Advance Interaction Design - Group Project Documentation

Design for Awareness

A conceptual investigation into how design can raise awareness among EV users and encourage them to regulate their charging habits.

Authors

DANIEL PEÑA LÓPEZ

JOSEF JÖNSSON

KARTHIK VENKATARAMAN MEENAAKSHISUNDARAM

LAUREN VAN LOO

SOFIA STRÖMQVIST

This report proposes a new system that would be used by EV users in their everyday routines. The system has the aim at raising awareness about the constraints on Uppsala electricity grid, giving people information they need to optimize their charging for a greener Uppsala. The system would be mainly used on the home and working charging environment. It encompasses a color-system to indicate the status of the grid, an illuminating power cord that shows when V2G is activated, as well as two screens providing the users with information about the positive change that is possible when uniting towards a common goal. With the climate debate emphasizing on reducing consumption of resources, the system gives EV owners an active role within the electrical ecosystem, giving them the opportunity to alleviate grid constraints when needed.

1. INTRODUCTION: THE ROLE OF THE CONSUMER IN ELECTRICITY MANAGEMENT

Electricity consumption has changed immensely over the past years and is predicted to grow partly because of increased residential electricity demands. Growing electricity demand in combination with the sustainable goals of moving towards (intermittent) renewables, calls for a more informed and active relationship between electricity consumers and producers, ensuring a stable electricity grid [1]. Demand Side Management (DSM) is a concept that incentivizes electricity consumers to actively monitor and control their power usage to achieve certain favorable outcomes for the grid [2]. Such an outcome is the relief of congestion in the grid, which during peak hours of the morning/evening, does not have enough capacity to deliver the needed electricity to consumers. DSM can help alleviate this, by rewarding consumers to decrease their consumption during those peak hours, and therefore reducing the overall electricity demand, matching the physical limitation of the grid [2]. Such is the case of Uppsala, which experiences grid congestion challenges every now and then. This project aims at investigating potential solutions for Uppsala's grid challenges, with an aim and emphasis on increasing consumer awareness through design. This could pave the way for a more active relationship between electricity consumers and producers in Uppsala. With regards to the potential of Demand Side Management, previous studies have aimed at understanding the incentives needed for consumers to make more informed choices in their everyday electricity usage. Whilst some studies have stressed the importance of pro-environmental attitudes for user adoption of greener solutions, marketing, and consumer behavior studies raise the importance of social aspects that are tied to social influence and normative behavior [3]. Within the context of alleviating Uppsala's unbalanced consumption production relationship, this project will further investigate the behavioral aspects of consumer motivation, attitudes, and incentives needed to help balance that relationship.

2. AIM: VEHICLE TO GRID, A WAY FOR CONSUMERS TO HELP BALANCE THE GRID?

Uppsala's electricity grid is currently not working sufficiently for the growing demand. Project stakeholder STUNS listed two significant challenges with Uppland's power grid. First, there is a capacity challenge meaning the grid does not have the capacity to supply enough power to meet the demand in the Upplands district. As a result, penalties are in place for those that consume over a specific limit. Secondly, there is a power challenge in which not enough electricity is generated to the grid. The production needs to match the consumption, but not enough can be produced for the increasing demand.

To reduce the stress on Uppsala's electricity grid, awareness and behavioral changes need to happen. Since the electrification of Electrical Vehicles (EV) is increasing rapidly, it is essential to improve the owner's awareness of their contribution to the electricity usage in Uppsala and how they can decrease the stress levels by changing their behavior. At the moment, most EV owners charge their cars during peak hours in the morning and evening. However, many of them are unaware that this behavior causes an additional surge in electricity consumption. This project aims at investigating how to motivate and inspire EV owners to participate in tackling the strain on Uppsala's electricity grid. By inspiring and helping them make better choices and change their charging behavior, they can help flatten the curve.

Besides charging Electrical Vehicles outside peak hours, EV owners should be encouraged to charge their vehicles using Vehicle-to-Grid (V2G) technology. Vehicle-to-Grid can give back electricity to the grid by for example using public charging stations provided in the city. This type of charging allows the car's battery to give back some of its power to help balance the consumption peaks and the available capacity in the grid [4]. In addition, when talking about renewable energy, this should either be used directly or stored somewhere to be used at a later moment. Car batteries are a cost-effective solution for storing energy and can be used as small storage containers when the vehicle is not being used [4]. With V2G, it can then push back the stored power to the grid whenever needed.

3. DESIGN PROCESS

Based on the brief provided by electricity companies in Uppsala as well as desktop research conducted by the team, a model of assumptions was set following relevant qualities our design potentially contain.

3.1. MODEL (ASSUMPTIONS)

1. EVs need to be charged with electric power
2. Uppsala electric grid does not have the capacity to cover further power demands
3. People need incentives to be open to change
4. EV demand is expected to grow in the future which will worsen the Uppsala capacity challenge
5. EV users are not aware of the capacity challenges faced by Uppsala
6. Charging systems are not providing EV car owners with insights or encouraging sustainable behavior
7. EV charging is done mostly in the evening peak and not spread out in the other hours
8. The capacity challenge can be reduced if the charging is spread throughout the day instead of peak hours
9. People tend to feel protective of their own items and routines and might not be open-minded to compromising their comfort
10. People tend to feel safer when they have their EVs fully charged, even though it is not necessary sometimes
11. People are not informed about V2Gs benefits

3.2. RELEVANT QUALITIES OF A SOLUTION

1. Show the users both the positive and negative aspects of their charging habits and ways to optimize it
2. Provide information so users can make informed choices regarding their charging
3. Give incentives to EV car owners for charging in non-peak hours
4. Make their users feel safe having their cars charged with just the necessary amount of energy
5. Present sustainable charging habits as something easy and fast to do/learn
6. Be free
7. Cover the be-goal: effective altruism
8. Inform users about V2G benefits

3.3. HYPOTHESES

Based on the assumptions made and a preliminary set of designing principles, the group came up with five different hypotheses, design ideas to further investigate. To broaden the set of ideas produced, the framework for each hypothesis varies on the level of interactivity with the design, stretching from physical non-digital solutions to highly interactive digital applications. Following are the teams’ first set of ideas to tackle the problem areas described previously.

Hypothesis 0: without additional technical support

The first idea aims at solving the problem without adding any technological support. The concept of an old school newsletter took shape, which would be sent to the car owners' houses (mail to door) once a month. The letter would inform the user of the state of the grid for the last month. This would be a transparent retrospective of the grid and would enable car owners to become more aware about the status of the grid. Such a monthly letter could also give information about sustainable EV charging habits, general V2G information, general grid information, and how the Uppsala grid is changing and developing. It would be driven by Uppsala Parkering or Uppsala Municipality.

Figure 1: Hypothesis 0 prototype

Pros: It would satisfy the needs of keeping citizens in the loop of the general status of the grid. It could inform people and give incentives to some extent about the benefits of more aware electricity usage.

Pitfalls: The information would not be contextual based and situated in the moments where car owners make their choices. With it coming once a month, it does not spark a sense of urgency either. There is a risk of the newsletter having a low impact due to people not taking the time to read it properly, which will make it less likely to spark action for behavior change.

Hypothesis 1: Non-interactive approach

For the non-interactive hypothesis, the idea of an informative screen for active updates about the grid came to play. Idea: Every parking station and home station (indoors for the home station) has a screen where the daily prognoses regarding the grid peaks are noted, there could also be room for information about good V2G habits. If connected to features in our other hypotheses (check 2 and 3), the non-interactive screen could also showcase the energy saved by charging in non-peak hours/contributing to the grid.

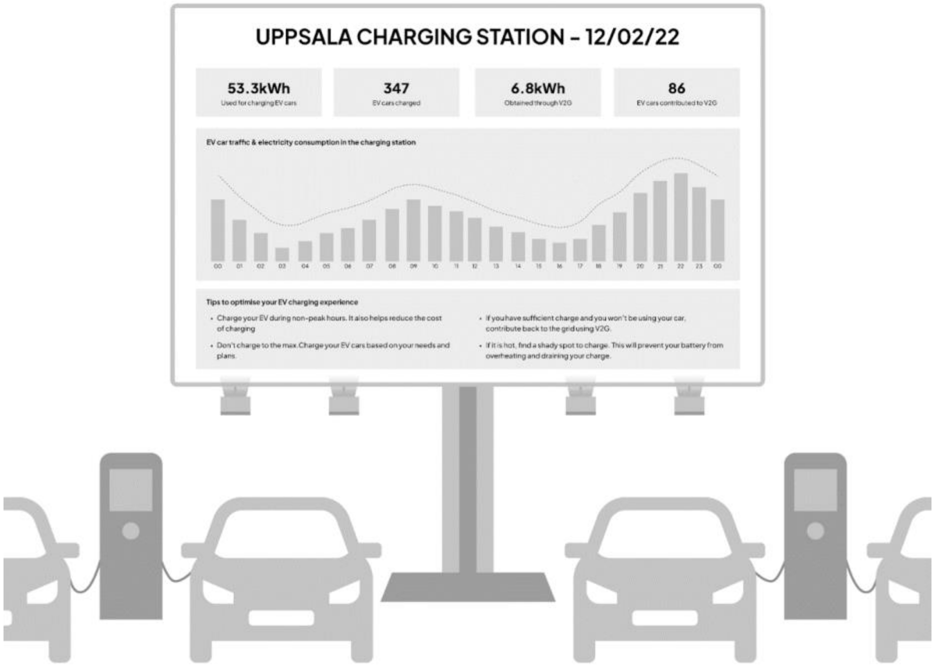

Figure 2: Hypothesis 1 prototype. Big screen at charging station

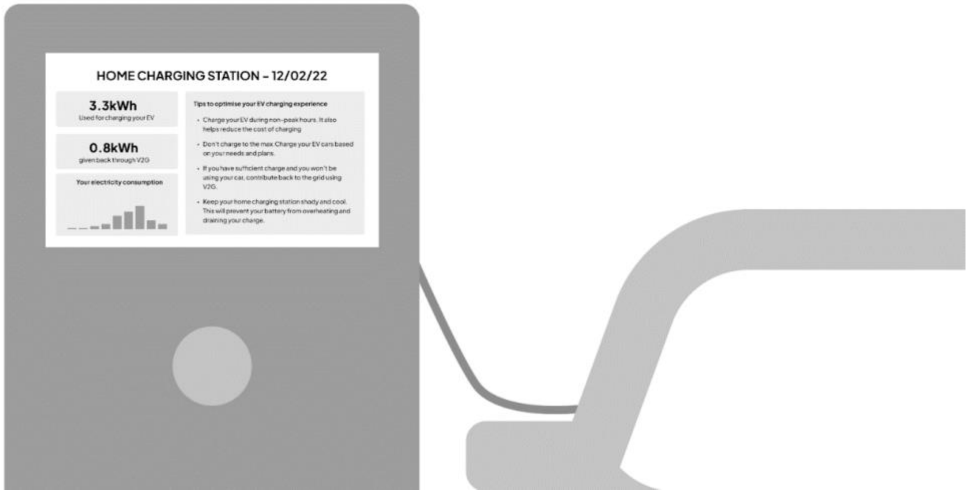

Figure 3: Hypothesis 1 prototype. Individual screen at charging station

Pros: On its own, such a solution would be solely to inform. Such an overview and one-way communication could give a sense of togetherness if connecting information of the contribution of all EV owners in public spaces.
Pitfall: it could, however, easily be negligible since it does not spark further engagement due to its one-way format.

Hypothesis 2: Screen-based interactive approach

For an interactive approach we had an idea of a personal application in the EV owners' phones to track their charging behavior, spot patterns in their usage, and be able to (together with recommendations provided by the app) tailor a perfect charging schedule for the user, as well as the grid. A free app that shows the charging stations spots that are available to be used for charging and V2G in non-peak hours. It also notifies users about the peak hours and surges in pricing. The app gives suggestions for a sustainable charging schedule and motivates the user to follow it. It also shows positive and negative aspects of the user's current charging patterns and ways to optimize one's schedule. It suggests when V2G can be done and users are given a choice to opt-in/out for it. When the car is charging the app shows how far the user can go with the charge it has. Design of the representation of power in terms of driving distance could be further explored (using cities/towns places as a reference point) to help users grasp what different levels within their batteries would mean for them. E.g. with 80%, you can drive all the way to Stockholm and back (80+ km).

For example, with the tracking and summarizing features of the app, making users aware of their weekly energy pattern, the app could help users feel comfortable only charging the car with the electricity they need. Through these patterns, they might realize and take comfort in the fact that their daily usage only needs a 60% charged battery at the start of the day. Ideally, a limit on the charging should be implemented to only charge their car up to 60% on a daily basis.

This would be highly individual and based on each car's daily/weekly patterns. Which will give them a sense of control in knowing how much energy is directly linked to their need, and thus change the limit accordingly. A charge to the maximum of 100 % is of course possible but advised as only to be done if they are planning a longer trip that breaks their weekly pattern or if their daily activities are demanding such a high charge rate.

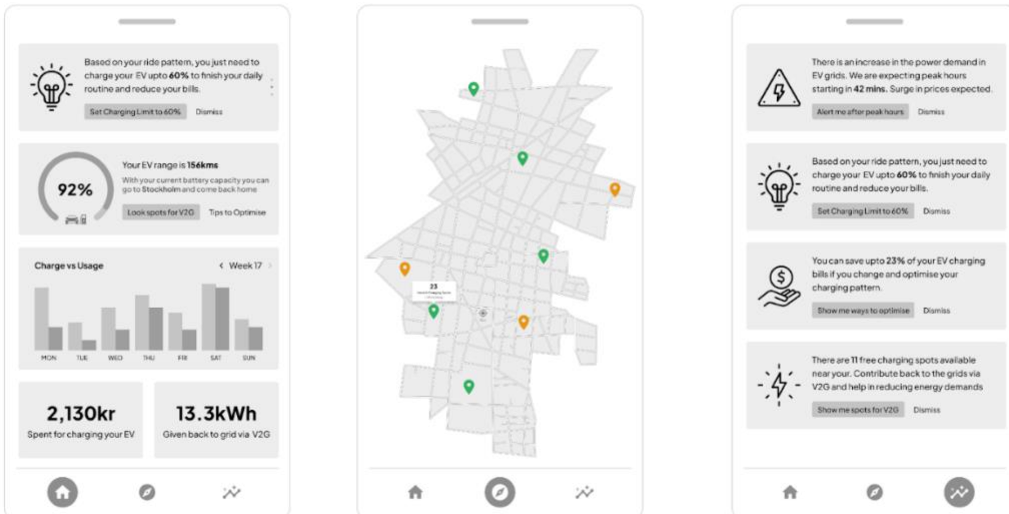

Figure 4: Hypothesis 2 prototype

Pros: Gives a sense of control with a battery not fully charged. Tracking their usage pattern will help them understand their usage and pave the way for change for the better. Important to give good incentives for how such a change in behavior would be beneficial for not only the grid but the users, this could be connected to a motivating reward system (see hypothesis 4). Additionally, the app will inform the user about peak forecasts, and v2g opportunities which will also motivate the user.

Pitfall: We felt it to be important that such a charge limit can be automatically set based on their routine usage, since people are unlikely to go and manually stop charging once the battery has reached a certain percentage. Nudges in the form of recommendations are provided that showcase their usage and how much charge they usually use. User can choose to set the limit via the app or can dismiss that suggestion.

Hypothesis 3: Screen-less interactive approach

For the screen-less but interactive approach we thought about ways and incentives for people to give back energy to help stabilize the grid. Why would people engage with V2G? With inspiration from the power-aware charging cord [5], we came to a hypothesis that would give real-time charging feedback, visualizing the V2G interaction. This idea would follow a color-coding system (to be further explored). Currently, the idea is for the cable to turn into the color of the state of the grid. Green would indicate that the grid is functional and not constrained (ok to charge!) yellow/orange would indicate light stress on the grid (charge to a minimum) and red would signal a lot of stress on the grid (charging not possible). The solution for the red state would lie in the color blue, which signals that a car is actively giving back energy to help balance the grid.

This solution could be feasible in public parking lots. At-home users would potentially have control on their phone/or in other formats, in which this solution might not be needed. We also believe that the visual cues showing the blue color of how other people behave/gives back to the grid could create a good social pressure. Important however in relation to such pressure, is the emphasis on the positives to not risk an unintended negative social sanctioning response. When engaging with V2G, a button is provided for the users to be in full control on how many percentages to boost the grid back with. The options provided are: charge (no V2G), not engage at all or to give back a certain amount (as a boost to help the grid).

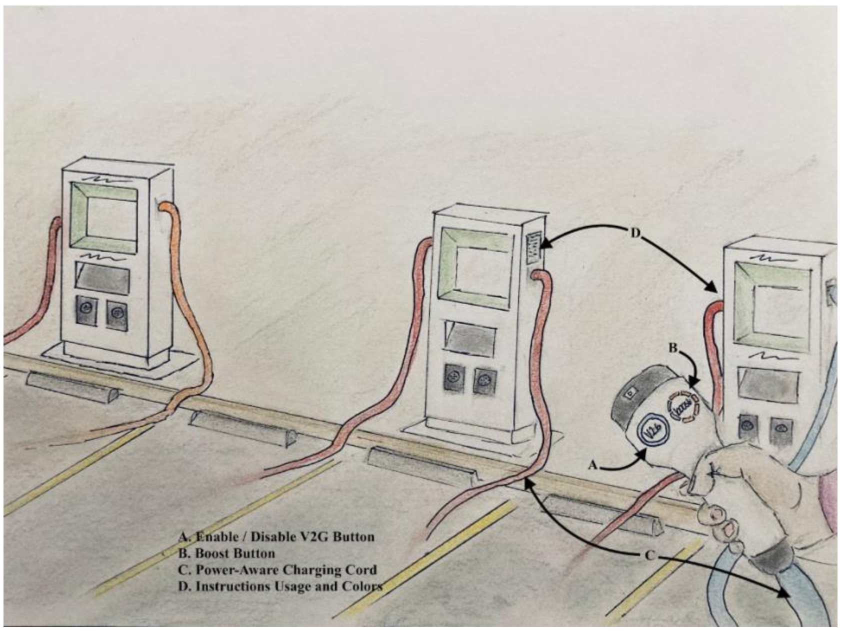

Figure 5*: Hypothesis 3 prototype*

Pros: Could spark the feeling of contributing together. Not an individual effort but something that citizens together would like to take part in as part of the goal of helping the grid, and the community in which they live.
Pitfalls: Perhaps it's not possible to color code the cables (Choice was made due to it being novel and fun to showcase the state of the grid through the flow of energy). However, such a barrier could easily be worked around with cues of the colors provided through perhaps lights on the charging spots. Also, the social outcome of such a design is also important to follow through in research to ensure it has the positive outcome as intended. The design is aimed at boosting car owners to partake in V2G, as a collective effort.

Hypothesis 4: Gamified Approach

When being given the framework of a gamified solution, the car owners were considered both individually, but also as a potential community. The following features are regarded as part of a phone application helping users to track their usage, the status of the grid to help them optimize their electricity usage and charge accordingly (much like hypothesis 2 of this report).

Idea for individual use: Within the app, green points would be rewarded to the user when following a suggested sustainable charging schedule. Resulting in a beneficial relationship for both car owners, and Uppsala's electricity grid. No points are obtained if charging is done outside the suggested hours. Points are also obtained for V2G contribution (Eg: 10000 points for 10kwh contribution). Ideally, these points can be later redeemed for free charges (such as free parking), get discounts while charging, shop real-life deals, coupons or offers inside the application or in relevant portals. This gamified aspect turns to incentives on an individual level.

Idea for collective use: Building on top of the individual reward system as incentives, we also discussed a social angle. We wanted to find an aspect that could help bring people together, inspire each other to work towards a common goal. For doing this, we took inspiration from Snapchat's map, which showcases happenings on the map based on user activity.

The app could adopt a social and community building feature through a Snapchat inspired designed map of Uppsala, highlighting the public spots for parking. Heatmap inspired areas on the map could show the current charging activity in Uppsala, giving an overview on how EV owners as a collective contribute to stabilizing the grid. Using a battery as a visual design representation, the overall current state of Uppsala's grid could be viewed at all times in the app. Making it a powerful overview, spotting blue areas across Uppsala symbolizing the collective effort of EV owners actively choosing to give back and boost the grid.

For this idea we thought of using similar colors as introduced in hypothesis 3. Blue area (heat map inspired) means that many people give back to the grid, whilst green indicates that the overall grid is stable and there are no issues with charging your EV. Whilst this overview of the current charging activities aims at creating a sense of togetherness, it could also be part of the individual gamified reward system in each EV owner's phone application. It would be possible to individually earn points if you contribute with a marginal percentage of one's battery, within the 'blue' parking spaces in the map. These "special" points indicate that you are contributing to the community effort. In the end this map is part of creating a narrative of a bigger story, inspiring people to help and contribute to balance Uppsala's electricity grid.

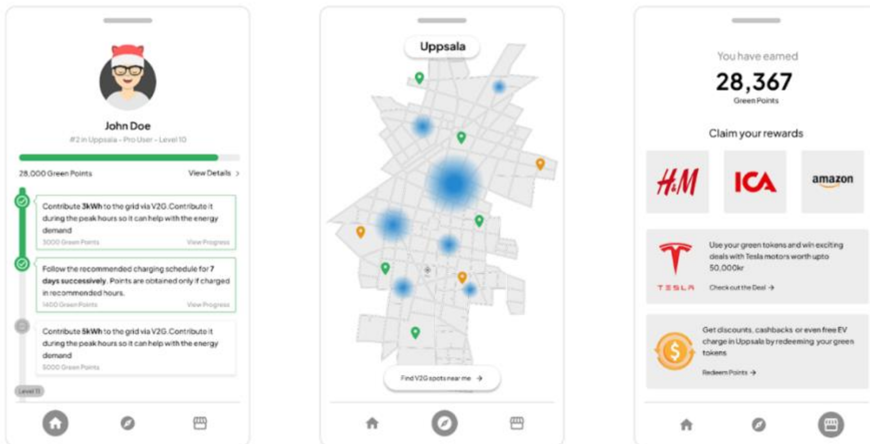

Figure 6: Hypothesis 4 prototype

Pros: Would give frequent and continued incentives to users, being rewarded for their efforts. The design also uplifts the positives of an optimized charging schedule, which is beneficial for both car owners as well as the grid. It could also be further developed for a continuous learning journey for users, which could give further intrinsic stimulus if one of the users 'be'-goals is to partake in the change towards a greener society.

Pitfalls: Designing with values of social pressure could be a slippery slope. We would have to research this angle to avoid any potential negative social sanctions, towards users who for various reasons won't give back energy to the grid at the given times. Moreover, giving discounts or special offers to users would imply giving money away which might not be the preferred solution from the profit point of view.

3.4. CHOOSING HYPOTHESES TO PURSUE

Falsification: feedback

When choosing elements of the hypotheses to pursue, we used the falsification assignment feedback from our fellow classmates as part of the first evaluation of our ideas. The main learnings we took from it were the following:

- Our decision of including V2G as a main part in some of our hypotheses was commended. Therefore, we decided to continue including this technology in our project.
- There were some comments about the type of user motivators in the proposed solutions. For instance, one of our peers suggested to analyze why people buy EV cars to know if they usually follow intrinsic or extrinsic motivations for their decisions related to their cars.

With this feedback in mind, we divided the project in two layers:

The base layer: Designing for raising awareness about peak hours, thus making users more aware in their everyday and perhaps find alternatives to charging during peak hours. The first layer therefore has the aim at alleviating the additional stress EVs put on the grid during peak hours.

The second layer: Incentivize users not only to avoid charging during peak hours, but to engage with V2G during those hours. We realize that V2G contribution must be built on top of awareness. Thus, this layer of the project would further address the incentives needed for users to actively engage and "give back" some of their power to help stabilize the grid.

Secondary user research

To further understand intrinsic incentives and potential reasons for EV owners to engage with V2G, secondary user research was explored to see how such ideal motivators align with the reality of EV owners. As a starting point, we found one use case of a couple engaging with V2G in the UK, with the main incentive to reduce their carbon footprint [6].

> "We didn't do V2G because of the financial incentive at all, but financially it's worked out very well indeed". [6]

This is a use case that ticks both the initial intrinsic incentive of caring about the environment, but with resulting extrinsic monetary benefits as an additional motivator. Which was a combination we as a team thought desirable for the design, both to follow the desired quality of altruism (see part 3.2 Qualities) as well as a following individual reward for their contributions. We also found a qualitative study containing twenty semi-structured interviews conducted with EV owners in the Netherlands [7]. The study addressed the owner's acceptance towards V2G. Intrinsic motivators was touched upon and had two slightly different nuances. The first aspect was regarding the grid constraints as a societal and local issue impacting the community:

> "If the grid becomes overloaded, we will all experience the disadvantages of it. The grid balancing problem is a societal issue which I, as an EV driver, contribute to...when I can do something back for society by participating in V2G and help to balance the grid, it is a good thing" [7].

The second one was also describing it meaningful to give back, but connected V2G to the larger issue of the ongoing green shift towards renewables:

> "A better ecological footprint is important for me. We are dreaming about gas-free households and a transition towards solar energy and wind energy. I like the idea that my car can contribute to that." [7].

Following our goal of designing for altruism (see part 3.2 Qualities), the study came to give insights that intrinsic motivators were prevalent among the EV owners of the study and shaped their attitude towards V2G. However, some important barriers and hesitations was equally raised by users that needs to be taken into consideration. A few factors were described as crucial for fostering an acceptance of V2G among the owners:

Financial compensation & transparent communication: A financial compensation of their contribution was something important for the participants of the study, especially due to the potential degradation of their car's batteries. V2G was accepted among the participants with the condition of transparency regarding the battery wear and that there should be some compensation for it. With the aim to design for behavioral change and the quality of altruism, our goal is to design something that would foremost spark intrinsic motivation coming from within. Thus, making V2G a meaningful activity for users. However, with the clear feedback on monetary compensation from users of the study, such an extrinsic motivation should be taken into consideration and could be added to the design to cover both aspects. This would combine the feeling of doing good and being rewarded for doing so, such as the example of the first user statement [7] mentioned previously.

Reliable control of the system: Another barrier for the user of the study was the anxiety of not being able to leave at any moment with their cars [7]. How would they be reassured that even though they are engaging with V2G, they are able to drop out of it and leave if needed? This was a barrier we found to be important for our design since it tackles our set design quality of ensuring freedom of the users see part 3.2 Qualities). It's important that our design aligns with users' everyday routines and the flexibility they desire.

A desired feature for control: An interface on the charging station was something suggested by the users of the study to increase transparency. It could display information about both the cars battery, charging activity and V2G. This could allow the end-user to view certain settings of the V2G system [7]. This is a feature we also choose to develop further, with transparency and control for users as guiding designing principles.

Contexts in which V2G seemed feasible: Regarding the location of engaging with V2G, EV owners suggested the home and work environment as relevant contexts of use. It was stated to being feasible since they would park during longer duration, and that V2G would be more likely to be done successfully. This aligned with the areas of application discussed within the team. Since V2G is only relevant at the time of the peak (morning/evening), home and work contexts seemed like good focal points moving on.

4. DESIGNING FOR A MEANINGFUL CONTRIBUTION

As was clear in the use cases presented above, the sustainable and social contribution was something important for users. The two nuances (community/ environment) provided in the statements by users showcases how not only the grid benefits from V2G activity, but that it's also part of a bigger movement in society related to the green shift towards renewables.

> "Secondly, the power grid and the planet both benefit from V2G, as the technology makes it possible to reserve renewable energy and pull it back into use exactly when it's needed. Because the production of solar and wind energy is extremely unpredictable, without V2G, a lot of renewable energy would go to waste." [3]

We found this narrative to be powerful, and relevant to highlight within our design for creating the sense of meaningful contribution by the car owners. Making this narrative around "pull it back" even more abstract, the phenomenon of V2G is also a powerful message in its essence of *giving back*. With the urgent climate crisis on our hands, the narrative of people giving back to nature was something we as a team also found interesting to pursue. It also highly connects to our desired quality of altruism and connects to the global goals of more sustainable ways of living our lives [8]. When searching for inspirational designs related to the narrative of "people giving back to nature" we stumbled upon Ecosia, the green search engine who with the search of its users, plants trees [9]. This was something we found highly inspirational, with the trees being a tangible contribution based on the activity of the users.

4.1. FROM INPUT IN RESEARCH, TO OUTPUT IN DESIGN

With an ambition to cover both the base layer of raising awareness, and the second layer of designing for V2G, we realized that our design would need to contain multiple elements from our hypotheses to be successful. We decided to create a system that would be used by users in their everyday routines, with the core focus on the home and working charging environment. We draw upon multiple elements of our hypotheses to create a coherent whole:

- With regards to awareness, the color coding from our hypothesis 3 (power aware chord) came to be implemented, whilst slightly different.
- Regarding the sense of giving back elements from hypothesis 1 (non-interactive screen) was implemented to communicate with the car owners collectively at the charging lots.
- For the sake of control and transparency, we also introduced an interactive interface on the charging machines for individual use, as was suggested by users in the study [6].

4.2. PAYING IT FORWARD: PLANTING TREES

Emphasizing on designing for a meaningful sense of giving back, an additional tangible contribution of planting trees came to be the core of our final design. In this way, our system would amplify the individual contribution of giving back (V2G), having the power provider/system owner paying this good deed forward in the form of planting trees. The whole system and how the trees are integrated, will be presented next in more detail.

5. OUR DESIGN

The system has the aim at raising awareness about the constraints on Uppsala electricity grid, giving people information they need to optimize their charging for a greener Uppsala. Since EV batteries can store renewable energy that would else be lost, the system also serves the purpose of sparking an even bigger conversation on the utilization of V2G as a temporary solution to tackle some of the uncertainties with renewable energy. Thus, the system provides solutions that both address the local constraints regarding Uppsala's grid during peak hours, but also gives a concrete way for citizens (driving EVs) to actively partake and contribute to society's shift towards renewables. With the climate debate emphasizing on reducing consumption of resources, the system makes the EV owners an active agent of the electrical ecosystem, giving them the opportunity to give back when needed.

5.1. OVERVIEW

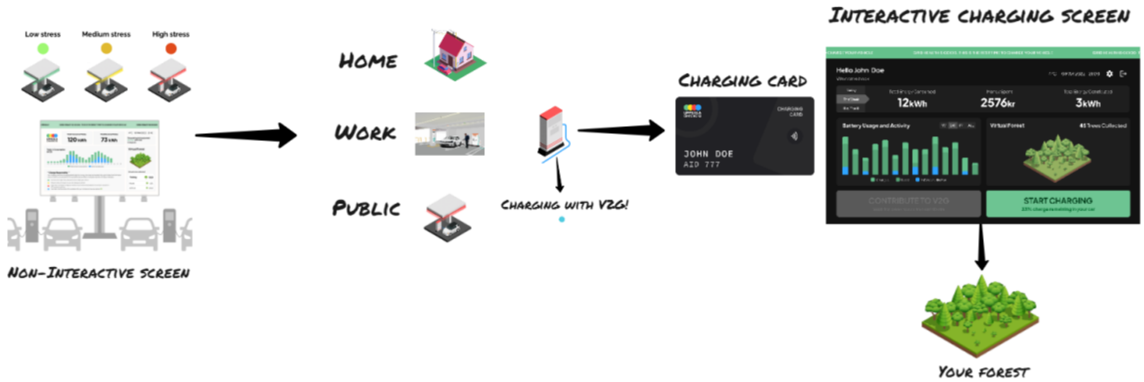

Figure 7: The Overall System

5.2. ELEMENT BY ELEMENT

Colored lights

The core of the designed system is to raise awareness using a color system always signaling the status of Uppsala electricity. The colors will be shown through elements of light at the charging machines at home as well as at the workplace. At public charging stations, the colors could also be implemented on larger design elements (such as a roof) to be easily viewed by EV owners as they are driving in the city. The color system is the base layer of the system and has the aim at increasing awareness so that EV owners as a starting point would become aware of the peaks (red periods) and learn alternative times that would be ideal for them to charge (green periods). It was important for us in this project that we could find solutions for the EV users to become more aware and conscious about Uppsala power grid. That's why one of our core design system ideas was to add light details to all our charging stations and screens that corresponded to the current stress on the power grid (see figure 8). The chosen colors follow common western color metaphors, used in traffic lights. Green means the grid stress levels are low while red means the grid is experiencing high stress levels. Yellow acts like the in-between color, informing of a grid that is close to being stressed. This is also a time where we hope that in the. long run, an EV user will be reminded to start planning ahead for their charging, further optimizing their charging habits. Finally, we choose the color blue to represent the use of V2G, but more is written about that in the charging cable section.

Figure 8: Light details on station

To address the possible problems that people with color blindness could experience to differentiate between green, yellow and red, we suggest showing a pattern together with the color to let everyone recognize the state of the grid. As you can see in Figure 9, a straight line represents green, a fluctuating line represents yellow, and a triangle wave represents red. The inspiration to choose these patterns was given by the Atlas of Emotions supported by the Dalai Lama [10], which divides the emotions in 5 big groups. The most negative emotions such as anger are represented with patterns with more peaks and the most positive ones are represented with patterns without peaks. Because of this relationship between peaks and emotions, we decided to relate a high stress of the grid with a pattern with peaks and a low stress of the grid with a pattern without peaks. Yellow is a pattern in between those two.
You can see how people with different color blindness would see the different colors and type of patterns in figure 10.

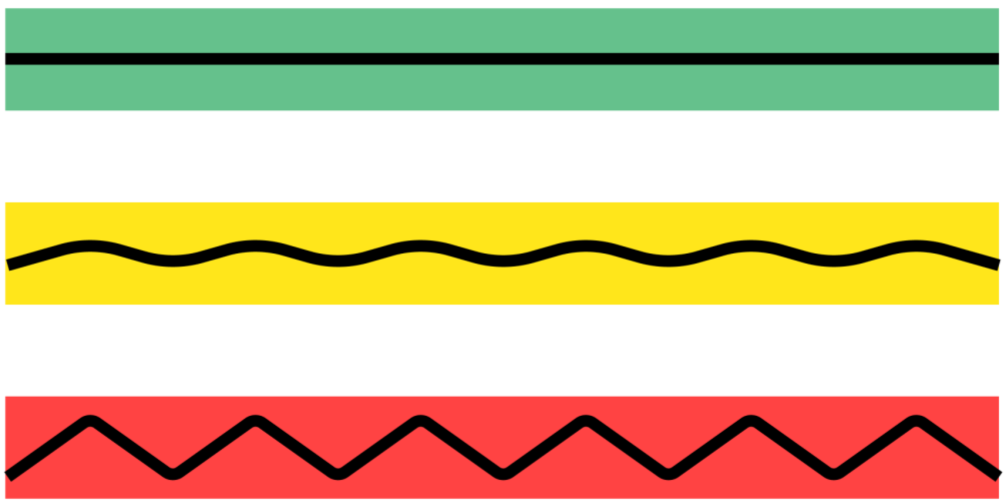

Figure 9: Patterns Used to Show Grid Health

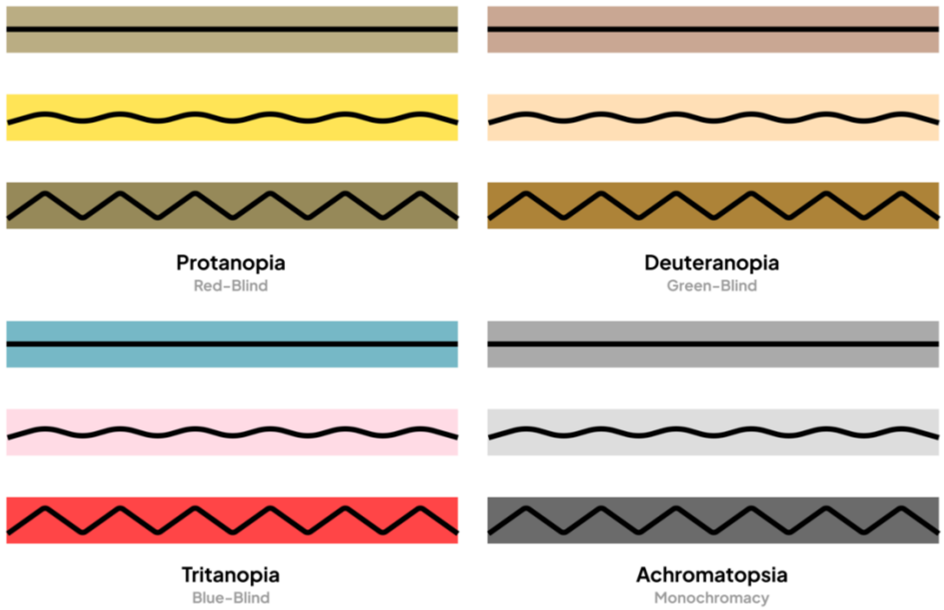

Figure 10: Patterns Seen by Different Color Blind Users

These light details can be seen in all our station types and serves a few different purposes. As previously noted, it could potentially create both long-term and short-term user awareness. It also catches the attention of EV drivers, even from a distance, which is a continuous reminder to think about better charging habits. In the same way, this might spark interest even in non-EV users, creating a larger impact. Furthermore, we argue that these colors could create additional social incentive, where the users see each other charging and at what color level. Our design system could be seen as an eco-system, where the many different elements all incentivize the EV users to want to be smarter and sustainable in their charging habits. We hope that seeing your neighbor or work colleague charge with V2G, or not at all, during stressed times will nudge you to do the same.

Charging cable

To create additional user awareness, we decided on adding an illuminative charging cable to our design system. The cable has to functionality to light up in blue color, whenever an EV user turns on V2G charging at a charging station, which can be seen in Figure 11. This idea was inspired by the creative ideas and knowledge learned in a study by Gustafsson & Gyllensvärd (2005). They found that while their participants were using the illuminative "power-aware cord", experiences increased awareness for the use of electric products. The product made the users conscious about energy usage through the transparent visual information portrayed in the design [5]. As previously noted in section 3.5, transparency is an important factor in how to properly motivate users to use V2G, supporting the need of our design concept.

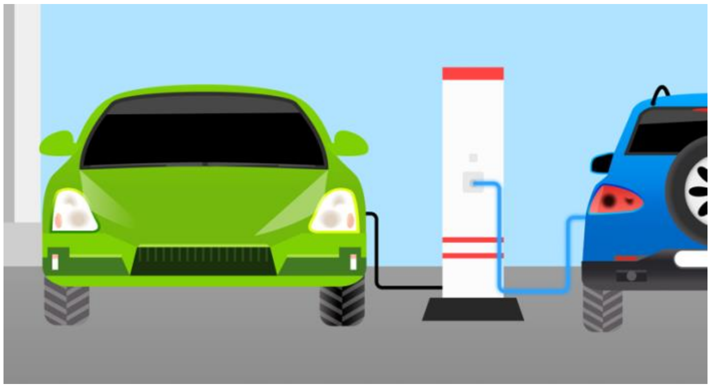

Figure 11: V2G Charging cable

The illuminative cable design will be used in both personal homes, at work parking spots and at public charging stations. In addition to the light design elements at the stations themselves we hope that the cable design is going to fit right in, both esthetically and in how it will grab the attention of the users. To see other users adopting the V2G charging during stressed grid-hours could create extrinsic motivation and nudging, through inspirational social pressure and overall increase of user awareness.

Charging screen

Our charging screen is a very important element and serves as a interface connecting the user with the overall system. Our intention is to provide a uniform experience for the users when using the chargers in public, work and home context. The same UI will be seen and interacted by the users in all charging stations thus reducing their learning curve. Login screen of our charging system can be seen in Figure 12. After logging in using the charging card, the user lands on the personalized dashboard show in Figure 13. From here they continue to see the current state of the Uppsala power grid, battery level, range, virtual forest and buttons to perform charging and V2G actions. They can drill down and see various statistics, configurations and update their preferences through this dashboard in the charging screen. The statistics and visualizations can help a user be aware of their charging behavior and motivate them to improve. Same design language, colors and patterns have been used to design the system to bring a universal language to the overall ecosystem we have proposed.

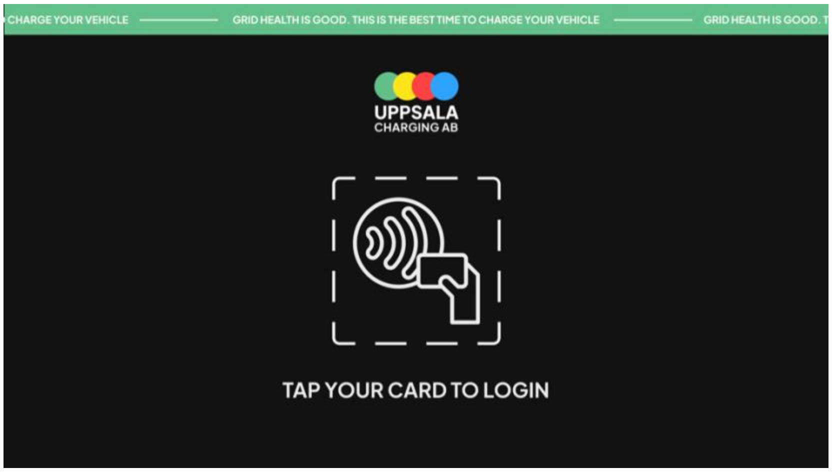

Figure 12: Login screen

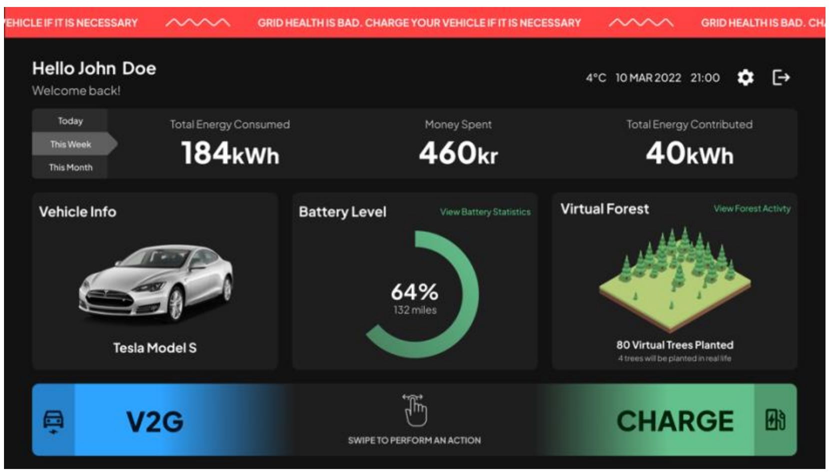

Figure 13: Personalized Dashboard

Users can charge their car by performing a swipe interaction towards the right side and begin charging. If the charger is not connected to the car our system will show a prompt. Figure 14 shows the screens users will see while charging their cars. It has a dial that shows the battery progress, amount they have spent for charging and the charging tariff. They also get an option to opt-in for V2G contribution if there is a peak period happening during the charging session. This gives them the agency to opt-in and out in an effective way.

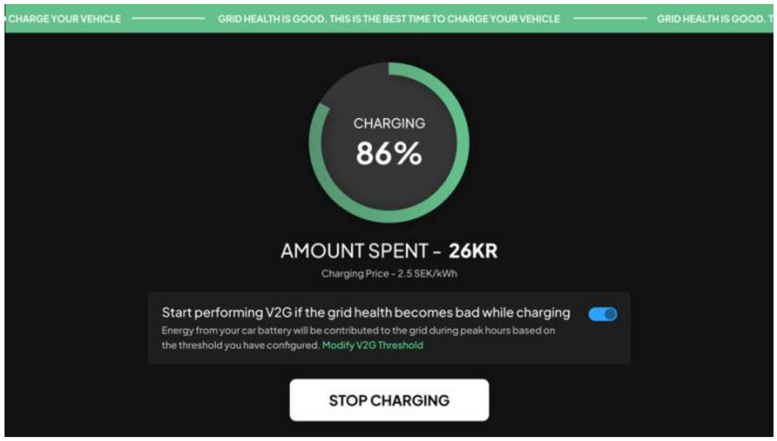

Figure 14: Screen shown during charging

In Figure 13, we can see the grid in a bad or stressed state. During such times users can also perform V2G contribution. They can swipe left to start V2G process. Figure 15 shows the screen users will see during V2G. It shows all the essential information about V2G like energy contributed, current battery level and how much percentage is left to reach the confugred threshold. Along with that users also get an option to enable charging after the V2G session is over. This helps them to have their car in a ready-to-use state and don't have to worry about the bettery left after the session. They can also see how much virtual trees they have planted in the V2G session.

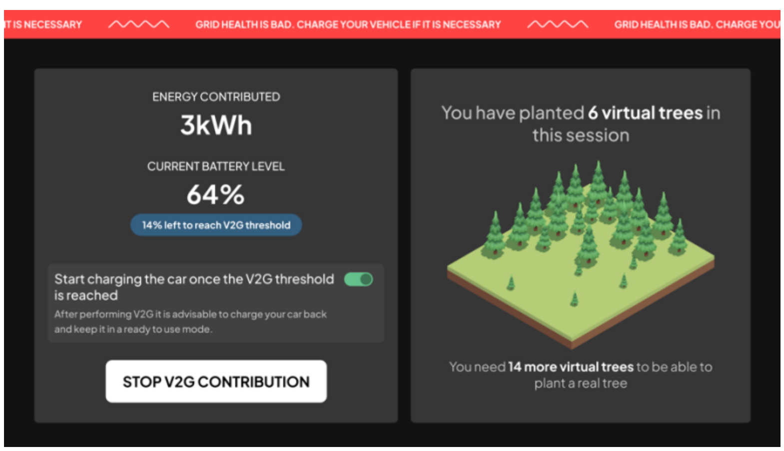

Figure 15: Screen shown during V2G session

User control was an important requirement which was discovered during our secondary user research. Users expressed their interest and concern for configuring certain parameters as per their convenience to be able to take control over actions like V2G. Hence we have brought in a preference module where users can configure their preferred paramerters and the charging system takes it into account. These are one time actions which can be done by an user in their home charging interface. Since all the data are synced with the same account and user logs in to perform the action the preferences will be considered while performing relevant actions.

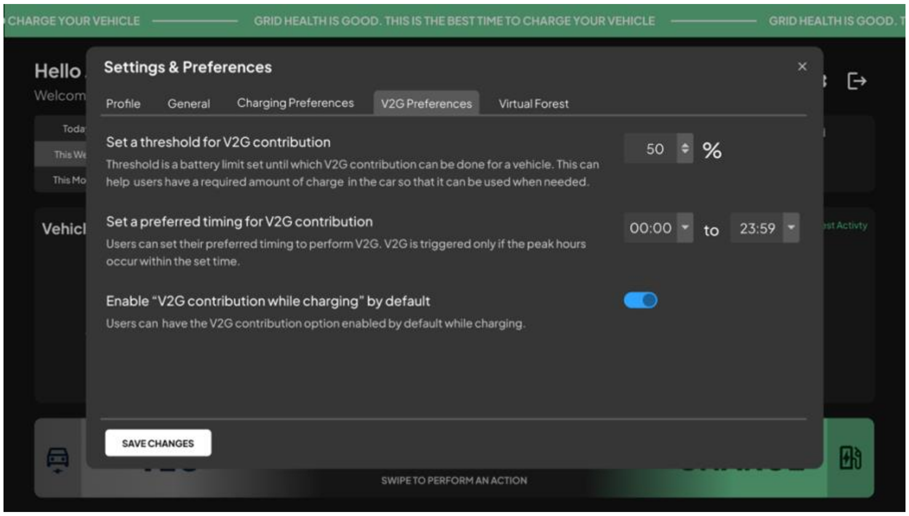

Figure 16 Screen showing the V2G preferences

Trees

With the support of intrinsic motivations for accepting V2G [7,13], such as wanting to reduce their carbon footprint, the system gives users the opportunity to do just that. Besides creating awareness for EV owners about green and recommended periods to charge during the day, the system enables the user the contribute to a good cause during those red periods using V2G. The system rewards the user's contribution to stabilizing the grid by planting trees. With the V2G contribution of EV owners, Uppsala Parkering or energy companies save money. They could use this money as a good deed forward and plant trees in places around the world where nature conservation is needed, such as Africa, South America, and South-East Asia.

To achieve this our design adds a gamified element by showing virtual trees being grown based on the amount of kWh that the user gives back during V2G. Moreover, it will be implemented in the collective and individual interfaces of our solution. In the individual screen it shows the user's personal virtual forest where each tree symbolizes 0.5 kWh of V2G contribution (the amounts will be explained later in this section). The user can make their forest personal by choosing the type of tree that they would like to plant. Figure 17 shows the info about the virtual forest and the activity.

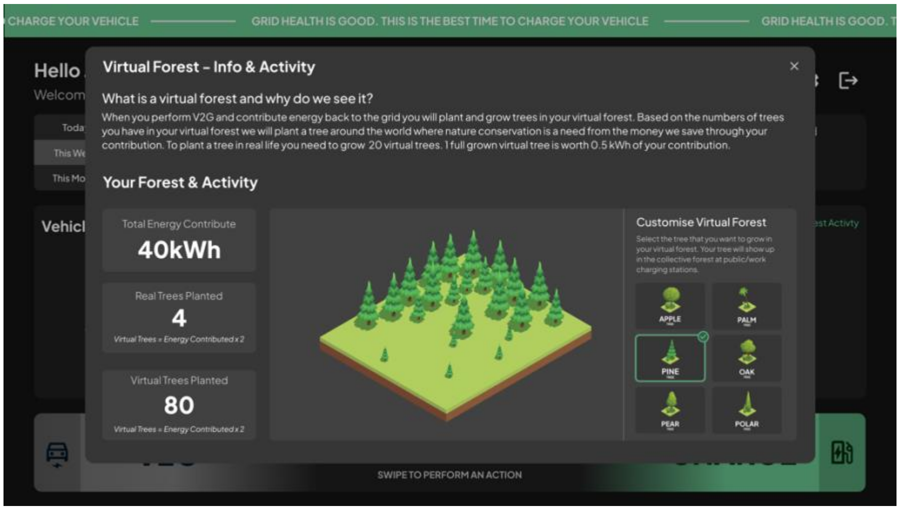

Figure 17 Screen Showing Forest Info and Activity

Collective screens showcase a forest grown out of all the different trees of each individual user partaking V2G at that charging spot. Companies can have their own “company forest” showing a similar forest of the collective trees that were grown. These collective screens show the collective effort of EV owners to flatten the curve. However, since the user has chosen their own tree, they would still be able to distinguish their contributions to some extent on the collective screen. shows a collective forest at a public parking lot and at a company.

The good deed of V2G contributions by users would be amplified with the planting of trees by the system owners. The virtual trees grown by EV owners will be converted to real trees when a certain amount of kWh V2G contribution has been reached. For this we assume the following details:

- The cost of a planting one real tree is estimated to be around 25 SEK [11]
- The normal price to charge 1 kWh is on average 2.50 SEK in public charging stations [12].
- We decided that we will generate one fully grown virtual tree for every 0.5 kWh contribution. We set a low contribution value to a virtual tree because this can generate a significant number of virtual trees at the end of a V2G session, thus motivating users to contribute more and generate more virtual trees. With a higher value the user may not see much tree generation activity in their forest, which may be demotivating.

As shown in Figure 18, with these details the amount of kWh needed to plant one tree equals 10 kWh which will be generated by growing approximately 20 Virtual Trees.

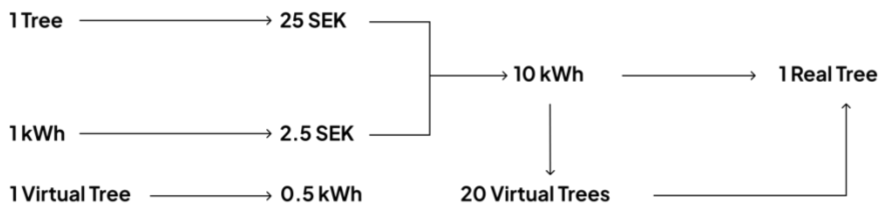

Figure 18: Overview connection virtual trees and real trees

The non-interactive screen in a fictive scenario

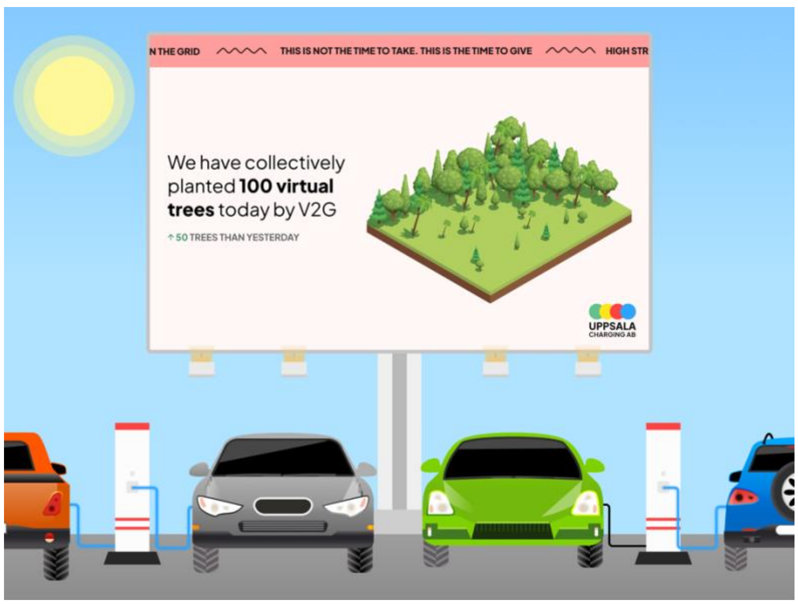

Figure 19 Non-Interactive station screen

For an example we can imagine the use case of a parent being able to show their kids the growing forests that they together are contributing with. In this instance, the growing forest could serve as an educational and fun visualization that highlights the ongoing need of reducing consumption and on the contrary "giving back" to nature. The big screen serves such a purpose. Showing the collective effort of giving back together could thus serve as an important conversation starter in and between generations, for EV owners as well as other viewing the message on the screen.

Card

The card we designed is the user connector and collector of data. Through this card the user can tap into any station, where it will recognize the user and bring up his/her personal data. The card itself has a familiar look, showing the typical credit card details and the symbol of tap-functionality (see Figure 20*)*. On the backside of the card, the user can read about grid stress levels and relevant color coding.

Figure 20: The card

6. EVALUATION OF THE DESIGN

6.1. INTERNAL EVALUATION

To ensure the relevance of our selected elements of the system and avoid redundance, the team conducted an internal evaluation where we checked off each element in relation to the desired qualities we set as desirable from our solution *(see appendix).* This was a way to see which part of the system that had the strongest impact, as well as providing an overview of how the elements interlink.

The importance of the card was raised for discussion at this point. Within our evaluation table (see appendix), the card only ticks two of our desired qualities. In one way it is the physical link that people tap in and out of their charging machines to set the details of their charging (or V2G activity). It could also be a good element to add the monetary compensation to, potentially showing the discount obtained on their card once they tap it on the screen. We did however find this element replaceable. Other alternatives could be further explored. Ideas regarding a mobile application to connect the system was brought up, as well as the alternative of Bank ID to log in for the charging machines without having to have a card.

However, both an application and Bank ID would require more steps for the user to always navigate through. The encounter with the charger would happen regardless and integrating a dashboard with the desired functions within that already existing activity was thus something we viewed as desirable. With the card being the link between users and the system, this area would be of core importance to validate together with users, finding the link with the least steps to ensure a smooth experience.

6.2. EXTERNAL EVALUATION

For the external feedback, we again turned to our fellow classmates during an evaluating workshop of our design. During this session we got some valuable pros and cons to further consider.

User 1:

- Information about the color-system should be clearly communicated within the interactive screen at the charging machine
- There needs to be an extra motivator for V2G (intrinsic is good to some extent)
- An app might be helpful to connect the system

User 2:

- Monetization reward might be convenient
- Big screen inspires people, a good conversation starter
- Trees were viewed as an additional engaging gamified element

We also did another round of validation towards the needs and desires found in the secondary user research report presented earlier in the report [7]. Following are the strengths and weaknesses found:

Strengths

*Reliable control: r*egarding the insecurity of not being able to leave at any moment if engaging with V2G, our function of setting a minimum threshold for their batteries when doing V2G covers this issue. At the charging machine interface, they set their own personal limit to be in full control. In addition to that, the system could provide a recommended threshold based on the user's charging history.

Social contribution as something meaningful: The local grid constraints were described as impacting everyone within the community. Being able to help the community to avoid this bad impact was seen as something good and meaningful [7]. While learning the color coding of our design, EV owners would hopefully make more aware choices to avoid charging during peak hours. Thus, also alleviate surges and high electricity costs for the community. Engaging with V2G would emphasize even more on giving back and support the community.

Intrinsic motivator to partake in the green shift in society: The main focal point of the system is to transform charging into an aware and meaningful practice. With the tree as a tangible contribution, we aimed at creating a sense of actual impact by the users. Our system highly accommodates the desire of reducing one's ecological footprint as was raised in the study [7]. We also found it inspirational for the power providers to pay the good deeds by individuals forward. Hopefully, it could create a snowball effect for good. Both covering the level of people inspiring people, but also business to business with regards to the bigger need of sustainable change.

Weaknesses

Financial compensation: Realizing that whilst the EV owners of the research highlighted the motivation of reducing their carbon footprint and being able to contribute to good, the need for a financial compensation or reassurance of no battery wear when engaging with V2G would need to be met. Currently the system is designed to emphasize on the intrinsic motivation of people. An additional monetary reward could as previously mentioned be an addition to the system, ensuring users that their contributions will be worth their while.

Transparent communication: V2G was accepted among the participants with the condition of transparency regarding the battery wear and that there should be some compensation for it. The systems potential wear of the battery would need to be observed over time and a plan for compensation needs to be set and clearly communicated to the users. To reduce this barrier or hesitation among users, upfront and transparent information about the battery wear would be a good path as well as following that up with a reassuring plan for support by the system providers regarding this issue.

7. FUTURE RESEARCH

The following are relevant research areas to further improve the concept of the system:

7.1. EXTRINSIC REWARD

Alternative for financial compensation for the user's effort should be further addressed. Especially in relation to the insecurity of battery degradation.

7.2. ETHICS

Research needs to be done on the effects of showcasing the individual effort (V2G) in a collective setting. This is currently the case with our illuminative cable turning blue showcasing the V2G activity of each car. Research needs to be done to ensure it having the positive inspirational effect as intended. Alternatively, the collective and anonymous non interactive screen could be enough.

7.3. USER CONTROL

As was mentioned both in the internal evaluation as well as the feedback from classmates, a phone application could be a potential good alternative to give users greater control, not only when physically being at the charging machine. An interface for greater control by users was also something suggested in the study of 20 EV owners [7]. We implemented such an interface at the charging machine, but alternative areas could be further explored. Within a phone application, further gamified elements relating to the forests could also be implemented, making our design even more engaging. Having access to your forest within your phone would also make it easier to show it to anyone in other contexts besides the physical parking lot. This could be desirable to boost the feeling of recognition of the good users are contributing to.

8. REFERENCES

[1] Gianluca Trotta. 2021. Electricity awareness and consumer demand for information. International Journal of Consumer Studies 45, 1 (2021), 65–79. DOI:https://doi.org/10.1111/ijcs.12603C. Pang, M. Kezunovic and M. Ehsani, "Demand side management by using electric vehicles as Distributed Energy Resources," 2012 IEEE International Electric Vehicle Conference, 2012, pp. 1-7, doi: 10.1109/IEVC.2012.6183273.

[2] C. Pang, M. Kezunovic, and M. Ehsani. 2012. Demand side management by using electric vehicles as Distributed Energy Resources. 2012 IEEE International Electric Vehicle Conference (2012). DOI:https://doi.org/10.1109/IEVC.2012.6183273

[3] Johan Jansson, Annika Nordlund, and Kerstin Westin. 2017. Examining drivers of sustainable consumption: The influence of norms and opinion leadership on electric vehicle adoption in Sweden. Journal of Cleaner Production 154, (June 2017), 176–187. DOI:https://doi.org/10.1016/j.jclepro.2017.03.186

[4] Vehicle-to-Grid (V2G): Everything you need to know. Retrieved March 11, 2022 from https://www.virta.global/vehicle-to-grid-v2g

[5] Anton Gustafsson and Magnus Gyllenswärd. 2005. The power-aware cord: energy awareness through ambient information display. In CHI '05 Extended Abstracts on Human Factors in Computing Systems (CHI EA '05), Association for Computing Machinery, New York, NY, USA, 1423–1426. DOI:https://doi.org/10.1145/1056808.1056932

[6] 2021. Gary earns money by plugging his car into the wall. What's the catch? ABC News. Retrieved March 11, 2022 from https://www.abc.net.au/news/science/2021-08-10/v2g-vehicle-to-grid-pays-ev-owners-for-electricity/100353072

[7] Koen van Heuveln, Rishabh Ghotge, Jan Anne Annema, Esther van Bergen, Bert van Wee, and Udo Pesch. 2021. Factors influencing consumer acceptance of vehicle-to-grid by electric vehicle drivers in the Netherlands. Travel Behaviour and Society 24, (July 2021), 34–45. DOI:https://doi.org/10.1016/j.tbs.2020.12.008

[8] THE 17 GOALS | Sustainable Development. Retrieved March 11, 2022 from https://sdgs.un.org/goals

[9] Ecosia - the search engine that plants trees. Retrieved March 11, 2022 from https://www.ecosia.org/

[10] Stamen Design. The Ekmans' Atlas of Emotion. The Ekmans' Atlas of Emotions. Retrieved March 11, 2022 from http://atlasofemoti ons.org/

[11] Ge bort träd. Vi-skogen. Retrieved March 12, 2022 from https://viskogen.se/gava/ge-bort-trad/

[12] Ladda din elbil - Laddstationer och laddstolpar | Grönbil.se. Grönbil.se - Miljöbilar till salu. Retrieved March 12, 2022 from https://www.gronbil.se/ladda-bilen/

[13] 2021. Gary earns money by plugging his car into the wall. What's the catch? ABC News. Retrieved March 12, 2022 from https://www.abc.net.au/news/science/2021-08-10/v2g-vehicle-to-grid-pays-ev-owners-for-electricity/100353072

Tinghua Li. 2020. The Metaphorical Expressions of Basic Color Words in English and Chinese. ELT 13, 3 (February 2020), 85. DOI:https://doi.org/10.5539/elt.v13n3p85

Adam Zipperer, Patricia A. Aloise-Young, Siddharth Suryanarayanan, Robin Roche, Lieko Earle, Dane Christensen, Pablo Bauleo, and Daniel Zimmerle. 2013. Electric Energy Management in the Smart Home: Perspectives on Enabling Technologies and Consumer Behavior. Proceedings of the IEEE 101, 11 (November 2013), 2397–2408. DOI:https://doi.org/10.1109/JPROC.2013.2270172

Caroline Algvere. 2020. Designing Electric Vehicle Charging Station Information. Retrieved March 11, 2022 from http://urn.kb.se/resolve?urn=urn:nbn:se:uu:diva-415168

Magdalena Wiksten. 2021. Elbilsparkörer som resurs : Den tekniska och sociala potentialen förelbilsladdning som flexibilitetsresurs. Retrieved March 11, 2022 from http://urn.kb.se/resolve?urn=urn:nbn:se:uu:diva-441575

9. APPENDIX

			Solutions we	have finalised		
Qualities trying to cover	**Charging Screen**	**Lights (Roof Lights and lights on chargers)**	**Charging Cable**	**Non-Interactive Screen**	**Card**	**Trees**
User awareness about capacity challenge	Yes (Shows Peak and suggests v2G action)	Yes (Shows peak using colours in the roof and charging station	Yes (visualising v2g contribution indicated there is a peak)			
To get an overview on their behavior	Yes (Logged in person can view their stats, v2g contributions, trees planted etc)		Yes (shows they are doing v2g)	Yes (Shows collective behaviour and influence other's behaviour)	Yes (Gives access to stats)	
Get people onboard on the idea of V2G	Yes (Shows Peak and suggests v2G action)	Yes (Shows peak using colours in the roof and charging station and can motivate to do v2g)	Yes (Seeing blue cables might give social pressure to do v2g also)	Yes (Screen will show motivation message to contribute to v2g during peak)		Yes (Intrinsice motivator. Sparks engagement)
Awareness on V2G			Yes (Blue color will make user aware that he is contributing)	Yes (Screen will show message to create awareness for v2g)		
Avoid the peaks		Yes (Red light makes people not charge at that time)		Yes (Shows the collective stats and graph which creates an awareness of peaks and can make user charge in non peak hours)		
Make their users feel safe having their cars charged with just the necessary amount of energy	Yes (Set a percentage limit)					
Contribute for good and without any expectations	Yes (Shows Peak notifactions which might make the user do good by contributing to v2g)	Yes (By avoiding red periods they do good)	Yes (Blue color of others will influence them to give power and do more good)	Yes (Seeing some good motivation message can push them to do good. Community building/contribution)		Yes (Intrinsic motivation)
Monetary benefits					Yes (Cards give access to token obtained)	

Figure 21: Internal Evaluation