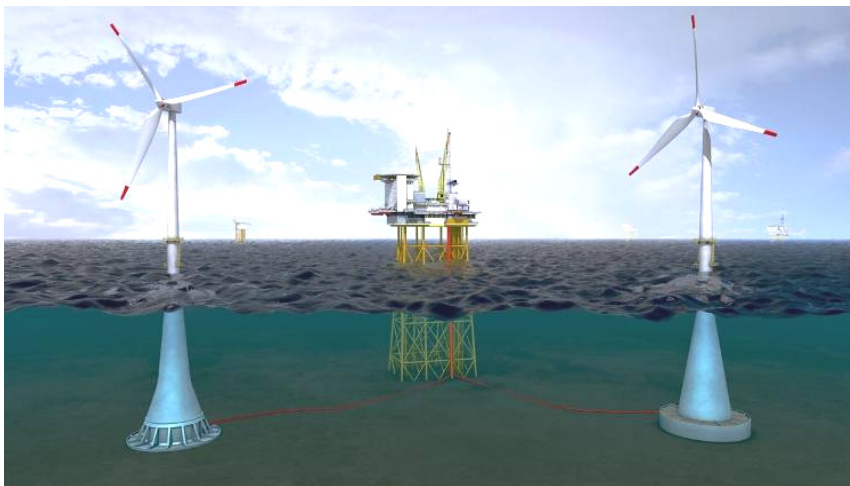


Offshore Wind Turbines: Concrete Foundations

no heavy lift – no piling – marine life friendly – very long design life

A new and innovative design has been developed for concrete foundations suitable for large offshore wind turbines in water depths 30-100m. This robust and durable solution significantly reduces risks and costs associated with transport and installation offshore. And it minimizes impact on marine life.



The concrete foundation structure allows for inshore assembly of complete wind turbines, including foundation, tower, generator and rotor. In this way the use of expensive offshore cranes for installation is avoided. The complete turbine is towed to site and installed by ballasting. The concrete foundation provides a

stiff and strong base for the wind turbine, preventing unfavorable dynamic effects and fatigue problems. Very long design life - 100 years or more – can be achieved and no maintenance is required. This opens for reuse and adds significant value to the project since wind power will last indefinitely.



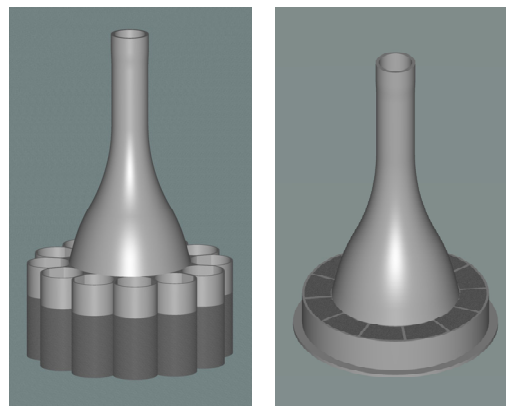
Main Features

- Applicable water depths: 30 to 100 meters
- Simple and robust structure with long design life
- No Offshore Heavy Lift Vessel required. Can be towed to site complete with tower and turbine.
- Testing and mechanical completion inshore
- Simple offshore installation by ballasting – less sensitive to weather conditions
- No piling or anchors - no disturbance of aquaculture
- Maintenance-free foundation structure
- Suitable for soils from stiff clay/dense sand to soft soil
- Optimal stiffness and dynamic characteristics
- No fatigue issues for foundation structure, reduced fatigue of steel tower
- Simple to remove/decommission or reuse at suitable location
- Well-proven and patented technology

Key Figures

Example for 40m water-depth, Central North Sea environmental conditions and 5MW turbine:

- Air gap concrete structure : 20,0 m
- Hub height above LAT : 89,0 m
- Base outer diameter : 34,0 m
- Outer diameter, base of shaft : 19,2 m
- Outer diameter, top of shaft : 6,6 m
- Concrete volume : 1790 m³
- Steel reinforcement : 650 t
- Solid ballast : 5151 t
- Submerged weight : 69 MN

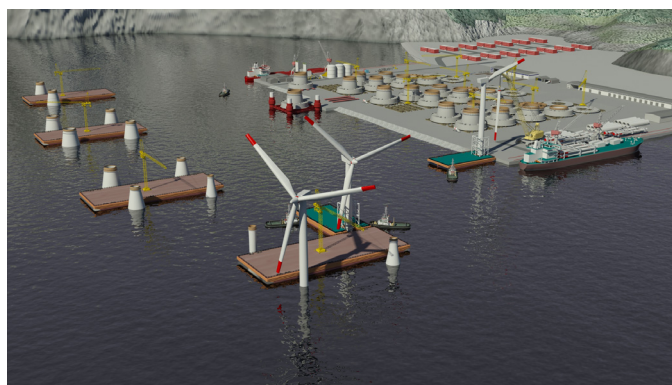


Alternative foundation solutions

Depending on soil conditions the structure can be gravity based or skirt piled, or any favourable combination (se pictures above).

Fabrication

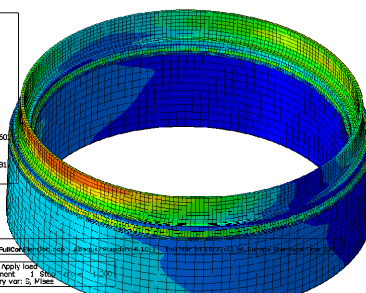
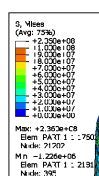
The concrete foundations can be constructed locally worldwide, with a limited infrastructure in place. There are many local contractors worldwide that can build these structures with proper supervision by ViciVentus.



Fabrication of the base structure can be done on floating barges, in a dry dock or on a quay. For low cost mass production an efficient fabrication yard on land will be established. Mass production is expected to reduce cost per unit significantly compared to one-off projects. After setting the base structure afloat the remaining shaft is cast while the structure is moored in sheltered waters. The steel tower and turbine may be lift installed inshore to reduce risk, to avoid use of costly offshore cranes and to increase weather window for offshore completion.

Connection steel/concrete

The connection between the concrete foundation and the steel tower is a bolted connection. A steel ring transition unit is connected to the top of the concrete shaft by post tensioning. The steel turbine tower is bolted to the transition ring. This provides a rigid and very strong connection between concrete and steel, not sensitive to fatigue and without the grouting issues recently discovered for monopiles.



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