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Erkka Niemi

Sustainable Maritime Power Alternatives for Cruise Business

Metropolia University of Applied Sciences

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Thesis

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Author	Erkka Niemi
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The purpose of this study was to find out the current situation in sustainable alternatives energy sources in cruise business and to propose which role a marine cluster company can play in the climate-challenged future. The thesis looks into the marine cluster business on a sector level, and there is no specific case company in this work.

The analysis starts with the case studies in the marine cluster business. First, it overviews what existing methods are in use for generating energy in different forms for cruise ships when the ship is visiting at ports. Second, it looks into the existing alternative energy generation methods, and third, into the cases where the created customer value can potentially (in the future) turn into a new development project for a marine cluster company.

After the current state analysis, the thesis studies existing knowledge to understand the current state of sustainable alternatives for generating electricity and energy in different forms for cruise ships when the ship is visiting at ports. It requires to create a view what existing methods are in use, and how to improve these methods in energy generation economically and environmentally. In addition to that not forgetting the perspectives of investors, business developers, portfolio managers, technology managers and start-up's role which constantly consider different strategies and new business cases daily during these times of rapid change. For this part, the thesis used literature, articles, research, and previous studies and also published know-how from different marine cluster companies.
The outcome of this thesis were the Customer Value Proposition (CVP) and conclusions to help understand the business opportunities in cruise and port business from the energy economy as well as environmentally wise perspectives, and suggestions about the role that marine cluster companies could play in this business. The conclusions also include a little look to the issue from the economic perspective and also a feasibility perspective. Thus, the proposal points to the opportunities to deliver sustainable energy to cruise ships in today's markets, which can create different scenarios for future alternative technologies, product and services.

Due the COVID-19 pandemic and impact to marine cluster industry at spring 2020 which caused wide joint negotiations in Finland, this thesis has also changed its direction, thus the confidential data and original case company is not mentioned or included in this thesis. The thesis subject was modified to create a general CVP without a specific case company.

Keywords	Sustainable alternative energy sources, Cruise, Port, Alternative Marine Power

Contents

Introduction

This thesis investigates the current situation in sustainable alternatives energy sources in cruise business and explores which role a marine cluster company can play in the climate-challenged future. The thesis looks into the marine cluster business on a sector level, rather than benefitting one particular company.

1.1 Business Context

Cruise industry began from the early 1970's and nowadays its modernized version has been growing significantly from where it all began. Presently, cruise industry has a remarkable role for tourism industry, and it has a great influence on the worldwide economic factor. Nowadays cruise industry makes a great example of globalization with numerous new cruise ports around the world and with international passengers onboard from every continent. This means also that the number of clients in cruise industry has increased remarkably, and it has developed economic, environmental, and social interferences.

As the cruise business has been scaling up constantly since 1970's, the vessel sizes and carrying capacities have been increasing to over to 3,000 passengers. This trend has also had a counter impact to the vessels' energy consumption and carbon footprint, although the efficiencies of cruise vessels are still better than decades back. Cruise industry continuously improves and upgrades efficiency and environmental solutions in vessels both at sea and also upon visiting at ports. For example, a couple of the largest companies in the cruise business self-reported its carbon emissions in 2016 & 2017 and these readings show on average that shipping companies' carbon emissions are growing by just over 1 percentage further up per year. (Windrosenetwork, The-Cruise-Industry)

The IMO (International Maritime Organization), the umbrella organization for maritime transport industry, also plays a role in monitoring and reducing emissions from all shipping. Since 2005, IMO has starter to create new regulations for the reduction of sulfur oxides in maritime transport and in port visits. Since then, these emission limits have been increasing regularly and on the 1st of January 2020 these regulations were tightened and emission control areas has been increased and standard marine fuels as HFO could not be used in ports of in emission control areas. (IMO 2020) Since marine HFO fuel price is noticeably cheaper than low Sulphur MDO fuel, this will make significant

large notch to cruise business companies' wallets; this is not forgetting today's pressures of green values and use of sustainable energy alternative sources.

All these factors make this topic interesting to explore and seek new commercial ideas for the marine cluster. So far there are many marine cluster companies working with new development ideas. There are also already developed ideas such as exhaust gas cleaning, LNG fuel and hybrid power generation.

1.2 Business Challenge

There is a growing demand for the use of renewable energy technologies in marine cluster to generate sustainable energy sources due to concerns over climate change. For example, around 300 hundred cruise ships enter the port of Helsinki alone during the short four-month season. In the port, such cruisers consume an immense amount of fossil fuels and give out huge CO2 emissions when generating electricity by themselves. A more sustainable alternative for generating electricity would be steam, chilled water, heated water and electricity transmitted by and from the port to the ship. Port supplied alternatives are a business opportunity to marine cluster companies in the form of supplying land-based energy interface solutions.

The current situation with regard to ships' port calls is unsustainable and costly due to the above-mentioned factors and also due to the new IMO regulations. Ships consume a lot of energy while visiting at the port, and the prices of cleaner marine fuels are rising, which make cruise business less attractive and profitable for owners.

Ports are also becoming more critical of emissions from the ships in the urban area, and today, during port visits, vessels need to use expensive clean marine fuels.

As this thesis is not company specific, it focuses on creating a general case study for any marine cluster company or marine start-up, and results can be implemented in future marine and port business. In Finland, we have a few key players in the marine cluster which are interested to be in the sustainable play field now and in the future. Marine cluster companies continuously search and invest into R&D to be market leaders, also in the new form of sustainable development solutions. In this study, we focus on the marine cluster business segment and look into the best offerings of sustainable power alternatives for cruise industry, with high quality standards and efficiency to be the top one priorities in the business.

1.3 Objective and Scope

The objective of this thesis is to develop proposals concerning sustainable maritime power alternatives for the cruise business and be the solution for ports, cruise industry and potentially for all shipping industry.

More specifically, the objective in this study is to create a process roadmap for developing a Customer Value Proposition (CVP) for supplying *land-based energy interface solutions.* At the same time, the focus is placed on business development in alternative solutions that are available nowadays but not paired in multi form of sustainable energy alternatives.

The scope is limited to a roadmap for the customer value proposition, and it will not include such vital topics as a payback time, profit and loss estimations and the project concept information, nor a detailed CVP, although they are critical for business development. This is to keep the scope wise.

1.4 Thesis Outline

The thesis will include the following steps, in brief:

- Current state analysis, research
- Existing knowledge, literature review (conceptual framework)
- a Process Roadmap for CVP, a plan for the customer value proposition (proposal) & a brief feasibility evaluation
- Validation of the proposed roadmap to the customer value proposition.

The purpose of the work is to provide in-depth view on the concept and to roughly determine whether this business case is feasible, not forgetting sustainable values of now and the future. Hopefully, this roadmap to the customer value proposition would find interest among investors in marine and port business.

2 Method and Material

This section describes the research approach, research design, and data collection and analysis methods used in this Thesis

2.1 Research Design and Approach

As shown in Figure 1, this thesis is based on a number of steps in the research process. It starts with selecting the business challenge and setting the objective. After the business challenge was studied and fully understood, the research focus was defined. After that, the thesis moved to the current state analysis, followed by exploring existing knowledge of different energy transfer technologies.

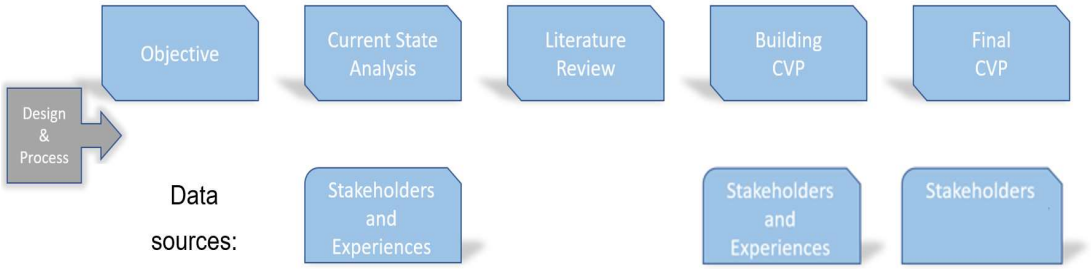

Figure 1. Research design and process in this thesis.

Based on the results of the current state analysis and supported by suggestions from existing knowledge and best practice, the data was collected for building a CVP including the necessary key performance indicators, technical information, customer needs, available technologies as suitable elements for CVP. Importantly, this study does not go through the competitor analyze since this is not a company specific thesis. However, it takes a look at competitors in different industries and what they have to offer for this business for example. The main sources of data are interviews with experts and cases.

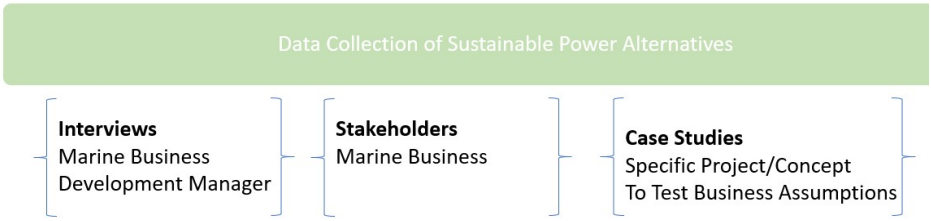

Figure 2. Data sources in this thesis.

In this thesis, the research design and process have three actual data collection rounds, focusing more on the use of existing data and experience. The interviews were short and not all data could be used in the study either so that the work will not became company specific. Also, some confidential numeric research data is excluded from this design. Thus, the thesis mostly uses qualitative research methods. The features of qualitative research can be seen from its comparison to quantitative methods below.

TABLE 1.1 Assumed characteristics of research

Qualitative research	Quantitative research
Uses words	Uses numbers
Concerned with meanings	Concerned with behaviour
Induces hypotheses from data	Begins with hypotheses
Case studies	Generalisations

Source: adapted from Hammersley, 1992

Figure 3. Features of qualitative and quantitative research (Silverman 2011).

As seen from Figure 3, qualitative research is based more on the analysis of textual data and perceptions when compared to quantitative research which in turn is based on the numerical analysis. Quantitative research is based more on the statistical, mathematical or numerical analyses of collected data, as well as statistic data from surveys or utilized computational data (James 2019). This study is mainly based on a review of existing literature and interviews which are qualitative methods.

2.2 Data Collection and Analysis

This study draws from a variety of data sources, and the data was collected in three data collection rounds. Table 1 shows details of Data collections 1-3 used in this study.

Table 1. Details of Data collections 1-3 used in this study.

	Participants / role	**Data type**	**Topic, description**	**Date, length**	**Documented as**
	Data 1, for the Current state analysis (Section 3 or 4)				
1	Respondent 1: Development expert	Face to face interview	The case approach and Experiences in coordinating different sales development projects	November 2019, 60min	Field notes
2	Respondent 2: Development expert / cooperation coordinator	Face to face Interview	Experiences in coordinating different sales development projects	January 2020, 60min	Field notes
3	Respondent 3: Development expert / cooperation coordinator	Face-to-face Interview	Experiences in coordinating different sales development projects	February 2020, 60min	Field notes
4	Respondent 4: External research partner/cooperation coordinator	Telephone interview	Experiences in coordinating different sales development projects	April 2021, 30min	Field notes
5	Respondent 5: Researcher / Cooperation initiator	E-mail interviews	External research cooperation, from the external point of view	April/May 2021,	Field notes
	Data 2, for Proposal building (Section 5)				
8	Participants 2	Telephone and e-mail	Proposal building	May 2021	Field notes
	Data 3, from Validation (Section 6)				
9	Respondents 1	Interview	Validation, evaluation of the Proposal	May 2021	Field notes

As seen from Table 1, data for this Thesis was collected in three rounds. The first round, collecting Data 1, was conducted for the current state analysis and included interviews, benchmarking the current cases of sustainable energy use in port visits, and collecting and analyzing information about the arising new interesting cases.

In the next round, Data 2 was collected to gather suggestions from the subject matter experts and business and technology professionals for developing the proposal. This data included telephone and email conversations.

In the third round, Data 3 was collected when conducting validation of the initial proposal. Data 3 included feedback for the proposal from the industry expert.

In this study, the main methods of data collection were the document analysis and interviewing. The interviews were conducted as semi-structured, mostly online interviews, with questions created in advance. The field notes were taken. The questions for the interviews can be found in the Appendix B. The textual data was analyzed using Thematic/ content analysis.

Additionally, Data 1-2 also included other types of data, secondary data (for example, analysis of published documents reporting on the sustainable energy cases, industry white papers etc). They are listed separately below.

Table 2. Published cases used in the current state analysis, Data 1.

	Name of the document	**Number of pages/other content**	**Description**
A	DNV-GL Onshore Power Supply for Cruise Vessels	69 pages	Case study and data source
B	VTT report about Ship energy efficiency technologies − now and the future	143 diagrams	Case source
C	GREEN CRUISE PORT - GREEN CRUISE PORT ACTION PLAN 2030	115 pages	Case and data source
D	GREEN CRUISE PORT - Emission sources and possible mitigation measures of cruise terminals	66 pages	Case study and source
E	How to decarbonize international shipping: options for fuels, technologies and policies	47 pages	Case and data source

F	Becker Marine - LNG Power Barge Clean power for cruise ships in port	4 pages	Data Source
G	CIRCULAR ECONOMY MODELLING TO ACCELERATE THE TRANSITION OF PORTS INTO SELF-SUSTAINABLE PORTS	115 pages	Case and data source
H	SNG Generation via Power to Gas Technology: Plant Design and Annual Performance Assessment	22 Pages	Data Source
I	Market data – Nord Pool	1 page	Annual average electricity data

As seen from Table 2, this study also analyzed several published cases as secondary data. The main documents included were analyzed for Data collection 1 round, the current state analysis, to understand what the current situation and views on alternative forms of energy in European ports and cruise business is.

The biggest part of data was analyzed for the current state analysis, to establish the current state of sustainable energy solutions for vessels visiting ports. The findings from the current state analysis are discussed in Section 3 below.

3 Current State Analysis of Generating Energy for Cruise Ships Visiting at Ports: Current and Sustainable Ways

This section reports on the results of the current state analysis focused on the current state of energy generating solutions for the cruise ships visiting at ports, with a special interest in the available sustainable solutions.

3.1 Overview of the Current State Analysis Stage

The current state analysis starts with the case studies in the marine cluster business. First, it briefly overviews what existing methods are in use for generating energy in different forms for cruise ships when the ship is visiting at ports. Second, it looks into the cases of existing sustainable energy alternatives in marine and port business. Third, it looks into the cases where the created customer value can potentially (in the future) turn into a new development project for a marine cluster company.

Thus, once the business problem was understood, the next step was to look for the current state and for existing alternative solutions to solve cruise ships emissions, consumption and reduce port pollution with sustainable power alternatives when cruise ships are visiting in ports, and look at the current strengths and weakness in existing port environment

Available public data were used to support the current state analysis. To analyze the data, the current state analysis used GAP analysis methods.

3.2 Description of Existing Methods in Use for Generating Energy in Different Forms for Cruise Ships Visiting at Ports

Considering the Port of Helsinki and its cruise traffic volume, from 2018 to 2019 there has been an increase in cruise passenger volumes plus 16% with total 603,500 passengers and total 303 cruise vessels were visiting at the port of Helsinki. But when we compare a total amount of cruise plus ferry passengers in Helsinki port, then the total 12.2 million passengers in 2019 means the port of Helsinki remains the busiest port in Europe. (Haapasaari 2020)

Comparing to the busiest cruise port Barcelona in Europe, the cruise passenger traffic is only 1/5 part of that in Helsinki than that of Barcelona, however, a cruise season is also

shorter in Finland. It means, there is a significant amount of passengers transiting trough Helsinki port every year. This is the reason Port of Helsinki has already constructed the shore power connections to Katajanokka ferry terminal in 2012, and the second shore power system is currently under commissioning in the South port of Helsinki and should be in commercial use since December 2020. It is also an important step to becoming a carbon neutral port by 2035, as CEO of Helsinki Ville Haapasaari says. (Haapasaari 2020)

At present, several European and Baltic countries and cities are likely to commit to EU Green Cruise Port projects in 2016 - 2019, which have explored sustainable and alternative solutions for the future port environment. They have deeply studied different types of solutions, such as shore-connection, LNG bases energy generation in port, smart port systems, etc. and made strategic decisions in favour of sustainable solutions.

Figure 4. Green Cruise ports in Baltic Sea region (Source: Greencruiseport.eu).

As shown in Figure 4, the above countries are committed to the Green port project. The project is at the EU level and organized by Interreg Baltic Sea Region. Moreover, several ports from the map have already acquired the shore connection power systems to reduce

emissions in port environment, or they are planning to invest more in future to achieve the action plan 2030 goal. In this action plan, the main work package WP1 is Project management and coordination plan, but the second work package plane WP2 is the strategy for new solutions and innovation for Sustainable energy supply and Innovate solutions for emission reduction. (GREEN CRUISE PORT ACTION PLAN 2030, 2019) The Green cruise port mission has also other work packages in addition to these above mentioned work packages, but those are not essential to this study although those are very important for the future port environment.

A typical alternative shore to the ship power connection is described in the illustration below, where ships can shut down their engines while visiting at port. This type connection reduces pollutions (NOx, SOx and CO2) and noise pollution to the local environment from ships.

The shore connection system contains basically the onshore side; the substation with frequency conversion units, since with this method power can be supplied to different electrical standard vessels. In addition, the system has MV and LV distribution (switch board, cables), a cable management system, and a shore connection unit. On the ship side, the system contains the shore to ship power panel, and the automated power transfer system. (Source: ABB)

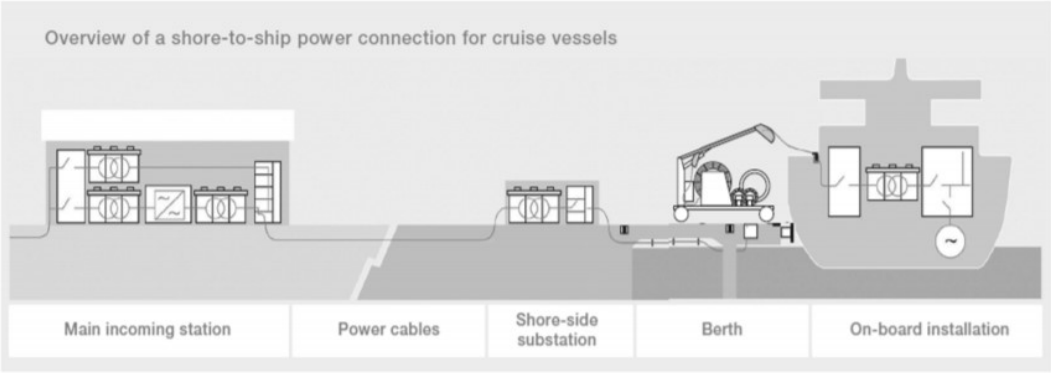

Figure 5. Overview of a shore connection (Source: ABB, internal document).

As seen from Figure 5, the left shows the onshore substation solution for the ports and onboard of the vessel is the shore to ship power system with cable connection.

Currently, there are several forms of traditional energy generation that are used for cruise port business:

First, Generating energy with vessels auxiliary or main engines at the port, using low sulphur MGO or MDO fuel. This has been the most traditional energy generation since decades. To reduce more pollution and NOx to the environment vessels uses SRC and closed loop scrubber technology during visiting at port.

Second, Generating energy with vessels auxiliary engines at the port, but vessels' engines are converted to dual fuel and they can be switched to run with LNG at port or they can run LNG also at sea. Normally these types of dual fuel engines can run three different type of fuel, LNG, MDO, HFO. However normally dual fuel type engines need few percentage of MDO to ignite LNG in pilot fuel combustion chamber.

Third, Shore-to-ship energy connection to the vessels, where generating energy comes from the main grid or other energy generating source at port as from combustion engine LNG power station, which are built for this purpose and can be activated when vessel is connected to the shore-to-ship connection. To be able to use shore-to-shop connection port infrastructure and vessels systems should be upgraded for such energy transition. In port environment with stabile main grid the this would be good option.

From the business perspective, there are also other questions that are of interest to ask about the current solutions, before selecting alternatives, namely: in which other ways the efficiencies on board could be improved to reduce fossil fuel usage? Could we transfer energy or manufacture a system that could easily be taken to extra urban places at the globe and could this happen in the near future as well? What is the current situation with sustainable energy alternative forms in maritime and port environment and similar questions? They need to be answered before an alternative solution can be selected in a grounded manner.

3.3 Analysis of Existing Sustainable Energy Alternatives in Marine and Port Business

Sustainable energy alternatives in marine and port business has been a topic of discussion for many years in marine portfolio business. In many populated metropolitan areas, the ports had already introduced the ship-shore connection more than ten years ago. A standard shore connection system's idea is to reduce the big marine diesel engines'

idling times and use less fossil fuels during the port visits. An alternative shore connection system has also a nickname “Cold Ironing” - historically, when ships used to run with steam and coal powered boilers and, once the system was shut down, it cooled down to cold.

Simply put, the alternative shore power connections mean the system, in which the cruise vessels that are visiting tourist ports, get connected to the alternative shore power. There are supply cables between the cruise ship and the port, where the other end is connected to the port side electrical switch board to supply, and the outgoing side is connected to the cruise ship’s electrical switch board. This is done with special flexible cable connections and there are several different methods to do these connections. The port side electrical switch board is connected to the grid, which we can call the state grid or stock grid, or the independent grip supplier with own separate power generators, since it depends on who owns the power network. With this system, there are possibilities to reduce emissions, fossil fuel usage at ports, and it also has the general and economic interest of reducing the use of fossil fuels in ports. (Safety4Sea 2020).

As I discussed with the General Development Manager (Respondent 1), he found it interesting to explore alternative forms of energy and energy transfer to cruise ships. The same issue also raised the issue that these forms of energy transfer could increase the overall energy efficiency of cruise ships. In a way, it would be an intelligent use of energy that would require a comprehensive study of ships and infrastructure.

This CSA examines precisely this model and the fact that this system currently supplies electricity to ship systems such as lighting, cooling, air conditioning, heating and other systems. To call this system “sustainable” power alternative, it could bring more advantages than only electricity and many ports create. CSA result is focused on the current state analysis of sustainable energy alternatives.

Sustainable energy alternatives mean that marine exhaust gas emissions will be cut in the Green cruise ports and OPS system has already been introduced a number of large ports which belongs to Green cruise port partners. At present, as remains in effect in the Baltic Sea and the Northern areas, the vessels is required to use fuel more stringent standards for low 0.1% sulfur content. Besides, the equipment such as a “scrubber” can be used to reduce sulfur. In addition, the new European Sulfur Directive stipulates that the maximum sulfur value of marine fuel may be 0.5% in the European Union. This new

regulation came into force in 2020 and is intended to reduce sulfur emissions worldwide. (Schmidt, Steenbeck, Borsch, Hofmann, Kroh 2019)

The shore power system in shore will reduce pollution in port and urban areas certainly, and this is the key point why this alternative power system will play an important role in future.

> *"The shore power energy system is easy to implement and the suppliers can be found in the market. Here, perhaps the main question is how to get shipping companies to acquire the power transmission systems needed for their ships even if their acquisition costs are not a threshold issue." (Respondent 1, General Development Manager)*

This is also where EU and national regulators are aiming in the future. The cost estimation for cruise business is approximately less than half million euros per vessel to obtain the shore connection system. Nevertheless, this is small cost and payback time is short versus the onshore system for ports which is around 10-40 times more, depending on the country and port where to invest and how large system to invest. Operating and maintenance costs are still really moderate 2000 EUR annually, and after the first ten years it will grow approximately five times more which is still considered to be reasonable. (Green Cruise Ports, DNV)

> *"Another threshold is whether energy is cheaper to use in classic forms, such as fossil fuels than shore grid electricity, and how it should be used and supported so that cruise ship companies would switch to grid electricity." (Respondent 1, General Development Manager)*

Thus, the shore power system will also bring advantages due to fewer running hours at port which will lead to less maintenance for cruise ships auxiliary engines. Maintenance cost for the cruise ship shore power side is really minimal as the system is part of cruise ship electrical distribution system.

To demonstrate further advantages, the analysis focuses on several case examples that were discussed with the experts in the interviews during the current state analysis.

Case 1 of existing sustainable examples, at Berth

Considering a cruise ship at berth, in this setup a cruise ship will produce the necessary energy in stand-alone, to use on board auxiliary engines with sustainable alternative fuels, such as LNG or biodiesel during the port visits. Other alternatives are to use exhaust treatment system as scrubber and SRC's to reduce emissions from the standard MDO/MGO fuels at port visits. Sustainable alternative fuels are more environmentally friendly than the standard low sulphur marine fuels, compared to the standard fuels. MDO/MGO are available with suphur content 0.1%, which can be considered to be very low.

The average port visit for cruise vessel is 11-12 hours and average energy demand at berth per cruise vessel is 5,5MW which is approximately <1 ton of MGO per hour in large marine 4-stroke engine efficiency's can go up to 50%. (Wärtsilä 2017). The average MGO price in 2021's Europe is 530$ per one ton. (DNV) During 12 hours port visits, the fuel cost will be approx. 6360$.

In case a cruise ship is equipped with LNG tanks and dual fuel engines, the same average values would be with 5,5MW approximately 0,85 ton of LNG per hour in large bore 4-stroke dual fuel engine plus 13-14 kg of pilot MGO fuel per hour, and efficiency might go up to 50%. The average LNG price in 2021's Europe is 318$ per one ton (DNV). It means, during 12 hours port visits, the fuel cost will be approx. 3244$ plus 162$ for MGO.

This means port savings would be 2954$ per day, and from the environmental point of view, it can also reduce CO2 up to 20% comparing to other fossil fuels. LNG is also sulphur free, which means SOx emissions will be almost vanished in exhaust gas, NOx emission can be reduced up to 90% due to reduced peak temperatures in the combustion process. However, LNG can process "methane slips" in storage tanks, which is 20 times stronger greenhouse gas than CO2. (Danish Maritime Authority 2012), (CLEANSHIP 2013), (Green cruise ports).

Additionally, MGO and LNG has maintenance and operation cost as bunkering which would be added on top of rest of the costs.

Cruise ship connected to on shore supply, in this set up, the cruise ship will switch off main engines or auxiliary engines. All the needed energy will be transferred from on the shore side to the ship with the shore to ship power connection. The average needed energy would be the same 5.5MW, with the average spot price is approximately in 2021, 4,458snt EUR per kWh/h plus 0,25snt margin in Finland. One hour would cost 258,94€ plus the 20% port charge on top of the electricity spot price in Finland.

In computation of LNG price to the electrical on shore connection, the price differences do not seem to be very big in direct comparison. Advantages of on shore power system is that the emissions of the vessels are almost zero when a cruise ship is connected to electricity. Also, environmental noise pollution levels of the ship will drop down notably when main or auxiliary. (Nord pool). Network tariff cost is not included in these calculations as well national grid taxes. However, these taxes and tariffs would increase electricity price up to over one and a half times, which might increase electricity prices over fossil fuels. Some grid companies have offered electricity for ports with flexible or reduced grid tariffs when the electricity price become attractive for cruise ships to use on shore power systems in economic terms.

Case 2 of existing sustainable examples, Aberdeen

The case of Aberdeen has calculated the overall capital cost of installing cold ironing technology to medium-sized ports. It found that the cost would be around £6.6 m (€7.4 m), while the system would save annual emissions of 108 tonnes of NOx, 2.7 tonnes of PM and 4,767 tonnes of CO2 emissions worth £1.3 m (€1.4 m). (Innes, Monios)

On shore power system has also maintenance and operation costs which would be added on top of the electricity spot price.

Thus, a cruise ship connected to LNG power barge, in this set up, a cruise ship would use an offshore LNG power barge which would be possible to re-mobilize to different harbors and ports. LNG power barges would have on

board power station with the same equipment than onshore system.(Becker Marine) The average energy needed to transfer these power barges to a cruise ship would be the same 5.5MW, which means consumption of LNG is approximately the same as if the cruise ship would have its own LNG engines. There would be a small advantage to use efficient large bore 4-stroke LNG engines instead of small in container LNG engines, and this is the reason why LNG consumption can vary 0.81 ton/h up to 1 ton/h. 257,6$ up to 318$. Thus, this would have effect of electricity pricing in different ports in case there are different type of LNG barges. This type of LNG barge can also transfer heat to the cruise ship meanwhile it generates energy.

Additionally, LNG barges can be built to be quite silent and moved on the top of the ports to reduce the environmental noise they cause. This requires also onshore cable management system. (Green cruise ports.)

Finally, LNG barges have also operational cost as bunkering, crew and maintenance cost which would be added on top of the electricity price. In the world, there are not many LNG power barges in the ports, therefore there are not much usable data of electricity price on LNG barges but these barges have the advantage to supply also district heat.

Thus, in Case 1, on shore power connection would be most promising solution to reduce emissions as well as noise pollution in ports during cruise ship visits. (Green cruise ports.)

3.4 Analysis of Sustainable Energy Alternatives of the Future

This part of the analysis is focused on the sustainable energy alternatives of the near future, where the created customer value can potentially (in the future) turn into a new development project for a marine or port business.

As one most obvious possibility, the future sustainable energy alternative could be on shore power to ship connection. Besides, it could also have implemented hybrid features to upgrade energy efficiency. In future, shipping and port business is aiming to reduce carbon footprint in all activities, and this means abandonment of fossil fuels in the future.

As forecasts say, electricity price is expected to grow in the future up to 2030, which could be compensated with smaller on shore power tax or grid tariff. But this also means that without compensating the electricity taxes or grid tariff, it is not as attractive a choice as some could believe. National grid electricity demand will increase a lot in future which also means grids maintenance cost, electricity production costs will also increase rapidly up to 2030's since there are a lot of fossil based power plants, which will be shut down over the next few years. (DNV 2018), (Green Cruise Port 2018).

Perhaps, there could be demand of hybrid onshore to ship connection systems where spot electricity could be charged to battery storages in vessel or at the port side during the nighttime when there is less usage of electricity, and the electricity spot price could go down due smaller grid demand. These battery storages could be connected to, for example, a solar power plant on top of the port's terminal buildings or some wind power plants at the top of the port to reduce grid energy usage at the port. (Green cruise port) & (fathom.world)

Additionally, some future sustainable alternative fuels would be valuable in future for marine and port business. These fuels could potentially replace MGO/MDO fuels in vessels such as methanol fuel, liquid bio gas, ethanol and hydrogen. There are a lot of studies and research focusing on the future alternative fuels and how to produce different sustainable fuels. For example, hydrogen might be one of the most attractive sustainable fuel in future since it produce almost none greenhouse gases. However, currently the production of hydrogen from CO2 uses more energy than what (energy) hydrogen can produce. (Clean Energy Wire CLEW 2018) This is the reason why currently hydrogen is mainly produced from LNG or from methane.

As expected, there are a lot of new sustainable alternative fuels coming up in future such as methanol and synthetic methane. The challenges in bringing these to the market are that they are still in the development stage and production in large production scale is challenging and expensive. Important in these future alternative fuels is that they are non-fossil fuels. In the short-term future, one could say bio methane could be one important fuel during moving to the new sustainable alternative cleaner fuels. Bio methane production would be possible from waste sewage or food waste materials with current technology. There are also power to gas solutions in already available where CO2 can be collected and in methanation process with hydrogen and it will be generated to methane gas (hydrogen is generated in electrolysis first from water H2O + electrolysis=H2

hydrogen). Comparing this method to bio methane production, it does need a lot of energy to generate pure methane comparing it to bio methane production, in this power-to-gas ideas the main idea is to storage wind and solar energy to methane energy in future, and then methane energy is available as gas energy storage. (Forbes 2020), (Swiss Liquid Future AG 2020), (Clean Energy Wire CLEW 2018).

There is also power-to-x development research on going in Finland LUT University, in this process CO2 and hydrogen will be processed to methanol fuel (LUT Nieminen 2020) Methanol is interesting fuel in future as well and it is most compact fuel to storage CO2+ hydrogen energy as well there are possibilities to generate different fuels from methanol. These are definitely future fuels and energy sources in the transition to fossil-free future. Most of these fuels are able to use in with nowadays techniques to generate energy.

LNG power barge solution with different hybrid features could be also one to be taken into account solution. However, it is based on fossil LNG solution unless bio methane, bio gas, future synthetic fuels and green hydrogen would be utilized. Maybe, liquid bio gas could be the more advance solution in future as bio methane. LNG power station could be installed on the barge or it could be LNG power container which can be mobilized easily to different place. One of the weaknesses LNG has, is that the energy produced by a conventional internal combustion engine might cause a methane slip to atmosphere because internal combustion engines do not burn all methane purely. However, there is existing technology to clean the methane slip in internal combustion engine solutions as “Catalytic oxidation of methane”. (Riviera Maritime Media Ltd 2019)

> *“Methane slip may be an X factor for the future use of both LNG and methane, esp. if internal combustion engines are still dominant. Hydrogen is potential if the supply infrastructure is solved, as shore supply or floating barge.” (Senior Scientist, in questionnaire)*

So far, there is not much research of LNG barges for onshore power system applications except Becker Marine LNG power barge “Hummel”. Since spring 2015, the barge has been in operation at the Port of Hamburg. According to Becker Marine “Hummel”, 7.5MW LNG power barge can have an efficiency up to 39,7% power efficiency and 45,4% heat efficiency. Thus, combined efficiency would be 85,1% which is a relatively very good total efficiency if the heat could be used for onshore power transfer and also transferred to heat port terminal infrastructure. (Becker Marine)

"The mobile power barge is an interesting concept to explore as it is possible to move to different environments for example during cruise seasons. In this way, its use can be maximized to be efficient and profitable. Alternative fuels could also be introduced on this type of barge in the future." (Respondent 1, General Development Manager)

According to Becker Marine, local emissions also would drop CO2 20%, NOx 88%, SOx 100%, PM Emissions 100%. Finally, Becker Marine also mentioning that LNG barge advantage is a silent operation and year-round concept where barge can be moved to different location to provide electricity and district heat. Thus, so far it seems one of the most feasible alternative options.

3.5 Strengths and Weaknesses of Sustainable Energy Alternatives in Marine and Port Business

The Marine industry is continually searching for new sustainable energy alternative sources to be a key player in climate-challenged future. In the current situation, there would be a need and demand for alternative forms of energy production simply because new clean Sulphur 0,1-0,5% fuels are expensive for shipowners to obtain. Obstacles today are still the infrastructure capacity of the urban and port areas to support large-scale shore power systems, as well as the financing and procurement side of who is in question who acquires these expensive systems. This acquisition and investment will naturally go to the ports as it will be their infrastructure. In some ports, the utilization rate is high, while in others it may be low which does not guarantee an expensive system payback time. Presumably, the cruise business can make these purchases with less investment because the port system is the main system and the ship's system only serves as a connection point to the onboard system. The grid based onshore power systems also require a stable city grid in most port locations, and this might also be a significant cost factor for many ports to acquire onshore power systems.

Figure 6 summarizes the three main sustainable alternative power sources.

Investigative energy triangle	Ship's own power production	On shore power system	LNG or LBG Power barge
Environment	Marine gas oil CO2, NOx, SOx, PM* LNG or LBG (liquid natural gas) CO2, NOx, SOx, PM*	Grid power CO2, NOx, SOx, PM* Fossile fuels usage 2020 in energy production Finland 37%	LNG (Liquefied Natural Gas) CO2, NOx, SOx, PM* Methane slip risk LBG (Liquefied Bio Gas) or Bio Methane
Economic feasibility	Cost efficiently No public acceptance if fossile fuels are used	Feasibility risk Only stationary use approx. (450-550 h/year) Grid tariff and national tax has impact to energy price Positive public acceptance	Feasibility risk Year-round concept (365 days/year) Generates power, heat – and revenue Investment and maintenance cost
Guaranteed energy supply	Well-established technology No public acceptance if fossile fuels are used	Grid-dependent Low capacity (city grid) 50 Hz frequency (cruise ships 60 Hz)	Grid-independent Guaranteed supply 60 Hz frequency (cruiseships) Available on demand (24/7)

Figure 6. Investigative energy triangle of sustainable alternative power sources.

In Figure 6 above, the investigative energy triangle chart was inspired by Becker Marine's similar study energy sector diagram, but above charts includes the weaknesses and the strengths taken into account, nor is it made to marketing a LNG solution alone.

First, in *Ship's own power production:* **Environment vise** this is standard fuel burning concept with ships own engines. Considering that, marine gas oil is the main fuel driver this is not the future solution to environment wisely. There are ways and techniques to clean the exhaust gas emissions from fossil fuels in addition or convert the cruise ships to LNG or LBG fuels to be more green than with marine gas oils.

Economically this is the main stream to create energy for vessel, it is affordable to implement and use for cruise ships when considering the total amount of all costs and ship as well operationally. Negative point is that it is not clean energy when running with MGO fuel example and it does not have good public image. Additionally, it has a **Guaranteed energy supply** independent of external factors.

Second, in *On shore power system:* **Environment vise** this solution has zero emissions at point it stands, however still in 2020 37% of grid energy were made with fossil fuels in Finland.

Economically implementation costs might vary of ports and application and thus can be considered implementation costs are moderate, stationary annual usage might create low profitability but good public acceptance and image.

In relation to **Guaranteed energy supply,** it is dependent of the grid quality in which is dependent of the city grid capacitance to supply such amount of energy. Most ships have 60Hz electricity systems so in EU area this system is dependent of frequency converting station.

Third, in *LNG or LBG Power barge:* **Environment vise** this solution has almost zero NOx, SOx and PM emission and CO2 emissions are also 20% less than MGO fuels. However methane slip might chop this 20% percentage advance. When using the Bio gas the CO2 emissions recovered in the collection process must also take into account as CO2 reducers.

Economically implementation costs are in the class the high/moderate, but it is year round concept and it gains revenue for the owner. Operational cost are highest in the class since it does need regular maintenance for certain operating hours.

In relation to **Guaranteed energy supply**, it is independent of external factors and can supply energy to cruise ships when they need it 24/7.

The strengths and weaknesses has been put stress in the text content to highlight which are the strengths and the weaknesses.

In addition, Figure 7 below shows a summary table of the conclusions where to proceed with proposal and a short summary of selected alternatives. Deep green colour describes the main points of the selected aspects and the light green colours highlight best features of existing methods to use for the selecting alternatives methods for the proposal.

Selecting alternatives and proceeding to proposal stage						
1.Existing methods	2. Benefits	3.Interest	4. Environment	5.Feasibility	6.Economy	7. Selected alternatives
Ship's own power production	Independent of external factors	Mandatory for the ship when at sea.	Normally fossile fuels in use but cleaner fuels available to reduce emissions	Well-established technology easy to implement	For new build ship moderate cost effective to adapt, for retrofit it is costly	**Land based sustainable alternative modular energy solution for the cruise and port business, which features, multipurpose usage solution in addition it has three optional setup which are (1. Thermal power district heat, 2. Biogas methanation process module, and integrated OPS system between modular energy solution and grid). (Setup.2 selected as an additional alternative since it is an important part of the carbon capture goal).**
On shore power system	Good technology exist	Positive public acceptance, Green values	Zero emission in the vicinity	Easy to implement, not multi-purpose	Moderate cost effectiveness depending on the destination grid infrastructure	
LNG or LBG Power barge	Mobility, alternative fuels and heat supply	Interesting concept in remote locations or destinations with weak grid balance	LNG and LBG fuels will reduce emissions significantly	Existing technology, implementing more difficult	Expensive cost-effectiveness, multipurpose usage reduce pay back time and increase revenue	
Collection for proposal, collected with green color	Three good key point to collect for proposal stage	Green values and Interest rate is matching with targets	LNG and LBG are alternative fuels in the short term to reduce emissions	Existing technology	Multipurpose usage, customer's financial benefits	

Figure 7. Selecting alternatives and proceeding to proposal stage.

Summary shown in Table 7 shows the selected alternatives for the Proposal(s) to proceed, which are: **Land based sustainable alternative modular energy solution for the cruise and port business**, which features a multipurpose usage solution; in addition it has three optional setups which are (1. Thermal power district heat, 2. Biogas methanation process module, and integrated OPS system between modular energy solution and grid). (Setup 2 was selected as an additional alternative since it is an important part of the carbon capture goal).

4 Existing Knowledge on Establishing Roadmaps, Creating CVP's and Identifying Business Opportunities

4.1 CVP Building in Business Practice

There are several prominent approaches to defining the Customer Value Proposition, CVP. This section will examine two main methods, Osterwalder´s and the method by Harvard Business School.

Osterwalder (2010, 2014) suggests to approach a CVP from the point of view of finding a fit between the Customer Profile (Customer Gains, Pains and Jobs-to-be-done) and the company's Value Proposition (Gain Creators, Pain Relievers and the Product&Service proper). According to Osterwalder (2014), a CVP consists of several elements that truly bring the value for the customer. To identify these elements, the customer's value should be explored and defined and valuable solutions should be listed, and the results should match in the values presented in the canvas between the Customer and the Company. To help build a CVP, Osterwarder at al (2014) developed the Value Proposition Canvas as shown in Figure 8 below (Osterwalder et al. 2014: 61).

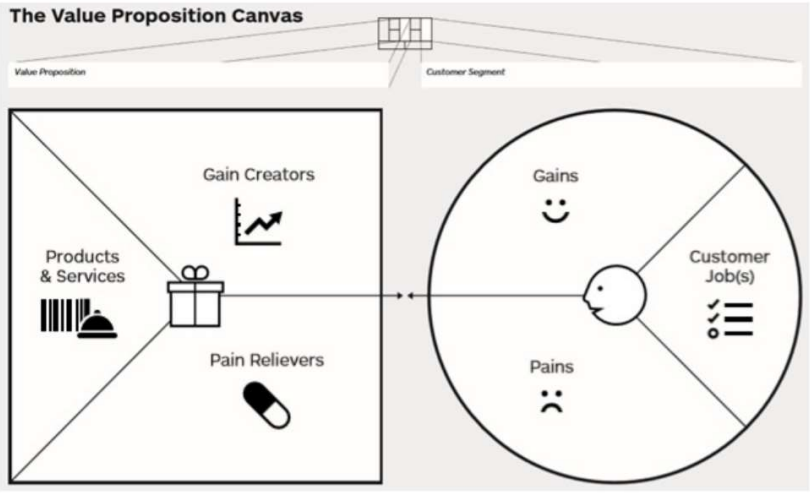

Figure 8. Value proposition canvas (Osterwalder et al. 2014).

As shown in Figure 7 above, Value Proposition Canvas has two separated areas: the Customer Profile and the Value Map. The first function of the area is to clarify how the canvas user understand their customer (Customer Profile), the second function of the area is to visualize how to be able to bring value for the customer. The Canvas has also

pointing arrows in the middle which are meant to illustrate (Fit) when the aspects on the both Canvas meet each other's. (Osterwalder et al. 2014).

The "Customer Profile (customer Gains, Pains and Jobs-to-be-done)" are the aspects in canvas. The Jobs-to-be-done can be split into three different main customer jobs to be done and supporting job categories as Functional, Social, and Emotional jobs. (Osterwalder et al. 2014). Customer pains can be described to be anything that annoys the customer on the way to get job done. These are the disadvantages which prevent to get the job done only with bad results or not at all. Customer gains are the positive indicator which describes the benefits the customer wants. Customer gains are also considered as the concrete elements of the Value proposition since they describes the most benefits for the customer. (Osterwalder et al. 2014). Customer Profile consist of tasks which investigate, search, and learn ranking each of the Customer Jobs, Pains, and Gains.

Figure 9 shows the customer priorities which can be ranked in the below map with posters beside of each arrows. This prioritization is the last step after all customer segment and identification for customer profiles are done. (Osterwalder et al. 2014).

Figure 9. Ranking model for value proposition canvas.

When the Customer Profile Jobs, Pains, Gains are understood and studied several times, the next step in the Value Proposition Canvas is to define the Value Proposition which joins in the benefits of the Product and Services which customer has in expectation. (Osterwalder et al. 2014). The first area is the Product and Services in the Value Map part, which is a simple list of Products and Service to offer for customer. The Product

and Services in this parts of Value Map are the Gain creators to customer to satisfy customer expectations in all of aspects and basic needs, but it is good to be aware these Product and Services not always or only by themselves bring the value in uniformity of gains, pains, and jobs. (Osterwalder et al. 2014). The Pain Relieve area describes how much the products and services help alleviate a particular type of pain for a customer. It outlines the things that can be improved or problem areas that can be smoothed out so that the customer does not encounter these annoying issues throughout the timeline as they try to get the job done. (Osterwalder et al. 2014). The Gain Creators tell you how the products and services make a revenue for the customer. They clearly explain how the company is working to get results as well as the benefits from it that the customers are waiting for, also taking into account the dynamic utility, Social benefits, positive feeling and saving the costs. (Osterwalder et al. 2014).

This Value Map section can be summarized briefly as a value map is created by listing products and services, followed by an outline of pain relievers as well as an outline of gain creators. The above aspects can then be ranked in order of priority and uses the ranking listing, as shown above in Figure 8.

Finally, there should be a fit between of these two areas. It is something that is achieved if the customer gets excited about the offered Value proposition. This can be considered to be achieved normally when the value proposition has created essential gains, the pains have been relieved, and the important jobs are done. (Osterwalder et al. 2014).

In some of the value proposition testing processes, it could be possible invite the customer to the teamwork, for example, which would be a great opportunity to create a perfectly Fit Value proposition, or test the value proposition several times and present the gains, pain relievers, and the jobs every time again.

Value Proposal Canvas has also three different kind of Fits which have been made for application in different sectors and their use depends on what the company offers and what their customers wants. Startup companies often call them Problem Solution Fit or Product Market Fit (see, for example: Leibson 2018), and the last Fit can be found when the Business Model Fit is customizable and makes profit. (Osterwalder et al. 2014).

An alternative to Osterwalder, which was actually developed earlier in time, was the Harvard Business School approach represented by Johnson et al. (2008). This approach

focuses - similar to Osterwalder (2010) - on the business model building, where CVP makes one integral part. According to Johnson at al. (2008), CVP means the way to “get the job done”. “Job to be done” refers to solving an important problem of fulfilling an important need for the target customer (similar to Osterwalder´s customer jobs-to-be-done).

Johnson et al. (2008) defines four elements of a business model essential to create and deliver value. In the approach of Johnson, the CVP refers to the value creation (element 1), whereas the profit formula /element 2), the key resources (element 3) and the key processes (element 8) all define the value delivery.

Figure 10 below shows elements of a business model of Johnson et al. (2008).

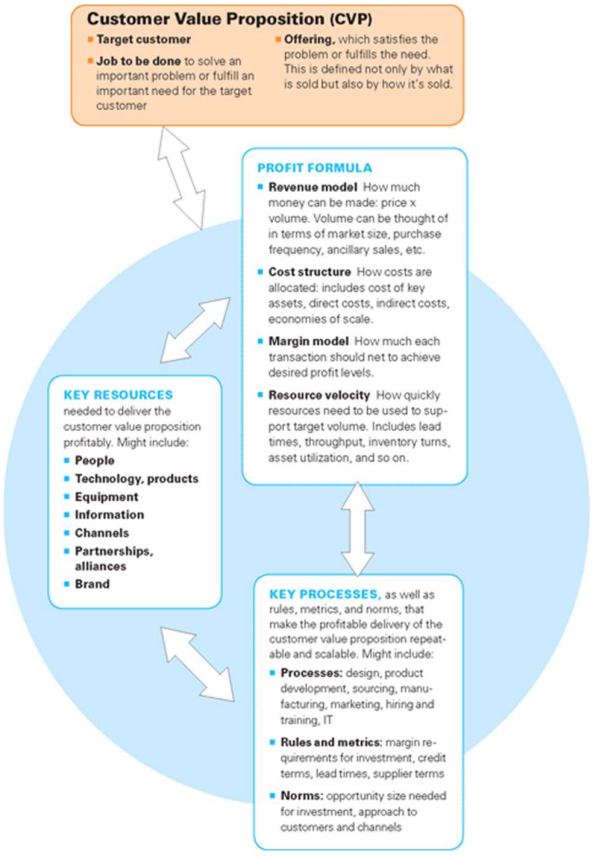

Figure 10. CVP elements in the approach by Johnson et al. (2008: 54).

As seen from Figure 8, CVP (element 1) includes the Target customer, Job-to-be-done and Offering that satisfies the job to be done. (2) Profit formula defines how the company creates value for itself. i.e. the financial aspects of a business model, including revenue

model, cost structure, margin model and resource velocity. (3) Key resources include resources required to deliver the CVP, such as people, technology, equipment, channels partnerships, etc. Finally, (4) key processes define how the CVP is delivered. (Johnson et al. 2008: 54).

To detail the CVP content, Harvard Business School suggests to ask questions. In this study, the questions can be specified as follows, for example, so that to use them in the conceptual framework:

- Which challenges need to be solved?
- Which objectives should meet to address these challenges?
- Which capabilities do need to deliver in order to meet the objectives?
- Which actions are required to bridge the capability gaps?
- Which solutions do need to bridge the capability gaps?
- Which solution are the higher priority?
- Which solution should be invested in delivering and in which order over time?

Harvard Business School describes that also “finding unique value proposition involves new way of segmenting markets” and “value propositions as novel expanding the markets”. (Harvard Business School)
Therefore Harvard Business School has also developed method to “Define the value proposition: Three Essential Questions”

- What Customers?
- Which Needs?
- What Relative Price?

(Harvard Business School)

The above questions will be used to synthesize the conceptual framework for Section 4.3 and later in Section 5 to propose steps and action points for creating the roadmap for this study.

4.2 Scorecards Method for Selecting New Business Opportunities

Scorecard methods were selected for framework since scorecard based approach would be identical for such sustainable alternative solution to identify product or start up opportunities. To set the primary goals in nowadays are finding product and start up solutions for markets as fast as possible and spending small volume of labor cost and money as reasonable in for the process. Scorecard methods for product and start up opportunities is developed originally for business management model which supports this prioritization. (Cabage, Zhang 2013) Balanced Scorecard method was developed in 1990's by Robert Kaplan and David Norton's an accounting professor at Harvard University, and David Norton, a consultant. (Niven 2006: 12.)

Balanced Scorecard method acknowledges the tendency of businesses to emphasize certain goals over others, which can cause long-term imbalances and dysfunctions within an organization. The Balanced Scorecard provides a more holistic and pragmatic approach to setting the priorities of the organization. (Cabage, Zhang 2013)

Figure 11. Balanced Scorecard method (Kaplan and Norton 1996).

In this method of the Balanced Scorecard, the objectives, key performances measures, targets and purpose and initiatives are identified and compared according to values described in the card below. Figure 9 below shows the spread sheet measures for the Balanced Scorecard derived from the objectives, measures, targets and initiatives and appearing key performances, as financial, customer, processes and learning and growth criteria similar than this below. (Cabage, Zhang 2013)

	Objectives	Measures	Targets	Initiatives
Financial				
Customer				
Process				
Learning				

Figure 12. Balanced scorecard spread sheet (Cabage, Zhang 2013)

In rapid ramp-up product design, this scorecard method is ideal, for example, when looking for new product platforms or starting a new start up business says (Cabage, Zhang 2013). Although the scorecard as a tool was originally developed for a different use than the product or to develop a new start up, product management and start-ups can apply the balanced scorecard to suit their own business, but the starting point for the design is often considered to be based on the original Kaplan and Norton model (1996). The Balanced scorecard is seeking to create a balance between four different perspectives being measured:

The Four Perspectives of Balanced Scorecard

Finance perspective. The financial measures are important as well as critical in a balanced scorecard, especially if the company is aiming for profit. The goals in this perspective tell that whether the strategy, with the goals and measures selected from the perspectives of other categories, will lead to better results. (Niven 2006, 16). A successful economic strategy, in a nutshell, requires that all aspects of the perspective of the four different categories be properly designed to serve the achievement of the objectives.

Internal Process. This perspective should take into account all the key processes that the company must have in place in order continue to bring added value to customers and, ultimately, to shareholders. The described operation of customer areas requires efficient operation in internal processes and their identification. Internal process role is

to identify those processes and develop the best possible objectives and measures to monitor progress. To satisfy the assumptions of customers and shareholders, it may be necessary to identify an entirely new way of operating the internal process rather than simply improving the old way of operating. This may be very common on the product development side, for example. (Niven 2006, 15)

Learning and growth. Employees learning and growth prospects are the important drivers when it comes to achieving ambitious goals and results for internal processes, customers, and ultimately, shareholders. Employee objectives and measures the learning and growth perspective of a balanced scorecard are indeed the enabling factors for the other three perspectives. Basically, they are the foundation on which the balanced scorecard is built. Once targets are identified, actions and related initiatives within your client and internal process perspective, there is very possibly a some gaps between them in the current organization infrastructure and practices, of employee skills. Objectives and measures designed in this perspective will help close the gap and ensure sustainable performance in the future. (Niven 2006, 16)

Customer perspective. When choosing measures from the customer's perspective of the scorecard organizations need to answer three critical questions about of the main our target customers? What is in serving our value proposition to these customers? And what do the customers expect or demand from the company? The performance indicators which organization should development, of the perspective includes measures as: customer satisfaction, customer loyalty, for example, market share and customer acquisition in selected customer segment. These indicators are also widely used today as value disciplines to measure. (Niven 2006, 14-15)

As stated above, “different business areas can apply balanced scorecard methods suit them to fit best to their own business”. Cabage (2014) has developed various methods for product development and start up concepts as Startup scorecard tool which is based on the model 6 Market Dynamic with the goal to identify market opportunities and adapts partially same aspects as Balanced Scorecard methods. The main aspects are customer, product, competition, timing, financial, and team as drivers. (Cabage 2014) Figure 13 below describes Cabage’s model 6 Market Dynamics.

Figure 13. Neal Cabage's, The 6 Market Dynamics with the Startup Scorecard. (Cabage 2014).

According to Cabage (2014), each of the aspects in 6 Market Dynamic should be studied to assess the need and the view of the market as well the capability to create business case which is valuable. (Cabage 2014) To create a Startup scorecard with 6 Market Dynamics, each of the aspects in 6 Market Dynamics need to be considered. Figure 14 below describes each of them for 6 Market Dynamics and as well is the baseline for the startup scorecard design from Neal Cabage's start up scorecard tool.

Customer	**Product**
Un meet need or desire	Customer focuses solution
Right size market or segment	Low barriers to adoption
Reliable customer channels	Clear value proposition
Customer score:	Product score:
Timing	**Competition**
Recent innovation enabler	Clear market inefficiency
Demand already established	Low barriers to entry
No signs of commoditization	Differentiable position
Timing score:	Competition score:
Finance	**Team**
Low capital requirement	Subject matter expertise
Clear profit model	Functional competence
Economies of scale	Supplier partnerships
Finance score:	Team score:
(Letter grade A - F)	Overall score:

Figure 14. Neal Cabage's Startup scorecard tool.

As seen from the scorecard above, these are the letter grades (A-F) which are selected instead of numeral grades. Cabage sums up in one sentence that numerical grades would feel too precise, as these are entirely subjective evaluations. The reason for using letter grades is also, that it helps to think holistically, and this is just a framework that helps to highlight important criteria to be taken into account in evaluation. (Cabage 2014)

Later, Section 5 will use the scorecard model, as well as describe where the grades obtained from them.

4.3 Conceptual Framework

The conceptual framework for conducting next steps in this study is based on suggestions from literature and existing knowledge which were re-considered for application in sustainable marine and port energy alternatives and also from the environmental aspect.

By merging the suggestions from literature reflected against the results of the current state analysis, the study comes up with the following conceptual framework, as illustrated in Figure 15 below.

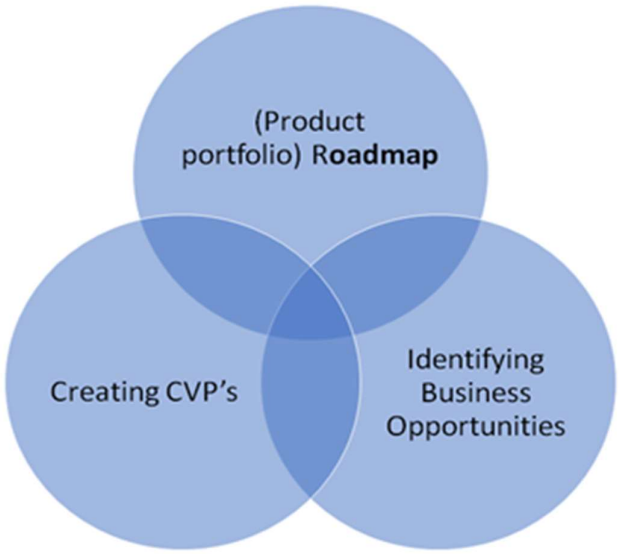

Figure 15. Conceptual framework: key dimensions.

Among these key dimensions, one (roadmap) was also further specified below.

	Current State	Future State	Gap	Actions to Close Gap
What	Alternative land based port shore connection taken partially in use globally	Sustainable energy alternative, to supply, power, heat, cooling etc...	Port infrastructure readiness, investors, emission limits, financial cost estimate and back payment period.	Analyse port infrastructure readiness, better solution to reduce costs, fossile fuel price increase, tightening emission laws.
Where	Confusion is to understand usage value of the others sustainable energy alternatives	Investing more to R&D and for alternative energy transfer methods. Arousing the interest of the stakeholder. When economical and environmental values meet.	Energy alternatives could reduce 20% of standard electric power consumers from shore connection and reduce markable amount of used steam in cruise ship.	Stakeholders as port, environmet organizations, cruise business and marine cluster companies.
When	Transformation from non alternative to half alternative shore power connection is on going.	Trasformation is continuous, due changin economy and environment climate targets.	Sustainable energy alternatives for port shore connection could be implemented anytime, technology is here.	Sustainable energy alternatives will be addressed in next ten years around the metropolitan ports.
Who	Usage in main metropolitan ports, in demand to reduce pollution and consumption of fossile fuels.	All ports in main cruise ship ports areas, all cruise companies committed to use energy alternatives.	Environment organizations, ports, cruise companies to identify and companies that have to provide a business solution to the problem.	Investors, stakeholders, environmental organisations (changes in the law) and inflation in fossile fuels.
How	voluntarily moving away from fossil fuels in the port environment.	By moving systematically and away from fossil fuels in the harbor environment.	Improvisation comes through alternative development ideas, analyses and from CVP.	Customer value proposition and grounded analyze

Figure 16. Conceptual framework to guide the roadmap building (based on GAP analysis).

Step 1 is to understand in the beginning what kind of ideas for solution could play a role in sustainable marine and port energy alternatives in the future, a roadmap can be taken to use as scheduled action plan and product portfolio roadmap can be established for

high-level visual representation of the sustainable marine alternative product development. Step 2 is to define the Future State. Step 3 is to define the Gaps. Step 4 is to Define actions to close the gaps. In this conceptual framework, concreate actions will play a role where the technologies will define the new way of working and enabling existing technologies. Ideas are pulled together from various sources and possible solutions already existing as product or concepts. These ideas are intended to develop a hybrid solution for sustainable marine and energy alternatives.

As seen in Figure 16, there are three different key dimension presented which are the key dimensions of conceptual framework. Each of the dimensions have the sub references which will be taken in use in Section 5.

5 Developing proposals concerning sustainable maritime power alternatives for the cruise business

This section merges the results of the current state analysis and the theoretical framework into the Proposal for the recommended alternative solution.

5.1 Overview of the Proposal Building Stage

The goal of the proposal was to propose a concept for existing sustainable energy alternative technology, but create a new idea built from pulling together the ideas from different sources. The proposal used the form of a roadmap to CVP to provide an idea of where potential high-efficiency systems have been utilized and low-emission systems could be used more than fossil fuel-based solutions. The proposal was built in co-creation with experts who made their input into the roadmap and CVP.

The first step in the proposal building was a roadmap. It outlined the activities in four time horizons, the *Completed*, the *Current*, the *Near Future* and the *Future* points in time.

The second step in the proposal building was an outline of a CVP that pointed to the three main questions based on the Harvard Business School essential questions to the CVP.

The third step in the proposal building was to look into and outline the opportunity scorecard.

The final step in the proposal building was to pull together the full proposal in the summary for the management.

The selected solution is the proposal was the *land based energy interface solution* for cruise and port business.

5.2 Proposal Element 1: Roadmap

The roadmap is a scheduled action plan in excel format which is based on the results from CSA and conceptual framework suggestions. The proposal is mainly based on studies and publications on future sustainable and alternative forms of energy, fuels and the future to be CO2-neutral by 2050 objectives in European shipping and port operations.

The discussed technology already exists for alternative forms of energy and the roadmap has been used for pulling together the most interesting emission neutral options of the future.

Figure 17 the roadmap for building the CVP for *land based energy interface solution* for cruise and port business.

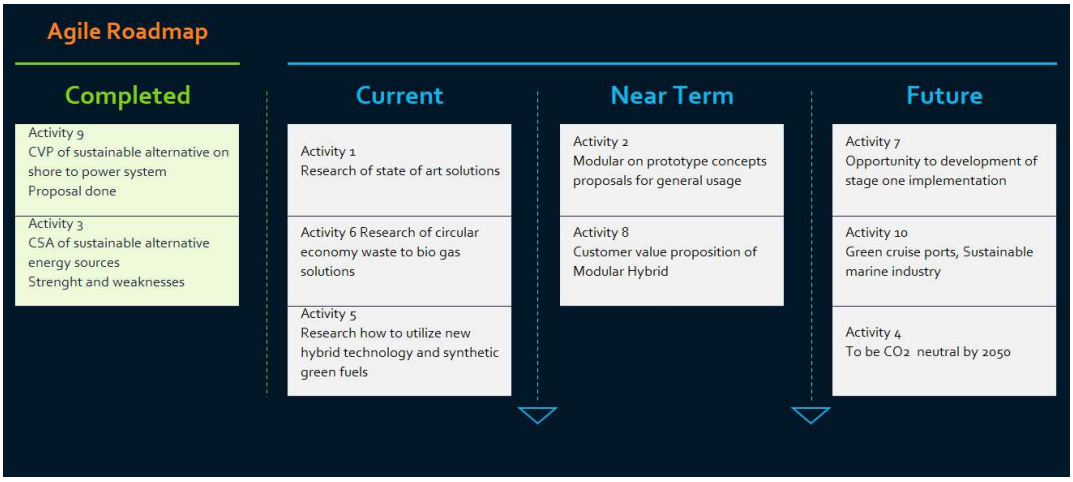

Figure 17. Roadmap for building the CVP for the land based energy interface solution for cruise and port business.

As seen above, the steps on the road map consist of the following time horizons: Completed > Current > Near Term > Future.

First, at the *Current* point in time, Activity 1 includes creation of deep analyses of current and deep research of state of art solutions of sustainable alternative energy platform which platform could be feasible.

Second, at the *Near Future* point in time, Activity 2 includes design and testing the analyzed data to create prototype concept which would create gains, relieve pains, and jobs for markets.

Third, at the *Future* point in time, Activity 7 includes this would be the implementation phase where to start execute the designed concept. This activity means there are investors and demand for the concept.

Also, at the *Completed* point in time, Activity 9 included current Customer value proposal for further investigation and to arouse interest for current sustainable alternative energy source market demands. This includes, the points which have been achieved.

Fourth, at the Current point in time, Activity 6 includes optional deep research of circular economy and waste to bio gas analyses. To understand the feasibility of waste to gas concept and whether it is possible to combine as sustainable alternative energy platform.

Fifth, at the Near Future, Activity 8 includes ready Modular hybrid energy platform concept CVP, this can be considered the CVP is in near of Product Market Fit stage when aiming to the future targets. When this activity is achieved many testing and mapping have been done before that to identify gains, pain relievers, and the jobs.

Sixth, at the Future, Activity 10 includes the main target where to aiming in the future. This bring the concept and product to markets in an effort to become part of future green port projects or to take a part to sustainable marine industry concepts.

Also, at the *Completed* point in time, Activity 3 included CSA – Current State Analyses of current energy platform technology available, this also include strengths and weaknesses of current technology available. This activity have been achieved in this point.

Seventh, at the Current point in time, Activity 5 include optional deep research of new hybrid energy technology and analyze the feasibility to use them in sustainable alternative energy platforms. This also includes new synthetic green fuels and deep research of the feasibility in future energy platforms.

Eight, at the Future, Activity 4 is the target where aiming to carbon neutral future, this is the global movement for carbon neutrality to achieve by 2050 according to (UN). European union has already set the line to 2050 to committed to do so. This is the key business target where to aiming with new carbon capture technologies and with new green fuel options as hydrogen and synthetics. This new technology will be the second baseline between the energies of nature as wind, solar and hydro energy.

To have answers to these questions is essential for a roadmap. The proposal also makes an attempt to create the first visual roadmap on way to create a product portfolio solution-based CVP.

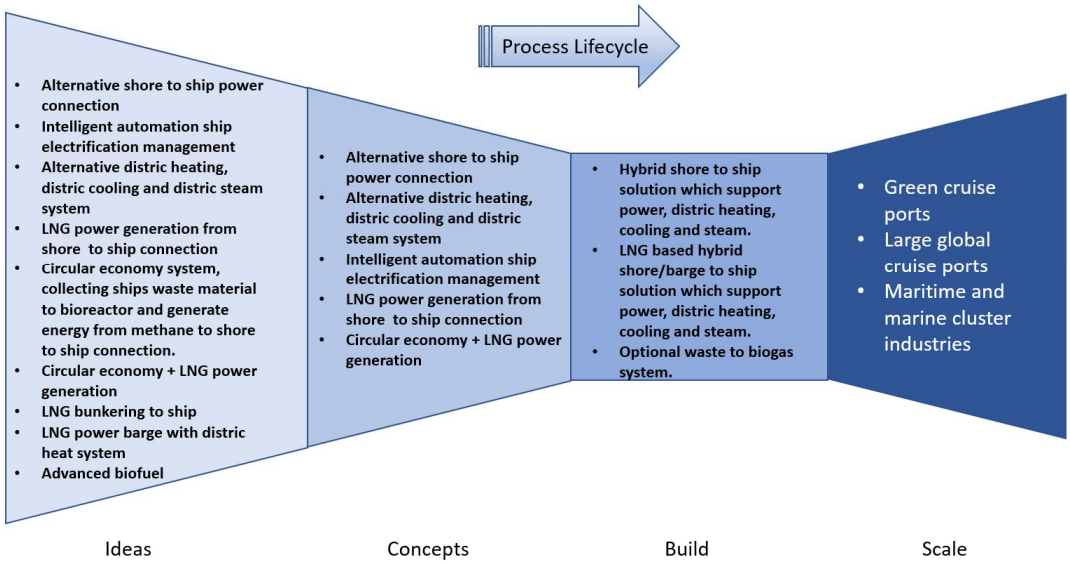

Figure 18. Product portfolio roadmap has visual output of a possible concept solution.

This roadmap shows the steps in product portfolio building. There are several ideas which should be analyzed for the best use. From them, the concept models could be created from which best candidates are selected for the building level. Finally, the roadmap presents the scale at which building-level concepts should be taken forward at the CVP level.

5.3 Proposal Element 2: CVP Proposal

This section combines the results of the current state analysis toward the preliminary CVP. For the discussions with experts and CVP building, the study used SWOT analyze, value proposition canvas, and product scorecard methods.

As identified from the discussions with experts and suggestions from literature, exploring the possibility of land base shore power system should start from questions what would be the benefits of exploring cruise ships' electricity consumption and how it could be made greener and more efficient. These questions stand at the heart of a future CVP for this solution. Other questions, exploring the competing solutions, should be: what other forms of energy could be utilized in cruise ships and ports than electrical energy, and

which fuels would be best for sustainable development. Additionally, such questions as: Would it be cost effectively to implement concepts of greener energy forms for cruise and port business to get marine sectors investors to excited of the CVP and would it have glorious future prospects, could also be asked.

For approaching the customer value proposition, Harvard Business School method has been used as a tool, as shown in Figure 19 below.

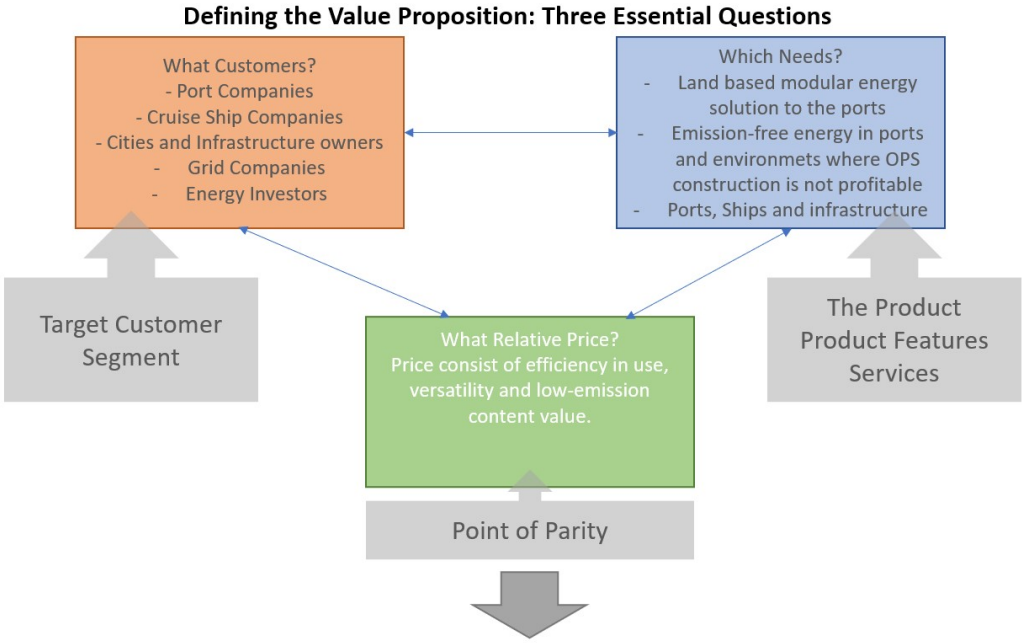

Figure 19. Harvard Business School's essential questions.

Above is Harvard Business School's essential question to defining the Value Proposition, these questions have three different segments.

The First question box on left asks What customers, for this section it is defined the **target customer segments** who would be perhaps interested of land based modular energy solutions and are looking new drivers and new concepts.

Defined ideal customers would be Port Companies, Cruise Ship Companies and the Cities and Infrastructure owners, Grid Companies, and Energy Investors these customers are the category this concept would target. This is the Customer segment it would best

serve, as Harvard Business School describes. When customer segment have been selected as ideal this redirect the next question box needs and then to the next until the three question triangle which define the suitability of product or concept in this case.

The Second question box on right asks Which needs, for this section it is defined the **Product, Product Features, and Services**. This is basically what to offer for customer and what the customer expects and needs. Defined ideal needs would be Land based modular energy solutions to the ports, Emission free energy in ports and environments where OPS construction is not profitable, who it would serve is defined Ports, Ships, and Infrastructure. This would be the special ability of product concepts to this customer segment with special sustainable alternatives features. Main major thing is that the value proposition would appeal to customer from traditional segment, but as well arise their perspective to same carbon neutral future as the customer who already think out of the box.

The Third question box on below asks What relative price, that should be the price which provides acceptable value for customer as well provides acceptable profit for the company Harvard Business School sump up. The Value proposition in this case been targeted to achieve Point of Parity with customer who are looking invest to such energy platform concept and would select the concept for their needs of efficiency, versatility and low-emissions to achieve future emission neutral goals. As the concept would be ideal for example startup company to piloting for the customer and gain visibility in markets and the price can be determined together with customer. When the customer and company have same aiming and direction that can be called Point of Parity. This can be considered also as unmet need which might be the decisive connection in the three triangle.

To find unmet need of would be the best scenario for this value proposal, it would mean that the value proposal is unique and customer with unmet need have been waiting for this the new segmenting on the markets. Making the value proposal as a **Novel** would also expand the markets increase demand says Harvard Business School.

5.4 Proposal Element 3: Opportunity Scorecard

Finally, the proposal suggests an opportunity scorecard for CVP.

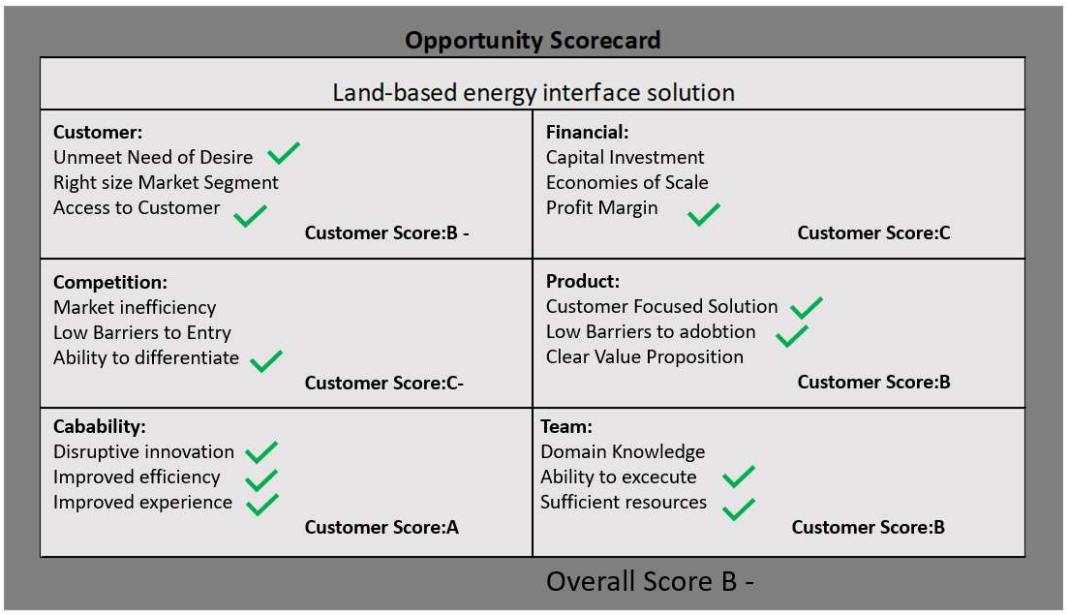

Figure 20. Opportunity score card for CVP.

Figure 20 above shows the Opportunity Scorecard what is done using Neil Cabage's Startup Opportunity Scorecard methods. In Section 4.2 that method was discussed and here it will be presented practically. All above boxes in scorecard have three aspects which determine what kind of significance of that need or desire this opportunity could determine, and decide if this opportunity is something where the company should add effort to pursue.

Customer aspect, *Unmeet Need of Desire*, this is the part where the concept should stand out the others and be different, something what the customers have yet to find but they have been searching. In this Scorecard, they are considered as achieved (V).

Right Size of Market Segment, this is the part which describes where to select what is the market needs and abilities to meet. In this Scorecard, they are considered to be moderate no value, since it is something not all customers are willing to invest such amount at this point for piloting a concept.

Access To Customer, this is the part where to recognize if the company or start-up can identify reliable and diverse which connecting the customers and the concept owner company. In this Scorecard, they are considered as “can be achieved” (V). (The total Customer aspect score is B -)

Competition aspect, *Market inefficiency,* this is the part which defines the market efficiency, where big single market leaders might become single dominant, markets are inefficient when markets are new, fragmented as such geography barriers and lack of discovery. In this Scorecard, they are considered as moderate since there are no enough searched data globally so geography barriers might become restrictive since discovery has been focused to European union area.

Low Barriers to Entry, this is the part which define if markets have mature offering which the startup’s offering cannot beat without using insignificant time and money to beat the competitors. Even some dominant market leaders can starve company out of the markets. In this Scorecard, they are considered as moderate since there are some big dominant players in market who can easily ramp up fast track concept and fulfill market needs.

Ability to Differentiate, this is the part which define that if the company has ability to differentiate to other competitors. Even if the concept would be similar than others in the market, in this the company can differentiate and offer concept with advantage over the others. This will reduce competitive the pressure in the markers and build unique needs. Start-ups cannot compete with dominant market players but perhaps they can offer their concept for market players to build their fast track solutions. In this Scorecard, they are considered as achieved (V). (The total Competition aspect score is C -)

Capability aspect, *Disruptive Innovation,* this can be summed up as pure innovation and good timing. When the company has innovation of technology or services, markets unmeet desires might wake up. In this Scorecard, it is considered that the concept innovation would give gain for customers and their needs. The correct timing would be now before it is late. In this Scorecard, it is considered as achieved (V).

Improved efficiency, this is the part which define if the concept, product or service can increase customer’s efficiency and benefits, what the customer would get more if using

the concept. Example ports can increase their efficiency and make better profit with environment friendly concept. In this Scorecard, it is considered to be achieved (V).

Improved experience, this is the part which defines that if the product, concept or services can offer new capabilities which create better customer experiences. Customers are mostly ports and cruise ship companies which for sure appreciate new concept to help their business. In this Scorecard, it is considered to be achieved (V). (The total Competition aspect score is A)

Financial aspects, *Capital Investment* this is the part which define what are the risks for this capital investments and is the risk worth of taking; or would the cost of development utilize the all capital investments at the beginning. In this Scorecard, they are considered not to be achieved without private equity investors or a market dominant company which would invest into the concept. (In this Scorecard, it is considered as not achieved)

Economies of Scale, this is the part which describe the opportunity which could scale up the profitability. This is mainly important for companies who have desire to make aggressive growth with good profitability. In this Scorecard, it is considered not to be achieved since this kind of technology startup is not fats ramp up business with high profitability. (In this Scorecard, it is considered as not achieved)

Profit Margin, this is the part which define company's profit margin and how the company can project the profit margin early on. In this Scorecard, it is considered that a profit margin can be built to a healthy profitable level with the new concept. (In this Scorecard, it is considered as achieved (V). (Competition aspect score is C)

Product aspects, *Customer Focuses Solution,* this is the part which define if company product, concept or services have main customer focus segment. In this case, the concept have a well-selected customer focus concept. (In this Scorecard, it is considered as achieved (V)

Low Barrier to Adoption, this is the part which define if the company's product, concept or service are easy for customer adoption. In this case, the concept have a well-known technology so adoption of concept should not be an obstacle. (In this Scorecard, it is considered as achieved (V)

Clear Value Proposition, this is the part which define the quality of value proposition and value proposition to fill unmet need. In this case, the concept have a value proposition with think-out-the-box ideas that might not raise demand of unmet need in customers at the moment. (In this Scorecard, it is considered as not achieved. (Competition aspect score is B)

Team aspects, *Domain Knowledge,* this is the part which define if company has deep knowledge of market where it is entering. This is also deep understanding what customers need and what the competitors offers in this market segment. At this point it could be difficult to tackle all these obstacles for the concept. In this Scorecard case to be considered not achieved.

Ability to Execute, this is the part which define the company's team capacity to execute and accelerate. This is the capacity to build efficient solutions and maintain business relationships. Without these abilities it is difficult enter the markets. This would not be the biggest obstacle to build a great team with such ability for the concept. (In this Scorecard, it is considered as achieved (V).

Sufficient Resources, this is the part which define if the company have sufficient resources available and on top of that company needs capital to run the office and other expenses. For a start-up, this would be obviously running with low capital and with founders at the beginning. In this case, it can be assumed that private equity investors and dominant marine cluster companies would invest into a start-up company. In this Scorecard, it is considered as achieved (V). (Competition aspect score is B)

5.5 Summary of the Proposal for the Management

The thesis recommends focusing on *the land-based or barge based modular concept on shore power system* with high combined efficiency. Simultaneously, this solution would be an almost emission-free power source which could be used year-round if needed to supply energy to cruise ships, port terminal infrastructure or in opposite case to the city grid. Meanwhile, when it is generating electricity, it can also produce district heat to cruise ships, terminal infrastructure or directly to city district heat. It could be operated with LNG (Liquide natural gas), LBG (Liquide biogas), bio methane and optional with green hydrogen or new synthetic fuels as methanol.

Summing up, the customer value proposition for conceptual sustainable land-based shore power system shows that this solution can reduce emissions, noise, maintenance fees and have optional circulation economy features. This sustainable land-based shore power system can be also scaled to floating barge solution or it can be modular which makes it easily movable to different locations.

Concept proposal:

7,6MW land based modular energy solution which is able to extend to 11,4MW unit due different capacity demand in different ports. 7,6MW can cover the average power demand of a cruise ship when ship is visiting the port. Modular energy solution includes 4x1,9MW internal combustion engines. These engines can run with biogas, liquid biogas, sewage gas, bio methane and with green hydrogen blend. Energy efficiency would be up to 43% and thermal efficiency would be up to 41%. (MTU-Solutions) To reduce methane slip, the engines are equipped with Catalytic oxidation of methane system.

Concept proposal is proposed on the ports where building OPS system is not economically viable and the project has no advantages other than operating in short seasonal periods.

It is possible to install the modular energy solution on the barge, and in addition the modules can be re-mobilized in short periods to another place. Movable 5 x 45” high cube sea container solution. External green gas fuel tanks 2 x 40” container easy to switch another or re-fill.

Optional setup.1

Due to its characteristic to produce thermal power as well, this can be used for district heat to the public district heating system or it can be connected to cruise ships heating system in case cruise ship is equipped with such heat transfer system.

Optional setup.2

Beside the modular energy system, there is an optional setup for modular biogas storage system and biogas methanation solution system. In addition, this option can be scaled up to sewage gas system where all sewage from cruise ships, ferries and port terminal building could be collected to ports own sewage plant.

Optional setup.3

During a low cruise ship season, the energy demand might be almost zero at port except for the ferry traffic. Modular energy solution can be equipped with OPS system which can transfer electricity back and forth from grid to grid. This is the option for where port's infrastructure can establish their own energy company as well or the grid company could become an investor for this setup since the concept would support all parties depending on different seasonal cruise situations.

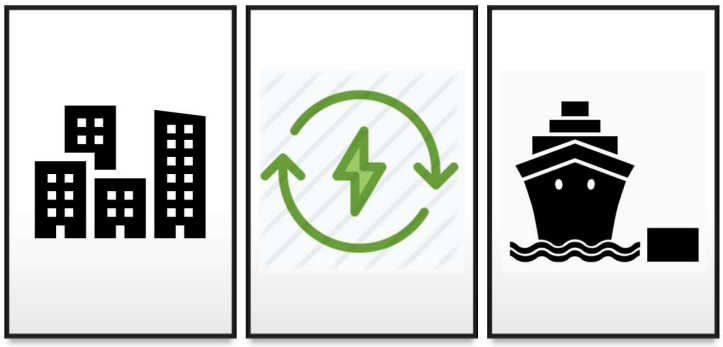

Figure 21. Diversified green energy production in connection with cities and public infrastructure.

Benefits of sustainable alternative fuels usage as biogas "CH4" or renewable natural gas comes when biogas is processed or captured from waste process or from landfills example. During the biogas burning process it will still produce certain amount of CO2 to atmosphere but due to its characteristic it is collected from the plants "which naturally removes CO2 from the atmosphere". This is the reason why CO2 emissions are considered as climate neutral (EDF blog 2019)

Emission to the environment would be considered relatively small for biogas solution compared to the fossil-based fuels and for the fact approximately "one third" of grid-based energy is produced with coal or other similar fossil fuels. Environmental noise emission would be also relatively low due to the high technology and advanced sound insulations in module structure. Modules can be also located to the outermost part of the port area to reduce noises.

Finally, the payback period as well as the operating costs for this type of concept is relatively varied because the location of the port and active operating hours, as well as

the potential utilization of the solution is an important focus with the entire solution. Example in port which is in the middle of city or edge of the city might have remarkably weak grid connection to apply traditional OPS system would this modular energy solution over benefit OPS system even the construction costs would be almost identical. System would make revenue for the system owner as well and the price of energy is competitive for standard grid prices due the high tariff prices. System would be quite flexible and alternative to use on the side of port, and for cruise business there is always second user option as the grid company.

To sum up, Figure 22 below summarizes the proposal's benefits as gains, overall performance and the proposal key initiatives. Key Milestones are described from the proposal stage up to the first possible delivery of stage 1 concept.

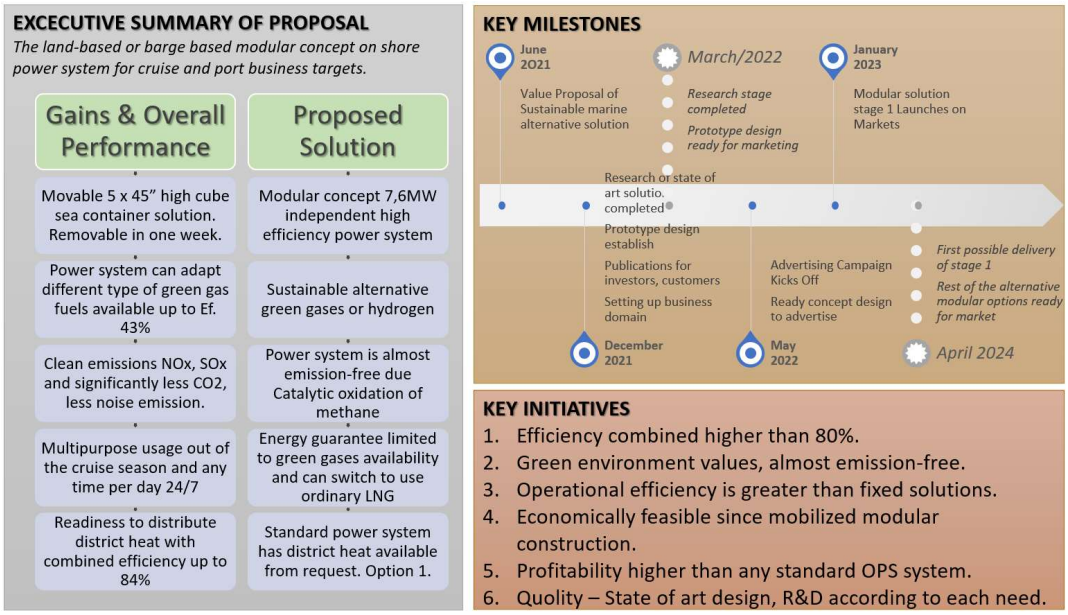

Figure 22. Summary of the key elements of the proposed alternative energy solution.

6 Validation of the Proposal

This section reports on the results of the validation stage and points to further developments to the initial Proposal.

6.1 Overview of the Validation Stage

This section reports on the results of validation and feedback for CVP from the various parties who have commented on the proposal. At the validation stage, the proposal and its feasibility were weighted, and whether in a structure like this, implementation for investors makes sense to start considering implementation and financing; as well as how the solution could be successfully integrated and what other negligible costs could be included in this type of solution.

6.2 Feedback, Further Development to the Proposal, and Implementation

The thesis recommended to focus on the land-based or barge-based modular concept on shore power system with high combined efficiency. Simultaneously, this solution would be an almost emission free power source which could be used year-round if needed to supply energy to cruise ships, port terminal infrastructure or in opposite case to the city grid. Meanwhile, when it generating electricity it can also produces district heat to cruise ships, terminal infrastructure or directly to city district heat. It could be operated with LNG (Liquide natural gas), LBG (Liquide bio gas), bio methane and optional with green hydrogen or new synthetic fuels as methanol.

The comments to this proposal were received and the feedback view was positive. It was also stressed that the general situation is that, at present, many cruise companies are interested in funding solutions like this as well as ordinary OPS solutions. This means that investment costs would mainly come from projects in ports and cities that own and control the areas.

Implementation of CVP land based or barge based sustainable energy plants system was seen as necessary. This study was done only on a general level, not for any specific company, so it is hoped that it would open up the interest of researchers in various positions, investors as well as port, cruise industry experts. More extensive and wider research should answer the question if this outlined proposal would be the correct option

in the fight against global warming and reducing the use of fossil fuels and other emissions into the atmosphere.

In the future, a standard OPS system will probably become the standard in the most of ports to reduce emissions. Most likely, ports with their own modular energy generation system will also be in the minority and in proportion considerably less than OPS systems. LNG fuel belongs to fossil fuels and the resulting methanol slip are also tricky to determine, so this can be a bad equation in the formula. However, biogas is an ethically greener option as well as its capture causes carbon capture. Green hydrogen and synthetic green fuels are also evolving/coming up, so preparing technology for these in the future would gain more value and opportunities as well.

Figure 23 below describes the final proposal's benefits as gains, overall performance and the proposal key initiatives. Key Milestones are described from the proposal stage up to the first possible delivery of stage 1 concept. (During the validation, there were no comments added, therefore the proposal stays the same).

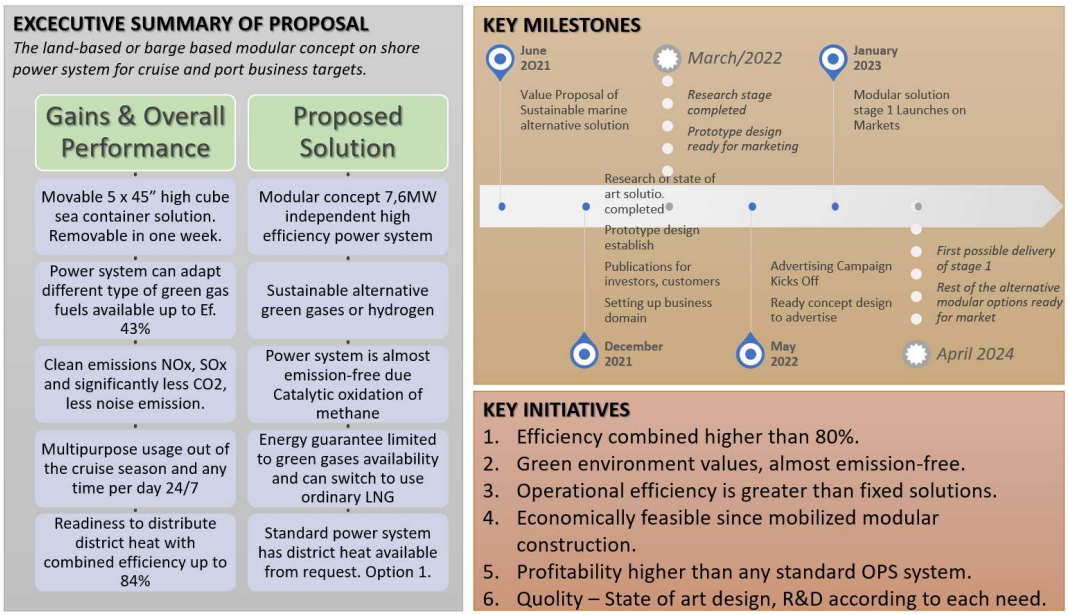

Figure 23. Final proposal.

7 Conclusions

This section presents the conclusions from the study and next steps in the direction of the proposal implementation.

7.1 Executive Summary

The purpose of this study was to find out the current situation in sustainable alternatives energy sources in cruise business and propose which role a marine cluster company can play in the climate-challenged future. The thesis looked into the marine cluster business on a sector level, and there was no specific case company in this work.

The thesis objective was to search for the best practical solution to reduce emissions now and in the future for the ports and cruise ship business with the goal of an emission neutral future. The objective was not to focus on a single form of energy, but to seek out the best possible forms to use in ports so that it is environmentally friendly and economically attractive for both, the cruise ship companies and the port companies. Another important objective was also to inspire marine companies, cruise ship companies and ports companies and potential investors to think in a more sustainable way and build profitable emission-free solutions.

The thesis started with the analysis of the case studies in the marine cluster business. First, it overviewed what existing methods are in use for generating energy in different forms for cruise ships when the ship is visiting at ports. Second, it looked into the existing alternative energy generation methods, and third, into the cases where the created customer value can potentially (in the future) turn into a new development project for a marine cluster company.

After the current state analysis, the thesis studies existing knowledge to understand the current state of sustainable alternatives for generating electricity and energy in different forms for cruise ships when the ship is visiting at ports. It required to create a view what existing methods are in use for building CVP, which considers different strategies in the form of a roadmap and applying scorecard methods for evaluating new business opportunities. For this part, the thesis used literature, articles, research and previous studies and also published know-how from different marine cluster companies.

The outcomes of this thesis were the roadmap to the Customer Value Proposition (CVP) and proposals for the management of the selected alternative solution to help understand the business opportunities in cruise and port business from the energy economy as well environmentally wise perspectives, as well as suggestions about the role that marine cluster companies could play in this business. Thus, the proposal pointed to the opportunities to deliver sustainable energy to cruise ships in today's markets, which can create different scenarios for future alternative technologies, product and services.

Due the COVID-19 pandemic and impact to marine cluster industry at spring 2020 which caused wide joint negotiations in Finland, this thesis has also changed its direction, thus the confidential data and original case company is not mentioned or included in this thesis. The thesis subject was modified to create a general roadmap for building a more detailed CVP without a specific case company.

The thesis recommends focusing on the land based or barge based modular concept on shore power system with high combined efficiency. Simultaneously, this solution would be an almost emission-free power source which could be used year-round if needed to supply energy to cruise ships, port terminal infrastructure or in opposite case to the city grid. Meanwhile, when it is generating electricity it can also produces district heat to cruise ships, terminal infrastructure or directly to city district heat. It could be operated with LNG (Liquide natural gas), LBG (Liquide bio gas), bio methane and optional with green hydrogen or new synthetic fuels as methanol.

7.2 Self-evaluation of the Trustworthiness of the Study and Its Outcome

The final section of the thesis evaluates outcome to the original objectives and compares the reliability and validation of the thesis.

Objective of this thesis was to build a proposal of sustainable maritime power alternatives cruise business. The thesis does not have a specific case company and the outcome is more fit to be suitable in start-up and investor segment direction. The outcome of the proposal was to propose an alternative power solution which could be suitable for today and the future plans to be emission and carbon neutral by 2050. The logic does contain explanation of how the framework and proposal development proceeded structurally. During the CSA stage, it was clear that the world is full of different solutions. To build a competitive proposal would be challenging and without good domain knowledge almost impossible. In this case, it was decided to limit the territory to the European territory with

a few exceptions in CSA stage. The conceptual framework uses literature and methods found to be proven for this study, but also newer less commonly used methods. In general, sustainable marine and port energy alternatives have quite narrow literature as this field is limited and most literature are studies are commissioned by research institutes, with very few articles or business the case. It is understandable that many of marine cluster companies also have a lot of inside knowledge but this data is not publicly available. therefore, the thesis used the most common business tools for building roadmaps CVPs and identifying business opportunities.

The initial proposals was built to suggest the most suitable alternative power solution following the methods discussed in the literature review. Analysis and outputs were based on the CSA and the proven practices of literature, public cases etc.

Validation used an external interview with the industry expert. During the validation the hope was to get more interviews and views from stakeholders but it was limited due the thesis do not having a specific case company whom to support in such a way. Therefore, the researcher had to rely on one expert interview and own knowledge learned during his career in energy industry. It is obvious that the more data and knowledge should have been gathered to create the thesis, and some important inputs were missed. Thus, this thesis is based on open source data and a limited number of interviews. Last conclusion of the thesis is that it could be much easier to build the thesis for some specific case company and have opinions internally and use internal knowledge of maritime alternatives and internal best practices.

7.3 Next Steps

From a cruise business perspective, we could understand owners in that switching to an expensive marine fuel to shore connection system is not, in principle, easy because it incurs additional costs for the cruise company. A low electricity price in a port with a shore connection could help support the transition. In the future, however, it is believed that fossil fuels will become more expensive in the short term and this could even accelerate cruise companies to invest in a shore connection system.

But it is also possible that cruise companies will switch from fossil fuels to electricity and alternative forms of energy for ethical, environmental and aesthetics reasons in the future. An assumption is that the cruise business could gain advantages when the ships

are visiting in shore power ports and save on operating costs while visiting in environment-friendly ports. At the port´s level, this is considered as a major investment for the future since like these infra ports do not invest often, this means investments requires high-level political decision from EU, Governments and international side in order to plan, design and build such a system. It is the ports that will has a greater role in the environment, ethics and aesthetic in adapting to a carbon-free future. When ports are ready to offer this kind of services, will other marine segments follow the development. This is also future goal to aim at EU and international level.

Whatever plays a role in future key objectives, it is certain that the most important object is to aim for a carbon and NOx neutral future. This is helped by new fuels already under development. Business research should therefore develop efficient ways of exploiting these new green fuels and enabling their low-energy production by exploring different manufacturing options. Now, however, these forms of energy can be used with reasonable efficiency to storage energy from, for example, wind and sun and converting this energy into hydrogen, methane or other synthetic fuel for later use.

From the researcher’s personal perspective, this thesis has been a rewarding journey. The more I have expanded the field of study, the more interesting it has become because there are many different prototypes in the world that are potentially ready for commercial use. This study has also allowed me to do a little research into the chemistry of energy technology and how new green fuels are created.

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Appendix 1.

A. List of Abbreviations

AE	AUXILIARY ENGINE
AFC	Alkaline Fuel Cell
BES	Battery Energy Storage
CE	Circular Economy
CH4	Methane
CO2	Carbon Dioxide
CVP	Customer Value Proposal
GHG	Greenhouse Gases
H2	Hydrogen
H2O	Water
HFO	Heavy Fuel Oil
IMO	International Maritime Organization
LBG	Liquefied bio gas
LNG	Liquefied natural gas
MDO	Marine Diesel Oil
MGO	Marine Gas Oil
MW	Megawatt
MWH	Megawatt hour
NOx	Nitrogen Oxides
OPEX	Operating Expenses
OPS	Onshore power supply
SOx	Sulphur Dioxides
SRC	Selective Catalytic Reduction
TCM	Thermal Energy Storage
VPP	Virtual Power Plant
VRE	Variable Renewable Energy

Appendix 2.

E-mail interview questions to selected specialist in the field

Questions.1: Senior Scientist

1. What energy sources you would see in use of European ports in near future mainly in cruise and ferry business?
On the port side, the main energy source will remain as electricity in the near future. Cold ironing will become normal as part of cruise and ferry operation in ports.

2. Would you see potential in district heat, steam, cold from on shore to ship connections in future*? Not really, partly due to the practical complexity and the current design of heating and cooling networks on board vessels.*

3. Would you see hydrogen or methane as potential energy source in future beside LNG if it could be possible produce at port of on floating barge next to port? *Methane slip may be an X factor for the future use of both LNG and methane, esp. if internal combustion engines are still dominant. Hydrogen is potential if the supply infrastructure is solved, as shore supply or floating barge.*

Questions.2: No responses received

1. What energy sources you would see in use of European ports in near future mainly in cruise and ferry business? (No responses received)

2. Would you see potential in district heat, steam, cold from on shore to ship connections in future? (No responses received)

3. What is your opinion of port's and shipping companies' interest to invest to sustainable energy sources in future? (No responses received)

4. Would you see hydrogen or methane as potential energy source in future beside LNG if it could be possible produce at port of on floating barge next to port? (No responses received)