity. Another 379GW of solar power is under construction, and the market's combined offshore and onshore wind capacity has passed 310GW. This is roughly equal to the combined wind capacity of the other top seven markets.[11]

In 2022, investment in solar power skyrocketed by 232% to reach CNY286.6b (US$39.2b). Fitch Ratings believes this robust growth in renewable-capacity installations will continue, supported by energy transition needs and decreasing project costs. China's investments in generation assets rose by 54% year on year in 1H 2023, to CNY332b (US$45b), with 64% in solar and wind. Wind and solar power supplied about 17% of its total power consumption in 1H 2023, exceeding the 2023 target of 15.3%.[12]

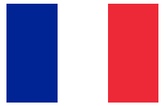
China has targets to source 33% of its power from renewable energy by 2025 and to reach net zero by 2060. If it can achieve its net-zero target, climate experts believe it could curb global warming by 0.2°C to 0.3°C this century.[13]

China has also launched its green power certificates, with projects granted a certificate by the government for each megawatt hour of renewable power produced. All wind, rooftop, ground-mounted and concentrating solar power systems, geothermal, biomass and ocean energy developments are eligible for the certificates, which are valid for two years and can be traded in for payments by the government.[14]

4

Up 1

RECAI ranking



France: Massive 10GW offshore wind tender proposed

France is in the early stages of developing its offshore wind sector, as it looks to accelerate uptake of renewables to reach its climate targets. The market's energy transition minister has said an offshore wind auction of "unprecedented size" will be held after maritime spatial planning and zoning, which is expected to be completed by September 2024. The French government has not indicated the size of the tender, but industry body France Renouvelables has proposed a 10GW tender.

Paris has also indicated that it will use contract for difference style auctions for future offshore wind allocations. A target of 40GW of offshore wind by 2050 has been set, with a 2030 goal of 18GW – an ambitious endeavor considering France's offshore wind capacity was 482MW at the end of the second quarter of 2023.

France is updating its energy and climate programming law to incorporate EU climate targets. Near-term goals have already been set, with the market vowing to quit coal use and produce one million electric vehicles and heat pumps annually by 2027. It has also committed to go from 60% fossil fuels to 40% by 2030.[15]

France must triple its use of renewable energy by 2035 to reach its EU climate targets. In addition to rapidly developing its offshore wind sector, it wants to increase its onshore capacity from 21GW in 2022 to 35GW by 2030, while almost quadrupling its PV solar capacity from 16GW to 60GW over the same period.[16]

5

Up 2

RECAI ranking

Australia: 1.2GW battery signals breakthrough for energy storage

Australia has granted federal approval for one of the world's largest batteries to be built at the Melbourne Renewable Energy Hub. Developer Equis will now work to secure a notice to proceed with construction of the 1.2GW/2.4GWh battery, planned to start in late 2023, with commercial operations scheduled to begin in 2025.

The enormous battery, which will use lithium iron phosphate batteries, will have the capacity to power more than one million households. It will feature six separate 200MW points of connection to Australia's grid to satisfy different uses and grid responses simultaneously. The project will also include a small solar component and will have the potential to be expanded in another phase, to include hydrogen and battery recycling facilities.[17]

Australia has set a near-term target of generating 50% of its electricity from renewable sources by 2030. At the end of 2022, 35.9% of the market's power came from renewable sources, only a modest increase from 32.5% at the end of 2021. To accelerate its energy transition, Australia will ramp up wind power generation, with the aim of adding 20GW of new wind power by 2030. Additionally, it has earmarked up to AU$3b (US$2b) from the National Reconstruction Fund for renewables manufacturing to combat supply chain challenges in the global offshore wind sector.[18]

7

Down 3

RECAI ranking

UK: Onshore gets a boost as offshore stumbles

Offshore wind flopped in the UK's latest Contracts for Difference (CfD) round in September. For the first time, no power deals were awarded for fixed-bottom or floating offshore wind projects, a huge setbacks in the UK's goal of reaching 50GW of offshore capacity by 2030.

The sector had been warning for months that the terms on offer were too low given the major cost and supply chain pressures that the sector has experienced since the previous auction, when 7GW of fixed-bottom offshore was awarded. Currently, the UK's offshore wind capacity is 14GW, and its offshore sector has been a global leader. However, faced by increased costs of roughly 20% to 40%, bidders expressed hesitancy at the rates on offer.[19]

HM Treasury has held talks with developers and supply chain companies to discuss initiatives to help offset the rise in capital expenditure that is plaguing projects. New support measures could be unveiled in November's Autumn Statement, including capital allowances and a more favorable tax status, such as, potentially, reforming the Electricity Generator Levy on renewables, a 45% tax on revenues above £75/MWh.[20]

After last year's record renewable energy auction, in which 11GW was awarded, just 3.7GW was granted in this year's auction, with solar power receiving 1.9GW of capacity and onshore wind 1.5GW.[21] It marks a change of fortune for onshore wind after the government's streamlining of planning rules, in place since 2015, that had impeded development of new onshore wind farms because a single objection could stop a project from progressing. A new measure to incentivize more onshore projects will also be introduced to allow communities supporting local wind farms to benefit from cheaper energy.[22]

15

Up 2

RECAI ranking

Poland: First offshore wind project attracts record financing

Poland is to begin construction of its first offshore wind farm after a final investment decision was taken to build the 1.2GW Baltic Power offshore wind farm. The project, 23km off the coast from Leba, is expected to be completed in 2026 and will supply renewable energy to about 1.5 million households. With a generation capacity of 4,000GWh of electricity, it will produce the equivalent of about 3% of Poland's current electricity output. The €4.73b (US$5b) project has secured a €4.4b (US$4.6b) loan, the largest financing for a single investment in the market's history.

An offshore wind farm installation terminal – capable of handling and installing wind turbines of 15MW or above – will also be constructed at the Port of Świnoujście and is expected to be finished in early 2025. After supporting the construction of the Baltic Power project, it will be used for other projects in the Baltic Sea, including ventures in German, Swedish and Danish waters.

Meanwhile, Poland's state-controlled energy company ORLEN has been granted licenses for an additional five offshore wind farms that, collectively, will generate 5.2GW of renewable energy capacity.[23]

Poland has also signed a memorandum of understanding (MoU) with Norwegian Offshore Wind, a Norway-based representative body, and the two markets will examine ways to harness collective expertise and share resources to drive innovation and improve the competitiveness of the Polish offshore wind sector.[24]

In addition, Poland has introduced new legislation to increase the proportion of renewable energy sources in its energy mix. The bill removes permit requirements for solar PVs up to 150kW[25] and has changed the 10-times-height distance rule for wind turbine locations to 700m.[26] At the end of June, Poland's installed renewable capacity was 25GW, up 5GW in the last 12 months.

19

Down 1

RECAI ranking

Brazil: Investment ramped up in wind and solar

Brazil is targeting growth in its solar and wind sectors after an August announcement of plans to invest BRL41.5b (US$8.2b) and BRL22b (US$4.3b) respectively. It will build out solar capacity in the states of Bahia, Ceará, Minas Gerais, Paraíba, Pernambuco, Piauí and Rio Grande do Norte, adding 8.6GW of new solar power. The market will also invest in 120 projects that will add 5.2GW of wind power across the states of Bahia, Ceará, Paraíba, Pernambuco, Piauí and Rio Grande do Norte.

In addition to solar and wind, Brazil will develop 20 small hydroelectric projects as part of the third edition of its Growth Acceleration Program. The program will also earmark BRL89b (US$17.5b) for transmission projects to increase renewable generation capacity by up to 70%.[27]

Brazil is in the middle of regulating the development of a carbon credit market. A bill, which was unanimously approved by the senate, will now be debated in the lower house. Under the proposed legislation, all companies that issue more than 10,000 tonnes of CO_2 per year will be entered into the carbon market. Companies that do not reach their greenhouse gas reduction targets will be able to buy credits from others that do reduce their emissions. The purchase and sale of the carbon credits will be conducted on stock exchanges.[28]

31

Down 3

RECAI ranking

Egypt: Moves to accelerate pace of low-carbon transition

Egypt has brought forward its target of generating 42% of its energy from renewable sources from 2035 to 2030, as part of its updated Nationally Determined Contribution climate plan. To expedite the achievement of this goal, Egypt will seek grants and soft financing of €500m (US$526m) as it aims to add 10GW of new renewable energy.[29]

During the current fiscal year, the North African market is targeting investment of more than EGP81b (US$2.6b) and will add US$2.2b in public investment to boost the renewables share of its energy mix to 11.8%. The market has also hinted that it plans to enforce legal frameworks for the renewables sector to attract more investment.[30]

With an abundance of sun and high wind speeds, Egypt aims to build on its position as a regional energy hub and export wind and solar energy to the UK via subsea cables. Wind speeds can reach 10.5m per second along the Gulf of Suez, helping the market produce 1.64GW of wind energy in 2022. Egypt already boasts a 250MW interconnector with Jordan, as well as an 80MW interconnector with Sudan.[31]

32

Up 1

RECAI ranking

Philippines: Law change boosts outlook for solar PV

The Philippines is seeking to unlock its huge solar potential, with reforms to foreign ownership laws spurring growth in commercial and industrial solar power.

In December 2022, changes to the Renewable Energy Act removed the requirement for 100% Filipino ownership of certain renewable energy assets, and spurred solar PV development. This, combined with a liberal energy market and the only spot market in the Association of Southeast Asian Nations (ASEAN) region, is making the Philippines a popular choice for solar developers. The regulatory framework for permits has also been streamlined and there is a greater degree of freedom to operate in the market compared with monopolies in other ASEAN markets.[32]

In October, the Philippines' first canal-top solar irrigation project came online, and more than 140 solar-powered irrigation projects are expected to be finished before the end of the year. A further 180 projects are in the pipeline for development in 2024.[33] In August, plans were also announced to develop 1GW of floating solar power on the market's largest freshwater lake, Laguna de Bay.[34]

However, some obstacles to solar power's growth in the Philippines still exist. Slow construction of transmission lines, and the market's archipelagic geography, means it lacks a developed grid to connect large-scale solar PV plants to the network. This is forcing the Philippines to focus more on developing mini-grids and standalone clean power systems.[35]

40

Down 1

RECAI ranking

Saudi Arabia: Rapid acceleration needed to reach renewables target

Saudi Arabia is moving its renewable energy sector forward, with 22.8GW of projects in development as of October 2023, 2.8GW of which are expected to be operational by the end of this year.[36]

The Kingdom has indicated it will embrace all sources of renewables, and study emerging technologies carefully, to achieve its national targets. In October, it signed an MoU with India for green hydrogen, electrical interconnections and supply chains. Under the agreement, the markets will cooperate on the exchange of electricity in peak times and during emergencies, the co-development of projects and the establishment of resilient renewables supply chains.[37]

Saudi Arabia also revealed in September that it is in discussions with a Chinese solar materials manufacturer to build an overseas factory in the Kingdom. This will be capable of producing 120,000 tons of polysilicon annually, a crucial material in the solar PV supply chain.

The share of renewables in Saudi Arabia's installed electricity generation capacity has soared more than twelvefold since 2020 – but, despite this terrific growth, it still accounts for only 1.3%. With its current renewable energy generation capacity at just 1.2GW, Saudi Arabia will need to bring online 50 times more green power capacity in just seven years to reach its ambitious 2030 target of 58.7GW of renewable energy generation.

Recognizing the steep acceleration required to meet this goal, the Ministry of Energy has said it expects Saudi Arabia to invest US$293b in renewable energy projects by 2030, with significant funds earmarked for upgrading distribution networks and transport lines.[38]

Where the wind blows

Stormy waters surround the offshore wind market. Will they bring about a paradigm shift in how we fund and build large-scale energy projects? And what could this mean for investors?

In brief

- After years of success, offshore wind is at a crossroads in its development, as spiraling costs and supply chain issues force developers to reassess projects.
- Surprising results from recent contract auctions worldwide suggest factors other than price should be taken into account when assessing bids.
- Governments must ensure a regular flow of new projects, and adjust subsidies and budgets to market changes, so developers get a reasonable return on investment.

On 12 July 2023, you might just have heard sharp intakes of breath the world over as the results of Germany's first dynamic offshore wind auctions were announced. The winning bidders promised to pay €12.6b (US$13.46b) for the rights to build offshore wind projects in the North and Baltic Seas – ventures that are expected to contribute 7GW of clean sustainable energy to the German national grid, enough for more than six million homes.

A couple of hundred miles away, another auction was taking place that would produce another significant number: zero. On 8 September 2023, it was announced that the UK's fifth allocation round (AR5) for sustainable energy generation had failed to attract a single bidder for offshore wind contracts, despite offering similar locations and climatic conditions as the German sale.

Other signs of turbulence are appearing too. Projects in late-stage development are being put on hold by developers who say they can no longer make a return on their investment. The reasons behind this tell us much about the complexity of the offshore wind market and hint that a change might be in the air.

US$280b

amount that cost inflation could add in capital expenditure for the offshore wind sector (excluding China) over the next decade.

Rising project costs

Until recently, offshore wind was widely seen as a runaway success: Ever-declining construction costs, attractive government subsidies, low interest rates and an insatiable demand fed by stringent net-zero energy targets have given investors, developers and manufacturers a great environment in which to do business.

The risk and volatility caused by the continuous pressure to be bigger, better and cheaper, compounded by supply chain imbalances on the back of the COVID-19 pandemic and the war in Ukraine, have, however, created uncertainty with the economics of projects and squeezed margins in the supply chain.

Turbine manufacturer Siemens Energy reported profit before special items for the third quarter of 2023 of negative €2.048b (Q3 FY 2022: negative €222m). While this was mainly driven by quality issues of certain onshore platforms, challenges in the offshore business related to "increased product costs and ramp-up challenges" contributed to it.[39] Margins for turbine manufacturers (and for the industry as whole) were squeezed when input costs (such as steel and labor) increased in an unprecedented way, making it difficult to hedge. This has led to a substantial re-pricing of supply and installation contracts as original equipment manufacturers try to rebalance their books. Cost inflation could add around US$280b in capital expenditure[40] for the offshore wind sector (excluding China) over the next decade – a gap that can only be bridged by higher offtake prices, funded directly by consumers or indirectly through additional fiscal and tax incentives.

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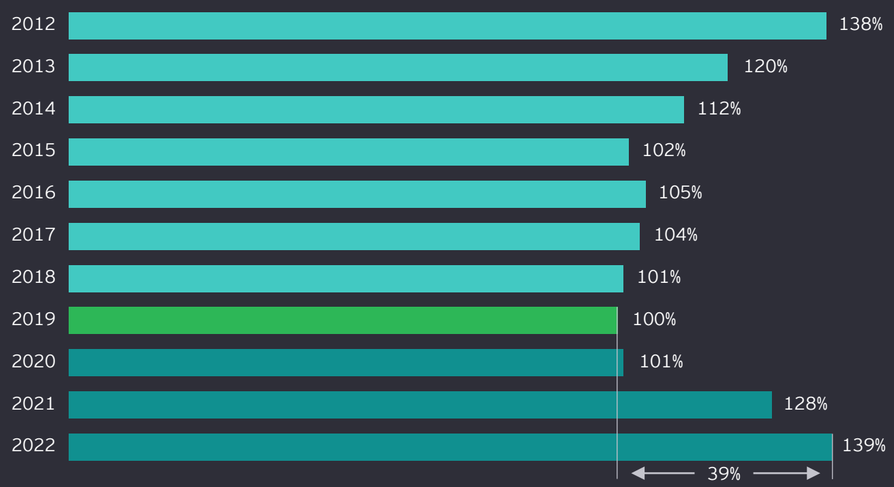
Wind turbine costs have jumped 39% since 2019 due to supply chain constraints and rising raw material costs

Average wind turbine equipment costs have increased **39% in the last three years**. This trend reverses the decline seen in previous years, with costs falling due to advancements in technology and increased process efficiency.

Change in average per megawatt equipment cost of wind turbine, indexed to 2019



Note: The change in average equipment is the percentage difference in the average per megawatt equipment cost of wind turbine in the respective years compared with the cost in 2019 (base year). In the past decade, the average equipment cost of wind turbine were lowest in 2019.

Source: EY analysis of data from GlobalData.

> “We’ve been lucky to have very low-cost power coming through offshore wind, with the low cost of money and a supply chain that has carried on reducing prices as scale has increased, but the actual cost per hour has now changed. We’ve seen a correction, and that correction is here to stay.
>
> **Andrew Perkins**
> Partner, Corporate Finance, Ernst & Young LLP

Furthermore, the impact of rising interest rates on project economics cannot be underestimated. “Offshore wind is a mature technology and a product of the macro environment in which it sits,” says Andrew Perkins, Partner, Corporate Finance Ernst & Young LLP. “Policymakers have had it very good up until now – as have consumers. We’ve been lucky to have very low-cost power coming through offshore wind, with the low cost of money and a supply chain that has carried on reducing prices as scale has increased, but the actual cost per hour has now changed. We’ve seen a correction, and that correction is here to stay.”

The impact is reduced levels of interest in auctions, some canceled contracts, and a refocus on core geographies. All of which will have an effect on the supply chain, which will experience a pinch point when the delayed projects finally make it through to market – along with other new tenders – toward the back half of this decade.

It’s not all about the price

Many auctions for offshore wind projects use a contract for difference (CfD) model, by which participants compete to offer the lowest per-unit cost at which they will sell energy (the “strike price”). It’s a format that encourages value for the taxpayer and provides stability to generators, but the maximum strike price that bidders are allowed to offer needs to reflect current market conditions if bidders are to have confidence. When it doesn’t, we can face the kind of situation the UK found itself in with AR5.

With AR5, the UK government set a maximum strike price of £44 (US$54) per megawatt hour (MWh) for offshore wind,[41] which was not enough to entice developers to bid. Curiously, this was less than the strike prices offered for solar and onshore wind in the same auction.

Anthony Tricot, EY UK&I Head of Generation and Power Markets, explains: “The government has a role in setting auction parameters to ensure they deliver value for money for consumers. The fundamental thing, however, is that this is an auction where you rely on competition to set the price. By setting a low price cap, they prevented the market from clearing at a competitive price.”

Existing CfDs from previous auctions, such as AR4, are also now being looked at through the lens of rising project costs. Investors are asking themselves if they can make reasonable returns or whether they should walk away from the CfDs and seek corporate power purchase agreements (PPAs) or sit and wait for better conditions.

In 2022, for example, Swedish wind energy specialist Vattenfall won the contract to build the Norfolk Boreas wind farm with a joint record-low strike price of £37.35/MWh (US$46.21/MWh). Since then, however, Vattenfall has warned that costs for equipment and construction expenses have increased to the point where the venture is no longer economically viable – up 40% from the CfD decision point – and, in August 2023, it decided to stop development of the project. Vattenfall could terminate its CfD and reapply for another CfD contract in the future if a more attractive strike price can be achieved.

Similarly, Danish energy company Ørsted has warned that it might pause the Hornsea 3 project in the UK – expected to be the world’s largest wind farm when it opens – unless it gets help with surging costs. Hornsea 3 has the same £37.35/MWh strike price as Norfolk Boreas.

It’s not that the sector is fundamentally broken. Other countries managed to successfully conclude offshore wind tenders at reasonable prices. In Ireland, for example, more than 3GW was awarded

in June 2023, at an average strike price of €86/MWh (US$91/MWh). In the Netherlands and Germany, subsidies are not even needed, given their specific circumstances. More recently, Lithuania concluded its first 700MW lease auction with no subsidy available, in which an Ocean Winds/Ignitis Renewables joint venture won with a €20m (US$21m) development fee.

There is a real possibility that the UK government could take the lessons learned from AR5, increase the strike price ceiling to match the current reality, revise its budget, and oversize the next auctions, AR6 and AR7. This would minimize the material delays and supply chain disruptions that will otherwise be created by AR5 (and potentially AR4) delivering next-to-zero megawatts.

In theory, future UK auctions could also see a move away from a price-only format toward the inclusion of non-price factors for seabed leases or for CfDs, as happens already in markets such as Germany, the Netherlands and France. At some point, it might be in the sector's collective self-interest to do this, to deliver true benefit to society in terms of jobs, environmental improvements or system integrations.

And this isn't just a UK issue; challenges exist across the Atlantic in the US, where we also see material price differences across regions and many projects struggling.

Earlier this year, Avangrid terminated the PPA for the Commonwealth Wind project in Massachusetts, paying a US$48m penalty. In addition, Rhode Island Energy canceled an auction where Revolution Wind 2 (owned by Ørsted and Eversource) was the sole bidder, because the price asked was deemed too expensive and not in the best interests of consumers.

Some auctions for US lease areas have also run out of steam. While those off the East Coast attracted record-breaking prices in February 2022, and the Bureau of Ocean Energy Management (BOEM) auctions in California attracted a large crowd (albeit with much lower prices potentially reflecting more challenging conditions), the more recent Gulf of Mexico auctions attracted very low levels of developer interest. On 29 August 2023, BOEM announced that there were only two participants in the auction, bidding for just one of the three areas available. RWE was declared the winner after only two rounds, paying just US$5.6m for the Lake Charles, Louisiana, territory (approximately US$54 per acre) – way below the prices paid for areas off the Californian coast (US$2,490 per acre).[42]

The reasons behind this are complex: US states are subject to different power markets, have their own mandates for renewable energy, and have differing levels of pro- and anti-renewables legislation. The US is also subject to the same global supply chain pressures as the rest of the world, although stringent local content requirements and the Inflation Reduction Act (IRA) could result in developers relying more heavily on a domestic supply chain, rather than importing from overseas.

So, has CfD had its day? Maybe not, but factors other than price may need to be included as the next phase of offshore wind comes into sight. "We need to recognize that offshore wind has matured," says Perkins. "Bidders need to be assessed in terms of delivery risk, their business plan, their supply chain contracts and their balance sheets – everything else. These contracts shouldn't be won just on price."

Chained by the supply chains

Given the current market conditions, projects are being delayed in the expectation that construction costs will reduce and revert closer to historical levels. Globally, 24GW of offshore wind projects that have secured a route to market, and are scheduled online between 2025 and 2027, have not yet reached a final investment decision (FID).[43]

Furthermore, around 80% of the 15 markets with offshore wind targets for 2030 are predicted to miss their stated goals. To reach 2030 forecasts, an average capacity of 35GW will need to be installed annually worldwide;[44] less than 9GW of new offshore wind has so far been added in 2023.[45] The climate emergency and associated net-zero targets mean there is an urgent need to ramp up investment in the offshore wind supply chain all around the world.

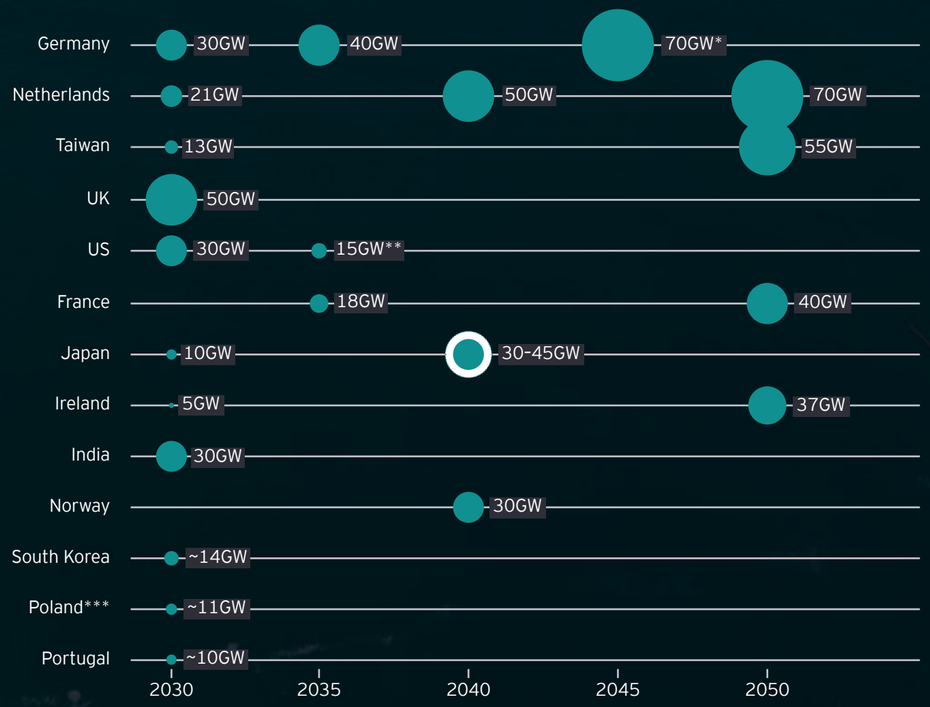
Many investors are also concerned that if the supply chains are built out to satisfy peak installation demand in 2030 (somewhere close to government targets), there will be insufficient demand to support it after 2030.[46] And the FID delays observed now only make things worse. More certainty is required after 2030 in terms of targets and planning by governments to smooth out deployment to realistic levels and provide the long-term visibility needed to support more investments in manufacturing capacity. Even so, without extra support such as tax breaks, debt financing schemes or specific industrial policies supporting the whole value chain, it is unlikely that factories and ships will be built fast enough.

80%

proportion of the 15 markets with 2030 offshore wind targets that are predicted to miss their goal.

More than 500GW of combined offshore wind capacity is targeted by 2050

Key regions with ambitious offshore wind targets



Illustrative only.

* Greater than or equal to 70GW.
** Floating offshore wind target.
***Poland has set a target of 10.9GW for 2027.

Note: Rest of the world has a combined target of 39GW. The countries include Columbia, Greece, Spain, Vietnam, and regions of Canada and Australia.

Source: EY analysis of data from Global Wind Energy Council.

The US and Europe are likely to see supply bottlenecks for turbines and components as early as 2025, as the positive impact of the US Inflation Reduction Act (IRA) is felt. Increased ambition in Europe, continued rapid buildout in China Mainland and large developing markets speeding up their deployment are also factors at play.

One challenge – until at least 2035 – will be to secure enough of the critical materials and metals essential to turbine manufacture. These are at high risk of supply disruption.

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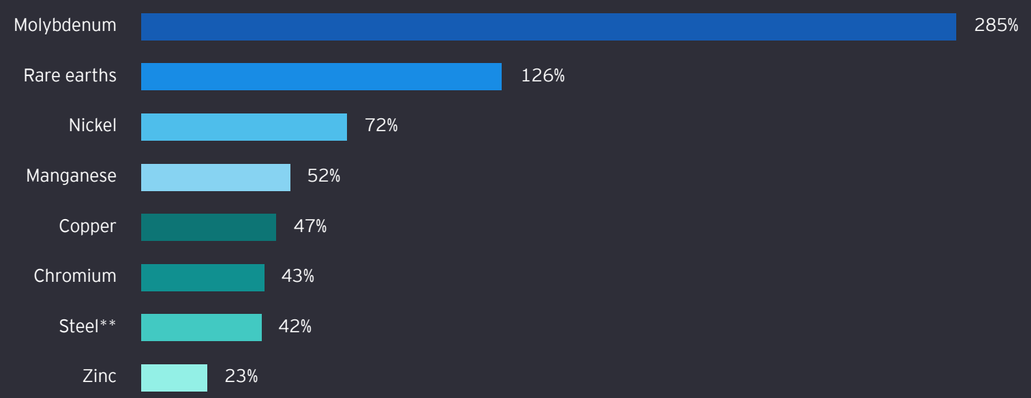
The average price of eight key materials needed to build a wind turbine have increased by ~86% since 2020

A major driver of cost escalation is the increase in the price of critical materials required to manufacture wind turbines. Beyond the steel used to build the tower, the most significant materials requirements for a wind turbine are chromium, copper, manganese, molybdenum, nickel, rare earths and zinc.

Increase in wind turbine material prices 2020 to 2023*



* January 2020 to March 2023 (except steel).
** Steel percentage is the change in steel prices based on the average of US HRC Domestic and China HRC Export prices between January 2020 and August 2023.

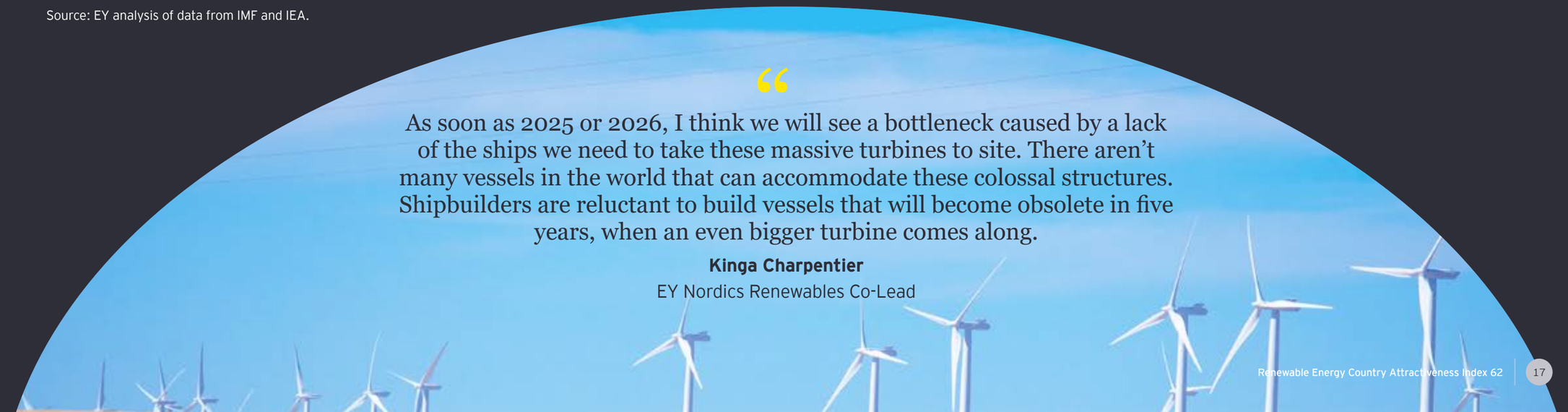
Source: EY analysis of data from IMF and IEA.

It's fair to say that the offshore sector has also become a victim of its own success. It has driven down costs in a kind of "race to the bottom," aiming to make turbines not just cheaper, but also bigger. In July 2023, the world's largest wind turbine – featuring 123m-long blades and capable of producing 16MW – began testing off the coast of China's Fujian province.

The problem with a race to the bottom is that, eventually, you reach the bottom, and can't go any further. A common complaint from the offshore wind supply chain is that it doesn't have time to recoup the costs of R&D before more is demanded by developers – all of whom are looking to gain a competitive advantage over their neighbors down the coast.

"Turbine manufacturers are constantly being pushed to produce new, innovative turbines – bigger turbines," says Perkins. "That doesn't just mean their return is poor; they are also unable to pass on economies of scale or value to others in the supply chain. Developers think that they are getting good value because they are getting a turbine that is bigger and better and can beat someone else's, but this is just driving up R&D costs, labor costs and vessel costs, and squeezing the turbine supply chain so there's no money in it."

These ever-increasing turbines not only need larger and stronger structures to support them, but also bigger warehouses, ports and ships to store and transport them. "As soon as 2025 or 2026, I think we will see a bottleneck caused by a lack of the ships we need to take these massive turbines to site," says Kinga Charpentier, EY Nordics Renewables Co-Lead "There aren't many vessels in the world that can accommodate these colossal structures. Shipbuilders are reluctant to build vessels that will become obsolete in five years, when an even bigger turbine comes along."



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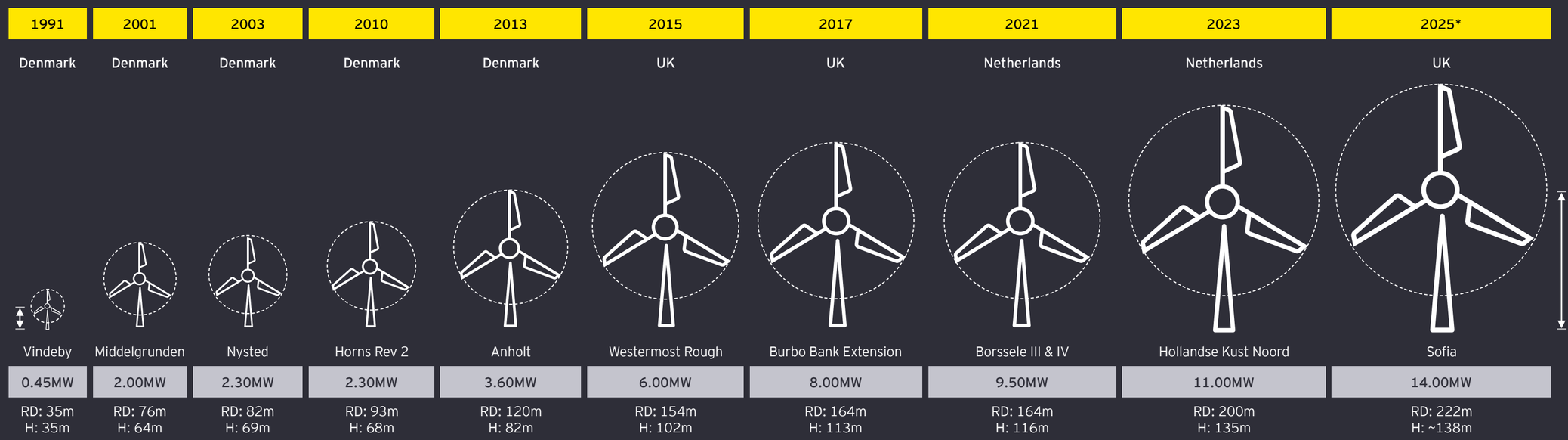
>
> **Kinga Charpentier**
> EY Nordics Renewables Co-Lead

Offshore wind turbines expanding in size

Offshore wind turbine size has increased exponentially in the last decade. The rotor size has increased by 185% since 2013, and the hub height has almost doubled. This has increased the electricity generation capacity per turbine, by ~400%.

Illustrative only



* Under construction.
Note: The infographics do not include the prototype or demonstration projects, which include Vestas 15MW offshore wind turbine prototype in Denmark (V236-15.0 MW) as well as the testing of 16MW wind turbine (MingYang Smart Energy MySE 16-260) and unveiling of the 18MW wind turbine (CSSC Haizhuang H260-18MW) by Three Georges Energy in China.

Source: EY Knowledge analysis of data from publicly available media articles.

Where does the supply chain go from here? Perkins believes "it's for industry to recognize the increase in long-term commercial risk as turbines get bigger, and to change. To say, 'OK, we want these things to work and to be cost-effective in the long term. Let's recognize that these turbines need to operate at a high level and be financeable, so let's not necessarily go for the cheapest deal possible – let's put constraints around it.'"

Could governments put a limit on the size of offshore turbines to relieve this supply chain tension and give manufacturers more confidence? Some might say such a move would stifle innovation, and one industry player we spoke to described such a move as "completely ridiculous." Others could argue that it might motivate research into how to make turbines more efficient in ways that don't involve scale.

One thing is for certain: The drive toward nationalism and protectionism seen in governments the world over in recent years is not helping the supply chain to become more global. While intergovernmental collaboration might be too much to expect, a different approach is needed to make the supply chain work.

Entering a new chapter

As we move into a new era for offshore wind, it's time to start thinking about value, as well as cost. Nuclear, fossil fuel or offshore wind are the options when it comes to baseload (or pseudo-baseload) power generation. Of these three, offshore wind is highly competitive on price, even with the need to create a regulatory and policy environment that enables offshore wind to be built at a price that offers a fair return to investors.

Jonathan Cole, CEO of specialist offshore wind developer Corio Generation, agrees that offshore wind is still a great place for investors to put their money: "The long-term outlook is very positive; renewable energy has an incredible growth journey ahead of it to meet decarbonization goals, and offshore wind will play a huge part in that. Over this short-term, five- to six-year future, there needs to be a huge exercise in protecting those projects that have got off the ground – that are already agreed and under way. This means price renegotiation with whomever the price setters are."

Charpentier agrees and adds: "There is a new reality now. Price expectations need to be adjusted for investors to be able to get a reasonable return. It's an adjustment that will happen, because people will still need to deploy capital, but it may take a couple of years for the market to readjust."

As we move into offshore wind's new chapter and the sector matures, there may well be casualties, but inefficiencies will be driven out, and new competition (capability, service, quality and asset performance) will enter the space that will benefit the consumer.

Governments need to adapt to support this new, more volatile phase and ensure a regular flow of new projects to market. They need to be quick to react to market changes, adjusting subsidy and budgets so developers can realistically expect a reasonable return on their investments.

Governments should also be seeking ways to simplify and expedite the consenting process, minimizing the time between the award of an offtake and FID. Generators are exposed to risk during this period (construction cost, interest rates, inflation, etc.) until their cost base is fixed.

Finally, subsidy regimes could incorporate mechanisms that mitigate the risks over which developers have little to no control. This could be adjustments to strike prices through construction-related indices (as in Ireland) or to reflect movements in the risk-free rates (as in France). Non-price factors, such as environmental considerations and job creation, could also help ensure these large projects deliver broader benefits to society.

In its new chapter, the offshore sector will not only supply cheaper, greener electricity, it will also help the evolution of the heat industry, green hydrogen production and the e-mobility economy. This is really what we have been investing in for the past 30 years, and now we are at this crucial and necessary point – the point at which the offshore industry grows up and starts delivering on its enormous potential.

Wind-powered hydrogen

Electrification isn't the only way to net zero: Hydrogen can decarbonize what electrification cannot – particularly heavy industry and transport. As well as being a clean fuel, it is a fundamental building block in the chemical industry. Its importance cannot be overstated.

"Green hydrogen" is made with sustainable electricity, used to split water molecules into their component atoms via electrolysis (in contrast to gray hydrogen, made from natural gas or methane, or blue hydrogen that uses natural gas with carbon capture and storage).

It's an attractive prospect for organizations within the petrochemical industry, which have experience and infrastructure that can be directly converted and adapted for the transport and storage of hydrogen. Output from offshore wind turbines could even be used to directly power electrolyzers onshore, near the offshore transmission cable landfall, minimizing the use of a market's national grid, which would attract extra costs.

Hydrogen electrolyzers can also be attached to turbines, working alongside desalination plants to turn seawater directly into hydrogen, which can be piped or shipped to land.

RECAI 62 scores

					Technology-specific scores							
Ranking	Market	Previous ranking	Movement vs. previous	Score	Onshore wind	Offshore wind	Solar PV	Solar CSP	Biomass	Geothermal	Hydro	Marine
1	US	1	●	73.9	58.4	59.5	58.3	46.8	40.8	47.4	39.6	20.7
2	Germany	2	●	71.4	53.4	52.3	56.1	32.4	50.7	38.1	41.4	20.9
3	China Mainland	3	●	71.4	52.5	55.7	61.5	55.0	49.3	24.8	51.0	17.9
4	France	5	▲	70.6	56.2	52.3	54.8	23.9	46.9	39.8	42.1	38.5
5	Australia	7	▲	70.2	53.5	42.4	57.2	47.2	41.8	15.8	27.1	25.7
6	India	6	●	69.2	53.7	28.7	62.7	34.3	43.6	24.8	48.9	20.0
7	UK	4	▼	68.3	57.6	57.6	48.0	15.1	54.8	36.8	39.3	34.8
8	Spain	8	●	67.1	54.0	35.6	54.0	29.2	40.0	15.4	23.2	23.0
9	Denmark	11	▲	66.3	54.1	51.5	47.0	17.4	45.4	16.4	22.3	22.1
10	Netherlands	9	▼	66.1	53.5	48.3	48.8	16.0	51.7	24.8	27.7	16.8
11	Canada	12	▲	65.1	55.8	39.5	48.2	19.9	36.4	26.3	47.9	26.9
12	Ireland	13	▲	63.4	49.6	47.3	46.4	19.7	36.2	17.9	21.9	24.7
13	Japan	10	▼	63.3	48.4	50.7	49.1	18.5	56.6	44.3	37.3	22.6
14	Italy	15	▲	63.2	47.2	40.9	51.1	31.1	42.1	32.3	45.7	18.4
15	Poland	17	▲	62.4	49.1	41.1	49.2	14.0	46.3	20.1	36.4	14.7
16	Chile	14	▼	61.9	51.5	22.4	48.0	55.3	42.7	47.0	45.1	28.0
17	Sweden	20	▲	61.4	49.0	42.6	42.6	16.3	44.3	18.8	36.6	27.8
18	Greece	16	▼	61.1	49.0	30.9	47.9	36.0	43.6	25.5	39.0	15.1
19	Brazil	18	▼	60.8	50.0	31.9	52.5	24.8	49.4	12.9	45.0	18.5
20	Finland	21	▲	60.0	60.1	30.2	37.0	15.7	45.3	15.7	23.1	15.7

RECAI 62 scores

					Technology-specific scores							
Ranking	Market	Previous ranking	Movement vs. previous	Score	Onshore wind	Offshore wind	Solar PV	Solar CSP	Biomass	Geothermal	Hydro	Marine
21	Belgium	24	▲	59.9	51.2	39.5	42.0	18.5	41.5	22.8	25.7	18.1
22	Portugal	22	●	59.7	43.6	24.0	49.3	25.3	40.5	23.2	36.9	23.9
23	Israel	19	▼	59.7	41.8	15.3	54.1	36.4	28.7	14.7	17.7	15.0
24	Taiwan	26	▲	59.1	42.0	47.2	45.9	19.0	29.9	27.2	33.8	29.2
25	Morocco	23	▼	58.8	45.1	17.4	51.1	50.7	25.2	13.9	34.0	13.9
26	Norway	31	▲	58.2	46.1	43.2	39.9	15.8	33.8	18.2	46.7	33.6
27	South Korea	25	▼	57.3	38.3	40.8	48.1	18.2	48.5	16.7	29.3	32.4
28	Austria	29	▲	57.3	46.0	22.5	43.5	14.4	42.5	17.8	42.5	21.5
29	Argentina	30	▲	56.9	50.4	22.1	49.0	31.6	36.7	18.1	35.5	17.7
30	Turkey	27	▼	56.7	48.9	20.6	48.4	23.8	41.6	42.5	45.4	19.6
31	Egypt	28	▼	56.5	47.2	15.8	53.8	36.6	24.6	11.5	23.0	11.5
32	Philippines	33	▲	56.1	42.6	20.5	47.4	19.9	40.2	44.0	41.7	21.2
33	Vietnam	36	▲	56.0	45.4	42.0	44.3	17.6	39.3	13.1	46.6	18.7
34	Switzerland	34	●	55.9	41.3	17.8	44.2	18.5	36.2	25.3	39.0	15.5
35	Mexico	35	●	55.5	42.1	21.3	48.0	24.5	34.9	40.2	35.1	19.1
36	Kazakhstan	32	▼	55.4	49.8	16.2	43.2	18.1	35.0	16.3	41.4	13.8
37	South Africa	37	●	54.3	46.9	20.0	44.7	47.4	31.6	12.5	19.8	20.7
38	Thailand	38	●	54.2	42.7	16.2	44.2	21.6	41.8	16.6	31.7	18.6
39	Romania	44	▲	53.9	41.4	17.2	43.6	13.7	34.6	16.3	34.5	13.7
40	Saudi Arabia	39	▼	53.7	45.1	17.9	46.5	28.1	23.6	15.8	12.1	11.8

RECAI 62 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 the market actively seeking to reduce reliance on fossil fuels?
- 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 Phil Dominy.

Normalized index methodology

With the largest global markets tending to top the core 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 the average of the three preceding years' GDP to produce a "normalized score," the index identifies those smaller renewable energy markets that perform 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 core RECAI but could be doing more to support the green transition.

See the normalized index ranking on page 5.

PPA Index scores

Ranking	Market	Previous ranking	Movement vs. previous	Normalized score (0–100)	PPA Index score	PPA market maturity	PPA future market score	PPA policy score	RECAI score
1	Germany	1	●	100.0	25,458,114.4	74.4	88.2	54.3	71.4
2	Spain	2	●	99.0	25,200,665.6	82.5	89.1	51.1	67.1
3	US	3	●	90.8	23,107,989.4	100.0	55.1	56.7	73.9
4	UK	4	●	82.3	20,946,282.6	73.4	82.2	50.8	68.3
5	France	5	●	78.8	20,067,288.7	64.8	82.0	53.5	70.6
6	Australia	6	●	66.4	16,908,887.9	76.2	54.2	58.4	70.2
7	Denmark	8	▲	63.6	16,183,026.8	58.1	82.3	51.1	66.3
8	Netherlands	9	▲	61.7	15,705,718.6	61.4	76.0	50.9	66.1
9	Sweden	11	▲	58.4	14,871,986.5	63.2	78.6	48.8	61.4
10	Poland	10	●	56.6	14,412,940.2	64.1	64.7	55.7	62.4
11	Finland	12	▲	56.2	14,299,173.4	64.3	70.1	52.9	60.0
12	Italy	13	▲	56.1	14,272,693.3	54.0	82.9	50.4	63.2
13	India	7	▼	48.7	12,408,130.7	63.2	41.8	68.0	69.2
14	Norway	15	▲	42.5	10,810,453.7	57.6	65.0	49.6	58.2
15	Brazil	14	▼	34.5	8,789,615.4	62.5	54.3	42.5	60.8
16	Canada			28.2	7,181,813.4	43.1	50.2	51.0	65.1
17	Ireland	19	▲	26.2	6,657,809.5	51.0	35.7	57.5	63.4
18	Chile	17	▼	21.5	5,484,434.4	43.5	38.5	52.9	61.9
19	Egypt	22	▲	21.2	5,386,356.5	45.2	38.8	54.4	56.5
20	Belgium	23	▲	20.5	5,225,614.0	55.0	31.9	49.8	59.9
21	Morocco	24	▲	19.8	5,052,994.9	39.3	37.1	58.9	58.8
22	Colombia	21	▼	18.9	4,817,710.6	50.5	39.4	49.6	48.8
23	South Africa	20	▼	16.7	4,260,528.5	40.8	36.2	53.2	54.3
24	Portugal	18	▼	16.5	4,205,165.4	20.9	65.8	51.3	59.7
25	Japan	16	▼	16.4	4,167,144.7	26.3	47.5	52.7	63.3
26	Greece	26	●	15.3	3,894,946.4	35.9	35.5	49.9	61.1
27	Romania	28	▲	14.5	3,688,908.0	35.8	36.0	53.0	53.9
28	Thailand	25	▼	12.8	3,270,352.6	40.3	24.3	61.6	54.2
29	Ethiopia	27	▼	12.4	3,155,146.3	36.1	34.6	58.6	43.1
30	Bulgaria			11.2	2,843,785.6	33.9	31.1	55.7	48.4

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 market. Forecast capacity installations and a weighted project pipeline score from 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 RECAI is also factored in as one of the fundamental pillars, because it 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 RECAI.

The RECAI 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.

What EY teams can do for you

A global renewables industry is maturing quickly, shaped by new technologies, new business models and new ecosystems. Opportunities are growing, but so is complexity, which creates uncertainty, risk and delay.

The number of organizations generating renewable energy is growing all the time. And so is the number of investors ready to finance new energy projects and innovation. For organizations intent on playing a leading role in renewables, the ability to move quickly and decisively will become more valuable, but also more difficult.

How do you find the right strategy to lead your organization through the transition to renewables? What's the actionable plan that executes that strategy while making best use of all the tax breaks, incentives and finance structures available? Which new technologies should you back, and to what extent? How do you take what works in one market and scale it globally? What can you learn from what's working elsewhere?

Leaders need decisive answers that point to clear actions, and rapid access to the capabilities that will help them take those actions.

At EY, we're using the combined experience of the EY global network to help you accelerate your transition to the world of renewable energy. We're supporting you to find better answers, take decisive action and move forward faster. We do that by sharing our deep experience in renewables across the globe and providing all the capabilities you need in one integrated EY team — from defining the right long-term strategy, to helping deliver and operate power generation assets, to managing tax incentives and financing structures.

We're committed to changing the way we do business, and we're playing a leading role in efforts to help others change. With EY Global Renewables, you'll be ready to lead your organization through the transition to renewables — and play your role in building the decarbonized, sustainable economy that creates measurable long-term value for everyone.

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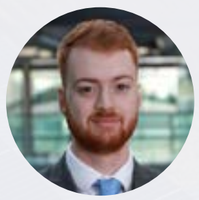

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