

# **Social Acceptance of Renewable Energies and Electric Mobility**

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The President:

Prof. Dr. Bernhard Ehrenzeller

*“Getting a new idea adopted, even when it has obvious advantages, is difficult.”*

— **Everett M. Rogers (2003, p. 1)**

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## List of Abbreviations and Symbols<sup>1</sup>

### Abbreviations

|                 |                                                                                                        |
|-----------------|--------------------------------------------------------------------------------------------------------|
| B2B             | Business-to-Business                                                                                   |
| CHF             | Swiss franc                                                                                            |
| COP             | Conference of Parties                                                                                  |
| CO <sub>2</sub> | Carbon dioxide                                                                                         |
| ct./kWh         | Cents per kilowatt hour                                                                                |
| EV              | Electric vehicle                                                                                       |
| GWh             | Gigawatt hour                                                                                          |
| H               | Hypothesis                                                                                             |
| IEA             | International Energy Agency                                                                            |
| km              | Kilometer                                                                                              |
| m <sup>2</sup>  | Square Meter                                                                                           |
| MW              | Megawatt                                                                                               |
| NIMBY           | Not in My Backyard                                                                                     |
| PIMBY           | Please in My Backyard                                                                                  |
| PV              | Photovoltaic                                                                                           |
| SCCER CREST     | Swiss Competence Centre for Energy Research -<br>Center for Research in Energy, Society and Transition |
| %               | Percentage                                                                                             |

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<sup>1</sup> Please note that relevant abbreviations are introduced within each paper.

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## Statistical Symbols and Abbreviations

|                |                                                                            |
|----------------|----------------------------------------------------------------------------|
| Adjusted $R^2$ | Coefficient of determination (adjusted for the number of terms in a model) |
| ANOVA          | Analysis of variance                                                       |
| CBC            | Choice-based conjoint analysis                                             |
| CE             | Choice experiments                                                         |
| df             | Degrees of freedom                                                         |
| EMCB           | Ethically minded consumer behavior                                         |
| F              | F-Statistic                                                                |
| HB             | Hierarchical Bayesian                                                      |
| M              | Arithmetic mean                                                            |
| MED            | Median split                                                               |
| n              | Number of observations                                                     |
| $\eta^2$       | Eta-squared (measure of strength of relationship)                          |
| p              | Error probability                                                          |
| $R^2$          | Coefficient of determination                                               |
| SD             | Standard deviation                                                         |
| SE             | Standard error                                                             |
| SPSS           | Statistical Package for Social Sciences                                    |

## Abstract

The COP 21 in Paris at international level and the Energy Strategy 2050 at national level have defined the framework for making our energy system more sustainable. However, implementation at the local level is proving difficult. Despite high levels of general acceptance of renewable energy and electric mobility, its uptake is slow. The literature has conceptualized this contradiction between a high level of general acceptance and the difficult implementation at the local level, by using the term *social acceptance*. Researchers agree that a better understanding of the social acceptance of renewable energy and electric mobility is crucial for increasing uptake and, thus, achieving our climate targets.

With this dissertation, I seek to contribute to a better understanding and management of different elements of social acceptance of wind and solar energy, as well as electric mobility. I present recommendations for more successful project development and suggest policy implications that advocate for the deeper integration of social-acceptance issues in policy. I also examine specific challenges related to the respective technologies, as follows.

In the *first paper*, we examine local preferences for different financial-participation models and their impact on the social acceptance of wind-energy projects. The results of the experimental study show that the introduction of a financial-participation model can increase the social acceptance of such projects, with the collective “wind resource tax” model being the preferred option.

In the *second paper*, we analyze the social acceptance of utility-scale solar PV projects in alpine regions. The expansion of such projects has untapped potential to help meet electricity demand in the winter half-year. The results of our choice experiment identify a design that minimizes visual impact, includes local ownership, and has a low level of impact on the local flora and fauna, crucial to increasing the social acceptance of a project.

In the *third paper*, I investigate the social acceptance of electric mobility in corporate fleets. In a field experiment with car pool users, I test the effect of personal experience with electric vehicles on their acceptance, as well as the adoption of electric mobility. The results show that more personal experience can lead to an increase in purchase intention and higher acceptance levels and for several EV-related elements.

## Zusammenfassung

Mit dem COP 21 in Paris auf internationaler Ebene wie auch der Energiestrategie 2050 auf nationaler Ebene wurden die Rahmenbedingungen festgelegt um unser Energiesystem nachhaltiger zu gestalten. Die Umsetzung auf lokaler Ebene erweist sich jedoch als schwierig. Trotz hoher Akzeptanzwerte auf nationaler Ebene für erneuerbare Energien und Elektromobilität, schreitet der Ausbau nur langsam voran. Die Literatur konzeptualisiert diesen Widerspruch zwischen hoher genereller Akzeptanz und lokalem Widerstand bei der Umsetzung mit dem Begriff der *sozialen Akzeptanz*. Die Forschung ist sich einig: ein besseres Verständnis der sozialen Akzeptanz ist entscheidend für den weiteren Ausbau wie auch für die Erreichung der Klimaziele.

Mit dieser Dissertation trage ich zu einem besseren Verständnis und Management von verschiedenen Aspekten der sozialen Akzeptanz von Wind- und Solarenergie sowie Elektromobilität bei. Ich präsentiere Handlungsempfehlungen für eine erfolgreichere Projektentwicklung wie auch für eine stärkere Integration der sozialen Akzeptanz in die künftige Gesetzgebung. Ich untersuche dabei spezifische Herausforderungen:

Im *ersten Beitrag* untersuchen wir lokale Präferenzen für verschiedene finanzielle Beteiligungsmodelle und deren Auswirkungen auf die soziale Akzeptanz von Windenergieprojekten. Die Ergebnisse der experimentellen Untersuchung zeigen, dass die Einführung eines finanziellen Beteiligungsmodells die Akzeptanz für ein Windprojekt erhöhen kann, wobei die bevorzugte Option die Einführung des kollektiven "Windzins"-Modells ist.

Im *zweiten Beitrag* untersuchen wir die soziale Akzeptanz von gross angelegten Solaranlagen im alpinen Raum. Der Ausbau von Solaranlagen im alpinen Raum ist ein bisher wenig genutztes Potenzial zur Deckung der Stromnachfrage im Winterhalbjahr. Die Resultate unseres Wahlexperiments identifizieren ein naturnahes Design, eine lokale Eigentümerschaft sowie geringe Auswirkungen auf die lokale Flora und Fauna als ausschlaggebende Elemente um eine hohe soziale Akzeptanz zu erreichen.

Im *dritten Beitrag* untersuche ich die soziale Akzeptanz der Elektromobilität in Firmenflotten. In einem Feldexperiment mit Fuhrpark-Nutzer teste ich den Effekt von persönlicher Erfahrung im Umgang mit Elektrofahrzeugen auf die Akzeptanz der Elektromobilität. Die Resultate zeigen, dass mehr persönliche Erfahrung zu höherer Akzeptanz sowie auch zu einer Erhöhung der Kaufabsichten führen kann.

# Introductory Chapter

## 1. Motivation and research background

At the 21<sup>st</sup> conference of parties (COP) in Paris in December 2015, more than 190 parties came together to address climate change related risks by agreeing to implement action to limit the potential increase in global temperature to no more than two degrees Celsius above pre-industrial levels (UNFCCC, 2017). The result was an urgent need to transition away from an energy system based on such fossil resources as oil, gas, and coal, to a more sustainable energy system based on renewable energy, such as solar and wind energy, as well as more sustainable mobility solutions, notably electric mobility. Undeniably, in addition to moving toward more electric mobility, the expansion of renewable energy sources can play an essential role in the transition to a sustainable energy future and reducing CO<sub>2</sub> emissions (Agnew & Dargusch, 2015; de Sisternes et al., 2016; Intergovernmental Panel on Climate Change, 2018).

The international community, such institutions as the European Union, and individual countries have set themselves targets for expanding renewable-energy use and increasing electric mobility, which vary by ambition (Araújo, 2014; Yildiz et al., 2015; IEA, 2019b). For instance, Switzerland set national targets for the expansion of renewable energies and electric mobility, with the adoption of its Energy Strategy 2050 by popular vote in May 2017. In 2019, wind and solar energy accounted for 4.2% of total electricity production in Switzerland, corresponding to 284 kilowatt-hours per capita and leaving Switzerland only 24<sup>th</sup> out of 29 countries on a European ranking (SES, 2020). With the Energy Strategy 2050, Switzerland envisages increasing the production of renewable energy (without hydropower) to at least 4,400 gigawatt-hours by 2020 and at least 11,400 gigawatt-hours by 2035 (SFOE, 2017). In the mobility sector, the Swiss Federal Council foresees increasing the share of electric vehicles in the pool of newly registered passenger cars to 15% by 2022. In 2018, electric vehicles in Switzerland accounted for 1.7% of all newly registered passenger cars (BFS, 2019), with an average output of 137.3 grams of CO<sub>2</sub> per kilometer, making Switzerland the European country with the highest CO<sub>2</sub> emissions for newly sold cars (JATO, 2019). In 2019, among overall new registrations of passenger cars, the share of electric vehicles rose to 4.2% (BFS, 2020), but it remains clear that the next few years will be crucial, in

terms of the achievement of the goals that define the increase in electric mobility and the expansion of renewable energy.

The status quo in Switzerland for both solar and wind energy, as well as electric mobility, shows that despite intensified national efforts to increase the deployment of renewable energy and the number of electric vehicles, actual development is relatively slow. In the case of wind-energy projects, for example, lengthy planning procedures, and local opposition confront investors in Switzerland (Tabi & Wüstenhagen, 2015; Gamma et al., 2017), resulting in significant project delays. Within the mobility sector, the increase in the market share of EVs is slower than that of other European countries, such as the Netherlands, Portugal, or Sweden (IEA, 2019a). This development is surprising; the Swiss people report positive attitudes toward such renewable-energy technologies as solar and wind (AEE, 2019; Vuichard et al., 2019; Cousse & Wüstenhagen, 2019), as well as electric mobility (Cousse & Wüstenhagen, 2018, 2019).

However, in practice, these positive attitudes do not necessarily translate into uptake of the related technologies. In the last two decades, the notion of the *social acceptance* of renewable energy and electric mobility has theoretically conceptualized this gap between positive public attitudes (toward renewable energy and electric mobility) and slow implementation. The research field of social acceptance of renewable energy and electric mobility has attracted increasing academic interest (Wüstenhagen et al., 2007; Ellis & Ferraro, 2016; Devine-Wright et al., 2017; Globisch et al., 2018). Understanding local responses to renewable-energy projects is of considerable relevance to the successful implementation of projects at the local level (Enevoldsen & Sovacool, 2016; Firestone et al., 2018; Lienhoop, 2018). Acknowledgment of its importance issued in significant efforts to reveal why local resistance toward renewable-energy projects arises and how it can be mitigated. Results from early research projects focusing on wind-energy projects can be summarized in one word: “NIMBYism” (i.e., the Not in My Back Yard phenomenon) (Bosley & Bosley, 1988; Dear, 1992; Burningham et al., 2007). However, other researchers claim that the NIMBY concept tends to oversimplify low levels of local acceptance (i.e., community acceptance) (Devine-Wright, 2005, 2007; Walker & Devine-Wright, 2008; Walker et al., 2010). Some studies within the field focus on other variables that may affect community acceptance, such as institutional factors. Wolsink (2007) and Dimitropoulos and Kontoleon (2009) claim that community acceptance includes two main factors: procedural and distributional justice (i.e., fair decision processes and the fair distribution of project costs and

benefits). Procedural justice and the issue of public engagement have been researched heavily (Devine-Wright, 2009; Aitken, 2010; Haggett, 2011; Ryghaug et al., 2018). In the literature on distributional justice, evidence shows that two factors can increase the social acceptance of wind-energy projects: a) community ownership that involves sharing the profit that wind-park projects generate between local investors and operators and b) the financial involvement of locals in such schemes (Toke, 2005; Toke et al., 2008; Aitken, 2010; Warren & McFadyen, 2010; Sovacool & Ratan, 2012; Rand & Hoen, 2017).

Although smaller in volume, similar academic discussion occurs in the research field of social acceptance of electric mobility. Electric mobility is associated with high general-acceptance levels (Sierzychula, 2014; Quak et al., 2016; Kaplan et al. 2016) and strong future purchasing intentions. Using the results of a survey among Swiss potential car buyers (citizens), Cousse and Wüstenhagen (2018) show that 42% would consider an electric car as either their first or second choice. Nevertheless, actual uptake is relatively slow (IEA, 2019a). Numerous identified barriers explain the gap between the slow uptake of electric mobility and high levels of support and positive intentions to purchase. These include higher upfront investment costs (compared to those of conventional vehicles) or the limited availability of a vehicle-charging infrastructure (Laurischkat et al., 2016; Quak et al., 2016; Shao et al., 2016; Newbery & Strbac, 2016; Biresselioglu, 2018). However, these barriers alone do not fully explain the slow uptake. Consequently, the field of research focusing on the social acceptance of electric mobility has emerged (Wikström et al., 2014; Sierzychula, 2014; Globisch et al., 2018).

Scholars agree that a better understanding of the social acceptance of renewable energy and electric mobility is crucial for its further expansion (Kaplan et al., 2016; Globisch et al., 2018). With this thesis, I seek to contribute to a better understanding and management of elements of social acceptance of wind energy, solar energy, and electric mobility, aiming to provide project developers and policy makers with recommendations for a smoother and more successful implementation of renewable-energy projects, as well as more rapid uptake of electric mobility. Hence, insights from this thesis can also contribute to achieving the goals of the Swiss Energy Strategy 2050.

This dissertation is particularly relevant to two kinds of stakeholders. First are *project developers* of renewable-energy projects (i.e., utilities, cooperatives, or private energy companies) and electric-mobility projects (i.e., fleet managers), who face the challenge

of designing their projects so that they enjoy high local acceptance levels. What such designs should look like and which elements are particularly important are underinvestigated topics. The second group comprises *policy makers*. Politicians must take social acceptance into account as an important component during the project-implementation process, and they would be well advised to adopt a relevant legal and political framework and issue respective guidelines.

## 2. Research focus and objectives

This dissertation project's objective is to shed light on different elements of social acceptance of wind energy, solar energy, and electric mobility. I have selected different social acceptance related aspects of each type of technology, embodied in three papers that each address one such aspect. I broadly present the foci of the three papers in Figure 1 and Table 1 and further outline them below. In the following chapters, I call the papers *Paper 1*, "Individual or Collective? Community Investment, Local Taxes, and the Social Acceptance of Wind Energy in Switzerland" (Vuichard, Stauch, & Dällenbach, 2019); *Paper 2*, "Keep it Local and Low-Key: Social Acceptance of Alpine Solar Power Projects" (Vuichard, Stauch, & Wüstenhagen, 2020); and *Paper 3*, "Electrifying the Company Car: Adoption of Electric Mobility in a B2B Context and the Role of Social Acceptance" (Vuichard, 2020).

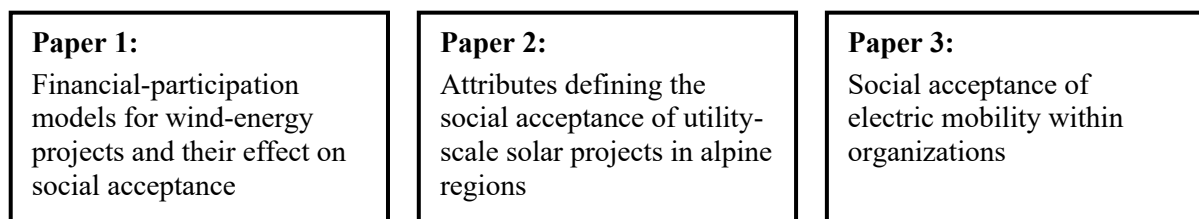


**Figure 1:** Foci of the three papers of the dissertation

*Paper 1* investigates the effects of various financial-participation models on the social acceptance of wind-energy projects. Previous research mainly explores the role of procedural justice (i.e., fair decision processes) (Devine-Wright, 2005; Jones & Eiser, 2010; Khorsand et al., 2015; Enevoldsen & Sovacool, 2016; Firestone et al., 2018),

while rigorous empirical research on distributional justice (i.e., the fair distribution of a project's costs and benefits) is rare. Some studies examine the influence of financial participation (Aitken, 2010; Warren & McFadyen, 2010; Hübner et al., 2013); however, they have not further specified its design. To address this gap, Paper 1 presents an experimental analysis of local preferences for specific financial-participation models and their influence on acceptance levels for wind-energy projects. The findings demonstrate that the level of social acceptance of wind-energy projects can rise with the introduction of a financial-participation model. Further, the paper highlights that from among a variety of financial-participation models, a wind-resource tax is preferable to a wind bond overall, and important subgroups (such as politically center-progressive individuals and those with a strong community identity or aversion to risk) also favor it over direct forms of participation, such as a wind share and a wind bond.

*Paper 2* focuses on the social acceptance of utility-scale solar projects in alpine regions, which benefit from greater levels of solar irradiation, higher efficiency, and fewer fog days (Díaz & Van Vliet, 2018; ZHAW, 2019). Promoting solar power in alpine regions may thus help to meet the winter electricity demand. Despite these advantages, major solar projects modify the landscape (as do wind projects); thus, social-acceptance issues may arise. Multiple authors have investigated the numerous factors that can affect the social acceptance of wind-energy projects (Jami & Walsh, 2017; Firestone et al., 2018; Dwyer & Bidwell, 2019), but less research has been published in relation to the social acceptance of utility-scale solar photovoltaic (PV) (Michel et al., 2015; Brewer et al., 2015; Carlisle et al., 2015). The objective of this paper is to identify the general social-acceptance level of solar projects in alpine regions and to analyze the attributes that determine its social acceptance. A qualitative prestudy followed by a choice experiment reveals the importance of the different attributes. An important insight of the paper is that alpine solar PV projects are associated with high levels of general socio-political acceptance, and the local population affected may be more accepting of such projects than inhabitants of non-alpine regions. Additionally, the paper also demonstrates how design can both positively and negatively affect the social acceptance of alpine solar projects.

In *Paper 3*, I investigate the social acceptance of electric mobility within organizations. Research has already identified so-called hard barriers limiting the uptake of electric mobility, which include the higher initial investment cost of electric vehicles

or the limited availability of vehicle-charging infrastructure (Hjorthol, 2013; Koetse & Hoen, 2014; Rezvani et al., 2015), but which fail to completely explain the slower-than-expected uptake of electric mobility. Accordingly, the research focus now also involves creating a better understanding of the social acceptance of electric mobility, now seen as a prerequisite for its widespread uptake and, more specifically, its intraorganizational use (Wikström et al., 2014; Sierzechula, 2014; Globisch et al., 2018). Using an online survey with Swiss fleet managers, I can reveal important prevailing acceptance-related soft barriers, such as a lack of both knowledge and employee demand. Incrementally, I develop a behavioral-intervention campaign (i.e., a one-week trial of EVs in daily business, free of charge and without obligation) to address acceptance-related soft barriers to the adoption of electric mobility within organizations, and assess it in a field experiment with car pool users. Importantly, I find that acceptance-related soft barriers figure prominently in the organizational uptake of electric mobility, while findings from the related field experiment show that the exposure of car pool users to the intervention campaign can induce a significant increase in the level of acceptance of a variety of EV-related variables and purchase intentions. The paper concludes that incorporating ways to address acceptance-related soft barriers in the overall policy mix may increase the social acceptance of electric mobility for key people within organizations and, thus, the uptake of electric mobility in corporate fleets.

| No | Title                                                                                                                                   | Authors                                                                                               | Objective                                                                                                                                                                                                                                                                                                                        | Method                                                                                           | Publication status                                                        |
|----|-----------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|
| 1  | <b>Individual or Collective?</b><br>Community Investment,<br>Local Taxes, and the<br>Social Acceptance of Wind<br>Energy in Switzerland | Pascal Vuichard <sup>a</sup> ,<br>Alexander Stauch <sup>a</sup> ,<br>Nathalie Dällenbach <sup>a</sup> | Examine local preferences for<br>specific financial-participation<br>models, as well as their influence<br>on the overall acceptance of wind-<br>energy projects.                                                                                                                                                                | Interviews,<br>experimental survey<br>design                                                     | Published in<br><i>Energy Research<br/>and Social Science</i>             |
| 2  | <b>Keep it Local and Low-</b><br><b>Key:</b> Social Acceptance of<br>Alpine Solar Power<br>Projects                                     | Pascal Vuichard <sup>a</sup> ,<br>Alexander Stauch <sup>a</sup> ,<br>Rolf Wüstenhagen <sup>a</sup>    | Analyze the social acceptance of<br>solar-PV projects in alpine regions<br>and identify the different elements<br>that influence the social acceptance<br>of such projects.                                                                                                                                                      | Interviews, Conjoint<br>analysis (Choice-<br>based conjoint)                                     | Published in<br><i>Renewable &amp;<br/>Sustainable Energy<br/>Reviews</i> |
| 3  | <b>Electrifying the<br/>Company Car:</b> Adoption<br>of Electric Mobility in a<br>B2B Context and the Role<br>of Social Acceptance      | Pascal Vuichard <sup>a</sup>                                                                          | Investigate the adoption of electric<br>mobility within organizations by<br>assessing whether a behavioral-<br>intervention campaign addressing<br>acceptance-related barriers could<br>influence the acceptance levels of<br>different EV-related variables and,<br>consequently, purchase intentions<br>for electric mobility. | Interviews, online<br>survey, field<br>experiment with a<br>behavioral-<br>intervention campaign | Under review at<br><i>Energy Research<br/>and Social Science</i>          |

<sup>a</sup> Institute for Economy and the Environment, University of St.Gallen, Switzerland

**Table 1:** Overview of the papers in the dissertation

### 3. Theoretical and conceptual foundation

An energy system is not simply a collection of different technologies and associated infrastructure, but a sociotechnical system deeply embedded in society (Miller et al., 2013). The energy transition — i.e., the complete change of our energy system away from fossil resources to renewable energy — will not only involve a change in technology and infrastructure but also affect society. This insight is central to understanding the term *social acceptance*; the concept emphasizes the fact that technological development depends on other social factors and developments, and even if the benefits appear to be obvious, new technologies can ultimately fail, due to societal factors (Sovacool, 2009). Nonetheless, this interconnectedness of the energy system with society can also lead to technologies thriving, if they generate a positive response from society, such as support for or pride in renewable-energy projects (Batel & Devine-Wright, 2015). Additionally, renewable-energy projects can also offer such opportunities as stimulating the local economy by creating jobs in rural areas (Jenssen et al., 2014; Schumacher, 2019). All these elements combined can ultimately help society transition away from an energy system based on fossil fuels, to one based on renewable energy. In brief and in the words of Ellis and Ferraro (2016): “Society may need renewable energy, but renewable energy also needs society.” (Ellis & Ferraro, 2016, p. 11)

#### 3.1. Defining social acceptance

Today, the term *social acceptance* is much used in various fields, including social sciences, politics, and industry. However, the term’s exact meaning is still a bit hazy — Busse and Siebert (2018) point to the lack of a common understanding about it. Lucke (1998) was one of the earliest scholars to attempt to define the term “social acceptance.” For her, it is the result of a multidimensional process that subjects (individuals or groups), objects (i.e., wind- or solar-energy projects), and their specific conditions determine. Lucke (1998) focuses in her early definition on the micro level, although during the last two decades, the definition has become extended to include elements that go beyond the micro level. The discussion is still ongoing in the literature and among stakeholders, with most contributions originating in the fields of sociology, environmental psychology, political science, geography, economics, and innovation research (Schumacher, 2019). Of course, the number of published research papers also

reflects this distribution, with a considerable number of studies investigating drivers and elements of social acceptance for different energy technologies and applications over the last two decades. Data from Scopus indicates that between 1998 (Lucke's definition) and 2019, 1,367 published articles used the keywords “social acceptance” and “energy,” with a strong increase occurring toward the end of the period (see Figure 2). Social acceptance has developed from a rather marginal and rarely studied topic into a major research area in the field of social sciences (Fournis & Fortin, 2017).

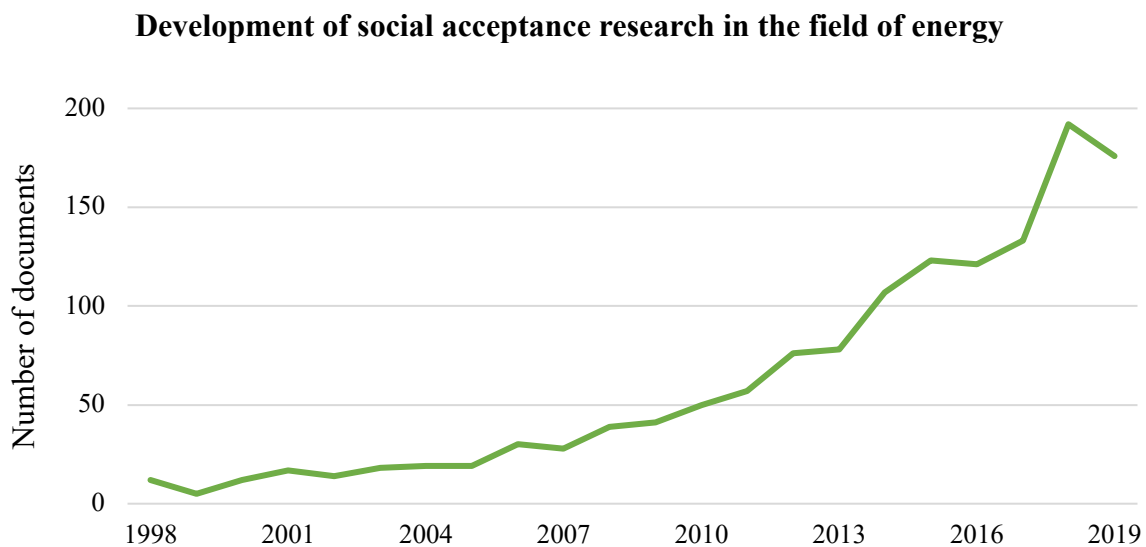


**Figure 2:** Number of articles published per year with keywords “social acceptance” and “energy” (1998-2019) (Source: Scopus<sup>1</sup>)

Naturally, the term *social acceptance* should not be reduced to the direct relationship between local residents and (for example) a renewable-energy project. This relationship would be very relevant for social acceptance, but it is necessary to add certain elements. In order to go beyond the micro-level of direct relationships and include social aspects that go further, previous scholars have added different levels to the concept of social acceptance. One of the most often cited papers, entitled “Social acceptance of renewable energy innovation: An introduction to the concept,” by Wüstenhagen et al. (2007), lists three different levels of social acceptance (see Figure 3): socio-political acceptance, community acceptance, and market acceptance. Socio-political acceptance refers to the widest level of acceptance, involving key stakeholders, the public, and the political

<sup>1</sup> See <https://www.elsevier.com/solutions/scopus>

decision-makers affected by a specific national (i.e., non-site-specific) renewable-energy technology. Community acceptance addresses the social acceptance of local (site-specific) projects. Local stakeholders, as well as local authorities and residents, are the focus of this level. The market's process of adopting an innovation is known as market acceptance (Wüstenhagen et al., 2007). Aspects include the willingness of investors to invest in the technology and the willingness of consumers (as well as organizations) to engage with the markets created by the technology (Upham, 2015; Ellis & Ferraro, 2016).

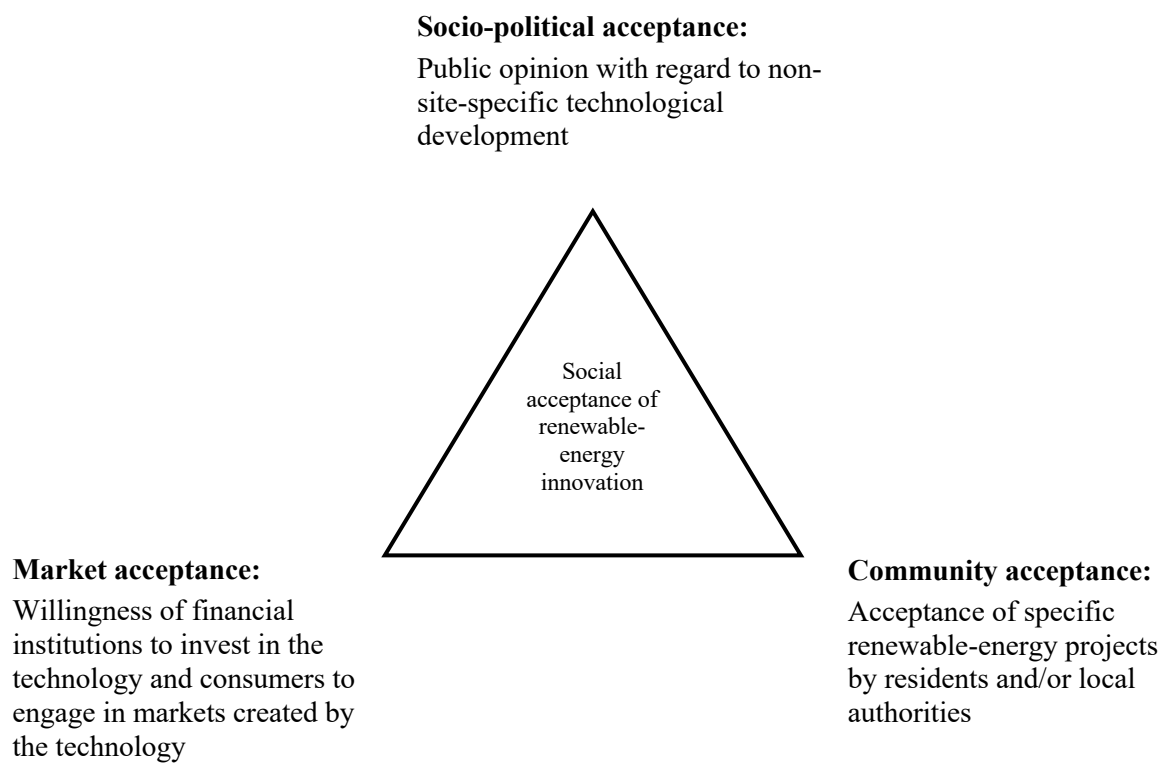


**Figure 3:** The triangle of social acceptance of renewable-energy innovation.  
Adapted from Wüstenhagen et al. (2007).

The three levels — socio-political, community, and market acceptance — are also interrelated. An increase in challenges in the area of community acceptance can lead to effects on a pre-existing high level of socio-political acceptance. In response, policies at the socio-political level may change and increase related risks, thereby undermining market acceptance. A current example involves the developments in the wind-energy

industry in Germany. An increase in problems and opposition at the local level (community acceptance) has led political decision-makers at the national level to consider relevant policy changes (i.e., the introduction of a minimum 1000-meter distance rule and a resulting significant reduction in the number of permits for the development of wind turbines). In their study, Stede and May (2019) show that such a change can translate into a strong negative impact on market acceptance (i.e., strongly reduced investment activity). This implies that social acceptance is a multidimensional, context-specific, and dynamic phenomenon (Upham et al., 2015; Ellis & Ferraro, 2016). Wolsink (2018) further complements the model of Wüstenhagen et al. (2007) by underlining the nonhierarchical and multilevel character of the three dimensions of social acceptance. According to Wolsink (2018), the socio-political dimension provides the basis of social acceptance, since the conditions established in this dimension (e.g., national legislation for energy markets) function as "rules of the game" and strongly influence the acceptance processes in the other two dimensions (community acceptance and market acceptance) (Wolsink, 2018).

Identifying a conclusive definition that aptly incorporates all these elements is difficult. From my perspective, the most complete definition is that of Upham et al. (2015), contained in a paper titled "Towards a cross-paradigmatic framework of the social acceptance of energy systems". The authors describe social acceptance as follows: "A favourable or positive response (including attitude, intention, behaviour and — where appropriate — use) relating to a proposed or in situ technology or socio-technical system by members of a given social unit (country or region, community or town and household, organization)" (Upham et al., 2015, p. 107).

Upham et al. (2015) further refer to different actors. A community is not necessarily a homogeneous unit. Local residents sometimes have a variety of different roles within the community (for example, they can be homeowners, electricity consumers, or environmental activists [Walker & Cass, 2007]). This suggests that social acceptance is formed at different levels, and a diversity of actors and the relationships between them also affect it. Table 2 includes a description of this range of actors by Upham et al. (2015).

|             |             | Level                                                                                                                                                             |                                                                                                                                                                 |                                                                                                                                                    |
|-------------|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
|             |             | General<br>(Socio-political acceptance)                                                                                                                           | Local<br>(Community acceptance)                                                                                                                                 | Organization / end user<br>(Market acceptance)                                                                                                     |
| Actor group | Political   | National political acceptance toward implementation of a technology (by national, formally instituted decision-makers)                                            | Local political acceptance toward implementation of a technology (by local, formally instituted decision-makers)                                                | User acceptance toward implementation of a technology (by individual citizens with views on energy policy)                                         |
|             | Stakeholder | Stakeholder acceptance (by other nationally active market and nonmarket policy groups)                                                                            | Local stakeholder acceptance (by other locally active market and nonmarket policy groups)                                                                       | Stakeholder acceptance (by commercial and other organized users)                                                                                   |
|             | Public      | Attitude toward the implementation or adoption of a proposed technology by the general population as citizens with views on national policy<br><br><b>Paper 2</b> | Attitude toward the implementation or adoption of a proposed technology by the local population as citizens with views on national policy<br><br><b>Paper 1</b> | Attitude toward the implementation or adoption of a proposed technology by household, organization, and individual end-users<br><br><b>Paper 3</b> |

**Table 2:** Actor groups and social acceptance at different levels. Adapted from Upham et al. (2015).

Table 2 also illustrates how the three papers of this dissertation are embedded in the conceptual and theoretical framework. *Paper 1* researches the local population's attitude toward and preferences for different financial-participation models for wind-energy projects (community acceptance). *Paper 2* focuses on the social acceptance of utility-scale solar projects in alpine regions, both on a broad level for the general population (socio-political acceptance) and with a subsample for the local population (community acceptance). *Paper 3* investigates the acceptance and purchasing intentions (market acceptance) touching electric mobility within organizations, for both key stakeholders (fleet managers) and such individual end-users as car pool users.

### 3.2. Social acceptance: Different focus for different technologies

Several studies have found a high level of socio-political acceptance for different renewable-energy technologies (Ellis & Ferraro, 2016; Langer et al., 2016; Cousse & Wüstenhagen, 2018; AEE, 2019). In addition, key renewable-energy technologies, such as solar and wind energy, have experienced impressive learning curves, resulting in

major cost reductions (IRENA, 2016; IEA, 2019c). In many parts of the world, renewable energies are now the most cost-effective source of new electricity generation, and as the costs of solar and wind technologies, in particular, continue to fall, this will be the case in even more countries (IRENA, 2019). Onshore wind and solar power (without financial support) will consistently provide a cheaper source of electricity than the cheapest fossil fuel alternative (IRENA, 2019). This has led to the literature contending that socio-political and market acceptance are currently not considered the main limiting factors in the further deployment and implementation of renewable-energy projects (Ellis & Ferraro, 2016). On the other hand, community acceptance increasingly is such a limiting factor (Fournis & Fortin, 2017; Firestone et al., 2018; Dwyer & Bidwell, 2019). Fostering community acceptance is seen as a main challenge to increasing the deployment of new renewable-energy projects (Ellis & Ferraro, 2016).

Various studies also show high socio-political acceptance levels for electric mobility (Quak et al., 2016; Kaplan et al. 2016; Cousse & Wüstenhagen, 2018, 2019). Additionally, the literature discusses electric mobility from an economic (Bubeck et al., 2016; Palmer et al., 2018), technical (Khan & Kockelman, 2012) and ecological point of view (Faria et al., 2012; Cox et al., 2020) and has identified great potential. Nevertheless, the uptake of electric mobility is increasing only slowly in most countries. Fostering market acceptance is the primary challenge (Ziefle et al., 2014) and, therefore, is a key element within the research area of “social acceptance of electric mobility.”

The two current key areas of research that scholars previously identify — fostering *community acceptance of renewable energy* and *market acceptance of electric mobility* — are also important focus elements of this dissertation, discussed in more detail in the next two chapters.

### ***3.2.1. Community acceptance of renewable energy***

Procedural and distributional justice (i.e., fair decision processes and a fair distribution of project costs and benefits) are two key concepts of equality theory (Adams, 1963), the basis for the assumptions of various studies in the field of community acceptance of renewable energy (see e.g. Wüstenhagen et al., 2007; Goedkoop & Devine-Wright, 2016; Schumacher, 2019).

**Procedural justice:** The top-down development of renewable-energy projects is advantageous, in that capacity can be expanded relatively quickly as decision-making

power is transferred away from the local level, to a superordinate level (Ottinger et al., 2014, Walker & Baxter, 2017). In the long term, however, such an approach can give rise to a sense of injustice that can lead to the development of an opposing political momentum, able to slow down project implementation, as well as the growth of the industry as a whole (Aitken et al., 2008). Increasing local implementation problems have led to increased research activity in the field of procedural justice, in relation to renewable-energy projects. Recent research papers, such as those by Jami and Walsh (2017), Firestone et al. (2018), and Dwyer and Bidwell (2019), claim that more direct forms of public consultation and engagement in processes that lead to the realization of wind farms can positively affect the social (community-level) acceptance of projects. Researchers identify various criteria that must be met for these forms of consultation and engagement of the public to be considered fair:

- Meetings must be accessible;
- Decision-makers must recognize the legitimate contributions of citizens in local communities; and
- Public input should have some influence on final decisions (Schlosberg, 2009; Walker & Baxter, 2017).

These criteria also appear in Arnstein's (1969) eight-level "ladder of citizen participation." The participation levels herein range from nonparticipation (e.g., manipulation) to the highest level of public participation (e.g., direct citizen control). It is important to not only pay attention to the elements of procedural justice in the decision-making process but also evaluate what results are actually achieved — i.e., to what extent a high degree of procedural justice actually improves/changes elements of the renewable-energy project (Walker & Baxter, 2017).

**Distributional justice:** The idea that the creation of ways for local populations to benefit from such projects (either directly, through participation opportunities for the population, or indirectly, through contributions to the community for the benefit of the population) can modify the social acceptance of renewable-energy projects is not novel (Ellis & Ferraro, 2016). Various research projects show that the financial participation of the local population can positively influence social acceptance of these projects (Aitken, 2010; Warren & McFadyen, 2010; Sovacool & Ratan, 2012; Hildebrand et al., 2012; Walter, 2014; Rand & Hoen, 2017). The renewable-energy industry has also

reacted to findings from research and applied elements of distributional justice to increase the level of social acceptance of the local population (community acceptance). However, there is no evidence of a consistent approach. Different countries use different approaches: France relies on collectivist models (contributions to the local community), Germany mainly on individual models (e.g., local ownership of wind parks), and Great Britain and Ireland on schemes operated according to government guidelines and industry codes of best practice (Aitken, 2010). Today, participation schemes are a well-recognized and almost an expected element in the development of (mainly) wind- and large-scale solar-energy projects (Ejdemo & Söderholm, 2015).

### ***3.2.2. Market acceptance of electric mobility***

A high level of market acceptance (i.e., willingness to invest in the technology and engage with markets the technology creates) by both important stakeholders and individual end-users is a prerequisite for the successful expansion of electric mobility (Steinhilber et al., 2013; Globisch et al., 2018). So far, both citizens and organizations have been reluctant to fully embrace electric mobility, despite EVs' association with lower operating costs and already competitive position relative to conventional vehicles, in terms of total cost of ownership (Palmer et al., 2018; IEA, 2019c). Previous research has investigated various elements (e.g., hard and soft barriers) that influence this reluctance and low level of market acceptance (Hjorthol, 2013; Koetse & Hoen, 2014; Rezvani et al., 2015; Biresselioglu et al., 2018), with hard barriers still seen as the main means of explaining the slow growth of electric mobility. However, scholars such as Ziefle et al. (2014) and Biresselioglu et al. (2018) advocate not underestimating the importance of soft barriers. Different areas that determine soft barriers are:

- *Experience*: Positive experience with an earlier (conventional) vehicle and consequently a lack of experience with a new technology can be a limiting factor (Skippon & Garwood, 2011; Ziefle et al., 2014);
- *Emotions*: Buying a vehicle is never a purely rational decision, but is linked to emotional attitudes (Sheller, 2004; Moons & De Pelsmacker, 2012), social esteem, and branding (Shamsuddoha et al., 2010), all of which influence the purchase decision and, thus, the market acceptance of electric mobility.

- *Ease of Usability*: Whether a new technology is favorably assessed significantly depends on its perceived ease of use, user-friendliness, and utility (Shao et al., 2016; Biresselioglu et al., 2018).
- *Information*: How information is presented and access to information about the new technology is ensured are also key factors in determining the social acceptance of the technology and the willingness of users to adopt it (Anable et al., 2011; Bakker & Trip, 2013; Ziefle et al., 2014).

The area of electric mobility requires further research to determine the extent to which more focus on these acceptance-related elements can influence the attitudes of important stakeholders and individual end-users and, ultimately, market acceptance (Ziefle et al., 2014).

## 4. Methodology

The selected elements of social acceptance for wind energy, solar energy, and electric mobility were addressed with different methodological approaches.

For *Paper 1*, we chose a two-step approach consisting of a qualitative prestudy and a subsequent experimental survey. Using this experimental-survey design, we investigated the impact of a single, manipulable factor (the independent variable) — namely, the effect of financial-participation models on the social acceptance of wind-energy projects (defined as the dependent variable), while controlling for other potentially influential variables. Experimental-survey designs are considered unobscured by other processes (Kirk, 1995; Webster & Sell, 2007) and, therefore, can contribute to overcoming methodological limitations based on mostly observational data (Yildiz & Sagebiel, 2019). During our qualitative prestudy, interviews were conducted with wind-industry experts about aspects of the prototype wind park used in the experimental scenario, as well as aspects of the financial-participation models (in total, we assessed three different financial-participation models — wind share, wind bond, and wind resource tax), used as experimental manipulations. The experimental survey setup consisted of four groups, three of which were manipulated by adding a financial-participation model, while one group served as a control group. Our sample consisted of 1,207 Swiss citizens divided among the four different groups. The whole sample and all subgroups were representative of the wider Swiss population according

to age, gender, income, region, and political-party preference. The wind bond, wind share, and wind resource tax — the three financial-participation models employed in the analysis — were formulated in light of regulatory developments in the renewable-energy sector in other European countries and experience with the case of Swiss hydro plants. The analysis focused on the question of whether the introduction of financial-participation models for a wind farm leads to significant changes regarding social acceptance by the local population (community acceptance) for the designated wind-energy project.

*Paper 2* focuses on the social acceptance of utility-scale solar projects in alpine regions. We chose an empirical approach to identify the relative importance of attributes that define the social acceptance of such alpine solar projects. With a choice-based conjoint experiment, we derived the preferences of the surveyed respondents for different attributes of a hypothetical utility-scale solar PV project. As a research method, a conjoint analysis is often used in developing new products, especially when actual purchasing behavior is not yet observable (Ewing & Sarigöllü, 2000); therefore, it is particularly suited to this research. Within a choice experiment, each choice task elicits the respondent's willingness to accept tradeoffs among more or less desired project attributes, the levels of which vary randomly depending on the choice task. Project attributes were selected on the basis of a literature review and a pretest with industry experts. The former included procedural and distributional justice, attributes already well recognized in the social-acceptance literature, as well as local ownership. Innovative design elements were among the more novel attributes incorporated. The sample consisted of 1,036 Swiss citizens, each of whom responded to eight choice tasks associated with four options (hypothetical scenarios), namely, three variants of the hypothetical alpine solar project, and a "none" (i.e., none of the former) option, creating a dataset of 8,288 experimental choices. The analysis focused on the importance of the alpine-solar-project attributes and the part-worth utilities of the specific levels.

In *Paper 3*, I opted for an online survey followed by a field experiment that included a behavioral-intervention campaign. Study 1 (online survey with fleet managers) sought to elucidate the variety of motivating factors for and barriers to electric mobility in corporate fleets and to facilitate analyzing whether acceptance-related soft barriers are relevant among the currently prevailing barriers. The purpose of Study 2 (field experiment with car pool users) was to help discover whether a behavioral intervention

campaign that addresses such acceptance-related soft barriers may increase the level of acceptance of important EV-related variables and, hence, purchase intention within organizations. As electric vehicles in corporate fleets are still rare, it was considered important to analyze aspects of social acceptance in field trials in which consumers (i.e., car pool users) could test electric vehicles over a longer period. Making valid predictions about future behavior without giving car pool users a chance to evaluate and experience such new products is unlikely to be methodologically sound (Schneider et al., 2014; Sierzechula, 2014; Globisch et al., 2018). Therefore, for *Paper 3*, I chose a methodological approach focused on how the actual usage of an electric vehicle (behavioral intervention) influences the acceptance levels of EV-related variables and purchase intentions. Together with the Office for Energy and Environment of the city of St.Gallen, I developed the behavioral-intervention campaign “*Wirtschaft unter Strom*,”<sup>2</sup> designed to provide test drives with electric vehicles in connection with participants’ daily business in a simple and unbureaucratic way, free of charge, and without any obligations. The research method for assessing the campaign was a field experiment. For survey research methods or laboratory experiments, field experiments may be superior at helping to explain complicated relationships and individual perceptions (Allen, 2017), making them a particularly useful approach for investigating understudied topics (Baldassarri & Abascal, 2017). The field experiment included a longitudinal element (at T0, the expectations and assessments of the car pool user regarding electric mobility were determined **prior** to the trial period, and at T1 **after** the trial period), allowing me to identify potential changes in acceptance levels and purchase intentions over time.

## 5. Conclusion

This dissertation’s three papers generated valuable insights into different theoretical fields and for the primary types of stakeholders addressed, namely, project developers and policy makers. I discuss the insights for each paper in more detail, distinguishing between theoretical and practical contributions. The chapter closes with a discussion of overall limitations and suggestions for further research, as well as a general reflection on the development of research methods within social-acceptance research.

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<sup>2</sup> For more information please visit: <https://wirtschaftunterstrom.ch/>

## 5.1. Theoretical contributions

The three papers in this dissertation make important contributions to the research stream concerned with the social acceptance of renewable energy and electric mobility.

*Paper 1* contributes new insights in the field of distributional justice for wind-energy projects. Insights from our experimental survey support such findings as those by Hyland and Bertsch (2018), who show that promoting distributional justice with collective-participation models tends to be the most effective means of increasing the social acceptance of a wind-energy project. This is of particular interest since previous studies, e.g., Aitken (2010), Warren and McFadyen (2010), and Hübner et al. (2013), indicate that financial participation in wind-energy projects can help to increase social acceptance, although they do not specify the design of such financial participation. Our research contributes to enlarging the theoretical background by examining the preferences for different financial-participation models in an experimental setting.

*Paper 2* investigates the topic of the social acceptance of utility-scale solar projects in alpine regions. Thus far, social acceptance related research on renewable energy has tended to focus on wind energy (Gaede & Rowlands, 2018) as wind energy deployment has slowed down in many areas due to local acceptance problems, creating a need to consider alternatives (Horbaty et al., 2012; Sagebiel et al., 2014; Walker & Baxter, 2017). Alpine regions may make very appropriate locations for larger solar PV projects, due to their high levels of solar irradiation, fewer fog days, lower temperatures, and snow reflection (Michel et al., 2015; Díaz & Van Vliet, 2018; ZHAW, 2019). However, utility-scale solar projects would also impact the landscape, potentially causing social acceptance related concerns. Our paper shows that solar PV projects in alpine regions are associated with a high level of socio-political acceptance. Additionally, we also found a PIMBY (Please In My Back Yard) effect — the local population has significantly higher acceptance levels than the rest of the sample (i.e., people not living in alpine regions). By examining the different attributes that define the social acceptance of utility-scale solar projects in alpine regions, we add new theoretical insights to the debate. For example, we confirm the findings of the literature on social acceptance for renewable energy, which suggests that high levels of procedural and distributional justice (Walter, 2014; Rand & Hoen, 2017; Jami & Walsh, 2017; Firestone et al., 2018; Dwyer & Bidwell, 2019) can help to increase social-acceptance levels. In line with findings about wind-energy projects, the present research confirms that low

environmental impact and an increase in local ownership may increase social acceptance. Notably, the paper also confirms the relevance of solar-project design as a factor shaping social acceptance. Earlier research in relation to wind (Dimitropoulos & Kontoleon, 2009; Maffei et al., 2013) and solar energy (Sánchez-Pantoja et al., 2018; Hille et al., 2018) confirms that factors such as installation design and color may influence the social acceptance of such projects. We support those findings by demonstrating that making the color of solar panels conform to natural surroundings can significantly increase the social acceptance of such utility-scale solar projects.

*Paper 3* joins the relatively new research stream focused on the social acceptance of electric mobility — more particularly, the social acceptance of electric mobility within organizations. Wikström et al. (2014), among others, argue that electric mobility becoming a more significant part of corporate fleets requires a high level of social acceptance. With *Paper 3*, I add theoretical value by identifying important acceptance-related soft barriers. Additional value is added by analyzing the effect of a behavioral-intervention campaign that addresses such acceptance-related soft barriers on the acceptance levels of various EV-related variables, as well as purchase-related intentions toward electric mobility. Results indicate that such a campaign can not only raise social-acceptance levels, in connection with such acceptance-related barriers as a lack of knowledge, but also increase acceptance levels confronted by important hard barriers, such as the limited range of EVs or the limited availability of charging infrastructure. These findings add to results from other scholars, such as Wang et al. (2019) or Held and Gerrits (2019), who claim that exposure to acceptance-related soft barriers can reduce the effectiveness of other policy instruments, e.g., those that provide financial incentives to buy EVs. The results of this paper indicate that the reverse conclusion — i.e., addressing acceptance-related soft barriers can help to reduce prevailing hard barriers — also holds, further supporting the call of Held and Gerrits (2019) for a more holistic policy approach to EV adoption.

## 5.2. Practical contributions

The three papers in this dissertation shed light on different practical issues related to wind energy, solar energy, and electric mobility, providing findings of value to policy makers and project developers in the respective fields.

Generally, one of the most important implications for policy and practice emphasizes that social acceptance does not simply consist of the direct relationship between a renewable-energy project and the local population, but reaches much further (Ellis & Ferraro, 2016; Schumacher, 2019). This insight implies a more holistic policy approach that integrates the economic, technical, and social aspects of the energy transition. In turn, this requires new and innovative processes for interacting with citizens and highlights the key role of public authorities in shaping future framework conditions for achieving high levels of social acceptance — for example, through their responsibility for legislation and financial incentives. The three papers show both policy makers and project developers new ways of incorporating the topic of social acceptance.

*Paper 1* highlights the importance of understanding citizens' preferences for different models of financial participation for wind-energy projects. In terms of policy implications, creating and disseminating comprehensive national guidelines for potential financial-participation models available for such projects could influence community acceptance at the planning stages of wind-park developments. The paper further demonstrates different significant positive effects of financial-participation models on the social-acceptance level of important subgroups. Policy makers at the local level would be well advised to approach relevant stakeholders (i.e., those with a center-progressive political mindset) to make them aware of any financial-participation options for a planned wind project. Opposition to wind-energy projects tends to form at early stages (Aitken, 2010), making such approaches particularly important.

*Paper 2* provides a window into citizens' preferences for alpine solar projects. We demonstrate that from a social-acceptance perspective, utility-scale solar PV projects in alpine regions could offer a promising option for increasing the seasonal diversification of the renewable electricity supply. In line with this conclusion, various pathways both nationally (such as setting specific targets for solar power generation in alpine regions and providing guidelines for project implementation) and locally (such as including utility-scale solar PV projects in spatial-planning procedures) can be deduced for policy

makers. Additionally, the data from our conjoint experiment are highly relevant for project developers. We provide insights into the most important attributes that define the social acceptance of an alpine solar project. Project developers are advised to remain well aware of the need to design projects as closely adapted to natural surroundings as possible and to opt for ownership models with a strong local component.

*Paper 3* highlights the relevance of tackling acceptance-related soft barriers to the further expansion of EVs within organizations. I demonstrate that a campaign specifically designed to tackle these barriers can help to address them and increase social-acceptance levels and purchase intentions related to EVs for key individuals within an organization (car pool user). I recommend integrating acceptance-related soft barriers as an integral part of national-level policy-makers' roadmaps, especially for electric mobility in corporate fleets. At the local level, the campaign (*Wirtschaft unter Strom*), created as part of the research effort, could serve as an additional element of local policy mixes with the goal of meeting local electric-mobility targets.

### **5.3. Overall limitations and suggestions for further research**

As with any research project, this dissertation is subject to limitations that could provide a starting point for further research. Additional paper-specific limitations are listed in each paper; below, I discuss important limitations that affect at least two out of the three papers in the dissertation.

A general limitation concerns the *chosen attributes*, as well as *project characteristics* for the research projects. In *Papers 1* and *2*, the chosen attributes and project characteristics of the respective hypothetical projects determine the results of the experimental survey and the choice experiment. Although the importance of the selected attributes for both the wind and the solar PV project was investigated using qualitative prestudies, real-life decisions involve additional interconnected elements. Further research could replicate the studies with adjusted or extended attributes and varying project characteristics. For the case of financial participation in wind-energy projects, it would be interesting to see whether changing the levels of attributes, such as interest rate or contract duration, would affect the results. For the case of alpine solar projects, future research might study whether changing the size and/or location of the proposed project would affect the general social acceptance level. For *Paper 3*, the elements chosen for the behavioral-intervention campaign "*Wirtschaft unter Strom*" drive the

results of the field experiment, and replicating the field experiment but varying the elements of the intervention campaign (e.g., time) to examine whether the effects change with changing the number of days (e.g., trial day vs. trial month) could merit further study.

Another limitation that affects *Papers 1* and *2* is using *stated preferences* in our analysis. For both papers, research remains scarce in their respective fields, so we opted to examine preferences based on hypothetical scenarios. Although the methodological approaches chosen for *Paper 1* (experimental-survey design) and *Paper 2* (choice experiment) can mitigate the downsides (e.g., a social desirability bias) of some revealed preference methods (e.g., interviews or case studies), they were not conducted in real-life situations. The chosen methodological approaches are associated with several advantages over traditional valuation methods. Respondents face realistic decision situations, and, in the case of the choice experiment, indirectly surveying preferences helps to minimize biases that can occur when respondents are asked to directly state their preferences. Still, results from both analyses in *Papers 1* and *2* do not reflect real-life behavior. Future research projects based on revealed preferences would be an interesting research avenue, not least to see whether our results could be confirmed.

One general limitation is the *narrow geographical context*. As citizens' preferences depend on context, our findings may not reflect the local preferences of non-Swiss residents. Both *Papers 1* and *2* are limited to the Swiss context; *Paper 3* focuses on a field experiment with participants from within the city of St. Gallen. Switzerland shares many similarities with other developed countries pursuing a more sustainable energy system, but examining the preferences of citizens in regions with different cultural backgrounds could be considered. The case of financial participation in wind energy would be particularly interesting to investigate, to see whether citizens in such countries as Germany, Denmark, or France (where different financial-participation models have already been introduced) share similar preferences to those we found for the Swiss case. In analyzing the social acceptance of utility-scale PV in alpine regions, specificities of the Swiss context (e.g., a relatively high per-capita income, the absence of carbon-intensive domestic power generation, or the tradition of participatory democratic decision-making) might have influenced our findings. A further investigation of the preferences of individuals living in other alpine regions, such as those in Canada, Central Asia, or South America (i.e., different cultural contexts) would be instructive.

## 5.4. Development of research methods in social-acceptance research

A characteristic element of this dissertation is the variety of research methods used to investigate the different aspects of social acceptance of renewable energies and electric mobility. Therefore, I conclude the introductory chapter with a general reflection on the development of research methods within social-acceptance research.

The largest number of research projects in the stream of social acceptance of renewable energies and electric mobility apply qualitative case studies as their research method (Ellis & Ferraro, 2016; Batel, 2018). Increasingly, scholars also apply mixed-method designs combining the advantages of qualitative and quantitative methods. Such mixed-method designs (e.g., combining quantitative surveys with a field experiment) can use the strengths of each method to increase the validity of the results (Schumacher, 2019).

The numerous qualitative case studies, especially within the research stream of social acceptance of renewable energy, obtain various findings on different aspects of social acceptance (e.g., influence of procedural acceptance, influence of the height of wind turbines). The findings of these case studies are very valuable but also highlight the room still available for expanding the range of research methods applied. Several scholars argue for more cross-sectional, longitudinal, comparative, or experimental research methods (Wüstenhagen et al., 2007; Schumacher, 2019). Sovacool (2014) also addresses the lack of comparative cross-cultural research. According to Ellis and Ferraro (2016), studies that examine "natural experiments" before and after the experience with the respective technology would be particularly useful. Also, Batel (2018) argues for more innovative research methods, such as ethnography (observation in people's daily lives for an extended period), which could help to identify implicit ways of resisting change, seldom expressed verbally but displayed in everyday actions and habits. New methods that combine verbal data with other data (e.g., visual data) could help to better explain responses to renewable-energy projects (Batel et al., 2016).

Within this dissertation, I attempt to incorporate novel and innovative methodological approaches cited by scholars such as Wüstenhagen et al. (2007), Batel et al. (2016), or Schumacher (2019). In *Paper 1*, we added new insights to the research stream by applying an *experimental setting* in which to assess the influence of financial participation on the social acceptance of wind-energy projects, thereby specifically examining one isolated element (i.e., financial participation) for which an experimental

survey is particularly suited. In *Paper 2*, we attempt to *combine verbal data with visual data* (Batel et al., 2016) within the choice experiment. Finally, in *Paper 3*, I apply a field experiment (i.e., car pool users testing the electric vehicle daily for a week in their daily work life) and add a *longitudinal element* (observing a potential behavior change between T0 before the trial period and T1 after the trial period).

Additional novel and innovative research approaches in order to further develop the research stream, such as comparative and intercultural studies (Sovacool, 2014), are not part of this dissertation, but they are an interesting route for future research projects, as are innovative qualitative research methods, such as ethnography.

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# Paper I

## Individual or Collective?

### Community Investment, Local Taxes, and the Social Acceptance of Wind Energy in Switzerland<sup>1</sup>

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#### Abstract

This research paper describes the effect of different financial-participation models for wind-energy projects on the social acceptance of a hypothetical project. Based on the configuration of three different financial-participation models tested in a prestudy with several industry experts, we conducted an experimental survey with a representative sample of Swiss electricity customers (N=1202). Our results indicate that a local resource tax that benefits the entire community is favored over individual financial-participation models (namely, the opportunity for local citizens to participate through shares or bonds). For key stakeholders such as community attached people or those with a politically centrist, progressive mindset, the local resource tax leads to a significant increase in acceptance. As findings about specific financial-participation models for wind-energy projects are rare, our research creates a foundation on which social acceptance of wind-energy projects at the local community level can be fostered.

#### Keywords:

Wind energy, Financial participation, Experimental study, Social acceptance

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# 1. Introduction

As part of international efforts to combat climate change, many countries have introduced policy instruments and measures designed to increase the share of renewable energies in the national energy mix (REN 21, 2018). In line with these developments, Switzerland's voters approved a comprehensive national energy strategy in May 2017. A central pillar of the Swiss Energy Strategy 2050 is the expansion of renewable energies, including wind energy (BFE, 2017, 2018).

To date, however, the deployment of wind energy has been slow. Despite high levels of approval for wind energy at the national level (Tabi & Wüstenhagen, 2015; Gamma et al., 2017), wind-energy projects face a number of acceptance-related issues at the local level (Horbaty et al., 2012). Local resistance in Switzerland and other countries has repeatedly led to major project delays, ultimately resulting in projects being abandoned,<sup>4</sup> and also negatively influencing the financial attractiveness of wind-energy projects (Tabi & Wüstenhagen, 2015).

While the *Not In My Backyard* phenomenon (NIMBY) has been criticized for offering an oversimplified explanation for the low level of community acceptance (Devine-Wright, 2005, 2007; Wüstenhagen et al., 2007; Walker & Devine-Wright, 2008; Walker et al., 2010), a number of related studies have focused on institutional factors. According to Wolsink (2007) and Dimitropoulos and Kontoleon (2009), the two main institutional factors are:

1. *Procedural justice (To what extent are various stakeholders involved in the decision-making process?), and*
2. *Distributional justice (Are the benefits and costs of the project fairly distributed?)*

When it comes to empirical evidence, the role of procedural justice has already been widely explored in literature (Devine-Wright, 2005; Jones & Eiser, 2010; Swofford & Slattery, 2010; Khorsand et al., 2015; Enevoldsen & Sovacool, 2016; Firestone et al., 2018), while rigorous empirical research on distributional justice is rare. Even though some studies have examined the influence of financial participation (Aitken, 2010;

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<sup>4</sup> Since 2012, nine out of twelve votes in cantons and municipalities have been in favor of planned wind turbines, however, the implementation of these projects is progressing only slowly due to objections from private individuals or organisations (Zehnder, 2017).

Warren & McFadyen, 2010; Hübner et al., 2013), they have not further specified how this financial participation should be designed, setting the stage for further research in this important area.

Creating a better understanding of the effects of various financial-participation models on social acceptance is relevant for addressing distributional justice issues in the context of wind-energy projects and thus facilitating local acceptance. Based on these considerations, the research described herein was designed to shed light on local preferences for specific financial-participation models, as well as their influence on the overall acceptance of wind-energy projects. Accordingly, the following two main research questions were drawn up:

1. *How does the option to financially participate in a wind-energy project affect its local acceptance?*
2. *How do citizens' preferences with regard to different financial-participation models vary, and what are the resulting implications?*

The remainder of this article is structured as follows: The following section discusses and reviews relevant literature in the field of social acceptance of wind-energy projects with a focus on distributional justice. Building on this, we derive three hypotheses. Section 3 illustrates our research design and presents the sample used in the analysis. Section 4 describes the results of the experimental study and discusses the verification of our hypotheses. Finally, we close this paper in Section 5 by offering general conclusions and specifying important policy implications and recommendations for project developers. We also provide a discussion of limitations and opportunities for further research.

## **2. Literature review and hypothesis development**

### **2.1. Distributional justice and wind-energy projects**

The complexity associated with the social acceptance of renewable energy technologies – in particular, wind energy – is reflected in a growing body of literature. Various empirical studies have investigated the relationship between social acceptance and different attributes of wind-energy projects such as the height of turbines (Dimitropoulos & Kontoleon, 2009; Meyerhoff et al., 2010), the size of wind parks

(Dimitropoulos & Kontoleon, 2009; Meyerhoff et al., 2010; Dobers et al., 2015), the proximity of turbines to settlements (Meyerhoff et al., 2010; Dobers et al., 2015) and the location of wind parks (Van der Horst, 2007; Ek & Persson, 2014).

One specific stream of research in the field uses justice theory – namely, procedural and distributional justice – to explain the social acceptance of wind energy. So far, the main focus has been on procedural justice: Bergmann et al. (2006), Dimitropoulos and Kontoleon (2009), Ek and Persson (2014), Sagebiel et al. (2014), Walker and Baxter (2017), Jami and Walsh (2017), Firestone et al. (2018) and Dwyer and Bidwell (2019) elicited preferences for stronger and more direct forms of consultation and engagement of the public as well as greater inclusion of the public in procedures that lead to the construction of wind parks. Public participation in the planning process has been analyzed by Devine-Wright (2005), Wolsink (2007), Dimitropoulos and Kontoleon (2009), Jones and Eiser (2010) and Swofford and Slattery (2010). Finally, Gross (2007) as well as Firestone et al. (2012) have explored how fairness within planning processes affects perceptions of local wind-energy projects.

The issue of distributional justice for wind-energy projects centers around the main question of how the perceived benefits (e.g., profits from electricity sales, or the value of the local electricity supply) and costs (e.g., impact on the landscape, or noise emissions) are fairly divided between project developers and local residents, as well as among the local community as a whole (Tabi & Wüstenhagen, 2017). Within the distributional justice literature previous research has found evidence that the financial participation of the local population and community ownership for the purpose of sharing profits between wind-park operators and the local community can positively influence the social acceptance of wind-energy projects (Toke, 2005; Toke et al. 2008; Aitken, 2010; Warren & McFadyen, 2010; Sovacool & Ratan, 2012; Hübner et al., 2013; Walter, 2014; Rand & Hoen, 2017). For example, Warren and McFadyen (2010) compared public attitudes toward a community-owned wind park with attitudes toward developer-owned wind parks in Scotland. The authors note that community ownership reinforces preexisting favourable attitudes toward wind power and simultaneously suppresses unfavourable ones, ultimately resulting in community wind projects that are more liable to be socially acceptable. A longitudinal study by Aitken (2010) supports the idea that the introduction of financial-participation models generally leads to greater acceptance. The author's case study suggests that, due to heterogeneity within local communities, this relationship may not always be straightforward: groups and

individuals that benefit from a particular community benefit package tend to view the related developments as beneficial, while others may perceive the same benefits as bribes from wind-park developers (Aitken, 2010). One possible precautionary measure aimed at improving the acceptance of a wind-energy project is including community members in the process of designing community benefit models, preferably during the early stages of a wind-park development (Aitken, 2010). However, a key concern in this respect is that due to a lack of confidence project leaders may not be willing to discuss the specifications of financial-participation models with the local population during the planning process (Aitken, 2010).

Following previous work that suggests that there is a generally positive relationship between the perceived fairness of how benefits and costs are shared in the context of a wind-energy project and its social acceptance, we test the following hypothesis:

*Hypothesis 1:* A wind park with a financial-participation model is more likely to be accepted than a wind park without a financial-participation model.

## **2.2. Financial-participation models – the status quo**

Financial-participation models for wind-energy projects already exist in several European countries with the goal of positively contributing to distributional justice in the context of wind-energy development. Denmark (Mey & Diesendorf, 2017) and Germany (Bovet & Lienhoop, 2015; Kalkbrenner & Roosen, 2016; Lienhoop, 2018) have been identified as role models in the field of community renewable energy. Given our aim of testing the acceptance of realistic financial-participation models, we subsequently outline the regulations that have been put in place to foster community participation in the former European countries. Finally, we also consider prior empirical findings about Swiss citizens' preferences for different financial-participation models.

On a state level, Germany has passed legislation to promote the financial participation of individuals in renewable-energy projects. In the state of Mecklenburg-Western Pomerania, for example, developers are under an obligation to offer financial participation to communities and residents within a 5km radius of new wind-energy projects (Bovet & Lienhoop, 2015; Landesrecht Mecklenburg Vorpommern, 2016; Lienhoop, 2018). According to Lienhoop (2018), developers are obliged to establish a company with limited liability and to offer residents the opportunity to participate financially in the wind park. The specific structure of the financial-participation

legislation in Mecklenburg-Western Pomerania requires that 20% of all shares must be offered to residents. However, the developer has alternatives to providing shares: they can either offer financial compensation in the form of reduced electricity tariffs for local households, negotiate an annual compensation payment with the respective municipality, or transfer 10% of company profit to a bank, which in turn sells savings bonds to residents (Bovet & Lienhoop, 2015; Lienhoop, 2018). The savings bond option has the advantage of being less risky for private investors, especially compared to investing in shares, as it avoids any potential losses from wind-energy projects.

Denmark has similar regulation in place. Regulations about participation rights are laid down in the Danish Renewable Energy Act (Papke, 2018). Any developer who plans a wind park and goes through the approval process should sell a legally prescribed minimum of 20% of shares to local residents. Thus, by participating in wind parks citizens not only benefit from economic gains, but also share the economic risk of projects with developers. In Denmark, too, the project developer has an alternative and can offer bonds the total value of which is required to be at least 20% of the total upfront investment of the wind-energy project (Papke, 2018). According to Papke (2018), such participation rights are awarded to two main target groups: first, all adult residents living within a radius of 4.5km of the wind park. In the second rank are all adults who reside in the municipality in which the wind park will be established. The right to participate gives citizens a viable way of getting engaged with wind-energy projects and profiting financially from the wind park in their immediate vicinity without having to be involved in project implementation (Papke, 2018).

As mentioned, previous research provides some evidence that the financial participation of local residents can positively influence the acceptance of wind-energy projects (Buchholz & Huge, 2014). However, empirical evidence about preferences for different financial-participation models for local residents in renewable-energy projects is scarce. A representative nationwide survey conducted in Switzerland in 2017 shows that there is untapped potential for investment into renewable-energy projects, as Swiss citizens express a willingness to financially participate in community projects: Although so far only 2% of respondents have invested in such a project, 62% would be interested in doing so in the future (Gamma et al., 2017). While the most preferred technology seems to be solar power (54%), 40% expressed an interest in financially participating in a community wind project (Gamma et al., 2017). Following the previous example, we

state the following hypothesis:

*Hypothesis 2:* Community investment (via shares or bonds) leads to greater social acceptance of wind-energy projects.

### **2.3. Collective financial-participation models**

The examples described in the previous chapter indicate that financial-participation models can mainly be categorized into two categories: debt-based models via bond investments, and equity-based models via share investments. The experience of the case of Swiss hydropower plants presents an alternative allocation approach, characterized by the fact that profits are shared between operators and *all* residents living in the municipality where the hydropower plant is situated. Since 1918, Swiss hydropower plant operators have compensated municipalities and cantons for the use of their waterways by means of a local resource tax (in German: *Wasserzins*) (Luchsinger, 2006; Tabi & Wüstenhagen, 2017). A central notion that stems from social psychology is that relative material payoffs affect behavior (Adams, 1963; Fehr & Schmidt, 1999). This indicates that the design of a financial-participation model may decisively define whether it is perceived to contribute to the distributional justice of a project. Individuals' assessments about distributional justice are guided by three main rules: equity, need, and equality (Deutsch, 1975). Equity theory (e.g. Adams, 1963) has introduced the equity principle, which proposes that people compare social processes based on the input/outcome ratio among the individuals involved in a social exchange. The "needs" rule suggests that individuals should be rewarded on the basis of their neediness. When people judge distributional justice based on how equally rewards are divided among each other, irrespective of how much they have invested, the equality rule applies. The application of these rules in the design of a financial-participation model appears to be a challenging endeavour (Tabi & Wüstenhagen, 2017), as opinions about fairness vary, making it difficult to find a consensus among stakeholders' preferences (Aitken 2010; Johansson-Stenman & Konow, 2010). Nevertheless, when studying preferences for community financing models, it is critically important to acknowledge that diverse models usually fulfil these principles differently, leading to distinct outcomes in terms of people's judgments about the distributional justice of wind projects. Compared to private-investment type models, whereby only residents willing or able to invest benefit from a redistribution of profits, a local resource tax redistributes the generated income

more equally among residents who – most likely – are all impacted by a large infrastructure project such as a hydropower plant or a wind park (Luchsinger, 2006). Thus, a local resource tax is more liable to uphold the principle of equity. In addition, the equality principle may also be perceived to be more applicable in the case of a local resource tax: Private investment models pay attention to the equality principle to the extent that a larger investment (input) results in greater reward (outcome). However, residents unwilling or unable to invest are excluded from this approach to improving distributional justice, even though they may face the same or even higher costs from a wind-energy project. Thus, in some cases the said models may ultimately result in the perception of greater inequality by those residents who are most affected by the wind park but not interested in private investment. A local resource tax permits some inequality as it does not result in greater rewards for individuals that incur higher perceived costs (e.g. residents who live closer to turbines than others). However, compared to private-investment models there is a smaller risk that residents will perceive such a model to result in greater inequality. The concept of inequity aversion suggests that it is especially individuals who experience disadvantage inequality that dislike outcomes that are unequal (Fehr & Schmidt, 1999). Dawes et al. (2007) show that inequity aversion may motivate individuals who experience inequity to pay a fee to reduce the income of others, especially those with an above-average income. With respect to the design of a model best suited to adhering to the principle of distributional justice, a further consideration is that, in the case of the Swiss local resource tax, revenues flow directly into the general budget of the municipality or canton. However, with other ecological taxes (such as the CO<sub>2</sub> tax) the literature suggests that acceptance increases with (partial) earmarking of revenues for climate-protection measures (Kallbekken & Aasen 2010; Baranzini 2017). This is mainly because people are of the opinion that an environmental tax should create environmental benefits (Kallbekken et al., 2011). Another interesting finding which Kallbekken et al. (2011) point out is that earmarking revenues lowers within-group inequality. These findings show that financial-participation models that do not satisfy the principles of distributional justice may contradict egalitarian motives and thereby – in the worst-case scenario – negatively affect the overall acceptance of a wind project. We thus arrive at the third hypothesis:

*Hypothesis 3:* The overall level of social acceptance of a wind-energy project will be greater if a financial-participation model is in place which distributes financial benefits equally among all residents, instead of offering individual participation options.

### 3. Data and methodology

In the following we outline our empirical approach based on four different samples (three of which were exposed to a financial-participation model, plus one control group). These samples were surveyed to collect information about (1) how financial-participation models influence the social acceptance of a wind-energy project, and (2) how the preferences for the three different models vary.

Methodologically, we applied an experimental survey design to analyze the effect of a single and manipulable factor – namely, the availability of financial-participation models – on overall social acceptance in isolation of other influencing factors. In doing so, the results were not obscured by other processes, which is often the case when using different methodological approaches (Kirk, 1995; Webster & Sell, 2007). The experimental approach can therefore help to contribute to overcome methodological limitations from studies based on observational data (Yildiz & Sagebiel, 2019). The main goal of our experimental design was to establish a causal connection between the financial-participation model as independent variable and the level of acceptance of the wind-energy project as the dependent variable (Kirk, 2012).

#### 3.1. Experimental stimulus and treatment

The factor subject to manipulation in this experiment was a hypothetical, locally planned wind-energy project. In this scenario, participants were asked to imagine that a wind park was being planned within their community. The wind park which participants were confronted with was a predefined project whose attributes were based on representative Swiss wind-energy projects<sup>5</sup> and interviews with industry experts. The description of our experimentally tested Swiss wind park included information about the project developer, number of turbines, the location and height of the turbines, the ecological impacts, and procedural justice aspects (Appendix B); all relevant factors in

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<sup>5</sup> Specifications of currently installed Swiss wind energy projects (Windenergie-Daten Schweiz, 2018).

the planning and implementation of a wind park (Tabi & Wüstenhagen, 2015; Langer et al., 2017). In order to give participants a better idea about the wind park and to help them visualize it (Hevia-Koch & Ladenburg, 2019), an image was incorporated for illustration purposes (Appendix B).

The experimental manipulation of the hypothetical wind park was realized by adding one of three different financial-participation models. Consequently, three groups of participants received a financial-participation treatment, while participants in the fourth group (the control group), did not. The control group only had access to the basic information (as described above) about the hypothetical wind park within their community. The three financial-participation models used in this study were based on regulatory developments which have occurred in Germany and Denmark (see Chapter 2), experience from the case of Swiss hydro plants (Chapter 2), and previous examples from the Swiss wind sector. Given our second and third hypothesis, we included both individual and collective participation models, resulting in a total of three different financial-participation models: (1) wind share, (2) wind bond, and (3) wind resource tax. Participants who received a financial treatment were informed as follows:

- The **wind share** option gives participants the opportunity to become a co-owner of a local wind park by purchasing shares at 500 Swiss Francs (CHF) per share in exchange for a market-dependent yearly dividend ranging from 2 to 5% based on the wind park's performance. As a co-owner, the buyer benefits from full profit-sharing on the one hand, but must also bear the project risks (e.g., falling electricity market prices, or major damage to the wind park), which is reflected in lower return rates and in the worst-case scenario in a loss of the initial investment. Shareholders are invited to an annual general meeting and can thus take part in shaping the future of the wind-energy project.
- The **wind bond** option allows participants to purchase bonds at 500 CHF per unit in exchange for a fixed annual rate of return of 2%. Lenders incur lower project risks compared to the wind share model, and benefit from a fixed and guaranteed annual interest payment.
- The **wind resource tax** represents a collective financial-participation model: In addition to legally binding compensation payments (e.g. for land use), the wind-energy project owner pays a wind resource tax to the municipality in which the wind park is located. Income from the wind resource tax is paid into an earmarked community fund. Concretely, the project owner would pay tax to the

amount of 10,000 CHF per turbine per year into a community fund earmarked for leisure and/or environmental projects. This model is inspired by and therefore comparable to the local resource tax for hydropower plants that has been established in Switzerland (see Chapter 2).

The following table summarizes the three financial-participation models:

|                                       | Wind Share                                                                                              | Wind Bond                                                                                               | Wind Resource Tax                                                                                                |
|---------------------------------------|---------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|
| <b>Concept</b>                        | Allow individuals to voluntarily benefit financially from the wind park by means of personal investment | Allow individuals to voluntarily benefit financially from the wind park by means of personal investment | Share financial benefits equally among local residents; revenues earmarked for environmental or leisure projects |
| <b>Price</b>                          | 500 CHF per share                                                                                       | 500 CHF per bond                                                                                        | No cost: Nothing to buy or invest in                                                                             |
| <b>Duration</b>                       | Max. 20 years                                                                                           | Max. 20 years                                                                                           | Max. 20 years                                                                                                    |
| <b>Compensation/<br/>Remuneration</b> | 2-5% return on investment per year (“dividend”)                                                         | 2% fixed return on investment per year (“coupon”)                                                       | 10,000 CHF per wind turbine/year, to be paid into earmarked fund                                                 |
| <b>Cancellation</b>                   | Possible at any time                                                                                    | Possible at any time                                                                                    | After 20 years                                                                                                   |
| <b>Target Audience</b>                | Individuals, community members                                                                          | Individuals, community members                                                                          | Community as a whole                                                                                             |

**Table 1:** Overview of experimental treatments

### 3.2. Survey structure and variables

In the introduction to the experimental survey, study participants were informed that the questionnaire is a survey among end-users in the Swiss energy market, that the topic is wind energy, and that the data that is being collected would be solely used for research purposes. Additionally, each participant was provided with some general facts about wind energy in Switzerland (Appendix A). This was followed by the presentation of a hypothetical wind park (Appendix B). Directly after the presentation of the planned wind park, one of the three financial-participation models (see Section 3.1) was presented. The treatment was coded as a categorical variable (0 = control group, 1 = wind share, 2 = wind bond, 3 = wind resource tax). Thereafter, participants were asked

to indicate their level of acceptance of the locally planned wind-energy project (dependent variable). The remaining part of the online survey covered the measurement of independent and control variables. The survey had an average completion time of approximately 15 minutes.

The dependent variable, participants' level of acceptance of the wind park, was measured on a five-point Likert scale (1 = fully disagree, 5 = fully agree). Independent variables included the different financial-participation models, control variables included community identity based on van Vugt (2001) which was measured using three items and a five-point Likert scale, and risk aversion (Bao et al., 2003; Sharma, 2009; Hampl & Sposato, 2017), which was measured using six items and a five-point Likert scale. Both scales and their items are attached in Appendix C. Additional demographic variables comprised age, gender, gross household income,<sup>6</sup> and political orientation (indicated by party preference).

### **3.3. Data collection and sample configuration**

The experimental study was conducted online. Data were collected from 1,202 Swiss citizens by a professional Swiss market research institute between April 17 and May 16, 2018. A total of 1,330 participants started the survey, which means that 10.6% of all recruited participants did not finish the survey and were therefore excluded from the final analysis. The final sample of 1,202 participants was representative of the Swiss population in terms of gender, age, income, political party preference and geographical area, as ensured by the quotas used by the market research institute. The survey was available in German and French, as the French-speaking part of Switzerland was also part of our research interest. The Italian and Rhaeto-Romanic-speaking parts of Switzerland were excluded as they represent only 8.1% and 0.5% of the total population, respectively (BFS, 2016). Quotas were also used for each subgroup to ensure representativeness and comparability. Table 2 shows our sample configuration in more detail:

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<sup>6</sup> Monthly household income could be indicated using five different income classes, presented in Swiss Francs, or by a «no indication» field. The five measured monthly income classes were collated into the following three income segments: Low Income = below 4,880 CHF, Med Income = 4,880 - 9,702 CHF, High Income = more than 9,702 CHF.

|                                                         | Control Group<br>n=300 | Wind Share<br>n=302 | Wind Bond<br>n=300 | Wind<br>Resource Tax<br>n=300 | Total Sample<br>n=1202 | Swiss<br>Population <sup>a</sup> |
|---------------------------------------------------------|------------------------|---------------------|--------------------|-------------------------------|------------------------|----------------------------------|
| Age <sup>a</sup> 18-29                                  | 16.7%                  | 19.5%               | 15.3%              | 18.3%                         | 17.5%                  | 16%                              |
| Age 30-44                                               | 26.3%                  | 25.2%               | 26.7%              | 26.3%                         | 26.1%                  | 26%                              |
| Age 45-59                                               | 27.7%                  | 25.8%               | 27.3%              | 27.3%                         | 27.0%                  | 28%                              |
| Age 60+                                                 | 29.3%                  | 29.5%               | 30.7 %             | 28.0%                         | 29.4%                  | 30%                              |
| Women                                                   | 50.7%                  | 52.3%               | 50.7%              | 50.7%                         | 51.1%                  | 51%                              |
| Men                                                     | 49.3%                  | 47.7%               | 49.3%              | 49.3%                         | 48.9%                  | 49%                              |
| Political Attitude <sup>b</sup> :<br>Conservative       | 55.0%                  | 52.0%               | 63.0%              | 53.0%                         | 55.7%                  | 57.4%                            |
| Political Attitude <sup>b</sup> :<br>Center-progressive | 10.3%                  | 12.3%               | 9.7%               | 13.0%                         | 11.3%                  | 8.7%                             |
| Political Attitude <sup>b</sup> :<br>Left-wing          | 28.0%                  | 28.8%               | 23.0%              | 25.0%                         | 26.2%                  | 25.9%                            |
| Income <sup>c</sup> Low                                 | 12.3%                  | 12.6%               | 11.7%              | 12.3 %                        | 12.2%                  | 16.1%                            |
| Income <sup>c</sup> Mid                                 | 43.7%                  | 40.4%               | 48.0%              | 35.7%                         | 41.9%                  | 49.4%                            |
| Income <sup>c</sup> High                                | 26.7%                  | 30.1%               | 31.1%              | 34.3%                         | 30.6%                  | 34.5%                            |
| Region:<br>Central-West                                 | 21.5%                  | 22.5%               | 24.3%              | 21.3%                         | 22.3%                  | 22%                              |
| Region:<br>Central-East                                 | 29.3%                  | 31.1%               | 27.3%              | 26.7%                         | 28.6%                  | 29%                              |
| Region:<br>Alps                                         | 24.3%                  | 21.5%               | 24.0%              | 26.0%                         | 24.0%                  | 24%                              |
| Region:<br>French-speaking<br>Switzerland               | 25.3%                  | 24.8%               | 24.3%              | 26.0%                         | 25.1%                  | 25%                              |

<sup>a</sup> Non-adults (below 18 years) were excluded from the survey as this age segment typically does not invest in financial entities. Further, non-adults are usually not responsible for household budgeting decisions and electricity purchases. Additionally, non-adults are excluded from political decision-making processes. Consequently, they clearly do not belong to the target group of this research project.

<sup>b</sup> “Conservative” includes the following political parties; SVP, FDP, CVP. “Center-progressive”: BDP and GLP. “Left-Wing”: SP and GPS. 6.8% of the total sample had no or another political attitude.

<sup>c</sup> Income was indicated as monthly gross income per household. 15.3% of the total sample selected «no indication» in the survey. The five measured income classes were collated into the following three income segments: Low Income = below 4,880 CHF, Mid Income = 4,880 - 9,702 CHF, High Income = more than 9,702 CHF.

<sup>d</sup> Sources for the demographic data about the Swiss population: Age (BFS, 2017), Gender (BFS, 2017), Political Attitude (BFS, 2017), Income (BFS, 2014) and Region (BFS, 2017).

**Table 2:** Structure of the sample

## 4. Results and discussion

### 4.1. Results

#### *Overall effect of financial-participation models on acceptance level*

Figure 1 shows participants' average levels of acceptance for the planned wind park according to the respective financial treatment; control group ( $M = 3.65$ ,  $SE = 0.065$ ,  $N = 300$ ), wind share ( $M = 3.61$ ,  $SE = 0.066$ ,  $N = 302$ ), wind bond ( $M = 3.54$ ,  $SE = 0.067$ ,  $N = 300$ ) and wind resource tax ( $M = 3.72$ ,  $SE = 0.066$ ,  $N = 300$ ). According to the total sample ( $n = 1202$ ), our dependent variable *social acceptance* reached a mean of 3.63 ( $n = 1202$ ,  $mean = 3.63$ ,  $SE\ mean = 0.033$ ,  $SD = 1.142$ ,  $Min = 1$ ,  $Max = 5$ ). Based on a 1x4 ANOVA<sup>7</sup> ( $n = 1202$ ,  $F = 1.391$ ,  $df = 3$ ,  $p = 0.244$ ) using the treatment variable, the overall results indicate a preference for the wind resource tax, although the difference in the acceptance level between the control group and the wind resource tax is not significant ( $p > 0.411$ ,  $\eta_p^2 = 0.001$ ,  $mean\ difference = 0.07$ ). However, the ANOVA results show a significant difference for the financial treatments. Respondents' acceptance significantly increases ( $p > 0.045$ ,  $\eta_p^2 = 0.007$ ,  $mean\ difference = 0.18$ ) based on a small effect size<sup>8</sup> when a wind resource tax is proposed compared to participation based on wind bonds. To compare the control group to different financial-participation models a single factor ANOVA was conducted which compared the control group to an aggregation of all financial-treatment groups ( $N = 902$ ). Results show no significant ( $p > 0.757$ ) effect on acceptance.

<sup>7</sup> ANOVA: Analysis of variance (ANOVA) tests the hypothesis that the mean values of two or more populations are equal. ANOVAs evaluate the significance of one or more factors by comparing the mean values of the response variables at the different factor levels. The null hypothesis is that all mean values of the populations (the mean values of the factor levels) are equal, while the alternative hypothesis is that at least one mean value differs from the others (Cox & Reid, 2000; Kirk, 2012; Aker et al., 2013). A 1x4 ANOVA corresponds to one factor (treatment) with four levels (control group, wind share, wind bond and wind resource tax).

<sup>8</sup> According to Cohen (1988) and Ellis (2010), a partial eta squared ( $\eta_p^2$ ) of 0.01 refers to a small effect size, 0.06 to medium effect size, and 0.14 to large effect size.

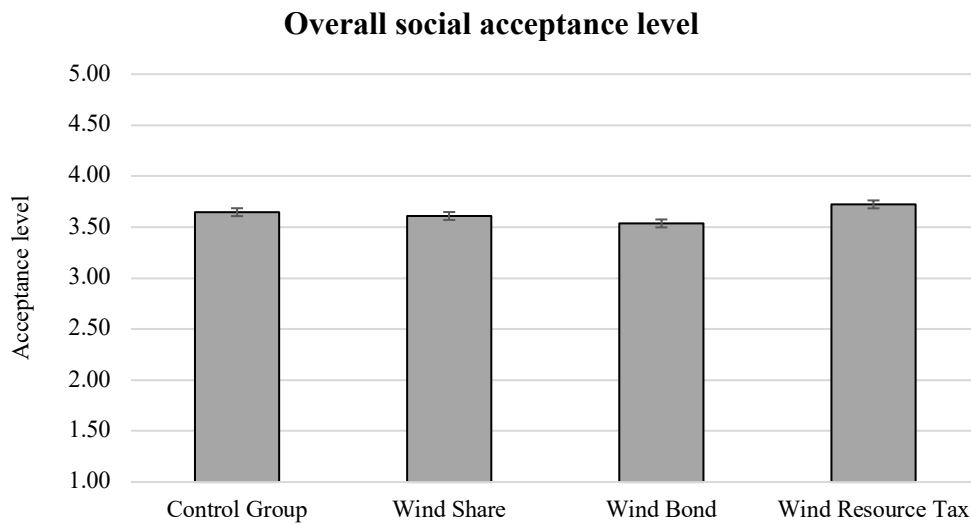


**Figure 1:** Overall level of social acceptance for the four different groups

### Community identity

To analyse the variable community identity (the related three-item scale reached a Cronbach Alpha of 0.775, which according to George and Mallery (2002) is acceptable for its use as a scale), we divided the sample into participants with high or low community identity based on a median split ( $MED = 3.667$ ) (Iacobucci et al. 2015a, 2015b; Chen & Sintov, 2016; Stefanelli et al., 2017). We applied a 2x4 ANOVA based on participants with high community identity (yes = 1, no = 0) and the treatment variable (control group vs. financial-participation models) as the between-subject factor for the acceptance level of the wind park. The 2x4 ANOVA ( $n = 1202$ ,  $F = 1.681$ ,  $df = 7$ ,  $p = 0.126$ ) revealed no main effect ( $p > 0.151$ ,  $\eta_p^2 = 0.002$ ) for high community identity and also no interaction effect ( $p > 0.175$ ,  $\eta_p^2 = 0.004$ ). This indicates that community identity has no significant effect on the acceptance in general, while the treatment effect on acceptance is also not dependent on community identity. However, a more in-depth analysis reveals some exceptions. Based on a pairwise comparison using the least significant difference adjustment we found that participants with high community identity ( $MED > 3.667$ ,  $N = 603$ ) experienced a significant increase in their acceptance level based on a small effect size when a wind resource tax was proposed compared to a wind share model ( $p > 0.050$ ,  $\eta_p^2 = 0.010$ , *mean difference* = 0.25) or a wind bond model ( $p > 0.010$ ,  $\eta_p^2 = 0.021$ , *mean difference* = 0.36). On the other hand, the level of acceptance of participants with low community identity ( $MED < 3.667$ ,  $N = 599$ ) did not significantly increase for any of the financial treatments.

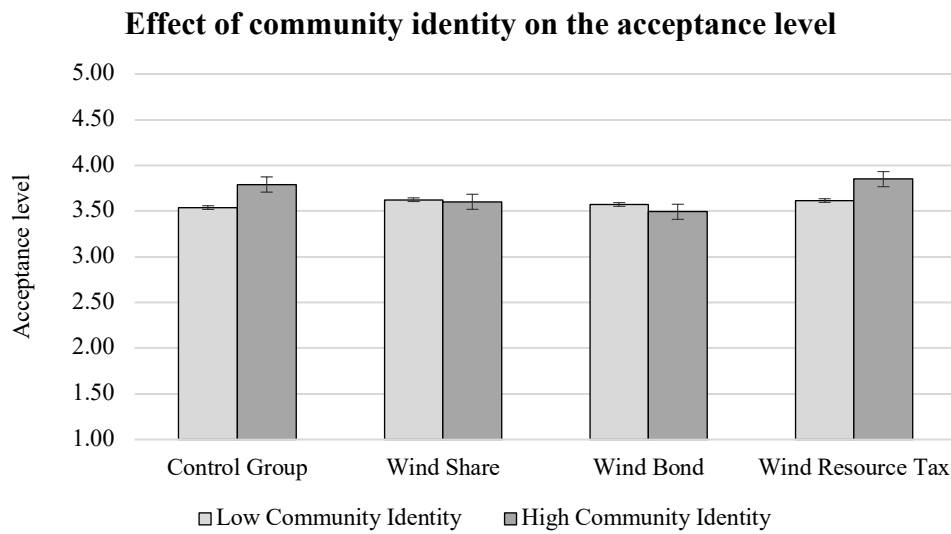


**Figure 2:** Acceptance levels for community members with high and low community identity

### Risk aversion

To analyse the effect of risk aversion (the related six-item scale reached a Cronbach Alpha of 0.765, which according to George and Mallery (2002) is acceptable for its use as a scale), the sample was divided into participants with high/low risk aversion based on a median split ( $MED = 2.667$ ). We applied a 2x4 ANOVA based on participants with high risk aversion (yes = 1, no = 0) and the treatment variable as the between-subject factor for the acceptance level of the wind park. The 2x4 ANOVA ( $n = 1202$ ,  $F = 1.874$ ,  $df = 7$ ,  $p = 0.070$ ) showed a weak and small main effect ( $p > 0.067$ ,  $\eta_p^2 = 0.003$ ) for high risk aversion but no interaction effect ( $p > 0.135$ ,  $\eta_p^2 = 0.005$ ). This indicates that risk aversion has a small and weak effect on overall acceptance, while the treatment effect on acceptance is not dependent on risk aversion. A more detailed analysis reveals some exceptions. Based on a pairwise comparison using the least significant difference adjustment, we found that the level of acceptance of participants with high risk aversion ( $MED > 2.667$ ,  $N = 621$ ) based on rather small effect sizes significantly increased when a wind resource tax was proposed compared to a wind share model ( $p > 0.018$ ,  $\eta_p^2 = 0.020$ , *mean difference* = 0.31), a wind bond model ( $p > 0.007$ ,  $\eta_p^2 = 0.023$ , *mean difference* = 0.35) or the control group ( $p > 0.080$ ,  $\eta_p^2 = 0.012$ , *mean difference* = 0.23). The acceptance level of participants with low risk aversion ( $MED < 2.667$ ,  $N = 581$ ) did not significantly change for any of the presented treatments.

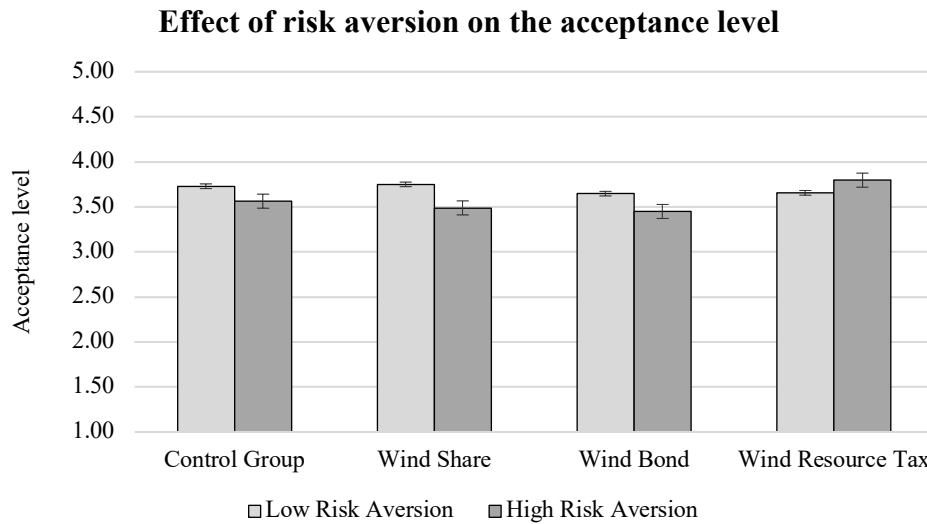


**Figure 3:** Acceptance levels for community members with high and low risk aversion

### Political attitude

Switzerland's political system is peculiar in that the federal government is composed of all major parties. However, the parties on the right side of the political spectrum (SVP and FDP) as well as the conservative center-right party (CVP) regularly oppose initiatives and parliamentary motions that favor the expansion of wind energy. To account for this, we defined three groups (left-wing, center-progressive, and conservative) and allocated the conservative center-right party (CVP) to the conservative group. Based on this consideration, political attitude was coded as a categorical variable (0 = conservative, 1 = center-progressive, 2 = left-wing).

To analyse the meaning of political attitudes in the context of social acceptance for wind energy and different financial-participation options we applied a 3x4 ANOVA ( $n = 1121^9$ ,  $F = 7.011$ ,  $df = 11$ ,  $p = 0.000$ ) based on participants' political attitude and the treatment variable as the between-subject factor for the acceptance level of the wind park. The 3x4 ANOVA showed a medium-size, significant main effect ( $p > 0.000$ ,  $\eta_p^2 = 0.057$ ) for political attitude but no interaction effect ( $p > 0.587$ ,  $\eta_p^2 = 0.004$ ) with the treatment. This indicates that political attitude has a significant, medium-size effect on acceptance in general, while the treatment effect on acceptance is not dependent on political attitudes. A more in-depth analysis reveals one exception. Based on a pairwise

<sup>9</sup> Eighty-one participants with no or other political attitude could not be classified according to our three political attitude categories and were therefore excluded from our 3x4 ANOVA.

comparison using the least significant difference adjustment we found that participants with a center-progressive political attitude ( $N = 136$ ) experienced a significant increase in their acceptance level when a wind resource tax was proposed compared to the control group setting ( $p > 0.030$ ,  $\eta_p^2 = 0.063$ , *mean difference* = 0.58). On the other hand, participants with a conservative political attitude ( $N = 670$ ) experienced no significant differences in their acceptance levels across all groups, a finding which also holds true for the left-wing group ( $N = 315$ ). The results also show medium effect sizes and significant differences between the conservative group and the left-wing group regarding wind park acceptance on the overall level (control group:  $p > 0.001$  and  $\eta_p^2 = 0.048$ , *mean difference* = 0.52) and within all financial treatment options (at least  $p > 0.001$  and  $\eta_p^2 > 0.050$  for every experimental group).

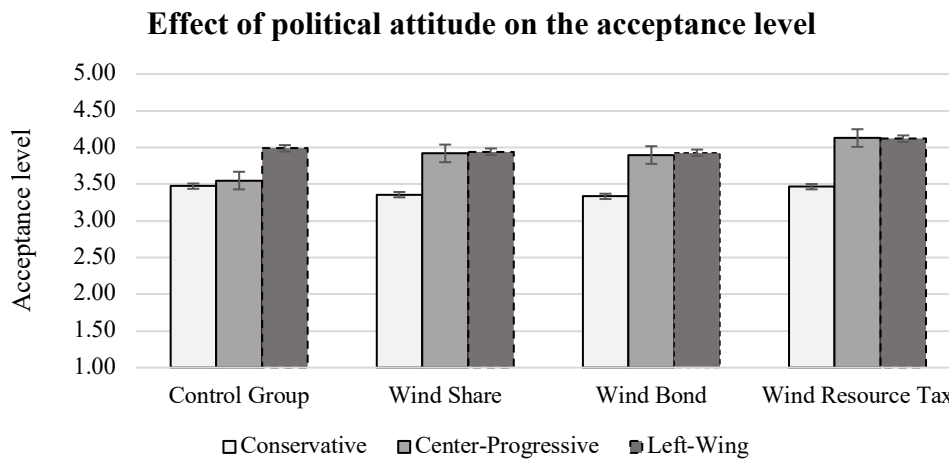


**Figure 4:** Acceptance levels for different political attitudes

## 4.2. Discussion

*Hypothesis 1*, “A wind park with a financial-participation model is more likely to be accepted than a wind park without a financial-participation model,” is rejected.

The overall result shows that participants who were exposed to the financial-participation model “wind resource tax” supported the planned wind park most strongly. This lends support to other findings such as those described in Hyland and Bertsch (2018) who also found that promoting distributive and collective justice by means of participation models without personal investment tends to be the most accepted. However, as mentioned in Section 4.1, the increase in acceptance of the wind resource tax group compared to the control group is not significant. We can therefore only state

that there is some<sup>10</sup> but not significant experimental support for the assumption that the inclusion of financial-participation models in the process of constructing a wind park can lead to an increase in social acceptance by the local population. As already mentioned, previous research has found evidence that financial participation and community ownership can positively influence the social acceptance of a wind park (Toke, 2005; Aitken, 2010; Warren & McFayden, 2010; Corscadden et al., 2012; Hübner et al., 2013). However, our results do not support this claim since acceptance levels varied by no more than 0.1 points on a scale from 1 to 5. In general, the introduction of a financial-participation model alone will not lead to people changing their opinion about whether to accept a wind-energy project. Previous studies which show that the financial-participation attribute is not the most influential factor concerning the social acceptance of a project confirm this result. The ecological impact of a wind park, its location, and residential proximity to turbines as well as the choice of the project developer have a greater influence on the acceptance level than the financial-participation attribute (Tabi & Wüstenhagen, 2015; Langer et al., 2017). The hypothetical wind park in our experimental study was designed to meet high standards regarding the aforementioned criteria in that it was defined as having low environmental impact and a project management under local control. Further, the planned turbines in the hypothetical project were located on agricultural land and partly in industrial and commercial zones – less critical areas than in the vicinity of residential areas or in protected landscapes (nature reserves). Finally, extended procedural participation was emphasized in the hypothetical wind park description, resulting in a high overall level of acceptance for the planned wind park (3.65 for the control group, 3.73 for the wind resource tax option). Our study shows that in this setting financial participation alone does not significantly impact the acceptance level of the overall sample. However, the availability of financial-participation models can positively influence important target groups, as discussed subsequently.

*Hypothesis 2*, “Community investment (via shares or bonds) leads to greater social acceptance of wind-energy projects,” is rejected.

Results from the overall sample suggest that there is no significant experimental

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<sup>10</sup> This hypothesis can be accepted for the subgroup center-progressive voters and risk averse people. For these individuals, the financial-participation model “wind resource tax” has a significantly positive effect on overall social acceptance compared to the control group. For center-progressive voters this effect is of medium size, while for risk-averse people the effect size is small.

evidence that share-based or bond-based participation models increase the social acceptance of wind-energy projects compared to the control group setting without financial participation. Within the subgroup of community-attached people, the financial-participation option “wind bond” leads to slightly but statistically significant less acceptance of the wind park. For the subgroup of politically center-progressive oriented people, the community investment options “wind share” and “wind bond” increase acceptance, although not to a significant level. In general, it is observed that of all financial-participation models the wind bond model tended to have the least impact on the acceptance of the wind-energy project. However, the differences were usually not significant. In addition, the order of preference of the wind share model and the wind bond model was also determined by the conditions of the respective models (e.g., the average yield on investments for the wind share was 5%, and on investments with the wind bond model 2%). Equity investments and bond investments also appeal to investors with different risk profiles, thus it would not be advisable to exclude community investment options from the outset, even if we do not find any significant positive effect for community investment models on the social acceptance of wind-energy projects.

*Hypothesis 3*, “The overall level of social acceptance of a wind-energy project will be greater if a financial-participation model is in place which distributes financial benefits equally among all residents, instead of offering individual participation options,” cannot be rejected.

The results of our experimental study indicate differences between the three financial-participation models in the overall sample and for different key stakeholder groups. Regarding the overall sample, the wind resource tax is significantly preferred compared to the wind bond option and is also preferred to the wind share option, although not significantly. In addition to the collective orientation and the correspondingly more equally distributed benefits among residents, the financial-participation model “wind resource tax” also included the earmarking of revenues for environmental protection measures and/or leisure activities. As suggested by the literature discussed in Chapter 2, the earmarking of revenues and the collectivistic nature of the wind resource tax can positively influence the perception of distributional justice of the local community. Therefore, it is likely that the former two characteristics are the main reasons for the higher level of acceptance of the wind resource tax compared to

that of the two financial-participation models focused on individual investment opportunities. Three important sub-groups, identified through the control variables, also show a significant preference for the wind resource tax. Participants with a strong community identity significantly preferred the wind resource tax over the wind share and the wind bond option. This is an important finding, as community-attached people tend to actively engage with their communities and subsequently also support related projects; a claim supported by the findings described in Sposato and Hampl (2018). The introduction of a financial-participation scheme could risk crowding out those citizens' intrinsic support for projects (Deci et al., 2015; Schwartz et al., 2015). Interestingly, the acceptance level of community-attached people decreases significantly (based on a small effect size) when the individual financial-participation model wind bond is offered. This indicates that it is key for project developers to identify local preferences for financial-participation models before implementing them. Apart from community-attached individuals, the subgroup of risk-averse people is another important target group with regard to acceptance, as risk-averse people tend to be rather reluctant to support changes within their community (Bao et al., 2003; Sharma, 2009). Our results show that risk-averse people are significantly more likely to accept a wind park when a wind resource tax exists. This result is significant compared to the control group, as well as to the other two models "wind share" and "wind bond" (based on small effect sizes). Research also shows that risk-averse people are rather inequality averse (Ferrer-i-Carbonell & Ramos, 2010). These insights may explain why our results indicate that risk-averse individuals tend to prefer the wind resource tax, which is the financial participation model that distributes benefits most equitably among residents.

The implementation of renewable energies in general and wind energy in particular always has a political component. Therefore, it is not unexpected that we also find differences between the different political movements (conservative, center-progressive, left-wing) in our results. Not surprisingly, we find significant differences in acceptance levels between left-wing (high acceptance) and conservative respondents (lower, although still positive acceptance). The most striking finding, however, concerns the movement in the acceptance level of center-progressive voters. In the situation in which financial-participation models are absent (i.e. the control group setting), center-progressive voters have identical acceptance levels to conservative voters. With the introduction of financial-participation models, their acceptance level increases. The increase in acceptance of center-progressive voters peaks with the introduction of a wind

resource tax and is, compared to the control group, significant with a medium effect size. These results show that center-progressive voters are another important target group whose acceptance can be significantly increased through the introduction of a wind resource tax. As can be seen in Figure 4, the introduction of a wind resource tax can increase the acceptance level of center-progressive voters to the level of the left-wing group. This finding highlights the potential for mobilizing supporters of a wind park. During the planning and implementation phase, infrastructure projects typically face a divided community characterized by a small group of strong opponents, a small group of strong proponents, and a large silent majority (Gross, 2007). The introduction of a wind resource tax could have a positive impact on center-progressive voters' attitudes concerning the wind-energy project, potentially increasing the number of strong proponents.

## 5. Conclusions and policy implications

This paper contributes to the research stream of social acceptance of wind-energy projects, specifically in the field of distributional justice, and adds value by experimentally exploring the impact of financial-participation models on the overall social acceptance of a wind park. The research described in our paper was designed to answer two research questions: *(1) Does the introduction of financial-participation models affect the overall social acceptance of wind-energy projects, and (2) Are there substantial differences between the effects of three financial-participation models?* As information about the impact of specific financial-participation models on wind-energy projects is rare, our findings create an important foundation on which policy makers may build to facilitate the social acceptance of wind-energy projects, as well as help project developers to make appropriate decisions when faced with the question of how to tailor a specific financial-participation model.

### 5.1. General conclusion

Our research has illustrated that introducing a financial-participation model for wind-energy projects can increase social acceptance, but that the relationship between financial participation and social acceptance is not clear. We find some experimental evidence (based on small effect sizes and a medium-size effect for political attitudes)

that the introduction of a wind resource tax can increase the overall social acceptance of a wind-energy project. Regarding the discrepancies between the different financial-participation models, our research shows that a wind resource tax is significantly preferred over a wind bond in the overall sample and significantly preferred over the wind share as well as the wind bond model by important sub-groups such as people with strong community identity, strong risk aversion, or a center-progressive political orientation. These findings lend support to those of Hyland and Bertsch (2018), who found that promoting distributive and collective justice without personal investment tends to be the most effective means of facilitating acceptance of a local wind park.

## **5.2. Political and practical implications**

Our research has illustrated that understanding citizens' preferences for different models of financial participation can be an important factor in successfully expanding wind-energy projects, and subsequently also for meeting renewable energy policy targets. Important policy implications can be derived from our paper. Authorities at the national level would be well advised to draft guidelines that inform wind-energy project stakeholders about the different financial-participation models that are available, including a description of the risks and benefits. Such guidelines would represent a helpful instrument to which stakeholders could refer in the early stages of wind park development. Empirically as well as from a research perspective, the design of a wind resource tax has received limited attention. As our results suggest, including this model in the portfolio of proposed financial-participation models is likely to be of value in terms of the social acceptance of wind-energy projects. Particularly in the Swiss case, the conditions for social acceptance of wind-energy projects may only improve through the introduction of a wind resource tax, while a wind bond option may not achieve the intended effect.

At a local level, it is important that authorities and project developers approach relevant stakeholders (i.e. those with a center-progressive political mindset, as the latter are identifiable and, as our results show, subject to a medium-size effect) in order to make them aware of the wind resource tax option early on in the planning process. This is particularly important, as opposition to wind-energy projects tends to form at early stages of projects (Aitken, 2010).

### **5.3. Limitations and further research**

There are some limitations to our research that can be a starting point for further research on this topic. The first of these concerns the preferences of the local population. Citizen preferences are always context dependent, so our results do not necessarily represent local preferences in other countries. It would thus be interesting to examine the preferences of German and Danish citizens to see if they would also prefer a wind resource tax to other legally prescribed forms of participation. Additionally, it would be interesting to replicate our study in countries with a context similar to Switzerland's, such as exists in other northern European countries like the Netherlands and Belgium. Also, our results are limited to the attributes used for our different financial treatments. Changing the levels of some attributes such as interest rate or contract duration could affect the results. It would be interesting to replicate our experiment with varying attribute levels in order to investigate to what extent different framework conditions impact the influence of financial-participation models on the social acceptance of wind-energy projects. Another limitation concerns the financial-participation options included in our study. The participants in our survey were not presented with a combination of two financial-participation models. They were confronted with only one financial-participation model, or none in the case of the control group. To what extent a combination of community investment options (such as investment in wind shares or wind bonds combined with a local wind resource tax) could contribute to the social acceptance of a wind park is an interesting question for further research. Finally, attempting to replicate our research in relation to other renewable energy projects with different technologies (e.g. hydropower or solar) could result in interesting findings (with hydropower projects the project lifetime would increase to 80 years, while smaller investments are feasible with solar projects).

### **Acknowledgments**

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## Appendix

### Appendix A – Survey introduction text

#### *Introductory Text:*

The Institute for Economy and the Environment at the University of St.Gallen deals, among other things, with issues related to wind energy. To this end, we conduct studies directly with end consumers. It is not necessary for you to have any previous knowledge about wind energy to participate in this study.

It is important to note that this study is for research purposes only. Please answer all questions truthfully. The questionnaire is absolutely anonymous. No conclusions can be drawn about participants on the basis of the data collected herein. The data will not be passed on to third parties at any time.

Please read carefully the following text about wind energy in general and the wind project in particular. You will then be asked a few questions:

In Switzerland, 37 large wind turbines currently produce electricity for around 35,000 households. One of the goals of the Energy Strategy 2050 is to increase the share of renewable energies such as wind energy. Wind energy can still develop strongly in Switzerland: By 2020, wind turbines are expected to produce around 600 GWh of electricity per year (compared to the 132 GWh today).

### Appendix B – Hypothetical wind park for Switzerland

#### *Text:*

Imagine that the following wind park with three turbines is planned within your municipality: The three wind turbines will produce about 18 gigawatt hours of electricity – this is the annual electricity demand of about 3,500 households. On the regional side, the local utility is involved as a partner in project implementation – various information events have already taken place and attempts are being made to ensure the flow of information through regular media releases. The environmental impact assessment of the wind farm and the wind measurements were carried out successfully. The construction of a wind farm within your municipality therefore makes ecological and economic sense. The wind turbines have a mast height of 140 metres and a maximum

overall height of 200 metres. The planned turbines will be located on agricultural land and partly in industrial and commercial zones.

*Attributes:*

- Local project developer
- Quantity of electricity produced – equals the amount of electricity consumed annually by 3,500 households
- Number (3) and height (200m) of turbines
- Location of the turbines – partly on agricultural land and partly in an industrial zone
- Ecological effects – environmental impact assessment of the wind farm was successfully carried out
- Procedural aspects – information events, media releases take place on a regular basis

*Illustration:*



Illustration of hypothetical Swiss wind park (SRF, 2017)

## Appendix C – Survey scales and items

| Scale                                  | Item<br>number | Item                                                                  |
|----------------------------------------|----------------|-----------------------------------------------------------------------|
| Community Identity<br>(Van Vugt, 2001) | 1              | I feel strongly attached to the community I live in                   |
|                                        | 2              | There are many people in my community whom I think of as good friends |
|                                        | 3              | I often talk about my community as being a great place to live        |
| Risk Aversion<br>(Sharma, 2009)        | 1              | I tend to avoid talking to strangers                                  |
|                                        | 2              | I prefer a routine way of life to an unpredictable one full of change |
|                                        | 3              | I would not describe myself as a risk-taker                           |
|                                        | 4              | I do not like taking too many chances to avoid making a mistake       |
|                                        | 5              | I am very cautious about how I spend my money                         |
|                                        | 6              | I am seldom the first person to try anything new                      |

Appendix C: Scale and item table

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## Paper II

### Keep it Local and Low-Key<sup>1</sup>

#### Social Acceptance of Alpine Solar Projects

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#### Abstract

Impressive growth rates of solar photovoltaics (PV) in higher latitudes are raising concerns about seasonal mismatches between demand and supply. Locating utility-scale PV projects in alpine regions with high solar irradiation could help to meet demand during the winter season. However, similar to wind farms, large solar projects change the landscape and may therefore face social acceptance issues. In contrast to the rich literature on wind energy, social acceptance of solar power has received less attention. This paper helps close this gap with the help of a large-scale survey (N=1036) that examines the acceptance of alpine solar projects in Switzerland through choice experiments. In addition to attributes that are well established in the social acceptance literature, such as local ownership, along with both distributional and procedural justice, we also investigate the influence of innovative design elements on acceptance. Our findings suggest that local ownership, as well as colored solar panels that reduce the perceived landscape change may increase social acceptance, implying that projects should be kept local and low-key. We also find that acceptance of alpine solar projects is higher among the affected population than among inhabitants of non-alpine regions.

#### Keywords:

Photovoltaics, Alpine regions, Choice experiment, Social acceptance, Design.

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## 1. Introduction

Among the renewable energy technologies, solar energy has one of the highest growth rates, and could therefore contribute substantially to reducing dependence on fossil fuels (Carlisle et al., 2014). Initiatives designed to increase the proportion of renewable energies in the national energy mix have been introduced in many countries (REN 21, 2018). One concern with electricity systems relying on a high share of renewables is their ability to match demand and supply at any given time. In densely populated areas of higher latitudes, such as Central Europe, the Northern US or Canada, a particular concern is the seasonality of solar power generation, which peaks in the summer, whereas electricity demand tends to be high in the winter. One way of alleviating this mismatch is to build up a diversified portfolio of wind and solar power (Speth, 2013; Lima et al., 2017; Shahriari & Blumsack, 2018; Sinsel et al., 2019), as there tends to be more wind during the winter half-year (Sinden, 2007). However, despite being widely supported at the national level (AEE, 2019; Vuichard et al., 2019), the growth of wind power has recently been slowing down in various countries due to local acceptance issues (Horbaty et al., 2012; Sagebiel et al., 2014; Walker and Baxter, 2017). Apart from diversification across technologies, geographical diversification is another possibility to address seasonality. For solar power in particular, locating utility-scale projects in alpine areas could allow for an increased share of electricity generation during the winter half-year. Alpine regions benefit from up to 50% higher levels of irradiation, less fog, lower temperatures and greater snow reflection (Michel et al., 2015; Díaz and Van Vliet, 2018; ZHAW 2019) than lowland areas, making them a promising location for solar PV projects. At the same time, utility scale projects can have an impact on the landscape, which may raise social acceptance issues. As landscape is perceived to be one of the most important elements of leisure and tourism attractions, sensitivity is usually high regarding alterations to the former in alpine regions (Aitchison et al., 2000). While a variety of attributes that modify the social acceptance of wind energy projects have been investigated recently (Rand and Hoen, 2017; Jami and Walsh, 2017; Firestone et al., 2018; Dwyer and Bidwell, 2019), social acceptance of utility-scale solar photovoltaics has received less attention (Michel et al., 2015; Brewer et al., 2015; Carlisle et al., 2015).

Accordingly, the goal of the present research was to highlight the attributes as well as their levels that determine the social acceptance of solar projects in alpine regions. To this end, we implemented a choice experiment capable of testing the combined influence of a number of attributes: environmental impact, distributional and procedural justice, local ownership, and design. This resulted in the following two main research questions:

- 1) What are the attributes that determine the social acceptance of utility-scale solar PV projects in alpine regions?*
- 2) Which attribute levels can increase the local acceptance of a solar PV project?*

The following sections of this research paper are structured thus: The next section provides a review and discussion of literature associated with the social acceptance of renewable energies, focusing on solar PV. Our hypotheses are drawn up on this basis. The design of the research and the types of choice attributes and levels are described in Section 3, along with a presentation of the analytical sample. Section 4 elucidates the outcomes of the choice experiment in relation to the hypotheses. Section 5 concludes with policy implications and recommendations targeted at project developers. This section includes a discussion of the limitations of the paper and contains suggestions for further research.

## **2. Literature review**

### **2.1. Social acceptance of renewable energy**

An increasing amount of research is being dedicated to the topic of social acceptance of renewable energy (Wüstenhagen, Wolsink & Bürer, 2007; Batel, Devine-Wright & Tangeland, 2013). Several studies have found very high overall acceptance for different renewable energies (Cousse & Wüstenhagen, 2018; AEE, 2019). A notably high level of support for ambitious national renewable energy targets has also been identified (Eurobarometer, 2014). Moreover, among the variety of renewable energy technologies, solar PV may be distinguished by its more positive public perception and acceptance (Cousse & Wüstenhagen, 2018). Solar PV is also widely associated with positive

features such as environmental protection and job creation (Kaenzig et al. 2013). Cousse & Wüstenhagen (2019) found that high social acceptance levels for solar PV uphold when moving from support for the technology at an international (88%) to a national level (85%) in Switzerland, whereas the same measure drops from 70% to 57% for wind energy. In the same survey, 66% of respondents said they would be proud to see solar PV projects being installed in their vicinity, more than twice as many as for wind energy (28%). In line with earlier work that claims that solar PV is unique among renewable energy technologies in relation to the level of social acceptance, we formulate the following hypothesis:

*Hypothesis 1:* Solar PV projects in alpine regions are associated with a high overall level of acceptance.

## **2.2. From socio-political to local acceptance of renewable energies**

High overall levels of socio-political acceptance are necessary but inadequate for the successful deployment of energy technologies. A crucial question is to what extent this translates to high levels of local acceptance (Wüstenhagen, Wolsink & Bürer 2007; Sütterlin & Siegrist, 2017). In the case of wind energy, several studies have found high levels of socio-political acceptance (Ellis & Ferraro, 2016; Langer et al., 2016), although landscape-related concerns are just one of the issues that affect the public acceptance of wind energy projects at the local level (Horbaty et al., 2012). These issues of resistance may directly translate into major project delays or even abandoned projects (Enevoldsen, 2016; Enevoldsen & Sovacool, 2016). Aitchison et al. (2010) identify a high level of sensitivity regarding landscape changes for alpine regions, given their reliance on tourism. To implement renewable energy projects in such sensitive regions, project developers and local governments must establish a clear understanding of the possible negative effects of such projects and identify appropriate mitigation measures.

One of the elements that has been shown to moderate the effects of landscape changes on social acceptance, is the level of procedural and distributional justice (Wenz, 1988; Hübner et al., 2013; Enevoldsen & Sovacool, 2016; Firestone et al., 2018), i.e. fair decision processes and a fair distribution of the project's costs and benefits. The literature shows that a high degree of distributional as well as procedural justice can have a positive influence on the social acceptance of a renewable energy project, for example, in relation to the effect of the level of procedural justice in relation to wind

energy projects. Jami and Walsh (2017), Firestone et al. (2018) and Dwyer and Bidwell (2019) conclude that greater involvement of the public (e.g. more consultation) is required at the stage of project development, while concerning the social acceptance of projects, Warren and McFadyen (2010) show that community ownership can reduce dispreferences and simultaneously strengthen favourable attitudes towards wind power. Following previous work that suggests that a high degree of procedural and distributional justice are important for mitigating the negative effects of renewable energy technologies, we test the following hypotheses:

*Hypothesis 2a:* Distributional justice increases social acceptance of solar PV projects in alpine regions.

*Hypothesis 2b:* Procedural justice increases social acceptance of solar PV projects in alpine regions.

### **2.3. The influence of design on social acceptance**

Of the negative effects of renewable energy technologies, one of the most often cited is visual impact (Ellis & Ferraro, 2016). In the context of wind energy, various studies have identified a moderating influence of factors such as design, size, and color on social acceptance (Tsoutsos et al., 2009; Dimitropoulos and Kontoleon, 2009; Maffei et al., 2013), although the results of other studies have been inconclusive in this regard (Meyerhoff et al., 2010; Ek, 2006; Wolsink, 2007). Sánchez-Pantoja et al. (2018) review the literature on aesthetic impacts of solar energy systems and point to factors like color, glare and texture. For residential PV systems in particular, Hille et al. (2018) find that adjusting the color to the surroundings can increase acceptance. More specifically, they found that Swiss homeowners would prefer panels that are red (which is the prevalent color of roof tiles in Switzerland) over conventional blue panels. Similarly, Jolissaint et al. (2017) discuss the advantages of colored panels for smooth integration of solar PV into the built environment, and Bao et al. (2019) identify a preference among affluent homeowners for low-visibility solar systems.

A second, more novel way of addressing the landscape effects of PV projects is to use solar art. Solar art is gaining popularity as a new means of providing design elements for solar PV projects (CSEM, 2017). Innovative artistic designs include utility-scale solar projects in China in the shape of a giant panda (Nace, 2017), or the concept of a

solar tree (Hyder et al. 2018). One emerging stream of research that spans architecture and urban planning suggests that context sensitivity may increase the aesthetic quality of PV installations, and that designing solar landscapes is more than just an engineering task (Sánchez-Pantoja et al. 2018; Lobaccaro et al. 2019). Introducing solar art could address visual concerns and increase the overall acceptance of solar PV projects in alpine regions. We therefore state the following hypotheses:

*Hypothesis 3a:* Adjusting the color of solar panels to the surroundings increases social acceptance of PV projects in alpine regions.

*Hypothesis 3b:* Artistic design elements increase social acceptance of PV projects in alpine regions.

### **3. Methodology and data**

#### **3.1. Methodology**

A choice experiment was undertaken with Swiss residents in order to respond to our research questions. An alpine country with an ambitious national energy strategy, Switzerland has one of the most rapidly growing markets in Europe for solar energy, but past growth has mainly focused on rooftop PV on residential and commercial buildings. Given the slow pace of wind energy deployment, the country is in need of new solutions for seasonal diversification of its renewable energy supply. In combination with a direct democratic setting, this makes it an ideal candidate to study social acceptance of solar PV projects in alpine regions. Because of its federalist political system, large Swiss renewable energy projects are subject to social acceptance issues on national, regional (cantonal) and local levels. We therefore drew on a nationwide sample (N=1036), while controlling for respondents' place of residence in order to investigate any differences between inhabitants of alpine regions and respondents residing elsewhere.

Choice experiments (CE), which have become more popular in energy and environmental economics research in the last few years (e.g. Sammer & Wüstenhagen, 2006; Kaufmann et al., 2013; Gampfer et al., 2014; Klinglmair et al., 2015), originate from market research and are a well-established method of assessing the preferences of consumers. They are often used in the process of developing new products when real

purchasing behavior cannot be observed (Ewing & Sarigöllü, 2000). The use of CE compared to traditional valuation methods is associated with several advantages: respondents are presented with realistic choice situations, while the indirect nature of preference surveying reduces the bias created by asking survey respondents to state their preferences directly (Zacharakis & Meyer, 1998). The latter factor is especially important within the context of the energy and environmental field due to the analytical challenge of handling direct survey responses that are affected by social desirability bias. The most widely used type of CE, choice-based conjoint analysis (CBC), was chosen (Sawtooth, 2013) for use in the present study.

### **3.2. Survey design and variables**

The survey design included four parts: (1) general introduction and project description, (2) general social acceptance measurement, (3) choice experiment, and (4) control and socio-demographic variables. In the first part, participants were introduced to the topic and given information about solar PV in alpine regions, including information about the size of the hypothetical project, the annual electricity production, and the potential location of the project, as well as information about the efficiency of solar PV projects in alpine regions (Appendix A). A diagram was included to help inform and illustrate to respondents the details of the project (Hevia-Koch & Ladenburg, 2019) (Appendix B).

In a second section, respondents were asked to state their overall level of acceptance of the (hypothetical) solar PV project located in the Swiss alpine region. The description and visualization of the hypothetical alpine solar project used in the survey is attached in Appendix B. To measure the level of acceptance, participants had to indicate to what extent they agree with the following statement: "I would accept solar installations in alpine regions (as described above)", with the term "as described above" referring to the description of the hypothetical alpine solar project. Responses were indicated and measured using a 5-Point Likert scale. Similar approaches to measure general acceptance were also used in other research papers such as Tabi and Wüstenhagen (2017) or Vuichard et al. (2019).

In the third part, a choice experiment was set up to identify respondents' preferences for a variety of scenarios with different attributes and levels (see Table 1), which were based on a literature review and a previously conducted pre-test with industry experts. Subsequently, each participant responded to eight choice tasks, in each of which they

had to choose from four scenario options – three versions of the hypothetical alpine solar PV project, and a none option (which could be selected if none of the proposed projects was acceptable to the participant). The choice task was formulated as follows: *“Imagine you could choose between three solar PV projects in alpine regions of Switzerland (ground-mounted projects that would produce 1.5 gigawatt hours per year in the vicinity of existing infrastructure – as outlined before). Please select your preferred project (by clicking). The projects are different in the following ways:..”* The different attributes and levels used in the choice experiment were as follows:

- The first attribute, *“design”*, refers to the different design options of the solar PV project. Levels ranged between conventional blue solar panels to green solar panels<sup>4</sup> which blend better into the landscape, to art elements: a solar PV system designed in the shape and color of a capricorn<sup>5</sup> or the Swiss flag.<sup>6</sup> By using Sawtooth’s mouseover feature, participants could see illustrative pictures of each of the design options (Appendix C).
- The second attribute, *“ownership”*, refers to the project developer. Its four levels ranged from a foreign energy company to a local utility (with or without citizen investors), to a farmers’ cooperation. We used this attribute to test for the effect of local (co-) ownership on acceptance.
- The third attribute, *“ecological impact”*, described the solar PV project’s potential damage to local fauna and flora (NABU, 2010). The main adverse ecological impacts of solar PV projects in alpine regions are damage to grass roots when installing the panels, as well as the construction of access roads to the project site. On the other hand, there may also be positive ecological impacts of ground-mounted solar projects such as erosion prevention, improved soil fertility, habitat for species, and an increase in water-use efficiency (Hernandez et al., 2019). Since the survey was intended to be understood by lay respondents, the complexity of the former effects was reduced by including simplified

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<sup>4</sup> There are different technological options to change the color of solar PV panels. One recently commercialized approach is to apply colored nanotechnology films to absorb particular wavelengths of sunlight (see for example solaxess.ch). This technology leads to only minor reductions in conversion efficiency (approx. 10%).

<sup>5</sup> China has already built several solar power projects in the shape of giant pandas – other countries have also planned to build solar power projects in the shape of animals (Nace, 2017). We chose the capricorn as it is part of the flag of the canton of Graubünden, one of the largest alpine cantons in Switzerland.

<sup>6</sup> Large (textile) Swiss flags on alpine slopes are a common sight in Switzerland and are widely accepted (SRF, 2013).

references to them, associated with levels that varied between net positive, almost none, small and medium ecological impact.

- The fourth attribute, “*distributional justice*”, described different options of distributing the project’s economic benefits. Regarding local taxation, unlike the water resource tax associated with hydropower (Tabi & Wüstenhagen, 2017), Swiss legislation does not require utility-scale solar PV project operators to financially (or otherwise) compensate local community stakeholders (residents, etc.). However, the operator may introduce a voluntary community benefit scheme (“solar resource tax”). This factor was thus included in the choice experiment as one level (defined as 1 ct./kWh payable to the municipality, equivalent to 15,000 CHF per year assuming 1500 full load hours and 1 MW of installed capacity). Additional levels included the opportunity for individuals to financially participate in the solar PV project and benefit from dividend payments, compensation for individual landowners, or hardly any local financial benefits.
- The fifth and final attribute, “*procedural justice*<sup>7</sup>”, investigated preferences for public involvement in the project’s planning phase. The degree of involvement ranged from only legally required participation, to public information events, to citizens co-determining the design, and potentially also the size and location of the project.

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<sup>7</sup> This attribute is similarly operationalized as in Tabi & Wüstenhagen (2017), who examined the influence of procedural justice on social acceptance of hydropower projects.

| <i>Attributes</i>                     | <i>Explanation</i>                                                                              | <i>Levels</i>                                                                                                                                                                                                                                                                         |
|---------------------------------------|-------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Design of the solar PV project</b> | Design of the solar PV project with conventional design, color variations, or artistic elements | (1) conventional solar panels<br>(2) green solar panels<br>(3) artistic element: animal design (Capricorn)<br>(4) artistic element: Swiss flag design                                                                                                                                 |
| <b>Ownership</b>                      | Developer responsible for building and/or operating solar PV project                            | (1) international utility<br>(2) local utility<br>(3) combination of local utility and inhabitants<br>(4) farmers cooperation                                                                                                                                                         |
| <b>Ecological impact</b>              | Impacts on the surrounding ecosystem (flora and fauna)                                          | (1) medium<br>(2) small<br>(3) almost none<br>(4) net positive                                                                                                                                                                                                                        |
| <b>Distributional justice</b>         | Extent to which solar PV project benefits are shared                                            | (1) hardly any local financial benefits<br>(2) compensation for private landowner (5000 CHF / per year)<br>(3) individual participation in the project through financial investment and dividend payments<br>(4) compensation to municipality via a solar tax (15,000 CHF / per year) |
| <b>Procedural justice</b>             | Public involvement in solar PV project at stages of decision and planning                       | (1) legally required participation<br>(2) public information events<br>(3) co-determining the design of the solar PV project<br>(4) co-determining the design, size, and location of the solar PV project                                                                             |

**Table 1:** Attributes and levels of alpine solar PV projects presented in the choice experiment

The fourth and final part of the survey consisted of control and socio-demographic variables about our respondents. Control variables included *nature bonding* (people's attachment to the alpine region) based on a four-item scale which is part of the concept of place attachment based on Raymond et al. (2010), and a ten-item scale to measure *ethically minded consumer behavior* (EMCB) based on Sudbury-Riley & Kohlbacher (2016). Both *nature bonding* as well as *EMCB* were measured using a five-point Likert scale. Additionally, we asked participants if the municipality they live in would potentially be suited to an alpine solar PV project as described in the survey introduction text (coded as 1 = yes, 2 = no). Socio-demographic variables included age, gender (1 = male, 2 = female), education, gross household income, and political attitude (based on Swiss party preference indication, which was classified into three categories, see Table 2).

### 3.3. Data analysis

The CBC approach derives the preferences of surveyed respondents in relation to

different attributes of hypothetical solar PV projects. It is closest to a real decision making situation and best suited to reveal real preferences for unfamiliar or new products or projects (see also Tabi & Wüstenhagen, 2015; Salm et al., 2016; or Priessner & Hampl, 2020). Further, compared to questions measuring self-reported answers, the CBC approach is superior in terms of revealing the real preferences of participants for each of the attributes and corresponding levels by creating trade-offs between the attributes within the presented choice tasks. From the point of view of the participants, the various project combinations have certain advantages and disadvantages when they are evaluated subjectively. This leads to the fact that the participants have to weigh the importance of the project attributes relatively against each other and thus become aware of the actual importance of the individual project attributes. Consequently, results of a CBC approach have lower self-reporting or social desirability biases (Albers et al., 2009; Backhaus et al., 2011).

The project attributes used (see Table 1) were independent of each other in order to generate an undistorted estimation of respondents' preferences. Each choice task elicits the respondent's willingness to accept tradeoffs among more or less desired project attributes, the levels of which vary randomly depending on the choice task. Each of the 1036 respondents evaluated eight choice tasks, leading to a total of 8288 experimental choices. Choice data were analyzed in two stages with the use of a hierarchical Bayesian (HB) estimation (Allenby et al., 2005) in the following way: The HB estimate initially sorted the attributes of the hypothetical solar PV project into a ranked list of "importances" (expressed as percentages). The latter indicate the relative strength of preference of a project attribute compared to others in the set (Orme, 2010). We then calculated the part-worth utilities associated with each attribute level, attributing a negative sign to the parameter estimates for levels that respondents were reluctant to accept. The result was a set of regression coefficients that approximated participants' part-worth utilities for attribute levels.

### 3.4. Sample

Respondents were selected from an actively recruited online consumer panel containing more than 100,000 individuals that was constructed by a professional market research company.<sup>8</sup> Data collection took place between October 6 and October 20, 2019.

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<sup>8</sup> Intervista: <https://www.intervista.ch/panel/?lang=en>

The original sample included 1189 participants with an overall drop-out rate of 12.9%, giving a final sample of 1036 participants. This sample was deemed representative of the population of Switzerland in terms of age, gender, income, political preference (party), and geographical area (see Table 2). The survey was translated into French and German, the two main official national languages. Because Italian- and Rhaeto-Romanic-speaking parts of Switzerland account for only 8.1% (0.5%) of the Swiss population (respectively), they were omitted (BFS, 2018).

|                                                | Total sample<br>(n=1036) | Swiss population <sup>9</sup> |
|------------------------------------------------|--------------------------|-------------------------------|
| Age <sup>a</sup> 18-29                         | 17.9%                    | 16%                           |
| Age 30-44                                      | 25.6%                    | 26%                           |
| Age 45-59                                      | 27.3%                    | 28%                           |
| Age 60+                                        | 29.2%                    | 30%                           |
| Men/Women                                      | 49% / 51%                | 49% / 51%                     |
| Political Attitude <sup>b</sup> : Conservative | 44.4%                    | 45.8%                         |
| Political Attitude <sup>b</sup> : Centrist     | 21.2%                    | 22.2%                         |
| Political Attitude <sup>b</sup> :<br>Left-wing | 26.4%                    | 25.9%                         |
| Income: Low <sup>c</sup>                       | 29.7%                    | 29.4%                         |
| Income: Mid <sup>c</sup>                       | 42.8%                    | 44.9%                         |
| Income: High <sup>c</sup>                      | 27.5%                    | 22.3%                         |
| Region: French-speaking Switzerland            | 25.3%                    | 25%                           |
| Region: Alps and Pre-Alps                      | 19.6%                    | 24%                           |
| Region: Central-West                           | 25.8%                    | 22%                           |
| Region: Central-East                           | 29.3%                    | 29%                           |

<sup>a</sup> Respondents younger than 18 years old were excluded (the age values specified by the Swiss Federal Office of Statistics also exclude this age group).

<sup>b</sup> Political attitude was determined in relation to the outcome of voting in the 2015 Swiss national election. Eight different party preferences were consolidated into the following broad groups of political attitudes: conservative (SVP, FDP), centrist (CVP, BDP, GLP, EVP) and left-wing (SP, Green). The category “other political party” categorized 8% of the total sample (representing a preference for a party(ies) not represented in the Swiss parliament).

<sup>c</sup> Classified as gross monthly income per household, with the five reported income classes merged into three income groups: Low Income = less than 6,000 CHF, Middle Income = 6,000 – 12,000 CHF, High Income = above 12,000 CHF.

**Table 2:** Parameters of sample in relation to Swiss population

<sup>9</sup> Swiss Federal Office of Statistics (BFS) (2018); Swiss Parliament (2018): Seat distribution.

## 4. Results and analysis

### General acceptance level

Figure 1 illustrates the overall acceptance level for the overall sample ( $n=1036$ ): Sixty-four percent of respondents agreed or fully agreed that they would accept a solar PV project in an alpine region, whereas only 14% of the participants stated that they would not be willing to accept such a project.

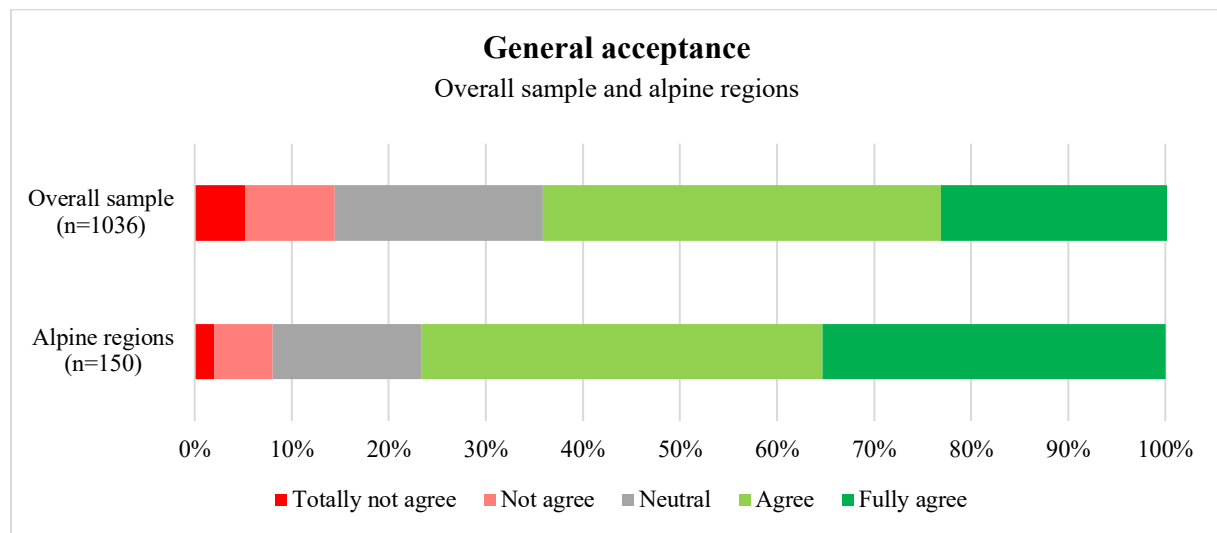


**Figure 1:** General acceptance for alpine solar PV projects: overall sample and alpine communities

A segmented analysis revealed further insights: participants living in alpine regions (who would be directly affected by such solar PV projects) indicated a significantly higher overall acceptance level compared to participants who were not (i.e. the rest of Switzerland) (see Figure 1). The mean acceptance value for participants living in alpine regions was 4.02 ( $SD = 0.97$ ,  $N = 150$ ) compared to 3.63 ( $SD = 1.09$ ,  $N = 886$ ) for the rest of Switzerland ( $p < 0.000$ , based on one factor ANOVA). Seventy-seven percent of all respondents living in alpine regions agree or fully agree that they would accept an alpine solar PV project in their region, whereas only 8% would not or absolutely not accept such a project.

Similar to Walker et al. (2018) and Tabi and Wüstenhagen (2017) we find that political attitude acts as an important predictor of the social acceptance of renewable-energy projects. Centrists ( $m = 3.86$ ,  $SD = 0.99$ ,  $N = 220$ ) and left-wing voters ( $m = 3.90$ ,  $SD = 0.90$ ,  $N = 273$ ) are significantly ( $p < 0.000$ , based on a one factor ANOVA,

for centrist and for left-wing voters) more willing to accept alpine solar projects than conservative voters ( $m = 3.47$ ,  $SD = 1.18$ ,  $N = 460$ ).

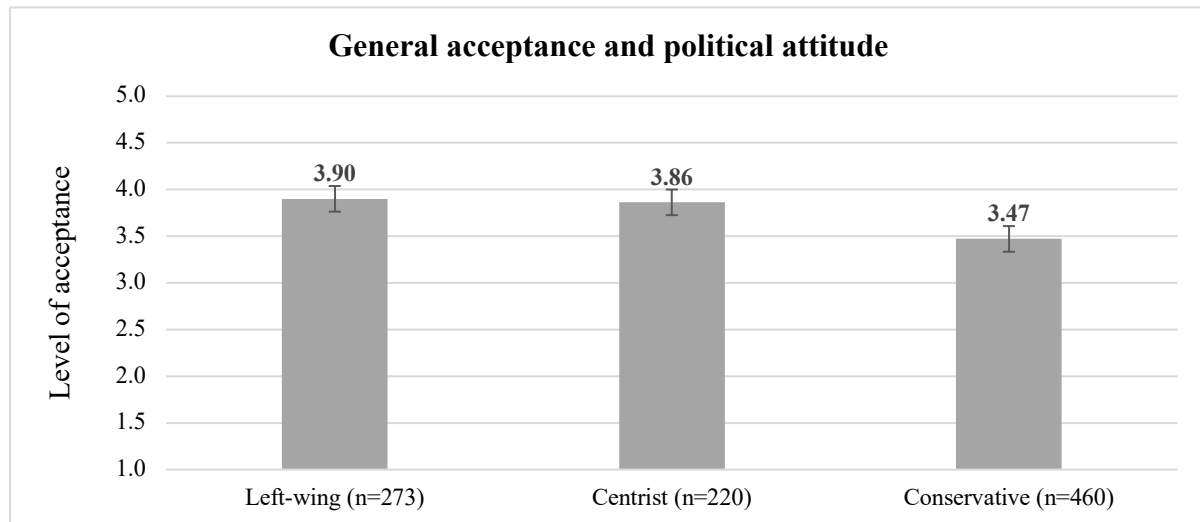


**Figure 2:** Political attitude and general acceptance of alpine solar PV projects

#### *Influence of socio-demographic and control variables on general acceptance level*

To analyze the influence of our control and socio-demographic variables on the general acceptance level of alpine solar PV projects, we ran a linear regression model. The regression model included the dependent variable (general acceptance level) as well as the socio-demographic variables. Table 3 illustrates the outcome (calculated using SPSS):

| Variable                        | B         | Standard error | t      | F       | Sig.  |
|---------------------------------|-----------|----------------|--------|---------|-------|
| Alpine region <sup>a</sup>      | -0.390*** | 0.093          | 4.195  | 17.598  | 0.000 |
| Nature bonding <sup>b</sup>     | -0.163*** | 0.049          | -3.318 | 11.007  | 0.001 |
| EMCB <sup>c</sup>               | 0.250***  | 0.052          | 4.811  | 23.144  | 0.000 |
| Age <sup>d</sup>                | 0.001     | 0.002          | 0.600  | 0.360   | 0.549 |
| Gender <sup>d</sup>             | -0.093    | 0.067          | -1.394 | 1.942   | 0.164 |
| Income <sup>d</sup>             | -0.059**  | 0.028          | -2.120 | 4.495   | 0.034 |
| Political attitude <sup>d</sup> | 0.136***  | 0.035          | 3.873  | 15.003  | 0.000 |
| Intercept                       | 3.381***  | 0.240          | 14.103 | 220.490 | 0.000 |

\*\*  $p < 0.05$ ; \*\*\*  $p < 0.01$ , dependent variable = general acceptance

<sup>a</sup> Coded as 1 = alpine region, 2 = rest of Switzerland

<sup>b</sup> Four-item nature-bonding scale *Cronbach's Alpha* = 0.716 (based on  $n = 1036$ )

<sup>c</sup> Ten-item EMCB scale *Cronbach's Alpha* = 0.905 (based on  $n = 1036$ )

<sup>d</sup> Age in years; Gender (1 = male, 2 = female); Income based on 3 levels, low income = 1, med income = 2, high income = 3 (see Table 2); political attitude coded as 0 = other, 1 = conservative, 2 = centrist, 3 = left-wing (see Table 2).

F-test of total model:  $n = 1036$ ;  $F = 11.056$ ;  $df = 7$ ;  $Sig. = 0.000$ ;  $R\text{ squared} = 0.070$ ;  $Adjusted\ R\text{ squared} = 0.064$

**Table 3:** Linear regression - SPSS output table

The regression model reveals the importance of socio-demographic variables in predicting acceptance levels for alpine solar PV projects. Attitudes such as nature-bonding as well as pro-environmental consumption behavior (EMCB) have a significant impact on the general acceptance level. While people with strong feelings about pro-environmental consumption are more likely to accept alpine solar PV projects, people who are strongly attached to nature and want to preserve it as it is are more likely to not accept such projects. Additionally, income and political orientation also have a significant influence on the general acceptance level. Conservative voters are more likely not to accept alpine solar PV projects compared to people who have a centrist or left-wing political orientation. Finally, respondents with a higher income are more likely to reject alpine solar PV projects than those with a lower income.

### *Choice experiment: Attribute importance and part-worth utilities*

Results of the choice experiment were analyzed in Sawtooth using the hierarchical Bayesian (HB) estimation. The average RLH<sup>10</sup> of the HB model is 0.676 with an average percentage certainty<sup>11</sup> of 0.718, which indicates good model fit. In terms of attribute importances for the overall sample, the HB estimation shows that “design of the solar PV project” is the most important attribute (36.68%,  $SD = 15.18$ ), followed by (local) ownership (21.00%,  $SD = 9.35$ ). The three other attributes of the alpine solar project, ecological impact (15.60%,  $SD = 8.39$ ), distributional justice (14.19%,  $SD = 5.58$ ) and procedural justice (12.53%,  $SD = 5.42$ ) exhibit similar, and somewhat lower, importance levels.

Additionally, we also compared the average importance levels of the attributes for alpine regions ( $n=150$ ) to the levels for the rest of Switzerland ( $n=886$ ). The analysis showed no significant differences concerning the importances of the different attributes (see Figure 3). The design attribute remains by far the most important attribute for both samples, followed by the ownership structure and the ecological impact. A difference can be observed with regard to distributional and procedural justice. In Alpine regions, procedural justice is considered to be more important in comparison to distributional justice, whereas in the rest of Switzerland, distributional justice is rated slightly higher compared to procedural justice.

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<sup>10</sup> The logit equation predicts the probability of choice for each of the alternatives (concepts) in a choice task for each respondent. RLH (Root Likelihood) is the geometric mean of the predicted likelihoods for the concepts the respondent actually chose. (Sawtooth, 2019)

<sup>11</sup> Pct. Cert. (also known as pseudo R-squared) is a related statistical value but is calculated differently. Its meaning essentially asks, "what percentage of success - between the null prediction and the best possible prediction - were we able to achieve with this model?" (Sawtooth, 2019)

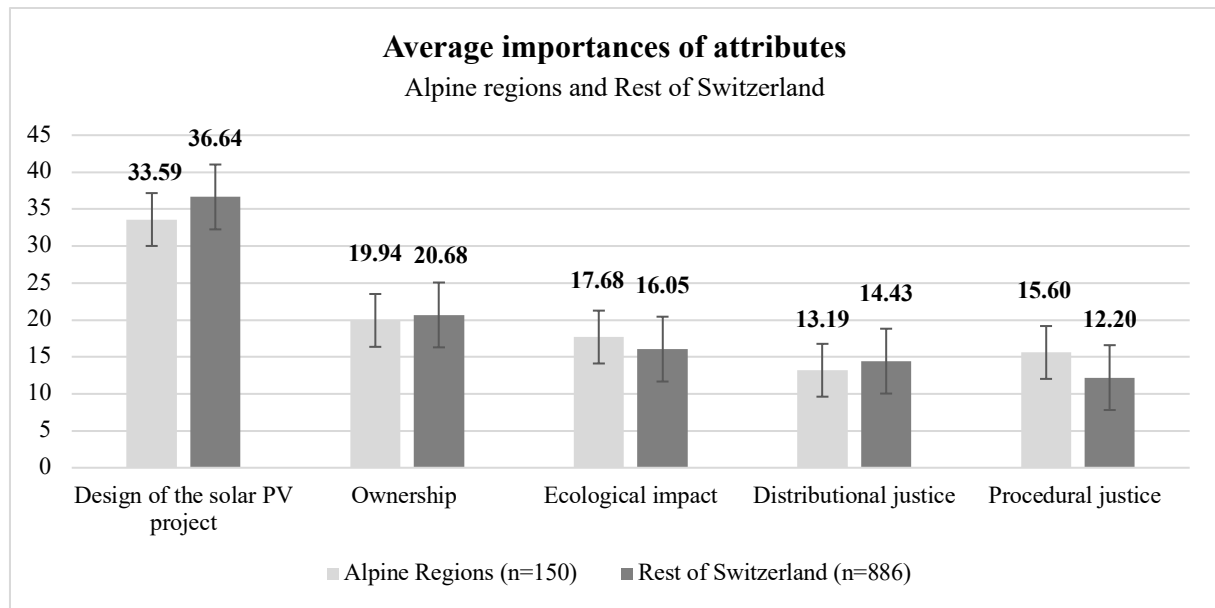


**Figure 3:** Average importances of attributes for samples “Alpine regions” and “Rest of Switzerland”

A deeper look at part-worth utilities (for the overall sample) associated with different levels of attributes (Table 4) creates further insight. The design attribute leads to relatively strong reactions, with green panels adjusted to the landscape (score of 75.06) being clearly preferred over conventional panels (20.23). On the other hand, innovative artistic design elements are less well received, with the capricorn-shaped installation (-38.74) scoring relatively higher than the Swiss flag (-56.56). As can be seen from Figure 4, young respondents are relatively more open to innovative design concepts than old respondents, but the preference for green panels that improve the solar plant’s embeddedness in the surroundings is shared across age groups. Furthermore, voters of the national-conservative party are also skeptical towards innovative design elements, but they slightly prefer the installation in the shape of the Swiss flag (-38.59) over the capricorn design (-41.96).

As for the second most important attribute, ownership, the most preferred level is a combination of a local utility with inhabitants (33.93), while an international utility is the least preferred option (-54.65), suggesting that local ownership contributes positively to social acceptance. When it comes to ecological impact, the third most important attribute overall, the direction of the effect is as expected: projects with lower ecological impacts are preferred over projects with higher ecological impact. Figure 4 shows that young respondents are more sensitive to environmental aspects of the project than older respondents: Among 18-29-year-olds, the preference for a project with net positive ecological impact (45.38) is twice as strong as among 60+-year-olds (23.98). In

terms of the attribute distributional justice, the key insight is that sharing the financial benefits with the local population increases social acceptance of an alpine solar PV project. Which kind of benefit sharing is pursued has less of an influence, as there is only a slight preference for direct financial participation models compared to collective participation via the solar resource tax. Procedural justice turns out to be relatively less important, but the effect is also as expected: offering additional participation options beyond the legally required minimum has a small, but positive effect on social acceptance of the project. Interestingly, young respondents, in contrast to senior citizens, prefer a public information event over more active, but therefore also more time-consuming forms of participation, such as co-determining the size, location and design of the project. Given the lower openness of the older generation towards innovative design features, this lukewarm willingness of the 18-29-year-olds to show hands-on involvement may represent a barrier towards implementing such new approaches. Finally, the none-option had a score of -81.22, indicating that participants rarely chose this option in the choice task and generally preferred any of the offered three hypothetical solar projects over no project at all, in line with the high levels of acceptance observed in the direct question (see above).

|                                              | Average utilities<br>(zero-centered diffs) | Standard deviation |
|----------------------------------------------|--------------------------------------------|--------------------|
| <b>Design</b>                                |                                            |                    |
| Conventional solar panels                    | 20.23                                      | 54.31              |
| Green solar panels                           | 75.06                                      | 67.30              |
| Art element: animal design (Capricorn)       | -38.74                                     | 57.38              |
| Art element: Swiss flag design               | -56.56                                     | 62.67              |
| <b>Ownership</b>                             |                                            |                    |
| International utility                        | -54.65                                     | 38.19              |
| Local utility                                | 19.91                                      | 27.00              |
| Combination of local utility and inhabitants | 33.93                                      | 24.05              |
| Farmers' cooperation                         | 0.81                                       | 26.30              |
| <b>Ecological impact</b>                     |                                            |                    |
| Medium                                       | -15.68                                     | 27.83              |
| Small                                        | -19.87                                     | 24.09              |
| Almost none                                  | 2.12                                       | 18.87              |
| Net positive                                 | 33.43                                      | 35.05              |
| <b>Distributional justice</b>                |                                            |                    |
| Hardly any local financial benefits          | -36.91                                     | 21.10              |
| Compensation for private landowner           | 13.97                                      | 22.41              |
| Individual participation in the project      | 12.21                                      | 17.92              |
| Compensation via solar resource tax          | 10.73                                      | 18.00              |
| <b>Procedural justice</b>                    |                                            |                    |
| Legally required participation               | -28.70                                     | 24.26              |
| Public information events                    | 6.14                                       | 18.42              |
| Co-determining the design of the project     | 7.78                                       | 18.38              |
| Co-determining the size, location and design | 14.78                                      | 18.75              |
| <b>None Option</b>                           | -81.22                                     | 192.50             |

**Table 4:** Results of the HB model estimation – zero-centered part-worth utilities

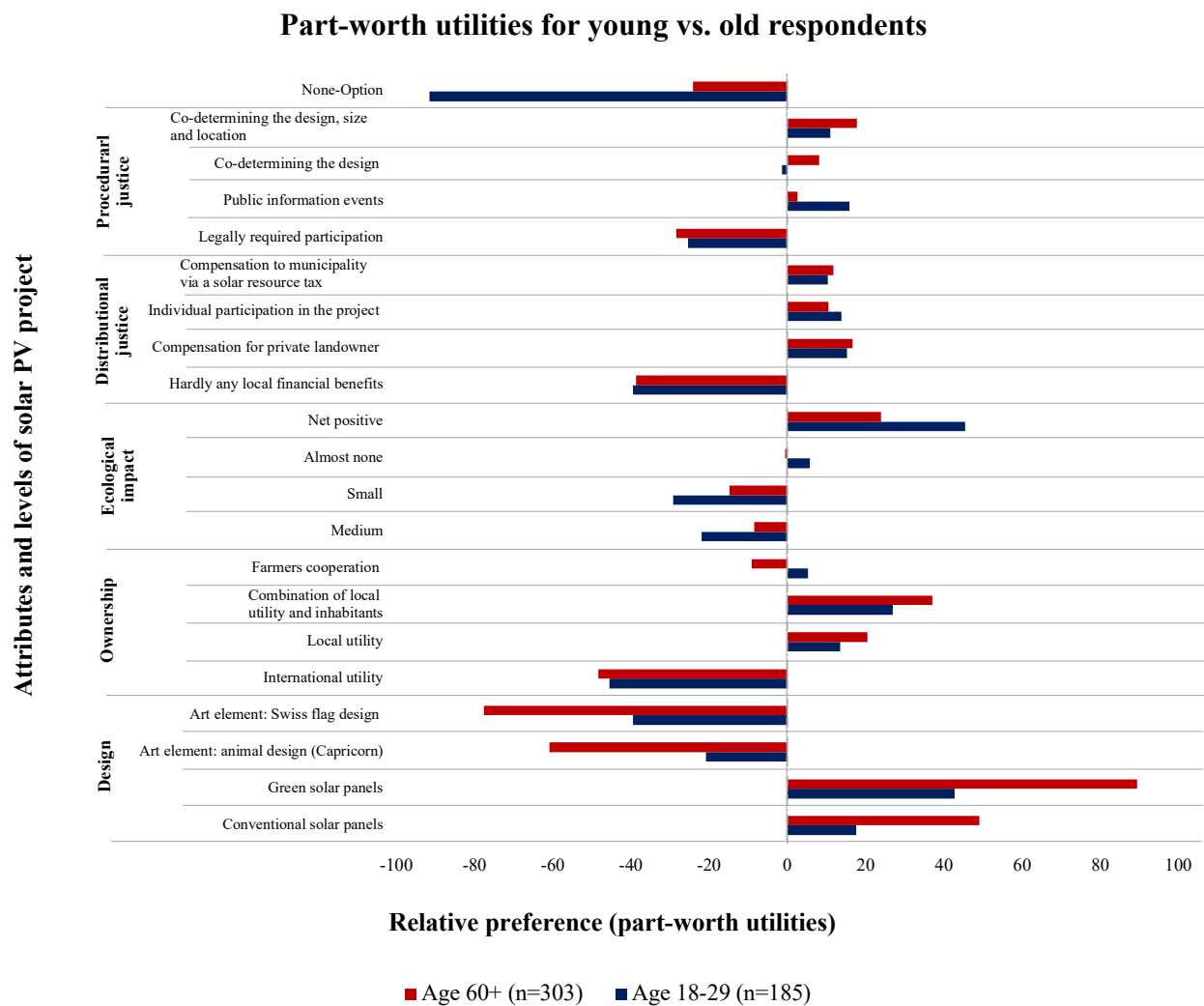


**Figure 4:** Part-worth utilities for young vs. old respondents

## 5. Discussion

Using the results and analyses presented above, we can subsequently discuss the hypotheses presented and derive relevant policy implications and recommendations for project developers.

Our first hypothesis, “*Solar PV projects in alpine regions are associated with a high overall level of acceptance*” is confirmed. 64% of all participants would accept solar PV projects in alpine regions, resulting in a mean acceptance value of 3.68 ( $SD = 1.08$ ,  $N = 1036$ ). This result supports findings by authors such as Kaenzig et al. (2013), Sütterlin and Siegrist (2017), Plum et al. (2019), and Cousse and Wüstenhagen (2019), who have shown that solar PV has a unique position among renewable energy

technologies in terms of social acceptance. It also adds to the findings of Michel et al. (2015) who identified a high level of acceptance for alpine solar PV projects on existing infrastructure, such as avalanche barriers. Our results indicate that the acceptance level also remains high when the solar PV project is located in the vicinity of existing infrastructure.

Results from the segmentation analysis produce further interesting insights. Residents of alpine regions, who would be directly affected by the solar PV projects, are more likely to accept such projects compared to people not living in alpine regions. This high level of local acceptance resembles of a PIMBY (Please in My Backyard) more than a NIMBY (Not in My Backyard) effect (Wolsink, 2000; Van der Horst, 2007; Brinkman & Hirsh 2017), and may be related to the fact that electricity generation with solar PV projects creates a new source of income for alpine regions (Díaz and Van Vliet, 2018). Tangible financial benefits have been shown to facilitate local acceptance in a wide range of energy technologies, including nuclear waste repositories (Frey et al. 1996) and hydropower plants (Tabi and Wüstenhagen, 2017), even if their implementation needs to be carefully designed, preferably with the direct participation of the local population as shown in Figure 3, to avoid unintended side-effects (Aitken, 2010). Additionally, Michel et al. (2015) mention the above-average exposure of alpine regions to climate change – awareness of this situation might contribute to the high local acceptance level among residents of alpine regions. There may also be affective factors in place, such as a sense of pride about the solar project (Cousse and Wüstenhagen, 2019) contributing positively to local patriotism (Salm et al., 2016; Devine-Wright et al., 2019).

The implementation of renewable energy projects also has a political component. Our results show that centrist and left-wing voters are significantly more likely to accept an alpine solar PV project compared to conservative voters. Nevertheless, conservative voters also have a total overall acceptance level of  $m = 3.47$  on a five-point Likert scale ( $SD = 1.18$ ,  $N = 460$ ). Interestingly, conservative voters who live in alpine regions have a significantly higher overall acceptance level ( $m = 3.93$ ) than conservative voters ( $m = 3.39$ ) living elsewhere. Their level of acceptance is even higher, although not significantly, than that of left-wing ( $m = 3.90$ ) and centrist voters ( $m = 3.86$ ) not living in alpine regions, which in sum further strengthens our finding concerning the high level of acceptance of solar PV projects in alpine regions, especially at a local level.

Hypothesis 2a, “*Distributional justice increases social acceptance of solar PV projects in alpine regions*” can only partially be confirmed. Findings from the choice experiment suggest that a lack of local benefits decreases the social acceptance of solar projects in relation to the three benefit-sharing levels. This conclusion supports the findings of the literature about the social acceptance of wind energy (Aitken, 2010; Warren and McFadyen, 2010; Sovacool & Ratan, 2012; Rand and Hoen, 2017; Langer et al., 2017) and hydropower (Tabi & Wüstenhagen, 2017). However, distributional justice turned out to be only the fourth most important attribute - this overall picture holds true for the sub sample of the Alpine region, where procedural justice is slightly preferred to distributional justice, but both attributes rank fourth and fifth, respectively. This outcome indicates that other factors are stronger determinants of social acceptance. This may be specific to the Swiss context, where environmental awareness is relatively high, which is reflected in the higher importance of the attribute ecological impact in the results of our choice experiment. Among the different possibilities of local benefit sharing included in our analysis, respondents showed a slight (but not significant) preference for direct financial participation options (compensation for landowner or individual participation in the project through financial investment and dividend payments) over collective financial participation options, operationalized in this research project through a *solar tax* which would benefit the community as a whole.

Similarly, hypothesis 2b, “*Procedural justice increases social acceptance of solar PV projects in alpine regions*” can only partially be confirmed. Our results show that higher levels of procedural justice correspond to higher levels of social acceptance, but the effect is less pronounced than for the other attributes. Participants stated a preference for co-determining the size, design, and location of projects (score of 14.78) over all other levels, especially over the lowest level of procedural justice “legally required participation” (score of -28.70). This adds to findings by Devine-Wright (2005), Wolsink (2007), Dimitropoulos and Kontoleon (2009) and Lienhoop (2018), who also researched public participation in the planning process of renewable energy projects and identified a demand for greater consultation of the public. However, the HB estimation also reveals that procedural justice is the least important attribute in the overall choice-experiment (12.53%), mirroring the findings of Tabi & Wüstenhagen (2017) who, for the case of hydropower, pointed out that this may be due to the fact that Swiss citizens take high levels of procedural justice for granted, given the high number of options that already exist to directly participate. In summary, procedural justice can help to increase

the social acceptance of a solar PV project, but above all, developers must get other attributes of the project right, such as a context sensitive design, local ownership, and low ecological impact.

Hypothesis 3a, “*Adjusting the color of solar panels to the surroundings increases social acceptance of PV projects in alpine regions*” can be confirmed. With an importance level of 36.68%, the design of the project is the most important attribute in terms of explaining respondents’ decision to accept one of the proposed alpine solar projects in our choice experiment. The visual appearance of solar PV projects seems to be an important driver of social acceptance. This adds to findings from research on visual impacts of renewable energies, mainly in the context of wind energy. Elements such as the height of turbines of wind energy projects (Tsoutsos et al., 2009) or the proximity of turbines to residential areas (Dimitropoulos and Kontoleon, 2009; Dobers et al., 2015) as well as the specific location of wind parks (Maffei et al., 2013) were identified as important factors determining local acceptance of a project. Looking at part-worth utilities of the levels of the design attribute shows that the option “green solar panels” (score of 75.06) is strongly preferred over conventional panels (20.23). This confirms the importance of context sensitivity in solar design (Sánchez-Pantoja et al. 2018; Lobaccaro et al. 2019) and adds to the findings of Hille et al. (2018) who identified a match between the color of solar panels and the surrounding roof as a factor increasing acceptance of rooftop solar among Swiss homeowners. Adjusting the color of solar panels to the natural surroundings may also be a way of addressing the concerns of people who feel strong bonds to nature and might otherwise be opposed to utility-scale projects in the mountains.

Hypothesis 3b, “*Artistic design elements increase social acceptance of solar PV projects in alpine regions*” cannot be confirmed based on the analysis presented in this paper. Our exploratory approach to suggest a novel element of solar art was not well received among respondents. The HB estimation of the part-worth utilities revealed that including innovative solar art elements did not have the intended effect: both an installation that resembled a Swiss flag (score of -56.56) as well as the capricorn design (-38.74) reduced the likelihood of the project being accepted compared to a conventional design. This is somewhat in contrast to the positive media coverage that pilot projects of solar art have received, such as the panda-shaped utility-scale solar projects (Nace 2017) or installations of “solar trees” (Hyder et al. 2018). One possible explanation is

the novelty of this idea to respondents – after all, young people showed somewhat more positive reactions than older respondents. For the time being, though, our results suggest that adjusting the color of the panels to the natural surroundings is a more promising route to increasing acceptance of alpine solar projects than more extravagant artistic elements.

### ***Policy implications and recommendations for project developers***

Our findings lead to several policy implications and practical recommendations. We show that from a social acceptance perspective, utility-scale solar PV projects in alpine regions could be a promising option of improving seasonal diversification of renewable electricity supply. Especially in situations where other options for increasing renewable energy supply in the winter season, such as wind energy or hydropower reservoirs, are facing social acceptance challenges, national policymakers might want to consider setting specific targets for solar power generation in alpine regions. They should also provide guidelines for project implementation to ensure that issues that are important for local acceptance, such as adequate benefit sharing schemes and securing low or even net-positive environmental impacts, are considered in the project development process. On a local level, including utility-scale solar PV projects in their spatial planning procedures and identifying suitable areas might be a way for alpine communities to attract new investment and allow for local value creation.

One useful instrument which stakeholders could refer to in the early stages of project planning would be a clear national- and local-level framework. In relation to this, and in line with our findings, project developers:

- are advised to design ownership models that contain a significant local component, possibly including options for citizens as potential to co-invest in the PV project. Such co-ownership models would allow local residents to participate in the financial value added of alpine solar projects.
- should be aware of the need to design projects in a way that is as closely adapted to natural surroundings as possible (e.g. using green solar panels and minimizing ecological impact).
- are well advised to keep in mind that fair processes are a precondition for maintaining the license to operate even if procedural justice was less of a concern for respondents in our sample. While residents will differ in the extent to which they want to be actively involved, and we found evidence that older citizens seek

more involvement than younger ones, offering participation options for citizens during the project planning phase may contribute to a smooth implementation process later on.

## 6. Conclusions

Through a targeted investigation of the attributes that determine the social acceptance of solar PV projects in alpine areas of Switzerland, this paper notably adds to the research stream concerning the social acceptance of solar PV. Specifically, two research questions were addressed: *(1) What are the attributes that determine the social acceptance of utility-scale solar PV projects in alpine regions, and (2) Which attribute levels can increase the local acceptance of a solar PV project?*

Based on a large-scale survey in Switzerland (N=1036), we find that solar PV projects in alpine regions are associated with a high level of overall acceptance. 64% of all respondents indicated they would agree or fully agree with such a project, while only 14% of all respondents indicated they disagree or fully disagree. This suggests that among the options to provide seasonal diversification in renewable energy systems, alpine solar power generation looks like a potentially promising candidate from a social acceptance point of view. We also find more of a PIMBY than a NIMBY effect: the social acceptance level for residents of alpine regions is significantly higher (77% agree or fully agree with such projects; only 8% disagree) than among “lowlanders” residing outside those regions.

The results of the choice experiment confirm the findings of previous literature, especially within the literature for social acceptance of wind energy, suggesting that procedural and distributional justice, even though they are not the most important attributes in our choice experiment, correspond to higher levels of social acceptance. We also find that low environmental impact, as well as local ownership, are positively related to acceptance – this has already been identified for wind energy projects, with this research paper we demonstrate that it also applies to utility-scale solar PV projects in alpine regions. Importantly, we demonstrate that design can play a key role in either increasing or decreasing local acceptance of alpine solar projects. Participants clearly preferred a design which minimizes the visual impact of the project by adjusting the color of the panels to the natural surroundings: switching from conventional solar panels

to green panels significantly increased the chances of the project being accepted. In contrast, the effect of innovative solar art features showed some variation among respondents, such as relatively higher support from young people, but did not have a positive effect on acceptance overall. To successfully implement solar PV projects in alpine regions, it appears to be crucial to keep them local and low-key, in the sense of minimizing the perceived landscape change.

### ***Limitations and further research***

There is still a lack of research about the social acceptance of utility-scale PV, in spite of the obvious relevance of solar power in the global energy transition. The choice experiment described herein adds important empirical insights to the related debate. Earlier research in this area has tended to focus on specific, isolated impacts (such as the impact of solar PV projects on tourism). We successfully deployed a choice experiment to quantify the relative importance of different attributes associated with a solar project based in an alpine region in explaining respondents' level of acceptance of the latter. Moreover, we believe that the research is one of the first attempts to investigate the relative effect of a) design elements, as well as b) distributional and procedural justice on the level of social acceptance of solar PV. We also compare these effects with those of other attributes, including environmental impact and local ownership.

Naturally, the research involves limitations that suggest further research opportunities. First, our results are based on the chosen attributes and levels of a hypothetical alpine solar project. Further research could replicate our study with different attributes and different attribute levels. For instance, our study is the first to explore the influence of innovative design elements on social acceptance of utility-scale solar PV. Our findings suggest, that innovative design elements decrease, rather than increase acceptance. Before taking this as an indication that design does not positively influence social acceptance, we would caution that this was probably the first time that respondents were confronted with the idea of such innovative design elements, and their preferences may change after they have had more time to get used to it. It would be interesting to see whether solar art finds higher support in regions where such projects have already been implemented, such as the panda-shaped PV projects in China, or whether participatory design processes, involving local schools or well-known artists, would lead to higher acceptance.

Second, our survey was conducted with a representative sample of the national population and controlled for differences between inhabitants of alpine regions and residents of other parts of the country. While average preferences of the population are an important determinant of social acceptance, further segmentation could lead to additional insights. For example, we observed significant differences between the preferences of young and old respondents with regard to design, but also to their preferred level of participation. Further research could investigate whether solar projects in alpine communities with a higher share of young people in the population or in local politics face less social acceptance challenges than projects in regions that are characterized by a different demographic setting.

Finally, our research project has focused on a particular geographical context. While Switzerland shares many similarities with other developed countries that have embarked on a low-carbon energy transition, there are also specificities such as a relatively high per-capita income, the absence of carbon-intensive domestic power generation, and a tradition of participatory democratic decision making that might have influenced our findings. An examination of citizen preferences in different cultural contexts, such as alpine regions in Canada, Central Asia or South America, might also be fruitful.

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## Appendix

### Appendix A – Survey introduction text

At the Institute for Economy and the Environment we are investigating various questions relating to the energy transition, including questions about solar energy. In order to gain important insights, we also conduct studies with end consumers. To participate in this study, you do not need to have any previous knowledge of solar energy. The present study is conducted for research purposes only.

We ask you to answer the questions truthfully. Our study is absolutely anonymous and no conclusions can be drawn about the participants. The data will not be passed on to third parties at any time.

We ask you to carefully read the following text on solar energy in general and on the solar project in an alpine region in particular. Afterwards you will be asked some questions:

In Switzerland, solar energy accounts for 3.4% of the Swiss electricity consumption. There is still great potential for the further expansion of solar energy. For this reason, the main goal is to use the huge areas on roofs and facades. However, one of the aims of the Energy Strategy 2050 is also to expand the production of renewable energy in the winter half-year. Ground-mounted solar PV projects in alpine regions can make a contribution to this. Due to their size, they are more economical than smaller roof systems. Alpine regions also benefit from increased solar radiation, fewer fog days, and additional snow reflection: optimal conditions for the production of renewable energy in the winter half-year.

## Appendix B – Hypothetical alpine solar PV project for Switzerland

### *Text:*

The solar project in the alpine region is expected to produce around 1.5 gigawatt hours of electricity – equivalent to the annual electricity requirement of around 1,250 people. The plant would have a total area of about 6,000 m<sup>2</sup> (about the size of a football field) and be located on a slope in the vicinity of existing infrastructure (cable cars and buildings).

The picture below shows you how such a solar PV project might look in reality (example illustration).

### *Illustration:*



Illustration of hypothetical solar PV project in an alpine region (authors' figure, 2019)

## Appendix C – Conjoint attribute ‘Design of the solar PV project’



**Level 1:**  
Conventional PV panels



**Level 2:**  
Green PV panels (adapted to surroundings)



**Level 3:**  
Art element: animal design (Capricorn)



**Level 4:**  
Art element: Swiss flag design

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## Paper III

### Electrifying the Company Car<sup>1</sup>

#### Adoption of Electric Mobility in a B2B Context and the Role of Social Acceptance

*Pascal Vuichard*<sup>23</sup>

#### Abstract

Electric mobility has an important role to play in the transition to a more sustainable transportation system. However, adoption is still relatively slow in most countries, as well as within organizations and their corporate fleets. Much-cited hard barriers, such as the limited availability of charging infrastructure and higher upfront investment costs, do not fully explain this slow uptake. Recently, the research field of social acceptance of electric mobility has emerged, arguing that a better understanding of the social acceptance of electric mobility, especially within organizations, is crucial for its further adoption. This paper adds to the debate new theoretical and practical insights. Methodologically, the paper is based on a survey with Swiss fleet managers and identifies important acceptance-related soft barriers, such as a lack of both knowledge and employee demand. A behavioral-intervention campaign to address the identified acceptance-related barriers provided one-week test drives with EVs to car pool users in the normal course of business life, in a simple and unbureaucratic way, free of charge, and without obligation. The campaign was developed, implemented, and assessed in a field experiment with car pool users in the city of St. Gallen. The results offer clear evidence that designing a specific campaign to address acceptance-related soft barriers can help to increase social acceptance and EV purchase intentions for key individuals in organizations, indicating the potential to expand the current policy mix.

#### Keywords:

Electric mobility, Corporate fleet, Social acceptance, Behavioral-intervention campaign, Field experiment

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# 1. Introduction

Transitioning away from our present transportation system may well be one of this generation's hardest tasks (Geels et al., 2011; Sovacool, 2017). To achieve it, the International Energy Agency (IEA, 2017) states that at least 20% of all road-transport vehicles globally must be electric by 2030. In general, electric mobility plays an important role in reducing greenhouse-gas emissions, as electric vehicles operate more efficiently than vehicles with internal combustion engines, relying on electricity that can be sourced sustainably (Tran et al., 2013; SES, 2017). As a result, many countries and organizations have introduced roadmaps and scenarios, such as the *IEA EV30@30 Scenario* that targets a 30% share for electric vehicles in the vehicle fleet (except for two-wheelers) by 2030 for all participating parties (IEA, 2019). Individual countries have also drafted and signed roadmaps. For instance, Switzerland foresees an increase of EVs in the share of newly registered passenger cars to 15% by 2022. However, the adoption of electric mobility is still relatively slow for private individuals, as well as for corporate fleets which are of particular importance in the further expansion of electric mobility, given that corporate vehicles have higher annual mileage than privately owned and used vehicles (Orsato et al., 2011; Dijk et al., 2013; Plötz et al., 2014; Sierzechula, 2014) and are also resold more quickly than private cars, thus diffused faster via the used-car market (Plötz et al., 2013; Gnann et al., 2015; Globisch et al., 2018).

The literature identifies several *hard barriers* (such as limited availability of charging infrastructure or the higher upfront investment cost) and *soft barriers* (such as the lack of knowledge or low perception of ease of use) that influence the slow uptake of electric mobility (Hjorthol, 2013; Koetse & Hoen, 2014; Rezvani et al., 2015; Biresselioglu et al., 2018). Consequently, many countries have introduced policy instruments to reduce the barriers and accelerate the adoption of EVs (Lieven, 2015). The most widely implemented policy instruments are monetary incentives (e.g., cash grants, road-tax exemptions), traffic-regulation incentives (such as free use of downtown parking spaces or bus/priority lanes), or incentives for building charging stations (Lin & Greene, 2011; Lieven, 2015). Despite the introduction of these policy instruments, the aforementioned barriers prevail (Globisch et al., 2018; Rietmann & Lieven, 2019). Recently, a new field of research has emerged, focusing on social acceptance of electric mobility (Wikström et al., 2014; Sierzechula, 2014; Globisch et al., 2018) and arguing that a better understanding of the social acceptance of electric

mobility, especially within organizations, is crucial for its further adoption (Kaplan et al., 2016; Globisch et al., 2018).

Thus, this paper adds to the topic of social acceptance of electric mobility within organizations. Its objective is to investigate whether important prevailing acceptance-related barriers can be identified (*Study 1*) and how a behavioral-intervention campaign that addresses such barriers (*Study 2*) could influence the social acceptance of electric mobility by key people within organizations and, consequently, the adoption of EVs in corporate fleets. For this purpose, I chose a mixed-method approach: *Study 1* consists of a survey of fleet managers, and *Study 2* conducts a field experiment with car pool users, including the specific behavioral-intervention campaign. This resulted in the following three research questions:

1. *What are the biggest sources of motivation and barriers for Swiss fleet managers with regard to the electrification of corporate fleets?*
2. *To what extent do acceptance-related barriers influence the electrification of corporate fleets?*
3. *How does a behavioral-intervention campaign that addresses acceptance-related barriers affect the likelihood of choosing electric mobility in corporate fleets?*

The rest of this paper is structured as follows. The next section reviews and discusses the relevant literature concerning social acceptance and the adoption of electric mobility in corporate fleets. Sections 3 and 4 present and discuss the two studies undertaken to address the research questions. The paper concludes with section 5, which presents general conclusions, suggests related policy implications, and adds a definition of limitations, as well as a description of opportunities for further research.

## **2. Literature review**

### **2.1. Motivators and barriers to EV adoption in organizations**

Previous scholars have extensively studied sources of motivation, as well as barriers to adoption of electric mobility. Most of these studies focused on understanding the private-consumer perspective, including demand preferences, forecasting, and related policies (Zhang et al., 2011). However, as Sierzechula (2014) and Klauenberg et al. (2016) discuss, organizations are likely at the forefront of adopting electric mobility,

mainly due to their high vehicle-purchasing rate and the more intense use of these vehicles than those privately owned (Lane & Potter, 2007; Sovacool & Hirsh, 2009; Wikström et al., 2015; Biresselioglu et al., 2018). Company vehicles account for a significant proportion of newly registered passenger cars — 64% in Germany (KBA, 2018) and 57% in Great Britain (Department for Transport, 2018). Therefore, the paper focuses on *motivators* and *barriers* from an organizational point of view.

Important *motivators* for electric-mobility adoption center on environmental aspects, such as the positive impact of electric mobility on reducing CO<sub>2</sub> emissions, their low noise level compared to conventional combustion-engine vehicles, and their positive effect on reducing air pollution (Barisa et al., 2016; Quak et al., 2016; Biresselioglu et al., 2018). From an economic perspective, lower fuel costs and higher efficiency (and, thus, lower overall operating costs) are the main drivers for adopting electric mobility in corporate fleets. In the regulatory domain, incentives that reduce the tax levy on EVs (or increase it for conventional vehicles) can further bolster the acceptance of electric mobility and, consequently, serve as a source of motivation (Haddadian et al., 2015). In addition, incorporating electric vehicles into the corporate fleet can promote a positive corporate image, due to EVs' high level of general acceptance by the public (Sierzchula, 2014; Quak et al., 2016; Kaplan et al. 2016).

On the other hand, the literature also identifies several *hard* and *soft barriers* to the further expansion of electric mobility, especially within corporate fleets. Hard barriers include the lack of charging infrastructure (Sierzchula, 2014; Laurischkat et al., 2016; Biresselioglu et al., 2018) and economic factors such as higher upfront investment cost (Quak et al., 2016; Shao et al., 2016; Newbery & Strbac, 2016). Sierzchula (2014) shows that higher investment costs could discourage smaller companies, in particular, from integrating electric vehicles into their fleets. Other hard barriers include more technical aspects, such as grid-related issues, that may play a role when simultaneously charging large fleets, or the limited availability of electric vehicles tailored to the needs of organizations (Quak et al., 2016; Matthews et al., 2017). Soft barriers include issues such as a lack of trust, the role of information and knowledge, and the perception of the ease of use of electric vehicles (Shao et al., 2016; Biresselioglu et al., 2018; Globisch et al., 2018). Shao et al. (2016) show in their study that the gap between customers' expectations and perceptions can influence the acceptance of electric mobility within organizations. Biresselioglu et al. (2018) add further evidence to support the claim of soft barriers' importance by showing that a lack of knowledge about EVs already on the

market (for example, on their environmental performance, total cost of ownership, or ease of use) may be a significant barrier to their further adoption (Biresselioglu et al., 2018). Globisch et al. (2018) also support these findings by revealing the importance of social aspects, such as the role of motivating car pool users toward adoption of electric mobility within organizations, as do Axsen and Kurani (2011), who found that interpersonal influence plays an important role in whether specific technologies are favorably assessed (in this case, plug-in hybrid-vehicle technology). Additionally, Skippon and Garwood (2011) found that technologies with which consumers have little or no experience are perceived as abstract, limiting their further expansion.

## **2.2. Social acceptance of electric mobility within organizations**

The adoption of electric mobility is increasing only slowly in most countries, despite studies that indicate high levels of general social acceptance (Quak et al., 2016; Kaplan et al., 2016; Cousse & Wüstenhagen, 2018). Within the concept of social acceptance, Wüstenhagen et al. (2007) differentiate three different levels of social acceptance: socio-political acceptance (i.e., general acceptance, public opinion regarding a technological development), market acceptance (i.e., organizations' willingness to invest in the technology and consumers' to engage in markets the technology has created), and community acceptance (i.e., acceptance of specific projects by residents, organizations, and/or local authorities).

For electric mobility, fostering market acceptance is still seen as a major challenge (Ziefle et al., 2014). A high level of market acceptance by both important stakeholders and individual end-users is a prerequisite for the successful expansion of electric mobility (Steinhilber et al., 2013; Globisch et al., 2018). So far, both citizens and organizations have been reluctant to fully embrace electric mobility, despite EVs' association with lower operating costs and already competitive position relative to conventional vehicles, in terms of total cost of ownership (Palmer et al., 2018; IEA, 2019). The previous chapter identifies various hard and soft barriers that influence this reluctance and low level of market acceptance (Hjorthol, 2013; Koetse & Hoen, 2014; Rezvani et al., 2015; Biresselioglu et al., 2018), with hard barriers still seen as the primary means of explaining the slow growth of electric mobility. However, the role of reducing soft barriers in achieving a high level of market acceptance should not be underestimated (Ziefle et al., 2014; Biresselioglu et al., 2018).

Globisch et al. (2018) and Sierzchula (2014) point out the importance of social aspects and emotional attitudes of employees, such as the role of car pool users' motivation in the adoption of electric mobility within organizations. Kaplan et al. (2016) conclude that the level of acceptance of EVs in companies that have already introduced several is higher than in companies without EVs. Positive experience with an earlier (conventional) vehicle and a consequent lack of experience with the new technology can be a limiting factor (Skippon & Garwood, 2011; Ziefle et al., 2014). In line with these findings, Shao et al. (2016) and Biresselioglu et al. (2018) argue that favorable assessment of electric mobility in organizations depends significantly on its perceived ease of use, user-friendliness, and utility. Finally, Anable et al. (2011), Bakker and Trip (2013), and Ziefle et al. (2014) highlight that the presentation of information and how access to information about the new technology is ensured affect market acceptance of electric mobility (and, thus, purchase-related intentions).

### **2.3. The role of policy instruments in adopting EVs in organizations**

Policy instruments can help to address prevailing barriers to the adoption of EVs in corporate fleets and foster market acceptance. Bjerkan et al. (2016) categorize the existing policy instruments into four general *areas*. Within the *regulatory area* are such restrictions as obligatory emission targets for new vehicles or production standards. Within the *economic area*, price or quantity changes through tax reductions or direct subsidies influence market outcomes (Leurent & Windisch 2011; Kley et al., 2012). Within the *organizational area*, hurdles for developing the necessary infrastructure are reduced, e.g., by developing the charging infrastructure network or creating free parking spaces in city centers. Finally, the *suasive area* includes measures for persuading buyers through information and education (Leurent & Windisch 2011; Kley et al., 2012).

Of all these general policy areas, the *economic area* is of particular relevance at the early stage of commercialization (IEA, 2013) and the most intensively researched (Larson et al., 2014; Sierzchula, 2014; Lieven, 2015; Bjerkan et al., 2016; Rietmann & Lieven, 2019). Nonetheless, the results of studies show that the effectiveness of financial incentives is not straightforward. For example, Zhang et al. (2014) report finding a very weak association between (purchase-related) subsidies and the willingness of consumers to buy EVs. Furthermore, financial incentives may have less effect on the further uptake of electric mobility if customers are also exposed to *soft barriers*, such as a high degree of unfamiliarity with the technology (i.e., display of a lack of trust or knowledge) (Egbue

& Long, 2012; Sierzechula et al., 2014) or low exposure to electric vehicles in the fleet around them (misperceptions about ease of usability) (Eppstein et al., 2011). This indicates that the mix of policy instruments should treat the adoption of electric mobility in a more holistic way (Held & Gerrits, 2019), addressing both *hard* and *soft barriers*.

In a practical case for the adoption of EVs in corporate fleets, Wikström et al. (2014) show that it has three prerequisites. The first two are fulfilling the transport requirements and expectations of drivers and/or operators and making the EVs economically competitive or even more attractive than comparable conventional vehicles, in terms of life-cycle costs. The third prerequisite is the social acceptance of electric mobility within the company (Wikström et al., 2014; Kaplan et al., 2016). Meeting these prerequisites calls for a holistic mix of policy instruments. The first two prerequisites are satisfied by reducing hard barriers through technological development and the deployment of policy instruments in the economic, regulatory, and organizational domains. Fulfilling the third prerequisite, a high level of social acceptance, requires further research on how to reduce acceptance-related soft barriers, such as a low level of usability or a lack of trust and knowledge. Again, this underlines the fact that a better understanding of the social acceptance of electric mobility within organizations is crucial for its further adoption (Kaplan et al., 2016; Globisch et al., 2018).

### 3. Study 1

Until now, most organizations have engaged in cautiously testing EVs, with the result that their economic potential and ecological benefits have not been exploited to the extent possible and necessary to meet climate goals (Minnich, 2017). Study 1, an online survey with Swiss fleet managers, is aimed at determining their preferences regarding motivators for and barriers against adopting electric mobility in corporate fleets and identifying policy-instrument preferences.

#### 3.1. Methodology

##### *Data and sample*

An online survey with Swiss organizations with corporate fleets, specifically targeted at fleet managers, was the basis of Study 1. A two-step procedure was used in the design of the survey instrument: First, relevant survey elements were identified, consistent with

feedback obtained from four expert interviews and a literature review (i.e., qualitative prestudy). The expert interviews were implemented with fleet managers from large Swiss companies between October and November 2017. Second, I identified potential survey participants (i.e., fleet managers) using keyword searches related to fleet management, applied to company lists and the websites of umbrella organizations. These individuals (n=125) were then contacted twice by e-mail (a first mailing and a reminder) and asked to participate by accessing a link to the online survey.

Data were collected between December 11, 2017, and January 21, 2018. In total, 85 fleet managers accessed the survey. Sample cleaning eliminated double entries and incomplete responses, resulting in a final sample containing data for in-depth analysis from 30 fleet managers (response rate of 24%). In online surveys with decision-makers from a specialized target group (in this case, fleet managers of large Swiss companies), the sample sizes are typically rather small (Chassot et al., 2014; Salm, 2018). Also, the decision-makers in the chosen target audience tend to be very busy and have difficulties deducting 15-20 minutes from their schedule to participate in a survey, explaining the rather low response rate.

### *Survey and measurement*

Respondents were first introduced to the project and the topic of electric mobility in corporate fleets. Several survey questions followed, grouped into three sections:

- *Section 1:* Fleet management criteria;
- *Section 2:* Motivators and barriers to the adoption of electric mobility in corporate fleets;
- *Section 3:* Preferences for policy instruments to increase the adoption of EVs.

The survey questions were selected based on a literature review and insights from expert interviews conducted prior to the survey (see Appendix A). The first set of questions in Section 1 analyzed the different criteria that organizations apply in their fleet-renewal processes. Section 2 asked fleet managers to indicate the most important motivators and barriers in relation to the introduction of electric vehicles into corporate fleets. Finally, Section 3 identified preferences for different policy instruments (local vs. national, monetary vs. nonmonetary). Question types were mainly designed as single or multiple-choice questions with responses entered on a four-point Likert-scale.

### 3.2. Results

Figure 1 shows how fleet managers ranked various fleet-management criteria by their importance. Not surprisingly, the criteria of reducing operating costs and purchasing prices are of great importance within fleet management, with both criteria evaluated as “important” or “very important” by 80% of respondents. Environmental considerations in fleet management (66% “important” or “very important”) and the possibility of servicing vehicles in the region (67% “important” or “very important”) are also highly relevant, whereas employee brand preferences (56% “not important” or “less important”) and reducing the number of vehicles in the fleet (74% “not important” or “less important”) are less relevant to fleet managers.

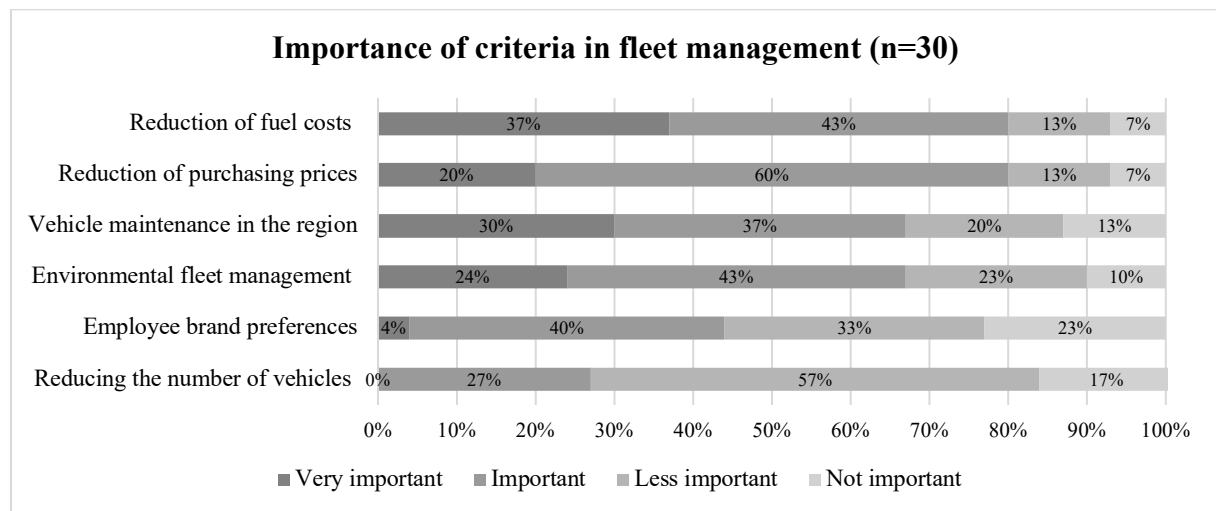


**Figure 1:** Importance of criteria in fleet management

Figure 2 shows the main motivators for introducing electric mobility in corporate fleets. Consistent with findings from the literature, the motivators “image gain” (77% “important” or “very important”) and “environmental friendliness” (70% “important” or “very important”) are significant motivators for electric mobility in corporate fleets. The need to motivate employees (44% “important” or “very important”) and reduce operating costs (43% “important” or “very important”) by introducing EVs are potential motivators, to a lesser extent. No evidence was found that technical elements, such as better fleet control (14% “important” or “very important”) or further sharing opportunities (16% “important” or “very important”), are significant sources of motivation. Consequently, only 30% of respondents perceive generating competitive

advantage through fleet management focused on electric mobility as an important motivator.

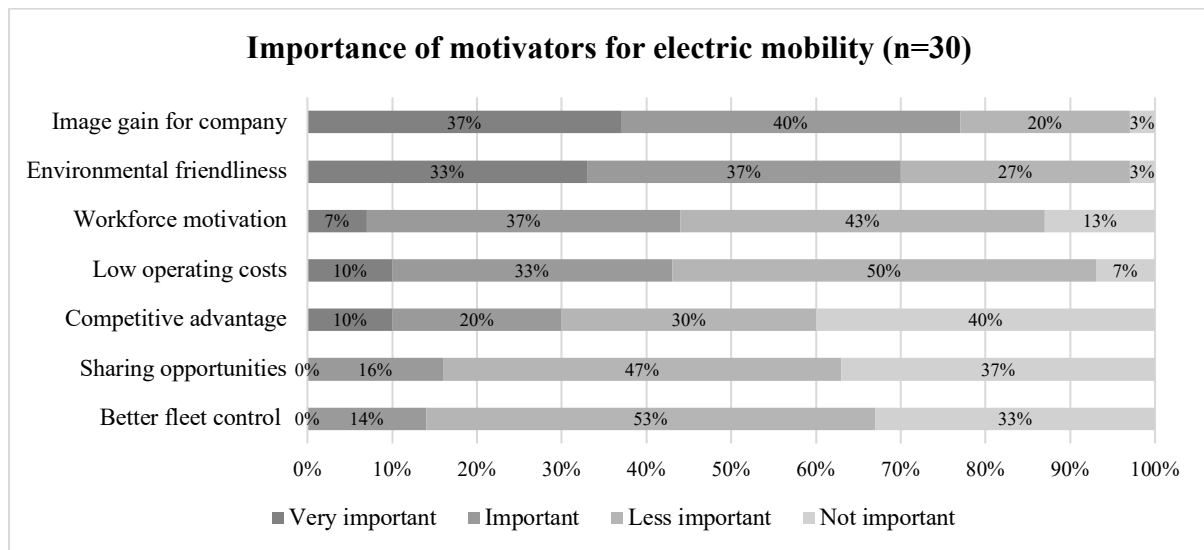


**Figure 2:** Importance of motivators for electric mobility

Figure 3 illustrates several significant barriers to electric mobility in corporate fleets. Participant responses constitute supporting evidence for such barriers as the limited availability of charging infrastructure (76% “important” or “very important”), the limited range and product portfolio of EVs (77% and 80%, respectively, rated them “important” or “very important”), and the higher upfront investment cost of EVs (80% “important” or “very important”). Further, the results show that in addition to the prevailing hard barriers, *soft barriers* should not be neglected. Acceptance-related soft barriers, such as a lack of knowledge (63% “important” or “very important”) as well as the lack of employee demand (56% “important” or “very important”) are important. A lack of management support does not seem to be a relevant factor, as only 27% of the respondents indicated it as an important or very important barrier.

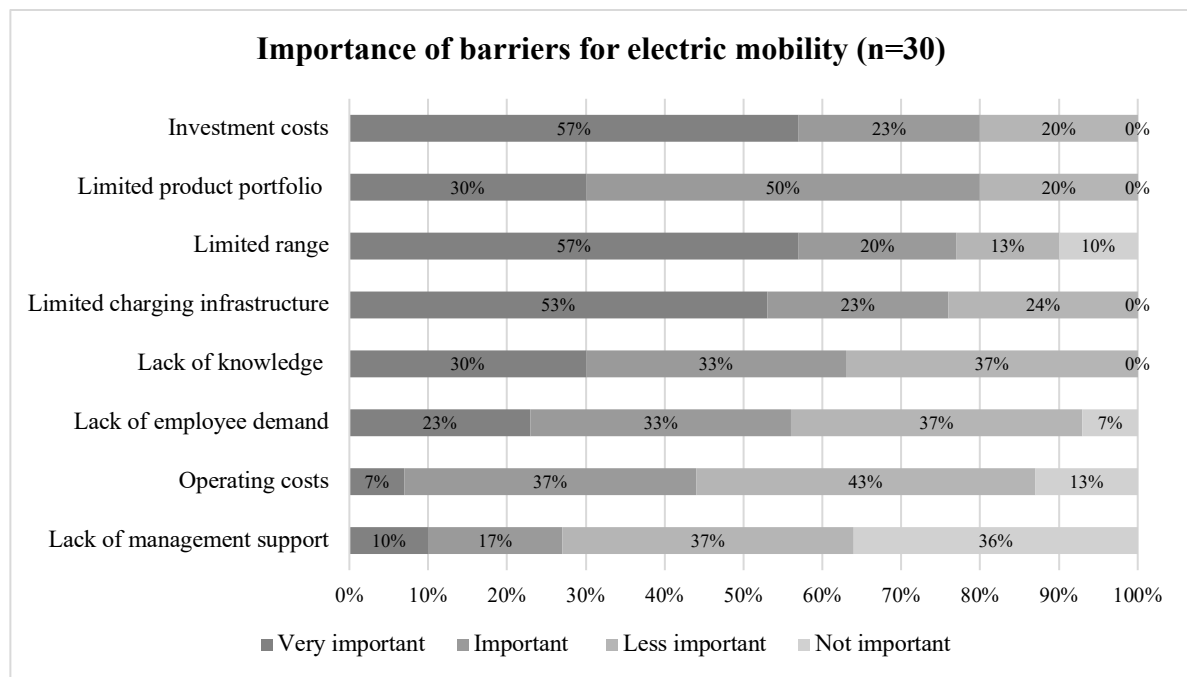


**Figure 3:** Importance of barriers for electric mobility

Regarding preferences for policy instruments, respondents indicate a preference for an increased federal commitment to the installation of charging infrastructure along highways. This is in line with findings where insufficient charging infrastructure density is identified as one main hard barrier. Free parking spaces on a municipal level are not seen as an important policy instrument (63% “not important” or “less important”). A reduction of the motor-vehicle tax at the state level is perceived differently: 56% of respondents consider this to be “important” or “very important,” whereas 43% consider it to be “less” or “not at all important.”

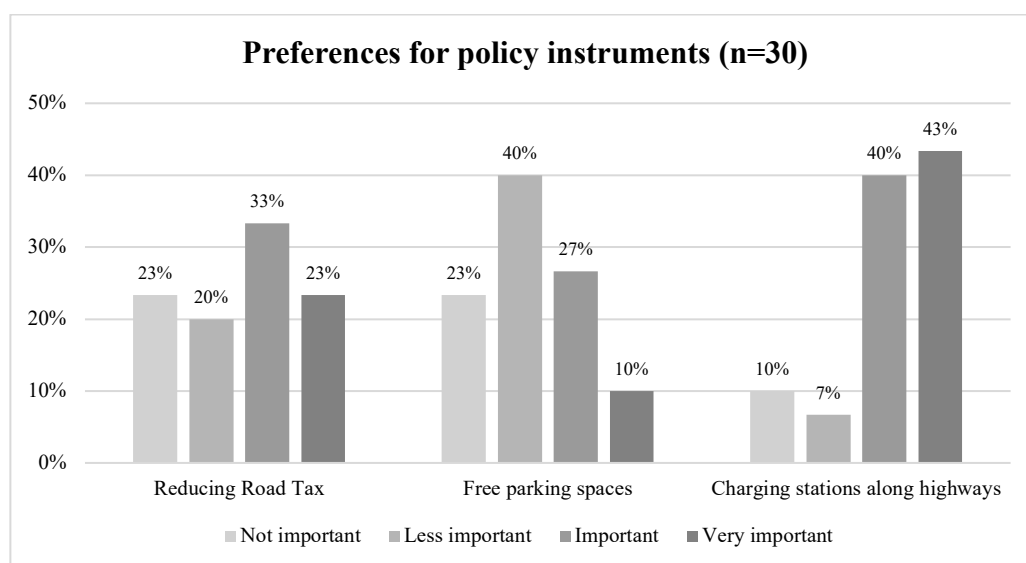


**Figure 4:** Preferences for policy instruments

### 3.3. Discussion

The results of Study 1 support other scholars' findings. For example, Barisa et al. (2016), Quak et al. (2016), and Degirmenci and Breitner (2017) show that important motivators for electric mobility center on their positive environmental impact and positive contribution to corporate image. In line with their findings, the results of Study 1 show that the motivators "*image gain*" and "*environmental friendliness*" are seen as most important for the further expansion of electric mobility within organizations. Interestingly, the literature also states that lower fuel costs and high efficiency (i.e., low operating costs) of EVs are an important source of motivation (Haddadian et al., 2015). The results of Study 1 also show that reducing operating costs is one of the main criteria in the fleet-management process generally (80% of respondents indicated it is "important" or "very important"). However, only 43% of surveyed fleet managers consider the ability to reduce operating costs through the introduction of EVs to corporate fleets as an important motivator. This indicates that the barrier of lack of knowledge also represents a major hurdle at the fleet-manager level. EVs not only benefit from lower operating costs but are already competitive with conventional vehicles in terms of total cost of ownership (Palmer et al., 2018; IEA, 2019).

The present results support other scholars' findings on *hard barriers* that limit the uptake of EVs in corporate fleets. Biresselioglu et al. (2018) and Newbery and Strbac (2016) also show that such barriers as limited charging infrastructure, a limited range and product portfolio, and the higher upfront investment costs of EVs still prevail. These results further support the findings of Study 1 in the area of policy-instrument preferences. The surveyed fleet managers clearly prefer an expansion of the charging infrastructure on a national level and, to a lesser extent, a reduction of motor-vehicle taxes on a state level, which, in turn, would reduce the barrier of higher upfront investment costs.

Most striking, however, is the confirmation of the importance of *soft barriers* for the further uptake of electric mobility within organizations, as identified by scholars including Ziefle et al. (2014), Shao et al. (2016), and Globisch et al. (2018). Acceptance-related aspects, such as a lack of knowledge (indicated to be "important" or "very important" by 63% of respondents) and, to a lesser extent, the lack of employee demand (56% "important" or "very important") are regarded as significant barriers to the further uptake of electric mobility within organizations. Also, Biresselioglu et al. (2018) show

that a lack of general knowledge about EVs may constitute an important barrier to their further adoption. Consequently, *Study 2* was conducted to further investigate the role of acceptance-related soft barriers and, especially, to analyze whether and how to reduce them and subsequently increase social-acceptance levels.

## 4. Study 2

Study 1 showed that acceptance-related soft barriers are important and can be a limiting factor in the further uptake of electric mobility. Currently, only a very limited number of campaigns are in place to address acceptance-related soft barriers.<sup>4</sup> Therefore, a specific campaign was created in collaboration with the Office for Environment and Energy of the city of St. Gallen.<sup>5</sup> The aim of Study 2 was to conduct a field experiment to test whether a campaign, developed to address the acceptance-related soft barriers identified in Study 1, can affect social acceptance and, hence, behavior and the likelihood of organizations adopting electric vehicles.

### 4.1. Behavioral-intervention campaign for addressing acceptance-related soft barriers

The behavioral intervention campaign (“*Wirtschaft unter Strom*”<sup>6</sup>) was designed to provide professional users with electric-vehicle test drives in the normal course of business life, in a simple and unbureaucratic way, free of charge, and without obligation (see Appendix B). Companies could reserve an electric vehicle of choice for the desired week on a reservation platform. The EV was delivered to the company and its functioning explained to the car pool user, after which the company and the car pool user could test the electric vehicle daily for one week. Temporary charging infrastructure was also provided as part of the campaign (the municipal utility of St. Gallen was in charge of installing the necessary temporary infrastructure directly on site<sup>7</sup>). After the trial week, the company returned the vehicle and assumed no further costs, consequences, or liabilities.

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<sup>4</sup> One example in the Swiss context: *Trade association of the city of Basel—EVs for your organization*: <https://gewerbe-basel.ch/themen/umwelt-energie/wirtschaft-strom/>

<sup>5</sup> The developed campaign is based on the campaign implemented by the trade association of the city of Basel.

<sup>6</sup> See Appendix B, and for more information: [www.wirtschaftunterstrom.ch](http://www.wirtschaftunterstrom.ch)

<sup>7</sup> The costs for this were negligible, as the municipal utility provided mobile charging stations that could be set up and dismantled on-site without much effort.

## 4.2. Methodology

In most countries, the share of electric vehicles in the overall vehicle fleet is still low.<sup>8</sup> This has important implications for the methodological approach. Skippon and Garwood (2011) report that newer forms of technology with which consumers lack experience may be perceived as more abstract. Therefore, a methodological approach that asks car pool users to evaluate new products without the necessary experience can hardly lead to valid predictions of likely future behavior (Schneider et al., 2014; Sierzchula, 2014; Globisch et al., 2018). This research paper focuses on a field experiment that allows consumers to test electric vehicles over a longer period.

As a research method, the field experiment offers several advantages. First, field experiments take place in the natural environment; hence, they are more generalizable to the real world (Allen, 2017). In addition, field experiments can help to reduce concerns about a social-desirability bias (Baldassarri & Abascal, 2017). Field experiments are also suited to finding out more information about complicated relationships or perceptions than survey research methods or laboratory experiments can (Allen, 2017). This makes field experiments particularly useful when the topic has only received limited study (Baldassarri & Abascal, 2017). On the other hand, concerns to consider are associated with the experimental design and the manipulation. To counteract these requires a clear and well-structured design and intervention (Allen, 2017).

Accordingly, a field experiment with the behavioral-intervention campaign outlined above was applied. This allowed examination of how the perceptions of key individuals (car pool users) for different elements of electric mobility change and how the level of acceptance changed when car pool users were exposed to the campaign and gained experience with electric vehicles. The field experiment included a two-stage interview process to identify potential changes in social acceptance levels for different EV elements over time:

- At **T0**, the expectations and assessments of the car pool user regarding electric mobility were determined **prior** to the trial period.

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<sup>8</sup> In 2019, electric vehicles accounted for 4.2% of newly registered passenger vehicles in Switzerland. Overall, electric vehicles represent 0.6% of the Swiss overall passenger-vehicle fleet (BFS, 2020).

- At **T1**, the expectations and assessments of the car pool user regarding electric mobility were determined **after** the trial period.

### *Variables and measurement*

To measure the dependent variable (degree of acceptance of various EV-related elements), participants were asked to answer 17 questions classified into eight categories (ease of use/usefulness, environmental friendliness, enthusiasm, range, charging infrastructure and process, price competitiveness, information intentions, and purchase intentions) and measured on a seven-point Likert scale ranging from “1”=“entirely disagree” to “7”=“entirely agree”. The behavioral-intervention campaign acted as the independent variable. The interviews included questions about the expected advantages and disadvantages of electric vehicles and general acceptance-related elements, as well as more detailed questions about the specific characteristics of electric vehicles and related infrastructure (see Appendix D).

### *Sample and procedure*

To include a sufficient number of participating companies in the field experiment, after the campaign was finalized, the following procedure was implemented.

- The city of St. Gallen launched the new campaign, “*Wirtschaft unter Strom*”, with an official media release followed by an additional newsletter to all companies located within the city boundaries of St. Gallen.
- Within three weeks, 13 companies registered for the new offer. They were all contacted individually and asked whether they would be willing to take part in a two-stage interview process as part of the campaign. Of the 13 companies, 10 agreed to participate in the interviews.

The two-stage interview process was implemented for each participating company. The ten companies operate in various sectors and are of different sizes, thus representing a broad spectrum (a description of all companies participating in the field experiment appears in Appendix C). In general, the interviews ranged from 20 to 30 minutes for each stage and were conducted in person. Pretesting with industry experts as well as a trial company, to verify and adapt the interview questions and guidelines, occurred in advance. After the pretest, the interview questions and guidelines were maintained for all ten companies. The interviewer took notes during the interviews, then transcribed and documented them in a standardized format to increase overall analytical validity.

### 4.3. Results

Figure 5 shows the extent to which the levels of acceptance in the categories changed from before (T0) to after (T1), the trial period. The results of the field experiment show that the level of acceptance rose in all categories. Therefore, the behavioral-intervention campaign appears to have had a clearly positive effect on the social acceptance of electric mobility for key people within the organizations (car pool users).

A closer look at the individual categories reveals further interesting findings. Categories with a focus on acceptance-related soft barriers, such as “Ease of use/usefulness” (increase from 5.00 in T0 to 6.17 in T1) or “Enthusiasm” (motivation to adopt electric mobility within organizations, increased from 4.83 in T0 to 6.17 in T1) show a strong increase in acceptance.

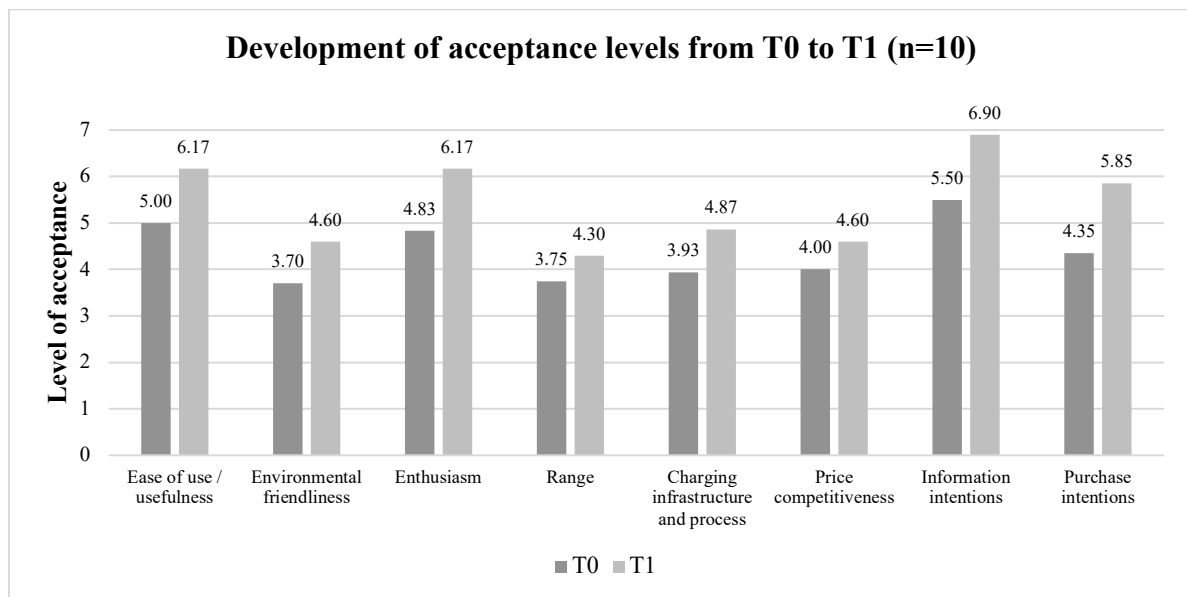


**Figure 5:** Development of acceptance levels from T0 to T1

The results further indicate that introduction of such a campaign can address the perception of prevailing *hard barriers*, although to a lesser extent than categories with acceptance-related elements (*soft barriers*). The results for the hard barriers, such as limited range (increase from 3.75 in T0 to 4.30 in T1), the limited availability of charging infrastructure (assessment of sufficient charging infrastructure increased from 3.93 in T0 to 4.87 in T1) and higher upfront investment costs (assessed via question asking whether EVs are financially competitive with conventional vehicles; increased from 4.00 in T0 to 4.60 in T1) indicate as much. Finally, categories concerning future

behavior (information as well as purchase intentions) also indicate a strong increase in acceptance. “Information intentions” (assessment of whether the car pool user will become more informed about electric mobility in the future) increased from 5.50 (T0) to 6.90 (T1). “Purchase intentions,” (assessed using the question whether the car pool user today would recommend that others buy an electric vehicle and to what extent they would consider buying an electric vehicle at the time of next vehicle purchase or replacement) increased from 4.35 (T0) to 5.85 (T1). These results highlight the positive effect of the behavioral-intervention campaign on the social-acceptance level of electric mobility by car pool users and in relation to information and purchasing intentions.

#### 4.4. Discussion

The objective of Study 2 was to analyze whether the campaign “*Wirtschaft unter Strom*” could address the acceptance-related soft barriers identified in Study 1 (lack of knowledge and lack of demand by employees) and, consequently, increase the social acceptance, as well as the likelihood of adopting electric vehicles within organizations.

The results indicate a generally positive effect for various social acceptance related elements, especially *soft barriers* and, to a lesser extent, *hard barriers*. Thus, overall, the campaign appears able to contribute to one of the prerequisites for the further expansion of electric mobility, namely, the establishment of a high level of social acceptance for electric mobility within organizations. This result supports findings of other scholars, such as Held and Gerrits (2019), who advocate for a more holistic way of addressing EV adoption, especially by addressing soft barriers next to the prevailing hard barriers; as well as Bühler et al. (2014), who also show in their case study that experience exerts a positive effect on the general acceptance of EVs.

More particularly, the results of the field experiment indicate the ability to address specific acceptance-related soft barriers. In all categories, the degree of acceptance and the increase in knowledge about specific elements (range, price, ease of use, enthusiasm, charging infrastructure, environmental friendliness) were observable (see Figure 5). Thus, the introduction of such a campaign can reduce the “lack of knowledge” barrier, identified as an important barrier in Study 1. The results further indicate that it is possible to address relevant elements defining the social acceptance of electric mobility, such as social aspects and emotional attitudes that Globisch et al. (2018) mention. The results show that the campaign positively influences the level of “Enthusiasm,” thus motivating key people (car pool users) within organizations to become more enthusiastic

about electric mobility and, subsequently, to spread this enthusiasm within the organization. Additionally, the strong increase in future information intentions after the trial period can contribute to car pool users taking on the role of influencers within the organization, to provide relevant information to other members.

This research project supports Anable et al.'s (2011) and Schmalfuß et al.'s (2017) claim that having more information and experience about such new technology as electric mobility can increase the intention to purchase. Obtaining first-hand experience of electric mobility in the workplace environment over an extended period, and thus, more information about the technology, positively affects both information-related and purchasing intentions, exerting a positive effect on market acceptance. This is in line with Roger's diffusion theory (2003), namely, that trialability (the degree to which experimenting with new technology can occur) positively correlates with the adoption rate. The more an innovation can be tried, the faster it can spread (Rogers, 2003).

Overall, the campaign "*Wirtschaft unter Strom*" proved capable of helping close the gap between expectations and actual perceptions of electric mobility in corporate fleets, increasing the level of social acceptance among key individuals within organizations.

## 5. Conclusions and policy implications

### 5.1. Summarizing remarks

This paper adds to research that examines the social acceptance of electric mobility in corporate fleets. It adds theoretical as well as practical value by identifying important acceptance-related soft barriers and designing, applying, and evaluating a behavioral-intervention campaign that addresses such barriers. The design of the research that this paper describes aimed to answer three research questions:

1. *What are the biggest sources of motivation and barriers for Swiss fleet managers with regard to the electrification of corporate fleets?*
2. *To what extent do acceptance-related barriers influence the electrification of corporate fleets?*
3. *How does a behavioral-intervention campaign that addresses acceptance-related barriers affect the likelihood of choosing electric mobility in corporate fleets?*

Literature in the field of social acceptance of electric mobility in corporate fleets remains scarce. Based on an online survey with Swiss fleet managers and a field experiment including a behavioral-intervention campaign, the present results indicate that several *hard barriers* to the further expansion of electric mobility, especially in corporate fleets, still prevail. The results further indicate the importance of acceptance-related *soft barriers*. A lack of knowledge was identified by 63% of respondents as an important or a very important barrier, and a lack of demand from employees was similarly identified by 56% of respondents.

The results of the field experiment indicate that the behavioral-intervention campaign can successfully address acceptance-related barriers, associated as it is with a significant positive increase in the acceptance levels of EV-related variables. An increase in the acceptance level for EV-related elements (range, price, ease of use, charging infrastructure, environmental friendliness, and enthusiasm), due to the increase in experience and knowledge, can be observed at T1 (after the trial offer). Furthermore, positive intentions relating to future behavior were also identified. Information intentions as well as purchasing intentions strongly increased from T0 to T1.

These results also support the findings of other researchers concerning the fact that reducing exposure to *soft barriers*, such as lack of knowledge or the perceived low level of EV usability, can help to increase the effectiveness of other policy instruments (e.g., financial incentives (Wang et al., 2019)). This research paper adds evidence for tackling *soft barriers* alongside *hard barriers* to ensure that current policy instruments focusing on overcoming hard barriers have the intended effect (Held & Gerrits, 2019).

## 5.2. Policy implications

The findings of this research project have several policy implications. Authorities at the national level would be well advised to consider introducing campaigns that target acceptance-related *soft barriers* as an element of their policy mix, as well as an integral part of their roadmaps, especially for corporate fleets. Further institutionalizing acceptance-related features within the policy mix could help to increase the share of electric mobility. For instance, Swiss policy envisages different instruments for corporate fleets but aims at overcoming acceptance-related soft barriers only at a later phase of its electric-mobility roadmap (UVEK, 2019). Establishing more behavior-oriented communication with campaigns that target acceptance-related soft barriers as a

central pillar of the policy mix, alongside the pillars that address hard barriers, could benefit the further adoption of electric mobility.

On a local level, city and municipal authorities could replicate or adapt the campaign “*Wirtschaft unter Strom*,” including it in their local mobility concepts as part of the local policy mix to reach their mobility targets. Alternatively, municipalities in a region could partner up and launch corresponding campaigns in cooperation with local car dealers.

Adding a campaign such as “*Wirtschaft unter Strom*” as an additional element in the overall policy mix could represent a missing piece of the puzzle for promoting the further adoption of electric mobility in corporate fleets.

### **5.3. Limitations and further research**

The research this paper describes has limitations that may spur further research. First, the results of the field experiment are based on the chosen elements of the campaign “*Wirtschaft unter Strom*.” Further research could replicate the field experiment with varying the components. For example, the free-trial test offer was limited to one week of normal business. It would be interesting to see whether the effects changed if the duration were increased or decreased (for example, trial day vs. trial month).

The unique part of this research project is the combination of an online survey and a field experiment with a behavioral-intervention campaign. Both the online survey (Swiss fleet managers) and the field experiment (car pool users from companies within the city boundaries of St. Gallen) used a limited number of participants. A second promising research initiative might be scaling both the survey and the experiment. For example, cooperation with a car rental company could achieve a multiplication effect.

Finally, the focus on the B2B context is one element that makes this study distinctive. It would thus be interesting to explore the topic of intrafirm diffusion dynamics — i.e., to conduct interviews with colleagues of the car pool user who were exposed to the behavioral-intervention campaign, such as fellow car pool users, the fleet manager, and management board members, to see the extent to which peer effects emerge.

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## Appendix

### Appendix A: Online survey design

*Survey introduction text:*

Welcome!

This survey is part of a research project on the topic of "Electric mobility." Electric mobility is currently being intensely discussed. For companies too, the issue of adding electric vehicles to the corporate fleet is becoming more important. Therefore I would be thankful if you could take the next 15-20 minutes to answer the following questions. Please take your time and read the questions carefully. In order to get a realistic picture, we ask you to respond to the questions and tasks honestly. If you have any questions or want to know more about the project, please feel free to send me an e-mail: [pascal.vuichard@unisg.ch](mailto:pascal.vuichard@unisg.ch)

The survey data will be treated confidentially and no conclusions will be drawn about individuals. This means that all your answers and comments will be completely anonymous.

Thank you very much in advance for your participation!

Please click on "Continue" to start the survey.

*Survey questions<sup>9</sup>:*

| <b>Question 1:</b> Which criteria are relevant for your company in the corporate fleet renewal process? |                      |                |           |                |
|---------------------------------------------------------------------------------------------------------|----------------------|----------------|-----------|----------------|
|                                                                                                         | Not at all important | Less important | Important | Very important |
| Reduction of purchase price                                                                             |                      |                |           |                |
| Reduction of fuel costs                                                                                 |                      |                |           |                |
| Reduction of number of vehicles                                                                         |                      |                |           |                |
| Brand preferences of employees                                                                          |                      |                |           |                |
| Vehicle maintenance in the region                                                                       |                      |                |           |                |
| Environmentally conscious fleet management, e.g. through fleet electrification                          |                      |                |           |                |

Appendix A: Survey questions I

| <b>Question 2:</b> To what extent are the following people involved in the decision-making process of establishing the criteria for the fleet renewal process? |                     |   |   |   |                     |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|---|---|---|---------------------|
|                                                                                                                                                                | Not involved at all | - | - | - | Main decision-maker |
| Fleet manager                                                                                                                                                  |                     |   |   |   |                     |
| Management                                                                                                                                                     |                     |   |   |   |                     |
| Purchaser                                                                                                                                                      |                     |   |   |   |                     |

Appendix A: Survey questions II

<sup>9</sup> Questions have been translated from their original German versions.

| <b>Question 3:</b> Where do you see the main opportunities for the electrification of your corporate fleet? |            |     |        |      |
|-------------------------------------------------------------------------------------------------------------|------------|-----|--------|------|
|                                                                                                             | Not at all | Low | Medium | High |
| Low operating costs                                                                                         |            |     |        |      |
| Environmental friendliness                                                                                  |            |     |        |      |
| Motivation for employees                                                                                    |            |     |        |      |
| Image boost for company                                                                                     |            |     |        |      |
| Competitive advantage over rivals                                                                           |            |     |        |      |
| Better sharing of fleet                                                                                     |            |     |        |      |
| Better control and management of fleet                                                                      |            |     |        |      |

Appendix A: Survey questions III

| <b>Question 4:</b> Where do you see the main barriers to the electrification of your corporate fleet? |            |     |        |      |
|-------------------------------------------------------------------------------------------------------|------------|-----|--------|------|
|                                                                                                       | Not at all | Low | Medium | High |
| Limited reach                                                                                         |            |     |        |      |
| Limited availability of charging infrastructure                                                       |            |     |        |      |
| High operating cost                                                                                   |            |     |        |      |
| High up-front investment cost                                                                         |            |     |        |      |
| Lack of knowledge                                                                                     |            |     |        |      |
| Limited availability of vehicle models                                                                |            |     |        |      |
| Lack of management support                                                                            |            |     |        |      |
| Lack of demand from employees                                                                         |            |     |        |      |

Appendix A: Survey questions IV

| <b>Question 5:</b> Policy measures for electric mobility: What measures do we need in Switzerland? |                      |                |           |                |
|----------------------------------------------------------------------------------------------------|----------------------|----------------|-----------|----------------|
|                                                                                                    | Not at all important | Less important | Important | Very important |
| Reduction of motor vehicle tax at state level                                                      |                      |                |           |                |
| Creation of free parking spaces by municipality                                                    |                      |                |           |                |
| Installation of charging stations along motorways by federal government                            |                      |                |           |                |

Appendix A: Survey questions V

## Appendix B: Behavioral intervention campaign «Wirtschaft unter Strom»

Homepage link: <https://wirtschaftunterstrom.ch>

Procedure I:



Illustration of booking process I (authors' figure, 2020)

*Procedure II:*

**Reservieren**

Fahrzeug Datum Personalien Bestätigen

---

**Personenwagen**

Audi A3 e-tron Nissan Leaf Peugeot iOn VW e-Golf

BMW i3 Hyundai Kona electric Renault Zoe

**Nutzfahrzeuge**

Mercedes Benz eVito Nissan E-NV Peugeot Partner Electric

**Weiter**

Illustration of booking process II (authors' figure, 2020)

## Appendix C: List of companies that participated in the field experiment

|    | Company                         | Sector                                                  | EV tested                |
|----|---------------------------------|---------------------------------------------------------|--------------------------|
| 1  | Funk Holzbau Programme GmbH     | Woodworking company, construction sector                | Hyundai Kona             |
| 2  | Alea Iacta AG                   | Communication agency, communication sector              | Audi e-tron              |
| 3  | Mock-Technik in Holz AG         | Woodworking company, construction sector                | VW e-Golf                |
| 4  | St.Galler Kantonalbank AG       | Regional bank, financial sector                         | Audi e-tron              |
| 5  | R. Christen AG                  | Metalworking company, construction sector               | Peugeot Partner Electric |
| 6  | ASGA Pensionskasse              | Regional pension fund, financial sector                 | Nissan Leaf              |
| 7  | Restaurant Fondue Beizli Neueck | Local restaurant chain, hospitality sector              | Audi A3 e-tron           |
| 8  | BodyArtWork                     | Company with various therapeutic offers, medical sector | Audi e-tron              |
| 9  | merz+egger AG                   | Roofing company, construction sector                    | Mercedes Benz eVito      |
| 10 | Nänny + Partner AG              | Civil engineering company, construction sector          | VW e-Golf                |

Appendix C: List of companies that participated in the field experiment

## Appendix D: Field experiment questionnaire and categories

| Questionnaire on electric mobility      |                                                                                 |                 |                   |                            |                |              |                |  |  |
|-----------------------------------------|---------------------------------------------------------------------------------|-----------------|-------------------|----------------------------|----------------|--------------|----------------|--|--|
|                                         | Entirely disagree                                                               | Mostly disagree | Somewhat disagree | Neither agree nor disagree | Somewhat agree | Mostly agree | Entirely agree |  |  |
| Category:<br>Simplicity / usefulness    | I think using an electric vehicle is easy.                                      |                 |                   |                            |                |              |                |  |  |
|                                         | I think operating an electric vehicle would be clear and understandable for me. |                 |                   |                            |                |              |                |  |  |
|                                         | I believe that electric vehicles are useful for day-to-day business.            |                 |                   |                            |                |              |                |  |  |
| Category:<br>Environmental friendliness | I believe that electric vehicles are environmentally friendly.                  |                 |                   |                            |                |              |                |  |  |
|                                         |                                                                                 |                 |                   |                            |                |              |                |  |  |
| Category:<br>Enthusiasm                 | I think electric mobility would fascinate me.                                   |                 |                   |                            |                |              |                |  |  |
|                                         | I have positive views about electric mobility                                   |                 |                   |                            |                |              |                |  |  |
|                                         | I believe that electric mobility brings great driving pleasure.                 |                 |                   |                            |                |              |                |  |  |

Appendix D: Field experiment questionnaire and categories part I

| Questionnaire on electric mobility   |                                                                                                      |                 |                   |                            |                |              |                |
|--------------------------------------|------------------------------------------------------------------------------------------------------|-----------------|-------------------|----------------------------|----------------|--------------|----------------|
|                                      | Entirely disagree                                                                                    | Mostly disagree | Somewhat disagree | Neither agree nor disagree | Somewhat agree | Mostly agree | Entirely agree |
| Category:<br>Range                   | I believe that electric vehicles have sufficient range.                                              |                 |                   |                            |                |              |                |
|                                      | I have a lot of confidence in the indicated range of electric vehicles.                              |                 |                   |                            |                |              |                |
| Category:<br>Charging infrastructure | I believe that the charging time of EV batteries is short.                                           |                 |                   |                            |                |              |                |
|                                      | I believe that the process of charging EV batteries is easy.                                         |                 |                   |                            |                |              |                |
|                                      | I believe that there are enough charging stations available.                                         |                 |                   |                            |                |              |                |
| Category:<br>Cost                    | I believe that electric mobility has low investment costs (e.g. purchase price, leasing rates).      |                 |                   |                            |                |              |                |
|                                      | I believe that electric mobility has low operating costs (e.g. electricity price, insurance, taxes). |                 |                   |                            |                |              |                |

## Appendix D: Field experiment questionnaire and categories part II

| Questionnaire on electric mobility         |                                                                                         |                 |                   |                            |                |              |                |
|--------------------------------------------|-----------------------------------------------------------------------------------------|-----------------|-------------------|----------------------------|----------------|--------------|----------------|
|                                            | Entirely disagree                                                                       | Mostly disagree | Somewhat disagree | Neither agree nor disagree | Somewhat agree | Mostly agree | Entirely agree |
| <b>Category:</b><br>Information intentions | In the future I will become better informed about the development of electric vehicles. |                 |                   |                            |                |              |                |
|                                            |                                                                                         |                 |                   |                            |                |              |                |
| <b>Category:</b><br>Purchase intentions    | When I buy my next vehicle, I will consider an electric vehicle.                        |                 |                   |                            |                |              |                |
|                                            | Today, I would recommend that others buy an electric vehicle.                           |                 |                   |                            |                |              |                |

Appendix D: Field experiment questionnaire and categories part III

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## Curriculum Vitae



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### Education

|                   |                                                                                                                                                                                                     |
|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 02/2016 – today   | <b>University of St. Gallen (HSG), Switzerland</b><br>PhD candidate at the Institute for Economy and the Environment – with focus on social acceptance of renewable energies and electric mobility  |
| 09/2013 – 04/2016 | <b>University of St. Gallen (HSG), Switzerland /<br/>London School of Economics (LSE), Great Britain</b><br>Master in Accounting and Finance (M.A. HSG) and CEMS Master in International Management |
| 09/2009 – 02/2013 | <b>University of St. Gallen (HSG), Switzerland</b><br>Bachelor in Business Administration (B.A. HSG)                                                                                                |
| 08/2011 – 12/2011 | <b>Université Laval Québec, Canada</b><br>Exchange semester, focus on finance and international management                                                                                          |

### Professional Experience

|                   |                                                                                                                                                                                                                                |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 02/2016 – today   | <b>University of St. Gallen (HSG), Switzerland</b><br>Research Associate and Programme Manager of the Executive Education Programme in Renewable Energy Management (REM-HSG) at the Chair for Management of Renewable Energies |
| 01/2020 – 09/2020 | <b>ZHAW Zurich University of Applied Sciences, Switzerland</b><br>Lecturer in business administration with a focus on sustainability                                                                                           |
| 04/2020 – 09/2020 | <b>Glarus hoch3 AG</b><br>Member of the board of directors                                                                                                                                                                     |
| 04/2018 – 09/2020 | <b>Alters- und Pflegeheime Glarus Nord, Switzerland</b><br>Member of the board of directors, strategic responsibility for marketing and sustainability of the elderly care centers in Glarus Nord                              |
| 06/2018 – 09/2020 | <b>Landrat Kanton Glarus, Switzerland</b><br>Member of parliament, member of the commission for energy and environment                                                                                                         |
| 04/2018 – 09/2020 | <b>Gemeinde Glarus Nord, Switzerland</b><br>Member of the executive city council, responsible for the department of health, youth and culture                                                                                  |
| 06/2013 – 09/2013 | <b>WOTR India, Ahmednagar, India</b><br>Research intern in the field of water management and renewable energies                                                                                                                |
| 04/2012 – 06/2013 | <b>SAP, Regensdorf, Switzerland</b><br>Inside Marketing Executive                                                                                                                                                              |