



# Swappable Container Waterborne Transport Battery

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Reducing the Cost of Large Batteries for Waterborne Transport

D2.3

Recommendations Ship & Shore Interfaces

1 April 2021



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## GLOSSARY OF TERMS

Term	Definition
BMS	Battery management system
CD	Current Direct
CD.ESS	Current Direct Energy Storage System
EaaS	Energy as a Service
EMS	Energy management system
F&G	Fire and Gas
FCR	Frequency Containment Reserve
FiFi	Firefighting
Inland Waterway Vessel	A vessel intended solely or mainly for navigation on inland waterways
Motor cargo	A vessel, other than a motor tanker, intended for the carriage of goods
Motor tanker	A vessel intended for the carriage of goods in fixed tanks.
Passenger vessel	A day trip or cabin vessel constructed and equipped to carry more than 12 passengers
PCS	Power Conversion System
PMS	Power management system
Pusher	A vessel specially built to propel a pushed convoy
Short Sea Shipping	Maritime transport between ports in mainland Europe
SOC	State of charge
SOH	State of health
Tug	A vessel specially built to perform towing operations
Volume Production	An annual production of 500MWh

## DOCUMENT PROPERTIES

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## REVISION HISTORY

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## PROJECT SUMMARY

Current Direct, a new research and innovation project funded by the European Commission’s Horizon 2020 program, will revolutionize the way we move goods and people by water. The vast majority of water transport in Europe is propelled by dirty, noisy diesel engines. By cutting the cost of today’s marine battery electric drivetrains in half and relieving ship owners of the burden of capital expense, Current Direct will enable rapid adoption to reduce greenhouse emissions.

Current Direct’s innovative Energy as a Service platform will enable ship owners to accelerate their participation in the shift to clean energy while creating new business opportunities for shipyards and local entrepreneurs. By changing the model for acquiring and storing energy aboard vessels, Current Direct will create a new energy economy, adding thousands of new jobs. Current Direct provides a vehicle for energy companies, institutional investors, and government stakeholders to participate in the green transformation of Europe’s merchant and passenger fleet.

Current Direct brings together thirteen dynamic partners from across Europe’s marine electrification value chain. The project is led by Spear Power Systems, makers of the world’s lightest, most flexible marine batteries certified to the most stringent international safety standards. Blackstone Technology is lowering the cost of manufacturing tomorrow’s 3D printed lithium-ion cells using state of the art active materials from Umicore. The University of Hasselt will use its electrochemical expertise to develop physics-based models of the Current Direct cells that will help optimize the life and return on investment of battery systems deployed across Europe as part of the Current Direct Energy as a Service platform developed by the accomplished engineers and data scientists at Rhoé Urban Technologies and Aviloo. Naval architecture and marine engineering company Foreship will lend its expertise to EDP CNET’s in depth knowledge of electrical markets to ensure the Current Direct platform targets optimal vessels and locations maximizing reductions in emissions. VUB’s material science experts are creating low-cost composites to improve the safety of battery packs that are designed for recyclability and feature VITO’s smart cell monitoring electronics. Wärtsilä will develop modular battery containers and charging infrastructure that will be certified to innovative standards developed together with Lloyd’s Register. The project will culminate in a demonstration of the Current Direct battery, shore charging, and asset management platform by Kotug in Rotterdam.

The Current Direct EcoSystem is shown in [Figure 1](#).

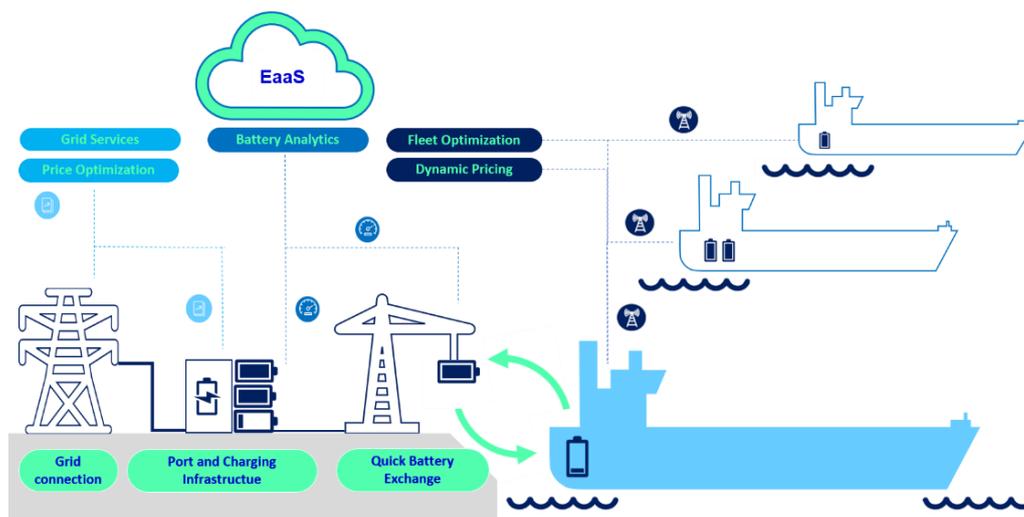


Figure 1. Current Direct EcoSystem

## 1. SPECIFIC OBJECTIVES FOR WORK PACKAGE 2

### 1.1. Introduction

This WP will define the requirements for the two Current Direct technology pillars: the Waterborne Transport Battery and the EaaS platform. This WP will also assess the current state of the Waterborne Transport market to provide inputs for WP6 regarding classification societies, national maritime authorities, independent standards bodies, and de facto commercial standards. It will synthesize the power and energy requirements, operating profiles, and installed propulsion topologies of various vessel types across Europe’s inland waterways and coastal shipping routes. While this work package will generate deliverables D2.1, D2.2 and D2.3 in month M3 to provide a solid baseline for the Phase II Development work, the requirements and specifications will be updated throughout the Development phase until the tasks they feed into reach a design freeze.

Specific Objectives:

- Identify and engage relevant stakeholders to define market technical and financial needs
- Define operational requirements for the Waterborne Battery & supporting vessel infrastructure
- Define business requirements for the EaaS platform
- Define the current state of certification and regulatory frameworks for waterborne transport batteries and analyze opportunities for standardization
- Assess current vessel integration and port electrical infrastructure for battery charging
- Specify design requirements to maximize recyclability of the Current Direct solutions

### 1.2. Capture Methodology Introduction and Description

The owner for work package 2 is Foreship. For gathering information and requirements, a kick-off meeting was held with all the consortium members on January 15<sup>th</sup>, 2021. The process and the methodology were described and agreed during the meeting. The workflow, time schedule and Owners of the different sub-categories was communicated. The common platform for gathering the requirements is Box. Revision handling of documents are done in Box, using a manual methodology.

The main principles of the process for gathering requirements are described in [Figure 2](#).

### Workflow and process

- Workflow (revision and version handling) are described in *CD Requirements Outline*

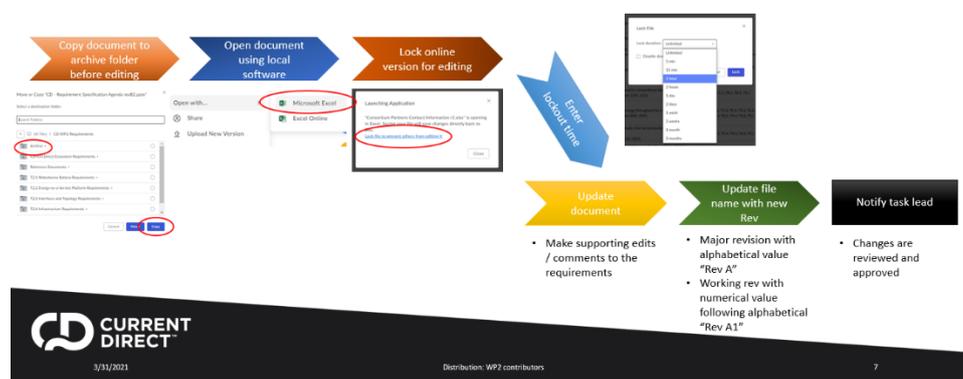


Figure 2. Workflow and Process for Gathering Requirements

### 1.3. Requirement Structure and Information Gathering Principles

#### 1.3.1. Current Direct Requirements Structure Outline Document Description

This document outlines Current Direct’s requirements hierarchy, document lead, content descriptions, file locations, member access rights, and editing rule. The document is saved under the common folder available to all members.

#### 1.3.2. Technical and Financial Requirements

The requirements are broken up into two categories: technical requirements, and financial requirements. Technical requirements are saved at the file locations indicated in the Requirements Hierarchy section below. Financial requirements are located in the member’s folder providing the component or service so financial privacy can be maintained.

### 1.4. Requirements Hierarchy and Relationship

Figure 3 below outlines Current Direct’s requirements hierarchy. The Ecosystem is the highest-level document from which all other requirements are derived from.

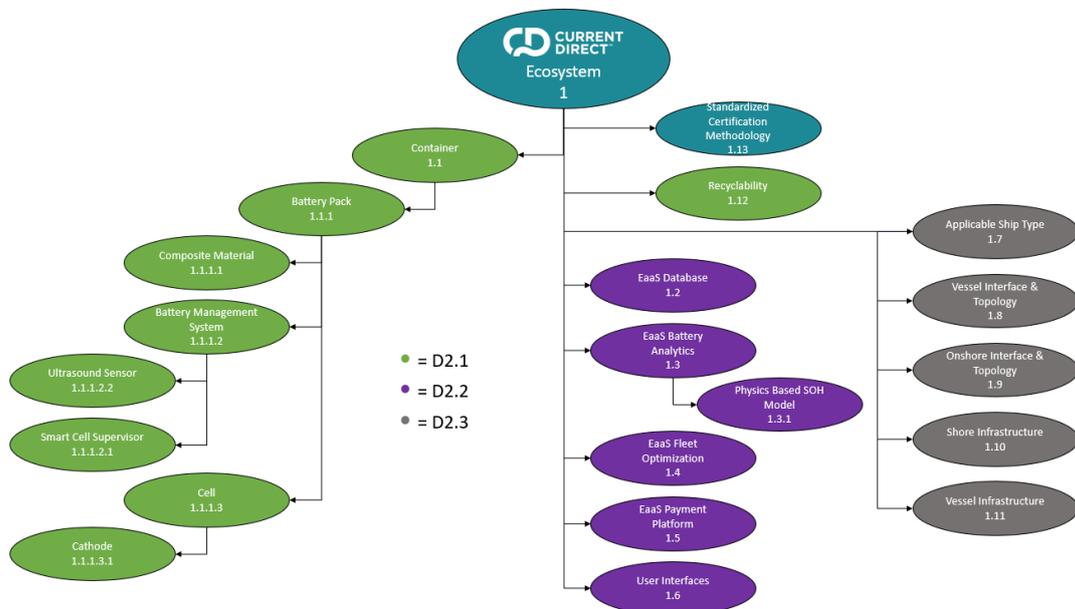


Figure 3. Requirements Hierarchy

Requirement documents are also related to one another independent of the serial hierarchy. This means that a requirement document in one branch of the system can driver or refer to one from a separate branch. An example would be the container interfaces which determine aspects of both the vessel and onshore systems.



## 2. ECOSYSTEM KPI'S

### 2.1. Introduction

Current Direct KPI and lifecycle considerations are gathered in a separate document called Ecosystem requirement, where KPI's are described. The Ecosystem KPI's are presented in [Table 1](#).

Table 1. Ecosystem KPI's

Requirement Category	Description	KPI ID [A]	Target
Key Performance Indicators	Cost Reduction	A1.1.1	20% cost reduction over current commercial marine cells at volume production
		A1.1.2	Achieve $\geq 12,000$ cycles at 70% Depth of Discharge before reaching 70% State of Health.
		A1.1.3	Cost 500 €/kWh for the waterborne transport battery container.
		A1.1.4	Have a cost per unit energy throughput 1/2 that compared to today's waterborne battery transport battery systems.
		A1.1.5	Have an OPEX $\leq$ compared to conventional diesel fuel.
	Increased Energy	A1.2.1	Cell level density $\geq 500$ Wh/L
		A1.2.2	Pack level energy density $\geq 200$ Wh/L
		A1.2.3	Have an installed capacity $\geq 2$ MWh in a 20' container.
	Environmental	A1.3.1	Reduce GHG emissions $\geq 1.5$ MT per discharge cycles when compared to tradition diesel propulsion.
		A1.3.2	Have $\geq 90\%$ of the total waterborne battery container mass can be recycles
		A1.3.3	Reduce recycling processing cost by 30% when compared to today's containerized waterborne transport battery systems
	Market Acceleration	A1.4.1	Have a State of Health uncertainty of $\leq 2\%$
		A1.4.2	Accommodate $\geq 15\%$ of today's and $\geq 85\%$ of tomorrow's inland waterway and coastal shipping vessels
		A1.4.3	Support a container swap in $\leq 5$ minutes
		A1.4.4	Have an EaaS operating cost $\leq$ the operating cost of diesel propulsion
		A1.4.5	Develop standardized certification methodology for marine battery systems.
		A1.4.6	Develop standardized certification methodology for vessels which adopt containerized energy storage systems through Current Direct's ecosystem.
		A1.4.7	Reduce battery system approval time by 30%
		A1.4.8	Reduce battery system approval cost by 75%
		A1.4.9	Be scalable to $\geq 6,000$ users.
A1.4.10		Be capable of supporting $\geq 23,000$ deployed containers.	

Requirement Category	Description	KPI ID [A]	Target
	Project	A1.5.1	Demonstrate the Current Direct Energy-as-a-Service platform through simulation
		A1.5.2	Establish a working demonstrator ecosystem featuring a waterborne battery container, supporting infrastructure, and the EaaS platform to a vessel in operation
		A1.5.3	Develop a demonstrator ecosystem with Technology Readiness Level (TRL) 7.
		A1.5.4	Create a demonstrator report every 3 months of operation
		A1.5.5	Create 1 Product Brochure
		A1.5.6	Create $\geq 3$ Press Releases
		A1.5.7	Host $\geq 2$ International Presentations
		A1.5.8	Host $\geq 1$ Workshop

### 3. DESIGN RECOMMENDATION AND REQUIREMENTS

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#### 3.1. General

Design Recommendations for the Current Direct Waterborne Transport Battery's Ship and Shore Interfaces will clearly describe verifiable, independent performance, safety, and cost requirements. Certain requirements will be specified as Performance Indicators (PIs). The requirements will synthesize inputs from suppliers, operators, classification societies, governments, and recyclers. They are the output of T2.3 and T2.4.

Design requirements shall also be considered according to both the demonstration unit and the wider commercialization beyond the end of the funded project.

##### 3.1.1. Requirement Definition

Requirements are divided by category, identifier, description, type, and target.

- Requirement category - Category name for organization only (i.e., Physical Characteristics)
- Requirement ID – Unique identifier for each requirement. ID do not change once assigned. Each requirement document has its own unique ID which prevents requirement ID's being duplicated used across documents.
- Description - Requirement description for organization only (i.e., Size).
- Type – There are three different types of requirements
- Reference; information only
- Shall; product must comply
- Should; compliance is preferred, but not required
- Target – Pass / Fail limits where applicable, design constraints, design standards

#### 3.2. T2.3 Analysis and Specification of The Waterborne Transport Market to Establish Standardized Interface and Topology Requirements

Lead: Foreship; Contributors: EDP, Wartsila, Kotug, Lloyd's

This task will leverage T9.3 stakeholder meetings, market surveys, and existing data platforms to analyze the various mechanical, electrical, and communication architectures of the existing European inland waterway and coastal shipping fleets, as well as any other related waterborne transport use cases identified as candidates for the Current Direct solution in T2.1. The market study conducted in 7.1 will provide necessary input so that the requirements are structured to accommodate as broad of the target markets as possible. Recommendations for the specifications of the development work in T6.2 and T6.4 will be provided. This report D2.3 will be the primary input for Standards development in T7.1 and T7.2.

##### 3.2.1. Applicable Ship Types (1.7)

The requirements to define and identify applicable ship types adopts a methodology utilizing guiding parameters against a matrix of advantages, drawbacks, and recommendations.

Applicable ship types requirements capture is ongoing though owner / operator stakeholder engagement. The outcome of this task will provide a comprehensive matrix defining requirement details for each ship type and their impact on the ecosystem design.



The guiding parameters assessed the applicability across a range of categories as per [Table 2](#).

**Table 2. Guiding Parameters**

Guiding Parameters
Operational profile for power applications <ul style="list-style-type: none"> <li>Propulsion Type, Installed Power, Operational Profile</li> </ul>
Ability to accommodate CD system (area availability and access)
Ability to swap (load/ unload) CD system
Ability to accommodate safe connection/integration with ship's PMS/ER
Integrity of CD installation onboard – critical issues
Operational availability of the CD system
Structural Impact onboard
Stability Impact Onboard
Impact on Safety/F&G Detection/Fire Protection/Hazardous Area Class
Class & Statutory Compliance Requirement
CD System Type Approval or Certification Requirements

Ship types applicable for the service of Current Direct are presented in [Table 3](#).

**Table 3. Applicable Ship Types**

Requirement Category	Requirement ID [R]	Description
Tugs	R3.1.1	Harbour tugs
	R3.2.1	Seagoing tugs
	R3.3.1	Escort tugs
	R3.4.1	Pusher (<500 kW)
	R3.4.2	Pusher (500-2000 kW)
	R3.4.3	Pusher (≥2000 kW)
Motor vessel Liquid Cargo	R4.1.1	Oil (inland)
	R4.2.1	Chemicals (inland)
	R4.3.1	Agricultural
	R4.4.1	Oil (short-sea)
	R4.5.1	Chemicals (short-sea)
Motor vessel Dry Cargo	R5.1.1	Bulk (inland)
	R5.2.1	Container (inland)
	R5.3.1	Car / Ro-Ro (inland)
	R5.4.1	Bulk (short-sea)
	R5.3.1	Container (short-sea)
	R5.4.1	Car / Ro-Ro (short-sea)
Passenger Vessel	R6.1.1	Cruise
	R6.2.1	Ferry
	R6.3.1	Cruise (inland)
	R6.4.1	Day Cruise (inland)
	R6.5.1	Ferry / double-ender (inland)
	R6.6.1	Day Cruise (short-sea)
	R6.7.1	Ferry / double-ender (short-sea)
Other	R7.1.1	Service Vessels (Patrol / Pilot / etc.)
	R7.2.1	Fishing Vessel
	R7.3.1	Offshore Service Vessel

### 3.2.2. Vessel Interfaces & Topology (1.8)

Requirements for vessel interfaces are presented in Table 4.

Table 4. Vessel Interfaces & Topology

Requirement Category	Description	Requirement ID [S]	Type	Target
Vessel General	Location Requirements	S3.1.1	Shall	Owner requirements/restrictions
		S3.1.2	Shall	Ship type requirements
		S3.1.3	Shall	Class Society requirements
		S3.1.4	Shall	Flag State requirements
	Structural Requirements	S3.2.1	Shall	Class Society requirements
		S3.2.2	Shall	Flag State requirements
		S3.2.3	Shall	Ship type requirements
	Safety Requirements	S3.3.1	Shall	Class Society requirements
		S3.3.6	Shall	Flag State requirements
		S3.3.7	Shall	Owner requirements/restrictions
	Digital Ships	S3.4.1	Shall	Class Society requirements
		S3.4.2	Should	Owner requirements/restrictions
S3.4.3		Should	Equipment supplier requirements/restrictions	
Vessel Electrical Interfaces	Emergency Stop	S4.1.1	Shall	Hardwired interface for emergency stop
	Alarm Systems for Monitoring	S4.2.1	Should	Serial interface
		S4.2.2	Should	Wireless interface
	Fire and Gas Alarm	S4.3.1	Shall	Hardwired
	Safety Systems	S4.4.1	Shall	Hardwired
	Battery Container - Power Connection	S4.5.1	Shall	Galvanic connection
		S4.5.5	Shall	Support human connection / disconnection
		S4.5.6	Shall	Solution shall ensure connection is de-energized before connection / dis-connection is permitted
		S4.5.7	Shall	Allow for certain container movement
	Battery Container - Instrument Connection	S4.6.1	Shall	Galvanic connection
S4.6.5		Shall	Allow for certain container movement	
S4.6.6		Shall	Support human connection / disconnection	
Structural Interfaces	Container Securing	S5.1.1	Shall	Container shall be safely secured to the vessel
		S5.1.4	Shall	Use standardized means of securing container



Requirement Category	Description	Requirement ID [S]	Type	Target
	Container Stacking	S5.3.1	Should	Solution should support container stacking

### 3.2.3. Onshore Interfaces & Topology (1.9)

Requirements for onshore interfaces are presented in Table 5.

Table 5. Onshore Interfaces & Topology

Requirement Category	Description	Requirement ID [T]	Type	Target
General Information	Connection Charging Station - Battery Container	T1.3.1	Shall	Galvanic Connection
		T1.3.2	Shall	Direct connection with proper charging infrastructure
	Road Vehicles – Vehicle to Grid Communication Interface	T1.4.2	Should	To allow Bidirectional flow DC chargers would facilitate the process
Regulatory	Power Conversion System (PCS)	T3.1.1	Shall	IEC 60146-1-1:2009
	Battery System Connection to The Grid	T3.2.1	Shall	CEI CLC/TS 50549-2
	Digital Ships	T3.3.1	Shall	ISO 19847
		T3.3.2	Shall	ISO 16425
		T3.3.3	Shall	IEC 62443-1-1
Electrical Interfaces	Substation HV-MW	T5.2.1	Shall	Dedicated MV substation fulfilling V and P levels required
		T5.2.2	Should	Existing Port substation if complying with V and P requirements
	Interface Substation-Charging Station	T5.3.1	Shall	Dedicated AC plugs and connectors supporting the required V and Current levels
		T5.3.2	Shall	Dedicated stationary cables connecting substations and charging station interfaces, supporting required V and Current levels
		T5.3.3	Shall	Dedicated AC auxiliary power connection (LV)
	Interface Charging Station - Battery Container	T5.4.2	Should	Dedicated AC auxiliary power connection (LV)
		T5.4.3	Shall	Plugs and connectors supporting local weather conditions (port environment)

Requirement Category	Description	Requirement ID [T]	Type	Target
		T5.4.4	Shall	Support maximum operational charge/discharge currents at maximum operating temperature.
		T5.4.5	Shall	Be easily accessible for fast connection/disconnection
		T5.4.6	Shall	Protection system easily accessible for safety shut-down
		T5.4.7	Shall	Support human connection/disconnection compliant to security requirements
		T5.4.8	Should	Support automatic connection/disconnection compliant with security requirements
		T5.4.11	Shall	Voltage and current rates compliant with container requirements
		T5.4.12	Shall	Bidirectional flow
		T5.4.13	Shall	Cables insulated according to required V and Current levels

### 3.3. T2.4 Analysis and Specification of the Infrastructure Requirements

Lead: Foreship; Contributors: Spear, Rhoé, EDP, KOTUG, Lloyd’s, Wartsila

This task focuses on Current Direct’s supporting vessel and shore infrastructure. Ports, naval architects, ship owners, and utilities will be engaged through the same T9.3 process as T2.1, T2.2, and T2.3. Related standards for movement of containers, grid battery interconnection, and other related topics will be reviewed for potential commonality. D2.3 recommendations will serve as the requirements for T6.2 and serve as the foundation for T7.1 & T7.2.

#### 3.3.1. Shore Infrastructure (1.10)

Requirements for shore infrastructure are presented in [Table 6](#).

**Table 6. Shore Infrastructure**

Requirement Category	Description	Requirement ID [O]	Type	Target
Safety	Battery Energy Storage	O4.1.1	Shall	IEC 62933-5-2:2020
	Electrical Energy Storage Systems	O4.2.1	Shall	IEC 62933-5-1:2017
	Testing Methods and Procedures	O4.3.1	Shall	IEC 62933-2-1:2017



Requirement Category	Description	Requirement ID [O]	Type	Target
	Safety Requirements for Secondary Batteries and Battery Installations.	O4.4.1	Shall	BS EN 50272-1:2010
	Test Methods and Requirements and Information for Safety	O4.5.1	Shall	IEC 62281:2019
	Under Development Standards	O4.6.1	Should	IEC 62897
	Safety Colours And Safety Signs	O4.7.1	Shall	ISO 3864:1984
	Graphical Symbols — Safety Signs — Safety Way Guidance Systems (SWGS)	O4.8.1	Shall	ISO 16069:2017
Electrical Infrastructure	Connection Substation - Charging Station	O6.1.1	Shall	Auxiliary power connection to LV feeder
	PCS (Protection for Its Critical Components)	O6.2.1	Shall	Protection against high temperatures
		O6.2.2	Shall	Communication failure protection
		O6.2.3	Shall	Protection in case of failure of battery system
		O6.2.4	Shall	Protection in case of failure of cooling system
		O6.2.5	Shall	Protection in case of failure of auxiliary power supply
		O6.2.6	Shall	Protection against voltage or power peaks
		O6.2.7	Shall	Power conversion management system (PCMS)
Structural Infrastructure	Crane	O7.1.1	Shall	Sufficient SWL, outreach and height range to reach onboard installation location
		O7.1.4	Should	Provide crane if not already available
		O7.1.5	Shall	≤ 5minutes container swapping
	Storage	O7.2.1	Shall	Storage for non-charging and charging containers
	Transportation	O7.4.1	Should	Horizontal transportation from/to vessel from charging/storage position

Requirement Category	Description	Requirement ID [O]	Type	Target
Charging Station	Power Conversion System	O9.1.7	Shall	Inverter efficiency compliant with IEC 60146
		O9.1.8	Shall	Round-trip efficiency compliant with IEC62933-2-1
		O9.1.10	Shall	System response time to an impulse compliant with IEC62933-2-1
		O9.1.12	Shall	Electromagnetic Compatibility compliant with IEC61000, IEC 61800
		O9.1.13	Shall	Total harmonic distortion compliant with EN50160-2010
		O9.1.14	Shall	Compliance with standards for safety and security
Provision of Grid Services	Bi-Directional Power Flow Capability	O10.1.1	Shall	Sale of energy into the grid
	Frequency Containment Reserve	O10.2.1	Should	Minimum accuracy of frequency measurement: 10mHz
		O10.2.2	Should	Full activation time: 30s
		O10.2.3	Should	activation frequency deviation: +- 0.2Hz
		O10.2.4	Should	Capability to provide full active power-frequency response for at least 15-30 min
	Grid Reactive Support and Other Ancillary Services	O10.3.1	Should	Reactive power support function
		O10.3.2	Should	Active filtering function
	Participation in Local Flexibility Market (E.G. Port Hub)	O10.4.1	Should	Peak shaving and load levelling

### 3.3.2. Vessel Infrastructure (1.11)

Requirements for vessel infrastructure are presented in [Table 7](#).

**Table 7. Vessel Infrastructure**

Requirement Category	Description	Requirement ID [P]	Type	Target
Ship General	Capacities	P3.4.1	Shall	Accommodate container(s) size needed to support vessel operations
		P3.4.2	Shall	Accommodate container(s) weight with respect to stability, heel and trim

Requirement Category	Description	Requirement ID [P]	Type	Target
		P3.4.3	Shall	Accommodate retrofitting, replacement of mechanical drive train with electric propulsion and associated equipment
	Speed	P3.5.1	Should	Support existing and future power vs speed operational profiles
	Design and Construction Standards	P3.10.1	Shall	Any additional design will need to match existing or standard construction design from shipyard/owner/designer
	Technical Standards	P3.11.1	Shall	ES_TRIN
Hull and Painting	Framing	P4.3.1	Shall	Retrofit - Framing in way of CD.ESS will need to be verified
		P4.3.2	Shall	New Building - Framing in way of CD.ESS is adjusted to optimize placement and strengthening
	Welding	P4.4.1	Shall	All welding will be according design standards
	Testing	P4.5.1	Shall	Any testing to be according Class requirements
	Superstructure	P4.9.1	Shall	Placement of CD.ESS cannot hinder the superstructure
	Surface Preparation and Painting	P4.10.1	Shall	No special requirements should come from the CD.ESS
	Cathodic Protection	P4.11.1	Shall	No special requirements should come from the CD.ESS
	Hull and Deck Outfitting	Hull and Deck Fittings	P5.2.1	Shall
Loading System		P5.3.1	Shall	Placement of CD.ESS cannot hinder the Loading System
Side Thrusters		P5.4.1	Shall	No special requirements should come from the CD.ESS
Rudders and Steering Gear		P5.5.1	Shall	No special requirements should come from the CD.ESS
Anchor and Mooring Equipment		P5.6.1	Shall	Placement of CD.ESS cannot hinder Anchor and Mooring Equipment
Lifesaving Appliances		P5.7.1	Shall	Placement of CD.ESS cannot hinder Lifesaving Appliances
		P5.7.2	Should	The CD.ESS should not increase the requirements on Lifesaving Appliances

Requirement Category	Description	Requirement ID [P]	Type	Target
	Stairs and Ladders	P5.8.1	Should	Placement of CD.ESS cannot hinder Stairs and Ladders
	Windows	P5.9.1	Shall	Shall not be influenced by the CD.ESS
	Exterior Doors	P5.10.1	Shall	Shall not be influenced by the CD.ESS
	Emergency Escape Routes	P5.11.1	Shall	Placement of CD.ESS cannot hinder emergency escape routes and muster stations
Interior Outfitting	General	P6.1.1	Shall	Not to be influenced by CD.ESS
Ship Systems and Services	Piping Schedule	P7.2.1	Shall	No additional change due to CD.ESS container
	Air Conditioning and Ventilation	P7.3.1	Shall	No additional change due to CD.ESS container
	Heating and Refrigerating	P7.4.1	Shall	No additional change due to CD.ESS container
	Fire Fighting	P7.5.1	Shall	No additional change due to CD.ESS container
	Water Systems	P7.6.1	Shall	No additional change due to CD.ESS container
	Waste Water Systems	P7.7.1	Shall	No additional change due to CD.ESS container
	Garbage Treatment System	P7.8.1	Shall	No additional change due to CD.ESS container
Machinery Main Components	Electric Propulsion	P8.3.1	Should	Electric Propulsion is required due to source of energy stored in CD.ESS.
	Emergency Power	P8.4.1	Shall	Emergency Power remains on vessel, in accordance with Class/Flag
	Ballast and Bilge Systems, Gutter Pipes, Outside Accommodation	P8.10.1	Shall	CD.ESS should not interfere with Ballast, Bilge or Gutter Pipes
Electrical and Communication	General	P9.1.1	Shall	Electric systems compatibility will need to be verified
	System Voltages	P9.2.1	Shall	IEC 60092
	Electricity Generation	P9.3.1	Should	Other than 'hotel load' no Electricity Generation is required
	Transformers	P9.4.1	Shall	Transformers to match existing electrical-system and CD.ESS to be provided (if needed)
	Switchboards	P9.5.1	Should	CD.ESS should not require additional Switchboard(s) on vessel

Requirement Category	Description	Requirement ID [P]	Type	Target
	Batteries / UPS	P9.6.1	Should	CD.ESS should not trigger any requirement demanding change of Batteries / UPS requirements
	Energy Storage System	P9.7.1	Should	CD.ESS system be available for redundancy and/or swap-coverage
	Starter Switchboards and Motors	P9.8.1	Should	CD.ESS should not require additional Switchboard(s) or motors on vessel
	Electric Installations	P9.9.1	Shall	IEC 60092
	Lighting Systems	P9.11.1	Should	Supply sufficient lighting for container area
	Communication Systems	P9.13.1	Shall	CD.ESS is not to interfere with any Communication System
	IT Systems	P9.14.1	Shall	CD.ESS is not to interfere with any IT System
Navigation, Safety and Security	General	P10.1.1	Shall	CD.ESS is not to interfere with any Navigation, Safety and Security System. Nor enhance the requirements for any of these.
	Navigation Equipment	P10.2.1	Shall	Navigation equipment shall not be interfered by CD.ESS.
Automation	General	P11.1.1	Shall	Automation shall be modified to include the CD.ESS, or a dedicated system for CD.ESS.
	Power Management System	P11.4.1	Shall	PMS shall be modified or installed for CD.ESS
	Ship Process Control and Monitoring Systems	P11.5.1	Shall	No additional change due to CD.ESS container

## 4. FURTHER WORK

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The requirement specification written has been divided into requirements that needs to be in place for the demonstration unit timetable as well as for the requirements for the commercialization. At this stage, the deliverable contains mainly requirements related to the demonstration unit. The specification requirement work continues and will follow the project schedule.

Additional internal / external workshops have been planned to further define / refine requirements for capture and definition to refine the needed items for the demonstration unit, followed by the requirements towards the commercialization.

Furthermore, a requirements relational data base is under development to provide intelligence, analytics and insights that will drive future phases of the project.

Market research and workshops will be conducted to develop further understanding of applicable ship types and required shore infrastructure for the service of Current Direct.