Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences

Graduation Plan: All tracks

Submit your Graduation Plan to the Board of Examiners (Examencommissie-BK@tudelft.nl), Mentors and Delegate of the Board of Examiners one week before P2 at the latest.

The graduation plan consists of at least the following data/segments:

Personal information	
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Studio		
Name / Theme	Sustainable Design Graduation Studio	
Main mentor	Andy van den Dobbelsteen	Climate Design & Sustainability Architectural Engineering + Technology
Second mentor	Nico Tillie	Landscape Architecture
Argumentation of choice of the studio	Master: Building Technology Nowadays a lot of research goes into making cities sustainable to reduce climate change. However, not only governments need to act, but also businesses, civil society and citizens. The cruise industry is a growing business, with an average growth of 6.9% per year. In 2019, 18 new ships where build to sustain to the demand for cruises vacations. Cruise ship, sometimes called floating cities, have a lot of similarities with cities. All the daily needs and activities which people find and do in cities can also be found on cruise ships, for example; sleeping places, restaurants, gyms, swimming pools, shops, bars and theatres. Next to this, similar streams can be found as water streams (sewage, drinking water), gas streams (pollutant emissions from engines) and solid streams (food, plastics etc.) This research tries to contribute to reduce climate change by using techniques from the architectural sector into relating sectors as the cruise industry.	

Graduation project	
Title of the graduation project	Circular Cruise ships Preventing waste from entering the environment
Goal	
Location:	Royal Caribbean Cruise ships are used as a case study.

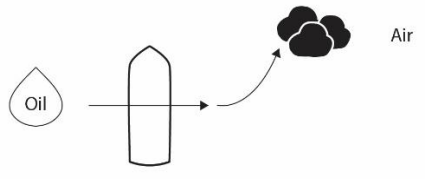
The posed problem,	**Background information (shortened):** Naturally occurring fluctuations in the climate can be found throughout the history of earth (Wong, 2015). However, these gradual changes took place in a range of tens of thousands or even a million years (Hardy, 2003). Due to the increase of greenhouse gasses as carbon dioxide, heat is trapped in the lower atmosphere what will make the temperature rise, also called 'climate change'. Efforts to reduce greenhouse gasses and strengthening the resilience and adaption to climate impacts can be seen as a definition of climate action. Actions as integrating climate change measures into national policies, creating awareness and providing the needed education need to be taken (United Nations Development Programme, n.d.). Cities are trying to make the transition from fossil-based energy to zero-carbon energy to limit climate change by reducing their CO2 emissions. Greenhouse gasses are not the only harmful substances entering our environment. A circular economy tries to prevent waste streams coming in contact with our environment. In a circular economy, renewable energy sources are used, and used products and materials are not seen as waste products but are reused (Het Groene Brein, n.d.). Actions as these are needed to protect the planet from further harm. Statistics show that the Cruise industry is a growing business. In 2009 17.8 million cruise passengers were enjoying this type of vacation. The expected amount of cruise passengers in 2019 is 30 million, this is an increase of 12.2 million passengers compared to 2009. The cruise industry has an average growth of 6.9% per year. In 2019 there are 272 cruise ships in operation which fall under the cruise lines international Association (CLIA) (CLIA, 2019). Due to the increase of passengers 18 new ships are scheduled to be launched in that same year. This makes a total of 290 cruise ships at the end of 2019. These statistics show that cruising is becoming more popular. Cruise ships have a big environmental impact. They have several waste streams which should be taken care of. An important and overall know waste stream is the air pollution the ships emits by their exhaust gasses such as nitrates, carbon dioxide and Sulphur. These exhaust gasses come free for the propulsion of the ship and electricity need, for example, ventilation, appliances and lighting. However, this is not the only type of waste stream from a cruise ship. Next to this gaseous waste stream, there are also fluid waste streams, for example, black- and grey water from the sinks, showers and galleys, bilge water and ballast water. Beside these gas and water streams, also solid waste streams can be found on cruise ships such as solid waste and hazardous waste.

The problem statement that follows from this background research is:

"Waste streams from cruise ships come back into nature which negatively influences the environment."

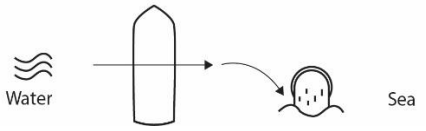
Gas waste streams

Fuel is used as energy source for the propulsion and electricity need of the ship. Pollutant emissions come free by the combustion of fossil fuel. These emissions go into the atmosphere where it traps the heat and amplify climate change. This has a negative influence on human health. The beginning of this stream, obtaining fossil fuel, negatively influence the environment by land degradation. In short, something dirty, scarce and bad for the environment goes into the ship, fuel, and something dirty and bad for the environment comes out of the ship, see figure below.



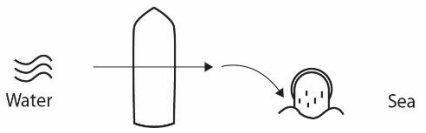
Fluid waste streams

Water is needed on a cruise ship and has several functions; sewage, cleaning, stabilizing, showering etcetera. This clean water what goes into the ship is used for the specific function and becomes polluted. This polluted water comes out of the ship into the sea where it harms the aquatic environment and indirectly the human health, see figure below.



Solid waste streams

Solid products as plastics, cans, bottles, food and light bulbs are needed in the daily life of cruise passengers and crew. These products come on board, are used and then not needed anymore. These products are stored in containers and tanks on the ship and disposed to land when the ship is in port. Some of these materials as food grease and cleaning equipment comes in contact with water and end in the sea, see figure below

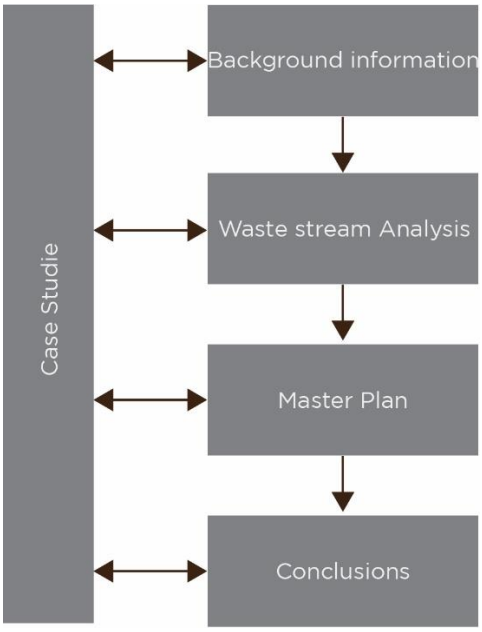


	From the figures above can be seen that the waste streams do not stay on board but end up in the sky, the sea or on land. These three ‘’incidents” collide with goals number #6 Clean Water and Sanitation, #7 Affordable and Clean Energy, #12 Responsible Consumption and production, #13 Climate Action and #14 Life Below Water from the UN. To prevent this from happening in the future, action needs to be taken.
research questions and	The research question in this master thesis is: Which steps need to be taken, focusing on gas waste streams, fluid waste streams and solid waste streams to make the transition towards circular cruise ships following the city-Zen method to comply to the UN sustainable development goals? Several sub-questions need to be asked to answer the main research question: SQ 1: What are the emissions and waste streams of a cruise ship -What are they, how many, where does it come from. SQ 2: What is the current legislation? SQ 3: What are the existing sustainability goals and actions Royal Caribbean Cruises Ltd. already takes? SQ 4: Who are the involved stakeholders? SQ 5: What are the future scenarios for cruise ships? SQ 6: How does a sustainable cruise ship look like? (vision, goals and principles) SQ 7: How can the sustainability goals be reached? (the roadmap)
design assignment in which these result.	The main objective of this master thesis is to contribute to the development of sustainable, circular cruise ships. Specifically, the gas-, fluid- and solid waste streams. The final product is a roadmap, based on waste stream analyses, towards a set of targets and goals. The first step for making the transition to sustainable, circular cruise ships, should be made possible by following this roadmap. The City-Zen method is used as the starting point for this master thesis. The following objectives are made following the City-Zen method. -Determine the emissions and waste streams of a cruise ship. -Determine the existing legislation for cruise ships. -Determine the existing sustainable goals and action cruise ships already take. -Define the involved stakeholders. -Determine the external variables what will influence the future state of cruise ships. -Define the (end) goals and principles cruise ships should comply to, to become circular.

Process

Method description

The main research question in this master thesis is: "Which steps need to be taken, focusing on gas waste streams, fluid waste streams and solid waste streams to make the transition towards circular cruise ships following the city-Zen method to comply to the UN sustainable development goals?"
This research can be divided into four main sections, background information, waste stream analysis, master plan and conclusions, see figure below. These four main sections are all in relation to the case study, cruise ships from the Royal Caribbean Ltd.



This study starts with literature research. In the research framework, background information is given to understand the scope of the research. This gives information about climate change and what causes it. Furthermore, general data about the, growing cruise industry and how this can be linked to the climate changes through the UN sustainable developments goals are given. Additionally, it describes the City-Zen method what will be used as guideline for the master thesis.
The next step is the waste stream analysis. A well-documented cruise organization, the Royal Caribbean Ltd., is used as case study and will be analyzed with the focus on gas waste streams, fluid waste streams and solid waste streams. These findings will be checked with the existing legislation which are made for Cruise Ships and with the goals and actions taken by the cruise line itself. Next to this a research is conducted into the stakeholders which have influence on the goals and rules, what indirectly influence the waste streams.
From the literature study and case study qualitative and quantitative data is obtained, which will be used as input for the master plan. Future scenarios and boundary conditions, which are not developed under the influence of involved actors need to be investigated. This is needed to describe the future visions and goals for cruise ships, what will result into a guideline/design. The last step is visualizing this master plan into a roadmap towards circular cruise ships.

Literature and general practical preference

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Reflection

1. **Relation graduation with master track.**
   In this master thesis, the City-Zen method is used as a guideline to create a roadmap which can be followed to help cruise ships to become circular. The City-Zen method is originally a guideline for the built environment to help cities with the transition to a carbon-neutral built environment by 2050. This method is developed by a professor from the Faculty of Architecture and the Built Environment (TU Delft), Andy van den Dobbelsteen. In this master thesis, this method is used as a guideline. This is possible because cruise ships can be compared to cities. They host the same facilities and the same (technical) streams. A cruise ship can be seen as a very isolated city. This makes a cruise ship a good case study to find out if cities have to potential to become circular. The research into circular design and energy transitions fit into the climate design studio, which is part of the master Track Building Technology.
2. **Relevance of graduation work.**
   Times are changing regarding the way we look at our environment and how we deal with it, we are in a transition. Arrangements as the Paris agreement and the UN sustainable development goals are made to get the transition started by making end goals to strive for. At the moment, governments are mainly concerned about the energy transition by making plans and new laws. However, companies and other organizations should also contribute to this energy transition, not because the law says so but because they realize something needs to happen.
   The World Tourism Organization UNWTO (2019) states that there is a growth of 6% of international tourist arrivals and they expect it to grow around 3% to 4% in 2019. The cruise industry, part of the tourist industry, has an average growth of 6.9% per year with 290 cruise ships operational in 2019 (CLIA,2019). Cruise ships can be compared with small cities, both systems must deal with; air pollution from cars or the engine, with waste streams as grey- and black water, food waste, solid waste, hazardous waste and with electricity need for

appliances, heating, light etcetera. The law of the European Union says, "Environmental integration in all relevant policy areas is essential in order to reduce pressures on the environment resulting from the policies and activities of other sectors and to meet environmental and climate-related targets" (European Union, 2013, p. 3). There is a need for an integral approach especially in key sectors like transport and buildings (European Union, 2013). This research is a stepping stone to a method which cruise ships can use to minimize their pressure on the environment regarding their gas waste stream, fluid waste stream and solid waste stream. A lot of scientific research is already done into the transition to sustainable cities, for example in the Climate Design & Sustainability chair at the TU Delft. The City-Zen roadshow is a research that is conducted to make this transition happening. This research is related to the City-Zen roadshow because it uses the outcome, the City-Zen method, as a guideline to create an energy master plan for cruise ships. Lee & Brezina (2016) state that there is a lack of academic research focusing on the cruise industry. With this master thesis, more literature is added to close this gab.

Planning

This researched is divided into five main phases, the period between the presentations.
P0-P1: Research framework (literature review)
P1-P2: Waste stream Analysis of cruise ships (literature research & Case study)
P2-P3: Master plan part 1, future scenario's and vision and goals
P3-P4: Master plan part 2, climate-neutral cruise ship and roadmap
P4-P5: Finalizing the report and making the presentation

More detailed planning is made to get a feeling of what the time span is to conduct this research, see figure below. A weekly schedule is made to see how much time can be used for which sub research question. The waste stream analysis is scheduled to be finished between p2 and p3 to be sure enough time is left for the master plan itself. The waste stream analysis is part of the literature study and the master plan can be seen as the "Design" part. This is something that should not be underestimated timewise. A lot of time goes into processing the information, finding connections and visualize this in a design/roadmap. After every presentation, some time is scheduled to revise the work that was handed in according to the given feedback. The last period is reserved to finalize the report, writing the conclusions, limitations, abstract etcetera and look back on the research framework to adjust where needed. The orange cells are the set dates for the (interim) presentations. The green cells are planned excursions. The light green cell on the bottom reserved for a possible excursion on a cruise ship. This is something that would benefit my Master Thesis, but I did not succeed in arranging this (yet).

Project Plan