# TOWARDS AN EVALUATION OF INCENTIVES AND NUDGES FOR SMART CHARGING

*Research in Progress*

Hanna Marxen, University of Luxembourg, Luxembourg, Luxembourg, hanna.marxen@uni.lu

Raviteja Chemudupaty, University of Luxembourg, Luxembourg, Luxembourg, raviteja.chemudupaty@uni.lu

Valerie Graf-Drasch, Chair of Digital Management, University of Hohenheim, and FIM Research Center, Project Group Business & Information Systems Engineering of the Fraunhofer FIT, Stuttgart, Germany, valerie.graf-drasch@uni-hohenheim.de

Michael Schöpf, University of Luxembourg, Luxembourg, Luxembourg, michael.schoepf@uni.lu

Gilbert Fridgen, University of Luxembourg, Luxembourg, Luxembourg, gilbert.fridgen@uni.lu

## Abstract

*Electric vehicles (EVs) are an important cornerstone to achieve transport decarbonization. Still, simultaneous charging of EVs when home charging increases peak demand, especially during evenings. Smart charging allows optimal distribution of load, thus preventing peak loads. Nevertheless, this incorporates certain risks for the EV user, e.g., unavailability of EVs for unplanned events. This might lead to a lack of user acceptance. This paper focuses on specific incentives and nudges, motivating users to adopt smart charging. We conducted an integrative literature review, bringing together literature from different areas. Possible incentives and nudges are monetary incentives, feedback, gamification, or smart charging as a default-setting. We conducted three focus groups with 13 EV users in Luxembourg to get first insights into which of those incentives and nudges they prefer. Preliminary results indicate that incentives and nudges should be individualized. In the future, we would use these first insights to develop a large-scale survey.*

*Keywords: Smart charging, incentives, nudges, user behaviour.*

## 1 Introduction

A central step towards mitigating climate change includes the transformation of society towards carbon neutrality. Thereby, particularly the decarbonization of the transport sector is paramount, as this sector accounts for a quarter of the EU's total greenhouse gas emissions (European Environment Agency, 2021). Out of the many solutions to reduce the emissions associated with the transport sector, replacing the internal combustion engine with an electric drivetrain seems to be the most viable one (Wentland, 2016): When charged with renewable energy, the emissions of electric vehicle (EV) usage are almost negligible. Thus, electric vehicles (EVs) represent a key lever for putting the brakes on carbon emissions (Huber et al., 2019a). In that notion, favorable conditions such as EV-friendly policies, efficient drivetrains, or reduction in battery costs have rapidly increased the EV market penetration. This development is expected to accelerate in the forthcoming years (International Energy Agency, 2020).

Still, even if EVs address aspects of the climate crisis, the rapid electrification of the transport sector causes a rise in electricity demand. The situation further exacerbates when EVs charge simultaneously, thus causing a significant strain on the power grid (Huber et al., 2019b). This caveat could be tackled either from the supply side or the demand side: First, solutions associated with the supply side imply an increase in conventional generation capacity to meet the rising peak demand due to EV charging. This is quite expensive and incompatible with the renewable energy expansion goals (Amin et al., 2020). Second, solutions associated with the demand side refer to the control of EV charging by using demand response programs (Ireshika et al., 2019). Within such demand response programs, the EV load is controlled using indirect and direct load control strategies. In an indirect load control strategy, various dynamic pricing schemes are designed that positively correlate with peak demand, and users adapt their charging schedules to minimize their total cost (Amin et al., 2020). In a direct load control mechanism, the electricity provider alters the load based on the requirements of power systems, albeit adhering to the user requirements (Eid et al., 2016). The adaption of EV charge cycles to the conditions of power systems and the user requirements is known as 'Smart Charging' (IRENA, 2019).

Several studies have already investigated the economic feasibility of smart charging (e.g., Alghamdi et al., 2021; Eldeeb et al., 2018; Rashidizadeh-Kermani et al., 2018; van der Meer et al., 2018). All of them optimally scheduled the EV charging to maximize the profits of energy suppliers by considering the electricity market prices. Further studies ascertain that smart charging is feasible from both an economic and a technical perspective (Deilami et al., 2011; Franco et al., 2015; Richardson, 2011). These works developed an optimal solution for the efficient integration of EVs into the existing distribution systems. However, the acceptance of EV users, which is pivotal in large-scale adoption of smart charging, was rarely discussed in the studies mentioned above. This is somewhat counterintuitive since incentivizing the users is one of the most obvious ways to promote smart charging usage among EV users.

These studies on incentivizing the users to use smart charging mostly investigate the impact of monetary incentives on EV users' smart charging acceptance but less on the influence of non-monetary options. For example, Ensslen et al., (2018) developed a 'load-shifting-incentivizing' (dynamic) tariff which benefits both users and the energy suppliers. A smart charging trial in the UK found out that by implementing dynamic tariffs, most EV users shifted their charging events to off-peak periods (Greenflux, 2020). However, a recent report from the UK suggests that "over a quarter of EV users charge their vehicles during peak hours despite the cost benefits and carbon impacts" (Grundy, 2021, p.1). These contradictory results imply that monetary incentives alone might not suffice for large-scale adoption of smart charging (Will and Schuller, 2016). This ascertains that while developing an incentive scheme and strategies for smart charging, nudges should also be considered. Thaler and Sunstein (2008) define nudges as "any aspect of the choice architecture that alters people's behavior predictably without forbidding any options or significantly changing their economic incentives" (p.6). Incentives in contrast, refer to monetary benefits which arise from the choice of the desired alternative. Incentives and nudges could help ensure that smart charging is attractive to users and that they are willing to accept a certain degree of discomfort. Our research in progress study aims to better understand the behavioral component in smart charging systems and, specifically, the role of incentives and nudges for smart charging. We thus formulate two research questions:

*RQ1: Which incentives and nudges in the context of smart charging are regarded as most attractive regarding user perception?*

*RQ2: What is the user's motivation for regarding certain incentives and nudges as attractive?*

Figure 1 depicts an overview of our approach to answer these research questions. We first conducted an integrative literature review in different streams of research. Based on the literature review results, we identified incentives and nudges, which could be important from a smart charging perspective. We conducted three focus groups with 13 EV users in Luxembourg to get first insights into how attractive they perceive different incentives and nudges.

Preliminary results in this research in progress paper are that different motivations for EV usage seem to influence which incentives and nudges EV users prefer. The three motivations were ecological, economic, and technological. We will analyze focus group material using qualitative content analysis

(QCA) as a method. We will conduct a large-scale survey in a follow-up full paper to validate and determine which factors affect the perception of incentives and nudges.

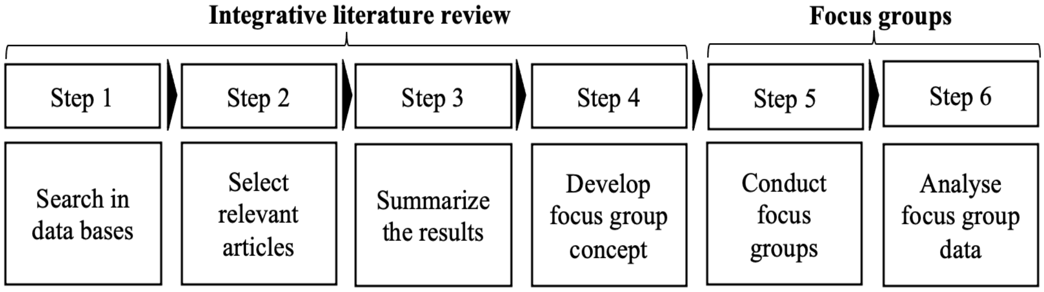


*Figure 1. Research Approach.*

## 2 Integrative literature review

Previous research has already described the impact of incentives and nudges on smart charging adoption to a small degree. Still, the number of those studies is limited. Therefore, we conducted a first integrative literature review, bringing together smart charging, energy saving and information system (IS) intersecting sustainability literature (e.g., Green IS, ICT4D). As a lens for our methodological proceeding, we used the guidelines for integrative literature reviews (Torraco, 2016). We searched in the SCOPUS and Google scholar data bases with combinations of search strings of two categories (Table 1). The search strings of the first category refer to smart charging and related concepts. Related concepts are similar to smart charging as they have the same underlying principle where the energy consumption is adapted based on the user requirements (e.g., residential). We also consider studies on energy savings. These are mostly referred to in the existing literature on incentives and nudges for smart charging (e.g., Huber et al., 2019b). The search strings of the second category are related to incentives and nudges.

Our search comprised two steps: The first step was structured with the aim to find as many relevant papers as possible about incentives and nudges for smart charging. We searched with the search strings of the first category (e.g., “smart charging”) and combined them with those of the second category (e.g., "incentive"). We looked further into the identified papers using the forward-backward search to find more relevant papers. We also included papers focusing on incentives and nudges for vehicle to grid technology, a further development of smart charging technology that allows the power flow from the EV batteries to the power grid. In the second step, we focused on the papers that designed incentives and nudges to other similar concepts that could be theoretically transferred to smart charging. We combined the search strings of the first category (e.g., “EV adoption”) with those of the second category (e.g., “nudge”). As there is a lot of literature on this in related fields, we aimed to get an overview of the literature and not cover the whole literature. Thus, we followed a narrative approach. In our team, we discussed and evaluated the applicability of incentives and nudges from other sectors to smart charging. The combination of the structured and narrative approach should yield a broad understanding on which incentives and nudges exist and are potentially effective for smart charging.

| | **Category 1** | | **Category 2** |
|---|---|---|---|
| **Step 1 Structured approach** | “smart charging” OR “flexible charging” | AND | “incentive” OR nudge” OR “behavior change” OR “consumer perspective” OR “user perspective” OR “motivation” OR “persuasion” |
| **Step 1 Narrative approach** | “load shift” OR “demand shift” OR “demand side management” OR “demand response” OR “EV adoption” OR “EV acceptance” OR “energy saving” OR “energy-efficient” OR “smart home management” OR “green information system” | AND | |

*Table 1. Search strings for the integrative literature review in step 1 and step 2.*

Inclusion criteria for papers were the following: Papers needed to be in English or German and should state or measure the effect of incentives and nudges. In the first step, to find as much smart charging incentive literature as possible, we considered empirical papers, theoretical papers, conference papers, journal papers, doctoral theses, and university project reviews. In the second step, as fields related to smart charging were not the core focus of the paper, we mainly looked at the reviews and meta-analyses. In the first step, we found 12 papers[1]. In the second step, we selected 23 papers[2]. We looked more closely at those 35 papers. The results of the integrative literature review are that monetary incentives and the nudges *framing*, *feedback*, *gamification*, or *default-setting* can motivate people to use smart charging. In the following, we summarize this literature and provide details on related research.

First, *monetary incentives* in the context of smart charging, often refer to a discount on every kWh or the monthly base prize (Will and Schuller, 2016). Studies come to different conclusions regarding the effect of incentives and nudges on the use of smart charging. In the study of Schmalfuss et al., participants who tested smart charging for five months named monetary incentives most frequently as benefit for smart charging. Handke et al. (2012) claim that users need monetary incentives to accept smart charging. However, according to the survey results by Will and Schuller (2016), monetary incentives do not affect the acceptance of smart charging. Paetz et al. (2012b) tested a time-shifted charging concept for the charging of electric vehicles with 14 participants. The time-shifted charging mechanism allows users to adapt their charging schedule based on their requirements. For the participants of this study, however, monetary incentives were not the reason for time-shifted charging, but environmental aspects. The authors also doubt that time-shifted charging can work completely without monetary incentives.

Also, in the energy-saving literature, the effect of monetary incentives on energy-saving behavior is mixed. Some studies claim or find a positive effect (Alasseri et al., 2020; Azarova et al., 2020; Dütschke et al., 2013; Ito et al., 2018; Spandagos et al., 2021). However, a meta-analysis, which included 52 empirical studies, found a negative effect of monetary incentives on energy-saving behavior: Cost-saving information led even to higher energy consumption (Buckley, 2020). Despite disparate results, in the context of smart charging, monetary incentives may have a certain impact. According to Schmalfuß et al., (2015) and Tamis et al. (2018), EV users expect financial compensation for making their flexibility available to the energy provider. In summary, monetary incentives are potentially promising for smart charging. Previous smart charging studies mostly look at the perception of monetary incentives. Future studies on monetary incentives should also examine the impact of incentives on behavior change. But in practice, as monetary incentives are not effective for everyone, they should not be the only incentive (Tamis et al., 2018); nudges should also be considered.

*Framing* can be regarded as a nudge and "is the conscious formulation and description of the decision situation to encourage people to behave in a certain way" (Huber, 2020, p. 87). In the context of smart charging, this could mean using text messages to influence the decision-making situation so that EV users are more likely to use smart charging. Framing messages can be shown in an application before the user decides whether to use smart charging or not. In the study by Huber et al. (2019a), only cost frames were effective, environmental frames had no effect and social frames led even to a lower intention to use smart charging. Before charging, cost frames inform EV users to save money through smart charging (Huber et al., 2019b). Environmental frames make clear to the EV user that smart charging contributes to environmental protection (Huber et al., 2019b). Social frames show the user that the network is shared with other users and that everyone benefits from using smart charging (Huber et

[1] Selected papers in step 1: Antunes et al., 2018; Delmonte et al., 2020; Geske, 2014; Handke et al., 2012; Huber et al., 2019a; Huber et al., 2019b; Huber & Weinhardt, 2018; Jochem et al., 2012; Paetz et al., 2012b; Schmalfuß et al., 2015; Tamis et al., 2018; Will & Schuller, 2016.

[2] Selected papers in step 2: Alasseri et al., 2020; Allcott & Rogers, 2014; Azarova et al., 2020; Broman Toft et al., 2014; Buckley, 2020; Chatzigeorgiou & Andreou, 2021; Delmas et al., 2013; Dütschke et al., 2013; Frenzel et al., 2015; Günther et al., 2020; Horne & Kennedy, 2017; Ito et al., 2018; Johnson et al., 2017; Ming et al., 2020; Momsen & Stoerk, 2014; Morganti et al., 2017; Paetz et al., 2012a; Paetz et al., 2012c; Schaule & Meinzer, 2020; Soomro et al., 2021; Spandagos et al., 2021; Tiefenbeck et al., 2019; Vetter & Kutzner, 2016.

al., 2019b). In the energy-saving literature, Schaule and Meinzer (2020) had similar results: Cost frames led to an increased willingness to shift the run times of dishwashers and washing machines, and environmental frames showed no effect. “Social framing even showed a slight decrease in the readiness to shift run times for dishwashers” (Schaule and Meinzer, 2020, p. 1).

To summarize, especially cost framing messages seem to be successful. However, researchers should further investigate the effect of framing messages on the smart charging decision. Here, studies should investigate the effect of framing messages on real EV users' actual smart charging behavior.

Third, *Feedback* could be a significant nudge for smart charging. It can be given on the financial consequences or the respective carbon footprint of a user’s charging behavior (Huber and Weinhardt, 2018). However, according to the meta-analysis of Delmas et al. (2013), feedback on cost savings in terms of energy savings leads to an increase in energy consumption and not a decrease (Delmas et al., 2013). Still, especially feedback on environmental contribution could be significant because eco-values, as well as ecological motives, are considered the main motivation for smart charging and the integration of renewable energy sources as the main acceptance factor (Frenzel et al., 2015; Geske, 2014; Huber et al., 2019a; Jochem et al., 2012; Paetz et al., 2012c; Schmalfuß et al., 2015; Tamis et al., 2018; Will and Schuller, 2016). Feedback on an environmental contribution would show users their contribution to environmental protection and motivate them to continue using smart charging. Schmalfuß et al. (2015) show in their survey study, for example, that EV users “are motivated by the feeling of doing something good” (p. 9) to use smart charging. The way feedback is given could be, e.g., historical, real-time, or socially comparative. Regarding the energy-saving literature, Chatzigeorgiou and Andreou (2021) regard historical feedback as a standard for feedback on energy consumption on mobile devices. Research results show that comparative social feedback and real-time feedback are particularly effective. Regarding comparative social feedback, US energy provider OPOWER received information every month about how their energy consumption varies compared to their neighbors (Allcott and Rogers, 2014). Even after the feedback reports were stopped for two years, there was an energy saving of 10-20% compared to when the feedback reports were received. According to Allcott and Rogers (2014), comparative social feedback could also be effective in the long term. Besides comparisons with other consumers, artificial norms can also be successful if the target group feels addressed (Soomro et al., 2021), e.g., encouraging hotel guests to reuse their towels. Concerning real-time feedback, Buckley (2020) concludes in his meta-analysis that real-time feedback is one of the most promising ways to give feedback. To give an example, hotel guests who “received real-time feedback on their energy consumption while showering used 11.4% (0.21kWh) less energy than guests in a control group“ (Tiefenbeck et al., 2019, p.1). In addition to the distinction between historical, real-time, and social comparative feedback, feedback can be personalized or, for example, reflect the behavioral tendency. This is where personalized feedback seems most effective (Buckley, 2020; Delmas et al., 2013).

*Fourth, gamification* is “the use of game design elements in non-game contexts” (Deterding et al., 2011, p.9), e.g., tips, virtual currency, or badges (AlSkaif et al., 2018). It can be regarded as a form of feedback (Chatzigeorgiou and Andreou, 2021). The demarcations between gamification and feedback are blurred. Feedback and gamification differ, however, in their aims. Feedback aims to get the users to reflect on their behaviors. Gamification aims to engage the user and to enhance their activity and retention (Deterding et al., 2011). Game elements “vary widely in terms of the type of games, target, and features that might be appealing and motivating” (Morganti et al., 2017, p. 101). AlSkaif et al. (2018) classified the most important game elements for residential energy applications into the following categories: Information provision (e.g., tips), rewarding system (e.g., virtual currency), social connection (e.g., energy community), performance status (e.g., badges) and user interface (e.g., progress bar).

There is a lack of studies investigating the effect of gamification on the smart charging behavior of EV users. Still, in practice, current smart charging applications use numerous gamification elements (e.g., ev.energy, 2020). With regard to energy-saving behavior, studies find a positive effect of gamification elements (Chatzigeorgiou and Andreou, 2021; Johnson et al., 2017; Morganti et al., 2017). Gamification elements (e.g., personalized goals, feedback, social comparison, prizes, lottery) can enhance energy saving behavior and eco-driving (Günther et al., 2020; Ming et al., 2020). Regarding mobile energy applications, a limited number of studies examine the effect of gamification on behavior change (Beck et al., 2019). Also, existing studies often only consider individual gamification elements in isolation or differ in the combination of gamification elements they consider, e.g., compare the study of Ming et al. (2020) and Günther et al. (2020). It, therefore, seems difficult to describe the effect of the gamification elements on behavior change. However, some authors describe individual gamification elements further in literature and the effect on behavior: According to Buckley (2020), e.g. tips fall into the information provision category are very effective if individualized. According to their meta-analysis, general tips on saving energy even led to an increase in consumption. In general, the core principle behind tips is like feedback and framing. However, tips solely focus on improving user performance based on their behavioral patterns. Concerning social connection, Horne and Kennedy (2017) emphasize the role of social norms, which can be established via new technologies and can influence energy-related behavior. Peer pressure can be built up online and can impact the behavior of users (Spandagos et al., 2021).

*Fifth, to set smart charging as a default* is recommended by the UK Energy Task Force (Energy Task Force, 2019) and Delmonte et al. (2020), as this reduces user interaction with the smart charging system. In other areas, setting a desirable option as the default has proven effective, e.g., for organ donations (Shafir, 2013). Regarding the choice of environmentally friendly energy contracts, to set a contract with energy from renewables as the default was the only incentive that had an impact on whether people chose a contract where the energy came from renewable sources (Momsen and Stoerk, 2014): The default setting increased the proportion of those who opted for the green contract by 44.6%. In the study by Vetter and Kutzner (2016), the default setting also influenced whether a green contract was selected: Environmental attitudes did not influence the decision. For smart grids, the use of an opt-out frame leads to a significantly higher participation rate than the opt-in frame (Broman Toft et al., 2014). However, to make smart charging the default, smart meters and wall boxes should first be installed. If these conditions are met in the future, smart charging as a default could be possible. Still, EV users might just use it if there are no additional costs for purchasing infrastructure.

According to initial research results, different groups of people perceive incentives and nudges as differently attractive. Cultural and demographic factors and different motivations (e.g., ecological versus economic) influence, for example, how different they are perceived. Regarding cultural differences, e.g., monetary incentives are perceived as more attractive in Portugal than in the Netherlands; in contrast, social comparison is perceived as more negative in Portugal than in the Netherlands (Antunes et al., 2018). Besides cultural factors, different motivations for smart charging could also influence how attractive incentives and nudges are for different groups of EV users. Bailey and Axsen (2015) distinguish between EV users who could be motivated by cost-saving and those motivated by using electricity from renewable energy sources. In terms of how different consumers respond to demand response, Sharda et al. (2021) describe consumers based on the literature using four dimensions: Selfishness, importance of price, eco consumption, and demand responsiveness.

Concerning the price dimension, Sharda et al. (2021) distinguish between price optimizers (price prioritized over comfort), price-sensitive (tradeoff between comfort and price), and price-insensitive consumers (comfort prioritized over price). Regarding eco consumption, they distinguish between eco consumer (minimum power demand from the grid), the average consumer (average power demand from the grid), and waste consumer (comfort prioritized over price). Before incentives and nudges are applied, researchers need to conduct consumer research to investigate which incentives and nudges are appropriate for the respective target group. They “must fit the context and the targeted user group, as otherwise, they can backfire and even have adverse effects” (Huber, 2020, p. 68).

# 3 Focus groups

Focus groups are a well-established method to get customers’ and users’ perspectives on new technologies or products (Paetz et al., 2012a). In that, focus groups allow a deep investigation of reasons underlying a product evaluation and thus go far beyond superficial responses (Mert and Tritthart, 2009). Participants get the possibility to „ask questions and also to stimulate each other in evoking associations and perceptions to discuss them as a group” (Paetz et al., 2012a, p. 28).

To analyze the feedback and input received in the focus group, we later plan to use qualitative content analysis (QCA) as a deductive and an inductive approach to analyze data (Cho and Lee, 2014): We will first deductively develop categories according to which the data will be coded. Afterward, we will derive further categories with the help of an inductive procedure.

## 3.1 Conduct of focus groups

The primary goal of our focus groups was to perceive the users' preferences for different incentives and nudges in the context of EV charging and understand the factors driving these preferences. We conducted three focus groups ($n_1 = 4$, $n_2 = 4$, and $n_3 = 5$) in Luxembourg with 13 EV users (2 female, 11 male). We selected the EV users who drove their EV for at least several months. Participation was voluntary. All the focus groups were recorded and transcribed.

We conducted the focus groups onsite with a predefined agenda: After a short introduction, this agenda contained three central building blocks lasting 30, 15, and 90 minutes. First, we asked the participants to share their EV usage patterns as it also might influence the perceived attractiveness of incentives. Second, we described the concept of smart charging. We illustrated the importance of customer flexibility, which served as a transition for the third part, "discussion about incentives." Third, we selected the incentives and nudges based on the results of the integrative literature review. We discussed the five incentive and nudge groups *monetary incentives*, *framing*, *feedback*, *gamification*, and *smart charging as a default* with the participants. Regarding gamification, we discussed four gamification elements: badges, credit points, tips, and energy communities. Each gamification element reflects a category of AlSkaif et al. (2018). We created a presentation containing a brief description of the incentives and nudges and discussion questions to guide the discussion. Respective discussion questions were to deduce the rationale behind the participants' interest/disinterest towards a specific incentive or nudge. After the discussion, we asked participants to rank first the five incentives and nudges and second, the four gamification elements according to attractiveness using a survey.

# 4 Preliminary results and discussion

In the following, we provide some preliminary results of the focus groups and the participants' ranking of incentives and nudges. Regarding the first research question, "Which incentives and nudges in the context of smart charging are regarded as most attractive regarding user perception?*"*, the rankings provide the first results (see table 2). For example, out of 13 participants, five participants ranked monetary incentives as first. Overall, the participants regarded monetary incentives and smart charging as default as most attractive. Concerning gamification, they considered tips as most attractive.

| Incentives/ Nudges | Ranking results |
|---|---|
| Monetary incentives | ranked 1st (n = 5), 2nd (n = 1), 3rd (n = 1), 4th (n = 2), 5th (n = 1) |
| Smart charging as default | ranked 1st (n = 5), 2nd (n = 4), 3rd (n = 3), 4th (n = 0), 5th (n = 1) |
| Feedback | ranked 1st (n = 0), 2nd (n = 3), 3rd (n = 4), 4th (n = 4), 5th (n = 0) |
| Framing Messages | ranked 1st (n = 1), 2nd (n = 2), 3rd (n = 2), 4th (n = 2), 5th (n = 4) |
| Gamification | ranked 1st (n = 0), 2nd (n = 1), 3rd (n = 2), 4th (n = 3), 5th (n = 5) |
| 1. Tips | ranked 1st (n = 6), 2nd (n = 2), 3rd (n = 2), 4th (n = 2) |
| 2. Credit points | ranked 1st (n = 5), 2nd (n = 4), 3rd (n = 3), 4th (n = 0) |
| 3. Energy communities | ranked 1st (n = 1), 2nd (n = 3), 3rd (n = 4), 4th (n = 4) |
| 4. Badges | ranked 1st (n = 0), 2nd (n = 3), 3rd (n = 3), 4th (n = 6) |

*Table 2. Ranking perceived attractiveness of incentives and nudges.*

The ranking of the incentives and nudges was mostly consistent with the participants' answers during the focus group discussions. About the focus group discussions, we want to highlight two striking features. First, the participants, in general, were concerned about information overload. Thus, in the context of feedback, framing, and tips, they wanted to receive only a limited number of messages on their smartphone, e.g., one message per week or just when they open their smart charging application. Second, participants largely rejected most gamification elements in the discussion. However, participants in all three focus groups considered gamification elements might be attractive for the younger generation.

Regarding the second research question, "*What is the user's motivation for regarding certain incentives and nudges as attractive?*", participants' motivation seemed to be related to their motivation to purchase an EV. Three motivations for purchasing an EV were ecological, economic, and technological. Participants with an ecological motivation had their EV for ideological reasons, to contribute to environmental protection. They were mainly interested in nudges indicating their contribution to environmental protection (e.g., feedback, framing). Participants with an economic motivation owned their EV mainly because their company covered most of their purchase costs and partly charged their EV at work. They had a higher preference for monetary incentives. Participants with technological motivation purchased EVs for their driving experience. It was not clear which incentives or nudges they preferred.

As the three motivations seem to be related to different incentives and nudges, it might be useful to incentivize and nudge EV users differently. Analog to different contexts, individualization approaches foster an effective EV user targeting for smart charging. Besides different underlying motivations, also socioeconomic characteristics (e.g., age) may influence the perception of incentives and nudges.

The results of the integrative literature review inform researchers and practitioners which incentives and nudges can potentially be effective. The review is comprehensive as we looked at the incentives and nudges literature for smart charging and other relevant sectors. A limitation of the integrative literature review is that we only used two data bases. Future research should extend the literature review and include data bases as AIS E-library, IEE Xplore, ScienceDirect and SAGE Journals.

The focus groups helped to get an insight into which incentives and nudges are attractive for EV users. One limitation of the focus groups is that the sample size of 13 is small, and therefore its results cannot be generalized. This is the reason why after analyzing the focus group transcripts, we want to design a large-scale survey based on the focus group's results. One main goal of this large-scale survey is to obtain generalizable results on users' perceptions of different incentives and nudges. We aim at investigating which incentives and nudges are attractive for different EV users and which factors (age, nationality, income, education level, occupation, ecological, economic, and technological motivation) influence individuals' perception. Incentives and nudges and the above-mentioned factors are independent variables. Using multiple regression, we then want to investigate the influence of these independent variables on the perception of incentives and nudges. Here, we want to investigate how both EV users and non-EV users perceive the incentives and nudges and compare their perceptions—the rationale behind including non-EV users as they could serve as potential EV users. In addition, however, we want to test in an experiment within the framework of the survey which incentives and nudges are effective.

The results will help practitioners develop individualized incentive schemes in different contexts (e.g., different countries). In the academic field, we want to initiate research that further investigates the behavioral aspects of smart charging. Such research is highly relevant, as smart charging cannot be established without the acceptance of EV users.

## 5 Acknowledgement

The authors gratefully acknowledge the financial support of Fondation Enovos under the aegis of the Fondation de Luxembourg in the research project INDUCTIVE. Supported by PayPal and the Luxembourg National Research Fund FNR, Luxembourg (P17/IS/13342933/PayPal-FNR/Chair in DFS/ Gilbert Fridgen).

## References

Alasseri, R., Rao, T. J., & Sreekanth, K. J. (2020). “Institution of incentive-based demand response programs and prospective policy assessments for a subsidized electricity market”, *Renewable and Sustainable Energy Reviews* 117, 1–16.

Alghamdi, T. G., Said, D., & Mouftah, H. T. (2021). “Profit Maximization for EVSEs-Based Renewable Energy Sources in Smart Cities With Different Arrival Rate Scenarios”, *IEEE Access* 9, 58740–58754.

Allcott, H., & Rogers, T. (2014). “The short-run and long-run effects of behavioral interventions: Experimental evidence from energy conservation", *American Economic Review* 104 (10), 3003–3037.

AlSkaif, T., Lampropoulos, I., van den Broek, M., & van Sark, W. (2018). “Gamification-based framework for engagement of residential customers in energy applications”, *Energy Research & Social Science* 44, 187–195.

Amin, A., Tareen, W. U. K., Usman, M., Ali, H., Bari, I., Horan, B., Mekhilef, S., Asif, M., Ahmed, S., & Mahmood, A. (2020). “A Review of Optimal Charging Strategy for Electric Vehicles under Dynamic Pricing Schemes in the Distribution Charging Network”, *Sustainability* 12 (23), 1–28.

Antunes, C., Bohnsack, R., Caridade, L., Gregorio, V., Groot, J., van den Hoed, R., Khan, S., Matos, L., Mendes, R., & Oliveira, A. (2018). *me2: Integrated smart city mobility and energy platform* University of Applied Sciences Amsterdam, 1-11.

Azarova, V., Cohen, J. J., Kollmann, A., & Reichl, J. (2020). “Reducing household electricity consumption during evening peak demand times: Evidence from a field experiment”, *Energy Policy* 144, 1–13.

Beck, A. L., Chitalia, S., & Rai, V. (2019). “Not so gameful: A critical review of gamification in mobile energy applications”, *Energy Research & Social Science* 51, 32–39.

Broman Toft, M., Schuitema, G., & Thøgersen, J. (2014). “The importance of framing for consumer acceptance of the Smart Grid: A comparative study of Denmark, Norway and Switzerland”, *Energy Research & Social Science* 3, 113–123.

Buckley, P. (2020). “Prices, information and nudges for residential electricity conservation: A meta-analysis”, *Ecological Economics* 172, 1–14.

Chatzigeorgiou, I. M., & Andreou, G. T. (2021). “A systematic review on feedback research for residential energy behavior change through mobile and web interfaces”, *Renewable and Sustainable Energy Reviews* 135, 1–16.

Cho, J., & Lee, E.-H. (2014). "Reducing confusion about grounded theory and qualitative content analysis: Similarities and Differences", *The Qualitative Report* 19 (64), 1-20.

Deilami, S., Masoum, A. S., Moses, P. S., & Masoum, M. A. S. (2011). “Real-Time Coordination of Plug-In Electric Vehicle Charging in Smart Grids to Minimize Power Losses and Improve Voltage Profile”, *IEEE Transactions on Smart Grid* 2 (3), 456–467.

Delmas, M. A., Fischlein, M., & Asensio, O. I. (2013). “Information strategies and energy conservation behavior: A meta-analysis of experimental studies from 1975 to 2012”, *Energy Policy* 61, 729–739.

Delmonte, E., Kinnear, N., Jenkins, B., & Skippon, S. (2020). “What do consumers think of smart charging? Perceptions among actual and potential plug-in electric vehicle adopters in the United Kingdom”, *Energy Research & Social Science* 60, 1–12.

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). “From game design elements to gamefulness: Defining gamification” in: *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments*, 9–15.

Dütschke, E., Paetz, A.-G., & Wesche, J. (2013). “Integration Erneuerbarer Energien durch Elektromobilität – inwieweit sind Konsumenten bereit, einen Beitrag zu leisten?”, *uwf UmweltWirtschaftsForum* 21 (3–4), 233–242.

Eid, C., Koliou, E., Valles, M., Reneses, J., & Hakvoort, R. (2016). “Time-based pricing and electricity demand response: Existing barriers and next steps”, *Utilities Policy* 40, 15–25.

Eldeeb, H. H., Faddel, S., & Mohammed, O. A. (2018). “Multi-Objective Optimization Technique for the Operation of Grid tied PV Powered EV Charging Station”, *Electric Power Systems Research* 164, 201–211.

Energy Task Force. (2019). *Engaging EV users in smart charging and energy services*. Work package.

Ensslen, A., Ringler, P., Dörr, L., Jochem, P., Zimmermann, F., & Fichtner, W. (2018). "Incentivizing smart charging: Modeling charging tariffs for electric vehicles in German and French electricity markets", *Energy Research & Social Science* 42, 112–126.

European Environment Agency. (2021). *Greenhouse gas emissions from transport in Europe—European Environment Agency*. Report.

ev.energy. (2020). *ev.energy | EV Owners—Ev.energy*. A Greener, Cheaper, Simpler Way to Charge Your EV. https://ev.energy/solutions/app/ (visited on September 23).

Franco, J. F., Rider, M. J., & Romero, R. (2015). “A Mixed-Integer Linear Programming Model for the Electric Vehicle Charging Coordination Problem in Unbalanced Electrical Distribution Systems”, *IEEE Transactions on Smart Grid* 6 (5), 2200–2210. https://doi.org/10.1109/TSG.2015.2394489

Frenzel, I., Jarass, J., Trommer, S., & Lenz, B. (2015). *Erstnutzer von Elektrofahrzeugen in Deutschland—Nutzerprofile, Anschaffung, Fahrzeugnutzung*. Report, DLR Institut für Verkehrsforschung.

Geske, J. (2014). “Präferenzen, Geschäftsmodelle und Marktpotential der V2G-Technologie - Geschäftsmodelle und Marktpotential der V2G-Technologie” *in: 13. Symposium Energieinnovatione*, 1–9.

Greenflux. (2020). *Powered up: Charging EVs without stressing the electricity network.* Report.

Grundy, A. (2021, October 14). *Over a quarter of EV drivers still charging at peak hours despite costs and carbon impacts*. URL: https://www.current-news.co.uk/news/over-a-quarter-of-ev-drivers-still-charging-at-peak-hours-despite-costs-and-carbon-impacts (visited on)

Günther, M., Kacperski, C., & Krems, J. F. (2020). “Can electric vehicle drivers be persuaded to eco-drive? A field study of feedback, gamification and financial rewards in Germany”, *Energy Research & Social Science* 63, 1–9.

Handke, V., Helga Jonuschat, & Wölk, M. (2012). *Untersuchung zur Akzeptanz von Elektromobilität als Stellglied im* Stromnetz. Report, Institut für Zukunftsstudien und Technologiebewertung.

Horne, C., & Kennedy, E. H. (2017). “The power of social norms for reducing and shifting electricity use”, *Energy Policy* 107, 43–52.

Huber, J. (2020). *Engineering user-centric smart charging systems*. PhD thesis, Karlsruhe Institute of Technology.

Huber, J., Jung, D., Schaule, E., & Weinhardt, C. (2019a). “Goal framing in smart charging—Increasing BEV users’ charging flexibility with digital nudges” *in: 27th European Conference on Information Systems (ECIS)",* 1–16, Uppsala.

Huber, J., Schaule, E., Jung, D., & Weinhardt, C. (2019b). “Quo vadis smart charging? A literature review and expert survey on technical potentials and user acceptance of smart charging systems”, *World Electric Vehicle Journal* 10 (4), 1–19.

Huber, J., & Weinhardt, C. (2018). “Waiting for the sun—Can temporal flexibility in BEV charging avoid carbon emissions?” *Energy Informatics* 1(1), 116–428.

International Energy Agency. (2020). *Global EV Outlook 2020*, Report.

IRENA. (2019). *Innovation Landscape brief: Electric-vehicle smart charging*. International Renewable Energy Agency (IRENA). Report.

Ireshika, M. A. S. T., Preissinger, M., & Kepplinger, P. (2019). “Autonomous Demand Side Management of Electric Vehicles in a Distribution Grid” in: *7th International Youth Conference on Energy (IYCE)*, 1–6.

Ito, K., Ida, T., & Tanaka, M. (2018). “Moral suasion and economic incentives: Field experimental evidence from energy demand”, *American Economic Journal: Economic Policy* 10 (1), 240–267.

Jochem, P., Kaschub, T., Paetz, A.-G., & Fichtner, W. (2012). “Integrating electric vehicles into the German electricity grid – an interdisciplinary analysis”, *World Electric Vehicle Journal* 5 (3), 763–770.

Johnson, D., Horton, E., Mulcahy, R., & Foth, M. (2017). "Gamification and serious games within the domain of domestic energy consumption: A systematic review", *Renewable and Sustainable Energy Reviews* 73, 249–264.

Ming, H., Xia, B., Lee, K.-Y., Adepoju, A., Shakkottai, S., & Xie, L. (2020). "Prediction and assessment of demand response potential with coupon incentives in highly renewable power systems", *Protection and Control of Modern Power Systems* 5 (1), 1–14.

Momsen, K., & Stoerk, T. (2014). "From intention to action: Can nudges help consumers to choose renewable energy?" *Energy Policy* 74, 376–382.

Mert, W., & Tritthart, W. (2009). "Get smart! Consumer acceptance and restrictions of Smart Domestic Appliances in Sustainable Energy Systems", *TRANSPOSE Midterm Conference*, 1–21.

Morganti, L., Pallavicini, F., Cadel, E., Candelieri, A., Archetti, F., & Mantovani, F. (2017). "Gaming for Earth: Serious games and gamification to engage consumers in pro-environmental behaviours for energy efficiency" *Energy Research & Social Science* 29, 95–102.

Paetz, A.-G., Dütschke, E., & Fichtner, W. (2012a). "Smart homes as a means to sustainable energy consumption: A study of consumer perceptions", *Journal of Consumer Policy* 35 (1), 23–41.

Paetz, A.-G., Jochem, P., & Fichtner, W. (2012b). "Demand Side Management mit Elektrofahrzeugen – Ausgestaltungsmöglichkeiten und Kundenakzeptanz" in: *Symposium Energieinnovation*, 1–14.

Paetz, A.-G., Kaschub, T., Jochem, P., & Fichtner, W. (2012c). "Demand response with smart homes and electric scooters: An experimental study on user acceptance", *ACEEE Summer Study*, 224–236.

Rashidizadeh-Kermani, H., Najafi, H., Anvari-Moghaddam, A., & Guerrero, J. (2018). "Optimal Decision-Making Strategy of an Electric Vehicle Aggregator in Short-Term Electricity Markets" *Energies* 11 (9), 1–20.

Richardson, P. (2011). "Optimal Charging of Electric Vehicles in Low Voltage Distribution Systems", *IEEE Transactions on Power Systems* 27 (1), 268–279.

Schaule, E., & Meinzer, N. (2020). "Behavioral aspects of load shifting in household appliances" in: Science Lab, 1–5.

Schmalfuß, F., Mair, C., Döbelt, S., Kämpfe, B., Wüstemann, R., Krems, J. F., & Keinath, A. (2015). "User responses to a smart charging system in Germany: Battery electric vehicle driver motivation, attitudes and acceptance", *Energy Research & Social Science* 9, 60–71.

Shafir, E. (Ed.). (2013). *Decisions by Default. The Behavioral Foundations of Public Policy*. Princeton University Press.

Sharda, S., Singh, M., & Sharma, K. (2021). "Demand side management through load shifting in IoT based HEMS: Overview, challenges and opportunities", *Sustainable Cities and Society* 65, 1-22.

Soomro, A. M., Bharathy, G., Biloria, N., & Prasad, M. (2021). "A review on motivational nudges for enhancing building energy conservation behavior", *Journal of Smart Environments and Green Computing* 1 (3), 1–20.

Spandagos, C., Baark, E., Ng, T. L., & Yarime, M. (2021). "Social influence and economic intervention policies to save energy at home: Critical questions for the new decade and evidence from air-condition use", *Renewable and Sustainable Energy Reviews* 143, 1–16.

Tamis, M., Wolbertus, R., & van den Hoed, R. (2018). "User motivations and requirements for Vehicle2Grid systems" in: *European Electric Vehicle Convention on Infrastructure*, 1–7.

Thaler, R. H., & Sunstein, C. R. (2008). "Nudge: Improving decisions about health", *Wealth, and Happiness* 6, 14–38.

Tiefenbeck, V., Wörner, A., Schöb, S., Fleisch, E., & Staake, T. (2019). "Real-time feedback reduces energy consumption among the broader public without financial incentives", *Nature Energy* 4 (10), 831–832.

van der Meer, D., Chandra Mouli, G. R., Morales-Espana Mouli, G., Elizondo, L. R., & Bauer, P. (2018). "Energy Management System With PV Power Forecast to Optimally Charge EVs at the Workplace", *IEEE Transactions on Industrial Informatics* 14 (1), 311–320.

Vetter, M., & Kutzner, F. (2016). "Nudge me if you can—How defaults and attitude strength interact to change behavior", *Comprehensive Results in Social Psychology* 1 (1–3), 1–28.

Wentland, A. (2016). “Imagining and enacting the future of the German energy transition: Electric vehicles as grid infrastructure”, *Innovation: The European Journal of Social Science Research*, 29 (3), 285–302.

Will, C., & Schuller, A. (2016). “Understanding user acceptance factors of electric vehicle smart charging”, *Transportation Research Part C: Emerging Technologies* 71, 198–214.