Technical University of Denmark

Viability Strategy for the Deployment and Exploitation of Multiuse Marine Platforms

Modular multi-use deep water offshore platform harnessing and servicing Mediterranean, subtropical and tropical marine and maritime resources. Deliverable 5.6

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D5.6 Viability Strategy for the Deployment and Exploitation of Multi-use Marine Platforms

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Abstract

This report presents the Deliverable 5.6 – Viability Strategy with the purpose to analyse the integration of the different TEAL service modules (Transport, Energy, Aquaculture and Leisure) in order to identify the synergies and commonalities arising in the whole system. Considering earlier deliverables of the TROPOS project (D5.2 - An assessment of the economic impact on local and regional economies of the large scale development, D5.3 - Technology pricing of multi-use marine platforms, D5.4 - Lifecycle assessment of multi-use marine platforms, D5.5 - Supporting infrastructure, supply chains and logistics for the deployment of multi-use marine platforms, D6.1 - Report describing a framework for the environmental and socio-economic study and D6.2 - Report on environmental impact assessment and mitigation strategies), the viability of the three ICS concepts, Leisure Island, Green and Blue and Sustainable Service Hub, is assessed based on hard infrastructure such as ports and vessels, soft infrastructure such as legislation and personnel and training, the private economic viability, the macro-economic impacts and environmental effects.

The analysis have resulted in a list of recommendations to ensure the viability of the three TROPOS ICS concepts with respect to hard infrastructure and soft infrastructure including environmental aspects and finance.

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1 INTRODUCTION TO THE TROPOS PROJECT

The TROPOS Project (Modular Multi-use Deep Water Offshore Platform Harnessing and Servicing Mediterranean, Subtropical and Tropical Marine and Maritime Resources) is an EU FP7 (The Ocean of Tomorrow) funded collaborative project revolving around the offshore sector. The TROPOS project's main objective is to develop a floating modular multi-use platform system for use in deep waters, with an initial geographic focus on the Mediterranean, Sub-Tropical and North Temperate zones, but designed to be flexible enough so as to not be limited in geographic scope.

The main hypothesis is that the multi-use platform (and the development of it) will be beneficial to the European society and to stakeholders investing in the TROPOS concept in the long run and potentially also in the short and medium time scale. By developing a modular and multi-use platform it is expected that there will be great synergies and an overall reduced development and operation cost compared to a distinctive development by each of the four different industries targeted in the TROPOS project.

1.1 TROPOS Background

The TROPOS project is funded by the FP7 program The Ocean of Tomorrow program alongside the Mermaid project (www.mermaidproject.eu) and the H2Ocean project (www.h2ocean-project.eu). All three projects have the purpose to explore the possibilities of future utilisation of the oceans. Furthermore, the TROPOS project develops upon two earlier EU FP7 research projects: ORECCA (www.orecca.eu) and MARINA platform (www.marina-platform.info), among others. The goals of the ORECCA project (Off-shore Renewable Energy Conversion platforms – Coordination Action) were to create a framework for knowledge sharing and to develop a roadmap for research activities in the context of offshore renewable energy. The goals of MARINA a were to establish a set of equitable and transparent criteria for the evaluation of multi-purpose platforms for marine renewable energy (MRE). Using these criteria, the MARINA project produced the whole system set of design and optimisation tools addressing, inter alia, new platform design, component engineering, risk assessment, spatial planning, platform-related grid connection concepts, all focussed on system integration and reducing costs. With this background the TROPOS project was initiated and to ensure a continuous and complementary development of the projects leading key persons are represented across the projects.

1.2 Objectives of the TROPOS Viability Strategy

The aim of the TROPOS viability strategy is to enhance and enable a realisation of the TROPOS project with respect to the infrastructure and economic aspects of multi-use floating offshore platforms.
The objective of the viability strategy is to develop a set of recommendations that can enable policy decision makers to implement policies that will ensure the further development and success of the TROPOS concepts.

1.3 Method for Developing the TROPOS Viability Strategy

The recommendations will be developed based on the following stepwise approach (steps 1-4 are undertaken by other WPs in TROPOS, e.g. TROPOS WP5 D5.5 and WP6 D.6.2)[1]:

[1] Not all of these steps will be explicit in the report, since the main focus is on the recommendations as instructed by key-stakeholders in the TROPOS project.

1) Study and description of the current state of A) hard infrastructure[2], B) soft infrastructure[3], and C) finance[4] – all with regard to fairly similar offshore concepts to what has been defined in the TROPOS application.
2) The Interdisciplinary Cohesion Subcommittee (ICS) has defined the future desired and more detailed concepts of TROPOS.
3) Analysis of what is necessary within A, B and C to achieve the concepts of TROPOS defined by ICS.
4) An analysis of the differences between the current state within A, B and C and what is necessary to achieve the TROPOS concepts will result in an identification of gap (and/or "no-gaps").
5) The identified gaps (and/or "no-gaps") will lead to a set of recommendations (necessary changes) to ensure the success of TROPOS. These set of recommendations will target policy makers at the EU and Member State level.

Since there are no formal rules on how to conduct a viability strategy, the business strategy literature was used as a guide since it seems to have the same underpinning ideas as what has been expressed by the key stakeholders of the TROPOS project. To deliver a trustworthy viability strategy it is necessary to demonstrate that the viability strategy has been based on a rigor and well-tested methodology. The PESTEL (Political, Economic, Social, Technological, Environmental, and Legal) framework (Johnson et al. 2005) found in the business strategy literature is a well-tested methodology used for developing business strategies. The PESTEL framework will be used here as a guideline in developing the TROPOS viability strategy. Based on the information gathered in the different ELI (Economic, Lifecycle, and Infrastructure) reports and inspired by the PESTEL analysis the TROPOS viability strategy focuses on the areas mentioned above (Hard infrastructure, Soft infrastructure, and Finance).

1.4 Target Audience of the TROPOS Viability Strategy

The principal target audience of the recommendations set out in the report are policy makers at the EU and Member State level. However, the recommendations are also of high importance for other stakeholders in the offshore sector (aquaculture and offshore wind energy and others).

1.5 Scope of the TROPOS Viability Strategy

The TROPOS viability strategy is a sub-strategy which will feed into the TROPOS overall deployment strategy (TROPOS D5.8) as well as another sub-stragety related to technical aspects . Figure 1-1 illustrates how the TROPOS viability strategy and TROPOS technical strategy interact and lead to the overall TROPOS deployment strategy.

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[2] The Hard Infrastructure section covers mainly means of transport (vessels), and ports, shipyards, docks (manufacturing and maintenance for the offshore platform) and electric grid.

[3] In the Soft Infrastructure section the focus will be on legislation and regulation, personnel and training and environmental aspects.

[4] The Finance section focus on what economical support mechanisms there can be used in the three different ICS concepts.

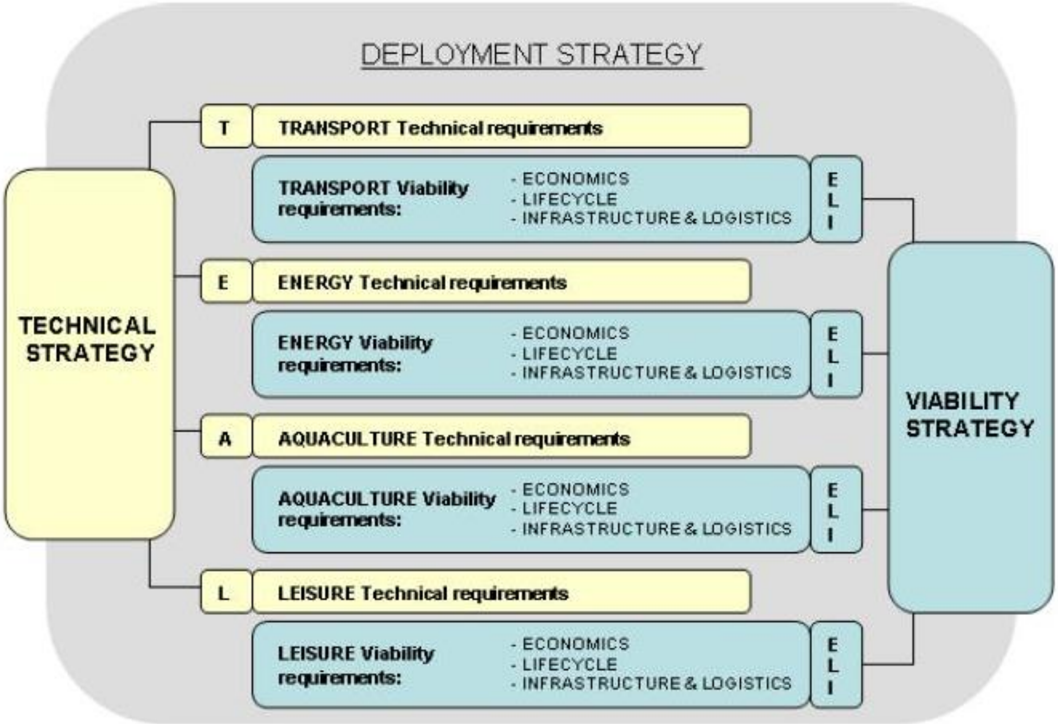

Figure 1-1 TROPOS Overall Deployment Strategy plan (taken from TROPOS D5.1 (2012), p. 23 Landscaping and Methodology for Overall Deployment Strategy)

1.6 Structure of the Report

The report is structured as follows: Chapter 2 presents the four service modules – Transport, Energy, Aquaculture and Leisure – also referred to as the TEAL components, and presents the tree TROPOS ICS concepts: Leisure Island ICS Concept, Green and Blue ICS Concept and Sustainable Service Hub ICS Concept. In Chapter 3 the existing hard infrastructure and the requirements for it are analysed both regarding ports and vessels as well as related facilities. Chapter 4 deals with soft infrastructure and identifies the gaps within legislation and regulation, personnel and training as well as assessment and mitigation of environmental impacts. In Chapter 5 the needs and arguments for financial support for the three ICS concepts are analysed and recommendations regarding support mechanisms are presented. In Chapter 6 the synergies of the recommendations given on hard and soft infrastructure as well as financial support are highlighted for the three ICS concepts. In Chapter 7 the recommendations for the three ICS concepts are summarised, and finally Chapter 8 discusses the risk and uncertainties related to the viability strategy as well as the three ICS concepts.

2 MULTI-USE PLATFORM (MUP)

The Multi-Use Platforms (MUPs) are the base for deploying multi-purpose services. The workers are living on the MUP, hence the infrastructure on the platform is both for living and working. This idea is not new, since oil rig platforms have been used in this way for more than 50 years. Therefore, there are many similarities between MUP and present oil rig platforms. Floating platforms have been working both offshore (oil rigs) and near shore (e.g. the platform at Marina bay in Singapore), see Figure 2-1. In the TROPOS project the platform will be the central unit for each concept.

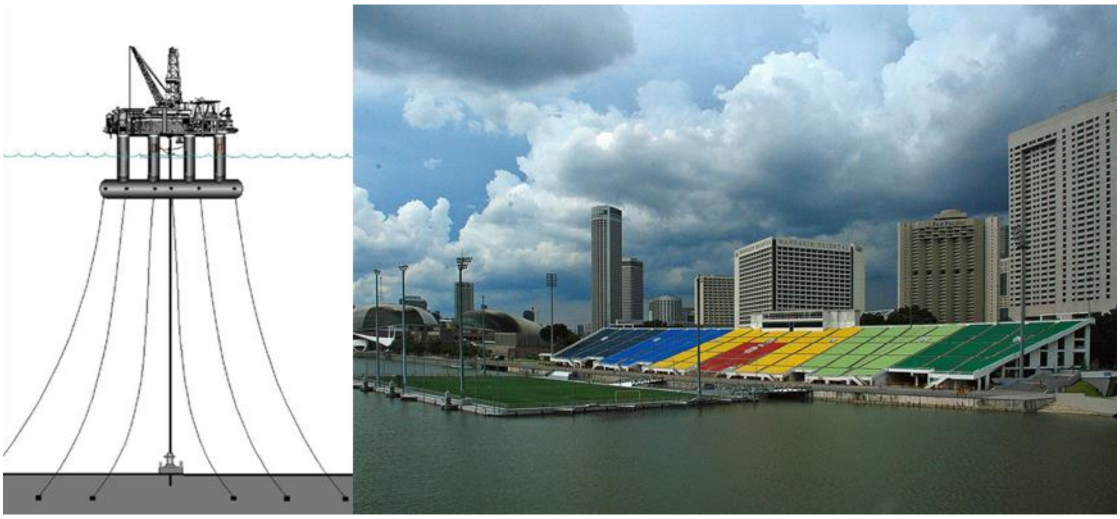

Figure 2-1 A conceptualconcept drawing of a semi-floating oil rig (to the left) and the floating platform (football pitch) in Singapore (to the (right)

The following sections will describe the TEAL concepts in more detail.

2.1.1 ***Transport (T)***

The first TROPOS transportation concept was based on the transport sector as a container terminal, because the limiting factor to the growth of the vessel is the limitation in the sizing of ports (TROPOS D5.3 2014, p. 10). During the TROPOS investigation it has been proven that a floating container terminal would have difficulties of being economically viable (TROPOS D5.3 2014). Hence, the concept has been re-evaluated and changed.

The transportation of personnel and good to and from the platform is the main purpose of vessels in a MUP. However, there are other operations, such as mooring, that require different vessels. For this reason, in the latest TROPOS transportation concept the transport will not be a single sector of the platform, but it will support the deployment of other sectors which are present. The transport sector will be a part of the hard infrastructure in each concept and it will be analysed in section 3 "Hard Infrastructure".

On the MUP, there is a need for infrastructure such as mooring. This is required to support the operation of the different vessels, which are needed for the specific TEAL on the platform in each ICS concept. The vessels will in general have the purpose to transport personnel and goods towards the platform and waste from the platform to shore, since it is not legal to dump waste into the water depending on the kind of waste and the location (protected vs unprotected areas, distance to shore, etc.) (TROPOS ICS concepts - 2014).

2.1.2 *Energy (E)*

The energy supply in TROPOS will use renewable energy technologies; the main focus will be on technologies which have been proven to be effective. Several technologies have been investigated, some of which, e.g. wave and OTEC (Ocean Thermal Energy Conversion technology), resulted in not being chosen for the final ICS concepts (but included in some other scenarios, considered as future concepts). The final ICS concepts included wind turbines and PV cells. These will be used on floating satellite stations where synergies can be exploited, such as shared mooring lines and grid connections. The wind turbines will have innovative concepts such as floating foundations, because of the high depth at the locations for the TROPOS platform.

2.1.3 *Aquaculture (A)*

As the population grows, there is an expected increase in demand for fish. The Food and Agriculture Organization of the UN (FAO; www.fao.org) expects that in 2030 the population of the world will have exceeded 8 billion, resulting in an expected extra demand of 29 million tonnes of fish which is expected to be produced by the aquaculture (fish) industry (TROPOS D5.1 2012, p. 30). Traditionally, aquaculture facilities are placed near shore. However, when production increases, finding near-shore locations can become an issue, since developments there can put a substantial pressure on near-shore ecosystems. There are several factors which must be taken into account while considering offshore aquaculture, e.g. the wave height, the depth of the water and the distance to a harbour (TROPOS D2.3 2013, p. 43). Since the aquaculture moves from near-shore to offshore, there is a need for R&D supportin order to make the technologies for offshore environment ready (TROPOS D5.1 2012, p. 34). Aquaculture will be a separate sector on the TROPOS platforms, but there are expected synergies such as shared mooring lines with wind turbines.

2.1.4 *Leisure (L)*

In the leisure part of the TROPOS concept there will be different activities: aqua sports, swimming pool, underwater bar with a view to marine animals and a restaurant. Furthermore, it will include an educational part with a visitor centre as base. The platform is also equipped with a modular structure with the infrastructure capabilities to service at-sea activities for educational tourism. The MUP should be placed in a location which will be perceived as being sustainably and ecologically responsible. The transportation for passengers from shore to the MUP (and back again) will be provided by a ferry.

2.2 ICS Concepts

The different TEAL components will be combined on a central unit in three different combinations. These combinations are generally referred to as "the Interdisciplinary Cohesion Subcommittee Concepts" or short "the ICS Concepts". The final recommendations in the viability strategy report are intended to support and enhance the further development of the three ICS concepts. In this section the three concepts will briefly be described. The concept descriptions are based on the TROPOS ICS Concepts (2014).

2.2.1 *Leisure Island ICS Concept, Canary Islands*

The Leisure Island will have three different TEAL, where the main part will be the leisure part, as indicated by the name of the ICS Concept. The Leisure Island Concept will be located in Canary Islands in Spain, where the specific location specifications are defined in Table 2-1.

Table 2-1 Specifications for the defined Leisure Island ICS Concept

Location	Atlantic OceanOcean, Canary Islands, West of Gran Canaria Island, Spain
Distance to shore	3.2 km
Depth	50 metres
TEAL	Transport, Energy and Leisure

The Leisure Island will be a tourist attraction in Canary Islands, and aquasport facilities will be implemented on the platform; furthermore, there will be an educational tourism centre, which will be part of an international offshore research centre.

The Leisure Island will be located in a protected area (nature reserve). The shuttle vessel between the onshore port and the Leisure Island will transport both visitors and waste/goods to decrease the overall transport cost. The capacity of the vessel is 140–150 persons.

The Leisure Island on board visitor capacity is 400, there will be a daily average of 950 visitors on the Leisure Island. The Leisure Island will have PV cells installed, where the electricity generated will be used to supply partly its own facilities. Additionally, there will be a grid connection to shore, and for safety reasons an emergency generator will be installed at Leisure Island, as a backup system, to supply electricity in case of a cut-off or a breakdown of the grid connection to shore.

2.2.2 Green and Blue ICS Concept, Crete

The Green and Blue ICS Concept will be focussing on renewable energy and aquaculture (both fish and algae). The floating platform will be a central unit for the workers to live on, and the energy and aquaculture farms will have 30 satellite units placed close to the central unit. The Green and Blue Island will be located in Crete, Greece, where the specific location have the current specifications defined in Table 2-2.

Table 2-2 Specifications for the defined Green and Blue ICS Concepts

Location	Aegean sea, Crete, Greece
Distance to shore	90-128 km
Depth	0–1000 metres
TEAL	Transport, Energy and Aquaculture

The Green and Blue ICS Concept will not be open for tourism. The people that will be staying at the MUP will all be staff working on the farms or the platform. Each of the 30 satellite units will have an aquaculture cage, where fish or algae will be produced. There will be two wind turbines of 3.3 MW and PV cells on each unit. The combined (Green and Blue ICS Concept) farm will have a production capacity of 211 MW and annually produce around 7000 tonnes of fish and 2000 tonnes of algae.

The biomass will be handled on the platform, where the algae will be dried and prepared to be shipped to shore. 25 % of the fish will be sold fresh, 55 % will be sold as frozen fish products or as modified atmosphere fish products. Finally there will be another 20 % of by-products. The fish and algae will be transported onshore by vessels.

The waste from the Green and Blue ICS Concept will be handled (recycled if possible) on board the platform and transported to shore, if necessary. Some of the waste will be burned in a high quality incinerator on the MUP. The Green and Blue ICS Concept will have a grid connection to shore, where the electricity produced by the PV and wind farm will be transported to both shore and the MUP.

2.2.3 Sustainable Service Hub ICS Concept, Dogger Bank

The Sustainable Service Hub ICS Concept will be providing O&M for a wind farm. The workers will be living on the platform and the wind turbines will be located at satellite units nearby. The Sustainable Service Hub is located in Dogger Bank and the specifications can be seen in the Table 2-3.

Table 2-3 Specifications for the defined Sustainable Service Hub ICS Concept

Location	North sea, Dogger Bank, England
Distance to shore	125–290 km
Depth	18–63 metres
TEAL	Transport and Energy

The Sustainable Service Hub will not be available for tourism. It is assumed that 45 full time workers will be needed on board, and the MUP will have capacity for 55 people. The satellite units will consist of 100 units/5 MW wind turbines. There will be a grid connection to shore for distributing the electricity from the wind farm. The power needed at the Sustainable Service Hub is expected to be supplied by the wind farm. The personnel will be transported from the MUP to onshore by vessels, together with maintenances equipment, goods, waste etc.

2.3 Future ICS Concepts[5]

2.3.1 Green and Blue ICS Concept, Taiwan

The Green and Blue ICS Concept, Taiwan, it will be focussing on renewable energy and aquaculture (both fish and algae). The floating platform will be a central unit for the workers to live on, and the energy and aquaculture farms will have the satellite units placed close to the central unit. The platform will be eventually located in the LiuChiu Yu Island, in Taiwan. Due to the lack of water and electrical power, the site relies on the transport from the main island in Taiwan. This case utilizes the Kaohping undersea canyon's topography, develops the OTEC to generate electric power and indirectly desalinates it to get water. Also the OTEC provides the lower temperature water to assist algae aquaculture development. Algae can also help fish aquaculture to reduce the eutrophication phenomena.

2.3.1.1 Type of modules

- Fish aquaculture module: Although aquaculture cages are installed in the satellite units, space on the platform is required for supporting the activity together with auxiliary facilities. This includes support and control base, maintenance support and surveillance services, storage office and staff accommodation.
- Algae aquaculture module: The necessary space for the control of the algae biomass production. These include support and control base, maintenance support and surveillance services, storage office and staff accommodation.
- Processing plant: This is the main module of the central platform for the Green and Blue ICS concept. It is developed for the processing of the aquaculture production obtained in cages. It will include a plant with different levels of processing and also room for temporary storage and an export base of final products.
- OTEC module: In this module the Ocean Thermal Energy Conversion (OTEC) equipment will be installed for powering with electricity the required systems on the Central Unit and the other modules.
- Accommodation: This module could include few accommodation and related service, food & beverage spaces for tourists. This space will be separated from the aquaculture area entirely, and provides some high-valued accommodations.

Refer to (TROPOS D3.3 2014,p. 53-54).

2.3.2 Sustainable Production ICS Concept, the Gulf of Guinea and Panama

The Sustainable Production ICS Concept will combine different activities such as:

- Exploitation of marine resources: Facilities supporting oil & gas industry, facilities for systems supporting marine renewable energy, mining, desalination, surveillance and security, etc.
- Maritime traffic services: Terminal containers, bulk cargo terminal, LNG terminal, fishing terminal, etc.

[5] Potential ICS Concepts which will not be analized in this report.

- Fleet services: Terminal bunkering, repair terminal, marina, harbour of refuge, etc.

For the Sustainable Production ICS Concept there are two possible locations for the installation of the MUP, one is the Gulf of Guinea and the other is Panama.

The types of modules available in this platform are designed for transport and industry, and can be divided into three distinct types:

2.3.2.1 Type of modules

Based on the analysis done in (TROPOS D3.3 2014 p. 56), it was determined that the available modules installed on the MUP are:

- Container terminal: The purpose of this module is to streamline the maritime traffic by providing facilities for loading and unloading containers as well as storage space, so it will be required for ships to unload at onshore ports.
- LNG terminal: The purpose of this module is either to serve as a receiving unit for the transfer of liquid natural gas (LNG) through pipelines to land or to provide bunkering services to vessels which sail near the area of operation of the module.
- Repair terminal: Module for the repair of ships and floating platforms located in the vicinity of the site.
- Bunkering terminal: The purpose of the bunkering terminal is to provide refuelling services to ships which arrive at the platform or sail by on routes close to the location of the module.
- Security, surveillance and anti-piracy: The purpose of this module is to monitor environmental conditions and provide safety to the platform and ships operating on routes located in the vicinity of the site which may be exposed to risks of piracy.

3 HARD INFRASTRUCTURE

The common vessels for the installation of the MUP will be described in the following sections. For the specific ICS concepts, vessels for the maintenance of the respective items (cages, wind turbines etc.) and for the operation of the MUP will also be outlined.

Additionally, there will be a description of the respective facilities for both the performance of the O&M services (shipyards, dry docks etc.) and for the manufacturing of the MUP and the satellites. Electric grids and substations will be described according to their use within the offshore wind energy sector. Finally, a set of gaps and recommendations will be identified in order to understand the current barriers that MUPs will face in the future.

It should be stressed that the analysis of the hard infrastructure is based on the TROPOS D5.5 (2014). Please see the reference for further details regarding more technical aspects.

3.1 Requirements for Transportation

*3.1.1 **Common Requirements***

In this section, common vessels are identified for the installation and maintenance of the different components of the Leisure Island, the Green and Blue and the Sustainable Service Hub concepts. Table 3-1 summarises the common vessels required for the performance of each ICS concept.

Table 3-1 Vessels needed for the installation and operation of the three different ICS concepts

Vessel	Function	Example
Tugboat	Required for towing and anchoring the central and satellite units from the shipyard to the deployment zone	Atlantic Kestrel
Barge	Required for transporting heavy goods; the barge is not self-propelled, so it will be towed by a tugboat	Anchor Handly Tug Supply (AHTS) "Offshore Bh1"
Semi-submersible barge	Required for transporting heavy goods, equipped with external buoyancy tanks to allow self-ballasting	Teras 002
Multi-purpose vessel	Required for transporting large turbine components lifting over 171 tonnes /90 metres height (maintenance to the nacelle)	Saipem 3000
Subsea vessel-ROV	A subsea inspection vessel with remote operated vehicle support is required to inspect and maintain the submerged parts of the platforms' structures,	MSV Olympic intervention IV

	the moorings and the cablings regularly	

3.1.1.1 Installation Vessels

Multi-purpose vessels continue to lead the market. Vessels such as jack-up barges and heavy lift vessels are flexible and can be used by a number of sectors. Vessels also have a geographic flexibility to travel to different areas to work (Salvatore et al. 2011). For example, they could be developed for the ICS concepts in Europe, but they are flexible enough to move around the globe to work on similar concepts or in different sectors.

Despite the large selection of multi-purpose vessels that can be used across sectors, specialised vessels for the installation of offshore wind turbines have also been developed. The high deployment rates and long term investor certainty in the offshore wind sector was necessary to achieve this. In offshore wind, the recent trend in terms of vessels has also been moving away from having separate vessels for the installation of towers, turbines, foundations and cables, and towards to large scale vessels which are able to carry out all of these functions. This trend favours the largest vessels which are even able to carry multiple pre-assembled wind turbines (Salvatore et al. 2011). This information is important to consider when planning the use of different vessels for the construction of the MUP.

According to TROPOS D5.5 (2014), there are two possibilities for vessels for the installation:

- Shallow waters

  For shallow waters, offshore structures well-known technologies can be used, such as multi-purpose vessels (jack-ups).

- Deep waters

  Deep water installation vessels are still under development stage. For floating offshore wind structures, the installation vessel requirements will be different to those for shallow water deployments. For instance, a catamaran can be used equipped with heavy lift winches, transport and installation equipment for spar type floating wind turbines could be used.

3.1.2 Leisure Island ICS Concept

For the Leisure Island concept, there is a need for a special multi-purpose vessel that can be used as a mean of transport from the MUP to onshore for the following:

- Passengers.
- Cooled and uncooled supplies.
- Solid and liquid waste.

The proposed type of vessel for this transport solution is a relatively small and closed passenger ferry with a Length Overall (LOA) of 27.1 metres, a beam of 7.2 metres and a nominal draft of 2.25 metres. This vessel has a gross registered tonnage (GRT) of 88 tonnes and is capable of transporting up to 140 passengers (TROPOS D5.5 2014).

3.1.3 Green and Blue ICS Concept

In this section, vessels for the operation of the Green and Blue Concept are identified. Table 3-2 shows the required vessels for the operation and maintenance of both the satellites and the central unit for the Green and Blue ICS Concept.

Table 3-2 Vessels for O&M (Green and Blue Concept)

Vessels	Function	Capacity	Units
Offshore diving boat (Polar circle diving 820)	Fish aquaculture and algae O&M (underwater inspections) and personal transport (between central unit and satellites)	2.27 tonnes/15 persons	1
Cabin work boat (Polar circle cabin 920)	Fish aquaculture and algae O&M (inspections, net cleaning) and personal transport (between central unit and satellites)	1.4 tonnes/8 persons	1
Work barge (AWB 50)	Fish aquaculture O&M, harvesting tasks, net changing and equipment transport between the central unit and the satellites	32 tonnes	1
Wellboat (Rolls-Royce NVC 386)	Transport the fish from the satellites to the onshore port	450 tonnes	1
Forage carrier (Rolls-Royce NVC 401)	Transport and deliver of fish feed in bulk	-	1
Liquid CO_2 tanker (M/T Yara Gas III)	Supply of CO_2 to cryogenic storage tanks	1,200 tonnes	Required 6 times a year
Container ship (Vectis Eagle)	Transport container with fish and algae from the central unit to the offshore port	377 TEU/2 cranes 80 tonnes lifting each	Required 18 times a year
Transit ferry (Catamaran)	Transport of personnel from the coast to the processing module	52 persons	Required each 7–10 shifts

*3.1.4 **Sustainable Service Hub ICS Concept***

This section shows the required vessels for the operation and maintenance of the MUP and satellites. The following vessel specifications are proposed to cover the O&M requirements of a wind farm of 100 units/5 MW fixed foundation offshore wind turbines.

Table 3-3 presents the vessels required for the O&M of the satellite units.

Table 3-3 Vessels and helicopterfor O&M (Sustainable Service Hub Concept)

Vessels/Helicopter	Function	Capacity	Units
Personal transfer vessel (PTV)	Transport equipment and technicians from the central unit to the wind turbine to be maintained	15 persons	-
Platform supply vessel (PSV)	Transport different supplies, diesel and aviation fuel, spare parts, personnel, consumables etc. from the onshore port to the central unit	45 persons/67 tonnes diesel	-
Multi-purpose vessel (MPV)	O&M heavy lifting, gearbox, generator, blades etc. fromfrom onshore port to the central and satellite units	-	-
Helicopter (Agusta West land AW101)	O&M when it is not possible to use a boat because of the bad weather conditions	5 persons/14.6 tonnes	-

3.2 Ports and Related Facilities

In order to manufacture, maintain and operate the central and the satellite units, it is necessary to have the adequate shipyards and ports that fulfil both technical and operational requirements for the correct deployment of the TROPOS project. However, it is important to mention that port infrastructure required for manufacturing and heavy duty maintenance of any TROPOS concept is differentiated from port facilities that are required exclusively for the operation of the three TROPOS concepts Leisure Island, Green and Blue and the Sustainable Service Hub.

3.2.1 Common Requirements

Table 3-4 summarises the common technical requirements for the manufacturing and maintaining of the central units and satellites.

Table 3-4 Common technical requirements

Item	Technical characteristics	Manufacturing and maintaining
Central unit	LOA 80 metres, Beam 56 metres, DWT 17.2 metres draft 24,764 tonnes, DWT for 14	Possible to manufacturing in any shipyard with capacity for a Malaccamax vessel (Malaccamax - Wikipedia the free encyclopedia 2014) some example are: • Hellenic Shipyards, Athens, Greece (Hellenic Shipyards S.A. 2014)

	meter draft 22,276 tonnes and DWT 11 meter draft 19,944 tonnes	Graving Dry Dock: 421 metres LOA, 75 metres beam, 500,000 DWT Cranage: 3 x 5 tonnes, 100 tonnes, 120 tonnes. Floating crane: 130 tonnes, 36 tonnes • Navantia, Puerto Real Shipyard, Cádiz, Spain (Port of Cadiz Bay 2014) Graving Dry Dock: 525 metres LOA, 100 metres beam, 1,000,000 DWT Cranage: 9 x 1,200 tonnes
Satellite units (main floater)	LOA 91 metres, Beam 117 metres, Light displacement 3,700 tonnes	Manufacturing in a dry dock, for example: • Harland & Wolff Heavy Industries Limited, Belfast, United Kingdom (Harland and Wolff Heavy Industries Ltd. 2014) Graving Dry Dock: 556 metres LOA, 93 metres beam, 150,000 DWT Cranage: 2 x 840 tonnes gantries, 2 x 65 tonnes, 1 x 80 tonnes, 2 x 40 tonnes
Satellite units (algae floater)	LOA 200 metres, Beam 50 metres, light displacement 173 tonnes	There are 2 alternatives for manufacturing: • If the floater structure is self-supporting on land and can be lifted in air environment, the structures can be assembled onshore at an appropriate area near the quay • If the algae floater is too fragile to prevent any lifting in air environment – even of parts of the floater structure – the structure has to be assembled directly on a semi-submersible barge Requirements for the shipyard: Minimum assembly area of over 200 metres x 50 metres (less when considering partial assembly; more when considering series production) Maximum lifting capacity: 173 tonnes (less when considering partial assembly) Maximum quay length 200 metres (less when considering partial assembly)

According to the TROPOS D5.5 (2014) for the central unit, only one of the 143 identified suitable shipyards has a ship lift system, 16 have floating dry docks, 44 have slipways and 98 have graving docks. For the main floater, none of the 33 identified suitable shipyards has a ship lift system, only one has a floating dry dock, six have slipways and 28 have graving docks. Finally, for the algae floater, the identified parameters and values apply to a great number of ports worldwide and it is assumed that the manufacturing of the algae floaters does not limit TROPOS platform deployment anywhere in the world.

3.2.2 Maintenance

It will be possibly to undertake maintenance service for the central unit and satellites in the ports. Generally, it can be assumed that any shipyard capable of manufacturing the offshore platform is also able of performing maintenance of them.

Table 3-5 summarizes the possible facilities and potential providers that can perform the maintenance of the offshore platform for each ICS concept.

Table 3-5 Facilities and providers for the maintenance services

ICS Concept	Possible maintenance facilities	Potential service providers
Leisure Island	Port of Las Palmas on Gran Canaria (Spain)	REPNAVAL(Repnaval Shipyards 2014) and ASTICAN (ASTICAN - Repairs & Conversions 2014)
Green and Blue Island	Port of Ermoupoli on the Syros Island (Greece)	Nerion Syros Shipyards (Syros Shipyards 2014)
Sustainable Service Hub	Port of Belfast (England)	Harland & Wolff Heavy Industries Limited, Belfast, United Kingdom (Harland and Wolff Heavy Industries Ltd. 2014)

3.2.3 Power Infrastructure

In this section the current grid infrastructure is described together with what would be needed to support the ICS concepts.

According to the European Wind Energy Association (EWEA, 2013) two of the major grid challenges are as follows: a) the distance from the shore and the availability of networks at the point of connection, and b) the moving section of the cables. The motion induced by the turbine and the non-fixed foundation can put high loads on the cables.

According to the Off-Shore-Grid (2011) the development of the offshore grid is going to be driven by the need to bring offshore wind energy online and by the benefits from trading electricity between countries. This involves the connection of the wind energy to where it is most needed, and linking high electricity price areas to low electricity price areas.

According to the Off-Shore-Grid (2011) project, in addition to its techno-economic advantages, a split design has environmental benefits (compared to a non-split design) because it reduces the total circuit length. Moreover, it improves the redundancy of the wind farm connection, which improves the system security and reduces the system operation risks, the need for reserve capacity, and the loss of income in case of faults. When performing detailed assessments for concrete cases, such as for the ICS concepts, these merits should not be overlooked.

Important aspects of offshore electrical transmission cable systems are the operating mode Alternating Current (AC) or Direct Current (DC), the cable type (i.e. Cross-linked polyethylene (XLPE) or paper impregnated), the power rating and voltage, the reactive power consumption and the electrical losses and last but not least the price.

Many offshore wind turbine farms have been constructed during the past decade. Most of these wind power systems are relatively close (fewer than 50 km) to shore and have an HVAC connection to the onshore grid.

The type of cables to be applied in offshore AC transmission systems depends on the power to be transferred and the distance. If no intermediate compensation is possible or feasible, 150 kV AC is used up to 120 km and 380 kV AC is used up to about 40 km.

The highest voltage level for a three-core XLPE submarine cable in existence is 170 kV in the 21 km long 630 mm^2 cable linking the Horns Rev Offshore Wind Farm to the Danish mainland. This level could potentially go up as high as 245 kV by employing a slightly larger insulation thickness. At present, this represents the maximum realistic voltage limit because beyond this level the three-core cable size would be so great that the production, handling and transportation would be impractical.

The power transportation capacity of an AC offshore cable is firstly limited by the maximum allowed temperature, which determines the maximum current and secondly, by the distance, which determines the reactive power required by the cable. HVAC transmission involves a capacitive current, since the insulation materials act as a capacitor.

For long AC cables, a large part of their current-carrying capacity is used for the capacitive charging current (i.e. reactive current), so less active power can be transferred to the grid onshore. The charging current increases linearly with the voltage and also linearly with the length of the cable. The latest technology on 400 kV offers the advantage of being able to carry up to 1000 MW, on distances not more than 100 km.

The capability of transmission over long distances is decreased by increasing the rating of the voltage. Moreover, for the same transmission distances the electrical losses are increasing by decreasing the voltage level. For a 100 km transmission, losses of 3–4 % are obtained for 400 kV and 230 kV.

If there is a need to connect larger amount of power at long distance, multiple connections have to be designed. The ICS concepts should be divided into clusters with individual offshore substations and connections to the main grid.

Offshore compatible HVDC (power electronic converters suitable for placement at an offshore platform) is still under development and currently costs considerably more than AC transmission at moderate distances. With the increase in power and voltage of the power electronic converters, however, HVDC is becoming more feasible.

From the former paragraphs it can be inferred that HVDC systems are favourable for offshore energy transmission at distances above 100–150 km. Then the reactive current substantially limits the power of the HVAC system, until superating DC converter and cable overall losses.

The weight of the cables is an important aspect. For example a transmission system rated at 550 MW over 75 km distance needs HVDC cables with a specific weight being only 40 % of the weight when applying an HVAC system. Important to mention is that AC needs 3 cables and DC only 2 (bipolar). This aspect brings an important advantage related to cost of the cables and the deployment cost.

3.2.4 Generic Floating Offshore Substations[6]

Floating alternatives have their issues, primarily due to the ability to operate with large wave loads. The equipment that is fitted into the substations is developed with the assumption that it will be static, especially during operation. Floating platforms are subjected to translational and rotational motions, which may add

[6] This section is based on TROPOS D5.6 (2014)

dynamic loads to the equipment on-board. There are, however, some components of the substation that have counterparts designed to operate on Oil and Gas (O&G) platforms and on ships, which can be adapted to the relevant ICS concepts. Other issues relating to the use of floating substations include the position keeping of the platform, in order to avoid damage to the umbilicals and export cables.

Floating offshore wind turbines are already being tested across the world, but these are single device projects, and without the use of offshore substations. However, floating options for offshore substations are being developed. These come in two basic concepts: A) mobile/self-installing offshore substations, which do not operate while floating, but can be easily tugged into location for installation, and B) floating offshore substations, that operate while floating. The latter are of more interest within the concept of TROPOS, but as only one example exists, the former has also been included in this section.

Offshore substations are used to reduce electrical losses by increasing the voltage and then exporting the power to shore. In the case of DC transmission, these also include rectifiers.

Generally, a substation does not need to be installed if:

- The project is small (~100 MW or less).
- It is close to shore (~15 km or less).
- The connection to the grid is at collection voltage (e.g. 33 kV).

Offshore substations will typically comprise the following key components:

- Transformers.
- Electrical switchgear.
- Back-up electrical generator and batteries.

Table 3-6 shows offshore platforms that have been used for the O&G and for the wind energy industry.

Table 3-6 Offshore platforms and substations

Item	Function	Considerations
Mobile Offshore Application Barge (MOAB), Global Tech 1 project in the North Sea (Project-Global Tech 1 2014)	Used to deploy offshore substations	The towing and installation of the structure have weather limitations, e.g. a five days of weather window was required for the Global Tech 1 Project (Transformer station)
Semi-submersible, DolWin Beta HVDC (Dolwin Beta/Heavy Lift Specialist 2014) (Norway)	Semi-submersible offshore platform	Instead of being mounted on the foundation structures, it is lowered onto the seabed
Fukushima Kizuna	Offshore floating	-

(Fukushima Recovery, Experimental Offshore Floating Wind Farm Project /News & Info - Shimizu Corporation 2014) (Japan)	substation (the first in the world)	

3.3 Gaps and Recommendations for Hard Infrastructure

This chapter presents gaps and recommendations for hard infrastructure.

3.3.1 Leisure Island ICS Concept

When looked at individually, nearly all of the ICS concept activities and applications are existing today as standalone applications that can be manufactured, installed, operated and maintained utilising existing procedures, vessels and infrastructure. One small exception is the required vessel for transportation of passengers, supplies and waste on the selected vessel.

Due to the claimed necessity to combine the transport of passengers, supplies and waste in one single vessel no suitable vessel could be identified to fulfil this requirement (TROPOS D5.5 2014).

As discussed in TROPOS D5.5 (2014), a feasible solution in order to minimise costs with respect to transport of passengers, supplies and waste, is to convert a passenger ferry into a specialised suitable vessel, at least in the short term. In the short term, when the ICS concepts are still in the developing phase the most feasible and likely adaptations to a vessel will have to be made to the main deck to enable the transport of any supply of waste containers. This would probably include removable passenger seats and additional loading hatches in the hull.

In the long term the conversion of a passenger ferry might be a costly approach when taking into account the scaling effects of global deployment of numerous Leisure Island platforms and also considering the potential utilisation of mass produced standardised components given that the concept is deployed at a regional or global scale. Hence, a strategy of having large scale production of multi-use vessels should be considered as viable and and feasible.

In the short term it is recommended to use converted ferries that can facilitate the multi-use transportation from shore to and from the MUP.

In the long term, large scale production of suitable multi-use vessels, supporting transport of persons, supplies and waste for the Leisure Island ICS concept, should be facilitated by relevant authorities and supported by appropriate legislation.

3.3.2 Green and Blue ICS Concept

The dimensions of the Mass Production Satellite Units pose a serious problem on the logisticswhen considering that these floaters are supposed to be items of mass production when being deployed in numbers of 30 or even more with a single Green and Blue ICS Concept.

An estimation of the mass production suitability of the current Satellite Unit design shows that the most suitable type of dry dock is, based on the research done so far, a graving dock.

These docks are considered the "classic" type of dry dock and are not a novel development and are commonly found all around the world, see Figure 3-1. However, the high beam values of the ICS concepts are the primary limiting factor when considering availability of suitable docks.

In cases where an extreme amount of construction space is required, a temporary graving dock should be created near-shore. As an example, see Figure 3-2. Additionally, it is possible and economically feasible to manufacture several Satellite Units with a series production approach in a graving dock but only a handful of shipyards in the world (of which only two are located in Europe) are capable of manufacturing the Satellite Units.

With the given maximum LOA values of the identified suitable European graving docks it should be possible to manufacture up to four Satellite Units at a time in one dock (TROPOS D5.5 2014).

The longest suitable graving dock in the world with a beam of 92 metres and a length of 950 metres is located in Taiwan (CSBC Corporation 2006). In this dock up to eight Satellite Units could be manufactured in parallel, which is still a small number when compared to the required 30 units for a single Green and Blue ICS Concept (TROPOS D5.5 2014).

Facing super-tanker and super-container ship companies as competitors for these scarce shipyard capacities it appears questionable if the TROPOS Green and Blue ICS Concept will be able to stand up to the fight of the bidders.

Considering the global applicability of TROPOS Green and Blue ICS Concept it is therefore recommended to A) investigate how much the LOA beam of the Satellite Unit floater can be reduced in order to be manufacturable and maintainable at a greater number of shipyards and become an item of true mass production anywhere in the world, and/or B) consider expanding docks facilities that can manufacture large scale constructions, such as the Satellite Units in the Green and Blue ICS Concept. For the latter recommendation a well-documented business plan would be needed to ensure the feasibility of such dock production facilities.

It is recommended to investigate how far the dimensions (LOA and beam) of the satellites units floater can be reduced to be manufacturable and maintainable in mass at more shipyards worldwide.

Provision of docks facilities that can manufacture large scale constructions, such as the Satellite Units in the Green and Blue ICS Concept should be provided by relevant authorities supported by suitable legislation.

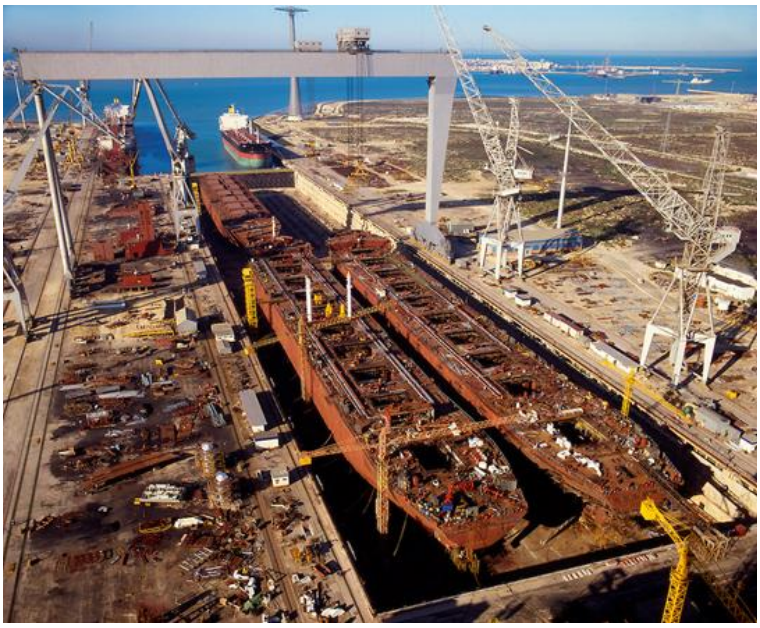

Figure 3-1 Graving dock with three newly built tankers in Cádiz, Spain (Mira 2014)

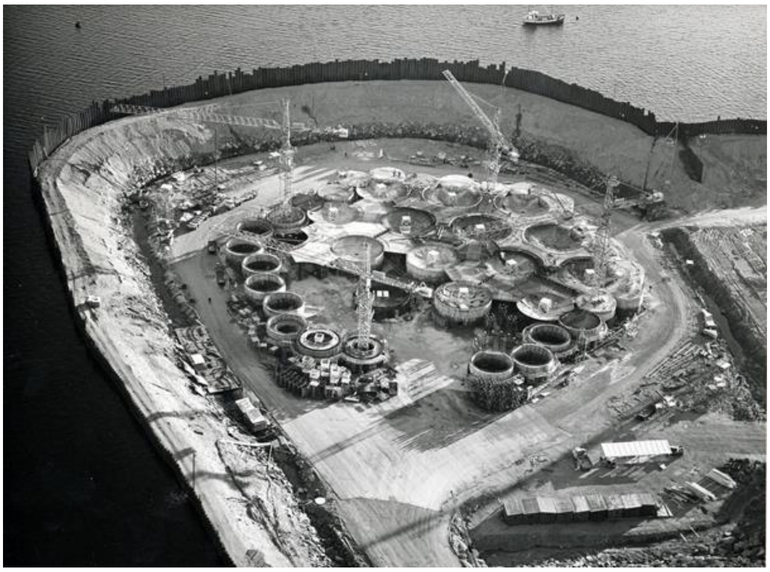

Figure 3-2 Temporary graving dock for the manufacturing of the "Condeep" O&G platform's concrete floater

(Norsk Oljemuseum 2012)

3.3.3 Green and Blue/Sustainable Service Hub ICS Concepts

When considering *in situ* maintenance of floating wind turbines it appears that there is a lack of vessels. It should be noted that most vessels currently active in this service segment today are jack-up barges. Part of the utilised vessels is even purposely built for offshore wind services. None of these vessels can be utilised in water depths larger than approximately 65 metres.

In such cases floating heavy lift vessels are required (TROPOS D5.5 2014). The existing floating heavy lifting vessels are normally active on the O&G market and it can be expected that a large portion of these vessels are seldom available, because they will be too costly to operate for the TROPOS concepts, inefficient or not capable at all to perform the tasks required for the TROPOS/ICS concepts to be developed.

When maintenance and heavy duty lifting is needed, then, at least in the short term, it is recommended to tow a defective floating wind turbine back to shore and then do maintenance and repairing onshore (TROPOS D5.5 2014). A concern is that the handling of the subsystems in this approach (the fish cage and the algae floater) becomes a challenge since they are dependent on the physical presence of the wind turbine floater and the supporting services provided by it. An adequateprocedure for the subsystems left behind should be developed. For example, a backup module where the subsystems left behind can be attached to while maintenance of the wind turbine take place.

In the longer term it is recommended to consider a development of the appropriate vessels that can handle the in situ maintenance of the floating wind turbines and other large scale constructions. For the latter recommendation a well-documented business plan would be needed to ensure the feasibility of the developed vessels.

For maintenance of the large scale constructions it is, in the short term, recommended to tow a defective floating wind turbine back to shore.

For in situ maintenance of the large scale constructions in the multi-use platforms it is recommended to facilitate the development of appropriate vessels through appropriate legislation, financial support and a well-documented business plan.

Regarding the grid connection of floating wind turbines it appears that there is a lack of experience. From the grid perspective the Green and Blue and the Sustainable Service Hub ICS Concepts are similar to a floating offshore wind farm and also similar to a floating offshore substation.

Still, one important issue to be taken into account is the lack of developed/mature technology with grid connected floating offshore wind turbines and whole farms in particular. Although, a number of single experimental floating wind turbines have been developed and partially deployed by now, the first floating wind farm (with only five units) is still in the planning phase (WindFloat Pacific 2014).

Furthermore, a floating offshore substation is a fairly new concept and at the time of writing the longest known operational experience for a floating offshore substation is only eight months. This substation has a transmission capacity of 25 MVA, which is only a fraction of what would be needed for the Green and Blue ICS Concept (240 MVA or approximately a factor of 10) and especially the Sustainable Service Hub (~ 540 MVA or approximately a factor of 20).

However, the existence of mobile floating offshore substations and converter stations in the region of 480 MVA and 900 MW indicate that floating substation solutions in higher capacity regions, in principle, are possible.

It is recommended to develop the necessary offshore grid connection technology for floating ICS platforms enabled by relevant authorities and R&D financial support.

4 SOFT INFRASTRUCTURE

This chapter describes the soft infrastructure of the TROPOS project and especially focuses on the three ICS concepts. Soft infrastructure is defined as all the required regulation and legislation regarding health and safety, personnel training, design standards and environmental aspects, which must be considered before implementing the ICS concepts.

The required soft infrastructure for the ICS concepts is to a great extent comparable to soft infrastructure needed for the O&G industry, the leisure cruise ship industry, the offshore wind energy industry, and the aquaculture industry.

The soft infrastructure needed for the ICS concepts is to some extent to the above mentioned industries' soft infrastructure. This is beneficial for the overall TROPOS project since it is easier to use already existing knowledge, e.g legislation, rather than start a new type of legislation.

Additionally, the chapter provides significant insights regarding the impacts on the environment that the installation and operation of the MUP and satellites may bring on the considered locations. Finally, a set of gaps and recommendations are presented.

All considerations and recommendations should be carefully reviewed by third party to ensure that no important aspects are missing, misunderstood, or underestimated.

4.1 Legislation and Regulation

4.1.1 Health and Safety for Offshore Oil and Gas

This section is based on the analysis provided by the TROPOS D5.5 (2014), and it resumes relevant regulation and legislation for a generic deep water offshore platform. Particularly the focus is on the health and safety for the offshore O&G sector (IPIECA 2013 and HSE (Health and Safety Executive (in the UK)) 2014), see the Table 4-1.

Table 4-1 Health and Safety regulation and legislation for offshore platforms within the O&G sectors

Personnel welfare regulations and legislations	Safety of structure regulations and legislations
• Training and qualifications of on-board personnel must be up to date	• Consider the ageing and life extension of offshore installation. E.g. fire, explosion and risk assessment
• Risk and crisis management criteria and training has to be set	• Consider electrical and control system. E.g. prevention of electrical shock and injuries due to arcing, fire and explosion caused by electrical equipment and systems

• Implement health performance indicator (HPI). E.g. industrial hygiene and control of workplace exposures	• Consider evacuation, escape and rescue plans. E.g. availability of helicopters, lifeboats, life jacket and escape ladders in case of emergency
• Provide accommodation. E.g. shower rooms, or the provision for separate use of shower rooms, and lavatories and washbasins, for men and women	• Design according to structural integrity. E.g. design to withstand large wave and impacts from docking vessels
• Consider human factors. E.g. managing shift work and fatigue offshore	-
• Consider occupational health risk offshore. E.g. initial and continued fitness to perform a job safely	-
• Consider safety management systems. E.g. work control and permits to work	-

According to the Offshore Installations (Safety Case) Regulations 2005, the multi-use platform operators should be able to demonstrate that the overall systems provided for the offshore installation are sufficient to support the structures and provide acceptable levels of safety during all phases of the lifecycle of the installation. Finally, operators must also demonstrate that the factual requirements of the schedules to the Offshore Installations Regulations 2005 are met.

4.1.2 Personnel Training for the Oil and Gas Sector

Due to the harsh conditions of the offshore environment, training is essential to ensure that workers can safely carry out their occupational duties.

The EU has adopted a directive (Directive 2013/30 EU of the European Parliament and of the Council of 12 June 2013) which states the EU requirements for safety for offshore O&G, see Table 4-2.

Table 4-2 EU and HSE regulations for safety and personnel training for the offshore O&G sector

EU regulations (training and safety)	Areas regulated by HSE
• Platforms should have an Internal Emergency Response Plan which includes arrangements for training personnel in their platform duties, and where necessary, coordinating this with external emergency responders • Member States are required to fund essential training, communication, access to technology, travel and subsistence of competent authority personnel for the carrying out of their duties and to facilitate the active cooperation between competent authorities • Member States require operators and owners to communicate details for the national arrangements for the mechanisms to their employees and contractors connected with the operation and their employees, and to ensure that reference to confidential reporting is included in relevant training and notices	• Noise and vibration • Mechanical handling and crane operations • Diving • Water quality and food hygiene

4.1.3 *Personnel Training for the Cruise Ship and Commercial Vessels Sector*

All cruise ships must comply with the International Maritime Organisation (IMO) which is responsible for the safety and security of shipping, as well as the prevention of marine pollution.

Seafarers, regardless of their duties on-board the platform or vessel, are required to undergo a Standards in Training Certification and Watchkeeping for Seafarers (STCW) certification programme for the use of commercial vessels, see Table 4-3 (STCW 2014).

Table 4-3 STCW areas of training within the cruise ship sector

STCW areas of training
• General provisions • Master and deck department • Engine department • Radio communication and radio personnel • Special training requirement for

personnel on certain types of ships • Emergency, occupational safety, medical care and survival functions • Alternative certification • Watchkeeping

4.1.4 Personnel Training for the Offshore Wind Energy Sector

The legislation and regulation regarding personnel training for offshore wind farms is directly related to the Sustainable Service Hub ICS Concept.

The responsibility for safety of an offshore windfarm falls on the IMO and national governments. In addition to the guidelines provided by IMO, the Global Wind Organisation (GWO) also requires workers to be medically fit and are required to adhere to its Basic Safety Training Standard (BSTS) which included training, see the Table 4-4.

Table 4-4 Safety and personnel training within the offshore wind sector

Contractors Unlimited (minimum safety training)	IMO & Global Wind Organisation (areas of training)
• Introduction to the hazardous offshore environment • Working safely including safety observations systems • Understanding the risk assessment process • Tasks that require permit • Personal responsibility in maintaining asset integrity • Using manual handling techniques every day • Controlling the use of hazardous substances offshore • Knowledge and practices of working at height • Being aware of mechanical lifting activities	• First aid • Manual handling • Fire awareness • Working at heights • Sea survival

4.1.5 Personnel Training for the Aquaculture Sector

The training, legislation and regulation concerning to aquaculture is directly related to the Green and Blue ICS Concept.

In order to move traditional aquaculture to an offshore environment, gaps will need to be identified and mitigated. These guidelines will identify the needs of the fish farms, vessels and regulations and legislation regarding the processing of food, see the Table 4-5.

The HSE has published regulation for the handling of meat, poultry and fish; however, none of these standards specifically mention fish farms. These standards include for instance, infections at work-controlling the risks and duties of food handlers (HSE safety and training INDG345(rev1), 2012, Ghie, 1988).)

Table 4-5 HSE safety and training guidelines for the aquaculture sector

HSE safety and training guidelines	HSE training for unloading/loading fish vessels
• Training on the procedures for rescuing people from the water (including rescue into a boat) and also on the correct fitting, maintenance and use of lifejackets is needed • Suitable training will normally need to be given on correct lifting techniques for items such as nets, feedstuffs and containers of fish • Employers and workers at an installation need to be given adequate first aid training • Operators will need to be trained on the correct method of administering vaccinations and associated procedures • All employees are to be given adequate information, training, instruction and supervision in respect of all matters affecting their health and safety at work. Adequate reference to these needs to be included in the written safety policy statement, required where five or more workers are employed • In addition to general operational training, specific training standards and competency certificates exist and will normally be necessary for operators of fork-lift trucks and boat	• Suitable training in such matters is necessary for persons who enter confined spaces • Training is needed for lifting plant operators • Training is needed for drivers handling wet fish • If there is a risk of fuel fire, there should be a trained person to use firefighting equipment • Only trained people should inspect the lifting equipment • Only trained people should inspect the respective vehicles

4.1.6 Legislation and Regulation Analogies for the ICS concepts

4.1.6.1 Analogy for Leisure Island ICS Concept

In order to understand the applicability of the different standards, regulation, and legislation to the Leisure Island ICS Concept, it has been necessary to investigate an analogy between both the Leisure Island ICS Concepts and a cruise ship, basically because both will perform similar activities.

In this case, the cruise ship selected was the "Celebrity Solstice" which is owned and operated by Celebrity

Cruises (2014). The Celebrity Solstice cruise ship includes solar PV panels on-board to provide electricity to power 700 LED bulbs or elevators.

Additionally, the dimensions and capabilities of the Celebrity Solstice cruise ship are comparable to the Leisure Island ICS Concepts, so it can be assumed that any legislation and regulation applicable to a cruise ship of the presented class (Solstice-class cruise ship) is fully applicable to the Leisure Island ICS Concept with one restriction: Leisure Island is permanently deployed in a protected marine area. This will most likely affect all legislation and regulation aspects that are related to environmental impact, e.g., disposal of waste and any emissions in general (noise and others).

For further details regarding to standards, regulation and legislation for the Leisure Island Concept, see the Section a) of the Appendix.

4.1.6.2 Analogy for Green and Blue ICS Concept

The analogies that cover most of the legislation and regulation and design standards that would be needed for the Green and Blue ICS Concept are as follows:

- The regulation and legislation, and design standards which are used for fish processing vessels because they are large ocean-going vessels with extensive on-board facilities for processing and freezing of caught fish.
- The legislation and regulation and design standards which are used for a fixed offshore wind farm, because it belongs to a well-established industry where regulations and legislations are already in place.

According to what has been described in the section 4.1.4 and in the section 4.1.5 it seems like, as separate legislation, most of the current legislation and regulation regarding health and safety and personnel training are already in place. However, there might be an exception for the offshore handling of fish. When co-location of these combined applications and location in novel environments are considered, a number of gaps can be expected.

For further details regarding to regulations and legislations (health and safety) for the Green and Blue ICS Concept, see the Section b) of the Appendix.

4.1.6.3 Analogy for Sustainable Service Hub ICS Concept

The Sustainable Service Hub ICS Concept is comparable to an offshore power substation and to an offshore wind mothership designs. Some cases of each of the applications are presented below.

One example of a comparable existing offshore wind substation is the Global Tech 1 substation, GT1S (2014). A mobile seven story high Wind Power Offshore Substation (WIPOS) is mounted on a self-installing Mobile Offshore Application Barge (MOAB). The substation is located 180 km away from Bremerhaven in the North Sea.

Another example of an existing offshore wind substation is the Fukushima Kizuna Substation FKS (2014), a floating substation designed by Hitachi mounted on an advanced spar floater designed by Japan Marine United Corporation. The substation is located 23 km offshore the coast of Fukushima, Japan.

A recent design of a dedicated offshore windfarm mothership is the IMT9180 "Sea-Wind" design SWD (2014), a submersible dock ship designed by Offshore Ship Designers. This type of vessel is aimed at improving uptime of deep-water wind turbines and reduce maintenance costs and carbon emissions whilst offering a solution to the logistics problem of carrying out simultaneous maintenance to multiple wind turbines. The vessel would remain on station in offshore deep-water wind farms and deploy multiple catamaran workboats to carry engineers to service the turbines.

Currently the available standards, legislation and regulation (from the HSE, the IMO and the Global Wind Organisation areas of training) concerning the maintenance of the base, installation of electrical grids for the substation, accommodation and transportation of personnel are already in place. However, it is expected that there will be gaps when all services are integrated, e.g. fire risk, permanent exposure to electromagnetic fields etc.

For further details regarding to standards, regulation and legislation which are applicable to for the Sustainable Service Hub concept, see the Section c) of the Appendix.

4.1.7 Applicability of Legislation and Regulations within the ICS concepts

4.1.7.1 Applicability of Legislation and Regulation on the Leisure Island ICS Concept

Regarding the applicability of the personnel training regulation for a cruise ship to the Leisure Island ICS Concept, there is no need for a change in the specific regulation, as the regulation for personnel training that covers the cruise ship also can cover the Leisure Island ICS Concept, since there are no significant changes between the two concepts apart from the fact that the cruise ship is sailing and the Leisure Island ICS Concept is stationary.

4.1.7.2 Applicability of Legislation and Regulation on the Green and Blue ICS Concept

Regarding the applicability of the personnel training regulations for the aquaculture activities in the Green and Blue Concept, the personnel should obtain the required expertise to execute all related tasks, particularly in relation to the specific areas of expertise given below:

- Cage aquaculture, e.g. fish nutrition.
- Algae aquaculture, e.g. algae biology and monitoring.
- Fish processing unit, e.g. equipment operating (processing machinery).
- General aquaculture support, e.g. storekeeper.

4.1.7.3 Applicability of Legislation and Regulation on the Sustainable Service Hub ICS Concept

Taking the use case of the Global Tech 1 as an example, the personnel stationed on-board of this substation have to fulfil virtually the same spectrum of tasks as personnel stationed on the Sustainable Service Hub ICS Concept. Therefore, the personnel should obtain the required training to execute the following tasks:

- Lifting operations.
- Helicopter support operations.
- Piloting PTVs.
- Checking and performing light maintenance to wind turbine components.

- Checking and performing light maintenance to substation components.
- Checking power cable connections above and below the waterline.
- Checking the integrity of structures above and below the waterline.
- Firefighting (in case that it may be required).
- Vessel based rescue operations.
- Catering and other accommodation related services.

Special training required for the following:

- Training and competence related to use of helicopters in offshore environments, e.g. Helicopter Underwater Escape Training (HUET), a training provided to offshore O&G industry staff and military personnel who are regularly transported to and from facilities by helicopters over water (as opposite to over land). The purpose of this training is to prepare the personnel for emergency exit in the case of a crash landing over water.
- Training and competence of offshore wind farm service technicians. E.g. technician training scheme, such as training requirements for offshore O&G technicians from the British O&G Academy, or/and training requirements based on Offshore Petroleum Industry Training Organisation (OPITO), or/and the British Engineering Construction Industry Training Board (ECITB).
- Training and competence of offshore crane operators and banksmen/slingers, regulatory benchmarks (HSE 2014), e.g. Recommended Practice for the Operation and Maintenance of Offshore Cranes, API RP 2D (2003).

4.2 Environmental Aspects

In order to ensure the smallest possible impact from the ICS concepts on the environment it is necessary to do the following:

a) assess the environmental impacts which the ICS concepts might pose, and

b) establish mitigation actions such as a management plan and a continued monitoring strategy to guarantee the fulfilment of the local environmental regulation and legislation.

Based on the analysis performed in TROPOS D6.2 (2014) the following paragraphs highlight the important environmental aspects of the ICS concepts.

4.2.1 Assessment of Impacts

4.2.1.1 <u>Receptor Sensitivity</u>

The area of Gran Canary Island where the Leisure Island ICS Concepts will be located is characterised by oligotrophic, low productivity waters. The water quality and sediment quality are good, and not very pre-stressed, but as the platform will be located within an environmental protected area, water and sediment quality were categorised as being of high and medium sensitivity, respectively.

There are many marine mammals (mainly dolphins), birds, and turtles present these. As the area is a special protected area all the receptors are categorised as highly sensitive. The receptor 'Landscape/Seascape' is considered of a medium sensitivity, because the platform is not so far away from the coast compared to the other two scenarios. The Leisure Island ICS Concept involves more shipping traffic due to the tourist shuttles.

The area of the Green and Blue Scenario near Crete is one of the few areas where the monk seal still occurs. This seal is the most endangered pinniped species in the world, accordingly, sensitivity of the receptor 'marine mammals' is high. Two endangered sea turtle species are also found in the area. The sea is rather oligotroph, phosphorous limited, and expected to be of medium sensitivity. The Table 4-6 summarises the impacts on the local receptors within each ICS concepts.

Table 4-6 Sensitivity of the receptors considered in the assessment at the three TROPOS locations

Receptor	Canary Islands (Spain)	Crete (Greece)	Dogger Bank (UK)
Air Quality (including climate)	Medium	Medium	N.A.
Water Quality	High	Medium	N.A.
Water Temperature	Low	Low	N.A.
Sediment Dynamics	Low	Low	N.A.
Sediment Quality	Medium	Low	N.A.
Landscape/Seascape	Medium	Low	N.A.
Microorganisms	Medium	Low	N.A.
Benthic Fauna and Flora	High	Medium	N.A.
Pelagic Fauna and Flora	High	Low	N.A.
Fish and Turtles	High	High	N.A.
Birds and Bats	High	Medium	N.A.
Marine Mammals	High	High	N.A.
Humans	Medium	Medium	N.A.

4.2.2 Mitigation Actions

Ensuring the smallest possible impact for all the three ICS concepts includes establishing mitigation actions such as a management plan and a continued monitoring strategy.

4.2.2.1 Management Plan

The operation of the different ICS concepts will require appropriate management schemes to ensure the best feasible protection of the environment. Best Available Practice (BAP) and Best Management Practice (BMP) should be applied in all cases.

The best available material and up-to-date techniques should be used for construction, operation and decommissioning of the platforms and all its elements.

Efficient safety and emergency response involving fast reaction for the platform including all elements, as well as for shipping traffic, are essential to avoid accidents and unplanned events and to reduce their impact on the environment.

Comprehensive waste and wastewater management, including recycling, treatment, and safe transport to shore are of a major importance.

The light and noise regime will require appropriate management, in particular in the Leisure Island ICS Concept.

An optimum management plan has to be thoroughly developed and carefully prepared for each of the ICS concepts, with sustainable use of resources, resource sharing and an efficient logistic management being an important component.

4.2.2.2 Monitoring Strategy

An efficient and comprehensive monitoring strategy is required to test the correctness and efficiency of applied mitigation measures (TROPOS D6.3, 2014).

In particular, stressors and receptors involved in impacts identified as being of major or critical significance in the scope of the Environmental Impact Assessment (EIA) need to be well monitored.

Endangered species and key species of the particular ecosystem should be monitored in any case to assure that no impact was missed or overlooked in the EIA.

4.3 Gaps and Recommendations for Soft Infrastructure

For each of the ICS concept all considerations and recommendations regarding personnel training, health and safety and design standards, should be carefully reviewed by third party to ensure that no important aspects are missing, misunderstood, or underestimated.

4.3.1 Leisure Island ICS Concept

Regarding regulations for personnel training on the Leisure Island ICS Concept it is inferred that the regulation for personnel training is already existing. Therefore, the regulation for personnel training that covers the cruise ship also can cover the Leisure Island ICS Concepts, as the only difference between the two concepts is that a cruise ship is sailing and the Leisure Island ICS Concept is stationary.

It is recommended that the relevant policy makers adopt the legislation and regulation with respect to personnel and training that applies for Solstice cruise ship class to cover the Leisure Island ICS Concept.

With respect to environmental issues, noise from shipping traffic and operation of leisure facilities, as well as artificial lighting from bars and restaurants have been identified as the most critical impact on the environment. Additionally, solid and liquid wastes from leisure facilities and the fish aquaculture may in combination significantly affect water quality and the living community.

While some of the identified negative effects, such as impacts due to waste and wastewater, can be efficiently mitigated by an appropriate treatment and management, other negative effects, such as noise generated by mooring installation, shipping traffic and leisure facilities or artificial lighting are difficult or impossible to avoid. These impacts can be reduced using appropriate mitigation measures, but the reduction capabilities are limited.

It is recommended to apply appropriate legislation for monitoring strategies and efficient management plans, to minimise any negative environmental impacts on the Leisure Island surroundings.

4.3.2 Green and Blue ICS Concept

There is a need for increased skill requirements for technicians on the Green and Blue ICS Concept compared to the existing onshore based sector. Considering minor and unplanned maintenance in the existing offshore wind sector, the situation is characterised by high availability of specialised personnel. If maintenance is required for a certain technical system it is relatively easy to contact the system's manufacturer and deploy specifically qualified service technicians reasonably quickly to any near-shore installations. With the Green and Blue ICS Concept the situation is more difficult: the platforms are located far offshore and are probably neither easily nor quickly reachable. Support by external service technicians is therefore an issue. As a consequence, certain technical maintenance services should be provided by personnel permanently stationed onboard the platform. Since the personnel and the equipment available are currently conceived to perform O&M tasks for the aquaculture sector, it is necessary to consider specificly energy related training for the technicians to perform the required tasks.

It is recommended to introduce legislation and guidance for the training of multi-disciplinary offshore wind and aquaculture personnel operating in the multi-use platform environment.

As for environmental effects the Green and Blue ICS Concept (Crete) is not expected to have very critical detrimental effects on the environment, because the existing environment is not of extremely high sensitivity. However, the water is phosphorus-limited and the deposits and remains from the fish aquaculture may result in a boost of local primary production due to phosphorous input.

4.3.3 Sustainable Service Hub ICS Concept

As can be observed from the presented cases in the section 4.1.6, the Global Tech 1 floating substation, the Fukushima Kizuna floating substation and the Wind-Sea mothership share many features with the Sustainable Service Hub ICS Concept. However, there are still some differences and the consequences for the legislation and regulation are outlined below.

The most important difference between the Wind-Sea mothership and the Sustainable Service Hub ICS Concept is that the mothership has no substation onboard. The legislation and regulation of an offshore wind mothership, and in particular legislation and regulation that are related to the impact of motions on substation components, power cables, cable connectors and risers, have some gaps.

The most important gaps are the survivability and structural integrity of the platform itself, operability and safety of the built-in electrical components (especially the liquid-filled transformers) as well as survivability and durability of the attached power cables, cable connectors and risers.

It is recommended to adobt relevant guidelines for design standards, legislation and regulation for the Fukushima Kizuna and the Global Tech 1 taking scale differences into consideration.

Floating platforms can and will be moving when they are affected by waves, wind, and current induced motions. These circumstances lead to an increased need for a highly specialised training of crane operators, banksmen, and any other involved supporting personnel, including those on board of the supply vessel in question.

It is recommended to develop specialised training and safety programs for the offshore floating platforms, which will match the dynamic and challenging environment in which the ICS concepts are expect to placed in.

4.3.4 Green and Blue/Sustainable Service Hub ICS Concepts

According to the investigation carried out in TROPOS D5.5 (2014), no standardised trainings and certification processes could be identified that would qualify a dedicated offshore wind service technician. Such trainings are, however, in place in the offshore O&G industry.

For the Green and Blue and the Sustainable Service Hub ICS Concepts, it is recommended to adopt and adapt existing training, qualification, and certification schemes which are in place within the offshore O&G industry.

5 FINANCE

The purpose of this chapter is to provide recommendations for each of the ICS concept with regard to financing. The recommendations are based on an analysis of existing support mechanisms and their applicability to the ICS concepts. The first section provides an introduction to support mechanisms in general, followed be an analysis for each ICS concept. Finally, the recommendations are presented.

The analysis considers TROPOS D5.2, D5.3 and D5.4 (2014), providing the macro- and micro-economic analysis as well as an LCA analysis for the carbon footprint. While the micro-economic analysis indicates the need for support, the macro-economic analysisanalysis along with the LCA provide the arguments for supporting.

The recommendations in this section focus on the opportunities to make the three ICS concepts economically viable.

5.1 General Support Mechanisms

Emerging technologies are often supported as the new technologies which have not yet reached market maturity. In the case of renewable energy, the competing technologies are fossil fuels, whereas for offshore aquaculture the competing technology is onshore aquaculture and the competing technologies for offshore leisure activities are cruise ships, near-shore leisure activities etc.

The main argument for supporting renewable energy sources (RES) is usually environmental issues such as climate change and local air pollution where RES technologies have a clear advantage compared to fossil fuels (TROPOS D5.4 2014). The same argument is applicable for offshore aquaculture which leads to less spread of fish borne diseases, preservation of natural ecosystem biodiversity, effluent from the fish cages would be dispersed over a larger water mass and less use of medications and antibiotics relative to (BAU) in terms of near shore aquaculture (TROPOS D5.4 2014).

Furthermore, emerging technologies are often supported based on the assumption that the investments as well as the longer term operation provide indirect benefits to the society in terms of increased economic activity, employment effects and further spin-offs to the rest of the economy further increasing activities (TROPOS D5.2 2014).

In general, when supporting emerging technologies there is a range of support mechanisms to choose from. The choice of support schemes also depends on, apart from political agendas, the maturity of the technology. First of all, the support will depend on the "activity" being supported, i.e. whether it is Research and Development (R&D), the investments or the output, which is supported. R&D and Demonstration (RD&D) support targets the immature and developing technology and will most often granted as research funding. In case of an immature technology there are high risks associated with the technology. In this case investment support, e.g a capital grants, will be the preferred support tool as it removes the uncertainty from the investor. Additionally, the investment costs are presumably high and the investor would demand very high rate of returns to cover the uncertainty. As the technology matures and the risks associated with the technology diminish price-based incentives such as a feed-in tariff (e.g. a fixed price per output) will be the natural support mechanism. Later, as the technology becomes more ready for more market-exposed variations price-based incentives such as feed-in premium (e.g. a fixed add-up on top of the varying price of the output) is the most relevant support scheme.

5.2 Finance and Support Mechanisms for the ICS Concepts

The purpose of this section is to identify the relevant support mechanism to assure viability of each ICS concept. By taking following on TROPOS D5.2, D5.3 and D5.4 (2014) the necessities as well as the arguments for supporting the ICS concepts are discussed. Types of instruments applied in related onshore or near-shore sectors are analysed and instruments that apply for the ICS concepts are determined. The instruments directed towards the investment costs are identified as well as the instruments targeted towards the income related to the concept. Recommendations are made on this basis.

5.2.1 Common Support Mechanisms – Multi-Use Platforms

This section analyses support mechanisms available for the ICS concepts that are all based on the Multi-Use Platform concept. Some mechanisms will therefore be relevant for all the concepts.

The size of the ICS concepts is in the range of a medium size company (regarding yearly turnover and the number of workers) by the (EU 2014a). Since the EU wishes to increase the number of small and medium sizes companies, this is beneficial for the financing opportunities as it gives easier access to loans and research funding (EC 2011).

R&D support can be given to research opportunities in order to decrease the investment costs of the platform. This is highly relevant as long as the technology is at a rather immature stage, e.g. the technology of a floating platform has not been used in deep sea, and further research is needed. Furthermore, the investment costs can be reduced by offering favourable loans for the cost of the construction of the platform.

The required technical solutions necessary to fulfil the TROPOS platform concept's grid requirements already exist in the offshore O&G sector. Such components and solutions may to some extent be too costly for the newly developed TROPOS concepts. In the long run, the Multi-Use Platform can use the scaling effects, when the demand for such components increases it can lead to standardisation of the manufacturing process which can in turn lead to lower prices. This will decrease the cost for the Multi-Use Platform in general (TROPOS D5.5 2014).

According to TROPOS D5.3 (2014) there are several synergies for the Multi-Use Platforms, which indicates it is desired to increase the number of sectors (Transport, Energy, Aquaculture and Leisure) on one platform to share the investment costs of the platform.

5.2.2 Leisure Island ICS Concept

The Leisure Island ICS Concept provides different services, such as a visitor centre, a hotel, a shuttle, and a dock. These different services will generate income. The assumed prices for the visitor centre, restaurants, bar, party room, accommodation, meeting rooms and swimming pool adds up to the income of 7.75M € per year (TROPOS D5.3, table 22 2014). For the investment to generate a surplus the income should cover the operation costs as well as the investment costs((TROPOS D5.3, 2014). According to TROPOS D5.3 (2014) the income does not cover both operation costs and investment costs and in order to attract investors the Leisure Island Concept needs economic support.

A large investment such as the Leisure Island Concept would generate economic activity in the local area as well as nationally. According to TROPOS D5.2 (2014) investing in the leisure island concept will result in increased economic activity as well as increased employment. These positive economic effects to a certain extent justifies supporting the Leisure Island Concept.

In order to attract investors to the Leisure Island Concept, the profitability of the investment has to be increased. Increasing the profitability can be done by decreasing the investment costs or by increasing the income of the investors.

In Spain, the total travel and tourism contribution to the national gross domestic product (GDP) is above 10 % (EU, 2014b). Specifically, the Canary Islands, the area where the Leisure Island is located, are focusing on the tourism sector and intend to increase the diversity of the offered activities. The Leisure Island Concept will contribute to reaching that goal (Alzola 2014). An increase of tourism in the EU is in line with the EU 2020 policy and there is a chance that it can be supported (EU, 2014b). Tourism activities such as sport tourism are specifically mentioned in the goals. The Leisure Island Concept contains exactly that. Furthermore, the Leisure Island could be used as a tourism magnet, and therefore increase the general tourism in Spain. This would increase the probability that the Government of Spain would support the Leisure Island Concept.

Another target of the EU 2020 policy is to increase the employment in the region. As the investment contributes significantly to the economic activity, the chance of obtaining support increases. Research and innovation, which the visitor centre in the Leisure Island Concept will conduct, also could obtain support. There are previous examples of a visitor centre in Germany obtaining economic support (EU, 2014d), indicating that it is possible to get economic support to this specific part of the Leisure Island.

The PV installed on the platform of the Leisure Island is expected to be a known technology already frequently installed onshore. However, PVs are not competitive at the current state compared to electricity produced using conventional technologies and operation support such as net-metering is a relevant tool to use.

The economic viability of the Leisure Island Concept can be improved by increasing the income of the platform. As economic support for running a hotel is not a possibility, the income could be increased by raising the prices for the services provided and by increasing the rate of luxury or decreasing the luxury, decreasing the operation costs and increasing the number of visitors (TROPOS D5.3 2014).

5.2.3 Green and Blue Concept

The Green and Blue Platform Concept combines aquaculture facilities (both fish and algae) with an offshore wind farm. Selling fish, algae and electricity will generate the revenue for the investors. At the present technological stage, offshore aquaculture in the TROPOS platform setup is not viable in the sense that the potential revenues do not offset the investment and operating costs (TROPOS D5.3, 2014)). Based on the results presented in TROPOS D5.3 (2014) it is plausible to assume that adding a wind farm will not provide the necessary revenue to cover the additional investment costs as well as the loss generated by fish and algae production. In order to attract investors to the Green and Blue platform financial support is required.

Turning a concept such as the Green and Blue platform into reality will require a significant investment from local as well as regional and national companies. Investment ofof that magnitude will generate a positive feedback into the economy and will lead to an increased economic activity as well as increased employment (TROPOS D5.2 2014). The increased economic activity in combination with possible environmental benefits provides the arguments for supporting the technology.

Europe is the largest market for fish across the world and consumption has been increasing over the last decade (STECF 2013). The aquaculture sector in the EU is significant and reached 1.28 million tonnes and 3.51 billion € in 2011 producing a Gross Value Added of more than 1.5 billion € in 2011 (STECF 2013). However, over the last decade the landing of wild fish has stagnated as well as of aquaculture production. This has resulted in an increase of the net import and self-sufficiency has decreased (STECF 2013). The EU aquaculture sector faces a strong competition on the global market, bringing market prices down. Furthermore, high labour and capital costs and administrative burdens are a barrier to the full potential of the EU. Furthermore, as the real price of fish has come down, real incomes have increased and consumers have become more health conscious, causing a positive shift in demand for fish. The demand of fish produced by aquaculture is expected to increase by 29 million tonnes putting a huge pressure on near shore ecosystems. One major advantage from moving aquaculture offshore is environmental issues such as less spread of fish borne diseases, preservation of natural ecosystem biodiversity, effluent from the fish cages would be dispersed over a larger concentration of water and less use of medications and antibiotics relative to business as usual in terms of near shore aquaculture (TROPOS D5.4 2014).

When a new technology such as offshore aquaculture is developed, the technology will take some time to mature and become competitive. One possibility to make this process happen faster is to assure that the technology is deployed by providing financial support. The Common Market Organisation (CMO) and the new European Maritime and Fisheries Fund (EMFF) are organisations which can support business growth through adequate allocation of funds to aquaculture activities including production and marketing plans. Further, they allocate funds to improve the links between R&D and the industry. The European Commission can also play an important role in coordinating and supporting research and innovation for aquaculture through all the relevant EU programmes and funds (European Commission, 2013). Another possibility is tax exemptions. An example is a case where companies investing in R&D are allowed to deduct their expenses, 35 % as expenses to R&D and the remaining 65 % as expenses related to production. This has been used in particular within the aquaculture sector (AQUA, 2014).

The general support to the aquaculture sector in Europe is only for R&D focussing on the technical aspect, the operation function is market based and does not receive economic support (Varadi et al. 2001). Operating support in aquaculture is, however, granted to theto owners with the purpose of improving the sustainability of the production methods. Those traditionally supporting aquaculture have been local communities, national, private, and multilateral banks, governments, multilateral and bilateral agencies, non-governmental organisations, aquaculture associations and cooperatives, aquaculture research institutes, universities, and technical schools and colleges (Anon 2001). The support has mainly been targeted expansion of production facilities, research (including monitoring), disease diagnosis capacity, feed production, hatchery development, processing facilities, market channels, education, training, technical assistance, improving research and extension capacities on technical aspects etc.

As mentioned earlier, renewable energy is often supported on the basis of environmental issues, such as climate change and local air pollution where RES technologies have a clear advantage compared to fossil fuels, as well as the positive impact renewable energy investments have on the economy. Renewable energy is supported worldwide and the need to support RES stems from the fact that the new technologies are not competitive compared to conventional energy technologies such as fossil fuels.

Often used support schemes are investment support, price-based incentives such as feed-in tariff (e.g. a fixed price per kWh) and feed-in premium (e.g. a fixed premium on top of the varying electricity price), green certificate schemes or similar tradable green quotas and finally tendering, which is often applied in cases of larger specific projects, such as offshore wind farms, where the chosen support will be granted as feed-in tariff or premium. All of the mention support mechanisms are used for the offshore and offshore wind farms in different countries, e.g. quota in the UK, feed-in premium in the Netherlands and feed-in tariff in Denmark (Kitzing et al, 2012, CEER 2013).

For an emerging technology such as floating offshore wind there are certain indications that the rapid development within the technology could lead to commercialisation within the next ten years (EWEA 2013), and that Levelised Costs Of Electricity production (LCOE) are comparable with existing jacket foundations from around 50 metres water depths. R&D support is crucial for the technology to approach commercialisation. R&D support includes public funds for research, development, demonstration and financing (ORECCA, 2011). In order to reduce costs there is a need for a large scale development of the technologies through demonstration projects, which should be accompanied by a secure and stable regulatory framework and public R&D financing (EWEA 2013). It has been investigated which support mechanism that has the highest effect on offshore wind turbines (Salvatore et al. 2011). It was found that feed-in tariff and capital investments are the most efficient mechanisms.

The solar PV technology applied on the platform is not expected to differ from the technology already installed on numerous places onshore and the only support suggested for solar PV is operating support. Solar PV is, however, still relatively immature and a feed-in tariff will be the relevant support tool.

In addition to financial attractiveness other conditions also have to be fulfilled in order to attract investors (Salvatore et al. 2011):

- Stable political environment with long-term and consistent policies: if the future policies are unknown, the risk for the project increases, which will decrease the interest of the investors. The lifetime for the ICS concept is 20 years hence it is important that the political scene is stable assuring the needed support mechanisms.
- Required grid connections: both the grid connection to the platform and the internal connection in the country should be able to control intermittent power production from renewable energy sources.
- Favourable power market: the power market in the specific country should be able to use or sell the extra electricity made from the offshore platform. If there is no demand for the extra power the platform will decrease the electricity price, and thereby the economic advantage of the renewable energy will decrease.

5.2.4 Sustainable Service Hub

The Sustainable Service Hub Concept consists of an offshore structure which is focusing on transport and energy related aspects while having the necessary facilities to accommodate the workforces and therefore has capacity to host a large number of people. The Sustainable Service Hub is situated at a distance 124–290 km from shore (TROPOS ICS Concepts - 2014), servicing a 500 MW wind farm. The purpose of the Sustainable Service Hub is to provide operation and maintenance as well as substation for the 500 MW windfarm. The offshore service hub will support the floating offshore windfarm by increasing the number of full load hours and thereby increasing the revenues (TROPOS D5.3 2014). The savings in O&M costs from the platform are expected to balance the O&M costs associated with the offshore service hub. Furthermore, an offshore substation will reduce the losses in transmission and thereby increase revenue.

The income for the owners of the Sustainable Service Hub stems from payment for the operation and maintenance paid by the owners of the windfarm. Considerable expenses must be expected in relation to the accommodation of the workers (TROPOS D5.3 2014). According to TROPOS D5.3 (2014) the income from servicing the windfarm will not be sufficient to cover investment costs as well as costs related to running the Service Hub. There are, however, significant advantages from the Service Hub, such as contributing to a reduced carbon footprint of the offshore farm, as the presence of the Service Hub allows the reduction of shipping traffic between the offshore installation and the shore;service and maintenance operations can be carried out directly from the Service Hub. The decrease in shipping traffic goes along with reduced fuel consumption and emissions to the atmosphere, and reduced risk of accidents and/or unplanned events. Moreover, the service hub will allow a much faster reaction in case of emergency or malfunction (TROPOS Project 2014 and TROPOS D5.4 2014).

Furthermore, as demonstrated in TROPOS D5.2 (2014), investing in the realisation of the Sustainable Service Hub Concept will generate positive feedback throughout the economy, nationally as well as regionally, leading to increased employment and further providing an argument for supporting this emerging technology. The increased economic activity in combination with possible environmental benefits provides the arguments for supporting the technology.

As mentioned above, the company size of the Sustainable Service Hub Concepts is expected to be in the range of a medium size company increasing the opportunities to achieve loans and research funding (European Commission, 2011).

The main costs related to the Service Hub are the investment costs, and in the long run these costs have to be reduced in order to ensure the profitability of the Service Hub. One way to reduce the costs in the long term is by granting R&D support. Furthermore, in the short run investment costs can be reduced by capital grants or favourable loans. MoreoverBesides, supporting the operation of service could be done through the tax exemptions such that the tax of selling the product (O&M of the windfarm) is reduced. The possible profit from the platform will thereby increase, which will attract investors.

As described in Section 3.2.3, there are certain challenges connected to floating offshore substations. To reduce these challenges in the long run R&D support is a relevant tool.

Apart from the security, to achieve a positive return on the investment a list of conditions should be fulfilled (Salvatore et al. 2011):

- A political environment with long-term and consistent policies taking the lifetime of the technology into account. The profitability and thereby the realisation of the Service Hub are dependent on investments in offshore wind, and are thus dependent on the long-term plans for supporting renewable energy.
- The realisation of the Service Hub is dependent on sufficient grid connections.
- The relevant power market(s) should be able to use or sell the extra electricity from the offshore platform.

The profitability of the Service Hub may increase if the windfarm increases in size to the extent that the Service Hub would not have to enlarge. This would, however, increase the need for personnel on the platform.

5.3 Gaps and Recommendations for Finance and Support Mechanisms

In order to implement any of the ICS concepts a set of common requirements must be in place to attract the possible investors:

- The political situation regarding the renewable energy has to be long term and stable (this applies for the Sustainable Service Hub and for the Green-Blue ICS Concepts).
- Clear roles and responsibilities of various stakeholders in the involved sectors must be set.
- A significant large power market must exists with a sufficiently high electricity demand (except for the

Leisure Island ICS Concept).

- Grid connection both from the platform and in the countries importing the electricity is required.

From the analyses in the sections 5.2.2, 5.2.3 and 5.2.5 a set of the recommendations regarding financing and support mechanisms for the ICS concepts were identified. They are given in the following sections.

5.3.1 Leisure Island ICS Concept

For attracting investors to the Leisure Island ICS Concept the investment costs have to be reduced and the income must be increased. Important aspects are the sports facilities, the visitor centre as well as the general support for tourism and in particular for small and medium size firms in the EU.

It is recommended that relevant authorities provide favourable loans to organisations building the first multi-use platform. R&D support for innovations should be granted with the purpose of performance improvements, increased reliability and long-term production of multi-use platforms.

To improve the profitability of the MUP it is recommended that relevant authorities grant tax exemptions to the operation of the MUP as well as supporting the installed PV by net-metering.

In order to improve the profitability it is recommended to grant support for education and research for the maritime sector connected to the visitor centre.

5.3.2 Green and Blue Island ICS Concept

To increase the interest from investors the Green and Blue Island ICS Concept must be developed further in terms of investment costs as well as O&M. As offshore wind and PV as well as offshore aquaculture contribute positively to the environment further R&D support should be granted. Furthermore, investment costs should be reduced alongside an increase in the income to the MUP owners.

It is recommended to provide favourable loans to organisations building the first floating offshore wind farms in connection to the MUP. Providing R&D support for innovations should result in performance improvements, increased reliability and long-term production of floating offshore wind farms.

It is recommended that the relevant authorities provide operation support for the electricity produced by PV in terms of a feed-in premium and for the electricity produced by the wind farm in terms of a feed-in tariff.

It is recommended to provide favourable loans to organisations developing the first offshore floating aquaculture in connection to the MUP. Providing R&D support for innovations should result in performance improvements, increased reliability and long-term production of floating aquaculture.

To decrease the cost of offshore floating aquaculture it is recommended to provide tax exemptions on the sale of the product (volume).

To increase the attractiveness for investors and optimising and simplifying administrative legal procedures is recommended.

5.3.3 Sustainable Service Hub Concept

An offshore service hub contributes significantly to the reduction of the ecological footprint as well as the economic viability of a deep sea offshore windfarm. However, in order to attract investors, further R&D is needed. Additionally, the investment costs should be reduced in combination with tools increasing the income of the owners.

By providing R&D support for innovations performance improvements, increased reliability and long-term production of floating offshore service hub is expected. It is recommended to provide favourable loans to organisations developing the first floating offshore service hub. In order to increase the profitability it is recommended that the relevant authorities provide tax exemptions for the income of the floating offshore service hub.

6 SYNERGIES

In this section the expected synergies will be identified by analysing the integrated TEALs within each ICS concept. It is important to understand that synergies stand for the combined work of the TEALs on the platform that will bring an increased performance for each ICS concept.

The expected synergies regarding hard and soft infrastructure and finance will be pointed out from the previous Chapters 3, 4 and 5, and discussed later on how they will impact on the ICS concepts.

6.1 Leisure Island ICS Concept

6.1.1 Soft Infrastructure

For the Leisure Island ICS Concept synergies were identified between both energy and leisure were identified regarding personnel training. The required personnel training for fulfilling occupational safety requirements and for performing operational task – e.g. O&M for electric equipment for running the facilities and the PV plant – is expected to be the same according to the STCW. This will reduce the number of required electricians.

6.2 Green and Blue ICS Concept

6.2.1 Hard Infrastructure

The concepts are expected to have synergies regarding multi-task vessels, docks and grid connection:

- Offshore diving boat (Polar circle diving 820): this boat will perform different tasks from fish and algae underwater inspections to transport of personnel between the central unit and the satellites.
- Cabin work boat (Polar circle cabin 920): this boat will perform tasks from fish and algae O&M (inspections, net cleaning) to transport of personnel between the central unit and the satellites.
- The dock required will be used for mooring passenger vessels which will bring the personnel for the operation of the fish/algae farms and the wind farm.
- The grid connection will supply electricity to on shore and for the operation of the process plants which will be on the MUP.

The mentioned synergies will bring benefits to the MUP operator, for instance, multi-task vessels will allow to transport technical personnel from shore to the MUP for performing O&M tasks when catamaran is not available because of a breakdown. Another benefit is that since the grid connection will join shore and the MUP, there is no need to install a power generator onboard.

6.2.2 Soft Infrastructure

For the Green and Blue ICS Concept synergies were identified regarding personnel training, between both aquaculture and offshore wind energy sectors were identified.

- Performing lifting operations such as lifting of the fish cages and spares for the wind farm, the required personnel training is expected to some extent to be similar, as in accordance with the HSE (unloading/loading training).

- Performing specific tasks such as O&M of electric equipment in the fish process plant and in the wind farm is expected to require a similar personnel training, in the areas of occupational safety and specific training, according to the HSE.
- Performing diving inspections to detect possible failures in different items such as fish cage structures and wind turbine floaters; it is expected to be performed by the same diver, who will have receivedsimilar training, according to the HSE (diving training).

The mentioned synergies will bring benefits to the MUP operator, particularly the reduction of the required personnel on the MUP and its respective training.

6.2.3 Finance

For the Green and Blue ICS Concept synergies were identified regarding financing in terms of support directed towards developing the platform were identified., Also support directed towards developing the satellite units and increasing the income of the platform owners: synergies were analysed.

- R&D support for developing the platform and thereby reducing long term investment costs.
- R&D support for developing the satellite units and thereby reducing long term investment costs.
- Reducing investment costs in terms of capital grants.
- Providing operating support in terms of tax exemptions to increase the income.

6.3 Sustainable Service Hub ICS Concept

Since the Sustainable Services Hub ICS Concept basically is a single use concept, no synergies have been identified.

7 POLICY RECOMMENDATIONS

This chapter summarises the policy related recommendations from the analysis performed in the Chapters 3.3, 4.3 and 5.3. These recommendations are summariseded up in the *Table 7-1*, *Table 7-2*, *Table 7-3* and *Table 7-4*.

Table 7-1 Recommendations for the Leisure Island ICS Concept

Transport of Passengers, Supplies and Waste on the Selected Vessel:

- *In the long term, large scale production of suitable multi-use vessels, supporting transport of persons, supplies and waste, should be facilitated by relevant authorities and supported by appropriate legislation.*

Regulations for Personnel Training:

- *It is recommended that the relevant policy makers adopt the legislation and regulation with respect to personnel and training that applies for Solstice cruise ship class to cover the Leisure Island ICS Concept.*

Support Mechanisms:

- *It is recommended that relevant authorities provide favourable loans to organisations building the first multi-use platform. R&D support for innovations should be granted with the purpose of performance improvements, increased reliability and long-term production of multi-use platforms.*
- *In order to improve the profitability it is recommended to grant support for education and research for the maritime sector connected to the visitor centre.*

Environmental Management Plan and Monitoring:

- *It is recommended to apply appropriate legislation for monitoring strategies and efficient management plans, to minimise any negative environmental impacts on the Leisure Island surroundings.*

Table 7-2 Recommendations for the Green & Blue ICS Concept

Mass Production of Satellites Units:

- *It is recommended to investigate how far the dimensions (LOA and beam) of the satellites units floater can be reduced to be manufacturable and maintainable in mass at more shipyards worldwide.*
- *Provision of docks facilities that can manufacture large scale constructions, such as the Satellite Units in the Green and Blue ICS Concept should be provided by relevant authorities supported by suitable legislation.*

Increased Skill Requirements for Technicians:

- *It is recommended to introduce legislation and guidance for the training of multi-disciplinary offshore wind and aquaculture personnel operating in the multi-use platform environment.*

Support Mechanisms:

- *It is recommended to provide favourable loans to organisations building the first floating offshore wind farms in connection to the MUP. Providing R&D support for innovations should result in performance improvements, increased reliability and long-term production of floating offshore wind farms.*
- *It is recommended that the relevant authorities provide operation support for the electricity produced by PV in terms of a feed-in premium and for the electricity produced by the wind farm in terms of a feed-in tariff.*
- *It is recommended to provide favourable loans to organisations developing the first offshore floating aquaculture in connection to the MUP. Providing R&D support for innovations should result in performance improvements, increased reliability and long-term production of floating aquaculture.*
- *To decrease the cost of offshore floating aquaculture it is recommended to provide tax exemptions on the sale of the product (volume).*
- *To increase the attractiveness for investors and optimising and simplifying administrative legal procedures is recommended.*

Table 7-3 Recommendations for the Sustainable Service Hub ICS Concept

Comparability of the Sustainable Service Hub ICS Concept with Substation Module(s):

- *It is recommended to adobt relevant guidelines for design standards, legislation and regulation for the Fukushima Kizuna and the Global Tech 1 taking scale differences into consideration.*

Personnel training and Safety:

- *It is recommended to develop specialised training and safety programs for the offshore floating platforms, which will match the dynamic and challenging environment which the ICS concepts.*

Support Mechanisms:

- *By providing R&D support for innovations performance improvements, increased reliability and long-term production of floating offshore service hub is expected. It is recommended to provide favourable loans to organisations developing the first floating offshore service hub. In order to increase the profitability it is recommended that the relevant authorities provide tax exemptions for the income of the floating offshore service hub.*

Table 7-4 Recommendations for the Green & Blue / Sustainable Service Hub ICS Concepts

Necessity of in situ Maintenance of Floating Wind Turbines (Lack of Vessels):

- *For in situ maintenance of the large scale constructions it is recommended to facilitate the development of appropriate vessels through appropriate legislation, financial support and a well-documented business plan.*

Grid Connection of Floating Wind Turbines:

- *It is recommended to develop the necessary grid connection technology for floating ICS platforms enabled by relevant authorities and R&D financial support.*

Standardised Training and Certification for Offshore Wind Service Technicians:

- *For the Green and Blue and the Sustainable Service Hub ICS Concepts, it is recommended to adopt and adapt existing training, qualification, and certification schemes which are in place within the offshore O&G industry.*

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9 ACRONYMS

ID	Abbreviation	Full name
1	TEAL	Transportation, Energy, Aquaculture, Leisure
2	ICS	Interdisciplinary Cohesion Subcommittee
3	MUP	Multi-Use Platform
4	LCA	Life Cycle Assessment
5	EIA	Environmental Impact Assessment
6	ELI	Economic, Lifecycle, and Infrastructure
7	OTEC	Ocean Thermal Energy Conversation
8	PESTEL	Political, Economic, Social, Technological, Environmental, Legal
9	PV	PhotoVoltaic
10	MPV	Multi-Purpose Vessel
11	O&M	Operation and Maintenance
12	ROV	Remotely Operated Vehicle
13	BAU	Business-As-Usual strategy[7]
14	GRT	Gross Registered Tonnage
15	LOA	Length Overall
16	DWT	Deadweight tonnes
17	HVAC	High Voltage Alternating Current
18	HVDC	High Voltage Direct Current

[7] In this report the BAU strategy is the same as the "return-to-port" strategy – as defined in the TROPOS D5.4 LCA report.

19	FAO	Food and Agriculture Organization
20	O&G	Oil and Gas
21	XLPE	Cross-Linked PolyEthyline
22	EWEA	European Wind Energy Association
23	RES	Renewable Energy Sources
24	GDP	Gross Domestic Product
25	PTV	Personal Transfer Vessel
27	AC	Alternating Current
28	DC	Direct Current
29	MOAB	Mobile Offshore Application Barge
30	CSBC	China Shipbuilding Corporation
31	kV	Kilovolt
32	MVA	Megavolt Ampere
33	MW	Megawatt
34	IPIECA	International Petroleum Industry Environmental Conservation Association
35	HSE	Health and Safety Executive (in the UK)
36	HPI	Health Performance Indicator
37	LED	Light Emmiting Diode
38	API	American Petroleum Institute
39	kWh	Kilowatt hour

10 APPENDIX

a) Standards, Regulation and Legislation Related to the Leisure Island ICS Concept:

Health and safety regulations:

· R.D 486/1997, April 14, the minimum health and safety requirements set out in the workplace.

· R.D 1215/1997, July 18, laying down minimum safety and health requirements for the use by workers of the teams are set.

Fire-Fighting regulations:

· Building Code. 2006. (R.D.314-of March 17, 2006).

· Fire Safety Regulations in the Industrial Platform (RD 226 / / 2004 of 3 December).

· Regulation of Fire Protection Facilities (RD 1.942/1.993).

Electrical installation regulations:

· Low Voltage Electrotechnical Regulations according to decree 842/2002 dated the MIE August 2, 2002.

· Regulations for Electrical Checks and Regularity of Energy Supply as MIE decree dated 12 Mar.54 (BOE 15 Abr.54 7 Abr.79, 6 Jun.79).

· Regulation and Safety at Work by decree 432/1971 of 11 Mar.71 Ministry of Labour and by 9 Mar.71 General Ordinance and safety at work is approved.

Rules on Installing Plumbing and Sanitation Network:

· Building Code. 2006. (R.D.314-of March 17, 2006)

b) Standards, Regulation and Regislation Related to the Green & Blue ICS Concept:

Green & Blue 'Crete': Boat factory related Health & Safety regulations

· Canadian Food Inspection Agency-Food-Fish and seafood-Compliance and Assessment Guide for Schedule I and II of the Fish Inspections Regulations-Chapter 6-Vessels

· (EC) 852/2004 Regulation on the hygiene of foodstuff (Annex II)

· (EC) 853/2004 Regulation on specific hygiene rules for food of animal origin

· (EC) 854/2004 Regulation on official controls on foods of animal origin

· (EC) Council Directive 2002/99 on animal health and General principles of Certification

· (EC) 882/2004 Regulation on official controls for feed and food, animal health and animal welfare rules

· (EC) 2073/2005 Regulation on microbiological criteria for foodstuffs and feed production

· (EC) 2074/2005 Regulation implementing measures for Hygiene Package Regulations and models of certificates

Green & Blue 'Crete': Boat factory related design standards

· American Bureau of Shipping-RULES FOR BUILDING AND CLASSING FLOATING PRODUCTION INSTALLATIONS 2014

· DET NORSKE VERITAS RULES FOR CLASSIFICATION OF SHIPS-Fishing Vessels-PART 5 CHAPTER 6-JULY 2011

· Loyd's-RULES AND REGULATIONS FOR THE CLASSIFICATION OF SHIPS-OTHER SHIP TYPES AND SYSTEMS-JULY 2007-PART 7

· RINA Rules for the Classification of Naval Ships - RINAMIL

· Germanischer Lloyd (GL)- Rules & Guidelines-I-Ship Technology

· Nippon Kaiji Kyokai (ClassNK)- Regulations and Guidance for the classification and registry of ships (2014 Edition)

· Russian Maritime Register of Shipping (RS)-RULES FOR THE CLASSIFICATION AND CONSTRUCTION OF SEA GOING SHIPS

Green & Blue 'Crete': floating offshore fish farm related Health & Safety regulations

· Environmental, Health, and Safety Guidelines, AQUACULTURE, International Finance Corporation

· Code of Conduct for European aquaculture, the Federation of European Aquaculture Producers (FEAP) 1999

· FAO Code of Conduct for Responsible Fisheries:

· Health and safety on floating installations fish farm, Health and Safety Executive

· The Health and Safety at Work etc Act 1974

· Health and Safety (First Aid) Regulations 1981

· Diving at Work Regulations 1997

· Loading and Unloading of Fishing Vessels Regulations 1988

· Electricity at Work Regulations 1989

· Management of Health and Safety at Work Regulations 1999

· Workplace (Health, Safety and Welfare) Regulations 1992

· Provision and Use of Work Equipment Regulations 1998

· Lifting Operations and Lifting Equipment Regulations 1998

· Personal Protective Equipment at Work Regulations 1992

· Manual Handling Operations Regulations 1992

· Control of Substances Hazardous to Health Regulations 1999

· Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995

Green & Blue 'Crete': floating offshore fish farm related design standards

· NYTEK – National Norwegian regulations (Government)-Define and describe the system – certification,

· NS (Norwegian Standards) 9415-Marine fish farms Requirements for design, dimensioning, production and operation

· BAP (Best Aquaculture Practices) Standards- Global Aquaculture Alliance (GAA)

- NS 470:1969 Rules for design and fabrication of welded steel structures
- NS 2905:1975 Fishing nets – Netting – Basis terms and definitions (translation of ISO 1107:1974)1)
- NS 3471:1973 Aluminium structures – Design rules
- NS 3472:2001 Steel structures – Design rules
- NS 3473:1992 Concrete structures – Design rules
- NS 3490:1999 Design of structures– Requirements to reliability
- NS 3491-4:2002 Design of structures – Design actions – Part 4: Wind loads
- NS 3622:1986 Polyethylene pressure pipes (PE)
- NS 6082:1979 Marine industry – Deck and bulkhead pieces of pipe with threads for plastic pipes
- NS 9410:2000 Environmental monitoring of marine fish farms (Corrigendum AC:2000 incorporated)
- NS 9422:1998 Water quality – Guidelines for sediment sampling in marine areas
- NS 9425-1:1998 Oceanography – Part 1:Current measurement at fixed points
- NS 9425-2:2003 Oceanography – Part 2: Current measurement using ADCP
- NS-EN 287-1:1992+A1 Approval testing of welders – Fusion welding – Part 1: Steels (Amendment A1:1997 included)
- NS-EN 287-2:1992+A1 Approval testing of welders – Fusion welding – Part 2: Aluminium and aluminium alloys (Amendment A1 included)
- NS-EN 288-1:1992+A1 Specification and approval of welding procedures for metallic materials – Part 1: General rules for fusion welding (Amendment A1:1997 included)
- NS-EN 288-2:1992+A1 Specification and approval of welding procedures for metallic materials – Part 2: Welding procedure specification for arc welding (Amendment A1:1997 included)
- NS-EN 288-3:1992+A1 Specification and approval of welding procedures for metallic materials – Part 3: Welding procedure tests for arc welding of steels (Amendment A1:1997 included)
- NS-EN 1090-1 Specification and approval of welding procedures for metallic materials. Welding procedure tests for the arc welding of aluminium and its alloys
- NS-EN 473 Non-destructive testing - Qualification and certification of NDT personnel - General principles
- NS-EN 696:1995 Fiber ropes for general service. Polyamide
- NS-EN 697:1995 Fiber ropes for general service – Polyester
- NS-EN 698:1995 Fiber ropes for general service – Manila and sisal
- NS-EN 699:1995 Fiber ropes for general service– Polypropylene
- NS-EN 818-1:1996 Short link chain for lifting purposes - Safety - Part 1: General conditions of acceptance
- NS-EN 818-3:1999 Short link chain for lifting purposes. Safety. Medium tolerance chain for chain slings. Grade 4
- NS-EN 1677-2:2000 Components for slings - Safety - Part 2: Forged lifting hook with safety latch-ratio 8

- NS-EN 1677-3:2001 Components for slings. Safety. Forged steel self-locking hooks. Grade 8
- NS-EN 1677-4:2000 Components for slings. Safety. Forged steel components, Grade 8
- NS-EN 12201-2:2003 Plastic piping systems for water supply. Polyethylene (PE). Pipes
- NS-EN 13173:2001 Cathodic protection for steel offshore floating structures
- NS-EN ISO 1806:2003 Fishing nets - Determination of mesh breaking force of netting (ISO 1806:2002)
- ISO 1704:1991 Shipbuilding – Stud-link anchor chains
- ISO 3790:1976 Fishing nets – Determination of elongation of netting yarns
- DIN 53842-1:1976 Testing of Textiles; knot tensile test for single and plied yarns
- DIN 53842-2:1976 Testing of textiles; knot tensile test for netting yarns for fishing yarns

Green & Blue 'Crete': floating offshore algae farm related Health & Safety regulations

- USDA (United States Department of Agriculture) Animal and Plant Health Inspection Services -Regulations
- EPA (environmental Protection Agency) laws and regulations
- FDA (United States Food and Drug Administration) Good Manufacturing Practices –Regulations

Green & Blue 'Crete': floating offshore algae farm related design standards

- Algae Biomass Organization (ABO)- Technical Standards
- Renewable Fuels standards
- NIH (United States National Institutes of Health) Office of Biotechnology Activities-Guidelines

Green & Blue 'Crete': floating offshore wind farm related Health & Safety regulations

Code of Federal Regulations	
29 CFR Part 1910	Occupational safety and health standards
30 CFR Part 585	Renewable energy alternate uses of existing facilities on the outer continental shelf
33 CFR Part 67	Aids to navigation on artificial islands and fixed structures
33 CFR Parts 140 to 147	Outer continental shelf activities
33 CFR Part 322	Permits for structures or work in or affecting navigable waters of the United States

Federal Aviation Administration	
FAA AC70/7460-1K	Obstruction marking and lighting
FAA AC150/5390-2C	Heliport design
U.S. Coast Guard	
USCG COMDTINST M16672.2D	Navigation rules international-inland

Green & Blue 'Crete': floating offshore wind farm related design standards

American Institute of Steel Construction (AISC)	
AISC 335-89	Specification for structural steel buildings—Allowable stress design and plastic design
American National Standards Institute (ANSI)	
ANSI/ICEA S-93-639/ NEMA WC 74	5–46 kV Shielded power cable for use in the transmission and distribution of electric energy
ANSI/ICEA S-94-649	Standard for concentric neutral cables rated 5–46 kV
ANSI/ICEA S-97-682	Standard for utility shielded power cables rated 5–46 kV
American Petroleum Institute (API)	
API Bull 2HINS	Guidance for Post-hurricane Structural Inspection of Offshore Structures

API Bull 2INT-DG	Interim Guidance for Design of Offshore Structures for Hurricane Conditions
API Bull 2INT-MET	Interim Guidance on Hurricane Conditions in the Gulf of Mexico
API Bull 2U	Stability Design of Cylindrical Shells
API Bull 2V	Design of Flat Plate Structures
API RP 2A-WSD	Planning, Designing and Constructing Fixed Offshore Platforms—Working Stress Design
API RP 2FPS	Recommended Practice for Planning, Designing, and Constructing Floating Production Systems
API RP 2GEO/ISO 19901-4	Geotechnical and Foundation Design Considerations
API RP 2I	In-service Inspection of Mooring Hardware for Floating Structures
API RP 2MOP/ISO 19901-6	Marine Operations, Petroleum and natural gas industries specific requirements for offshore structures-Part 6: Marine Operations
API RP 2N	Planning, Designing and Constructing Structures and Pipelines for Arctic Conditions
API RP 2SK	Design and Analysis of Station-keeping Systems for Floating Structures
API RP 2SM	Recommended Practice for Design, Manufacture, Installation, and Maintenance of Synthetic Fiber Ropes for Offshore Mooring
API RP 2T	Recommended Practice for Planning, Designing and Constructing Tension Leg Platforms
API RP 2X	Ultrasonic and Magnetic Examination of Offshore Structural Fabrication and

	Guidelines for Qualification of Technicians
API RP 2Z	Preproduction Qualification for Steel Plates for Offshore Structures
API RP 95J	Gulf of Mexico Jack-up Operations for Hurricane Season—Recommendations
API Spec 2B	Specification for the Fabrication of Structural Steel Pipe
API Spec 2F	Mooring Chain
API Spec 2H	Specification for Carbon Manganese Steel Plate for Offshore Platform Tubular Joints
API Spec 2MT1	Specification for Carbon Manganese Steel Plate with Improved Toughness for Offshore Structures
API Spec 2MT2	Rolled Shapes with Improved Notch Toughness
API Spec 2SC	Manufacture of Structural Steel Castings for Primary offshore Applications
API Spec 2W	Specification for Steel Plates for Offshore Structures, Produced by Thermo-Mechanical Control Processing (TMCP)
API Spec 2Y	Specification for Steel Plates, Quenched-and-Tempered, for Offshore Structures
Bundesamt für Seeschifffahrt und Hydrographie (BSH)	
BSH 2008	Ground Investigations of Offshore Wind Farms
BSH 2003	Standard for Geotechnical Site and Route Surveys- Minimum Requirements for the Foundation of Offshore Wind Turbines

International Electrotechnical Commission (IEC)	
IEC 61400-1	Wind turbines—Part 1: Design requirements
IEC 61400-3	Wind turbines—Part 3: Design requirements for offshore wind turbines
IEC 61400-11	Wind turbine generator systems—Part 11: Acoustic noise measurement techniques
IEC 61400-12-1	Wind turbines—Part 12-1: Power performance measurements of electricity producing wind turbines
IEC/TS 61400-13	Wind turbine generator systems—Part 13: Measurement of mechanical loads
IEC/TS 61400-14	Wind turbines—Part 14: Declaration of apparent sound power level and tonality values
IEC 61400-21	Wind turbines—Part 21: Measurement and assessment of power quality characteristics of grid connected wind turbines
IEC 61400-22	Wind turbines—Part 22: Conformity testing and certification
IEC/TS 61400-23	Wind turbine generator systems—Part 23: Full-scale structural testing of rotor blades
IEC 61400-24	Wind turbines—Part 24: Lightning protection
IEC 61400-25-1	Wind turbines—Part 25-1: Communications for monitoring and control of wind power plants—Overall description of principles and models
IEC 61400-25-2	Wind turbines—Part 25-2: Communications for monitoring and control of wind power plants—Information models

IEC 61400-25-3	Wind turbines—Part 25-3: Communications for monitoring and control of wind power plants—Information exchange models
IEC 61400-25-4	Wind turbines—Part 25-4: Communications for monitoring and control of wind power plants—Mapping to communication profile
IEC 61400-25-5	Wind turbines—Part 25-5: Communications for monitoring and control of wind power plants—Conformance testing
IEC 61400-25-6	Wind turbines—Part 25-6: Communications for monitoring and control of wind power plants—Logical node classes and data classes for condition monitoring
IEC/TS 61400-26-1	Wind turbines—Part 26-1: Time-based availability for wind turbine generating systems

International Standards Organization (ISO)	
ISO 19900	General requirements—Petroleum and natural gas industries
ISO 19901-1	Met-ocean design and operating considerations
ISO 19901-2	Seismic design procedures and criteria
ISO 19901-3	Topsides structures
ISO 19901-4/API RP 2GEO	Geotechnical and foundation design considerations
ISO 19901-5/API RP 2MOP	Weight control during engineering and construction
ISO 19901-6	Marine operations

ISO 19901-7	Station keeping systems for floating offshore structures and mobile offshore units
ISO 19902	Fixed steel offshore structures
ISO 19903	Fixed concrete offshore structures
ISO 19904-1	Floating offshore structures—monohulls, semisubmersibles and spars
ISO 19904-2	Floating offshore structures—tension leg platforms
ISO 19905-1	Site specific assessment of mobile offshore units—Part 1: Jack-ups
ISO 19905-2	Site specific assessment of mobile offshore units—Part 2: Jack-ups : Commentary and detailed sample calculation
ISO 19905-3	Site specific assessment of mobile offshore units—Part 3: Floating units
ISO 19906	Arctic offshore structures
ISO 81400-4	Wind turbines—Part 4: Design and specification of gearboxes

c) Standards, regulation and legislation related to the Sustainable Service Hub ICS Concept:

Module 1: Maintenance Base

· **IMO 2000 HSC Code**: A complete set of comprehensive requirements for high-speed craft, including equipment and conditions for operation and maintenance, by the International Maritime Organization (IMO).

· **MCA Area Category 2 & 3 codes**: A construction standard for PTVs by the British Maritime & Coastguard Agency (MCA). According to source [4CO14b] currently over 50 % of PTVs operated in Europe are coded to the MCA Cat. 2 code. This code allows vessel operations up to 60 nm from a safe port or harbour. However, for the TROPOS platform concepts vessels coded MCA Category 3 for operating in up to only 20 nm distance to a harbour are sufficient.

· **DNV GL Wind Farm Service Vessels (WFSV) 1 & 2**: A construction standard for PTVs servicing offshore wind farms. The first part "Wind Farm Service 1" is for vessels carrying up to 12 passengers or technicians and up to a load length of 24 m. The second part "Wind Farm Service 2" is for vessels of unrestricted size and passenger/technician complement. In the case of Wind Farm Service 2 the rules address only hull strength, machinery, electrical systems, control and monitoring, cargo handling systems, stability, weather tight and watertight integrity.

· **IMCA SEL 025 Rev. 1 / IMCA M 202 Rev. 1**: Guidance on the transfer of personnel to and from offshore vessels and structures by the the International Marine Contractors Association (IMCA).

· **OGUK Best Practice for the Safe Packing and Handling of Cargo to and from Offshore Locations**: A guidance document by Oil and Gas UK (OGUK).

Module 2: Substation

In terms of AC cables, the standardisation of system voltages has not been achieved worldwide although there is some move towards this. IEC has published voltage designations, which are approaching universal acceptance particularly among European countries.

There is not any globally accepted definition of voltage classes as low voltage, medium voltage and high voltage. Therefore, the usual specification of the voltage rating is preferred. However, catalogues of the suppliers of power cables typically consider medium voltage designs all the ones included between 3 kV and 20 kV of nominal voltage.

Some standards that are of interest in the context of the Sustainable Service Hub are as follows:

· **GL Rules for the Certification and Construction IV-7-3: Offshore Substations**: Rules published by Germanischer Lloyd (GL) covering Risk Assessment / Hazard Identification, Marking Platform, Means of Escape and Evacuation, Live-Saving Appliances, Access and Transfer, Fire Safety and Fire and Gas Detection Alarm Systems of offshore substations.

· **DNV-OS-J201**: Offshore Standard published by Det Norske Veritas (DNV) regarding offshore substations for wind farms.

· **IEC 60092: "Electrical installations on ships":** this standard gives the main system design features of electrical installations in ships, with special attention paid to cable construction, testing and installation. It also provides useful guidelines for low-voltage submarine power cables design adapted to wave energy converters. However, care should be taken in applying the ratings specified in this reference since different operational and environmental conditions are to expected in umbilical cables.

· **API IEEE Std. 1120-2004: "Guide for the Planning, Design, Installation, and Repair of Submarine Power Cable Systems":** this document gives an exhaustive list of the numerous aspects to be taken into account for the planning, design, installation and repair of submarine power umbilicals. It also provides useful recommendations related to cables installation techniques, quality assurance, operation and faults detection.

Module 3: Helipad:[KA2]

· **ICAO publication Annex 14 Volume 2**: international standard for helidecks laid out by the International Civil Aviation Organisation (ICAO).

· **EASA Air Operations Regulation**: regulation on Air Operations by the European Aviation Safety Agency (EASA).

· **CAP 437**: standards for Offshore Helicopter Landing Areas by the British Civil Aviation Authority (CAA).

· **NORSOK BSL D 5-1**: Norwegian Oil and Gas Recommended Guidelines for Flights to Petroleum Installations by the Norwegian Civil Aviation Authorities NORSOK (CAA-N).

Module 4: Accommodatio :

HSE Guidance for the provision of accommodation offshore – Operations Notice 82

Supplementary guidance on the provision of accommodation on offshore installations by the British Health and Safety Executive (HSE).

HSE Offshore accommodation standards men and women sharing cabins – Operations Notice 77

This notice explains HSE's policy and role in the inspection and enforcement of the requirement for separate cabins for men and women on offshore installations.