Gravity Base Foundations:
development for deeper water

Gordon Jackson

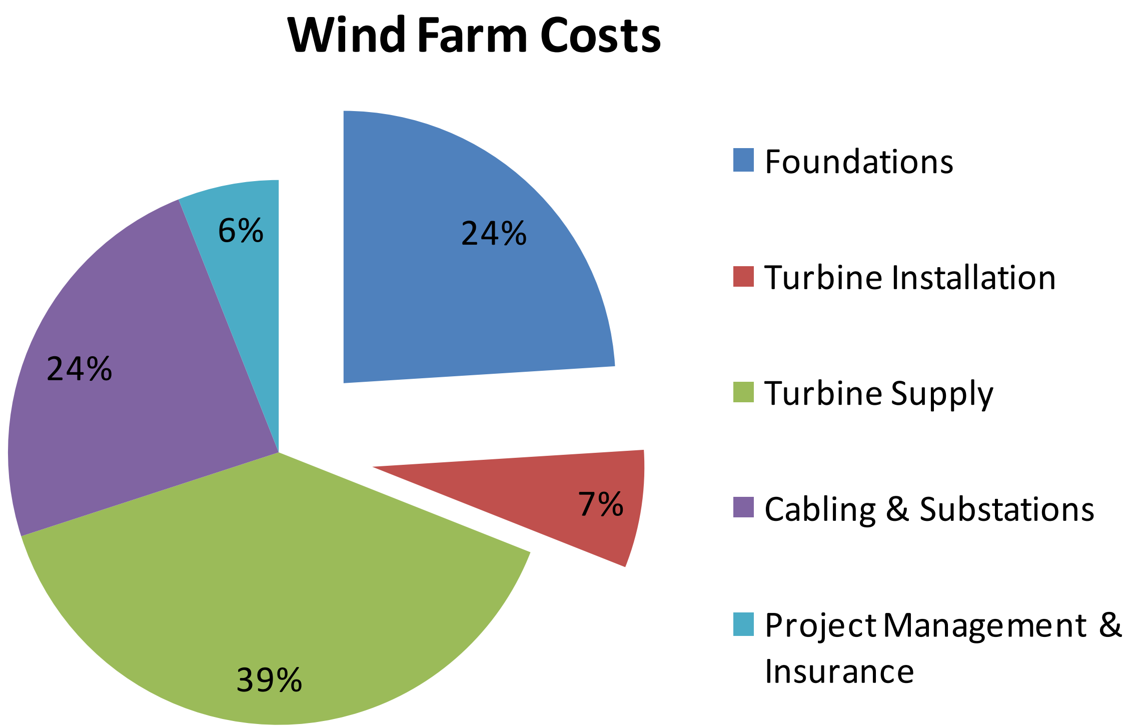
Director, Arup

gordon.jackson@arup.com

HOCHTIEF CONSTRUCTION AG COSTAIN ARUP

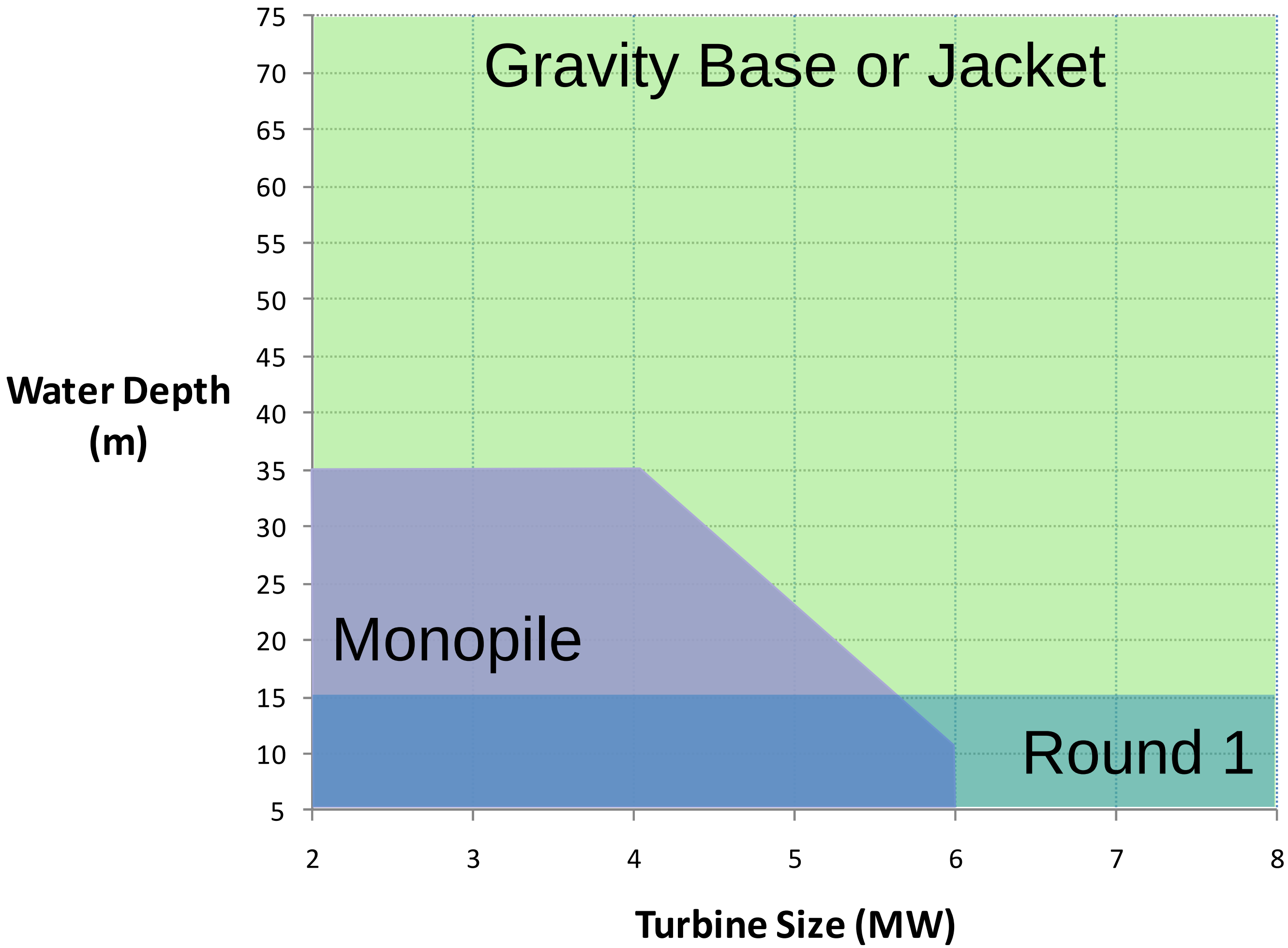
Capability

Scope of development work

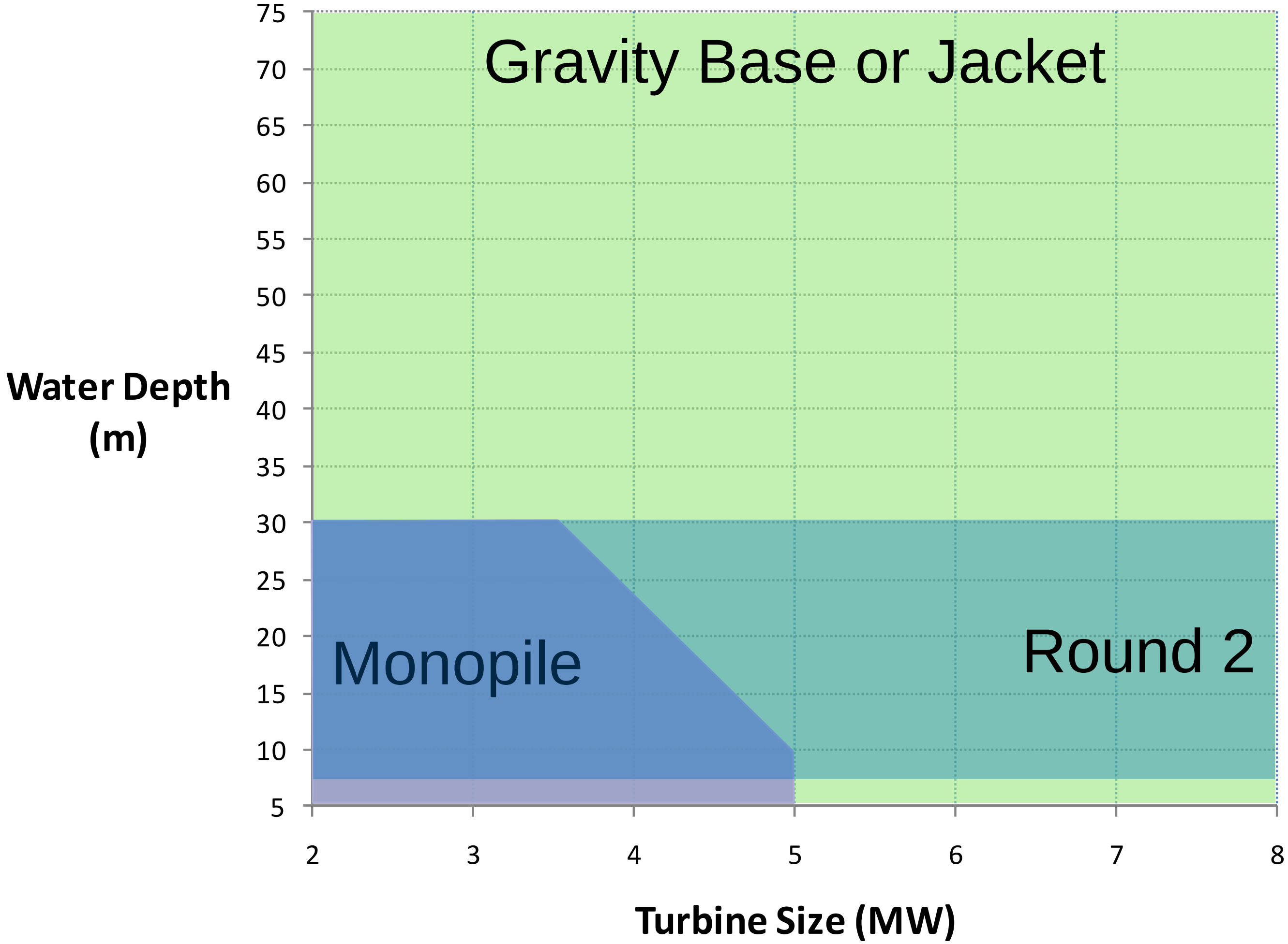


- **Benefits of combining turbine installation with foundations may be limited**
- **Greatest scope for cost-effective solutions in foundations alone**
- **Buy-in from turbine suppliers needed for combined solutions**

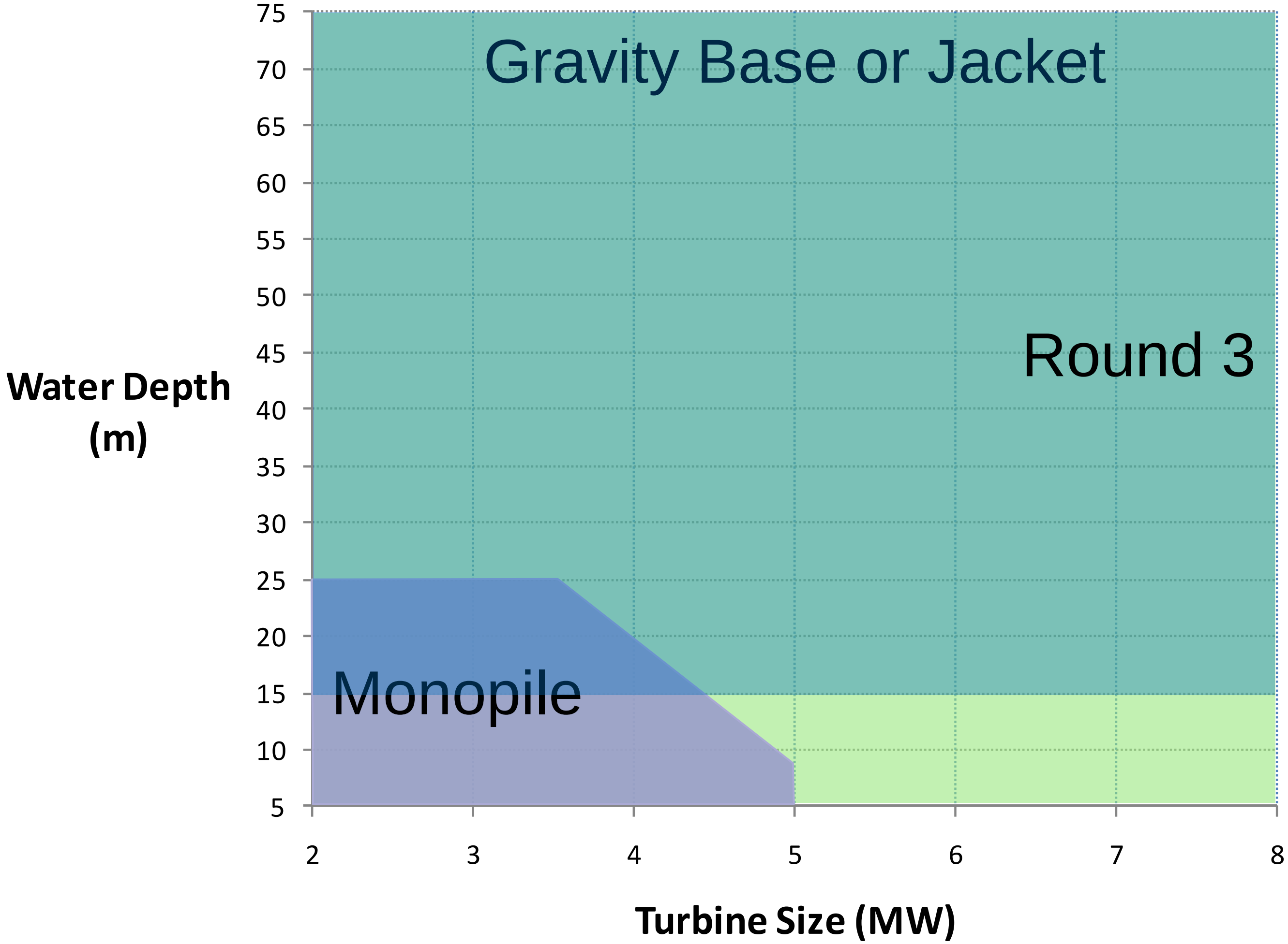
Foundation Selection



Foundation Selection



Foundation Selection

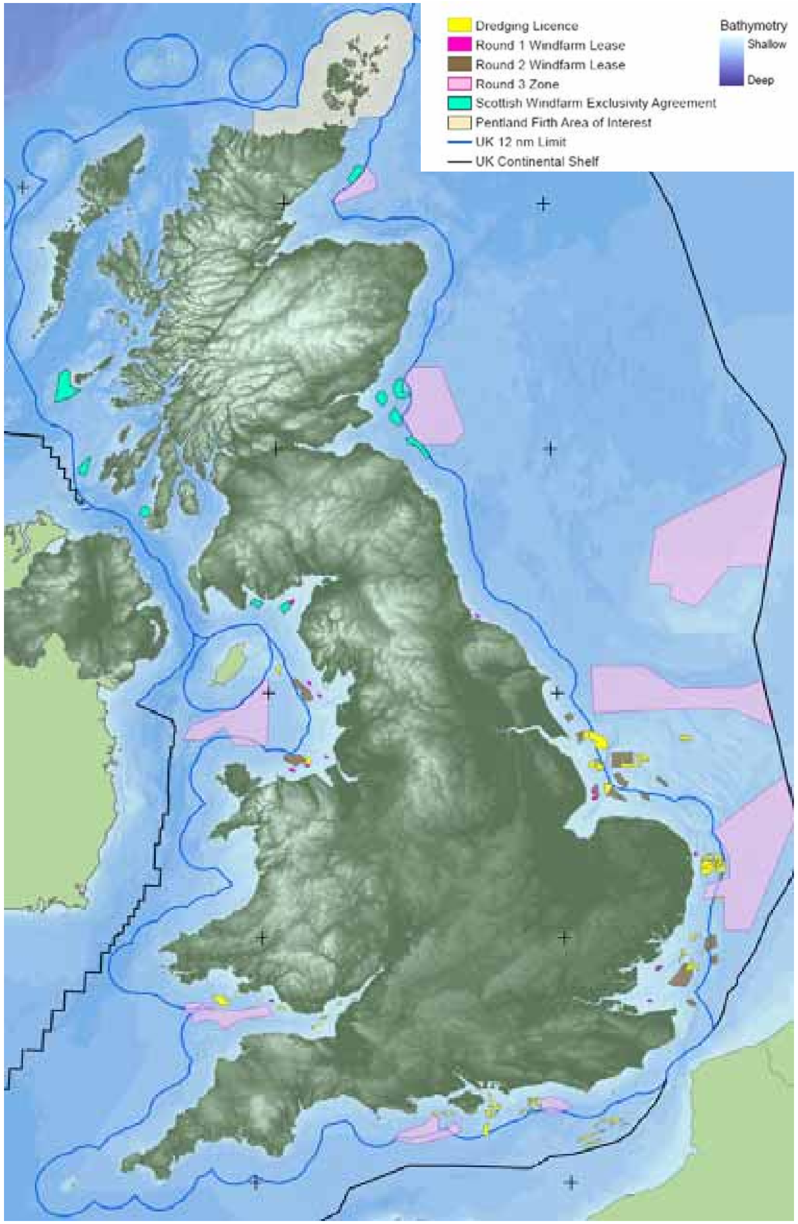


UK Market

Concrete gravity bases can be successfully deployed at all Round 3 windfarms around the UK coast

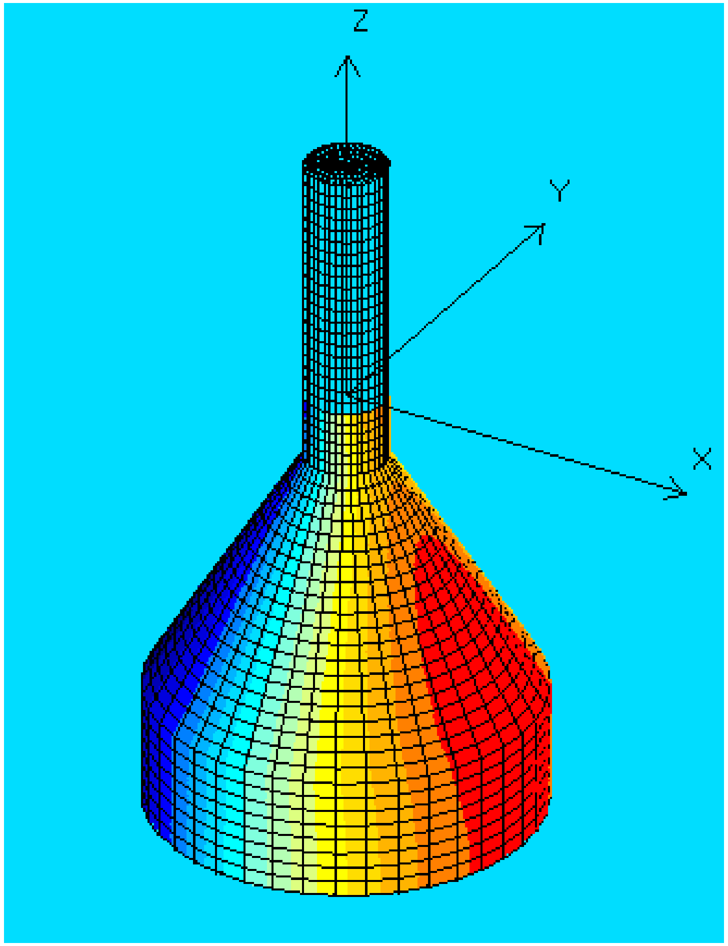
84% of the Round 3 site area is over 30m deep, where concrete foundations may prove to be the best solution

Round 2 extensions and Scottish sites could also adopt concrete foundations

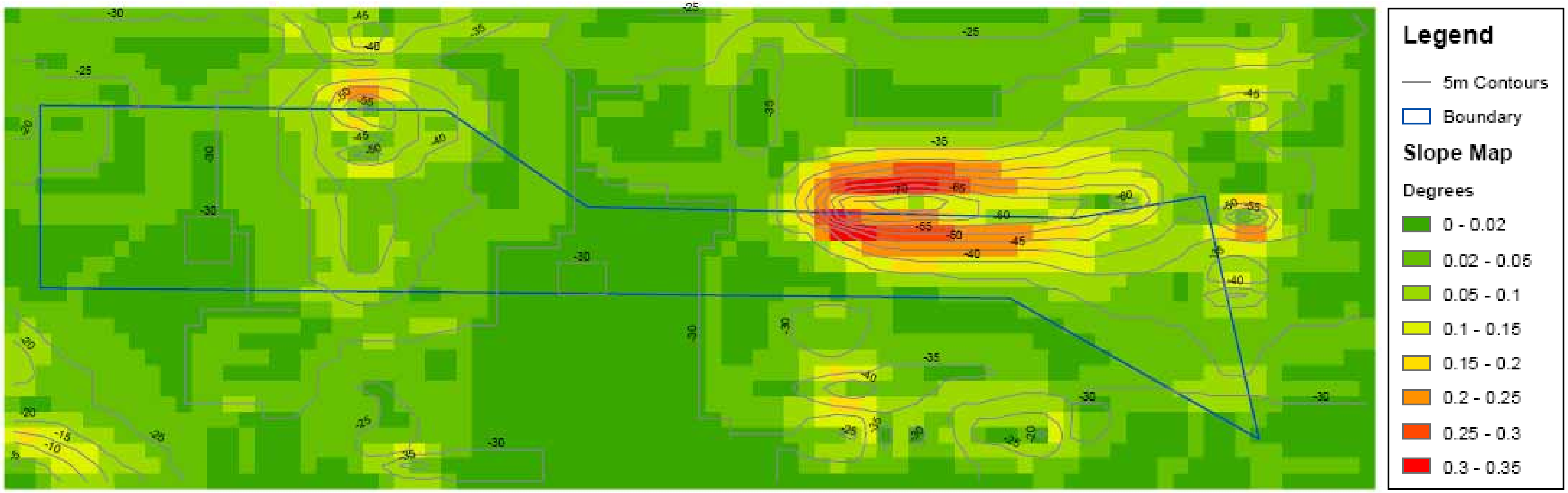


Development basis

- **35m water depth**
- **6MW turbine**
  - but no upper limit for the concept
- **Horizontal axis turbine**
  - Vertical axis acceptable too
- **Central North Sea environmental conditions**
- **Medium-dense sand soils over stiff clays**
- **UK construction location**
- **Tow-out from shore in 10m water depth**



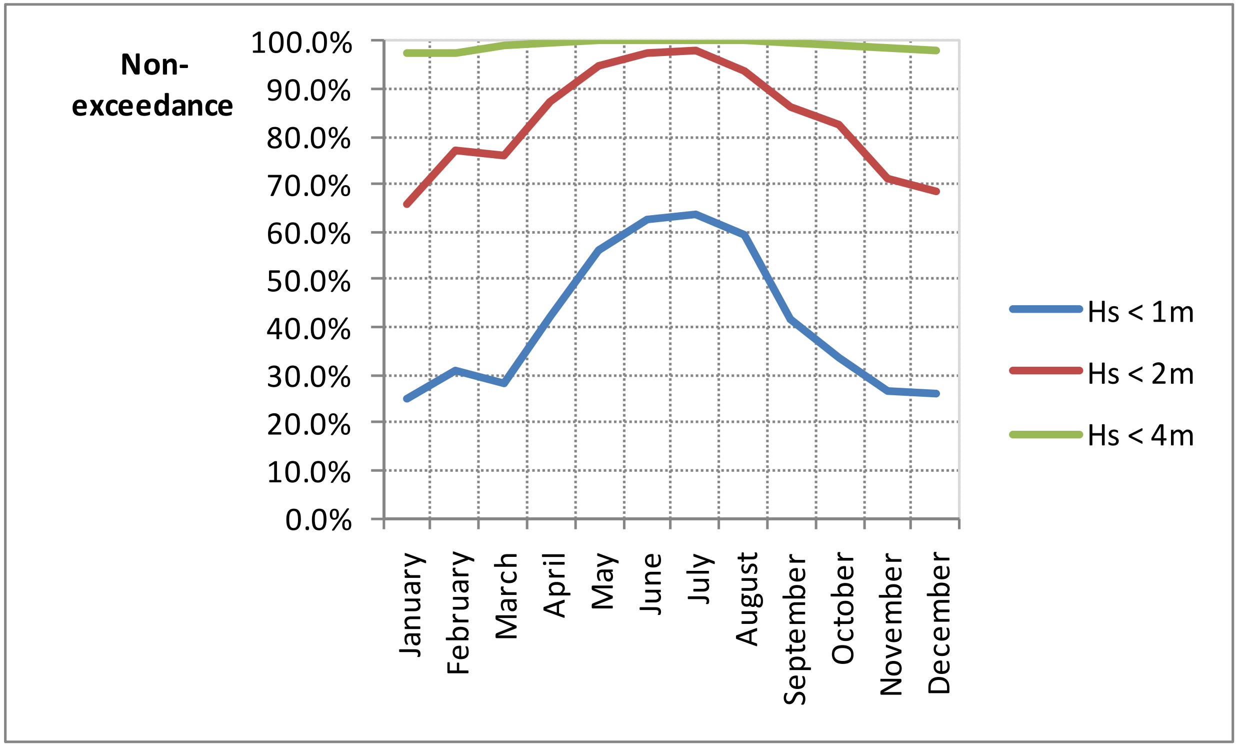
Foundation conditions

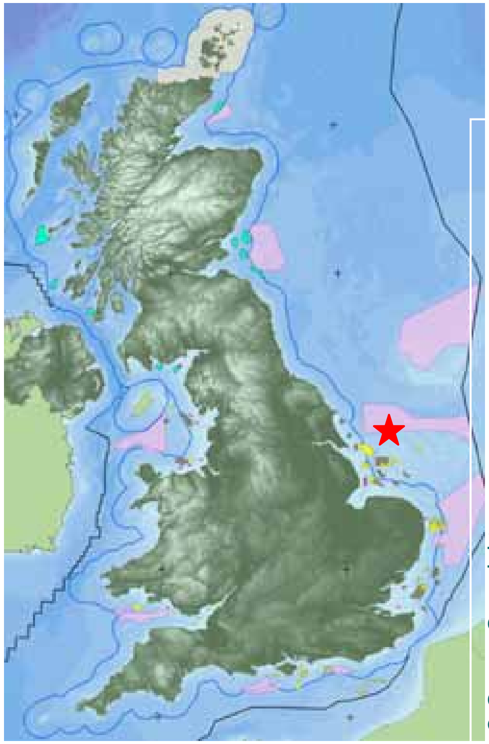


Hornsea area

- **Seabed slopes are small**
- **UK Round 3 surface sediments generally good for gravity foundations**
- **Target minimal sea-bed preparation**

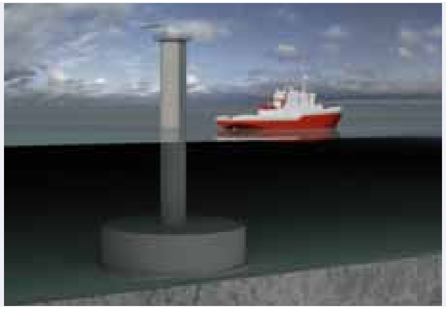
Marine Operations





- **Installation in 2m Hs will permit year-round deployment with only moderate downtime**
- **Towing will rarely be weather-restricted with foundations held in Hs of 4m and more**

Classes of gravity base

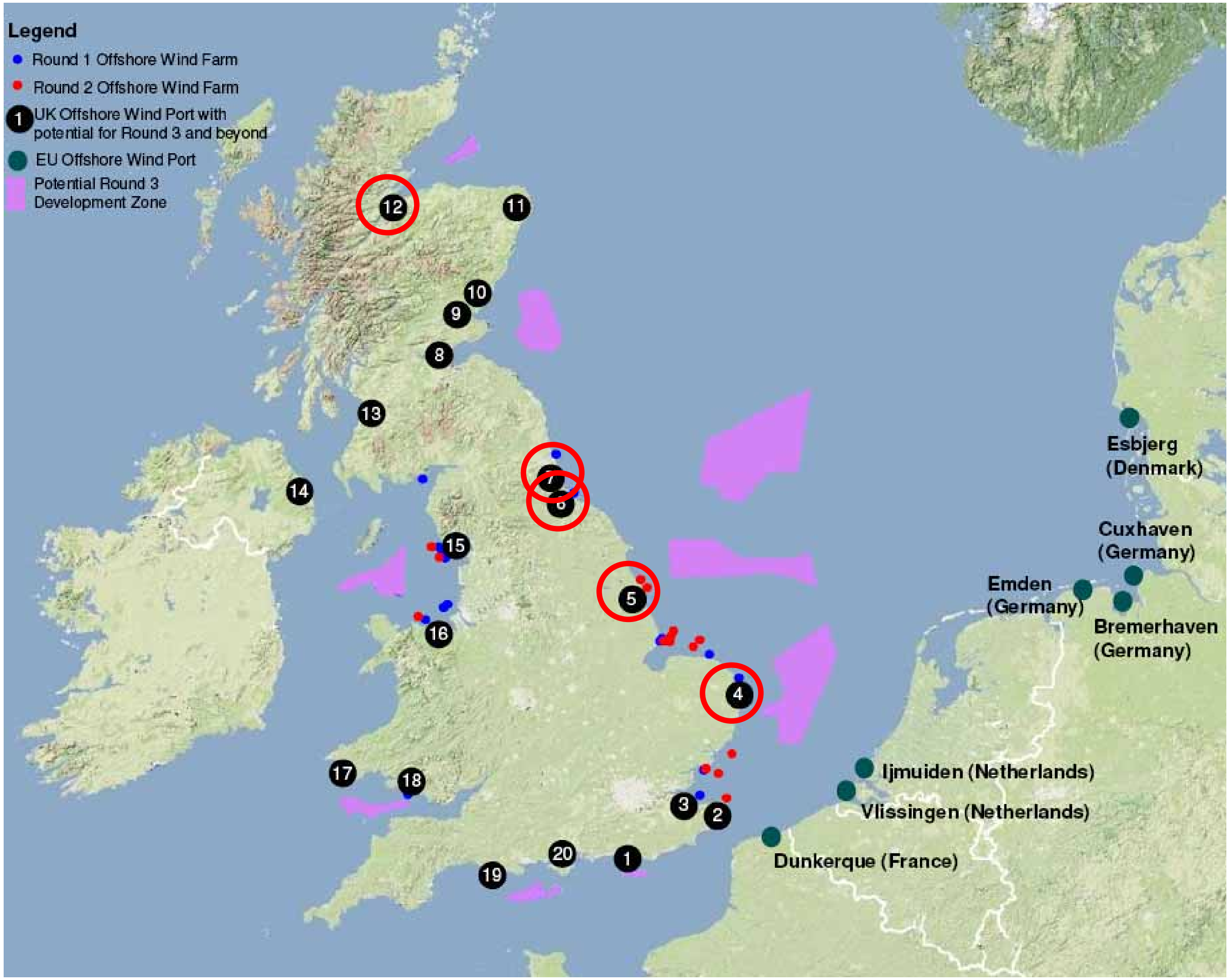
Type	Features	Example
Self-buoyant	Simple towing operation, no specialist marine equipment required	
Auxiliary buoyancy	Minimises concrete volume, requires simple means of attaching and removing buoyancy	
Crane lowered	Limited number of offshore-rated cranes. Has been used in sheltered areas	

Selected Arrangement

- **Option selection not possible on cost grounds because all within a small range**
- **Self-buoyant option is the easiest to install but currently requires longer to build and has greater quantities**
- **Further development will extend the installation window for options with auxiliary buoyancy**
- **All options can be built in the planned factory**
- **Room for further development in all options examined**

Construction Locations

- 20 locations have been proposed in UK as construction and logistics centres
- Perhaps half have enough space for a concrete foundation factory
- East coast favoured



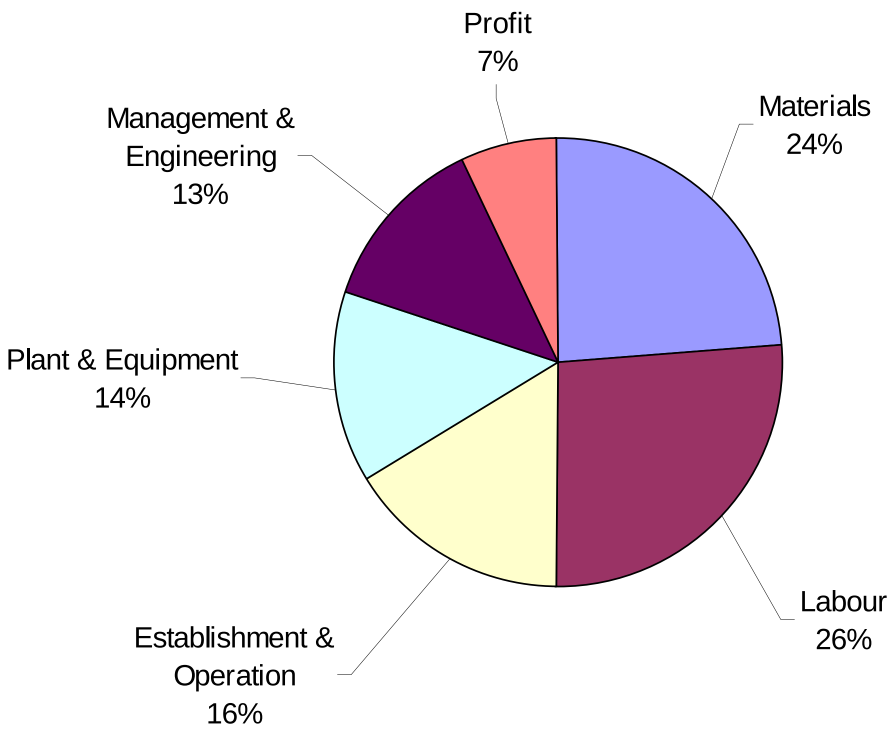
© BVG Associates

Mass production facilities

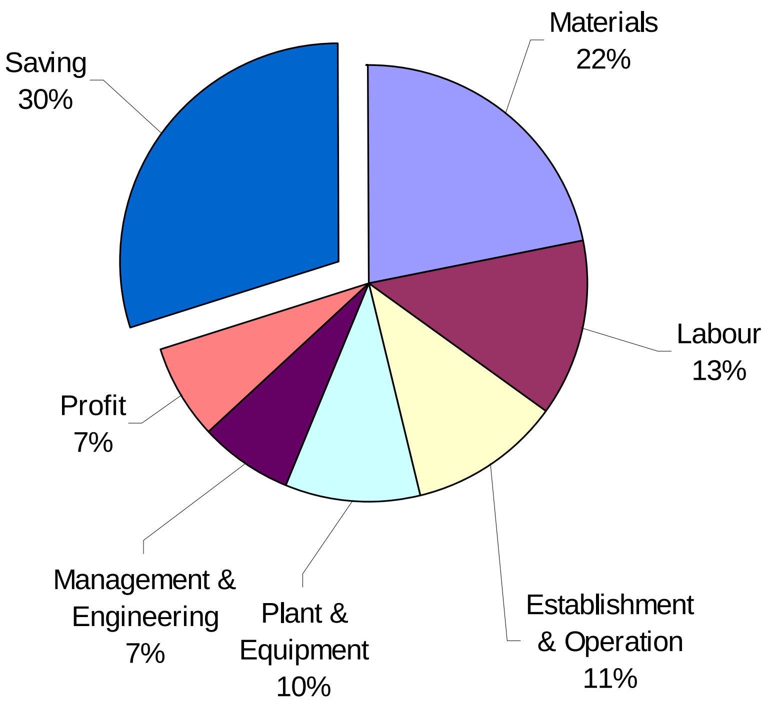
- **Target up to 200 foundations per year**
- **Self-buoyant option can commence in dry dock before being completed in covered wet dock**
- **Inshore storage area needed as buffer between construction and installation**

Savings through mass production

- **Steel fabrication efficiency already high giving less room for improvement**
- **Civil engineering pricing is currently based on one-off construction**
- **Therefore concrete will benefit more from mass production than steel**

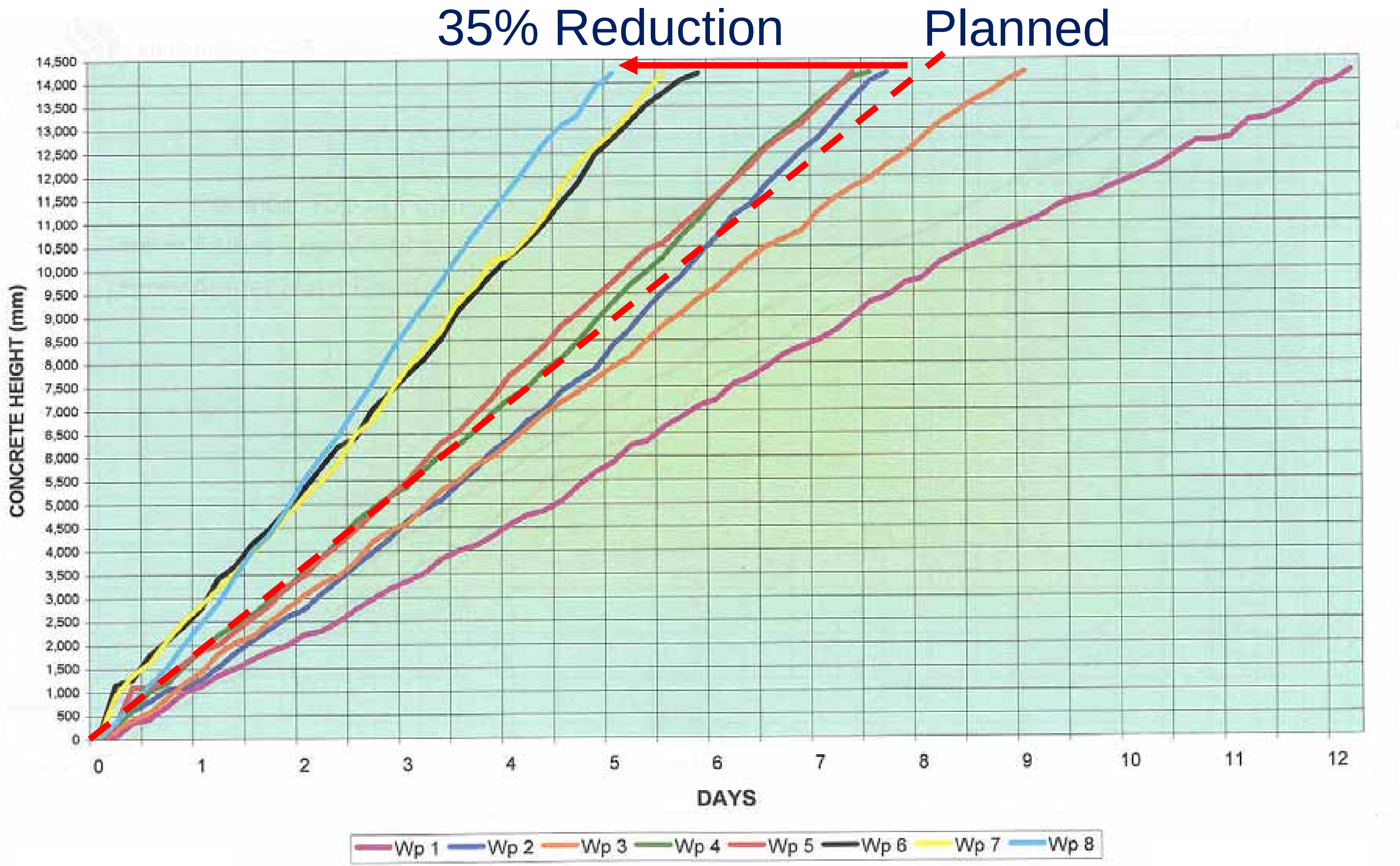


Concrete one-off construction

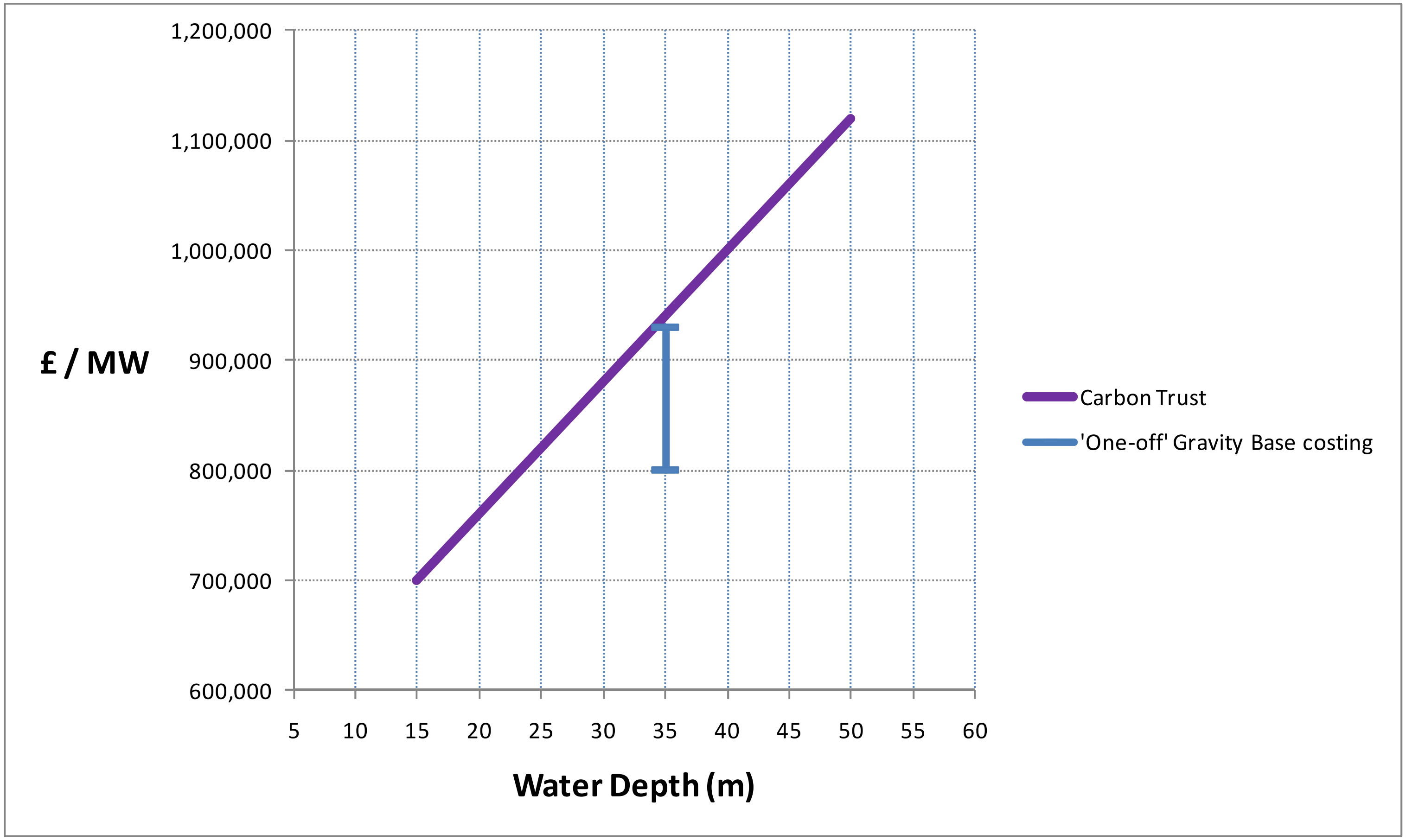


Concrete mass production

Wall Construction Productivity: Malampaya Platform

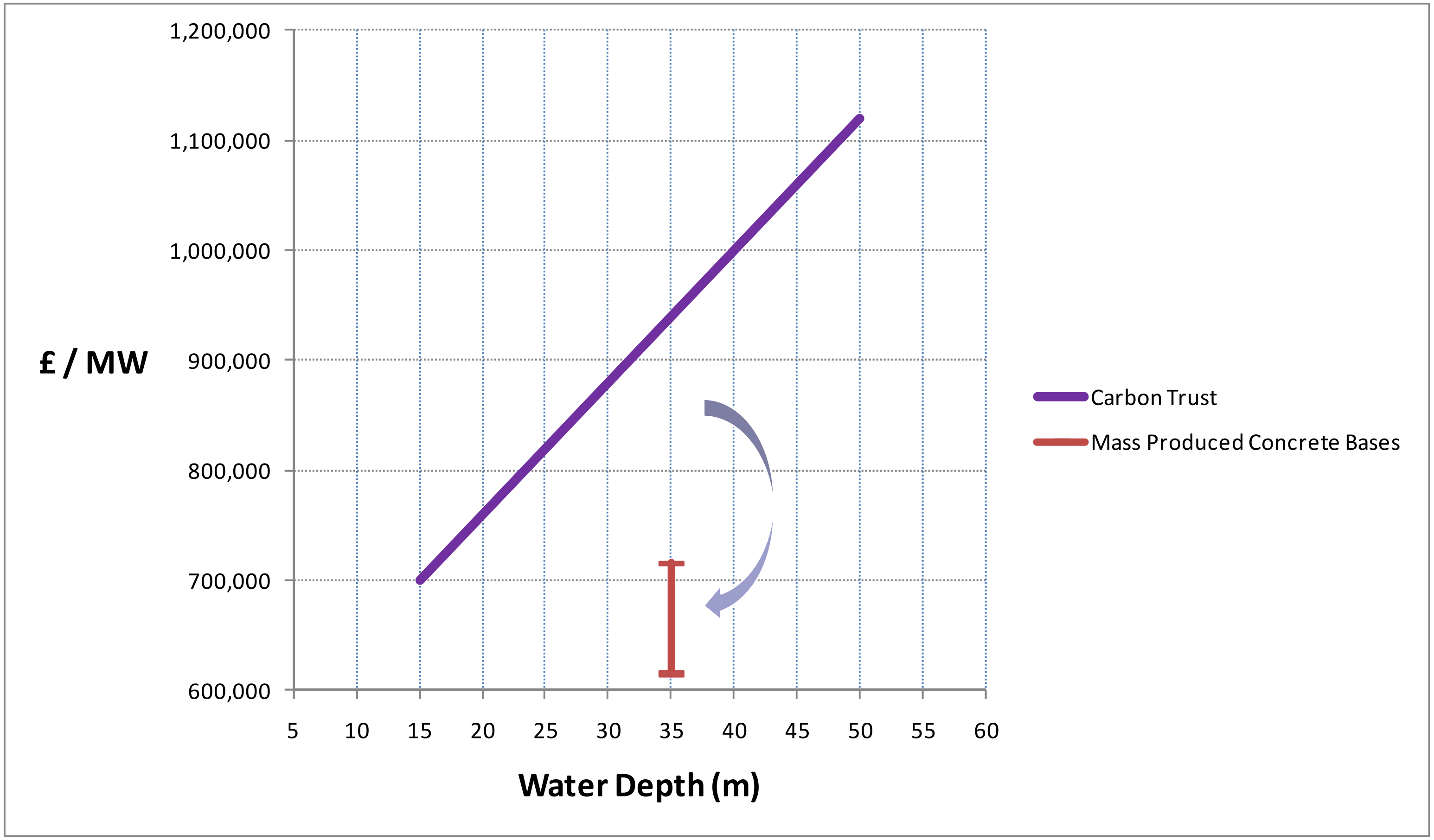


Costing



Source: Carbon Trust - Offshore Wind Power, Big Challenge, Big Opportunity

Costing



Source: Carbon Trust - Offshore Wind Power, Big Challenge, Big Opportunity

Next steps

- Continue to de-risk the options through the rest of the R&D programme
- Finalise where mass production facility will be located
- Engage with developers so that concrete is actively considered where monopiles are not first choice
- Put the GB into ‘GBF’

renewableUK

Offshore Wind 2010
Conference and Exhibition

Research & Foundations

Chaired by Colin McNaught, AEA Group