

November 2020 | 56th edition
Renewable Energy Country Attractiveness Index

RECAI

If green energy is
the future, how can
technology lead
the way?



The better the question. The better the answer.
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Building a better
working world

Contents

Introduction

A glimpse of what the energy industry might look like in the future was caught this spring, when COVID-19 lockdown measures resulted in the share of renewables used in the energy mix soaring across most countries because of depressed electricity demand, low operating costs, and priority access to the grid through regulation.

In Europe, there were instances of renewables surpassing 50% of the continent's total generation during lockdown. And across the Atlantic, in the US, renewables consumption passed coal for the first time in 130 years.

The pandemic and its impact on economics across the globe seem to have accelerated the drive to net zero and refocused investors' minds on the environmental, social and corporate governance (ESG) agenda and resilience in their investment portfolio, as evidenced by ESG fund assets surging to an all-time high of more than US\$1t in June. At the same time, economic recovery rhetoric from global leaders has a consistent and prevailing theme around green growth. For the low-carbon transition to be accelerated, renewables must stay at the top of the global agenda once the world comes out the other side of the pandemic.

At a policy level, commitment to reach carbon neutrality is growing. Last December, the EU Green Deal was presented, aiming to make Europe climate neutral by 2050, and in September, China – the world's largest emitter of greenhouse gases – made a landmark announcement that it will become a net-zero emitter of

carbon by 2060. In total, under the Climate Ambition Alliance, 120 countries have committed to net zero by 2050.

Reaching a net-zero future will require obstacles to be overcome, however. A coordinated effort across all industries will be needed and technological innovations must be leveraged. Specifically, an exponential increase in intermittent renewable energy will require technologies to be used to ensure a secure, reliable, and well-balanced grid.

This issue touches on two enablers – hydrogen and artificial intelligence (AI) – that look set to play critical roles in stabilizing grids as renewables are scaled up. The ability to convert renewable energy into hydrogen and create a chemical battery with greater long-term storage than utility battery storage could be a game-changer. While batteries are best suited to discharge times of four hours or less, hydrogen energy storage can be used for discharge times of days, or even weeks.

Meanwhile, AI algorithms – with their use of the internet of things, sensors and big data – can help stabilize central grids with improved prediction capability through demand forecasting and asset management, and, consequently, increase dispatch efficiency.

Both of our country deep-dive articles, focusing on Australia and Ireland, highlight the tremendous growth and potential for renewables, while acknowledging the barrier currently posed by grid stability.

The recovery from the COVID-19 pandemic presents an opportunity to build back better. Certainly, there will be headwinds in the short term, but renewables are well equipped to seize the opportunity and face the challenges ahead. Read on to discover how different countries are exploring innovative ways to meet their renewable energy targets and secure a net-zero future.



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recai

November 2020

Methodology

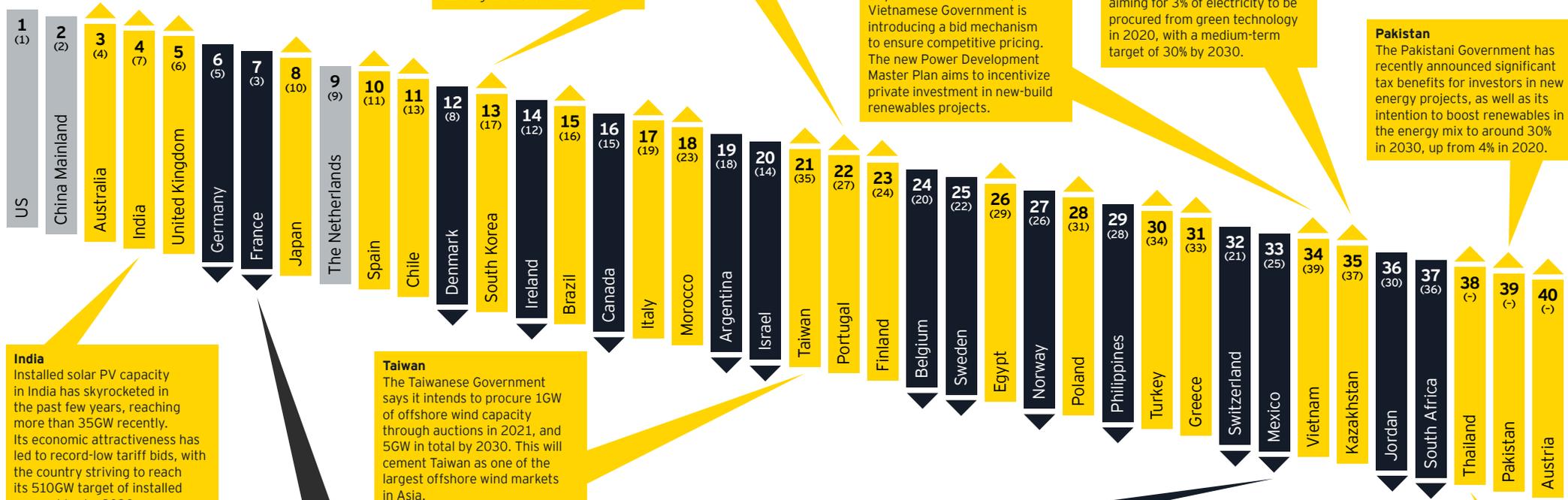
The Index was recalibrated in October 2020, with all underlying datasets fully refreshed. To see a description of our methodology, including how we are accounting for COVID-19, visit ey.com/recai.

LEGEND

- ▲ Increased attractiveness compared with previous Index
- ▼ Decreased attractiveness compared with previous Index
- No change in attractiveness since previous Index

Current ranking is in bold

(Previous ranking is shown in brackets; a dash indicates a new entry)



South Korea
South Korea's offshore wind sector is proving highly attractive to investors following the Government's announcement of its ambitious Green New Deal. This includes plans to reach 20% of generation from renewable sources by 2030, alongside its existing incentive schemes.

Portugal
Portugal's second state-run solar tender received record-breaking bids, with 670MW of new capacity awarded. This will be key for the country's 2030 target of 80% of installed renewable electricity, indicating a clear switch in its energy mix away from fossil fuels.

Vietnam
Beyond the end of 2020, the Vietnamese Government is introducing a bid mechanism to ensure competitive pricing. The new Power Development Master Plan aims to incentivize private investment in new-build renewables projects.

Kazakhstan
The new Kazakh leadership has approved 19 new renewable energy projects in its latest efforts to diversify its supply and meet green requirements. The nation is aiming for 3% of electricity to be procured from green technology in 2020, with a medium-term target of 30% by 2030.

Pakistan
The Pakistani Government has recently announced significant tax benefits for investors in new energy projects, as well as its intention to boost renewables in the energy mix to around 30% in 2030, up from 4% in 2020.

India
Installed solar PV capacity in India has skyrocketed in the past few years, reaching more than 35GW recently. Its economic attractiveness has led to record-low tariff bids, with the country striving to reach its 510GW target of installed renewables by 2030.

Taiwan
The Taiwanese Government says it intends to procure 1GW of offshore wind capacity through auctions in 2021, and 5GW in total by 2030. This will cement Taiwan as one of the largest offshore wind markets in Asia.

France
Following a period of uncertainty caused by the COVID-19 pandemic, several renewable energy auctions in France were pushed back and have yet to be held. The Government has committed to a significant recovery package - with a focus on renewables, sustainability and the production of green hydrogen - to a value of €30b (US\$35b).

Mexico
The Mexican Energy Regulatory Commission's decision to hike transmission fees for operational power projects approved before the 2014 energy reform is under review, and has been suspended temporarily. If the decision is taken to go ahead with the increase, more than 250 renewables projects in Mexico will be adversely affected.

Issue 56 incorporates a number of notable changes:

- The COVID-19 scoring parameter's impact has been reduced by one-third on account of the impacts beginning to be reflected in other datasets. Furthermore, the COVID-19 scoring parameter now reflects the real-world impacts of the pandemic on both a health and economic front.
- Datasets around project pipelines and forecasts have been updated. This change in datasets is partially responsible for some of the movements.
- Our assessment of the enabling infrastructure for renewables now includes more data points and weighting toward the presence of existing and planned storage assets.

Thailand
Thailand's Power Development Plan is being implemented, with an ambitious growth target of around 20GW by 2037 - representing 37% of the national energy mix - as well as a commitment to invest in smart grids across the nation.



| Key developments

The COVID-19 lockdowns briefly shifted the power mix to renewables, but countries now seek solutions to a lasting net-zero future.

Germany boosts offshore wind and hydrogen

In recent months, the German Government has taken significant steps to support the country's offshore wind sector, as well as the development of green hydrogen, an emissions-free alternative fuel created using electrolysis powered by renewables.

Long-awaited [draft amendments](#) to offshore wind legislation were agreed by the German Cabinet in June. Changes include a 5GW increase of the 2030 offshore wind target, to 20GW, and a new target of 40GW by 2040. The draft also includes greater flexibility for auction scheme volumes, to account for future grid connection issues as renewable generation continues to increase to meet targets. To address future hydrogen needs, it establishes a basis for a new legal framework to allow for offshore wind farms without a grid connection, which would be used for green-hydrogen production.

The latest draft of Germany's [national hydrogen strategy](#), published in June 2020, discusses connecting German electrolyzer capacity to other EU states, to use North Sea or Baltic state offshore wind capacity to produce green hydrogen for German consumption.

In September, the German and [Australian](#) Governments also agreed to explore the possibility of cooperating on a green-hydrogen supply chain between the two countries. The joint study will look at production, storage, transport and use of green hydrogen, as well as current technology and research.

In another boost to Germany's green-hydrogen industry, its Ministry of Economic Affairs and Energy awarded the [Westküste100](#) green-hydrogen project an initial €30m (US\$35m). The five-year project aims to build a 30MW electrolyzer connected to offshore wind. It will study equipment operation, maintenance, control and grid compatibility, with the aim of scaling up to a 700MW-capacity electrolysis plant. The consortium behind the project, which includes EDF Deutschland and Ørsted Deutschland, wants to "map and scale a regional hydrogen economy on an industrial scale," producing green hydrogen for transmission in the gas network and use in industrial processes.

In addition, the German Government committed to ending all coal-powered generation in the country by 2038 with the adoption of the [Coal Phase-Out Act](#) on 14 August 2020. From this date, no new coal-fired plants can start operating unless they were granted a license before 29 January 2020. The commitment also amends the German Renewable Energy Sources Act, to raise the country's renewable generation goal to 65% by 2030.

India's solar auction attracts record-low tariff bid

India's April 2020 solar auction had a record-low tariff bid from Spanish developer Solarpack of INR2.36 per kilowatt hour (US\$0.03/kWh).

This was the [ninth tranche of the Interstate Transmission System solar PV tender](#) operated by the Solar Energy

Corporation of India, the company established by the Ministry of New and Renewable Energy to facilitate solar development in the country. The auction attracted international interest, with other winners hailing from countries including Canada and the UK, as well as India.

In July, India's Power Minister, R. K. Singh, set a [new target](#) for the country to reach 60% renewables generation – 510GW – by 2030, extending the 172GW target by 2022. He made the announcement at the launch of a report, by the Energy and Resources Institute, that argues India can integrate more than 30% wind and solar generation before security of supply and electricity system costs are affected.

France's subsidy-free PPA market has an active summer

Despite low wholesale power markets, several deals were signed in France's subsidy-free power purchase agreement (PPA) market over the summer, and a landmark offshore project finalized financing.

Transport company SNCF Mobilités signed a 25-year PPA for 150MW of solar power with French producer Voltalia in June, the first of its size and length in France, [according to the developer](#). The deal will support the construction of three new solar facilities, with commissioning expected between 2022 and 2023.

Canadian wind producer Boralex has also signed offtake agreements in recent months – one in July with telecommunications company Orange France and another

in September with French retailer Auchan. The **Orange deal** will give the company the full 39MW generated by Boralex's Ally-Mercoeur wind farm in the Auvergne Rhône-Alpes region for five years from 1 January 2021. And **Auchan Retail France** will take 16MW from two wind farms for three years from January, to supply outlets and warehouses in northern France.

Renewable developer RES and Swiss power company Alpiq **signed a contract** in July to repower a French wind farm. The deal will see the replacement of six wind turbines and increase the park's electricity production by 30%.

In the offshore sector, one of France's first offshore wind projects – the €2b (US\$2.3b), 500MW **Fécamp project**, off the north-west coast – finalized financing agreements in early June.

The **European Investment Bank**, among other investors, committed a €450m (US\$527m) credit line, which will be guaranteed by the European Fund for Strategic Investments (the Juncker Plan). The project is underpinned by a 20-year PPA agreed with the French Government in June 2018.

The French renewables sector will also benefit from the launch of a €100b (US\$117b) **economic stimulus package** by the Government in September. Almost a third of the funds have been earmarked for green projects. The recovery plan will finance efforts to decarbonize industry and develop green technologies, including €7b (US\$8.2b), invested over 10 years, to develop the country's green-hydrogen industry.

Citing the central role of green hydrogen in the recovery plan of France, among other countries, French energy multinational Engie and aerospace company Ariane Group announced plans in October to work on a **joint hydrogen initiative**. The project will look at liquefaction solutions for the heavy-duty and long-distance transportation sector.

China's renewables market sees mixed pandemic impact

China is forecast to add 251GW of new wind before the end of the decade, according to figures from **Wood Mackenzie**, to reach cumulative grid-connected capacity of 461GW by 2029. The research firm points out that developers face several challenges at present; in addition to the termination of national subsidies by the end of this year, the COVID-19 crisis has affected 10% of new capacity additions in 2020.

However, the pandemic has had little impact on China's photovoltaic (PV) solar industry, according to **Wang Bohua**, Vice-Chairman of the Chinese Photovoltaic Industry Association. Speaking about the PV industry in the first half of the year at an **online industry briefing** in July, he said Chinese solar-panel production has grown by 15.7% versus the same point in 2019.

The Netherlands addresses renewables shortfall

Denmark and the Netherlands **agreed to a statistical transfer of renewable energy** in June, to help the latter reach its 2020 green energy target. Under the EU agreement, the Dutch will pay €100m (US\$117m) for 8TWh of renewable energy, with the option to purchase a further 8TWh if it notifies Denmark before August 2021. Denmark plans to use the payment to finance a tender for green hydrogen production projects.

Meanwhile, the Netherlands is looking into ways to improve future renewables generation capacity. In September, Dutch transmission system operator TenneT announced plans to cooperate with the commercial development arm of the UK's National Grid on an **interconnector** to share offshore wind capacity.

The subsea cable would link up to 4GW of Dutch and British offshore wind generation to the energy systems of both countries. It would also allow the countries to trade any spare transmission capacity. The companies want to develop a "pathfinder" project by the end of 2021, with the aim of delivering an operational asset by 2029.

The deal will help both countries reach ambitious offshore wind targets set this year. UK Prime Minister Boris Johnson boosted his country's target by 10GW, to 40GW by 2030, in his **October keynote** at the Conservative Party conference, while the Dutch have pledged to reach 11.5GW of offshore capacity by 2030, before adding 20GW-40GW more by 2050.

Japan sets sail on journey away from fossil fuels

Japan's first **offshore tender** was launched in June, for the 16.8MW Goto Islands floating wind project, which the country hopes will be a catalyst for larger fixed-bottom and floating projects. A supply price has been set under the feed-in tariff regime at JPY36/kWh (US\$0.34/kWh), one of the world's most attractive tariffs. The bid deadline for developers is 24 December, with the winner of the auction to be announced in June 2021.

After last year's launch of a new offshore wind bill, Japan aims to boost development of the sector across **30 potential locations**, with a target of 10GW by 2030. The sector will face challenges though, because Japan's deep waters make floaters the only practical solution for utility-scale offshore wind.

As the nation aims to achieve **carbon neutrality by 2050**, developing affordable floating offshore wind technology will be crucial, as Japan has limited available land and lacks shallow coastal areas.

It is counting on an increase in renewable capacity after announcing, in July, that it will **shut down** about 100 of the nation's oldest and most inefficient coal-fired power plants by 2030, in a bid to reduce emissions. Japan's 144 coal plants currently account for 32% of its energy supply mix, and it is seeking to lower that level to its target of 26% by 2030.

Portugal's record-breaking solar auction includes storage options.

Portugal's second solar auction in August drew developers' attention, and the highlight was **Enerland's record-low price bid** of €11.14/MWh (US\$13.12) for a 10MW lot. The country's **first solar auction** last year also yielded a record-low bid.

Q CELLS was awarded 315MW in August's auction, winning six of the 12 lots available, and other winners were Enel, Audax, Iberdrola and TagEnergy. Although 700MW were available, the final figure stood at 669MW because one batch of 100MW was only awarded 69MW.

The developers now have 15-year contracts with Portugal's national grid operator and perpetual access to the grid, one of the enablers for the low bids.

It was the first auction in Portugal to invite firms to place bids with a storage component included, with eight of the 12 batches awarded to solar-plus-storage projects. The auction's popularity meant that instead of the system paying for storage to be included, the projects committed to pay the system at an average of €37,000/MW (US\$43,400) of installed storage capacity per year. As a result, at least 100MWh of energy storage will now be deployed in Portugal by 2024.

Because of the COVID-19 pandemic, Portugal only held one solar auction this year, but looking ahead to 2021 and beyond, the Government hopes to hold two per year, awarding a total capacity of 1GW per annum.

South Africa moves to ease its power shortage

Seeking to fill its short-term electricity supply gap, South Africa **announced** in September that it would organize a procurement program for 11,813MW of new power infrastructure, including **6,800MW** of renewable energy.

A number of bid windows will now be opened up, including 6,800MW of wind and photovoltaic and **513MW of storage**. Deployment is expected during 2022 and will be an important contribution to halting loadshedding, which continues to plague the nation.

The competition round targets risk-mitigation capacity that will help South Africa fill its short-term electricity supply gap and reduce the use of diesel-based peaking electrical generators. A closing date of 25 November has been set for the tender round.

This follows a **tender**, kicked off in August, for 2GW to come from a range of sources through a request for proposals (RFP) invitation. The tender round is being held under the Risk Mitigation Independent Power Producers Procurement Programme. Projects will need to be in commercial operation by mid-2022 and the proposed technical solutions must be dispatchable and able to provide "a range of support services to the grid system operator."

South Africa estimates the RFP will attract investment in the region of ZAR40b (US\$2.4b).

Mexico's regulatory uncertainty clouds renewables future

A tug of war between state-owned utility CFE and energy generators has engulfed Mexico's energy sector, after CFE published new transmission fees in June, with **increases of up to more than 800%**.

High tension fees, applicable to energy generators with legacy permits, changed from Peso 0.049 (US\$0.0023) to Peso 0.27857 (US\$0.013), a 469% increase.

Medium tension fees were changed from Peso 0.049 (US\$0.0023) to Peso 0.2586 (US\$0.012), a 428% increase, while low tension fees were raised more than 800%, from Peso 0.09799 (US\$0.0046) to Peso 0.8928 (US\$0.042).

Generators obtained legacy permits before energy reforms in 2013. These provided low tariffs as a way to incentivize investment in clean energy, but CFE contends the legacy permits are unfair. The hike in transmission fees has since been suspended, although a final ruling has yet to be made by the Mexican Supreme Court.

Many private energy generators fear the increased fees could bankrupt them, as companies – desperate to cut costs because of the COVID-19 pandemic – could seek to end PPAs that no longer look advantageous.

This follows a **dispute**, earlier this year, between the energy ministry (Sener) and renewables developers over

a policy that placed limits on the number of permits issued for wind and solar projects, and prohibited their construction in parts of the country.

In response to a complaint filed by Mexico's antitrust regulator that this violated free competition, the Supreme Court suspended the policy, although Sener can appeal the decision.

Egypt building back better with wind, solar and infrastructure projects

Egypt was granted a **€225m** (US\$253m) loan from the African Development Bank in June, to support its electricity sector's resilience during the COVID-19 crisis. The loan will help finance Egypt's Electricity and Green Growth Support Program, and will be used partly to address infrastructure gaps and improve confidence among domestic and international investors.

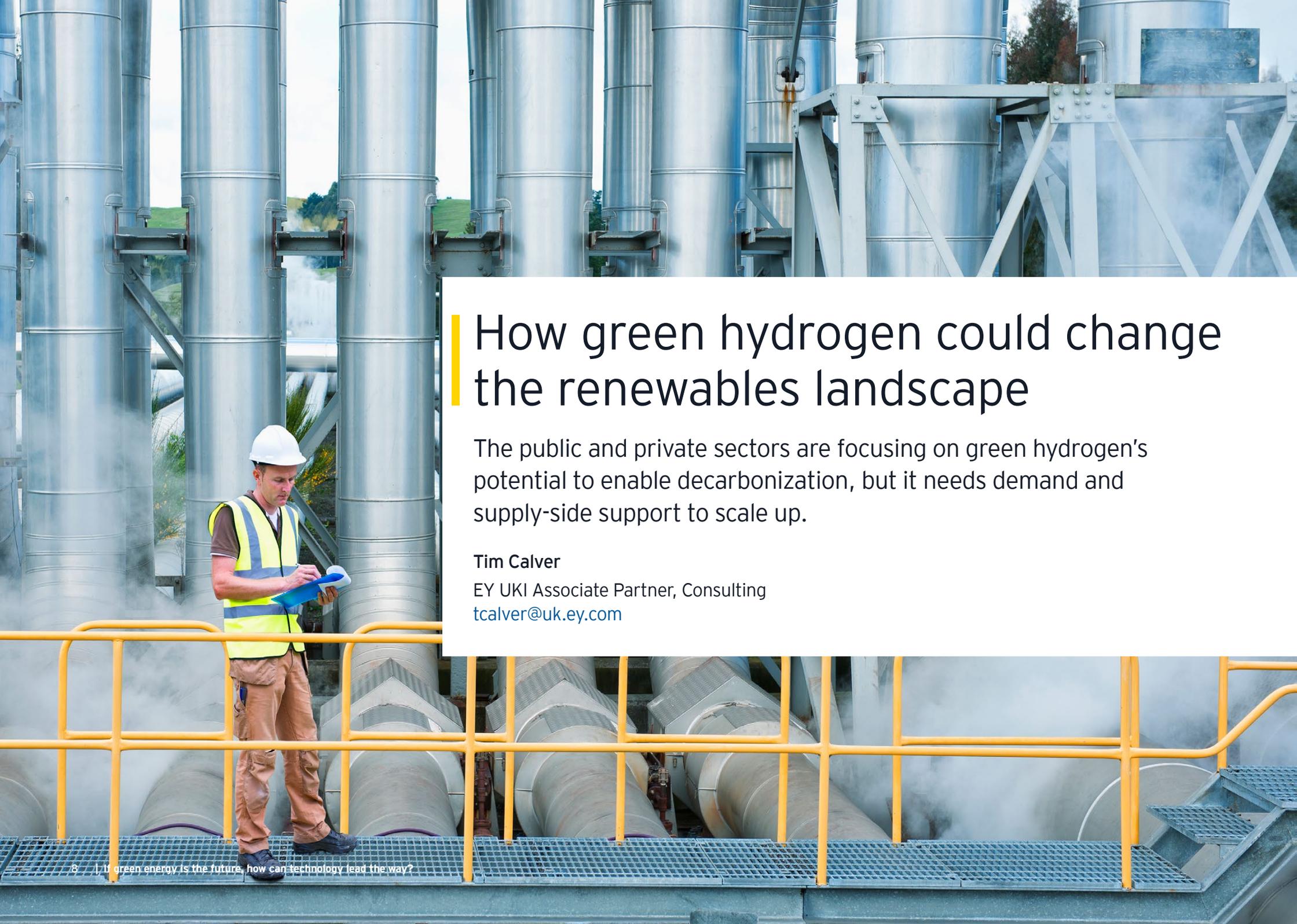
Pressure has been mounting on the nation's energy supply because of a growing population and years of underinvestment in the energy sector due to the 2011 revolution and subsequent fiscal crunch.

However, with an abundance of land, sunny weather and high wind speeds, Egypt is seeking to capitalize on its prime location for renewable energy projects. It is considered a "sun belt" country, with between **2,000kWh/m²/year** and 3,000kWh/m²/year of direct solar radiation. It also enjoys excellent wind along the Gulf of Suez, with

an average speed of 10.5m/s, and the Government has allocated 7,845km² in the Gulf of Suez region and the Nile banks to implement additional wind energy projects.

Egypt currently has about 500MW of wind-power plants in operation, plus three privately owned independent power producers (IPPs) with a generation capacity of 2.5GW. It also has about 1,340MW under development. The Government's renewable energy plan for 2015-2023 has a target of 3.2GW of government projects, including 1.25GW under Build Own Operate models and 920MW as IPPs.

Looking further ahead, Egypt's **2035 Integrated Sustainable Energy Strategy** seeks to increase the supply of electricity generated from renewable sources to 42% by 2035, with wind providing 14%, hydro power 2%, photovoltaic 22%, and concentrating solar power 3%. In total, this would amount to **61GW** of renewable energy. The private sector is expected to deliver most of this capacity, with the Government also seeking to increase the share of local developers.



How green hydrogen could change the renewables landscape

The public and private sectors are focusing on green hydrogen's potential to enable decarbonization, but it needs demand and supply-side support to scale up.

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The EU launched its hydrogen strategy in July, placing low-carbon or clean versions – and in particular “renewable” hydrogen – front and center as an enabler to meet ambitious net-zero targets across the regions.

While the existing market for hydrogen is dominated by “gray” production, which uses fossil fuels resulting in carbon emissions, the EU strategy focuses on the development of «clean, renewable” or green hydrogen. This is produced through electrolysis of water, using carbon-free electricity from solar or wind resources. Another low-carbon option, blue hydrogen, is produced using fossil fuels from which the carbon emissions are captured and stored.

Between now and 2024, the EU aims to install at least 6 gigawatts of the electrolyzers used to create green hydrogen, to produce up to 1m tonnes. By 2030, it wants to have at least 40GW of renewable hydrogen electrolyzers, producing up to 10m tonnes of green hydrogen.

Such targets will require electrolyzer investments of €24b-€42b (US\$28b-US\$49b) before 2030, according to the EU strategy. An additional €220b-€340b (US\$257b-US\$396b) would be needed to scale up and connect 80GW-120GW of renewable energy production capacity to these electrolyzers.

While green hydrogen is the main focus of the plan, blue hydrogen will play a short- to medium-term role in the EU strategy.

Blue will “rapidly reduce emissions from existing hydrogen production and support the development of a viable market at significant scale,” according to the [EU strategy](#). And it calculates that retrofitting enough existing plants with carbon capture and storage facilities to accommodate this will cost around €11b (US\$13b).

Individual European governments, including in France, the Netherlands and Germany, have followed suit in incorporating low-carbon hydrogen into their decarbonization strategies. Exploration of the role it could play in a future low-carbon economy is also taking place in other parts of the world, including Japan and Australia.

The belief that both blue and green hydrogen can play important and complementary roles in decarbonization efforts appears throughout the wave of hydrogen policy released in recent months. However, green hydrogen is beginning to attract more attention from both policymakers and investors because of its long-term sustainability.

With renewables capacity increasing globally and the cost of this power continuing to fall, green hydrogen presents a sustainable way to create and store zero-emission energy for use throughout the decarbonized economies of the future.

Making low-carbon hydrogen more cost-competitive

If green hydrogen is to fulfill this role at scale, it must become cost-competitive with blue and gray hydrogen and other conventional alternatives. According to Hydrogen Europe’s *Clean Hydrogen Monitor 2020* report, the current estimated cost of producing gray hydrogen is around €1.5 per kilogram (US\$1.76/kg) in Europe, depending on natural gas prices and disregarding CO2 costs. Blue hydrogen costs around €2/kg (US\$2.35/kg) while green is currently produced for between €5-€6/kg (US\$5.87-US\$7.04/kg) on average in most EU countries.

The report adds that, for hydrogen to realize its potential in a decarbonized economy, it must be produced “on a mass scale in a sustainable way. For that to happen, however, clean [green and blue] hydrogen needs to become cost-competitive with conventional fuels. Today, neither renewable [green] hydrogen nor low-carbon [blue] hydrogen [...] are cost-competitive against fossil-based hydrogen.”

Multiple studies have shown that low-carbon hydrogen costs are falling. For green, in particular, a Hydrogen Europe analysis based on average wind and solar conditions in individual European countries shows production costs could be as low as €2.9/kg (US\$3.40/kg) when using photovoltaic (PV) in southern Europe and €3.5/kg (US\$4.11/kg) in Germany.

But with costs still as much as two to three times higher than gray in most countries at present, reaching these lower levels will require government support. “Whether it’s blue or green hydrogen, it’s not yet competitive with the fuels it needs to replace – that gap needs to be filled, and policy could do that,” says Allan Baker, Global Head of Power at Société Générale. “Similar to renewable energy development, that whole industry has moved from complete reliance on subsidies to a more commercial regime, and we see the same thing happening for hydrogen.”

The fact that clean-hydrogen development is starting from an earlier point than renewables should also be taken into account, argues Alan Mortimer, Director of Innovation, Renewables, at energy services company Wood. As a result, he says: “In the early stages, some targeted support will be required, including grants and support for infrastructure to increase the volume of activity as early as possible. This will help the market to function and bring costs down efficiently as the industry scales up.”

Decreasing renewable energy prices are a significant contributor to falling production costs for green hydrogen in particular, as are the strides taken to develop electrolyzers in recent years.

“

Similar to renewable energy development, that whole industry has moved from complete reliance on subsidies to a more commercial regime, and we see the same thing happening for hydrogen.

Allan Baker, Global Head of Power at Société Générale

“The cost of renewable power dominates the revenue model [for green hydrogen],” says Dr Graham Cooley, Chief Executive of UK electrolyzer producer ITM Power.

“The cost of the electrolyzer and its load factor are secondary, and the desire of industry to buy the hydrogen once produced is also important.”

This fact has caught the attention of investors, who are becoming increasingly active right along the value chain, but particularly in the electrolyzer space.

“Electrolyzers are probably the most interesting part [of the market],” says Claes Orn, Chief Executive and Managing Partner of Geneva-based wealth management firm Orn & Cie, which manages the Thematica Future Mobility Fund. “This is the backbone of the green-hydrogen economy. It’s at a very early stage, but it’s very promising.”

Christophe Hautin, Deputy Portfolio Manager of Allianz Global Investors’ Climate Transition Fund, which invests in the European hydrogen space, adds: “As investors, we’re happy to see commitments from governments and corporates in Europe to invest significant amounts of money into the sector to develop technology – electrolyzer capacity in particular. That’s what is driving investor interest and the valuation of those companies in the market.” However, he adds: “Subsidies are part of the solution, but certainly not enough to support the development of hydrogen to a large scale.”

Indeed, scaling up production is only one side of the equation; stimulating demand for low-carbon hydrogen production will also be key to its development – and that will require support from industry and policymakers, according to investors.

Helpfully, public and private investment interest in production has also spurred a change in the industry’s attitude towards integrating future low-carbon hydrogen supply. “Because the policy is there, they see incentives coming, and that has really boosted interest in [green] hydrogen recently,” Cooley adds.

Governments are tightening emissions targets, making decarbonizing hard to reach, so high-emitting sectors such as transportation, domestic heating and heavy industry are an increasingly important goal.

Helping green hydrogen reach scale by developing demand.

In the transport sector, large vehicles and public transport networks are ideal candidates for a switch to hydrogen because of the high energy demands and the need for quick refueling. Long-haul trucks have the onboard space to store hydrogen tanks, while fleet vehicles – such as buses and taxis – could use centralized infrastructure for refueling.

Transportation examples such as these can also drive demand and bring down costs in a way that would enable further expansion, says Jo Bamford, owner of energy producer Ryse Hydrogen and Northern Ireland's Wrightbus.

"I have 200 buses going back to a depot every evening – that's demand," he explains. "If I've got demand, I can make production, and if I've got production, I can apply it to the rest of the economy – trucks, trains, ferries, and so on."

However, infrastructure remains "a bit of a weak link" for transportation, says Orn, of the Thematica Future Mobility Fund, although he admits there is "great will" from policymakers and industry to address this issue.

"Infrastructure is extremely important, whether it's pipelines, onsite storage or refueling stations," he says. "We see a lot of possibilities and progress on the infrastructure side. It needs investment, and the focus on the need to scale that up is now growing."

As such, this kind of high-value, relatively low-volume application is expected to be developed regionally, in line with distributed green-hydrogen production, or added to high-volume demand sources to improve economics.

In the power sector, green hydrogen could tackle intermittency issues as renewables' share of generation continues to grow. Converting power into hydrogen creates a chemical battery with more scope for long-term storage than utility battery storage.

"Whether storing wind energy that was generated at night for use the next day, or shifting solar power from the summer into the winter, that could happen at a pretty meaningful scale with hydrogen," says Alex Helpenstell, Strategy Consultant at EY-Parthenon.

While any form of clean hydrogen could be integrated into the power sector, Mitsubishi has launched a US\$3b project to develop three green-hydrogen-ready power plants in New York, Virginia and Ohio. Initially capable of operating on 30% hydrogen and 70% natural gas, they could eventually reach 100% green hydrogen, according to Paul Browning, President and Chief Executive Officer of Mitsubishi Power. Once online, Mitsubishi will then build underground storage facilities connected to pipelines, to enable the plants to transition to hydrogen-only over time.

"We are trying to solve the chicken-and-egg problem where investing in hydrogen is unattractive unless there are power plants to offtake that hydrogen, but no one is going to invest without the infrastructure to supply the

hydrogen," Browning explains, making a point that applies equally to any type of clean hydrogen.

"By starting out with power plants that use 30% green hydrogen we can create economies of scale, enable more renewables, and prepare for a future when we can make the infrastructure investments to fully transition from natural gas to 100% hydrogen and become part of the renewables landscape," he adds.

Pilot projects to inject hydrogen into the natural gas grid are happening in the US, Australia, Japan and throughout Europe. This could present a significant near-term demand source for low-carbon hydrogen, of which a limited amount can be blended with natural gas before existing pipeline infrastructure needs to be upgraded or end-use applications adapted.

The amount that can be blended varies by country. Germany currently allows the **highest volume blend in certain circumstances**, while, in France, a group of gas infrastructure operators has suggested a blend of up to 6% hydrogen could be possible right now without major changes to pipelines and end-user boilers.

In a report on its findings in this area, the group recommended a system-wide target of 10% blended hydrogen by 2030 and 20% beyond. By 2050, the report found, injected hydrogen volumes of up to 40 terawatt-hours (32% by volume) would be possible.

Reaching 100% hydrogen deployment in the gas-infrastructure sector would require large-scale conversion

of end-user appliances, such as domestic boilers, and the development of safety measures for the use of hydrogen in a residential setting. However, blending even 5% would provide a significant source of demand relative to current hydrogen production, especially in the early stages of the market.

There is scope for governments to implement a feed-in tariff mechanism, as is currently used to encourage biogas injection into the UK gas grid, to help establish the existing gas market as a demand source for hydrogen.

Similarly, given the important role he believes clean hydrogen could play in terms of longer duration storage, Browning suggests a combination of state and company requirements for utilities to add more energy storage capacity, “along with incentives in the early days to help offset higher costs as we are deploying this technology and achieving scale.”

He points to the UK’s **contracts-for-difference mechanism**, and the investment and production **tax-credits models** used in the US for renewables development. “Those are familiar incentives that we think could equally apply to storage,” Browning says.

In addition to these specific use cases, such mechanisms could also be used to incentivize investment in hydrogen production and, if applied to some of the rapidly emerging use cases around the world, to stimulate demand. Focusing efforts on developing production and demand in this way is the surest route to bringing clean hydrogen to scale.

Supporting hydrogen development through clusters

Heavy industry presents a high-volume use case for low-carbon hydrogen that could produce the necessary scale to solve the industry’s “chicken and egg” dilemma, according to Jorgo Chatzimarkakis, Secretary General of Hydrogen Europe. He argues heavy industry is the low-hanging fruit that could switch to hydrogen use relatively soon.

Industrial clusters are already being explored as a way to support both production of and demand for low-carbon hydrogen simultaneously. The UK’s Gigastack project, for example, is studying the feasibility of powering an industrial cluster in the Humber region in northern England. The current phase of the project would connect a 100 megawatt electrolyzer to the 1.4GW Hornsea Two wind farm, which is set to be the world’s largest offshore wind development upon completion in 2022. On the demand side, the Phillips 66-owned Humber Refinery would offtake the green hydrogen produced, providing a significant demand anchor for the project. Last February, the project received £7.5m (US\$9.7m) in funding from the UK Government to support this phase.

Explaining the cluster concept, EY-Parthenon’s Helpenstell says: “There would be a single point of production with an anchor industrial demand, shared infrastructure for local refueling and distribution, paired with demand from ships, trains, buses, forklifts and industry operating in the area. Local authorities can support development of hydrogen by creating policies for these zones, leading to an end-to-end market in that space.”



Gigastack aims to identify the regulatory, commercial and technical needs of developing clusters of hydrogen demand in energy-intensive geographic areas, such as ports that have high carbon emissions and multiple potential demand applications. Although this particular project focuses on green hydrogen, industrial clusters can also be used to support blue and green-hydrogen development, with both satisfying the same demand sources using the same infrastructure.



We see a lot of possibilities and progress on the infrastructure side. It needs investment, and the focus on the need to scale that up is now growing.

**Claes Orn, Chief Executive and Managing Partner,
Orn & Cie**

Local governments can apply incentive mechanisms and production models to a specific area where a market can be created and nurtured. Infrastructure can then be built out to a nearby city for transportation, residential heating and power needs.

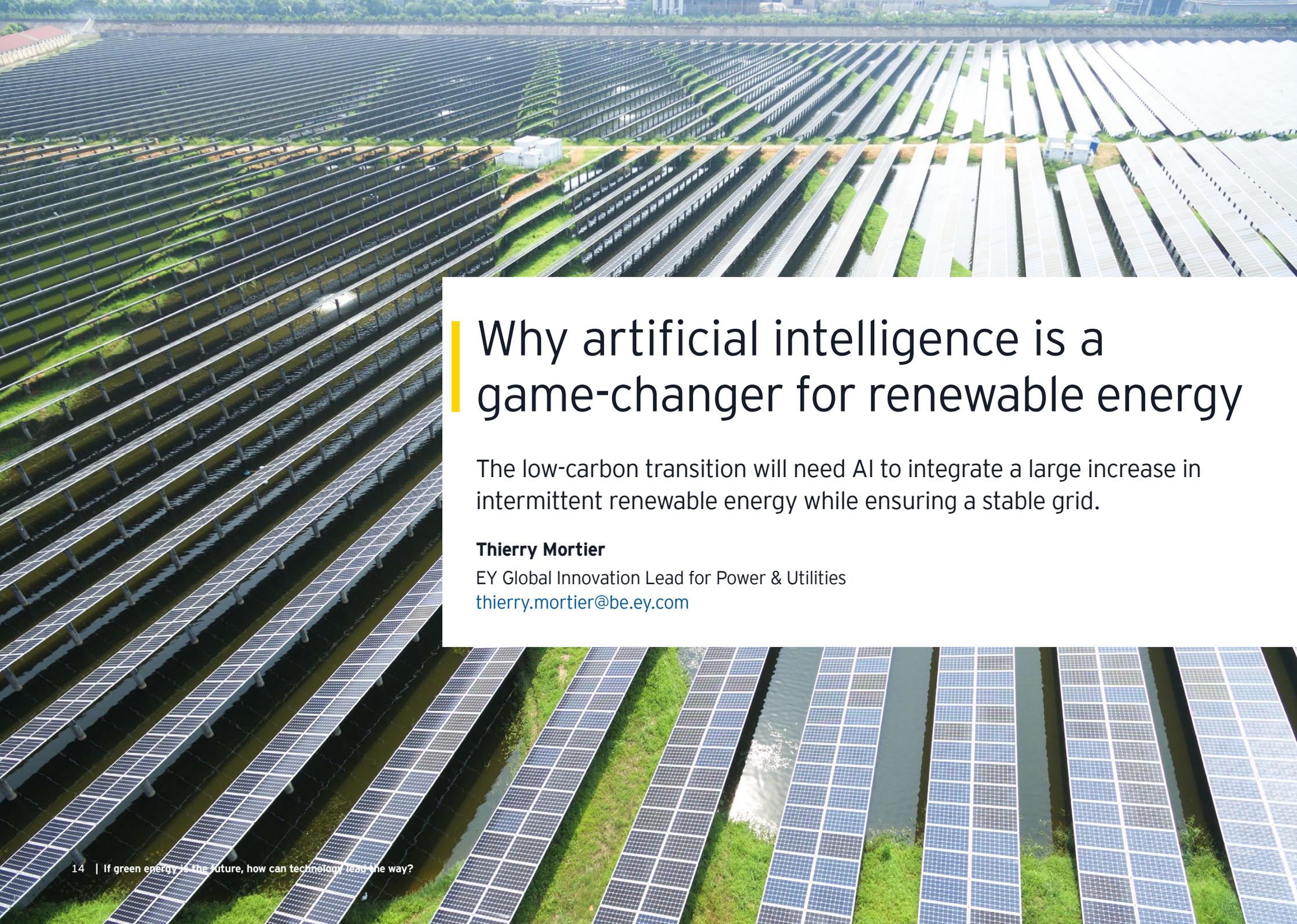
Even further down the line, hydrogen could play a role in helping entire countries to decarbonize. For those with limited domestic renewables resources, this approach could be key to reaching net-zero targets. At the moment, countries including Australia and Japan are looking into possibilities around transportation of liquefied hydrogen.

The [European Hydrogen Backbone project](#) is also exploring an almost 23,000 km pipeline network that would connect future hydrogen supply and demand centers across Europe by 2040. Three-quarters of the network would be converted from existing natural gas pipelines.

The timeline for scaling the green-hydrogen industry will depend on technical and economic factors, including the right Government support to help the industry grow.

Most importantly, large-scale development will depend on coupling renewable generation with growing electrolyzer production capacity and connecting this to a significant demand anchor, such as an industrial cluster. This will help to drive the economies of scale required to bring the hydrogen industry into line with increasingly ambitious government decarbonization targets.

Now that policymakers have recognized hydrogen's potential in relation to decarbonization, supporting such projects will create the right signals to attract private investment to match public funds. This will enable green hydrogen to play a major role in meeting global climate action goals.



Why artificial intelligence is a game-changer for renewable energy

The low-carbon transition will need AI to integrate a large increase in intermittent renewable energy while ensuring a stable grid.

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The energy sector faces pressing challenges and needs to act with urgency. Policy commitments to a net-zero future, such as the Paris Agreement, mean the transformation to a low-carbon economy must come at pace.

Major disruption to the electricity sector is on the cards as governments ramp up renewables and transition away from fossil fuels. While renewable energy looks set to flourish amid this backdrop, its intermittent nature means solutions will need to be found to keep grids stable. Additionally, the industry is changing from a market based on commodity pricing to a market based on technology solutions in order to integrate renewable energy. As the energy industry continues to utilize more variable generation sources, accurate forecasts of power generation and net load are becoming essential to maintain system reliability, minimize carbon emissions and maximize renewable energy resources.

As we move into the Fourth Industrial Revolution, grid operators, developers and consumers are harnessing artificial intelligence (AI), paving a path for a smooth transition to a greater use of renewables. AI's ability to provide better prediction capabilities is enabling improved demand forecasting and asset management, while its automation capability is driving operational excellence – leading, in turn, to competitive advantage and cost-savings for stakeholders.

Supported by other emerging technologies, such as the internet of things (IoT), sensors, big data and distributed ledger technology, AI has the ability to unlock the vast potential of renewables. Failure to embrace it would leave the renewable energy sector falling behind.

AI is far superior to humans when it comes to carrying out complex tasks at speed. Given that an energy grid is one of the most complex machines ever built and requires split-second decisions to be made in real time, AI algorithms are a perfect fit.

How AI is transforming renewable energy

As an increasing amount of megawatts feeds into the grid from variable renewable energy sources, predicting capacity levels has become paramount to secure a stable and efficient grid. This is due to the fact that with renewables taking up a greater share of the grid, there is a loss of baseload generation from sources such as coal, which provide grid inertia via the presence of heavy rotating equipment such as steam and gas turbines. Without grid inertia, power networks will be unstable and susceptible to blackouts. Now, with the application of sensor technology, solar and wind generation can provide an enormous amount of real-time data, allowing AI to predict capacity levels.

Before harnessing AI, most forecasting techniques relied on individual weather models that offered a narrow view of the variables that affect the availability of renewable energy. Now, AI programs have been developed – such as IBM's program for the [US Department of Energy's SunShot Initiative](#) – which combine self-learning weather models, datasets of historical weather data, real-time measurement from local weather stations, sensor networks and cloud information derived from satellite imagery and sky cameras.

The result has been a 30% improvement in accuracy in solar forecasting, leading to gains on multiple fronts. “We found that improved solar forecasts decreased operational electricity generation costs, decreased start and shutdown costs of conventional generators, and reduced solar power curtailment,” says Hendrik Hamann, IBM Distinguished Researcher and Chief Scientist for Geoinformatics.

Forecasts of the base variables – wind speed and global horizontal irradiance, as well as the resulting power output – allows for a view on a range of time horizons, from minutes and hours ahead (for maintaining grid stability and dispatching resources) to day-ahead (optimizing plant availability), to several days ahead (scheduling maintenance).

With increasingly larger data sets becoming available, predictions can now go far beyond the weather to train algorithms to predict more remarkable outcomes. For instance, how much additional power is used during a festive holiday, a large-scale international event, or how much altitude impacts a community's energy use.

For generators and energy traders, more accurate forecasting of variable renewable energy at shorter timescales allows them to better forecast their output and to bid in the wholesale and balancing markets – and, importantly, to do so while avoiding penalties.

“The earlier and more accurately you can predict, the more efficient it is for energy traders to rebalance their position. I see AI providing a way of dealing with lots more sites and using more granular and diverse data than historic forecast methods,” says Alex Howard, Head of Strategy at Origami. “Ultimately, that means making a better financial return.”

For generators and energy traders, more accurate forecasting of variable renewable energy at shorter timescales allows them to better forecast their output and to bid in the wholesale and balancing markets – and, importantly, to do so while avoiding penalties.

Meanwhile, for grid operators, AI algorithms with vast amounts of weather data can ensure optimal use of power grids by adapting operations to the weather conditions at any time. More accurate short-term forecasting can result in better unit commitment and increased dispatch efficiency, thereby improving reliability and reducing operating reserves needed.

“Now, with AI, we can predict more accurately what renewables are likely to do, so we can control other power plants more accurately, like coal plants that take many hours to ramp up,” says James Kelloway, Energy Intelligence Manager at National Grid ESO.

In turn, cost-savings can be passed along. He adds: “What we want to avoid is turning the renewables off. From a price-tag perspective and the way the system is configured, renewables are not only greener, they are usually cheaper.”

Through a grid-stability lens, with AI ensuring that the power grid operates at optimal load, grid operators can optimize the energy consumption of consumers. But it is not only transmission system operators that can utilize AI; its application goes beyond central planning and can play a bigger role on the edge of the grid with machine-to-machine communication. In an ideal situation, electricity generated within a neighborhood grid or solar PV system can be used to improve reliability and combat grid congestion – which is associated with complex, decentralized systems with bi-directional electricity flow.



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Hendrik Hamann, Chief Scientist for Geoinformatics, IBM

Equally important is accurate demand forecasting – and here, too, AI has a key role to play given its ability to optimize economic load dispatch and improve demand-side management. Increasing installation of smart meters has enabled demand data to be sent to utility providers.

AI algorithms can absorb the data, which can be sent as frequently as hourly, and predict network load and consumption habits accurately.

For consumers, utility bills can be reduced, with AI systems predicting a building’s thermal energy demand to produce heating and cooling at the correct times through optimization of home solar and battery systems. Efficiency gains are combined with load shifting to times when electricity is cheapest, with renewable electricity available in the system.

“We can now predict when demand spikes will occur and discharge energy to keep customers’ grid-supplied electricity below a certain set point, and, consequently, help customers control energy costs without interrupting operations or requiring any involvement on their part,” says Josh Lehman, Senior Director of Product Management at US energy storage firm Stem. He adds that the company’s AI-driven software has improved customer savings by approximately 5% year-on-year.

In the all-important flexibility jigsaw, the ability to understand consumers’ habits and actions creates greater flexibility in a smart grid because AI algorithms can make predictions about a building’s energy use 24 hours in advance, based on its experiences in the past.

Battery storage also has an important role to play in providing demand flexibility, with AI again playing a pivotal part. As storage batteries can be activated quickly and used to manage excessive peaks – as well as minimize the back-up energy needed from diesel generators, coal-

fired power plants or other gas-fired “peaker” plants that are utilized at peak demand – AI can predict and make energy storage management decisions by considering forecast demand, renewable energy generation, prices and network congestion, among other variables.

Battery owners can deploy their storage pack according to the compensation for the services provided by the battery. Stem has developed AI algorithms to map out energy usage and allow customers to track fluctuations in energy rate to use storage more efficiently.

In the all-important flexibility jigsaw, the ability to understand consumers’ habits and actions creates greater flexibility in a smart grid because AI algorithms can make predictions about a building’s energy use 24 hours in advance, based on its experiences in the past.

Similarly, US-based software-as-a-service platform provider AMS uses AI in versatile battery storage systems to optimize opportunities to purchase electricity from the grid when prices are low, and then sell back to the market when prices are high. Another case is Australia’s Hornsdale battery, with 150MW, which operates an

autobidder AI algorithm, developed by Tesla, that has allowed the project to capture revenue streams about five times higher than an energy trader, according to AMS.

For electricity providers, AI can also assist with operations and maintenance of asset management. AI algorithms can automatically detect disturbances in real time of mechanical failure, thereby improving reliability and efficiency in the power system. By using data from sensors, algorithms can learn to distinguish and precisely categorize normal operating data from defined system malfunctions.

“Unexpected disruptions across the industry can cost 3%-8% of capacity and US\$10b annual lost-production cost,” says Brian Case, Chief Digital Officer at GE Renewable Energy. Its Predix software is embedded with AI-based algorithms that can interpret industrial data to make predictions on machine health and recommend actions to improve efficiency for assets such as wind farms.

AI’s ability to root out system malfunctions immediately can also prevent a chain reaction. For instance, if one power plant should fail, an abrupt spike can be expected in the load placed on other power plants. This, in turn, slows down the generators, and the frequency decreases. If the frequency sinks below a threshold value, the operator may be required to cut off sections of the grid to maintain system stability. The ability of AI algorithms to make split-second decisions allows for appropriate, fully automated countermeasures to be taken.

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Unexpected disruptions across the industry can cost 3%–8% of capacity and US\$10b annual lost-production cost.

Brian Case, Chief Digital Officer at GE Renewable Energy

Finally, at a regulatory level, AI unlocks legislation to be created more effectively. It also provides insight into human motivations tied to renewable energy adoption and how consumer behaviors could possibly be changed to optimize the energy system.

The challenges of applying AI across the sector

AI’s potential to be a game-changer for the renewable energy sector is undeniable, but that does not mean its greater application across the sector is devoid of challenges.

In today’s digital age, concerns have emerged that relying on AI too much could leave energy networks vulnerable to cyber attacks. A wake-up call came in 2015, when hackers took 30 substations offline in Ukraine, leaving 230,000 people in the dark for six hours. A second,

much smaller attack occurred on a transmission station a year later, in Kiev. It is believed the 2015 attack required months of planning and a team of dozens working in coordination and was largely due to the fact employees fell for a phishing campaign.

Another type of cyber attack on power grids that has been deployed more recently involves exploiting vulnerabilities in firewall firmware. In 2019, the North American Electric Reliability Corporation revealed that the first attack on a US grid network occurred with an undisclosed utility suffering communication outages between its control center and generation sites. The disruption was a result of an outside party rebooting the company's firewalls. Each communication failure lasted less than five minutes, but the entire attack went on for about 10 hours.

However, the likelihood of another successful large-scale attack appears minimal. Operational technology (OT) systems are isolated from information technology (IT) systems, with no network connections between the two, and are, therefore, much more difficult to infiltrate. In addition, OT systems are more customized and esoteric, so they are far less familiar to would-be hackers.

If hackers did get into operations networks, they would need to learn the equipment and setups. Moreover, whatever equipment setup a utility may have, its physical processes can require real expertise to manipulate, as well as months' more effort and resources. Ultimately, experts believe the vast majority of grid-penetration incidents will amount to little more than spear phishing.

From a performance perspective, data bias, audit and ongoing verification of algorithms are issues that AI systems must consider when developing algorithms. Machine learning is ultra-sensitive to poor data, with the adage "garbage in, garbage out" holding true here. It is critical that data is taken and made machine readable, so that it is quality in, quality out. For trusted AI, frequent verification of data is a necessity to ensure algorithms remain valid over time and that as the machines learn they do not deviate from the original algorithms.

Concerns have emerged that relying on AI too much could leave energy networks vulnerable to cyber attacks. However, operational technology systems are isolated from IT systems, with no network connections between the two, and are, therefore, much more difficult to infiltrate.

That is not always as easy as it sounds, however. "AI may have some limitations in areas that don't have the historical data available to find the intelligence, because it has never occurred or existed before," warns Hamann, at IBM. "You can, though, overcome these challenges by using different, more, and more selective data sources, as well as different techniques."

From a technology perspective, reliance on cellular technologies would limit AI's potential in rural and other under-served areas in many emerging markets, particularly low-income countries. Smart meters rely on constant data communication, so a lack of reliable connectivity is a substantial impediment in areas where cellular network coverage is sparse or limited.

As with all new technology, AI is likely to face initial mistrust from consumers. Building owners and occupants are likely to be skeptical that the technology can deliver reductions in either energy consumption or cost without compromising energy services and comfort. Robust education and marketing programs will be needed to convince customers to trust the technology.

Regulatory barriers also exist, including the fact that energy markets' rules must permit the trading of flexible demand at a scale that allows commercial buildings to participate in the market. In some energy markets, for instance, the minimum allowable bids for participating are higher than the size of flexible loads likely to be offered by commercial buildings. In addition, some energy markets require access fees for participation, which might pose a barrier to entry for small-scale participants.

Determining project viability with AI: a case study

For investors and developers, the million-dollar question is whether a prospective project will be financially viable. By using AI, that question is now easier and quicker to answer than ever before.

Investors and developers have long been hamstrung by the opacity surrounding energy data. There is no shortage of open-access data on grids and power-generation assets in the public domain, but developers need validated data to identify technical and financial risks for a prospective project to be profitable.

This is where image recognition – a rudimentary form of AI – can play a huge role in validating open-access data. ENIAN, a UK software firm, boasts one of the world's largest renewable energy project databases, having gathered publicly available data on power plants and grid assets, and their coordinates. The company uses a matching script to run across the data sets, and the AI is trained to recognize what a wind turbine looks like. The AI takes millions of sets of wind-turbine coordinates, and identifies which images and coordinates match up.

AI can then be used in cost prediction, with an enterprise platform simplifying project managers' workflow. With trustworthy data retrieved from image recognition, the platform provides datasets detailing assets' grid connections, distance to nearest substation, existing power-generation assets in the area, and indicators on the performance of assets.

Investors and developers have long been hamstrung by the opacity surrounding energy data. There is no shortage of open-access data on grids and power-generation assets in the public domain, but developers need the ground truths to identify technical and financial risks for a prospective project to be profitable.

Projects are augmented by AI and managers can examine qualitative details such as how many competitors are in the area and if other projects in the area have failed – and, if so, why. The data also reveals solar irradiance and wind speeds for potential sites, as well as an optimal route-selection estimate for connecting a power-generating asset to the grid, so project managers can make quick and accurate models of what a solar or wind farm can yield. An algorithm then produces a preliminary cash-flow model that indicates whether a project is worth pursuing further.

These tools could open up frontier markets – such as Central Asia, for instance, where there is tremendous potential for wind and solar farms – but development has lagged behind. “Very little is known about the grid networks of these countries, and the data you may find is outdated and fragmented. This tool allows us to run a scan and see what is there, and work backward after identifying the site,” says Phillip Bruner, ENIAN CEO.



“There is so much opacity around where, actually, the nearest points of interconnection are, a project’s available capacity, and who the owner is, so having this data without having to rely on third parties is very useful.”

For developers, the name of the game is operational excellence, and automation through AI can allow firms to get a leg up on the competition by identifying profitable prospective projects quicker. The ability to rapidly scale data collection and analysis through automation also frees up time for project managers to focus on getting deals sealed faster, projects started earlier and timelines moved forward.

By augmenting project managers with verified data, projects become more predictable, efficient and cost-effective, and, ultimately, lead to better returns on investment.

While AI has been criticized for its impact on the labor market, focus should be shifted to its ability to free up skilled labor from linear tasks. As Bruner puts it: “AI is coming for the tasks you hate to do, such as spending lots of time processing data and validating data. The machine can step in and do those mundane tasks, so it augments everyone’s capabilities.”

Increasing research and development to bolster AI’s capabilities

AI and its sidekicks of emerging technologies, including IoT, sensors, big data and distributed ledger technology, are game-changers for the renewable energy sector. Key accelerators such as prediction capability through demand forecasting and asset management, combined with increased automation providing operational excellence, are already leading to major cost-savings, better yields and improved returns on investment.

Just as R&D in the solar industry has driven down prices, further R&D in AI has the potential to lower costs drastically, while its capabilities should grow and solutions to its limitations could emerge. Governments are realizing this, too, with the US Department of Energy announcing in August 2020 **US\$37m of R&D funding** for AI. The UK is also funding several new research hubs that will be created to develop robotic technology to improve safety in offshore wind.

“We are now at the point where the most sophisticated market participants are turning proofs of concept into real, scalable applications of the technology,” says Howard, from Origami, adding that he expects these applications to de-risk the area for others.

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Alex Howard, Head of Strategy at Origami

“If we are going to reach a net-zero future, the grid needs to be a lot smarter,” says Bruner, from ENIAN. “It needs to be able to adapt to a lot of different power-generating and power-consuming devices that are interconnected, and that is where AI has the most potential to help renewable energy grow.”

For a net-zero future, AI could be the missing piece of the flexibility jigsaw. Its ability to ensure an efficient and stable grid will be paramount as an increasing amount of renewable energy floods into the grid.



How Australia's vast resources could make it a green energy superpower

Developers and investors are tapping the country's sunshine, land and strong winds to drive a renewables revolution, despite policy issues.

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For Australia's renewable energy sector, there is a renewed sense of optimism. Last year, Australia was deploying new renewables 10 times faster per capita than the global average, and four times faster per capita than in Europe, China, Japan or the US. Another sign of Australia's ambition to lead the renewables revolution is the more than 10GW of roof-mounted solar photovoltaic (PV) deployed, by far the largest per capita rooftop-PV deployment in the world.

Recently, though, the pace has slowed. The COVID-19 pandemic has caused the biggest fall in global energy investment in history, and the Australian sector was not spared, falling off a cliff in the second quarter. Only AU\$600m (US\$429m) was invested in large-scale renewable projects, a drop of almost half from the first quarter, with uncertainty over federal policy and delays in grid connection also to blame.

With Australia reaching its Renewable Energy Target of 33,000GWh by 2020, a year early, incentives are lessening, with new solar and wind farms no longer as reliant as they were on subsidy support. However, a rapidly maturing corporate power purchase agreement (PPA) market is leading a shift in direction and there are predictions aplenty that corporate PPAs will drive investment in renewables throughout Australia over the long term.

Meanwhile, in its [Integrated System Plan](#), grid operator Australian Energy Market Operator (AEMO) forecasts that renewable energy may, at times, provide nearly 90% of electricity by 2035. Growth in utility-scale pumped hydro, large-scale battery energy storage systems, distributed batteries, and virtual power plants will all provide increased dispatchable resources.

With Australia reaching its Renewable Energy Target of 33,000GWh a year early, fewer incentives are required. However, a rapidly maturing corporate PPA market is leading a shift in direction and there are predictions aplenty that corporate PPAs will drive investment in renewables over the long term.

AEMO's optimal development path for the [National Electricity Market](#) (NEM) also suggests solar panels, backed by small batteries, could provide between 13% and 22% of electricity by 2040. In addition, electricity from new large solar and wind farms is expected to replace some 15GW of coal-fired generation that is scheduled to shut.

Clearly, there are high hopes for renewables in Australia, as their use continues to accelerate at a rapid pace. However, currently, renewables still represent a small portion of the nation's energy mix, with fossil fuels accounting for 79% of total energy generation last year.

At the policy level, the opportunity to build back better in the wake of the COVID-19 crisis could provide a watershed moment for the renewables sector. An [EY assessment](#) commissioned by the [World Wide Fund for Nature](#) suggests stimulus programs backing clean energy as a path out of recession would create nearly three times as many jobs for every dollar spent on fossil fuel developments.

However, the Australian Government continues to champion a recovery built on gas, offering AU\$52.9m (US\$37.2m) in funding to unlock more gas specifically for the domestic market. The Government announced it will continue to fund the Australian Renewable Energy Agency with AU\$1.43b (US\$1.18b) over the next decade, but it has overhauled its mandate, shifting investment in solar and wind to hydrogen, carbon capture and storage, microgrids and energy efficiency.

Betting big on battery storage

Grid problems have been causing delays to the Australian renewable energy development pipeline. Project sponsors, regulators and grid operators are starting to realize the importance of the role energy storage needs to play to allow the smooth penetration of intermittent clean electricity. Increased procurement of battery storage projects and the ancillary services they can provide, government funding, and regulatory signals to favor co-location of batteries with generation are some of the top drivers for the country's promising energy storage market.

This year, Australia is set to add 1.2GW of energy storage, more than double last year's total, according to Wood Mackenzie, as developers look to maximize returns from their wind and solar projects.

Power prices look set to drop with the country's trailblazing battery storage expansion. French developer Neoen's Tesla-built Hornsdale Power Reserve – a 150MW/194MWh grid-connected energy storage system, co-located with the Hornsdale Wind Farm – held the title of the largest lithium-ion battery in the world until earlier this year.

In September, the Government of the Australian Capital Territory announced that **Neoen and Global Power Generation** will supply 200MW of wind power to the national capital at record low prices, with the firms also building 50MW and 10MW/20MWh big batteries respectively. For Neoen, it is the first stage of the AU\$3b (US\$2.1b) **Goyder project** that proposes to combine 1.2GW of wind, 600MW of solar and 900MW/1,800MWh of battery storage. Each component will be the biggest of its kind in Australia and, together, the hub will be the largest of its kind in the world.

Australia is set to add 1.2GW of energy storage this year, more than double last year's total, as developers look to maximize returns from their wind and solar projects.

Although surpassed this year by front-of-the-meter, behind-the-meter capacity is expected to grow by an impressive 581MWh. Policy support has been provided, with state Government schemes in South Australia and Victoria offering generous subsidies to help households install batteries to reduce their energy costs, in response to record-high retail prices last year. As a result, comparatively low feed-in rates for exported PV energy and market-competitive energy storage costs have pushed Australia's household storage capacity above 1GWh.

Amid these favorable conditions, the costs of energy storage systems are expected to decline by 27% over

the next five years. By 2025, the levelized cost of electricity of solar-plus-storage and solar-and-wind-plus-storage are expected to be lower than that of gas plants, which should mark a tipping point for Australia's renewables sector.



Targeting pole position in the export market

Australia has long been a net exporter of energy, with predominantly coal and gas equalling to around two-thirds of production. As the country's energy sector transitions to a low-carbon future, however, it seeks to also transform its exports and become a renewable energy export superpower.

At a policy level, a major statement of intent was made in July, when the **Government announced** it will fast-track an ambitious US\$16b 10GW/30GWh solar/battery project that will send 24-hour renewable electricity to Singapore via a 4,500km cable. Granted "major project status" by the Government, developer Sun Cable's Australia-ASEAN Power Link is to be built by the end of 2027.

Although yet to win support from Singapore's Government, the project would consist of the world's largest solar array, biggest battery and longest power cable, providing 3GW of dispatchable electricity. About 3,700km of the high-voltage, direct-current cable would be under the sea and would connect Australia to the planned 16-nation ASEAN power grid, while also supplying power domestically to Darwin. Ambitious expansion plans could result in connections being established from India to New Zealand.

Meanwhile, another mega-project – the 15GW Asian Renewable Energy Hub, backed by Macquarie Bank and energy groups Vestas, CWP Energy and InterContinental Energy – is equally ambitious. With a US\$20b price tag, it will be the world's largest wind-solar hybrid project, with the vast amounts of renewable energy generated used to produce green hydrogen and ammonia for export to Asian

markets. The hub also plans to sell about 3GW to iron-ore mines and liquefied natural gas facilities in Western Australia. Construction will not start until 2026, with the first exports expected one or two years later.

Policymakers have already pledged their support, with the Government agreeing to co-fund an AU\$500m (US\$352m) pilot project in Victoria to generate “blue” hydrogen from coal and store the emissions produced in an undersea basin. The Council of Australian Governments (COAG) Energy Council has estimated the potential value of the nation’s hydrogen export industry could reach AU\$26b (US\$18b) by 2050, transforming the nation into a major force in renewable energy.

The two mega-projects would elevate Australia to a renewable energy export superpower, but it must still be proven to investors that the projects are profitable and there is the know-how to conquer the complex technical challenges posed.

Price volatility and grid stability cloud the picture

While developers and investors are driving renewed growth, and ambitious export plans lie in the pipeline, the sector is facing headwinds on grid stability and price volatility. Renewables projects have been held back by grid bottlenecks and have faced the risk of radical curtailment because of insufficient network capacity and system strength.

Policymakers have fast-tracked [Project EnergyConnect](#), which will play a key role in improving grid stability and reducing energy price volatility. The 330kV above-ground transmission line, with approximately 800MW transfer

capacity, will connect South Australia and New South Wales, with an added connection to north-west Victoria, and should be completed by 2023. In parallel, the New South Wales Government is creating three Renewable Energy Zones, involving the development of new grid infrastructure in energy-rich areas.

The construction of pumped hydro project [Snowy 2.0](#) will provide an additional 2GW of dispatchable, on-demand generating capacity and approximately 350GWh of large-scale storage to the NEM, to alleviate some of the grid constraints in southern New South Wales.

Meanwhile, electricity retailers have tried out new tools to manage price volatility. AGL Energy has started a number of virtual power plant trials that will allow customers to harness the power of their solar battery systems in return for credits. Almost 25% of standalone homes – around 1.7 million in total – have solar systems installed, and AEMO estimates an additional 150,000 will be installed by 2025. Clearly, this signals a shift in mindset in consumers and approaches to managing price volatility.

Policymakers have fast-tracked Project EnergyConnect, which will play a key role in improving grid stability and reducing energy price volatility. The 330kV above-ground transmission line, with 800MW transfer capacity, will connect South Australia and New South Wales, plus north-west Victoria, and should be completed by 2023.

With a half dozen coal plants exiting the system over the next 15 years, and the only material replacement, other than Snowy 2.0, being significant volumes of non-synchronous generation, price volatility could be a major long-term issue. In response, the Government announced in mid-September that it is prepared to construct a new gas-fired power station if the Liddell coal-fired power station is not replaced.

The move is built on fears of a price spike akin to the rise in wholesale prices, by 85%, after the closure of the Hazelwood coal-fired power station. The Government will also set a dispatchable capacity investment target of 1GW in New South Wales, to come online by the end of 2023.

In a reflection of the broad uncertainty surrounding policy in Australia’s renewables sector, the COAG Energy Council has tasked the Energy Security Board (ESB) with developing advice on a long-term, fit-for-purpose market framework that could apply from the mid-2020s. In the near term, more change could be on the horizon, with the ESB required to recommend any changes to the existing market design, or an alternative market design, by the end of the year.

Despite this policy uncertainty, the future should shine bright for Australia’s renewables sector. Developers have launched a renewables revolution, leading the global shift to a low-carbon transition. The closure of thermal plant, combined with the falling cost of renewables and batteries, provides a tremendous opportunity for continued impressive growth. If the industry can weather the storm caused by policy uncertainty, it will be supercharged for success.



How Ireland is securing a sustainable energy future

Clear targets and governance are helping the country's coalition Government lay the foundations for the long-term growth of renewables.

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New policy has underlined the growing importance of renewable energy development in Ireland, boosting confidence in its sustainability and enabling investment across a more diverse range of technologies.

The publication, in early October, of the **Climate Action and Low Carbon Development (Amendment) Bill 2020** set out a new path to meet Ireland's 2050 net-zero emissions targets via a set of five-year economy-wide carbon budgets. The bill is indicative of Ireland's recent efforts to create a clear and reliable framework for decarbonization that provides strong signals for investment in renewables.

The 2019 **Climate Action Plan** kicked off this new era. It specifically addressed the need for public- and private-sector support to develop Ireland's renewable electricity market. Restating Ireland's pledge that 70% of its electricity will come from renewable sources by 2030, the plan aligned a state-led auction scheme – the **Renewable Electricity Support Scheme (RESS)** – with a target for 15% of Ireland's renewable electricity demand to come from corporate power purchase agreements (PPAs) by 2030. It also highlighted the need to address planning, consenting and grid-connection issues for offshore wind development.

The Coalition's **Programme for Government (PfG)**, ratified by the Fianna Fáil, Fine Gael and The Green Party Coalition in June 2020, supports the 2019 plan. It stated the intent to reach net-zero emissions by 2050 and upped the offshore wind development target from 3.5 gigawatts to 5GW by the end of the decade.

For RESS specifically, the Coalition promised annual RESS auctions in its PfG, and it held the first in July 2020. Further, it awarded €3m (US\$3.5m) in capital funding to support the creation of community projects under RESS in its most recent **budget**. The introduction of this scheme has provided the detail and stability needed to generate interest and create confidence in a more diverse renewables sector in Ireland.

Such policies will be vital to transforming Ireland's poor performance in reducing its carbon emissions to date. In 2018 – the latest year for which figures are available – Ireland's renewable energy share was 11%, versus the 16% target set for the country's gross final consumption of energy under the EU's Renewable Energy Directive. Ireland's Environmental Protection Agency has also forecast that the country will achieve only a 2%-4% reduction on 2005 (base year) emission levels in 2020, considerably lower than its 20% target.

In addition, while the new RESS should boost diversity in terms of technology, Ireland's renewables sector has traditionally been dominated by onshore wind. Total wind capacity installed increased by 69% between 2015 and 2019, showing growing interest in the sector, but RESS should now encourage much more diversification in terms of technologies.

The first RESS auction in July 2020 has generally been seen as a success, particularly in terms of diversification. However, key sectoral issues must be addressed to ensure that the confidence in RESS continues to build.

Restating Ireland's pledge that 70% of its electricity will come from renewable sources by 2030, the Climate Action Plan aligned a state-led auction scheme – the Renewable Electricity Support Scheme – with a target for 15% of Ireland's renewable electricity demand to come from corporate power purchase agreements by 2030.

Auction results

The first RESS auction contracted 1,275.5 megawatts of capacity from 19 wind farms and 63 solar projects. The latter was particularly welcome news for solar after more than a decade in which onshore wind has dominated. More generally, this strengthens the investment environment for renewables by supporting diversity in terms of the technologies available in the market.

However, the prevalence of smaller projects, particularly within solar – which range in size from 0.5MW to 119MW, with around half at 4MW – could lead to funding issues for this first set of RESS auction winners.

After the formal notice of award for RESS on 25 September 2020, projects had 30 working days to enter an Implementation Agreement, post a €25,000

(US\$29,310) per MW performance bond, and commit to achieving commercial operations by the end of 2023 at the latest.

Smaller developers and projects can find such requirements onerous in the short term, as bank financing requires a detailed due diligence process that could take six to nine months. If banks concentrate financing on larger projects that generate higher fees, smaller developers may need to sell the asset or take on a partner, diluting their share of the project.

Corporate buy-in

Alongside the RESS auctions, the Government also hopes to drive the uptake of corporate PPAs to cover 15% of renewables demand by 2030. This will fill in the gaps around government auctions by providing an alternative demand source and revenue stability for developers, as well as portfolio diversification.

A lack of large corporates in Ireland makes the 15% target quite ambitious. This equates to about six terawatt-hours (TWh) of EirGrid's Tomorrow's Energy Scenarios forecast. The state-owned electric power transmission company predicts an overall electricity requirement for Ireland of approximately 41TWh by 2030. However, the expected proliferation of data centers around the country will help to meet this goal. Amazon has already signed three PPAs to power its Irish data centers, which should add 229MW of renewable energy to the grid. In August, Facebook signed its second long-term renewables contract in Ireland, for 28.8MW of wind power from a new project in County Tipperary, to support its business in the country.

Sectoral challenges

While successful RESS project developers will now be working towards finding finance, the Government must look much further ahead. Addressing key sectoral challenges, including grid capacity, planning and setting appropriate commercial rates, will be crucial now that it has a successful first auction under its belt.

Delays or issues around planning and rates can usually be factored into the development process, but insufficient grid capacity would stop this power from reaching the market and cause Ireland to miss its 2030 targets.

“Dispatch down” curtailment and constraint figures for wind averaged 11.5% during the first half of this year, according to EirGrid. The [Irish Wind Energy Association \(IWEA\)](#) has pointed out that this is enough to power Galway city for a year.

This issue could also jeopardize the Government's aim to develop offshore floating wind potential on the Atlantic Coast. While the Government believes there is potential to develop at least 30GW in this area, some of this would probably be for export and, therefore, potentially would not need to be factored into Ireland's future grid capacity. The PfG pledges to add offshore wind to the annual RESS auctions schedule from next year, aiming to develop 5GW by the end of the decade. However, it also addresses the need for investment in new technology and interconnectors.

A new marine planning framework and licensing regime, due to be adopted in late 2020 under the Marine Planning and Development Management Bill, aims to tackle planning and consent issues for offshore wind.

Change ahead

As the coalition attempts to create the necessary tailwinds to fully develop Ireland's renewables sector, the industry is now looking ahead to the second RESS auction next year. The first was undoubtedly a success, but the Government will still be expected to consider some changes, particularly with regards to indexation of bid prices.

Auction bids were made without indexation to any inflationary measure in the first RESS auction, pushing prices €10-€12 (US\$12-\$US14) higher, according to IWEA. It has called for a review to address this.

Although there is more to do, the coalition has signaled its intent to address sectoral issues in the renewables space by delivering bills to tackle offshore-wind planning and provide greater detail on pursuing net-zero targets well within its first year in government.

More generally, creating a detailed legislative framework to tackle climate change and a solid mechanism for renewables development with RESS has given a welcome boost to Irish renewable energy development. These elements will provide a solid foundation for Ireland to build a leading position in renewables.

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EYG No. 008045-20Gb1

EY-000126908.indd (UK) 11/20.

Artwork by Creative Services Group London.

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