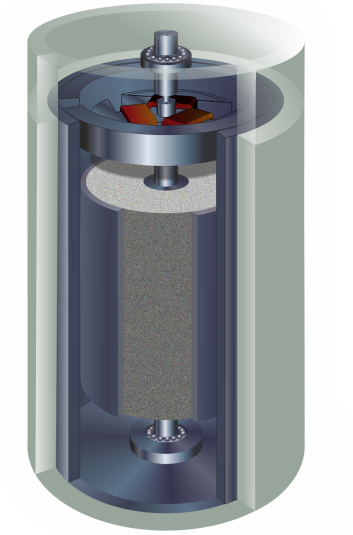
FENT2900 - BACHELOR THESIS

Preliminary Project

On flywheel batteries



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Spring 2023

NTNU
Norwegian University of Science and Technology
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Preface

This preface builds the foundation for the bachelor thesis for the group BIFOREN23-22, which will be written in spring of 2023. The group consists of two third year students at the Renewable energy programme at NTNU.

The preface was established in January 2023. The purpose of the preface is set a plan for the execution of the bachelor thesis. The preface has brought discussion and elaboration between the group members and has led to a project definition, project goals, a progress plan and a collaboration agreement.

The project definition is formulated in cooperation with the group's supervisor, Reidar Kristoffersen. A huge thank you associate professor Reidar Kristoffersen at the institute of energy- and process engineering for great help and interest for the project.

Cover image from: www.energiestro.net

Contents

1 Goals and limitations

1.1 Orientation

This project was chosen because of common interests between the group members. The group has interests specially within, among other things, electronics and thought this project could offer some problems connected to this subject. The group members also had a small amount of knowledge about flywheels and thought it would be interesting to expand on this knowledge. The project was chosen after a lot of deliberation during the autumn of 2022, but was ultimately chosen as the most suitable project for the group members. There are no companies associated to this bachelor thesis, which the group sees as both a benefit and a disadvantage. The lack of a company associated to the bachelor theses contributes to group having more of a freedom of what to write about. Although, this also means there aren't as many professionals to ask directly if the group has questions related to the project.

1.2 Project definition

The theme of the bachelor thesis is to establish more knowledge about flywheels integrated in new or existing energy storage systems. The goal is to use simulations and retrieved research data to document whether or not flywheels can be used as a viable energy storage system. It will be analyzed whether or not this is an economic method, as well as the safety involving the installation and use of such flywheels. Further it will be compared to commercial battery packs, such as Lithium-ion batteries, when it comes to whether these systems works best together or if they thrive in different situations.

1.3 Effect goal

The group's goal is to bring light onto a relatively young technology which can be used to solve some of the many problems revolving the climate crisis and the green shift towards renewable energy. The project could be a contribution to get closer to achieve some of the Sustainable Development Goals (SDG) set by the United Nations. The SDG number 7 (Affordable and clean energy for everyone), 9 (Industry, innovation and infrastructure) and 11(Sustainable cities and communities) are the main goals the project could contribute to. The group desires to get a deeper knowledge about flywheels as an energy storage system, and wants to make the information revolving around flywheels more accessible and easy legible.

1.4 Limitations

There is no opportunity to do any physical experiments attached to this project. Therefore, money nor equipment will be necessary. Neither materials nor any special rooms, like NTNU's laboratories, will be needed. Due to time limitations the simulations will be limited to simple models and not show a full view of a real situation.

1.5 Potential challenges

- Gathering or retrieving of data could be time consuming and challenging.
  - Not a lot of literature about flywheels
  - There is few large-scale flywheel projects.
  - Few companies that work with flywheels. Retrieving any information directly from a

company could show to be challenging.
- Few experts to contact.
- Could be challenging to know who owns the retrieved data.

- Deviation from real life in simulations.
  - Simulations using MATLAB and other programs will not simulate a perfect real life situation
  - The group doesn't have access to real life data which can be used in simulations. Therefore, assumptions will be made.

2 Organization

This project is written by the group members for NTNU. The group has one internal supervisor.

2.1 Group members

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Third year student at the Renewable Energy programme.
Majoring in energy storage.
Competence within energy storage, thermodynamics, fluid mechanics, Heat- and mass transfer, electrical engineering, control engineering, district heating and electric energy systems, wind energy and design of wind turbine and electric machines.

Jo Emil Spakmo
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Third year student at the Renewable Energy programme.
Majoring in hydro- and wind energy.
Competence within energy storage, thermodynamics, fluid mechanics, Heat- and mass transfer, electrical engineering, control engineering, district heating and electric energy systems, wind energy and design of wind turbine and electric machines.

2.2 Supervisors

Reidar Kristoffersen
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Associate Professor
Department of Energy and Process Engineering

3 Project description

The group has chosen to split the project in to four phases. This is done to make the planning more organized. The Gantt Chart in Appendix A is also divided into these phases. In the following subsections they are explained in more detail. Each phase does not require the previous phase to be finished and each phase will overlap other phases.

3.1 Phase 1: Planning

Prior to the project

- Agreement- and assignment form
- Collaboration agreement

Project definition and project goal

- Specify the project definition
- Further development of project description
- Set goals for the project

Prelimany project

- Partitioning of project phases
- Finish the prelimany project

3.2 Phase 2: Research and data collection

This phase will consist of the main research for the literature study part of the project. The topics to research included as following:

- Theory behind flywheels
- Construction of a modern flywheel
- Research existing and planned flywheel projects
- Flywheels in the energy system
- Flywheels compared to other energy storage systems
- Safety concerns

3.3 Phase 3: Simulations and analysis

This phase consist of using the data and information acquired in phase 2 to simulate different scenarios.

- Simulate charging and discharging of flywheels with different parameters.
- Simulating a flywheel in different energy systems.
- Simulating flywheels compared to other forms of energy storage.

Analyse and discuss costs of flywheels

- What types of flywheels would be most efficient?
- Isolated systems or integrated in current energy storage systems

- Comparison between flywheels and other energy storage systems

3.4 Phase 4: Creating the final report and presentation

This phase consists of assembling the information gathered in phase 2 and the simulation results in phase 3 in to a report.

Discussion and conclusion

- Are flywheels a viable method to use to solve the world's energy storage problem?
- Could flywheels be used to reduce the power peaks in the power grid?
- Conclusion
- Further work for flywheels in general

Completion of the final report

- Dividing information in to suitable sections
- Evaluate if necessary theory, method, discussion and conclusion are complimentary to the project.
- Proofreading

Final presentation

- Extract the key information from the project.
- Create the presentation
- Rehearse the presentation.

3.5 Milestones

Table 3.1 presents the milestones for the project and their due date.

Table 3.1: Project milestones

Milestone	**Date**
Submission of prelimanary project	27.01.23
Submission of poster	03.03.23
Time of first presentation	17.04.23
Submission of final report	22.05.23
Time of final presentation	25.05.23

4 Quality assurance and follow-up

4.1 Quality assurance

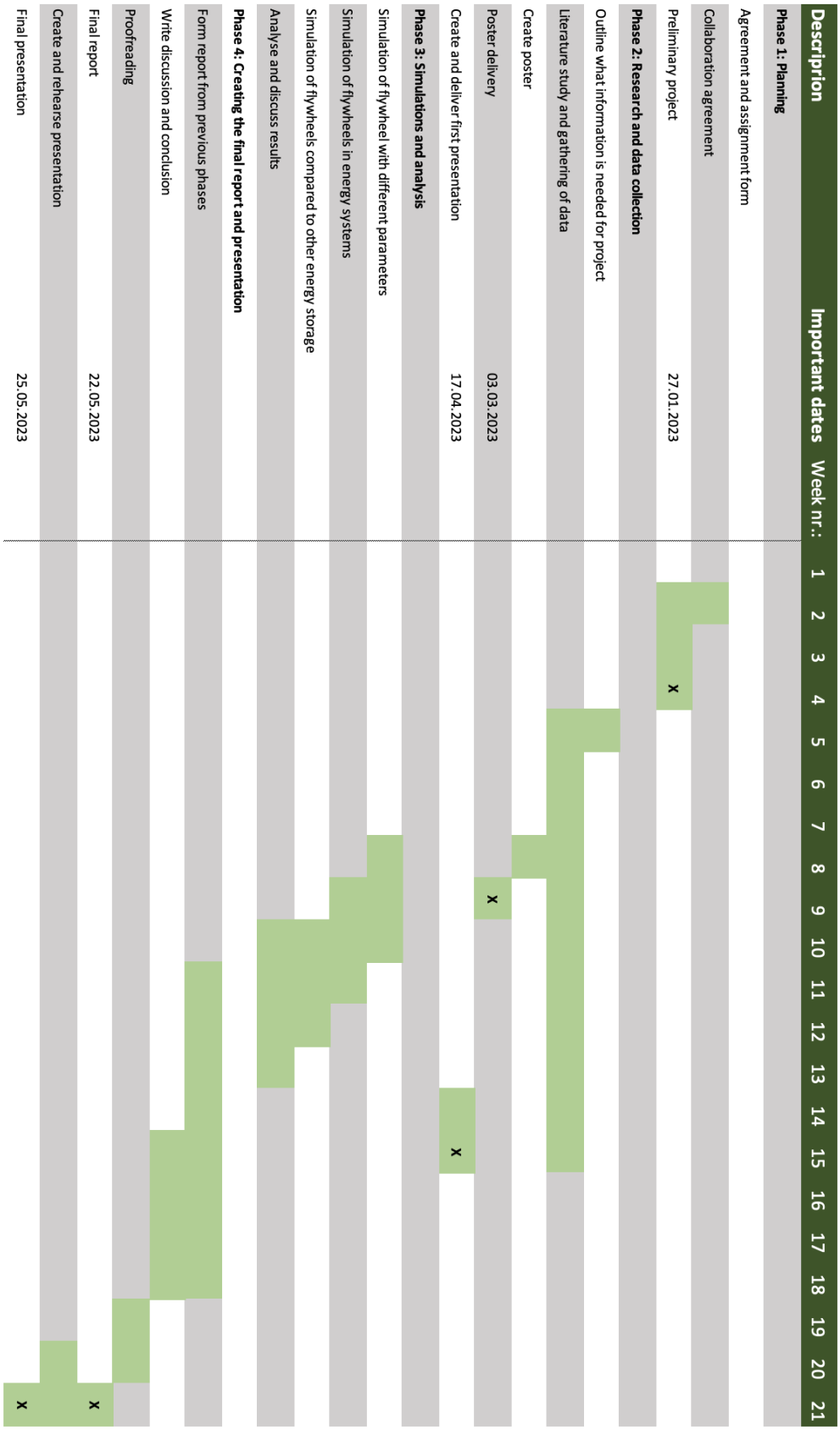
The group wants to hold the project to a high standard and will therefore be done various measures to accomplish this. It will be held continuous group meetings during the whole semester. The literature will be coming from trustworthy sources and it will be judged by the group members if the sources reliability is good enough.

The supervisor will be held updated during the whole semester on progression and eventual challenges with the work. Meetings with the supervisor will be held weekly on each Friday.

The group will use various digital platforms such as Teams, Overleaf, Google Disk and Discord. These will be used to create a clear and easy overview for the group members to be updated at all time.

To make sure both members of the group maintains a high standard when working, an internal collaboration agreement is signed as shown in Appendix B.

A Gantt Chart



B Collaboration Agreement

FENT2900 - COLLABORATION AGREEMENT

Spring 2023

This agreement applies for the collaboration between the following participants:

1. Magnus Langelid
2. Jo Emil Spakmo

1. Aim for the collaboration

- The aim of this collaboration is to write a collaborative bachelor thesis about flywheel energy storage. The group aims to learn and develop their skills in research, writing and teamwork.
- The group aims to attain the highest grade. Both group members dedicated to working hard are aware that they have to work together.
- The workload is to be divided as equal as possible and none of the group members should feel that they work more than the other.

2. Meeting time and attendance

- Meetings will take place at the BIFOREN students bachelor room in the Geologi-building at Gløshaugen.
- During the period from 11.01 to 07.03 the group members will meet from 09:00 to 16:00 on Thursdays and Fridays to work on this project. Mondays to Wednesdays in this period is dedicated to the intensive course INGT2300.
- The period from 08.03 to the presentation of the project on 25.05 the group members will meet and work on the project from 10:00 to 15:00 every weekday.
- If the group members find it necessary to work more than the allocated time, the group members will decide if this can be done at home or if extra meeting time is needed. If the group finds the allocated time being too much and the group completes the planned task a lot quicker than anticipated, the group can take time off.
- Meeting with the supervisor, Reidar Kristoffersen, will be weekly each Friday at 12:15. At these meetings the group members updates what progress that has been done since last time and then discuss further work with the supervisor. These meeting will take place at the supervisor's office.

3. Absence

- If a group member know they are going to be absent on a meeting day, they must notify the other group member as soon as possible.
- If a group member is sick on a meeting day, they must notify the other group member as fast as possible.

4. Preparation

- The group will follow the schedule as closely as possible, but a few exceptions is expected.
- Each group member must come prepared to each meeting. This includes completing planned work.

5. Possible complications in the collaboration

- Complications and dilemmas between the group members is strongly unwanted. If it does occur each group member should behave professional and try to solve the disagreement.
- If the complications turn out to be long lasting, the group members should contact the supervisor.

Trondheim, 26.01.2023

Jo Emil Spakmo

Magnus Langelid