# Reflection Report for Investigation project on the focus on reuse of materials

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Group Number: 3

## 1. Introduction

The purpose of this project was to investigate what is done to reduce the carbon footprint in the construction industry, especially focusing on the reuse of materials. We based our investigation on the NTNU Unified Campus project. The global construction industry is responsible for roughly 40% of all emissions, and a reduction in the carbon footprint is necessary to reach agreements, such as The Paris Agreement (IEA, 2019). We have done an investigation project, where the project purpose is to investigate the reuse of materials in the construction sector. We are specifically focusing on the NTNU Unified Campus project. The goal of the project is to gather all NTNU academic communities into one big campus.

To do this investigation we first identified possible stakeholders for the NTNU campus project and categorized them. This categorization was based on the interest each stakeholder had in the project and how much influence they may have. From this, we found out that Statsbygg is the project developer and NTNU is the project owner, making them the most influential stakeholders in addition to the Norwegian government, who gives financial support. By contacting several possible stakeholders, Eivind Selvig, the environmental administrator from Statsbygg, was positive to give an interview. In addition to this, we contacted the Ph.D. candidate at NTNU Hasan Hamdan, for advice regarding the investigation and he gave us useful insights and sources.

The NTNU Unified Campus project is both doing renovations of old buildings and constructions of new buildings. In this case, it is important to get information on how the project is planning to reuse the materials from the old buildings. Other questions that are asked are about their greenhouse gas emission goals and if they are planning to implement sustainable measures in order to facilitate a circular economy.

### 1. Evaluation of Project management effort

The project group consists of three students: Emilie, Bjørnar and Anniken. We have chosen to evaluate the project management effort by referring to the Tuckman graph in Figure 1. This makes our answers to questions a, b, c and d a bit fluent, but we thought this way of answering would give a more overall picture of the project development. "Tuckman's Stages of Group Development" is a theory from 1965 by the psychologist Bruce W. Tuckman. This theory consists of 5 stages: Forming, storming, performing and adjourning (PROJECTPM, 2021).



Figure 1: The Tuckman graph illustrating the progress of our project development

We started on the project on 15<sup>th</sup> of September, where we constructed a project plan and a problem statement. Every group member was excited to get started and to have meetings to discuss what kind of project we wanted to do. As a group we felt excitement, motivation, and curiosity. All of us are studying at the same institute, the institute of Electrical Power Engineering. Therefore, we already knew each other, even though we haven't been close friends. This was an opportunity to get to know each other even more. Our common backgrounds result in similar thinking, as all of us are practically and analytically minded. There were no conflicts in the group at this stage. This stage is called the forming stage in the Tuckman graph.

The storming already started on the 22<sup>nd</sup> of September. The root cause of the conflict was different priorities, as all of us have other heavy classes and did not dedicate that much time to this project. We are also 5<sup>th</sup>-year students and have a master thesis to focus on. We therefore got a real wake-up call when we realized during an ordinary project meeting on the 22<sup>nd</sup> that the very deadline for the pre-report was the same day. This made the group stressed, and the project planning did not go as well as it should have. In the group, Emilie is the most outgoing team member and started the problem-solving by dividing the tasks that had to be done among the team members. Anniken and Bjørnar are more introverted yet taking great interest in and commitment to the tasks they were responsible for. This resulted in a decent pre-report being delivered, even though it was made in a hurry. We got the feedback for the pre-report on the 1<sup>st</sup> of October from the teaching assistants. The response was mainly constructive feedback regarding the scope we had chosen for our task. The main response was that the scope was too wide, and we needed to narrow it down a lot. Getting constructive feedback on a plan we initially thought we did well, did influence the motivation of each team member. However, we managed to have good discussions about what we could do to fix

our problem. We had listed a couple of success factors in the pre-report, and these were still applicable.

The most crucial success factor was arranging a meeting with the teaching assistants, for which Emilie was in charge. We hoped that this would help us move into the performing phase. We reached out on October 5<sup>th</sup> for assistance after attempting to adjust the project plan based on the feedback. This was more difficult than expected, as we were unable to find a common timeslot with the teaching assistants. When we finally got a meeting settled, the teaching assistant did not show up. To answer question 1b), this is probably the major factor leading to a failure in the risk plan, as we made no progress in the project while waiting for a timeslot. With reference to question 1c), a crucial part of the communication plan was to have weekly meetings. However, we did not see the necessity of this without a new problem statement to work towards. The days passed, and no work was completed, making us postpone the deadlines in the project plan. Several emails were exchanged, but due to poor communication from both sides it was difficult to arrange a second meeting.

On October 20<sup>th</sup>, we received guidance from the course professor after waiting 15 days for guidance. During the guidance session, we decided to change the problem statement and project type entirely, as our initial thought was too broad to be narrowed down. Instead of doing a literature review on sustainable measures within the oil sector, we decided to make an investigation on the reuse of building materials in the NTNU Unified Campus project. The group has concluded that this day and especially the first part of the meeting with Prof. Bassam Hussein, represents the lowest point in the Tuckman graph. Emilie, being the planner of the group, arranged a meeting the next day to restart the project with new motivation. She also sent emails to the project manager of the NTNU Unified Campus project and to the Ph.D. candidate Hasan Hamdan, whose contact information was provided by Prof. Hussein. The norming and performing phase began this day.

The norming and performing stages are fluid and occur in between each other. As the group became more motivated, the group dynamics improved, and the work morality increased. The different skills of the team members were useful to the group's efficiency. Emilie is the organizer, taking the initiative to arrange meetings, taking the lead in the meetings to set goals for the day and distributing tasks with helpful input from the rest of the team. Anniken is excellent at sparring with the subjects Emilie brings to the table. Bjørnar is analytical and more laid-back during the conversation, yet he keeps a close eye on everything. This was a successful group dynamic. The whole group was motivated to work, doing their jobs with great enthusiasm. Bjørnar had the responsibility to make the introduction, remake the project schedule seen in Figure 2 and the WBS. He also wrote about the NTNU Unified Campus project. Emilie had the responsibility to investigate how circular economy is implemented within the industry, and how materials are handled in the construction sector. Anniken was in charge of identifying the project stakeholders and characterizing them. She also noted the group dynamics and important dates throughout the project so that we could use the Tuckman graph to define the progress of the project.

Project: In	vestigate the eff	fect on the carbon footprint by re cifically focusing on the NTNU Can	using npussa	mate amlin	rials i g pro	n the iect	cons	tructi	on se	ctor,	
ۍ.	1.1 Define p	roblem									
are-repor	1.2 Project p	plan									
7612	1.3 Deliver	pre-report									
		2.1.1 Current state in construction sector									
	2.1	2.1.2 Study about circular economy									
	Litterature review	2.1.3 Identify the needs									
		2.1.4 Discuss implementation tactics									
Lelivery	2.2	2.2.1 Question to PhD candidates									
Final OC	Stakeholder	2.2.2 Question to Project Manager									
2.	2.3	2.3.1 Reflections on project work									
	Evaluation	2.3.2 Lessons learned									
	2.4	2.4.1 Finalize paper									
	The product	2.4.2 Video presentation									
	v	Veek	36	37	38	39	40	41	42	43	44

Figure 2: New project schedule for the investigation project

The productivity of the team escalated quickly after the meeting with Prof. Hussein. The group followed the initial rules in the communication plan where we constantly received information and communicated well. It is difficult to determine exactly when the performing phase replaced the norming phase, but 10 days after the guidance, all the major parts of the project were completed. On October 21<sup>st</sup> we received a response from one Ph.D. candidate and investigated the sources he provided on the circular economy within the construction sector. On October 25<sup>th</sup>, the project team developed questions for the interview with Eivind Selvig from Statsbygg, which was held on October 28<sup>th</sup>. Anniken was in charge of holding the meeting with Statsbygg, while Bjørnar was taking notes and asking follow-up questions. On October 30<sup>th</sup>, major parts of the reflection and project part were finished.

To answer question 1d), the problem-solving in the period from October 20<sup>th</sup> to the finish line was to a large extent based on the success factor stated in the pre-report. The first success criterion mentioned, "clarity of project purpose", can be considered the most important. It does not matter how creative and productive a group is if they don't know what to do or what the goal is. After guidance from Prof. Hussein, the problem statement was clear. We got the opportunity to plan how to reach our goal and thereby obtain a clear task distribution and strict deadlines. These were two listed success factors that were critical for successful collaboration. The strict time schedule before the deadline might also have motivated the group. We would say that we evaluate our project management as successful after we got guidance from the professor, as shown in Table 1.

<b>Table 1:</b> Answer to the statement:	"We evaluate ou	t project manag	ement effort as	successful"
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Scale	Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree
Your				Х	
response					

## 2. Evaluation of the impact

Our target audience is wide. Our project results are significant for the construction sector where it can be seen that Statsbygg is highly focused on reducing their carbon footprint and reusing construction materials as much as possible. NTNU as a project owner and other universities that are interested in developing their campus areas will gain knowledge on how to plan low-emission projects in the future based on our results after the interview with Eivind Selvig from Statsbygg. Furthermore, students who are interested in how to work together to reduce the carbon footprint would be interested to read our project report. Since we are students, we know that many students will be pleasantly pleased by our findings, as we did not expect the NTNU Unified Campus project to give that much focus to the reuse of materials to lower the carbon footprint. Since the world is highly focused on the ongoing climate change, the project results demonstrating that carbon footprint and reuse of building materials have been taken into consideration when planning the campus project are of high interest.

We have used reliable sources for the literature review, for example using a master thesis when writing about the circular economy. Another example is using the book "The road to success" by Prof. Hussein which is used in our course. This was used when describing stakeholders and success factors among other things. During our investigation, we interviewed Eivind Selvig, the project environmental administrator working for Statsbygg. Statsbygg is a large and influential company in the Norwegian construction sector and is therefore a reliable source of information. Selvig also provided us with documentation of where he got information from. This documentation was for example the Norwegian standard for accounting for greenhouse gas emissions and the standard for environmental programs, as can be seen in Appendix 2. To discuss the quality of our final result, the use of reliable sources and interviewing a significant company in the construction sector gives the project report a higher quality. We are satisfied with the quality of the final result, and we believe that we have done good work producing a high-quality investigation project report.

Table 2: Answer to the statement: "We evaluate the quality of our final results as outstanding"

Scale	Strongly	Disagree	Neither agree	Agree	Strongly
	Disagree		nor disagree		Agree
Your				Х	
response					

## 3. Factors that have contributed to failure / success

In our project plan, we listed important factors to make our project succeed. Based on these, we will evaluate if the project has been successful or not, but also discuss new success criteria obtained during the project work. In (Hussein (2018) p. 93) there are 3 categories of factors listed: case-specific factors, structural factors and cultural factors. Case-specific factors are factors that are unique to this specific project. Structural factors are factors regarding the organization of the project group and communication within the project. Communication with stakeholders is an example of a structural factor. Cultural factors can describe the motivation of each member and the group collaboration.

The first factors we stated were "clarity of project purpose" and "a detailed project plan". As we had to change our project, we also had to change our project plan and purpose. We changed the plan without making a new physical pre-report, but we made sure that all team members were on the same page regarding the new plan. We considered "support from teaching assistants" as another important success factor. As mentioned in Chapter 1, we got far behind with the project work because we were unable to get a guidance session for two weeks when we needed it the most. If we would have a meeting a few days after we requested guidance, we would have been able to change the plan earlier and then get more time to prepare for the interview and to write a better project and reflection report.

"Clear roles in the project" have been particularly important. We would not have been able to create a structure for our project plan, project report and reflection report if we had not defined concrete responsibilities. In addition, specific roles have been defined on how the different team members work together. We discussed which roles everyone wanted and divided after this. This way all members were motivated to work on the member-related tasks and discuss their findings during the project meetings. This also gives good team motivation because the deadlines are held, and everyone contributes to the group.

"Making deadlines" did in the beginning contribute to success after the big turn of the project purpose and project plan. With less time to complete the project, we needed to be very strict on new deadlines for each task in the project. We decided on these deadlines in the meeting to make sure everyone agreed on them. Because all three team members were working on three different projects at the same time, we needed to make an optimistic and pessimistic time schedule in order to get the project done. The willingness to work was at the beginning large for all team members. The optimistic time schedule was to be finished some days before the deadline in order to be able to work on other important projects. However, due to the lack of motivation and work from one of the team members, it was impossible for the group to finish according to the optimistic time schedule.

Throughout the project, we have discovered that there are more success factors to the project than listed in the project plan. An example of a new success factor is "managing to adjust the project plan when necessary". This has been relevant in our situation. We immediately had a group meeting after the guidance session with Prof. Hussein where it was recommended to change the project. Another success factor is "group dynamics". The project group members were chosen because we knew each other from before, and we were familiar with the working morale and capabilities. We already understood that we needed high group work efficiency to complete the project on time since we knew how much work each member had on other projects. Because of the change in project type and purpose, we are sure that we succeeded in delivering the project on time because of the group dynamics. We have had discussions but have never had real fights between any of the members. Furthermore, "stakeholder involvement" is another important success criterion as we would not have a good investigation project report without the interview with Statsbygg.

To conclude, we believe the project to be a success. The reasons for this conclusion are that despite not following the original project plan, we were able to properly execute the revised plan. The most significant factors for our project to succeed are changing the project plan when necessary, stakeholder involvement, guidance from Prof. Hussein and clear roles. It can be observed that many of our success factors can be found in (Hussein (2018) p. 92). The book lists some success factors that are not mentioned in this reflection report but are still relevant to our project work. These are for example "inclusive project manager", "honesty in reporting" and "continuity of project development". In this reflection report, we have tried to be as honest as possible to show how group dynamics are influencing the project work.

## 4. Most important lessons from your project

The project has challenged us in many ways, and we have gained a lot of experience from it. The main takeaways from the project development part are the following:

- Start identifying the type of project of interest and the learning objectives of the project. Choose a project task and purpose based on this. It is very important to identify possible stakeholders together at the beginning to know if you should try and get in contact with some of them. We were very lucky that Eivind Selvig was interested in having a meeting with us to talk about their project and the reuse of materials.
- 2) We advise you to make the project simple. This makes it easier to stick to the project plan and to finish the project on time with high quality. Our problem before we made changes to the project plan was that we were too ambiguous and made a plan that was not possible to execute. In addition, we recommend you to create a strict project schedule and define responsibilities for each team member in order to get everything done in time. This is especially significant when team members do not know each other from before.
- 3) During project work we learned that physical meetings and discussions are the most effective way to work. We experienced that when group members worked on their own, they were less productive. This makes sense because it is easier to discuss potential problems and get new perspectives. Working together also gives an opportunity for the group to make sure that all group members are participating in the project work.
- 4) Give each other constructive feedback on the collaboration. As a result, each team member may develop based on the feedback they receive from the rest of the group, which should improve the team's productivity and group dynamic.

## 5. Reflection on learning and unlearning

During the meeting with Statsbygg, we were pleasantly surprised that Statsbygg is specifically focusing on how to contribute to as low greenhouse gas emissions as possible and to reuse materials in the new buildings. This demonstrates that the construction sector works to reduce their carbon footprint in all parts of the project.

The learning outcome from the project itself was huge. As this was an investigation into an industry that is unknown to the group, the learning curve regarding the construction industry was steep. In addition, we investigated how the industry handles the recirculation and reuse of materials and products. It has been enlightening to discover the potential, and where the process of implementing a circular economy meets resistance. As confirmed from the conversation with Statsbygg, the will and desire to implement sustainable measures is high. However, the construction sector's biggest contribution is to sort out the waste they produce during construction. The paperwork necessary to reuse products and materials is either non-existent or too demanding to do. One could discuss that the demand for knowing more about the system for reusing materials and highlighting the issue regarding this could contribute to improving the situation. There more who knows, the closer we are to a solution.

Regarding the project management, we have made some reflections on our own role and contribution to the project. We have also given each other constructive feedback on what could have been done better, so that we can evolve on the feedback. This is shown in Table 3.

A common habit in team projects is that group members use team meetings as a "check-point", and then sit by themselves and contact the rest of the group through technological platforms such as Teams. If that is going to work, the task being done and the deadline for the task needs to be very clear and strict, and the communication needs to be at a certain level. This project is to a large extent based on creativity, and our experience is that the group is most productive when we sit physically together. We had to unlearn that relying on technological communication alone is insufficient when the deadline is approaching fast, and the task to be solved is complex.

Type of	Emilie	Anniken	Biørnar
teamwork			
Task oriented	Emilie is an opinion	Anniken has a drive,	Bjørnar is characterized as
roles	giver, meaning that she	meaning that she has a	an initiator, meaning that he
	is not afraid of	drive to keep the	is coming up with many
	speaking her opinions.	project work going,	good ideas, for example
		which is crucial for	several good questions for
	She is also an initiator,	getting things done.	the interview with
	where she comes up		Statsbygg.
	with ideas and	She is also described as	
	suggestions for	an orienteer; she is	He is also analytic, meaning
	improvements.	good at keeping control	that he has a clear view and
		of where we are in the	is great at quick thinking.
		project plan.	
Relationship	Emilie is characterized	Anniken is supportive	Bjørnar is described as a
oriented roles	as an encourager	and encourages the	tension releaser because he
	because she shows	other members to	is good at using humor to
	acceptance for others	further elaborate on	ease the group and get
	in the group and is in a	their ideas. She is also	everyone to relax. He is also
	good mood which	a narmonizer, as she	an intelligent introvert, as he
	boosts other members.	avoids conflict in the	does not take up that much
	a tension releaser as	the group on the same	on the project and
	she talks a lot which	wavelength	contributes when he sees
	contributes to lowering	wavelength.	something that must be
	the shoulders.		done.
Constructive	The feedback Emilie	Anniken's feedback is	Biørnar's feedback is that he
feedback	received was to take up	that she is a bit shy of	should work on taking up
	a smaller space in order	conflicts, which not	some more space in the
	to give room to others.	necessarily is a good	group. It can be a liability
	-	thing. She is a little	for the rest of the team if he
		uncomfortable with	does not contribute as much
		receiving feedback,	as he could have.
		which also is	
		something she should	
		work on.	

**Table 3:** Positive and constructive feedback. Inspired by "Book of Reflections" (NTNU, 2020)

## 6. Acknowledgments

We would like to express our deepest gratitude to Professor Bassam Hussein for guiding us when we really needed it. This was crucial for the development of the project. Further, we would like to thank Eivind Selvig from Statsbygg for having a conversation with us and sharing how the NTNU Unified Campus project implemented sustainable measures to cut emissions. Last, but not least, we would like to thank Ph.D.-candidate Hasan Hamdan for advice and sources.

## 7. References

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## 8. Appendix

Appendix 1: Pre-report Appendix 2: Investigation report Appendix 3: Video presentation

## **Appendix 1. Pre-report**

## **PROJECT PLAN:** Theoretical review focusing on challenges with sustainability measures in different sectors

Anniken Eriksrud Karlsen, Bjørnar Turi and Emilie Birgitte Marskar

#### Focus of the literature review

The focus of the literature review is to construct sustainable measures for different projects in different sectors. The goal is to achieve a preparation for project practitioners to lean on, in order to help them decarbonize the projects. We will especially be focusing on projects within the energy sector and the construction sector. The former is divided into two categories, respectively projects regarding fossil energy sources and renewables. The literature review will also include an analysis of the influence of stakeholders onto the project. This is relevant, as an understanding of who the stakeholders are and how they are affected by the project is crucial. Without the stakeholders' support, the project may not survive. We will therefore investigate the importance of keeping the stakeholders informed of the project's development and value. We will also highlight research challenges regarding developing and implementing sustainable projects today, and how low-carbon measures can be implemented in order to achieve sustainable projects. The cost of implementation of sustainability is key, as the low-carbon solutions have to be competitive on the market. At the end of the report, we will compare the different projects and how the measures differ between them. The reason is to enlighten the different needs for sustainable measures the projects have, depending both on the type of project and the sector it belongs to.

#### Importance of the investigation

The world is facing an urgent climate crisis. Global warming due to emissions from human activity, threatens the global community with a long range of consequences if the global temperatures rise. In the Paris Agreement in 2015, all countries decided to decrease emissions to keep the global temperature from increasing more than 2 degrees (FN, 2020). This is known as the 2 degree goal, and has sent a green wave throughout the global industry to decrease the emissions of greenhouse gasses (GHG). This challenges the project practitioners to be creative and innovative to reduce the carbon footprint whilst being competitive on the market. The demand for low-carbon products has increased, making it an advantage adapting to low-carbon solutions. Several companies are aiming to become climate-neutral within 2050, such as Equinor (Equinor). This makes sustainable measures relevant for project practitioners. The energy sector is essential to focus on when it comes to sustainable measures, as a lot of emissions come from the burning of fossil fuels. This is because it contains a lot of carbon, which when burned is released into the atmosphere. For the renewable projects producing green energy, there are other challenges where GHG-emissions

are related. This is among others infrastructure, logistics and distance between production site and demand site.

Another factor for the energy sector being relevant, is the energy crisis the world is facing due to low supply of power (EnergiNorge, 2022). The power market functions as any other market, based on supply and demand, and the prices are high when the supply is low. Due to the Russian invasion of Ukraine, the supply of gas has shortened a lot. In addition, the year has been incredibly dry in Europe. Europe needs to build more power producing units. It is, however, important to keep the energy crisis from overshadowing the climate crisis, even though the energy demand must be met. Therefore sustainable measures are important, as we need to keep the climate crisis in focus while handling the energy crisis. In order to realize both renewable projects and low-carbon fossil energy projects, it is important to keep stakeholders informed, so that everyone feels included in the process. The second sector we have chosen to focus on is the construction sector, as this is highly relevant for an increasing population in need of more infrastructure, buildings and other construction projects. It is also a sector with large emissions. In 2015, it accounted for 40% of the world's GHG emissions (Tekna, 2015). This is why we find it highly relevant to match the sustainable measures for projects where they will gain a high and positive impact on the environment.

#### Potential stakeholders and involvement

A stakeholder can be defined as an individual or organization involved in or affecting the project, with interests that may be affected by the project (Smith, 2000). Possible stakeholders in this project can be the following:

- Politicians and departments
- Customers
- Local authorities such as counties
- Commercial enterprise on the market (construction entrepreneurs, power producers and so on)

We will involve commercial enterprises by initiating a dialogue with them. For the energy sector, Equinor is a central part of energy production and the phasing-in of green solutions. The company has long roots in both fossil and renewables, and is operating in many countries. We will participate in a presentation held by Equinor by asking them questions after the presentation. They are the leading operator on the Norwegian continental shelf. In addition to this, one of the group members has already been at a banquet with Equinor. Here, she exploited the opportunity to ask Equinor more about their plan to implement sustainable measures for their projects.

Further, we want to investigate the different political parties' interests in different projects we are looking at. It is important to involve all stakeholders.

#### Project risk assessment plan

The risks that can occur in this theoretical review project are:

- Failure to deliver on time
- Strong disagreements between project members
- Failure to cite sources correctly
- Using unreliable literature sources

The risks can be evaluated using a 2x2 matrix with probability and consequence as parameters, as shown below.



#### Consequence

Failure to deliver on time has a low probability but the consequences are big, yielding a medium risk. The biggest consequence with failure to deliver on time is that we may not pass the course. Measure to be taken in order to minimize this risk is to have weekly check-ups of the project plan with time estimates we have agreed on.

Disagreements between project members can lead to low group morale and consequently a bad output from the project. This has a low probability, due to that all group members know each other from previous work. The consequences can be large, hence it becomes a medium risk. To avoid strong disagreements between members we need to have an open dialog with respect to each other.

Failure to cite correctly also has a low probability, but the consequences can be large as it can lead to plagiarism. This makes this a medium risk. Measures to be implemented are proofreading by the other members.

Using unreliable literature sources is not a main risk, but the outcome of the theoretical review can be seen as not trustworthy.

#### Skills

The following skills are important to acquire in order to produce our literature review:

- Critical and analytical thinking
- Being able to contact and interact with people
- Investigation skills
- To be able to break down a task into several subtasks

Critical and analytical thinking and investigation skills are something that all of us have as individuals. However, it is important that we discuss critical thinking and literature that we find. This way we will be able to get a more objective insight of the literature.

When it comes to the ability to initiate conversation with other people, all members of the group will have different qualities. Therefore, working together will make it easier to interact with people during our literature project. It is also possible to ask for help from the teaching assistants during the project work, either to discuss some literature that we have found or how we are working during the project period.

We are sure that we will gain experience during the project work. We will make some mistakes and learn from it by discussing why we did as we did and how we could have done a certain task in another way.

#### Project breakdown structure

The project breakdown structure with major deliverables, sub-deliverables and work packages is presented in the figure below.



#### **Project schedule**

Based on the project breakdown structure, a project schedule with time estimates of each task has been made.

Project:	Theoretical revi	iew focusing on challenges with su	staina	bility	meas	ures i	n diff	erent	sect	ors				
art	1.1 Define	problem										1 !	-	Planned
re-reput	1.2 Project	plan										1 .		
2 <sup>p/2</sup>	1.3 Deliver	pre-report										] !	-	Ongoing
		2.1.1 Current state										] .		
	2.1	2.1.2 Future projects										] /	-	Finished
14	Litterature review	2.1.3 Identify the needs												
telivery		2.1.4 Discuss implementation tactics										]		
e Final of	2.2	2.2.1 Reflections on project work												
1.	Evaluation	2.2.2 Lessons learned												
	2.3	2.3.1 Finalize paper												
	The product	2.3.2 Video presentation												
	1	Week	36	37	38	39	40	41	42	43	44			

#### **Success factors**

Below is a list of what we agreed on as the most important success factors of the project.

- Clarity of project purpose
- A detailed project plan
- Support from teaching assistants
- Clear roles in the project where everyone has concrete responsibilities
- Weekly meetings to secure good communication and involvement of all parts and good feedback
- Deadlines for different parts of the project, realistic schedule

#### Roles and responsibilities in the project

For teamwork to succeed, everyone needs to participate in order to achieve the best possible result together. This demands good communication, and a fair distribution of tasks among the team members. The responsibilities have so far regarded both the project planning itself, making this project plan, and the area we will be in charge of for the investigation. We have decided to accommodate the sectors among the team members, and answer the four questions given in the project schedule above, regarding literature review. Bjørnar will be looking into the construction sector. From a common brainstorming, we think it is a good idea to look into challenges regarding emissions from building materials. Potential solutions to this issue could be reusing building materials, or performing a life cycle assessment (LCA). He will also look into challenges regarding emissions from the infrastructure and logistics necessary for a construction site. Regarding the energy sector, we have decided to divide it into a renewable-part and fossil energy-part, which Anniken and Emilie will respectively look into. For the renewable project, there are challenges regarding stakeholders, new technology, high electricity prices and also building infrastructure and grids. For the fossil energy subsection, there are challenges regarding economic incentives and emissions. The CO2-prices and electricity prices could be decisive for the development within this sector, and thus the

emissions from it. Emilie will also look into a couple of specific solutions, such as steam methane reforming (SMR), hydrogen production and carbon capture and storage (CCS). The common goal for all the team members is to construct sustainable measures that project managers and practitioners can support themselves on when developing the project in order to reduce the carbon footprint as much as possible.

#### **Communication plan**

The communication plan for the group project is to keep constant communication through the entire project period. To achieve this, we have decided to have weekly meetings with the project group. These meetings represent deadlines for parts of the project, as described in the project schedule. In the meetings, we will address potential issues we have come over and give feedback to what has been delivered at the deadlines. We will adapt the project plan to the progress, and continuously update the project plan. The aim is to keep the plan to schedule or in advance.

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## Appendix 2. Investigation report

Title of the investigation:

Investigation on the reuse of materials to reduce the carbon footprint of a construction project

Group number:

3

#### Abstract

The construction industry is responsible for roughly 40% of all greenhouse gas emissions, and over 90% of this comes from indirect emissions such as the production of new materials. Linear economy is the norm in the construction industry today, implying that an implementation of a circular economy will significantly reduce the greenhouse gas emissions from this sector. The industry is willing to adapt to the reuse of old materials, but it is a difficult bureaucratic process.

The NTNU Unified Campus project was originally planned as a zero-emission project. However, after a large budget cut, it is now a low-emission project. After mapping the stakeholders, an interview was conducted with Statsbygg. It was discovered that the project will aim to have as low greenhouse gas emissions as possible during renovation and construction. One of the measures to reduce emissions is to reuse already existing building materials. The project is still in early preliminary planning and these goals are not further defined. How much the project's carbon footprint will be reduced depends on how much of the materials are reusable, which will be determined at a later stage of the project.

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## 1. Introduction

This project report investigates the effect on the carbon footprint by reusing materials in the construction sector. It will specifically focus on the NTNU Unified Campus project, which as the name indicate is a project to gather all NTNU campuses in Trondheim to one.

The construction industry is a large CO2 contributor and is responsible for roughly 40% of the greenhouse gas emissions in the world. It is therefore of interest to reduce the carbon footprint in order to achieve the Paris Agreement commitment. However, from 2010 to 2019 the carbon emission from the construction industry has increased by 7% rather than decreased (IEA, 2019). For a project in the construction industry, it is normal to distinguish between two components of emissions, direct and indirect emission. Direct emissions are emissions tied to construction and site activity during building. Indirect emissions come from the emissions connected with production of materials, transportation, and other non-building activities (Vivek, 2021). Huang (2017) concluded that 94% of all emission from the global construction sector comes from indirect emissions, such as production of new materials.

The NTNU Unified Campus project is a project that will gather all NTNU's academic communities in Trondheim into one big campus. The project duration is set from 2018 to 2028. The triggering factor for the project is the need to share synergies across the different professional environments by collecting it in one unified campus. The project goals are to facilitate increased collaboration between environments, leading to better quality in education, research, innovation, and communication.

The original plan of the NTNU Unified Campus project involved the need to build and upgrade 129 100 square meters of educational buildings. The total cost of the project was estimated to be 11.9 billion NOK. However, after a revised version the project shall build and upgrade up to 91 000 square meters of educational buildings and within a budget of 5.75 billion NOK (NTNU, n.d.).

## 2. Literature review

## Circular economy is the key to reach low emission projects

The world is more globalized than ever, leading to enormous amounts of production and trade across national borders and continents. The capitalistic economic wheel spins according to supply and demand of goods. The life cycle of a majority of products, both in general and in the construction sector, begins at a production site, whereas the product later gets sold, used and finally thrown away as waste (EllenMacArthur, n.d.). The process is linear, making the economy earn its name as a linear economy. As the product goes out of the system, the opportunity to use the product in its entirety or the resources in it, is lost. In a circular economy, the waste is circulating back into the different steps of the production system, enabling the materials to be used again.

This is illustrated by the butterfly diagram shown in Figure 1, with green and blue circles characterizing respectively the circulation of biological and technical materials. In the biological circle the life cycle of biodegradable materials is circulated until they finally become nutrients to the soil, making them renewable. In the technical circle, finite and unrenewable materials are being used as long as possible through the processes illustrated in the diagram. This is favorable to society, as the earth's resources are finite. The concept of sustainability is to preserve resources for the next generations as well. It is also favorable to the ecosystem of the planet, as a circular economy lowers the greenhouse gas emissions, which is a crucial to handle the climate crisis.



**Figure 1**, A butterfly diagram from the Ellen MacArthur Foundation illustrating the process of a circular economy, characterized as technical and biological materials.

The construction sector is on a global scale known as the "40-sector" because they account for roughly 40% of the world's greenhouse gas emissions, energy use, raw material uses and waste (Innovasjon Norge, n.d.). The Norwegian construction sector alone generated 2,1 million tons of waste in 2020 only (SSB, 2021).

## The industry's supply chain is designed for a linear economy

According to Gjølme (2020), it is a cumbersome bureaucratic process to reuse old materials in new buildings today. Depending on the purpose of the reused materials, they must satisfy the same quality and properties as new materials, according to the Norwegian Building Authority (Gjølme, 2020). If these documents are hard to find, new ones must be made according to the standards of ETA, European Technical Assessment. The standards are designed for assessing raw materials and new products and are unsuited for assessing reused materials as well. Due to this, the implementation of a circular economy is unfit for the standards of today. This is one spot in the bureaucratic ladder where the transition to a circular economy has stalled.

### Stakeholders

PMI (2013) defines a stakeholder as individuals or organizations involved in the project, whose interests may be affected by or who can affect the project or its result. Bassam (2018) describes stakeholder management as important to make a project succeed. There are three important steps:

- Identification of stakeholders
- Identification of the relationship between each stakeholder and the project
- Developing strategies to involve each stakeholder, where communication is an important part

Upon completion of identifying the stakeholder, it is important to classify them accordingly. There are some methods available, but one method explained in Bassam (2018) is to do a "Stakeholder mapping". This can be done by grouping the stakeholders and analyzing them according to their influence and interest. Once completed the project will get a better understanding of who has the most authority and influence, which signals what needs to be done in order to reach success (Bassam, 2018).

## 3. Method

## Identifying and classifying stakeholders

Firstly, all the stakeholders in the project must be identified. After identifying the stakeholders in a project, it is important to be able to analyze the stakeholder's position in the project. The method used in the project is "Stakeholder mapping". This method involves position stakeholders according to their influence and interests.

For the NTNU Unified Campus project the identified stakeholders are:

- NTNU: Directly involved as project owner
- Statsbygg: Directly involved as builder
- Subcontractors: Hired by Statsbygg
- Consultants: Hired by Statsbygg
- Suppliers: Material suppliers for the project (resources)
- Norwegian government: Financial support from the state budget
- Students and end users: NTNU students and jobs tied to the buildings
- Community: The local community

By classifying the stakeholders as previously explained by influence and interest, the stakeholders were grouped as shown in Table 1.

Table 1: Classification	of stakeholders	in the	e NTNU	unified	campus	project.

Stakeho	olders	Interest				
		Small	Large			
	Marginal	Community	Students and end users Academia			
Influence	Critical	Norwegian government Subcontractors Suppliers Consultants	Statsbygg NTNU			

## Interview

To get the newest and most relevant information about the NTNU Unified Campus project, an interview with someone involved in the project was of high interest. So, after identifying the stakeholders for the NTNU Unified Campus project, it was clear that both NTNU and Statsbygg had high interests and influence. The group then reached out to several individuals from both stakeholders through e-mail. After a couple of days, the environmental administrator for the NTNU Unified Campus project Eivind Selvig responded and offered to do a meeting over Teams.

Prior to meeting with the environmental administrator, the group gathered to perform a brainstorming of relevant questions and discussion points. The key question during this brainstorming was, *how has Statsbygg implemented a circular economy in the NTNU unified campus project?* 

After some discussion the group landed on a few very important questions, regarding recycling of used materials for the NTNU Unified Campus project:

- Does the project have an active goal to keep greenhouse gas emissions down? If so, what is the goal?
- Do you intend to create a greenhouse gas emission report for the project?
- What happens to the old materials in the areas you are going to renovate?
- Do you plan to reuse old materials in the new buildings?

## 4. Findings

### Literature review

The NTNU Unified Campus project has established an environment program with the purpose of it being the project management document. The main goal regarding greenhouse gas emission from the environment program is that the new unified campus shall have a low climate footprint. However, this is not further specified and is therefore up for discussion.

The environment program also covers goals regarding circular economy. The main goal for the projects circular economy is that the new unified campus shall have area efficient solutions with buildings that are prepared for re-use, alteration, dismantling and material recycling (NTNU, 2022).

Still today, there are not a lot of projects that aim to focus on reusing old building materials. One of the most known projects where the reuse of materials was the goal, is Kristian August Gate 13 in Oslo. In this project 80% of the materials was reused which resulted in a decrease greenhouse gas emissions by 70% compared to a building within TEK17 regulations. It is important to note that the reused materials did not only come from the previously existing building, but came from several "donor" buildings (Futurebuilt, 2022)

#### Interview

The interview is presented here as a Q&A and will be discussed further in the next chapter.

## How does the relationship work between the project owner NTNU and the project builder Statsbygg?

NTNU is the project owner and Statsbygg is the builder. However, during the construction, Statsbygg is both the builder and project owner and must follow a rigid assignment letter from the ministry of education and research. But even though Statsbygg does decide a lot of how the building should be done, they do propose their ideas to NTNU and take feedback. It is important for Statsbygg that the end-users are happy with the outcome of the project.

Statsbygg will also strive to follow with other demands that NTNU have, such as the ones mentioned in the environment program regarding greenhouse gas emissions.

## Does the project have an active goal to keep greenhouse gas emissions down? If so, what is the goal?

Prior to the project being revised and cut down, the campus was planned to be a zeroemission campus. Extensive re-use of materials was planned to be done, however due to the cost reductions the goal has changes. After the audit, the climate goal for the project is that greenhouse gas emissions should be as little as possible. This is stated in the environment program for the project. One of the sub-goals is to reuse building materials. The project is however still in not in the preliminary stage so it is unsure how much can be reused. The project is currently working on a system with architects and builders on how to dismantle properly.

#### Do you intend to create a greenhouse gas emission report for the project?

Yes, and a rough estimate has already been made. The basis for this report is greenhouse gas emission reports from 140 similar project in Norway. It is also required by regulations to make a greenhouse gas emission report for all office buildings over 1000m<sup>2</sup>. When the project moves to the point where construction starts, there will be a greenhouse gas emission report for each building.

#### What happens to the old materials in the areas you are going to renovate?

Old materials from the areas that are going to be renovated is going to be mapped. This means that the project will register the old materials and sort it accordingly. This is already required in the regulations.

In the original zero-emission plan it was planned to develop a system for the open market, such that local entrepreneurs could use leftover old building materials. This would be sort of like the "Too good to go"- app, where leftover food can be bought cheaply instead of thrown away. But after the budget reduced substantially Statsbygg has moved away from this idea.

#### Do you plan to reuse old materials in the new buildings?

Yes, as much as possible. But there are a two criteria's that needs be fulfilled first; applicability and whether it is economically justifiable. Some of the building materials are so old that there is not enough information about the integrity and building strength. This can cause problems in the engineering phase of the project when simulation of the building strength is done. It is therefore a higher chance that internally non-load bearing materials can be re-used.

The other criteria are the economy aspect of reusing materials. For the materials to be reused they need to be properly dismantled and stored during construction. Proper dismantling and storing takes space and time, which costs money. Some old material may also need to be refurbished before being used again. The project will need to take all this into account and see if it is economically justifiable re-using materials.

## 5. Discussions and conclusions

## Circular economy in the construction industry

In this investigation, we are focusing on the facilitation of a circular economy in the construction sector during the construction phase. Sustainability and green products are hot topics in most parts of society, and the construction sector is no exception. The performance of new and modern buildings is characterized as zero house, plus house and as energy efficient. However, the circular economy's most important principle is to substitute production of new products by utilizing reused or recycled products instead. Therefore, the scope of this project was to investigate the measures taken to cut emissions during production. If the modern houses with a top grade on the energy efficient scale are built in an ecologically destructive way, the point of projecting sustainable houses would be gone. In addition, it can be received with a feeling of false advertising and even greenwashing.

This suggests that there is huge unused potential for implementing a circular economy in the construction sector, with all the advantages that come with it. It is more beneficial to reuse already existing products, and it could be a potential business too. The next question in line is *"What is stopping us?"*.

There are several factors that facilitate a linear economy in the construction sector today. The most prominent factors are the following. Firstly, the framework that applies to the construction sector must change, for example the standards that building materials must satisfy according to the Norwegian Building Authority (Gjølme, 2020). The reused materials must satisfy the same standards as new materials. The quality of the materials used must be documented, which can be hard to find for reused materials from old buildings. The standards of today were not made for a circular economy and is not suited for reused materials. Secondly, raw materials are attractive as the prices are low and the availability of them is high. However, we have gotten the impression that the industry has a desire to implement circular economy in order to enhance material reusage, reduce greenhouse gas emission and possibly reduce cost.

## Carbon footprint for the NTNU Unified Campus project

The NTNU Unified Campus project aims to have a minimal carbon footprint throughout the project, but the project has still not specified any number to this claim. The project also aims to reuse old materials "as much as possible", according to Statsbygg. Being that the project is still in a very early stage it is hard to determine how much that can be reused. It can be easy to say prior to the construction phase that the project aims to reuse as much as possible, but in reality it may be harder to do because of applicability and cost.

Old building materials that cannot be reused in the project can be recycled e.g., in a heating facility. This will however also increase the carbon footprint, with emissions from both burning it and producing new materials.

For the NTNU unified campus project, the original plan was to develop a zero-emission project. However, after the project was revised with a substantial budget decrease, they had to change their plans to a low-emission project. This was a decision made by the government, to be more specific the ministry of education and research. This is a prime example that the influence of stakeholders can change a project. The Norwegian government is a big stakeholder in this project as they are responsible for the financial support, and they decided that the original plan was way too expensive.

## Conclusion

The construction industry is a massive contributor of greenhouse gas emissions and is responsible for roughly 40% of all emissions globally. Today, the industry consists mainly of a linear economy. By implementing a circular economy in the construction industry there is a huge potential to reduce the large carbon footprint. The industry is giving signals that they are willing to implement a circular economy, but it is a difficult bureaucratic process as the regulations have not yet adapted to the reuse of old materials.

The NTNU unified campus project is a big project that will include both renovations and construction of new buildings. The original plan was to have a zero-emission project, but due to cost reductions, it is now a low-emission project. In the NTNU environment document, it is stated the project shall have as low as possible greenhouse gas emissions.

Through an interview with the environmental administrator from Statsbygg it was made clear that Statsbygg will strive to reuse old building materials as much as possible. How much they will be able to reuse is still not defined, as the project is still in the very early stages. There are some concerns regarding the building strength of old materials, implying that it is more likely that non-bearing materials will be used during renovations and constructions.

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## Appendix 3. Video presentation

Link to presentation on BlackBoard below

https://ntnu.blackboard.com/ultra/courses/\_37263\_1/cl/outline