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TRADE AND ENVIRONMENTAL SUSTAINABILITY STRUCTURED DISCUSSIONS (TESSD)

COMMUNICATION FROM THE UNITED KINGDOM

Addendum[1]

The following communication, dated 23 May 2023, is being circulated at the request of the delegation of the United Kingdom.

OFFSHORE WIND ENERGY

Technical paper by the United Kingdom

ANNEX I.

VALUE CHAIN DIAGRAMS FOR OFFSHORE WIND ENERGY

Value chain diagrams – key:

Chevron Colour	Meaning
	Activity or process involved in the **'Development and project management'** stage of an offshore wind farm's lifecycle. In the delivery of a service, this represents a sub-stage of service delivery. In the delivery of a good (whether it is an input, intermediate, or final good), this represents a manufacturing activity or production process.
	Manufacturing activity or production process involved in either the manufacture or assembly of a **wind turbine**
	Manufacturing activity or production process involved in the manufacture, assembly, or installation of an offshore wind farm's **balance of plant equipment**
	Manufacturing activity, production process, or installation process involved in the **final installation and commissioning** of an offshore wind farm
	Manufacturing activity, production process, or installation process involved in the **'Operation, maintenance and service'** stage of an offshore wind farm
	Activity or process involved in the 'Decommissioning' stage of an offshore wind farm's lifecycle
	Input product, intermediate product, final product, or a service deliverable in any stage of an offshore wind farm's lifecycle

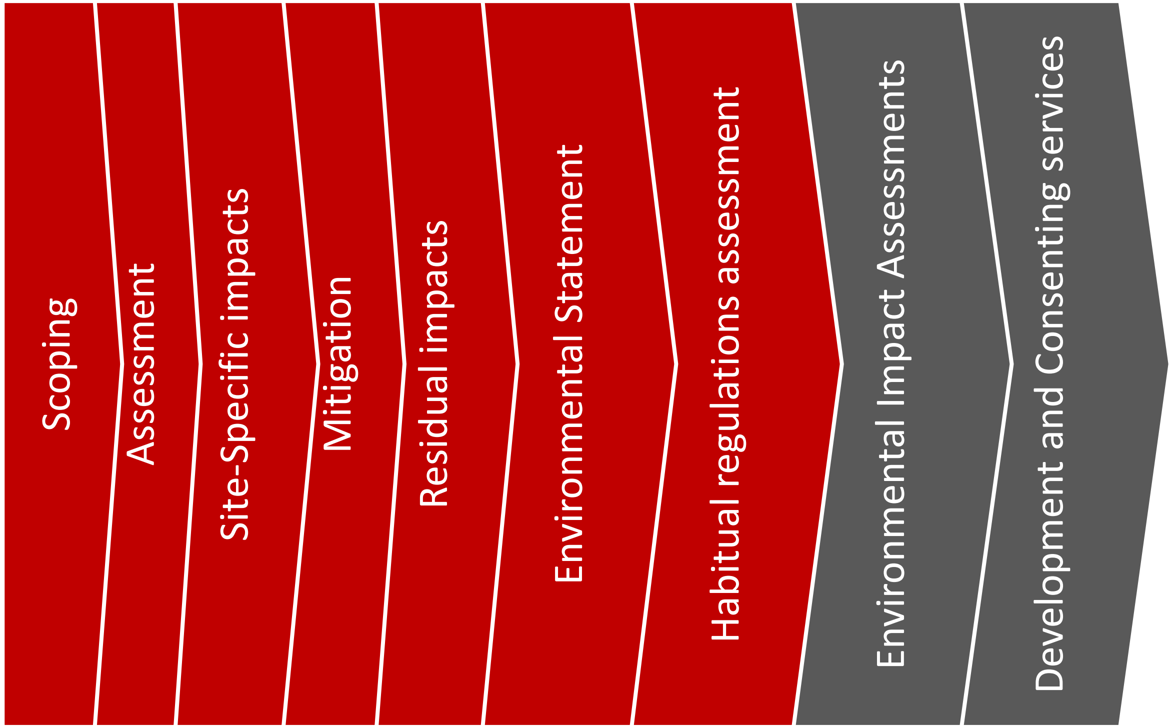
[1] This Addendum supplements the paper titled "Offshore Wind Energy – Submission of Information to trade and Environmental Sustainability Structured Discussions (TESSD) from the United Kingdom", INF/TE/SSD/W/26.

Contents

I.1. Development and project management

I.1.1. Development and consenting services

Development and consenting covers the work needed to secure consent and manage the development process through to financial close.



I.1.2. Environmental surveys

To determine the environmental impacts, a full suite of environmental surveys of the wind farm location and its surroundings is undertaken. These surveys establish the baseline for the assessment and allow impact modelling to be undertaken.

- **Benthic environmental surveys:** Benthic studies survey species that live on the sea bed and in sediment. The survey data and analysis is used to define areas of similar environmental conditions on the sea bed and to inform habitat and species impact studies.

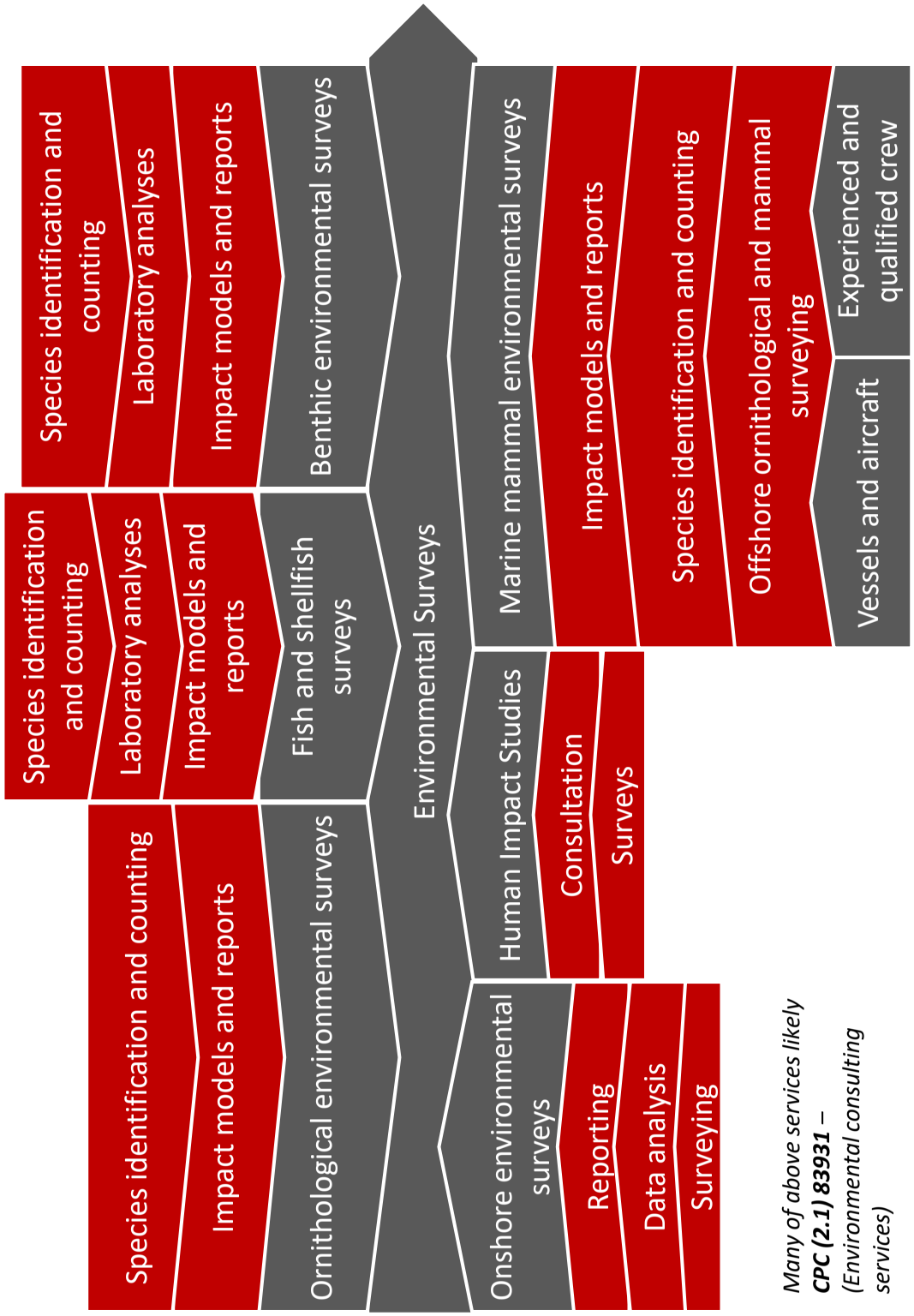
- **Fish and shellfish surveys:** establish what species are present in the water column within the proposed wind farm site and surrounding areas. The resulting data is used to inform impact analysis and reporting.

- **Ornithological surveys:** establish the presence and behaviour of birds within the wind farm boundary and surrounding areas. The data from these bird surveys is used to establish the risks to birds that a wind farm may pose.

- **Marine mammal surveys:** establish the diversity, abundance, distribution and behaviour of cetaceans (including porpoises, dolphins and whales) and seals within the wind farm boundary and surrounding areas. Surveys are typically undertaken monthly for at least two years to establish how these variables change across seasons and between years. The data from these surveys is used to establish the potential impacts to marine mammals that a wind farm may pose.

- **Onshore environmental surveys:** consider the potential ecological impact that cable-laying and onshore substations may have on the onshore environment.

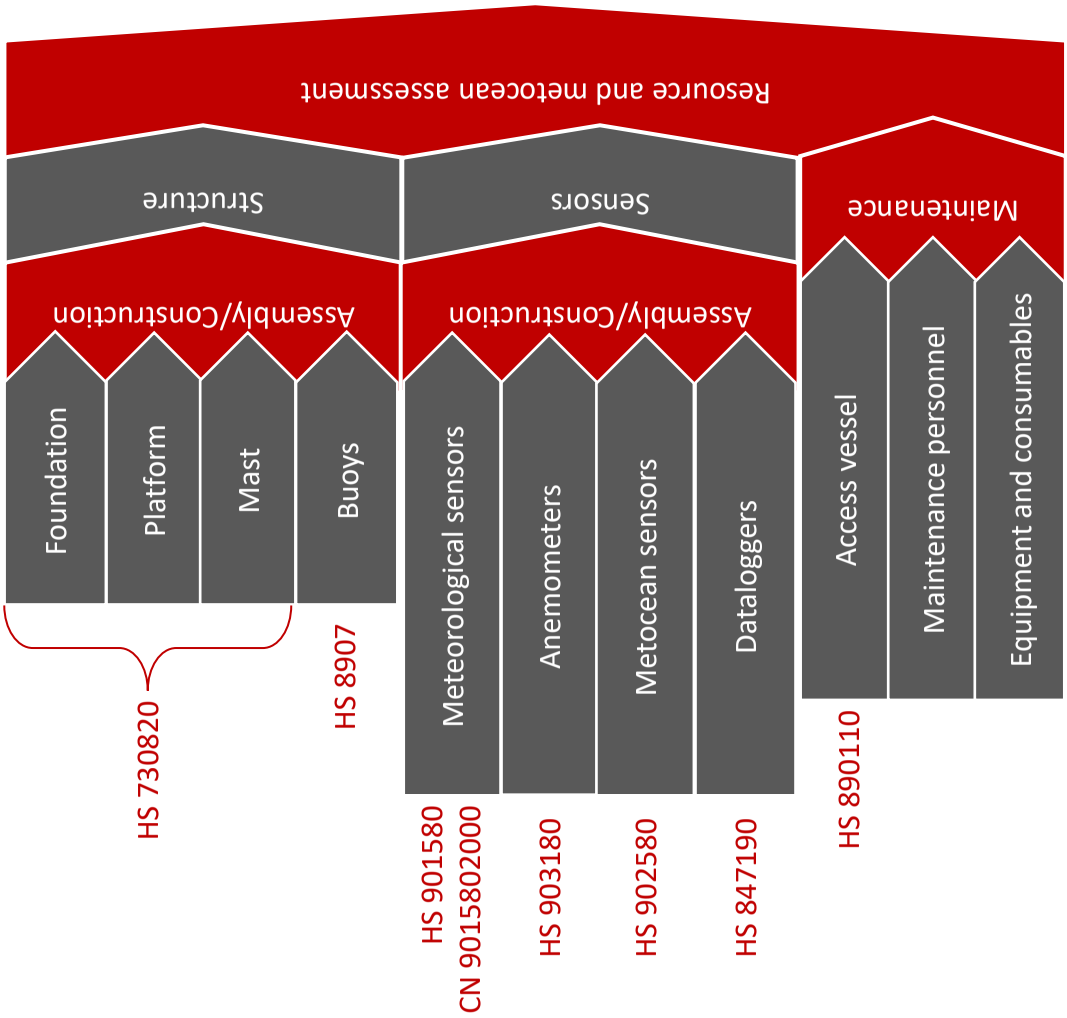
- **Human impact studies:** assess the impact that a proposed wind farm may have on the community living in and around the coastal area near the wind farm.


Species identification and counting
Laboratory analyses
Impact models and reports
Benthic environmental surveys
Species identification and counting
Impact models and reports
Fish and shellfish surveys
Marine mammal environmental surveys
Species identification and counting
Impact models and reports
Ornithological environmental surveys
Offshore ornithological and mammal surveying
Species identification and counting
Impact models and reports
Vessels and aircraft
Environmental Surveys
Experienced and qualified crew
Human Impact Studies
Consultation
Surveys
Onshore environmental surveys
Reporting
Data analysis
Surveying
Many of above services likely CPC (2.1) 83931 – (Environmental consulting services)

I.1.3. Resource and metocean assessment

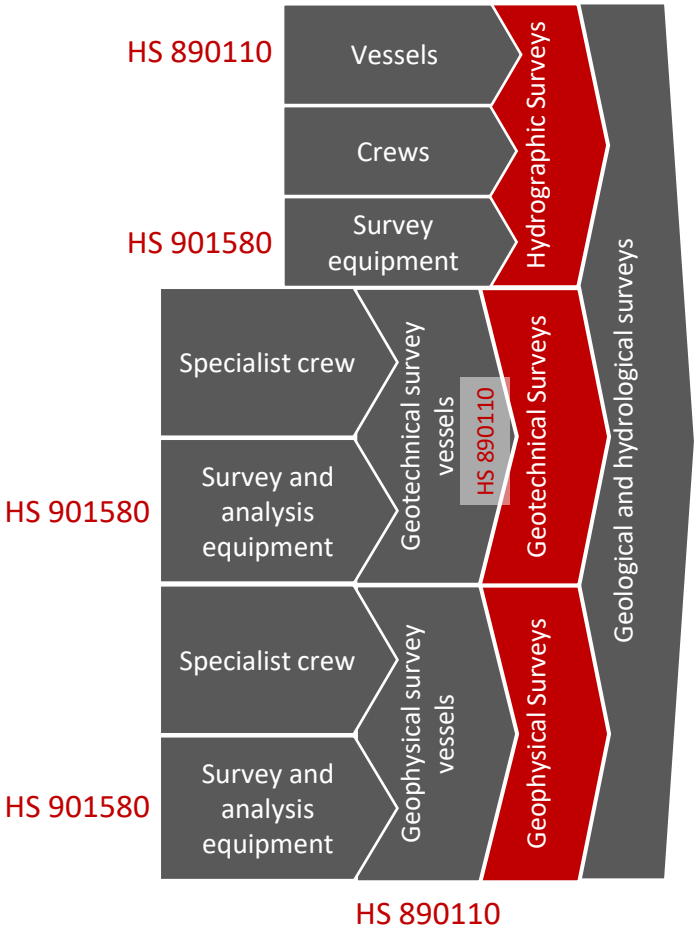
A resource and metocean assessment is carried out to provide atmospheric and oceanographic datasets to inform the engineering design of a wind farm, the potential future energy production, and to fully describe the likely operating conditions at the proposed wind farm location.

- **The structure:** provides the mounting for the meteorological and metocean, sensors and auxiliary systems plus safe access for personnel.
- **Sensors:** provide data on meteorological and oceanographic conditions at the site of interest. Data loggers provide data storage, processing and remote communications capability.
- **Maintenance:** Offshore wind and metocean systems will require maintenance, including inspection, cleaning and refuelling (where diesel generators or hydrogen fuel cells or similar are used).


Resource and metocean assessment
Structure
Sensors
Maintenance
Assembly/Construction
Assembly/Construction
Foundation
Platform
Mast
Buoys
Meteorological sensors
Anemometers
Metocean sensors
Dataloggers
Access vessel
Maintenance personnel
Equipment and consumables
HS 730820
HS 8907
HS 901580
CN 9015802000
HS 903180
HS 902580
HS 847190
HS 890110

I.1.4. Geological and hydrographical surveys

Seabed surveys analyse the sub seabed environment of the proposed wind farm site and export cable route to assess its geological condition and engineering characteristics. The data collected is utilised in a wide range of engineering and environmental studies through the design and development phase.



I.1.5. Engineering consultancy

Front-end engineering and design (FEED) studies address areas of wind farm system design and develop the concept of the wind farm in advance of procurement, contracting and construction. Earlier on in the process, pre-FEED studies are used to develop an outline concept of the project for the purposes for defining the consent envelope and to inform environmental impact studies. The FEED study is continually refined through the development process and is ultimately used to frame and process substantial engineering and procurement decisions.

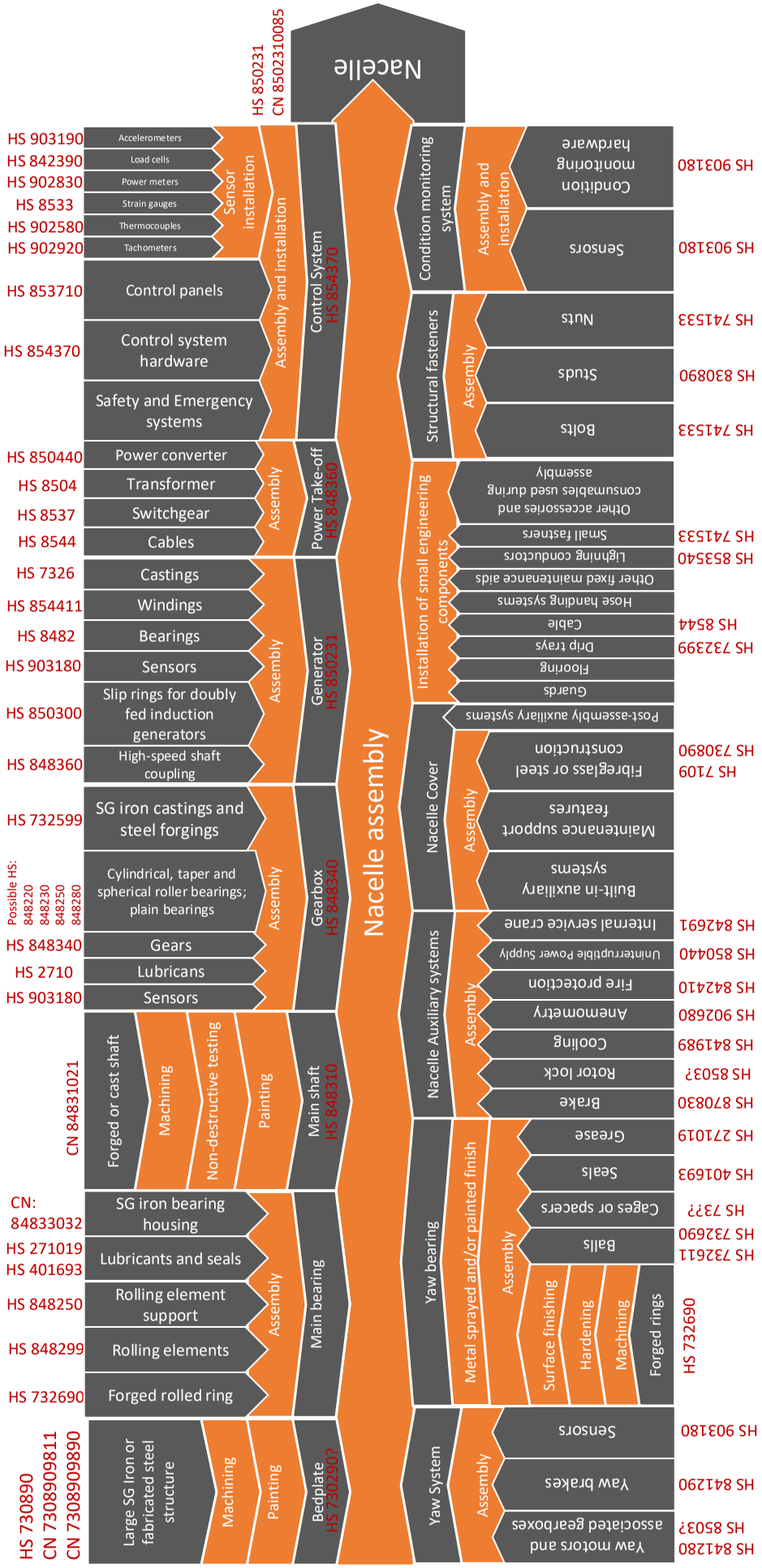
I.2. Wind Turbine

The turbine converts kinetic energy from the wind into three-phase AC electrical energy.

I.2.1. Nacelle

The nacelle supports the Rotor and converts the rotational energy from the rotor into three-phase AC electrical energy.

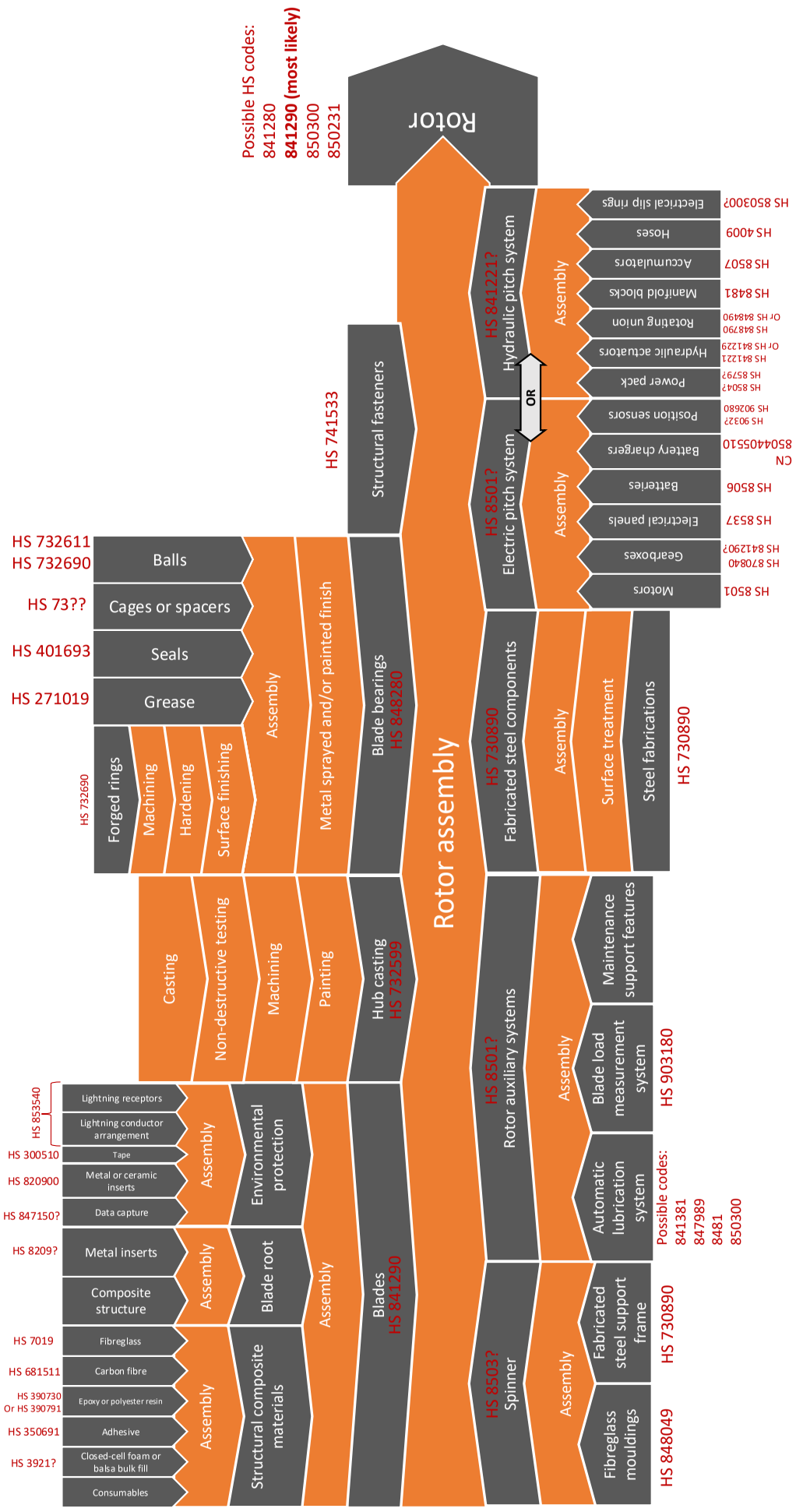
- **Bedplate:** supports the drive train and the rest of the nacelle components and transfers loads from the rotor to the tower.
- **Main bearing:** supports the rotor and transfers some of the rotor loading to the nacelle Bedplate.
- **Main shaft:** transfers torque from the rotor to the gearbox or, for some direct drive designs, the generator. It is supported at the rotor end by the main shaft bearing and at the other end either by the gearbox / generator or separately mounted bearing.
- **Gearbox:** converts rotor torque at a speed of 5-15 rpm to a speed of up to about 600 rpm for a medium speed gearbox and 1500 rpm for a high-speed gearbox for conversion to electrical energy by the generator.
- **Generator:** converts mechanical energy to electrical energy.
- **Power take-off:** receives electrical energy from the generator and adjusts voltage and frequency for onward transfer to the wind farm distribution system.
- **Control system:** provides supervisory control (including health monitoring) and active power and load control in order to optimise wind turbine life and revenue generation, while meeting externally imposed requirements.
- **Yaw system:** orients the nacelle to the wind direction during operation.
- **Yaw bearing:** connects the nacelle and tower, enabling the yaw system to orient the nacelle to any wind direction during operation.
- **Auxiliary systems:** facilitate ongoing unattended operation of the wind turbine for the vast majority of the time, and support planned maintenance, which typically should be only on an annual basis.
- **Nacelle cover:** provides weatherproof protection to the nacelle components plus support and access to external components such as coolers, wind measurement equipment and lighting protection devices.
- **Small engineering components:** make up the rest of the nacelle assembly.
- **Structural fasteners (either bolts or studs):** are used in a range of critical bolted joints, for example connecting rotor to main shaft, main bearing housings to nacelle bedplate and yaw bearing to the underside of nacelle bedplate.
- **Condition monitoring systems:** provide additional health checking and failure prediction capability.


Nacelle
HS 850231
CN 8502310085
Nacelle assembly
Sensor installation
Assembly and installation
Control System
HS 854370
Accelerometers
Load cells
Power meters
Strain gauges
Thermocouples
Tachometers
HS 903190
HS 842390
HS 902830
HS 8533
HS 902580
HS 902920
Control panels
Control system hardware
Safety and Emergency systems
HS 853710
HS 854370
Power converter
Transformer
Switchgear
Cables
HS 850440
HS 8504
HS 8537
HS 8544
Assembly
Power Take-off
HS 848360
Castings
Windings
Bearings
Sensors
Slip rings for doubly fed induction generators
High-speed shaft coupling
HS 7326
HS 854411
HS 8482
HS 903180
HS 850300
HS 848360
Assembly
Generator
HS 850231
SG iron castings and steel forgings
Cylindrical, taper and spherical roller bearings; plain bearings
Gears
Lubricans
Sensors
HS 732599
Possible HS:
848220
848230
848250
848280
HS 848340
HS 2710
HS 903180
Assembly
Gearbox
HS 848340
Forged or cast shaft
Machining
Non-destructive testing
Painting
Main shaft
HS 848310
CN 84831021
SG iron bearing housing
Lubricants and seals
Rolling element support
Rolling elements
Forged rolled ring
CN: 84833032
HS 271019
HS 401693
HS 848250
HS 848299
HS 732690
Assembly
Main bearing
Large SG Iron or fabricated steel structure
Machining
Painting
Bedplate
HS 7302902
HS 730890
CN 7308909811
CN 7308909890
Condition monitoring system
Assembly and installation
Condition monitoring hardware
Sensors
HS 903180
HS 903180
Structural fasteners
Assembly
Nuts
Studs
Bolts
HS 741533
HS 830890
HS 741533
Installation of small engineering components
Other accessories and consumables used during assembly
Small fasteners
Lighning conductors
Other fixed maintenance aids
Hose handing systems
Cable
Drip trays
Flooring
Guards
HS 741533
HS 853540
HS 8544
HS 732399
Nacelle Cover
Assembly
Post-assembly auxiliary systems
Fibreglass or steel construction
Maintenance support features
Built-in auxiliary systems
HS 7109
HS 730890
Nacelle Auxiliary systems
Assembly
Internal service crane
Uninterruptible Power Supply
Fire protection
Anemometry
Cooling
Rotor lock
Brake
HS 842691
HS 850440
HS 842410
HS 902680
HS 841989
HS 8503?
HS 870830
Yaw bearing
Metal sprayed and/or painted finish
Assembly
Grease
Seals
Cages or spacers
Balls
Surface finishing
Hardening
Machining
Forged rings
HS 271019
HS 401693
HS 7326??
HS 732690
HS 732611
HS 732690
Yaw System
Assembly
Sensors
Yaw brakes
Yaw motors and associated gearboxes
HS 903180
HS 841290
HS 8503?
HS 841280

I.2.2. Rotor

The rotor extracts kinetic energy from the air and converts this into rotational energy in the drive train.

- **Blades:** capture the energy in the wind and transfer torque and other unwanted loads to the drive train and rest of the turbine.
- **Hub:** connects the blades to the main shaft.
- **Blade bearings:** enable adjustment of blade pitch angle to control power output from the turbine, minimise loads and start/stop turbine as required.
- **Pitch system:** adjusts the pitch angle of the blades to control power output from the turbine, minimise loads and start/stop turbine as required.
- **Spinner:** provides environmental protection to the hub assembly and access into the hub and blades for maintenance personnel.
- **Rotor auxiliary systems:** may be incorporated to lubricate bearings and provide condition monitoring and advanced control inputs.
- **Fabricated steel components:** often required to stiffen the blade bearing support and provide a connection for hydraulic pitch system actuators.

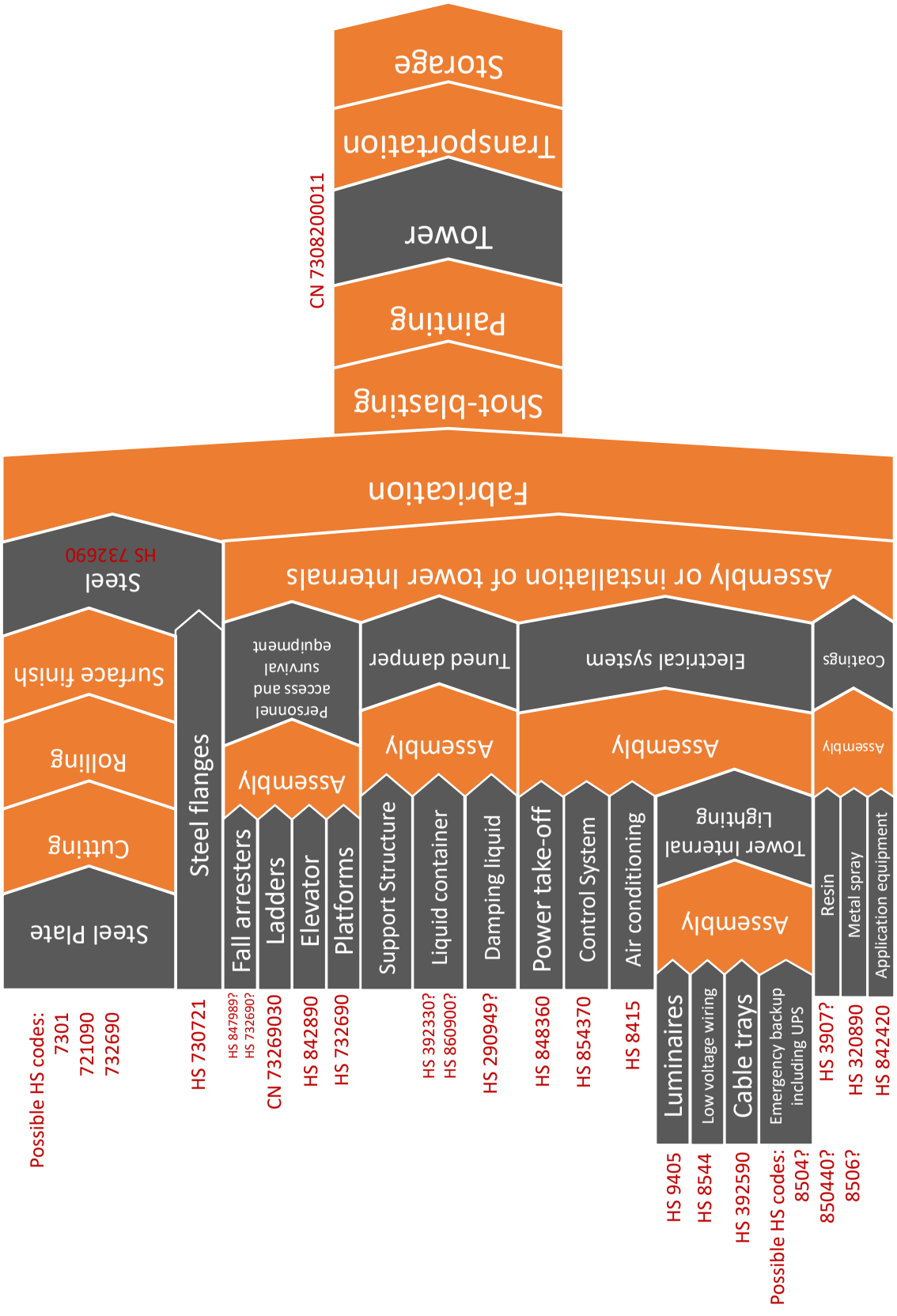

Rotor
Possible HS codes:
841280
841290 (most likely)
850300
850231
Rotor assembly
HS 741533
Structural fasteners
HS 732611
HS 732690
Balls
HS 73??
Cages or spacers
HS 401693
Seals
HS 271019
Grease
Assembly
Metal sprayed and/or painted finish
Blade bearings HS 848280
HS 732690
Forged rings
Machining
Hardening
Surface finishing
Casting
Non-destructive testing
Machining
Painting
Hub casting HS 732599
HS 8501?
Electric pitch system
HS 841221?
Hydraulic pitch system
OR
Assembly
Motors
HS 8501
Gearboxes
HS 841290?
HS 870840
Electrical panels
HS 8537
Batteries
HS 8506
Battery chargers
8504405510
CN
Position sensors
HS 903??
HS 902680
Power pack
HS 8504?
HS 8579?
Hydraulic actuators
HS 841221
Or HS 841229
Rotating union
HS 848790
Or HS 848490
Manifold blocks
HS 8481
Accumulators
HS 8507
Hoses
HS 4009
Electrical slip rings
HS 850300?
HS 730890
Fabricated steel components
Assembly
Surface treatment
Steel fabrications
HS 730890
HS 8501?
Rotor auxiliary systems
Assembly
Maintenance support features
Blade load measurement system
HS 903180
Automatic lubrication system
Possible codes:
841381
847989
8481
850300
HS 8503?
Spinner
Assembly
Fabricated steel support frame
HS 730890
Fibreglass mouldings
HS 848049
Blades HS 841290
Assembly
Structural composite materials
HS 7019
Fibreglass
HS 681511
Carbon fibre
HS 390730
Or HS 390791
Epoxy or polyester resin
HS 350691
Adhesive
HS 3921?
Closed-cell foam or balsa bulk fill
Consumables
Blade root
Assembly
Metal inserts
Composite structure
HS 8209?
Environmental protection
Assembly
HS 847150?
Data capture
HS 820900
Metal or ceramic inserts
HS 300510
Tape
HS 853540
Lightning conductor arrangement
Lightning receptors

I.2.3. Tower

The tower is typically a tubular steel structure that supports the nacelle. It also provides access to the nacelle and houses electrical and control equipment. Also provides shelter and storage for safety equipment.

- **Steel:** the most commonly used material for the manufacture of towers.

- **Tower internals:** provide means of access, lighting and safety for maintenance and service personnel, plus means of transferring hand tools and components to the nacelle. They provide support for control and electrical cables and housing of switch-gear, transformers and other elements of power take-off. Tower internals also provide storage for survival equipment. A tuned damper may be located at the top of the tower to aide damping of tower and structure resonances.

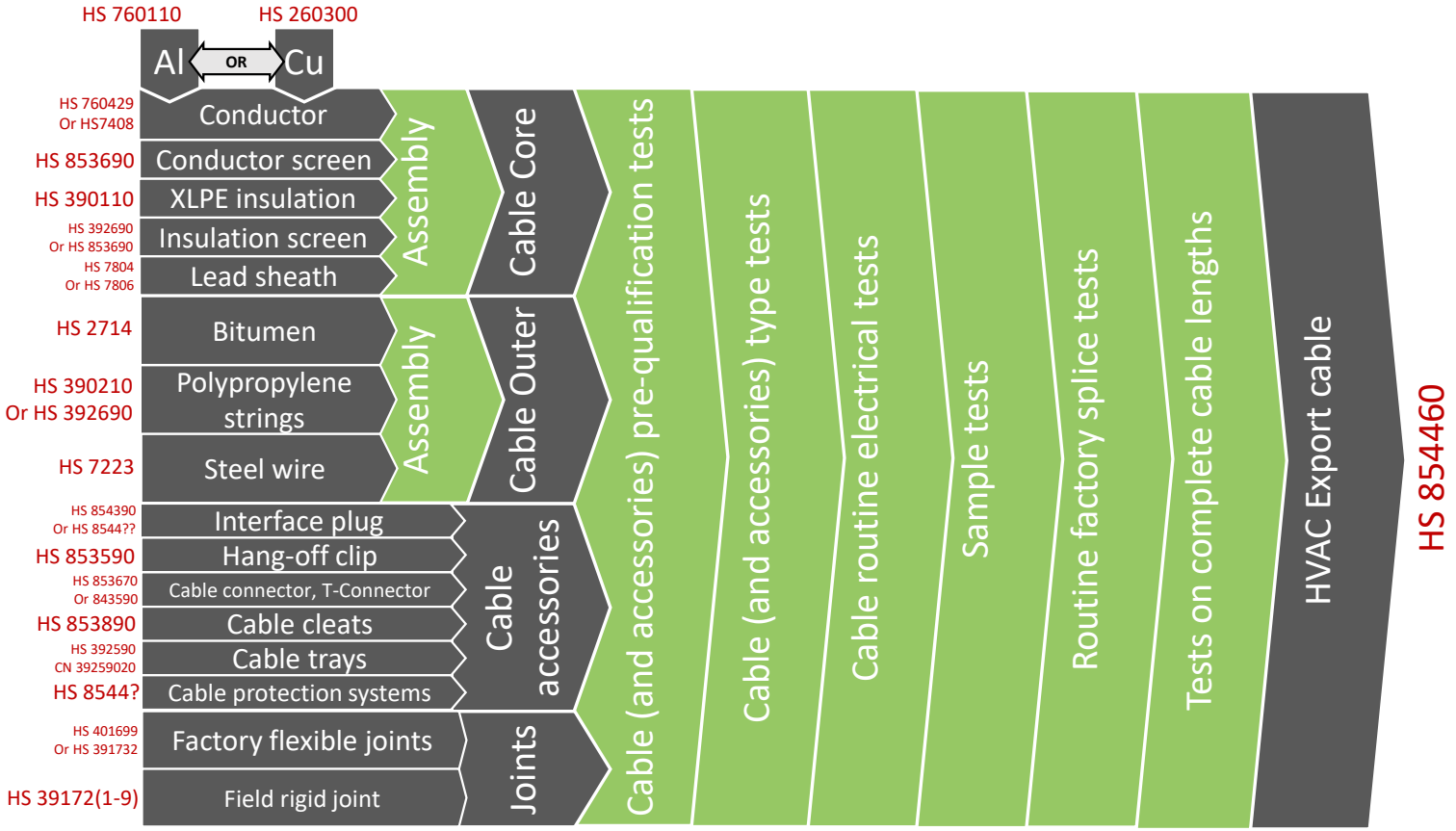

CN 7308200011
Storage
Transportation
Tower
Painting
Shot-blasting
Fabrication
Assembly or installation of tower internals
Steel
HS 732690
Surface finish
Rolling
Cutting
Steel Plate
Possible HS codes:
7301
721090
732690
Steel flanges
HS 730721
Assembly
Personnel access and survival equipment
Fall arresters
HS 8479897
HS 7326907
Ladders
CN 73269030
Elevator
HS 842890
Platforms
HS 732690
Assembly
Tuned damper
Support Structure
Liquid container
HS 392330?
HS 860900?
Damping liquid
HS 290949?
Assembly
Electrical system
Power take-off
HS 848360
Control System
HS 854370
Air conditioning
HS 8415
Assembly
Tower Internal Lighting
Luminaires
HS 9405
Low voltage wiring
HS 8544
Cable trays
HS 392590
Emergency backup including UPS
Possible HS codes:
8504?
850440?
8506?
Assembly
Coatings
Resin
HS 3907?
Metal spray
HS 320890
Application equipment
HS 842420

I.3. Balance of plant

The balance of plant includes all the components of the wind farm except the turbines, including transmission assets built as a direct result of the wind farm.

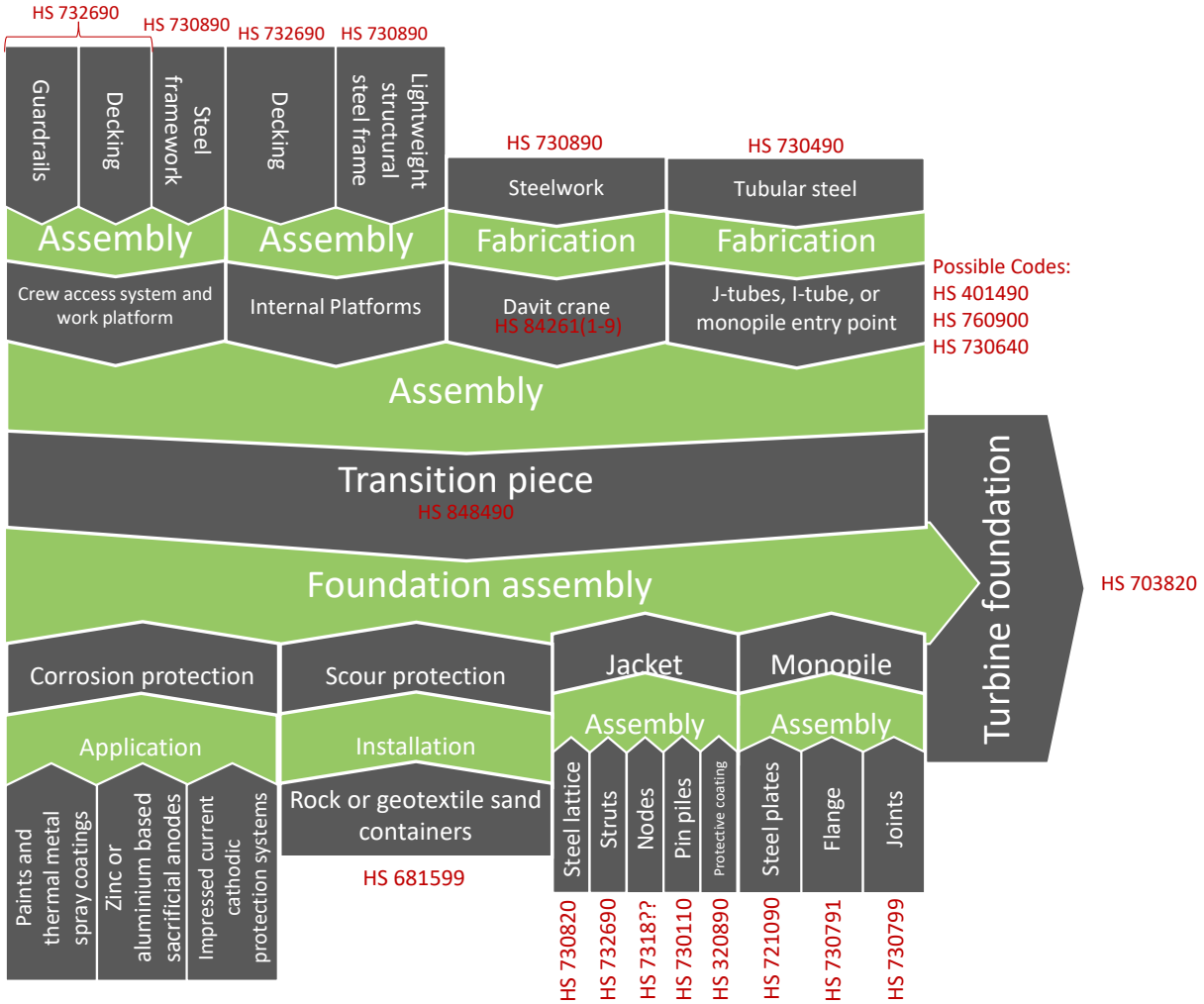
I.3.1. Cables

The cables deliver the power output from the wind turbines to the grid.



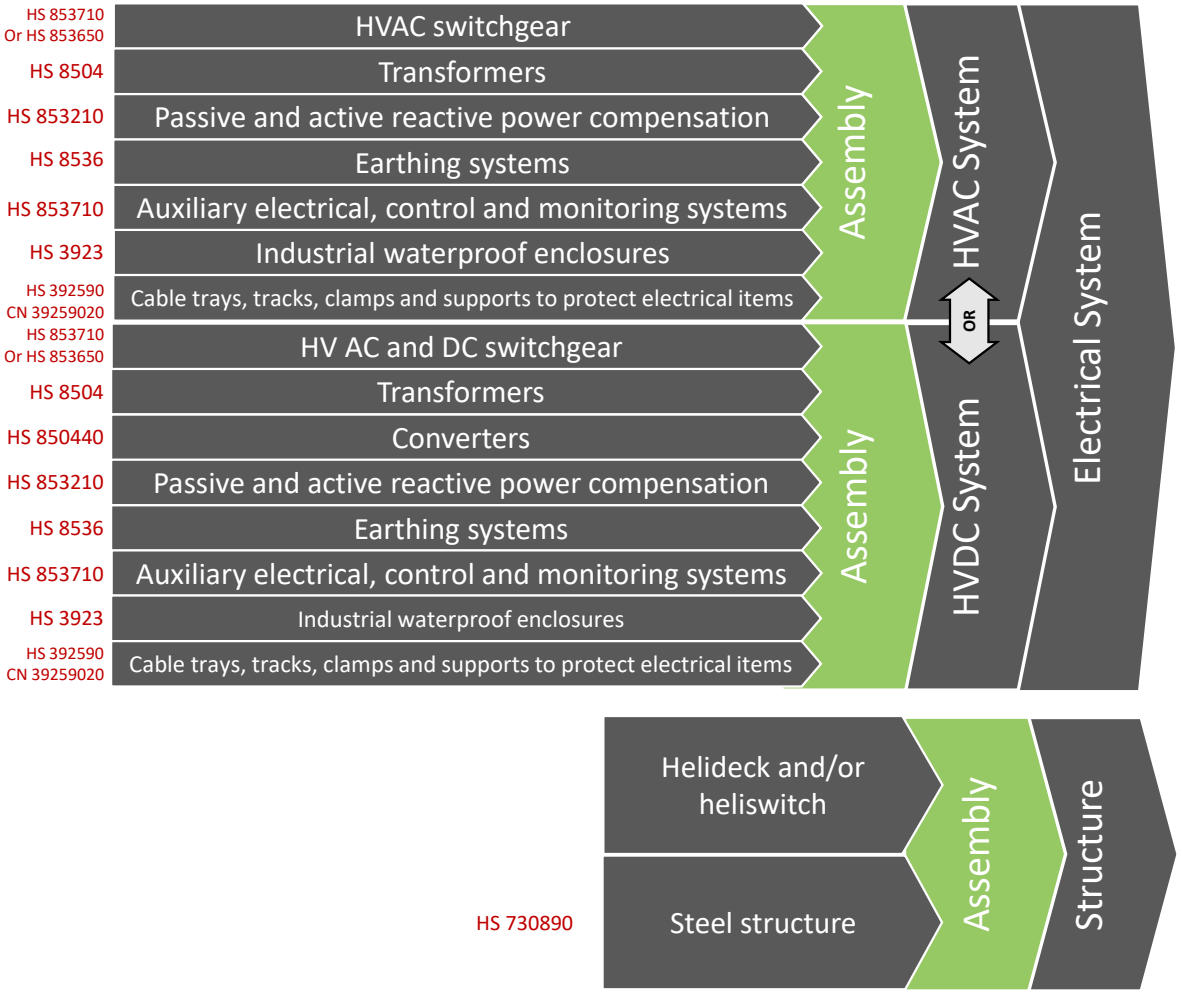
I.3.2. Turbine foundation

The foundation provides support for the wind turbine, transferring the loads from the turbine at the tower interface level (typically around 20m above water level) to the sea bed where the loads are reacted. The foundation also provides the conduit for the electrical cables, as well as access for personnel from vessels.



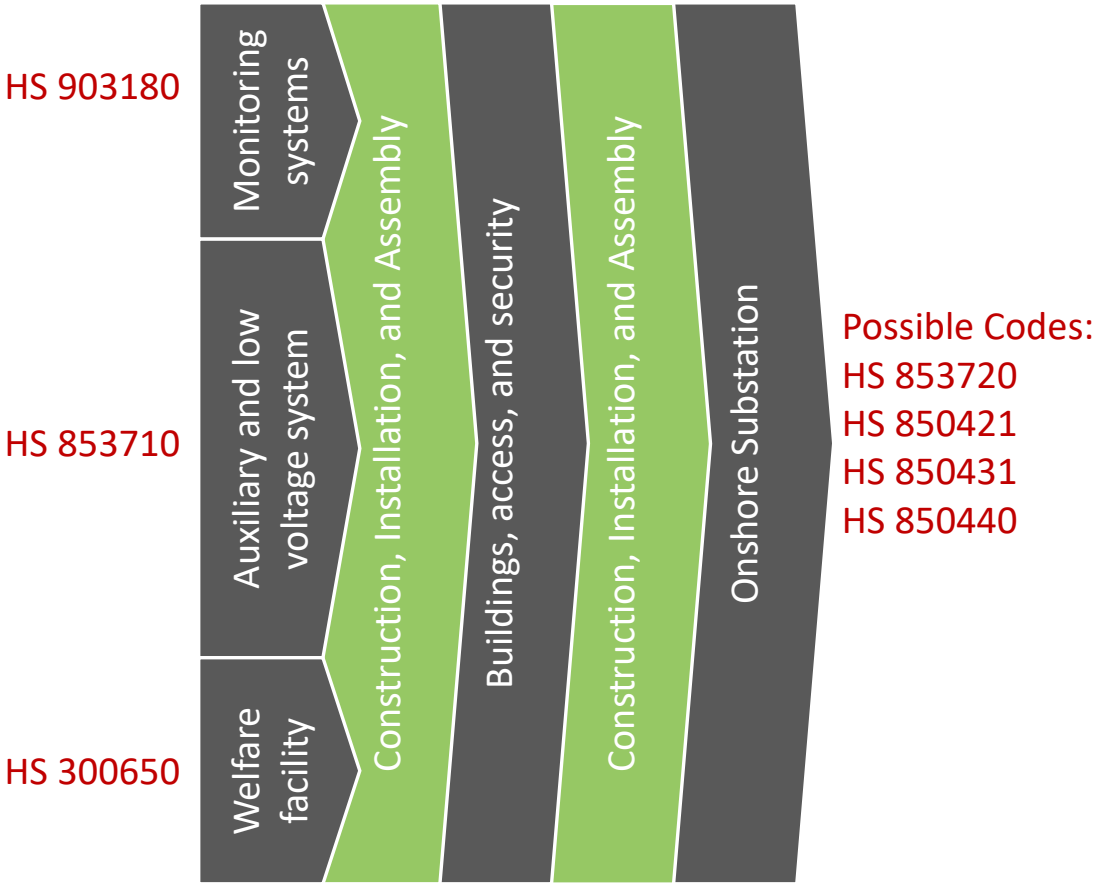
I.3.3. Offshore substation

Offshore substations are used to reduce electrical losses before export of power to shore. This is done by increasing the voltage, and in some cases converting from alternating current (AC) to direct current (DC). The substation also contains equipment to manage the reactive power consumption of the electrical system including the capacitive effects of the export cables.



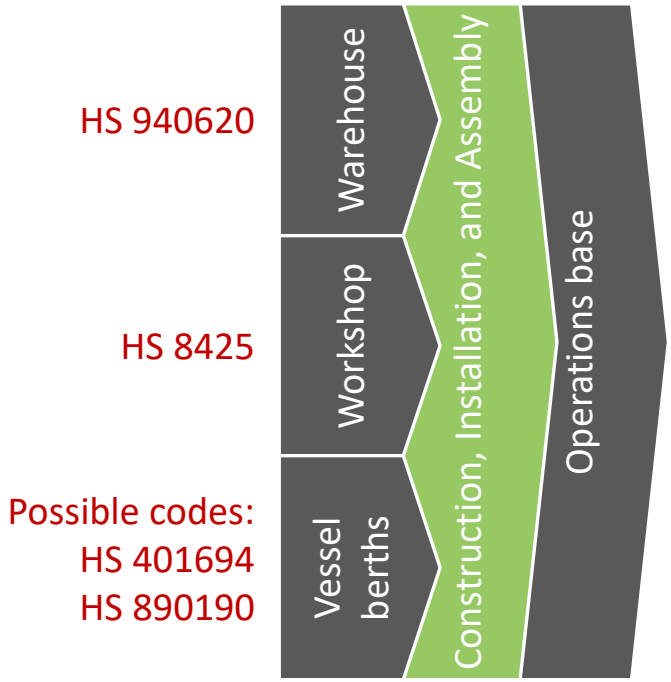
I.3.4. Onshore substation

The onshore substation transforms power to grid voltage, for example 400kV. Where a high voltage DC export cable is used, the substation will convert the power three phase AC.



I.3.5. Operations base

The operations base supports the operation, maintenance and service of the wind farm.

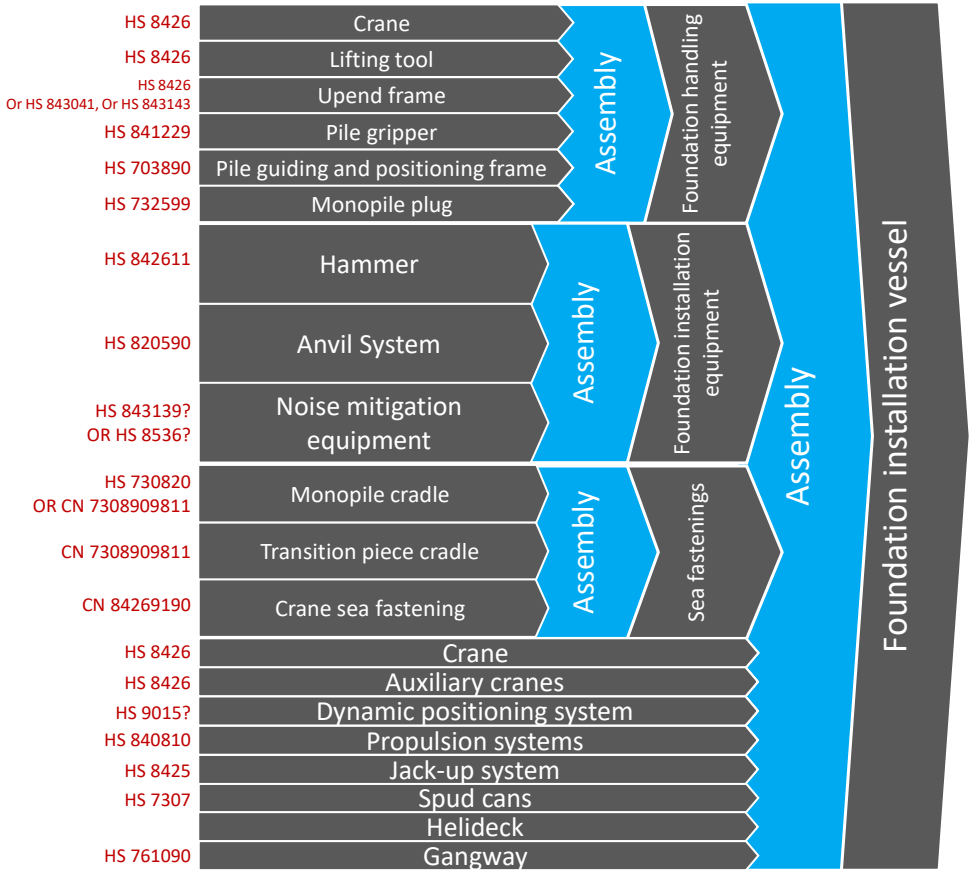


I.4. Installation and commissioning

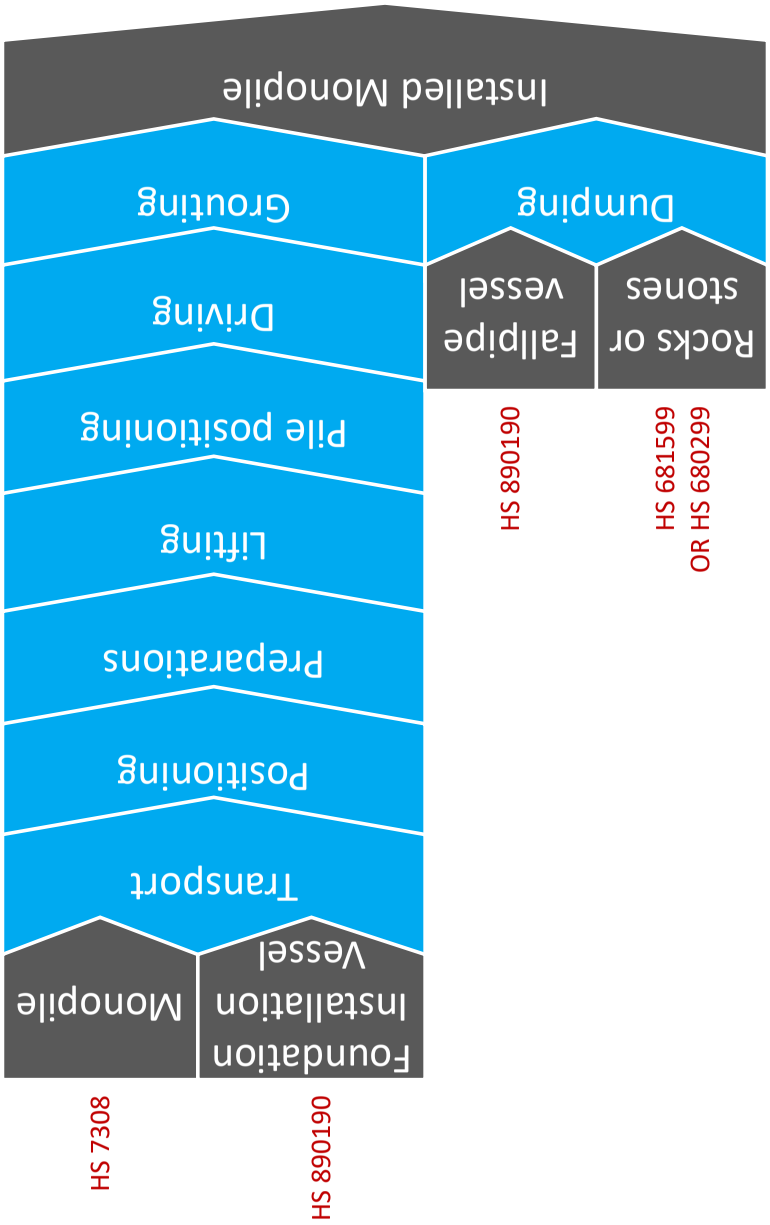
All installation and commissioning of balance of plant and turbines, including land- and sea-based activity. For offshore activities, the process starts by transporting components from the nearest port to manufacture to either the I.7 Construction port or straight to site. Activities are complete at the wind farm construction works completion date, where assets are handed over to operational teams.

I.4.1. Foundation installation

Foundation installation consists of the transport and fixing of foundation in position.

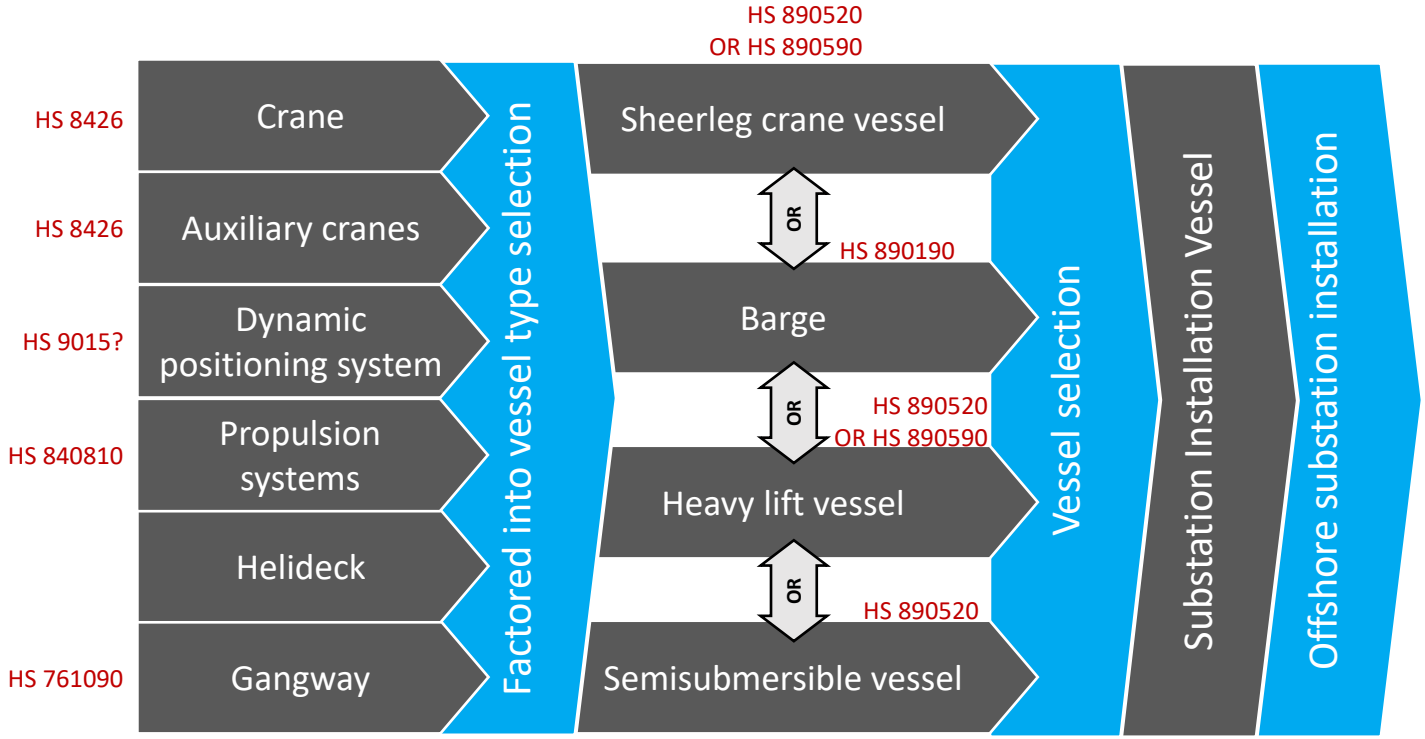


Other potentially relevant codes:
HS 843041
HS 843143


Installed Monopile
Grouting
Driving
Pile positioning
Lifting
Preparations
Positioning
Transport
Monopile
Foundation Installation Vessel
HS 7308
HS 890190
Dumping
Rocks or stones
Fallpipe vessel
HS 681599 OR HS 680299
HS 890190

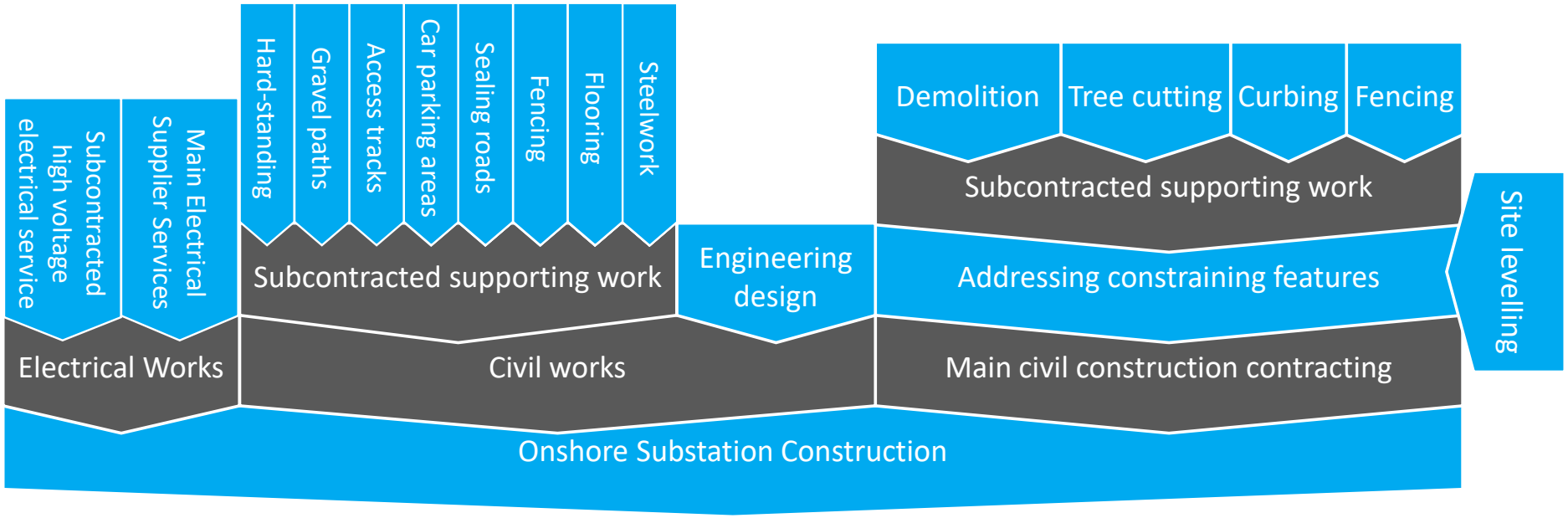
I.4.2. Offshore substation installation

The installation of the offshore substation consists of the transfer of the substation from its quayside fabrication site and the installation on the foundation.



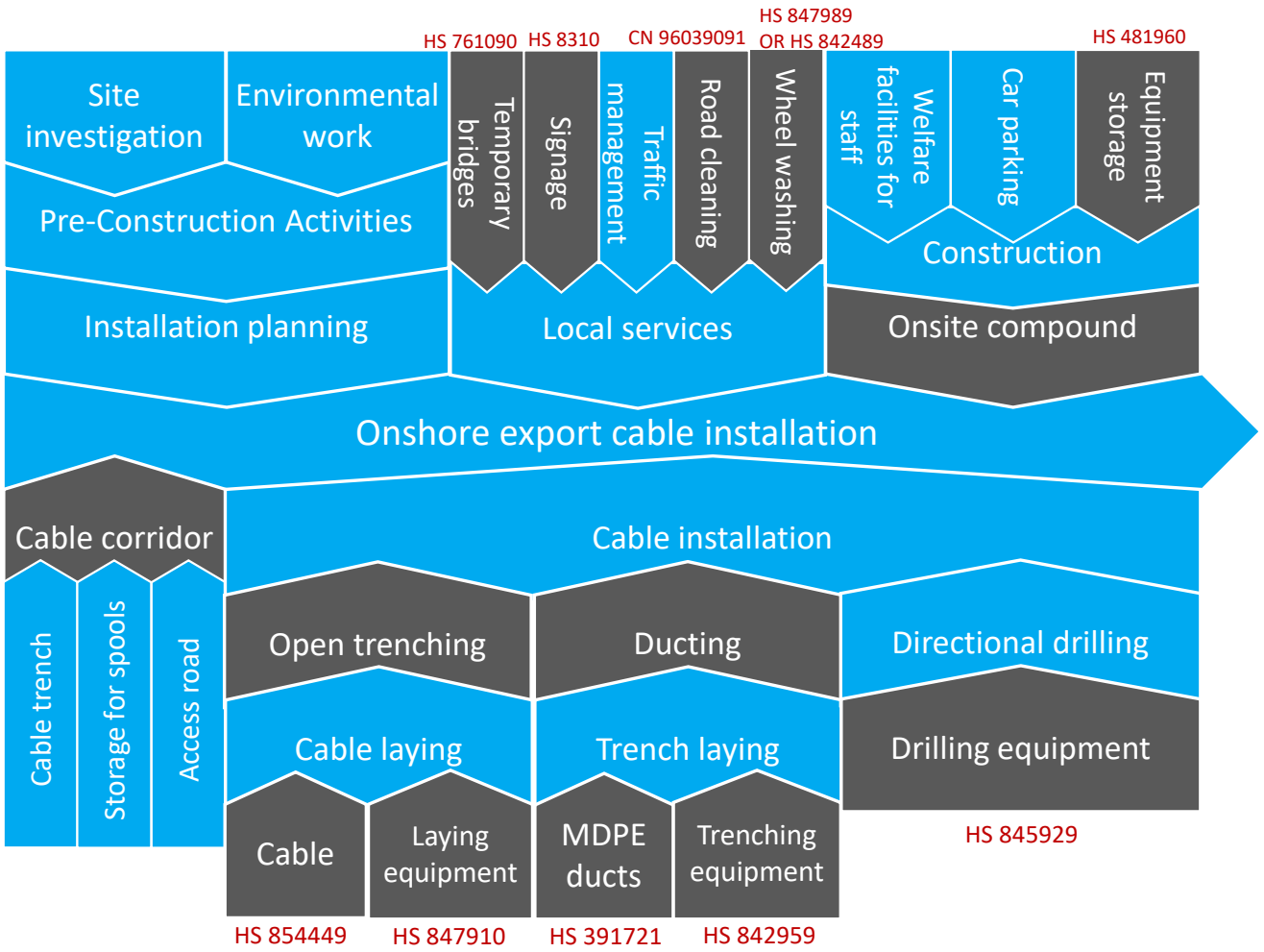
I.4.3. Onshore substation construction

The construction of the onshore substation consists of the construction of the infrastructure and the installation of electrical equipment.



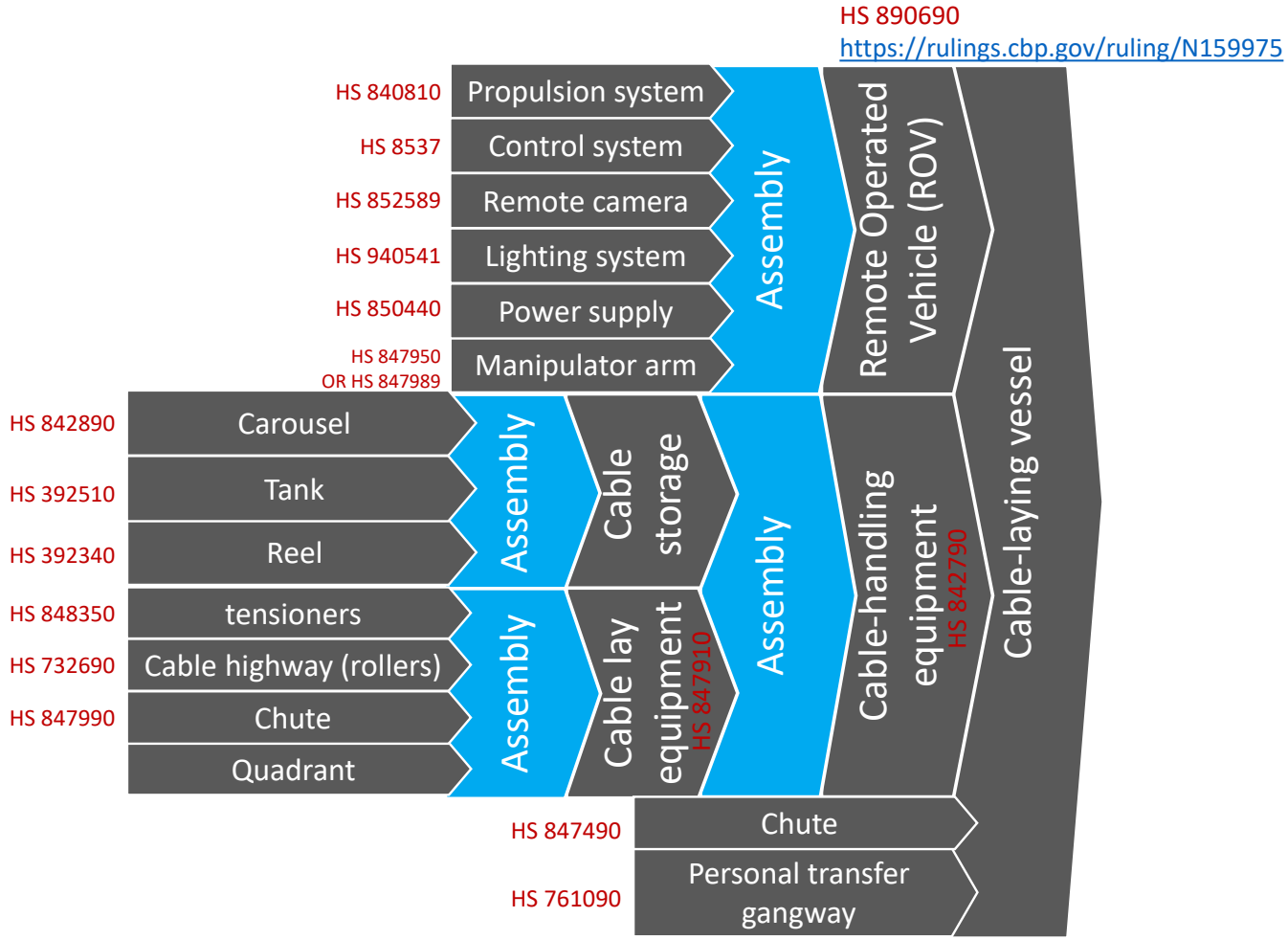
I.4.4. Onshore export cable installation

The installation of the onshore export cable completes the connection between the offshore export cable and the onshore substation.



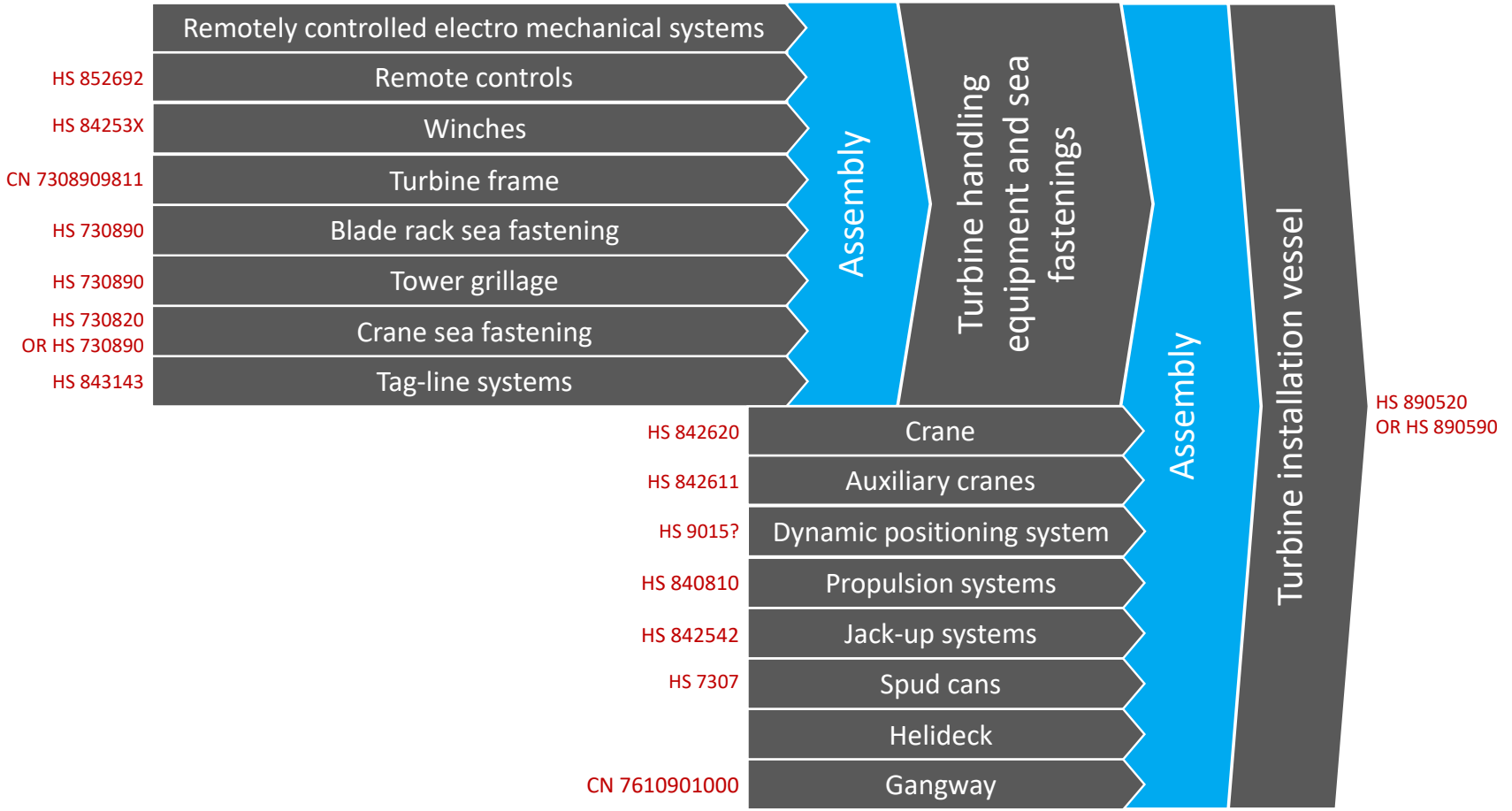
I.4.5. Offshore cable installation

The installation of array cables enables the connection of the wind turbines to the offshore substation whilst the installation of the export cable enables the connection between the offshore and onshore substations.



I.4.6. Turbine installation

Turbine installation involves transportation of the turbine components from the Construction port and installation of the turbine components onto the foundation.

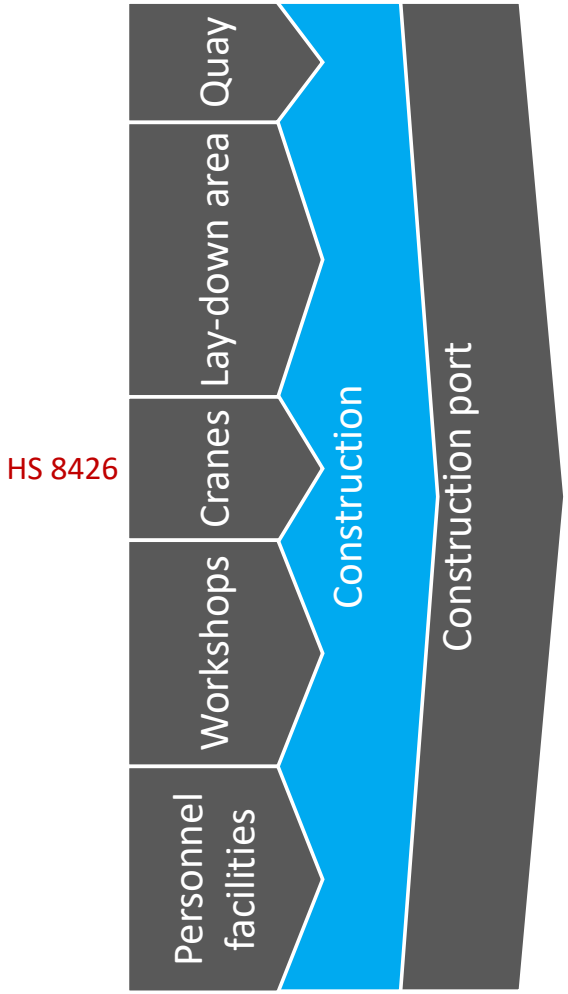


I.4.6.1. Commissioning

After installation, commissioning is the process of safely completing mechanical and electrical assembly, putting all systems to work and addressing punch lists before handover.

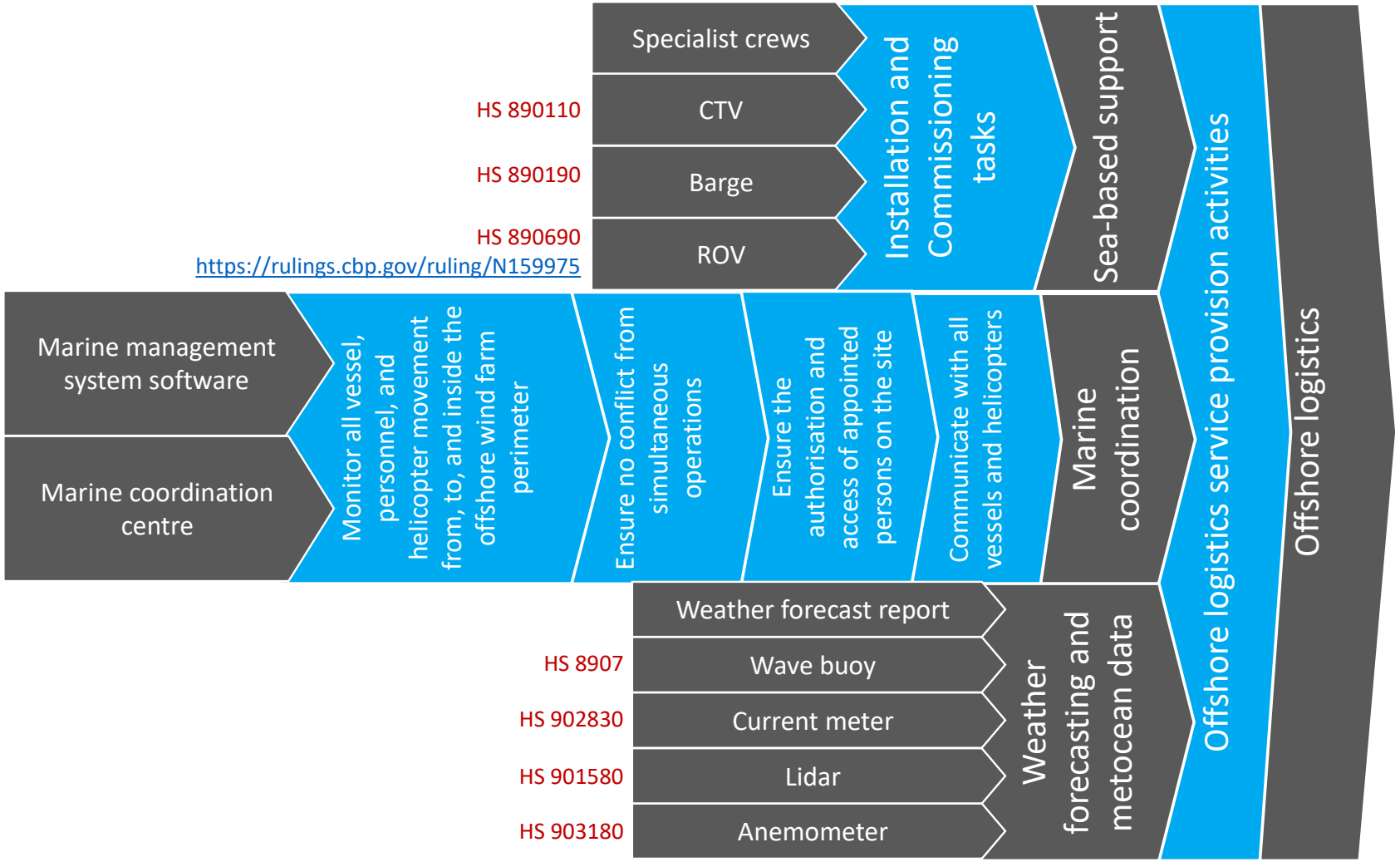
I.4.7. Construction port

The construction port is the base for pre-assembly and construction of the wind farm. Separate locations may be used for feeding foundations and the wind turbines to a wind farm. Location is critical as it affects the time spent in shipment and sensitivity to weather windows.



I.4.8. Offshore logistics

Offshore logistics involves coordination and support of offshore installation and commissioning activities.



I.5. Operation, maintenance and service

Operation, maintenance and service (OMS) are the combined functions which, during the lifetime of the wind farm, support the ongoing operation of the wind turbines, balance of plant and associated transmission assets. OMS activities formally start at the wind farm construction works completion date.

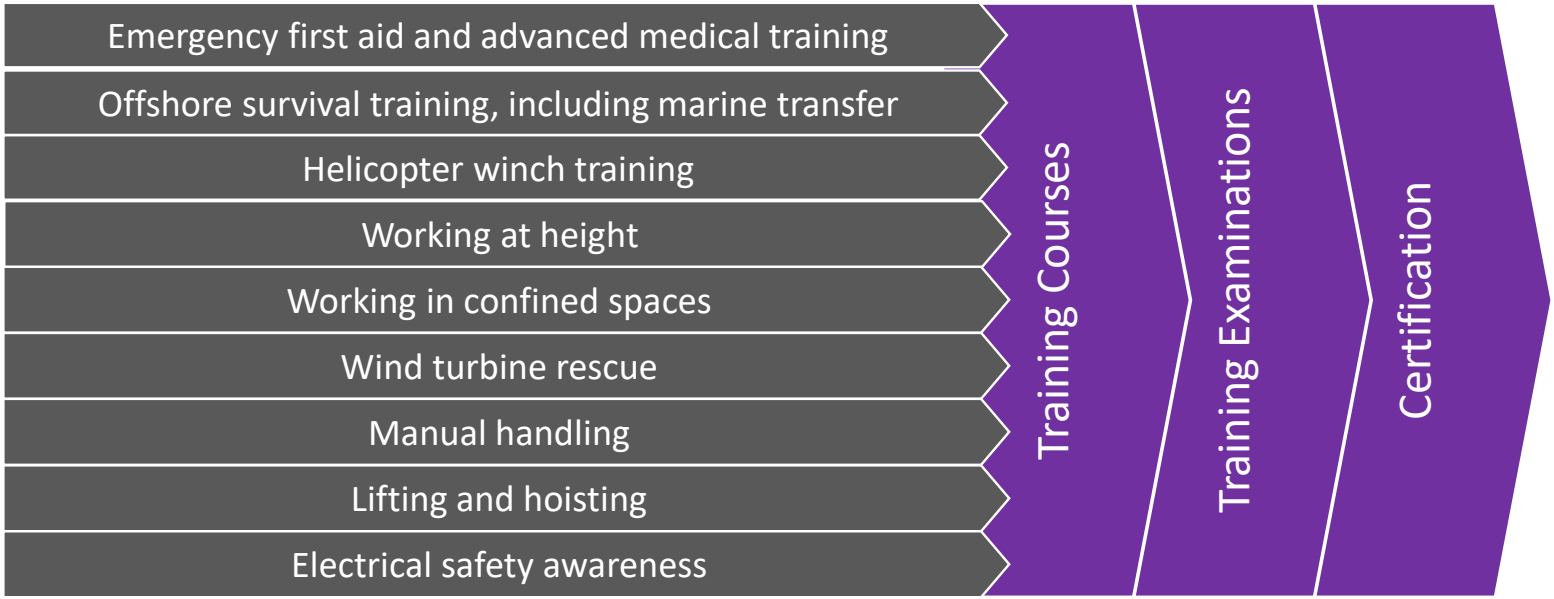
The focus of these activities during the operational phase is to ensure safe operations, to maintain the physical integrity of the wind farm assets and to optimise electricity generation.

I.5.1. Operations

Operations relate to management of the asset such as health and safety, control and operation of the asset including wind turbines and balance of plant, remote site monitoring, environmental monitoring, electricity sales, administration, marine operations supervision, operation of vessels and quayside infrastructure, and back office tasks.

I.5.1.1. Training

Training ensures that OMS personnel are qualified to fulfil the roles needed by the wind farm while ensuring their own safety and those of colleagues.

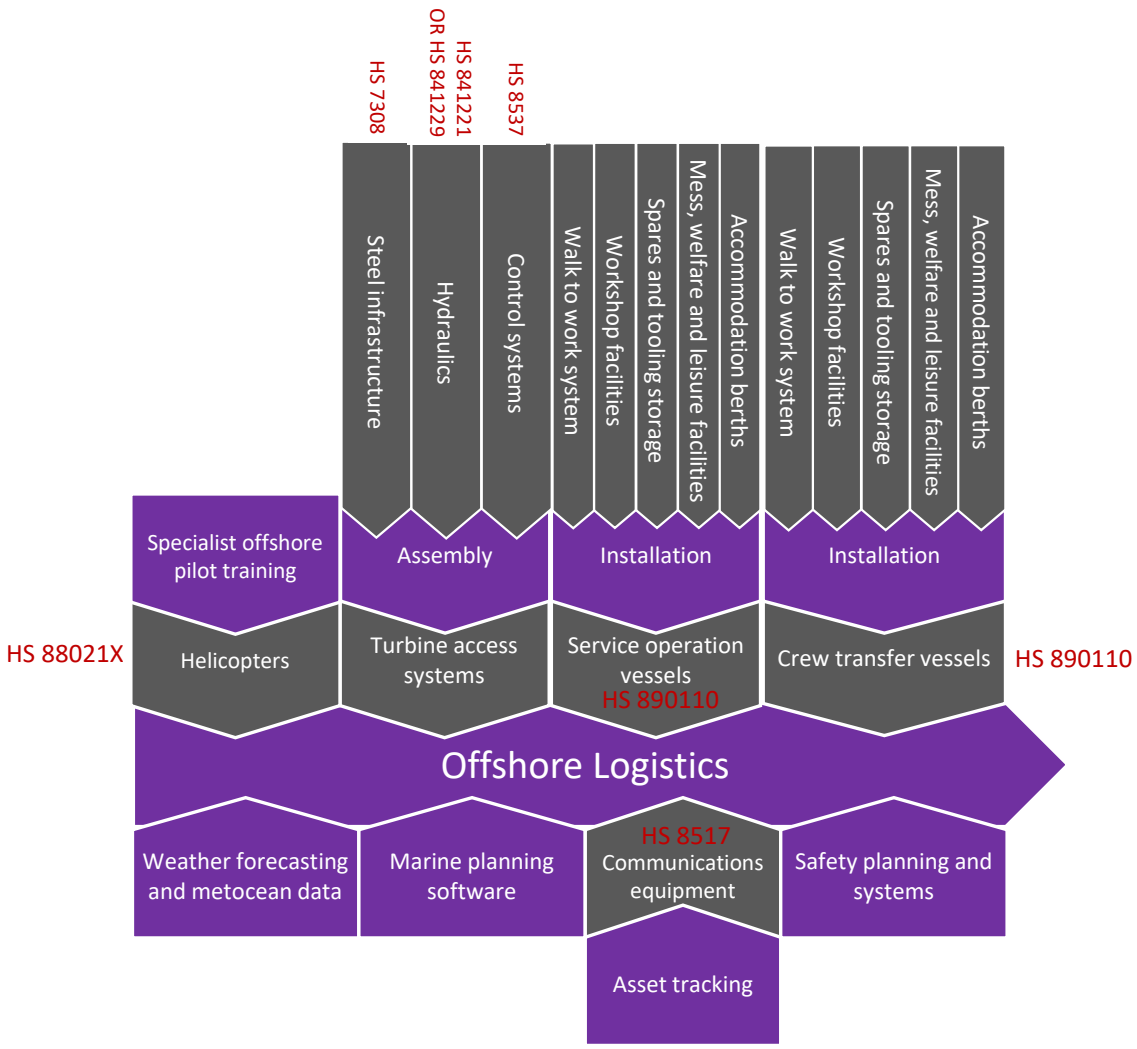


I.5.1.2. Onshore logistics

Onshore logistics involves support and resources to the wind farm operations, including quayside infrastructure, warehousing, logistics and operational planning.

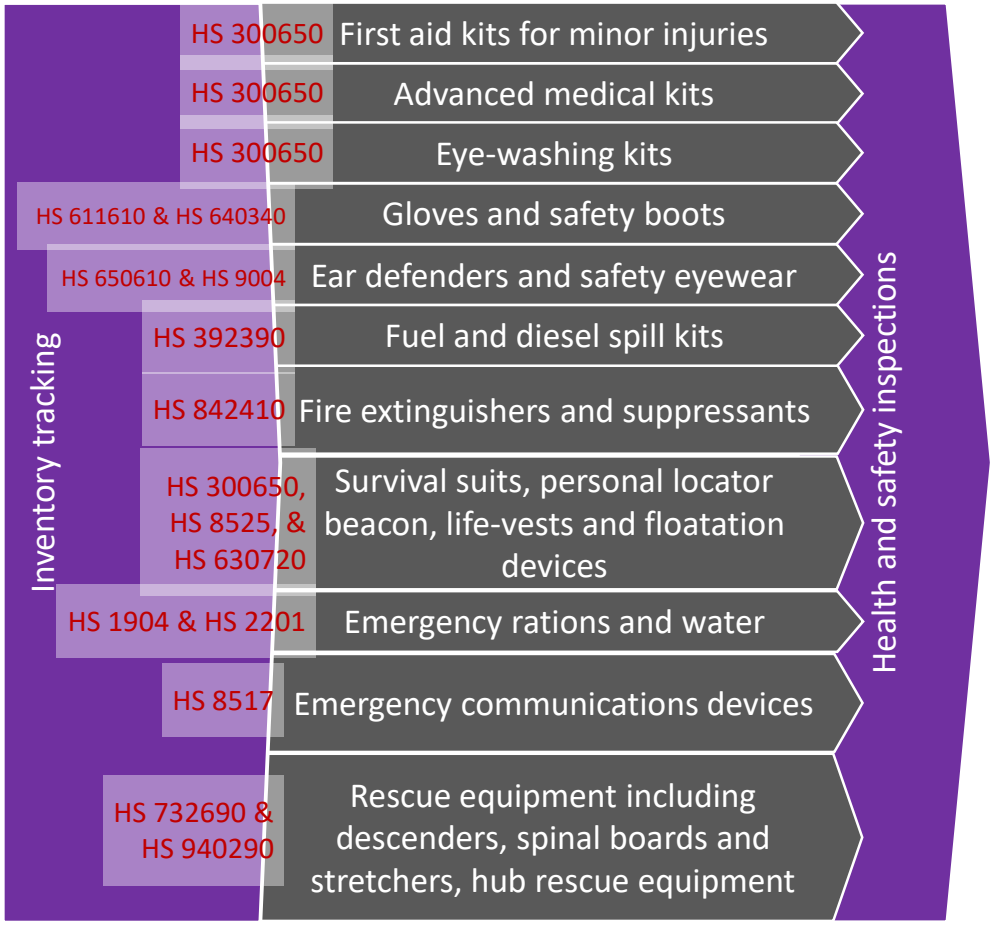
I.5.1.3. Offshore logistics

Offshore logistics involves management and coordination of all marine based activities and operations.



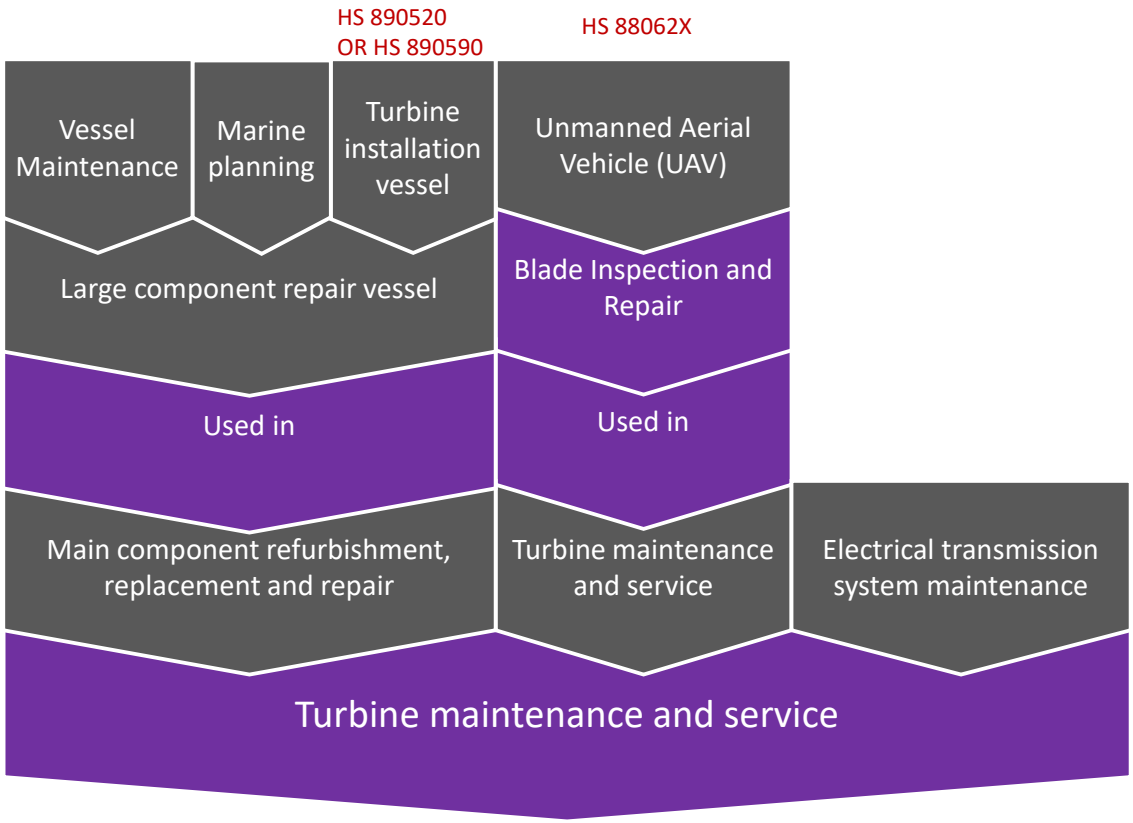
I.5.1.4. Health and safety inspections

Health and safety inspections are a crucial activity to ensure the ongoing safe operation of wind farm infrastructure and systems, and to fulfil statutory obligations to inspect safety critical systems on a regular basis.



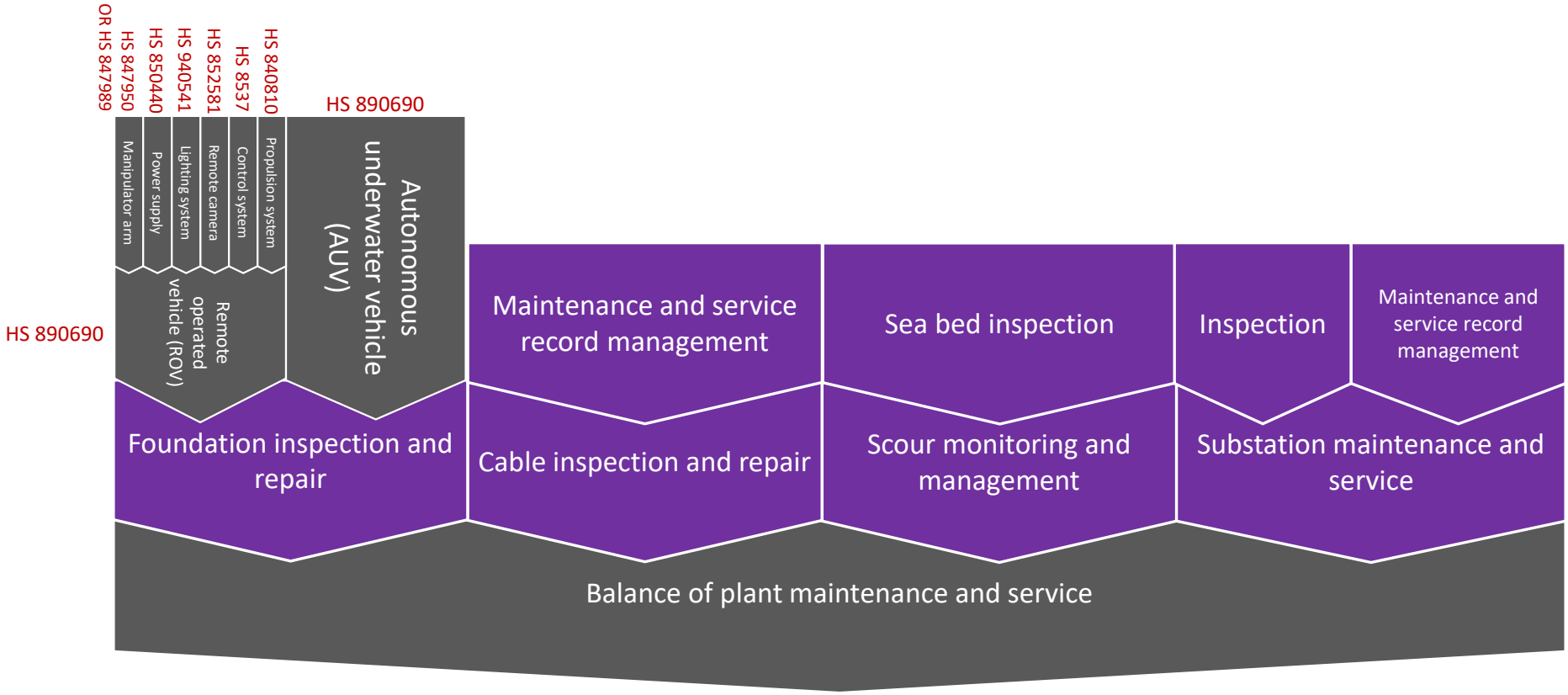
I.5.2. Maintenance and service

Maintenance and service activities ensure the ongoing operational integrity of the wind turbines and associated balance of plant, including planned maintenance and unplanned service in response to faults, either proactive or reactive.



I.5.3. Balance of plant maintenance and service

Balance of plant maintenance and service is focused on ensuring the operational integrity and reliability of all wind farm assets other than the wind turbines, including the substation(s), foundations, array cables, export cables, scour protection and corrosion protection systems.

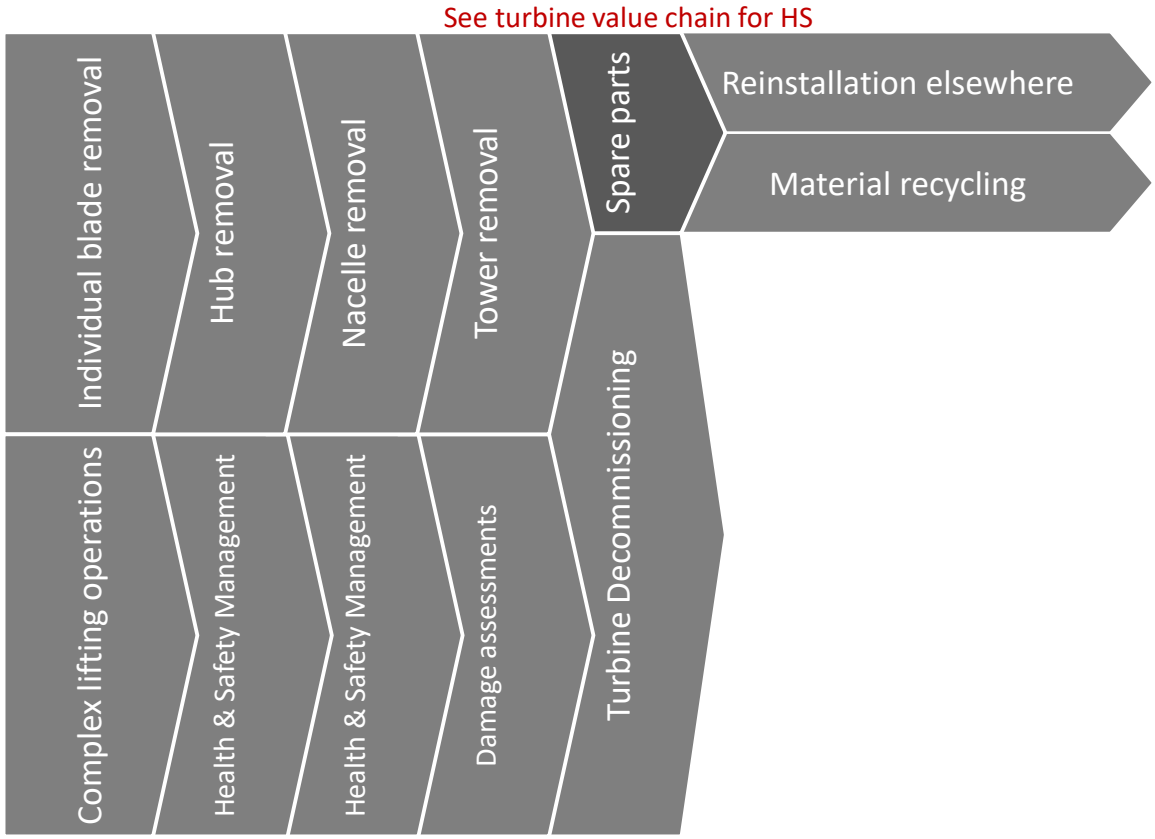


I.6. Decommissioning

Removal or making safe of offshore infrastructure at the end of its useful life, plus disposal of equipment.

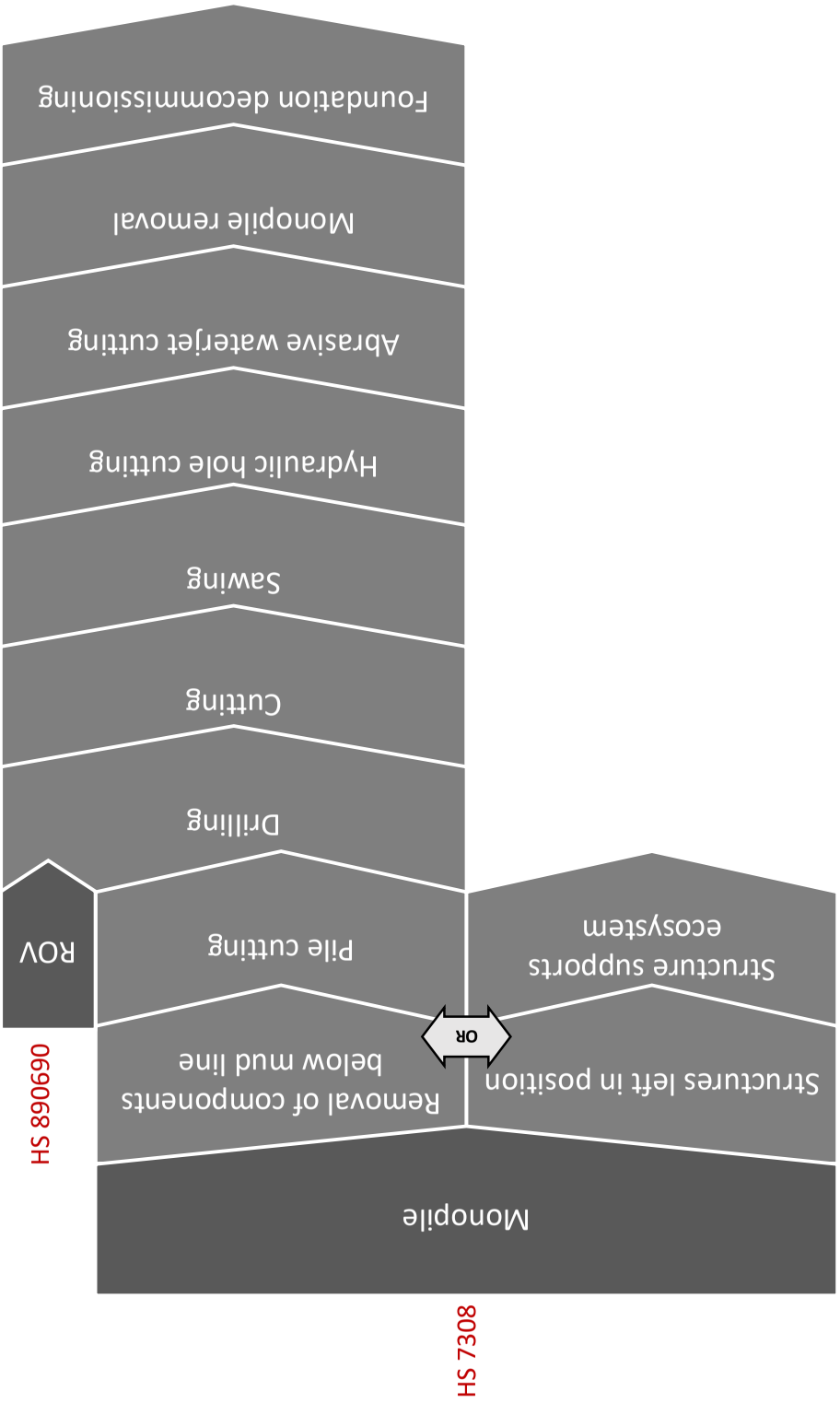
I.6.1. Turbine decommissioning

Complete removal and shipment to shore of turbine rotor, nacelle and tower.



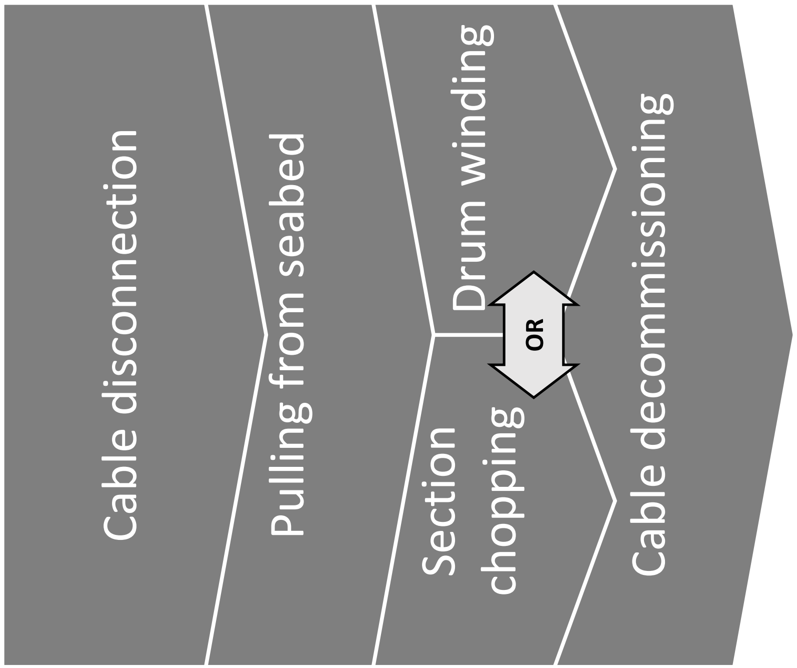
I.6.2. Foundation decommissioning

Removal and shipment to shore or cut-off at sea bed level and making safe.



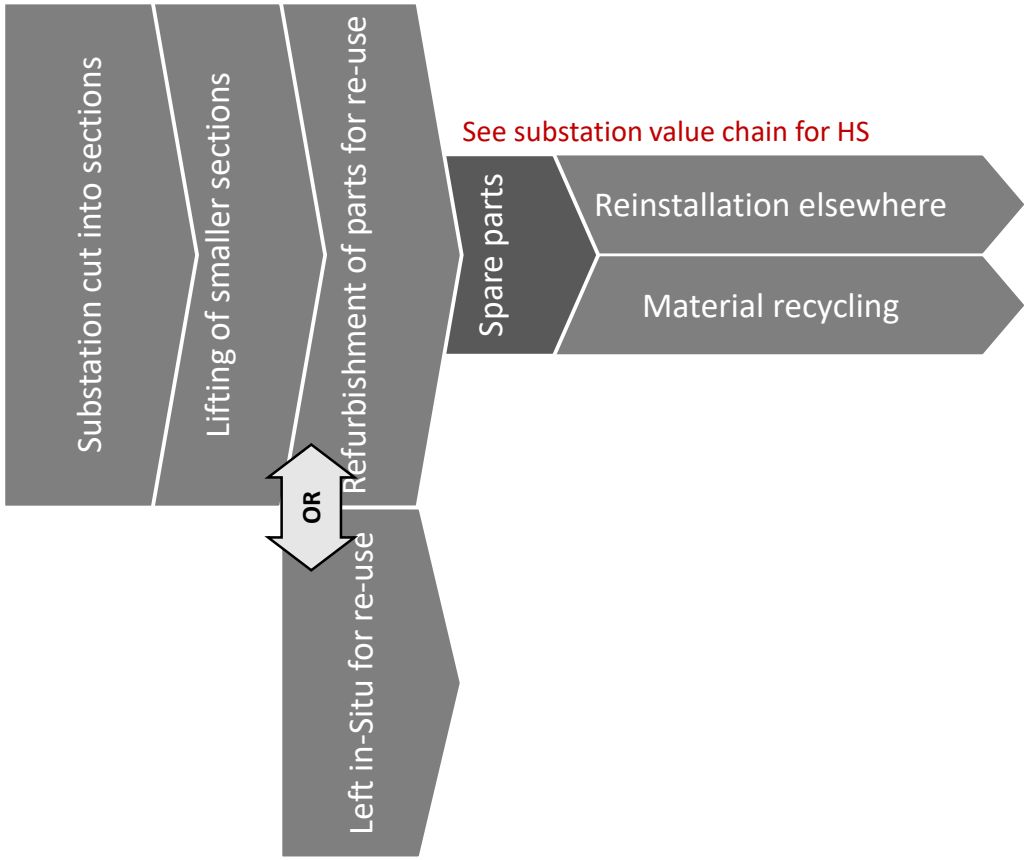
I.6.3. Cable decommissioning

Removal and shipment to shore.



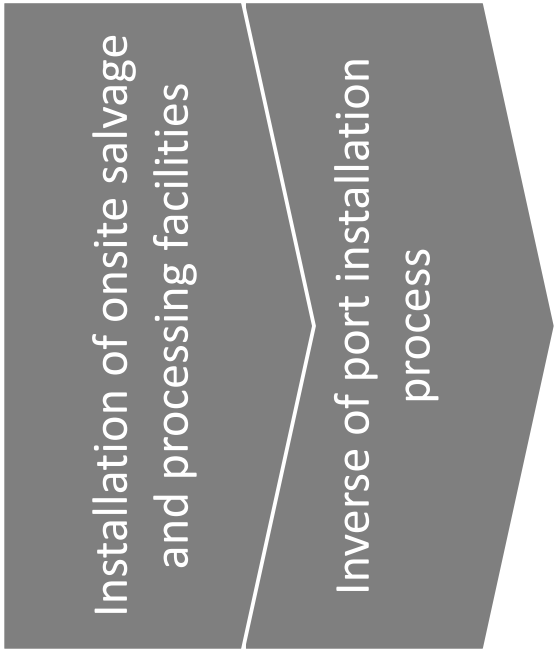
I.6.4. Substation decommissioning

Decommissioning plans typically are required as part of gaining approval to construct. These may define specific requirements for removal of components below the mud line which in turn may drive the choice or design of substation foundations and installation methods.



I.6.5. Decommissioning port

Port where equipment removed is offloaded and marshalled for next stage of processing.



I.6.6. Reuse, recycling or disposal

Once equipment is onshore, there is a motivation to extract maximum value via reuse, recycling or disposal.