How deep can the Monopile foundation, carry the offshore wind industry

Ioannis Lessis – Head of Engineering, Offshore, SSE Renewables

10/05/2023

What is a Monopile

Simple design

Monopile is a simple solution reliant on a single tubular structure to support the turbine down to the seabed. Made of flat plate rolled into tubulars and then welded together it is simple and quick to make

Prevalent

First used in the 1990s it has become the most prevalent solution for shallow (<60m water depths) wind farms

Better value

Marries well with the dynamic behaviour of the turbine tower. Cheaper than the alternative jacket solution

sse Renewables

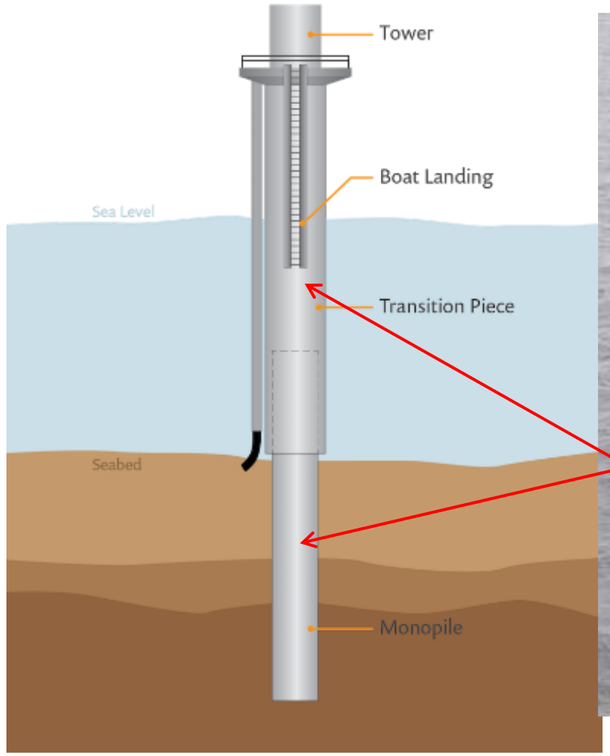
What is a monopile

The traditional monopile solution contains both the monopile which:

- Is driven into the seabed
- Is almost entirely a structural component
- Contains very little steel devoted to accessing the structure or supporting equipment
- Usually cannot be seen above the sea level

A transition piece which is:

- A significant structural component, connecting the tower to monopile
- However contains significant steel dedicated to accessing the structure and supporting equipment
- Is placed on top of the monopile with usually a bolted or grouted connection to the monopile
- Usually coated yellow (nobody knows why, its just tradition) can be seen above sea level at all times

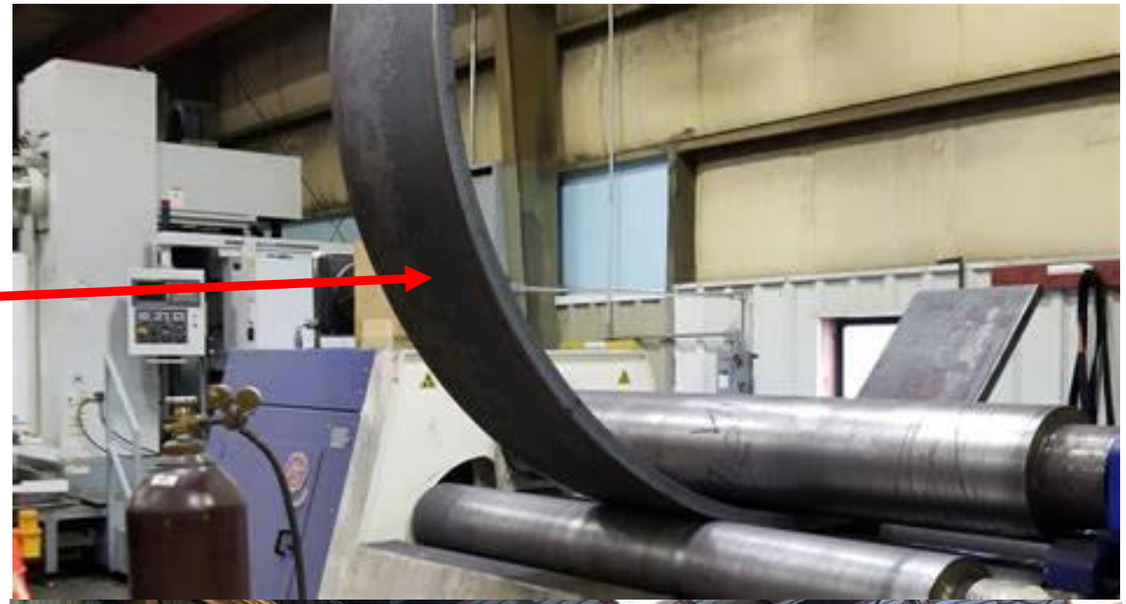


sse Renewables

How is a monopile

Fabrication

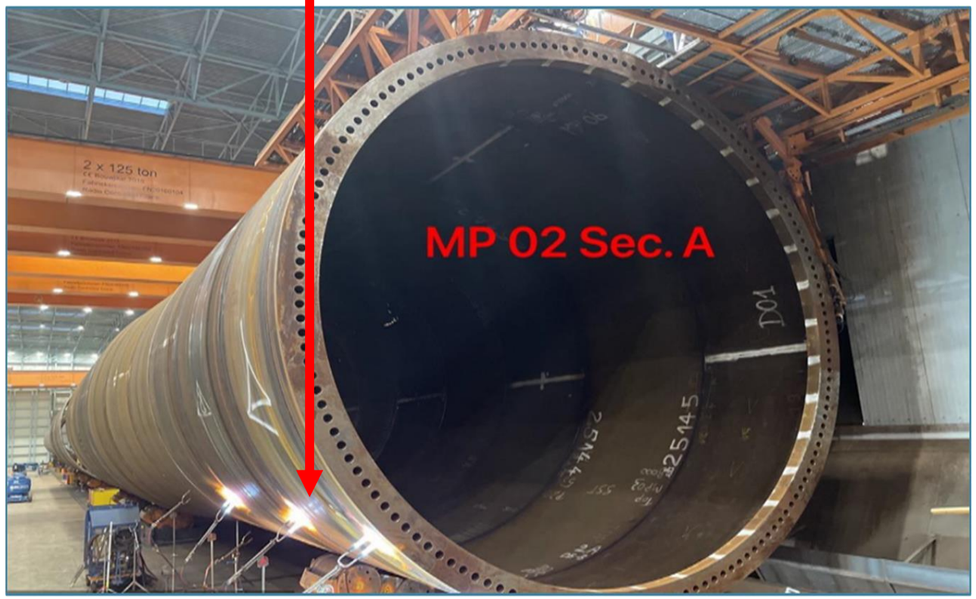
- Monopiles are first formed out of flat plate, rolled into the approximate curvature of the final pile
- Usually somewhere between 2 and 3 plates are required to make a full can of current diameters
- The rolled plates are then joined together to form a can using longitudinal welds

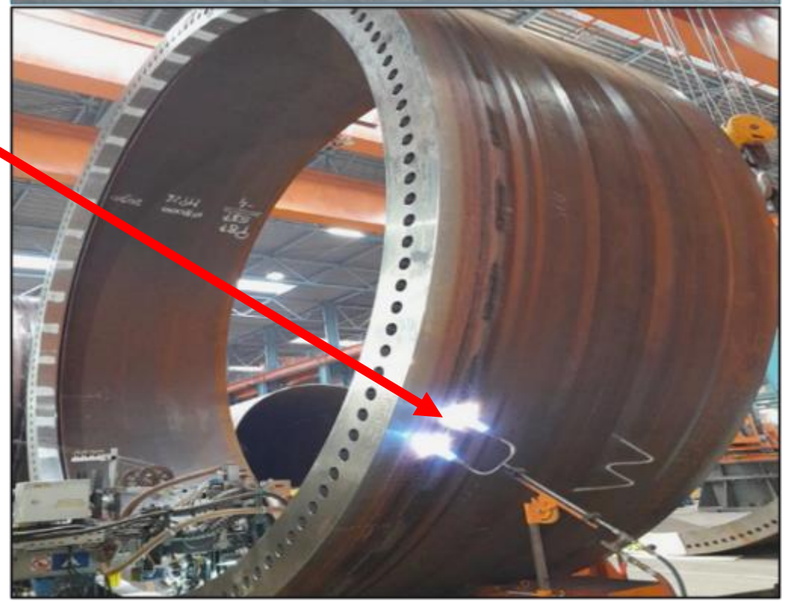


How is a monopile

Fabrication

- Longitudinal welds join the plate together
- Circumferential welds join the cans together into a monopile





sse Renewables

How is a monopile

Installation

- Monopile is upended, a very tricky challenge when moving a steel tube 60-100m long and weighing between 800-3000 tons, in current designs
- Monopile is then driven into the seabed using a hydraulic hammer, this involves a large weight being lifted using hydraulic pressure and then dropped onto the top end of the pile

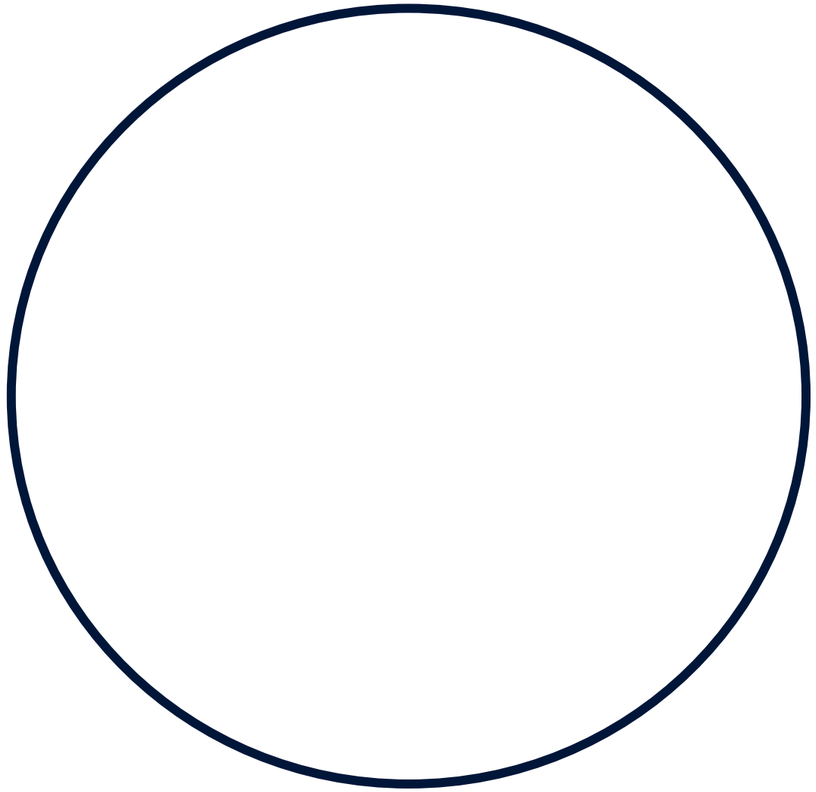
sse Renewables

Why is a monopile a preferred solution

The answer is a perfect circle

Circles provide many benefits from a structural perspective:

- They provide consistent structural response in all directions
- Reduce areas of high stress - corners, joints, attachments
- Provides a surface that fluids move around easily, meaning wind and wave loads are reduced
- Maintain their own structural weight when handled
- Are relatively easy to fabricate



Why is a monopile the best solution

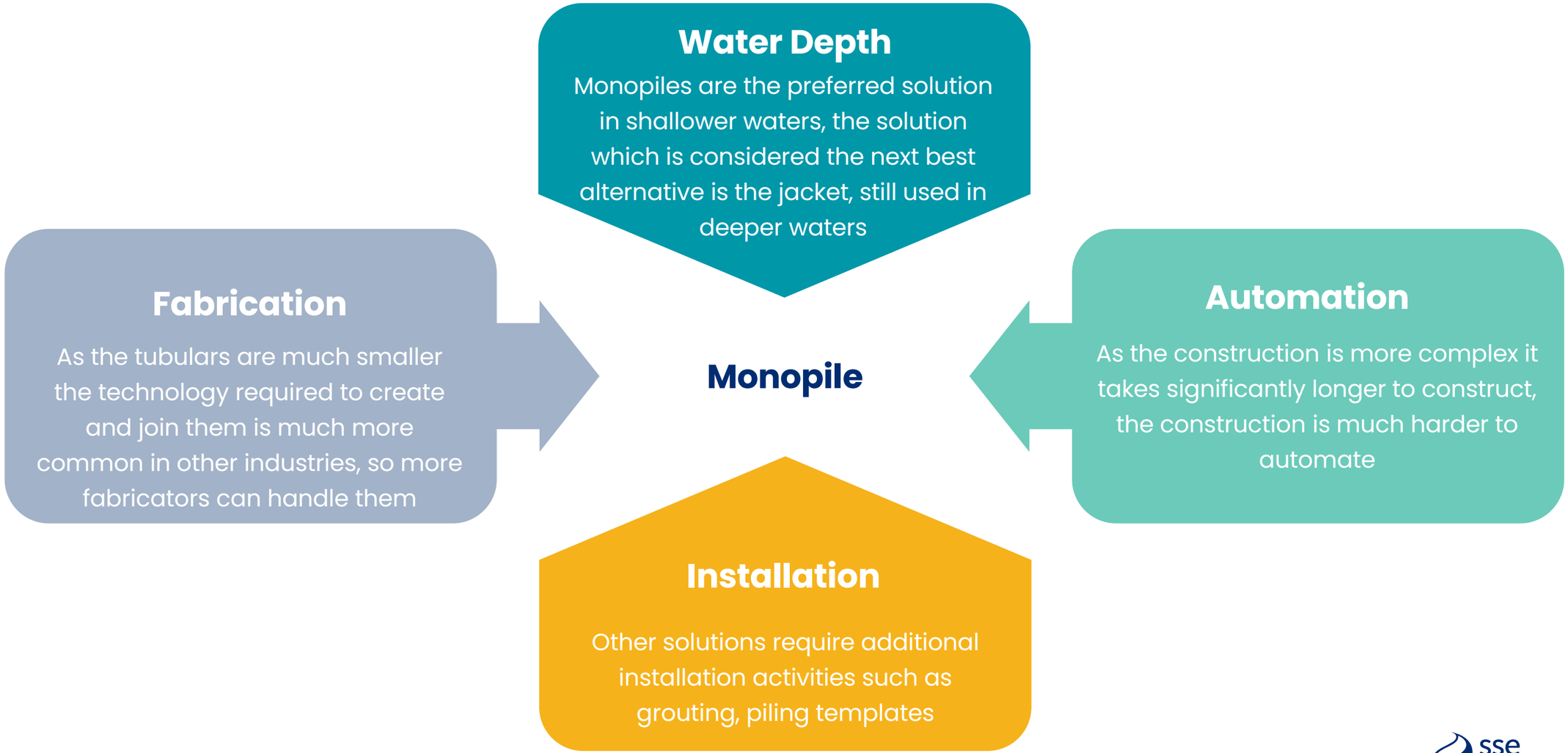
Early wind turbines had varied support structures, some still do today

The monopile being simple and quick to fabricate and having little influence on the flow of air to the blades has become the predominant solution world wide for onshore

The monopile extends this foundation solution down to the seafloor, so the connection between the two structures is relatively simple and the behaviour in response to external loading is somewhat continuous

sse Renewables

Why is a monopile the best solution



sse Renewables

CHALLENGES

Turbines

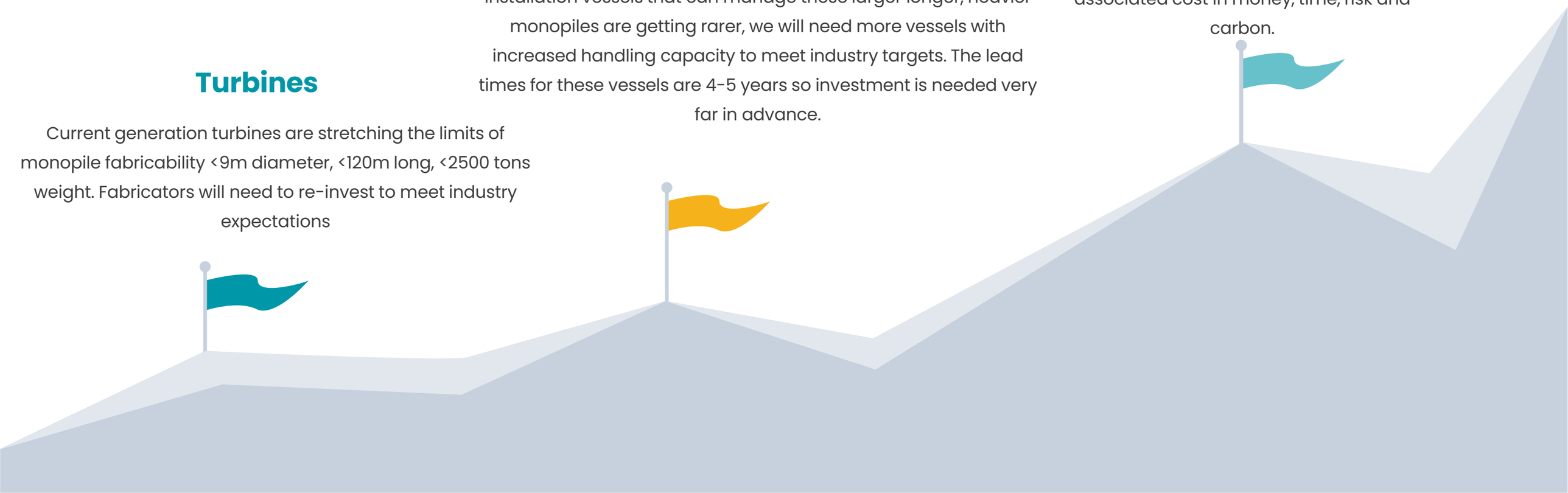
Current generation turbines are stretching the limits of monopile fabricability <9m diameter, <120m long, <2500 tons weight. Fabricators will need to re-invest to meet industry expectations

Installation

Installation vessels that can manage these larger longer, heavier monopiles are getting rarer, we will need more vessels with increased handling capacity to meet industry targets. The lead times for these vessels are 4-5 years so investment is needed very far in advance.

Supply chain

New markets often do not have the technology needed for monopiles being used for other industries, unlike jackets, so bespoke fabrication sites are being constructed in country, however country projects are shipping from Europe with an associated cost in money, time, risk and carbon.



CHALLENGES

Design Approach

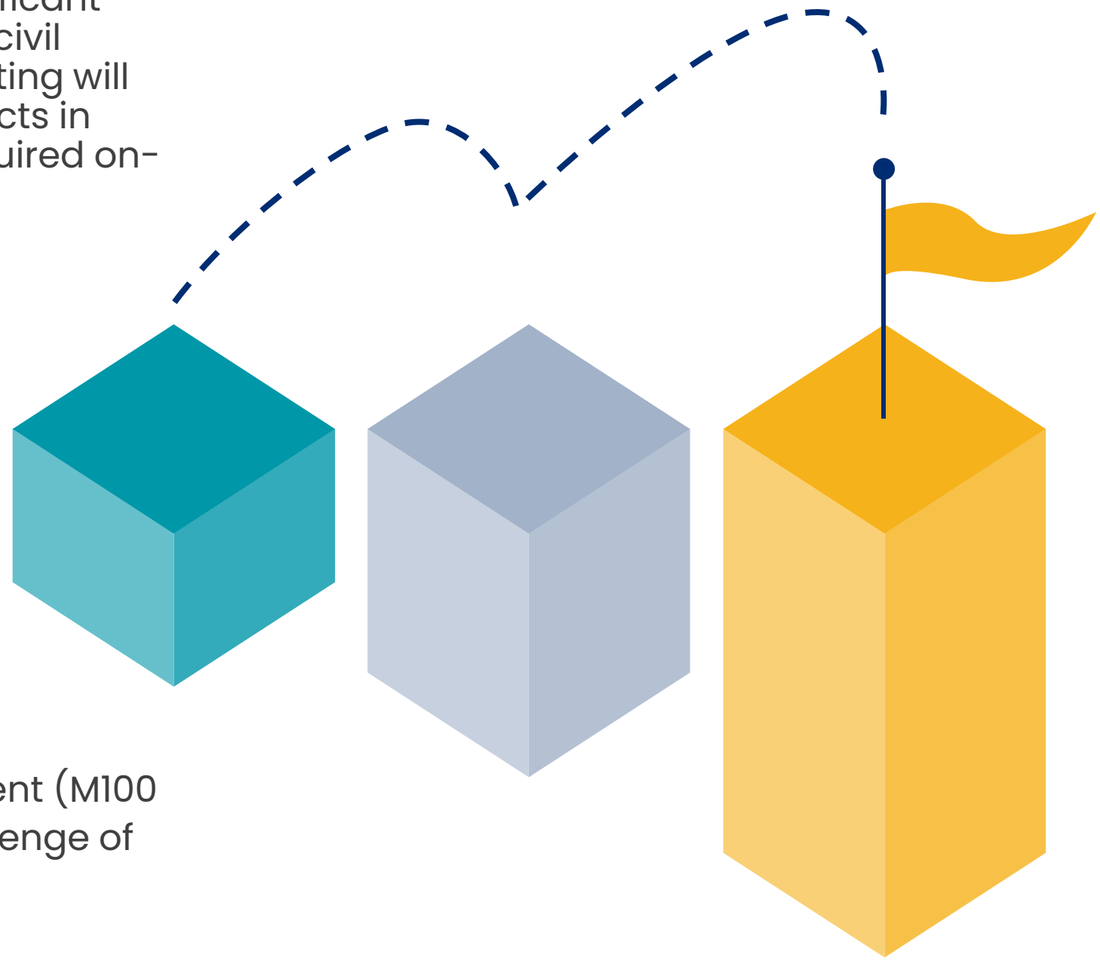
Design approaches are losing applicability as diameters grow, significant research base available for <2m diameter piles, onshore in general civil industry and offshore for oil and gas applications. Research and testing will need to keep pace with projects. Anecdotally there have been projects in recent history where testing of pile response in certain soils was required on-project to make the project financially viable.

Procurement

Limits to procurement, as projects require more steel for larger turbines in larger sections, as more projects in more areas of the world head toward construction, the pressures on the steel supply chain become more pronounced, noting recent high steel price due to the Russia-Ukraine conflict, as different markets compete for the same steel price volatility may become worse

Connections

Connections – current size of connectors is at the limit of procurement (M100 size bolts) and the limits of design, as monopiles get larger the challenge of joining them to towers or TPs become worse



sse Renewables