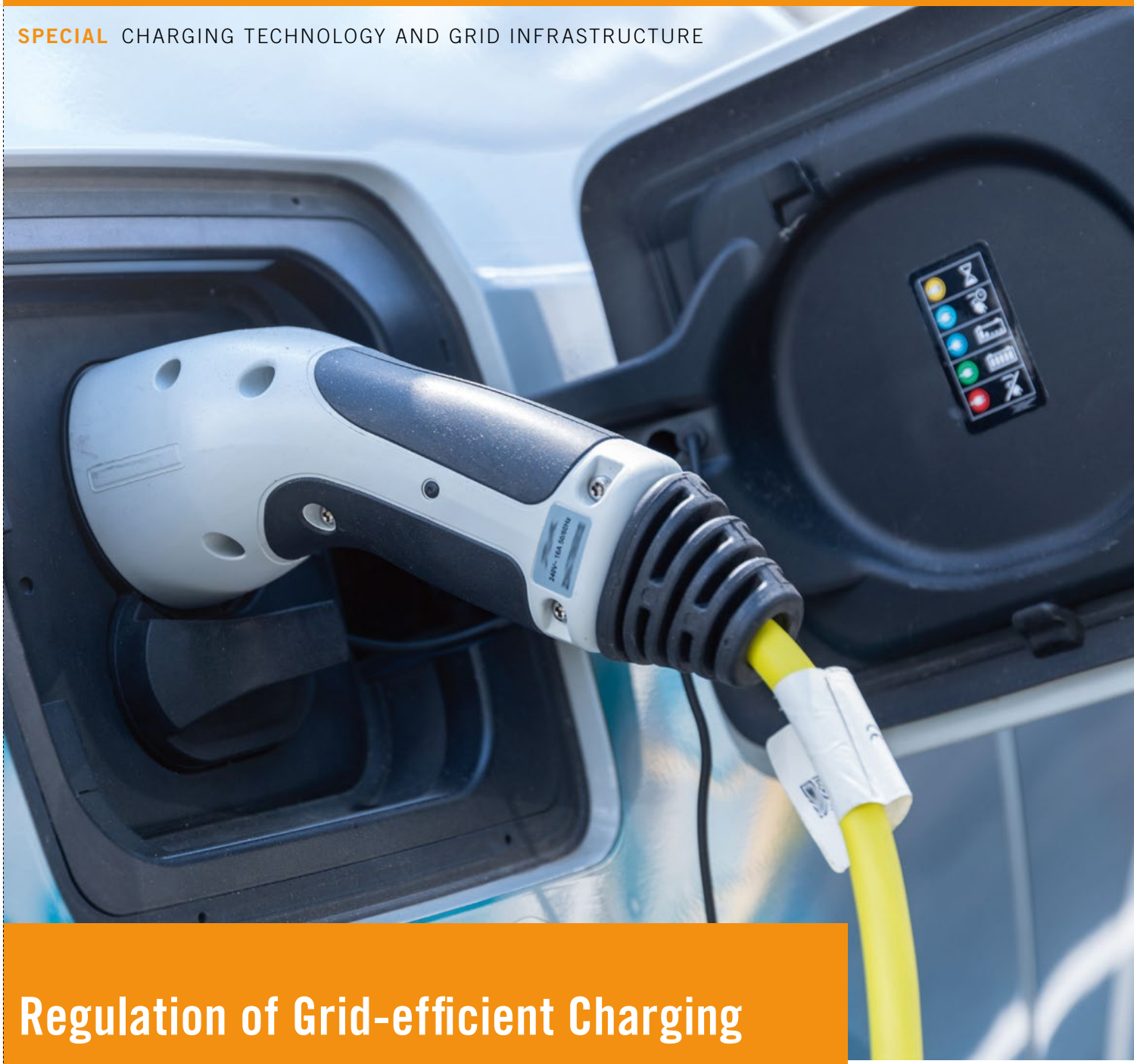

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# Regulation of Grid-efficient Charging from the User's Perspective

Grid-efficient charging is an important component in integrating the growing number of electric vehicles into the energy system of the future. A legal framework is currently being discussed which could in future oblige e-vehicle drivers to pay a surcharge for the ability to charge their vehicles unconditionally. A recent user study by the University of Passau, which was carried out as part of the research project Bidirectional Charging Management, indicates that this kind of regulation could affect the desired market deployment of electric mobility.

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## KEEPING ELECTRICITY SUPPLY AND DEMAND IN BALANCE

The climate protection program published in October 2019 includes the goal of reaching a national fleet of seven to ten million electric vehicles in Germany by 2030 [1]. Against the background of a further growing share of electric energy from renewable sources, electric vehicles – operated purely battery-electrically or in combination with an internal combustion engine as plug-in hybrids (Plug-in Electric Vehicles, PEVs) – with their battery storage can contribute to the success of Germany's energy transition. At the same time, electric vehicles connected to the power grid pose a challenge for Distribution System Operators (DSOs). The high demand for simultaneously charging PEVs can occasionally lead to overload and bottlenecks in low-voltage networks, if no countermeasures are taken.

The intelligent control of flexible consumption devices plays an important role in keeping electricity supply and demand in balance, and thus guaranteeing a stable electricity grid in Germany. Such devices are characterized by flexibility in terms of timing and power of their energy consumption. This includes heat pumps and electric storage heaters, as well as PEVs, which, due to long standing times, are not always dependent on being charged with the maximum contractual power. By implementing intelligent charging management systems, it is possible to interrupt the charging process in case of a network bottleneck or to reduce the charging power. In this way, it would be possible to ensure a high level of reliability of supply while optimizing the use of climate neutrally generated electric energy while simultaneously limiting the need for expensive grid expansion.

Intelligent charging solutions can be distinguished in terms of grid-compatible and grid-efficient approaches [2]. Grid-compatible charging describes a preventive market or system-based control of the charging process by a customer's own load management in times of uncritical grid conditions. The charging process follows predefined criteria: It can, for example, be charged as cheaply or with as much renewable energy as possible. Grid-efficient charging, on the other hand, refers to interventions, in the form of charging restrictions, by the DSO at times of imminent or existing network bottlenecks. In case of grid overload, for instance due to a high number of electric vehicles charging at the same time, the DSO can temporarily reduce or interrupt the charging power.

## LEGAL DESIGN OF GRID-EFFICIENT CHARGING

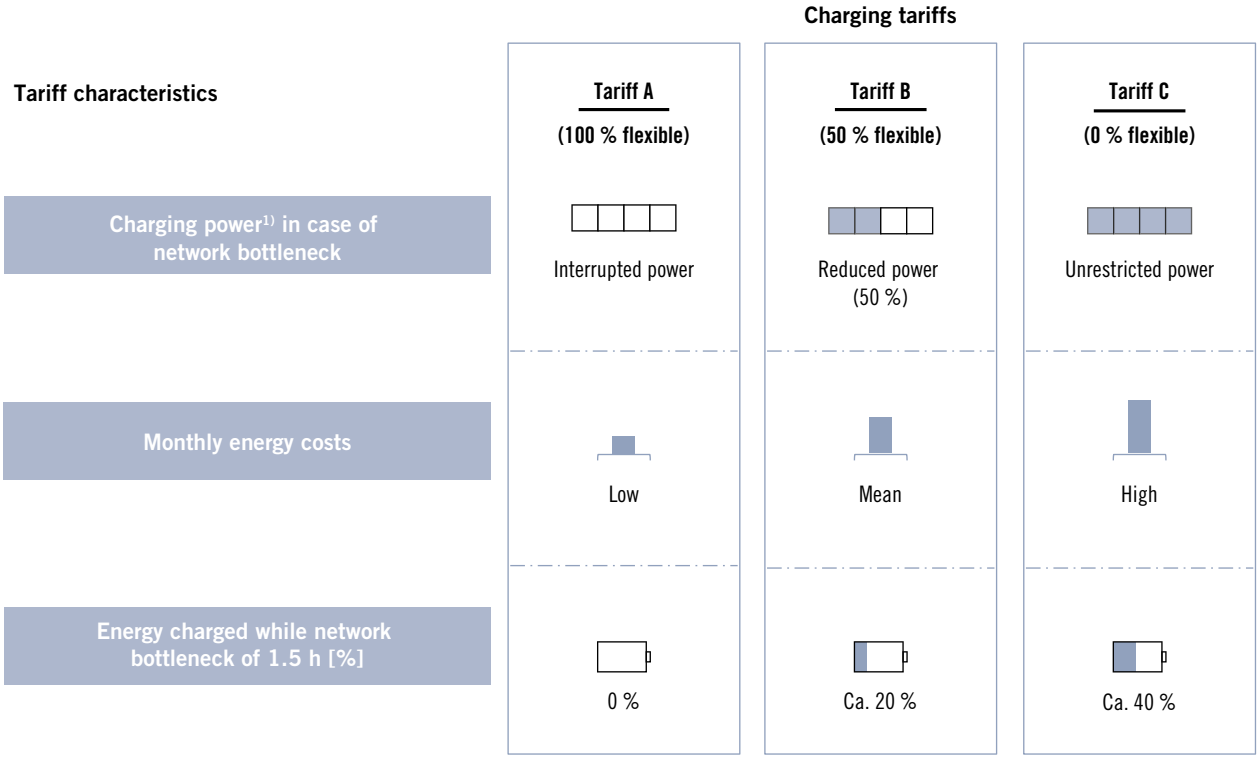
The legal framework for grid-efficient charging is currently outlined in § 14a of the German Energy Industry Act (EnWG, flexible low-voltage consumption devices). For its implementation in practice, however, regulations have to be drawn up which specify, among other things, the amount of financial compensation in the form of grid fee reductions, as well as the permitted interventions on the part of the DSOs and energy suppliers.

For this purpose, the German Federal Ministry for Economic Affairs and Energy (BMWi) has commissioned an expert report, outlining a proposal for the legal structure [3]. The latter is currently being discussed in a comprehensive consultation process by the Intelligent Electricity Grids and Meters working group and the so-called Smart Meter Gateway Standardization. Stakeholders from grid operators, energy suppliers, automotive, equipment and systems manufacturers, as well as consumer organizations, are involved.

## POWER ORDERING SYSTEM FOR FLEXIBLE LOADS

The core element of the legal regulation proposed is the introduction of an ordering system for the electricity supply of flexible consumption devices. Owners of such devices would therefore be obliged to order conditional and unconditional power. The use of conditional (thus flexible) power is rewarded with cost savings – in return, however, interventions by DSOs must be accepted in the event of a bottleneck. Unconditional (thus inflexible) power would be available for a financial surcharge. In addition, the installation of an intelligent measuring system with a so-called Smart Meter Gateway, transferring data on the utilized power at 15-min intervals, will become mandatory for households over 6000 kWh of annual electricity consumption. The

**FIGURE 1** Electricity tariff concept for grid-efficient charging (tariff concept and graphic representation based on Hayn, 2016) (© University of Passau)




[1] As long as there is no network bottleneck, all PEV drivers are provided with unrestricted power

timetable provides for the presentation of the corresponding drafts for the Federal Cabinet this year, as well as the adoption of legislative changes and regulations in the current legislative period.

This will also result in fundamental changes in electricity supply for persons in possession of a PEV. The regulatory measures described could not only lead to negative reactions from PEV drivers, but could also increase public reservations about electric mobility (for example feared mobility restrictions, concerns about outside intervention [4]). At worst, these would be accompanied by an impairment of the intended market deployment of electric mobility. It is therefore imperative to assess the (potential) users' perspectives on the planned regulatory measures.

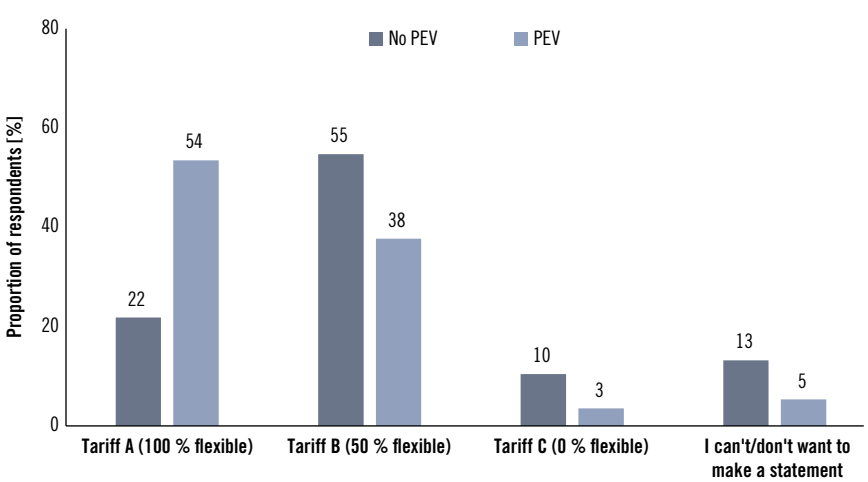



**FIGURE 2** Tariff choice based on the assumption of legal obligation (1223 respondents) (© University of Passau)

## USER STUDY ON THE REGULATION OF GRID-EFFICIENT CHARGING

The University of Passau investigated perceptions of (future) PEV drivers, conducting a broad-based online survey in the context of the project Bidirectional Charging Management (BDL). Special focus was placed on the acceptance of legally obligatory participation in the power ordering system as well as on user preferences for the design of offers and incentives.

1223 people in possession of a driving license were interviewed. The users of internal combustion engine vehicles were selected representatively according to age and sex for the total population of vehicle drivers in Germany. The proportion of PEV users in the sample was increased in order to evaluate the results for this specific target group. A total of 228 participants (approximately 10 % female) were PEV drivers.

## DESIGN OF THE STUDY

For the purpose of the study, the power ordering system proposed was translated into a simplified charging tariff concept,

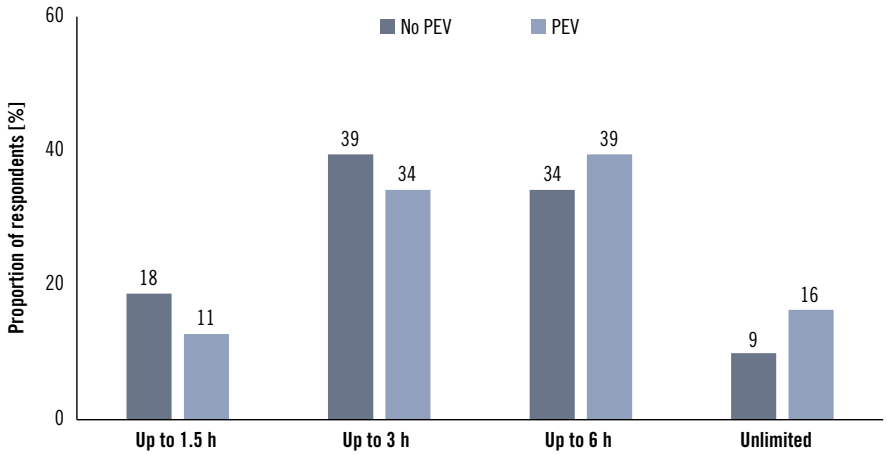



**FIGURE 3** Maximum daily (cumulative) restriction period (24 h) (969 respondents) (© University of Passau)

based on electricity tariffs with variable power prices [5]. The tariff concept offered respondents three options which allow different scope for intervention by DSOs within the framework of § 14a EnWG. The presented options differed on the basis of two characteristics: on the one hand, the available charging power in the event of bottlenecks in the power grid, and on the other hand, the energy costs incurred, **FIGURE 1**.

In the tariffs which include flexible power, the DSO has the possibility to completely interrupt the charging power of a PEV during bottlenecks (tariff A) or to reduce it to 50 % of the original power (tariff B). Tariff C guarantees unrestricted charging power. In return, however, tariff C is accompanied by higher energy costs: Respondents were informed that the total energy costs in tariff C would double in the case of average vehicle electricity consumption compared to conventional domestic electricity tariffs. The comparing calculation is based on the currently discussed grid fee system, taking into account all fixed and variable price components. Finally, the respective charged amount of energy (40 kWh capacity, 11 kW charging power) after a network bottleneck of 1.5 h was visualized.

## CHOICE OF TARIFFS AND USER PREFERENCES FOR THE DESIGN OF GRID-EFFICIENT CHARGING

Respondents were told to proceed on the assumption that there was a legal obligation to participate in the power ordering system and therefore one of the three tariffs had to be chosen. Under this premise, the majority of respondents (approximately 80 %) chose a tariff with flexible charging power (tariff A, B). Only a small proportion (about 10 %) would accept increased costs for unrestricted access to energy for their car (tariff C). The remaining proportion of respondents selected the "no-choice" option. PEV drivers chose the tariff with charging interruption in the event of a network bottleneck (tariff A) more frequently than respondents without a PEV, **FIGURE 2**. The latter increasingly fell back on tariffs B or C, or did not indicate the choice of a tariff. A possible explanation is that people without a PEV can only estimate their possible usage and charging needs and therefore decide more conservatively.

With regard to user preferences for the design of grid-efficient charging, the study showed that respondents who currently do not drive a PEV prefer a higher degree of planning security. In respect of the timeframe, 43 % of respondents without a PEV could imagine a cumulative restriction period over the day (24 h) of 6 h or more, whereas this is the case for 55 % of current PEV drivers, **FIGURE 3**. In addition, 77 % of respondents in possession of a PEV, but only 60 % of persons without a PEV, would prefer dynamic (varying as needed) over static (daily constant) time slots. Prior notice within 4 h or less before intervention by the DSO would be acceptable to 84 % of PEV drivers and 64 % of those without a PEV, **FIGURE 4**.

## MOTIVATIONS AND USER ACCEPTANCE

An analysis of the motivations showed that, above all, financial incentives in the sense of reduced grid fees drove the choice of a tariff with flexible charging power. Respondents who do not currently own a PEV attached even greater importance to financial incentives than PEV drivers. The desired savings depended on the flexibility of the tariff: In tariff B, respondents preferred a cost savings of 50 % compared to the unrestricted charging power of tariff C. However, respondents in tariff A expected savings of 70 %. In addition, non-financial factors such as contributions to Germany's energy transition and grid stabilization also played a role in choosing a flexible tariff, whereby respondents with a PEV regarded these aspects as even more persuasive and important compared to non-PEV drivers, **FIGURE 5**.

Consistent with their lower willingness to accept restrictions in the event

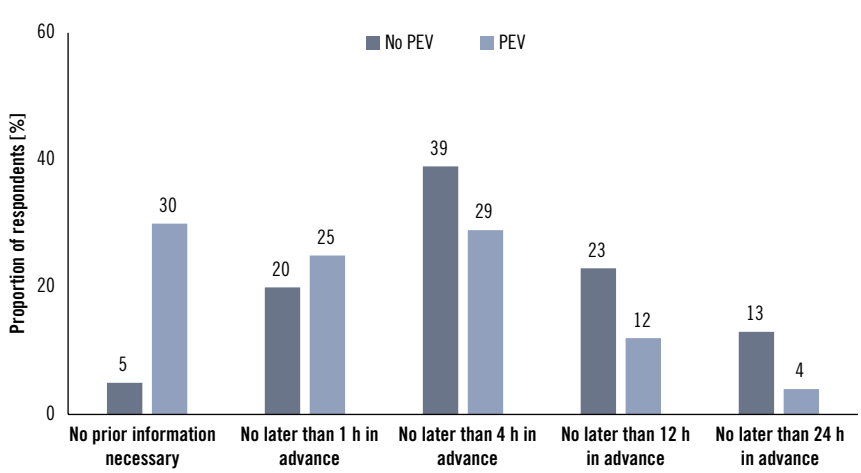



**FIGURE 4** Shortest warning period in case of selection of dynamic time slots (621 respondents) (© University of Passau)

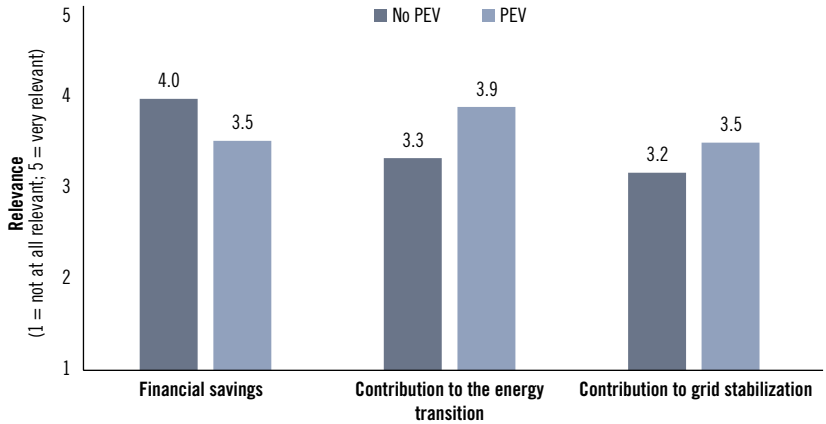



**FIGURE 5** Relevant aspects for choosing a tariff with flexible power (969 respondents) (© University of Passau)

of network bottlenecks, respondents who currently have no PEV reported a negative impact on their attitudes toward electric vehicles given a mandatory power ordering system. Their willingness to buy an electric car would be reduced by the planned regulations. However, a positive influence on current PEV drivers' attitudes and willingness to buy can be expected, **FIGURE 6**. This may be due to an even higher awareness of the non-financial benefits of grid-efficient charging within this target group.

## CONCLUSION AND RECOMMENDATIONS FOR ACTION

The mandatory participation in the currently discussed power ordering system could constitute an additional or even decisive barrier to purchase, especially for persons who currently do not have a PEV. In order to prevent such consequences, it is advisable to offer tariff models for grid-efficient charging on a voluntary basis and to establish attractive tariff packages and incentives.

It would be conceivable, for example, to offer free choice and, if necessary, modification of the contractual components in order to keep the entry threshold to electric mobility low. In this way, people who buy a PEV for the first time could initially familiarize themselves with their actual mobility needs. In addition, attractive financial incentives must be created, based on the degree of flexibility provided.

## OUTLOOK

The study carried out examined user preferences and acceptance for a limited number of flexible power tariffs to be selected within the framework of an electricity tariff concept. Future research should further investigate user preferences, e.g. on the degree of flexibility provided to the DSO, thereby giving suggestions for an optimal, that means user-friendly, design of tariffs and incentives.

The study results are an essential starting point for bidirectional charging. In the BDL project framework, conditions for retransferring energy to the grid are developed and evaluated from the user's perspective. The interaction of legal requirements is addressed not only with grid stabilization, but also with further application scenarios, such as the optimized use of privately generated energy in the domestic power grid.

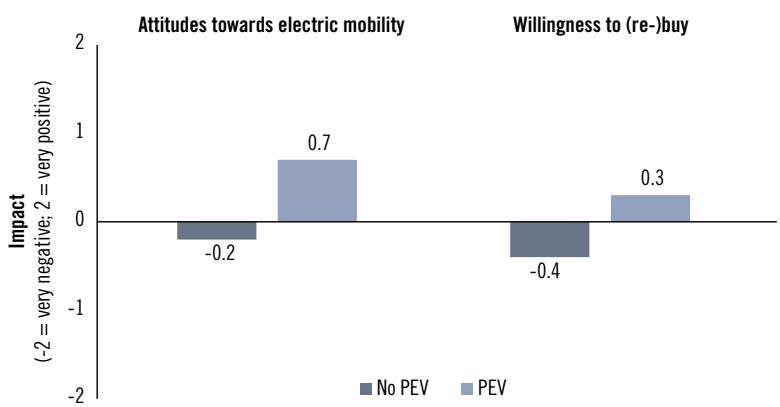



**FIGURE 6** Impact of a mandatory power ordering system on electric mobility attitudes and willingness to (re-)buy (1223 respondents) (© University of Passau)


**REFERENCES**

**[1]** Die Bundesregierung: Klimaschutzprogramm 2030. Online: https://www.bundesregierung.de/breg-de/themen/klimaschutz/klimaschutzprogramm-2030-1673578, access: September 28, 2020

**[2]** Nationale Plattform Zukunft der Elektromobilität: Netzintegration von Elektromobilität – Basis für eine erfolgreiche Sektorkopplung. Eine Definition. Online: https://www.plattform-zukunft-mobilitaet.de/wp-content/uploads/2020/07/NPM-AG5-Netz integration-von-Elektromobilit%C3%A4t-Basis-f%C3%BCr-eine-Erfolgreiche-Sektorkopplung-Eine-Definition.pdf, access: September 28, 2020

**[3]** Ernst & Young, B E T, WIK: Gutachten Digitalisierung der Energiewende. Kurzfassung Topthema 2: Regulierung, Flexibilisierung und Sektorkopplung. Online: https://www.bmwi.de/Redaktion/DE/Downloads/Studien/digitalisierung-der-energiewende-thema-2-kurz.pdf?__blob=publicationFile&v=4, access: September 28, 2020

**[4]** Kämpfe, B.; Zimmermann, J.; Dreisbusch, M.; Grimm, A.-L.; Schumann, J.-H., Naujoks, F. et al.: Preferences and perceptions of bidirectional charging from a customer's perspective – A literature review and qualitative approach. In: Netzintegration der Elektromobilität 2019. Ed. Dr. Johannes Liebl. Wiesbaden: Springer Fachmedien Wiesbaden, in press

**[5]** Hayn, M.: Modellgestützte Analyse neuer Stromtarife für Haushalte unter Berücksichtigung bedarfsorientierter Versorgungssicherheitsniveaus. In: Produktion und Energie, Volume 13. Karlsruhe: KIT Scientific Publishing, 2016



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