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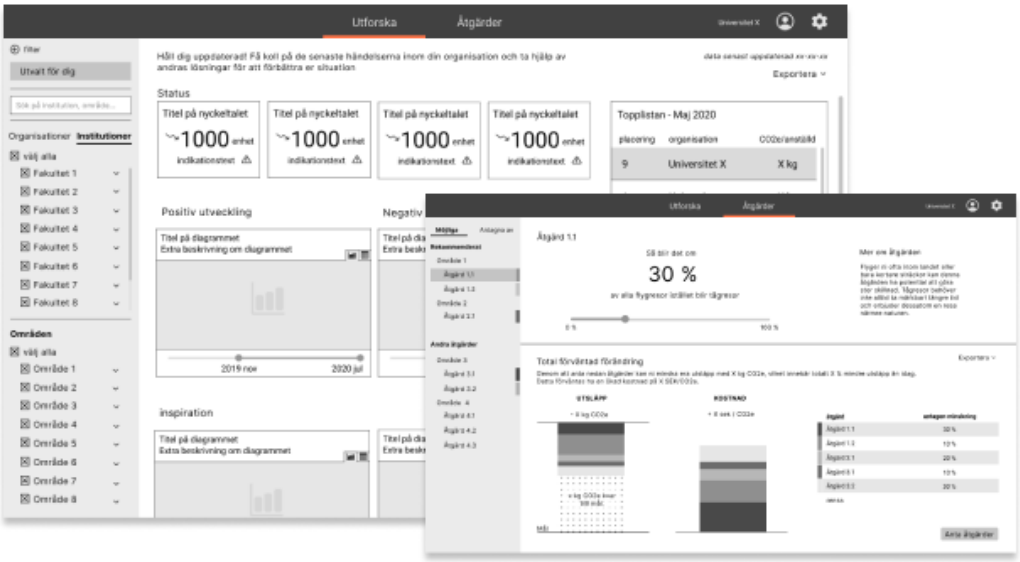

Interface design of a decision-support system for understanding the environmental impact of an organization

A study exploring nudging techniques and interaction design strategies in the context of supporting decision-making within an organization

Master's thesis report in Computer science and engineering

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Master's thesis report 2020

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Abstract

To keep global warming under 1,5 degrees Celsius is a core goal for the environmental and sustainability work in Sweden and many other UN countries today. Many organizations, that run big operations and have a high impact on the greenhouse gas emissions being released into the atmosphere, want to take their responsibility and reduce their carbon footprint. For an organization to enhance its prospects towards this goal, they need to understand the environmental impact of their operational activities, including gathering knowledge regarding potential improvements.

This master's thesis contributes to the above need by presenting suggested use of interaction design strategies and nudging techniques within the context of interface design of a decision-support system in the form of a desktop tool built around an organization's emission data. A prototype visualizing the above contribution presents a design proposal of such a system. Higher educational institutions are the representative organization type targeted during this project which is grounded in desires and visions of the company Svalna who initialized the thesis work. Furthermore, The report presents the design process, including user research, workshops, definition and validation of tool requirements, ideation, and evaluation of the prototype through reviews with UX experts.

Keywords: Sustainability, carbon footprint, decision support system, nudging, interaction design.

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Felicia Kernehed, Gothenburg, August 2020

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1
Introduction

Today, it is more crucial than ever to take better care of our planet and decrease the amount of carbon dioxide released into the already polluted air. Most products bought today and actions made contribute to pollution of greenhouse gases (GHG) which is causing global warming and severe climate change. Drought, melting ice in arctic, and extreme heat are some outcomes that have many negative effects on the earth and life on it. Clean air, safe drinking water and sufficient food are already and will only continue to be more threatened [1]. According to the World Health Organization [1], "between 2030 and 2050, climate change is expected to cause approximately 250 000 additional deaths per year, from malnutrition, malaria, diarrhea, and heat stress". Observations suggest that we are in the middle of the "sixth great extinction" [2] and that it is possible that half of the world's species will be extinct by 2100. Humans affecting the global climate is, along with misusing resources, fragmenting habitats, introducing non-native species, spreading pathogens and directly killing species, the cause of the extinction[2]. Considering this, international and national goals have been set to reduce humanity's impact on the climate. The UN has developed a 17 goals program, called Agenda 2030, to reach global sustainability [3]. Number 13 is specifically focused on climate change and brings up importance to not exceed the 1,5 degrees limitation of global warming. Sweden's most clear environmental goal is to reach zero net emissions by the year 2045 [4], which goes hand-in-hand with the international goals set by the UN. To reach these important goals more actions have to be taken. It is of importance to spread knowledge to support better well-informed decision-making regarding operations with environmental impact. Changes in organizations and companies are very relevant to climate change, which is why Svalna AB is one of the companies working in this area. They have developed a method for calculating the environmental impact of an organization and its operations based on their financial records. Svalna's goal is to develop an interactive desktop tool, much like a business intelligence system (calling it a *Carbon intelligence system*), built on the estimated emission data. With this challenge in mind they reached out to Interaction Design students and it became the base for this master's thesis work.

In the field of Human-Computer Interaction, design for behavioral change has mainly been studied in the context of individuals. For example, there exist many mobile applications with the aim to change unhealthy habits to healthier ones; apps that try to make you exercise more, eat a healthier diet or decrease your consumption for environmental reasons [5]. Nudging is a concept containing techniques of designing something to influence a user to behave in a desired way. This is frequently used in

the earlier stated types of apps as well as in other contexts where a certain desired behavior is beneficial. Thaler and Sunstein [6], who in 2009 first used the term nudging in the context of behavior economics, emphasize that it refers to guidance towards a sustainable behavior that is good for both the individual and the society. The decisions of one individual are affecting society. Thus, the decisions of an entire organization often come with an even bigger impact. Yet, organizations today often lack useful tools to help them in the right direction towards a sustainable operation [7]. In addition, technology-mediated nudging directed to organizations or groups does not take up a noticeable space in the existing theory. This report aims to fill parts of this gap.

1.1 Aim

This thesis aims to investigate what factors to consider when designing the interface of a desktop tool, built around an organization's GHG emission data, with the purpose to guide them towards taking operational decisions with reduced impact on their environmental footprint. Some of the found factors will be formulated into a number of interaction design guidelines with the purpose to serve as a future guide for the development of this and similar systems in the context of supporting decision-making regarding organizational operational activities. Theory of nudging will support the thesis research to find ways to create an interface that will influence the users into making decisions in the right direction, here being towards reduction of greenhouse gas emissions. Design proposals of visualizations and views of the tool will be made based on user-research conducted mainly at higher educational institutions in Stockholm and Gothenburg. These will be presented in one medium-fidelity prototype of a decision-support system, which Svalna aims to develop further.

1.2 Research question

What factors should be considered when designing an interactive system built around an organization's greenhouse gas emission data to support well-informed decisions on operational activities?

To help guide in the attempt to answer the above question, two supporting questions have been formulated:

- What strategies within interaction design can be used to support visualizations of organizations' emission data?
- What nudging techniques can be used to influence the decision-making within an organization towards reduction of their greenhouse gas emissions?

1.3 Delimitations

This report aims to fill the gap in theory regarding the use of nudging techniques and interaction design in the context of supporting decision-making within an organization towards more sustainable operational activities. The study provides a design proposition on the interface of a desktop tool supporting the above task, in which both the needs of the intended users (developed on further down in this section) and the vision of Svalna are considered.

When interpreting this deliverable along with the others (stated further down in section 1.4) it should be considered that they are solely based on user research from a narrow group of users, working in higher educational institutions (HEIs). Some reinterpretation of the result might be needed to have it work as guidance in other organizational contexts.

1.3.1 Types of Organizations

There are many different types of organizations. The definition of the term is: "a group of people who work together in an organized way for a shared purpose" [8]. Different organizations are built in different ways, have different opportunities and operational processes, etc. This thesis-work will focus mainly on HEIs. Further in this report, the term *organization* will refer to said limitation. This limitation comes from the pre-study made by Svalna and the University of Stockholm where it became clear that the university's interest in this type of tool was high. Chalmers and the University of Gothenburg also stated their interest. The main user-contact already established is estimated to be within these listed HEIs.

1.3.2 Stakeholders

As a pilot study involving the exploration of the need of this kind of tool was made by Svalna prior to this project start, some future users had already been found and established. It was a wish from Svalna that these were prioritized during user research and thus becoming the source of the information on which the entire project was based.

The first stakeholder are the users of the tool. These are the people within an organization who work with operational changes connected to climate issues. These can operate on different levels within the organization and thus have different responsibility leading to different needs. These are not required to have any specialist knowledge in order to understand the tool, more than an overall understanding about the operations of the organization. The group considered to be the primary one are the ones working on a central level, suggesting the internal climate goals and how to reach them. The people in charge of implementing changes on the institutions or faculties will benefit from understanding the background to the decisions made and the impact of previous actions. During the user research of this project these were found to be an important secondary user of the tool. All decisions regarding

environmental goals or actions need to be confirmed by the highest decision-making body, e.g. the principal within an HEI, making this person (or group) a possible third user of the tool.

A second stakeholder is the company, Svalna, with whom a close contact will be held during the execution of the project to make sure we are on the same page. Their knowledge within the subject should also be taken advantage of.

The third stakeholder is Chalmers and the institution of Interaction Design and Technologies. The project and its outcome need to follow specific requirements for it to be accepted as a master's thesis work which will result in a master's degree. Close contact with the assigned supervisor from the institution will be held throughout the project to guide the work through suitable methodology and theory as well as make sure it is inline with the requirements from Chalmers. The instructions from the examiner as well as his final approval of the thesis work is also taken into account.

The forth and last stakeholder is me, the person carrying out the project. My interests along with what I want to be associated with needs to be considered as well.

1.4 Deliverables

The intended result of this project is:

- A medium-fidelity prototype of a desktop tool (*the Carbon intelligence-system)*, including modules of interactive visualizations, with the aim to communicate a design proposal to use as a foundation for further development of a final tool.

- Guidelines within interaction design, suitable to consider when designing similar decision support systems built around emission data with the aim to guide organizations to reduce their environmental impact from operational activities.

- Nudging techniques, that are suitable for the context of the project, serving as a recommendation to consider during further development of a final tool or when designing similar system.

2

Background

This chapter presents the background of this project through the background of Svalna, information about their existing products and other related work on visualizing carbon footprint. Further, it presents some frameworks and goals, which have increased the need for such a tool among organizations. Lastly, it shows facts about the effect of greenhouse gases and gives a short insight regarding difficulties with change within an organization.

2.1 The background of Svalna

Svalna is a small company based in Gothenburg that has developed a unique technology to calculate greenhouse gas emissions based on financial data. With use of this technique they aim to reveal what impact our consumption has on the environment. Their most developed solution today is their personal carbon footprint calculator app, called Svalna. They have also developed an interactive digital tool, called The Climate Vision, showing how Swedish consumption affects greenhouse gas emissions. The newest project that Svalna is working on is the development of a digital tool for organizations and companies to keep track on their GHG emissions. The tool will take in financial data, such as invoices, and do estimations and calculations based on a method of Svalna. The output will be interactive information visualizations in the form of a business intelligence system, which this master's thesis is a part of. The reason behind Svalna's initiation to the project begins with a signature on the UN's Climate Emergency Letter for Higher Education from the principal of the University of Stockholm. This letter implies that the HEI undertakes to work towards carbon dioxide neutrality by 2040. To reach this goal, the University of Stockholm needed to start tracking their emissions in a more efficient and trusted way than before. The mission to create a method for this was given to Svalna. Their result, to use financial data to estimate the university's emissions from purchases of products and services, made other HEIs excited as well which gives this project a solid foundation of interest to build on. Other universities interested in Svalna's method, like the University of Gothenburg and Chalmers University of Technology, are a part of The Climate Framework-agreement which makes them obligated to continuously track their emissions as well. The Climate Framework is one main motivator for these Universities and is described further down in this chapter.

2.1.1 Svalna - the app

The application, Svalna, allows for individuals to through their bank transaction data receive information about their personal contribution on climate impact. The technology behind looks at where you bought a product and the price of that product. From this, estimations are made on how much GHG was emitted due to this purchase. The user is asked to answer some additional questions in order to refine the estimations. The visualizations shown in the app allow the user to drill down in categories such as household, 'food and beverages', 'transport' and 'shopping' to further understand the reason for the footprint. Furthermore, the app gives suggestions on possible ways to reduce one's footprint and lets you be a part of groups in which you together can work on a goal or compare your footprint to other users'. Examples of existing groups are Gothenburg city and The students of Uppsala. The app is constantly under development and improvement.

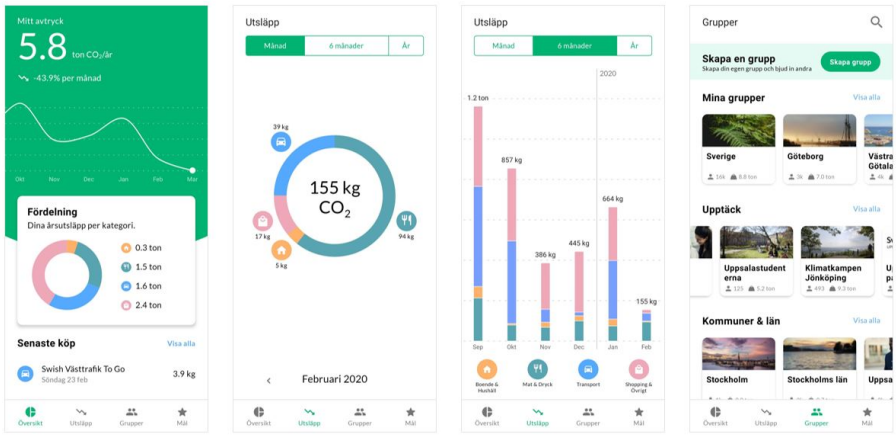

Figure 2.1: Screen shots of the mobile application Svalna.

2.1.2 The Climate Vision

The Climate Vision, or '*Klimatvisionen*', is a digital tool currently in beta use as a part of the exhibition Human Nature at the Museum of World Culture in Gothenburg [9]. By interacting with slider controls the user can explore the effects of different lifestyles changes on the total GHG emitted from the Swedish society. Changes as changing to a vegetarian diet, heat up houses with only renewable energy or to use public means of transportation are examples and which affects can be explored by the user. The tool has been developed together with researchers at Chalmers University of Technology and aims to help people understand the actions that need to be taken in order to reduce our negative impact on climate change.

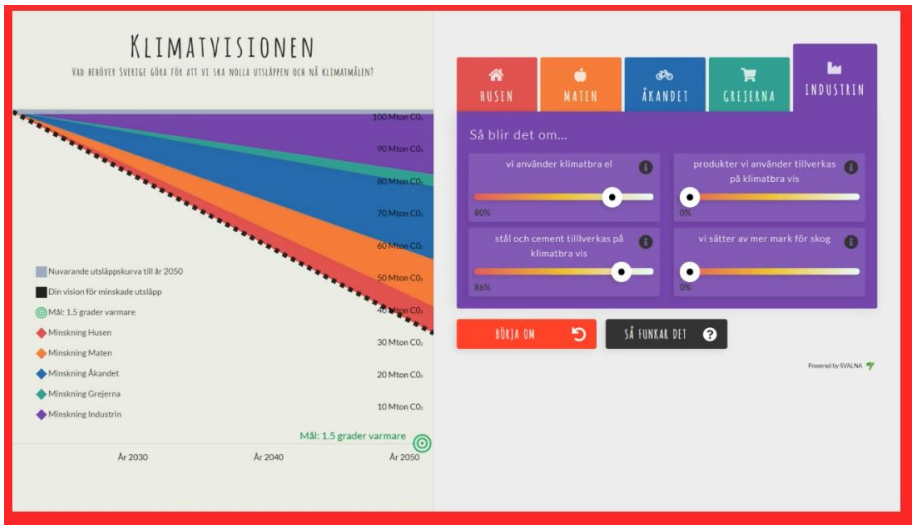

Figure 2.2: A screen shot of the Climate Vision tool, where some changes has been made to the society.

2.2 The UN's 17 global goals towards sustainability

In 2015 the member countries of the UN all agreed to work towards 17 sustainable global goals up until 2030 [3]. They include work within economical, social, environmental sustainability and require effort from both private- and public sector as well as cooperation between citizens in all countries. The general idea of the 17 goals can be summarized in four points: to eliminate extreme poverty, to reduce inequalities and injustices, to promote peace and justice, and to solve the climate crisis. One of the goals, number 13; "Take urgent action to combat climate change and its impacts" clearly connects to reduction of GHG emissions in order to keep global warming below 1,5 degrees Celsius. A report from the international climate panel, IPCC, [10] states that 2 degrees of warming, which was the previous stated limitation goal, will have much more serious consequences and therefore 1,5 degrees of global warming is a better aim. This will still have serious consequences, but considerably lower than at 2 degrees.

2.3 The Climate Framework

The Climate Framework, initiated by Chalmers and KTH in 2018 [11], is an agreement between 37 higher education institution (HEI) in Sweden. It is built on the UN's 17 global goals towards sustainability. The agreement focuses on the aforementioned goal number 13. To achieve this limit, global GHG emissions need to decrease by almost 50% each decade, which all signed HEI's have agreed to do. This international goal lies in line with Sweden's national target of zero net emissions by 2045. The framework should work as a starting point for each HEI to build its environmental work upon in order to achieve these national and international

goals. Key areas are presented in two groups; areas related to core activities of the HEI (indirect effect) and areas relating to operational activities of the HEI (direct effect).

Direct climate impact:

- Business trips
- Commuting, trips to and from work
- Food and food services
- Energy consumption
- Operation of property portfolio
- Property portfolio, new construction, and rebuilds
- Waste management
- Purchasing of goods and services
- Investments
- Carbon sinks

Indirect contribution to climate change adaptation:

- Education
- Research
- External engagement and societal impacts
- Students

The areas with direct climate impact are to be measured and reported in carbon dioxide equivalents. The climate Framework also includes proposals for operational changes that can lead to reduced environmental impact [12].

Because of this framework the HEIs that signed need no longer to just reduce their emissions but also to reduce with a certain amount. The exact process for this is up to the HEIs themselves as long as they aim for the target; to reduce GHG emissions by 50% every ten years. This goal calls for continuous tracking of GHG emissions which is one of the reasons why Svalna got in contact with some of the HEIs and why this project came to life.

2.4 Business intelligence tool from from NTNU

With the vision of being a pioneer university, the Norwegian University of Science and Technology (NTNU) has developed a Business intelligence system which visualizes data based on their greenhouse gas emissions. This allows them to keep track of their carbon footprint and help in the process to keep their environmental goals. Within the tool, it is possible to filter on things like departments, sections, or geographical location. Charts based on what has marked to be shown are displayed and updated along with the filtering.

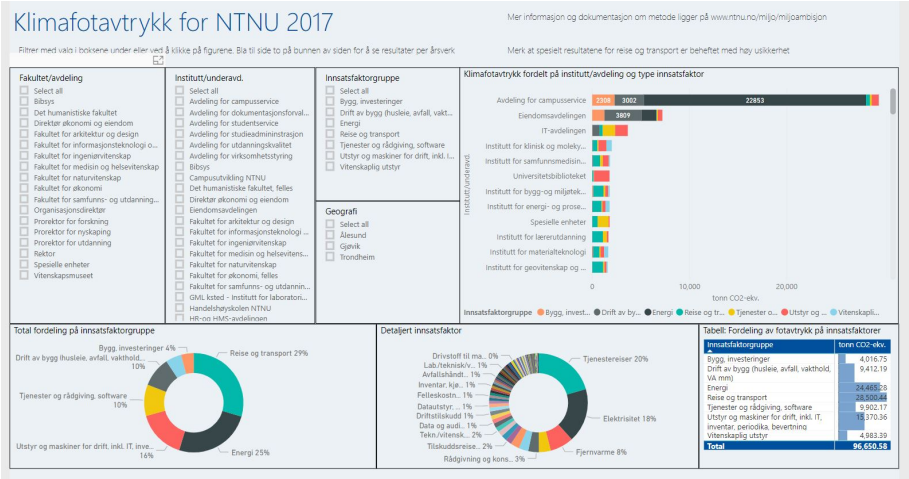

Figure 2.3: The first view of the Business Intelligence tool. Filtering is made by marking desired options.

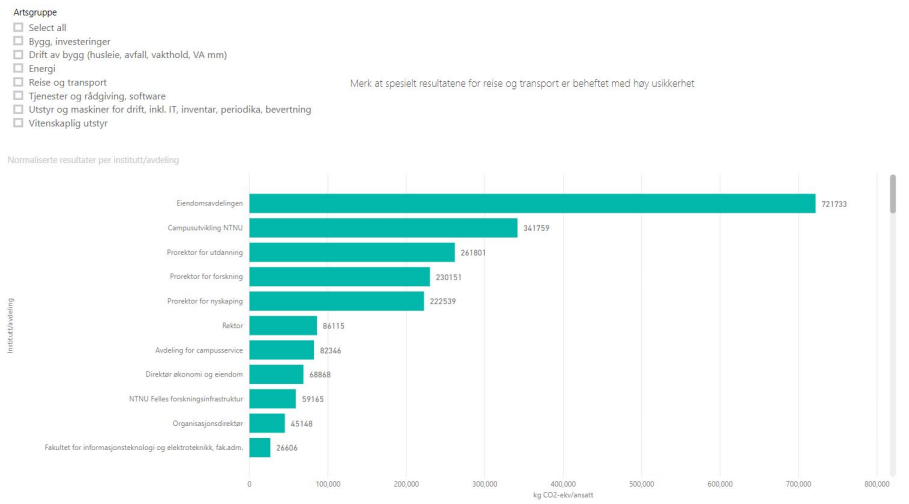

Figure 2.4: The second view of the Business Intelligence tool. Filtering is made by marking desired options.

2.5 The Effect of Carbon Dioxide

A greenhouse gas is one that absorbs heat from and gradually release it over time. To have these in our atmosphere is therefore crucial for life on earth. Without them, the average annual temperature would be -18 degrees celsius [13] instead of around 15.5 degrees celsius as it is today [14]. The natural greenhouse effect is needed, but the effect-increase due to a higher greenhouse gas level, is putting the temperature on earth out of balance causing global warming. Except for carbon dioxide, which is considered to be the most important greenhouse gas (the highest level in the atmosphere), others with high levels of the same kind are methane and nitrous oxide. Carbon dioxide differs from the others by staying much longer in the atmosphere, but at the same time it absorbs less heat per molecule [14].

The concentration of atmospheric carbon dioxide is often measured in parts per million. This concentration has been going up and down in the history of earth, due to natural circumstances like e.g. changes in the brightness of the sun or shifts in the angle of the axis of the earth. But never before, at least in the past 800 000 years, has the level been this high. According to EPICA Dome C data, a collection of analyses done on the the European Project for Ice Coring in Antarctica (EPICA)Dome C ice cores, put together by NOAA Climate.gov, average of this concentration was 407.4 ppm in the year 2018 which is more than a thirds increase from the last highest peak [14]. Research shows that this rapidly raising concentration level can not be explain by solely the natural occurring circumstances. Anthropogenic emissions, the ones caused by human, are instead the absolute main reason [13].

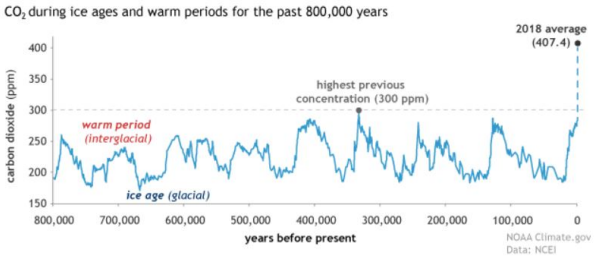

Figure 2.5: Global atmospheric carbon dioxide concentrations (CO2). This graph shows global atmospheric carbon dioxide concentrations (CO2) in parts per million (ppm) for the past 800 000 years. The peaks and valleys track ice ages (low CO2) and warmer interglacials (higher CO2). The graph is based on EPICA DOME C data [14]

Since this situation is new to us and to the history of the earth, even experts have a hard time anticipating the exact consequences. What we know for sure is that it will have and already has a huge impact on the ecosystem of the earth [13].

2.6 Organizations and sustainable change

As the trend of interest in sustainable products increases, the technological change is developing along with it. The cost of becoming sustainable are therefore more likely to decrease. To be able to tell and show on your organization's sustainability, is for many organizations considered to be very important. Even though this change seems important and compelling, often the change is happening slowly due to its complexity. Changes in the core business operations and structure within a company is one of the main challenges when integrating sustainable practices. Further, the attitude, identification of an organization are most likely required to be updated. At the same time, these aspects need to be balanced with the financial and social logic [15].

2.6.1 Nudging theory in the context of organizational change

The individual is usually the target stated in the theory regarding the use of nudging. Nudging techniques aim to make use of, or overcome, psychological effects triggered by perceptions of the outer world in order to guide individuals to a certain choice or behavior [5].

The use of nudging in a digital environment is found in different kinds of mobile application that target the user's unhealthy behavior in order to exchange them to healthier ones. There are many digital choice environments where nudging is used to push the individual in a preferred direction. Online shopping or the simple checkbox indicating on one's wish to subscribe to a newsletter or not, are examples of such environments [16][5]. The above example contexts all have in common that they revolve around an individual. The choices made are of personal sort in that sense that it is up to the individual to make them. In difference, in the context of organizational changes, the decisions made are rarely up to one person but need to be discussed in a group before taken. Personal feelings and desires seem to no longer be directly connected to the choice making process. Instead it is about the drives and desires of the collective that influence.

When searching, there was a lack of existing theory regarding this perspective of nudging. Therefore, it was considered interesting to explore how the existing theory listing techniques of nudging can be used in the context of operational organizational change in the form of attributes in an interface for a decision support system.

3

Theory

This chapter presents theoretical background for this project. The theory is related to interaction design, information visualization, and nudging.

3.1 Interaction Design

Interaction design is an umbrella term for describing the field of researching and designing computer-based interactive products to support people's communication and interaction in their everyday or working lives [17]. The focus lies on designing based on the understanding of the users, the technologies and every aspect working in between. This can be an extensive work which is why it is most often carried out by many people with different skills and occupations. In the field of Interaction design, some subterms often used are e.g. user experience and user centered design.

3.2 User Experience

User Experience (UX) is defined as "a person's perceptions and responses resulting from the use and/or anticipated use of a product, system or service" according to the International Organization for Standardization (ISO) [18]. It is about the entire experience a user has related to the use of a product/service. Not only during the exact use, but also before and after. Jesse Garrett's describes it like this: "Every product that is used by someone has a user experience: newspaper, ketchup bottles, reclining armchairs, cardigan sweaters" [17]. How does the product behave and how is the user satisfactory level because of it? User experience is not something to design, but something to design for [17].

3.3 User Centered Design

In User-centered design (UCD), as the term suggests, the user is considered to be in the focus of all steps in design decisions and in the iterative design process. There are three phases building up the UCD process: design research, design, and design evaluation [19]. In the first phase, various methods are used, involving close connections with the users, to understand the context and their behavior and needs.

Further, the second phase, designing, is conducted with all new knowledge into consideration. The solutions are later evaluated in phase three against the users. These steps are conducted in an iterative process, depending on the possibility and prerequisites, to gain a higher level of user-satisfaction as a result [20].

Important to consider is that even though users have a huge influence on the process, they are not the ones taking the design decisions, thus, they are not to be asked directly about what they want [19]. As Nielsen [21] expressed it: "Users are not designers and designers are not users", which is why we need the close communication between the two parts to successfully design products and systems that are to be used.

3.4 Information Visualization

Information visualization has its roots in many fields, some being human-computer interaction, computer science, and cognitive science [22]. The term stands for turning raw data into comprehensible information that the receiver can make use of. It often comes in the form of plots and charts in which one can discover patterns and emergent properties that give valuable insight into the context [23]. It is important to have a clear goal with what story the visualization wants to tell, or in what way it aims to help the user make well-informed decisions. Characteristics such as positioning, colors, symbols among others, are considered. Allowing for interaction within a visualization means allowing for epistemic actions, which are explorative actions made to find more information [24]. A good visualization should support an overview and the actions of zooming in for details, zooming out and filtering [23].

Visualization of information can be divided into four stages:

1. Collection and storage of data.

2. Preprocessing data into something easier to manipulate.

3. Mapping from selected data to visual representation.

4. The human perceptual and cognitive system.

This project will focus on the third stage, by understanding the forth and know the limitations of the second.

3.4.1 Model of perceptual processing

The brain picks up some characteristics of visualizations more rapidly than others. The model of perceptual processing suggests three steps in which the perceived visual information flows. In the first step, *parallel processing*, a human picks up low-level properties of the information seen to build a first opinion or interpretation. What is perceived here is understood quickly by the user, such as the orientation of edges,

colors, texture, and movement patterns. The second stage is called *pattern perception*. Here, simple patterns are perceived by dividing the scene into regions based on characteristics. The third stage, *visual working memory*, is reached through active attention and allows the human to make use of other visualizations or knowledge from the past [23].

3.4.2 Gestalt Laws

The gestalt laws, first established by a group of Germans in the beginning of the 20^{th} century, are rules to describe how patterns are perceived in a visual scene. They have shown to be very useful when designing for information visualization. Ware [23] points to six important ones:

Proximity: Things that are close to each other are grouped together.

Similarity: Similar elements (in shape, color, and size) are grouped together.

Connectedness: Elements connected by lines are grouped together.

Continuity: It is easier to identify and construct visual entities out of visual elements that are continuous and smooth.

Symmetry: Symmetry is perceived as stronger than parallelity.

Closure: A closed contour is seen as an object. We tend to perceive shapes as closed and whole even though parts of it are hidden.

3.5 Interactive information visualization

Below are some chosen terms related to interactive information visualization that will be taken into consideration when designing solutions during this project.

Iconic, *working*, and *long-term memory* are three important types of memory to consider when creating interactive visualizations.

Iconic memory stores image-related information for a very short while, only for less than a second or until the information is placed somewhere else.

The visual working memory of a human is a crucial part of the cognitive system around a human-computer interaction. It stores the object that currently is given visual attention to. Mostly it holds a combination of information from the long-term memory that is related to the external visual information also present. Information on one fixation like color, position, shape, and texture can be stored here. Three to five objects are commonly seen as the limitation, depending on the visualization and context [23].

Long-term memory is as stated before not completely separated from the visual working memory. Information here is collected from the experiences we live through [23].

A *data glyph* is an object presented visually to represent one or several data variables. The design of the data glyph is important to consider for it to be stored in the visual working memory and interpreted in the intended way. A glyph can store several variables of data in one shape, e.g. by altering its length, color, width or direction. Compare this with non-integrated glyphs where one glyph only contains one attribute and the first version is more effective to store in the visual working memory [23].

Change blindness refers to the small capacity of the visual working memory and the consequences it brings. Generally, people do not notice changes made from one view to another if it is not paid attention to. Separating one view from another can, for example, be an eye blink, eye movement or blanking of the display [23].

The *gist* is another term connected to how we perceive information. It refers to the already known information of certain contexts. This is stored in the long-term memory and is a huge part of the information perceived when we view something. Only a small part is external information meaning that we mostly see the world as we already know it [23].

Inattentional blindness also has to do with perception and means that people generally do not see what they do not pay attention to [23]. Therefore, bringing attention to something is crucial for the user to perceive it. According to Jonides [25], there are two central ways to move a person's attention. Either with pull cues, an object pulls attention to itself, or with push cues, an object message the user to change attention target. Of these two versions, pull cues are considerably more effective.

Epistemic actions are actions made by the user to discover new information. The one requiring the least work is eye movement altering the focus of the user. Other examples are hovering with the mouse, clicking on links or zooming in/out. A complete change of information displayed means a high cognitive cost. This relationship between cognitive cost and information displayed needs to be considered when choosing epistemic action. Visual working memory capacity should also be considered [23].

3.6 Dual processing theory

In dual processing theory, two different modes of thinking are considered to operate in the mind. The psychiatrist and scientist in behavioral economics Daniel Kahneman is one of many to refer to these two modes as system 1 and system 2 [26]. Cognitive processing in system 1 (the automatic thinking) is instinctive and operates fast and unconsciously without requiring effort. System 1 is also associated with learned skills. A recurrent exposure of certain information makes it perceived

as “easy” and will hence appeal to the automatic mode of thinking. Cognitive processing in system 2 (the reflective thinking) is on the contrary slow, calculative, and deliberative. It requires more concentration as it makes decisions through a rational process [27, 16, 26]. The two systems work together to control the sum of our attention. But as we tend to go for the path requiring least effort, system 2 only kicks in when system 1 is not enough. While the automatic system can function on its own, the reflective system consistently receives supportive unconsciously processed information from the automatic. For example, breathing is usually done through the first system. But the activity can also be overtaken by the second system, if a certain breathing pattern is desired or if one wants to keep one's breath. Still, the first system is present with information, processed unconsciously, such as if the current holding of breath is working out fine or not [27].

3.7 Nudging in Human Computer Interaction

Nudging is a term first initiated by Tahler and Sunstein [6] by them described as *“any aspect of the choice architecture that alters people's behavior in a predictable way without forbidding any option or significantly changing their economic incentive”*. The words of Hausman and Welch [28] stating that nudges are *"ways of influencing choice"* suggests that an intentional aspect of affecting should be part a correct definition. In the context of HCI, it is now an applied technique in the form of ‘technology-mediated nudges’ often used to improve people's health, security or sustainable behavior [16]. To include nudges does not lead to loss of the free choice, but instead alters the probability for a human to make a certain decision. Thaler and Sunstein [6] also states that nudges should be used in the interest of improvement for individual citizens as well as that of society, which is considered to be an important position through this work.

3.7.1 Nudging in system 1 and system 2

Different types of nudges appeal more to one or the other system. Either they target the automatic processing (system 1), such as graphical warnings. They do not need to be reflected upon, but instead live of heuristics, mental shortcuts, that “enable us to substitute information that is unavailable, or hard to access, for a piece of readily available information that likely to yield accurate judgments” [16]. Or they aim to make use of deliberate processing (system 2), such as factual disclosures and statistical information that can broaden the grounds on which the individual makes a decision [29]. The second type can be considered to show greater respect for the individuals and their own ability to make good decisions, compared to nudges appealing to the automatic and undeliberate system that might go unnoticeable to the user. On the other hand, appealing to system 2 requires more demands on the individual in terms of time and attention. There are also studies that show nudges targeting system 1 may be more effective in altering people's behavior whereas nudges targeting system 2 are more likely to change beliefs but not necessarily behavior [30].

Even though decisions processed through system 1 are very quickly made, these are the situations where we mostly get it right. We know it by heart, so we get it right automatically. In other situations, the information being presented require us to give a decision serious thought and reasoning. These are the times where we make most mistakes. This is one reason why it is important to consider what kind of information is being presented, for what reason, and how this is done, when targeting system 2 [29]. It will affect the user's stock of knowledge, used to make a decision. Hence, we need to present the user with the right kind of information.

3.7.2 Four categories of Nudging

Sunstein and Thaler [6] distinguish nudges between the two modes of thinking; the automatic and the reflective. Hansen and Jespersen [27] go one step further and add another variable: the level of transparency, meaning if the user is able to perceive the intentions behind the nudge or not. They use the presence of transparency to argue for a nudge not being manipulative but instead serve an influential purpose towards the making of a good decision. Based on the two variables, four categories of nudges are created, as figure 3.1 shows:

Automatic - Transparent: Nudges that aim to influence behavior.
E.g. add a default option.

Automatic - Non-transparent: Nudges that aim to manipulate behavior.
E.g. rearrange the layout in a store for customers to buy a certain type of groceries.

Reflective - Transparent: Nudges that aim to influence the user's reflective thinking towards a choice.
E.g. present the user with certain information.

Reflective - Non-transparent: Nudges that aim to manipulate a choice.
E.g. rearrange the order of alternatives in a list.

Hansen and Jesperson [27] bring up the importance of designing and using nudges with responsibility and caution. Even if the choice or behavior is not forced on anyone, the nudge is created to take advantage of the user in a particular context studied for this particular reason.

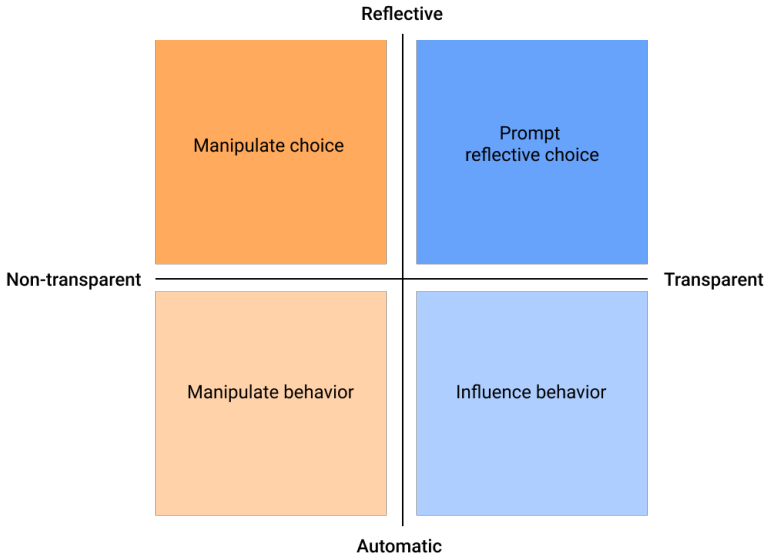

Figure 3.1: Grouping types of nudges along the transparency and reflective/automatic axes.

4

Methodology

This chapter presents several methods that are considered to be used during the execution of this masters' thesis project. They are categorized by the five phases in the design process presented below.

4.1 Design process

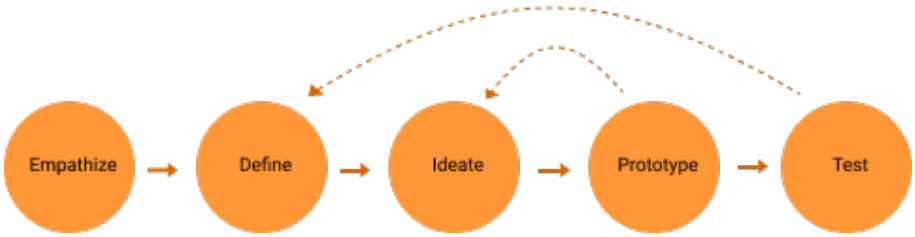

Figure 4.1: A simplified illustration of the 5-step design process.

There exist many different definitions of the design process, but all with a similar message and content. A well-established 5 step process, acknowledged by Dam and Siang [31] among others, will be the template used in this project. Although the model is presented in steps, it describes an iterative process meaning the designer can go back and rework steps in favor of finding a well-working solution. The five steps are; empathize, define, ideate, prototype, and test.

Empathize: Through user-research gain an empathetic understanding of the users and context of the project. The empathizer has to set aside their own preconceptions to truly be open-minded, develop empathy for the humans involved and let a correct picture of the stakeholders', especially the users, take form.

Define: Analyse and synthesize findings in the previous phase. Define the problem statement with the human in focus as well as the user-needs and product-requirements.

Ideate: Through ideation sessions generate as many ideas as possible on how to meet the problem stated in the define-phase. Let all ideas and thoughts come out with

the use of different ideation methods to help the creativity flow.

Prototype: By prototyping scaled-down versions of the product idea the designers can investigate how well it solves the stated problem. Inexpensive, fast lo-fi prototypes are used in the first prototype phase to quickly sort out what works and what does not work when compared to the needs and requirements.

Test: It is time to test and evaluate the best solution preferably with real users.

As stated before, the design process is iterative which means the result of the test phase usually leads to a re-definement of the needs and additional ideation sessions. Depending on the project limitations the iteration will take a different number of turns.

4.2 Empathize

4.2.1 Interview

To conduct interviews is a qualitative data collection method conducted with participants from the user group, with the aim to take note of the users' opinions, experiences, attitudes, and perceptions. The interviewee can also be an expert of a certain topic that one wants to understand better. In that case it is commonly called an *expert interview*. Interviews can either be carried out in person or remotely, the former being the one to favor since it allows for more full communication, hence, a better understanding [32]. An interview requires preparations in terms of knowing what information is to be collected. Depending on the type of interview; structured, semi-structured or unstructured, different levels of scripts have to be prepared.

A *structured interview* does not allow for deviation from the question scripts, which might prevent a flowing communication between the two parts. On the other hand, it is possible to conduct the exact same interview with several participants. The interview questions are more controlled, as is the result, which for this reason is less complex and easier to interpret. Structured interviews are appropriate when it might be extra important not to bias the participant [32].

An *unstructured interview* is not conducted in a strict way but contains open questions to follow the direction of the conversation. This is often more relaxed for the participant but requires a skilled interviewer to keep the interview from losing focus [32].

A *semi-structured interview* is a mix of the recently stated approaches, with both open and closed questions. A script is still used but from which it is allowed to deviate in favor of the flow of the interview and of the relevance of the collected data [17].

It is important to always consider who the interviewee is when preparing and con-

ducting an interview. Occupation, experience, and knowledge of the participant are typical factors that will affect, which might mean different script need to be prepared for different participants [32]. To document the output of the interview is helpful and necessary in order to remember and process it in retrospect. This can be done by note-taking or audio/video recording depending on the context and possibilities. If the interviewee will be recorded, she needs to be aware and asked for consent before the start of the recording [17]).

Sharp et. al. [17] argue that interviewing as a data-gathering method demands several things from the researchers:

- Be clear about why the interview is being conducted
- Let the participants talk and listen to them
- Try to make the participants be as comfortable as possible
- Never assume answers, instead, they must let the participants explaining exactly what they mean.
- Never ask the question in a way that can affect the participant, neither by formulation, voice or body language.
- Ask clear questions, if the question is too long or have multiple meanings, split them to multiple questions
- Ask questions in a way and with words that the participants understand

4.2.2 Competitive analysis

By conducting a competitive analysis, knowledge about products, services or companies in the market is collected. Their strengths and weaknesses are established in order to inspire or to make more informed decisions regarding the project in question. This method helps to understand the marketplace, to see what already exists (and how well it is working) as well as finding possible gaps that can be filled [33].

4.2.3 Triangulation

The purpose of using Triangulation is to get at least two different perspectives on what is being investigated to capture multiple dimensions of the subject [17]. Jupp [34] suggests four different types of triangulation:

Triangulation of data - data is collected at different times from different sources.

Investigator triangulation - collection and analysis of the data have been conducted by several different types of researchers (e.g. observers, interviewers).

Triangulation for theories - data has been interpreted through different theoretical frameworks.

Methodological triangulation - data has been collected using different appropriate methods. This is the most common type to use.

For it to be true triangulation the different approaches have to complement each other, giving something new to the table. In this way, it contributes to deeper insight and a more rich picture of the problem space [35].

4.3 Define

4.3.1 Content Analysis

Content analysis is a method used when organizing and understanding collected qualitative data. The most significant data findings are extracted, which could be e.g. a quote, an image, an observation. Depending on the content and meaning of this sample, it's coded with one or several suitable codes. The purpose of the code is to assign a property to the specific data, through one word or one short phrase [36].

The most common approach to this method is called inductive content analysis, which means to assign the collected data with codes while reading it through. An alternative approach is deductive content analysis. Here, codes and categories are established based on frameworks and literature before starting the analysis of the samples [32].

When the data has been coded it needs to be put in categories and subcategories to find patterns and general themes that can represent it. This can be done as an affinity diagram, through an iterative process changing categories and moving the code samples around seeing the findings from different point of views, thus understanding it as much as possible [32].

4.3.2 Kano analysis

Kano analysis is a method to establish the hierarchy between found product requirements. More features do not automatically mean better user experience which is why it needs to be decided which attributes are to be included for the best value. Applying Kano analysis means the found requirements are to be assigned to one of five categories [32];

Required attributes are the ones that must be included. They are the base requirements which presence is expected by the user, thus their absence will make the user highly dissatisfied most likely.

Desired attributes have a strong correlation with the satisfaction level of the users.

The presence of a desired attribute will increase the perceived value of the product and vice versa.

An *Exciter/Delighter* is an attribute that will surprise the user with its presence. It can only increase user-satisfaction but will most likely not have a negative effect if absent since the users will not know that they want them.

Neutral attributes are the attributes that will neither have a positive effect if present, nor negative effect if absent. The user feels indifferent towards them.

Anti-feature attributes are what should not be included. Their absence is instead desired by the user. Users might even want to pay extra not to have to deal with them (e.g. adds in a free version of an app).

To find the right category for the requirements one approach is to ask future users what they would feel about including/discluding each feature.

4.3.3 Scenarios

Scenarios are stories told with the user in the center, a sketch of use, describing a context and series of actions and events that lead to an outcome. They should entail user knowledge, motivations and other facts that are relevant for the design problem it should act as a guidance for [37]. Scenarios help designers to empathize with the user during ideation and to envision the future use of the product or service they aim to develop [32]. The use of scenarios also help designers when communicating with their stakeholders regarding functionality and usage possibilities [37].

4.3.4 User stories

User stories are built from gathered information about the users and the context they are active in. They are user-centered short scenarios that aim to capture the essence of the design problem and tell the story behind the user-requirements [38]. User stories help designers to empathize with the target users to allow for ideation on suitable and user-centered solutions. One user story needs to entail the user role (who), a desired task for this user (what), and the value the successful task leads to (why). It is often written with the structure below [39]:

As a [**user**] I want to [**task**] so that [**value**].

4.3.5 User story mapping

User story mapping is a method to visually structure the tasks a user goes through from beginning to end when using an interface. Usually sticky notes are used to contain each task, which are then structured from left to right in chronological order. Further, the mapping is structured with high level overall tasks in the top, also called the backbone of the map, which are then divided into subtasks below.

The method can provide a clearer view over the functionality and is usually used when planning implementations of functions and features in a system, especially for agile teams working to structure different releases [40]. In this project the method is used to specify what functionality to include in the resulting prototype.

4.4 Ideate

4.4.1 Brainstorming - Brainwriting and Brainsketching

Brainstorming is a traditional ideation method where the main rules are not to judge any ideas and to produce as many ideas as possible during a short period of time. Ideas feed new ideas which is why odd ideas tend to have positive effect on the creativity within the group [32]. Every session should preferably start from a problem statement. Brainsketching, also called brainwriting, is a version of brainstorming where each participant gets the same chance of contributing by developing ideas silently before they are brought up for group discussion [41]. Every participant has one piece of paper on which ideas are sketched during a few minutes. The papers will then rotate meaning that everyone will continue to develop someone else's ideas during the next few minutes. So it goes around usually for an entire lap, depending on group size or time restrictions. An advantage with brainsketching is that participants loose the feeling of ownership over their ideas, which can contribute to a more open and honest discussion later on [42].

4.4.2 "How might we"-questions

The "how might we" method lets the designer explore ideas in an organized matter with close consideration to the found insights and user-needs. A question should always start with these three words. Further it is important that it suggests several possible solutions to meet the insight or user-need. One way to build the questions is to formulate them based on a Point of View template (see Define section), which for each point takes three aspects in consideration; user, need, and insight [43].

4.4.3 Co-creation workshop

According to the Cambridge Dictionary the definition of a workshop is "a meeting of people to discuss and/or perform practical work in a subject or activity". The meaning is very broad as a workshop can have different aims, and be carried out in numerous ways. A workshop is good for working closer to the stakeholders. To have them feel more involved can increase their interest and excitement, hence be beneficial for the outcome. A co-creation workshop is when the designers invite stakeholders to join in on an ideation session [44]. It can be useful to invite different stakeholders to find solutions that work for everyone and to have the clients to understand what matters to the users. This method is highly time-effective since user-feedback will be direct and non-working ideas can be discarded faster. Conducting such a workshop requires a lot of preparation. A skilled facilitator has to be present to guide and give the workshop flow. To conduct a trial workshop is a

good idea for a non-experienced moderator to gain as much value as possible from the real one where the actual stakeholders are present.

4.4.3.1 Online workshop

A workshop can also be conducted online if the circumstances require it. This means a different environment and additional things to consider. The intentions and instructions of the workshop need to be even more clear to reach the participants through the screens. It is more difficult for the facilitator to pick up signs of misinterpretation or unsureness which is why full understanding from the participants needs to be confirmed before a task starts. Specific rules and codes of behavior, that in meetings in person are a natural part, might need to be established. The participants must feel comfortable with whatever tool is to be used. They might need additional time to play around with it or to conduct a practice task beforehand. Technical difficulties might become a big issue if not planned for. The necessity of working technology during an online workshop is obvious. A plan for how to deal with them is therefore required in order to have the best possible conditions for a successful workshop [45].

4.4.4 Focus group

Focus group is an attitudinal and qualitative method that can be used in different phases of the design process, with the aim to gain insights about themes or patterns. It is conducted by a skilled researcher who can moderate the group, containing of usually three to ten well-chosen participants. It is needed for the participants to view each other as peers and to eliminate the fear of being judged in order for natural conversations and true sharing to be present [32].

The skill level and behavior of the moderator is very critical using this method. The atmosphere of the session and the comfort of the group is highly dependent on this, which in turn affects the knowledge gained. Where the meeting takes place should be taken into consideration as well. The moderator should understand the effect this might have and have the skill to prohibit possible influences it might mean for the result [17].

4.4.5 Four categories method

The four categories-method is used when evaluating ideas or concepts. It makes participants compare the ideas as they categories them depending on potential and characteristics. The four categories to choose from are:

The most rational - Ideas that are most logical and useful.

The most delightful - Ideas that have best potential in providing the user with a high degree of pleasure and contentment.

The darling - The evaluator's favourite ideas.

The long shot - Ideas that involve a big risk but that also have the potential ability to provide great benefits with the right implementation.

Dividing the ideas into the different categories can be done in several ways. If the group of evaluators are small, choosing through discussion is possible. Otherwise, each evaluator can do their own categorization and later put it all together to reach a decision [46].

4.5 Prototype

4.5.1 Low-fidelity prototype

The fidelity of a prototype refers to the level of detail it includes and how close to a finished product it looks. It is important that the level of fidelity reflects how well-thought and validated the product actually is. Low-fidelity prototypes does not include look and feel. Instead it aims to communicate an intended design. The idea is to create inexpensive and fast first versions that still generate knowledge about working or non-working features. Paper-prototyping, such as sketching wire-frames, is the very basic version of lo-fi prototypes. As such, they still have "the highest potential ratio of value in user experience gained per unit of effort expended"[47].

4.5.2 Medium-fidelity prototype

Medium-fidelity prototypes are in the step between low and high-fidelity just as the term suggests. It can be suitable when more detail than low-fidelity is needed but project limitations, e.g. the time frame, makes a high-fidelity prototype not possible [47].

4.5.3 High-fidelity prototype

High-fidelity prototypes are suitable further in the process, when the look and feel and interaction design should be tested and evaluation of a version close to the real product is in place. The realistic look of it makes it more time consuming to create, hence, more expensive. Still it is worth to evaluate this kind of prototype before start programming for real [47].

4.6 Test

4.6.1 Usability testing

Usability testing is an empirical evaluation method to find flaws in an interface in order to improve its usability. A test is consisting of several specific tasks that the participant is to take on, one by one, preferably with a background scenario for an improved context perception and to provide additional information needed. It is important that the tasks and scenarios are written in such a way which does not

simplify the execution or suggests ways to solve the assignments [32]. The evaluator present should be involved as little as possible to not risk influencing the test.

According to Martin and Hanington [32] things to consider when observing the test are; time consumed, different approaches used to solve a task, to what extent a task or goal is understood, to what extent a task is solved, feelings expressed by the participant and stated opinions or suggestions made regarding the interface. As a conductor of the test, it is critical to make sure the participant understands that the interface is the what is being evaluated and not the participant herself. The test environment must support this fact in order for the participant to feel as calm and comfortable as possible.

4.6.2 Think aloud protocol

This technique is used while a test-user is solving a task involving an interface and requires her to share her thought process with the evaluator. The participant should say as much as possible about what she is doing, thinking or feeling to reveal opinions about the interface as well as what aspects that might delight, confuse or frustrate users. The findings collected from this method is used to improve the interface.

The most common way to carry out the method is by concurrent think-aloud. This means that the participant will 'think out loud' while conducting different tasks. Since this is an unnatural situation for most participants, it might be needed from the evaluator to remind the participant to keep talking out loud from time to time. The other way of conducting the method is called retrospective think-aloud, which means the participant is first asked to solve the tasks in silence while being video recorded. Afterward, when watching the video, she is asked to comment on her way of solving it and to share her thoughts and feelings that emerged during the test. This second approach allows the participant to have extra time to reflect, together with an additional point of view, which might give different insights [32].

4.6.3 Expert review

An expert review is a kind of usability inspection method where a reviewer with knowledge about UX inspects a system to reveal possible usability flaws and design problems. Through this method, helpful pointers from a fresh and unbiased mind with a little to no emotional connection to the system can improve the present version of the UI. This method can both be more rapid and less costly compared to usability testing with real users. It can also be a good choice of method when real users are not available. Although, since the takeouts from expert reviews and usability testing will differ, it is beneficial to conduct both [48].

One way of conducting an expert review is through a cognitive walkthrough. It contains a series of tasks for the representative user to go through initiated with necessary description regarding the scenario. Several action-steps are put together to build up one task. For each action, the evaluator should answer four questions

regarding the user's behavior and understanding of the system. These four questions can be formulated as follows [32]:

- Will the user be trying to achieve whatever affect the action has?
- Will the user see that the right action is available?
- Will the user associate the correct action with the effect she is trying to achieve?
- After the correct action is taken, will the user understand that progress is being made towards the desired solution?

4.7 Online Collaboration Tools

Below listed tools are the ones to be used during the project:

Metroretro: A simple tool for online post-it boards, to use for activities such as affinity diagrams. It allows for a flexible and sustainable way to organize findings.

Miro: The tool to use for online work boards, allowing for remote cooperation and making it well suitable for online co-creation workshops.

Figma: A well known online tool for designing and prototyping wireframes. This is the main tool in which the projects prototype will take form and in which the tests will be conducted.

Zoom: A video conferencing tool with e.g. a screen sharing function which makes it well suitable for online interviews and workshops.

5

Ethics

Using nudges when designing digital interfaces is an attempt to change behavior or attitudes. According to Caraban et al. [16], there are different types of nudges that differ in transparent-degree and if they are more likely to be picked up by the automatic mind or the reflective mind. The type of nudges that raise most ethical questions are the ones with a non-transparent motive and are most likely to be picked up unconsciously by the user. They aim to change behavior through manipulate behavior. Even though nudging is used to promote behavior that is better for the human, dealing with manipulation can be critical. An important part of nudging is to maintain freedom of choice, which if present, reduces the ethical issue.

Designing an interface to lift data visualizations comes with the responsibility regarding how the information is perceived. The perception effects the knowledge gained from the information, which in turn effects the decisions made from it. Delivering truthful unbiased information is of importance. In this context, influencing organizational decisions to decrease their carbon footprint, the result of the decisions does not only have the power to affect the organizations, but the entire society and the health of our world.

Furthermore, ethical considerations regarding the participants giving input to the study were made. The participants were informed of how their contribution was to be used, asked to fill in an consent form when recording was necessary, as well as informed that they had the right to abort an ongoing process at any time. The recordings made was stored offline, only accessible to the author of this thesis. All gathered data has been kept within the use of this project and not shared to any external parts.

6

Preparation and Planning

This project was conducted according to the five-step design process presented in the methodology chapter; empathize, define, ideate, prototype, and test. The thesis work was conducted through a user-centered approach, meaning that the future users was considered through the entire process.

Before beginning the information collection, preparation was needed. Research around what theory and methodology to include and built the project upon was made. Through meetings with the company, Svalna, and the institution supervisor expectations from both parts were communicated as they need to be included in the project scope. From the institution's point of view, the master's thesis needs to contribute to something new in the theory in the context of interaction design. This matter was indeed informed to Svalna initially in order to keep everyone in the light of what will be included in the project. A lot of thought behind the research questions has been put with guidance from the supervisor. To have a clear research question and to be sure of the deliverables is of great importance in order to know how to approach the methods and what to look for when analyzing the findings. It also makes the level of success possible to evaluate.

6.1 Time plan

The project began in late February 2020. In total, 20 weeks of full-time work was spent on the project. This time was distributed among the five phases of the design process and their connected tasks, which was illustrated in the time plan seen below in figure 6.1.

Documentation was be made throughout the entire project to keep the weight of report writing from being heavy by the end and to help remembering steps and decisions along the way. By the end of the 20 weeks, a presentation of the project was be held and an opposition of the report and presentation of peers was made.

The time plan was altered along with the execution of the project due to uprising situations unknown from the start.

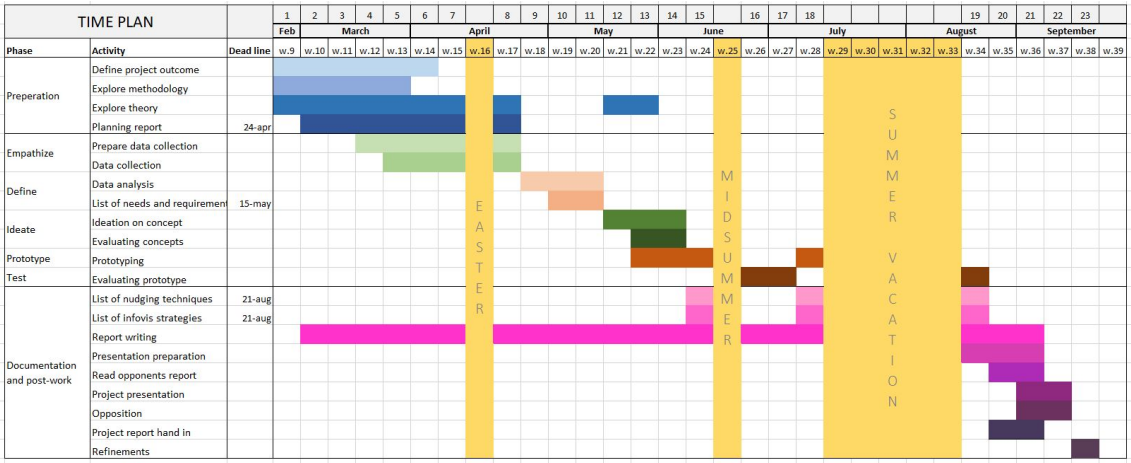

Figure 6.1: The time plan of the project visualized in a Gantt chart.

6.2 Limitations due to Covid-19

Due to the pandemic situation and the restrictions that followed, all activities within this project had to be planned to occur remotely. Interviews, workshops and check-in calls with supervisors, all were conducted via different tools online. Tools not used before were needed to be learned, and everything that comes with talking to people via a screen instead of in person was needed to be considered throughout the project. There was an uncertainty regarding how the virus was to develop over the time period of the project and thus also regarding to what extent it was to effect the project process.

7

Execution and Process

This chapter includes description of the entire project process and how it was conducted.

7.1 User research

The empathizing phase started with interviews with 3 people from 3 different universities. The interviewees had roles like sustainability strategist and environmental and sustainability coordinator. They all worked on a central organizational level with a huge impact on goals and strategies regarding the universities' sustainability work. These three are the same type of users and will later be referred to as User 1. The three interviewees had been in contact with Svalna during pre-study and had all expressed their interest in the digital tool, called the *Carbon intelligence system* (CI-system), that Svalna aimed to develop. They were glad to help out and have the opportunity to influence the outcome. Their enthusiasm and prior knowledge about the aim of the tool made the three of them a suitable group to research. Interviewing future users from different HEIs serves the purpose of collecting information widely to gain broad knowledge in the context of a solution suitable to as many as possible.

Before each interview, online research on the organization's website was made to gain prior knowledge about their official environmental work, helpful for the understanding of the context and information exchange during the interview. Official goals, strategic plans, frameworks they follow, and other connected documentation regarding their daily environmental work and decision-making within the context was read through. Each interview had the same general aim; To understand how the organization's environmental and sustainability work function today, how the decisions regarding this are made, and what information is needed to take a certain decision. Questions about possible tools they already use, regarding communication or analysis were asked as well. The goal of the research was to understand the user's needs and role in the context and use gathered information to create requirements for the CI-system. Since users from different organizations were asked, the script was altered a bit between interviews to fit the role and context of the interviewee. One of the used scripts can be found in Appendix A (in Swedish).

7.2 Exploring of existing solutions

Other data visualizing tools, such as business intelligence systems, were explored to gather inspiration useful to the system in development. Research regarding existing GHG emission visualizations was also made. The systems and visualizations chosen to be explored were found through prior recognition, recommendations from others, and through a google search.

The BI-tool from NTNU, described in section 2.4, was especially analyzed since it has been one of the triggers for this project. An interview with the researcher and designer behind it was held with the aim to gain information about the development of the tool, the effects of its use, and general feedback on it.

7.3 Analysis of data

The collected data was analyzed using inductive content analysis in order to find patterns and be able to navigate in the sea of possible knowledge. Data from the three interviews were made into codes which then were arranged in one affinity diagram. Categorization and ordering of the pieces needed numerous iterations to mediate the hidden knowledge. The structure in the final version of the affinity diagram was built up by three main parts considering if the finding was on an organizational, user, or tool-level. In each part, there were more narrow categories that in some cases were split between to parts. The affinity diagram helped to gain a clear overview and to understand the relationships between the findings. The categories used are listed below.

Organization:

- Communication
- Decision-making
- Governing documents (fixed from external sources)
- Governing documents (updated periodically)
- Differences between organizations

Organization/User:

- External influence

User:

- User type 1

- User type 2

User/Tool:

- Motivation
- Cooperation and inspiration

Tool:

- What to include
- How to include
- Why include

From analyzing the data it was clear that there was another type of user as well (Seen as user 2). This user played a big part in the decision-making process and should therefore be taken into consideration when designing the system. The user is working on a local organizational level, partially being in charge of the environmental and sustainability work at the institutions with the title *environmental representative*. With this understanding, two more interviews were held, this time with users working on a local level. Interviewing these newly found users, was not just going to give more information, but would also work as a validation of the information already gathered based on a different view within the organization. The two interviewees worked on the same Gothenburg located university but were representing different institutions. The contacts were given from one of the first interviewees. Important takeaways from the interviews were included in the affinity diagram and are developed further in next section.

Data gathered from exploring existing solutions were analyzed and collected within a second affinity diagram, kept separate from the first one in order to keep track of what information that had the future users as a source. Information such as functions, features, navigation, types of visualizations, and their content was seen as inspirational became part of the diagram. It was after several iterations of categorization organized into below categories:

- Filtering
- Ways to interact
- Animations
- What do display in the context of emission
- Forecast visualizations

- What to display - features
- Types of visuals
- Highlights
- Communicate
- Building up the tool/foundations
- Emission categories
- Types of values

7.3.1 Takeaways from interviews

Below follows a description of the most important findings from the in total 5 interviews made. The completed citations included are translated from swedish and marked with a letter and number which describe who it is from. Each of the five interviewees have their own letter-number combination:
E1, E2 and E3: Environmental strategists
R1 and R2: Institutional Environmental Representative

One important and significant insight from the interviews was that a lot of the environmental work is happening out on the institutions and not just on a central level. Every institution has an environmental representative who decides on a local action plan and makes sure that the local sustainability work is followed by checking of one action after another on the *list of actions* (sometimes called *list of activities*). The list of actions is built from overall goals set for the entire HEI, but is describing actions set on institutional level. Actions that are proposed by the strategists (on a central level) need to be synchronized with the environmental representatives of the institutions since they are the ones actually carrying through the work.

> “ Actions can be made on an institutional level. In that way, if one institution wants to go ahead (with stricture measures), they can. This will also allow for comparison between institutions and those who do well can receive positive feedback if their hard work will be shown to others. - E1

> “ It is a difference between the institutions regarding which aspects of sustainability apply to them. For example, some handle a lot of chemicals and others do not.“ -E1

The institutional representatives usually only work part time with this environmental focused role. They expressed their fear of having to do more work on the limited time available. There is a present frustration at institutional level. They feel that they should do more, but do not know if anything more can be done. Some find

the list of actions unexciting and insufficient. They can not know for sure if employees at the institution are following the set rules or recommendations and have no way of knowing if the actions have led to any change in the emission levels. One representative expressed his/her frustration regarding this:

> “ One activity on the list can be to inform the employees about something at a staff meeting (...) I give them the information and that is that. Maybe three listened actively, I can not know, but at least I have said it. Check on that. So... what now?” -R1

> “ It would be fun if we could do more (...) I want to feel the changes more (...) It is a bit sad that there is nothing more to it." -R1

They know via informal ways some exciting differences in the environmental work between institutions. And it has happened that they look for inspiration from each other:

> “ I know they are doing a good job (...) I thought maybe I could look on their list of actions and copy them a bit. “ -R1

In other cases they work more closely together with other institutions and have good communication with the head of the faculty, who collects info from all underlying institutions. Although, the representatives still feel that they lack continuous feedback regarding how the institution's environmental work is going. The feedback is solely on an organizational level.

The engagement level for some goes up and down as well as it seems to be on different levels at the institutions.

> “ One goes to an info meeting (with all the representatives and environmental strategists) and gets excited but then it fades away because it gets quiet.” -R1

> “ It is remarkable to see the development (...) slowly, slowly, the environmental questions are getting highest priority.” -R2

The HEI's have several governing documents regarding their environmental work. These include e.g. internal plans of action, agreements between organizations (Climate framework or the UN's sustainable letter), national laws, and global sustainability requirements. As a public authority, some HEIs have additional requirements such as the need to report certain figures to the Swedish Environmental Protection Agency (Naturvårdsverket) every year. Every institution usually has its own list of actions they plan to take to reach the common goals. All decisions and governing documents need to be approved by the HEI's board, including the principal as she/he is the one formally taking all decisions. Communication of environmental decisions goes up and down between the hierarchy levels of the organizations; through

the head of institutions, the head of the faculties, the environmental strategists at a central level, the board and the principal, as well as to external parts such as media or Naturvårdsverket.

> “Some things we only measure due to that we are obligated to report to Naturvårdsverket once every year.” -E1

> “Every year when we have compiled the collection of data, we have a meeting with the principal where we tell the results. Formally, it is he/she who approves the report(...) Almost all decisions are made by the principal.” -E2

> “The actions are synchronized together with those who will push them through later on a more local level.” -E2

> “The institution is the primary unit where things happen (...) so the total amount of emissions for the university must also be able to be aggregated at the institutional level. So that each head of institution has control over his/her emissions and can make decisions accordingly.” -E2

The signing on to agreements such as the Climate framework and UN's emergency letter has put the HEI's in a more demanding situation. This is pointing to the need for a system helping them to find where those measures can make the most difference.

> “Before, it (the goal) only said that we should reduce (level of emission) compared to the base year 2015, which is an easier thing to achieve, but thanks to the Climate Framework, we will now have to reduce by 6%.” -E2

> “A good year, the environmental management system has given us an improvement of 1%. With the climate framework, the measures need to be 6 times harder.” -E2

The way they gather data today differs between the HEIs but in common is that it takes time, and a lot of the work is done manually.

> “(To gather all data) It is extremely unauthorized. It is an enormous amount of imposition and takes a lot of time. Also, there is uncertainty, since I have my way of doing it while someone else would make other assumptions. It is depending on the person collecting the information.” -E2

The most accurate emission data gathered by the universities today are from business travels, from travel agencies. But to be able to call themselves Climate-neutral in the future or to show that they are in line with the Climate framework agreement, they need to have indications on their emission contributions in all categories. It

is not enough to take actions, check them off with the hope that they have made a difference. They also need to know that they have made a difference and receive an indication of how big this difference is. In order for the users to understand this, the presentation of the data needs to be distributed between different organizational levels and on material level, which all interviewees agreed upon.

> “We want to know what carbon dioxide load each laptop, chair, piston in the chemistry laboratory, is associated with.” - E2

> “The smaller categories (on material level) one has, the easier it is for us to find suitable actions to affect them.” -E1

> “To see the emission distributed between departments is very interesting since we are a decentralized organization. It would help the institutions’ a lot when making plans and setting new goals.” -E1

It is also of importance to have the incoming data updated fairly often for the decisions to be taken in time to reach set goals. If one only can see the result once per year, the environmental work is too slow.

> “I hope that this (gathering and presentation of data in the new tool) can happen quite automatically and above all continuously... If not in real-time then monthly or in the worst case quarterly. So that those who make purchasing decisions out in the organization can know how good or bad we are doing.” -E2

> “What if the economists only knew once a year how we were doing in terms of results, no one would accept that.” -E2

> “I want the ones responsible to see (their emissions) along the way, not just ones a year (...) I do not want just a report once a year.“ - E3

Sometimes external factors affect the emission levels heavily, aspects that can not be planned for or helped by the HEI’s. One such factor is the Covid-19 situation.

> “External factors, as the Corona situation, can help us achieve this.” -E2

Comparison between institutions or even between organizations that are similar to each other is seen as possible help to improve the motivation and give inspiration on how to act. Everyone is faced with the same problem and thus, could benefit from helping each other.

> “The board loves to be able to compare us to other similar universities, so we can see if we are better than them.” -E1

“ If one were able to compare institutions at different universities, I think that would be interesting as well. It might lead to increased creativity regarding proposed actions.” -E1

The interviewees also expressed their expectations on the tool to possibly give hypothetical indications on the emission contribution of certain operational actions. If they could see in beforehand the approximate effect an action could have on the total level of emission, it could help them make decisions. The economical costs are interesting for the board when it comes to making decisions regarding operational actions, and it would therefore be beneficial to include expectations of this nature as well.

“ It would be good to see, hypothetical, what effect different actions could have, together with an (economical) cost. This could work as a part of the basis of a decision (regarding the implementation of actions). One year later, we can look back and compare to how it actually went” -E2

“ It is important to measure the emissions but even more important to take actions, We can keep improving our measure methods but sometimes we have to call good enough and start making changes to reduce the emissions” -E1

“ We don’t want to just check off, check off. We want a way to be able to show: ‘Look here! This particular effort has paid off!’ ” -E3

Transparency of the underlying estimations made are important for the users to get access to. They need to be able to trust and understand the data in order to use it in their operational activities.

“ When working with scientists (..) I always need to be able to verify how I have reached my conclusions.” -E3

Overall the interviewees see big potential in a system like the one developed. Additional ways of measuring emission levels are needed to meet the new goals. The current ones are just not sufficient enough.

“ Such a system could sort out once and for all how much emissions the various parts contribute with.” -E2

“ Thanks to the fact that we have a blunt indicator, we have improved every year. Not because we emit less but because we have more employees.” -E2

“ I want a system that I can trust and that covers a larger part of the emissions.” - E3

7.4 Iteration one

7.4.1 Defining: User types

Clear definitions of the two found user types were written to support further work. User type 1, environmental strategists, is seen as the first user of the tool and is therefore in focus throughout the project. Findings regarding user type 2, institutional environmental representatives, are mostly based on the interviews held with users from this group but completed with information gathered from user type 1. They, as positioned higher in the organizational hierarchy, still have valuable knowledge regarding what they need from the institutional environmental representatives.

User type 1:
Environmental strategists (or similar role) working at higher education institutions with the overall responsibility for environmental and sustainability work. Assignments such as creating plans of action, setting goals, and continuously tracking as much as possible of the HEI's climate development. Their overall goal is to reduce negative and rise positive climate impacts from the HEI. This user communicates up to the principal and the board who always have the last saying and are officially the ones making the final decisions. The user also communicates down to representatives on faculty and institutional levels. Goals and expectations are shared via a meeting with all representatives and strategists 1-2 times per year. Sporadic communication is made with the faculty dean (or similar role within climate issues) as the man in the middle.

User type 2:
Institutional environmental representatives are in charge of the environmental work within the institution. They are usually free to make decisions regarding their local actions in order to work towards the general goals. They are required to update their action list each year and report how well the actions were executed. This user usually only has a percentage of full time set to climate work, thus, has other main tasks. This user communicates up in hierarchy via the faculty dean or through meetings with strategists and all institutional representatives.

7.4.2 Defining: Scenarios - first versions

Two scenarios, one with each user type in the centre, was written based on the previous gathered data to capture the design problem.

Scenario for User 1, the environmental strategist
E is an environmental strategist at a higher education institute in Sweden. She spends most of her working days collecting statistics regarding the organisation's carbon dioxide equivalent emissions, constantly looking for room for improvements to decrease their negative contribution of greenhouse gases into the atmosphere. The collection of data is made manually from numerous contractor or supplier systems, which is very time demanding. Far from all of their suppliers have systems from

which this kind of data can be fetched, meaning there is a big void in the resulting data. E is constantly trying to find new and better ways to measure the level of emission operational activities lead to.

Every year, E and her team update the organization's sustainability action plan, which entails the goals for the following year and how to reach them. This is mainly based on the narrow data that has been collected. Further, the team needs to pitch the plan to the HEI's board (including the principle), and sometimes argue hard to make their plan go through.

The principle of HEI has recently signed a document saying that the organization should cut their level of GHG emissions in half in ten years, meaning an approximate decrease of 6% each year. This puts E in a hard position as she currently does not have a way of estimating the total emissions of the organization.

Scenario for User 2, the institutional environmental representative
R works at the same HEI as E, within the institution of philosophy as an institutional environmental representative for the sustainability work. He has recently become a vegetarian and believes the sustainability work needs to be taken seriously. R is mainly a scientist and professor at the institution and has only a couple of hours a week set aside for the role as an environmental representative. His main responsibility as this role is to attend meetings with the strategists, update the institutional action plan, and make sure his colleagues and the students follow the plan and other rules regarding sustainability within the institution. R's engagement goes up and down. After the big meetings with the strategists he feels excited to contribute but soon he finds himself lost in his regular work tasks again. He does not feel up to date with the overall organizational sustainability work and there is no way of knowing if his work within the institution is making a difference. R feels uninspired and without knowledge to be innovative in his action plan.

7.4.3 Defining: Needs and requirements

Based on the affinity diagram containing data gathered from the interviews, user needs were listed with a clear connection to statements and findings from the interviews. Furthermore, the required functions and types of visualizations to meet these needs were added to the list, which helped to formulate clear requirements for the tool. The list of requirements was then prioritized according to the Kano analysis-method (4.3.2), between required attributes, desired attributes, exciter/delighter, neutral attributes, and anti-featured attributes. This was initially done based on the gained understanding so far, taking the users and the vision of Svalna into consideration. This first version of requirements was then validated with future users from the HEIs.

7.4.3.1 Validation of requirements

Validation was held with two users of the user type 1 from two different universities. Three users were asked via email if they were willing to help in this step

but one was unfortunately not available. The three users were the same as used in the first interviews, meaning the contact was already initiated. They had all expressed their consent to further be contacted regarding the project. Each validation session was conducted in two steps. First, an individual categorization was done by the user herself, unbiased by the existing categorization. Second, a talk where thoughts regarding the categorization were conveyed and discussed. The first step was conducted through the online workshop tool Miro, where the user was presented with a board (figure 7.1) with all requirements on post-it notes, in a random order, together with five empty squares, each representing one category from the Kano-method. Instructions on how to carry out the task and how to think regarding the different categories initiated the board. The user was also allowed to add their own requirements on different colored post-it notes to make sure any lost requirements were captured. The user had several days to finish the task and was encouraged to take help from colleagues. The second step was done through a one on one video call with the user.

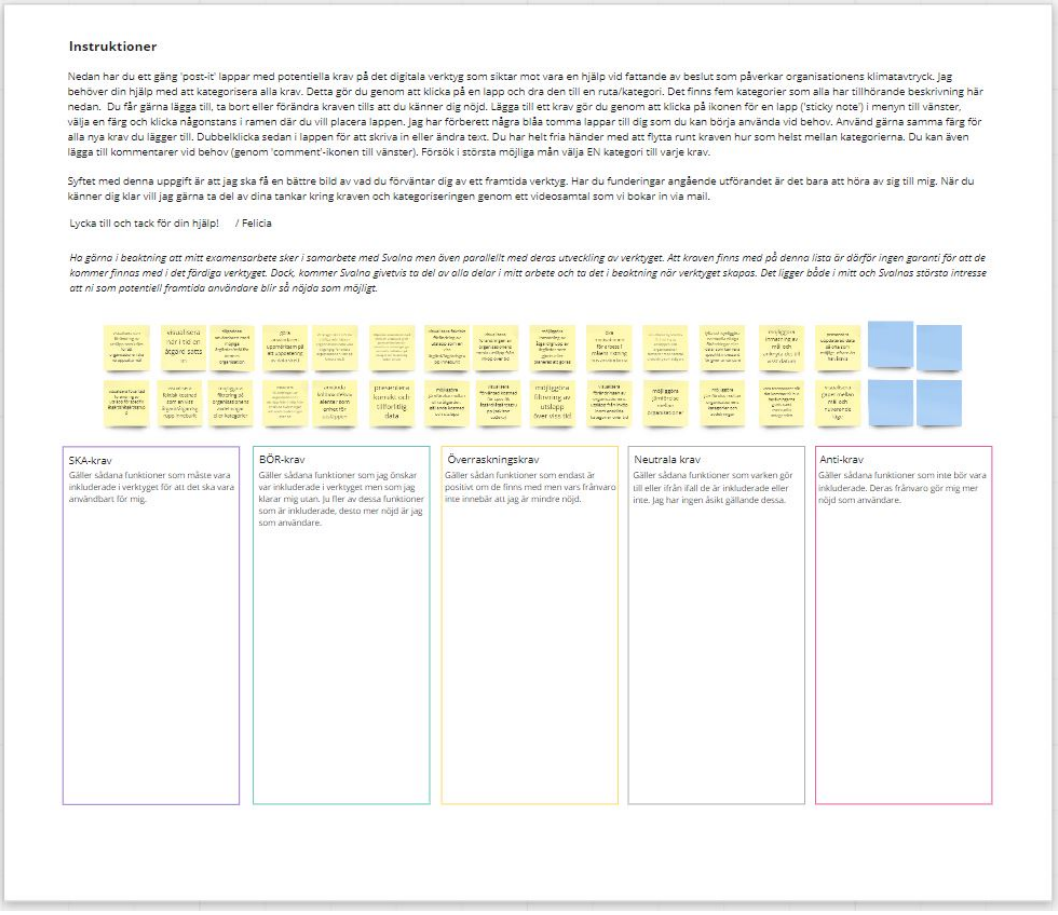

Figure 7.1: Template, made in Miro, used for remote validation of the requirements.

After the validation, the list of requirements was updated according to the user's reasoning, with room for compromise. The users had different expectations on the tool which made the updated version a result of weighing some requirements between

the different categories chosen by the users. Their different expectations on the tool were probably a result of them being introduced to the underlying idea in different ways and in different states of the pre-study during prior contact with Svalna. The vision of Svalna regarding the extent of the tool was also taken into consideration when updating the list.

7.4.3.2 List of requirements - updated version

Required attributes are the ones that must be included. They are the base requirements which presence is expected by the user, thus their absence will make the user highly dissatisfied most likely.

The tool will...

- 1.1 Visualize the total change in emission caused by the organization's purchase.
- 1.2 Visualize the change in emission caused by purchase divided on categories (based on the division possible based on the incoming invoices).
- 1.3 Visualize the change in emission caused by purchase divided on departments and sub-departments of the organization.
- 1.4 Visualize the change in emission that is necessary for the organization to reach set goals.
- 1.5 Visualize estimated change in emission if the organization continues in the same direction as before.
- 1.6 Enable data filtration on the organization's departments and emission categories.
- 1.7 Enable data filtration over different time intervals.
- 1.8 Enable comparison between departments and emission categories within one's organization.
- 1.9 Enable comparison between operational actions regarding their cost and emission contribution.
- 1.10 Update data as often as possible. More often than twice every year.
- 1.11 Use carbon dioxide equivalents (CO2e) as the unit for emissions.
- 1.12 Enable input of customized emission goal(s).
- 1.13 Enable input of operational actions that have been made, planned to be

made, as well as visualize when in time these actions were committed to.

- 1.14 Present correct and trustworthy data.

Desired attributes have a strong correlation with the satisfaction level of the users. The presence of the desired attribute will increase the perceived value of the product and vice versa.

The tool should...

- 2.1 Visualize estimated total cost and cost in SEK/CO2e for a specific operational action/group of actions.
- 2.2 Visualize actual total cost and cost in SEK/CO2e for a specific operational action/group of actions.
- 2.3 Visualize estimated change in emission due to a specific operational action/group of actions.
- 2.4 Visualize actual change in emission due to a specific operational action/group of actions.
- 2.5 Enable comparison between one's organization and other organizations.
- 2.6 Make possible important and interesting changes or parts of the data more salient and visible for the targeted user.
- 2.7 Present examples of operational actions or goals according to the potential of the user's organization or department.
- 2.8 Present at least one view with customized visualizations that gives a quick indication of the status of the organization/department and the development since the last update of the data was made.
- 2.9 Make the user aware that the data has been updated.
- 2.10 Enable export of the visualizations.
- 2.11 Enable accounts that differ in permission regarding available information and entry of actions and goals.
- 2.12 Be transparent regarding the method behind the estimations and regarding possible assumptions made.
- 2.13 Be a secure platform where invoice data cannot be retrieved via intrusion.

An **Exciter/Delighter** is an attribute that will surprise the user with its presence. It can only increase user-satisfaction but will most likely not have a negative effect if absent since the users will not know that they want them.

The tool might...

- 3.1 Contribute to increased motivation for users to work in the direction of their goals.
- 3.2 Enable certain users to collect all the actions taken together with data on its potential impact.
- 3.3 Enable the entry of goals for such operational activity, that is not directly linked to purchasing or carbon dioxide emissions, with the aim for the tool to be a single platform containing all the user's environmental goals.

7.4.3.3 Summary of changes made to the list of requirements

After validation, some attributes were considered to be more or less important than before validation. Some new attributes were found and added and some were just formulated differently and more accurately.

Listed below are the attributes that were considered to be more important and therefore upgraded to higher prioritization.

From *Exciter/Delighter* to *Desired attributes*:

- 2.1 Visualize estimated total cost and cost in SEK/CO2e for a specific operational action/group of actions.
- 2.3 Visualize estimated change in emission due to a specific operational action/group of actions.
- 2.7 Present examples of operational actions or goals according to the potential of the user's organization or department.
- 2.9 Make the user aware that the data has been updated.

From *Desired attributes* to *Required attributes*:

- 1.4 Visualize the change in emission that is necessary for the organization to reach set goals.
- 1.5 Visualize estimated change in emission if the organization continues in the same direction as before.
- 1.9 Enable comparison between operational actions regarding their cost and

emission contribution.

- 1.12 Enable input of customized emission goal(s).

- 1.13 Enable input of operational actions that have been made, planned to be made, as well as visualize when in time these actions were committed to.

Listed below are the attributes that were considered to be less important and therefore degraded to lower prioritization.

From *Required attributes* to *Desired attributes*:

- 2.6 Make possible important and interesting changes or parts of the data more salient and visible for the targeted user.

From *Required attributes* to *Exciter/Delighter*:

- 3.1 Contribute to increased motivation for users to work in the direction of their goals.

Listed below are the attributes that were not a part of the version before validation but added in cooperation with the users during the validation sessions.

Added to *Desired attributes*:

- 2.10 Enable export of the visualizations.

- 2.11 Enable accounts that differ in permission regarding available information and entry of actions and goals.

- 2.13 Be a secure platform where invoice data cannot be retrieved via intrusion.

Added to *Exciter/Delighter*:

- 3.2 Enable certain users to collect all the actions taken together with data on its potential impact.

- 3.3 Enable the entry of goals for such operational activity, that is not directly linked to purchasing or carbon dioxide emissions, with the aim for the tool to be a single platform containing all the user's environmental goals.

In general, many points were considered more important after validation. No attributes were put in the categories of *Neutral attributes* or *Anti-featured attributes*. The reason for this is believed to be that the attributes included in the first version and presented during validation were all produced with the thought of being valuable, not considered to fit into these last categories. Another possible reason is

that if as a user, you get presented with possible attributes to include, you probably want as much as you can get and will most likely see any attribute as at least an *Exciter/Delighter* instead of a *Neutral attribute*. It can also be hard to name attributes you don't want but that still has a valuable reason why they are listed as *anti-featured attributes*.

7.4.4 Defining: Three purposes

After having refined the list of requirements, the purpose of the tool could be defined into three parts with some possible overlap. Short definitions of the parts were created before ideation was initiated within one part at a time. Below are those definitions with additional thoughts.

Presenting current status of the Organization: Containing chosen visualizations to show on the organization's current emission budget status and their way towards their goal.

Should include visuals on emission distribution between institutions/faculties within the organization and between emission categories, averages on emissions and cost in SEK/kg CO2e for each category and division, and forecasts presenting future curves if the organization continues in the same way compared to what they aim for.

Enable exploration of possible possible operational actions: Allowing for an organization or a division of an organization to experiment with possible future actions and see what hypothetical effect these would have on emission and cost.

If several actions are explored, the total effect of these should be shown as well. It should be possible to filter these on emission categories.

Comparing us to other organizations: Allowing for an organization to compare themselves and their level of emissions to other similar organizations, to get inspired and triggered to work for change.

Filtering on organizations and categories should be possible. Visuals could be examples of good or bad changes in the development of different organizations or divisions of these organizations. To be labeled as a good or bad example could work as a motivational factor. Visuals and numbers on how all organizations contribute together, increasing the feeling of teamwork between them. On the other hand, a leader board could raise the feeling of competition between them and work as a motivational trigger. In every visualization, related data from the user's organization should be shown for easy comparison.

7.4.5 Ideation: "How might we..." and brainwriting

Ideation was initially made through several *How might we*-questions. With each question as a starting point, numerous sketches were made, using brainwriting and the crazy eight method. Some of the How might we questions used were:

How Might We...

- ...compare emissions between different divisions and categories?
- ...present the level of emissions?
- ...show the user where in the organization best potential for change (additional/different actions or goals) lies?
- ...make the user understand if/if not, why/why not they seem to reach their goal?
- ...make the user understand what changes a particular action can contribute to for the organization?
- ...rise motivation of the user?

Further, ideation on how different building blocks in the interface could be connected and positioned was made (figures 7.2 and 7.3). Possibly required panels, windows, and menus were cut out from paper and moved around in relation to each other to explore variation. One big focus here was to make sure to keep the entire tool as a whole, trying to reuse the composition of windows in all parts of the tool. To test size and position more realistically, grey box-wireframes was created in Figma (figures 7.4 and 7.5).

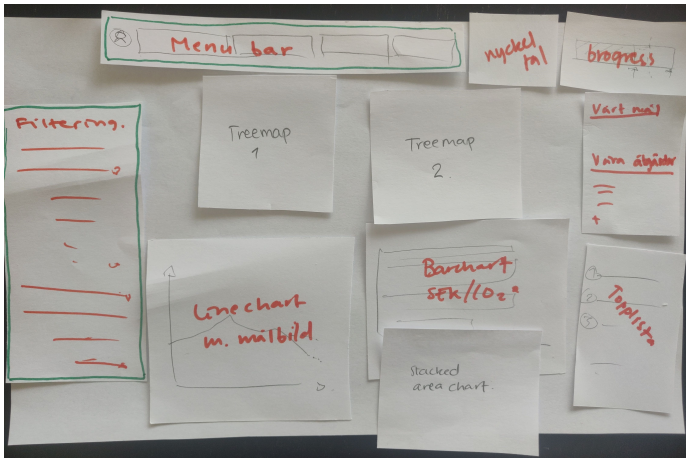

Figure 7.2: Paper prototyping on positioning.

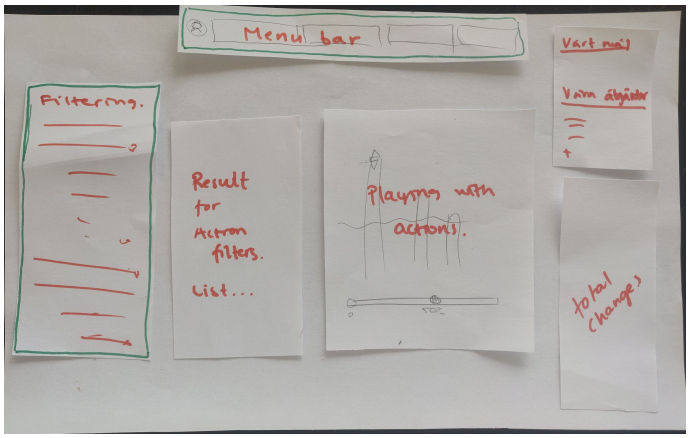

Figure 7.3: Paper prototyping on positioning.

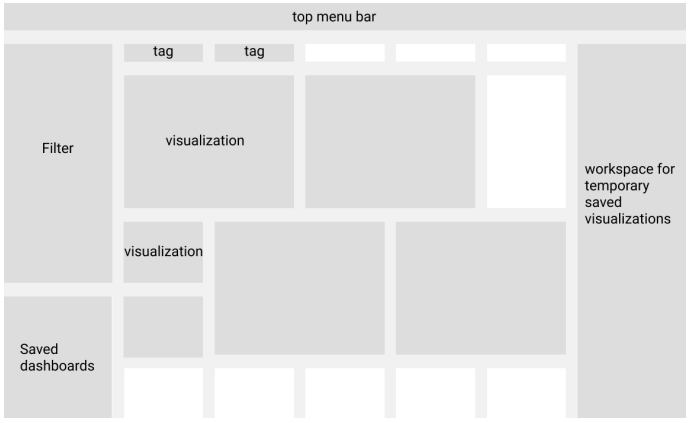

Figure 7.4: Examples of Greybox-wireframes in Figma

Figure 7.5: Examples of Greybox-wireframes in Figma

7.4.6 Ideation: Online co-creation workshop

Parallel to the one man ideation sessions, an online co-creation workshop was organized and held. The participants were two future users, from user group 1 who

had been interviewed in the data collection part of the project, and two from the company Svalna, one being the project supervisor and one with experience from UX-design. Stakeholders from both main groups were desired partly to make their connection stronger within the context and partly to more efficiently reach conclusions that appealed to both parts. Their different points could be beneficial to the discussion outcomes. Furthermore, the purpose of the workshop was to ideate together around possible functions, features, or what else that could come to mind regarding the system. The goal was to collect valuable ideas and thoughts regarding the future CI-system directly from the stakeholders and have them validate these on the spot. The participants were in beforehand informed about the arrangement and agenda of the workshop in order to come mentally prepared and have time to ask in beforehand if something was unclear. The entire workshop was recorded for later evaluation purposes.

The workshop started with an agenda overview and some basic rules to comply with. Then proceeded with a quick warm-up exercise to better get to know each other, the tool Miro, and to become more relaxed in the unnatural context. The main part of the workshop was made up of several brainsketching sessions, allowing participants to ideate on each others' ideas. The entire ideation was initiated with the following question:

How might we show the user where the best potential for change lies within the organization?

Additional supporting questions were:

How might we help the user understand where additional or more strict actions are needed?

How might we help the user understand to what extent these actions can make a difference?

The questions were kept broad to not restrict the participants' thoughts too much but still defined to help focus the mind of the participants in the same direction. The participants had 4 minutes to gather their ideas on their own virtual sheet within Miro. Then everyone talked through their ideas one by one which raised questions and discussions within the group. Each participant went on to a paper of another participant to build around their ideas in the next ideation session, still with the same questions as guidance. After 4 more minutes of ideation followed by a discussion around the new thoughts, the participants categorized their ideas according to the Four categories-method, which wrapped up the workshop. Lastly, they were asked to answer a short evaluation form about the conduction and content of the workshop.

7.4.6.1 Takeaways from workshop

The ideas and thoughts generated from the workshop are presented below, separated according to the participants' categorizations.

Most rational

- Mapping of the organization showing emission distribution and where there is potential for change. It should be possible to drill down/up.
- Current level of emission with projection on the future related to the organizational long term goal.
- Visualizations of emission levels of institutions for users on an institutional level. Can help them to find "low hanging fruits".
- Setting goals on an institutional level and aggregate them up in the hierarchy.
- The ability to see a "start value" for future reference.
- Two perspectives exist; central (organizational) level, local (institutional) level. This means different conditions and prerequisites for the system.

Delightful

- A dashboard presenting actions together with the emission level effect these could mean depending on to what extent they are to be taken. The extent can be altered in percentage, manipulated by the user on a slide-control. Keep it simple when estimating action effects. Universities often have scientists that gladly do their own calculations if specific numbers are needed.
- Actions could be presented as scenarios.
- Decision-makers with the last saying (top management) are interested in cost estimations, SEK/kg CO2.
- Group actions together to see their total effect.
- Compare results from actions both at the time of planning and at the time of evaluation.
- Visualize the result from a particular action of another organization/institution.
- Allow for the user to explore and play with actions and their effects on cost and emission levels. "How much does this kg CO2 cost?"
- If an action is made over the entire organization, the effects of this could be

distributed over all institutions for them to have more accurate data.

Darling

- All taken actions or future actions that are to be taken can be collected on a central level in order to understand current and future status.
- Allow for a follow-up to see if actions are followed as decided and if actions are making the expected difference.
- Set up an emission budget for the following year.

Long shot

- Users can create their own actions that can be integrated into the system.
- The system can make comparisons over time between similar organizations. Variation in e.g. number of employees and the size of facilities should be considered.
- Make the system possible to integrate with other systems or policies used by an organization.

7.5 Iteration two

7.5.1 Defining: User stories and user story mapping

Before more ideation was made, a clearer definition of the tool was needed. Lists of needs and requirements, which up until now had been the basis for ideation, do not serve the important purpose of structuring user tasks in relation to each other. A definition of the user journey had to be made and was so through the use of user story mapping. For each user type, short user stories were written which further turned into the backbone for user story mapping. Through prioritizations and limitations within the map, the extent of the tool became considerably more clear.

Below are the user stories listed, categorized by functionality. Notice that both user types are represented.

General

- As a *user* I want the system to know which organization and institution I am a part of so that I can be presented with customized visualizations.

Data and visualizations

- As an *environmental strategist* I want to see changes and updates in the data at least twice a year so that I can be up to date and apply changes in time to reach goals.

- As an *environmental strategist* I need to trust the data and visualizations and understand its background so that I can draw valid and correct conclusions from it.

Explore emission data

- As an *environmental strategist* I want to follow the development of total emission levels within the organization so that I know if adjustments in the action plan are needed in order for the goals to be reached.

- As an *environmental strategist* I want to follow the development of emissions within institutions and categories so that I can find where the potential for most effective changes lies.

- As an *environmental strategist* I need to see a forecast of our emission level if the curve follows the trend up to a given point in time so that I can understand where our levels will end up without making changes.

- As an *environmental strategist* I need to see a forecast of how the emission level needs to change if our goal is to be reached so that I know the size of the gap that we need to overcome.

- As an *environmental strategist* I want to receive inspiration from the environmental work of other similar organisations so that I can learn from others and make use of already existing and working solutions.

- As an *environmental strategist* I want to compare the emission levels of my organization to other organizations so that I can increase the motivation within the organization's highest decision-making organ.

- As an *institution environmental representative* I need to in a time efficient way interpret the emission visualizations regarding my institution so that I can quickly understand our development and current status.

- As an *institution environmental representative* I want to follow the development of our emission level so that I see how and to what extent our institution's operational actions have made a difference.

- As an *institution environmental representative* I want to see the emission levels of other institutions within the organization so that I can make comparisons and possibly get inspired.

Explore operational actions

- As an *environmental strategist* I need to see and compare costs and emission level changes for different possible operational actions so that I can know which proposal is the most cost effective.

- As an *environmental strategist* I want to follow the effective development of a specific action or group of actions so that I can understand which actions contributed to beneficial change.

- As an *institution environmental representative* I want to receive proposals on actions to take within my institution so that I can be time efficient when continuously developing our local operation towards the goal.

- As an *institution environmental representative* I want to frequently receive updates about the overall climate work in the organisation so that I can use this to raise motivation for me and within my institution.

7.5.2 Concept: Three main views

With a more clear definition of the prototype scope, ideation on navigation took a new up-swing. It became easier to focus on the path towards the user goal. With this, the three main purposes that earlier were acknowledged were re-worked and put together into three new main views of the tool; Explore, Actions, and Dashboards. Wireframes of these views were created in Figma and are shown below along with explanations.

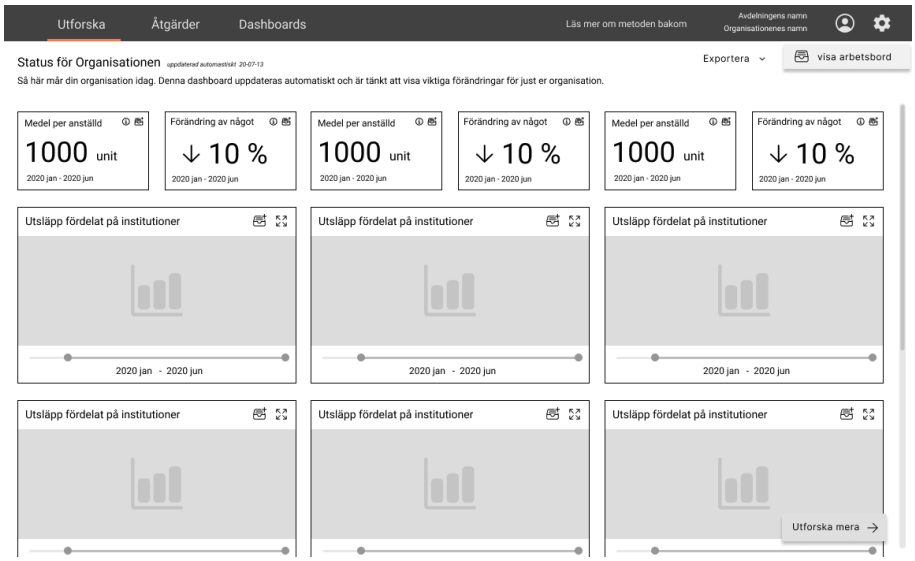

Figure 7.6: Concept Three main views: Explore-view presenting recommended visualizations.

The Explore-view (*Utforska*) is a combination of the purposes *Presenting current status of the organization* and *Comparing us to other organizations*. As part of the Explore view the user will after log-in always be presented with a customized status view with different visualizations suitable for the user to understand the development trend of her organization/institution (figure 7.6.

Choosing to "Explore more" (*Utforska mera*) allows her to filter on institutions within her organization and emission categories (figure 7.7. Visualizations according to the filtering will be displayed in the main window beside the filter panel. The user can save any found visualization within the Explore-view to the "worktable". Using the worktable ables her to create her own dashboard which can be exported if desired. This serves the purpose for the user to make her own summary of her session within the CI-system.

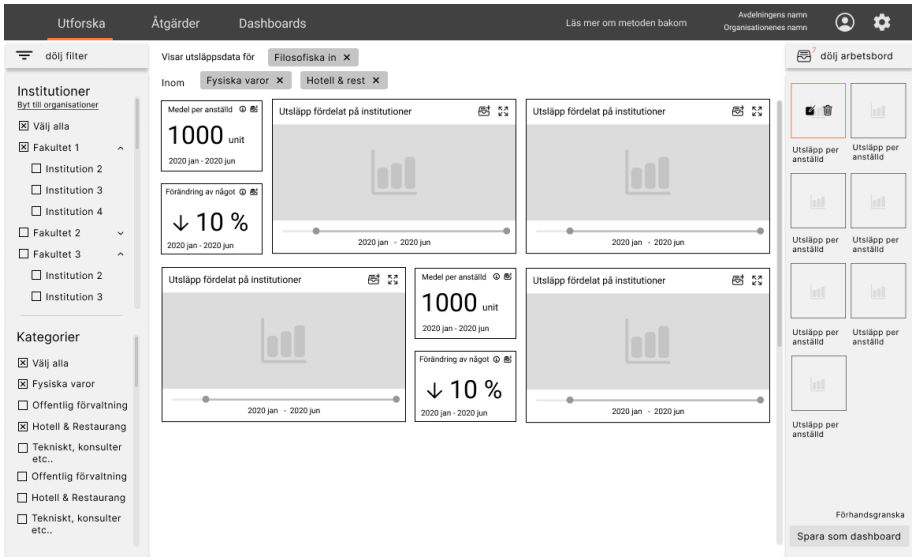

Figure 7.7: Concept Three main views: Explore-view where free exploration is enabled with the use of filters

The Dashboard-view allows the user to view and edit saved dashboards (figure 7.8. The worktable is still active here, for her to be able to add a visualization from an already saved dashboard to the new one in progress. Dashboards can be exported to use for communication purposes outside the tool.

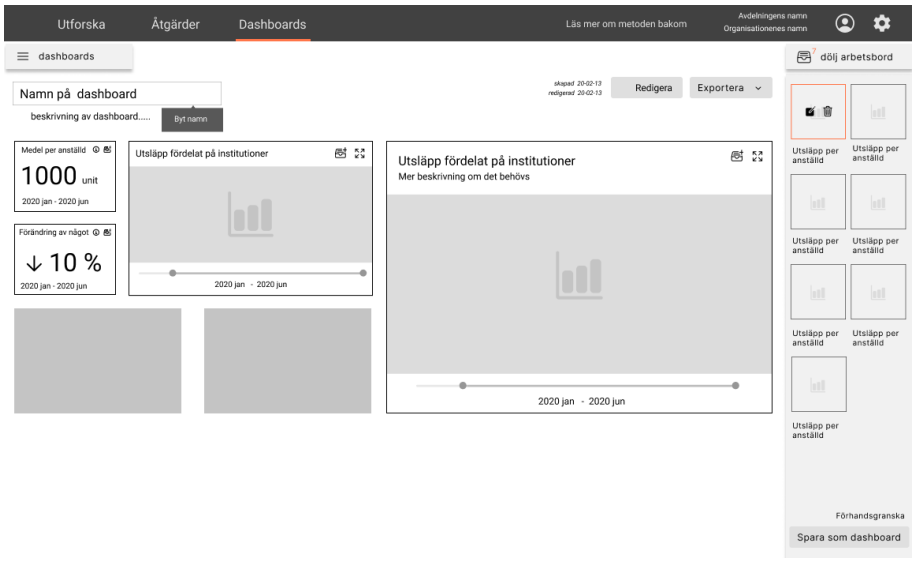

Figure 7.8: Concept Three main views: Dashboard-view

The Actions-view is generated from the purpose *Enable exploration of possible operational actions*, but with additional attributes. As before it is where the user is able to see hypothetical effects on costs and emission levels from taking different actions (figure 7.9. The user can filter on emission categories to be presented by different possible actions to take, or she can choose to display recommended actions for her organization/institution. Through a list of actions, she can choose one and further explore the contribution of this by altering to what extent the action should be taken represented by a percentage value. Other actions can be manipulated in the same way. The user will always be presented with the total contributed change from all these actions.

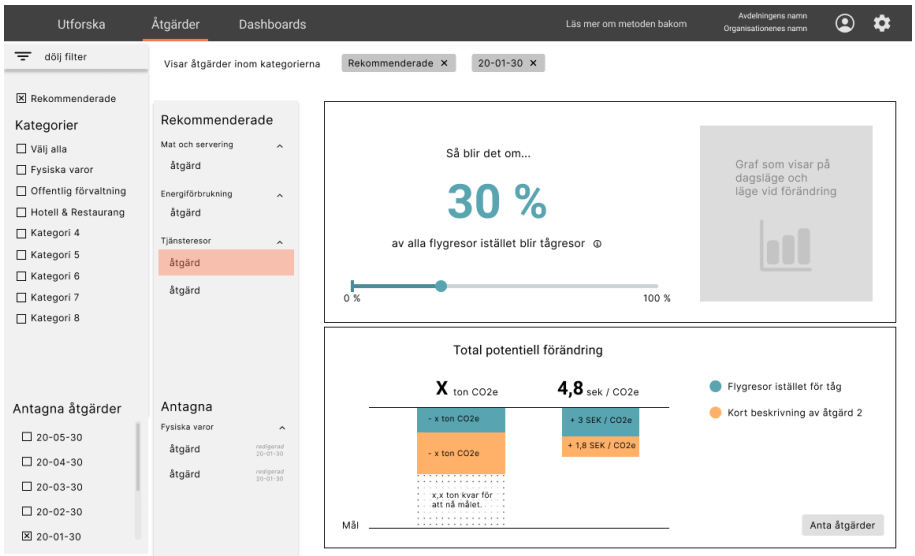

Figure 7.9: Concept Three main views: Actions-view presenting examples of operational actions possible to take

In addition, the user can view the formerly taken actions to see the actual contributed change in cost and emission, and possibly compare to the estimated change (figure 7.10).

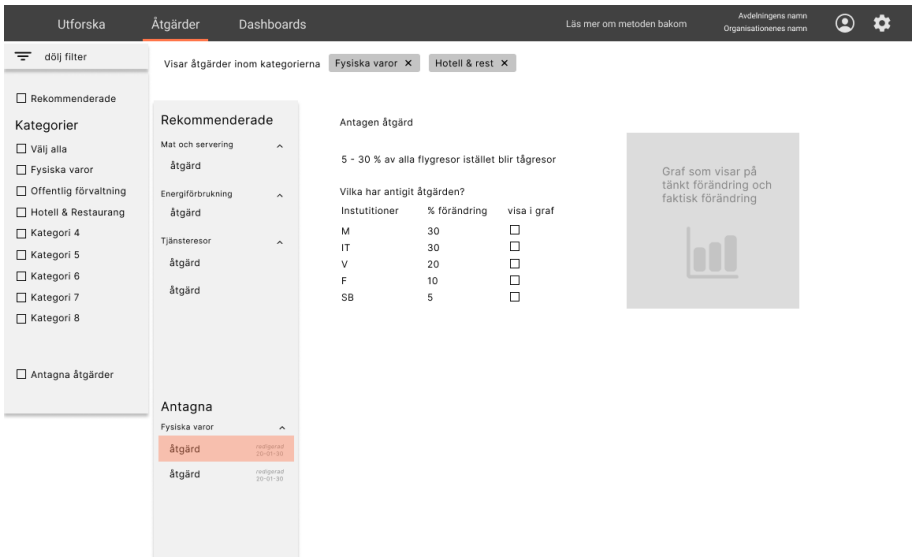

Figure 7.10: Concept Three main views: Actions-view presenting an overview of operational actions already committed to within the organization

7.5.3 Evaluating: with Svalna

Evaluation of the prototype above was made through a conversation/unstructured expert review with Svalna's UX-designer and project supervisor. An important takeaway from the meeting was that the concept in this stage could benefit from being simplified, meaning to reduce the scope of the prototype. Some functions were advised to be dropped in order to put more focus on others. Below follows some attributes, decided to be changed, excluded from, or added to the interface.

Attributes to change:

- The dashboard with recommended visualizations in the explore view should instead be seen as a type of filtering. This will keep the Explore-view more intact as the filter panel will be present constantly. It will also allow the user to easily navigate between recommended visualizations and visualizations based on category or institution filtration. The customized dashboard should always be marked by default in the filter panel and can include visualizations covering different institutions or categories, whatever is suitable to display interesting information for this specific user. Filtering on categories or institutions will therefore automatically untick the 'recommended for you' filter and show visualizations solely according to the new filtration.

- Tabs should be used to navigate between institutions and organizations instead of links. The navigation type is a better fit for the purpose. It gives the feeling

of staying in the same filter panel, whereas a link is more suitable for navigation away from the current position.

- In the action-view, tabs should be used to navigate between possible actions and already taken actions. This gives a cleaner interface and allows the user to focus on one thing at a time, which is more according to the written scenarios.

Attributes to exclude:

- The entire Dashboard view along with the ability to create dashboards. The users have not expressed the need for this kind of freedom. This function might unnecessarily raise the complexity of the tool and is therefore not considered a prioritization within this version. Still, there is reason to believe that a way to save scenarios for later use would increase effectiveness for some users. But more research on this needs to be made.

- When excluding the dashboard function entirely the worktable loses a big part of its purpose and should therefore be excluded from the interface. Its presence is also considered to risk making the interface more complex than needed in an early version, why it is reasonable to focus on more necessary attributes.

- The possibility to filter on emission categories in the Action view. The number of actions (possible to take) included in the system will most likely not be that many in an early version of the tool. To filter on such a few alternatives would be to add extra unnecessary steps for the user. The actions should instead be listed directly within emission categories or as recommended actions. If in a future version of the tool, more actions are added to the extent that it is time-consuming for the user to scroll through a list, the need for filtering could be considered.

Attributes to add:

- A date stamp for when the data was last updated should be visible in all views containing data to meet the user's desire of understanding the data better.

- A marker next to the actions in the list that have been manipulated during this user session. The marker will indicate that connected action has been manipulated and is a part of the presented summary of the total estimated change. The marker will have different colors connected to the action which will recur in the summery visualization for the user to notice an action's share in the total estimated change.

7.5.4 Defining: Two main views

The user story map was reworked since the user journey had been altered. The new map made the smaller scope of the prototype more clear. The three (a bit too

complex) views were reworked into two main views, with the purpose to include necessary parts in order for the main aim of the tool to be reached. The two views, Explore and Action, each contained two sections. For each subview, the connected *desired goal* for the user, the *information needed* (the content of visualizations), and the *knowledge gained* from it for them to reach their desire, were defined.

7.5.4.1 Explore-view

The Explore-view is as before where the user explores the levels of emission within desired categories and departments within her organization. She can also explore the total emissions of other organizations and compare them with her own. Filtering on recommended visualizations allows the user to quickly get an indication of the status and development trend within the operations she is responsible for.

Chosen for you
Offers a way for the user to quickly receive an indication of the organization's (for user 1)/institution's (for user 2) status and development by presenting a set of visualizations customized for the user which will differ depending on which level and in what organization she is active within.

Goal desired: To know our status as an organization/department.
Information needed: Indications of current status compared to the set goal, indications of current status compared to recent month/year, averages, e.g. emission or cost per employee, student, category, or departments over a certain time period (month/year), and cost in SEK/ kg CO2e and emission in kg or ton CO2e.
Knowledge gained: "We can not continue as we do", "We can continue as we do"

Goal desired: To know where the problem lies.
Information needed: Graphs telling within what categories and departments room for improvements exists or where prominent negative change has occurred. Annotations of important parts of the data.
Knowledge gained: "At first, we should focus on improvements within these categories (and departments)."

Goal desired: To know when we started to have problems
Information needed: Graph showing change over time. Annotations of important parts in the data, in time.
Knowledge gained: "It has become considerably worse during the last x months."

Goal desired: To know what we are doing good.
Information needed: Graphs telling within what categories and departments we are in the lead (possible to compare with other organizations or departments) or where prominent positive change has occurred. Annotate important parts in the data.
Knowledge gained: "These are our strengths."

Free exploration
Offers a way for the user to explore the data freely, by presenting a chosen set

of visualization types. Their content, in terms of the number of departments or categories, will be altered parallel with the user's filtering.

Goal desired: To explore the emission data freely, e.g to explore a certain section of the data that lies within my field of work.
Information needed: Visualizations containing emission data answering to the filtering made on emission categories and organizational division.
Knowledge gained: "I have a deeper understanding of the relations between categories/departments", "I have a deeper understanding of how my department is doing."

7.5.4.2 Actions-view

The Actions-view is as before where the user is able to see hypothetical effects on costs and emission levels from taking different actions. She can decide to sign on these actions if desired. Additionally, the user will be able to see the actual changes in levels that already taken actions contributed with.
The two subsections within this view are:

Possible to take
Offers a way for the user to explore the consequences of different actions as well as receive recommendations of possible actions. The user can also sign on to a group of actions for the entire organization or an institution (depending on the user type).

Goal desired: To know how we can do better.
Information needed: Allow for manipulation of one single action and see the hypothetical outcome of this, in terms of emission and cost. All actions need to be formulated so the manipulation can be done by changing a percentage of the present emission from a certain source. Show the total hypothetical outcome of all the manipulated actions.
Knowledge gained: "Action A will give us more value for the money than action B", "Action A and action B will lead us closer to our goal"

Already taken
Offers a way for the user to overview taken actions and compare their hypothetical contribution to the actual.

Goal desired: To know the result of our work on improvements.
Information needed: Allow for filtering on departments. A list as an overview of the taken actions with additional needed information, e.g. department, percentage, and progress. Graphs showing the difference between the hypothetical change (where we should be) and the actual change (where we are), in both emission and cost.
Knowledge gained: "We have not taken action A to the extent that we intended to.", "Action A turned out to have a lower direct economic impact than what was suspected."

Goal desired: To create a hypothetical forecast showing where the organization's levels of emissions could be if all taken actions are followed.
Information needed: A list of taken actions. Visualizations showing the total hypothetical change contribution.
Knowledge gained: "In the best-case scenario, we will lower our total emission level with X% by the end of the year, which will cost us approximately X SEK/kgCO2."

7.6 Iteration three

With a focus on the definitions of the views above, a structured prototyping session was done (figures 7.11 and 7.12), with the earlier version as a starting point. Each step in the user story mapping was thoroughly gone through one by one as the revised prototype took form with the constant reminder of having proper reasons for the decisions being made.

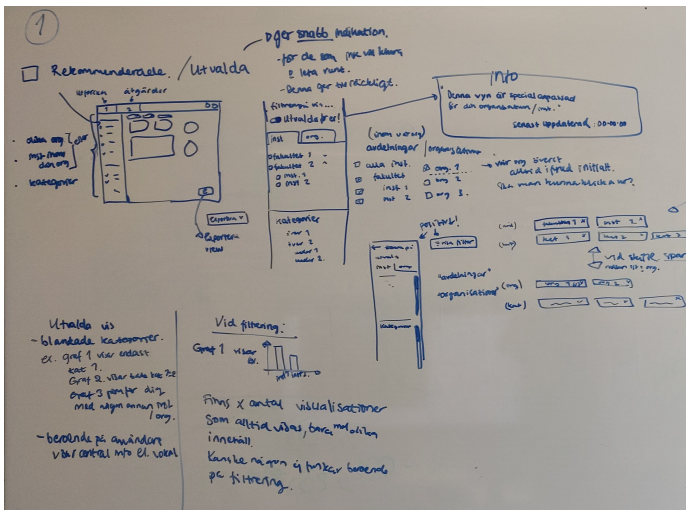

Figure 7.11: Parts of ideation and low-fidelity prototyping on the concept covering Two main views

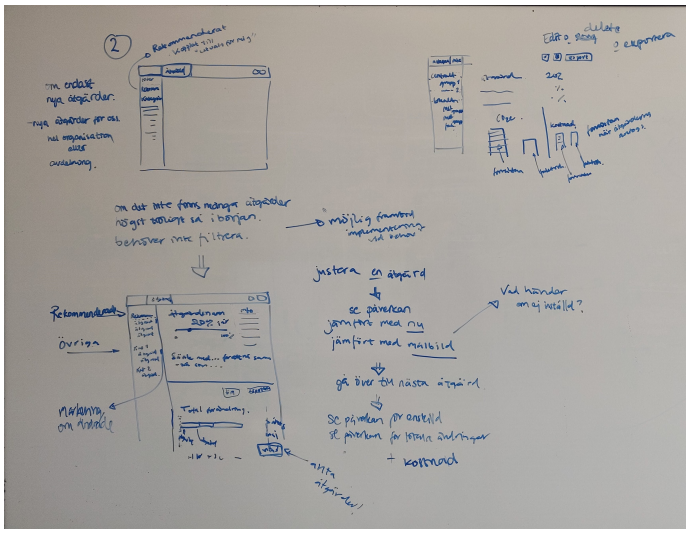

Figure 7.12: Parts of ideation and low-fidelity prototyping on the concept covering Two main views

7.6.1 Concept: Two main views

Based on the definitions of the two main views and the low-fidelity prototyping made a prototype in Figma was created which is described below.

7.6.1.1 Visualization modules

Two different visualization modules have been designed. One to entail a key-value, module 1 in figure 7.13, and the other any type of graph or table, module 2 in figure 7.14. They aim to be used as a basis for the data-containing parts in order for the interface to look uniform. Except for a placeholder for a visualization, module 2 also includes some interactivity.

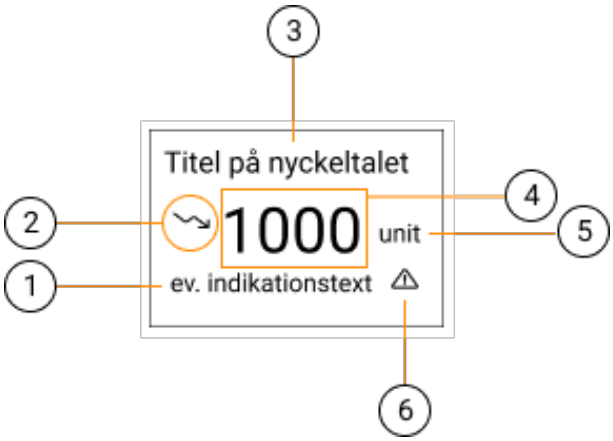

Figure 7.13: Concept Two main views: Module 1
1. Descriptive text of indication (eventual) 2. Indication icon (eventual) 3. Title 4. Key value 5. Unit 6. Icon indicating that extra attention might be needed (eventual)

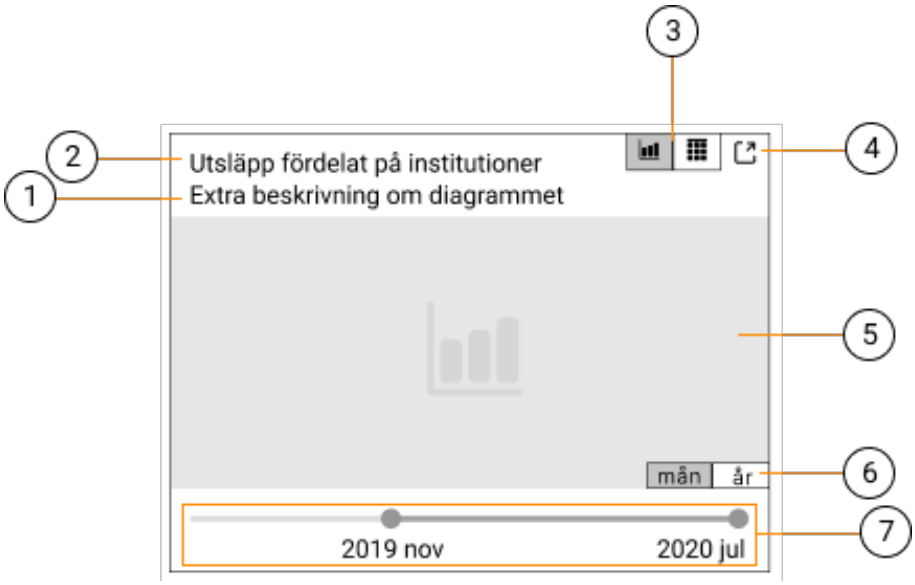

Figure 7.14: Concept Two main views: Module 2
1. Description 2. Title 3. Toggle buttons; display graph or table 4. Extend-link; extend the visualization 5. Visualization as graph or table 6. Toggle buttons; distribute data by month or year 7. Slide control; change time interval

7.6.1.2 Explore-view: chosen for you

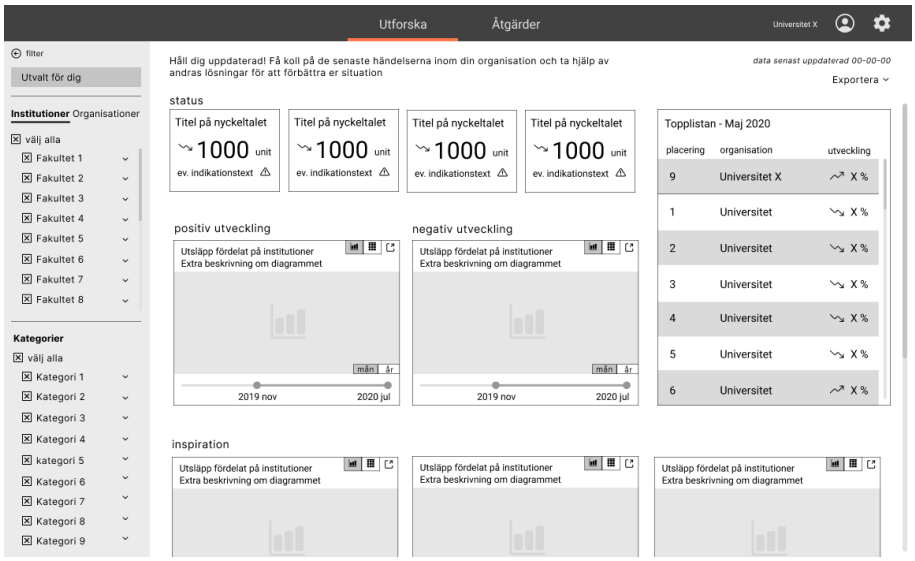

Figure 7.15: Concept Two main views: Explore-view presenting the section *chosen for you*

The first view presented for the user after log-in will always be the Explore-view with the customized dashboard chosen as a default (figure 7.15. The marked toggle button, *Utvalt för dig* (Chosen for you) indicates that this view currently is active. The visualizations are organized according to their purpose. Different purposes

are: to present key values indicating on the organization's/institution's status, to present examples of positive and negative development, and to present inspirational visualizations. A top list of all organizations registered in the tool will also be presented here to enable easy comparison and possibly increase motivation.

7.6.1.3 Explore-view: free exploration

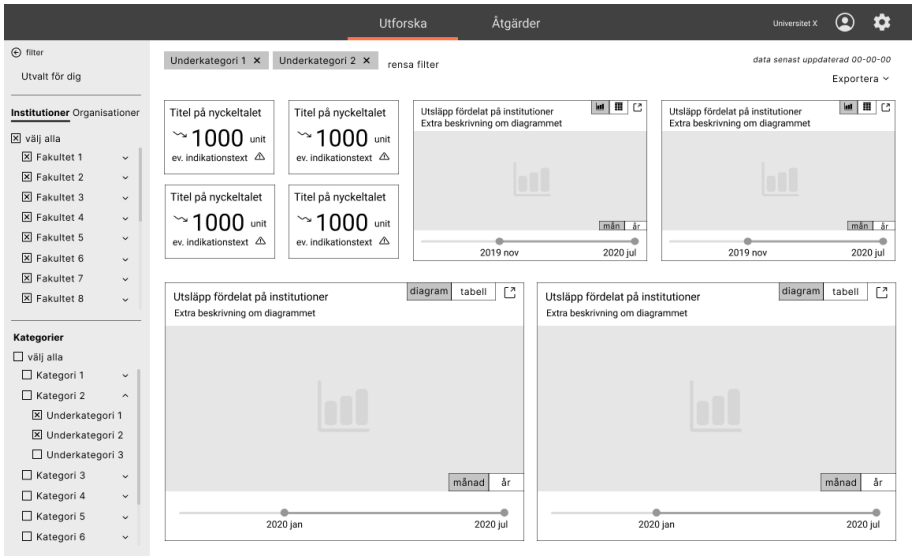

Figure 7.16: Concept Two main views: Explore-view, presenting the section *free exploration* under the institutions tab

As soon as the user starts to interact with the filter panel, the visualizations will change according to the filtering made, and the *chosen for you*-button at the top of the filter panel will stop being marked (figure 7.16. Filter tags will help the user to keep track of her filtering as the chosen alternatives otherwise might be hidden in several drop-down lists.

When navigating to the organization-tab in filter panel, the visualizations will instead show emission data from all registered organizations (here being HEIs), meaning the scope is zoomed out one step from institutions solely within one organization (figure 7.17).

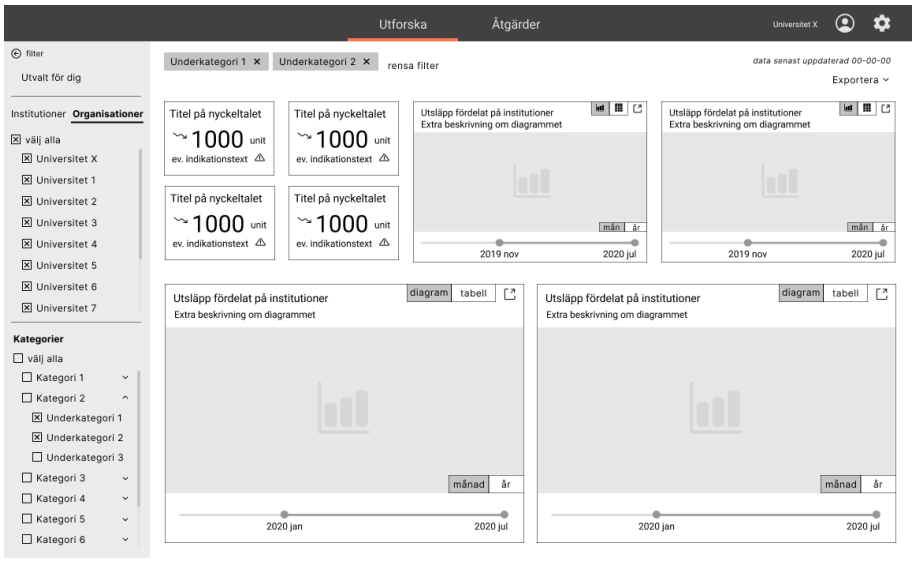

Figure 7.17: Concept Two main views: Explore-view presenting the section *free exploration* under the organization tab

7.6.1.4 Actions-view: possible to take

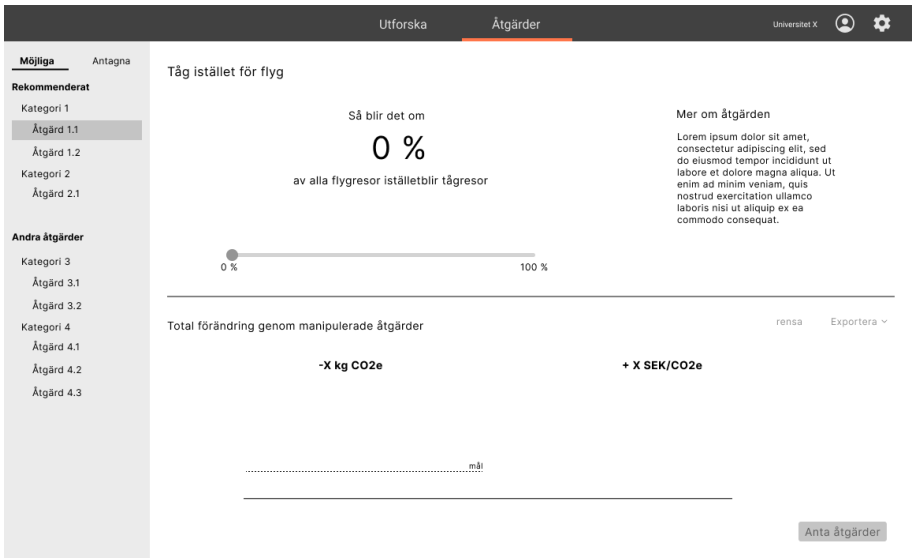

Figure 7.18: Concept Two main views: Actions-view presenting the first (empty) view of the section *possible to take*

Navigating to the view of actions, *Åtgärder* in the top menu bar, the first view will be in the section of actions that are possible to take (figure 7.18. A list of actions is divided into recommended actions and other actions, as well as within emission categories. The first recommended action will by default be marked showing additional information to it in the top half of the main window. This view will at first be empty of any data or visualizations, only showing an indication of the possibility of visualizations.

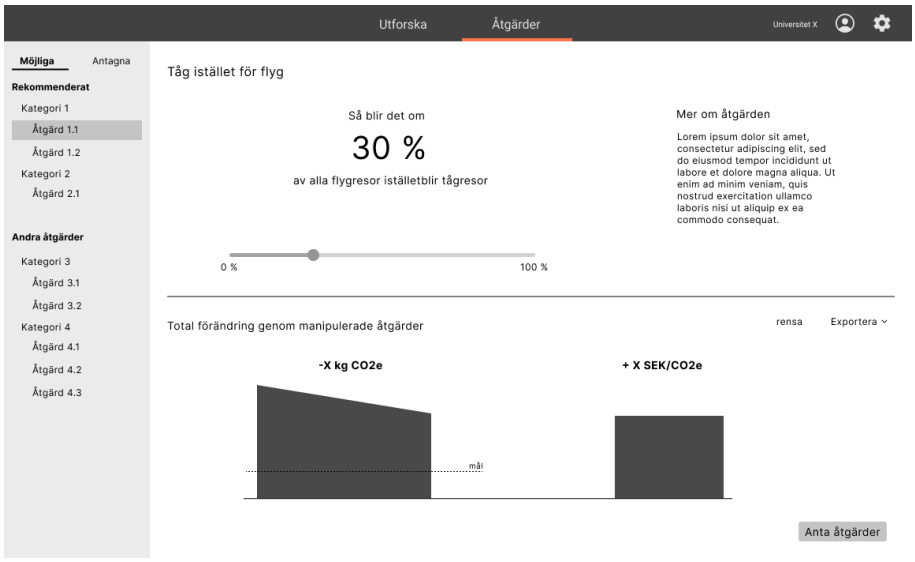

Figure 7.19: Concept Two main views: Actions-view presenting the interface when the first operational action has been manipulated

As the user alters the slide control, changing the percentage, visualizations at the bottom half of the main window will present the estimated effect this action will have in kg CO2e and in SEK/kg CO2e (figure 7.19). The graph of emission levels will also include an indication of where the goal is as a reference. These visualizations need additional information than what is included in this version in order to make sense. They are mainly visualized in a simple way here to explain the general thought.

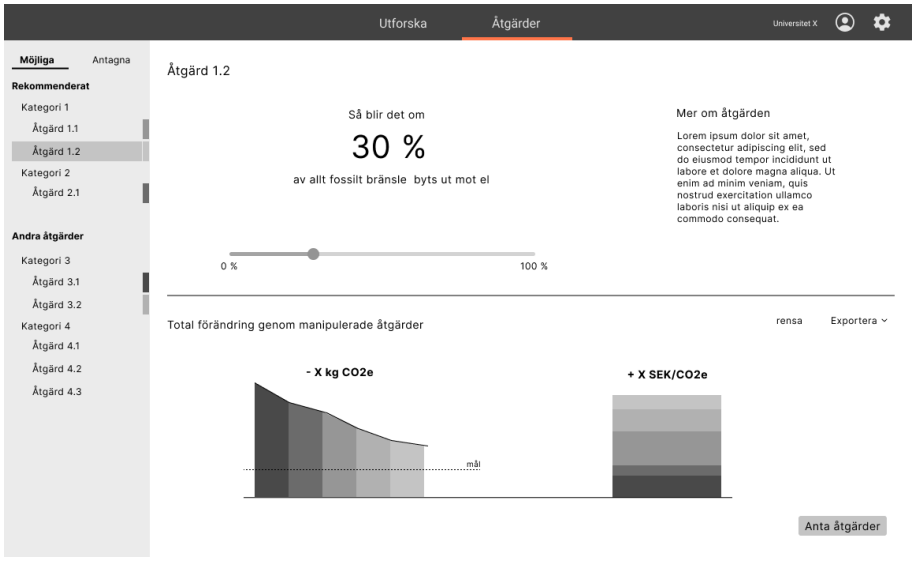

Figure 7.20: Concept Two main views: Actions-view presenting the interface when several actions have been manipulated

As more actions are being manipulated, the visualizations will become richer in data, always showing the total estimated change based on all manipulated actions (figure 7.20). Markers beside the titles of the actions in the left-side list are color-coded

to allow for the association to their part of the contribution in the visualization. Information about the estimated contributions can be exported for further sharing. The user can decide to commit to the actions manipulated by clicking on the button in the lower right corner (*anta åtgärder*).

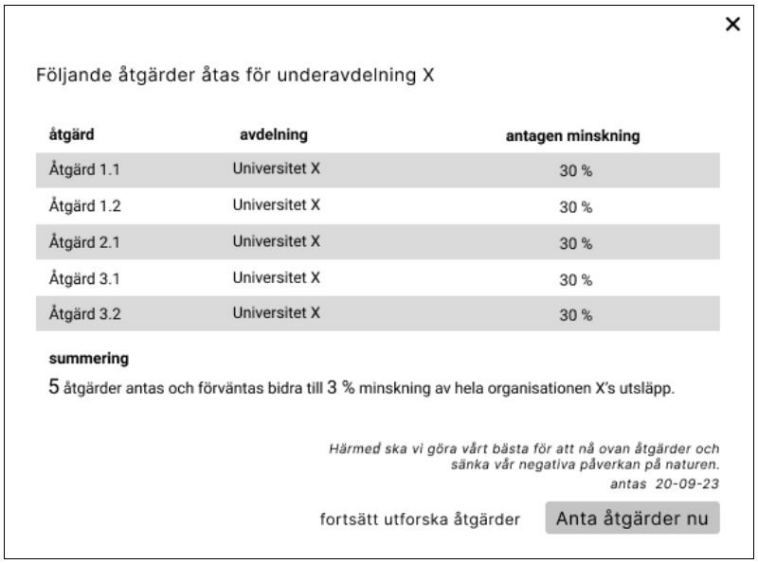

Figure 7.21: Concept Two main views: The pop-up displayed after deciding to commit to actions manipulated in the actions-view.

When clicking on the button to commit to the actions, a pop-up will be displayed, containing a summary of the actions one has chosen to commit to (figure 7.21. The summary and the additional text aims to have the user reconsider her commitment and make it feel serious for the engagement to be strong.

7.6.1.5 Actions-view: Already taken

The second tab in the left panel leads to the section with already taken actions (figure 7.22). The user can filter on parts of the organization to choose by who the actions showed have been taken. Visualizations will show both estimated change and the actual change in emission levels and costs based on the actions in the list. Just as the visualizations in the last action view, these need more work and mainly aim to help explain the concept.

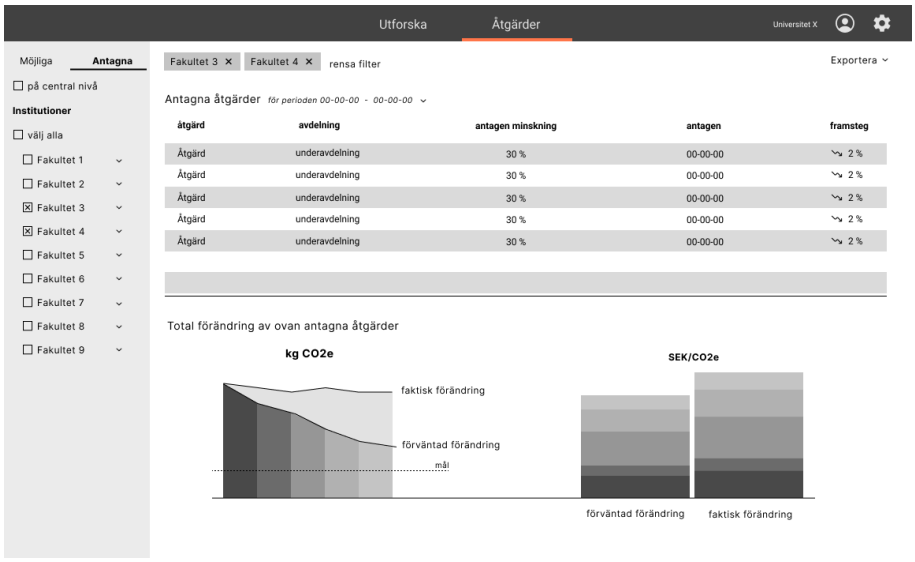

Figure 7.22: Concept Two main views: Actions-view presenting the section of actions taken.

7.6.2 Defining: Scenarios - second versions

Two new scenarios were written to capture the intended usage of the designed tool and to describe how the user needs were met in the final prototype.

Scenario for User 1, the environmental strategist
At the beginning of every month, E inspects the updated data within the Carbon intelligence system. She always begins to look over the visualizations that are recommended for her organization as it gives a quick indication of their status and wherein the organization an extra effort can be useful. The scoreboard between all HEIs in Sweden is always exciting. When not in the top, that is a direct extra motivation for E's team. As E is in charge of emissions regarding purchases in the organization, she continues within the tool and filters on the different subcategories within purchases as well as checks the institutional levels. She notices a huge positive difference in the levels for the institution of philosophy and decides to acknowledge this in the upcoming monthly update email to the entire organization. She exports the chart and the additional information and adds it to her document in progress.

E is also about to have a meeting with the board regarding the current status of the organization and how the prospects look in terms of reaching the 6% decrease until the end of the year. E uses the CI-system tool to learn about the current status if the organization this far into the year has lowered its contribution to pollution according to plan. Further, she inspects what actions the institutions have added to their list together with the total estimated changes it might lead to. She sees that, from the actions added within the system, the organizational estimated incline in emission is 4,5% by the end of the year. She decides to export these visualizations for the board meeting presentation. Also, the institutions make other operational actions, not yet integrated into the system but still possibly contributing to a positive change. E

needs to have a look at these as well together with her team to see if it is reasonable to estimate the last 1,5% out of their contribution. Otherwise, she needs to push for additional operational changes in order for them to reach their common goal.

Scenario for User 2, the institutional environmental representative
R's most used feature in the Carbon intelligence system is the first view, presenting visualizations of data recommended for his institution. From this, he receives a quick status and development indication which gives him a good idea regarding if his institution is doing good or needs to raise their effort in order to reach the organizational goal. In order to understand to what extent actions are needed to be taken he uses the function within the tool that allows him to play around with different actions and see their effects. R manipulates three of the, by the tool, recommended actions for his institution and overlooks the total effect from them. He clicks the button that says "anta åtgärder" (take actions). A pop up stating the commitment to the actions makes him think about what consequences the actions actually would mean and if they are reasonable to reach. He decides to discuss the commitment with some colleagues before they reach the conclusion to commit fully and try to succeed with the actions. He now feels obligated to do his very best, as well as excited to see how far the institution can reach.

Every month, R, as well as everyone else in the organization, receives an email from the environmental strategists with an update of the organization's status and sustainability work. In this month's email, R receives a shout out for excellent progress in lowering the institution's emission levels. He is happy to get noticed for his hard work and feels his engagement raises to another level.

7.6.3 Evaluating: Expert reviews

Evaluation of the prototype in this phase was done through expert reviews, conducted with three UX-designers and former peers in the master's program Interaction Design and Technologies. The prototype was made interactive to the extent to which a scenario could be followed in the reviews. The reviews were initiated with an introduction of the context, the purpose of the tool, and a description of the type of user as which the present expert played a role. The role of user 1 was used in order to cover the entire prototype in a reasonable way. For example, user 2 has no clear reason for why she would want to export information regarding the contributed change from all taken actions. The level of the prototype was gone through so the expert knew what to focus on in her inspection. The main part of the review was built up of short tasks based on the scenarios and divided into the two main views of the UI; Explore and Actions. For each task, the expert was asked to answer how she believed she was to interact with the interface, why she thought so, and what she thought was going to happen if that action was made. The expert also got to interact with a mini-prototype, which contained the functionality of the filter. Further, a free discussion covering specific noticeable parts as well as the prototype as a whole gave additional valuable feedback. The expert review script can be found (in Swedish) in Appendix B. The reviews were screen and voice recorded for them

to be available for retrospect. The prototype was improved between the reviews according to previous findings, which allowed for fast validation of some changes. Other discussed features were on the other hand not altered directly because their correct nature was still unclear and more discussion regarding them was entitled.

Being on the level medium-fidelity, the parts of the prototype desired to be inspected were navigation, controls, the behavior of the filter function, the clarity of the UI possibilities, and feedback (to some extent). The prototype did not include visualizations, such as graphs of emission levels that alter according to the filter, which is a big part of the user feedback. Solely one visualization was considered necessary for the intentions of the tool to go through and was therefore a part of the prototype. This was a first version visualization in the Actions-view showing levels of emissions and costs depending on operational actions.

7.6.3.1 Takeaways from expert reviews

Below follows a list of changes made to the prototype due to the inspections from the experts. The revised version is presented under the result as it is the project's final prototype.

Function and behavior of the filter

- A partial behavior of the filter, regarding how to check and uncheck boxes, that supported a use case which is not considered to happen frequently was deleted. It was considered to possibly confuse the "normal" user.

- The filtering behavior will follow the principle that it should, as far as possible, be avoided for the user to be presented with an empty filter (all alternatives unchecked). This is a view without value for the user. When the filter is cleared through the list of tags, all alternatives will be checked instead of none. To uncheck all boxes in one click, the user instead uncheck the alternative *välj alla*, Swedish for *choose all*.

- A search box was added to the filter panel for an alternative way to do the desired filtering. As the search text is being written, filter alternatives with resembling content will be presented as choosable tags below. A chosen tag will be added to the list of tags and the box connected to the same alternative in the filter panel will be checked. Some universities have a lot of institutions through which they otherwise would have to scroll through in order to select a desired one. With the search function, this scroll is not needed if the user knows the name of the desired alternative, and filtering can be made much faster.

- The order of the tabs in the filter panel, listing organizations or institutions, was shifted since it is considered to be more according to the mental model to have the bigger picture (organizations) on the left, followed by an in-zoomed view to the right. The most common case is for the user (both types) to be

interested in emission data within their own organization divided into their institutions. Hence, initially, the interface will start the user off within the tab of institutions.

Filter tags

- For extra clarity regarding the type of filter tag, they are to be connected through different colors as well as positions.

- A worst-case scenario when it comes to the list of filter tags is when all alternatives are chosen except for one, meaning a lot of tags that must be shown and navigated through. This is not a very likely scenario, but should still be possible for the interface to answer to. The solution chosen in this prototype version is a possibility for the user to extend the area of tags. If extended, the visualizations below will be pushed down as much needed for the entire list of filter tags to be shown. Other possibilities considered were a scrollable list of tags or to use tags representing faculties and the categories on the upper level. The scrollable list was rejected due to the small space available in which a scroll function might be hard to control. The second idea was rejected due to the fact that 4 different types of tags might arise confusion and does still not solve the possible state of almost all institutions in the faculties being marked but never an entire faculty.

Choice of wording in lists, menus, and tabs

- Some words were considered possibly difficult to connect with the intended action and therefore changed. Other words were changed to connect better with the user's real-life context.

- *Område*, the Swedish word for *area*, is the contextual word used to refer to the different emission categories within an organization. It will replace the word *kategori*, Swedish for *category*.

- The tab in the Action view referring to actions already taken does in fact refer to actions taken *by* different faculties and institutions. Its title was therefore altered.

Visualization in action-view

- The visualization showing the total effect from actions was changed into two similar looking bar charts. The earlier version of the chart was hard to interpret in an intended way and considered too complex for the level of the prototype.

- An overview listing manipulated actions was added beside the charts. It allows the user to edit or erase without having to find the right action in the left panel and make the desired changes within each action view.

- An additional guiding text makes it more clear that the unit SEK/kg CO2e refers to the cost of the chosen actions. It is a more common case that the cost will rise with more sustainable solutions. If an action comes with savings, the visualization will show a negative cost instead.

- The structure of the action view was also changed to better group connected parts of the window together.

- The use of space in the main information window could benefit from being altered in favor of the bottom part. The fact that the line separating the upper and lower part does not go all the way to the borders may be interpreted as if they are more connected then they are. The user might see the active action in the list as the starting point for both parts, which in fact is not the case. It should be clearer that the lower part represents a summary.

Visualization module

- The module was considered to have unnecessary icons and functions and was therefore simplified. As its squared shape made it resemble a clickable card, it was decided to be made into a card. The extend-icon was removed and more information than only a bigger version of the same graph will be shown when the card is clicked.

7.6.4 Final prototype

Based on discussions during the expert reviews regarding the topics above, a final revision of the prototype was made. This time with fewer changes than before. This concept is presented as a result of the project's final prototype.

7.7 Nudging

The work regarding nudging techniques in this project has been made through research within the theory and around existing solutions. Reflection around the findings and exploration of their possibilities and opportunities within the CI-system was also made.

Having defined nudging within the right context and what type of nudges that could be beneficial to use here, brainwriting was used to ideate on in what specific way nudges could be present in the interface. To fully be able to focus on the cause and effect of a nudge and take associated cognitive biases into account, ideation on nudges for the interface was mainly made outside of the rest of the ideation and prototyping. This was made rather late in the process, during the second but mostly third iteration, when the CI-system had a more clear content to work from.

A list of nudging techniques, that could be used in the context of guiding organizations to take the right decisions regarding operations effecting their level contributed

GHG emissions, is the intended result. The techniques included in the list will not all be used in the prototype as their presence and effect are not intended to be tested within the scope of this project. The list should be considered as a first draft of techniques that have good cause of being valuable in tools such as the designed CI-system.

7.7.1 Takeaways from nudging research

During reflection of nudging theory, an additional way of categorizing different types of nudging techniques within decision-making/support contexts was defined. This categorization helped when understanding the nature and effect of different techniques. This distinguishes between those that exist when the choice is made during the exposure of the nudge and those that exist when there is a delay between the exposure of the nudge and the choice. In an online choice environment, the use of default choices is a commonly used example of the first kind. The user will agree to subscription unless actively choosing not to, by the use of an already ticked checkbox. The second kind is easier to associate with the context of the CI-system as decisions regarding operational activities within an organization tend to come from reflections and discussions. These nudges will instead affect the reflections and discussions, hence, mainly targeting the second of the two established modes of thinking. The fact that decisions are not made by individuals but by individuals in groups reinforces the need for a delay between nudge and decision-making. Although, nudges leading to decision-making during exposure of nudge should not be discarded from the context of the intended tool. Nudges can still affect how the user chooses to navigate in the interface. This will, more or less, have an indirect effect on the decisions that will be taken by the users later. Both systems 1 and 2 can be targets for these kind of nudges (even if system 1 is the most obvious) as a reflection during exposure of the nudge may be preferable.

Alternative categorizations like the one above or the ones explained in the theory chapter of this report have helped to understand the rather broad concept of nudging better. Using the categorization by Hansen and Jespersen [27] dividing nudges in four groups with reflective vs. automatic along one axis and transparent vs. non-transparent one the other, found areas of nudging are presented below. These have promising characteristics suitable within the CI-system, followed by one that is recommended not to be used within this type of tool despite possible positive effects. The nudging techniques are founded from read literature ([5], [16], [27], [30], [49]) and reworked to fit the context of this project. Non of the nudging techniques presented below fit into the category of reflective and non-transparent, aiming to manipulate a choice. Solely one specific example of such a nudge is presented by Hansen and Jespersen [27] which is to "*add irrelevant alternatives to the set of choices with the goal of increasing the perceived value of certain choices*". Adding non real information to manipulate the reflection and to interfere with the users' stock of knowledge is by the author seen as ethically wrong and therefor not a part of the below list. The users rely on the system to be presenting truthful data which is also one of the set requirements (7.4.3.2). More general, attributes that prompt

reflection should, according to the author, be transparent in their reason to be a part of a business intelligence system. The users deserve to understand the background of their reflections and should be guided, not manipulated.

Reflective - transparent

Nudges that aim to influence the user's reflective thinking towards a choice.

Educative nudges
Presenting the users with good information and educational graphics that are adding to their stock of knowledge, making them more suitable to make well-informed decisions [29]. Making some data in a visualization or visualizations in a system more salient will affect the user's interpretation and the knowledge based on it. This is a wide type of nudge and could include all graphs within the interface. This point is very connected to everything within this report outside of the area of nudging. All knowledge gathered about the user, their context, their goals, and the scope of the digital tool in progress, can be seen as food for educative nudges. How well the user is perceiving the patterns within the information visualizations (to make knowledge out of) is depending on the use of the gestalt laws (see the section on Gestalt laws 3.4.2).

Risk: The designer of information graphics does always have a responsibility regarding the user's perception of it. As soon as it aims to influence the user, it is of high importance that the user understands in what direction it aims to push.

Presenting recommendations
Suggestions for alternatives could have the power to make the user consider things she otherwise might not have considered. It can help to create a more fair representation of reality. It can also influence what path the user will take within a system by giving her a first guidance (connected to the nudging technique *Presenting default views or visualizations* presented below). This can be done by presenting the user with customized views or lists of recommended visualizations or operational actions that can be taken. It will help the user to find suitable information and possibly make her work session within the tool more effective.

Risk: If the interface is not transparent about the fact that certain alternatives are recommendations, it could be considered a non-reflective nudge that aims to manipulate rather than influence [16], increasing the responsibility for the designer.

Comparison with others
Creating a context where the progress of one is visible to another and vice versa can have a motivational effect towards improvement. It takes advantage of the fact that we tend to overestimate the extent to which others notice our actions and therefore make an extra effort. When others' progress is visible to us it can awaken a behavior of wanting to replicate according to the herd instinct. This can be taken one step further by creating a fictional competition around the progress of organizations, e.g. ranking them and their emission levels in a top list. It could motivate towards

wanting to do more and be seen as 'the best'.

Risk: This nudging technique has a risk of backfiring if the ones we compare ourselves to are not living up to the goals, slowing us down with them.

Risk: Not everyone is motivated by contest. For example, the one in the top might feel contempt enough to subconsciously try less hard in the future. The same goes for participants in the bottom, who might feel less motivated since a place at the top seems unreachable. This has been seen in several studies summarized by Damgaard and Nielsen [49].

Making a commitment
Having made a stated commitment to do something will help us to stay with it. It is one of the 10 guidelines in the Trans-theoretical model of change, created to address different aspects of behavioral change [50]. The step is called Self-liberation and refers to the importance of choosing to commit to a decision. It can be done by e.g. sharing the commitment statement to others, making this technique close connected to the one above. This nudging technique can be used when the user is signing on to actions within the tool by making the commitment clear and important.

Risk: Making the context of the commitment seem too serious might scare away users, leading to less commitment made and possibly even less tries towards living up to the terms.

Automatic - transparent

Nudges that aim to influence behavior.

Direct the attention of the user
Design visual features in the interface that makes desired parts of it more salient for the user, in order to have her navigate in a certain way and to notice important information. This can be done through a short animation within a graph, showing on a certain development, grabbing the user's attention. The use of notifications within the interface is another example of working within this nudging technique. Here, the aspect of timing is of importance. Inattentional blindness should be considered when deciding on the duration and timing of a change in the interface.

Risk: It is important to also consider what the user's attention is directed away from, creating a possible risk of missing other valuable parts of the interface.

Presenting default views or visualizations
The path of least resistance refers to the user going the easy way, which can be the same as going with the default choice instead of actively choosing something else [16]. In the context of a decision support system, a designer could make use of this tendency by highly considering what views or visualizations to present at the start. These would theoretically have the power to give the user valuable insights even if no further choice is made. Another example of use, in this particular system, is to

by default have a percentage chosen for a certain operational action, representing to which extent the action will be taken, and thereby by default present its estimated change and perhaps lowering the barrier towards accepting it.

Risk: The default choice or default view can for some users become an annoying attribute that always cares for extra interaction in order to avoid it.

Automatic - non-transparent

Nudges that aim to manipulate behavior.

Affect the memory of the user
Intentionally make use of the peak-end rule, which refers to the tendency of a user to remember the most intense points and the final moment of a user journey [16]. If one can design for those moments, one can bias the long-term memory of the past experience. Important (and a possible difficulty) is that the user perception of the presented information should not differ from the truth. This makes the nudging technique less manipulative and more towards influential.

An intense moment can be colored by positive emotions or negative emotions or possibly both. Either way, in this context, it could be about exposing the user for something unexpected, presenting "amazing" information by taking consequences of certain developments or decisions several steps further. Important is not to exaggerate the consequences but to keep them truthful. Another way of creating an intense moment could be to celebrate success with confetti animations or sounds of applause. This is emotionally affecting the experience of the user, which should not be taken too lightly.

To make use of the memorable end of the user journey, a motivating message could be of use. Within a tool such as the CI-system, there are numerous paths for the user to take making it hard to know where the end will be. Although, if the user decides to sign on to a group of actions within that function of the tool, it will create a clear journey, perhaps within the entire user session. How the interface behaves when the actions are being signed on to could affect how the user interprets the commitment.

Risk: The difficulty to balance on the right side of highlighting parts of the user's memory and manipulating it towards something false.

Risk: To emotionally affect the experience of the user cares for reflection regarding ethics and what the user of such a system has signed up for before using it.

Deceptive visualizations
How data is presented within a graph, regarding bar sizes, colors, units, axis intervals etc, will affect how the data is perceived. *Deceptive visualizations* are types of nudges established by Caraban et al. [16] and include the use of graphic qualities within a visualization to influence the viewer into perceiving the information in

a certain way, not according to the truth. Nudges like this, that alter the users judgement by displaying exaggerating visuals, are not to be used in the CI-system and are also recommended not to be used in similar systems that aim to deliver truthful knowledge. To have correct knowledge about their organization and to base decisions on that, is for the users of high value. Nudges like deceptive visualizations are highly non-transparent and automatic, which is the most manipulative corner, hence, implies the most risk. For this reason, biasing the user's memory might be risky as well. Although, it is considered to be possible with the right knowledge and skill to design the nudge in a way that is not deceiving but instead prominently displaying valuable insights.

7.8 Formulating the guidelines

The interaction design guidelines presented as a part of the project outcome were created from insights during the design process. They were formulated along the way and based on knowledge gained from literature, the user interviews, the workshop, as well as from discussions with Svalna and during expert reviews. They are kept general to serve as a guide for the development for similar decision-support systems as this project's 'CI-system'. Below follows a list of the guidelines connecting them to the project findings.

GL1. Prioritize interface behavior according to the most common user-case

The CI-system has several intended users with different competence, time available, and goals. They will use the tool in different ways and thus, the use-cases need to be prioritized in order for the interface to remain apprehensible. For example, shown views or choices made as defaults in the tool have been considered with this guideline in mind. This guideline serves a purpose for other digital decision support systems aiming to support several types of users and for that reason contain paths towards different goals. Tasks required by the user might be desired for one user but would rather be skipped by another.

GL2. Provide the user with a customized set of visualizations.

This guideline is helpful for both types of users of the CI-system, to give them a push when starting to use the system through easily accessed data connected to their department of interest. The user group of environmental representatives working on an institutional level is more considered here. They have less time available and want to follow their progress with small efforts. Carefully chosen visualizations shown in the first view of the tool should therefore be included to make efficient use of the users' time. To make some data more salient than others, in favor of the logged-in user, will decrease her workload and simplify the path to the goal. Not only do the different types of users need different data, what data to make more salient depends on which department the user is a part of as well since they try to improve considering different prerequisites. The same effect goes for users of

other similar systems. This consideration is therefore suitable as a general design guideline.

> “ It is a difference between the institutions regarding which aspects of sustainability apply to them. For example, some handle a lot of chemicals and others do not. “

> “ I can’t say that I want to get more work on my table, because I do not have a lot of time available.”

GL3. Provide a fixed set of key values or visualizations

For the user to interpret the presented data into valuable knowledge regarding the status of the organization, there needs to be a reference for comparison. Always presenting the same kind of data in the same way over time, will serve as this reference. The user will recognize the fixed set of visualizations and be able to interpret the data more quickly than if it constantly changed in type or position. This fixed set is also useful in this particular context due to the present differences between the departments which makes it harder to make useful comparisons between them. Instead, comparison over time for one’s own department is important to make it possible in an efficient way.

GL4. Guide user back to content if an empty state is reached.

It should, as far as possible, be avoided to present an empty window showing no visualizations since this is a view without value for the user. Although, if an empty state is reached, the interface should guide the user to find her way back to useful information. The user should not be left alone with no clue why no content is shown or how to avoid it. In the CI-system the control towards and from an empty state is the filtering function among emission categories and departments. Design choices regarding the extent and behavior of this function will affect if and how it is possible to reach an empty state.

GL5. Always show when data was last updated

If a system receives data from another system in non-real-time, the user needs to know when it was last updated to minimize the risk of exploring the same data twice. This will add to the knowledge the user has regarding the data and make accurate conclusions possible. Without a timestamp, the data can not be fully understood. In the CI-system, the visualizations will be updated depending on when the system receives data from the organizations to do estimations on. As this might vary in frequency the users need to receive feedback from the interface regarding it.

GL6. Use units that make a comparison between organizations and departments possible

The future users of the CI-system have expressed their need and desire to be able to compare with other departments or organizations. Organizations/departments differ in size, have a different number of employees, and different operational activities. This will affect their possibilities when working to lower their emission levels. Rightful comparison between them is therefore dependent on the right kind of units, being averages, such as SEK/kg CO2e, CO2e/employee, CO2e/ square meters of facilities. Such averages can also be divided into emission categories for comparison between categories to be available.

“ The board loves to be able to compare us to other similar universities, so we can see if we are better than them.”

“ If one were able to compare institutions at different universities, I think that would be interesting as well. It might lead to increased creativity regarding proposed actions”

GL7. Enable transparency regarding the path of the data

A system built upon estimations and assumptions should provide documentation regarding the methods used to allow the user to track the origin of the data. It enables the user to make accurate conclusions and make well-informed decisions based on an honest foundation. Every calculation made within the method used by Svalna comes with a set of estimations, which might vary in time and depend on the type of purchase. This comes to both calculations based on purchases made and calculations showing contributions of possible operational actions. Future users interviewed have expressed the importance of making this open to some extent. This guideline is not met within the prototype scope but is recommended to consider during further development. A link to a view in which the user could read and learn about Svalna's estimation method could be a first solution.

“ When working with scientists (..) I always need to be able to verify how I have reached my conclusions.”

GL8. Enable the possibility to export found insights

The users of the CI-system needs to share information from the system to external parts, such as Naturvårdsverket. They also need to share within the organization and would benefit from using the tool's visualizations as discussion or presentation material. This can be done on different levels. Pictures of the visualizations or a designed customized report for a certain purpose would both be useful. Communication within and to external parts is always important and sometimes even obligated for an organization. Other similar systems should therefore consider this kind of function as well.

“ To be able to get the data out from the system is important so that we can use

it when communicating and informing”

8

Results

The results delivered in this chapter include a final medium-fidelity prototype together with an explanatory description, a set of interaction design guidelines, and a set of nudging techniques suitable for such a system as the prototype simulates. The design guidelines and nudging techniques that are a part of the prototype will be highlighted in the prototype description.

8.1 Final prototype

The final prototype presented below is the result of several iteration sessions based on desires from the two main stakeholders for this project, the users and the company Svalna. It is built around the list of requirements created and has the aim to serve as a decision support system for organizations in order to improve their operational activities towards a more sustainable future. The description below connects to the reached requirements, as well as points out the design guidelines and the nudging techniques when implemented in the prototype.

8.1.1 The interface structure

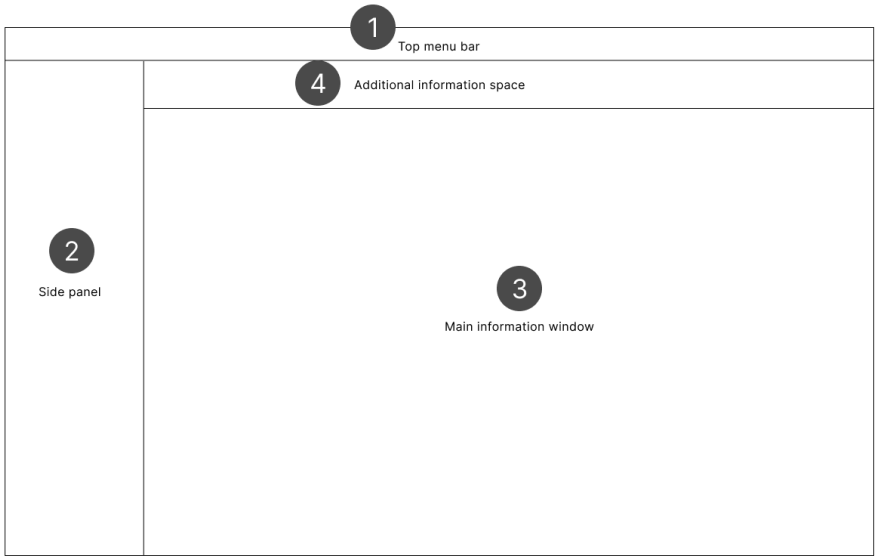

Figure 8.1: The overall structure of the prototype. 1. top menu bar 2. side panel 3. main information window 4. additional information space

Both main views of the prototype can be divided into four parts, presented in figure 8.1; top menu bar, side panel, main information window, and additional information space. *The top menu bar's* content will always be the same. It contains the links to the two main views, with the active one marked. The name connected to the account (name of organization or institution) will be presented next to links to a manage account-page and settings.*The side panel* holds different kind of lists, in which the user can make choices or filtrate on alternatives to manipulate the content in the main information window. *The main information window* contains visualizations of information. *The additional information space* is always reserved for information helpful when interpreting the visualizations in the main window, such as filter tags and a date stamp indicating on when the data was last updated (according to requirement 2.9, found on page 47). This date stamp is inline with GL5: Show when data was last updated. A drop-down menu of ways to export the current viewed information is presented here as well, which meets the requirement 2.10 (see page 47). This function is inline with GL8: Enable the possibility to export found insights.

8.1.2 Visualization modules

The two visualization modules designed to serve as a base for at least two types of data containers are presented below with English place holders.

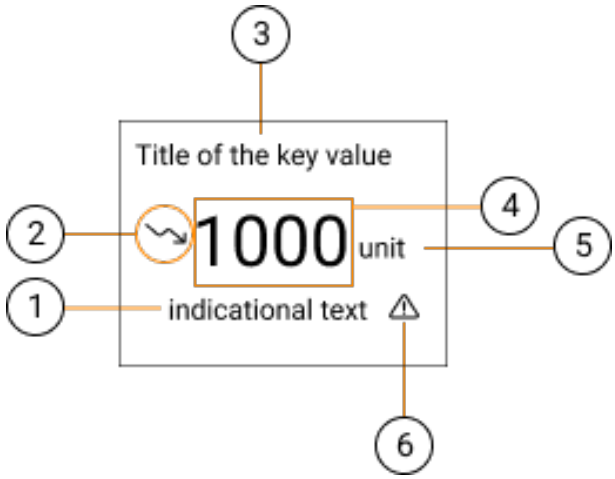

Figure 8.2: Final concept: Module 1
1. Descriptive text of indication (possible) 2. Indication icon (possible) 3. Title 4. Key value 5. Unit 6. Caution icon (possible)

Module 1 (figure 8.2) entails any kind of key value. The presence of some parts in the module is depending on what the key value is indicating, meaning they might not always be necessary. These are marked with *possible* in the caption of the module-figure. The descriptive text (1) aims to explain the development connected to the value if needed. E.g. it could hold information on how many percent the value has changed since the last update. The indication icon (2) aims to add additional visual understanding of the value if needed. This can be any kind of suitable descriptive icon. The cation icon (6) indicates that extra attention might be needed to this particular key value.

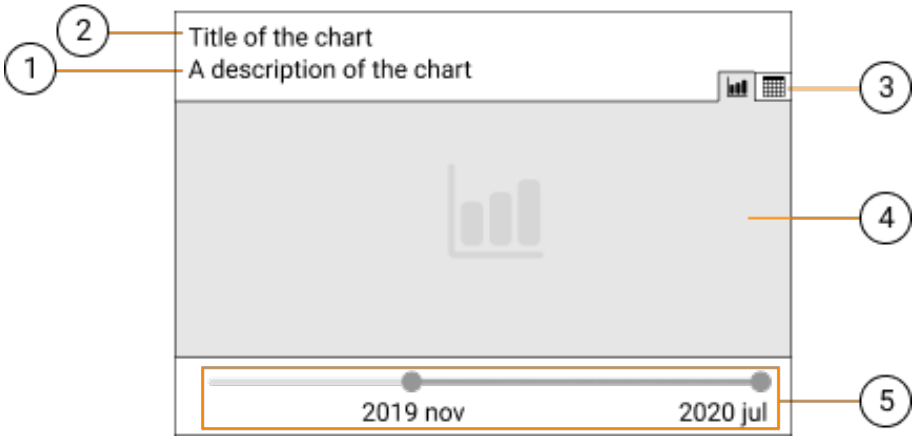

Figure 8.3: Final concept: Module 2
1. Description 2. Title 3. Tabs; display graph or table 4. Visualization as graph or table 5. Slide controls; change time interval

Module 2 (figure 8.3) entails graphs or tables and allows for some interactivity to alter the content. By activating either one of the tabs (3) a graph or table

representing the same data will be presented in the place holder. The time interval of the data can be altered by using the slide controls (5) at the bottom of the module. These visualizations are cards that will indicate the possibility to click on them when hovering over them. Clicking the title, description, or in any of the empty space within the module will open up the card and present additional data regarding the visualization (figure 8.4), for the user to be able to dig deeper in the data and zoom in on the visualizations.

These modules and additional visualizations are filled with information aiming to add to the user's stock of knowledge, making them more suitable to make well-informed decisions, hence open up for use of Nudging technique 1: *Educative nudges*.

Data regarding emissions within the visualizations should always be presented in carbon dioxide equivalent, according to requirement 1.11 (see page 46). The data should be updated as soon as new invoice data arrives at Svalna's end, which depends on the users themselves, but will most often be approximately every quarter of a year according to talks with Svalna, answering to requirement 1.10 (see page 46).

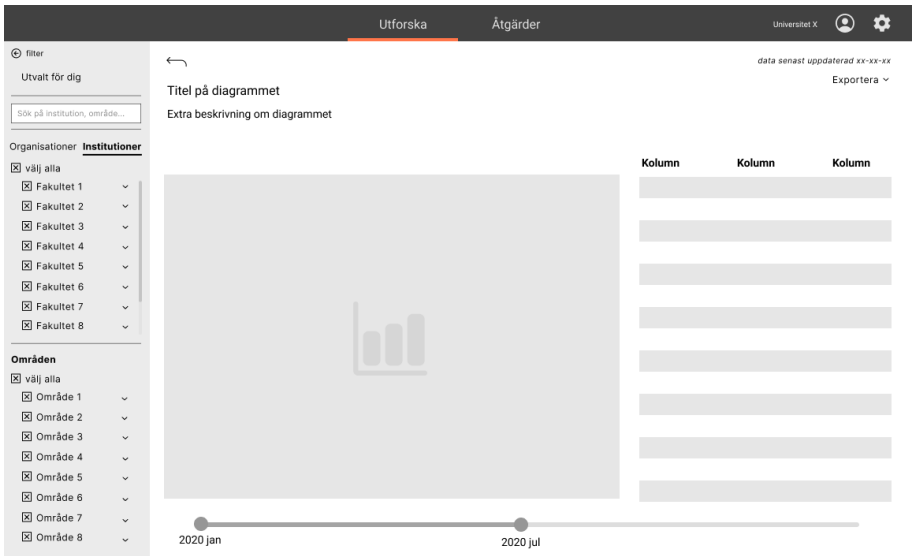

Figure 8.4: Final concept: The view when opening up a visualization card of module 2.

8.1.3 Explore-view

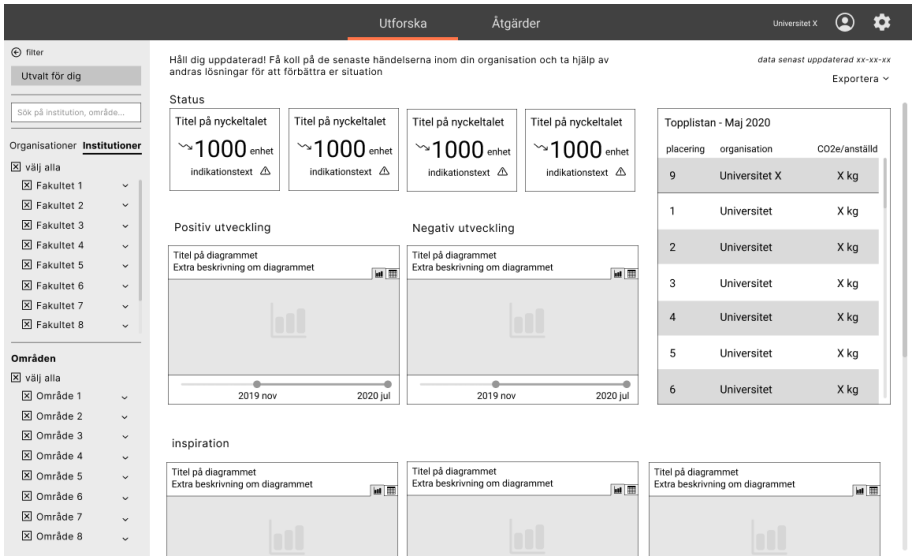

Figure 8.5: Final concept: The customized dashboard when the option *chosen for you* is active within the Explore-view

By default, the fist active view after log-in will be the customized dashboard under the Explore-view (figure 8.5). Having this view as default will make the data most available for the user. The risk for her to miss important data shown here is very small as it is the path with the least resistance (see the section on Nudging 7.7). This kind of customized data is useful for both kind of users, why it is suitable to show as default, according to GL1: Prioritize interface behavior according the the most common user-case, and GL2: Provide the user with a customized set of visualizations. The alternative *Utvalt för dig* (Chosen for you) at the top of the left side panel is active. This alternative is on its own and not possible to combine with the rest of the filter alternatives as it presents visualizations that may differ in categorizations and institutions. The visualizations are organized according to their purpose. At the top, there are valuable key values (key business indicators) indicating the status of the organization (user 1) or institution (user 2). The type of key values is a fixed set, always remaining the same in order to work as a reference, according to GL3: Provide a fixed set of key values or visualizations. Exactly what information for them to hold is out of the scope for this project. Some suggestions, based on the user research are the average kg CO2e / employee, the total level of CO2e polluted during this year, and a type of progress bar displaying how much is left of the total emission budget. Below the key figures are visualizations showing positive or negative developments. These will differ between use-sessions and could e.g. show the development in one particular category. They aim to make the user observant of possible risks or successes. Further down are inspirational visualizations, displaying any kind of change or information that is considered to be of use for this particular user. Visualizations could be of current developments from other organizations or institutions. A top list of all organizations registered in the tool will also be presented here to enable easy comparison and possibly increase moti-

vation. It is an example of how nudging technique 3: *Comparison with others* can be used, here, creating a fictional competition as well as putting the progresses on display. The user's organization will always be at the top even when scrolling for continuously available comparison. The unit representing emissions within the top list needs to be some sort of average in order for the comparison to make sense, according to GL6. Use units that make a comparison between organizations and departments possible. Different organizations have different conditions regarding the number and types of institutions, making the clean number of emission contributions not valuable for anyone else than themselves. For this cause, kg CO2e/employee is used here. This view serves the purpose of effectively presenting the user with status and development indications. This view aims to meet requirements 1.1, 1.4, 1.5, 2.5, 2.6, 2.8, and 3.1 (see pages 46-48). Nudging technique 6: *Presenting default views or visualizations* is used here, referring to the possible impact when displaying carefully chosen information which will affect the user without them making a single decision and just going with the path of least resistance.

Interaction with the filter alternatives, in the side panel, connected to institutions and categories will directly change the visualizations accordingly in the main information window. *Utvalt för dig* (Chosen for you) will no longer be marked as active (see figure 8.6) but a simple click on it will take the user back to the associated view.

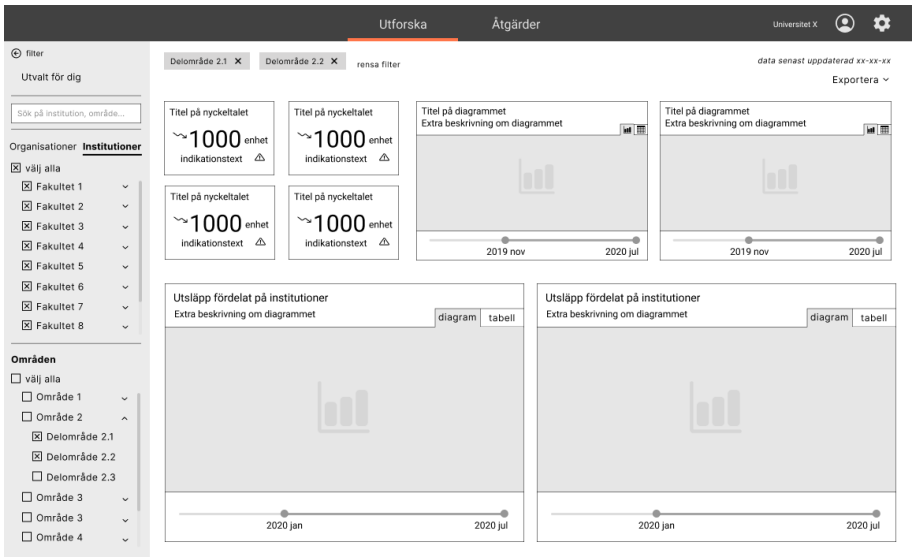

Figure 8.6: Final concept: Explore-view presenting where free exploring of data is made using the filtering.

Filtering is made through navigation among the two lists or search box in the side panel. The first list representing organizational division and the second representing emission categories. In the first list, the institutions-tab is by default active as it contains filter alternatives considered to be most commonly used. This design choice is inline with GL1. Prioritize interface behavior according the the most common user-case. The institutions are divided into faculties for the cause of easy navigation

and quick filtering. Clicking in the respective box of a faculty will select the entire faculty while clicking on the rest of the nearby area around the faculty name and arrow will open up the drop-down list of institutions. The second list of alternatives functions in the same way. The user is also able to tick or un-tick all alternatives at the same time on the (*välj alla*)-alternative at the top of every list. Only when starting to mark certain alternatives will filter tags be displayed accordingly in the additional information space. To clear filter (*rensa filter* in Swedish) will mean that all alternatives will be marked, showing data in the information window with no filtering. Filtering can also be made through the search box (figure 8.7). When the user starts to type, a list of matching alternatives will be presented from which the user can choose which to add to her filtering. This view aims the meet the requirements 1.2, 1.3, 1.6 1.7, and 1.8 (see page 46).

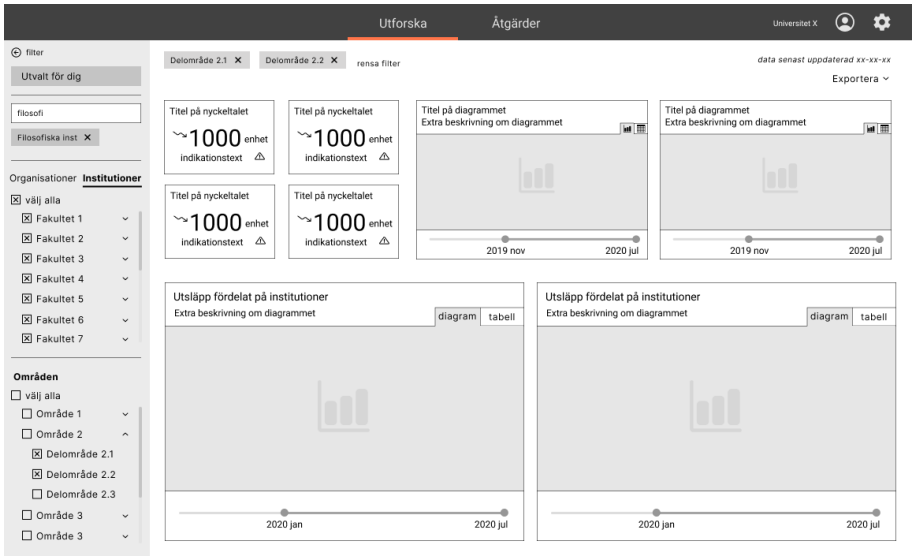

Figure 8.7: Final concept: Explore-view presenting a wire-frame when the filter search box is used.

Navigating to the organizations-tab in the side panel's first list, allows the user to zoom out one step and filter on and compare emissions between organizations instead (figure 8.8), which meets the requirement 2.5 (see page 47). As the two lists of alternatives are separated from each other this navigation will not affect the filtering already made in the second list. This function also keeps the user from having to redo her filtering, inline with a time-effective interface behavior.

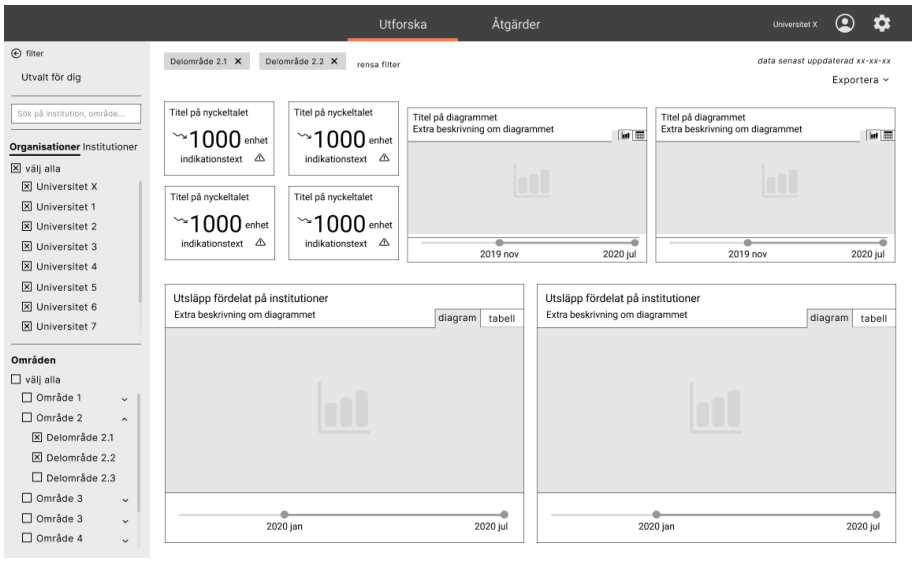

Figure 8.8: Final concept: Explore-view presenting the tab allowing the user to filter between organizations.

8.1.3.1 Edge cases

One of the edge cases considered in the prototype is when all filter alternatives are un-ticked. To follow the mental model of how a checkbox system work, no marked alternatives should mean the opposite from all alternatives marked. In this case, it means no chosen alternatives as in no data to show in the visualizations. The view (figure 8.9 will guide the user to alter her filtering in order to view the information in the main window. This behavior is inlinde with GL4: Guide user back to content if an empty state is reached.

Figure 8.9: Final concept: Explore-view when all alternatives have been un-checked and no visualizations are shown.

The second edge case shown in figure 8.10 is when almost all filter alternatives are chosen. To be consistent, the interface should display almost all filter tags. This is done through the possibility to extend the list of filter-tags. Extending the list will push down the visualizations below.

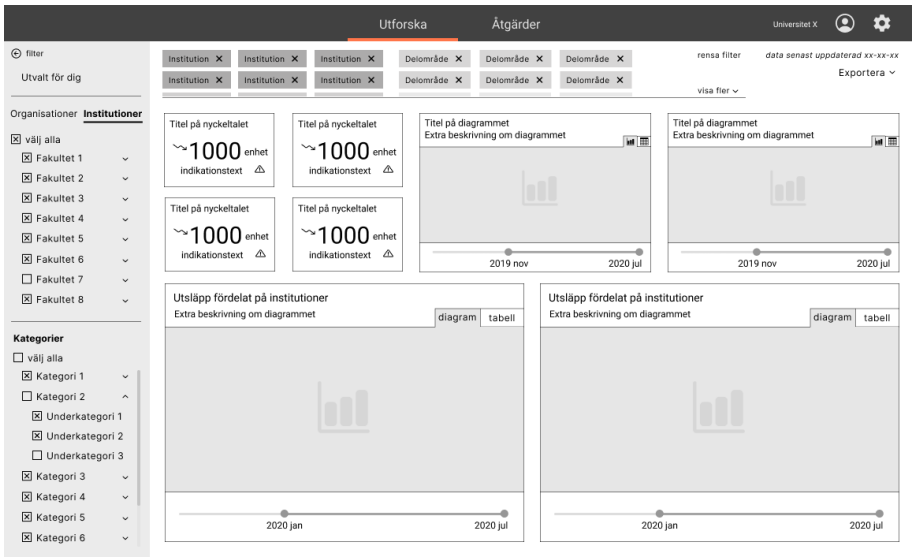

Figure 8.10: Final concept: Explore-view presenting an edge case where multiple filter tags must be shown

8.1.4 Actions-view

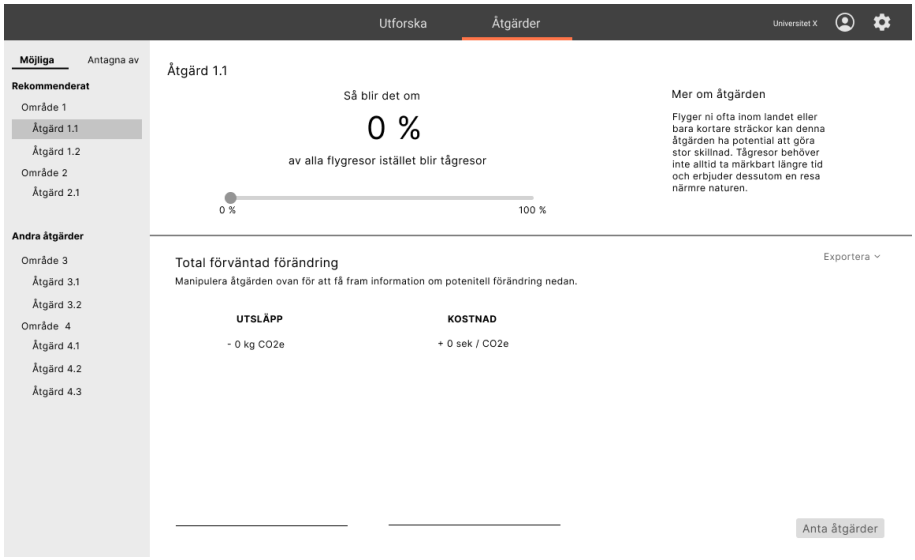

Figure 8.11: Final concept: Actions-view before any action has been manipulated.

By default, when navigating to the Actions-view the user will be positioned in the tab called *Möjliga* (Possible), representing the operational actions possible to commit

to within the system (figure 8.11. This list of actions is divided into recommended actions and other actions, as well as within emission categories for the user to have a structured overview. Recommended actions are the ones with the most potential based on the current situation of the organization/institution (meeting the requirement 2.7 found on page 47). This is also an example of how nudging technique 2: *Presenting recommendations* can be used, giving the user a first guidance. The first alternative in the list of recommended actions will be active which is directly affecting the upper view of the main window presenting additional information and a way of exploring the effect of the action. The lower window will remain the same until one action is being manipulated. Until then, it will present enough information for the user to understand what will be presented here and why. A descriptive text saying *"Manipulera åtgärden ovan för att få fram information om potetiell förändring nedan"*, in English *"Manipulate the above action in order for information regarding a potential change to show below"*.

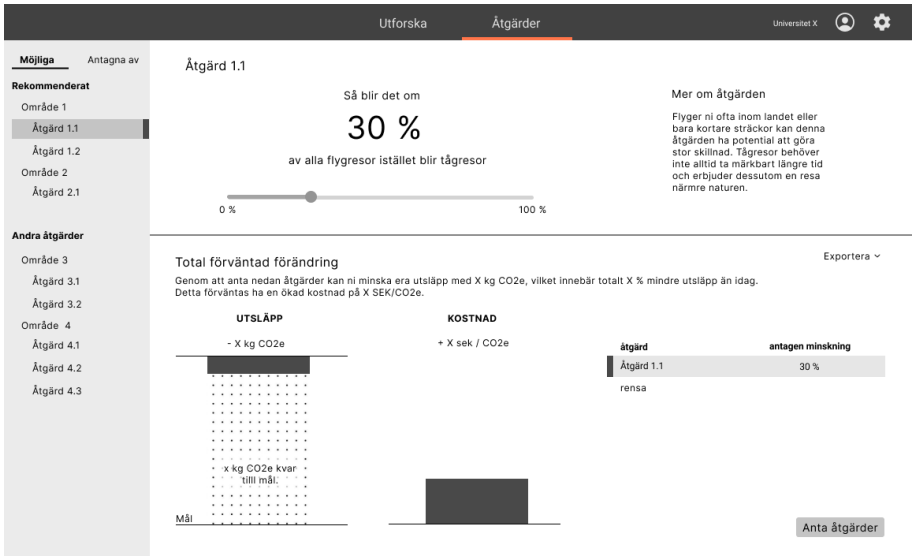

Figure 8.12: Final concept: Actions-view when one action has been manipulated

Adjusting the slide control will alter the percentage representing to what extent the action is to be taken. With this, according to the descriptive text, data will start to show in the lower part of the main window as shown in figure 8.12. It will show the savings of emissions and the economic cost as well as a list of (this far) manipulated actions.

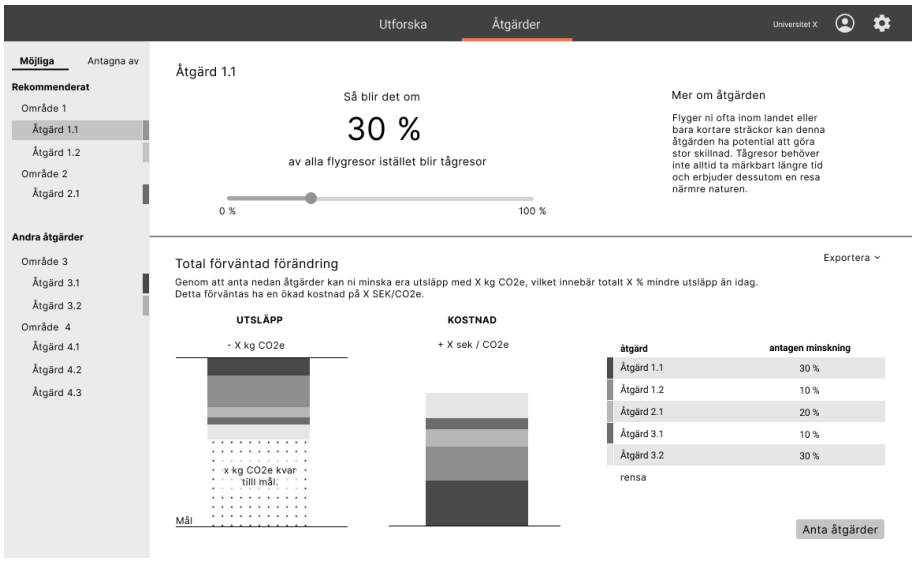

Figure 8.13: Final concept: Actions-view when several actions have been manipulated.

After having manipulated several actions, the contributions of these will add to the visualizations showing the total estimated change as shown in figure 8.13, meeting the requirements 1.9, 2.1, and 2.3 (see pages 46-47). All actions are color-coded to allow a clear overview and understanding of the contribution of each action. Additional information, such as values when hovering, within the visualizations will be needed for a full understanding of the data but was kept outside of the project scope. The list to the lower right provides an overview of the manipulated actions. It should be possible to edit or erase the actions directly in the list. The user can choose to export visualizations and data covering the actions she has manipulated, for external discussion or presentations. She can also choose to commit to the actions, which is done by clicking on the button in the lower right corner, *Anta åtgärder* (Take actions). This task is mostly connected to user 2 since she has a clear responsibility for the local operational actions. When clicking this button a pop-up will appear with a short summary describing what she commits to, as presented in figure 8.14. The pop-up message states in English *"With this, we will do our best to achieve these measures and reduce our negative impact on nature."* with the aim to have the user feel as if it is a written agreement, which she is to take seriously if committed to. This is connected to nudging techniques 4: *Making a commitment* as it reinforces the seriousness of the commitment. In the same way, it is also an attempt to create a memorable end in the user journey and thereby *Affect the memory of the user* which is nudging technique number 7.

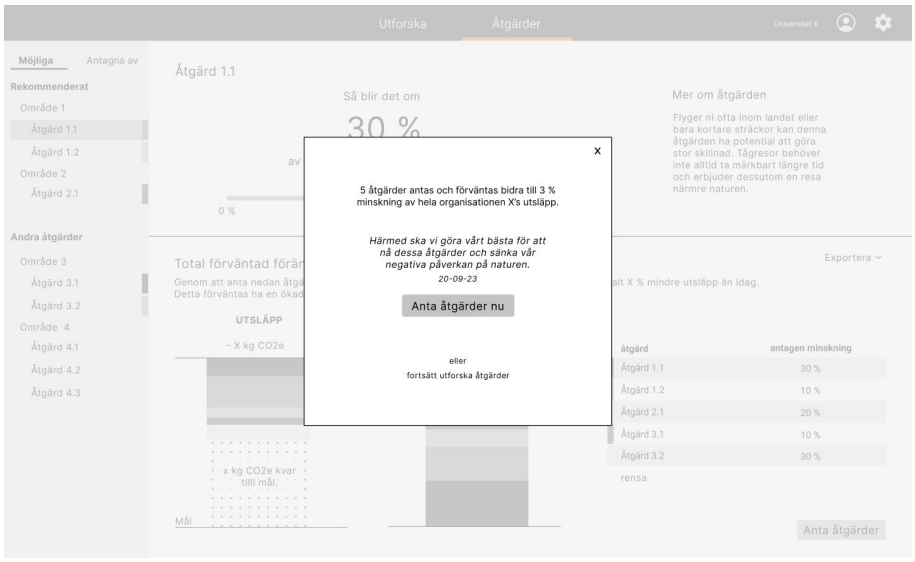

Figure 8.14: Final concept: Actions-view presenting the pop up when it is time for the user to commit to actions.

The second tab in the side panel, *Antagna av* (Taken by), takes the user to an overview of already taken actions within her organization along with a comparison of estimated contribution and actual contribution (figure 8.15), meeting the requirements 1.9, 2.1, 2.2, 2.3, and 2.4 (see pages 46-47). Through the use of the side panel, the user can filter among actions taken by institutions and actions taken on a central organizational level (the first alternative in the filter list). The user can also filter on a specific time interval presented above the list in the main window. The export function is available in this view as well, especially useful for user 1 in order to collect data of total potential impact from actions taken, which meets the requirement 3.2 (see page 48).

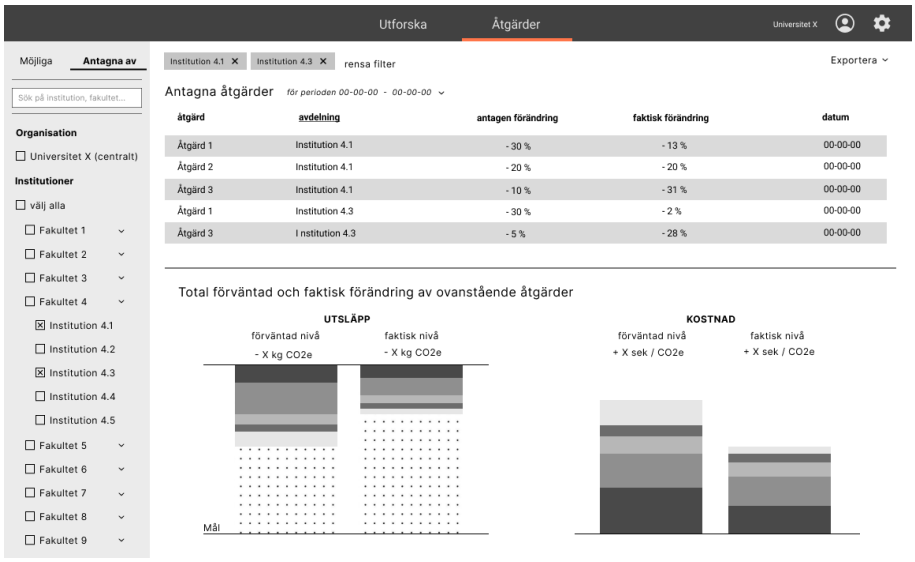

Figure 8.15: Final concept: Actions-view presenting the second tab containing actions already committed to.

8.2 Interaction design guidelines

Presented below is the final set of guidelines within the context of interaction design and decision support systems similar to the CI-system.

GL1. Prioritize interface behavior according the the most common user-case
Decision-supporting digital systems aiming to serve several types of users may contain paths towards several goals. Tasks required by the user might be desired for one user but would rather be skipped by another. Views and behavior of the interface that are according to the most common path of use should be prioritized for the system to be efficient for as many users as possible.

GL2. Provide the user with a customized set of visualizations.
The interface should help the user find useful and interesting information. To navigate and find information within graphs and tables is directly connected to the visual attributes. To make some data more salient than others, in favor of the specific user, will decrease her workload and simplify the path to her goal.

This guideline is connected to nudging technique 6: *Presenting default views or visualizations*. In the prototype they are represented by the same attributes since the customized visualizations are the ones shown by default. The customized visualizations aim to be a free guide, requiring no prior work from the user, towards making better decisions. Hence, it is suitable in this context for it to be a default view so the 'best' data always reach the user.

GL3. Provide a fixed set of key values or visualizations
For the user to interpret the presented data into valuable knowledge regarding the status of the organization, there needs to be a reference for comparison. Always presenting the same kind of data in the same way over time, will serve as this reference. The user will recognize it and be able to interpret the data more quickly than if it constantly changed in type or position.

GL4. Guide user back to content if an empty state is reached.
It should, as far as possible, be avoided to present an empty window showing no visualizations since this is a view without value for the user. Although, if an empty state is reached, the interface should guide the user to find her way back to useful information. The user should not be left alone with no clue why no content is shown or how to avoid it.

GL5. Always show when data was last updated
If a system receives data from another system in non-real-time, the user needs to know when it was last updated to minimize the risk of exploring the same data twice.

GL6. Use units that make a comparison between organizations and de-

partments possible
Organizations/departments differ in size, have a different number of employees, and different operational activities. This will affect their possibilities when working to lower their emission levels. Rightful comparison between them is therefore dependent on the right kind of units, being averages, such as SEK/kg CO2e, CO2e/employee, CO2e/ square meters of facilities. Such averages can also be divided into emission categories. This guideline is close connected to nudging technique 3: *Comparison with others*. For it to be possible to use this technique, this particular guideline is required.

GL7. Enable transparency regarding the path of the data
A system built upon estimations and assumptions should provide documentation regarding this to allow the user to track the origin of the data. It enables the user to make conclusions and take well-informed decisions based on an honest foundation.

This guideline is not met within the prototype scope, but is recommended to consider during further development. A link to a view in which the user could read and learn about Svalna's estimation method could be a solution.

Furthermore, the guideline is connected to the importance of showing truthful information and being transparent in the meaning of the visualizations. Nudging technique 1: *Educative nudges*, aims to be used in a way that goes together with this fact. The guideline is also connected to the right way of using nudging technique 7: *Affect the memory of the user*, which is in a non-deceiving way. That the decisions made thanks to the system are grounded in truthful and trustworthy data are by the author considered as more important than that decisions are made in the right direction but on wrong or unclear grounds.

GL8. Enable the possibility to export found insights
Often organizations are obligated to share information about their status and development to external parts. Being such a system that presents this kind of information, it should also allow for export. Even internal communication around the insights found in such a system will benefit from the possibility to export information.

8.3 Nudging techniques

Below follows a list of nudging techniques that are recommended to consider in the further development of the tool or when designing a similar system. They are presented in figure 8.16 and divided according to the categorization created by Hansen and Jespersen [27], which can be found in section 3.7.2.

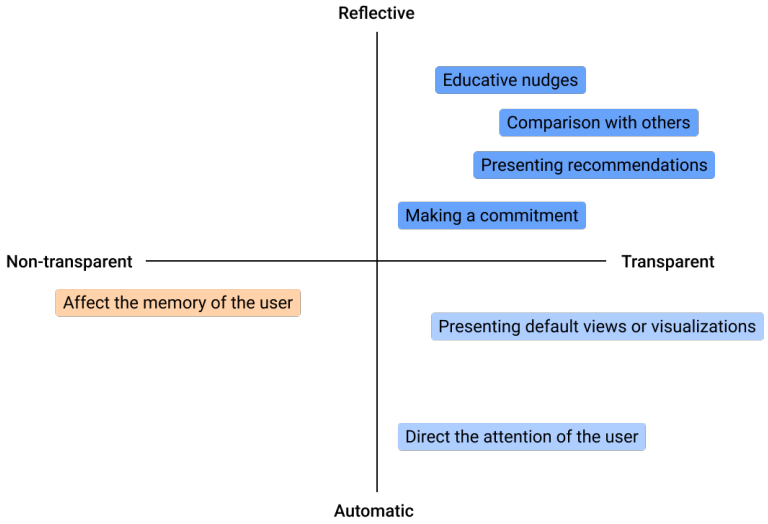

Figure 8.16: Nudging techniques positioned along the transparency and reflective/automatic axes.

The following nudges (NT1- NT4) aim to influence the user's reflective thinking towards a choice. They are presented upfront and not hidden from the user and are considered as *Reflective - Transparent*.

NT1. Educative nudges
Presenting the users with information and graphics that are adding to the users' stock of knowledge, making them more suitable to make well-informed decisions.

Risk: The designer of information graphics does always have a responsibility regarding the user's perception of it. As soon as it aims to influence the user, it is of high importance that the user understands in what direction it aims to push.

NT2. Presenting recommendations
Suggesting alternatives customized for the user in order to influence her attention and to help find for her suitable options. The interface should clarify that they are recommendations to keep the transparency.

Risk: If the interface is not transparent about the fact that certain alternatives are recommendations, it could be considered a non-reflective nudge that aims to manipulate rather than influence [16], increasing the responsibility for the designer.

NT3. Comparison with others
Creating a context where the progress of one is visible to another and vice versa can have a motivational effect towards improvement. Taking it one step further would be to create a fictional competition around the progress of development, ranking organizations in a top list.

Risk: This nudging technique has a risk of backfiring if the ones we compare ourselves

to are not living up to the goals, slowing us down with them.

Risk: Not everyone is motivated by contest. For example, the one in the top might feel contempt enough to subconsciously try less hard in the future. The same goes for participants in the bottom, who might feel less motivated since a place at the top seems unreachable. This has been seen in several studies summarized by Damgaard and Nielsen [49].

NT4. Making a commitment
Use the context of commitment-making to increase the effort of the user. A commitment can be perceived with different levels of seriousness.

Risk: Making the context of the commitment seem too serious might scare away users, leading to less commitment made and possibly even less tries towards living up to the terms.

The following nudges (NT5-NT6) aim to influence the behavior of a user in a certain direction. They are presented upfront and not hidden from the user and are considered as *Automatic - Transparent*.

NT5. Direct the attention of the user
Design visual features in the interface that makes desired parts of it more salient for the user, in order to have her navigate in a certain way and to notice important information.

Risk: It is important to also consider what the user's attention is directed away from, creating a possible risk of missing other valuable parts of the interface.

NT6. Presenting default views or visualizations
To influence the user's behavior within the system by taking advantage of the *The path of least resistance*. It could give value to the user's stock of knowledge, without requiring a choice from her.

Risk: The default choice or default view can for some users become an annoying attribute that always cares for extra interaction in order to avoid it.

The following nudge (NT7) falls into the category that aims to manipulate the behavior of a user in a certain direction. Its presence is hidden as a part of the UI and is therefore considered as *Automatic - Non-transparent*.

NT7. Affect the memory of the user
Intentionally make use of the peak-end rule, and especially consider what the user experiences during the most intense points and the final moment of the user journey.

Risk: The difficulty to balance on the right side of highlighting parts of the user's memory and manipulating it towards something false.

Risk: To emotionally affect the experience of the user cares for reflection regarding ethics and what the user of such a system has signed up for before using it.

9

Discussion

The following chapter holds a discussion around the thesis, covering aspects within its execution and process, its result including considerations of inclusion of nudging in decision supporting tools such as the one presented as a result. The chapter also suggests directions for future work.

9.1 Execution and process

9.1.1 Considerations on running online co-creation workshops

Time estimations of parts included in the virtual co-creation workshop turned out to be insufficient leading to delays in schedule. The last part, where ideas were to be evaluated and ordered into categories became especially affected. It had to be made quickly and without a walkthrough in the end. Since the sharing of ideas between ideation sessions was planned, it opened up for the possibility to start to discuss and evaluate even if this was not the plan. Therefore this part took more time than scheduled for.

When planing the workshop it was considered that conducting it online would lead to possible difficulties regarding facilitation, comparing to when conducted in the same room as the participants. Even so, it is hard to be completely prepared. The workshop could have benefited from having one or several co-helpers. To keep the conversation within the right frames according to schedule, be observant for arising ambiguity or confusion, and prepare for the upcoming task were difficult for one single facilitator to handle. Tasks we're kept more simple and the explanatory introduction was thorough end extensive due to consideration of this fact. Although, it led to the facilitator being less involving, of which the effects are difficult to estimate in retrospect.

Much of the thoughts brought up by participants had already been lifted in the earlier conversations (e.g. during interviews). A less wide "How might we..."-question as a starting point could have had a positive effect on this outcome. Having a broad question made the ideation space broad which led to the discussion jumping a bit

between different parts of the future tool, never going deep in any area. This might have affected the efficiency and clearness of the workshop negatively. On a positive note, a wider part of the tool functionality was handled due to the current approach.

Overall, the workshop gave value to the project and the participants voted a four (on a one-to-five scale) on average regarding their overall experience. Since the workshop was recorded, parts from the discussion could be picked up afterward.

9.1.2 Validation of the final prototype

Usability testing with real users would have been a good compliment to the expert reviews when evaluating the prototype. Due to time restrictions, usability tests had to be pushed outside of the project scope. Due to the pandemic situation, arranging with online tests would have been necessary which unfortunately would have been more time-consuming. Asking users to meet with them in person was considered not ethically right since it might have put them in a difficult position. This decision lead to users not taking part in the later evaluation parts of the project. One might, therefore, consider the user-centered approach only to be vaguely maintained.

9.2 Result

9.2.1 Including operational actions within the prototype

It might be difficult to interpret the meaning of the percentage used to set what extent an operational action will be committed to. This depends on the qualities of the actions and since these are not set yet, it is difficult to reason around in a current state. Difficult to interpret or not, it could still give a valuable, yet vague, indication of what changes are possible to make thanks to the connected estimations. On the other hand, when it comes to committing to actions, it is a necessity to understand the effects of them. The commitment will be hard to make otherwise, and if still made, it is not to be count on. Question marks as these need to be investigated further.

One reason to have actions possible to take within the system is the ability to further track the effect of them and present for the user. Other actions, that are not possible for the system to track, but yet desirable for the user to commit to, will therefore not be a part of the tool. In other words, the users still need to have an external way of keeping track of some actions. There is a possibility of this adding to the workload of the users which needs to be investigated further as it is not desirable.

9.2.2 How well the prototype meets the requirements

Some requirements stated in the list (see section Defining: Needs and requirements 7.4.3) was not mentioned in the result as "met". The reason for this is partly because they would lead to an increased complexity within the prototype which was not considered suitable based on the time available. The current prototype is

not considered to preclude the presence of attributes meeting these requirements in any later version. This mainly applies to requirements 1.12, 1.13, 2.12, and 3.3.

Another reason behind the exclusion of requirements is that they are closely connected to the underlying data and the back-end of the designed system which is not within the project scope. They were kept in the presented list of requirements due to their potential in still influencing the design work within the scope. This mainly applies to requirements 1.14, 2.11, and 2.13.

9.2.3 Including nudging techniques

The discussion about the use of nudging to influence human behavior or decision-making seems to have been ongoing since the term first was coined by Thaler and Sunstein [6]. They say it should be used in favor of the user and society as a whole. But it is far from always easy to know what is 'in favor', even objectively. Our society is split into several groups with different opinions about what is objectively best for us. What is best for society may not be the best for the individual. Or is it? I would argue that it depends on how far the question is taken. The time aspect makes a huge difference. What is considered best for an individual today may not be the best over time. This kind of thinking raises a lot of questions about the use of nudging. As for this thesis, I believe, as with many other cases, that the idea of nudging can be useful, despite the unclear definition. As long as the designers of the nudges, to their best ability, leave out manipulation as an ingredient. Even if manipulation can be used towards the "right direction", the word implies non-transparency and might, despite the reason, become unpleasant for the user as it keeps her from being in the driver's seat. Then again, how can you be sure that a user does not feel manipulated?

All designs influence the user. Nudging takes it one step further with an agenda that stretches further than the use of an interface. This cares for more consideration and realizing the power in the responsibility.

9.3 Future work

First of all, evaluation with real users needs to be done on the prototype. Since the prototype is currently considered to be between low and high fidelity, more design work is necessary in order to create a true high fidelity prototype that can be developed and connected to the system running in the background. Part of this work is to decide on specific graphs and visualization to hold the data. Svalna already has a graphic profile which is to be included in the further development of the CI-system.

The user wants to be able to compare levels of emission to their goal as a reference to how they are doing. This means their goal(s) over a certain time interval need(s) to be implemented in the system in some way. If this should be done by the users themselves or by the developers (at least in an early version) needs to be decided.

Additional views of the tool need to be designed, such as a log-in page and documentation regarding the method used for making estimations on emission contributions. The last one should be included in order to meet the need for the users to understand the presented information as much as possible.

Some attributes being a part of the prototype in iteration phase 2, e.g. the worktable, the ability to create own dashboards, or to save one's filtering, could be reconsidered and through further iteration, involving the users, possibly be included in a later version of the tool.

The use of nudging within the tool could be further investigated with help from the list of techniques presented in this report. The impact of such attributes needs to be carefully considered and tested before fully implemented.

The function of being able to explore possible operational actions needs more background work before being implemented. Research regarding exactly what actions are reasonable to include must be done and validated with users. Svalna's existing tool, The climate vision (presented in section 2.1.2), are to be used as inspiration.

As a big part of the user's (especially user 1) every day, tasks is to communicate the status of the organization and the opportunities and risks with its operational development, more consideration regarding the export function could be done. To export a view does not necessarily mean that exactly the already presented view will be exported. Additional data contributing to the overall understanding of the chosen information might be included as well. During interviews, it was mentioned that report-like exportation of data could be desirable. The less hands-on work is needed from the user before the information is shared, the better.

10

Conclusion

The research question(s) answered in this master's thesis work is:

What factors should be considered when designing an interactive system built around an organization's greenhouse gas emission data to support well-informed decisions on operational activities?

With the two supporting questions:

- What strategies within interaction design can be used to support visualizations of organizations' emission data?
- What nudging techniques can be used to influence the decision-making within an organization towards reduction of their greenhouse gas emissions?

This thesis work has its roots from a method by the company Svala, where they do estimations regarding the Carbon dioxide contribution caused by an organizations purchases. The input is invoice data and the output is kg carbon dioxide equivalents. Higher educational institutions in Sweden have high goals on their reduction of GHG emission and in order to reach them and make well-informed decisions, they need to understand where in the organization the potential for change lies.

The purpose of this thesis study is to contribute to the field of supporting organizations in their decision-making regarding operational activities towards a reduction of GHG emissions. This has been done through the development of a desktop tool which is to expand the understanding of the cause behind emission levels. The scope of this thesis work includes user research, defining user types, user stories, and requirements for the tool, ideating and prototyping on a design proposal of such a tool, as well as evaluating it from a UX point of view. The future users, that have been participating though out this project, work in higher educational institutions in Stockholm and Gothenburg, meaning it is within this type of organization that the result has been verified. Furthermore, contribution to said context have been made through the formulation of eight interaction design guidelines that are to serve

as a future guide in the development of above and similar decision-support systems. These guidelines are grounded in the thesis work and found from user-research and emerging discussions with stakeholders as well as during evaluation sessions. Theory of nudging has been researched to find suitable techniques that can be used to influence the users' interpretation of the system's content and their decision-making in the direction of GHG emission reduction. These highlighted techniques aims to serve as a first step in the process towards the use of technology-mediating nudging directed to influence decisions regarding operational activities in an organization.

From the user research, two main user types was found, both of which needs are considered throughout the project. The first, *the environmental strategist*, works at a central level in a HEI and works full-time with keeping track on the emission contribution while improving overall operations in favor of lowering this contribution. The second, *institutional environmental representative*, works at a local level in a HEI and has the responsibility for the planning and conduction of the operational sustainability work within an institution. He usually works part-time with these tasks.

The prototype developed serves two main purposes. *The first purpose* is to allow the user to explore and dig deeper within the emission-data. This can be done through a set of visualizations in which the data can be filtering on emission categories and on organisational divisions. The system also includes a set of customized visualizations that are put together in favor for the user's division, indicating on their current status, emerging trends that needs attention and inspirational developments within other divisions or organizations. *The second purpose* is to allow the user to explore the hypothetical emission and economical contribution that a certain operational action would mean. The user is also able to commit to these actions within the tool, with the aim to create a stronger engagement as well as allow the first user to gather data regarding all actions committed to within the organizations (or chosen divisions). This prediction of their future status can be used in when planning for necessary operational changes, increasing their chance of reaching goals in time.

Bellow follows *the final set of design guidelines* within the context of decision support systems that aim to help organizations regarding their operational activities towards decreasing their GHG emissions:

GL1 Prioritize content that is valuable for the broader user group

GL2 Provide the user with a customized set of visualizations

GL3 Provide a fixed set of key values or visualizations

GL4 Guide user back to content if an empty state is reached

GL5 Always show when data was last updated

GL6 Use units that make comparison between organizations and departments possible

GL7 Enable transparency regarding the path of the data

GL8 Enable the possibility to share found insights to external parts

The nudging techniques, suggested to further investigate the use of, are the following:

Reflective - Transparent

NT1. Educative nudges

NT2. Presenting recommendations

NT3. Comparison with others

NT4. Making a commitment

Automatic - Transparent

NT5. Direct the attention of the user

NT6. Presenting default views or visualizations

Automatic - Non-transparent

NT7. Affect the memory of the user

References

[1] World health organization. *Climate change and health*. URL: https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health. (accessed: 02.03.2020).

[2] Anthony Barnosky et al. "Has the Earth's Sixth Mass Extinction Already Arrived? Nature". In: *Nature* 471 (Mar. 2011), pp. 51–7. DOI: 10.1038/nature09678.

[3] The United Nations. *17 Goals to Transform Our World*. URL: https://www.un.org/sustainabledevelopment/. (accessed: 13.04.2020).

[4] Ministry of the environment. *The climate policy framework*. URL: https://www.government.se/articles/2017/06/the-climate-policy-framework/. (accessed: 09.04.2020).

[5] Tobias Mirsch, Christiane Lehrer, and Reinhard Jung. "Digital nudging: Altering user behavior in digital environments". In: *Proceedings der 13. Internationalen Tagung Wirtschaftsinformatik (WI 2017)* (2017), pp. 634–648.

[6] Richard Thaler and C. Sunstein. *NUDGE: Improving Decisions About Health, Wealth, and Happiness*. Vol. 47. June 2009. ISBN: 9780141040011.

[7] Linscott Ross Andersson David and Nordborg Maria. *Förstudie: Stockholms universitets klimatavtryck från inköp av varor och tjänster*. URL: https://www.svalna.se/sites/all/themes/svalna_wa/i/su_rapport.pdf. (accessed: 09.10.2020).

[8] Cambridge. *Meaning of organization in english*. URL: https://dictionary.cambridge.org/dictionary/english/organization. (accessed: 13.03.2020).

[9] Världskulturmuseerna. *Om forskningsprojekten i utställningen*. URL: http://www.varldskulturmuseerna.se/varldskulturmuseet/aktuella-utstallningar/human-nature/om-forskningsprojekten-i-utstallningen/. (accessed: 05.04.2020).

[10] International climate panel. *GLobal warming of 1,5 ºC*. URL: https://www.ipcc.ch/sr15/. (accessed: 31.03.2020).

[11] Hörstedt Fredrik. *Klimatramverk för svenska lärosäten*. URL: https://www.chalmers.se/sv/om-chalmers/chalmers-for-klimatet/klimatramverk/Sidor/default.aspx. (accessed: 09.10.2020).

[12] KTH and Chalmers. *KLimatramverket - vägledning för universitet och högskolor*. URL: https://www.chalmers.se/SiteCollectionDocuments/om%5C%20chalmers%5C%20dokument/Chalmers%5C%20f%5C%C3%5C%B6r%5C%20en%

5C%20h%5C%C3%5C%A5llbar%5C%20framtid/190522_A4_Klimatramverk_V%5C%C3%5C%A4gledning_SV.pdf. (accessed: 09.10.2020).

[13] Fredrik Gröndahl and Magdalena Svanström. *Hållbar utveckling-en introduktion för ingenjörer och andra problemlösare*. Jan. 2011. ISBN: 978-91-47-09348-9.

[14] Rebecca Lindsey. *Climate Change: Atmospheric Carbon Dioxide*. URL: https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide. (accessed: 11.03.2020).

[15] Rebecca Henderson, Ranjay Gulati, and Michael Tushman. *Leading sustainable change: An organizational perspective*. OUP Oxford, 2015.

[16] Ana Caraban et al. "23 Ways to Nudge: A Review of Technology-Mediated Nudging in Human-Computer Interaction". In: *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. CHI '19. New York, NY, USA: Association for Computing Machinery, 2019. ISBN: 9781450359702. DOI: 10.1145/3290605.3300733. URL: https://doi.org/10.1145/3290605.3300733.

[17] Helen Sharp, Yvonne Rogers, and Jennifer Preece. *Interaction Design. Beyond Human-Computer Interaction*. June 2019. ISBN: 978-1-119-54725-9.

[18] Online Browsing Platform (OBP). *ISO 9241-210:2010(en) Ergonomics of human-system interaction — Part 210: Human-centred design for interactive systems*. URL: https://www.iso.org/obp/ui/#iso:std:iso:9241:-210:ed-1:v1:en. (accessed: 30.09.2020).

[19] Ashley Williams. "User-Centered Design, Activity-Centered Design, and Goal-Directed Design: A Review of Three Methods for Designing Web Applications". In: *Proceedings of the 27th ACM International Conference on Design of Communication*. SIGDOC '09. New York, NY, USA: Association for Computing Machinery, 2009, pp. 1–8. ISBN: 9781605585598. DOI: 10.1145/1621995.1621997. URL: https://doi.org/10.1145/1621995.1621997.

[20] Interaction Foundation. *User-centered design*. URL: https://www.interaction-design.org/literature/topics/user-centered-design. (accessed: 09.03.2020).

[21] Jakob Nielsen. *Usability Engineering*. Jan. 1993. ISBN: 978-0-12-518405-2.

[22] Interaction Foundation. *Information Visualization*. URL: https://www.interaction-design.org/literature/topics/information-visualization. (accessed: 13.03.2020).

[23] Colin Ware. *Information Visualization, perception for design*. Elsevier, 2013. ISBN: 978-0-12-381464-7.

[24] David Kirsh and Paul Maglio. "On Distinguishing Epistemic from Pragmatic Action". In: *Cognitive Science* (Oct. 1994), pp. 513–549. DOI: 10.1016/0364-0213(94)90007-8.

[25] John Jonides. "Voluntary versus automatic control over the mind's eye's movement". In: 1981.

[26] Daniel Kahneman. *Thinking, fast and slow*. New York: Farrar, Straus and Giroux, 2011. ISBN: 9780374275631. URL: https://www.amazon.de/Thinking-Fast-Slow-Daniel-Kahneman/dp/0374275637/ref=wl_it_dp_o_pdT1_nS_nC?ie=UTF8&colid=151193SNGKJT9&coliid=I3OCESLZCVDFL7.

[27] Pelle Guldborg Hansen and Andreas Maaløe Jespersen. "Nudge and the manipulation of choice: A framework for the responsible use of the nudge approach to behaviour change in public policy". In: *European Journal of Risk Regulation* 4.1 (2013), pp. 3–28.

[28] Daniel Hausman and Brynn Welch. "Debate: To Nudge or Not to Nudge*". In: *Journal of Political Philosophy* 18 (Nov. 2009), pp. 123–136. DOI: 10.1111/j.1467-9760.2009.00351.x.

[29] C. Sunstein. "People Prefer System 1 Nudges (Kind Of)". In: *Duke Law Journal* 66 (Oct. 2016).

[30] Sandro Ambuehl, B. Douglas Bernheim, and Annamaria Lusardi. "The Effect of Financial Education on the Quality of Decision Making". In: 2014.

[31] Yu Siang Teo Rikke Friis Dam. *5 stages in the Design Thinking Process*. URL: https://www.interaction-design.org/literature/article/5-stages-in-the-design-thinking-process. (accessed: 06.04.2020).

[32] Bruce Hanington and Bella Martin. *Universal methods of design: 100 ways to research complex problems, develop innovative ideas, and design effective solutions*. Rockport Publishers, 2012. ISBN: 9781592537563.

[33] Brad Dalrymple. *Competitive Analysis. User research resources for beginners and pros*. URL: https://medium.com/user-research/competitive-analysis-b02daf26a96e. (accessed: 03.03.2020).

[34] Victor Jupp. *The SAGE Dictionary of Social Research Methods*. 2006. ISBN: 9780857020116. DOI: 10.4135/9780857020116.

[35] Claudia Bruen and Laura Valis. *The Power of Triangulation in Design Research*. URL: https://medium.com/design-voices/the-power-of-triangulation-in-design-research-64a0957d47d2. (accessed: 09.03.2020).

[36] Johnny Saldaña. "Chapter 1: An introduction to codes and coding". In: *The coding manual for qualitative researchers* (Jan. 2009), pp. 3–21.

[37] Mary Beth Rosson and John M Carroll. "Scenario based design". In: *Human-computer interaction. boca raton, FL* (2009), pp. 145–162.

[38] Interaction Design Foundation. *User Stories - Capturing the User's Perspective Quickly and Simply*. URL: https://www.interaction-design.org/literature/article/user-stories-capturing-the-user-s-perspective-quickly-and-simply. (accessed: 17.08.2020).

[39] Muriel Garreta Domingo. *User Stories: As a [UX Designer] I want to [embrace Agile] so that [I can make my projects user-centered]*. URL: https://www.interaction-design.org/literature/article/user-stories-as-a-ux-designer-i-want-to-embrace-agile-so-that-i-can-make-my-projects-user-centered. (accessed: 17.08.2020).

[40] Sarah Gibbons. *Journey Mapping 101*. URL: https://www.nngroup.com/articles/journey-mapping-101/. (accessed: 12.08.2020).

[41] Rikke Friis Dam and Teo Yu Siang. *Brainsketching: Collaborative Interaction Design*. URL: https://www.interaction-design.org/literature/article/learn-how-to-use-the-best-ideation-methods-brainstorming-braindumping-brainwriting-and-brainwalking. (accessed: 12.08.2020).

[42] Jay Vidyarthi. *Brainsketching: Collaborative Interaction Design*. URL: https://uxpamagazine.org/brainsketching/. (accessed: 12.08.2020).

[43] Yu Siang Teo Rikke Friis Dam. *Define and Frame Your Design Challenge by Creating Your Point Of View and Ask "How Might We"*. URL: https://www.interaction-design.org/literature/article/define-and-frame-your-design-challenge-by-creating-your-point-of-view-and-ask-how-might-we. (accessed: 06.04.2020).

[44] Vladlena Belozerova. *The Why, How, and When of Co-Creation During the Product Development Process*. URL: https://www.bresslergroup.com/blog/the-value-of-co-creation-in-the-product-development-process/. (accessed: 13.04.2020).

[45] David Griffith-Jones. Apr. 2020.

[46] *Four-Categories-Method*. 2020. URL: https://public-media.interaction-design.org/pdf/Four-Categories-Method.pdf. (accessed: 12.08.2020).

[47] Rex Hartson and Pardha Pyla. *The UX Book: Process and Guidelines for Ensuring a Quality User Experience*. 1st. San Francisco, CA, USA: Morgan Kaufmann Publishers Inc., 2012. ISBN: 0123852412.

[48] Aurora Harley. *UX Expert Reviews*. URL: https://www.nngroup.com/articles/ux-expert-reviews/. (accessed: 12.08.2020).

[49] Mette Damgaard and Helena Nielsen. "Nudging in education". In: *Economics of Education Review* (Mar. 2018). DOI: 10.1016/j.econedurev.2018.03.008.

[50] James O Prochaska and Wayne F Velicer. "The transtheoretical model of health behavior change". In: *American journal of health promotion* 12.1 (1997), pp. 38–48.

A

Appendix - Interview template

Following appendix contains an example of an interview template used in one of the three first interviews, with users of type 1, the empathize phase.

Innan möte: Skicka över ett formulär där de skriver på att jag får spela in dem och hur jag kommer använda infon jag får.

*Ge info om vad jag vill få ut av mötet: Som du vet jobbar jag tillsammans med Svalna med att ta fram ett Business intelligence systemet som fokuserar på utsläpp, som då förhoppningsvis i framtiden kan vara till hjälp i ert arbete mot att minska utsläppen. Varför?

- Få en bild av hur ert arbetssätt ser ut idag
- vad som krävs för att ett beslut ska tas
- vilken information ett sånt beslut måste grunda sig i
- förhoppningar och tankar kring det här verktyget

INTE för att jag på något vis ska döma ert arbete eller målen ni har osv. MÅLET är att verktyget ska passa er och andra organisationer som eran, så att ni har användning för det.

Samtyckesformuläret. Allt va ok? Ta emot det.

FÅ EN BILD AV DERAS ROLL OCH GRUPPENS ARBETSSÄTT

- Din roll kallas miljöcontroller. Kan du berätta vad den rollen innebär?

- Hur länge har du haft den rollen?

- Ni som arbetar med miljöfrågorna, hur är det teamet uppbyggt? Befattningar, antal? (I själva beslutstagandet)

- Vilka ramverk och strategier (mål) jobbar ni med i ert dagliga arbete? (FNs globala hållbarhetsmål, SU's åtgärdsplan)

- Hur stor plats i dagliga arbetet?

- Vem tar fram de klimatmål ni har idag?

- Hur ser processen ut?

- Har ni några mål idag som kräver specifika siffror?

- Hur utvärderar ni ifall ni lyckats att nå målen?

- Vad händer ifall man misslyckats med någon del?

- Har det hänt? Exempel?

- Upplevt att ni behöver övertyga för att få igenom mål/plan/förslag?

- Vad ser du som det största besväret med att förändra verksamheten idag till fördel för minskat klimatavtryck?

- Hur har SU koll på sitt koldioxidutsläpp idag? Mäter? Vilka kategorier?

- Varför har ni valt att inte vara en del av klimatramverket som KTH och Chalmers tagit fram?

KOMMUNIKATION OCH VERKTYG

- Hur kommunicerar ni kring miljöfrågorna? Möten? Mail? Hur/var lägger man fram ett förslag?

- Används några verktyg idag? Digitala, analoga.

EXTERN KOMMUNIKATION/RESEARCH

- Med vilka andra organisationer samarbetar SU?

- Hur ser de samarbetet ut? jämförelser?

- Tar ni inspiration till hållbara förändringar någonstans ifrån?

FÖRHOPPNINGAR PÅ SYSTEMET

- Har ni några förväntningar på vad ett sådant system skulle kunna hjälpa till med ?

- Dröm fritt, utan begränsningar. Vad hade du velat få ut av systemet?

- Hur skulle du vilja kategorisera utsläppen?

- Vilka ser du skulle kunna använda detta verktyget inom organisationen SU?

AVSLUTA:

Har du några funderingar till mig?
Min plan nu är att jag ska fortsätta samla in information om behov och sen arbeta fram förslag på systemet. De här förslagen vill jag ju hemskt gärna validera med er framtida användare. Skulle du vara intresserad av att va till hjälp då också? Närmare sommaren. Ni kommer höra mer från oss. Hör gärna av dig om du har tankar eller frågor om något. vad som helst! Andra kontakter? (Någon som dykt upp i samtalet innan)

B

Appendix - Expert reviews template

Following appendix is mainly in Swedish due to the expert reviews being held in this language.

Give info about the prototype level and how the review will work

Why? For the user to understand where in the entire design process we are right now. Since the user has knowledge about the process and the different levels of prototypes, this type of explanation can serve a purpose better than compared to if users with no UX knowledge would be participating.

Prototypen är i stadiet Medium fidelity. Det jag vill testa är övergripande navigering, kontroller, filterfunktionen, en del feedback, tydligheten i möjligheterna med gränssnittet. Det jag inte testar är look and feel på nivå av färg, font, exakta placeringar, storlekar, ordval. Jag testar inte heller visualiseringar, grafer eller dylikt. Dock finns grova skisser på några grafer, i ett försök att höja nivån av feedbacken i denna prototyp och skapa något slags innehåll att reagera på. Istället för riktiga visualiseringar med grafer har jag skapat moduler för visualiseringarna som inkluderar en del interaktion, vilket jag även det vill ha din input på. Det är bara delar ("rätt väg") av prototypen som är interaktiv. När det är dags att interagera med dem kommer jag säga till. Därför kommer testet till största del bestå av ett samtal kring stilla frames utan "spontanklickningar". Jag kommer ge dig en mindre uppgift i taget och ställa frågor angående hur du vill lösa dem. Det kommer bli mycket Vad tänker du att du ska göra? Varför? Vad tror du kommer hända? Hände det du trodde skulle ske?, samt tankar om förbättringar.

Give information about the fictual user and context

Why? For the user to get into the context and a better idea of the background of the actual user, why the UI should be used, and what the goal is.

Låt experten läsa igenom följande:

Vem är du, vad gör du och vad vet du?
Du jobbar som hållbarhetsstrateg på ett universitet. Det innebär att du har en central roll som gör dig och dina kollegor till spindlarna i nätet när det kommer till hållbarhetsarbetet på hela organisationen.

Några av dina huvuduppgifter är att:

- ta fram mål
- följa utvecklingen mot satta mål
- rapportera kring utvecklingen internt samt externt
- ha kontakt med miljörepresentanter på universitetets institutioner och fakultet samt att se till så att dessa tar fram åtgärder för hur de ska nå målen.
- ta fram åtgärder centralt för organisationen

Nyligen har ditt universitet skrivit under ett dokument tillsammans med nästan alla andra höga lärosäten i Sverige. Dokumentet innebär ett åtagande på att halvera universitetets utsläpp av växthusgaser under kommande 10 år (ungefärlig minskning på 6,6%/år). Detta för att ligga i linje med det internationella 1,5 gradersmålet.

För att nå detta stora mål har ni investerat i Svalnas Carbon Intelligence system, som tar in universitetets fakturadata kring alla inköp som görs och omvandlar denna, genom sina metoder, till uppskattningar på hur stor mängd koldioxidekvivalenter dessa köp bidragit med.

DEL 1

Du har loggat in i verktyget och möts sedan av denna vy.
Utforska - vy 1 (utvalt för mig)
Vad tänker du att du kan göra här? Vad förväntar du dig att se i huvudfönstret? Hur tolkar du filtret?

Om vi kollar närmare på modulerna på själva visualiseringarna.
På vilket sätt kan du interagera med dem? Hur tolkar du ikonerna?

Utifrån vad du ser här bestämmer du dig för att du vill titta närmre på utsläppen i underkategori 1 och 2 och dess fördelning mellan alla institutioner.
Vad gör du? (steg för steg) Varför? Vad tänker du ska hända?

Utforska - vy 2 (filtrerat på kategori 1 och 2, alla avdelningar)
Vad tänker du har hänt nu? Hur tolkar du vad du ser?

Efter lite utforskande här bestämmer du dig för kolla på underkategori 1 och 2, men endast jämföra mellan institution 1 och 2.
Vad gör du? Varför? Vad tänker du ska hända?

Du är fortfarande intresserad av att titta på underkategori 1 och 2 men behöver nu se hur ditt Universitet ligger till jämfört med andra Universitet.
Vad gör du? Varför? Vad tänker du ska hända?

Utforska vy - Organisationer
Vad tänker du har hänt nu? Vad det detta du förväntade dig?

Filtrering
Vi ska gå in mer på filtreringen och du ska få testa en liten interaktiv prototyp av detta för att känna på hur det beter sig.
Lek fritt. Hur uppfattar du det? Är det något som beter sig konstigt? Förbättringsförslag?

DEL 2

Som vi gick igenom tidigare så är det oftast ute på institutionsnivå som de flesta åtgärder görs. Det är också institutionerna själva som har ansvaret för att sätta in dessa åtgärder eftersom de känner sin egna lokala verksamhet bäst. En annan del av verktyget gör det möjligt att utforska en framtida påverkan av olika åtgärder samt se vilken den faktiska påverkan blivit av åtgärder som redan antagits. Trots att flest åtgärder sätts in lokalt kan det även vara intressant för dig i din centrala roll att sätta in åtgärder som gäller för hela organisationen (så för enkelhetens skull byter vi inte din roll). Det som annars är intressant för dig i denna vyn är att få en överblick över alla åtgärder och dess påverkan, för att kunna planera, informera och presentera vidare.

Åtgärder - nya
**Klicka in på åtgärder*. Du befinner dig nu i vyn Åtgärder.* Vad tror du att det finns för möjligheter här? Varför?

Ditt mål är att hitta ett antal åtgärder som universitetet i stort kan anta. För att göra detta vill du kontrollera den förväntade påverkan olika åtgärder kan ha. Du vill börja med åtgärden - tåg istället för flyg...
Vad du gör då? Varför? Vad tänker du ska hända? Varför?

Vy - åtgärder, en manipulerad
Hur tolkar du det du ser? Va det detta du tänkte skulle ske?

Du är nöjd med vad denna åtgärd bidrar med och vill hitta en annan att ställa in.
Vad gör du då? Varför? Vad tänker du ska hända?

Vy - åtgärder, flera manipulerade

Efter flera inställda åtgärder ser du detta.
Hur tolkar du det som hänt sedan förra framen?

Du är nu nöjd och vill binda Universitetet till dessa åtgärder.
Vad gör du ? Varför? Vad tänker du ska hända?

Inför ett möte med ledningen ska du förbereda en presentation över utvecklingen av klimatpåverkan för universitetet. En del av presentationen ska handla om de åtgärder som antagits ute på insitutionerna det senaste året och hur mycket dessa påverkat universitetets minskning.
Vad gör du först? Varför? Vad tänker du ska hända?

Åtgärder - Antagna
Hur tolkar du det som du ser här?

Slutligen: Diskutera uppfattningen av gränssnittet i sin helhet.