Boardroom Energy

Offshore wind prospects for Australia

Key points

- Offshore wind seeks to tap the same resources that powered global trade in the age of sailing ships.
- Offshore wind is based around broadly the same technology as onshore wind, only bigger.
- The technical challenges of installing wind in the sea or the ocean make it more expensive per MW than onshore wind. Ongoing maintenance is more expensive
- However, the strong winds that blow across the seas, especially in mid-high latitudes (the “Roaring Forties”), mean that offshore wind can run at a higher capacity factor.
- A similar trade-off exists between installing offshore wind on fixed platforms in shallow waters and using floating platforms in deeper waters. The latter is a less mature technology at present.
- Like other renewable technologies, costs are coming down. Countries that are most successful at driving down costs are those that are developing a supply chain ecosystem where multiple wind farms share specialist construction and maintenance equipment. The UK is a good case study of this.
- The 2020s are expected to see a big scaling up in offshore wind deployment. China, northern Europe and east coast US look likely to be the drivers of this increased deployment. Japan and Korea also have plans to start building offshore wind at scale.
- Unlike these countries, which are constrained in the land available for onshore renewables, Australia still has abundant sites for development of onshore wind and solar.
- While there are several projects in planning in Australia, it is hard to see how they will become genuinely cost competitive. The policy case for supporting a demonstration plant is weak, when onshore is systematically cheaper.

Introduction

Energy from wind has existed for millennia. On land, windmills spun to drive grindstones to make flour. On sea, humans used it to power their boats and ships, ultimately taking them round the world. The explorers who achieved this feat learned where the useful winds were. They discovered the "roaring forties" – a band of strong winds in the Southern hemisphere between the latitudes of 45 and 50 degrees and the doldrums nearer the equator where ships were becalmed for lack of wind. The Northern hemisphere equivalent of the roaring forties were weaker due to the greater land mass at these latitudes, but still formed the basis of key transoceanic routes.

Now with the risk of climate change we can generate clean, industrial scale electricity from wind turbines. It makes sense that developers look to exploit the earth's strongest winds on land and at sea. While a variety of factors influence wind resource, the westerly wind belts between 35 and 50 degrees are amongst the best and correspond closely to the old sailing routes. Much of the world's wind power deployment has been in or close to these belts, which encompass much of North America, Europe, North Asia (northern China, Japan, Korea) in the northern hemisphere and southern Australia, New Zealand, southern Africa and South America in the southern hemisphere. To date most wind has been deployed onshore but scarcity of suitable onshore sites (in Europe) has encouraged exploration of offshore wind projects. This report looks at offshore wind, its development internationally and prospects for Australia.

Offshore versus onshore

Onshore wind in Australia has been deployed since the early 2000's. It operates in every state and territory except the Northern Territory. At its peak, wind provides around a quarter of the NEM's energy, and recently delivered its highest output to date (6,428MW).

There is no offshore wind currently operating in Australia. There are two broad reasons for this. First, onshore turbines are significantly easier and cheaper to install and connect, and Australia has a relative abundance of onshore sites.

Second, the undersea coastline around Australia falls away relatively steeply, providing few sites for shallow water, seabed-anchored wind turbines.

The main physical difference between onshore and offshore wind turbines is size. Offshore wind turbines can be bigger than onshore turbines because their location is more remote and will not impact nearby communities.

While onshore wind turbines have grown in average capacity from 1.6MW to 2.6MW over the last decade, offshore wind turbine's average capacity has grown from 3 MW to 7.5 MW. This capacity growth is a function of size. Rotor diameters have increased from 112 m to 161 m on average, which allows for higher energy capture from the turbines and smoother energy output over the year. This makes offshore wind particularly useful in reducing overall intermittency.

Larger blades reach higher and can tap into higher wind speed wind resources. The best wind resources are over the seas and oceans because the water presents a smoother surface than the land and so there is less friction to slow the wind down. The combination of these factors means that offshore wind typically enjoys a higher average capacity factor than onshore wind. In Europe, recent offshore wind developments average 44 per cent capacity factor, versus 36 per cent for onshore. In China, however, offshore wind only achieves a 37 per cent capacity factor due to poorer wind resources. China is dominating recent installations (3GW in 2020 alone). The development of floating platforms for wind turbines is allowing offshore wind farms to be built further from shore could improve capacity factors. The world's first floating wind farm achieved a capacity factor of 57 per cent in 2020.

Both onshore and offshore wind turbines are predicted to continue to increase in size over the next decade. IRENA's target for 2025 outlined in its "Future of Wind" report is an average turbine size of 4-5MW for onshore turbines vs 12MW or more offshore. The largest turbine model available today, the 12MW Haliade-X has three carbon fibre turbine blades each 107m long (so a diameter of over 200m). Each is larger than the wing of a jumbo jet. This scale allows the blades to rotate at over 300km/h at the tips. The blades, generator and associated equipment weigh over 900 tonnes and so need to be mounted on a pylon capable of supporting the weight and rotational forces.

Offshore wind is more complex to install. Offshore wind farms must contend with installation and operation and maintenance (O&M) in harsh marine environments, making these projects costlier than onshore wind and giving them significantly longer lead times. The planning and project development required for offshore wind farms is more complex than that for onshore wind projects. Construction is even more complex and costlier, too, as is grid connection, increasing total installed costs.

The relative ease of building wind onshore rather than offshore means that the former has always been cheaper. As a result, the installed global capacity of onshore wind (699GW at the end of 2020) dwarfs that of offshore wind (35GW) by a factor of 20.

Fixed versus floating

Offshore wind turbines need to be mounted on a platform. Whether a wind farm is mounted on a fixed or floating turbine is dependent on the depth of the seabed. In waters shallower than 60m a fixed platform is feasible. Deeper than this requires the use of floating platforms. Fixed platforms are easier and cheaper to build. There is some uncertainty about how floating platforms might affect the efficiency of turbines as they pitch and roll with the waves, or the wear and tear on blades. Additionally, shallower waters typically correlate with closeness to shore, meaning cheaper transmission and maintenance due to the shorter distance cables or engineers must travel.

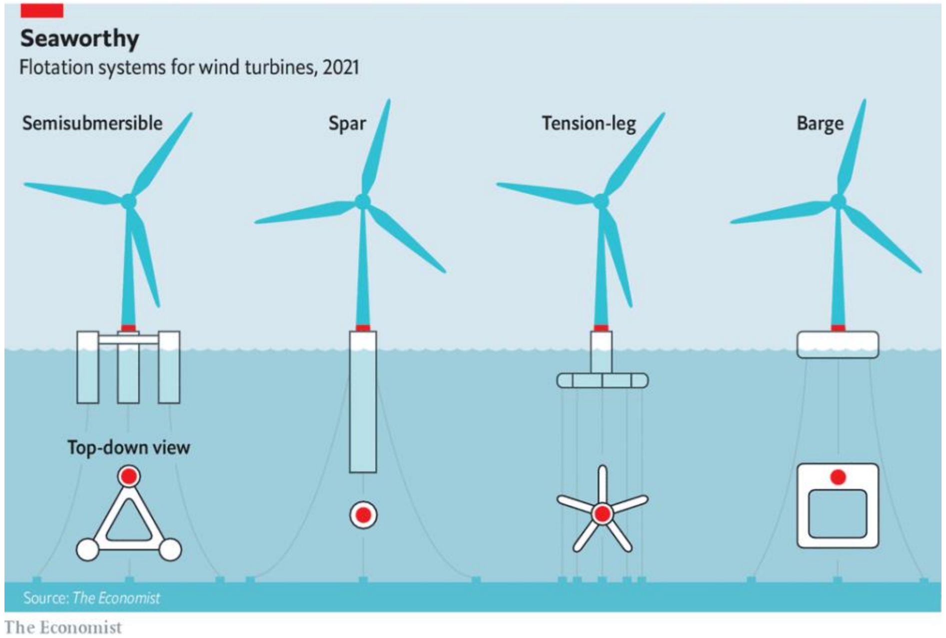
All these factors mean that the majority of offshore wind farms are fixed platform, and this technology is seen as relatively mature, while floating platforms are an emerging technology. The first floating wind farm was commissioned in 2017 versus the first fixed offshore wind farm in 1991. But floating technology will allow much greater areas and better and more consistent wind speeds to be accessed and will be an essential part of the sector if its more ambitious deployment targets are to be met. The expectation of rapid scaling-up of floating wind farm deployment has led to the development of specialist transformers for them.

While yet to be widely deployed there are a range of floating platform options that have been proven up through prototyping and testing. The first floating wind farm is Hywind off the coast of Scotland. This 30MW farm has 6x 5MW turbines using a semi-submersible platform, based on a 3-pronged floating tripod, anchored by cabling to the seabed (see Figure 1 for illustration).

The other main option in current use is the spar – an 80-metre-high concrete tube containing ballast to keep it in position. The ballast can be any cheap and heavy material.

Other options under development are the tension-leg and barge. The former is based on an approach used for deep water oil platforms in the Gulf of Mexico and the latter has been prototyped in Japan where it has apparently survived three typhoons.

Figure 1: Floating turbine platform options



Source: *The Economist*

The other challenge of floating wind farms relates to construction and maintenance. In shallower waters, a ship-mounted crane can be brought alongside and then "legs" dropped to the seabed to brace it while it operates. This is not feasible in deeper waters. One potential advantage of floating wind farms is that they can be towed. So, they can be constructed closer to land and then towed out to position or potentially towed back to shore for maintenance.

Costs and cost reductions

At present, offshore wind is more costly on a per MW (capacity) or a per MWh (levelized cost) basis than onshore wind. IRENA's 2020 renewable power cost report has onshore wind at US$1,355/KW and offshore more than double that at $3,185/KW. The higher capacity factor of offshore wind means that the gap narrows a little when measuring its levelized cost (LCOE): US$39/MWh for onshore versus $84/MWh for offshore. Cost reductions over the last decade have been similar for the two technologies, which is not surprising given their obvious similarities. However, solar PV has fallen even faster in cost and is now also cheaper than offshore wind.

The breakdown of these costs by component is set out in Table 1.

Table 1: Breakdown of offshore wind costs

Cost component	Cost proportion (per cent)
Turbines, pylons	33-43
Installation costs	8-19
Contingency/other costs	10-14
Transmission costs	8-24
Foundation costs	14-22
Development costs	**2-7**

Source: IRENA

There are outliers on the low cost side. The Netherlands completed an offshore wind project in 2020 which produced electricity at $66/MWh. The UK expects its offshore wind projects to be cost competitive with onshore wind by 2030.

Increasing scale helps drive cost reductions in manufactured equipment such as offshore wind turbines, through a phenomenon known as Wright's law.

Offshore wind cost reductions have been driven by both technology improvements and the growing maturity of the industry. On the technology side, as with onshore wind, this includes making turbines ever longer and more powerful with higher hub-heights and longer, more efficient and durable blades.

A range of other factors, including developer experience, greater product standardisation, manufacturing industrialisation, regional manufacturing and service hubs, and economies of scale have all contributed to cost declines. The average size of an offshore wind farm has increased from 25MW to 300MW over the last twenty years. The introduction of specialised ships for maintenance has contributed to lower O&M costs, as has zonal maintenance rather than organising separate maintenance arrangements for individual wind farms. Overall, O&M costs are in the range US$70/kW per year to US$129/kW per year. Europe and China have evolved the lowest O&M costs, using independent service providers, turbine manufacturers' service arms, in-house team, marine contractors, or a combination of each.

Wind turbine blades in a factory

Box 1: Wright's law

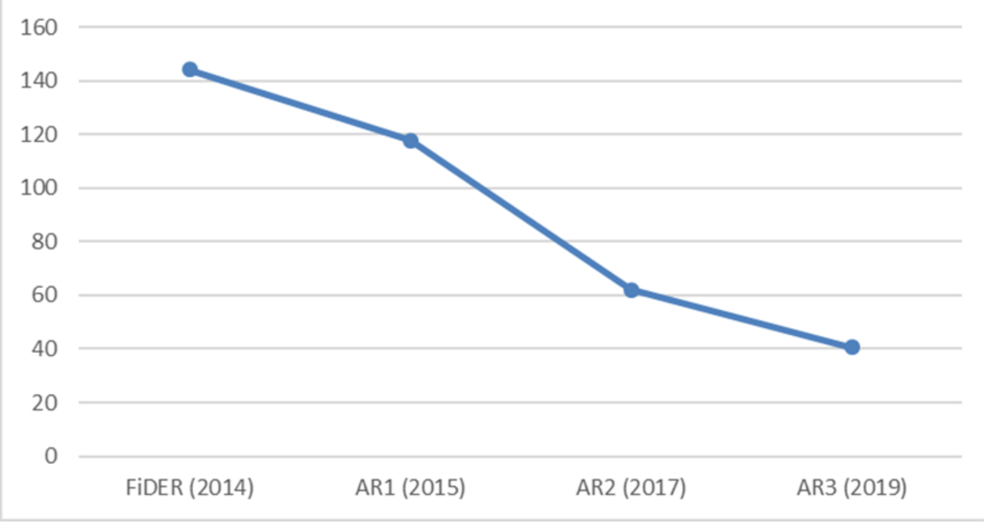
Wright's law (first applied to airplane production) posits a broadly consistent reduction in costs with each doubling of volume of output. For airplanes, it was 15 per cent. This effect has been observed across a broad range of manufacturing industries, though the rate of cost reduction varies. This effect can be enduring, as evidenced by the sustained reduction in costs of computer transistors since 1965, as predicted by the famous "Moore's law".

For energy technologies, this logic only applies to modular technologies that can be manufactured at scale, such as, wind turbines, solar PV cells, Lithium-ion batteries and hydrogen electrolysers. Technologies whose costs are driven by bespoke construction requirements, such as nuclear, carbon capture and sequestration or pumped hydro storage are not susceptible to these kinds of cost reductions.

Wright's law specifically applies to the manufactured component of an energy technology. There are other capital costs; the balance of system costs to secure, protect, connect and monitor the main components and the soft costs of project managing the installation through to commissioning. Then there are non-capital costs such as finance, fuel (where relevant) and operating expenditures that go up to make the unit costs per output. Balance of system and soft costs exhibit learning effects that lead to lower costs with greater scale of deployment.

Wright's law and the accompanying reduction in the other costs can be seen in the dramatic drop in the price of wind farm contracts in the UK's reverse auctions. On a global scale, IRENA estimates a 9 per cent learning effect for every doubling of offshore wind capacity, or 15 per cent on an LCOE basis (presumably indicating greater learning effects for soft costs and balance of system). However, these rates are lower than onshore wind and solar PV, which are already cheaper. Offshore wind's much lower installed base means that it can double capacity more quickly, giving it some chance to "catch up".

Figure 2: Weighted average CfD prices for offshore wind (£/MWh)



Source: Boardroom Energy from BEIS data

Transmission

The delivery of offshore wind energy to onshore markets requires subsea transmission. As projects get larger and further out, the economics of underwater transmission change from alternating current (AC) over shorter distances to direct current (DC) over longer. The latter requires an onshore conversion station (since the rest of the grid is AC). Deployment of high voltage direct current (HVDC) is increasing both onshore and offshore.

In some countries (China, Denmark, Netherlands) the regulatory framework allocates responsibility for connecting new plant to the transmission network, rather than to the generator. For a technology like offshore wind where transmission costs are typically high, this is an advantage, although these costs are still ultimately paid for by consumers either way.

The UK has used the greenfield nature of offshore transmission to create a competitive tendering approach, to reduce costs for consumers. However, as the tenders are offered on an individual project basis, and as the offshore wind sector grows, there may be some missed opportunities for efficiencies through more integrated planning of offshore transmissions.

Europe's geography means that many offshore wind farm sites will lie somewhere between two (or more) countries. This creates an opportunity to use offshore wind transmission as an interconnector, building cables to two countries so the wind can flow to whoever is prepared to pay the most for it.

Technical challenges

Over time, offshore wind farms are being deployed further from the shore and in deeper waters. While this has allowed various scale benefits, such as bigger turbines, access to higher wind speeds and larger precincts (i.e., more turbines in a given project) this has also increased the technical difficulty of installation.

In general, the further out and deeper water the site, the higher the planning and project development costs and the longer the lead times. Logistical costs are higher the farther the project is from a suitable port, while greater water depths require more expensive foundations, and ultimately a shift to using floating platforms.

One of the reasons for increased logistics costs is the cost of getting people out to the sites, initially for installation and construction and subsequently for maintenance. In the latter case, while helicopters have the advantage of speed, there is an emerging class of specialised ships, Service Operation Vehicles (SOVs). Standardised design and sharing of SOV use across projects (each SOV can service 150 turbines or more) is driving down costs, but this is predicated on having multiple projects in the same area, hence these are only currently being deployed in Europe's North Sea.

Drones are already being deployed to monitor wind farms and in the long-run, the greater logistical challenges of offshore wind may mean that robots are deployed for maintenance and construction earlier than other energy technologies.

Synergies with other sectors

Offshore wind shares some key characteristics with the offshore oil and gas sector. Some marine areas have an overlap in resource, notably the North Sea between Great Britain and northern Europe, but there is also the technical expertise around designing and constructing offshore fixed and floating platforms. The maintenance and servicing requirements are similar and given that offshore wind is growing while oil and gas is facing decline, there may be an opportunity for a relatively smooth transition.

Other prospective offshore renewables technologies such as wave, tidal and even floating solar have indicated they could share existing offshore wind infrastructure (if they manage to demonstrate commercial scale generation). They could access offshore transmission and shared maintenance facilities. However, these technologies remain very niche and may never be deployed at sufficient scale in their own right to be of much help in driving down costs for offshore wind.

Hydrogen

Pretty much every new technology comes with a hydrogen angle these days, and offshore wind is no exception. Unsurprisingly, Europe is taking the lead with both Germany and the Netherlands sponsoring pilot projects for offshore production of green hydrogen. The Dutch project, PosHYdon, is making use of an existing gas production platform and pipeline. Offshore wind power will be used for electrolysis of demineralised seawater and then the resulting hydrogen will be blended with the natural gas and pumped ashore. While the Dutch project is only a 1MW electrolyser, the German project envisages 300MW electrolysis capacity off the German island of Heligoland as the first stage of an eventual 10GW project that also sees Heligoland serving as a hub for a pan-European hydrogen network. The logic is that it will in the long run be cheaper to pipe hydrogen to shore than to build several large underwater cables to bring power to shore as electricity. This logic is supported by modelling for a potential UK pilot project, Dolphyn, and the cost advantage of pipelines increases the further the energy has to travel.

This offshore wind/renewable hydrogen nexus is still somewhat speculative, but offshore wind is seen as a good fit for hydrogen because of its higher capacity factor than onshore renewables and easy access to water. Siemens is even developing a combined wind/electrolyser unit in anticipation of this market growing.

Other issues

Outside of technical, market and financial challenges there are arrange of other environmental concerns and stakeholder management issues that an offshore wind farm has to contend with. These include:

- Impact on marine life and birds
- Impact on commercial fishing
- Impact on ship navigation
- Visual impact and other NIMBYism

The impact of each of these issues will be project specific. They can combine to block or delay projects.

Cape Wind, a project in Nantucket Sound in the US, was first proposed in 2001. For 16 years it had to contend with a range of local opposition that appeared partly motivated by the potential impact on real estate – numerous wealthy families (including the Kennedys) had property in the area, and the turbines were close enough to shore to be clearly visible. Local fisherman also opposed the project. Other objections were made on environmental grounds, although the local bird conservation group tentatively gave the project its support. A local ferry company was initially opposed due to the potential impact on its routes, but then decided that it presented an opportunity to run eco tours to view the turbines up close. Although the Cape Wind project received state and federal planning approval, it failed to arrange financing in time and the electric utility it was going to sell the power to terminated its contract. It's not clear how much the local challenges, which also included environmental complaints, contributed to the delay, but it's seen as a cautionary tale in the US of the challenges of managing stakeholder concerns in a new sector such as offshore wind.

Global developments

There are three clusters of major offshore wind development: northwest Europe, the northeast US and northeast Asia. These all share similarities: they have good a wind resource (all are on fairly similar latitudes), they have shallow waters, and they are near crowded industrial areas, where there is high load to serve but limited land space for onshore wind. Of the three, Europe is the clear leader to date, with Asia catching up fast, thanks largely to China. The Biden administration has revived US offshore wind fortunes, but this has yet to convert to deployment.

Europe

European offshore wind development is concentrated in the North Sea, although there are also wind farms in the Irish/Celtic Sea between Great Britain and Ireland and plans to develop multiple wind farms in the Baltic. From a national perspective, the sector is dominated by the UK, Germany and Denmark.

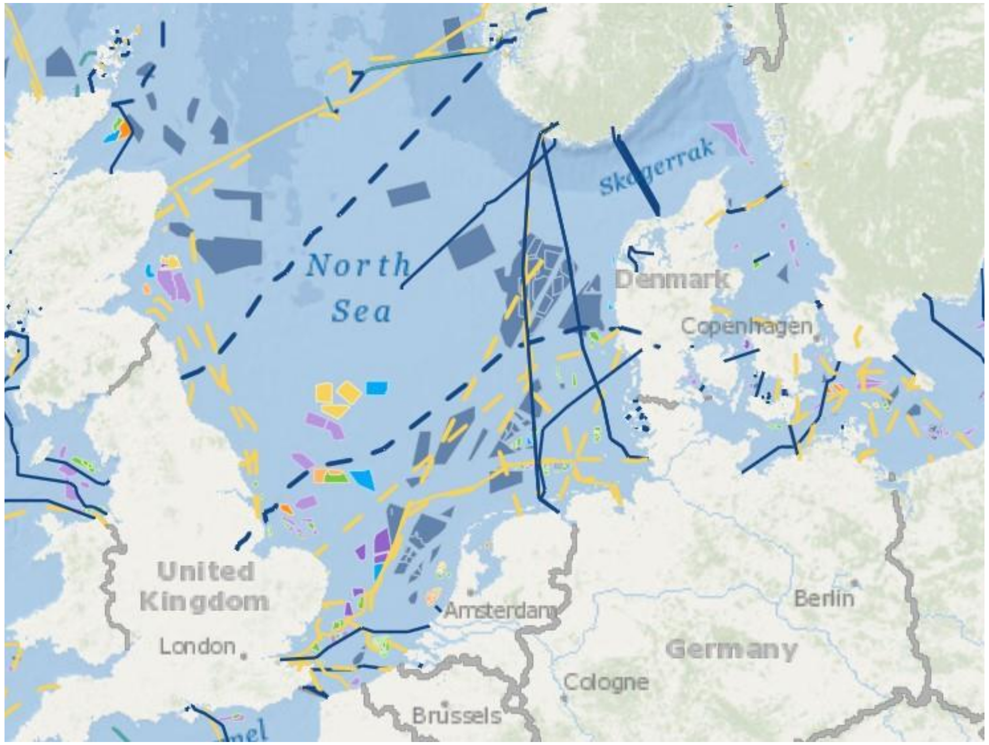
The North Sea, which still hosts an extensive – albeit declining - oil and gas sector has the potential to replace some of this energy supply from offshore wind generators. Increasingly, transmission routes are being designed to allow offshore wind output to flow to multiple countries depending on price signals for who needs it the most. Figure 3 illustrates this potential. The chart shows wind farms - operational, under development and development areas – and interconnectors both operational and prospective.

In its offshore strategy, the EU (i.e., excluding UK and Norway) is targeting an increase for offshore wind in the EU to 60GW by 2030 and to 300GW by 2050. Under this optimistic scenario, the North Sea will become a massive industrial zone.

UK

The UK was the world leader in offshore wind up to 2020 but has almost certainly been overtaken by China. The first few wind farms were supported by very generous subsidies, but the introduction of competitive tendering complemented by extensive R&D support, has led to significant cost reductions over only a few years.

Figure 3: Actual and prospective offshore wind and interconnectors, North Sea



Source: 4C offshore

Case study: UK offshore wind.

Due to geographic limitations and political/construction challenges with nuclear new build, the UK is investing heavily in offshore wind to support its plans to achieve zero emissions electricity. While the UK has multiple policy instruments to support decarbonisation of the power sector, the key tool for offshore wind is the contract for difference (CfD).

CfDs are awarded by a government owned company, the Low Carbon Contracts Company (LCCC) and effectively give each successful project a fixed revenue per MWh of output. The first round in which offshore wind projects participated was held in 2014, using administratively set prices for offshore wind of £140-150/MWh. Three subsequent rounds were held using competitive auctions to uncover the lowest price proponents would accept (while retaining a cap on the maximum CfD available to ensure value for money). The cost reductions have been dramatic with the latest auctions clearing at prices below expected future wholesale prices. In other words, they are effectively subsidy-free. The caveat is that the successful bidders have yet to complete these projects, so there may be an element of winners' curse in these prices.

The reasons attributed to falling supply costs were: improvements in technology, in particular the ability to build larger wind turbines further out at sea, economies of scale, supply chain development and lower financing costs.

These factors weren't simply due to good fortune. They were dependent on "a decade of concerted policymaking designed to reduce the risk for investing in offshore wind"; including research and development support and developing the local supply chain. Key policies included:

- Innovate UK (formerly Technology Strategy Board), which provided research and development grants across a range of industries, including around £40 million for over 60 projects supporting offshore wind.
- ORE Catapult, the UK's leading technology innovation and research centre for offshore renewable energy, which had a specific focus on supply chain development.
- The Carbon Trust's Offshore Wind Accelerator, which over a decade contributed to a 15 per cent reduction in the cost of energy for an average offshore wind project.

Denmark

Denmark is a pioneer in offshore wind. It commissioned the world's first offshore wind farm - the Vindeby project - in 1991. It is also home to one of the world's leading offshore wind companies, Oersted, which has reinvented itself from being an oil and gas company over the last decade.

Other European

Germany is currently the third largest offshore wind market after the UK and China. Germany has a coastline on the Baltic Sea as well as the North Sea. The Baltic is considered to have good potential but only has two offshore wind farms.

The Netherlands is an attractive market for developers because transmission frameworks transfer the cost of connecting on the transmission operator (and eventually consumers) rather than the generator. Partly for this reason, the Netherlands has already achieved a "subsidy-free" offshore wind project.

Belgium currently has the fifth largest installed capacity of offshore wind. France and Spain are exploring projects off their Atlantic coast. Norway's former national oil and gas company Equinor has become a developer with a focus on floating wind, as, like Australia, Norway has relatively little shallow water in which to install fixed platforms.

North America

The US offshore wind sector is still in its infancy. Several large projects proposed during the last decade never made it past the planning stage. The US's first and only operating commercial offshore wind project, the Block Island Wind Farm, came online in December 2016. It's a 30 MW project with five turbines off the coast of Rhode Island.

Amongst the bottlenecks the industry has faced has been lack of funding for the Bureau of Ocean Energy Management (BOEM), which is responsible for approving projects in federal waters, lack of local manufacturing facilities, and the Jones Act: an obscure law that requires all domestic shipping to be US-built, owned and crewed. This means the US can't borrow any of Europe's SOVs, so they will have to build their own vessels.

The sector, much like the rest of the clean energy sector, is expecting a big boost from the Biden presidency. Federal initiatives to support the sector include accelerating BOEM's planning and EIS processes, making up to US$3bn available through the clean energy loan guarantee program, R&D funding and infrastructure investments in onshore capability such as port upgrades.

States have established more than 29,000 MW of offshore wind procurement targets to date. There are 13 offshore wind projects in the development stage, for a total of 9,100MW. The key region for US offshore wind is the North-east Atlantic coastline. This has good wind speeds, shallow waters, high population (and thus load) density, and limited options for other renewables compared to the Midwest and West. The West coast has deeper waters and so will have to wait until floating wind becomes more cost-competitive.

China

China's offshore wind farms are still predominantly inter-tidal, or near shore, and in addition to not using the latest offshore wind turbine designs, these also have to contend with poorer-quality wind resources. As with everything in China, once the government decides to go into an industry or technology, they go big. China is expected to lead offshore wind capacity through the 2020s. The scale of installations and the development of Chinese manufacturing know-how as a result of this will help drive global costs down.

Other

Taiwan, Korea and Japan all have projects either under development or completed. Taiwan held its first offshore wind auction in 2018. In 2020, Taiwanese semiconductor giant TSMC signed a PPS with Oersted to take the full output of the 920MW Greater Changhua wind farm for 20 years, in what was at the time, the world's biggest renewable PPA agreement.

Korea has ambitions to develop two huge offshore sites, one fixed and one floating, for a combined capacity of 14.2GW. it currently has 124MW operational.

Japan has very limited shallow waters around its islands and is likely to need to adopt floating wind technology if it is to build a significant offshore wind sector. Its first commercial scale offshore wind farm at Akita is due to come online in 2022, adding 145MW to the country's grid. Auctions have been held this year for several further developments.

Future projections

IRENA has bullish forecasts for offshore wind in the Northern hemisphere. By 2030 they expect to see 23GW in North America, 78GW in Europe and 126GW in Asia. By 2050, it forecasts almost 1,000GW across these three regions, more than half in Asia. By contrast its forecast for Oceania, i.e., Australia and New Zealand is 1GW by 2030 and 3GW by 2050. In other words, it thinks there will be one large project in the next decade and one or two more by 2030.

Australia

Offshore potential

The factors to consider for offshore wind in Australia as with any other location include:

- Quality of the wind resource
- Distance from land/major load
- Water depths
- Diversity from onshore intermittent resource (wind/solar)

Wind resources

One of the co-operative research centres, the Blue Economy CRC, has an offshore renewables research stream. It has recently published a high-level review of offshore wind potential for Australia, which estimates the potential offshore wind resource around Australia. As with many resources, renewable or otherwise, the maximum theoretical resource is enormous, around 27TW (based on a reference 15MW wind turbine, which is larger than any currently in deployment). Screening for maximum water depth, distance from land and existing infrastructure, and avoiding environmentally protected areas (no-one is going to build a wind farm on top of the great Barrier Reef), and you are left with less than 10 per cent of this: 2,233GW. Given the NEM has a peak demand of 36GW, that would still be plenty. This screening of course only winnows out the most implausible sites – there is no guarantee that the remainder is remotely economic now or in the future.

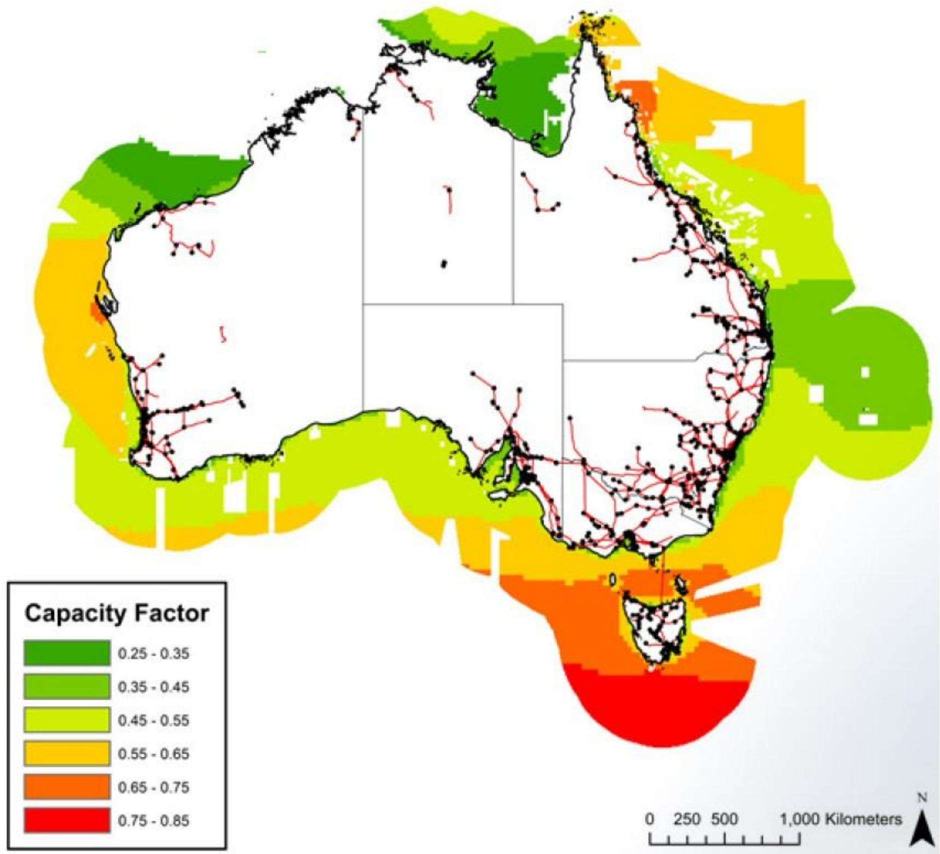
The regions covered in the international section above are mostly close to wind resources with average speeds of around 9-10m/s. Wind speeds of this level can be found in the Bass strait between Victoria and Tasmania, off the coast of the southern half of WA and a smaller area off Cookstown in North Queensland. Slightly higher wind speeds can be found around Tasmania and even more so heading south from the bottom of Tasmania.

Tropical and sub-tropical regions pose infrequent but intense risks from hurricane speed winds. This risk may deter projects in northern Australian locations.

Capacity factors are also better the further south one heads. The area around Tasmania theoretically could support capacity factors of 65 per cent and above, though this may not be achievable in practice. See Figure 4 overleaf.

The analysis by Blue Economy CRC suggest some diversity between offshore wind and onshore intermittent renewables, although there is typically strong overlap between onshore and offshore wind. The developers of Star of the South expect that their project would enjoy strong winds and thus high-capacity factors on hot days when demand is high (and onshore wind is often low).

Figure 4: Potential capacity factors in Australian waters



Source: Offshore wind in Australia

On Figure 4 the strongest resources are visible in red, around and to the south of Tasmania. But Tasmania is the last place in Australia that needs new renewables, with existing demand well served by its hydro systems and a few onshore wind farms. The economics of offshore wind for Tasmania therefore requires more interconnection with the mainland so that it can find its way to where most of the load is. For this reason, the Victoria side of the Bass strait is probably the best location in practice with reasonable wind resources and the mainland close by, including transmission infrastructure. Additionally, the Bass Strait is home to offshore oil and gas rigs, so there could be a modest opportunity for shared servicing infrastructure and some skills overlap with the oil and gas workforce.

Projects under consideration

Boardroom Energy has identified18 proposed offshore wind farms spread across eight proponents around the coast of Australia (see Table 2).

Table 2: Potential projects

Proponent	Number of Projects	Capacity GW	Location	Status
Star of the South	1	2.2	Victoria	planning
Oceanex	5	9.5	NSW/WA	unknown
Newcastle offshore wind	1	?	NSW	unknown
Green Energy Partners	5	11	Various	unknown
Pilot Energy and Triangle Energy	1	1.1	WA	pre-feasibility
Brookvale energy	1	2	Tasmania	pre-feasibility
Australis Energy/**Warwick energy**	3	1.4	Vic/SA/WA	pre-planning
Flotation energy	1	1.5	Victoria	pre-feasibility
Total	**18**	**28.7**		

Source: Company websites, Blue economy CRC report "Offshore wind in Australia, July 2021"

All projects are in a very early stage of development, with the Star of the South project off Victoria's Gippsland coast being the only one to have reached the planning stage.

None of the lead proponents have any track record of actually building offshore wind farms, although individuals associated with them have relevant experience. One company (Warwick Energy) carried out early development on two offshore wind farms and then sold them on to be constructed around a decade ago. Another has recently won a tender to build an offshore wind farm in the Irish Sea.

Notable by their absence are the heavyweights of Australian renewables development: POWaR, Neoen, Pacific Hydro or Infigen. Neither are the existing European offshore specialists such as Oersted, Equinor or Shell formally involved at this stage. It's likely that the goal of the current proponents is to get their projects to a certain stage of development and then sell on to one of the established players.

Star of the South

The wind farm — which would be built 10–25 kilometres offshore in waters near Port Albert in Gippsland, Victoria— would spread over 570 square kilometres. The proponent (also called Star of the South) has an exploration licence from the Australian Government to undertake site investigations and is also beginning community consultation and environmental assessment.

Star of the South has attracted investment from Copenhagen Investment Partners, (CIP) who have put together a $7bn renewables investment fund and have interests in European offshore wind farms.

The project includes a proposed transmission connection to the existing grid in the Latrobe Valley.

Other

To the extent information is available, all other projects are in the pre-planning or pre-feasibility stage. In two cases there does not appear to be functioning website, making it difficult to source reliable information. This may in itself be a sign of the immaturity of the projects. At this stage capacity information should be taken as purely indicative.

In terms of how likely these projects are, they collectively represent almost twice as much capacity as the US is planning to build in the next six years and almost ten times IRENA's forecast to 2050.

Issues

Offshore regulation

There is a gap in offshore regulation - simply because there are no existing projects that have needed it. Filling this gap with some sensible rules for the industry to follow is a key, but low-cost pre-requisite for industry development. It's likely that existing regulations for offshore oil and gas could be repurposed with relevant modifications.

Commonwealth waters begin 3km from the shore, so federal regulations are going to be the key for most offshore wind projects.

Research and development

ARENA is the Federal Government's clean energy early technology development funding organisation. Since its inception around a decade ago, it has supported a wide array of immature generation technologies, including wave, tidal, geothermal and solar thermal. But it has not supported any offshore wind projects to date.

Future ARENA funding programs are likely to be oriented around the Commonwealth's low emissions technology priorities. Last year's first Low Emissions technology statement envisaged no role for offshore wind.

One of the co-operative research centres, the Blue Economy CRC, has an offshore renewables research stream. It has recently published a high-level review of offshore wind potential for Australia, which has been a useful resource in developing this Backgrounder. However, the outcome of this review is limited to providing "communication materials to support Blue Economy CRC messaging on the role for offshore renewable energy in Australia" and identifying knowledge gaps.

While Australia doesn't have to reinvent the wheel, some local R&D is likely to be required as an important enabler of the first few projects, even if only to support pilot or demonstration projects. By contrast the UK has had several streams of R&D funding with a focus on supporting offshore wind, including over 60 specific research projects funded through Innovate UK.

Transmission

The regulatory framework for new transmission in Australia is complex and evolving. The standard paradigm in the eastern states is that generators pay for connection to the existing grid and consumers pay for general upgrades to the existing grid and new interconnectors to mesh the regions. Somewhere in between are Renewable Energy Zones – new transmission lines to areas that have not previously housed generation but are prospective areas for multiple renewables projects. The regulatory framework for these has yet to be established, although signs are that governments with ambitious renewable targets will underwrite these if necessary. The challenge for offshore wind proponents is that AEMO is the primary arbiter of where REZs should go, and AEMO currently does not see offshore wind as sufficiently economic to feature in its Integrated System Plan, which determines the location and priority of REZs.

Conclusion

Australia faces a fundamental paradox when it comes to offshore wind. Unlike the countries currently leading the sector (UK, Denmark, China, etc) it has abundant land and so has sufficient space for its electricity needs to be met by onshore resources: i.e., onshore wind, solar PV and a range of balancing dispatchable technologies. Offshore wind in Australia does not have the same land scarcity driver that it does in Europe and part of Northern America. Australia has not developed an offshore wind supply chain like the UK has. It's the UK approach that is really driving down offshore wind costs: from installation to project management to transmission to financing to ongoing O&M costs.

Without such an approach, offshore wind in Australia has little hope of getting close to cost-competitiveness with onshore renewables. Diversity benefits appear unlikely to outweigh the cost penalty.

This is why the Blue economy CRC report has played the hydrogen card. The prospect of large-scale hydrogen exports (and/or decarbonised industrial commodities using hydrogen as a key input, sch as green steel, aluminium, ammonia), is driving claims that Australia should be targeting *more than* 100 per cent renewables. Tasmania now has a formal 200 per cent renewables target. In these scenarios, it's the more the merrier and it's easier to create a narrative in which offshore wind may be deployed at scale in Australia.

Even in these optimistic scenarios, offshore wind will have to compete with the onshore megaprojects being proposed for western and Northern Australia, such as Sun Cable and Asian Renewable Energy Hub (Terry Kallis, chair of Star of the South, may be having a bet each way since he's also chair of Hydrogen Renewables Australia, which is looking to develop a 5GW wind/solar/desalination/hydrogen projects near Kalbarri). These are also predicated on Australia becoming a major producer and exporter of hydrogen, and they face fewer challenges and hurdles than offshore wind. This is not to say that these projects will definitely get built either, but they have distinct advantages.

None of this is to say the offshore wind should be abandoned or ignored. There are low-cost activities that can facilitate offshore wind projects, such as the development of the necessary regulatory frameworks for marine development, including resource testing activities, the allocation of development blocks and transmission frameworks. Offshore wind remains in principle eligible for ARENA and CEFC funding and is probably at least as prospective as some of the other technologies that will be competing for funding now onshore wind and solar PV have moved into commercial deployment. Although getting offshore wind onto the Commonwealth's Low Emissions Technology priority list may be critical to qualifying for a major ARENA support program.

Offshore wind projects may proceed in Australia as a result of falling costs or government support for individual projects on political grounds. But it's unlikely we will see extensive demonstration funding, such as that enjoyed by utility-scale PV over the period 2012-17 when ARENA funded five demonstration projects and then another 12 projects through the competitive large scale solar round. A benign state government may fund a demonstration project by 2030 – with Star of the South being in pole position to be that project. But wider deployment within the next decade looks implausible, and offshore wind may never be able to break the lock that onshore wind and solar PV has on Australian large-scale renewable developments.

Further Reading

- Renewable Power Generation Costs in 2020, IRENA, June 2021
- Future of wind, IRENA, October 2019
- Offshore Wind Energy in Australia, Blue Economy CRC, July 2021
- Offshore Wind - The Power to Progress, DNV GL, November 2019
- Offshore Wind Outlook, IEA, 2019