core marine

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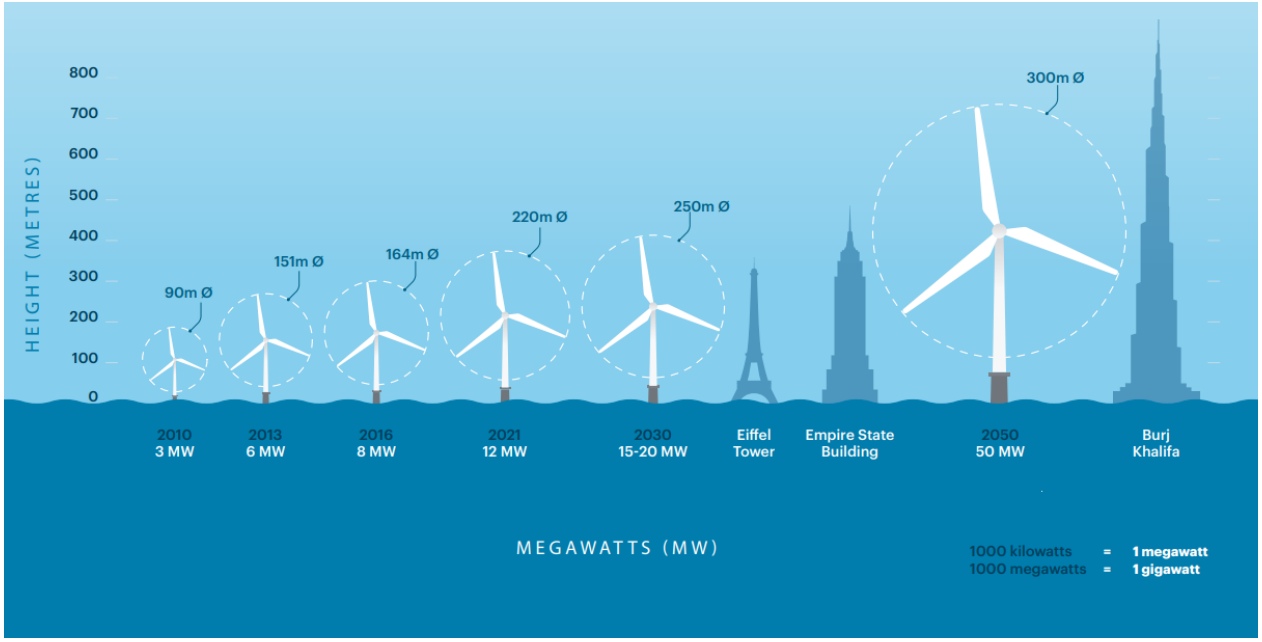
Offshore wind explainer: Australia

Why wind?

- Australia's ageing coal-fired power plants are shutting down more rapidly than initially planned, as renewable energy becomes more cost-competitive.
- Meanwhile, the 'electrification' of industries, transport and households traditionally powered by fossil-based fuels is driving demand for clean energy. The National Energy Market needs to double the electricity delivered by 2050 from 180 Terawatt hours (TWh) to 330 TWh.
- That's 9x Australia's current renewables capacity. Achieving the target requires a major investment into renewable energy generation and an upgrade to the national power grid and transmission lines, as well as investment into battery infrastructure. Today's grid is not ready to handle a widescale transition to renewable energy.
- The projected doubling of electricity demand doesn't account for the anticipated development of hydrogen or ammonia industries, which take a huge amount of electricity to produce. These fuels are tipped to replace fossil fuels in many sectors.
- Offshore wind turbines can generate a huge amount of energy to help meet this demand:
    1. The wind blows more steadily at sea away from land masses that disrupt airflow. This means the wind "resource" is higher quality, consistently blowing at speeds that allow for maximum power generation.
    2. Offshore turbines can be much larger, as there's more space and fewer limitations.
    3. Bigger turbines + better wind = a consistently higher energy harvest.
- Offshore wind is more expensive to install, and there is a significant investment required to prepare for the industry: port upgrades, local manufacturing of high-tech subsea power cables, specialised turbine installation and maintenance vessels. The first projects will be costly as this infrastructure is developed. However the cost curve then drops quickly. Australia has the benefit of learning from the already-established European offshore wind market, and the high energy yields from offshore wind make the industry economically viable.

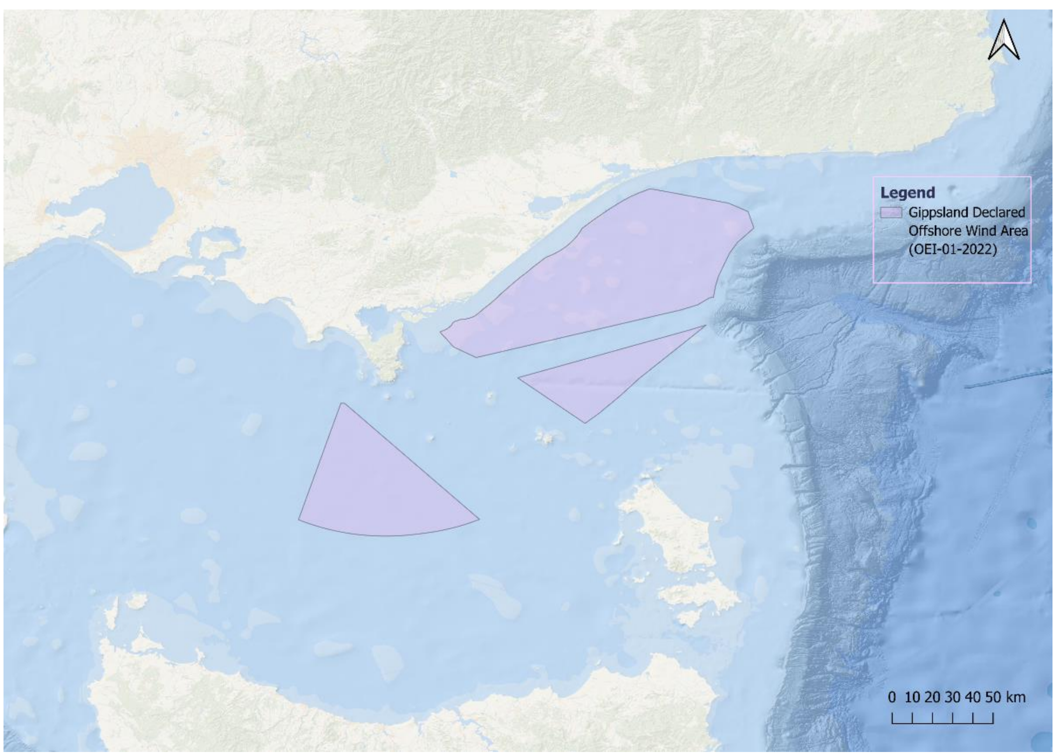
Key facts

- Offshore wind turbines are currently up to 260 m tall with a generation capacity of up to 15MW. Even larger turbines are already on the technology horizon. Depending on the turbine size selected, each offshore wind farm could produce up to 2GW of energy – powering almost 2 million homes per year.
- Turbine towers have either a single monopile or truss foundation (think the Eiffel Tower, but smaller – see image under 'Design and Manufacture' on p.4) fixed to the seabed, or in deeper water moored floating foundations can be used.

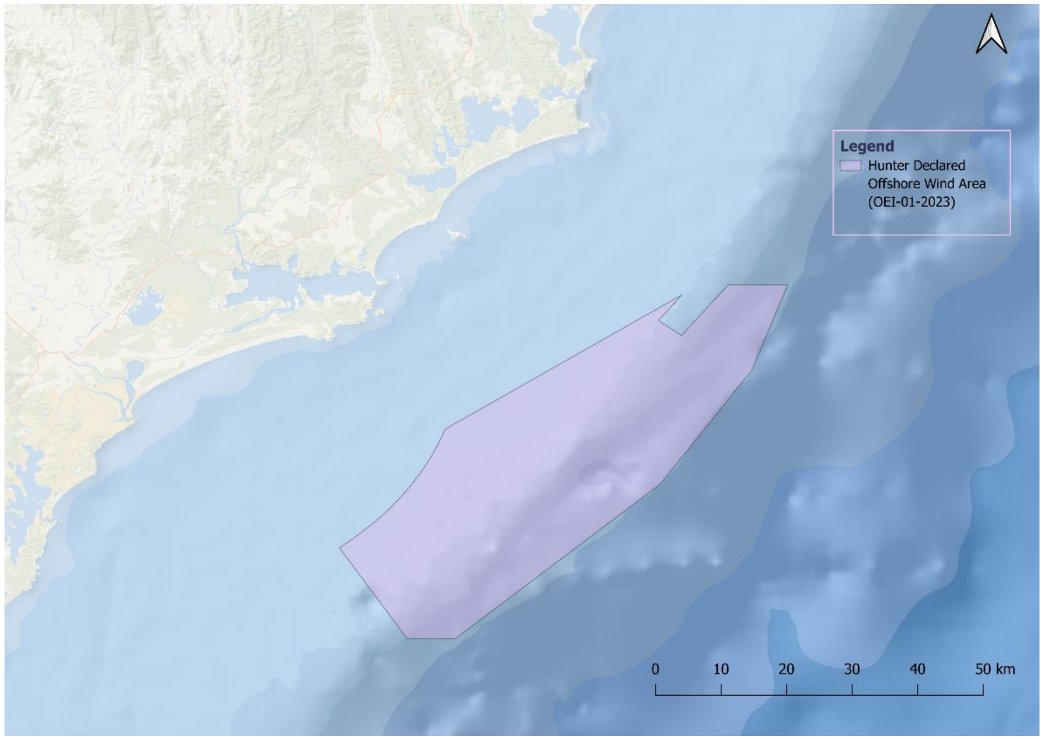


Evolution of wind turbine size and power output. Credit: NOPSEMA

- The Australian government has identified six zones for offshore wind development. Of these:
  - Two zones off the Hunter region in NSW and Gippsland in Victoria have been “declared”. This means from an initial large-scale consultation area, these areas have been defined as either suitable for offshore wind development, or carved out and excluded due to environmental, feasibility, First Nations or other industry impacts.



Gippsland declared zone. Credit: CoreMarine.



Hunter declared zone. Credit: CoreMarine.

- Three zones are under consideration:
    - A 10,000 km^2 area in Bass Strait 1,400 km^2 area off the coast of Wollongong in New South Wales, and the 5,100 km^2 Southern Ocean zone from Warrnambool in Victoria to the South Australian border.

- The zones that have been declared / are under consultation in Australia are a minimum of 10 km from the shore. Turbines in operation won't be audible from shore, but the nearest turbines may be visible on a clear day and marine and aviation lighting may be visible at night. Visualisations are available here.
- The federal Department of Climate Change, Energy, the Environment and water (DCCEEW) is responsible for developing the laws and regulations around offshore renewable development, identifying potential sites, public consultation, declaration of suitable sites, and assessing applications from developers. The Energy Infrastructure Commissioner handles community queries and complaints.
- According to DCCEEW a single 2 GW project can cost between AUD$8 billion and $10 billion. During construction about 1,200 workers will be needed. During operations and maintenance about 600 workers will be needed.
- Offshore wind projects are subject to the *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).* They may also be subject to the *Environmental Protection (Sea Dumping) Act 1981* and the *Underwater Cultural Heritage Act 2018.* Environmental factors are listed here.

Process for selecting and developing offshore wind zones

1. Phase 1: Area declaration (6-9 months)
   - Area identification and preliminary assessment
   - Public consultation on proposed area
   - Area declared, if suitable
2. Phase 2: Feasibility Licence (2-7 years)
   - Feasibility Licence Application
   - Environmental and other approvals received, community feedback
   - Management plan development, feedback to manage co-existence
3. Phase 3: Commercial Licence (up to 40 years)
   - Commercial licence application
   - Construction, Operation and Decommissioning with ongoing consultation to manage co-existence.

Detailed timeline available here.

Design and manufacture

- Most wind turbine **generators** are manufactured in Europe (Siemens Gamesa, Vestas, GE), with some in China (Mingyang, CSSC). It is a highly specialised manufacturing process, and we expect the turbine parts supply chain will continue to be based mainly out of Europe.
- Wind turbine **foundations** can either be fixed (monopile or jacket) or floating and moored to the seabed. Fabrication is in Europe (Navantia, Smulders, Sif, Bladt), China (Dajin, PJOE, CNOOD, Wison), South-East Asia (Century Wind Power, Unithai, Sembcorp, Keppel), and the Middle East (Lamprell). Parts of the foundation fabrication supply chain could potentially happen locally.

Offshore wind foundation types. From left to right: monopile, jacket, twisted jacket, tension-leg floating platform, semi-submersible platform, and spar-buoy. Credit: National Renewable Energy Laboratory.

- Subsea **high voltage (HV) power cables** connect the turbines to the power grid onshore. HV cable is currently produced by specialised manufacturing plants in Europe (Nexans, Prysmian, NKT, JDR) and Asia (Sumitomo, Furukawa, LS Cables). However, current production capacity will not meet the projected demand based on the number of upcoming energy projects requiring these cables. Projects will face significant delays as the global HV cable shortage creates bottlenecks. This demand creates an opportunity to establish new HV cable manufacturing plants in the southern hemisphere, despite the significant investment required to set up advanced manufacturing facilities. The recently announced $2 billion SunCable manufacturing plant flagged for Bell Bay in Tasmania is an example of this.
- Offshore wind manufacturing and construction provides many economic benefits for communities:
    - A large number of jobs are created in the development, installation and maintenance phases of a project.
    - This creates flow-on local economic development, with demand for nearby services including port developments, manufacturing facilities and general project services.
    - Countries that invest in supply chain development (e.g. manufacture of parts and cables) can then export offshore wind technology and expertise to other markets.
    - Diversification of energy supply will increase energy security. This means Australia will be less reliant on imported energy sources like fossil fuels, and less impacted by energy market volatility.

Installation

Ports

- Offshore wind farms are installed in the ocean, so operations need to be based out of a port near the site. Offshore turbines are bigger than onshore, and more turbines are installed in each windfarm. The greater size and quantity mean more space is needed to mobilise parts, the “laydown area” needs to be strong enough to bear the weight of these parts and the space needs to back onto sufficiently deep vessel berths (some dredging may be needed). Specialised vessels then collect the foundations and turbine components from the local staging port and install them at the offshore wind farm site.
- Australian east coast ports currently lack the capacity for wind turbine installation staging, which means there’s an opportunity for a port authority to develop an offshore wind precinct: all offshore wind developers awarded a licence in the vicinity would look to operate from that port.

Supply chain

- Building windfarms is extremely specialised, requiring bespoke installation vessels mobilising out of fit-for-purpose ports. Currently there are not enough wind turbine installation vessels (WTIVs) available globally to meet the projected project demand worldwide. This creates a bottleneck, potentially delaying projects.

- Until recently, Europe has been the epicenter of the offshore wind industry. Globally, 18 of the 22 WTIVs currently in operation are fully committed until 2028 (this number excludes China, which has its own industry and supply chain).
- Meanwhile, all proposed developments in Australia are for 15MW+ turbines. Bigger turbines mean bigger vessels, but only 40% of the current global WTIV fleet can install turbines larger than 12MW. This exacerbates the technology and demand gap in APAC, making the case for investment in newbuild WTIVs that will be snapped up by developers working in the region.
- Similarly, demand will far outstrip global supply for high voltage power cables (discussed above under Design & Manufacture), as well as cable lay vessels to install them. This creates a similar risk of project delays if the supply chain challenges aren't addressed.

Connection to grid

- Wind farms generate a lot of power, which needs to be transmitted from the offshore site to the local electricity grid. High voltage 'inter-array' cables connect each wind turbine to an offshore substation (OSS). The OSS then increases the voltage and sends the power through a subsea export cable, which runs from the offshore wind farm to the onshore grid connection point. While regulations are still under development, the preferred method for connecting power export cables to the shore is via a long tunnel drilled from near the onshore substation, deep under the beach, to a point hundreds of metres offshore. The cable is pulled through this tunnel underneath the beach which mitigates impact on sensitive coastal environments.
- The nascent offshore wind industries and hydrogen industries could also complement each other. Technology is developing to generate 'green' hydrogen offshore using wind energy and seawater. This could remove the need to connect offshore wind farms to an onshore grid, creating a closed-loop energy island. It would also maximise the amount of wind power converted to power, as some energy is lost through transmission to shore.

Operations and maintenance

- The operations and maintenance (O&M) of an offshore wind farm needs to be based out of a port local to the site. Small Crew Transfer Vessels (CTV) or medium-sized Service Operation Vessels (SOV) mobilise service technicians from the O&M base port to the offshore wind farm daily for routine operations, inspections and servicing of wind turbine components. Helicopters may be used where appropriate.
- Economic benefit: An O&M base port provides many local jobs for the full 25+ year project life. The number of jobs depends on the number and size of wind farms in the offshore energy zone.

Lifespan and decommissioning

- Lifespan: currently around 25 years, but with the ability to extend turbine life through refurbishment or component replacement.

- At the end of a wind farm's life, standard decommissioning practice is for the full removal of all installed components. However, some foundation parts may need to be cut off below seabed level if full removal is not possible.
    - Australia's offshore wind decommissioning guidelines and regulations have not yet been detailed in full, but processes similar to those for oil and gas (O&G) infrastructure may be used. In the O&G industry, there is scope to consider leaving some infrastructure in place where there's a net overall environmental benefit to do so; i.e. where it has created an artificial reef. This would only be considered if a significant amount of marine life in and around the structure would otherwise be destroyed by complete removal.
    - This only occurs after a thorough Net Environmental Benefit Assessment (NEBA) is performed by environmental consultants and approved by the Government environmental regulator (NOPSEMA and OIR).
- Turbine manufacturers globally have committed to produce 'zero waste' turbines by 2030 that can be completely recycled. Previously turbine blades have been difficult to recycle, but new resins have been developed which mean the blades can be broken down to base chemicals and fully recycled. Australia is developing a processing treatment and a pilot recycling facility for wind turbine blades.

Offshore wind FAQs

Here's a simple graphical explainer from Wind Europe.

Q: Does windfarm site testing harm marine animals?

A: Some seabed testing is required in selecting windfarm sites. This is typically done using High Resolution Geophysical (HRG) testing, not the high-energy, deep penetration seismic testing used by oil and gas exploration. We can't put it better than Greenpeace did here – "The difference between sonar mapping for wind and seismic blasting for gas is the difference between having Smooth FM on in the background, and being front row at a Slipknot gig."

Q: Do offshore windfarms harm birds and marine animals during turbine installation or while operating?

A: Windfarms do have some impact on the environment, but the benefit of going offshore is that there's so much more space to select sites that avoid migratory routes. Before an offshore wind zone is declared, migratory bird and sea life patterns are considered to make sure windfarms are not built in their paths.

All infrastructure projects create some environmental disturbance during construction, but there's a lot that can be done to mitigate the impact. For example, sound protection measures like "bubble curtains" dampen the distance noise travels through the water. Work can be paused during migratory seasons, and precautions are taken to minimise bird collisions.

Once a windfarm is up and running, there's no evidence they have any significant impact on whales. Turbine foundations can create artificial reefs to attract species and improve marine biodiversity. Both offshore energy zones and individual windfarms must strictly comply with the *EPBC Act*.

Q: Can offshore wind turbines be seen and heard from shore?

A: It depends on how far out to sea the windfarm is built as well as the turbine size. In the clearest conditions, a turbine 10 km offshore may be visible on the horizon, but will be out of beachgoers and homeowners' earshot. Power cables connecting to onshore substations will be underground and out of sight. There is mandatory marine and aviation lighting on turbines, but the intensity of these decreases substantially with distance.

Digital rendering of offshore wind turbines to illustrate how wind turbines in the proposed area may look from Devonport. This is a digital rendering for illustrative purposes only. Credit: DCCEEW

Q: Will other water users still have access to the zones?

A: This is considered on a case-by-case basis. Impact on other marine users is part of the consultation process at every project phase: feasibility, environmental approval, and commercial licensing.

Q: Will windfarms affect the swell and coastal breezes, impacting surfers, kiteboarders, windsurfers, paragliders, yachties etc?

A: No. Swell forms thousands of kilometres out to sea, and will flow around individual turbines and continue uninterrupted to shore. In terms of wind impact, there is some wake immediately behind a turbine, before wind speeds return to normal within a few hundred metres.

Q: What happens in a really big storm?

A: Offshore wind turbines are designed to operate safely in very fast wind speeds so they can generate energy in high wind environments. Beyond about 30 m/s wind speeds, turbines 'cut off'. This is where the blades rotate to be in line with the wind direction to not generate any lift forces, and a brake in the generator prevents the turbine from turning which makes the turbine storm-safe until wind speeds return to safe operating levels. The turbine generator control systems manage this automatically.

Offshore turbines are built to withstand major swells and do not get knocked over, or break their mooring lines or power cables. Fixed turbine jackets (a type of foundation) are designed so the jacket deck that the turbine tower sits on is above the largest modelled waves. The waves simply pass around and through the jacket members (steel tubes), similar to jetty pylons. Monopile-style foundations experience some wave load, but the monopile's circular shape minimises this. Waves generally diffract around the monopile.

Floating wind turbine foundations will 'ride' most swell conditions. The foundation and moorings are designed to withstand much greater than the largest expected waves to provide an additional margin of safety.

Q: Can offshore turbines be recycled?
A: Manufacturers are working on it. Several major global manufacturers have committed to zero waste turbines by 2030. Decommissioning and recycling must be managed and paid for by the windfarm licence holder.

Find detailed answers from DCCEEW here.