

FENT2900 - BACHELOR THESIS,
RENEWABLE ENERGY

Preliminary project



Andrea Steinsvik
Eirun Birkeland
Kristine Marie Embretsen

Bachelor in Engineering, Renewable Energy
Spring 2023



Norwegian University of Science and Technology
Department of Energy and Process Engineering

Preliminary project for the Bachelor thesis

The thesis working title: English: Ammonia production for Maritime transport Norsk: Amoniakk produksjon for maritim transport	Field of study Engineering, Renewable Energy
Project number BIFOREN23-14	Hand in date 22.05.23
Participants Andrea Rygh Steinsvik Kristine Marie Embretsen Eirun Hagen Birkeland	Business connection NTE
Internal supervisor Pauline Zimmermann pauline.zimmermann@ntnu.no	External supervisor NA

Preface

This is a preliminary project written in the collaboration of three third-year students studying renewable energy at NTNU in Trondheim. This is to build the foundation for a bachelor thesis for group BIFOREN23-14, which will be handed in the spring of 2023. All three students study with main focus on energy storage.

The preliminary project is written with the purpose of preparing the execution of the bachelor thesis. This is something that will be worked on and completed in January 2023. Working with the preliminary project has lead to discussion and elaboration of the thesis statement, cooperation agreement, project objectives, thesis description and progress plan.

The thesis statement was initially supposed to be formulated with Nord-Trøndelag Elektrisitetsverk (NTE), but they were unable to provide an external supervisor. The thesis statement is therefore put together by the group. A special thanks to our internal supervisor Pdd Candidate Pauline Zimmermann with Department of Energy and Process Engineering for valuable help, insight and interest in the task in the start-up phase of the project.

Contents

Preface	i
1 Introduction	1
1.1 Background	1
1.2 Limitations and assumptions	1
1.3 Project participants	2
2 Objectives and framework	3
2.1 Orientation	3
2.2 Thesis statement	3
2.3 Specifications	3
2.4 Objectives	3
2.4.1 Result objectives	3
2.4.2 Performance objectives	4
2.4.3 Process objectives	4
2.5 Framework	4
2.6 Potential challenges	4
3 Project description	6
3.1 Fase 0: Start-up and preliminary project	6
3.2 Fase 1: Project introduction and mapping	6
3.3 Fase 2: Analysis and data processing	7
3.4 Fase 3: Compilation of final report	7
3.5 Flowchart	7
3.6 Milestones	8
4 Follow-up and quality assurance	9
References	11
A Cooperation agreement	I
B GANTT chart	IV

1 Introduction

The preliminary project shapes the foundation for the bachelor thesis and further work during the spring semester. The preliminary project provides a tool to form the project and to keep track of the progress. This thesis will be about the potential of ammonia-powered ships and profitability in terms of cost and emissions.

The bachelor thesis is divided into four phases: 0, 1, 2, 3. Each of the phases has defined objectives and they are divided into result, process and performance objectives.

1.1 Background

Ammonia (NH_3) is one of the world's most produced chemical compound and it is most often used as a mineral fertilizer like ammonium salts and nitrates[2].

Liquid ammonia is increasingly used as a energy carrier, and ammonia production in maritime transport has gotten more attention in recent years because of the use as a carbon-free fuel[2]. Ammonia has a higher energy density than, for example, liquid hydrogen and it can efficiently be liquefied by condensation, and filled in tanks[1]. In shipping, where it is often long distances, it is essential with a fuel that can be stored with high energy density, which makes battery operation and pressurized hydrogen impracticable[1].

In this bachelor thesis, the group is going to look at the potential for ammonia as marine fuel. How ammonia-powered boats will perform on a chosen distance, and will be compared to fossil-powered boats. How much greenhouse gas emissions can we save on changing the fuel and how cost-effective will it be? Can this be the solution for maritime transport and their journey to be a green and sustainable sector.

1.2 Limitations and assumptions

The focus of the thesis is limited to a certain distance and type of boat. This is to inspire and influence the development within this specific field.

The scenario is relatively simplified due to limited time, and the simulations and models are made from the data that is available.

1.3 Project participants

Eirun Hagen Birkeland

Tlf: 480 04 738

E-mail: Eirunhb@stud.ntnu.no

Third year student in engineering in renewable energy with focus on energy storage.

Kristine Marie Embretsen

Tlf: 480 49 244

E-mail: Kristmem@stud.ntnu.no

Third year student in engineering in renewable energy with focus on energy storage.

Andrea Rygh Steinsvik

Tlf: 414 93 149

E-mail: Andrrs@stud.ntnu.no

Third year student in engineering in renewable energy with focus on energy storage.

2 Objectives and framework

This part provides an overview of the basis for the thesis statement. Furthermore, the preliminary project presents the thesis statement, limitations and various objectives that the group wants to achieve as a result of the bachelor project.

2.1 Orientation

The bachelor thesis has been chosen as a collaboration between the three student, who have a common interest in ammonia. Ammonia production for maritime transport is the overall topic the student will work on. The company responsible for designing the thesis is NTE (Nord Trøndelag Elektrisitetsverk). The company will not be an active participant in the process, the group are however hoping to get assistance with any necessary numbers. The group will do a more thorough research on which companies will be able to give the most suitable data needed for the thesis.

2.2 Thesis statement

The thesis statement for this bachelor is ammonia production for maritime transport. The goal is to find the best alternative for production of green ammonia to be used in the maritime sector, and to compare it with the current fuel distributor. The goal will be to figure out if it is more efficient to use ammonia as fuel in the three areas cost, efficiency and emissions. It is important to figure out which solution gives the best results, looking into a 10 year time frame.

2.3 Specifications

The bachelor project will concern ammonia production and usage in the maritime transport sector. There are some projects that revolves around this topic but all of them are still in the beginning stages.

2.4 Objectives

These goals/objectives is defined by the group in collaboration with the internal supervisor at NTNU. The goals project the wanted outcomes from this bachelor thesis.

2.4.1 Result objectives

The results from this bachelor thesis will give a clearer picture of which fuel is best to use forward. It is not given that it will be ammonia. The group will therefore carry out the task with a objective viewpoint regardless of the thesis.

2.4.2 Performance objectives

The students are investigating the potential use of ammonia in the maritime sector. It will lead to a broad knowledge within the field of ammonia. The goal is to see if this is a possible solution to FN's sustainability goal number 7 with clean energy to all, and number 13 to stop emissions within 2030. It is important and necessary to go thorough research whether this is a favorable answer to the current situation or not.

2.4.3 Process objectives

The group wish to accomplish a in depth understanding of the use of ammonia as fuel in the maritime sector. This can help gain a understanding in how the future as energy engineers can look, and gain experience within the field of energy storage, which is the students focus area.

2.5 Framework

This bachelor project does not require any financial means, specific or access to a laboratory from NTNU. The project may require the usage for digital programs such as Python or MatLab.

2.6 Potential challenges

Listed below are the potential challenges and uncertainties that the group might encounter during the bachelor project:

- Collection of data can be challenging and time consuming.
 - The companies that the group contacts might not want to give out the data that is wanted, for example emission numbers.
 - Could be difficult to know who owns the data that we are going trough.
 - It might be difficult to find data on ammonia in the maritime transport sector.
- Get general results when doing calculations.
 - Have too general numbers.
 - The prerequisites and limitations must be good enough.
 - Transferring code from one person to another or to a different program.
- Access to the right professionals.
 - To know who the right people and companies are, that has the relevant knowledge.
 - Professionals have busy schedules and it might take time to get an answer on emails.
- Deviation from ideal situation.

- Numbers and the ammonia industry might have been affected by the corona pandemic.
- There is no business supervisor to give guidance.

3 Project description

The phases bellow give an overview of the progress plan throughout the project. This will show how the group is planning on working with the project forward, and which areas the group will give a closer look.

3.1 Fase 0: Start-up and preliminary project

Formal requirements before the start of the project

- Cooperation agreement
- Set standards

Thesis statement and goals of the project

- Specify and define the problem
- Further develop task description
- Formulate the goals associated with the project

Preliminary project and resource use

- Division into project phases
- Primary distribution of tasks
- Complete preliminary project
- Make contact with companies within the maritime sector

3.2 Fase 1: Project introduction and mapping

Final Report

- Outline for final report
- Get the outline template approved

Map the need of data

- Technical documents for ships
- List data needed for comparison
- Sort data
- Visualize and present the data.

3.3 Fase 2: Analysis and data processing

Simulation and calculation

- Compare the different ways to apply ammonia and optimize
- Look at the dimensions and distances and if anything needs to be changed
- Look at the collected data and simulate the chosen distance with ammonia vs. fossil
- Present the data

Cost, emission and efficiency

- Compare the cost for implementation of ammonia vs the existing costs of fossil driven ships.
- Compare emission
- Look at the efficiency differences and savings

Produce finished results

- Make poster
- Hand in poster

3.4 Fase 3: Compilation of final report

First and last presentation

- Discussion
- Conclusion
- Draft
- Proofreading
- End rapport
- Make presentation
- Present bachelor thesis

3.5 Flowchart

Flowchart

The flowchart is a general summary of the phases and progress of the project.

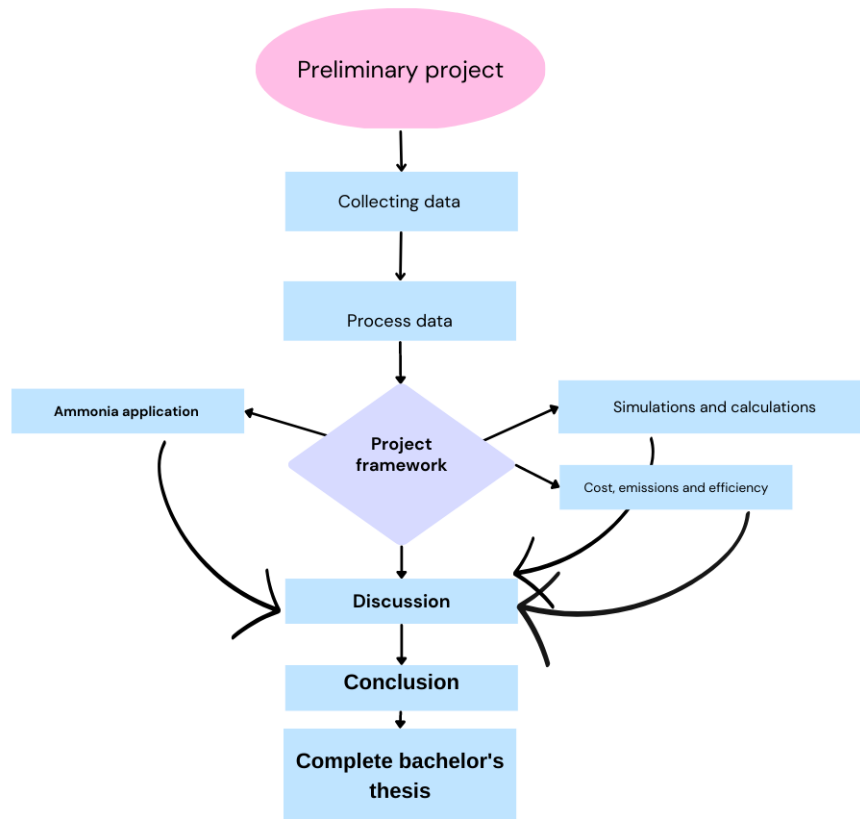


Figure 3.1: Flowchart

3.6 Milestones

The grey dates are the official deadlines, the purple are the groups own milestones.

What	When
First draft of preliminary project	25.01.2023
Hand in preliminary project	27.01.2023
Finish poster and proof-read	01.03.2023
Hand in poster	03.03.2023
Complete the main sections	15.04.2023
First presentation	17.04.2023
Finish end-rapport and proof-read	20.05.2023
Hand in end-rapport	22.05.2023
Presentation	25.05.2023

Figure 3.2: Milestones

4 Follow-up and quality assurance

To produce a thesis with high quality, certain measures must be implemented. Project meetings between the group members and supervisor are set weekly and the group itself will meet several times a week. The goal is to keep everyone updated throughout the project and to keep track of the progression.

If different literature is used, it must come from a reliable source. If there is any doubt, the supervisor should be consulted. References should be easy to track and find for everyone in the group. Before hand-in, the project should be proofread by every member of the group.

The group has decided that the hours used on this project will not be registered. The reasoning behind this decision is that the group feel like the work hours can be misleading and not show the actual workload. It is possible to work for 8 hours and only getting 2 hours of work done, and work for 2 hours and get 2 hours of work done. Instead of tracking hours the group decided to have several minor deadlines within the project which will track the progress.

To maintain good communication with each other and supervisor there will be used digital communication platforms like Teams, Overleaf, Google and OneDrive. This will ensure that the group has a good overview of the project and are keeping track of the changes and the tasks.

Every document, rapports and data will be collected and saved at the same place where each group member has access. This will make it easy for everyone to collect information when needed.

References

- [1] Knut Hofstad. *ammoniakk – energibærer*. no. May 2021. (Visited on 01/18/2023).
- [2] Bjørn Pedersen. *ammoniakk*. no. Jan. 2023. URL: <http://snl.no/ammoniakk> (visited on 01/18/2023).

A Cooperation agreement

FENT2900 - Cooperation agreement

Spring 2023

This agreement is valid for the cooperation between the following contenders:

1. Eirun Hagen
2. Andrea Steinsvik
3. Kristine Embretsen

1 The aim of the collaboration

- The goal is to get the highest grade as possible, and every group member understands that this requires a lot of work
- The goal with this cooperation is to write and form the bachelor thesis together. The title is "Ammonia production in maritim transport". There is a huge focus on learning and cohesion.
- Equal distribution of work is important because we will get a group grade. No one is supposed to do more work than others, and if this is to happen it is safe to talk to the group and suggest a change.

2 Meetings and working hours

- It will be set up meetings to be able to be efficient with our time. The meeting will start with a check in in turns where every member tells how they are doing today.
- It is possible to reschedule the meeting if something comes up that collides with the meeting times. This has to be agreed upon in advance.
- Meeting with the internal supervisor will happen every Wednesday at 10.00. All group members and the supervisor will be filled in on what has been done since the last time.
- Wednesdays before and after the meeting with the supervisor, and Thursdays 9-16 is reserved to work on the bachelor thesis until the course INGT2300 is finished

- There will be scheduled 3-4 meetings every week when the course INGT2300 is finished. When and where is to be agreed in more detail.

3 Planning and logging

- The group must strive to follow the work schedule.
- When the group or a group member is in contact with a business is must be put in the log for business interactions.
- The group will try to use a method where we work 50 minutes and then take a 10 minute break to prevent inefficiency.

4 Absence

- Completion of a resit exam is valid absence, but reading for the exam must happen outside the scheduled work times.
- Sickness is a valid reason for absence, and the member must notify the group as soon as possible.
- Family emergency's are valid reasons for absence. It is important to notify the group of the absence.
- The group must be notified if a group member is to leave Trondheim.

5 Expectations of other group members

- It is unwanted that the group members has strong feeling towards their writing. This makes it difficult to give feedback and change it.
- It is expected to complete the parts that is given to each member on time, and that everyone meets prepared to meetings.
- It is allowed to change members writing, but not any code written.

6 Complications

- If there is a conflict regarding the thesis, there will be a meeting to resolve it. The supervisor will be contacted if the meeting does not solve it.
- It will be resolved within the group if someone is behind schedule or struggling with their parts.
- If something were to happen and a group member is not able to finish the project, will this individual get a separate grade.

7 Duration and reformulation

This agreement is valid from the signing of it until the end of the bachelor project on the 25. of May 2023, when the last group presentation is. Every group member has the right to reformulate the agreement but this has to be admitted to the rest of the group, discussed and agreed upon.

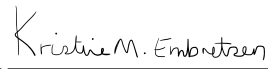
Trondheim 25.01.2023



Andrea Steinsvik



Eirun Birkeland



Kristine Embretsen

B GANTT chart

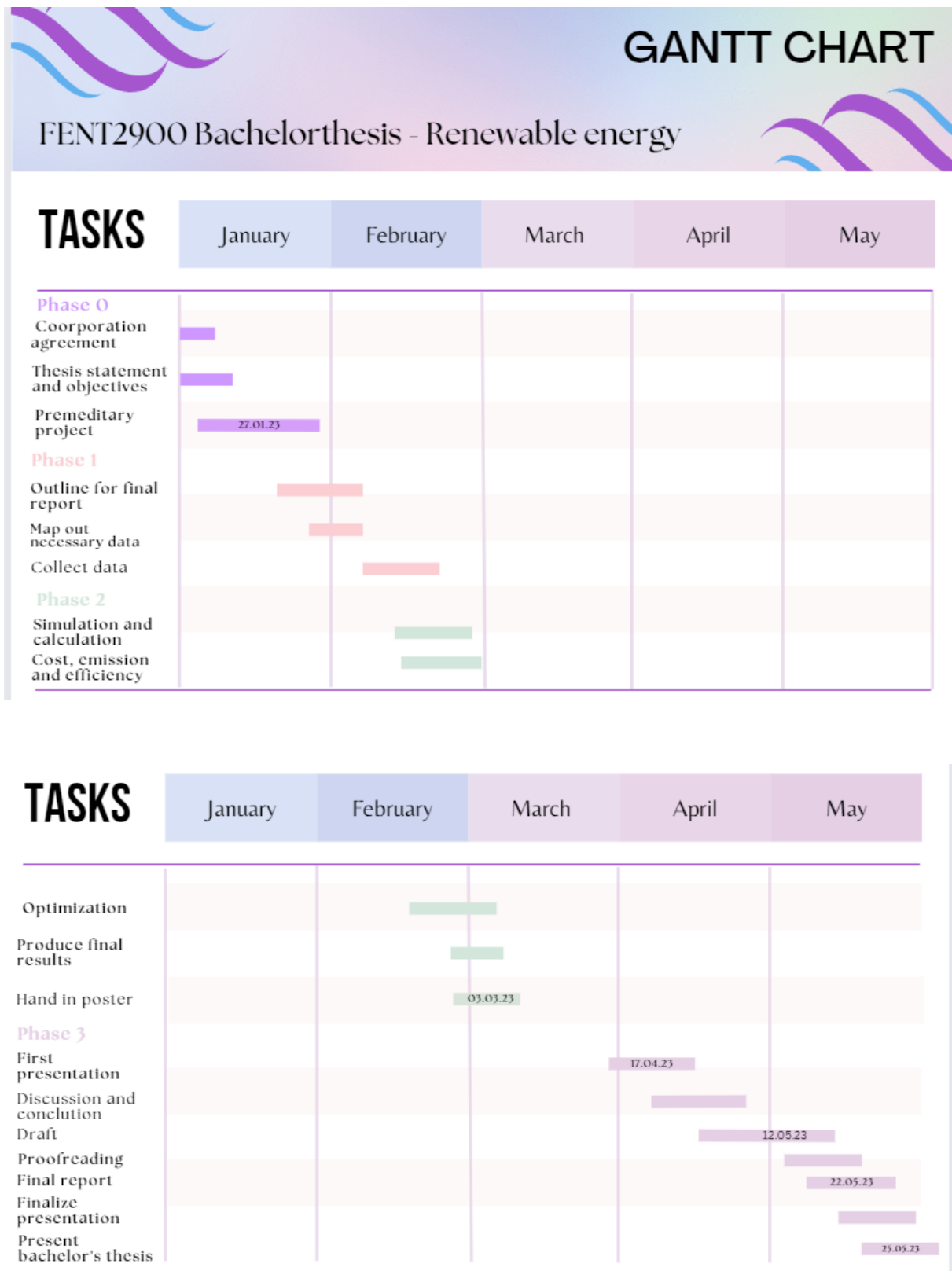


Figure B.1: GANTT chart