Fact sheet 1: **Secondary steel**

What is secondary steel?

Secondary steel refers to elements that fit on the main (primary) structural elements. These elements enable functions such as access to the turbine and protection for ancillary components. Secondary steel includes a wide range of subcomponents, from small scale items such as brackets and doors to large structures such as boat landings and work platforms as big as 50 tonnes.

Overall description

Secondary Steel refers to the steel elements that fit on the primary structure of the turbine (for example the tower or foundation).

Secondary steel systems can include the following subcomponents:

- Internal and external platforms and walkways
- Ladders and lifts
- Railings
- Cable protection structures (such as J-tubes), and
- Sacrificial anode support structures.

Secondary steel systems enable access to the turbine, provide safety for personnel, protect or support ancillary equipment, constrain water movement and enable the venting of noxious gases due to corrosion of the structure.

Secondary steel components vary in size and weight dramatically, with components ranging from <1 m and a few kg to >20 m and 50 tonnes. Actual dimensions vary for different designs, which greatly depends on turbine size.

Other steel components such as for mooring systems and anchors are considered by some to be secondary steel. Mooring systems and anchors are covered separately in *Fact sheet 2: Anchors and moorings.*

Corrosion protection is needed for secondary steel and is covered separately in *Fact sheet 5: Corrosion protection.*

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Secondary steel: Subcomponents

Walkways

Description: Walkways allow personnel to traverse the interior and exterior of the turbine, for access for inspections, servicing and maintenance.

Sub-components: Railings (see right), gratings, support structure

Applicable standards: DNVGL-ST-0358, DNVGL-OS-C101.

Typical weights: Between several hundred kilograms to several tonnes.

Typical dimensions: Walkways must be >1.2 m wide. The length of individual walkway sections will depend on the foundation design specified.

Railings

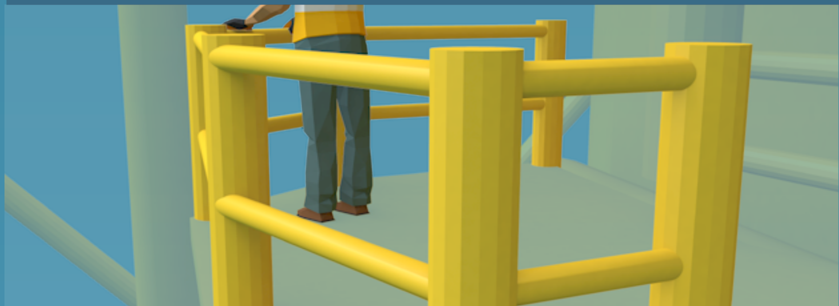
Description: Railings are a necessary safety component to prevent personnel from falling off walkways and platforms.

Sub-components: Uprights, handrail, horizontals, toe plate

Applicable standards: DNVGL-ST-0358, DNVGL-OS-C101.

Typical weights: Depends on height and length of the rail. Typically weighs 5 kg per metre.

Typical dimensions: Minimum of 1 m height, with uprights not more than 1.5 m apart. Crossbars must not be more than 380 mm apart.



J-tubes

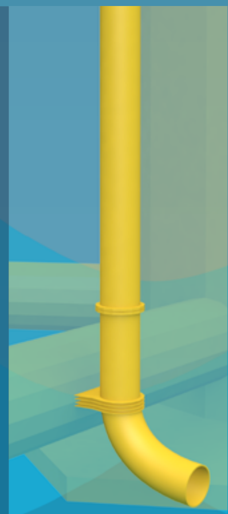
Description: J-tubes provide protection and support to cables between the turbine and seabed.

Sub-components: Tubulars, fixings

Applicable standards: DNVGL-OS-C101

Typical weights: Between 2 and 10 tonnes

Typical dimensions: outer diameters (ODs) ranging from between 450 to 750 mm. Full length >20 m (depending on foundation design).



Ladders and lifts

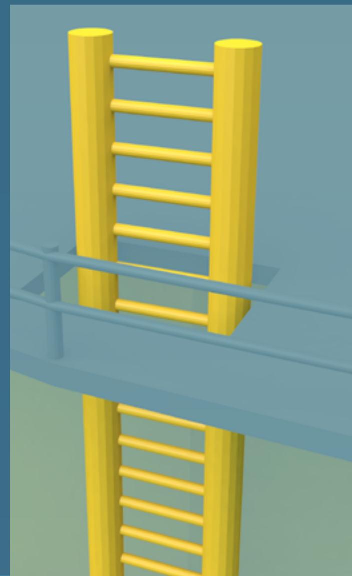
Description: On the foundation exterior, ladders provide personnel access from the height of vessels up to the turbine. On the tower interior, ladders provide access to the nacelle. Towers may also feature lifts or wire-guided systems to facilitate ascent and descent within the tower.

Sub-components: Rungs, uprights, fall arrest systems.

Applicable standards: EN ISO 14122-4, DNVGL-OS-C101.

Typical weights: Total weight of the interior and exterior ladder system is approximately 4.5 tonnes, including support structures.

Typical dimensions: The maximum length of a ladder module is unlikely to exceed 12 m, as per EN ISO 14122-4.



Secondary steel: Subcomponents

Work platforms

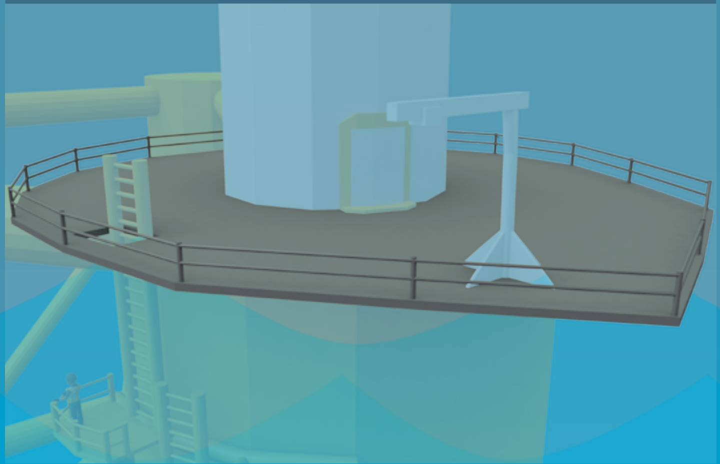
Description: Work platforms are used to provide safe level areas to perform inspection, maintenance and servicing tasks. Platforms are integrated into both the foundation and tower of the turbine.

Sub-components: Railings (see page 3), and gratings.

Applicable standards: DNVGL-ST-0358, DNVGL-OS-C101.

Typical weights: 10 to 50 tonnes.

Typical dimensions: Vary depending on foundation design but are typically the largest subcomponent in secondary steel systems. Due to challenges transporting such large structures, work platforms are typically constructed at shipyards for easy water access and transport.



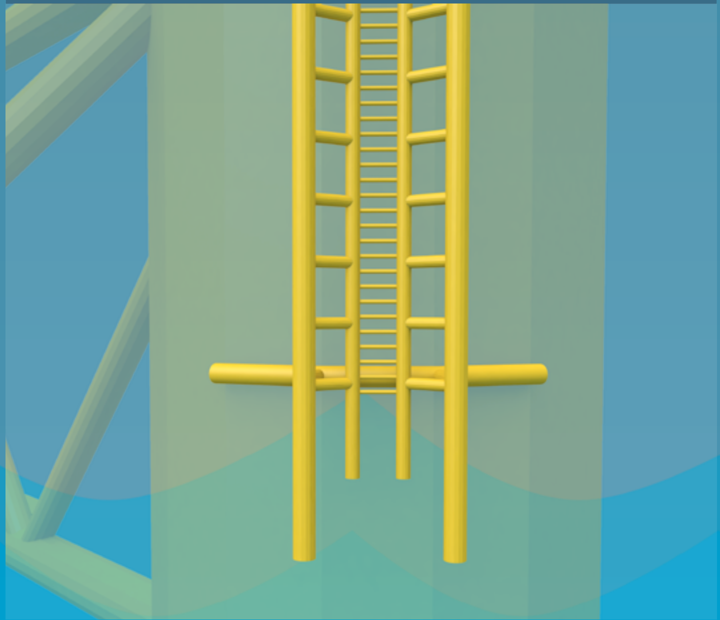
Boat landing

Description: Allows vessels to safely dock to the turbine and transfer personnel. Vessel will push up against the boat landing, allowing personnel to climb on to the attached access ladder (see page 2) and ascend to the turbine.

Sub-components: Bumper bars, support structure. Applicable standards: DNVGL-OS-C101.

Typical weights: between 5 and 10 tonnes.

Typical dimensions: Size will depend on the tidal range at site as the turbine needs to be accessible at both the high and low water marks. approximately 10 m for UK projects.



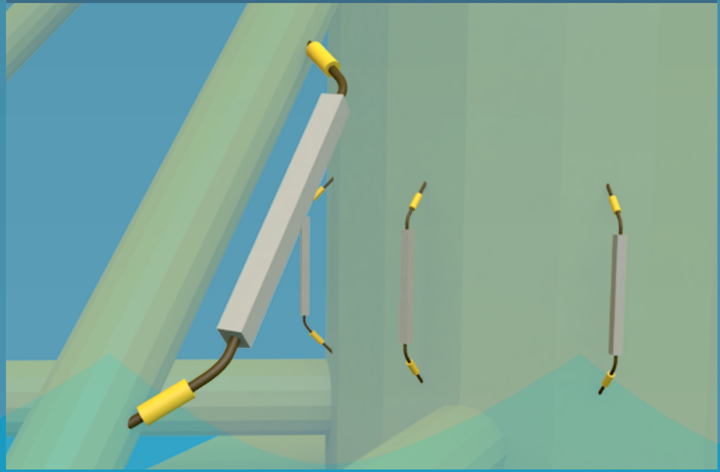
Sacrificial anode supports

Description: Sacrificial anode supports are used to attach the sacrificial anode to the turbine. Anodes can be supported by various designs, including stand-off structures, hang-offs or flush mounted.

Applicable standards: DNV-RP-B401, DNVGL-OS-C101.

Typical weights: Depending on the design, anode supports can range in weight from 10 to 250 kg.

Typical dimensions: Anodes supports hold the anodes on the frame. Their size will vary dramatically based on the anode shape and design, from 10s of cm to 2-3 m.



Secondary steel: Manufacture

Typical manufacturing process

- Due to the nature of wind turbine development, serial production is a key characteristic of secondary steel manufacture for offshore wind. This differs from steel manufacture for more traditional offshore installations such as oil platforms, which are typically very large structures manufactured in low or single quantities.
- To facilitate serial manufacture, production cells are set up within a main facility with workshop space dedicated to different secondary steel components to improve workflow.
- For most secondary steel components, final sub-assemblies are made of standard steel shapes (box sections, tubulars, plate etc.) that are welded together. Bolting can be used but is more vulnerable to corrosion.
- For complex tubular components requiring bending, such as J-tubes, boat landing bumper bars, curved walkways and platforms, or certain designs of anode support, hot and cold bending processes are required. Cold bending curves the steel without adding heat and is most suited for smaller diameter tubes.
- Steel components must then be coated to protect against corrosion. This is often outsourced to specialist applicators but can be done in-house. See *Fact sheet 5: Corrosion protection* for more detail.

Internal platform module being lifted.
Image courtesy of Hutchinson Engineering. All rights reserved.

Box section steel welding
Image courtesy of Hutchinson Engineering. All rights reserved.

Component materials

- Steel of various grades such as S355, S460 and S690 are commonly used. Per Execution Class 3, the highest grade required would be S700.
- Aluminium components.
- Glass-fibre reinforced plastics.
- Rubber for various interfaces.
- Paints and coatings, see *Fact sheet 5: Corrosion protection*

Manufacture facility requirements

Secondary steel manufacture facilities require the typical equipment needed for steel fabrication:

- CAD and CNC software
- CNC cutters and machining equipment
- Press brakes
- Roll forming machines
- Lifting equipment
- Induction pipe bending machines
- Various drills, grinders and saws
- Surfacing equipment
- Welding equipment, and
- If in-house coating is desired, coating equipment.

Platform module, showing ladders, gratings and railings.
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Secondary steel: Design data

Component/Sub-component	Approximate cost	Material	Typical mass	Typical dimensions	Design considerations
J-tubes	**Approximately £3,000 per tonne. Will vary depending on length**	-	-	-	**Should protect the cable while allowing it to be pulled up to the turbine during installation.**
Tubulars	-	Most common steel grades are S355/S460/ S690 depending on project requirements	Approx. 2 - 10 tonnes depending on length and diameter	OD 508 mm, sometimes up to OD 750 mm J-tube length depends entirely on wind turbine design. Can range from 5 m to over 20 m in length	Hot or cold bending depending on OD of the tube
Fixings	-	S355 steel or higher depending on design requirements	Approx. 1 tonne	Fixing sizes will depend on the OD of the J-tube. Assuming a J-tube with OD 508 mm, a clamp will be roughly 1 m3 with a hole slightly larger than the OD of the J-tube, which can then be grouted for greater security	J-tubes can be fixed to the transition piece with various support structures such as clamps, reinforcements, welds or grouting
Ladders (internal and external)	**Approximately £3,000 per tonne. Will vary depending on length and design**	-	-	-	-
Uprights	-	S355 steel	Approx. 10 – 35 kg per upright	Rectangular profiles approx. 70 x 25 mm Length approx. 2 – 6 m Thickness approx. 4.5 mm	-
Rungs	-	S355 steel	Approx. 1 – 2 kg per rung	Square profiles approx. 30 mm x 30 mm. Length approx. 500 mm Thickness approx. 4.5 mm	It is good practice to use diamond profile rungs made of square bar to improve grip Rungs spaced approx. 225 – 300 mm apart
Fall arrest system	-	S355 steel or Aluminium	Approx. 5 – 15 kg depending on section length	For a rail system, I/H profile attached to the middle or side of the ladder system Individual rail pieces approx. 2 – 6 m in length per module	The rail must be manufactured to be compatible with climbing trolleys

Secondary steel: Design data

Component/Sub-component	Approximate cost	Material	Typical mass	Typical dimensions	Design considerations
Railings	**£100-£500 per meter**	**-**	**-**	**Rail profiles cut to lengths determined by supplier**	**Railings are usually manufactured as profiles which are then assembled into railing modules**
Uprights	-	GRP or aluminium	Approx. 1.2 kg/m	Square or tubular post with minimum height of 1,100 mm	Should be designed to withstand side loading at 75 kg per meter Spaced <1,500 mm apart
Handrail	-	GRP or aluminium Polyethylene (for endcaps)	Approx. 1.3 kg/m	Tubular with OD 48 mm or U profile with dimensions depending on uprights (to allow for fitting)	Should be designed to withstand side loading at 75 kg per meter
Crossbars	-	GRP or aluminium	Approx. 0.64 kg/m	Tubulars of at least OD 34 mm	Crossbars must be no more than 380 mm apart
Toe plate	-	GRP or aluminium	Approx. 1.4 kg/m	At least 100 mm wide and 8 mm thick	Must be >100 mm in width. Vertical clearance between toe plate and floor <10 mm Horizontal clearance between plates <10 mm
Sacrificial anode supports	**Varies significantly based on design and size. Approximately £150 to £3,000 per unit**	**S355 steel**	**Large variations depending on design. Approx 50 kg to 1 tonne**	**Large variations depending on design. Approx 50 cm to 4 m**	**-**
Work platforms and walkways	**£100-£500 per square meter**	**-**	**-**	**-**	**-**
Railings	-	-	-	-	*See railings section above*
Grating	-	Galvanised steel or Glass reinforced polymer (GRP), often with a non-slip coating	Approx. 12 – 20 kg/m^2, depending on panel thickness and material	Minimum width 1.2 m, length dependent on design. Often provided in square sections and cut to size	Surface should be hard-wearing, oil resistant and non-slip, tested in accordance with BS 7976
Support structure	-	S355 or higher depending on design requirements	Approx. 10 – 50 tonnes depending on platform size	General length and breadth of the platform structure would be approx. 10 m by 12 m, with a hole in the centre to account for the turbine tower diameter, however exact shapes and dimensions vary	Must bear load so does not fail by: • Excessive yielding • Buckling, and • Fatigue fracture. As per DNVGL-ST-0358

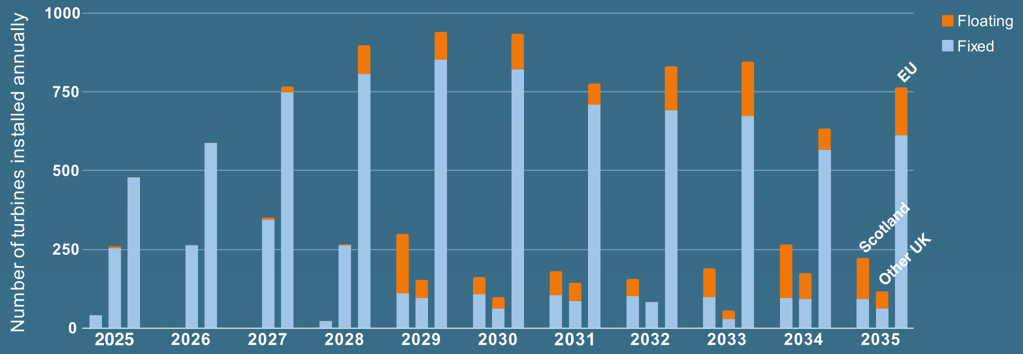
Secondary steel: Design data

Component/Sub-component	Approximate cost	Material	Typical mass	Typical dimensions	Design considerations
Boat landings	**Varies significantly based on size, design and function. Approximately £80,000 to £120,000**	**-**	**-**	**Lengths will ultimately depend on turbine design and tide conditions.**	**For in-depth guidance, see Design for recommended boat landing geometry, Carbon Trust**
Bumper bars	-	S355 steel	Approx. 3 tonnes per bar	Tubular with approx. OD of 406 mm and 10 m length.	The bumper bar must descend into the water 1 m below low tide to provide safety margin and prevent the CTV from becoming trapped under the landing. Distance between bumper bars should be 1,800 mm
Support structure	-	S355 steel	Approx. 500 kg per piece	Tubulars with similar OD to bumper bars with length of approx. 2 m to allow for space between primary structure and boat landing	Setting out distance between the ladder and bumper bars should be 850 mm
Integrated boat landing ladder	-	-	-	-	*See ladder section on page 5*
Uprights	-	S355 steel	Approx. 350 – 600 kg per upright.	Tubular with OD approx. 100 - 150 mm Length approx. 12m	
Rungs	-	S355 steel	Approx. 1 – 2 kg per rung	Square profiles approx. 30 mm x 30 mm Length approx. 500 mm Thickness approx. 4.5 mm	It is good practice to use diamond profile rungs made of square bar to improve grip Rungs spaced approx. 225 – 300 mm apart
Support structure	-	S355 steel or Aluminium	Approx. 30 – 70 kg per piece.	Tubulars with similar OD to ladder uprights Length of approx. 1 – 1.5 m	
Fall arrest system	-	-	-	-	Boat landing ladders will typically not use a rail system, and instead use a lanyard system

Secondary steel: Market

Available market

Secondary steel will be required on every foundation installed, for both fixed and floating projects, although requirements between these will differ. The forecasts below are based on BVGA's internal predictions, accounting for project pipeline, national targets, and expected growth in wind turbine rating. In 2035 the combined Scotland, UK and EU market accounts for 57% of the global fixed and floating market.



The above forecast of turbine numbers is used to forecast the components required in table below, based on the assumptions given and based on an 18 MW turbine capacity. Particularly for floating foundations, these may vary dramatically based on the chosen design.

Component	Assumption	Forecast for ScotWind / INTOG* ScotWind	INTOG
J-tubes	25 m per turbine	40,000 m	7,000 m
Walkways	10 m per fixed turbine, 30 m per floating turbine	38,000 m	9,000 m
Ladders	10 m external, 150 m internal	267,000 m	49,000 m
Railings	20 m per fixed turbine, 60 m per floating turbine	76,000 m	18,000 m
Sacrificial anode supports	50% of turbines, assuming 55 per fixed foundation and 130 per floating foundation	86,000 units	20,000 units
Work platforms	1 per turbine	1,700 units	300 units
Boat landings	1 per turbine	1,700 units	300 units

**this forecast is based on the entire ScotWind/INTOG capacity being installed. This number may decrease if projects are not taken forwards, or increase if projects increase their capacity.*

Route to market

- Secondary steel is usually integrated into the primary steel structure, making up a portion of the balance of plant.
- Manufacturers of secondary steel will typically source standard steel forms, such as box sections, tubulars, and plate and use these to manufacture the components.
- Traditionally, purchasers of secondary steel have been tier 1 fabricators (fabricators of the main foundation components), however, there has been a growing trend for developers and EPC(I) contractors to purchase secondary steel. Occasionally, OEMs may request secondary steel components.
- Secondary steel is easily transportable except for larger components such as platforms. Manufacturing facilities for smaller subcomponents can therefore be located flexibly, with platform fabrication facilities being located at shipyards or areas with easy water access.
- Incumbent suppliers include Hutchinson engineering, Kersten, Smulders, Vallourec, and Wilton Engineering.

Accreditation / regulatory landscape

Secondary steel manufacture is subject to the following accreditations and regulations:

- Individual design requirements are given in the Subcomponents section.
- The steel itself is subject to UKCA 1090, CE and secondary steel Execution Class 3 standards. ISO and DNV are the most common accreditation bodies.
- Welding should be certified to ISO 3834 standards.
- As prerequisites for securing a tender, 1090 class 3 and ISO 3834 are likely to be required.
- To secure certifications, an auditor from the accrediting body will examine documentation, manufacture facilities and products to ensure that components are being manufactured to the required standards. Audits are performed every 6 months with a 3-year recertification period.
- Suppliers should also conduct in-house quality control, including visual and mechanical testing of components to ensure quality and reliability.

Secondary steel: Costs

Typical costs / CAPEX requirements

- Secondary steel costs approximately £30 million for a 450 MW floating offshore wind farm.
- This equates to 67,000 £/MW or approximately £1 million for a 15 MW turbine's substructure.
- This is approximately 1.2 % of the total project cost
- This cost is for the secondary steel work packages for a typical floating offshore windfarm as outlined in the cost assumptions. This will include all the components described above.
- This cost will vary significantly depending on what is included in the secondary steel package, and the foundation design used.
- Costs are sourced from **The Guide to a Floating Offshore Wind Farm**. See for more information and detail of all cost assumptions.

Potential user costs

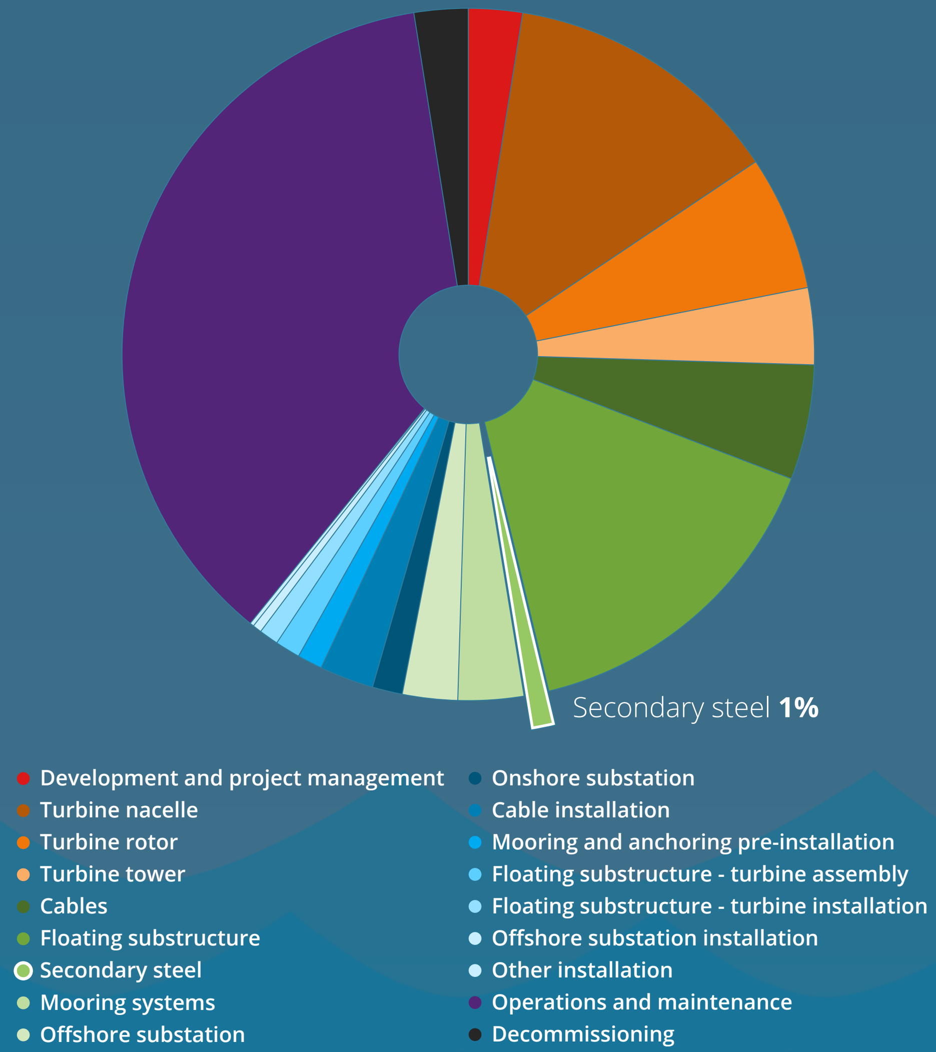
- Secondary steel systems are usually supplied to the structure fabricator for integration into the primary structure (both foundation and turbine tower), which will bear the cost of installation.
- The secondary steel must have corrosion resistant coatings applied.
- Performing coating in-house can reduce costs as parts do not need to be transported between fabricator to coating location.
- If surface treatment is done in-house, there is an added benefit that where the blasting process reveals defects, they can immediately be repaired without waiting for return of the component to the workshop.

Support available

For further details on offshore wind supply chain assistance, information, and support programmes available, please contact Scottish Enterprise: offshorewind@scotent.co.uk

450 MW floating offshore wind farm lifetime costs

Lifetime 450 MW windfarm cost approximately £2,600 million.



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Acknowledgements

Scottish Enterprise, Highlands and Islands Enterprise and South of Scotland Enterprise commissioned BVG Associates to produce a number of fact sheets on different aspects of floating offshore wind projects. They are intended to provide background information for companies wishing to enter the offshore wind supply chain. Other fact sheets are available including:

Fact sheet 2: Anchors and moorings

Fact sheet 3: Cable protection systems

Fact sheet 4: Cables and accessories, and

Fact sheet 5: Corrosion protection

Thanks to both Hutchinson Engineering and Kersten for providing information used in this fact sheet.

Further reading:

Guide to a Floating Offshore Wind Farm

The Guide to a Floating Offshore Windfarm provides more information on supply element of floating offshore wind projects. It has an overview of the important physical elements, lifecycle processes and costs of a floating offshore wind farm.

guidetofloatingoffshorewind.com

guidetofloatingoffshorewind.com/b-2-2-secondary-steel

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