Societal perception of electric road systems in Germany and Sweden

A working paper from the CollERS2 project

Uta Burghard[1]*, Aline Scherrer[1], Marvin Helferich[1]

[1] Fraunhofer Institute for Systems and Innovation Research ISI, Breslauer Str. 48, 76139 Karlsruhe

* uta.burghard@isi.fraunhofer.de

Content

1 Executive Summary

Road transport is still heavily dominated by fossil fuel usage. CO_2 emissions of heavy-duty road transport are even expected to continue to grow in the future. This points to both the necessity and challenge of a net-zero transition in this sector. Among the multiple alternative technologies enabling low carbon road transport, Electric Road Systems (ERS) have the potential to allow electric vehicles to drive longer distances without having to stop for recharging. In addition, dynamic charging while driving makes smaller battery sizes possible. ERS can either be designed as overhead catenary systems, as conductive tracks in the road, or as inductive tracks. However, the role of ERS in the transport system of the future remains unclear and research on the question in how far ERS meet relevant stakeholder requirements is needed.

In this working paper, a result of the CollERS2 project, we identify important acceptance factors for ERS in Germany and Sweden, taking into account different actor groups. The analysis includes two steps: (1) a literature review on actors and acceptance of ERS and on success factors of technology processes and experimentation and (2) two expert workshops on the experiences with and evaluations of ERS field trials in the two countries.

The literature review and the workshops show differences in the social acceptance of past and ongoing ERS field trials in Germany and Sweden. Local residents in Germany exhibit critical attitudes towards catenary trucks and infrastructure. In Sweden, the public were perceived as less critical. At the same time, similar benefits of the technology were identified in the discussion around the field trials in both countries.

The literature review revealed a number of success factors for technology field tests. Some of them were found to be lacking when analysing the discussions in the first workshop. For example, "strong and comprehensive coalitions" as well as a "vision for upscaling" seem to be missing in the ERS field tests, which could be linked to the lack of acceptance of certain industry actors. Finally, the experts discussed a potential negative influence of the Covid-19 pandemic on the social acceptance of ERS since fewer trucks than planned were operated on the test tracks and no social gatherings to explain the technology to local residents were possible. This related back to the (missing) success factors "Discourses" and "Public perception" identified in the literature.

In the second workshop, strategies to increase acceptance were discussed. The strategies to boost the success of the field tests that were discussed by the experts correspondedto some of the success factors identified in the literature review for field tests in general. For example, communicating the technical and environmental impact of the technology to affected local actor groups as well as public consultation formats were seen as effective measures to increase social acceptance. In addition, learning from similar technologies was seen as a way to inform the design of public participation and information measures and relates back to the succes factor "Evaluation, learning and capacity building".

The fact that not all of the success factors identified in the literature could be demonstrated in the field trials offers potential for improvement in current or future field trials on ERS.

2 Introduction

Road transport is still heavily dominated by fossil fuels usage. Globally, transport is responsible for about one third of CO_2 emissions from end-use sectors in 2021. The largest share of the transport CO_2 emissions comes from road transport with about 76% (International Energy Agency 2023). The CO_2 emissions of heavy-duty road transport are expected to continue growing in the future (International Energy Agency 2023). This points to the necessity and challenge of a net-zero transition in this sector.

Multiple alternative technologies enabling low carbon road transport are already becoming commercially available or are under development. These technologies include the direct use of electricity in battery electric and plug-in hybrid trucks (BET and PHET) with stationary or dynamic charging via so-called Electric Road Systems (ERS), Fuel Cell Electric Trucks (FCET), bio-fuels and synthetic renewable fuels. These options are in different stages of commercialisation and development for heavy duty vehicles (HDV), but have not diffused widely yet.

Electric road systems include catenary systems, conductive tracks and inductive tracks. ERS have the potential to allow electric vehicles to drive longer distances withouth charging. In addition, smaller battery sizes are possible (Gadgil et al. 2022). Despite these advantages, the role of ERS in the transport system is currently unclear. Most research so far focuses on technical and economic considerations. Hence, research on the question in how far ERS meet the stakeholder requirements is needed (Gadgil et al. 2022).

The present working paper is the result of an international collaboration on ERS research, the CollERS2 project. The aim of this working paper is to identify important acceptance factors for ERS in different actor groups, taking into account cultural differences and different political and infrastructural framework conditions. For this a joint conceptualization, analysis and supplementary empirical study are conducted in order to use the individual field trials and countries as comparative cases for a richer picture of the socio-technical system around catenary trucks and its drivers and barriers. The analysis takes two steps: (1) a synthesis of the available literature and (2) expert workshops on the experiences and evaluations in the different field trials in the studied countries.

This paper is structured as follows: Chapter 2 describes the theoretical background for the research. In chapter 3 the results of two literature reviews which provided the background for the empirical data collection are presented. Chapter 4 outlines the methods and results of the expert workshops on the experiences and evaluations in the different field trials in the countries participating in the project CollERS. Chapter 5 discusses the findings and in chapter 6, a conclusion and an outlook are given.

3 Theoretical background: Actors and acceptance in the context of ERS

3.1 Social acceptance

The concept of acceptance can be defined 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, organi-sation)" (Upham et al. 2015). In this respect, acceptance can manifest itself at different levels (from attitude to behaviour or use), refer to different objects (technology vs. socio-technical system) and manifest itself in different subjects of acceptance (from the individual to households and organisations to popula-tions of a country).

The concept of social acceptance also distinguishes between different acceptance dimensions (Wüstenhagen et al. 2007): socio-political acceptance (general social climate with regard to the object of ac-ceptance), community acceptance (reactions of those locally affected by the construction of a certain infrastructure) and market acceptance (acceptance of the market actors, i.e. suppliers and demanders, but also intermediaries such as network operators).

the concept of social acceptance is used in this paper to structure some of the findings of the literature review in chapter 3. In addition, the concept was used in the preparation of the workshops (chapter 4).

3.2 Sustainability transitions and strategic niche management

Sustainability transitions are “long-term, multi-dimensional, and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption” (Markard et al. 2012, S. 956–957). New technologies play a key role in these transitions but need to be supported in order to be able to substitute established unsustainable technologies. Strategic niche management (SNM) presents one approach for providing such support. The central idea of SNM is “that radical innovations emerge in ‘protected spaces’ (e.g. subsidized demonstration projects, experiments or dedicated users like the Army), which shield them from mainstream market selection.” (Köhler et al. 2019, pp. 4-5). The social networks, learnings, and joint expectations developed in these niches can then influence which trajectory a new technology will take (Schot und Geels 2008). Both the activities of actors consciously involved in SNM and those indirectly influencing the process therefore provide insights into the development potential of a novel technology.

4 Synthesis of the available literature on societal dimensions of ERS

In this section, we present the results of two literature reviews, which provided the background for the empirical data collection on acceptance in the workshops. The first review summarizes all literature on actors and acceptance, which has so far been published in the field of ERS in the countries participating in CollERS (i.e., Germany, Sweden, and France). The second literature review yields success factors of technology processes and experimentation on new technologies in general. This second review informs our understanding of a baseline against which the developments around ERS can be compared and understood.

4.1 Societal dimensions of ERS

To identify the social factors that play a role in the diffusion of ERS, we synthesized the available literature (i.e., grey literature and published journal articles) on actors and acceptance of ERS in all participating countries (i.e., Germany, Sweden, and France). To characterize and summarize the content of these studies, we then developed a matrix showing the theoretical foci and methods of the articles.In the following, we describe our approach and present the results derived through the matrix according to the identified theoretical foci.

4.1.1 Approach: Literature search

We first started with a general Google search to generate the search terms that would be used for the systematic literature search. We used a combination of technology-related and social science search terms in both English and German.[1] Table 1 displays the search terms and connectors that were used. That is, the terms in the columns were connected by the OR operator, the terms in the rows by the AND operator.

→ AND	
↓ OR	
Technology	**Social science**
Electric road system Catenary (truck) Overhead line Induction Wireless charging Conductive rail	Actors Stakeholder Acceptance Social (science) Politics Political Law Rules Regulations Policies Opinion
Oberleitung Induktion Stromschiene	Akteure Akzeptanz Sozial(-wissenschaft) Politik Gesetz Regeln Meinung

[1] Search terms in Swedish and French were not used, as most research on ERS is available in English (or German).

Table 1: Search terms and connectors used for the literature search

We performed the search in Scopus for published articles and in Google Scholar (until page 5) for grey literature. Additionally, we searched the website of the ERS conferences and used snowball sampling by screening the reference lists of all included articles. The search was performed in May 2022.

We identified a total of 13 articles fitting our search terms (Andersson et al. 2019; Berlin und Engwall 2018; Börjesson und Gustavsson 2018; Morales 2019; Wang et al. 2019; Wang et al. 2020; Wang und Meijer 2019; Burghard und Scherrer 2020; Schecker 2018; Scherrer und Burghard 2019; Scherrer et al. 2020a; Scherrer et al. 2020b; Gadgil et al. 2022). Of these, seven covered the Swedish context, five covered the German context and one the British context.[2] Most articles did not focus on one technology exclusively but at several at the same time. Thus, seven articles looked at ERS in general, while five looked at catenary technology and one article looked at inductive technology.

The different theoretical foci taken by the articles included stakeholder and actor analysis (8 articles), social acceptance including market, local and socio-political acceptance (3), and transition barriers and opportunities (3). One article also specifically addressed the views of the general public, and three articles looked at the industry and transport sector. The matrix below (Table 2) displays each article along with the country, technology, and theoretical approach. The methods applied in each article can be found in Annex**Fehler! Verweisquelle konnte nicht gefunden werden.**. Here it can be seen that articles applying qualitative methods (12) outweighed those applying quantitative methods (3), and three of the papers applyied both types of methods in multi-methods approaches. The different methods that were used included interviews, focus groups, surveys, media analyses, literature reviews, case studies, and network analyses.

[2] The search was not limited to studies from the CollERS countries as we assume that findings from work done in other national contexts are potentially transferable to the countries in CollERS.

Authors	Country	Technology			Theoretical focus / approach				
		General ERS	Catenary	Inductive	Stakeholder /actor analysis	Social acceptance	Barriers and opportunities for socio-technical transition	General public	Industry / transport sector
Berlin & Engwall (2018)	Sweden	x			x				
Börjesson et al. (2018)	Sweden	x							x
Schecker (2018)	Germany		x			x		x	x
Morales (2019)	Sweden	x					x		
Wang et al. (2019a)	Sweden	x			x				
Andersson et al. (2019)	Sweden	x			x				x
Wang et al. (2019b)	Sweden	x			x				
Scherrer & Burghard (2019)	Germany		x			x			
Wang et al. (2020)	Sweden	x			x				
Burghard et al. (2020)	Germany		x		x	x			
Scherrer et al. (2020a)	Germany		x		x				
Scherrer et al. (2020b)	Germany		x		x		x		
Gadgil et al. (2022)	UK			x			x		

Table 2: Country focus, technological focus and theoretical approach of articles identified in the literature search

5 Findings

Below, we describe the findings of the literature search according to the theoretical foci.

Stakeholder and actor analysis

Across electric road systems (ERS), both Andersson et al. (2019) and Wang et al. (2020) identified and analysed key stakeholders in Sweden. Six stakeholder groups defined as central in Wang et al. (2020) contrast with twelve stakeholder roles identified as central by Andersson et al. (2019). Both publications identified vehicle manufacturers, technology and infrastructure providers (or road owners), as well as operators and energy suppliers as central. Andersson et al. (2019) also added the user side, while Wang et al. (2020) added environmental authorities and society. Finally, Andersson et al. (2019) recommended an open design of the system, as exact roles would not be clear before the respective testing phases and a system should allow for further business opportunities as well as innovations and developments.

Following the stakeholder identification, Wang et al. (2020) came to an extended conclusion through an applied stakeholder analysis framework and a conducted participation process. Their compilation shows that stakeholders were concerned with different aspects such as safety, service, economy, environment and social impact - both in the current phase of the project and in relation to a long-term and sustainable development of ERS (see also Wang und Meijer 2019). Further analysis by the authors showed that financial and planning aspects were most important to stakeholders, but social aspects such as safety and public perception were also considered important by all stakeholders (Wang et al. 2019). Wang et al. (2019) also compared stakeholder interest and influence in ERS using a Swedish field trial as an example. Stakeholders identified as central also showed the highest values for interest and influence.

Berlin and Engwall (2018) compared two Swedish field trials using a stakeholder analysis in six overarching categories. The comparison led to eleven conclusions or necessary decisions for the organisation and implementation of further projects with ERS. With regard to stakeholders, the following results are interesting: In project management, a trade-off between efficiency and vulnerability emerged: centralised management was more efficient, but suffered more from the omission of individual actors. The omission of public relations due to financial pressure in the project can have a negative impact and logistics customers will play a central role in the transition to sustainable transport. An analysis of interest and influence showed that actors saw the trials mainly as an economic opportunity and marketing strategy. Local interest, i.e. the interest of communities in a field trial, was higher when local authorities were also actively involved in the project.

In a report by Burghard et al. (2020), the results from the accompanying scientific research of the ongoing field trials as well as from own analyses of the actors and acceptance of catenary trucks and infrastructure in Germany are presented. Analyses on the actors showed that over the past five years, the number of organisations involved in the catenary system and their networking has increased. This increase was largely due to the involvement of (new) local actors in the field trials. These were, for example, haulage companies, but also organisations active in the operation of the roads and electrification on site. No increase in the number of higher-level actors such as vehicle and infrastructure manufacturers as well as financing could be identified. These important activities have therefore continued to depend on a few actors.

Scherrer et al. (2020a) analysed actor-related barriers to the diffusion of catenary trucks based on factors from research on sustainability transitions. They showed a mixed picture of the actor situation in Germany with regard to the diffusion of catenary trucks for the period from 2013 to 2018. Barriers were identified in the precision and acceptance of expectations among niche actors as well as resistance from regime actors. Furthermore, a lack of support from advocacy coalitions was identified as a weakness.

Scherrer et al. (2020b) summarised six actor-related potential barriers to the implementation of catenary truck technology in Germany from two central theories of transition research - the multi-level perspective (MLP) and technical innovation systems (TIS): (1) lack of legitimacy, (2) lack of support from advocacy coalitions, (3) no or small (social) networks in the niche (without powerful actors), (4) no precise or widely accepted expectations in the niche, (5) resistance from regime actors through instrumental, discursive and material forms of power, (6) no or little overlap between regime and TIS actors (cf. Explanations Appendix A).

Social acceptance including market, local and socio-political acceptance

In the work of Schecker (2018), three types of influencing factors and their effects on the acceptance of catenary trucks and infrastructure were identified. Internal influencing factors, as the first type, relate to individual characteristics of the actors (potentially) affected by the technology (e.g. general public, local residents, ambulance service, road service, drivers of conventional trucks and cars). In the case of catenary trucks, the author found these internal influence factors to be, among others, infrastructure fears, willingness to innovate and personal environmental awareness. External influencing factors, as the second type, result from interventions and conditions of the environment. According to the author, the most important external influencing factors include, e.g., expansion standards, the driving behaviour of catenary trucks, and the noise level produced by the technology. The third and last type are influencing factors which are exerted directly by participants on other participants. Participants are defined as actors who have a direct influence on the technolgy, e.g. operators of the catenary infrastructure or truck manufacturers. These influencing factors are for example the origin of the electricity or possible instructions that the truck drivers receive from the haulage companies. Overall, these factors, in particular the internal influencing factors, predominantly fall under local acceptance. However, in the case of the external influencing factors and the third group of influencing factors, references to market acceptance as well as socio-political acceptance also become apparent.

Scherrer and Burghard (2019) analysed results from the accompanying research of ewayBW on the market acceptance of catenary trucks in Germany. The data showed a high level of acceptance of the technology on the part of the participating haulage companies and a willingness to participate in the trial with their own initiative. However, the satisfaction of the respective customers' needs was mentioned as an important condition for this positive attitude. Opinions of forwarding companies that were not yet active were also collected and revealed that logistics companies were generally open to trying new technologies, but that costs were crucial. Overall, larger fleet operators were found to be more interested in alternative propulsion than smaller operators.

Findings in Burghard and Scherrer (2020) on the social acceptance from the accompanying scientific research of the ongoing German field trials as well as from own analyses revealed that the visual similarity of the technology with rail transport sometimes evoked negative emotions in the media and among residents of the field trials, as competition between the technologies might have been assumed. In addition, the (financial) effort for the construction of the infrastructure was perceived as very high, which could have been a challenge for acceptance. In addition, the findings showed that the construction phase in particular can be a critical period of time, as residents' fears regarding (assumed) traffic problems can play a role here. Furthermore, it was shown that local acceptance could not always be separated from socio-political acceptance. Results from the field tests also showed that local actors would have liked more information and participation.

Transition barriers and opportunities

In the work of Morales (2019) an interview study and case study in the Swedish ERS demonstration project eRoadArlanda were conducted. The actor perspective on a potential transition towards ERS was investigated applying the theoretical perspective of transition management. The consortium of eRoadArlanda project was studied as the main actors. It was found that the motivation of establishing ERS has become more political and governed by ambitious climate goals in recent years. Three critical factors were identified that relate to the characteristics of a future ERS system and in relation to which the actors showed disagreement: 1) How fast should ERS be developed and commercialized? 2) Should ERS exclude usage from passenger cars? 3) Is the ERS pilot the right choice?

Scherrer et al. (2020b) identfied actor-related potential barriers to the implementation of catenary truck technology in Germany. A summary of this work can be found in the section on stakeholder and actor analysis.

Gadgil et al. (2022) conducted stakeholder workshops and focus group discussions in the UK to identify factors critical to the success of dynamic wireless power transfer (DWPT). Six categories of challenges were identified: 1) Condition of the vehicle—will it accept a charge and what power? 2) Journey that is undertaken—does the mission require a charge event? 3) User behaviour—what will be the type of charge that will result? 4) Economics—will there be a cost-benefit to a charge event? 5) Level of traffic—what will be the potential energy transferred? 6) Infrastructure—what is the availability for a charge event? (Gadgil et al. 2022). The factors, associated probability distributions and the relations between them (logic functions), can support decision making when implementing DWPT as one part of the UK electric vehicle charging infrastructure.

The general public

The study by Schecker (2018) is the only work studying the acceptance of ERS in the general public (among other groups). For a summary see the section on social acceptance.

Industry and transport sector

Börjesson and Gustavsson (2018) conducted interviews and workshops with trade organisations and business associations, forwarders and haulage contractors. The respondents voiced a general positive opinion towards ERS. However, the declaration of intents from large goods owners and transport buyers to order transports utilizing electric roads was stated as an important condition. If there would be fees for using ERS infrastructure, these would have to be small enough to still enable cost reductions for haulers. The authors found a willingness among forwarders and hauliers to make investments for new vehicles and add-on technology, but there was no readiness to make large-scale investments in ERS infrastructure. Instead, the interviewed actors expected that the infrastructure would be financed by other actors such as the government or large business actors.

Schecker (2018) identified influencing factors exerted directly by participants on other participants. These relate to the perspective of the industry and transport sector. For a summary see the section on social acceptance in this literature review.

Andersson et al. (2019) conducted a market dialogue (consisting of ten separate dialogue meetings with industry actors) and two information meetings with different market actors from the electricity, telecoms, forwarding, transport, and vehicle industries. The aim was to identify potential roles of different actors in a future ERS market and the conditions for their interest in engaging in ERS. For the participanting actors, different incentives and aspects to raise interest were identified in the market dialogue: Business opportunities for private actors should be made clear in the form of conditions and opportunities. In particular, the participants asked for more information on the operator's role and the role of the Swedish Transport Administration. Further, long-term development plans were called for in order for market actors to have something to base their estimates and assessments of business opportunities on, for example on the necessary development of the electric grid and the size of a potential future ERS network. Financial incentives may need to be strengthened; that is, subsidies, guarantees and possibilities of repurchasing the installation after the end of the contract period were suggested for the potential situation in which the ERS installation was owned by a private actor. Finally, the participants asked for an added value beyond the financial. In particular, advantages in the further development of electric roads as a result of participation in the pilot phase was put up for discussion.

Scherrer and Burghard (2019) looked at the acceptance of the technology on the part of both in ERS active and not yet active haulage companies. For the results we refer to the section on the social acceptance including market, local and socio-political acceptance in this literature review.

The literature results show positive to mixed reactions to ERS. Field trials in Germany have elicited some critical reactions from local residents. Market actors are basically open to the technology, but express conditions for using or supporting it. Many industry players also express uncertainty about the further development of ERS. Although the number of stakeholders active in ERS has grown, there still seems to be a lack of supportive networks.

5.1 Success factors of technology processes and experimentation on new technologies

The second literature review aimed at extracting success factors of technology processes and experimentation on new technologies to facilitate a sustainability transition. The goal was to create a category system of success factors in the literature in order to compare and understand the current developments around ERS.

5.1.1 Approach: Literature search

A systematic literature search on technology processes and experimentation on new technologies to facilitate a sustainability transition was conducted in October 2022. We consulted, among others, the literature on field trials and strategic niche management, and used the following keywords to construct search strings for this search:

- Technology
- Field trial (Feldversuch*)
- Strategic niche management (Strategisches Nischenmanagement)
- Success factors (Erfolgsfaktor*)
- Demonstration project (Demonstrationsprojekt*)
- Pilot project (Pilotprojekt*)

Different combinations of these keywords resulted in four different search strings. Table 3 displays each search string along with the date it was used and the number of hits it generated in the different search engines.

Search string	Date	Engine	Hits
Technology AND field trial AND strategic niche management AND success factors	Oct 26th, 2022	Scopus	4
Field trial OR strategic niche management AND success factors	Oct 26th, 2022	Scopus Google Scholar	10 10
Field trial* OR strategic niche management OR demonstration project* OR pilot project* AND success factor*	Oct 26th, 2022	Scopus	119
Feldversuch* OR Strategisches Nischenmanagement OR Demonstrationsprojekt* OR Pilotprojekt* AND Erfolgsfaktor*	Oct 27th, 2022	Scopus	2

Table 3: Search strings used for the literature search

The systematic search yielded a total of 145 records. After deduplication, every record was screened for thematic fit. That is, we excluded every record not studying technologies to facilitate a sustainability transition. Similarly, we excluded records studying field trials of new technologies but not specifically looking at success factors for these. These exclusion criteria led to a remainder of 23 articles.

The remaining articles can be broadly categorized into dealing with our research objective from a technology or a policy/governance viewpoint. Papers with a technology viewpoint look at bioenergy (Blumer et al. 2013), hydropower (Drinkwaard et al. 2010), windpower (Leary et al. 2020; Leary et al. 2019), concentrated solar power (Mirzania et al. 2020), low-sour gas reserves (Eylander et al. 2001), sector-coupling (Gabderakhmanova und Marinelli 2022), new propulsion systems (Heyma et al. 2001), reuse of construction products (Knoth et al. 2022), green retrofits (Liang et al. 2015), passive house networks (Mlecnik 2014), smart city logistics (Sista und Giovanni 2021), climate adaptation projects (van Buuren et al. 2018; Heilmann und Pundt 2017), microgrid communities (Warneryd und Karltorp 2022), and food, mobility and energy innovations (van den Heiligenberg et al. 2017). Papers with a policy/governance viewpoint study governance initiatives for urban greenspaces (Aalbers et al. 2019), governance for energy and built environment transitions (Kivimaa et al. 2017), intelligent green building policies (Kuo et al. 2016), and innovation platforms for agriculture (Schut et al. 2016). Yet other papers take both viewpoints, such as for the case of low-carbon transition projects in cities (Boulanger und Nagorny 2018). A few other papers rather take a meta-perspective on technology trials (Woltering et al. 2019; Struyk 2007).

The next step comprised of listing all the success factors that were named in the identified articles. Then, we used an inductive approach to build categories of success factors under which the individual factors could be subsumed. We ended up with nine categories consisting of three to 19 factors each.

5.1.2 Findings

The identified categories and success factors are (Table 4):

1. Facilitating communication and **discourses**[3] between all relevant stakeholders
2. Providing the necessary material and non-material **resources**
3. Forming strong and comprehensive **coalitions**
4. Knowing or establishing formal and informal **rules of play**
5. Granting attractive material and non-material **incentives**[4]
6. Ensuring **evaluation, learning and capacity building**[5]
7. Creating a **vision for upscaling**[6]
8. Creating a favorable **public perception**
9. Capitalizing on favorable **features of the technology**

[3] Created based on the work by Aalbers et al. 2019.
[4] Created based on the work by Blumer et al. 2013; Kuo et al. 2016; Schut et al. 2016.
[5] Created based on the work by Schut et al. 2016.
[6] Created based on the work by Sista und Giovanni 2021.

Category (1.-4.)	**Factors**	**Category (6.-9.)**	**Factors**
1. Discourses	• Agreement with and influence on municipal authority regarding goals and outlines of the initiative • Discourse in tune with the current social climate • Positive dissemination of discourse via the media • Influence within the municipal authority • Transparency in communication and safety demonstration • Existence of success stories • Communication and cooperation • Effective feedback loops • Information sharing • Consensus among stakeholders • Alignment of clients by responding to their concerns	**6. Evaluation, learning and capacity building**	• Evaluation of good practice examples • Understanding what is not working • Continuous performance improvement through learning • Wide exchange of lessons learned • Integration of experience and knowledge • Realistic evaluation of the technology's potential and a plan for how to achieve it • Dissemination of learning experiences • Center for know-how retrieval • Knowledge transfer • Investments in exchange of experiences
2. Resources	Material • Budget • Fund investments involving multiple foundations or companies • Green revenue model • Direct governmental investments or co-funding • Targeted subsidies • Access to development funding • Well-functioning research infrastructure Non-material • Communication and networking skills • Time and perseverance • Adequate technological support and management capabilities • Well-functioning research infrastructure	**7. Vision for upscaling**	• Clear and ambitious vision • Forming relationships and reinforcing a vision of future collaboration • Vision of how to scale it up

	• Relevant work experience (e.g., in cooperation with the local government)		
3. Coalitions	• Public support (residents, media, politicians) • Cooperation with local and regional partners • Support from the municipal authority, which draws on its network to make the initiative a success • Finding pragmatic ways of collaboration • Relationship with municipal authority based on trust and agreements • Intensive collaboration between all stakeholders • Collaborations between research and practice • Commitment of stakeholders • Endurance and continuing support of field operations staff • Careful and diverse composition of project consortium • Involving manufacturers as partners • Government endorsement of the technology • Inclusion of consumer and industry associations in the trial • Creating and capitalizing on synergies between different stakeholders • Consistency and degree of local leadership • As few implementing actors as possible • Co-development among involved actors	**8. Public perception**	• The project fits the community image and offers a possibility for people to identify with it • Interaction with user communities on a long-term basis • Wide public awareness and understanding of (dis)advantages • Willingness to adapt behavior among end-users • User involvement • Long-term commitment of consumers
4. Rules of play	Formal • Instruments to increase the technology's competitiveness • Policies that increase usage (mandatory or incentivizing) • Absence of bureaucratic barriers • Favorable legislation • Establishing clear norms and standards	**9. Features of the technology**	• Maturity of the applied technology • Existence of a market • Use of developed technologies • Maintainability of the technology • Complexity of the technology

	• Clear government programs and policy instruments Informal • Clear signals of authorities as to what is desired • Existence of strong lobbying activities • Reduction of political barriers • Lack of environmental barriers (e.g., no pollution or noise emissions by the new technology) • Efficacy, clarity, consistency, and flexibility of the novel policy		
5. Incentives	• Tax exemptions • Direct subsidies • Attractive credits and guarantees		

Table 4: Category system based on the scientific literature on technology processes and experimentation on new technologies.

The *formation of strong and comprehensive coalitions* (category 3) is the category most often identified in the studies. Success factors that fall under this category are for example public support, collaboration between stakeholders (especially between research and practice), or local and regional networks. It seems to be important that these collaborations take on pragmatic ways and are not hampered too much by bureaucracy. Additionally, trust between and commitment of the stakeholders as well as inclusiveness and comprehensiveness of the coalitions are important ingredients.

Resources (category 2) and rules of play (category 4) are the categories with the second-most identified factors. Resources are divided in material and non-material resources. Material resources include, in particular, financial resources. Non-material resources are skills or time, especially regarding communication and perserveance. Rules of play can be separated in formal and informal rules. Whereas formal rules are among others policies and legislation, informal rules refer to lobbying or clear communication, as well as the reduction of existing barriers (e.g., political, economic or environmental).

The next category, consisting of eleven factors, is called discourses (category 1) and includes positive communication efforts as success factors. Particularly, transparent communication, effective feedback loops, sharing of information and positive media dissemination are highlighted in order to generate support among the local population or the municipality. Additionally, it seems important to reach a consensus among the stakeholders and to align them by responding to their concerns.

The category 6 Evaluation, learning and capacity building consists of ten success factors. This category is about learning from the field trials. Specifically, it is about documenting and evaluating good as well as bad practices and learning from past experiences for the next endeavours. It is thereby important to ensure knowledge transfer by, for example, establishing a platform for know-how retrieval.

Public perception (category 8) is the next category, consisting of six subfactors. This category is mostly about generating awareness among the general public early on in the process and ensuring they understand the advantages as well as possible disadvantages of the technology being tested. Additionally, it is important to offer the public possibilities to interact with the technology, to get involved in the project and to identify with it. These endeavours should be held up in the long run.

Similar in the size of five factors, the next category is called features of the technology (category 9). Here, its success factors for technology importance include maturity of the technology (the more mature, the higher the success), the existence of a market, the maintainability of the technology, as well as its complexity. When it comes to technology experimentation, these criteria are unlikely to be met, but it seems important to keep them in mind when anticipating the success of a trial.

The smallest but no less important categories 5 incentives and 7 vision for upscaling include three factors each. Incentives are meant to increase engagement with the new technology and may include tax exemptions, direct subsidies or attractive credits. Throughout the whole process of a field trial or technology experimentation, it is important to create a clear vision of how this small-scale project may be scaled up in the future. Through this vision, the public may identify a greater purpose behind the project and be more willing to accept short-term drawbacks that may be outweighed by future advantages.

The number of factors in each category can be understood as a proxy for the category's importance in shaping the success of technology field trials. This would mean that a successful technology field trial would start with the formation of strong coalitions, securing resources and establishing or getting to know formal and informal rules of play. Once this ground is laid, one would proceed with wide public communication and establishing an infrastructure for evaluation, learning and capacity building. This would then help shape a favorable public perception and is supported by favorable features of the technology itself, such as its maturity. Lastly, a vision for upscaling should be communicated, which may have already been developed during the planning of evaluation, learning and capacity building. This upscaling may be supported by granting incentives to increase consumer engagement with the new technology.

Throughout the remainder of this paper, we will look out for these success factors in the empirical data collected as part of the CollERS project (described in the following chapter 4).

6 Experiences and evaluations in the different field trials in Germany and Sweden

With the help of online expert workshops, qualitative empirical data of the experiences and evaluations in the different field trials in the countries originally participating in the project CollERS, Germany and Sweden, was collected. The aim was to supplement and enrich the results from the literature with the current experiences and assessments of experts. The target group were experts from field trials and research on societal implications of ERS in both countries.

6.1 Approach: Online expert workshops

Two online expert workshops were conducted in 2022. The workshop concept is shown in Figure 1.

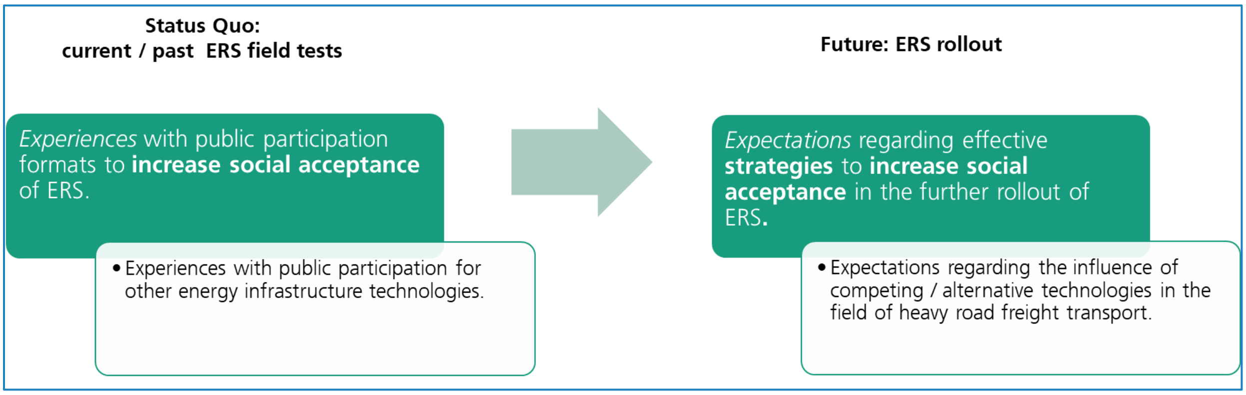


Figure 1: Workshop concept

The first workshop focused on the analysis of the status quo regarding social acceptance and public participation in the context of ERS projects. That is, the participants' experiences with acceptance and strategies for increasing acceptance were collected and discussed. The title of this first workshop was: "Workshop 1: Societal implications of ERS: Status Quo and experiences from field trials in Germany and Sweden." The second workshop focused on the future rollout of ERS and the implications for social acceptance and public participation and was titled: "Societal implications of electric road systems (ERS): Relevance for the further development of ERS in Europe."

The first workshop took place at June 2, 2022 from 10-12 AM in a digital format (MS Teams). After presenting the CollERS 2 project, the aim of the workshop, and the state of research, two discussion rounds were carried out, supported by the tools Sli.do and Miro. The first discussion round dealt with the question: What are your experiences with the social acceptance of ERS? In the second round, the key factors influencing the social acceptance of ERS were collected and discussed. The workshop concluded with a synthesis in which differences in societal factors between countries and technologies were worked out. In total, 14 experts from Germany and Sweden, including the CollERS project team, took part in this workshop.

The second workshop was held on 12 December 2022 from 10-12 AM in a digital format (MS Teams). The workshop started with a short presentation of the aim of the workshop and a short summary of the last workshop‘s results. This was followed by two rounds of discussions (supported by Miro): In the first round, it was discussed how social acceptance of ERS could be increased and which measures have proven to be effective. The second round dealt with the question how social acceptance of ERS would evolve as the system continues to roll out. Nine experts from Germany and Sweden, including experts of the CollERS project team, took part in this workshop.

6.2 Results of the workshops

6.2.1 Status quo regarding social acceptance and public participation in the context of ERS projects

The first part of the first workshop was a collection of *key actors for the implementation and diffusion of ERS* with the help of a Miro board. Participants were asked to name actors in Sweden and Germany with positive and negative communication or actions and to rate the degree of influence of these actors (Figure 2).

ERS developers, energy companies, ministries and the government, and some trucking companies were seen as actors with positive communication or actions in both countries. Actors with negative communication or actions (and also a large influence) were, from the perspective of the participants, the ACEA (European Automobile Manufacturers' Association) and most truck OEMs (both countries). In both countries, road users were seen as actors with small to medium influence - in Germany with positive communication or actions, in Sweden with negative ones. Local residents were seen as positive in Sweden and negative in Germany.

Environmental mobility associations, freight rail lobby, and local media were actors mentioned in Germany only. These were seen as communicating or acting in a negative way towards ERS.

In Germany, actors for catenary systems were identified in particular as there were three ongoing field tests focusing on this technology. In Sweden, actors for several ERS were named because the focus of the activities was broader here.

These actors communicating or acting positively or negatively on ERS can be linked to category 3 "Strong and comprehensive coalitions" from the literature review. Questions that are important in this context are, for example, "Are the coalitions strong and comprehensive enough?", "Were the public (sufficiently) involved?" and "Why are the OEMs opposed, why are local residents opposed to the ERS project?"

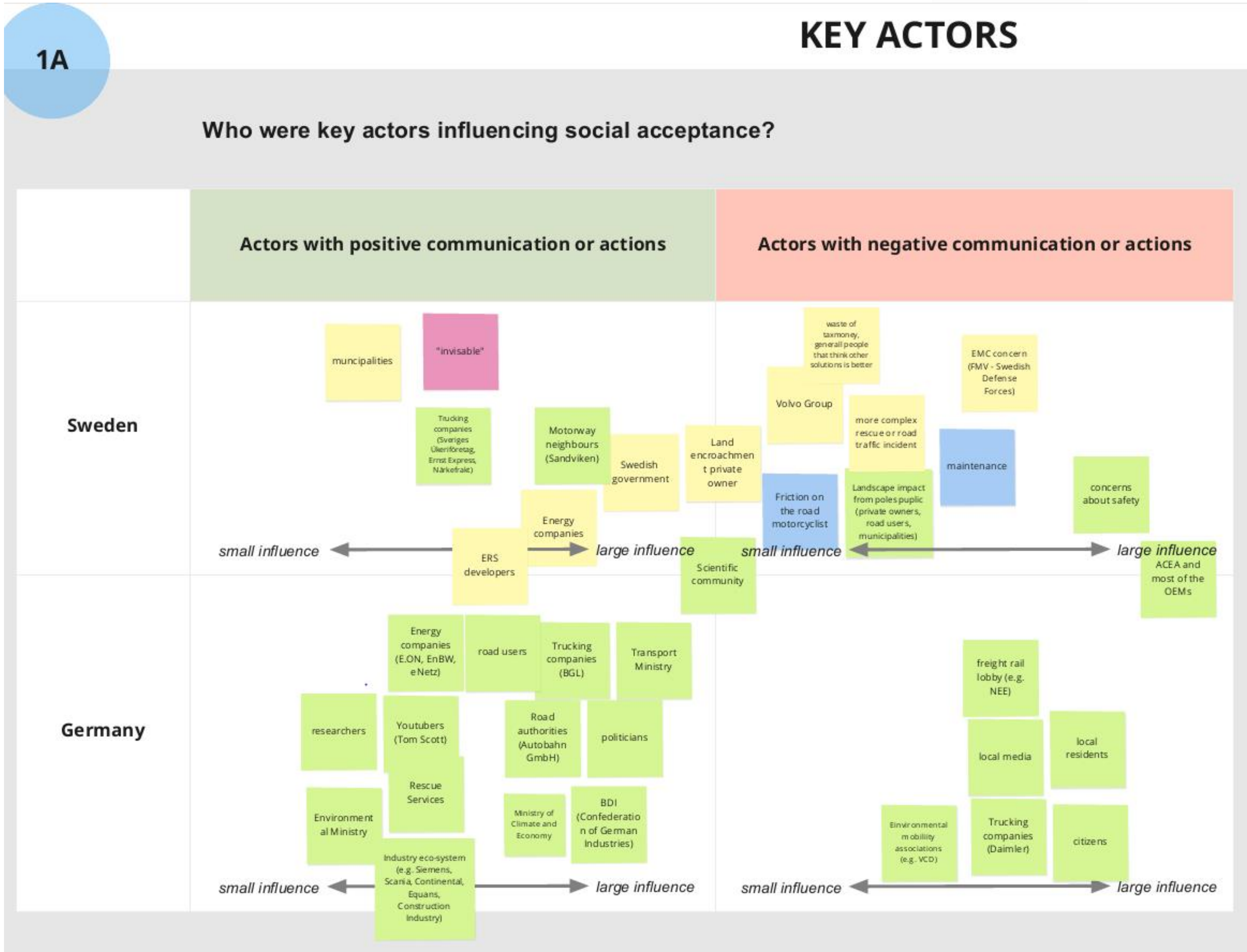


Figure 2: Key actors for the implementation and diffusion of ERS identified in workshop 1. Note: green: catenary, blue: conductive, pink: inductive, yellow: all ERS

In the second part of workshop 1, *key factors influencing the social acceptance of ERS* were collected on a Miro board and discussed (Figure 3). The findings show that similar positive factors for the support of ERS were perceived in both countries, such as technical factors (e.g. feasibility for highways, proven technology, high energy efficiency), innovativeness, environmental factors (e.g. less batteries have to be produced), compatibility with current road haulage systems but also with stationary charging, beneficial for energy system. The technical factors stated here refer to succes factor 9 "Favorable features of the technology" extracted from the literature (section 5.1).

The negative factors, however, appeared to differ between countries: Visual impairment, high perceived investment costs, lack of visibility of the technology, as well as comparison with rail (catenary) seemed to be only important in Germany. Road maintenance and danger for motorcyclists (conductive) were perceived in Sweden only. The latter factor refers to informal rules as part of the success factor 4 "Rules of play" identified in the literature. Removing safety or maintenance-related barriers is a success factor for pilot projects and field trials.

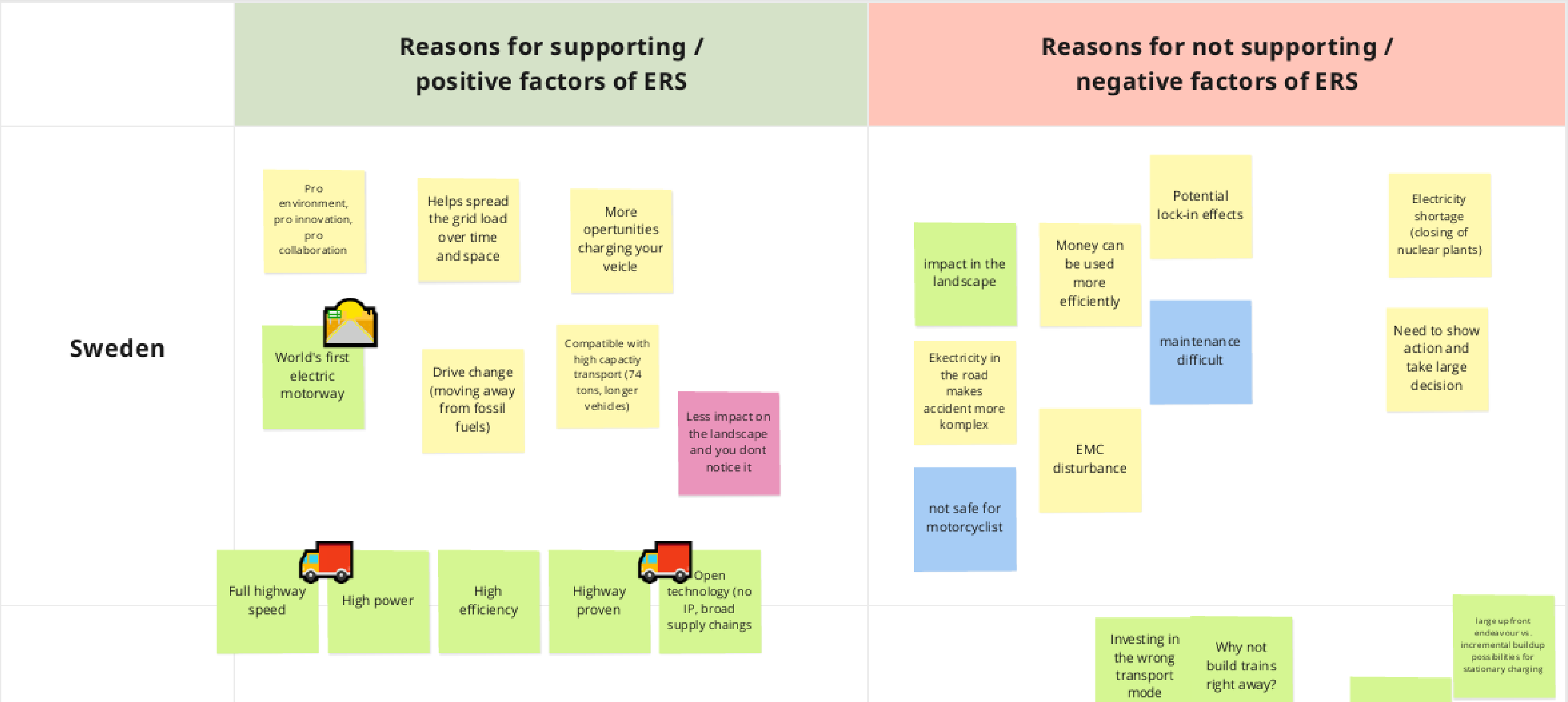
However, several negative factors were perceived in both countries: a fear of creating lock-ins, high investment costs, as well as high upfront investment before having benefits. Expansion costs were mentioned by some experts and were cited as a counter argument by certain OEMs. This argument can be linked to success factor 7, "Vision for upscaling", as identified in section 5.1. If a clear vision on upscaling is missing, the costs for a further expansion are perceived negatively. From the perspective of workshop participants, expansion costs were also a concern for the general public.

In Sweden, electromagnetic fields were seen as a general concern related to ERS projects; these concerns, however, could be resolved through public information/media reports.

2A

ACCEPTANCE FACTORS

Which reasons did the actors give for supporting or not supporting ERS?



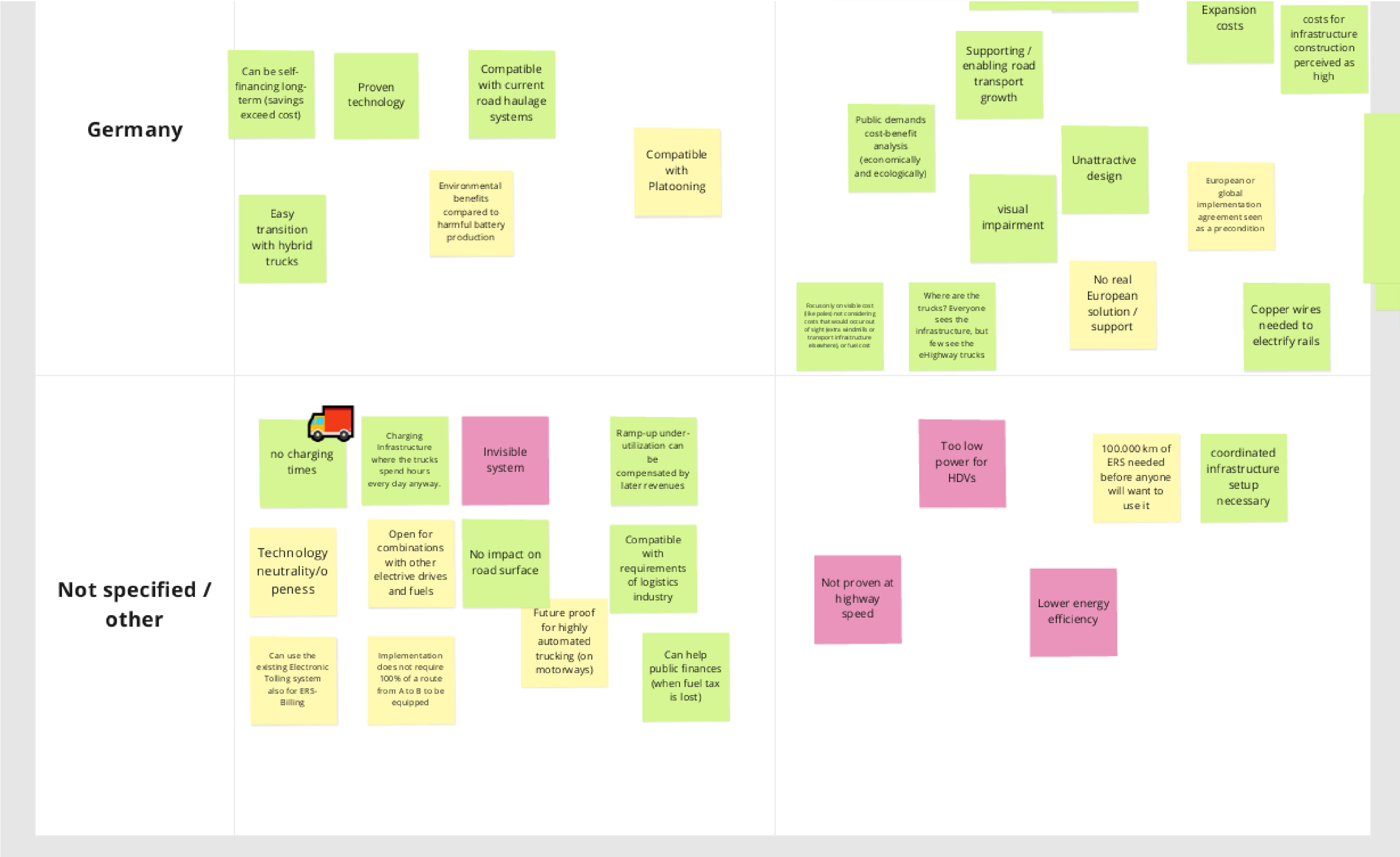


Figure 3: Key factors influencing the social acceptance identified in workshop 1. Note: green: catenary, blue: conductive, pink: inductive, yellow: all ERS

At the end of workshop 1, *differences in societal factors between countries and technologies* and general remarks were collected and discussed. In Germany and Sweden differences in leveraging rail as counter-argument were discussed. That is, the discussion on the comparison of ERS with railways was perceived as not as prominent in Sweden as it was in Germany. In addition, it seemed to the participating experts that the discussion as a whole on ERS was already broader in Germany than in Sweden. Participants stated that inn Sweden, only experts discussed ERS at the time of the workshop and there was not really a discussion in the public or media in Sweden yet.

For Sweden, the participating experts discussed that the closer to the implementation phase of ERS the more negative they expected the public to be. After the implementation, people were expected to become more positive about ERS again - a development that may apply to many types of field tests or infrastructure construction from the perspective of the participatns. In addition, the Swedish experts stated that the Government liked the technology because it is easy to frame it positively. However, they considered it critical to make a clear decision for or against the technology.

In Sweden and in Germany, it was discussed that the public have accepted that climate change is a serious problem but the knowledge on ERS in the public is still limited. That is, communication about the aim of the field tests and the strategy of the government on the decarbonisation of road freight transport is very important. This point relates to success factor 1 "Discourses" and to factor 8 "Public perception".

6.2.2 Future rollout of ERS and the implications for social acceptance and public participation

In the first part of the second workshop, the participants were asked: *How can social acceptance of ERS be increased? What has proven (not) to be effective?* As part of this first discussion round, experiences with different forms of public and stakeholder participation for ERS were collected and discussed with the help of a Miro board (Figure 4). In Sweden, workshop participants reported positive experiences with public consultation formats during the road planning process for ERS in general. For the catenary technology, an opening event of a field trial received positive feedback in the public; for experts, trial visits were offered which were also positively received. In addition, the technical and environmental impact of the technology was communicated to other regional authorities (including electrical authorities, defense department, environmental stakeholders) and feedback was gathered. This refers to success factor 1, "Discourses", as identified in the literature (section 5.1), since here communication, cooperation and information sharing play an important role.

In Germany, an opening event of a field test directed only to project participants received mixed reactions. Further examples of public participation and information formats that were mentioned were workshops and events on site with locally affected stakeholders, digital information events, exhibition of a catenary truck model, online questionnaires, and media coverage. Furthermore, experts gave advice to discuss legal opinions and challenges relating to the field tests with other experts in the planning process of a field trial. In Germany, it was observed that the further away people lived from the field test, the less knowledge and, in some cases, acceptance they had.

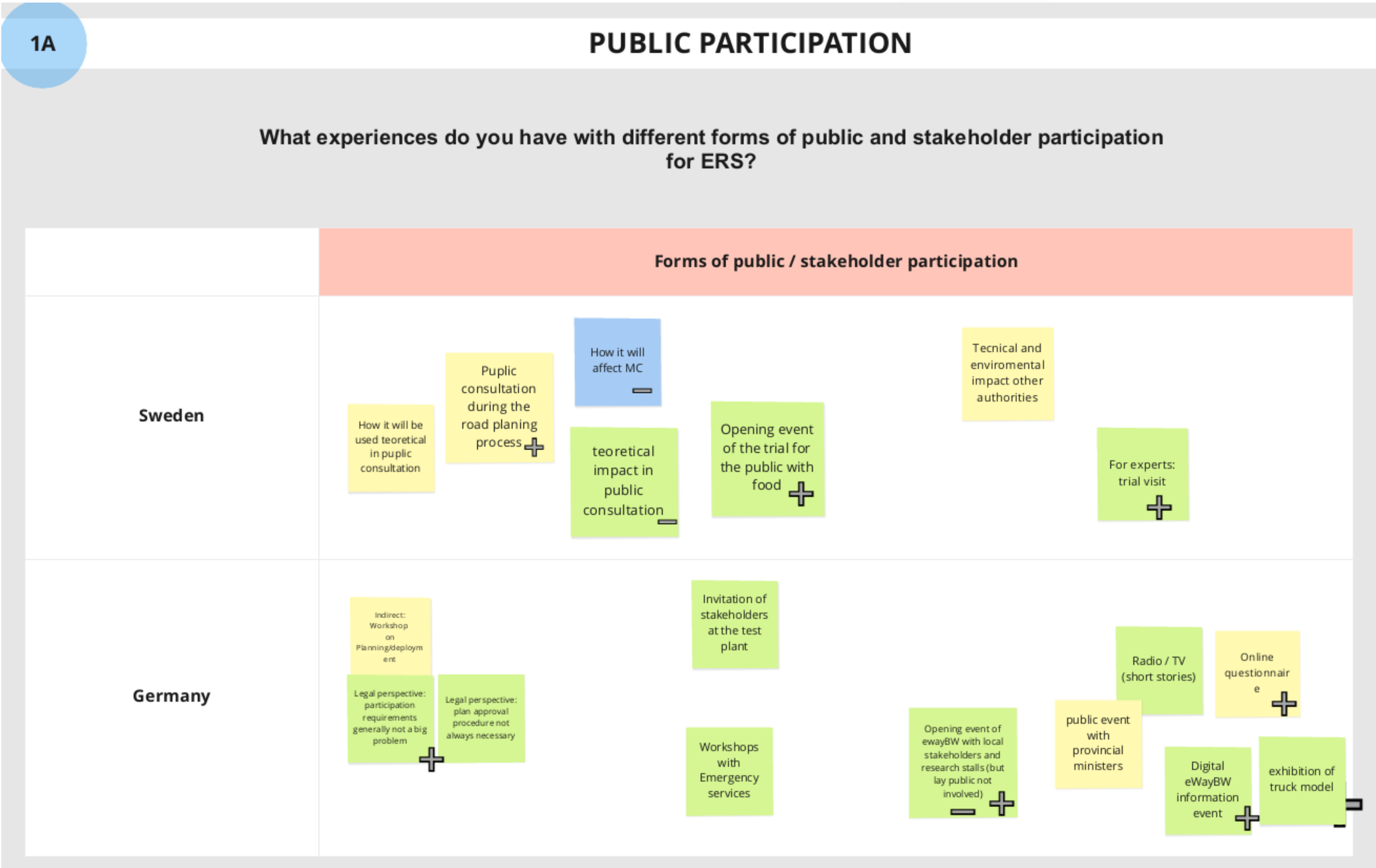


Figure 4: Experiences with different forms of public and stakeholder participation for ERS collected in workshop 2. Note: green: catenary, blue: conductive, pink: inductive, yellow: all ERS

After this discussion, the experts were asked the following question: *What can we learn from experiences with public participation with other technologies?* (Figure 5).

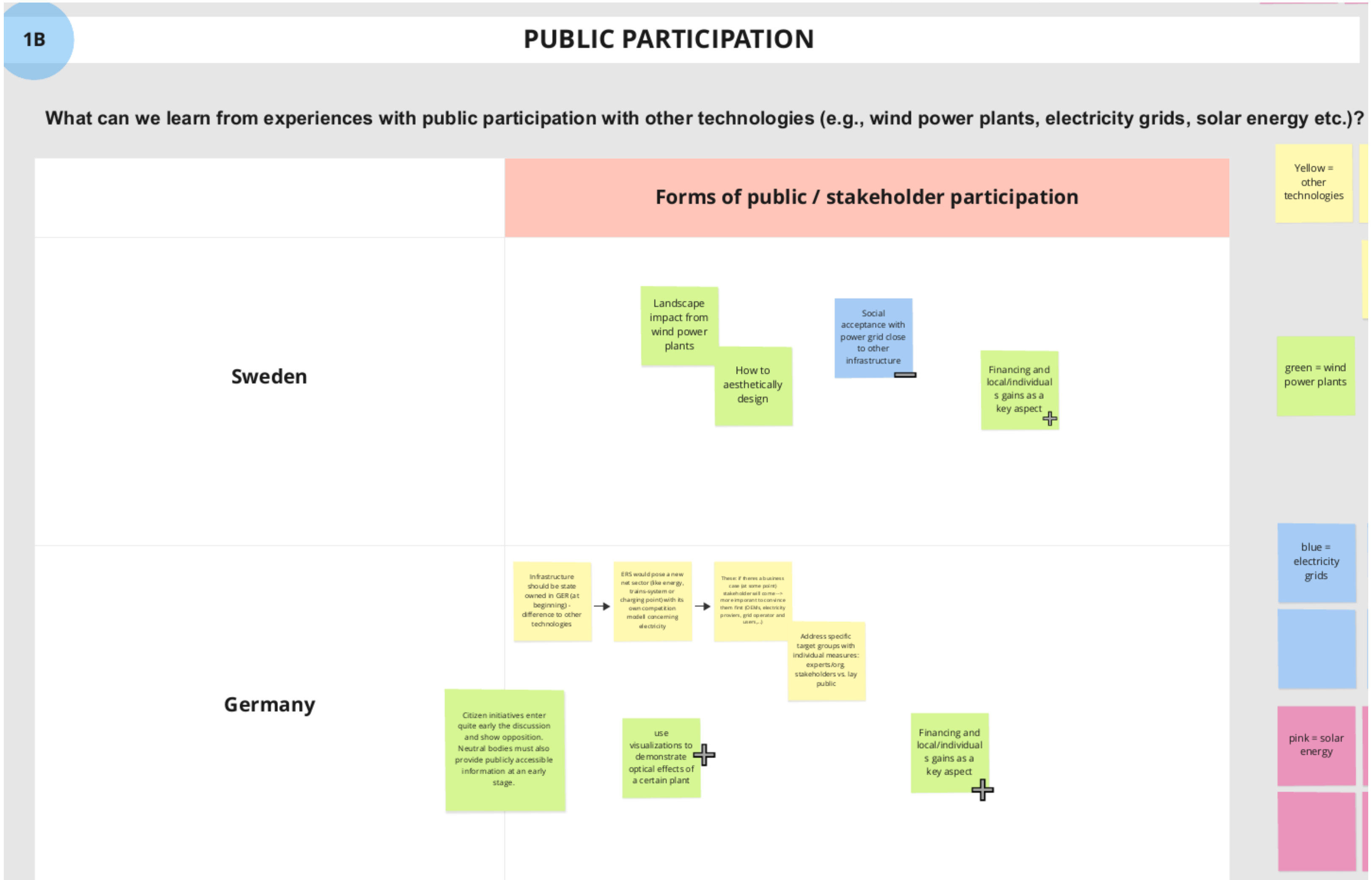


Figure 5: Lessons learned from experiences with public participation with other technologies collected in workshop 2. Note: yellow: other technologies, green: wind power plants, blue: electricity grids, pink: solar energy.

Experts in Sweden and Germany referred to wind power plants as a comparable technology that could offer lessons on acceptance: The effect on the landscape was considered similar to that of ERS, i.e. the catenary technology. For social acceptance of wind energy, experts stated that it was important to provide possibilities for financial participation of the local public. However, they did not consider this possible in ERS projects. Instead, other local benefits could be provided and it should be ensured to directly engage local residents. In addition, in wind energy projects, it was often observed that citizen initiatives entered the discussion quite early and showed opposition. When transferred to ERS, neutral bodies must provide publicly accessible information at an early stage. Another tip was using visualizations to demonstrate optical effects of a certain plant to the affected public. Another technology with similar implications for social acceptance that was discussed were power grids. A Swedish expert assumed that the public might have similar fears as towards overhead power lines because of the catenary overhead lines being close to the roads. Learning from similar energy technologies and infrastructures in designing public participation and information measures can be linked to success factor 6, "Evaluation, learning and capacity building".

In terms of energy infrastructures in general, in Germany, it was stated that communication should inculde the fact that ERS infrastructure would be state-owned.

In the second part of the workshop, the following question was discussed: *How will social acceptance evolve as the system continues to roll out?* At first, the experts identified strategies they expected to be effective at increasing social acceptance of ERS as the system continues to roll out (Figure 6).

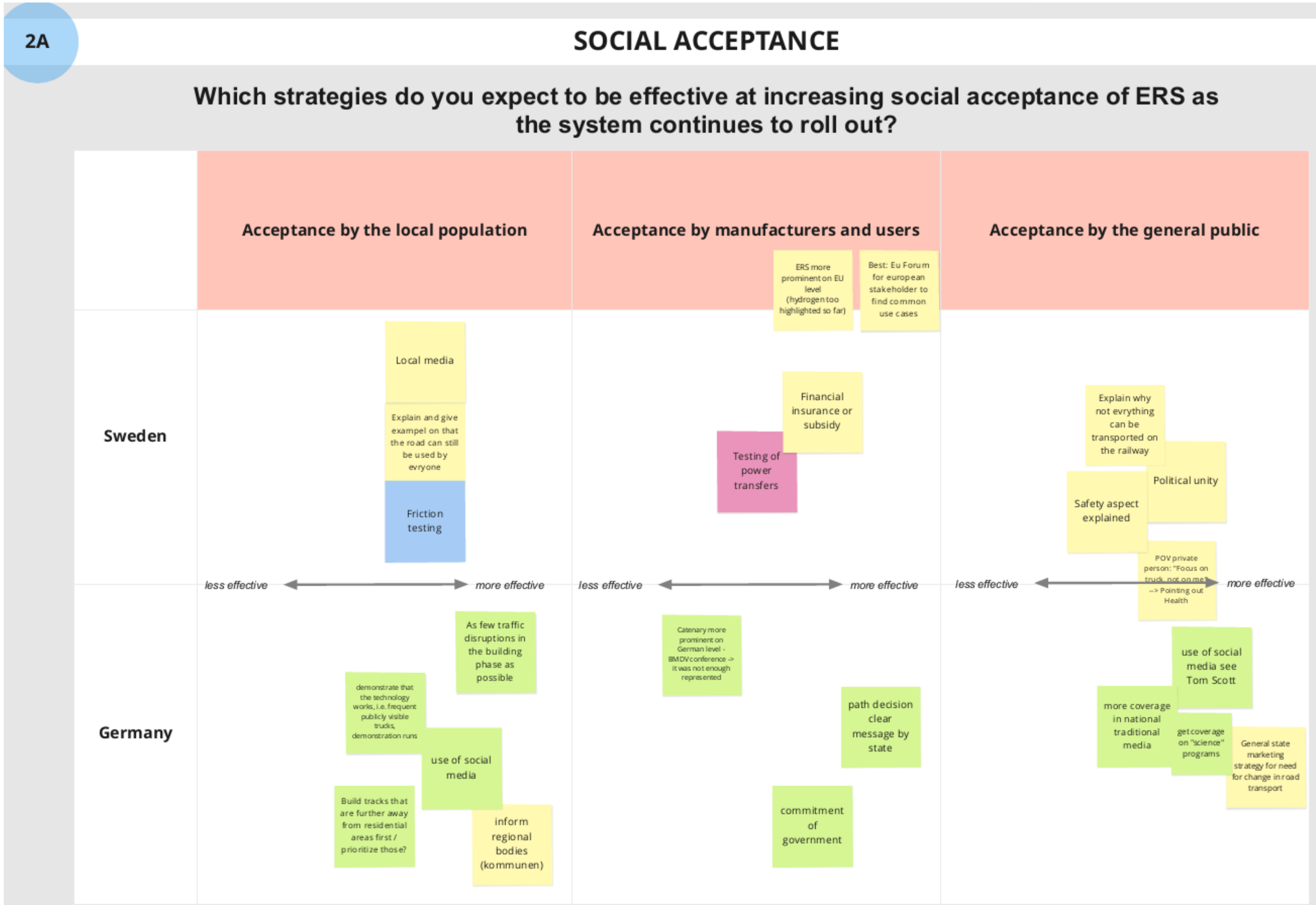


Figure 6: Strategies expected to be effective at increasing social acceptance of ERS identified in workshop 2. Note: green: catenary, blue: conductive, pink: inductive, yellow: all ERS

Strategies to increase social acceptance for ERS in general identified by experts for Sweden were, for example, clear communication about the potentials and limitations of rail freight transport, about the fact that ERS systems do not restrict traffic, and about safety aspects. In addition, ERS should be reframed in the communication as a public health issue, rather than a purely transportation-related issue.

In both countries, it was advised to increase the use of social and traditional media - on the local but also national level, because knowledge on ERS in the public was still limited. Good experiences had been made with an influencer reporting about ERS on YouTube.

In Germany, for the catenary technology it was stated that it should be demonstrated that the technology works. The participating experts stated that this could, for example, be done via frequent publicly visible trucks or demonstration runs. In addition, as soon as path decisions regarding the decarbonization of road freight transport were taken, this should be communicated to the public, e.g. in information campaigns or with the support of experts. Further recommendations related to choosing locations for field tests far away from residential areas and to ensure there would be as few traffic disruptions in the construction phase as possible.

After discussing the strategies, the experts debated on how competing or alternative technologies and infrastructures could influence the acceptance of ERS (Figure 7).

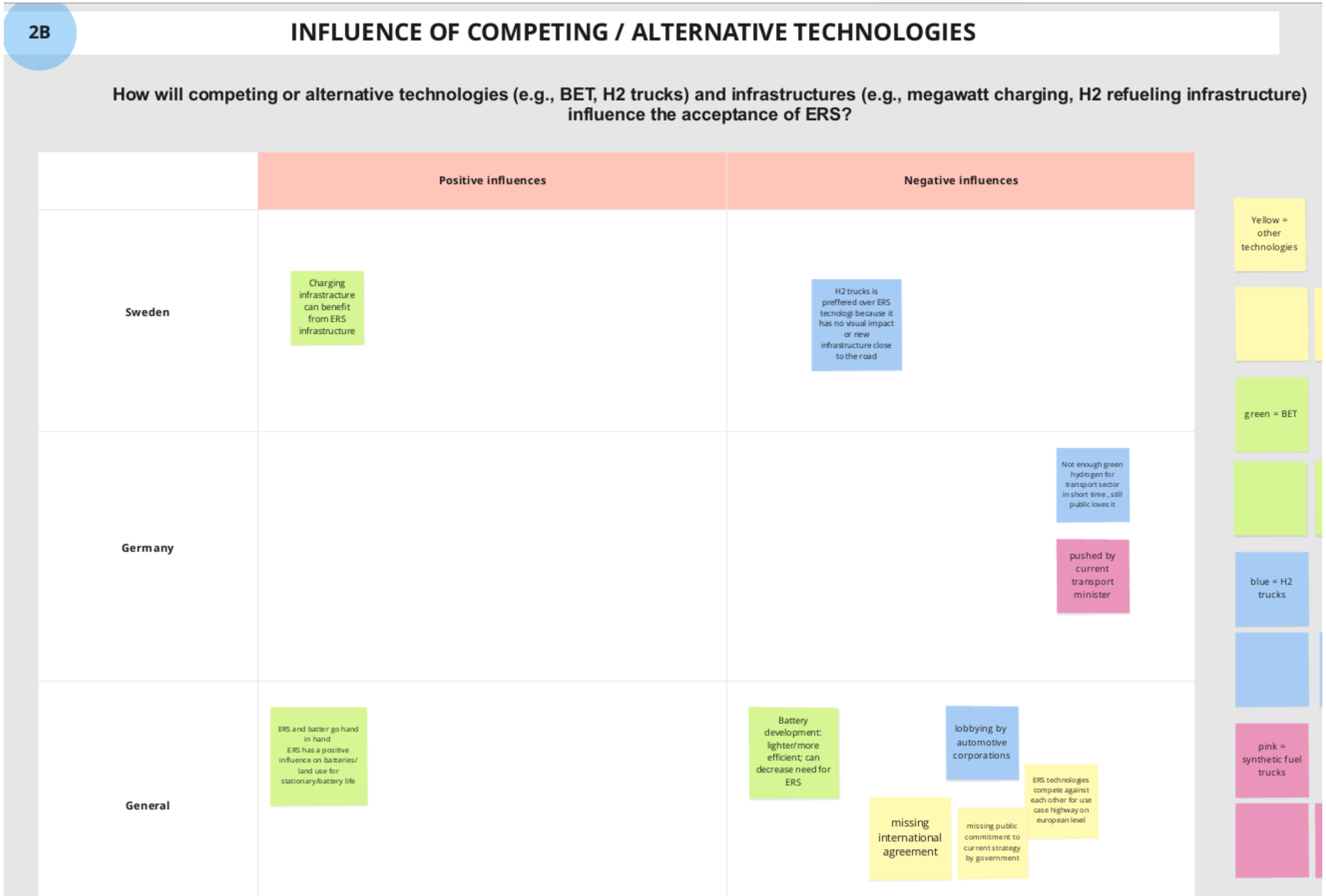


Figure 7: Competing or alternative technologies and infrastructures influencing the acceptance of ERS identified in workshop 2. Note: yellow: other technologies, green: battery electric trucks (BET), blue = H2 trucks, pink = synthetic fuel trucks

A positive influence was identified for battery-electric trucks in the sense that ERS and static charging infrastructures could benefit from each other. For example, when installing charging stations in parking lots, existing infrastructures and power lines for ERS infrastructure could be used. In addition, static and dynamic charging systems were considered to be able to go hand in hand, i.e. ERS requiring smaller battery sizes and less land use compared to static charging systems.

However, overall, more negative than positive influences were identified by the experts. Experts in Germany pointed to a decreased interest in ERS due to a fast development of batteries for BET. An expert assumed that the public might prefer hydrogen fuel cell trucks over ERS because they would have no visual impact right next to the roads. Lobbying activities in Germany were found to push hydrogen trucks. Further, experts found a positive attitude in the public towards hydrogen, although this technology would not be feasible for the whole fleet as the availability of green hydrogen was limited. Overall, they considered a lack of knowledge about these potentials in the public to lead to misconceptions. In Sweden, the experts stated that lobbying activities and what was pushed by politicians (especially synfuels) could have a great impact and that there was generally too much focus on equality among options and on technology openness. That is, there was a missing international agreement on which technology to choose.

7 Discussion

7.1 Summary and discussion of key results from the workshops

Workshop 1 dealt with the status quo regarding social acceptance and public participation in the context of ERS projects. In general, the participants identified more actors with positive or negative communication or actions for Germany compared to Sweden. In addition, the experts detected a broader discussion on ERS in Germany than in Sweden. This means, the technology reached more people in Germany compared to Sweden. This is due to the fact that there are more ongoing field tests in Germany than in Sweden.

In addition, in Germany there is more research on social acceptance of ERS conducted - with a focus on catenary trucks and overhead lines - which might have led to a greater sensitivity to social acceptance issues related to ERS in general and among the experts taking part in the workshops. However, since the focus in Germany has been on catenary trucks and infrastructure, experiences and scientific results on social acceptance are limited to this technology. In contrast, in Sweden, more experiences have been made from field trials with different ERS technologies.

Local residents were seen as being more critical towards ERS projects in Germany than in Sweden. Besides cultural aspects, which might be in part responsible for this finding (e.g. different attitudes towards science and technologies, see Belitz und Kirn 2008), in Germany there is a higher population and car density. This means the field trials affect more people in Germany than in Sweden. However, it must also be taken into account that the field trials are located in different proximity to settlements.

There are also economic differences between the two countries. In Germany there are more OEMs located, of which one manufacturer has openly expressed a critical attitude towards ERS. This might have had a negative influence on the public opinion about ERS. Since the automotive industry and suppliers are of greater importance for the gross domestic product in Germany, fears of a transformation of the vehicle sector, which could lead to job losses, could also play a role here. Lastly, the close proximity of the field trials to locations of OEMs with a critical stance towards ERS could also have influenced the perception of a project by locally affected actors.

In terms of acceptance factors, similar positive factors, such as technical and environmental factors were perceived by the experts for both countries. In contrast, negative factors appear to differ between the two countries. That is, perceived negative acceptance factors were often related to a certain ERS technology, such as aesthetics for the catenary technology and safety issues for the conductive technology. These negative factors were often related to the concrete implementation of the technology on site.

In the second workshop, the participants discussed the future rollout of ERS and its implications for social acceptance and public participation. Important points of dicussion were related to information and communication: The experts pointed to the need to increase knowledge on ERS among the public. A particularly important point to address in communication that might have a positive influence on social acceptance is for example the comparison with rail, i.e., to explain the limitations of rail transport for freight transport and decarbonization in order to increase the acceptance of road-based solutions such as ERS. Regarding public participation, the experts discussed in how far a direct involvement of local residents of field tests could be possible. Research has shown that the financial participation on renewable energy projects can increase social acceptance (Breitschopf et al. 2022). Participants discussed how this could be transferred to ERS but did not yet arrive at a joint solution. Another way to learn from related technologies that was discussed is to use visualisations in communication. In addition, more interactive formats of public participation were discussed. Here, social media can play an important role and the discussants suggested to make more use of these channels in the future.

Another challenge is to deal with the preference of the public for hydrogen fuel cell vehicles. Studies indicate that the public show a preference for hydrogen over electric mobility when comparing the attitudes towards different alternative drive technologies (Scherrer 2023). Knowledge gaps may play a role here, as hydrogen is more likely to play a secondary role in transport compared to electric vehicles. Overall, the experts identified more negative than positive influences of competing for alternative technologies and infrastructures on the acceptance of ERS. Besides hydrogen fuel cell vehicles, stationary charging and synthetic fuels were mentioned. That is, the experts assumed possible crowding out effects or the displacement of ERS by other technologies. However, studies point to the possibility of thinking catenary infrastructure and stationary charging, i.e. high power fast charging, for trucks together to make use of the benefits of both systems (Plötz et al. 2021).

7.2 Bringing together the empirical and the literature review results

Local residents in Germany were identified as holding critical attitudes towards catenary trucks and infrastructure - this was found in the literature on societal dimensions of ERS as well as in the workshops conducted as part of CollERS project. The finding from the literature that there is a lack of supportive networks was also identified as a potential barrier in the workshops.

Several success factors for field tests were identified in the literature review (see section 5.1) which can be compared with the results from the workshops on past or ongoing ERS field trials. This allows an evaluation of the current or past ERS field tests and the extent to which the identified factors are beneficial or detrimental to further dissemination of the technology. Some success factors were found to be lacking when analysing the discussions in the first workshop. For example, "strong and comprehensive coalitions" as well as a "vision for upscaling" in the ERS field tests seem to be missing, which might lead to a lack of social acceptance in certain industry actors. Finally, the experts discussed the influence of the Covid-19 pandemic on the social acceptance of ERS. Covid might have had a negative impact on the social acceptance of ERS since fewer trucks than planned were operated on the test tracks and no social gatherings to explain the technology to local residents were possible. This related back to the (missing) success factors "Discourses" and "Public perception".

In the second workshop strategies to increase acceptance were discussed. These are strategies to boost the success of the field tests, that is, these can be linked back to the success factors identified in the literature review. For example, communicating the technical and environmental impact of the technology to locally affected actor groups as well as public consultation formats were seen as effective measures to increase social acceptance. In addition, learning from similar technologies was seen as a way to inform the design of public participation and information measures and relates back to the succes factor "Evaluation, learning and capacity building".

8 Conclusion and outlook

The aim of this working paper was to identify important acceptance factors for ERS in Germany and Sweden, taking into account different actor groups. Cultural differences as well as different political and infrastructural framework conditions were also taken into account.

The literature reviews and the workshops conducted as part of the CollERS project have shown that there are some differences when it comes to the social acceptance of past and ongoing ERS field trials in Germany and Sweden. At the same time, similar benefits of the technology are seen in both countries. It has to be taken into account that the field tests have different sizes, locations, and partly also a different technological focus.

Not all of the success factors identified in the literature could be demonstrated in the field trials. This offers potential for improvement in the current or future field trials on ERS.

Open questions that are important for the further diffusion of ERS are the further development of alternative or competing technologies for decarbonizing heavy-duty road transport as well as the upcoming path decisions regarding the further promotion of the technological options.

9 Acknowledgements

The Swedish partners received funding from the Swedish Transport Administration (Trafikverket). The German partners are grateful for funding from the research programme "Erneuerbar Mobil" of the German Federal Ministry for Economic Affairs and Climate Action.

We would like to express our sincere thanks to the participants of the two workshops in 2022, experts in Germany and Sweden in the field of societal factors of ERS.

10 References

Aalbers, C.B.E.M.; Kamphorst, D. A.; Langers, F. (2019): Fourteen local governance initiatives in greenspace in urban areas in the Netherlands. Discourses, success and failure factors, and the perspectives of local authorities. In: *Urban Forestry and Urban Greening* 42, S. 82–99. DOI: 10.1016/j.ufug.2019.04.019.

Andersson, Linda; Skallefell, Per; Skjutar, Kristin; Suko, Emil; Arfwidsson, Viktor (2019): Roles, actor relations and risks in the electric roads market. Hg. v. EY.

Belitz, Heike; Kirn, Tanja (2008): Deutlicher Zusammenhang zwischen Innovationsfähigkeit und Einstellungen zu Wissenschaft und Technik im internationalen Vergleich. Vierteljahrshefte zur Wirtschaftsforschung. In: *Vierteljahrshefte zur Wirtschaftsforschung* 77 (2), S. 47–64. DOI: 10.3790/vjh.77.2.47.

Berlin, Daniel; Engwall, Mats (2018): Organizing ERS Projects: Implications for Demonstrations and Deployments. A Comparative Stakeholder Analysis of the Swedish ERS-Projects eRoadArlanda and eHighway E16.

Blumer, Y. B.; Stauffacher, M.; Lang, D. J.; Hayashi, K.; Uchida, S. (2013): Non-technical success factors for bioenergy projects-Learning from a multiple case study in Japan. In: *Energy Policy* 60, S. 386–395. DOI: 10.1016/j.enpol.2013.05.075.

Börjesson, Conny; Gustavsson, Martin G. H. (2018): User Perspectives on Electric Roads. In: *31st International Electric Vehicle Symposium and Exhibition, EVS 2018 and International Electric Vehicle Technology Conference 2018*, EVTeC 2018.

Boulanger, S.O.M.; Nagorny, N. C. (2018): Replication vs mentoring: Accelerating the spread of good practices for the low-carbon transition. In: *International Journal of Sustainable Development and Planning* 13 (2), S. 316–328. DOI: 10.2495/SDP-V13-N2-316-328.

Breitschopf, Barbara; Keil, Julia; Scheller, Fabian; Burghard, Uta (2022): Does Financial Participation Promote the Acceptance of the Energy Transition? In: *SSRN Journal*. DOI: 10.2139/ssrn.4093988.

Burghard, Uta; Scherrer, Aline (2020): Der eHighway aus gesellschaftlicher Perspektive. Erkenntnisse zur sozialen Akzeptanz und den Akteuren rund um Oberleitungs-Lkw-Systeme in Deutschland und Europa. Hg. v. Fraunhofer ISI. Karlsruhe.

Drinkwaard, W.; Kirkels, A.; Romijn, H. (2010): A learning-based approach to understanding success in rural electrification: Insights from Micro Hydro projects in Bolivia. In: *Energy for Sustainable Development* 14 (3), S. 232–237. DOI: 10.1016/j.esd.2010.07.006.

Eylander, J.G.R.; Holtman, H. A.; Salma, T.; Yuan, M.; Callaway, M.; Johnstone, J. R. (2001): The Development of Low-Sour Gas Reserves Utilizing Direct-Injection Liquid Hydrogen Sulphide Scavengers. In:. Proceedings - SPE Annual Technical Conference and Exhibition, S. 1817–1830. Online verfügbar unter https://www.scopus.com/inward/record.uri?eid=2-s2.0-1142290684&doi=10.2118%2f71541-ms&partnerID=40&md5=6cacaf8098bfd36b6e64fa63bb6226cf.

Gabderakhmanova, T.; Marinelli, M. (2022): Multi-Energy System Demonstration Pilots on Geographical Islands: An Overview across Europe. In: *Energies* 15 (11). DOI: 10.3390/en15113908.

Gadgil, Shamala; Ekambaram, Karthikeyan; Davies, Huw; Jones, Andrew; Birrell, Stewart (2022): Determining the Social, Economic, Political and Technical Factors Significant to the Success of Dynamic Wireless Charging Systems through a Process of Stakeholder Engagement. In: *Energies* 15 (3), S. 930. DOI: 10.3390/en15030930.

Heilmann, A.; Pundt, H. (2017): Evaluation of a transdisciplinary research project aimed at the development of climate change adaptation measures. In: Climate Change Research at Universities: Addressing the

Mitigation and Adaptation Challenges, S. 441–461. Online verfügbar unter https://www.scopus.com/inward/record.uri?eid=2-s2.0-85075643099&doi=10.1007%2f978-3-319-58214-6_28&partnerID=40&md5=fc7d468b377b516cb10cdffe1682f21b.

Heyma, A.; Zwaneveld, P.; Korver, W. (2001): The determination of success factors in European demonstration projects for new propulsion systems and transport concepts. In: *Transportation Research Part D: Transport and Environment* 6 (1), S. 1–20. DOI: 10.1016/S1361-9209(00)00008-0.

International Energy Agency (2023): Transport: Improving the sustainability of passenger and freight transport. Online verfügbar unter https://www.iea.org/topics/transport, zuletzt geprüft am 28.6.23.

Kivimaa, Paula; Hildén, Mikael; Huitema, Dave; Jordan, Andrew; Newig, Jens (2017): Experiments in climate governance – A systematic review of research on energy and built environment transitions. In: *Journal of Cleaner Production* 169, S. 17–29. DOI: 10.1016/j.jclepro.2017.01.027.

Knoth, K.; Fufa, S. M.; Seilskjær, E. (2022): Barriers, success factors, and perspectives for the reuse of construction products in Norway. In: *Journal of Cleaner Production* 337. DOI: 10.1016/j.jclepro.2022.130494.

Köhler, Jonathan; Geels, Frank W.; Kern, Florian; Markard, Jochen; Onsongo, Elsie; Wieczorek, Anna et al. (2019): An agenda for sustainability transitions research: State of the art and future directions. In: *Environmental Innovation and Societal Transitions* 31, S. 1–32. DOI: 10.1016/j.eist.2019.01.004.

Kuo, C.-F.J.; Lin, C.-H.; Hsu, M.-W. (2016): Analysis of intelligent green building policy and developing status in Taiwan. In: *Energy Policy* 95, S. 291–303. DOI: 10.1016/j.enpol.2016.04.046.

Leary, J.; Czyrnek-Delêtre, M.; Alsop, A.; Eales, A.; Marandin, L.; Org, M. et al. (2020): Finding the niche: A review of market assessment methodologies for rural electrification with small scale wind power. In: *Renewable and Sustainable Energy Reviews* 133, S. 110240. DOI: 10.1016/j.rser.2020.110240.

Leary, J.; Schaube, P.; Clementi, L. (2019): Rural electrification with household wind systems in remote high wind regions. In: *Energy for Sustainable Development* 52, S. 154–175. DOI: 10.1016/j.esd.2019.07.008.

Liang, X.; Shen, G. Q.; Guo, L. (2015): Improving management of green retrofits from a stakeholder perspective: A case study in China. In: *International Journal of Environmental Research and Public Health* 12 (11), S. 13823–13842. DOI: 10.3390/ijerph121113823.

Markard, Jochen; Raven, Rob; Truffer, Bernhard (2012): Sustainability transitions: An emerging field of research and its prospects. In: *Research Policy* 41 (6), S. 955–967. DOI: 10.1016/j.respol.2012.02.013.

Mirzania, P.; Balta-Ozkan, N.; Marais, L. (2020): One technology, two pathways? Strategic Niche Management and the diverging diffusion of concentrated solar power in South Africa and the United States. In: *Energy Research and Social Science* 69. DOI: 10.1016/j.erss.2020.101729.

Mlecnik, E. (2014): Which factors determine the success of strategic niche developments? Reflections from the emergence of a passive house network. In: *Construction Innovation* 14 (1), S. 36–51. DOI: 10.1108/CI-01-2012-0007.

Morales, Christian Nunez (2019): Reaching Commercial Deployment of Electric Road Systems. Barriers and Opportunities from the Perspective of eRoadArlanda.

Plötz, Patrick; Hacker, Florian; Jöhrens, Julius; Speth, Daniel; Gnann, Till; Scherrer, Aline; Burghard, Uta (2021): Infrastruktur für Elektro-Lkw im Fernverkehr: Hochleistungsschnelllader und Oberleitung im Vergleich – ein Diskussionspapier. Fraunhofer ISI; Öko-Institut; ifeu. Karlsruhe, Berlin, Heidelberg. Online verfügbar unter https://www.isi.fraunhofer.de/content/dam/isi/dokumente/cce/2021/BOLD_Truck_charging_discussion%20paper.pdf, zuletzt geprüft am 3.7.23.

Schecker, Fabian (2018): Analyse von Einflüssen auf die Akzeptanz des Systems eHighway. TU Darmstadt.

Scherrer, Aline (2023): How media coverage of technologies affects public opinion: Evidence from alternative fuel vehicles in Germany. In: *Environmental Innovation and Societal Transitions* 47, S. 100727. DOI: 10.1016/j.eist.2023.100727.

Scherrer, Aline; Burghard, Uta (2019): Social acceptance of catenary hybrid trucks in Germany - first results from the accompanying research of eWayBW. In: *3rd Electric Road Systems Conference 2019*.

Scherrer, Aline; Burghard, Uta; Brunzema, Iska (2020a): Actor networks around catenary hybrid trucks in central Europe: An analysis over time.

Scherrer, Aline; Plötz, Patrick; van Laerhoven, Frank (2020b): Power from above? Assessing actor-related barriers to the implementation of trolley truck technology in Germany. In: *Environmental Innovation and Societal Transitions* 34, S. 221–236. DOI: 10.1016/j.eist.2020.01.005.

Schot, Johan; Geels, Frank W. (2008): Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy. In: *Technology Analysis & Strategic Management* 20 (5), S. 537–554. DOI: 10.1080/09537320802292651.

Schut, M.; Klerkx, L.; Sartas, M.; Lamers, D.; Campbell, M.M.C.; Ogbonna, I. et al. (2016): INNOVATION PLATFORMS: EXPERIENCES WITH THEIR INSTITUTIONAL EMBEDDING IN AGRICULTURAL RESEARCH FOR DEVELOPMENT. In: *Ex. Agric.* 52 (4), S. 537–561. DOI: 10.1017/s001447971500023x.

Sista, E.; Giovanni, P. de (2021): Scaling up smart city logistics projects: The case of the smooth project. In: *Smart Cities* 4 (4), S. 1337–1365. DOI: 10.3390/smartcities4040071.

Struyk, R. J. (2007): Factors in successful program implementation in Russia during the transition: Pilot programs as a guide. In: *Public Administration and Development* 27 (1), S. 63–83. DOI: 10.1002/pad.430.

Upham, Paul; Oltra, Christian; Boso, Àlex (2015): Towards a cross-paradigmatic framework of the social acceptance of energy systems. In: *Energy Research & Social Science* 8, S. 100–112. DOI: 10.1016/j.erss.2015.05.003.

van Buuren, A.; Vreugdenhil, H.; van Popering-Verkerk, J.; Jan Ellen, G.; van Leeuwen, C.; Breman, B. (2018): The Pilot Paradox: Exploring Tensions between Internal and External Success Factors in Dutch Climate Adaptation Projects. In: Innovating Climate Governance: Moving beyond Experiments, S. 145–165. Online verfügbar unter https://www.scopus.com/inward/record.uri?eid=2-s2.0-85056770225&doi=10.1017%2f9781108277679.011&partnerID=40&md5=dfc283e16617e9b439bb2aa2f64071d2.

van den Heiligenberg, Harm A.R.M.; Heimeriks, Gaston J.; Hekkert, Marko P.; van Oort, Frank G. (2017): A habitat for sustainability experiments: Success factors for innovations in their local and regional contexts. In: *Journal of Cleaner Production* 169, S. 204–215. DOI: 10.1016/j.jclepro.2017.06.177.

Wang, Qiuchen; Berlin, Daniel; Meijer, Sebastiaan (2019): Uncovering stakeholder influences in electric road systems using two assessment methods: The case of eRoadArlanda. In: *Research in Transportation Business & Management* 33, S. 100422. DOI: 10.1016/j.rtbm.2019.100422.

Wang, Qiuchen; Hauge, Jannicke Baalsrud; Meijer, Sebastiaan (2020): Adopting an Actor Analysis Framework to a Complex Technology Innovation Project: A Case Study of an Electric Road System. In: *Sustainability* 12 (1), S. 313. DOI: 10.3390/su12010313.

Wang, Qiuchen; Meijer, Sebastiaan (2019): ERS Stakeholder concerns inspiration. In: *3rd Electric Road Systems Conference 2019*.

Warneryd, Martin; Karltorp, Kersti (2022): Microgrid communities: disclosing the path to future system-active communities. In: *Sustainable Futures* 4, S. 100079. DOI: 10.1016/j.sftr.2022.100079.

Woltering, L.; Fehlenberg, K.; Gerard, B.; Ubels, J.; Cooley, L. (2019): Scaling – from “reaching many” to sustainable systems change at scale: A critical shift in mindset. In: *Agricultural Systems* 176. DOI: 10.1016/j.agsy.2019.102652.

Wüstenhagen, Rolf; Wolsink, Maarten; Bürer, Mary Jean (2007): Social acceptance of renewable energy innovation: An introduction to the concept. In: *Energy Policy* 35 (5), S. 2683–2691. DOI: 10.1016/j.enpol.2006.12.001.

11 Annex

Authors	Methods								
	QUANT	QUAL	Interview	Workshop / Focus group	Survey	Media analysis	Literature review	Case study	Network analysis
Berlin et al. (2018)		x	x					x	
Börjesson et al. (2018)		x	x	x					
Schecker (2018)									
Morales (2019)		x	x				x	x	
Wang et al. (2019)		x	x						x
Andersson et al. (2019)		x	x						
Wang et al. (2019)		x	x				x		x
Scherrer & Burghard (2019)	x	x	x		x	x		x	
Wang et al. (2020)		x	x				x		x
Burghard et al. (2020)		x	x			x	x		x
Scherrer et al. (2020)	x	x			x				x
Scherrer et al. (2020)	x	x	x		x				x
Gadgil et al. (2022)		x		x			x		

Table 5: Methods used in the articles identified in the literature search