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Multi-system interactions and institutional work: Actor interactions at the interface of residential storage systems and electric vehicles in Germany

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ABSTRACT

Multi-system interactions are receiving increasing attention within transition research. However, understanding the consequences of increasing couplings between adjacent systems for transitions requires further research. In response, this paper applies the concept of institutional work to understand the role of actors creating institutional couplings for the reconfiguration of multiple systems. We further elaborate on enabling conditions for institutional work from a sector-sensitive perspective. In-depth interviews with energy and automobile sector experts and participant observation at industry association events show that cross-sectoral networks and advocacy are important mechanisms for creating regulative couplings. However, particularly actors in the automotive industry are able to advance into the electricity market due to increasing access to political institutions and enhanced intellectual and physical-material resources. Thus, we show how within-system incumbents leverage their resources and engage in cross-sectoral institutional work in order to gain knowledge and integrate new technologies.

1. Introduction

Research on sustainability transitions deals with the question of how the rigidities and path-dependencies of existing system structures are overcome towards new, more sustainable modes of consumption and production (Markard et al., 2012; Geels, 2002). These changes are traditionally conceptualized as single-sector phenomena, particularly in infrastructure sectors, since these sectors are highly institutionalized constellations of user practices, technologies, regulations and professional standards reflecting a high degree of path dependence, few technological opportunities and high entry barriers (Köhler et al., 2019; Jensen et al., 2016; Raven et al., 2016).

However, recent contributions have increasingly criticized transition studies for limiting analysis to isolated sectors (Andersen and Geels, 2023; Kanger et al., 2021; Andersen and Markard, 2020; Rosenbloom, 2020). Instead, transition pathways require interactions between multiple systems in terms of actors, institutions and technologies, such as complementary technological innovations, cross-sectoral business models or overarching policy and planning processes. This applies to decarbonization pathways considering, for instance, the electrification of transport or the fields of heat and power (Löhr and Chlebna, 2023; Rosenbloom, 2019). Thus, it is crucial

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to understand how changes in connected systems can stimulate or hinder systemic shifts.

This paper seeks to contribute to this debate by focusing on how the reconfiguration of multiple systems is shaped by actors creating institutional couplings. Reinforcing the relationship of agency and institutional change (Heiberg et al., 2022; Miörner et al., 2022; Fünfschilling, 2019; Fünfschilling and Truffer, 2016), we apply the concept of institutional work (Lawrence and Suddaby, 2006). A closer look on enabling conditions for institutional work accounts for associated motivations, expertise and assets and explains which actors and sector-specific endowments are associated with strong agency (Duygan et al., 2021b; 2019). Thus, we aim at explaining how institutional work activities condition the specific reconfiguration of system boundaries. Specifically, we suggest that the reconfiguration of system boundaries may take four main forms: missing couplings due to failing institutional work; an overlap of both systems in case actors from both fields succeed in creating couplings; changing market shares, when actors affiliated to one system find themselves better positioned to enhance their enabling conditions and diversify business activities; and finally, interface actors may create couplings and deliver required products and services.

The markets for residential storage systems and electric vehicles in Germany serve as case study. Combining private stationary storage systems with photovoltaics enables their users to increase the consumption of self-produced electricity. While initially actors affiliated to the electricity system, such as electric utilities or storage manufacturers, were the key players in this market, automobile companies are increasingly advancing into the market. Current business models encompass services in the field of mobility, such as private charging points or the leasing of vehicles. Hence, these offers are not solely delivered within the electricity system, but also by automobile manufacturers providing energy management systems, storage systems and green electricity along with electric vehicles. Correspondingly, automobile manufacturers also engage in institutional work in order to create smooth connections between the systems in technological, actor and institutional dimensions.

After presenting the conceptual background and methodological approach, this paper presents the institutional environment of the German electricity sector and depicts institutional work carried out by actors affiliated to the electricity and automobile system. We discuss which specific activities and preconditions stand out for strong agency and, thus, influence the way the different systems become connected.

2. Multi-system interactions and institutional work

2.1. Multi-system interactions in transition studies

Multi-system interactions capture how different relatively unconnected socio-technical systems and the associated actors, institutions and technologies become closely connected in the course of transitions. For example, decarbonization efforts require a better integration of the electricity sector with e.g. transport and heating (Löhr and Chlebna, 2023; Rosenbloom, 2019; Markard, 2018). Multi-system interactions have been conceptualized in different ways. Earlier contributions have focused on niche developments (Sutherland et al., 2015; Papachristos et al., 2013; Raven, 2007; Raven and Verbong, 2007; Geels, 2007) addressing, for instance, institutional and material ties of niches with multiple systems. Geels (2018) takes a more distributed view of change, including landscape forces as well as the interaction of multiple niche innovations within and across regimes. As regards relations between socio-technical regimes, Konrad et al. (2008) differentiate functional and structural couplings. Structural couplings relate to actors, infrastructures or institutions, which are used by two regimes (e.g., shared industry association representation) and are likely to result in synergies. Functional couplings refer to input-output relations between different complementary regimes often leading to co-evolutionary dynamics (e.g., the diffusion of electric vehicle resulting in an increasing electricity demand). In a similar vein, research on complementarities focuses on positive interactions between sectors and technologies in technology value chains, such as newly adopted technologies triggering technological change in input sectors (Mäkitie et al., 2022; Markard and Hoffmann, 2016).

While many of these earlier studies examine the nature of couplings and interactions from a system perspective, more recent contributions (Kanger et al., 2021; Rosenbloom, 2020; Andersen et al., 2020) revisit this work and emphasize the complexity, fluid nature and multi-dimensionality of multi-system interactions. Rosenbloom (2020, 338) highlights the role of agency and political conflict, since “actor networks […] diffuse knowledge, practices, and institutional logics across systems”. Similarly, Kanger et al. (2021, 53) call for more research on types of actors operating across systems and on “their perceptions, actions, and conflicts […] power and capacity to mobilize transition arenas”. The most recent research focuses more on concrete activities of actors connecting multiple systems. For instance, Andersen and Geels (2023) propose causal processes how actors generate new couplings between systems concerning technologies, actors and institutions (e.g., business models diversifying into other systems or actors engaged in institutional work to create institutional alignments). Löhr and Chlebna (2023) examine the activities and characteristics of system entanglers engaged in hydrogen-based pilot projects using the concept of transition work (institutional work attuned to transitions). Studying the example of the electrification of passenger ferries in Norway, Andersen et al. (2023, 9) scrutinize nexus-building processes across technological, agentic, institutional, and material resource dimensions. They suggest that “insights from research on institutional work and dynamics of organizational fields” are needed to further conceptualize interface-building processes. We take this as starting point for operationalizing agency by means of institutional work, which allows us to focus on the role of institutional work as conditioning factor for the reconfiguration of multiple systems in the course of transitions.

2.2. Institutional work and multi-system interactions

Multi-system interactions are usually structured in the three dimensions of technologies, actors, and institutions (Andersen and Geels, 2023; Löhr and Chlebna, 2023; Rosenbloom, 2019; 2020). Rosenbloom’s sites of interaction concern the relationship of technological innovations and existing system elements, changing system boundaries with respect to institutions and the role of actor networks in redefining institutions and technology applications within and across systems (Löhr and Chlebna, 2023; Rosenbloom, 2020). Reconceptualizing structural and functional couplings by Konrad et al. (2008), Andersen and Geels (2023) consider structural couplings to exist rather between (than within) systems and to give rise to new (functional) resource flows. The cross-system interoperability of transport and electricity, for instance, requires new couplings like charging technology, regulations, and standards for its equipment, operation, and payments, which are potentially provided by multi-system interface actors (Fig. 1).

We agree with Andersen and Geels (2023), who consider actors creating institutional couplings a causal process for multi-system interactions. Focusing on institutions (Geels, 2020; Fünfschilling, 2019; Markard et al., 2016), regimes are characterized by a dominant set of idiosyncratic formal (e.g., policies, regulations, standards) and informal institutions (e.g., norms, routines, visions) that actors comply with and reproduce, which results in stability (DiMaggio, 1988; DiMaggio and Powell, 1983). In the course of transitions, these mature fields are challenged by emerging and competing institutional rationalities, which often evokes tensions (Fünfschilling and Binz, 2018; Fünfschilling and Truffer, 2014; Kemp et al., 1998). Regarding the intersection of multiple systems, this implies that the scope of (in)compatibility between system-specific institutions influences the creation of new couplings. Institutional mismatches, such as disagreements and uncertainties over rules, roles, and objectives, among actors affiliated to different systems, might potentially hamper cross-system actor collaboration. Actors can mitigate initial misalignment towards compatible cross-system institutional couplings, which enable functional resource flows (Andersen and Geels, 2023; Andersen et al., 2023).

Responding to Andersen et al. (2023), we operationalize these efforts to create institutional couplings with the concept of institutional work (Lawrence et al., 2009; Lawrence and Suddaby, 2006), which has increasingly been featured within transitions studies (e.g., Löhr et al., 2022; Madsen et al., 2022; Kivimaa et al., 2021; Becker et al., 2021; Kainiemi et al., 2020; van Doren et al., 2020). This framework analyses concrete micro-level activities, which individual and collective actors pursue in order to induce divergent institutional change. Lawrence and Suddaby (2006) identified distinct activities, which aim at both the mobilization of rather tangible resources, such as political power, money, knowledge or social capital, and the (de-)construction of rationales and thereby shaping discourses. While some activities have been associated with the creation of institutions (e.g., *advocacy, educating*), the maintenance of institutions covers the idea of a constant need of ensuring compliance with existing institutions (e.g., by *policing* or *deterring*). Work aiming at the disruption of institutions undermines the compliance of actors with institutions by making them less attractive and delegitimizing them (e.g., by *officially changing rewards and sanctions)* (see Appendix 1 for the full list of institutional work types by Lawrence and Suddaby, 2006).

In carrying out institutional work in multi-system settings, actors have to reconfigure their capabilities and gather knowledge about rules, processes, actor roles etc. in hitherto foreign systems (e.g., by collaborating with existing actors in that system) (Andersen and

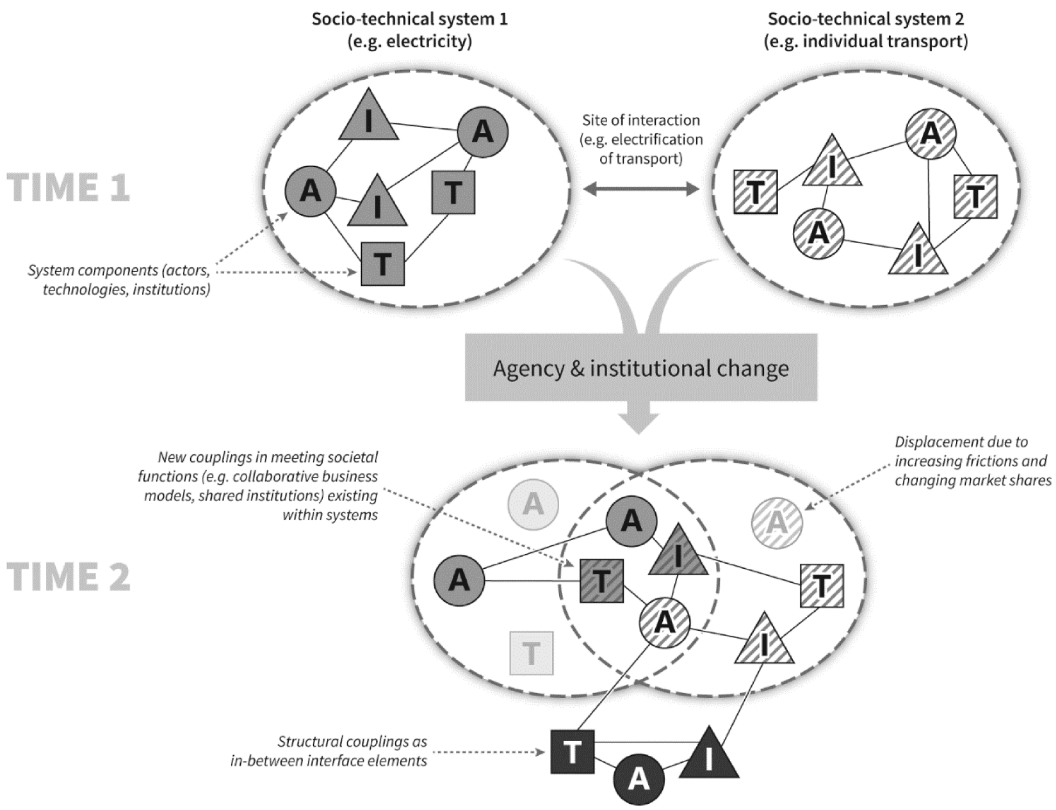

Fig. 1. Agency and institutional change in sites of interactions and the resulting changes of system boundaries (adapted from Rosenbloom, 2019).

Geels, 2023; Andersen and Gulbrandsen, 2020; Steen and Weaver, 2017). In order to better understand how actors attain strong agency to be effective in institutional work, we propose to take account of the foundations of actors' agency from a sector-sensitive perspective and complement the institutional work framework with the key elements enabling institutional work according to Duygan et al. (2019).

2.3. Enabling conditions for institutional work and system affiliation

Understanding the resources and features that orient actors towards institutional work allows for addressing questions on what attributes are required for different forms of institutional work, and why some actors create a higher impact on institutional arrangements than others (Duygan et al., 2021a, b). Therefore, sectoral field conditions as well as the structural position of actors need to be taken into account (Battilana et al., 2009; Battilana and D'Aunno, 2009). We consider this a highly relevant refinement for our case, as actors affiliated with different industries might be more or less effective in respect to certain activities compared to others. Thus, we refer to Duygan et al. (2019) who, based on a literature review of institutional entrepreneurship and institutional work, have identified resources, discourses and networks as key constituent elements for institutional work.

Physical-material resources refer to material artefacts, such as infrastructures or technological elements, which potentially lead technology suppliers and operators to induce a lock-in in order to benefit from path-dependency. Financial resources consist of capital, funds and monetary stocks that are crucial for activities like lobbying or running large-scale media campaigns (Duygan et al., 2019; Binz et al., 2016). Intellectual resources encompass mental abilities, expertise and experience. Finally, politico-judicial resources mean the formal authority of actors facilitating their access to decision- or policy-making venues or political instruments such as veto (Duygan et al., 2019; Lawrence and Suddaby, 2006). Discourses are understood as coherent storylines articulating visions and expectations and creating the legitimacy of an innovation. Through narratives, actors frame how current problems look like and how these issues should be addressed (Smith and Kern, 2009). Finally, (social) networks reflect the collective character of agency, as actors might strive for building trust, gaining legitimacy and accessing complementary resources. Accordingly, resources, discourses and social networks are likely to be complementing one another when facilitating institutional work (see again Appendix 1 for the relationship of constituent elements and institutional work as suggested by Duygan et al. 2019).

2.4. Conceptual framework

Fig. 2 summarizes our conceptual framework. At a site of multi-system interactions (e.g., the electrification of individual transport), actors from both fields arguably aim at creating smooth connections between systems in technological, actor and institutional

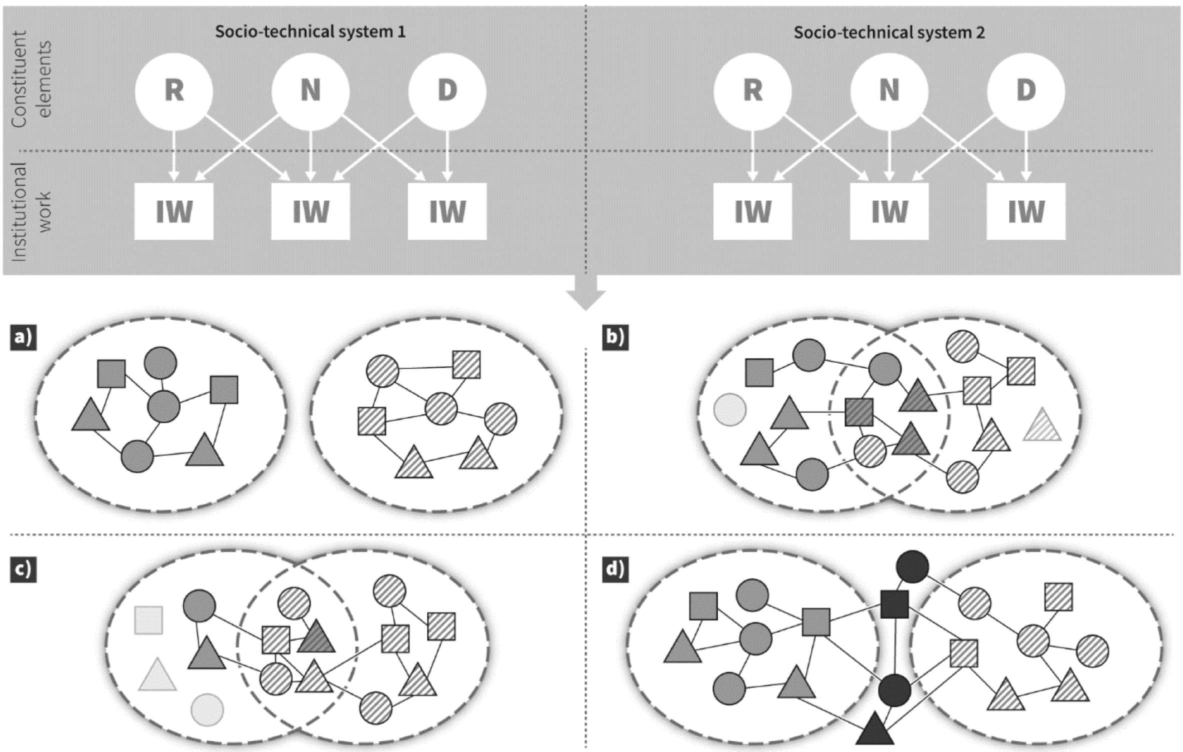

Fig. 2. Stylized illustration of conceptual framework (own elaboration).

dimensions. Relying on the concept of institutional work (IW) (Lawrence and Suddaby, 2006), we focus on institutions and examine the type of actors and activities they carry out in order to create institutional couplings (e.g., by *advocacy* or *defining*). By relating to enabling conditions therefore (Duygan et al., 2019), we aim at explaining, which actors and (sector-specific) endowments are associated with strong agency to shape institutions. Referring to Duygan et al. (2021b, 3), strong agency is understood as "the larger influence exhibited by some actors" in changing institutional structures due to beneficial enabling conditions for institutional work. Taken together, we propose that a better understanding of institutional work along with sector-specific preconditions helps to explain the course of changing system boundaries.

We expect four different options for the reconfiguration of system boundaries: (a) Failing institutional work may lead to missing couplings. (b) Actors from both systems succeed in creating institutional couplings, which results in an overlap of both systems, potentially characterized by collaboration. (c) Actors affiliated to one system might be better positioned to enhance their enabling conditions for institutional work and create couplings corresponding to their interests. Thus, they would be more likely to diversify business activities and exploit emerging opportunities in the other system or in between the systems. (d) Moreover, there is the option of interface actors taking charge of creating institutional couplings and delivering corresponding products and services (e.g., technology, regulations, and standards for equipment, operation, and payments for charging).

3. Case selection, methods, and data

3.1. Case selection: the electrification of individual transport in Germany

In order to gather deep insights about institutional work as a factor influencing the reconfiguration of multiple systems, we conduct a qualitative case study (Yin, 2018). We conceptualize the electrification of transport as empirical setting, which has been a widely used case in studies addressing multi-system interactions (e.g., Andersen et al., 2023; Mäkitie et al., 2022; Rosenbloom, 2019). As a refinement, we focus on the end consumer markets of residential storage systems and electric vehicles, as interactions are observable in terms of technologies (1), actors (2), and institutions (3). As regards technologies (1), lithium-ion batteries can be used independently for residential storage systems and electric vehicles, but at the same time constitute the shared key technology for business models involving both applications. Furthermore, this interface requires (public and private) charging technology emerging between the systems. Concerning actors (2), we observe actors and organizations originally belonging to one system (e.g., automobile companies, electric utilities, ministries) as well as interface actors (e.g., providers of charging equipment). These actors fulfil different roles, in their original field or diversifying their activities into other fields (e.g., storage manufacturers providing car leasing). (3) Institutions spanning the boundaries of both systems are needed, for instance, standards (e.g., on operation, payment) as well as regulation (e.g., on grid connectivity) ensuring the interoperability of charging. Furthermore, political regulation embedded within one system addressing specific targets, such as the feed-in tariff of renewable energies, needs to be attuned to interactions coming from the transport sphere. Relating to end consumer markets, informal institutions manifest themselves as public discourses and consumer conventions, which may face rather traditional mind-sets on the side of grid system actors.

Regarding these dimensions, Germany constitutes an emblematic case (Flyvbjerg, 2006). In general, the markets for residential energy storage systems with a maximum capacity of 30 kWh as well as for electric and hybrid vehicles have been characterized by massive rises in sales. The market for residential storage systems is the biggest in Europe in absolute terms and relative to population (ees Europe 2023, see Fig. 3). From a technological perspective (1), we have seen advances in battery technology in terms of materials, life spans and capacities leading to new application possibilities (Figgener et al., 2021). Combined with photovoltaics, storage systems can be used in residential energy management systems in order to enhance self-production and -consumption of electricity, also known as prosuming. More precisely, storing surplus electricity beyond current consumption increases the share of self-generated electricity among total electricity consumption in a household (Tepe et al., 2021; Kairies et al., 2019).

Besides self-consumption, business models increasingly encompass so-called 'multi-use' applications (Blasch et al., 2021; Mlinarič et al., 2019). For instance, large numbers of digitally aggregated photovoltaic and battery systems can be used for frequency containment reserve in order to balance variation of mains voltage by the withdrawing or storing of electricity in cases of grid disruption or overproduction (Sousa et al., 2019). Most importantly, batteries of electric vehicles are integrated into energy management systems, also including photovoltaics and stationary storages. The main aim is to facilitate vehicle charging with self-produced electricity (Rücker et al., 2022; Costa et al., 2022). Some business models even include leasing agreements for electric vehicles (e.g., *sonnenDrive*). As a further step – so far not implemented due to missing regulation – frequency containment reserve could be provided by bidirectionally charging mobile electric vehicle storages, known as vehicle-to-grid.

As regards actors (2), the supplier side is increasingly spanning boundaries (Costa et al., 2022). Prior to the integration of mobility services, the business models were mainly provided by medium-sized storage manufacturers (e.g., *sonnen* or *E3/DC*) and rather small green electricity providers (e.g., *Lichtblick* or *Polarstern*), followed by big electric utilities (e.g., *EnBW, E.On*) (Zademach and Käsbohrer, 2022). Nowadays, full-package offers potentially encompassing photovoltaics, stationary storage systems, electric vehicles, wall boxes, energy management software and residual power contracts are often collaboratively provided by both sectors (e.g. *Mercedes Benz* in cooperation with *E.On, BMW* with *Solarwatt,* or *Tesla* with *Octopus Energy Germany*). The *Volkswagen Group* has independently started to provide a full-package offer including green residual electricity along with electric vehicles and even mere electricity contracts without an electric car (*Volkswagen Naturstrom* in Fuhs, 2021). Charging tariffs, which regulate the contractual accounting at public charging points, are also offered by both, electric utilities (e.g., *EnBW mobility+, E.ON ÖkoStrom Home & Drive 24*) and automotive companies (e.g., *BMW charging, Audi charging, Mercedes Me Charge*).

The different use cases of these business models require the alignment of the regulatory framework (3). In fact, we have seen

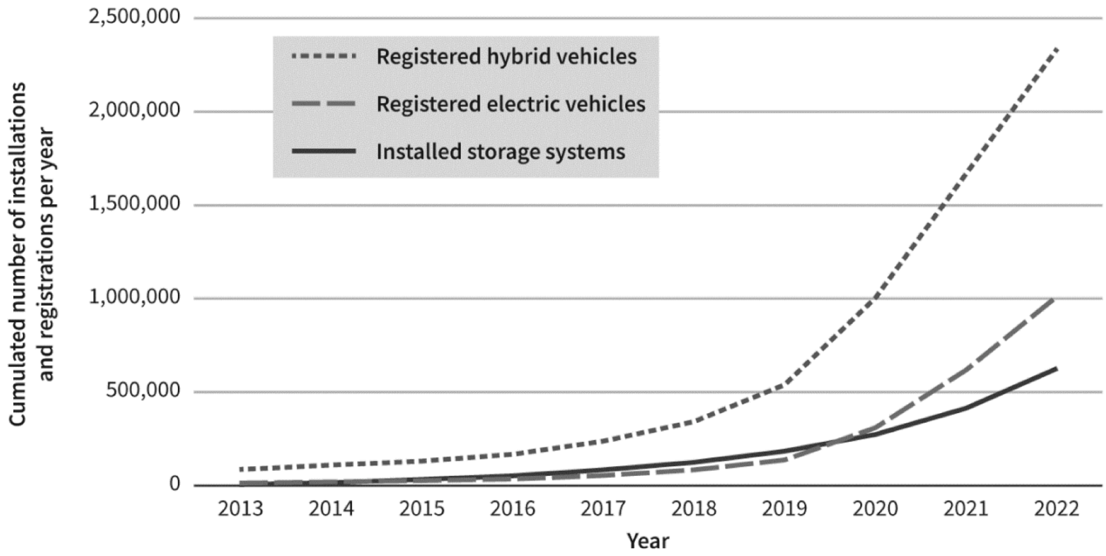

Fig. 3. Cumulated installation figures of stationary residential energy storage systems (up to 30 kWh) and stock of licensed passenger cars with electric or hybrid engines for the years 2013 until 2021 in Germany, estimated and rounded values at years-end, Sources: Bundesverband Solarwirtschaft e. V. (2023), Kraftfahrt-Bundesamt (2023).

amendments of key regulation in Germany during recent years. According to Duygan et al. (2019; 2021b) observing decision- or policy-making instances influencing institutional arrangements, such as revision of laws, technology standardization processes, or funding schemes, can provide a reference for assessing agency since actors typically try to influence formal institutions to direct the course of transitions. In spite of these amendments, the regulatory framework is still considered the main barrier for a further development of abovementioned business models, which emphasizes our focus on institutional work as influencing factor for changing system boundaries. The revision processes will be elaborated on in Section 4.1.

3.2. Data collection and analysis

The empirical analysis draws on the triangulation of different qualitative methods and data sources. Our market knowledge is based on extensive desk based research including market data, reports by utilities, ministries and industry associations as well as company websites and legal texts. We further draw on participant observations during 42 working group meetings of a German industry association in the electricity system, which members participate in to get informed about market trends, innovative developments and regulatory changes as well as to organize their institutional work targeting regulation (for a list of subjects see Appendix 2). The association's members are mostly affiliated with the electricity system (e.g., electric utilities, Distribution System Operators (DSOs), storage manufacturers), but increasingly also with the automotive industry (e.g., car manufacturers, suppliers in the field of charging). The meetings lasted between 60 and 180 min and took place between September 2020 and February 2023.

For the purpose of a data and perspective triangulation (Flick, 1995), we conducted a total of 32 semi-structured interviews with both electricity and automotive sector experts and industry leaders, ranging from academics, government officials and lawyers to representatives of utilities, industry associations, DSOs and Transmission System Operators (see Appendix 3). The first interview partners were either members of the aforementioned industry association or identified through desk based research, whereas further experts were sampled based on recommendations from those interviewed (snowball method). The sampling strategy targeted senior experts from both industries directly involved in institutional work or having an explicit knowledge about the market. The interviews were conducted by phone or videoconferencing software between February 2021 and May 2023 and lasted about 75 min on average. All but five interviews were recorded and transcribed verbatim. Extensive notes were gathered in the unrecorded ones.

We first asked the interviewees to describe the main obstacles to the implementation of new business models. With energy regulation being considered as the main barrier in almost all interviews, we further asked the interviewees to identify actors and organizations influencing regulation, their concrete actions as well as their enabling or constraining preconditions in order to push their particular agenda. We also covered further institutional work activities targeting formal (e.g., standards) and informal institutions (e.g., public discourse). The agency of actors is indicated by the extent of influence their institutional work had on changing relevant institutions. We assessed their agency through actual decision- and policy-making interventions, the salience of their arguments and activities, their network positions and endowment with resources as well as cross-validated statements about the estimated impact (Duygan et al., 2021a). The empirical material was subject to a qualitative content analysis based on a coding scheme that was informed by the theoretical assumptions (Mayring and Fenzl, 2019). During the coding process, the scheme itself was constantly refined (for exemplary quotes see Appendix 4).

4. Analysis

4.1. Institutional context and regulatory changes

The aforementioned business models contradict the rationality of a rather centralized electricity supply, which is mainly promoted by the Federal Network Agency[1] (BNetzA), part of the Ministry of Economic Affairs (BWWK, especially until the end of 2021[2]), several (mostly municipal) electric utilities and DSOs[3] along with their industry associations. The regulatory framework (mainly *Erneuerbare-Energien-Gesetz, EEG*, and *Energiewirtschaftsgesetz, EnWG)* is regarded by industry experts as being the central obstacle to a more profitable realization of the business models, since, for instance, some multi-use applications are associated with double grid fees, taxes and surcharges as well as high measurement requirements. Regulation regarding vehicle-to-grid is missing at all (see Tables 1 and 2).

As regards amending EEG and EnWG, formal decision-making power lies with the German federal parliament. The substantive work on the legislation mainly resides with the BMWK. Although being intended as downstream, executive authority, the BNetzA provides extensive advisory services to the ministry, thereby voicing its critical attitude towards residential storage systems. However, there have been changes benefitting a more profitable implementation of the business models. Among others, in 2023, the EEG surcharge was suspended (see again Tables 1 and 2; for a more detailed overview of the policy processes and actors involved see Appendix 5). The next chapters shed light on the enabling conditions for and concrete activities of institutional work inducing these and further changes.

4.2. Institutional work and enabling conditions

4.2.1. Electricity system

4.2.1.1. Actors with strong agency. Actors advocating the usage of residential storage systems potentially accompanied by e-mobility services are mainly the providers of these business models, that is storage manufacturers, rather niche green electricity utilities, but also the big conventional utilities (see Section 3.1). With respect to institutional work, interviewees identified big electric utilities and particularly industry associations as having decisive impact on policy processes, to a lesser extent storage manufacturers. Industry associations are the main stage for mobilizing allies and collective institutional work. There is a broad landscape of associations; part of our empirics were industry associations representing the solar industry, the production of renewables or the storage industry. By contrast, the influence of NGOs seems to be rather weak.

4.2.1.2. Enabling conditions. **Discourses**. The central narrative around the mentioned business models is concerned with the advantages of a decentralized, prosumer-driven electricity supply. Storing electricity allows for a flexible adjustment of load and generation, which is indispensable due to the further integration of renewable energies. The combination of storage systems and e-mobility increases the self-consumption of electricity. Especially industry associations highlight profitable use cases, such as frequency containment reserve (see chapter 3.1), which require regulatory adjustments (regarding fees, charges, and metering, see chapter 4.1). Particularly regarding advocacy, customers' benefits and fostering the overarching political targets of expanding renewable energies are considered salient arguments.

Another argument for advocacy work is the lacking compliance with EU legislation. Especially industry associations point to the necessity of aligning German regulation with EU legislation, which claims beneficial regulatory changes such as higher thresholds for exemptions from fees and surcharges (see chapter 4.1). The effectiveness of this argument is contested, as BMWK and BNetzA representatives argue that EU legislation is implemented pointing to inaccuracies in EU legislation, instead. Similarly, some interviewees (industry associations, electric utilities) consider rather the high complexity of regulation (e.g., metering requirements) as main reason for unfeasible business models. When it comes to advocating regulative changes towards politicians (esp. parliamentarians), the investigated industry association highlights the argument of supporting SMEs. A further development of business models would benefit SMEs dealing with developing, manufacturing and installing energy management systems including storages. Regarding public discourse and promotional activities, electric utilities and storage manufacturers highlight rather emotional aspects, such as autarky, contributing to the expansion of renewable energies and technology enthusiasm. Further arguments are financial savings and backup power supply.

> *"So storytelling in its purest form. Whether it always pays off, whether it all makes sense, that's often irrelevant. The customer wants to feel good. He wants to understand something." (Interview 8)*

[1] The Federal Network Agency for Electricity, Gas, Telecommunications, Post and Railway (*Bundesnetzagentur*, BNetzA) is a separate higher federal authority aimed at guaranteeing the liberalization and deregulation of the markets for telecommunications, post and energy via non-discriminatory network access and efficient system charges (BNetzA, 2023a).

[2] After taking office at the end of 2021, the new leadership of the then called Ministry of Economic Affairs and Climate Action (BMWK) (*Bündnis 90/Die Grünen, Alliance 90/The Greens*) has been influencing some regulatory changes of the EEG 2023 and the EnWG 2022 benefitting a more decentralized electricity supply.

[3] Regarding the approximately 870 German DSOs, our empirical material indicates great heterogeneity with some stakeholders welcoming residential storage systems and even launching research projects, but the large majority being critical towards them.

Table 1
Main regulatory barriers in EEG and the respective changes through recent amendments relevant for business models involving residential storages and electric passenger cars (still existing barriers in italics).

Main regulatory barriers in EEG 2017	Main regulatory barriers and changes in EEG 2021	Main regulatory barriers and changes in EEG 2023
Installation of photovoltaics and storage systems highly complex bureaucratically.	Easier grid access for storage systems (§8 Abs. 5 S. 3 EEG).	
Missing definition of ‘energy storage‘, instead treatment as consumer and generation facility (§ 3 Nr. 1 EEG).		In 2023, new definition of energy storage as new category besides generation, transport and consumption in EnWG (§3 Abs.15d), not yet in EEG. *However, one-year time limit to incorporate definition in main regulatory frameworks.*
Threshold for total exemptions of grid fees, taxes and (EEG-) surcharges at 10 kWh (§ 61a Nr. 4 EEG), de-facto double charging with grid fees, taxes and (EEG-) surcharges for installations > 10 kWh in the course of storing and withdrawing electricity from the storage (grid services) due to high and complex measurement requirements (§§ 60, 61l EEG). Regarding EEG-surcharge, in any case 40 % each time for storing and withdrawal of electricity (§ 61b EEG).	Threshold for exemptions of grid fees, taxes and surcharges set from 10 kWh to 30 kWh for new and existing installations (§ 61 Abs. 1 EEG). § 61l EEG simplified, grid services involving storing and withdrawing electricity from the storage possible for prosumers without double charging with taxes and (EEG-) surcharges. *However, not applied to grid fees and still highly complex in terms of measurement requirements.*	Suspension of EEG surcharge (§ 58 EEG). Simplified measurement at grid connection point (behind-the-meter): most fees and taxes only relate to withdrawals from and feed-ins of electricity to the grid, balancing of electricity flows (acc. to §21 EnFG ‘Energiefinanzierungsgesetz’, former § 61l EEG). *However, still contested: grid fees and electricity taxes in multi-use applications.* Storage losses are exempt from charges and fees (§ 21 EnFG).
Energy communities not implemented. Furthermore, joint production and usage of renewables by self-consumers located in the same building hampered by regulatory and bureaucratic requirements (§ 3 Nr. 19 EEG; §§ 21b Abs. 3, 23b EEG).	Joint production and usage of renewables by self-consumers located in the same building (landlord-to-tenant electricity) facilitated, as electricity can be delivered by a third party instead of the facility operator itself (§ 21 Abs. 3 EEG). Furthermore, higher government subsidies for projects in rental apartments (§ 48 EEG).	
Separation of green and conventional grid power as well as self-consumed and fed-in electricity flows, leading to complex metering of different electricity flows and hampering multi-use of storage systems (§ 3, Nr. 1 EEG; § 61l EEG)		
	Introduction of regulation for photovoltaic systems older than 20 years (§ 3 Nr. 3a EEG; § 19 EEG).	New rates of feed-in compensations for prosumers completely and partly feeding in (involving self-consumption) with the latter being reasonably high and, thus, enhancing the installation of a storage system in addition to photovoltaics (§ 100 Abs. 4 EEG).

Source: Erneuerbare-Energien-Gesetz (EEG) und Energiewirtschaftsgesetz (EnWG) in Bundesministerium der (2023a, b).

Table 2
Main regulatory barriers in EnWG and the respective changes through recent amendments relevant for business models involving residential storages and electric passenger cars (still existing barriers in italics).

Main regulatory barriers in EnWG 2011	Main regulatory barriers and changes in EnWG 2021	Main regulatory barriers and changes in EnWG 2022
Missing definition of ‘energy storage’ as well as mobile storages, instead treatment as consumer and generation facility (§ 3, Nr. 15 EnWG).		In 2023, new definition of energy storage as new category besides generation, transport and consumption (§3 Abs.15d EnWG). *However, one-year time limit to incorporate definition in main regulatory frameworks.*
Double charges with grid fees and charges (§ 19 Abs. 2 EnWG, § 17f Abs. 5 EnWG ‘offshore grid fee’ § 48 EnWG ‘concession fee’), double charges with grid fees (§ 118 Abs. 6 EnWG).	Fees and charges measured analogously to § 61l EEG. *However, not applied to grid fees (§ 118 Abs. 6 EnWG).*	
No regulation for bidirectional charging, e.g. *grid charging periods of private electric vehicles (§ 14a EnWG)*		*(Forthcoming, BNetzA in charge of regulation for grid charging periods allowing DSOs to control storage systems in exceptional cases (§ 14a EnWG))*

Source: Erneuerbare-Energien-Gesetz (EEG) und Energiewirtschaftsgesetz (EnWG) in Bundesministerium der (2023a, b).

Social networks. The high relevance and legitimacy of industry associations reflect the collective character of agency and the importance of networks for institutional work. Networks facilitate advocacy particularly by increasing credibility, especially if competitors or incumbent actors, such as DSOs, are involved:

> *“By addressing position with others, you increase your credibility […]. If you also have a DSO on board, that’s even better. Then […] you have fixed this problem.” (Interview 11)*

In this multi-system setting, an important feature of networking is bridging different actors groups that are otherwise not collaborating. This is illustrated by automobile companies becoming members of industry associations in the field of electricity. Vice versa, representatives of industry associations state that they benefit from the lobby weight of automobile manufacturers:

> *"The car lobby is incredibly strong in Germany. […] Well, they just use the political contacts they have in the [industry association in the electricity system] to mobilize the forces that then work in the same direction." (Interview 12)*

Moreover, cross-sectoral networks are necessary for defining, when it comes to initiate joint research and pilot projects, which aim at advancing technical standards (e.g., for measurement technology, reusing of mobile batteries for containment frequency reserve).

Resources. Electric utilities and storage manufacturers themselves lack formal authority over decision or policy-making. Their access is mainly limited to institutional work activities. In financial terms, many small, often municipal and unbundled utilities, handling the generation and distribution of electricity, lack capacity to be a member of industry associations. The same applies to SME storage manufacturers. Thus, big electric utilities are more likely to engage in advocacy work. Furthermore, large companies are able to invest in R&D, to start pilot projects, to cross-subsidize them, or to take the risk of making advance payments for the charging infrastructure, which is important for theorizing and defining. As regards intellectual resources, especially big electric utilities possess high knowledge on the regulatory environment in the electricity sphere due to longstanding memberships in industry associations or in-house lawyers. However, electricity system actors (such as electric utilities) are mostly lacking experience in terms of digital tractability (e.g., communication interfaces), which hampers, for instance, defining activities for intelligent charging.

Physical-material resources mainly concern the physical components of business model devices as well as the charging infrastructure. Public charging points are mainly operated by electricity system actors, such as electric utilities, metering point operators and DSOs,[4] but also by petroleum and automotive companies as well as by public authorities, major employers and commercial enterprises (e.g., supermarkets).[5] The argument of taking on social responsibility and serving the overarching energy transition by operating public charging infrastructure gives legitimacy and credibility:

> *"If you come across as a doer, then you have more weight than writing position papers without being active in this business model yourself." (Interview 25)*

When it comes to business model devices, transferring expertise and eventually specific products and services from the automobile to the electricity system comes with challenges. While it is feasible for electricity system actors to integrate storage systems into their business models (also by means of shareholdings) and e-mobility services such as charging tariffs, the integration of hardware is practically constrained to charging or leasing cooperations with automobile manufacturers. This again hampers, for instance, defining standards for bidirectional charging or grid connectivity for electric vehicles.

4.2.1.3. Institutional work. Regulative institutions (see again chapter 4.1) are the most important target for actors seeking to promote residential storage systems, especially for industry associations. One key task is to *educate* their member firms about recent regulatory changes and to discuss the associated consequences for their business models. The other main activity is political *advocacy* towards policymakers, such as ministries, network agencies or political parties (esp. parliamentarians) by means of, for example, opinion papers or associations' hearings. These papers inform about companies' regulatory requirements and aim at creating an appropriate institutional environment to further promote the aforementioned business models (e.g., by claiming reliefs from charges and fees). In order to influence the cognitive frames of policy makers, they *theorize* the benefits of a decentral electricity supply.

Press releases and position papers are also published by single stakeholders, like electric utilities, or in *normative networks* with other actors including competitors across sectors. The same applies to hosting and participating in conferences on cross-sectoral topics such as bidirectional charging. However, such cross-sectoral collaborations aiming at political advocacy happen rather ad hoc and on specific topics (e.g., proposing amendments on specific laws).

Particularly electric utilities are part of cross-sectoral research and pilot projects often involving automotive companies and DSOs. The aim is to *define* technical and regulatory standards, in order to ensure cross-system inter-operability (e.g., communication interfaces for grids, smart meters and vehicles or developing charging algorithms for car parks).

In addition to regulative institutions, cognitive and normative institutions can be relevant for enhancing the legitimacy of a product (Duygan et al., 2021a). In advertizing the aforementioned business models through public outreach campaigns (also via social media), providers often *construct an identity* of individuals actively contributing to the energy transition or being part of an autarkic energy community.

4.2.2. Automobile system

4.2.2.1. Actors with strong agency. Big manufacturers and industry associations (especially VDA, *Verband der deutschen Automobilindustrie*) are regarded as having the strongest agency to induce institutional changes, which promote the further diffusion of business models at the interface of residential storage systems and e-mobility. Especially German automobile manufacturers are engaged in

[4] According to the EU rule of unbundling electricity production and supply interests from the network of 2021 (in German regulation §7c Abs. 2 EnWG 2021), DSOs are only allowed to operate charging points in peripheral regions after market failure.

[5] In Germany, the operators with the most charging points are *EnBW mobility+ AG und Co.KG, E.ON Drive Gmbh, Tesla Germany Gmbh, EWE Go Gmbh and Lidl* (BNetzA, 2023b).

institutional work. In addition, particularly shaping public discourse and building up charging infrastructure, Tesla is deemed a further prominent player. Besides VDA, other, rather in-between associations, for instance, specialized in e-mobility, carry out institutional work.

4.2.2.2. Enabling conditions. **Discourses**. In general, automobile companies and industry associations share the narrative of a decentral, prosumer-driven electricity supply. Furthermore, bidirectional charging is depicted as solution for issues of grid stability through intelligent charging, at best accompanied by flexible electricity tariffs.

> *"But they [automotive industry] are actually very clever, by addressing problems that arise, especially regarding grid expansion, grid stability and bottlenecks, saying that they contribute constructively to the solution. [...] Of course, this also indicates a certain level of competence in the eyes of decision-makers." (Interview 25)*

Social networks. Most strikingly, we observe cross-sectoral networking in industry associations. Associations of both fields are collaborating and automobile companies increasingly become members in industry associations in the field of electricity. Thus, automobile companies particularly aim at gaining knowledge about regulation and policy processes as well as access to political institutions to improve their preconditions for advocacy. Particularly rather incumbents' associations in the electricity sphere provide access to decision-making. Although the automotive industry has maintained close ties with the BMWK ever since, it is stated to lack access to the ministry's energy department and to BNetzA.

> *"Getting into the issues, getting into the circles, which they [automobile manufacturers] also try to do with our help [industry association in the electricity system]."(Interview 27)*

Moreover, automotive companies are increasingly requesting consulting services on energy regulation from specialized consultancies and law firms, which are typically advising DSOs, utilities or project planners. As already mentioned, cross-sectoral research and pilot projects are an important endowment crucial for defining standards directed towards interoperability (e.g., regarding charging).

Resources. Corresponding to the electricity system, access to political decision-making of automobile manufacturers and associations is limited to institutional work activities. Regarding finances, our insights suggest that automobile companies resemble big electric utilities in that there are financial resources for advocacy work (memberships in industry associations, business units for advocacy), defining, theorizing and vesting (research and pilot projects, R&D).

Concerning intellectual resources, the automotive industry is stated to build up electricity related expertise, for instance, by networking and recruiting.

> *"We [electric utility] also see that many employees who used to be in the energy industry in charge of regulatory issues and industry association issues went to [an automotive charging subsidiary], for example. So you can see that competences are transferred there as well. [...] And we are pretty sure that there are the best contacts." (Interview 25)*

Regarding the transferability of energy related knowledge, some experts highlight the high regulatory standardization of electricity tariffs and argue that electricity supply itself does not require high levels of expertise and experience. In contrast, other industry experts emphasize electricity supply being a mass consumer business with complex and necessarily efficient administration and billing. Thus, only big automobile companies are expected to acquire the knowledge to profitably implement such processes. In terms of digitalization, technological know-how is clearly associated with the automotive industry, which facilitates defining standards.

> *„The energy industry stands in its own way, whereas the automotive industry has the finger on the pulse. For example, there are far more standards in cars than in the grid [...] that are sufficient to control cars." (Interview 31)*

As regards charging, automobile companies mainly operate fast charging points, such as the *Tesla Supercharger* or the *Ionity* high-performance charging station network along motorways.[6] While the charge point operator is responsible for the provision and the technical operation, the e-mobility provider contractually handles the tariffs, with the latter being increasingly assumed by automobile companies (e.g., *BMW charging, Mercedes Me Charge*).

Concerning the material components of business models, our interview partners almost unanimously regard the automotive industry in a better position since the vehicle itself makes up the largest proportion of value added of complete business models. Hence, the automobile companies are expected to more easily build up further competences and integrate electricity services, such as charging tariffs, or software and data applications, which are important preconditions for defining. Moreover, customers are likely to align their energy management system with this most expensive component, which is reinforced by the personal sales channel when purchasing a vehicle. In this context, some interviewees expect vehicle batteries to replace stationary storage systems due to vehicle-to-home, i.e. vehicle batteries able to provide electricity to households:

> *„Their [residential storages] role will probably change significantly with the further advent of e-mobility, because many of the [stock] storage systems are simply not suitable for charging electric vehicles. And the storage capacity of electric vehicles is larger, so that there may simply be a switch towards vehicles." (Interview 32)*

[6] Ionity is a joint venture of the *BMW Group, Mercedes-Benz Group, Ford Motor Company, Volkswagen Group* with *Audi* and *Porsche,* and *Hyundai Motor group* based in Munich (Ionity, 2023).

4.2.2.3. Institutional work. Automotive actors are increasingly carrying out *advocacy* work in the electricity sphere. §14a EnWG on controllable low-voltage consumption devices constitutes a striking example of the automotive industry intervening decision making in the electricity sector. In 2021, after an intervention of an automotive industry association, the former minister for Economic Affairs cancelled a draft law (§ 14a EnWG), which would have authorized DSOs to control charging periods of private electric vehicles.

> *"We [industry association in the electricity system] also had a very close alliance with the [automotive industry association]. Due to its tradition and its size, [the association] found its own access to the minister and the minister said: 'Ok, we'll stop that [§14a EnWG] because it's not going in the right direction.'" (Interview 1)*

As shown by this citation, there is collaboration in terms of political advocacy with stakeholders in the electricity system. §14a would also have affected residential storage systems and prevented customers from flexibly connecting their storages to the grid, making them less attractive.

Similarly to the electricity system, automobile companies publish joint position papers or host and participate in conferences on cross-sectoral topics in *normative networks,* also beyond industry associations. Cross-sectoral research and pilot projects involving automotive companies, DSOs, and electric utilities aim at developing technical and regulatory standards (*defining*). Furthermore, automotive companies and industry associations are mobilizing their storyline of bidirectionality being a solution to grid instability towards the media and political institutions in both sectors. Compared to residential storage systems, media coverage of e-mobility is assessed to be much higher. These discursive activities help to *change the normative associations* with e-mobility, which developed from being considered a rather niche topic for technology enthusiasts to having the image of a highly legitimized mainstream solution.

Upcoming tensions become evident as well. Interviewees in the electricity system (e.g., electric utilities) state that they feel increasingly put under pressure by automobile companies enhancing their intellectual resources and propagating the benefits of

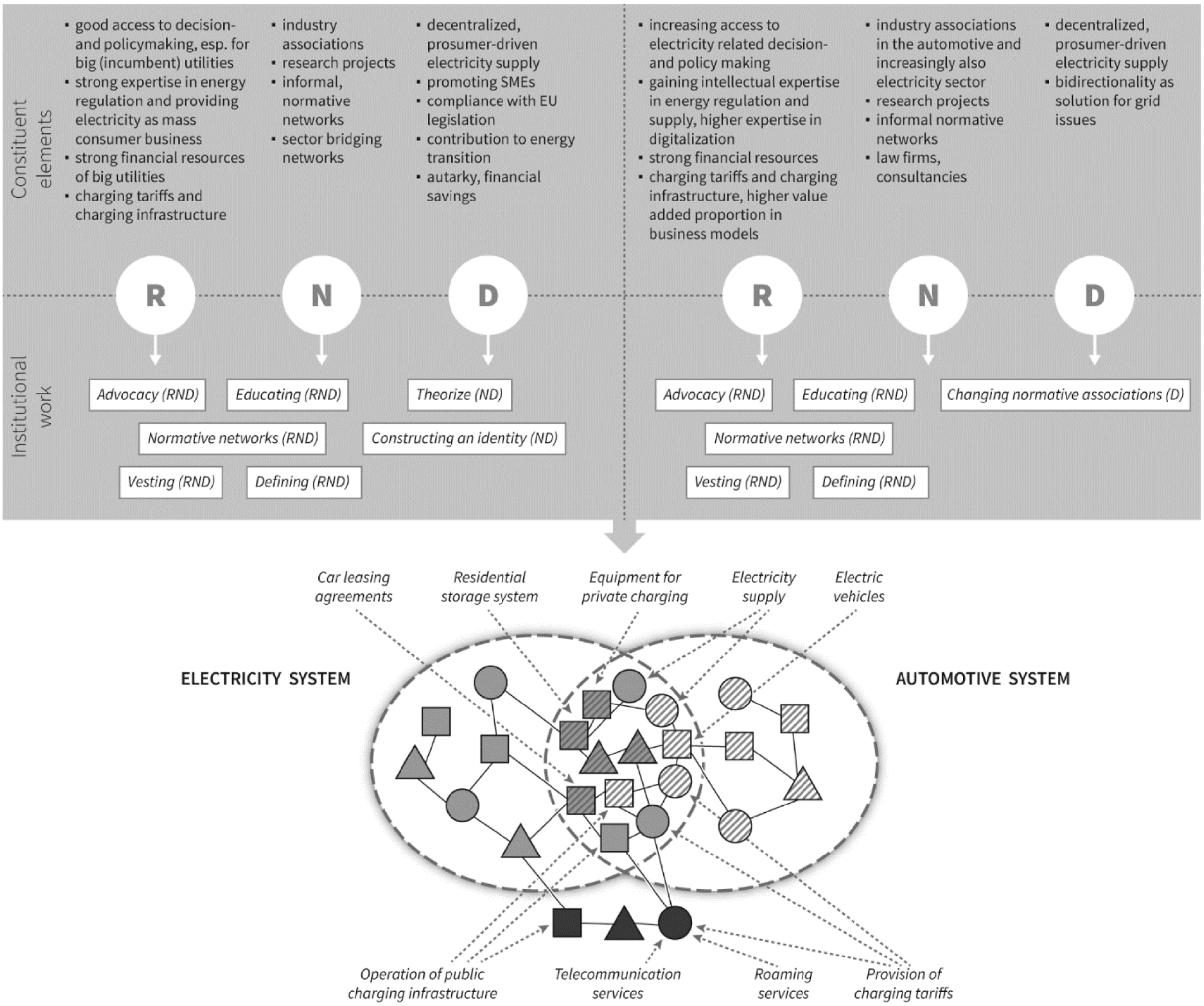

Fig. 4. Key constituent elements of agency (resources, discourses and social networks) and related institutional work carried out by actors from the electricity and the automotive system (own elaboration).

bidirectional charging. Furthermore, there is *defining and vesting* emanating from both fields about the communication interface for charging electric vehicles.

> *"Especially regarding the charging infrastructure or charging contracts, there are many efforts by the automotive industry, especially regarding this standard ISO 15118, which is about locating charging tariffs in cars and which […] decides who actually gets access to the customer in future. […] And these are topics where there is of course also friction between the energy and automotive sector, because, of course, everyone increasingly claims a part of the value chain for himself." (Interview 25)*

The automotive industry has been advocating for the so-called ISO 15118-communication standard enabling an electric vehicle to automatically be identified and authorized to a compatible charging station. Then, the charging tariff is pre-set in the vehicle. Alternatively, the charging contracts are being processed at the charging point via QR identification. Currently, both methods are possible.

To sum up, our results show a system reconfiguration, which resembles most option b (Chapter 2.4, Fig. 4) in that actors from both systems are well endowed with features enabling institutional work and succeed in creating institutional couplings. This results in coupled formal institutions, such as regulation allowing for emerging business models or standards for the interoperability of charging, but also informal institutions like the growing societal and political legitimation of e-mobility and prosuming.

However, we observe tentative tendencies towards option c. Developing an inventory of business model innovation at the interface of mobility and electricity on a global level, this is confirmed by Costa et al. (2022, 9) stating that the "confluence to date has been more about the automotive industry entering the electricity industry" in terms of capturing additional services and revenue. In the next section, we discuss how institutional work activities along with actors' preconditions influence this reconfiguration and reflect on references to recent research on multi-system interactions and institutional work.

5. Discussion

5.1. Actors with strong agency

Our empirical material suggests that in both fields the most effective agents in inducing institutional couplings are industry associations and big companies such as automobile manufacturers, electric utilities and to lesser extent storage manufacturers. However, in order to affect regulative institutions, single stakeholders mostly work together in associations. The same applies to some further in-between actors, such as the supplying industry for private charging equipment and manufacturers of power inverters or photovoltaics. Furthermore, we see collaborating associations across sectors or cross-sectoral networking within associations given that especially automobile manufacturers become members in associations in the electricity sphere. This corresponds to Löhr and Chlebna (2023), who identify cooperation between associations affiliated to different systems an important mechanism for system entanglement.

As regards the position of agents, Löhr and Chlebna (2023) highlight the need for new associations around emerging technologies or joint bodies of existing associations, arguing that system entanglers are more likely to be found in between or within both existing systems rather than solely within their original system of competence. By contrast, we highlight the strong agency of traditional industry associations and incumbent, infrastructure-rich players (electric utilities, automobile manufacturers incl. subsidiaries for charging), who come with their sector-specific experiences and aim at gaining knowledge in the adjacent system. This shows that incumbents are capable of leveraging their resources to integrate disruptive technologies when they face political and societal pressure as well as economic incentives (Hellsmark and Hansen, 2020; Turnheim and Sovacool, 2020; Steen and Weaver, 2017; Bergek et al., 2013). In addition, we also found rather new actors, such as storage manufacturers (which we attributed to the electricity system), and industry associations covering cross-sectoral topics (e-mobility, electrical industry) to be active in institutional work.

Some interviewees expect the emergence of further business opportunities and in-between players filling the vacuum of unsolved conflicts between powerful incumbents, such as in the field of digital services and applications for charging (Andersen et al., 2023), e.g. the recent emergence of roaming operators handling data traffic of public charging. Similarly, petroleum companies are expected to focus more on public charging infrastructure (e.g., in 2021, *bp* and *Volkswagen* announced to build up a fast-charging network, Aral, 2023). Some interviewees utter surprise at the fact that petroleum companies have not entered to the business of operating charging infrastructure earlier and to a greater scale. This ties in with Andersen and Geels (2023, 10) who expect "probably third-party, in-between actors (or intermediaries)" to monitor and manage the institutional and technological couplings, once these are created and sufficiently stable for the development of a market and new actor roles.

5.2. Institutional work and enabling conditions for creating couplings

A closer look on their enabling conditions explains the strong agency of (within system) industry associations and powerful incumbent players in fostering institutional couplings between systems. Corresponding to Andersen and Geels (2023) who highlight the relevance of cross-sectoral shared investments or joined ventures for accessing complementary assets such as knowledge or physical resource ownership, our focus on institutional work confirms that cross-sectoral collaboration (in industry associations) goes along with improving access to complementary resources. Especially automobile companies and associations seek access to political institutions and knowledge on regulation through electricity related industry associations, which enables them to engage in advocacy work on regulative institutions.

To some extent, the institutional work results in couplings benefitting both in a more system connecting way (Löhr and Chlebna, 2023), since the lobby weight of automobile manufacturers is particularly helpful in an institutional context characterized by reluctant grid actors (chapter 4.1). Examples for collaboration concern, for instance, private charging and accounting of company cars or successfully deterring the aforementioned controllability of charging processes on the part of DSOs in 2021 (§ 14a EnWG). In terms of discourses, both sectors share a common storyline of a prosumer-driven decentral electricity supply, with the market for home storages benefitting from the high media presence of e-mobility bringing battery technology to the fore.

5.3. Institutional work and enabling conditions resulting in increasing frictions

We also observe competitive and conflictive notions (Andersen et al., 2023; Kanger et al., 2021; Rosenbloom, 2020; 2019) pointing towards option c, in the sense of changing market roles and shares. There is enormous competition about charging tariffs with automobile companies pushing into this market. Furthermore, there are automotive players providing full-package offers including electricity contracts along with electric cars or even mere electricity contracts.

Our insights reinforce the particular relevance of physical-material and intellectual resources. As regards the latter, especially automotive manufactures (incl. subsidiaries and industry associations) are well positioned to enhance their knowledge on electricity supply and regulation (relevant for advocacy, educating, theorizing), e.g., by cross-sectoral networking. Regarding extending business models, the transferability of knowledge is a crucial dimension. While supplying electricity is stated to be transferable due to its high standardization, electric utilities or storage manufacturers aiming at integrating e-mobility services are practically limited to collaborating with automotive stakeholders. Furthermore, electric utilities are regarded as not being versed in digital communication and tractability, which is an indispensable requirement for defining standards. Whereas Löhr and Chlebna (2023) speak of “defining shared standards” in a system-entangling environment, we find defining as means to advance into the other system in the material dimension of public charging. In the sense of vesting, automotive players gain a competitive advantage by putting standards on communication interfaces, which automatically connects vehicle and charging station. Furthermore, customers are likely to align electricity supply with their car purchase, being the most expensive component of business models. Some interviewees even expect vehicle batteries to replace stationary batteries due to higher capacities for vehicle-to-home and vehicle-to-grid applications (Costa et al., 2022; Kester et al., 2018).

Taken together, this case study links to Rosenbloom (2020) who claims research going beyond single patterns of symbiosis and competition and reflecting on the complex and changeable nature of these relationships.

5.4. Sectoral context

The specific sectoral context reinforces the importance of targeting regulative institutions by means of classic political advocacy, as the diffusion and feasibility of business models is strongly linked to national energy regulation (Duygan et al., 2021a). Consequently, this enhances the agency of traditional industry associations and powerful incumbents due to longstanding access to political institutions. Furthermore, strong agency is needed given within-system contestation (Madsen et al., 2022) due to reluctant grid actors influencing legislation. This corresponds to Andersen and Geels (2023) who expect bottlenecks rather about grid institutions (limiting expenditures on grid upgrades) and about actor orientations (cost optimization instead of innovativeness by grid actors) instead of technological challenges. In other circumstances, other actors, such as newly emerging interface actors, might have stronger agency.

5.5. Relation with institutional work

Regarding actors associated with strong agency for inducing institutional changes, our findings emphasizing incumbent, well-endowed players correspond to Duygan et al. (2019; 2021b), who find agency to influence Swiss waste management during policy revisions lying in the hands of only a small number of actors necessarily endowed with large material and non-material resources. Being active and well embedded in networks is found as further sufficient complementary condition. Our results show, that this holds true for multi-system interactions. The specific multi-system setting is reflected by the importance of industry associations bridging different sectors for creating institutional couplings (Löhr and Chlebna, 2023; Löhr et al., 2022). In this vein, contradicting to Duygan et al. (2019), we would like to point out that networks have proven to leverage theorizing and educating.

Duygan et al. (2021b; 2019) emphasize the relevance of resources as being necessary, yet not sufficient conditions. Either (1) a high embeddedness in networks combined with a discourse utilizing various concepts or (2) a strong activity and embeddedness in social networks have to complement resources for strong agency in the specific case of influencing regulations in Swiss waste management. Regarding the last path, discourses seem to be important, yet not essential. While acknowledging the importance of resources and networks, our qualitative insights show that discourses are an indispensable element of all identified institutional work activities (Madsen et al., 2022). More concretely, our results confirm that a variety of arguments (benefitting the policy goal regarding renewables, customers’ benefits, compliance with EU legislation, economic benefits for SMEs, individual’s contribution to the energy transition) seems to be more salient than having moderate policy beliefs linking different discourse coalitions (Duygan et al., 2021b). The relevance of discourses for creating legitimacy in our case study might be reinforced by the specific institutional context (Duygan et al., 2019), since the consultation processes around amendments of the EEG and EnWG are rather transparent (including public associations’ hearings) and renewables and e-mobility are associated with a strong normative dimension and high media coverage in Germany (Finstad and Andersen, 2023; Duygan et al., 2021a).

6. Conclusion

This case study contributes to the debate on multi-system interactions by explaining the reconfiguration of two systems with the help of institutional work. In order to take better account of sector-specific preconditions, we complement institutional work activities with enabling conditions. The markets of electric vehicles and residential storage systems in Germany serve as empirical case.

We find that incumbent, infrastructure-rich companies in both systems (big electric utilities, automobile companies along with business associations) are well placed to carry out institutional work and create institutional couplings. To some extent, we observe cross-sectoral collaboration, particularly concerning advocacy. However, increasing competitive notions become evident. Especially automotive companies are able to get access to policymakers and to complementary knowledge (e.g., on regulation) by means of cross-sectoral networks. Furthermore, they take advantage of their intellectual and physical-material resources (especially in terms of digital communication interfaces) for capturing emerging business opportunities and advancing into the electricity market, especially in the field of public charging via defining and vesting.

A first limitation of this study lies in the change of the German Federal Government at the end of 2021. Since then, the BMWK has been led by the party *Bündnis 90/Die Grünen* (*Alliance 90/The Greens*), which has been considerably influencing the regulatory changes of the EEG 2023 and the EnWG 2022. Thus, this could be an alternative explanation for institutional change rivaling institutional work. However, there have been previous regulative changes. Furthermore, many civil servants in ministries and grid agencies kept their positions. Second, the categorization of electricity and automotive sector actors goes along with a certain homogenization. We assigned actors directly concerned with storages (e.g., manufacturers, industry association for storage technologies) to the electricity sector, as these actors were the pioneers in providing residential storage systems along with electricity contracts. Future research could stress intra-system differences as well as the time ordering of actor types carrying out institutional work.

Further potential for explaining institutional work in multi-system settings lies in system-specific differences in linkages to and power over upstream sectors providing, for instance, wall boxes, smart meters or battery modules. Furthermore, this field has recently seen a wave of acquisitions and shareholdings with players of the electricity, mobility and petrol sectors acquiring storage manufacturers, charging stations producers and telecommunications companies. The associated impact on capacities for institutional work merits further attention.

A recommendation for policymaking in this formative phase of two systems being interconnected would be to pay attention to in-between, maybe less resourceful and connected actors, such as researchers or industry associations covering cross-sectoral topics. Interests of incumbent actors having strong agency might not necessarily direct towards the best possible solution for society. Nonetheless, in this fast changing, multi-dimensional field, policy frameworks need to respond quickly to requirements across sectors so as not to be a barrier constraining transitions.

CRediT authorship contribution statement

Andrea Käsbohrer: Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Conceptualization. **Teis Hansen:** Visualization, Resources, Methodology, Conceptualization, Writing – review & editing. **Hans-Martin Zademach:** Supervision, Resources, Project administration, Funding acquisition, Conceptualization, Methodology.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendices

Appendix 1. Definitions of forms of institutional work and constituent elements required for different forms of institutional work. (R = resources; D = discourses; N = networks)

Institutional work	Definition	Constituent elements
Creating institutions		
Advocacy	The mobilization of political and regulatory support through direct and deliberate techniques of social suasion	R, D, N
Defining	The construction of rule systems that confer status or identity, define boundaries of membership or create status hierarchies	R, D, N
Vesting	The creation of rule structures that confer property rights	R, D, N
Constructing identities	Defining the relationship between an actor and the field in which that actor operates	D, N
Changing normative associations	Remaking the connections between sets of practices and the moral and cultural foundations for those practices	D
Constructing normative networks	Constructing of inter-organizational connections through which practices become normatively sanctioned and which form the relevant peer-group with respect to compliance, monitoring and evaluation	R, D, N
Mimicry	Associating new practices with existing sets of taken-for-granted practices, technologies and rules in order to ease adoption	R, D
Theorizing	The development and specification of abstract categories and the elaboration of chains of cause and effect	D
Educating	The education of actors in skills and knowledge necessary to support the new institution	R, D
Maintaining institutions		
Enabling work	The creation of rules that facilitate, supplement and support institutions, such as the creation of authorizing agents or diverting resources	R, D, N
Policing	Ensuring compliance through enforcement, auditing and monitoring	R
Deterring	Establishing coercive barriers to institutional change	R
Valorizing and demonizing	Providing for public discourse positive and negative examples that illustrate the normative foundations of an institution	D
Mythologizing	Preserving the normative underpinnings of an institution by creating and sustaining myths regarding its history	D
Embedding and routinizing	Actively infusing the normative foundations of an institution into the participants' day to day routines and organizational practices	D, N
Disrupting institutions		
Disconnecting sanctions	Working through state apparatus to disconnect rewards and sanctions from some sets of practices, technologies or rules	R, D, N
Disassociating moral foundations	Disassociating the practices, technologies or rules from its moral foundation within a specific cultural context	D
Undermining assumptions and beliefs	Decreasing the perception of risks of innovation by undermining core assumptions and beliefs	R, D

Source: Lawrence and Suddaby (2006); Duygan et al. (2019; 2021b).

Appendix 2. Overview of working group meetings of an industry association in the electricity system, participant observation

No.	Topic	Date
1	Energy law (working group)	Sep 2020
2	Energy politics (working group)	Sep 2020
3	Task force on EEG amendment	Sep 2020
4	Energy politics working group (presentation by member of EU parliament)	Sep 2020
5	Residential storage systems (working group)	Oct 2020
6	Finance and investments (working group)	Oct 2020
7	Workshop on residential storage systems	Nov 2020
8	Storage technologies (working group)	Nov 2020
9	Standards and quality criteria (working group)	Nov 2020
10	Trade fair about battery storage systems	Nov 2020
11	Energy law (working group)	Dec 2020
12	Residential storage systems (working group)	Dec 2020
13	Task Force on EnWG amendment	Jan 2021
14	Energy law (working group)	Feb 2021
15	Residential storage systems (working group)	Feb 2021
16	Trade fair about residential and industry storage systems	Mar 2021
17	International market development (working group)	Mar 2021
18	Energy law (working group)	Apr 2021
19	Energy politics (working group)	Apr 2021
20	International market development (working group)	Apr 2021
21	Workshop on storage systems and manufacturing industry	Apr 2021
22	Storage technologies (working group)	May 2021

(*continued on next page*)

(*continued*)

No.	Topic	Date
23	Energy law (working group)	May 2021
24	Residential storage systems (working group)	Jun 2021
25	Task force on Smart Meter Gateway	Jul 2021
26	Energy politics (working group)	Sep 2021
27	Energy law (working group)	Oct 2021
28	Energy law (working group)	Nov 2021
29	Storage technologies (working group)	Feb 2022
30	Energy law (working group)	Feb 2022
31	Energy law (working group)	Apr 2022
32	Residential storage systems (working group)	May 2022
33	Workshop on regulation for fast charging	Jun 2022
34	Energy law (working group)	Sep 2022
35	Storage technologies (working group)	Sep 2022
36	Residential storage systems (working group)	Sep 2022
37	Mobility (working group)	Sep 2022
38	Task force on §14a EnWG	Oct 2022
39	Energy law (working group)	Nov 2022
40	Task force on residential storage systems	Jan 2023
41	Residential storage systems (working group)	Feb 2023
42	Mobility (working group)	Feb 2023

Appendix 3. Overview of interviews

No.	Interviewee	Date
1	Industry association representative (electricity system)	Feb 2021
2	Company for energy management systems, telecommunications: CSO, Consultant	Feb 2021
3	Chamber of Commerce and Industry representative	Feb 2021
4	Private research institute representative	Feb 2021
5	Company for energy management systems, storage systems: Head of business development	Mar 2021
6	Private research institute: Executive director	Mar 2021
7	Storage manufacturer: In-house lawyer	Mar 2021
8	Electric utility: Product manager	April 2021
9	Chancery for energy law: Lawyer	May 2021
10	Electric utility representative	May 2021
11	Electric utility: In-house lawyer	May 2021
12	Chancery for energy law: lawyer	May 2021
13	DSO representative	May 2021
14	Federal Network Agency representative	Jun 2021
15	Industry association representative (electrical industry)	Jun 2021
16	Industry association representative (electrical industry)	Jun 2021
17	State Network Agency representative	Jul 2021
18	Researcher (E-mobility)	Jul 2021
19	Municipal DSO representative	Jul 2021
20	Ministry for Economic Affairs and Climate Action: Civil servant	Jul 2021
21	State Network Agency representative	Jul 2021
22	Transmission System Operator representative	Sept 2021
23	Researcher (electricity system)	May 2022
24	Storage manufacturer: In-house lawyer	Juli 2022
25	Electric utility: In-house lawyer	Juli 2022
26	Industry association: Executive director (e-mobility)	Sept 2022
27	Industry association: Executive director (electricity system)	Sept 2022
28	Industry association representative (automotive industry)	Sept 2022
29	Automotive supplier representative	Jan 2023
30	Storage manufacturer: Expert for e-mobility and energy management systems	Mar 2023
31	Storage manufacturer: CEO	April 2023
32	Industry association representative (electricity system)	May 2023

Appendix 4. Exemplary empirical material for discourses, resources, social networks and institutional work from interviews

	Electricity system	Automotive system
Discourses	*"It also has to be said that the market has become so big in the meantime, simply because self-consumption and self-generation includes the car and the heat pump. Therefore, the importance of the flexibility markets and the*	*"Even intelligent charging, delaying charging processes, charging while the electricity price is low, when renewables are in the system, of course, that brings incredible flexibility to the system. And at the same time, in our*

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	Electricity system	Automotive system
	entire grid is falling behind, because you can achieve a lot by saving electricity in the distribution grid." (Interview 31) "But he [the customer] buys one [a storage] because he wants it and because he has the money for it and because in his opinion it's great to produce his own electricity, to store his own electricity, to have such a fancy device in the basement and to say: Wow, how self-sufficient I am now. There is a feeling behind it." (Interview 11) "If you additionally have an electric vehicle and dimension the storage and the PV system a bit larger, then at some point you will come very, very close to this total self-sufficiency." (Interview 11) "Depending on the credibility of the company, they actually buy it that you act in the interests of your customers. Or in the sense of the goals that politics is pursuing anyway and not like: 'well, this is a particular interest.'" (Interview 11)	*opinion bidirectional charging will actually make a relevant contribution in the near future." (Interview 28) "And we [electric utility] look at it [bidirectional charging] a bit differently, because on the one hand we are very surprised, especially when it comes to frequency containment reserve, how much they [automobile companies] see and what they expect from it. That's a pretty good example to show how the automobile industry is advancing into a classic energy topic being extremely present." (Interview 25)*
Social networks	*"But of course, when something comes from a single company, it is always read through the lens of: "Yes, okay, what are the company's interests behind it?" That doesn't mean that you can't have an influence, but associations represent a broader spectrum." (Interview 11)* *"We [DSO] were co-initiators of a large research project, funded by the federal government, working together with other DSOs, with [an electricity provider], [a DSO], [municipal utility], [municipal utility], the entire German automotive industry with the exception of [a car manufacturer]." (Interview 13)* *"There are of course other committees and associations in which the automotive industry is more strongly represented and some of us [transmission grid operators] are certainly also involved. But the main area where we find this are research projects." (Interview 22)* *"The energy department [of BMWK] is dominated by the electric utilities, the grid operators and the municipal utilities, that's it. And someone else doesn't even get in there. It's been going on with us [industry association in the electricity system] for almost 10 years that we don't really get on the energy department and that's why we have to influence the energy department through the economy department." (Interview 27)*	*"Sure, we [association in the electricity system] are also in talks about the different topics with [a car manufacturer], with [an automotive charging subsidiary], with various Japanese and other car manufacturers. They are increasingly turning their backs on their car association, because the car association is a car association and not an energy system association." (Interview 27)* *"Obvious that the automotive industry and the mobility industry are also looking for access to the energy department in the ministry, of course. That was also the problem during the last years, because they didn't actually have this access, because they never had to worry about the issue of electricity, they have always been involved with the economic department in the Ministry of Economic Affairs. That's where they have the influence, that's where they set the agenda, and that's where they made their influence felt regarding § 14a." (Interview 27)* *"Or they [automotive companies] are considering developing a mobility concept, in which many customers are to be supplied with electricity, and they would like to know what to do then. Then we [law firm] advise on charging stations, what kind of tariff is required and how it should be set up." (Interview 9)* *"It is, at least up to now, not necessarily decisive who has the better arguments, but rather who is sitting closer to the BMWK because they write the laws. And so far that has certainly tended to be the electricity industry. But I would assume that something might change in the next few years. We can already see that in the management level of the BMWK, bidirectional charging actually enjoys a high priority right now and this will of course only be possible with us, the automotive industry." (Interview 28)*
Resources	**Authorativ** *"In this respect, the BMWi does not write such regulation on these topics [regarding fees and charges, controllability] without consulting the BNetzA, because the BNetzA has more people and more expertise when it comes to the technical details." (Interview 3)* **Intellectual** *"And we're very relaxed about it. If an automobile manufacturer actually has to earn money through his electricity subsidiary and then has 500,000 customers, then he is on the same level as us. He has to have the same systems, he has to have the same level of professionalism, and then you can see what is actually being earned in the end. Sometimes, that can go really wrong if you're unlucky. That will also clear up a bit again. I'm relatively convinced of that. It's such a hype. The telcos also tried to conquer the electricity market. [Telecom company] and Co. are all gone now because they realized: that's something different. We will see. And those who remain and know their business, that's fine. That's just a new market player or just a new competitor in the game." (Interview 8)* *"Because they [electricity sector] are inherently extremely weak regarding digitalization." (Interview 31) "Whereas DSOs have done nothing but prevent standardization for 50 years." (Interview 31) "Some of the problems regarding the sector coupling are homegrown, because both major industries, both the automotive and the electricity industries, have been very self-concentrated, and are actually very little open to each other's concerns." (Interview 29)* **Financial** *"We see it now internally in our association work. The little ones [electric utilities] often don't have the resources or the financial means to get involved in lobbying. Some of them don't even have the resources to send representatives to the respective [industry association in the electricity sector] working groups. They depend on an association that solves the problems for them. The larger a company is and the more business models depend on framework conditions, because you don't just*	**Authorativ** *See electricity system* **Intellectual** *"Yes, we [private research agency] are also involved with consulting services there [automotive sector]. But it's more about the other side. There is no understanding about the electricity side, especially about specific customer groups such as the PV owner." (Interview 6) "I do think that our companies [automotive sector] are basically predestined for this [bidirectional charging], simply because we have access to the data, have access to the flexibility and actually also have access to the customer, keyword customer relationship. [...] On the other hand, of course, one must also say that these markets require expertise, know-how that has not yet been particularly prevailing in the automotive industry." (Interview 28) "The automotive industry is now actually trying to integrate people from other industries." (Interview 29) "But whether that makes sense for a company like [a car manufacturer] in the long run, I'm not entirely sure either. Electricity for private customers is a tough mass customer business. That actually only works if you have a very large number of customers and can manage them extremely efficiently." (Interview 13) "The car will be well standardized in the future and will not pose an obstacle to the grid because you can reduce it, charge it, charge it smartly, because you can communicate with it, because you can get the information out of the vehicle." (Interview 31) "I think it is a big mistake to expect that the automotive industry will adapt the competencies and core competencies of the electricity industry and vice versa. [...] It won't work. Individual heads maybe, but not the industry." (Interview 26)* **Financial** *"But you have to be able to afford that there are employees there, both at EU level and at national level, who do more or less nothing else than take care of the regulatory and political framework. Looking at the automotive industry, I can very well imagine that there is a lot of money and a lot of resources there to deal with exactly such topics. Also from a*

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	Electricity system	Automotive system
	want to do standard business, but also want to enter new areas, the more you need suitable framework conditions. And accordingly, you have to provide the necessary resources." (Interview 25) **Physical-material** *"Of course, we [electric utility] see ourselves in a very good position, by offering both private and public charging infrastructure." (Interview 25) "Public charging infrastructure is largely a stranded investment. [Electric utility] has started massively in order to secure this business model and the locations before someone else does it, the good locations. I am very skeptical as to whether this model will work." (Interview 27) "What we find time and again in our studies is that the electric utilities are very active in the field of e-mobility - for example, everyone tries to set up charging stations in his own community." (Interview 6)*	*historical perspective, because it's just incredibly important to preserve business models. And now resources are needed to create the framework for the new business models that have become indispensable. But I couldn't say who is more efficient now." (Interview 25)* **Physical-material** *"And that's why the chances of the car are much higher than those of the electricity industry because the customer simply thinks of the benefit, and the electricity industry cannot provide them any benefit with a socket. That means they simply don't have the infrastructure you buy, and they're desperately trying to do that with rental models […]." (Interview 31) "The electric car is the absolute game changer in the entire energy system. At least for a few years, the e-car will probably become the mobile energy device that we have in our system, towards which everything will ultimately be geared and which will then have a very disruptive effect on the classic energy world. […] Tomorrow, I get my car from [car manufacturer], get the electricity from [car manufacturer], then I can turn the heating up and down via the digital services in my car. So, I will also have the entire energy management via my [car manufacturer]app." (Interview 27) "You can see that the business models of the electric utilities are being threatened by people from outside the industry, since [car manufacturer] and [car manufacturer] have their own charging electricity tariffs. And other automakers will follow. So the classic business model of the electric utilities,* i.e. *the sale of electricity, is taken over by others, which means they have more competition." (Interview 6) "The tail is wagging the dog, because the car costs more than the entire PV equipment in the end. You can say, if a customer pays a laid-back 2000 for aluminum rims, he might conclude an electricity contract that is cheaper than the aluminum rims per year. I can imagine that being a bonus." (Interview 13) "And because the electricity industry is taking a frontal stance against the automotive industry, because they will be competitors in the future, because the network is unbundled, and tell me one reason why, if you have advantages buying an [electric vehicle type] with a charging station and electricity contract, why shouldn't you do that, […] It just doesn't suit the electricity industry at all that storage systems are getting off the ground on wheels, it doesn't suit them as a load in the distribution grid and there will be eternal quarrels that can't be resolved except through standardization." (Interview 31)*
Institutional work	*"There is a new legislation by the EU commission and we [industry association in the electricity system] are part of the process. […] We maintain contacts with different institutions in legislation, with the Bundestag, the European parliament, EU Commission, different general directorates at EU and national level, different ministries, state ministries and parliaments." (Interview 1)* *„It's the case that many competitors are collaborating within working groups, particularly with respect to regulation, in order to exert influence in this regard. There is little activity regarding business models, little regarding technology, but a lot when it comes to regulation and requirements." (Interview 2)* *"Yes, of course, there are various mostly informal gatherings here in Berlin at the association level on all sorts of topics, you are then in different rounds." (Interview 3)* *"We [storage system manufacturer] fought with [car manufacturer] to ensure that the charging stations are not curtailed by the smart meter, but can also be curtailed via an energy management system. […] Eventually, one can say that this is lobbying for the manufacturers of energy management systems and components. […] That's what it looks like when two worlds meet, and you have to find a compromise." (Interview 31)* *„So far, however, one has to say that, for the most part, there is still consensus, one does not block each other all the time, there is still agreement on many issues at the moment. For now. Let's see how this develops." (Interview 25)* *"Of course, they are putting a bit of pressure on the energy industry. Well, that goes down well with us: 'Oh my God, bidirectional charging seems to be the ultimate now.'" (Interview 25)*	*"Of course, some of our member companies do this themselves to a certain extent, but as an association we work on communication in the media, and we also have our own press department, because of course the public mood also has a certain influence on political decision-making processes. That means we communicate with the general public and also with the political arena. This means that we are in regular contact with the federal government, with the individual ministries, and of course especially with the Ministry of Transport. Now more and more with the BMWK, simply because the topics related to grid energy are becoming more and more important for the automotive industry. With the Bundestag [parliament], but then of course also with the federal states." (Interview 28)* *"[Automotive charging subsidiary] has also been in the press for months now and is demanding reasonable conditions for bidirectional charging and is also painting an extremely positive picture of what can be done there now in the context of grid stability." (Interview 25) "I've [storage manufacturer representative] been doing energy transition issues since 2008, 2009, back then it wasn't even an issue. When you saw e-mobiles, they were always recumbent bikes, where some hobbyist screwed his battery into the back. Everyone said why it never worked, wasn't cool. At some point an Elon Musk will come along and just build a cool car and, as you say, create an enthusiasm that can then turn an entire industry upside down." (Interview 7)* *"Nevertheless, it is of course the case that the interests are sometimes very different. […] This also showed that the different sectors did not come to a common denominator, so that in the end, of course, the associations also fight for their cause to some extent and ultimately do this in public. […] There are simply different interests involved. And to a certain extent, these can also be resolved professionally, although there are many things we simply don't know yet to that extent." (Interview 28)*

Appendix 5. Institutional context and regulatory changes

The institutional context is mainly characterized by two dominant rationalities, a decentral electricity supply and a rather centralized electricity supply. Actors promoting the latter are mainly the Federal Network Agency (*Bundesnetzagentur*, BNetzA), part of the BMWK (especially until the end of 2021), several (mostly municipal) electric utilities and DSOs as well as the associated industry associations. Regarding the approximately 870 German DSOs, our empirical material indicates great heterogeneity with some stakeholders welcoming private storage systems and even launching research projects, but the large majority being critical towards them.

Their main arguments are, first, the objective of a secure supply. Therefore, predictability and central tractability of electricity load and generation are deemed indispensable. Electrical load and generation of households using residential storage systems, however, are stated as being difficult to predict and control. Furthermore, residential storage systems are considered rather expensive and resource consuming compared to their applicable capacities. BNetzA representatives question their need and profitability at all and rather plead in favor of a full feed-in of self-produced electricity. They draw on the arguments of following market signals in an efficient way and of a true-cost pricing of net electricity with grid fees, since electricity must be kept available to its full extent at any time in spite of storage systems. In the same vein, many sector experts doubt the benefits of frequency containment reserve and bidirectional charging due to the little demand, low prices, and therefore required customer behavior.

The regulatory framework is regarded by industry experts as being the central obstacle to a more profitable realization of business models involving storage systems and e-mobility services. In Germany, the renewable energy act (*Erneuerbare-Energien-Gesetz, EEG*) and the energy industry act (*Energiewirtschaftsgesetz, EnWG*) make up the central regulatory framework for the promotion of renewable energies. To exemplify a regulatory barrier, the term ‘energy storage’ has not been defined until 2022. Instead, EEG and EnWG regarded the storing of energy in a storage system as consumption and the extraction of electricity from the storage system as production. Thus, every storage and withdrawal in the course of self-consumption was charged with grid fees, taxes and EEG surcharge (*EEG-Umlage*). Furthermore, electricity trading as part of energy communities and the storage of grid power for the mentioned frequency containment reserve has gone along with vast complexity since the different electricity flows have been charged with different taxes and fees respectively and, thus, have to be measured separately. Regulation regarding bidirectional charging is missing at all (for a detailed overview including recent amendments see Table 1).

As regards amending the central policies, formal decision-making power over energy policy lies with the German federal parliament. The substantive work on the legislation is mainly the responsibility of the BMWK. However, although being intended as downstream, executive authority, the BNetzA wields considerable power over legislation providing extensive advisory services to the ministry, and even developing draft laws on their own initiative based on a high level of personal commitment.

Our empirical material suggests that the actor configuration in charge of energy regulation is to a large part characterized by a critical attitude towards residential storage systems. While a large majority of parliamentarians is in fact regarded as being rather open-minded towards the new business models (especially by industry associations), the BMWK (mainly until 2021) is criticized for consciously deterring private storages systems by means of the aforementioned regulatory barriers in EEG and EnWG. Some interviewees (mostly industry associations) even go as far as saying that certain laws (e.g., regarding charge reliefs) are deliberately made too complex to be applicable or that deadlines for industry associations to hand in positions papers are consciously set tight. Furthermore, German legislation is criticized for navigating around EU legislation, which claims a more storage friendly regulation. Beyond ensuring compliance with the energy acts on the part of DSOs, industry and end consumers, the BNetzA is stated by many interviewees to use its authoritative resources in order to favor the interests of DSOs, e.g. by promoting high charges and fees for self-consumption and far-reaching control options over storages and electric vehicles for grid operators. The agency communicates its critical attitude towards residential storage systems and its benevolence towards a large-scale market-based electricity trading to political parties, civil servants and the public.

However, there have been changes benefitting a more profitable implementation of new business models. Among others, recent amendments raised the threshold for exemptions from the EEG surcharge from a storage capacity of 10 kWh to 30 kWh and simplified metering by focusing merely on the grid connection point. The legal definition of ‘energy storage’ was introduced into the EnWG in 2023 and abholished the double charging with fees, taxes and surcharges. Also in 2023, the EEG surcharge was suspended. However, there are challenges remaining, for example, ambiguities concerning grid fees and electricity taxes for multi-use applications (especially energy communities) or permitted grid charging periods for electric vehicles.

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