

The roadmap towards circular cruise ships

Preventing waste discharge into the environment



Delft University of Technology

Sustainable Design Graduation Studio AR3B025
MSc. Architecture, Urbanism and Building Sciences
Track: Building Technology

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Reflection

Introduction

This report is my reflection of the master thesis: 'The roadmap towards circular cruise ships: Preventing waste discharge into the environment'. This master thesis is written as graduation research for the Master Architecture, Urbanism and Building Sciences, Track Building Technology, at the Technical University of Delft. It is made in the academic year of 2019/2020.

The reflection consists out of 5 parts; 1.) Position master thesis in the studio, 2.) Approach and Results, 3.) Research and Design, 4.) Master thesis and Societal Impact, and 5.) Dilemmas and Issues.

Position master thesis in studio

This master thesis is related to the climate design & sustainability chair of the sustainable graduation studio from the master track Building Technology. The master building Technology combines engineering and architectural design with the focus on innovative and sustainable designs. The climate design chair conducts research into improving the energy efficiency of buildings. This includes building physics and building service engineering. These aspects are also found back on cruise ships. In this master thesis research is done into the mechanical systems of the cruise ship to find out if it is possible to make the ship more efficient. By making the ships more efficient their negative effect on the environment can be reduced. Next to this, research is done into the transition to sustainable cities in the Climate Design & Sustainability chair. Professor Andy van den Dobbelsteen (TU Delft) developed the City-Zen method as a guideline for the built environment to help cities with the transition to become carbon-neutral by 2050. This method is used as a guideline to create the roadmap for the cruise industry which they can use as a steppingstone to minimize their pressure on the environment regarding their gas waste stream, fluid waste stream, and solid waste stream. This research focusses on three roadmaps; 1.) Fully Circular, 2. Collaboration Ship & Land, and 3. Positive effect on the environment. Cities and cruise ships can be compared to each other because they host the same facilities and have the same (technical) streams. A cruise ship is in principle an isolated city. In later research, a cruise ship can be used as a case study to find out if and how a city can become circular. Thereby this research tries to contribute to reducing climate change by combining engineering and design.

Approach and results

The main objective of this master thesis was to contribute to the development of sustainable, circular cruise ships. Focusing on gas, fluid, and solid waste streams. The final

product is a roadmap, based on waste stream analyses, towards a set of targets and goals. By following this roadmap, the first steps to sustainable, circular cruise ships, should be made possible.

To achieve this objective, literature research was needed. This master thesis is divided into four main sections; background information, waste stream analysis, master planning, and conclusions. Initially, the intention was that the background information and waste stream analysis both represented the research phase and the master planning the design phase. However, literature research was also done in the master planning to obtain more information about future scenarios, and the current and new techniques that can be used onboard. These four phases correspond to the various presentations, p1-p5. The literature research, the background information, and waste stream analysis were planned till the p2 and after the p2 the design phase should start, the master plan. In reality, this process was not so linear, the design and research phases were alternated.

I noticed that making a planning helped me during this master thesis. Besides the big overall planning, I made smaller planning's per week and even per day to keep me on track. The methodology made and followed in this master thesis worked well. By following this methodology all the needed steps were covered which led to the final objective. Focusing on one cruise line as a case study during the master thesis helped, next to the planning, with keeping on track during all the different phases. Without this case study, the scope of the research would have become too wide and I would get stuck by researching endless possibilities and variations of different ships. For me, it was challenging to focus on the core aspects. Because the field of research is so broad, I tended to lose myself in research that may have been less relevant. Following the structure made in the methodology kept me on track. However, the negative effect of this is that it also limits the research. Due to this specific focus, some paths are not investigated which could have led to other solutions. For example, no research is done into alternative bilge water treatment systems after electrochemical treatment was suggested in papers as a promising treatment. The key criterion in this report is the environment. Other criteria, as cost, energy consumption, and material use are not considered. On the other hand, I went sometimes too deep in a specific topic, for example, the detailed process of wastewater treatment. The danger of doing this is losing time for other facets that still needed to be done. Every time a well-considered decision needs to be made if more extended research is needed or not. The planning helped me with considering if the extra research was needed and if there was time to do so.

Research and Design

In order to make the roadmap (design) that cruise ships can follow to become circular, information is needed about the current circumstances. As described in the previous chapter, approach and results, this research is divided into four main sections; background information, waste stream analysis, master plan, and conclusions. The background information, the waste stream analysis and the master planning are all part of the literature study. This research is needed to understand which waste streams are produced by the cruise ship, which systems are connected to them and how these systems work. This knowledge is needed to find out what comes back into the air, sea, and land, and how this can be prevented. Also, research into the current legislation, actions & goals and involved stakeholders is needed to understand in which direction the cruise ships must develop, and which parties can help or counteract. The research that is conducted during the waste stream analysis is used as a base for the master planning. The first sub-question in the master plan is "What are the future scenarios for the cruise industry?" When making the methodology, I thought that the master planning would not include literature research. However, due to my limited knowledge into (designing) future scenarios, research had to be conducted into how to approach this. The conducted research into the waste stream analysis and the future scenarios is used as basic knowledge to describe the visions and goals of future cruise ships. The final step of this master thesis is the design of the roadmaps itself. However, I found out that I missed the needed information to design the roadmap. More detailed research into which particles come into the ship and which particles leave the ship was needed. To understand this, detailed technical research into the current treatment processes is done. This led to two schemes that summarize the input and output of the ship and the measures taken by Royal Caribbean. After the current techniques were clear, research needed to be done into new sustainable techniques. I would not be able to advise new techniques without this elaborated research. The design phase led to the insight that more research was needed into certain aspects. Research and design are strongly related to each other and complement each other in this research.

During this master thesis, I learned that I quickly dive into new and more research because I think I do not know enough. A benefit of this is that I dive deeper into the subject and learn more about this topic, but decisions are stalled as well as the design itself. A good balance must be found between this to work efficiently.

Master thesis and Societal impact

Times are changing regarding the way we look at our environment and how we handle it, the world is in transition. New arrangements as the Paris agreement and the UN sustainable development goals are made to get the transition started. These arrangements are needed to stop and reduce climate change and the depletion of resources. However, it is not only the responsibility and problem of the government, it is a worldwide problem and responsibility. This means that companies, institutions, and other organizations should contribute to this transition. The traditional view on energy supply, handling waste, and using resources should change throughout the whole society, from supplier to customer. This master thesis includes the cruise industry in this transition. Cruise ships can be compared with cities. The same facilities which are found in cities are hosted on cruise ships. Next to this similar waste streams can be found, as water streams (sewage, drinking water), gas streams (pollutant emissions from engines) and solid streams (food, plastics, etc.). The cruise industry is a growing business. It is important to continue this research and start implementing the outcome, the roadmap, from today on into new cruise ships. The roadmap results into a more sustainable cruise ship, which tries to prevent that the harmful waste stream comes back into the environment (sea, land, and air). Cruise ships have a life span of 30 years or longer and have high investment costs. This means that cruise ships are not replaced until they reached the end of their life. If we want sustainable cruise ships in the future, we must act now. This research investigates the possibilities to improve retrofit ships and newly build ships.

This research has also effect on the built environment. As stated before, cruise ships can be compared to cities due to their similar facilities and waste streams. A cruise ship can be seen as an isolated city. This makes a cruise ship a good case study to find out if cities have to potential to become circular. This research tries to contribute to reducing climate change and resource depleting by focusing on the cruise industry. However, the principles can also be applied to cities.

This research could also have a social-cultural impact. Passengers that go on sustainable cruise ships will be continuously aware of the sustainable aspects. The ship implemented greenery onboard, their food is grown on the ship, the products are reused and recycled, single used plastic is banned, and seminars about the environment are given. The passengers are constantly aware of the fact that they are on a sustainable ship and that everything they do has an effect on the environment. Passengers take this newly learned way of living home and pass it on to others.

This awareness could not only go from the cruise industry to passenger but also from the cruise industry to other industries.

These innovations will also lead to some ethical issues. What can cruise ships still do and what not, when they strive to a sustainable industry. For example, the treated bilge water, and black and grey water still contain a small number of pollutants. This treated wastewater is discharged into the sea because it complies with the limits set by IMO. However, questions as; are the limits set by IMO low enough, do we make our own limits, and does it matter in which region we discharge the wastewater, above a coral reef or only in the high seas rises.

Dilemmas and Issues

This master thesis forms a bridge between three disciplines; Architecture, Urbanism and Maritime technology. My education was focussed on Architecture and Engineering and not on Urbanism and Maritime Technology. However, during my research, I needed the basic knowledge of these disciplines to understand how for example the engines and wastewater treatment systems work on cruise ships. This made the research very broad and detailed at the same time. According to the planning, the first part was reserved for literature research and the second part for "designing" the roadmap. When I wanted to start with the roadmap, I found out that the general knowledge I obtained was not enough. Due to this, the time to do literature research was extended with several weeks to obtain more knowledge about the currently used techniques and possible new techniques. Research was done into the wastewater treatment systems, cleaning exhaust gasses, solid waste handling, and ways to generate renewable energy. This included basic knowledge about chemistry as chemical reactions and mechanics. Also, smaller topics as marine legislation and developing alternative future scenario's where aspects I never encountered before. Processing the information was sometimes hard and overwhelming. The information needed to sink in, before fully understood. Whenever possible, I ask for clarification from my supervisors. However, this was not always possible because it was also beyond their expertise.

Next to this, I had a hard time obtaining the needed information. The information about the number of emitted exhaust gasses, discharged wastewater, and solid waste was not open to the public. I mailed multiple cruise line organizations and contacted their employees on LinkedIn to establish a collaboration. Most of the corporations did not respond to my mail. Only AIDA responded with the message they had to reject my request due to their lack

of capacity. On LinkedIn, I established contact with a director, Business and Destination Development from the Royal Caribbean and a director partner relation from the CLIA, the Cruise Line International Association. After some messages and a Skype call with the director from the Royal Caribbean, I decided to take Royal Caribbean as a case study with the idea to receive more information. Sadly, this did not work out the way I hoped for. Perhaps one of the reasons why this did not work out was due to the sensitive nature of the needed information. The director of CLIA invited me to an event in London. However, this was cancelled because of the upcoming COVID-19 virus. The cruise ship visit was also cancelled due to the virus. This was very unfortunate but understandable. Also, other institutions as Meyer Werft could not collaborate with me because they only work with students working at Meyer Werft and with those, who are involved in a dual studies program with Meyer Werft. Due to this I had to work with limited information about the amount of emitted exhaust gasses, discharged wastewater and waste. Through this experience, I learned to be persistent and to wait till the appointment is made to get the hopes up. During the COVID-19 virus, I noticed a company Koedood in my village. This company is specialised in marine engines. I had a small talk with their director and a tour through their building to see and talk about the different type of engines. It was very interesting to learn how these companies see the future of sustainable engines.

As already mentioned briefly, the COVID-19 virus had some effect on my graduation project. Besides, the fact that the trips were cancelled it also affected the work itself. I had a good working flow and rhythm before the coronavirus. I went to the library every day to work on my thesis and came home when I was done. Due to the virus, the libraries and other public working venues closed. This forced me to work at home where my parents and brother also work and live. The first weeks were therefore focused on adjusting to this new forced work environment and getting into the new rhythm. After a few weeks, I found my rhythm. I started early in the morning so I could work a few hours in the living room without any distraction. This gave me the time to read and understand difficult papers. Then I moved to my room and worked further from there. This tight rhythm has helped me through these difficult and strange times. The tutoring and interim presentations were held online because of the coronavirus. In my opinion, online guidance works less well because discussing and showing work is more difficult. To make sure the guidance went as smoothly as possible, I made a PowerPoint presentation to be able to show and discuss my work. Also, a quick chat about a question with the professor on the faculty was no

longer possible. Small questions had to be sent by mail, which took some more time. The professors also had to put their other classes online, which made them very busy in the beginning period. Also, the interim presentations were held online. This felt very strange for me because you cannot see the reaction of your audience and react to that. This was a period of adaption for everyone.

During this master thesis, I also learned that you always have to schedule extra time for unexpected events. Around 7 weeks before my p4 I noticed that the elaborated research chapter was taking more time than planned. In the planning, one week was already scheduled for things like this. However, because I was afraid of having too little time at the end of my project, I made some longer days during those weeks. I realized that I preferred to work harder at that specific moment so that I had the time to finish everything calmly at the end. I think this strategy worked for me.

Overall, I had some ups and downs during this research, which I think is very logical during such a big project. Besides all the knowledge, I have learned to be persistent, to take the time, and to be prepared for the unexpected.