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112 What makes smart charging of EV's desirable for the driver?

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At this moment, charging your electric vehicle is common good, however smart charging is still a novelty in the developing phase with many unknowns. A smart charging system monitors, manages and restricts the charging process to optimize energy consumption. The need for, and advantages of smart charging electric vehicles are clear cut from the perspective of the government, energy suppliers and sustainability goals. But what about the advantages and disadvantages for the people who drive electric cars? What opportunities are there to support the goals of the user to make smart charging desirable for them? By means of qualitative Co-design methods the underlying motives of early adaptors for joining a smart charging service were uncovered. This was done by first sensitizing the user about their current and past encounters with smart charging to make them more aware of their everyday experiences. This was followed by another generative method, journey mapping and in-depth interviews to uncover the core values that drove them to participate in a smart charging system. Finally, during two co-design sessions, the participants formed groups in which they were challenged to design the future of smart charging guided by their core values. The three main findings are as follows. Firstly, participants are looking for ways to make their sustainable behaviour visible and measurable for themselves. For example, the money they saved by using the smart charging system was often used as a scoreboard, more than it was about the actual money. Secondly, they were more willing to participate in smart charging and discharging (sending energy from their vehicle back to the grid) if it had a direct positive effect on someone close to them. For example, a retiree stated that he was more than willing to share the energy of his car with a neighbouring family in which both young parents work, making them unable to charge their vehicles at times when renewable energy is available in abundance. The third and last finding is interrelated with this, it is about setting the right example. The early adopters want to show

people close to them that they are making an effort to do the right thing. This is known as the law of proximity and is well illustrated by a participant that bought a second-hand, first-generation Nissan Leaf with a range of just 80km in the summer and even less in winter. It isn't about buying the best or most convenient car but about showing the children that sometimes it takes effort to do the right thing. These results suggest that there are clear opportunities for suppliers of smart EV charging services to make it more desirable for users, with other incentives than the now commonly used method of saving money. The main takeaway is that early adopters have a desire for their sustainable behaviour to be more visible and tangible for themselves and their social environment. The results have been translated into preliminary design proposals in which the law of proximity is applied.

Keywords: Co-Design, Electric Vehicles, Mobility, Smart Charging, User Needs

Project: Smart Solar Charging

Within the project the aim is, using smart charging systems to make the best use of the potential of solar panels and electric cars to capture and distribute energy. Through this innovation, it is possible to store energy in the car and take it out later when needed. This relieves the energy grid, and at the same time develops a smart grid of cars, energy storage and distribution.

In the municipality of Utrecht, there are five experimental areas where the innovation and knowledge in the field of smart solar charging are valorized and further developed. The knowledge concerns the balancing at the area level of energy demand and supply with solar, demand-driven, and bi-directional charging.

This unique 'vehicle2grid' fast charging systems stores a surplus of solar energy in the cars during the day to be able to use it when energy prices are high. This involves innovative technology that enables a sustainable energy system at the neighbourhood level.

Case study: Bi-directional charging

This will be the first time that we as owners of cars, will take energy out of our cars to benefit from it in other ways.
One of the partners within the project developed an app for smart charging towards private-owned e-cars. Through this app, private e-car owners use optimized charging to benefit the most of cost-reduction while charging. As a result, the e-car owners can get a financial payment based on their charging behaviour.

The charging possibility at this moment is one-directional, this means only charging the car. Bi-directional charging is within the application still in development. To explore the obstacles and possibilities of bi-directional charging towards drivers, a co-design process was engaged. How to create a concept to support drivers within the app to apply bi-directional charging.

Methods & Tools

Co-Design & Co-creation

Often projects within smart sustainable mobility have feasibility of viability as an approach. The focus of this research is from the human perspective also known as the desirability principle (IDEO, 2015). The values and incentives for e-car owners are explored through different tools and methods within a co-design process. Co-Design can be used as a tool, mindset or method (Sanders & Stappers, 2008) Co-creation is a generative tool that can help researchers and designers towards getting better insights. The persons/users who we are designing for, are the “experts of their experience”. Thus, we should make use of their knowledge. By supporting the users and use generative tools to help the users express themselves and generate ideas and concepts. Co-design within this project is the whole of the design process in which we used several co-creation methods to create insights. The co-design process is composed of two co-creation sessions, working with the target group on their experiences related to smart charging and electric driving. Before this co-creation session, the participants will receive homework in a form of small assignments related to electric driving and smart charging. During the co-creation session itself, the sensitizers will be involved in the process, using value artefacts, making journey maps, and developing future perspectives and prototypes.
After the co-creation sessions, the data is analyzed, and consists mainly of transcribed video footage, assignments made and notes taken during the sessions. Then this information is processed on a large canvas so that clear insights emerge. Subsequently, these insights are interpreted to visualize initial concept directions. The focus of this paper is on the co-design process, the methods used, the results regarding smart charging and the desires of ev-drivers and the insights.

Sensitizing

To prepare people and get them more involved during the co-creation session, the participants are given tasks before the session. This can be workbooks, assignments, and diaries. It, therefore, supports them to self-document these experiences in their daily lives. The goal of a sensitizer isn’t necessarily to gain direct insights for the project but is more focused on preparing the participant for the Co-design session. The intended result is that during the Co-design workshop they are more attentive and remember more of the details and feelings regarding their experiences (van Dam et al., 2020).

Co-creation Session

In co-creation sessions, persons are invited to design their future vision in a visual presentation together. These results can be used as input for researchers and designers to further develop these ideas into concepts or prototypes.

Through various exercises during the co-creation session, individuals are guided to look at the present and the past. Then together they look and create a future. Herein a person can experience his or her dreams.
The Path of Expression is a process in which present, past, and future experiences are explored.
The present and past have already been explored by the sensitizers that were performed before the co-creation session. Through the sensitizers, the person already reflects on their own experiences that have relations to the subject.
During the co-creation session, each person's individual experiences and thoughts are explored in more depth. In addition, each person in the co-creation session will share his or her experiences and thoughts with the rest of the participants. Whereby there is an open and familiar environment in which people can talk to each other about their experiences and their thoughts.
By sharing, one creates an opening to the values and motivations. These values and drives are the first step to thinking and exploring what they experience as a future vision. (Sanders & Stappers, 2012)

“What if…” during a co-creation session.

Visualizing during idea generation promotes creativity and helps to come to a mutual understanding of what different team members mean (van der Lugt, 2002).
To realize a future vision, materials are offered during the session, in the form of craft materials, to let the participants build their vision of the issue in an accessible way. By building it and talking about it with each other, a joint image is created, which can be in the form of a poster but more often in the form of a prototype of a product, service, or system.
The next step is to be able to explain to the other participants and the researchers the rationals of the prototype that is developed. The explanation is often performed through a scenario in which the vision of the prototype is showcased.

Value artefact

One of the challenges during a co-creation session is to make sure everyone’s values will be taken into account during the whole session. Participants can lose their core values in the process of co-creation. It is easy to get carried away by a process, an enthusiastic idea, or a more dominant participant. The value artefact helped to ground them and protect the things important to them.

In this case, we developed value cards in the form of a credit card and are meant to be visual and physical reminders of the most important value the individual participants want to guard during the co-creation session. The value cards are personalized and the participants can write their value on them.

Customer Journey map
When creating a product or service it is always part of a bigger picture, a system (Sevaldson & Jones, 2019). A customer journey helps to walk in the user's shoes and see how the solution you're creating fits in their lives. Within the co-design session, we used journey mapping as a sensitizer. To gain more insights into their daily activities regarding driving their e-car and as input during the session to create more in-depth information.

Analysis

The analysis is divided into two parts, the first part focuses on the effects of using Co-design methods with contextually designed facilitation tools in a sustainability project. In the second part we look at the actual insights we gathered for the project by using these methods.

Contextually designed facilitation tools in sustainability projects

The tools and methods used for the Co-design workshop were tailor-made activities catered specifically to the session and its participants (Aguirre et al., 2017). By doing this we can pay careful attention to the situation and mindset of the participants. The goal of this is to gain deeper insights into their experiences and motivation than readymade or templated tools would achieve (Sevaldson, 2010).

Sensitizer
Our observations show three interesting effects. First is the expected; due to the users actively thinking about the subject in the week beforehand they are highly aware of their experiences, down to the small details. This is well demonstrated by the following quote: "And the most important argument that I experienced, and that is often underestimated, is that a traditional car gives an incredible amount of other pollution. The stinking exhaust fumes, the noise, the amount of waste that is created. The spilling of fuel, the leaking of oil. Apart from the CO2, it's just plain dirty."

The second finding is that we noticed a high level of commitment from the participants that we think is related to the reciprocity principle (Chen et al., 2009). Because they received a personalized package, with handmade items that are laser-engraved with their name, the participants realize that we spent time and effort to get good input from them. They sense that their opinion is valued and feel a need to give back to us.

The third effect is that talking about their sensitizers changed the conversation. The participants are all innovators and early adopters of smart charging systems since 3.16% of Dutch passenger vehicles are currently electric (Netherlands Enterprise Agency, 2021). They are often very keen on the technical aspect of their whole electric car system. So, the conversations between them were often about kWh, range, the effect of temperature on the battery, charging speeds, and installing 3-phase charging stations at home. But the positive and negative experiences of the week they recorded on the sensitizer were not about this at all. Suddenly we are talking about gas cars parking on EV charging spots. A young child who is finally able to sleep in the car due to the smooth and silent driving. And conversations at the Tesla Supercharger with a German man who lives in his car. With the sensitizer, we were able to quickly change the mindset of the participants from technological talk to share their actual experiences.

Customer Journey

Our observation is that it is especially useful for finding small details that otherwise go unnoticed, for example, the distance of a charging station from one's location can have a big impact on the way they use it, just like the presence of a neighbour who also uses the same station. The context of the user is important to understand the way they use a system.

Next to that, the customer journey is also a great setup for the upcoming value cards. By digging deeper into their EV journey, the actions, locations, and feelings that go with it, the participants are forced to evaluate habits and practices that they might not otherwise.

Value Cards

We've observed two effects that the value cards had, one on the side of the participant and one for the facilitators. For the participants, it was a reminder of what is most important for them throughout the design process.

From our perspective as facilitators, it helped to promote equal input. When designing in a group there is often a dynamic where a person, idea, or voice has the upper hand. By asking a group to incorporate everyone's value card in the design,

the process starts on a more equal foot. And as a facilitator, you can intervene when someone's values are in danger of being undermined, by simply asking; “wherein the design can we find this-and-this value?” This proves especially valuable with the technology-minded participants that tend to think of very technical solutions instead of solutions related to their values.

“What if…”
We provide the teams with a plethora of tools like whiteboards, markers, stickers, kinetic sand, Lego, scrap material, etcetera so they can build their ideas. And by giving the participants a fictional scenario we create an environment where they can think freely without restrictions or feeling hindered by prerequisites of their current situation.

The most important yield here for us is that everything comes together at this point. The participants must take into consideration the context, needs, wants, and problems of all team members which requires them to emphasize with each other and create solutions that work for a broader group of people.

These ideas are not finalized concepts that we can just take and apply in practice. It is about the stories they tell. And where the needs and wishes for the future can be identified and translated into user insights. These insights can then be used as guiding principles in the next phase of the design process.

Results regarding Smart Charging

Starting with their values, for a lot of participants the most important about driving an electric car is related to our future. Four out of eight people in group two mention this on their value card; “To plant a seed (for those around me)…”, “To be part of an innovative future”, “Setting an example for the future” and “Setting the right example”.

If we dive a bit deeper into what future they are talking about and for whom they are setting an example, we see that it is often focussed on those in close social proximity; “We have to do it together (being more sustainable). I try to propagate it in my surroundings as well.”, “And on the other side of the story are the children. I want to still be able to look them straight in the eyes in the future. In any case, I did as much as I could within my means. And I refrained from doing other things. To keep it liveable for you.”, “We want to be able to hand this earth over to our grandchildren. In a normal way without terrible weather conditions, the extremes I’m starting to see.”, “(My child said) daddy, when I grow up, I also want a Tesla. And I liked that. Those

children young and old see that car and realize, it is the future, it is good for the environment. I think that's really nice to see."

These underlying motivations and values of the innovators and early adopters are important to be aware of and can be used to guide the design but are not very concrete regarding the day-to-day use of an EV and smart charging system. A notable insight that might offer more direct guidance is that the participants often refer to the optimal use of their electric vehicle as a game or puzzle; "I think the energy transition is also the most beautiful thing, the most beautiful thing to solve, it is a fantastic puzzle.", "Yes, the whole puzzle, I find that fascinating...", "That is a puzzle that you can solve." Next to that, there is a lot of appreciation for the silent and smooth nature of driving electric; "And then when you drive through the beautiful nature, being the only one not emitting anything. I find that fantastic, about the driving.", "What I also find very important is the environmental aspect, but also, of course, very comfortable travelling. Um, and I think the peace and quiet are also very important." Another noteworthy observation is that for several participants the electric car also feels like compensation for other behaviour like, for example, flying; "To compensate a bit for the frequent flying I do for my job."

Figure 1. A participant talking about the beauty of solving the EV puzzle can be seen in the upper left corner of the customer journey.

The ‘What if…” tool where the participants explore possible future scenarios, helps us see what kind of solutions the participants would come up with. The first scenario is “What if the costs for charging your vehicle at the times you currently charge becoming five times as high?” This scenario is related to the need for peak shaving (Reihani et al., 2016). Here we see smart neighbourhood-based solutions with two main facets. First is a smart aspect that looks at the needs, desires, and agenda of the users and distributes energy from sustainable sources accordingly. There is also talk about offering alternative ways to travel if there is less sustainable energy available than the users want. Perhaps the system can suggest carpooling solutions or offer discounts for someone taking public transport, maybe compensate someone for choosing not to travel and work from home.

The neighbourhood part is based upon an understanding of the needs of those around us and a goodwill factor that is lacking among strangers. By not making energy a larger-than-life thing where your individual choices don’t seem to have a direct effect. Make the power grid small and tangible. A retiree for example stated that he was “more than willing to share the energy of his car with a neighbouring family in which both young parents work, making them unable to charge their vehicles at times when renewable energy is available in abundance.” This insight ties in well with the earlier observation that for a lot of people driving electric and participating in a smart charging system directly relates to setting a good example for those close to them.

Figure 2. Showcase: A smart neighbourhood based solution designed by the participants with a central bank collecting and distributing sustainable energy fairly.

Discussion

Experimental tools

The research group Co-Design, which we are part of, explores generative tools that contribute to the design capability of professionals (University of Applied Sciences Utrecht, n.d.). This means that some of the tools used in this research are experimental and have been tested with a small sample size and haven't been peer-reviewed. The Value cards are an example of this. We see great potential in providing participants with a physical object containing their previously stated core values, which carries over through various phases of a workshop or design process. The intended working mechanism here was mainly the physical aspect which serves as a constant reminder that makes the participants more aware of what their goals are. According to our observation, it also helped to create equality in a group process. But these are still preliminary findings and additional research is needed if we want to solidify the reliability of the results and use this tool for future projects.

Priming of the participants

Our previous experience while working with innovators and early adopters of emerging technologies are that this group is very technology-focused in their conversation. The novelty, innovation, and numbers related to the tech are primary topics among themselves. To find underlying motivations and steer the conversation in that direction we started the Co-design session with an icebreaker asking the participants what their ingredients are for a relaxed Sunday. While this had the intended effect and participants were suddenly talking about family, nature, and leisure, there is a potential issue regarding priming. By having the participants talk about a subject that of course brings up family and nature, we might have increased the perceived importance of these subjects regarding EV's and sustainability. In follow-up research, it would be important to see if the results stay the same when we start with a different icebreaker.

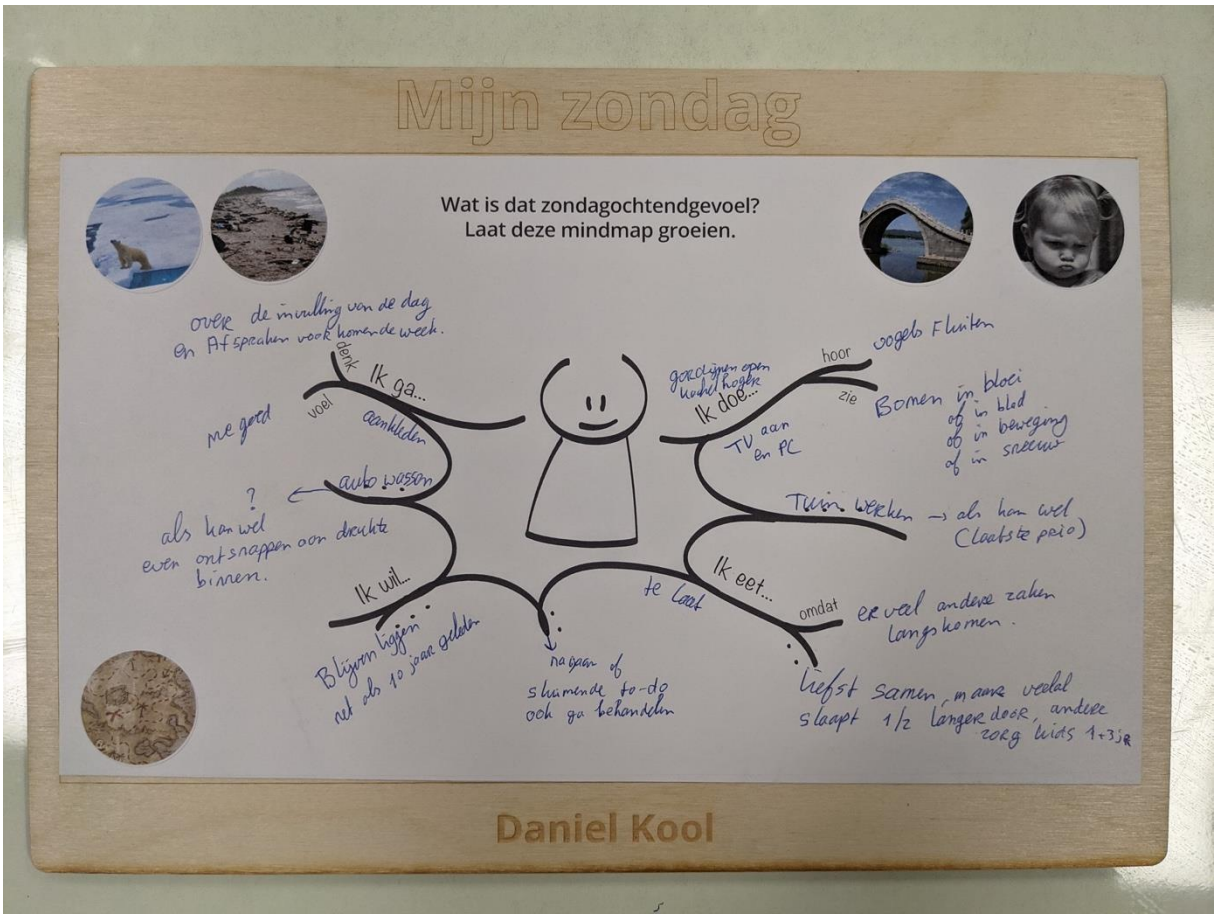

Figure 3. An example of a completed 'Sunday morning feeling' icebreaker.

Innovators and early adopters

This research was conducted in 2019 and the participants are still part of innovators and early adopters of EV vehicles and smart charging. This means that the results of this research don't necessarily carry over to the early and late majority, let alone the laggards. Innovators are eager to try new products and services, to the point where their venturesomeness can become a goal in and of itself. This also means they are willing to take larger risks and aren't deterred by the occasional setback. Due to their high interest they also often have complex technical knowledge. Eventually, when the adaptation of smart charging and EV's outgrows the early adopters and reaches the early majority it becomes important to cross-validate which of the findings carry over to this new demographic.

Conclusions

We have come away with three main findings. First is that the participants are more willing to participate in smart charging and discharging (sending energy from their vehicle back to the grid) if it has a direct positive effect on someone close to them. This offers great possibilities for the design of smart charging systems. Make the energy grid and the effect they have on it tangible for the user.

The second finding is about setting the right example. The early adopters want to show people close to them that they are making an effort to do the right thing. If someone does good, they'd like others to see it. This provides an opportunity for EV car-sharing services, parking places, and charging stations to put sustainability at the forefront and making it highly visible.

Last is that the money users save by adopting a smart charging application is often used as a scoreboard, more than it is about the actual money (the average amount saved monthly by the users of the smart charging app was below €10,-). It's part of a sustainable puzzle the users want to solve for themselves. And scoring better than they did before or better than others do is a great motivator. Designers of smart charging software can focus on this aspect to find new ways of motivating users next to or instead of money.

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