ORCADES MARINE
Management Consultants Ltd

Fortum

Device-specific Addendum to EMEC Wave Energy Test Site Navigation Risk Assessment

Penguin 1, 2 and 3 Array

CEFOW

Wello
DIRECT CONVERSION

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Table of Abbreviations	
ALS	Accidental Limit State
BP	Bollard Pull
CD	Chart Datum
EMEC	European Marine Energy Centre
ERP	Emergency Response Plan
HAT	Highest Astronomical Tide
HIRA	Hazard Identification and Risk Assessment
LAT	Lowest Astronomical Tide
MAIB	Marine Accident Investigation Branch
MCA	Maritime and Coastguard Agency
MHWN	Mean High Water Neaps
MLWN	Mean Low water Neaps
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs
NRA	Navigation Risk Assessment
RHIB	Rigid Hull Inflatable Boat
ROV	Remotely Operated Vehicle
TDP	Touch Down Point
WEC	Wave Energy Converter

Contents

1 Introduction

This Navigation Risk Assessment is an addendum to the updated the Navigation Risk Assessment (NRA) for the European Marine Energy Centre (EMEC) wave energy test site at Billia Croo in 2014 (*Anatec 2014*). This assessment used a device neutral methodology for the entire wave test site. The intention was that this would be combined with a device-specific annex, which this document provides. The purpose of this document is to identify all the relevant device-specific information required to inform the NRA annex for the existing Penguin 1 device along with the proposed two additional devices Penguin 2 and Penguin 3.

2 Device Specific Information

2.1 Development Outline and Schedule

A number of scale models of the Penguin have been built and tested successfully in laboratory and at sea, throughout the testing period prototype devices gradually increased in size. Between 2012 and 2014, Wello deployed their wave energy converter (WEC) at EMEC's wave test site, Billia Croo. After several testing periods in Scotland with a full-scale device, Fortum Corporation decided to invest in the technology and managed to secure €25 million of European Commission Horizon 2020 funding to deploy a 3MW array (otherwise known as the CEFOW project). This project was initially planned to be installed at WaveHub, in Cornwall, but now will be installed at EMEC, Orkney.

The Penguin device was reinstalled at Billia Croo in March 2017. It is full scale device and it has nominal power output of 1000kW. The anticipated program for the build out of the array is as follows:

Phase 1: Penguin 1 deployment – already completed

Phase 1 has been completed between February-August 2017. Moorings were prepared and deployed at the Berth 5 in February 2017 for Penguin 1. After deployment of moorings, Penguin WEC 1 was towed onsite and connected to the moorings in February. Electrical connection via the dynamic cable (umbilical cable) was connected by splicing to EMEC static cable on March 2017.

Phase 2: Penguin 2, deployment September 2018

All of the following deployments have been planned to be done in September 2018, dependent on the weather at the sea.
Moorings will be prepared and deployed September 2018 for Penguin WEC2.
An electrical hub will be deployed in September 2018 which will enable grid connection for three Penguin WECs.

When the moorings have been successfully deployed, Penguin 2 will be towed to the site and connected onto the moorings. The Penguin's umbilical cable will be connected directly to the Hub with a connector.

Phase 3: Penguin 3, deployment between May-July 2019

All the following deployments have been planned to be completed between May-July 2019, dependent on the weather.
The moorings will be prepared and deployed at the Berth in May 2019, for Penguin WEC3. When moorings has been successfully deployed, Penguin 3 will be towed to the site between and connected onto the moorings. The Penguin's umbilical cable will be connected directly to the Hub with a connector.

Operational period 2017-2020

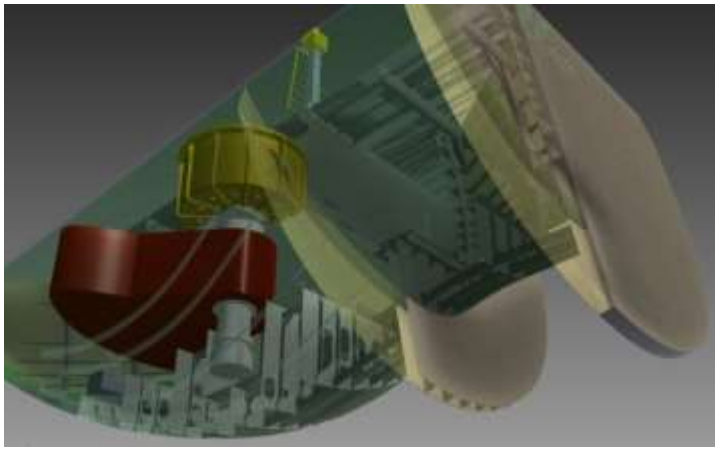
All three devices are planned to be operated continuously until summer 2020, depending on their technical performance.

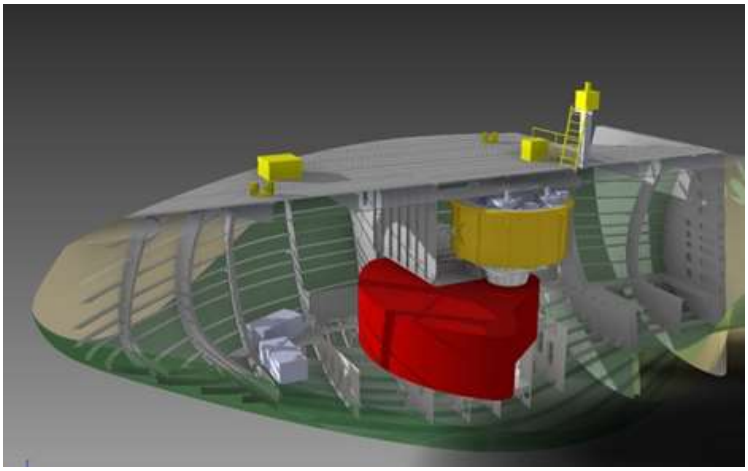
Decommissioning

After completion of the testing period the system will be decommissioned in the reverse order to the installation process. Decommission is expected to happen earliest in summer time (May-September) 2020, when this European Commission funded project will end.
Fortum as a leaseholder will be responsible for decommissioning. If possible, mooring components and static electric cables may remain in situ for future use as part of a larger planned array subject to future consent applications.

2.2 Device Description

The Penguin (WEC2) device is around 43 meters long, nine meters in height and has a draft of around seven meters. Only two meters are visible above the water surface.
The Penguin device has unique simple and durable design which is able to convert wave movement into power, with no moving parts outside the hull. The power generation is based on converting the movement of the waves to rotational kinetic movement inside the device by using the asymmetric shape of the hull. As the Penguin is based on continuous rotational movement the forces and the thus the wear of the component is reduced, and the power takeout is increased. The asymmetric shape of the Penguin’s hull has been optimised for maximum power generation and operates optimally in water depths of 50m or more, which makes it very attractive considering the site development worldwide, as there is no need to restrict to near-shore sites.





Figures 1: Operating principle of Penguin

The rotating mass is shown as the red component within the hull of the Penguin and this rotating mass is attached to the generator shown in yellow

Figure 2: Wello's current Penguin

Penguin 1 Wello's existing Penguin deployed in 2017 and currently on site.

Two other Penguins are to be deployed in summer 2018 and 2019. These devices will have the same working principle (all the moving parts are inside the hull), but will aim for increased power production rate and lower investment cost due to improved hull shape

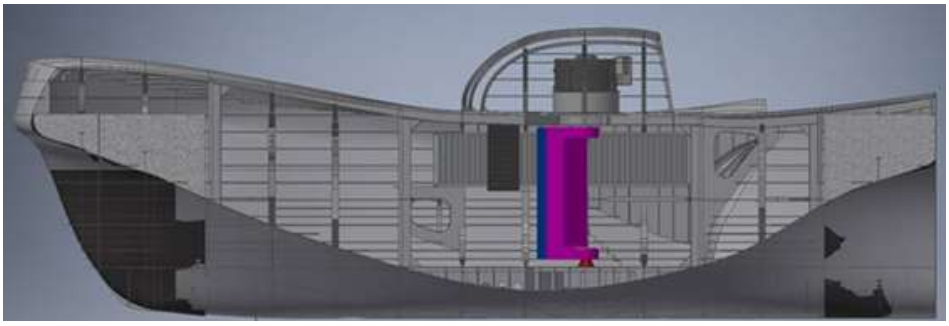


Figure 3: Sketch of WEC 2 with new advanced shape

2.3 Developer Details

The contact details for the point of contact in relation to anything relating to the project are as follows:

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2.4 Device Details

2.4.1 Description and Specification

The devices are broadly ship shaped with an asymmetric design, and can be classified generically as a “rotating mass design”. The main body of the structure is held in position on the sea surface with the “bow” pointing in the prevailing or optimal direction of the waves for the location. In the case of the location at Billia Croo, towards a west south westerly direction. The device is held in the centre of a six legged catenary mooring system.

Penguin 1 has the following dimensions

Displacement	1220+ te
Length	30m
Breadth	15m
Depth	7m
Draft	5m

Penguin 2 and 3 have the following approximate dimensions

Displacement	1600+ te
Length	43.2 m
Breadth	22m
Depth	9.8m (at lowest freeboard)
Draft	7m

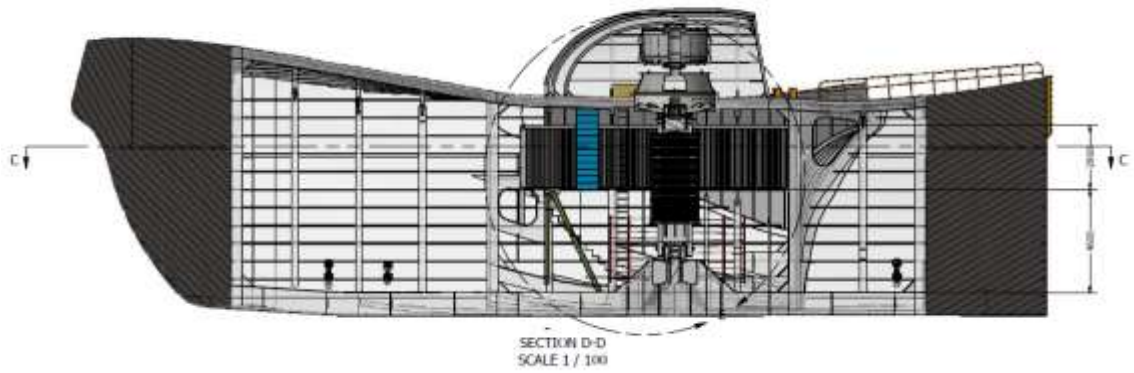


Figure 4 Longitudinal Cross Section of Penguin 2 & 3

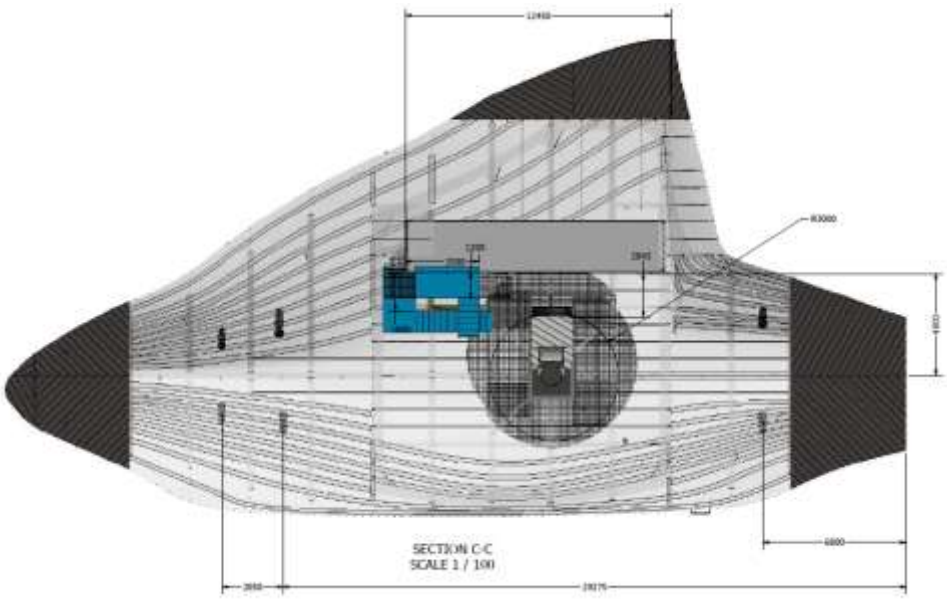
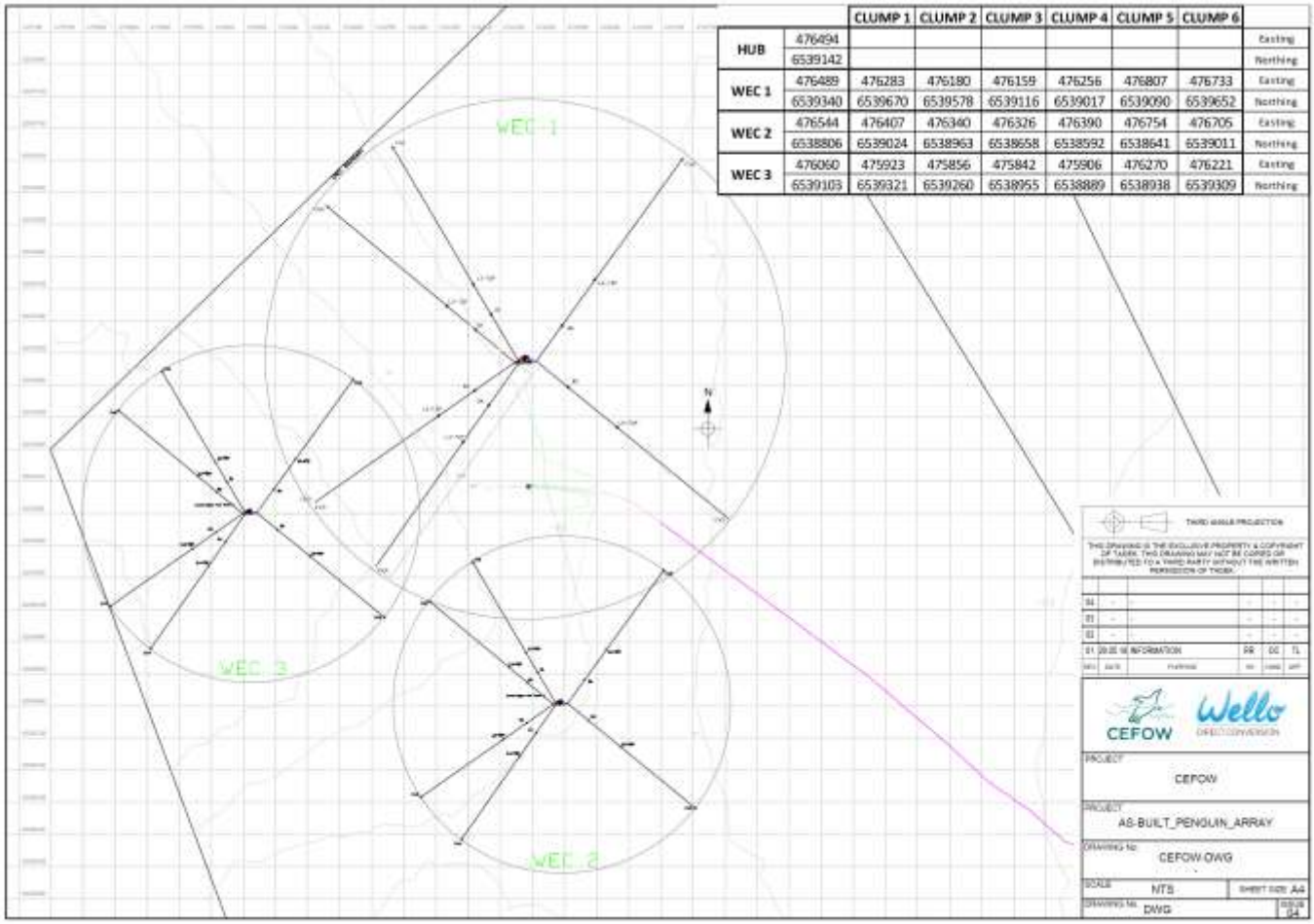


Figure 5 Plan view of Penguin 2 & 3

2.4.2 Mooring description

The mooring design is a 6-legged catenary system where buoys are used to provide compliance in the shallow water-depths. The mooring system has been designed with ease of installation as a main design parameter. The mooring system is designed so all phases can be executed in short weather windows or safely be aborted due to unexpected poor weather conditions. WEC 1 is anchored with gravity base anchors, the WEC 2 version (Penguin 2 and Penguin 3) embedment anchors will be utilised.



		CLUMP 1	CLUMP 2	CLUMP 3	CLUMP 4	CLUMP 5	CLUMP 6	
HUB	476494							Easting
	6539142							Northing
WEC 1	476489	476283	476180	476159	476256	476807	476733	Easting
	6539340	6539670	6539578	6539116	6539017	6539090	6539652	Northing
WEC 2	476544	476407	476340	476326	476390	476754	476705	Easting
	6538806	6539024	6538963	6538658	6538592	6538641	6539011	Northing
WEC 3	476060	475923	475856	475842	475906	476270	476221	Easting
	6539103	6539321	6539260	6538955	6538889	6538938	6539309	Northing

Figure 6 Mooring Layout of Penguin 1, 2 and 3

Each mooring leg is built up of different sizes of chain and a subsurface buoy that has a marker buoy above the surface. The design parameter of the chain is weight / meter to create the right shape of catenary. Additional safety factors have been built into the design of the mooring legs. Each mooring leg contains either a gravity base anchor or embedment anchor, seabed chain and catenary chain up to buoy and another catenary chain from buoy to WEC

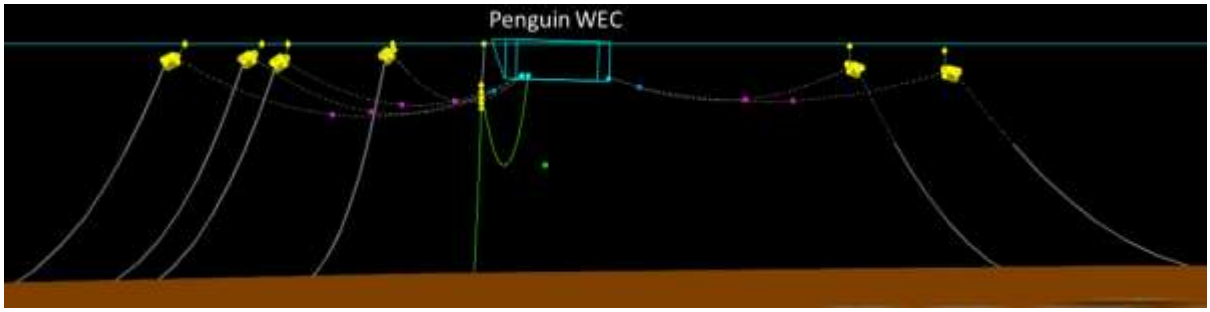


Figure 7: Principal layout of mooring system.

The radius of mooring spread for Penguin 1 is approximately 400 metres and the radius from the WEC to the touch down point (TDP) of the chain from the subsurface buoys to the sea bed is approximately 150 metres.

The radius of the mooring spread for Penguin 2 and 3 is approximately 250 metres and the radius from the WEC to the touch down point (TDP) of the chain from the subsurface buoys to the seabed is approximately 100 metres.

The suspended section of the cable is within the radius of the sub surface buoys

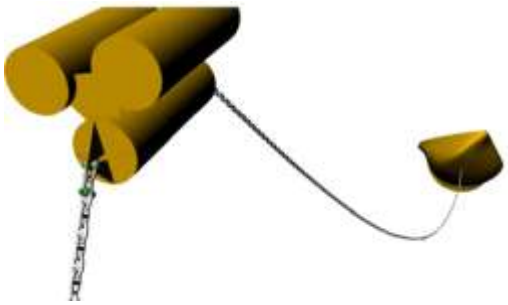


Figure 8: Illustrative picture of a sub-surface buoy

2.4.3 Subsea cables/infrastructure

To allow additional WEC devices to be installed at Berth 5 the export cable will be split using a 4-way smart hub as shown below

The smart hub is a ground-breaking solution to enable subsea switchgear, giving the opportunity isolate a faulty WEC and thus eliminate one device causing an earthing fault over the whole array.

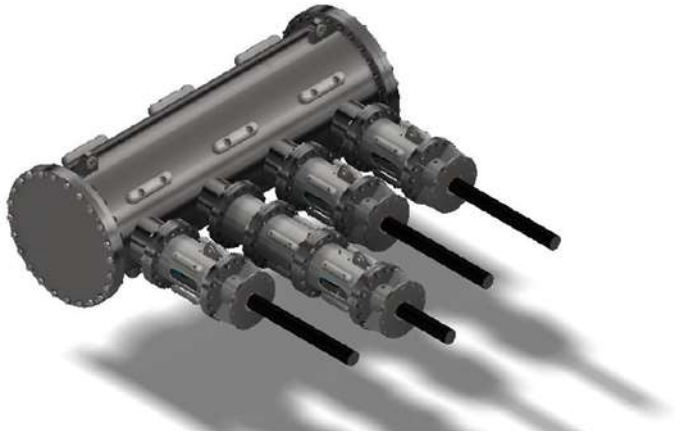


Figure 9 Four Way Smart Hub

2.5 Design Certification/3rd Party Verification

Third Party Verification was originally carried out on the moorings and structure of Penguin 1 by DNV on 24th January 2012. After modifications to the mooring design a further TPV was undertaken on Penguin 1 on 23rd February 2015 by Longitude Engineering. Subsequently further modifications to the Penguin WEC 1 were carried out and another TPV was undertaken by Orcades Marine in 13th April 2018 scoped to take account of the most recent modifications to Penguin 1. Third Party Verification on Penguin 2 and 3 is yet to be completed.

2.6 Device Location

Location	UTM	Lat and Long
HUB	476494 6539142	58 59.4701'N 003 24.5422'W
WEC 1	476489 6539340	58 59.5775'N 003 24.5787'W
WEC 2	476544 6538806	58 59.2900'N 003 24.4878'W
WEC 3	476060 6539103	58 59.4984'N 003 24.9950'W

Once the Penguin is installed on its moorings the excursion of the WEC even in the worst environmental conditions is designed not to exceed 25 metres radius from the centre point of the mooring spread.

Penguin 1 is marked with a yellow flashing light with characteristics 5s 2nM and yellow St Andrews cross top mark, yellow painting on the hull, and a radar reflector has been added. Penguin 2 and 3 will be marked in a similar fashion, with a different light characteristics.

The mooring spread of Penguin WEC 2 is adjacent to the West boundary of the Billia Croo test site and is in close proximity to the West Cardinal Buoy with the light characteristics VQ(9)10 s

The Billia Croo test site is marked on navigation charts as an area to be avoided.

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EUROPEAN MARINE ENERGY
TIDAL TEST SITE
59°09·0N 2°49·0W
Extensive testing of tidal energy devices, both above and below the surface, takes place in this area. Yellow buoys can temporarily be established near experimental devices to mark work in progress. Mariners should exercise caution whilst navigating in this area and obtain local knowledge.

EUROPEAN MARINE ENERGY
WAVE TEST SITE
58°58·5N 3°23·5W
Mariners should avoid passing within the test area marked by cardinal buoys. Experimental devices, usually marked by yellow buoys and lights with daymarks, are temporarily established in the area. Devices marked by buoys may also be deployed between this area and the coast.

Figure 10 Extract from Admiralty Charts Notes

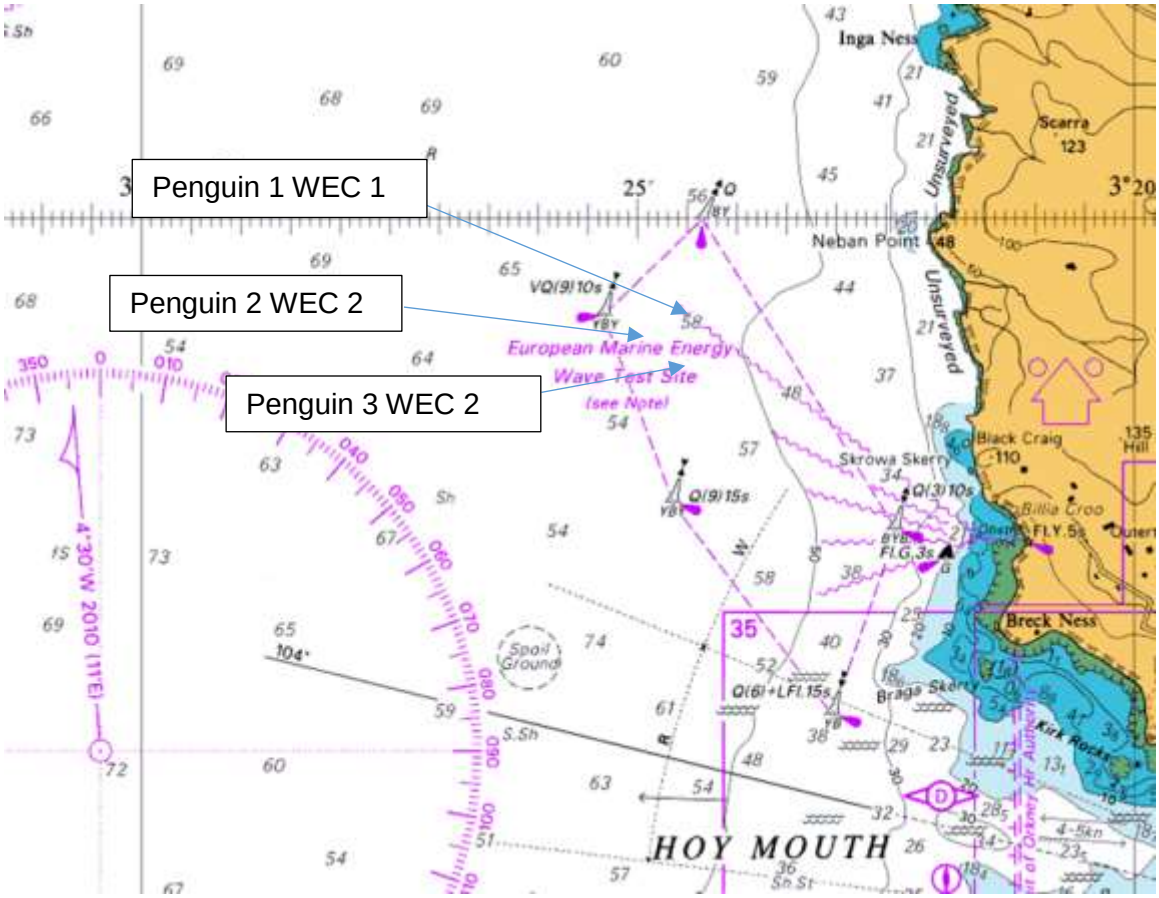

Figure 11 Chartlet of Billia Croo showing location of WEC's

2.6.1 Locational Risk

The danger to surface navigation exists due to the existence of an anchored floating object on the surface and a number of sub-surface buoys and the chain cables (six for each WEC).

The addition of two additional Penguin devices close to the existing Penguin 1, increases the area which will pose a danger to surface navigation.

There is also a high voltage electrical cable running from the WEC to the seabed supported by a sub-surface buoy. The suspended part of the electrical cable lies within the radius of the danger area posed by the WEC and the sub-surface buoys.

There is no increase in number electrical cables to the shore because electricity generated by the three WEC's will feed into the existing cable through a four way junction box.

The proposed installation of two additional WEC's and associated moorings is within the defined EMEC site which is therefore adequately covered by the Billia Croo NRA (*Anatec 2014*) Section 10 Risk Review.

Therefore the device specific risk (or in this case additional risk as a direct result of the addition of two further WEC's) is considered for the following situations:

- Vessels working in the site in connection with the Wello/Fortum project
- Vessels working in the site not involved with the Wello/Fortum project
- SAR vessels entering the site
- Vessels outside of the site due to loss of station of one or more WEC's or floating parts of the mooring system.

3 Phase Specific Information

3.1 Installation

A gravity based anchoring system has been installed and is in use for Penguin 1. Penguin 2 and 3 will have gravity based or drag embedment anchors which will be installed using an anchor handling vessel such as a multi-cat or other vessel. Each anchor will be deployed at predefined locations. Each anchor will be attached to ground chain with a riser and buoyed off.
The anchors will be loaded onto the multicat vessel at Copland's Dock, Stromness. This is the closest harbour facility to the Billia Croo test site. The anchors will be lifted onto the vessel and secured for transit. Once onsite, the anchors will be lowered to the predefined installation location. The anchors will be pre-tensioned during the installation process. The ground chain will then be laid and buoyed off. Only one suitable vessel is required to install the moorings although if deck space is limited multiple trips from the site to the port may be required

Following the installation of the ground chain, lower catenary and buoys, the Penguin will be towed to site and hooked up onto the mooring spread.

This will be achieved in the following stages:

- Phase 1: Tow Penguin device from either Hatston Quay or Lyness Pier to the Billia Croo test site.
- Phase 2: Undertake positioning on site and complete connection to buoys
- Phase 3: Connect to the midline
- Phase 4: Repeat Phase 2 and 3 for all mooring legs
- Phase 5: Electrical hook up

There are likely to be two multi-cats or tugs required to tow and position the Penguin on station while it is being attached to the pre-laid moorings, with support from a small

workboat or RIB for running mooring lines. Details of vessels likely to be used can be found in the Appendix.

Depending on the size of vessel used for the installation of the moorings the installation of one set of moorings for Penguin 2 and Penguin 3 is likely to take less than 3 days.

The attachment of the Penguin's onto pre-laid moorings will take no more than a day for each Penguin.

The marine operations required to connect each Penguin into the EMEC export cable will take approximately 2 days

3.1.1 Risks to Other Users During the Installation Phase

During the installation phase, risk to other users is occasioned by increase traffic transiting to and from the site from Stromness via Hoy Mouth, vessels engaged in towing operations may be restricted in their ability to manoeuvre.

For vessels entering or transiting the site including vessels working within the boundary of the EMEC site the risk of collision with sub surface buoys where the mooring system is only partially installed exists.

The EMEC Standard Operating Procedures for Simultaneous Operations is followed as well as the competent vessel operators' procedures for working in close quarters with other vessels.

3.2 Operation

The expected duration of the operational phase is two years until summer 2020. The WEC is designed so that no on site intervention is required for normal operations.

3.2.1 Planned Maintenance

A rigorous inspection program will be carried out on all the Penguin wave energy devices and their mooring components, on the surface and subsea using Remote Operated Vessel (ROV) underwater inspections which are proposed to take place every second month of their operation.

The device has been designed so that regular maintenance is not required. However, it is anticipated that during testing, maintenance and inspection will be required approximately once a month. This will essentially involve using a RHIB or small workboat to transfer personnel onto the device where maintenance and inspection will be conducted within the hull. Maintenance will only be carried out in calm sea conditions (with a wave height less

than ~1m Hs to ensure safe access to the device), and personnel will be on board for a few hours only with the RHIB in attendance at all times.

3.2.2 Unplanned maintenance

Deploying three wave energy converters for several years will inevitably reveal some need for unscheduled maintenance work. Some of the unscheduled maintenance work will be done on site but certain operations may need to be undertaken alongside in the harbour. Usually this is dependent on the physical size of the component which has to be repaired or replaced. It is therefore envisaged that it may be necessary to retrieve the Penguins from site through the duration of the licence.

Should the device need to undergo major maintenance/repair, the device will be towed to quayside using a multicat vessel or a tug. Once ready for redeployment, the hook up methods will apply. Local mariners and stakeholders will be informed prior to any device towing operations through the normal Notice to Mariners procedure.

3.2.1 Risks to Other Users During the Operations Phase

The risk of collision only exists during the operational phase if:

- Vessels enter the EMEC test site
- The WEC or any associated floating parts of the mooring system come adrift
- Vessels transit to and from the site

Collision with the WEC or sub surface buoys and chains would cause substantial and significant damage to small and medium sized vessels.

The WEC's are buoyant and have a freeboard of around 2 metres, a significant collision by a large vessel into the Penguin rupturing the hull would cause it to sink.

The mooring design has gone through a number of development phases during the life time of Penguin 1, based on operational experience and extensive modelling and analysis. The mooring analysis CEFOW- WPS-D3.1.1 dated 22.12.16 covers the ULS (ultimate limit state) and ALS (accidental limit state – where one mooring is detached in worst case environmental conditions) and it is likely that the risk of complete detachment of the WEC from its moorings is very low.

If however, a buoy or WEC broke free or was loose in calm conditions they would follow the flow of the tide mainly running north south across the site and generally not exceeding 0.5 m/s. Should any floating parts for the system or the WEC break free most likely during strong wind and wave conditions from the westerly semi-circle, they are likely to fetch up to the leeward of the wind direction in which case the most likely scenario would be to

strand on the beach or under the cliffs on the west coast of Orkney, if not intercepted by a vessel beforehand.

There is the possibility that a combination of tidal current and wind could take floating objects in the path of Hoy Mouth, posing a risk of collision to vessels entering Stromness and Scapa Flow.

If the WEC came adrift it would be noted by “sms” text alarm to the duty operations manager. The visual watch on the WEC is enhanced during bad weather conditions.

Providing conditions are not too severe to board the WEC it would be relatively easy to attach to a tow line as there are a number of strong bitts on board that can be used for towing in an emergency.

3.3 Device monitoring systems

Anticipated maintenance and physical inspection frequency is planned to happen on average every second month. During those visits an ROV can be used to check moorings and a visual inspection can be carried out inside the devices. In addition, inspections will be carried out after every severe storm especially during the first years of the project. This will require an ROV support vessel of the type described in the Appendix and the vessel will be on site for approximately 1-3 days every two months

The WEC’s are monitored via the control system, automatic “sms” messages are sent out in the event of cable failure, daily visual position checks are also carried out.

On receipt of an alert the Wello Emergency Response Plan would initiate and depending on the level of response local vessel operators, EMEC, local users, and SAR authorities would be informed, via direct communication and through navigation warnings.

3.4 Removal/Decommissioning

The decommissioning process will be the reverse procedure for the installation and is as follows:

Disconnection of the three WEC umbilical cables from the Four Way Smart Hub. Removal of the Smart hub from the EMEC cable and replacement with an EMEC connector or cap. This operation is expected to last 3- 5 days and will involve one multicat or similar vessel

Disconnection of the Penguin’s from the moorings and tow of each Penguin into port – which would be either Stromness or possibly Lyness on Hoy. Each disconnection and tow to port is expected to take one day and involve a total of two multicats or tugs and a small workboat/RHIB.

It is anticipated that the recovery of all the moorings for the three Penguins will take 6-9 days and involving one multicat or anchor handling vessel.

3.4.1 Risks to Other Users During the Decommissioning Phase

There are no other risks specific to the decommissioning process that have not been identified elsewhere.

4 Search and Rescue (SAR) and Emergency Response

Wello has in place an Emergency Response Plan for Penguin 1 which integrates local information and lines of communication in one document. The competent local contractors that will be contracted by Wello will have their own emergency response plan for their vessels and the area of operation, which would supplement the Wello ERP. These plans shall integrate under the EMEC site wide emergency response procedure.

There are a number of local marine contractors which can supply suitable vessels at short notice if required in an emergency. In addition the Harbour Authority maintains a fleet of three 55 te BP tugs within Orkney waters. There is an Emergency Towing Vessel (ETV) on standby in the Northern Isles between Orkney and Shetland.

4.1 Risks to SAR Surface Navigation

The WEC's are visually apparent and show as a good target on radar. The main risk to SAR craft including local RNLI vessels when entering the site is collision with the sub-surface buoys and cables which may not be readily apparent, hence an important mitigation should the SAR vessels need to enter the site is to provide the SAR authorities and/or contractors with up to date information on the location of subsurface obstructions, so that they can be made aware of the danger areas if required to proceed inside the buoy pattern or close to the WEC's.

5 Consultation

It is considered that there is not a significant increased risk and change to the envelope to which the site wide NRA was based and therefore further stakeholder consultation is not necessary.

6 Risk Assessment

6.1 Risk Review

The additional risks identified through the various phases of the project associated with installing Penguin 2 and Penguin 3 alongside the existing Penguin 1 are summarised below:

1. The WEC's and moorings, present a risk of collision to vessels which inadvertently or deliberately transit or proceed into the EMEC test site despite being charted as an area to be avoided. There is increased risk by the installation of two more WEC's, Penguin 2 and 3, due to increased number of collision targets.

2. The WEC's and moorings, present a risk of collision to vessels which are working on other projects within the EMEC test site. There is increased risk by the installation of two more WEC's, Penguin 2 and 3, due to increased number of collision targets

3. Vessel working on maintenance or intervention (within the buoy pattern) and in close proximity, present the risk of collision or fouling of mooring lines.

4. The further restriction on sea space within the site may give rise to risk of collision between vessels operating on the site.

5. SAR vessels needing to enter the site are exposed to the risk of collision particularly with sub-surface objects.

6.2 Mitigation

Proposed mitigation measures that will reduce the identified additional risks include:

6.2.1 Location

- The array is within the boundary of the Billia Croo test site and close by the west cardinal buoy marking the extremity of the site.

- The colour and lighting of the Penguin 2 and 3 are in line with the regulator's guidance as for Penguin 1.

6.2.2 Installation

- A Notice to Mariners containing full details of the nature, location, start time, and duration will be issued before the installation and decommissioning commences. Local Notice to Mariners will be broadcast to vessels in the proximity by Orkney VTS.

- All activities will comply with EMEC's Standard Operating Procedures and Emergency Response Plan – with particular consideration of Simultaneous Operations on site

- 3rd party verification has been carried on Penguin 1 and will be carried out on Penguin 2 and 3 against mooring and structural failure

6.2.3 Operation

- All activities will comply with EMEC's Standard Operating Procedures and Emergency Response Plan – with particular consideration of Simultaneous Operations on site.

- 3rd party verification has been undertaken on mooring and structural design of Penguin 1.

- Detailed site information will be provided to guide SAR activities if required to enter the site.

- Regular monitoring of position by visual means and automatic alerting.

- Use of competent vessel operators.

- Design of WEC's deck equipment provides ability to rig emergency tow in event of breakaway.

- Good availability of suitable rescue and towing vessels locally.

6.2.4 Decommissioning

As per installation

7 References

Navigation Risk Assessments and Guidance

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Orcades 07.04.17 OP 169 NRA addendum to Aquatera P343 Wello NRA

Maritime and Coastguard Agency, MGN 371 Offshore Renewable Energy Installations (OREIs) - Guidance on UK Navigational Practice, Safety and Emergency Response Issues.

Orcades 25.04.13 OP 021 Rev 2.0 Penguin Emergency Response Plan

EMEC 20.02.12 Marine Operating Guidelines

Design and Third Party Verification Documentation

Longitude 23.02.15 LGK.C192 P277 E022 rev 2.0 TPV Mooring System

Longitude 24.12.15 LGK 001052 CN01 Underdeck Structural analysis

CEFOW-WP3-D3.1.1 22.12.16 Mooring Design Report

Orcades 30.04.18 OP 212_001 Rev1.0 TPV mooring attachments points and underdeck structure

8 Typical Vessels Utilised For Installation Operation and Decommissioning

GREEN MARINE

Specification Sheet

Green Isle – DAMEN MULTI CAT® 2712

GENERAL

YARD NUMBER	571674 / A10058 (Damen Shipyards Hardinxveld)
DELIVERY DATE	Approx. end April 2015
BASIC FUNCTIONS	Anchor handling, dredger service, supply, towing, hose handling and survey
CLASSIFICATION	Bureau Veritas I ✠ Hull • MACH Tug Unrestricted navigation,• AUT-UMS
NAT. AUTHORITIES	MCA CAT 1 Workboat code
FLAG	United Kingdom
OWNER	Green Marine

DIMENSIONS (APPROX.)

LENGTH O.A.	27.70	m
BEAM O.A.	12.45	m
LENGTH LOAD LINE	23.90	m
DEPTH AT SIDE	3.90	m
DRAUGHT (RECONDITION)	± 2.85	m
DISPLACEMENT LIGHT SHIP	405	ton(nr)
GROSS TONNAGE	299	GT
BRITISH TONNAGE	178,8	BT

TANK CAPACITIES (APPROX.)

FUEL OIL	109.5	m^3
FRESH WATER	31.4	m^3
DIRTY OIL	1.5	m^3
SEWAGE	10.5	m^3
SLUDGE	1.3	m^3
HYDR OIL	2.2	m^3
LUB OIL	1.7	m^3
BILGE WATER	4.0	m^3
PW TANKS	51.8	m^3

PERFORMANCES (APPROX.)

BOLLARD PULL (AVERAGE)	33.0	ton(nr)
SPEED	10.0	knots

PROPULSION SYSTEM

MAIN ENGINES	2x Cat C32 TTA ACERT
TOTAL POWER	1790 bkW at 1800 rpm
GEARBOXES	2x Reintjes WAF 572L 7.091 : 1
PROPULSION	2x fixed pitch propellers in Optima nozzles, 1900 mm
BOWTHRUSTER	Kaliman Berta 250H, 200pk / 184kW Hydraulic driven

AUXILIARY EQUIPMENT

GENERATOR SETS	2x Cat C 04.4, 107 kVA each
HYDRAULIC POWER	Cat C12 TA, 339 kW 1800rpm
FUEL OIL SEPERATOR	Facet MV-11-AG

DECK LAY-OUT

ANCHOR	2x 300 kg Pool TW (HHP)
ANCHOR WINCH	1x Hydraulically driven, Krasjeveld
DECK CRANES	1x HS Marine AKC290 LHE3 11,3T @ 16.5m 1x HS Marine AKC185 HE4 6,44T @ 17,07m
ANCHOR HANDLING WINCH	1x single drum
CAPACITIES	100 ton@ 2,5m/min pulling force 1st layer 120 ton brake holding force 1st layer
TOWING WINCH	1x single drum
CAPACITIES	50 ton@ 6.8m/min pulling force 1st layer 90 ton brake holding force 1st layer
TOWING PINS FRONT	1x WK double pin type with chain stopper
TOWING PINS AFT	1x WK triple pin type in line
TUGGER WINCH	1x Dromec HPV 12000, 15T pull, SB aft
TUGGER WINCH	2x Northsea Winch CW5190, 11T pull, PS aft en SB front

ACCOMMODATION

Comfortable heated and air-conditioned accommodation for 7 persons in 5 cabins, galley, sanitary facilities, etc. Two double cabins and three single cabins.

NAUTICAL AND COMMUNICATION EQUIPMENT GMDSS AREA 3

SEARCH LIGHTS	2x Peach 2000 W
RADAR SYSTEM	1x Furuno, FAR 2117
RADAR SYSTEM	1x Furuno, FAR 8062
COMPASS	1x Cassens & Plat, Reflecta 1
GYRO COMPASS	1x Anshvetz, Standard 22
AUTOPILOT	1x Sea pilot 75
GPS	1x Furuno, GP-150 D
ECHOSOUNDER	1x Furuno, FE-700
SPEEDLOG	1x Furuno, DS-80
AIS	1x Furuno, FA-150
INTERCOM	Sigma-700
VHF	2x Sailor, RT6222, with DSC
HANDHELD VHF	3x TR 20
SSB	1x Furuno, FS-1570
INMARSAT - C	2x TT-3000E
NAVTEX	1x Furuno, NX-700
WATCH ALARM	1x Marlink, 421
ENTERTAINMENT SYSTEM	1x Seatel ST 24
FLEET SYSTEM	1x Fleet broadband FBB150
WIND INDICATOR	1x Obermat OMC 115
CHART PLOTTER	1x Transas NS 4000

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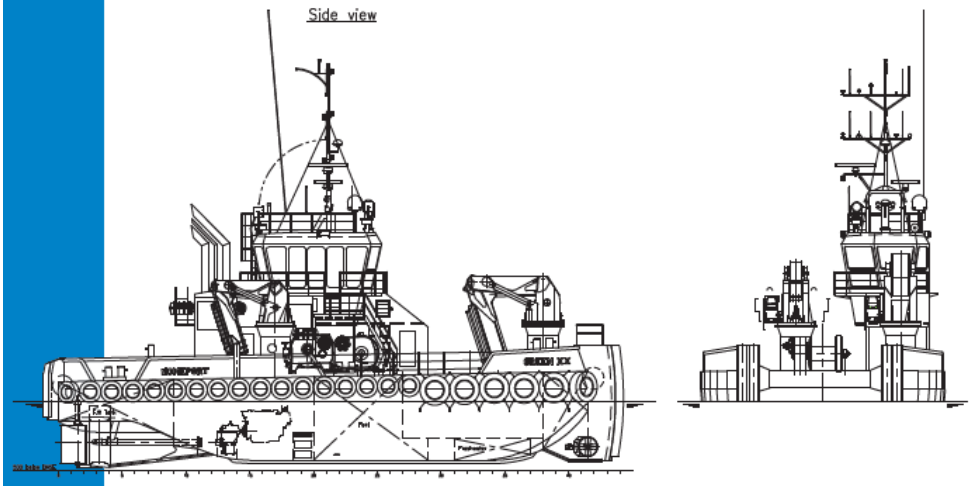
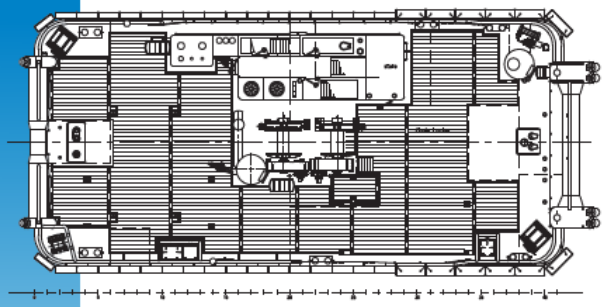
Specification Sheet

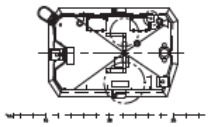
Side view



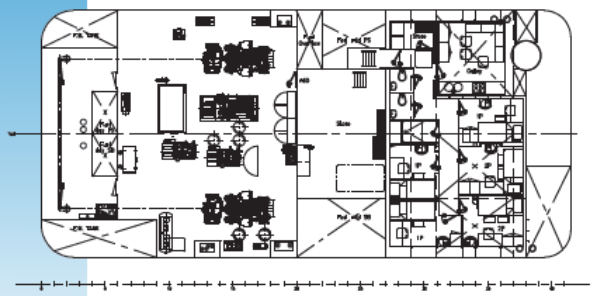
Main deck



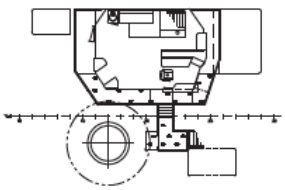
Top deck



Below main deck



Wheelhouse deck
7550 above base



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ARCADES MARINE
Management Consultants Ltd

GREEN MARINE

Specification Sheet

Green Chief – DAMEN Stan Tug 2608

Multi Purpose Tug / Workboat
Call sign - 2CRL5

Built 1980 | Rebuilt 2009
MMSI – 235.075.142

General

Type of vessel	: Damen Stan tug 2608
Builder	: Damen Shipyards – Yard No. 3113
Basic Functions	: Anchor handling, dredger service
	Towing, hose handling, survey
	Ship assist, supply
Classification	: Lloyds tug +100A1
	: Unrestricted navigation
	: Workboat Code Cat 1
	: MCA approved
	: 160 miles from shore

Dimensions

Length o.a.	: 26.00 m
Beam	: 7.80 m
Depth at sides	: 4.05 m
Draft	: 3.00 m

Supply Tanks

Fuel oil	: 82.60m^3 – Transfer 12m^3/hour
Fresh Water	: 17.80m^3

Performances

Bollard Pull	: 26 tons
Speed	: 12.4 knots

Propulsion System

Main Engines	: 2 x Caterpillar type D399
Total power	: 1678 bkW at 1250 Rpm
Gearboxes	: 2 x Reintjes 3.95:1
Propulsion	: 2 x fixed pitch propellers in nozzles
Rudders	: 2 x steering rudders
	: 4 x flanking rudders

Auxiliary Systems

Generator sets	: 2 x Cummins 6BT 80kVa
Hydraulic Engine	: Detroit DDA type 6-71N

Deck lay-out

Deck crane	: BS3004 30t/m 15t@1.85m, 2.2t@12.44m
Towing winch	: 35 ton pull, 90t brake, 700m x 44mm wire
Drum end	: 2 ton
Tugger winch	: 13 ton, 100m x 22mm wire
Capstan (Fwd)	: 2 ton
Free deck space	: 44.6m^2
Tow hook	: Mampaey 35ton
Stern roller	: 1.9 m
Stern opening	: 4.8 m
Push knee	: At bow

Accommodation

Comfortable heated and air-conditioned accommodation
For 8 persons in 5 cabins, galley, sanitary facilities etc

Navigation & Communication

Radar system	: 1 x Furuno FR-8252
	: 1 x Furuno 1715
Compass	: Observator Pilot II
Satellite Compass	: Furuno SC-50
Echosounder	: Furuno LS-4100
GPS	: Furuno GP150
Chart plotter	: Transas Navisailor
	: Seiwa Oyster
Autopilot	: Furuno NAVpilot-500
VHF	: Icom IC-M422
	: Icom IC-M411
	: Icom IC-M302 (DSC)
VHF handheld	: 2 x Icom GM1600 GMDSS compliant
	: 2 x Icom M32 working sets
Navtex	: Furuno NX-700A
AIS	: Transas M-2 Class A

GSM cellphone, email & internet (coastal)

Additionally Fitted

Plough & stern A-frame for seabed levelling/dredging

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GREEN MARINE

Specification Sheet

Green Quest – 18m MCA Cat 2

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RCADES MARINE
Management Consultants Ltd

GREEN MARINE

Specification Sheet

Green Quest

18m MCA CAT 2 Wind Farm Support Vessel

PERFORMANCE	
MAX SPEED	27 knots
SERVICE SPEED	22 knots

DIMENSIONS AND CAPACITIES	
LENGTH O.A.	17.8 m
BEAM O.A.	6.4 m
DRAUGHT	1.5 m
CARGO DECK AREA FWD	24 m2
CARGO DECK AREA AFT	14 m2
CARGO LOAD FWD	2.5 tons
CARGO LOAD AFT	2.5 tons
MAX DECK LOAD	1.5 t/m2
FUEL OIL	5 m3
FRESH WATER	0.78 m3
BLACK WATER	0.25 m3

DECK LAYOUT	
CRANE	Bonfiglioni, 470Kg@6.35m
MOUNTS	Multiple 5-Ton Lashing Points
FUEL TRANSFER	100 l/h 15m
PRESSURE WASHER	VEGA Psi 35-5000
FENDERING	Rubber D with Nipple

WELFARE	
SEATS	KAB 500
DECK HOUSE	12 seats, wet gear room, galley and heads
CABINS	Cabins for 4
HEATING	Webasto Thermo 90ST
ENTERTAINMENT	LCD TV, DVD, Radio, Internet

SAFETY EQUIPMENT	
SART	Tron SART 20
EPIRB	McMurdo Smartfind C1 406 MHz
LIFE RAFTS	2 x 8 persons
MOB	Waterlevel Platforms
SAR FINDER	TAIYO TD-L 1550
HANDHELD VHF	2 x ICOM M35
SEARCHLIGHT	Jabsco 135SL
ENGINE ROOM FIRE SYSTEM	Firepro Stat-X

MAIN ENGINES	
MAKE	CAT
TYPE	2 x C18
MAX POWER	1746 bhp (1300kw)

GEARBOXES	
MAKE	Twin Disc
MODEL	2 x MGX5145R

PROPULSION	
TYPE	Fixed Pitch Prop

GENERATOR	
ELECTRICAL SYSTEM	24v, 230v shore and generator
MAKE	Cummins Onan
TYPE	MDKBN (Spec A)
OUTPUT	11kw

ELECTRONICS	
MAIN RADAR	Raymarine RD424HD 24" 4Kw Radome
SECOND RADAR	Raymarine RD418HD 18" 4Kw Radome
ECDIS	Raymarine C140W + Raymarine A70D
NAVTEX	Furuno NX300
GPS	Raymarine Raystar 125
SATELLITE COMPASS	Raystar 125
ANEMOMETER	Maretron DSM250
ECHO SOUNDER	Raymarine DSM300
AUTO PILOT	Raymarine ST6002
AIS	Jotron TRT-2500
VHF	ICOM IC-M505 + ICOM M411
HAILER	Eagle 30watts
CCTV	Raymarine CAM100, IM-ENC-02
BROADBAND	3G Wireless Hub

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LEASK MARINE

MV Uskmoor

Specifications

General

Type of vessel	Workboat
Year built	1984
Category	MCA Cat 2 Up to 60 miles (from safe haven)
Passengers	14
Flag state	UK
Port of registry	Kirkwall
Official Number	705438
Call Sign	MDEF2

Basic Functions

Marine support vessel
Dive support vessel
Commuter

Dimensions

Length	16m
Beam	5.5m
Draught	1.5m
Gross tonnage	40.31gt

Deck Equipment

Hydraulic Stern Gantry certificated at 4 tonnes
2 tonne Hydraulic Deck Winch
2no. 2 tonn capstan winches
Hiab Crane XS 1222-2 lifting 3800kg at 2.8m/1280kg at 8.2m

Facilities

Spacious galley and day cabin
Webasto diesel heating system

Generator

1 off 9 KVA Generator
1no. 10m³ Compressor

Propulsion System

Main engines	2 x Doosan 200bhp
Propellers	Twin fixed in nozzles
Speed	9 knots

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LEASK MARINE

MV C-FENNA

Specifications

General

Type of vessel	Neptune Eurocarrier 2611
Year built	January 2013
Category	MCA Cat 1
	(Up to 150miles (from safe haven)
Passengers	12 (plus 3 crew)
Flag state	UK
Port of registry	Kirkwall
Classification	B.V.
Official Number	922340
IMO	9675963
Call Sign	MBAH3
MMSI	232008023

Dimensions

Overall Length	26.48m
LPP	23.65m
Beam	11m
Depth	3.5m
Draught	2.61m
Freeboard	847mm
Free Deck Space	145m²
Maximum Deck load 100te (6t/m²)	
Gross tonnage	160.78t
Net Tonnage	78t

Tank Capabilities

Fuel Oil	100m³
Fresh Water	40m³
Lub Oil	5.7m³
Hydraulic Oil	1.9m³
Dirty oil	2m³
Gearbox oil	1.9m³
Bilge Water	6m³
Ballast	34m³
Sewage	4m³

Propulsion System

Main engines	2 x Cummins QSK38-M
Total Output	2 x 1400 bhp at 1800 opm
Gearboxes	Reintjes WAF 364L 4.92:1
Propulsion	2xF.P. Ø 1630mm

Bow Thruster

360° 280kw

Auxiliary Equipment

Generator Sets	Caterpillar C9, 2 x 200KW, 250 kVA
Fuel Oil Separator	Westfalia 1740, L/H, OTC-3-02-137

Deck Equipment

Deck Cranes - FWD Hella HLRM 230-4SL, Fixed hook SWL 10.3te at 16.5m winch SWL
- AFT Hella HLRM 140-3S, Fixed hook SWL 10te at 12.17m winch SWL

Winches
- 1 x Anchor Handling Winch 100te
- 1 x Towing Winch 50te
- 4 x Tugger Winches 15te (Fwd Port, Fwd Stbd, Aft Port, Aft Stbd)

Towing Hook	1 x Mampaey 30te SWL
Towing pins	2 x Hydraulic + wire catcher
Anchor	2 x 265kgs
Chain	110m x 17.5mm
Anchor winch	1 x 17.5mm hydraulic heeling motor 140bar-60 ltr./min
Bow roller	6m

Performance

Speed	10 knots
Bollard Pull	35.6 ton

Accommodation

Heated and air-conditioned living spaces for 10 persons, consisting of 5 double crew cabins, a galley and mess and sanitary facilities.

Nautical Equipment

1 x X-band ATA Radar + ARPA, JRC type JMA-5212
2 x VHF radio telephones THRANE & THRANE type SAILOR RT 6222
1 x MF/HF radio telephone THRANE & THRANE type SAILOR 6300
2 x INMARSAT-C satellite communication systems THRANE & THRANE type SAILOR 6110
1 x Echosounder JRC type JFE-380/25
1 x Universal AIS JRC type JHS-182
1 x Auto Pilot ALPHASEAPILOT MFA
1 x Navtex JRC type NCR-333
1 x Satellite Compass JRC type JLR-21
1 x Magnetic Compass CASSENS & PLATH
1 x DGPS global positioning system JRC type JLR-7800
1 x EPIRB, MCMURDO type E5
1 x SART, MCMURDO type S4
1 x Speed log JRC type JLN-205
1 x GSM/UMTS system
1 x Bridge Navigational watch alarm system ALPHATRON

2 x portable VHF Radiotelephones GMDSS SAILOR type SP3520

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LEASK MARINE

MV C-Odyssey

Specifications

General

Type of vessel	Multiworker Twenty6
Year built	2011
Category	MCA Cat 1 Up to 150 miles (from safe haven)
Passengers	12 plus crew
Flag state	UK
Port of registry	Kirkwall
MMSI No.	235088132
IMO No.	9636307
Call Sign	2ETW7
Official Number	917987

Dimensions

Length	26m
Beam	10.5m
Depth	3.5m
Draught	2.5m
Air draught – mast up	13.9m
Air draught – mast down	8.2m
Gross tonnage	150t
Free Deck Space	120m²

Deck Equipment

Towing winch		80 t
Anchor handling (Combined lift)		60 t 120 t
Tugger winch	3 x	15 t
Towing hook	SWL	25 t
Capstan		5 t
Bow roller	5m SWL	120 t
Aft roller	3m SWL	60 t
Deck carrying capacity		100 t
Deck crane	His 185t/m 5530kg @	18.5m
Deck crane (aft)	His 60t/m 4630kg @	10m

Hydraulics towing pins/stopper

Pins	
SWL	50 t
Design load	105 t
Hub	400 mm
Stopper	
SWL	75 t
Design load	150 t
Hub	400 mm

Tank Capabilities

Fuel/oil	100m³
Black/grey water	9m³
Fresh water	45m³
Dirty oil	0.9m³
Ballast water	88m³

Accommodation

Cabins	2 off twin berth 2 off single berth

Large mess room
Galley and laundry

Generators

1 off 78 KVA
1 off 35 KVA
K.W. 1790

Propulsion System

Main engines	2 x caterpillar C32
Total power	2,400bhp at 1,800 rpm
Propulsion	2x fixed pitch propellers Nozzles 1,500mm

Performance

Bollard pull	27 t
Speed	10 knots

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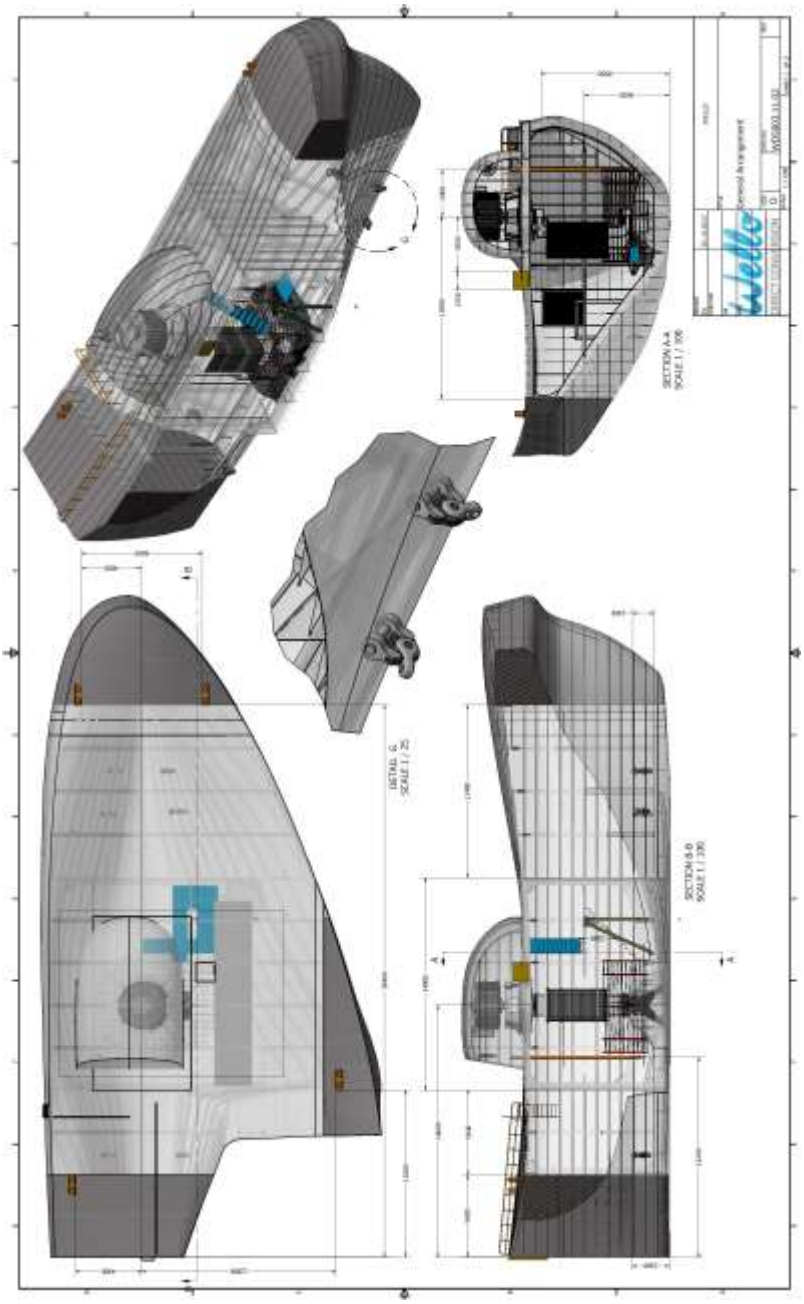
9 General Arrangement of WEC 2 Penguin 2 and 3



10 Risk Register

10.1 Risk Matrix

	CONSEQUENCE				
Descriptive Word	**Minor**	**Significant**	**Moderate**	**Major**	**Catasrophic**
Hazard Severity	**1**	**2**	**3**	**4**	**5**
Actual/Potential Illness or Injury	Single First Aid	Medical attention or multiple first	LTI or multiple medical attention	Single Fatality	Multiple fatality
Environmental	Limited harm to the environment	Limited harm to the environment	Potential harm to employees and environment	Potential harm to employees and environment	Harms public, employees, and environment. Widespread concern of companies operations.
Cost of loss	<10,000	>10,000	>50,000	>250,000	>1m
LIKELIHOOD					
Very Unlikely	**1**	**2**	**3**	**4**	**5**
Unlikely	**2**	**4**	**6**	**8**	**10**
Possible	**3**	**6**	**9**	**12**	**15**
Quite Likely	**4**	**8**	**12**	**16**	**20**
Certain or very likely	**5**	**10**	**15**	**20**	**25**

10.2 Risk Register

Task	Hazards	Risks	Consequence	Existing Prevention Measures	Existing recovery/emergency response measurements	Frequency	Severity	Initial Risk	Additional Prevention Measures	Additional recovery, emergency response	Frequency	Severity	Residual Risk
Installation - transitting to and from site	WEC under tow Vessels restricted in their ability to manoeuvre.	Collision	Fatality Injury Loss/Damage of Equipment	Follow vessels SMS and operating procedures for the safety of navigation under tow. EMEC Standard Operating Procedures COLREGS Use of competent Vessel Operators.	Vessels Emergency Response Procedures EMEC Emergency Response Procedures Project Specific Emergency Response Plan	2	5	10	A Notice to Mariners containing full details of the nature, location, start time, and Local Notice to Mariners will be broadcast on Channel 11.	Use of near-by vessels Coastguard Emergency Services	2	4	8
Installation - working within the boundary of the EMEC Site	Working within the boudaries of the test site.	Collision Collision with subsurface buoys where the mooring system is only partially installed. Entanglement with live HV cables	Fatality Injury Loss/Damage of Equipment	Follow vessels SMS EMEC Standard Operating Procedures COLREGS Use of competent Vessel Operators. Design of WECs deck equipment provides ability to rig emergnecy tow in event of breakaway.	Vessels Emergency Response Procedures EMEC Emergency Response Procedures Project Specific Emergency Response Plan	3	4	12	A Notice to Mariners containing full details of the nature, location, start time, and Local Notice to Mariners will be broadcast on Channel 11.	Use of near-by vessels Coastguard Emergency Services	2	4	8
Operation - planned maintenance	Transfer vessel working inside EMEC site Transfer or personnel and ROV Operations within site causing the vessels to become restricted in	Collision if other vessels enter site Collision if WEC or any associated parts of the mooring system come adrift	Fatality Injury Loss/Damage of Equipment	COLREGS EMEC Standard Operating Procedures 3rd Party Verification has been carried out on Penguin 1 and will be carried out on Penguin 2 and 3 against mooring and structural failure Design of WECs deck equipment provides	Vessels Emergency Response Procedures EMEC Emergency Response Procedures Project Specific Emergency Response Plan	3	4	12	A Notice to Mariners containing full details of the nature, location, start time, and Local Notice to Mariners will be broadcast on Channel 11.	Use of near-by vessels Coastguard Emergency Services	2	4	8
Operation - unplanned maintenance	Transfer vessel working inside EMEC site Transfer or personnel and ROV Operations within site causing the vessels to become restricted in their ability to manoeuvre.	Collision if other vessels enter site Collision if WEC or any associated parts of the mooring system come adrift Collision when vessels transit to and from site	Fatality Injury Loss/Damage of Equipment	Follow vessels SMS and Operating Procedures. EMEC Standard Operating Procedures. 3rd Party Verification has been carried out on Penguin 1 and will be carried out on Penguin 2 and 3 against mooring and structural failure	Vessels Emergency Response Procedures EMEC Emergency Response Procedures Project Specific Emergency Response Plan	3	4	12	A Notice to Mariners containing full details of the nature, location, start time, and Local Notice to Mariners will be broadcast on Channel 11.	Use of near-by vessels Coastguard Emergency Services	2	4	8

Operations	WEC or floating object breakaway from moorings	Collision with vessels outside of EMEC site boudary	Fatality Injury Loss/Damage of Equipment	Extensive analysis and evolutionary design of mooring system. Third party verification undertaken on Penguin 1	Vessels Emergency Response Procedures EMEC Emergency Response Procedures Project Specific Emergency Response Plan Auto text alerting Heightened vigilence during poor weather	2	4	8	Thirdv Party Verification to be carried out on Penguin 2 and 3	Use of near-by vessels Coastguard Emergency Services	2	4	8
Operation - unplanned maintenance - major repair	Device towed back to to the quayside (note: hazards will be the same as installation and	Risk will be as per installation and decommisioning	Fatality Injury Loss/Damage of Equipment	Follow vessels SMS and operating procedures for the safety of navigation under tow. EMEC Standard Operating Procedures	Vessels Emergency Response Procedures EMEC Emergency Response Procedures	2	5	10	A Notice to Mariners containing full details of the nature, location, start time, and Local Notice to	Use of near-by vessels Coastguard Emergency	2	4	8
De-commissioning - working within the boundary of the EMEC Site	Working within the boundaries of the EMEC test site.	Collision Collision with subsurface buoys where the mooring system is only partially installed.	Fatality Injury Loss/Damage of Equipment	Follow vessels SMS EMEC Standard Operating Procedures COLREGS	Vessels Emergency Response Procedures EMEC Emergency Response Procedures Project Specific Emergency Response Plan	3	4	12	A Notice to Mariners containing full details of the nature, location, start time, and Local Notice to Mariners will be broadcast on Channel 11.	Use of near-by vessels Coastguard Emergency Services	2	4	8
De-commisioning - transitting to and from site	WEC under tow Vessels restricted in their ability to manoeuvre.	Collision	Fatality Injury Loss/Damage of Equipment	Follow vessels SMS and operating procedures for the safety of navigation under tow. EMEC Standard Operating Procedures COLREGS	Vessels Emergency Response Procedures EMEC Emergency Response Procedures Project Specific Emergency Response Plan	3	4	12	A Notice to Mariners containing full details of the nature, location, start time, and Local Notice to Mariners will be broadcast on Channel 11.	Use of near-by vessels Coastguard Emergency Services	2	4	8
Throughout phases	Vessels engaged in SAR requiring access to site	Collision with WEC or other vessel	Fatality Injury Loss/Damage of Equipment	Detailed site information will be provide to guide SAR activities if required to enter the site.	EMEC Emergency Response Procedures Project Specific Emergency Response Procedures.	3	4	12	None	Use of near-by vessels Coastguard Emergency Services	2	4	8