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Shaping a sustainable shift; how planners and policymakers could influence the adoption and efficient integration of electric vehicles into cities

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Abstract

Amidst growing concerns about emissions and fuel prices, sustainable mobility has become a highly relevant policy goal within governments around the world. One key approach towards this end is the promotion of EV adoption. By introducing policy that positively affects the willingness of owners of internal combustion engine vehicles (ICEVs) to purchase EVs, emissions can be minimized. Besides the inherent financial background of such a shift, EV adoption also relates to spatial policy. Although the role of spatial planners and spatial policymakers within the process of EV adoption has been discussed in previous research, the linkage between said process and actors has often been implicit. Moreover, a clear overview of relevant spatial policy steps is lacking within the existing body of EV research. The aim of this study is to provide such an overview, which would not just add to literature, but could also serve as an inspiration for policy in practice. In addition, an emphasis on a distinction between adoption and integration provides a renewed perspective. To find relevant policy recommendations, a systematic literature review (SLR) was conducted, based on 26 journal articles. In order to maximize objectivity this study was partly constructed around the sample itself, by using a bottom-up categorization approach. Although previous literature on EV adoption often does not include the process of integration in the same way it is used here, this process this appeared to be a better fit for those policy recommendations that did not fully align with adoption. By differentiating between adoption and integration, policy steps could thus be categorized with more precision. The SLR showed a diversity of policy recommendations, such as grid integration or policy against induced traffic, although charging infrastructure was a dominant theme nonetheless. Range anxiety proved to be a recurring theme within the backgrounds of individual policy recommendations. The main research output consists of a policy model which includes a stepwise funneling of policy recommendations, as established based in the SLR, into an adoption, integration and a shared category.

Keywords

EV, EV adoption, EV integration, urban planning, electric mobility, sustainable mobility, urban car use

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List of abbreviations

BEV: Battery electric vehicle

EV: Electric vehicle

HEV: Hybrid electric vehicle

ICEV: Internal combustion engine vehicle

SLR: Systematic literature review

V2G: Vehicle-to-grid

VKT: Vehicle kilometers travelled

1. Introduction

1.1. EV transition, adoption and integration

Between 2010 and 2020, the global stock of fully electric personal vehicles has grown by over 40.000 percent (IEA, 2021). This rapid growth is a product of a revolution in the automotive industry. To limit fossil fuel dependency and emissions, a growing number of car users and car manufacturers is drawn to the idea of vehicles that use alternative, renewable power sources. Governments around the world support this sustainable shift through different types of incentives or adjusted taxation (IEA, 2021). The implications of this shift are not limited to a change in automobile supply and tax policies, however. Along with the growth in the use of electric vehicles (EVs), there is a growing demand for charging stations, which could be seen as the gas stations of the future. Some even claim that the availability of charging infrastructure is the main barrier to EV adoption (She et al., 2017). This call for an adaptation of the physical environment pushes the described transition into the realm of planning. This task of finding spaces for charging infrastructure that has the potential to fuel the EV revolution in a literal and figurative sense, is not the only challenge that planners face in relation to modern car use patterns and EVs.

Ever since the early mass-produced models such as the T-Ford, the automobile has been evolving into a central element within society, causing new priorities in terms of infrastructure, land use and general (urban) planning. Glaeser & Kahn (2003, p. 22) confirmed the central position of the car in urban areas, stating that it is “certainly the most important transportation technology to impact the city over the last two centuries”. Currently, roughly a century after the first mass-produced models were introduced, there are serious doubts about the often car-centric layout of public space and car dependency in general. This change in perception of car use is described by Tomalty & Mallach (2016, p. 4), who state that; “the automobile has given millions of people and unprecedented level of mobility and opportunity,” while they state the following about the recent situation; “Automobiles are invaluable for some purposes, but car dependency, particularly for the journey to work, has triggered unsustainable levels of energy consumption, congestion and disruption of quality of life.” The mentioned drawbacks of car dependency, still do not fully reflect the issues that come with car use, especially within an urban context. Cars are the least efficient mode in terms of space consumption, while parking spaces also demand substantial amounts of land (ITF, 2021). Because of this, among other reasons, car use is intertwined with sprawl, which is a process that obstructs compact city planning policies. Next to this, emissions are an undesirable side-effect of car use, posing a consistent threat to air quality and public health in cities. Some even argue that that car culture as a whole is not sustainable (Purcell, 2000). The negative consequences of car use are especially pronounced within cities, where the scarcity of urban space and a concentration of vehicle emissions, as well as a concentration of people affected by these emissions, make the car a problematic mode. The emphasis on urban areas is underlined by Crawford (2016, as cited in Chatterton, 2019, pp. 18-19); “The car brought with it major unanticipated consequences for urban life and has become a serious cause of environmental, social, and aesthetic problems in cities.” Cervero et al. (2017) note that oil dependency related to transport is also especially high in urban areas. As a consequence of such negative effects, doubts about urban car use have led to the emergence of a global car-free movement “encompassing social activists, urban planners, policy makers and campaign groups,” which is actively resisting the dominant position of the car in cities (Chatterton, 2019, p. 31). In numerous cases, growing doubts about the car-centric lay out of cities have led to a shift away from planning ‘around’ the car, resulting in the ongoing establishment of car-free zones or entire car-free city centers (Top & Pharoah, 1994).

Although the position of the car within cities is not uncontested, EVs provide a new perspective on urban car use. One of the key approaches within transport planning towards sustainable mobility is technology, "as it impacts on the efficiency of transport directly through ensuring that the best available technology is being used in terms of engine design, alternative fuels, and the use of renewable energy sources." (Bannister, 2008, p. 75). From this perspective, the innovation that is represented by the EV could work towards more sustainable mobility. In relation to the position of the car in the city, EVs could minimize one of the main negative effects associated with personal car use, which is the issue of urban emissions. Despite this benefit, the net sustainability of EVs has been questioned because of remaining "upstream emissions" related to electricity sources and the harmful effects of battery production (Lipman & Delucchi, 2010, p. 119). Nevertheless, EVs always bring benefits to their area of use, because of a reduction in local emissions (HEV, PHEV) or an altogether removal of tailpipe emissions (BEV). Apart from the physical space that EVs still take up, a key drawback of urban car use could thus be minimized or removed. If planning or spatial policies would indeed be useful tools to pave the way for the adoption and integration of EVs, this might shift the problematic position of urban car use within planning, not only because the aforementioned removal of a key drawback, but also because planners would be able to influence how these new vehicles would be incorporated in urban systems. If purposive spatial policy measures are designed and deployed, these could then directly influence the extent to which EVs become a viable substitute for internal combustion engine vehicles (ICEVs) in cities.

1.2 Research gap

Although the electric revolution within the automotive industry has been the subject of countless studies, there appears to be no clear view of the role and the potential influence of planners in this revolution. In addition, relevant spatial policy on the subject is dispersed. Articles on the subject of EV adoption often contain recommendations or findings related to (public) charging infrastructure (see for instance; Egnér & Trosvik, 2018; Ledna et al., 2022; Egbue & Long, 2012). Although there is an inherent spatial intervention behind such findings, such studies often do not recognize the role of planners towards described spatial interventions. Research on the subject of EV adoption often takes a broad perspective, meaning that the outcome could be a combination of socio-economic, spatial, technological and psychological factors, or a similar mix, regardless of research methods. Examples of such combined outcomes can be found in Nanaki et al. (2015), Wang et al. (2017) and She et al. (2017). In practice, combinations of policy measures are also used, including both spatial policies as well as other policy types. For instance, the Chinese government deployed a national EV policy for the public sector in 2009, which included both purchase incentives and investment in infrastructure for EVs (Zhang et al., 2022). However, to find out what the potential role of planners is within the EV transition, it is necessary to assess what the current state of affairs is within EV adoption research in relation to spatial policy. This way, both the relevance of spatial policy itself, as well as the position of planning within this context can be made more explicit.

When reviewing spatial policy in relation to EV adoption there also seems to be a conceptual gap. Within the context of EV adoption, integration is often limited to grid-integration or other integration processes related to electricity supply, with an emphasis on technical elements related to the grid itself (see for instance; Kim et al., 2012). However, grid-integration is not the only measure that appears to deviate from general measures towards adoption. For instance, Byun et al. (2017) discuss how the relatively low cost per kilometer travelled for EVs can also lead to a rebound effect that makes users make additional trips, negatively affecting the sustainability of EV use, which poses a challenge to policymakers who are tasked with promoting EV adoption. Measures against such a process deviate from measures such as investing in charging infrastructure, as the latter does not

necessarily take into account the environmental efficiency of EV adoption. Therefore, it is useful to split these categories into an adoption as well as an integration category. In previous research on EV adoption, such a distinction was either lacking altogether or the delimitation of the concepts of integration and adoption was not explicit. In this study, the distinction between adoption and integration is emphasized, since there appeared to be a division within suggested policy measures and approaches.

In light of the above, the aim of this thesis is to find out which policy measures would allow planners and policymakers to promote the adoption or the integration of electric vehicles into cities. The emphasis on cities is based om the aforementioned contested position of cars within cities. The research aim will be achieved through a systematic literature review (SLR) of existing academic literature on electric vehicle adoption. The added value of this study is twofold. Firstly, the academic relevance of this research lies with the knowledge that could be generated through a synthesis of the policy measures and approaches that are presented in existing research, as well as a new perspective with an emphasis on the distinction between adoption and integration. Secondly, the outcome of this study could be used in practice, since policy actors could draw inspiration from the synthesis, while they could also benefit from the distinction between adoption and integration, which would allow them to create a focused policy plan. The following guiding question is central in this study;

How can planners and policymakers promote the adoption and integration of electric vehicles into cities?

1.3 Research boundaries and background

Because of the emphasis on the distinction between EV adoption and integration, it is necessary to clearly define both concepts at the outset. Adoption is colloquially defined as; “accepting or starting to use something new” (Cambridge Dictionary, 2022a). Integration is defined as; “the action or process of combining two or more things in an effective way” (Cambridge Dictionary, 2022b). Just like these basic definitions imply, integration was interpreted as a step beyond adoption in this research. In turn, adoption could therefore be viewed as a step towards integration. Within the aforementioned definitions, policies designed to directly induce growth in the number of electric vehicles in cities relate to adoption. However, policies that are aimed at efficiently embedding EVs into the city after initial adoption relate to integration. As a general guideline, policy recommendations that could theoretically be implemented post-adoption were considered to qualify as integrative. By separating policy recommendations that primarily relate to either adoption or integration, policy recommendations could be categorized with more precision. Such a distinction could be especially helpful in practice. Some cities might require an emphasis on adoption because EVs are simply not as popular yet, whereas cities with prominent EV-presence might be better served by measures towards integration that could foster further embedding of the EV into the urban fabric.

Car-sharing is a subject that has gained attention within sustainable mobility literature, which also holds for EV-sharing. For instance, Kent and Dowling (2013) argue that; “Carsharing is a less problematic, more sustainable mode of mobility positioned against the dominance of the private car.” Similarly, Cervero et al. (2017) recognize how EVs could limit oil dependency, while limiting the use of private cars could serve the same purpose. Although it is clear that there are connections between the transition from EVs to ICEVs and the transition from private to shared vehicles, these transitions are essentially separate. It would not be possible to do justice to both transitions in a study of this size that revolves around a single transition. Therefore, EV-sharing has been excluded from the SLR sample as much as possible.

In order to eventually provide an overview of policies that could be used towards EV integration or adoption, the specific background of EVs is relevant. As the dominance of internal combustion engine vehicles (ICEVS) is declining, numerous substitute types are gaining popularity. Beside hydrogen-powered cars, EVs are the main substitute. Not all interpretations of what constitutes an EV are the same. The following three categories are generally recognized (Patel et al., 2021);

- *Battery electric vehicles* (BEVs); vehicles with externally charged electric engines.
- *Hybrid electric vehicles* (HEVs); vehicles that are propelled by any combination of an electric engine (without external charging options) and an internal combustion engine.
- *Plug-in hybrid electric vehicles* (PHEVs); hybrid vehicles with an external charging option.

Given the strong emphasis on charging infrastructure and the implications of a relatively limited range in EV literature, HEVs will not be as prominently represented as BEVs and PHEVs.

2. Methodology

2.1 Systematic literature review

In order to answer the research question, a systematic literature review (SLR) was carried out. The core of systematic reviews was described by Littell et al. (2008, p. 1) as follows; "to comprehensively locate and synthesize research that bears on a particular question, using organized, transparent, and replicable procedures at each step in the process." The usefulness of systematic reviews for synthesis-based research fits the aim of this study well, given the emphasis on existing studies and the single, central research question. Replicability is another key value that fits the research aim, since the research outcome is meant to reflect a research process that is built upon the sample articles themselves, rather than shifting the balance towards (non-replicable) personal interpretations. What sets systematic reviews apart from non-systematic alternatives, is the added discipline and transparency, which in turn help minimize research bias (Ibid.). The Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement, which has been endorsed by several hundred academic journals, offers guidelines that can be followed to ensure a truly transparent systematic review (PRISMA, 2022; Page et al. 2021). Therefore, the methodological steps that will be explained in this section are derived from the PRISMA 2020 checklist (Page et al., 2021, p. 5);

1. Eligibility criteria
2. Information sources
3. Search strategy
4. Selection process
5. Data collection process
6. Data items
7. Study risk of bias assessment
8. Effect measures (N/A)
9. Synthesis methods
10. Reporting bias assessment
11. Certainty assessment

2.2 Eligibility criteria and information sources

Since the input for the systematic literature review withing this research consists of academic articles, data collection was carried out through an academic search engine. Scopus was the academic search engine of choice, since it is one of the largest databases, but also because its

standards guarantee peer-reviewed journal articles of high quality (Elsevier, 2022). To collect data through this search engine, a single keyword search was carried out on February 15th 2022. To arrive at a focused sample that only includes relevant research, there was a need to add keywords and apply filters. Before any keyword input, the search engine was set to finished academic articles written in English with three separate 'LIMIT-TO' operators. The choice for articles over other sources such as book chapters is based on the peer-review system which is in place for articles. Having this guarantee of quality strengthens the credibility of the sample. Consequently, only finished articles could be included, as unfinished articles would not yet have been peer-reviewed. The use of the English language was another prerequisite, to ensure that the articles in the sample could be universally understood by the readers of this article. However, all articles turned out to be written in English.

No prerequisites for article-specific methodologies or fields were used, in order to avoid the exclusion of any article with a valuable policy implication related to planning. Year delineation was not applied, since the recency of EV literature means that there are no obsolete studies yet, meaning that there is no reason to assume that lessons from earlier research within this context do not continue to hold relevance today. As expected, most articles in the sample are products of recent research, as the earliest article that made the final selection was written in 2014 and 88 percent of all selected articles was written after 2017.

2.3 Search strategy and selection process

The initial assessment of literature was aimed at finding the right keywords that led to the inclusion of relevant articles, while allowing for the exclusion of those articles that did not fit this study. Given the specific focus on personal electric vehicles within cities and the necessary involvement of planners or policymakers, the Boolean search required an intricate list of keywords. Since the aforementioned distinction between adoption and integration of EVs is not present or at least not pronounced within the existing body of work on this subject, the searches on both concepts have not been included explicitly in this search. Another reason for this choice was the sparsity of usable search results when either concepts was used as keyword input. To avoid the unnecessary exclusion of articles that could be caused by a title search, the eventual search was a search within title, abstract and keywords. To provide clarity as to which keywords and operators were used, the full search string, as produced by Scopus, is presented below.

TITLE-ABS-KEY (electric AND mobility)) AND ((((personal AND vehicle)) AND (car)) AND (policy)) AND (urban AND planning) AND NOT (autonomous) AND NOT (scooter) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English")))

It is worth noting that by default, Scopus does not treat singular and plural versions of the same word differently (Beaty, 2022). Although several combinations of these keywords signify a degree of redundance, there are two reasons for the emphasis that was given. Firstly, the first three keywords collectively specify the outcome towards a combination of personal electric vehicles, with added emphasis on the car, in order to avoid the inclusion of other modes as a primary research subject. Towards a focused sample, 'electric mobility' turned out to be a better fit than 'electric vehicle,' as the latter led to the inclusion of more articles without a clear spatial background. To emphasize the urban context, 'urban planning' was chosen over 'spatial planning,' which was necessary due to a consistent prevalence of non-urban cases within search results. The policy keyword was included to ensure that all selected articles include actual policy implications or ideas. In line with the approach that was taken for selective keywords, two keywords were added as filters by using the Boolean

'AND NOT' operator for 'autonomous' and 'scooter'. The former was used to prevent the inclusion of policies on autonomous vehicles in search results. Similarly, the latter was used to exclude articles on electric scooters. The final part of the search string shows the general filters that were applied, as discussed in the previous section.

2.4 Data items and screening

2.4.1 Selection outcome

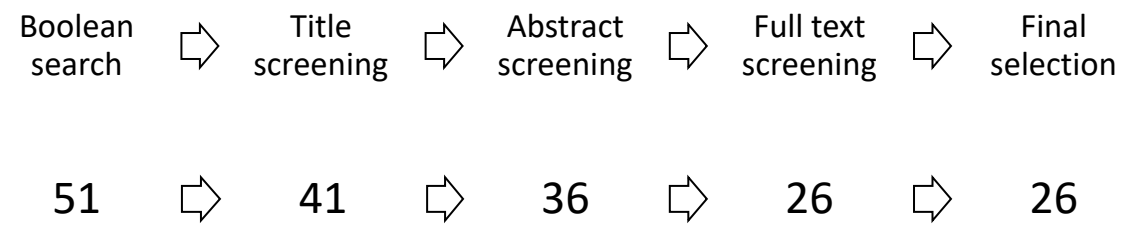

Figure 1: Articles by search engine step

Figure 1 shows the process steps that led to a final selection of suitable articles along with the amount of articles that were left after each stage. After applying basic filters and carrying out the Boolean search, title screening, abstract screening and full text screening completed the process. Throughout these steps, the goal was to identify and exclude any article that did not contain policy ideas, suggestions or experiences. Although the Boolean search was relatively specific, which helped omit a large amount of irrelevant articles at an early stage, the drop-off between the article input at the title screening stage and the final selection was still nearly 41 percent. The next two subsections are meant to explain how and why each separate step resulted in a decrease in articles towards the final selection.

2.4.2 Title and abstract screening

In addition to the steps highlighted in the PRISMA statement, the selection procedure for this SLR also included title screening. Ten articles were left out on the basis of their titles, since these immediately showed that the articles were unsuitable. An example of this is one article that only included research on e-scooters, which ruled out its relevance for this study. If the title gave any indication of suitability, the article was moved to the abstract screening phase. The abstract screening phase revolved around the following questions;

Does the article involve EVs for private use?

Does the article appear to be related to EV adoption or integration?

Does the abstract indicate that there is a potential policy implication?

After finding the answers to these questions for each article, five more articles were removed. Much like the preceding step, the aim was to only weed out articles that could be confirmed to be unsuitable at this point, while keeping any article that was at least somewhat promising. This is also the reason why the second and third question are less stringent than the first.

2.4.3 Full text screening

After abstract screening, all articles were screened in their entirety. This was especially necessary when the abstract had not provided sufficient clarity with regard to the content of the article. For

this step, stricter versions of the last two question mentioned in the section above were used to confirm the compatibility of all articles with this study. These revised questions were phrased as follows;

Is the article related to EV adoption or integration?

Does the article contain an explicit or implicit reference to a policy implication?

Based on these questions, eleven more articles were removed from the selection, resulting in a final selection of 26 articles. Since this was the final step, articles were checked for full suitability. In some articles the context did not relate directly to EV-adoption or integration, whereas other articles were written within the right context, but did not contain a clear or even an implicit policy implication.

2.5 Synthesis methods and categorization

To be able to identify planning or policy approaches that positively affect the adoption or integration of EVs into cities, categorization of articles was necessary. The approach to categorization for this study was inspired by a coding framework of Biesbroek et al. (2018) and Moher et al. (2019). In line with their approach, the categorization of SLR articles presented below was split between inductive and deductive categories. Firstly, all articles were categorized based on year of publication, journal and the location under study by continent. Since methodologies within the sample were dispersed, a categorization based on journals proved to be more insightful than a categorization based on methods. The aim of this basic, deductive categorization is to provide an overview of the general background of the SLR-articles, along with a better understanding of how the prevalence of literature on urban vehicle electrification policies has developed over time.

As stated before, inductive categories were also part of this SLR. The reason for this approach is that the findings of this study could have been limited by categorizing article content based solely on a pre-conceived framework. By partly building the categorization on the articles themselves, a higher degree of research neutrality could be attained, which aligns with the core values of systematic literature reviews. The categorization that was constructed after the SLR pre-analysis steps of the SLR were completed is visualized in the table below. Similar to Biesbroek et al. (2018), categories were created on the basis of recurring approaches within separate articles. By doing this, trends within the selected body of literature can be discerned, allowing for the creation of an overview of policy approaches and their prevalence. Moving to specific categories, every article was categorized based on the involvement of either planners, policymakers or both. This categorization is aimed at ensuring a clear distinction of theoretical insights when those are put into practice, as policymakers instead of planners might also be tasked with devising planning policies. This means that there is an imaginable disconnect between planners in theory and planners in practice, which will be further addressed in the following sections.

Table 1: SLR categorization

Deductive categorization	*Inductive categorization*	*Inductive policy categorization (binary)*
Year of publication	Policy implication(s)	Integration or adoption
Continent of location under study	Clarity of implication(s)	Implicit or explicit
Journal (field)		Approach or measure
		Planning or general policy

In addition, a separate ordered categorization framework based on policy recommendations was made, inspired by the ordered data structure introduced by Gioia et al. (2013, p. 21; Corley & Gioia, 2004). The framework is presented in figure 2. Every subsequent order has fewer categories, resulting in a funnel towards the final order. The aim of this categorization was to provide a synthesis of actual policy implications, which would show how policy subjects on EV integration or adoption relate to each other and which common themes can be discerned. The application of this framework to the SLR sample is presented in a policy model in section 4.4.

Figure 2: Ordered categorization framework

2.6 Bias assessment and limitations

The methods presented above come with several limitations. Part of the legitimacy of systematic literature reviews lies with transparency and objectivity. Although every effort has been made to show what steps shaped the research process, there is a fine line between choices or conclusions that flow directly from the methodology and those that originate from (necessary) interpretations. Without interpretation, there would be no meaningful analysis. Consequently, by relying on at least some interpretations, the study cannot be entirely true to SLR principles. Another limitation to consider is the selection of articles. Following the logic of the search engine input and the applied filters, these articles should provide a complete overview of policies towards EV adoption and integration. However, relevant articles might have been mistakenly excluded because of that input and the applied filters. In addition, there could be relevant policy in grey literature that has not been mentioned in academic articles yet. Lastly, a potential mismatch in research contexts is another limitation. Each article was written in and about a different context, despite the common themes across the selection. Since it is therefore not safe to assume universality of policy recommendations, any lesson drawn from the policy overview presented in this research should first be evaluated for applicability before it could be translated to the recipient context.

3. Results and findings

3.1 General background of selected literature

Before moving toward the outcome of the SLR, the tables below present background information which allows for further contextualization. Table 2 shows the relative recency of research on EV adoption, as the earliest articles in the sample were written in 2014. In addition, a clear majority of

articles was written after 2017. There appears to be an upward trend in the number of published articles from 2017 up until 2021. Since the article search was carried out in February, the list does not include any articles that were written in 2022, which was the same for the pre-selection articles.

Table 2: Year of publication

Year of publication	*N**
2014	2
2015	-
2016	-
2017	1
2018	4
2019	7
2020	5
2021	7

*N relates to the number of articles

Table 3 shows the research context by continent. Given the differences in scale between articles, this was the lowest scale level that allowed for a meaningful comparison. There was a strong emphasis on Europe in the SLR sample. Furthermore, there were four articles that did not include any specific geographical context. Two articles included both European and North American perspectives. It is worth noting that the sample does not contain any articles with a solely North American perspective.

Table 3: Research continent

Research continent	*N**
Europe	15
Asia	2
Latin America	2
Africa	1
Europe + North America	2
N/A	4

*N relates to the number of articles

Table 4 contains an overview of the journals from which the sampled SLR articles originate. Some journals have been combined into a single category. The spatial implications of the sample are evident in this table, as journals on the subject of transportation are prevalent. Journals on energy, sustainability, environment and ecology are common as well. As expected based on the absence of filters related to methodology, there is no uniformity of research fields within the SLR sample, although all journals can still be linked to the topic of this study.

Table 4: Journals within SLR sample

Journal	*N*
Transportation Research Part D: Transport and Environment	7
Other transport-related journals*	4
Energy journals*	4
Technological Forecasting and Social Change	3
World Electric Vehicle Journal	1
SN Applied Sciences	1
Travel Behavior and Society	1
Cities	1
Sustainability	1
Environmental Innovation and Societal Transitions	1
Ecological economics	1
IEEE Open Journal of Vehicular Technology	1

*Standardized journal category

3.2 Subject-specific background of selected literature

Although the selection of articles contains policy recommendations which differ strongly in terms of specific content, the general characteristics of all policy recommendation allow for a broad categorization. The following tables were constructed based on the inductive categorization that was introduced in Table 1. As shown by Table 5, most articles contain relate to both integration and adoption, based on the definitions that were established for this research. Rather than an apparent ambiguity in policy goals, this trend was caused by the prevalence of policy combinations within articles. Since these values are therefore slightly deceiving, it is useful to consult the overview of policy recommendations that were separated from the articles from which they originate, which is presented in section 3.3. Clarity, which is also included in Table 5, revolves around the extent to which a policy recommendation was stated as such, or if it was implied. The former situation was more common than the latter, as there were four articles that did not have any explicit policy recommendations.

Table 5: Characteristics of policy recommendations

Key goal	*N**	*Clarity*	*N*
Integration	4	Explicit	22
Adoption	4	Implicit	4
Both	18		

*N relates to the number of articles with a certain characteristic

Within the SLR sample, some policy recommendations consisted of a clear and specific measure, whereas others consisted of a broad approach or a guideline. In six cases, a combination of policy approaches and measures could be discerned. This division of these types is visible below the recommendation type variable in Table 6. Moving to the right side of the table, the policy implication is categorized along planning, general policy or both. Although planning policy often has a broad and multi-dimensional scope, policy recommendations on the subject of penalty taxes or social inequality cannot be covered solely by planning, if at all. As a result the policy implication section of Table 6 is not just divided between planning and general policy, but also includes a *both*-category.

Table 6: Characteristics of policy recommendations (continued)

Recommendation type	*N**	*Policy implication*	*N*
Approach	8	Planning	7
Measure	12	General policy	6
Both	6	Both	13

*N relates to the number of articles with a certain characteristic

3.3 Results

The aim of this systematic literature review was to extract policy recommendations from relevant previous research on the subject of EV-adoption and integration. The following table shows summarized policy recommendations that were found in each article. All article titles have been reduced to numbers for brevity, but a full overview including authors can be found in the appendix (6.3).

Table 7: Policy recommendations by SLR article

Article	*Policy recommendation*
1	Need for charging bay availability
2	Facilitate public charging infrastructure, emphasis on incentives, prevent grid overloading
3	Integration of EVs into micro-grids
4	Fostering EV integration through the support of EV-sharing systems
5	Need for abundantly available fast charging infrastructure, as well private charging infrastructure, leading to social acceptance
6	Need for policy on vehicle to grid (V2G) technology (instead of charging infrastructure)
7	Need for fast charging infrastructure
8	Need for public charging stations, policies against 'rebound effect' causing more vehicle kilometers travelled (VKT)
9	Carsharing as a means towards increased EV use in cities
10	Need for public and private charging locations
11	Need for public charging infrastructure, penalty taxes on conventional vehicles for sharing system operators
12	Focus on societal embedding processes
13	Policies to prevent induced traffic, public transport investment to provide alternatives for longer trips
14	Improving public charging infrastructure, fostering social embedding
15	Facilitate dedicated EV parking, accept EV sharing as a driver of EV integration
16	Need for investment in charging stations, smart grids and swapping stations (sharing)
17	Facilitate fast charging infrastructure, primary focus on home charging (prerequisite for newly built homes)
18	Need for grid integration and 'smart' charging stations
19	EV integration policies need to be adjusted to the size of the city
20	Increase service range of charging infrastructure, paying attention to function substitutions
21	Minimize injustice for broad integration
22	Need for EV and V2G policies that target specific subgroups
23	Introduce free parking for EVs (for carsharing), reduce public transport travel time to prevent mode displacement

24	Need for adequate charging infrastructure, both at home and public.
25	Need for fast public charging infrastructure or charging options at home
26	Policies should be adjusted to market segmentation

Table 7 includes a variety of policy recommendations, ranging from a single measure or approach to three separate recommendations. Since there is considerable overlap between recommendations from multiple articles, Table 8 provides a standardized overview of recommendations, as well as a further elaboration of each standardized policy recommendation with links to specific SLR articles. To avoid too much interpretation at this point, the categories that were thus created are still broad, but a more specific standardization and categorization is provided in the policy model (section 4.4).

Table 8: Standardized policy recommendations and background

Policy recommendation	*N*	*Background and explanation*
Public charging infrastructure	14	Public charging infrastructure is included in 14 separate recommendations, making it the most common subject. The availability of charging infrastructure and the lack thereof is often perceived as a barrier to adoption. In multiple cases, the phenomenon of range anxiety was found to be a key issue related to this lack of charging infrastructure (see for instance; Burkert et al. 2021; Hasan & Simsekoglu, 2020; Lin & Sovacool, 2020; Melliger et al. 2018). Range anxiety is described as "a specific form of psychological stress, which occurs to manage a present or anticipated critical range situation where the EV driver anticipates insufficient available driving range for the remaining travel distance" (Franke et al. 2016, cited in Hasan & Simsekoglu, 2020, pp. 1-2).
Fast charging Private charging (home)	3 5	Recommendations related to fast charging and private charging at home are also common. Melliger et al. (2018) state that home charging is a better option than public (fast) charging towards EV adoption. Others, such as Truffer et al. (2017) do not necessarily view home charging as a more desirable option over public charging. The need for fast charging infrastructure is recognized by Burkert et al. (2021, p. 13); "*faster charging and a greater availability of fast charging stations have the potential to increase public acceptance of electric vehicles*"
V2G technology	3	Staying close to the subject of charging, investments in vehicle-to-grid (V2G) technologies were included in three recommendations. V2G technology is based on a mutual linkage between EVs and the grid, instead of the conventional one-way grid-to-vehicle technology that is used when charging an EV. Chen et al. (2020), for instance, argue that EV adoption could be promoted through a redirection of a policy emphasis on charging infrastructure towards V2G technology.

Incentives	1	Incentives were recommended in a single article. Bakker et al. (2014) argue that governments could create the right conditions for EV implementation (i.e. adoption) through incentives for grid operators or car manufacturers, for instance.
EV-sharing	5	EV-sharing, which is a subject that actually led to the exclusion of numerous articles, is still a main subject in terms of prevalence. It should be noted that all recommendations on EV-sharing originate from articles that discussed EV adoption and integration through sharing or fleet electrification, whereas excluded articles had a focus on sharing itself. EV-sharing was also considered as a means to get people acquainted with EVs, potentially leading to adoption (Hoerler et al. 2021).
Social acceptance Social or societal embedding	1 2	Recommendations aimed at social acceptance and social or societal embedding are closely related. Burkert et al. (2021) suggest that the perception of EVs needs to be changed in order for social acceptance to be attained. Similarly, Kanger et al. (2019) recognize the need for a deeper integration of EVs into society, which even extends to the realm of culture.
Preventing VKT increase	3	Preventing VKT increase is a policy goal that was mentioned in three separate articles, which relates to integration. Instead of working towards adoption, this recommendation is an attempt to safeguard sustainability, which is a key benefit of EVs after all. However, induced traffic is an effect that is known to be associated with the EV-transition. As summarized by Langbroek et al. (2018, p. 152); "*The consequence of induced traffic is that it diminishes the contribution of EVs to a more sustainable mobility"*
Penalty taxes (ICEV)	1	While most policy recommendations are essentially so-called *'carrot'* measures or approaches, the recommendation of penalty taxes on ICEVs is a clear example of a '*stick'* measure. Within the context of shared vehicle fleets, Illgen and Hock (2018, p. 386) note that; "*penalty taxes on the purchase or operation of conventional vehicles in urban areas may also increase the attractiveness of EVs*"

Public transport investment	2	Two articles included policy recommendations that entailed public transport investment. In one case this investment had a strong integrative aspect, since it was meant to prevent mode displacement by making public transport a viable alternative to the shared EV-network (Sprei et al. 2019). Returning to EVs in general, Langbroek et al. (2018, p. 152) had a similar perspective, stating the following about the role of public transport towards EV-adoption and a prevention of rebound effects; "*efforts should be made to improve the public transport system, especially providing better alternatives for longer trajectories and for tangential connections where the current public transport system does not provide an attractive substitute for individual motorized transport*"
Dedicated or free EV parking	2	Dedicated or free EV parking is a straightforward measure that was twice put forward as an measure towards adoption within the context of EV-sharing networks (Luna et al. 2020; Sprei, 2019).
Smart grid investment (beyond V2G)	3	Recommendations revolving around smart grid investment beyond V2G imply a further integration of EVs into the urban energy system. In such cases, EVs could, for instance, benefit the overall energy performance of individual buildings (Barone et al. 2019).
Recharging and swapping station investment (for sharing)	1	Recharging and swapping station investment, as highlighted by Marletto (2014), is basically charging infrastructure investment within a sharing-context, although the swapping station investment is a new addition. Swapping stations allow for quick battery replacement, meaning that charging time can be avoided altogether.
Adjust policies to city size	1	Pucci (2021) emphasizes the need for EV adoption policies that are adapted to the size of the city. From this perspective, different (urban) contexts call for different measures.
Prevent grid overloading	1	Preventing grid overloading is a guideline that was introduced by Bakker et al. (2014). The following summarizes the problem that would have to be prevented; "*Because the capacity of local electricity grids is finite, only a limited number of EVs can charge simultaneously within a given area without overloading the network*"

Minimize injustice / target subgroups	3	Minimizing injustice and targeting subgroups are two intertwined recommendations. Injustice is linked to EVs because EV ownership tends to grow with income (Sovacool et al. 2019b), which indicates that any benefit for EV owners is not evenly, or justly, spread across societal groups, while it also reinforces arguments in favor of market segmentation. Targeting subgroups, as suggested by Zolfagharian et al. (2021), is not primarily motivated by social inequality, but rather by inefficiencies in the EV-adoption process without market segmentation.

4. Discussion and synthesis

After having established the results in the preceding section, this section provides a further interpretation, discussion and synthesis of the selected articles. Although the results section revealed the policy recommendations that were extracted from the SLR sample, a further contextualization of these results is needed to fully grasp the interlinkages between separate recommendations, but also to translate these steps to an actual, usable policy advice.

4.1 Interpretation of recommendation-specific concepts

4.1.1 Range anxiety

Although range anxiety was only included in the results in relation to charging infrastructure, this phenomenon is one of the fundamental problems that EV-adoption policies aim to solve. When the first EVs were introduced, ICEVs had been the norm ever since the combustion engine had been integrated into society. Even though recharging an EV is comparable to the refueling of an ICEV to an extent, the comparatively limited range of EVs combined with the relative scarcity of public charging stations, as compared to fuel stations, appear to be important hurdles that continue to keep consumers from purchasing an EV. All recommendations on the subject of charging infrastructure (Table 7) are partly, perhaps not always consciously, designed to prevent range anxiety, since a denser network of charging options will have a positive effect on range perception. Furthermore, social acceptance and embedding are goals that also relate to range anxiety, since the relatively limited range of EVs obstructs social acceptance, as vehicle owners appear to be reluctant to give up the range of the ICEVs they are used to. The dominance of policy recommendations related to range anxiety also show how most articles within the sample are geared towards BEVs instead of PHEVs or HEVS, as range anxiety is a less pressing issue in these EV types that do not solely rely on batteries. Lastly, range anxiety also entails an aspect of injustice. EV prices generally increase along with an increase in range, indicating that the relatively well-off should be less susceptible to range anxiety than those who can only afford an inexpensive EV (Burkert et al. 2021).

4.1.2. V2G and grid investments

V2G technology and grid investments challenge the distinction between EV adoption and integration that is central to this study. Apart from the fact that an adequate, reliable grid could be a prerequisite for EV adoption, grid investments in general fit the aforementioned definition of integration. In practice, these investments make EVs a part of existing systems, leading to mutual

benefits, including the energy system at large, as explored by Barone et al. (2019). Adoption, which would be directly promoting the use of EVs, does not immediately spring to mind when speaking of grid investments. However, Chen et al. (2019) found that V2G technology could indeed be a driver of EV adoption. This shows that some policy recommendations cannot be reasonably combined to fit the binary distinction that was proposed.

4.1.3. Social acceptance

Promoting social acceptance and social embedding are two recommendations that cannot be separated from other recommendations. Achieving social acceptance or embedding, is a purpose served by most measures that lead to either adoption or integration, especially considering the need to change the perception of EVs towards social acceptance that was discussed by Burkert et al. (2021). In that sense, these social recommendations are guidelines that can be followed by deploying an appropriate set of supporting policies, meaning that these social recommendations should not be viewed in isolation.

4.1.4. Rebound effect

Rebound effects were addressed in articles that included recommendations on either public transport investment or VKT increase. The root of this effect was demonstrated by Hasan and Simsekoglu (2020)

"*with the help of enhanced energy efficiency, lower maintenance costs, lower energy (electricity) cost, and most importantly user-based policy incentives—EVs offer a lower generalized cost of driving*"

Although this indicates a net benefit for EV owners, partly removing the financial hurdle of driving costs could cause an increase in their propensity to travel. Langbroek et al. (2018, p. 144) summarize the further implications of this rebound effect as follows;

"Electric vehicle adoption as such increases energy efficiency per kilometre compared to driving an ICEV, but if the amount of kilometres driven increases, part of the total energy efficiency gain would get lost."

Especially if the additional electricity used by EVs is not sustainably sourced, the extent to which EV use can truly be seen as sustainable is limited (Hasan & Simsekoglu, 2020). Therefore, incentivization of EV use should be balanced, to induce a substitution of ICEVs in favor of EVs without increasing the former VKT of these users in the process.

4.2 Policy prevalence

Even though all policy recommendations from the sample have been addressed equally, their prevalence is not uniform, as shown previously in Table 8. One conclusion that can be drawn is that (fast) charging infrastructure, be it public or private, is a central theme within this sample of articles. Policy recommendations related to EV-sharing also stand out, just like the combination of grid investments and V2G technologies. Other recommendations are mentioned in three cases, two cases or just a single case. Determining the weight of this evidence for trends within the total body of literature on EV adoption and integration is difficult, since the representativity of the sample cannot be confirmed. However, as 22 out of 51 recommendations are explicitly linked to charging infrastructure, this sample would justify the expectation of a similar trend outside of the sample. Looking beyond the issue of representativity, the imbalance in prevalence of policy recommendations in the sample leaves room for a different interpretation. One could conclude that

charging infrastructure investment is a sensible policy choice because of the prevalence of such investments within the recommendations. Similarly, there could also be value within those recommendations that are not mentioned as often. For instance, could it be that dedicated EV parking, though related to charging infrastructure, is an important step towards adoption that is overlooked? Both interpretations could be true, but further research into the performance of specific policy approaches would be necessary to formulate a fully supported conclusion.

4.3 Spatial implications and policy integration

Since the influence of planners is central to this research, it is necessary to assess the extent to which the presented policy recommendations actually relate to spatial interventions or space in general. Part of the reason why the research aim includes policymakers along with planners, is a perceived disconnect between the practical scope of planners and the theoretical scope of planning. Policies which relate to planning in theory might still be enacted or implemented by a policymaker external to the planner in practice, because of the scale, or because of context-specific government styles. Governments with high levels of policy integration reinforce this image, which is evident following a definition by Stead and Meijers (2009, p. 321);

"*the management of cross-cutting issues in policy making that transcend the boundaries of established policy fields, and that do not correspond to the institutional responsibilities of individual departments*"

When the boundaries of separate fields are blurred, it becomes increasingly difficult to link an issue, or a recommendation in this case, to a specific field in practice. Consequently, a high degree of policy integration indicates that policy recommendations for planners might also be relevant for actors from different fields, who might share the responsibility for a primarily spatial issue. Recalling table 8, it is clear that certain policy recommendations contain elements of fields external to planning, such as socio-economic policy and energy policy. In line with the SLR search objectives, most policy recommendations have a clear spatial implication within their approach, goal or consequences. However, recommendations on incentives and disincentives (see figure 3) are clear exceptions, as they do not have such a direct spatial implication, meaning that these recommendations do not necessarily concern planners. Minimizing injustice and targeting subgroups are two other recommendations that do not display immediate spatial implications, although the broadness of these recommendations could mean that spatial aspects are included as well.

4.4 Policy model

To bring all policy recommendations and categorizations together into a concise overview, a policy model based on the ordered categorization framework in Figure 2 is presented below in Figure 3. The first column represents clusters of policy recommendations that were taken from the SLR articles. The recommendations were clustered on the basis of a common theme, which is displayed in the next column. The dimensions were intended to show a more general overview that can be directly linked to the themes. Although the weight of each dimension related to the prevalence of connected recommendations is not mentioned in the model, it is worth noting from a theoretical point of view that nearly half of all policy recommendations belong to the spatial circumstances dimension. Four main policy goals in the next column provide a summary of what the recommended policies and their respective themes and dimensions aim to achieve. Within the last column, the distinction between adoption and integration is emphasized once more, as this is the link between individual policy recommendations and each of these guiding principles could be central to a focused policy plan. As mentioned in the preceding section, integration and adoption are intertwined within grid investments, which is why these recommendations are linked to a hybrid policy outcome including

both integration and adoption. For a theoretical perspective, the model is best interpreted from left to right, as this shows how policy recommendations relate to desired policy outcomes. For a practical perspective, an interpretation from right to left is useful, as planners or policymakers could pick a desired policy outcome and move towards relevant recommendations from there.

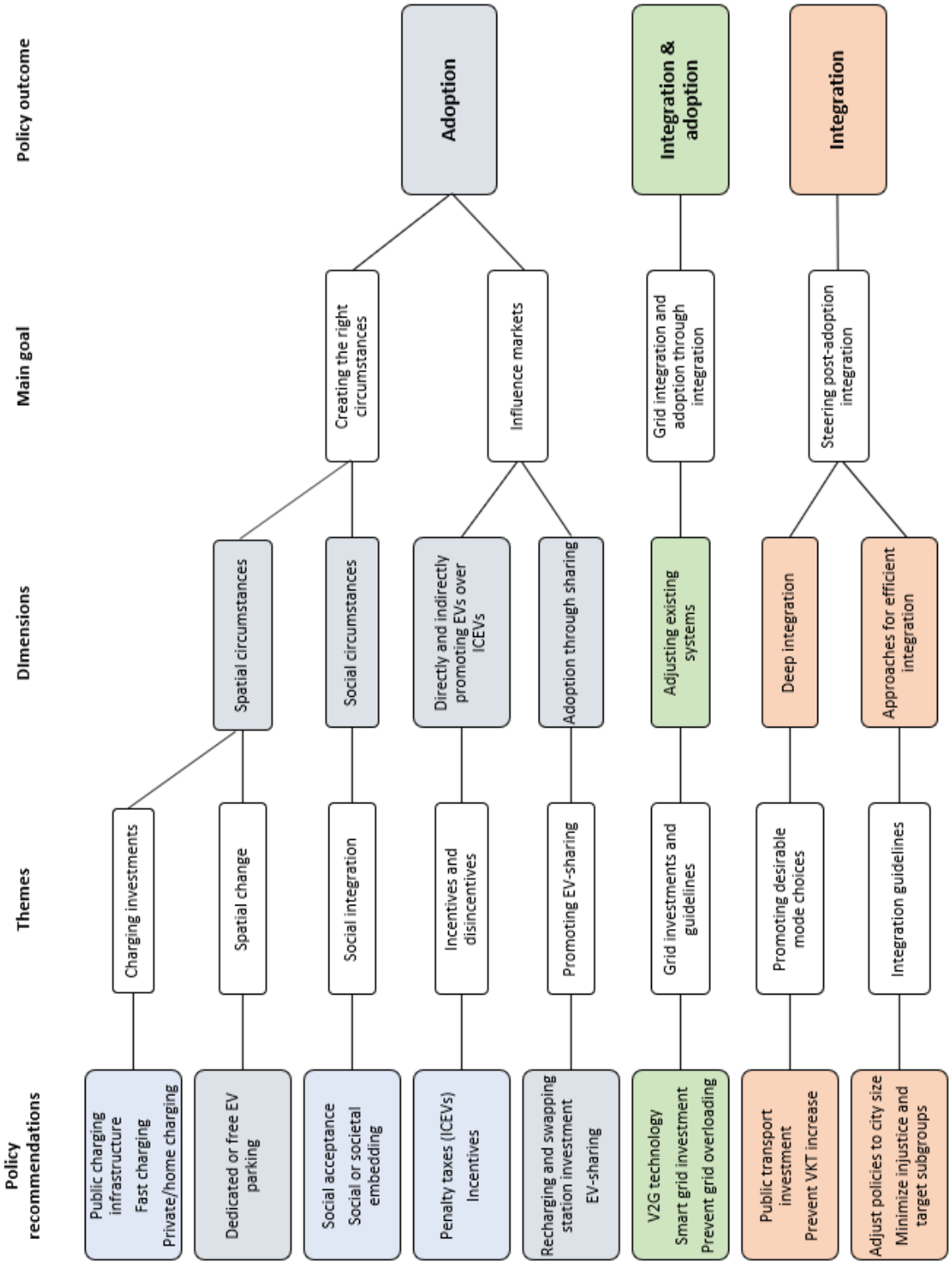

Figure 3: Policy model, based on Gioia et al. (2013, p. 21; Corley & Gioia, 2004)

4.5 Policy coherence

Although most policy measures and approaches that were presented might serve policy purposes detached from any related measure, it is imaginable that a combination of these measures or approaches will be deployed. Depending on the degree to which EV adoption or integration is prioritized within a city, a number of policy ideas could be transferred. Recalling the spatially dispersed origin of these ideas, however, the alignment of any combination of measures or approaches should be considered. For instance, if a local government recognizes a lack of public charging infrastructure as a main obstruction to EV adoption, investing in dedicated charging spots for sharing might be at the expense of locations for general public charging infrastructure. Therefore, the policy approaches introduced in Table 7 and the policy model (4.4) are not necessarily suitable for a *pick and mix* without careful consideration of their alignment. As an extension of this, the effectiveness of each measure and approach is also dependent on the recipient context. For instance, in a city with a generally underdeveloped public transport system, the investment required to make public transport a viable alternative to trips with a personal vehicle might not be feasible, especially considering the relative inexpensiveness of other measures in such a case. The article by Pucci (2021) acknowledges the importance of context, as the main recommendation revolved around the need for policies to be adjusted to the size of the city in which it is deployed.

The motivation behind policy goals for which any of the recommended measures or approaches would be deployed is also relevant. If the policy goal is simply maximizing EV adoption, straightforward measures towards adoption will suffice. However, these policies are partially blind to the underlying purpose of EVs. If environmental concerns -which are a key reason behind EV adoption after all- are also central to the policy goal, two particular recommendations that do not directly relate to adoption become relevant. Firstly, the prevention of additional VKT is an approach that will not benefit the process of EV adoption, but it will help safeguard the net environmental gain that is pursued. Public transport investment against mode displacement is a measure that would fit in with the aforementioned approach. All in all, while such policy ideas might be perceived as accessories to those policy actors who are only interested in EV adoption, they are relevant for actors with environmental motives.

The governmental structure within recipient cities and their respective countries also affects the applicability of policy recommendations. In some cases, a local or regional government might be limited by the scope of its own authority. Imposing taxes on ICEVs is one of the measures that necessitates central government intervention in countries where local government are not endowed with the authority to change taxes.

Before applying any policy recommendation, it also relevant to assess whom the recommendation is geared towards. All measures and approaches in the adoption category ultimately aim to change the behavior of private vehicle owners and owners of ICEVs in particular. EV-sharing recommendations deviate from other recommendations within the same category because of the inherent promotion of a business-model instead of a direct effect on the behavior of individuals, although this is still the final goal. Recommendations within the integration category are more dispersed. Public transport investment and the prevention of additional VKT increase are still aimed at influencing individual behavior, while ‘minimizing injustice,’ ‘targeting subgroups’ and ‘adjusting policy to city size’ are guidelines which could help policy actors to make efficient choices. In these cases, there is no direct attempt at influencing individual behavior.

5. Conclusion and recommendations

5.1 Conclusion

The aim of this study was to find out which policy measures would allow planners and policymakers to promote the adoption or the integration of electric vehicles into cities. By emphasizing the distinction between adoption and integration, policy measures could be separated on the basis of their underlying goals. Although this categorization has not been applied in such an explicit manner before and does therefore not necessarily reflect a conscious thought process behind previous research, a clear division between recommendations from either category could be established in nearly all cases. The systematic literature review based on previous research related to EVs resulted in a number of policy recommendations for both categories, including several policy measures that did not fit the pre-established binary categorization of adoption and integration. Although a large share of policy recommendations was related to charging infrastructure, a diverse range of recommendations was found. Most of these recommendations revolved around a specific policy measure, whereas some recommendations put forward a less concrete approach or a general guideline. To answer the main research question and briefly recall the results, the policy themes, as introduced in Figure 3, are listed below.

Adoption	*Integration*	*Adoption and integration*
Charging investments	Promoting desirable mode choices	Grid investments and guidelines
Spatial change	Integration guidelines	
Social integration		
Incentives and disincentives		
Promoting EV-sharing		

Along with the policy model, this research outcome provides planners and policymakers with an overview of potential steps towards their policy goals on the subject of EV adoption or integration. The model that was presented in Figure 3 allows these actors to find a suitable measure approach, which they can then translate to their own context. Within the context of existing literature on EVs, there are two key aspects which the present study contributes. Firstly, employing integration and adoption and the distinction between these principles as a conceptual backbone, this research provides a new perspective. This is not to say that research within the field sustainable mobility has never included both adoption as well as integration, but this has never been done in such an explicit manner nevertheless. The other key aspect is the overview of potential measures and approaches, divided between adoption and integration, as presented in the model. As mentioned previously, there is no guarantee that this overview is comprehensive, but it does show the general state of affairs within research on spatial policies in relation to EV adoption as of now.

5.2 Limitations

Even though the policy model that was designed based on this research is expected to be of value for EV literature as well as planning practice, it does not include practical implications of policy recommendations. Because of this absence of a readymade policy plan, the practical side of this model mainly serves the purpose of inspiration. Since the universal applicability of the presented recommendations cannot be guaranteed, given contextual differences in governments or the general recipient-situation, a policy translation will often be necessary. In addition, these policy recommendations are not compatible in all cases. This is another reason to emphasize the need for a

thorough selection process when taking policy recommendations from the model into practice. Furthermore, although the model is built upon outcomes of previous studies, the distinction between integration and adoption that was imposed upon the synthesis of earlier work is largely based on interpretation, as none of the articles in the sample contains a call for such a distinction. As mentioned previously, some policy recommendations do not have a clear spatial implication or cannot be linked to planning practice.

5.3 Suggestions for further research

Since this research was based on a single academic search engine, the use of multiple search engines to cast a wider net could still reveal additional perspectives on EV adoption and integration. Looking beyond the scope of this study, case studies in countries where EV adoption is relatively advanced could allow for further evaluation of policy measures. Such case studies are suitable for lesson-drawing and could add an assessment of policy performance, which is still lacking in the policy model presented here. Research on specific EV types could also add to the understanding of EV adoption and integration, since BEVs, PHEVs or even HEVs have different characteristics that might necessitate tailor-made solutions for each separate type. Lastly, an extensive study into the synergies that might exist or come to exist between EV adoption and car-sharing could also lead to new insights.

6. References and appendices

6.1 General references

Banister, D. (2008), The Sustainable Mobility Paradigm*, Transport Policy*, 15(2), pp. 73–80.

Biesbroek, R., Berrang Ford, L., Ford, J., Tanabe, A., Austin, S. & Lesnikowski, A. (2018), Data, concepts and methods for large-n comparative climate change adaptation policy research: A systematic literature review, *WIRE climate change,* 9(6), pp. 1-15.

Beaty, S. (2022), 6 simple search tips, lessons learned from the Scopus webinar, viewed on 23-2-2022, https://blog.scopus.com/posts/6-simple-search-tips-lessons-learned-from-the-scopus-webinar.

Byun, J., Park, S. and Jang, K. (2017), Rebound Effect or Induced Demand? Analyzing the Compound Dual Effects on Vmt in the U.S, *Sustainability*, 9(2), pp. 219–219.

Cambridge Dictionary (2022a), Meaning of adoption in English, viewed on 14-4-2022, https://dictionary.cambridge.org/dictionary/english/adoption.

Cambridge Dictionary (2022b), Meaning of integration in English, viewed on 14-4-2022, https://dictionary.cambridge.org/dictionary/english/integration.

Cervero, R., Guerra, E. and Al, S. (2017), *Beyond mobility : planning cities for people and places*, Island Press, Washington D.C.

Chatterton (2019), *Unlocking sustainable cities : a manifesto for real change*, London, Pluto Press.

Corley, K. G., & Gioia, D. A. (2004), Identity ambiguity and change in the wake of a corporate spin-off. *Administrative Science Quarterly*, 49, pp. 173-208.

Egbue, O. and Long, S. (2012), Barriers to Widespread Adoption of Electric Vehicles: An Analysis of Consumer Attitudes and Perceptions, *Energy Policy*, 48, pp. 717–729.

Egnér, F. and Trosvik, L. (2018), Electric Vehicle Adoption in Sweden and the Impact of Local Policy Instruments, *Energy Policy*, 121, pp. 584–596.

Franke, T., Rauh, N., Günther, M., Trantow, M., & Krems, J. F. (2016), Increasing the efficient usage of electric vehicle range -effects of driving experience and coping information. *Human Factors*, 58(1), pp. 13–26

Gioia, D.A., Corley, K.G. & Hamilton, A.L. (2013), Seeking Qualitative Rigor in Inductive Research: Notes on the Gioia Methodology, *Organizational Research Methods*, 16(1), pp. 15-31.

Glaeser, E. & Kahn, M. (2003), Sprawl and urban growth, *NBER working papers.*

International Energy Agency, (2021), Trends and developments in electric vehicle markets, viewed on 11-1-2022, https://www.iea.org/reports/global-ev-outlook-2021/trends-and-developments-in-electric-vehicle-markets.

ITF (2021), Reversing Car Dependency: Summary and Conclusions, ITF Roundtable Reports, No. 181, *OECD Publishing*, Paris.

Kent, J. L. and Dowling, R. (2013), Puncturing Automobility? Carsharing Practices*, Journal of Transport Geography*, 32, pp. 86–92.

Kim, E. L. et al. (2012), Carbitrage: Utility Integration of Electric Vehicles and the Smart Grid, *The Electricity Journal*, 25(2), pp. 16–23.

Ledna, C., Muratori, M., Brooker, A., Wood, E. & Greene, D. (2022), How to support EV adoption: Tradeoffs between charging infrastructure investments and vehicle subsidies in California, *Energy policy*, 165, pp. 1-11.

Lipman, T. E. & Delucchi, M. A. (2010), 'Expected greenhouse gas emission reductions by battery, fuel cell, and plug-in hybrid electric vehicles', in Pistoia, G., *Electric and hybrid vehicles: Power sources, models, sustainability, infrastructure and the market*, Elsevier, Amsterdam, pp. 113-145.

Littell, J. H., Corcoran, J. and Pillai, V. K. (2008), *Systematic reviews and meta-analysis*, Oxford University Press, Oxford.

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. (2009), Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement, *Journal of Clinical Epidemiology* 62(10), pp. 1006-1012.

Nanaki E.A, Xydis G.A and Koroneos C.J (2016), Electric Vehicle Deployment in Urban Areas, *Indoor and Built Environment*, 25(7), pp. 1065–1074.

Patel, N., Kumar Bhoi, A., Padmanaban, S. & Holm-Nielsen, J.B. (2021*), Electric vehicles: modern technologies and trends*, Springer, Singapore.

Page, M.J., McKenzie, J.E., Bossuyt, P.M. et al. (2021), The PRISMA 2020 statement: an updated guideline for reporting systematic reviews, *Systematic Reviews* 10 (89), pp. 1-11.

PRISMA (2022), PRISMA endorsers, viewed on 3-7-2022, https://prisma-statement.org/Endorsement/PRISMAEndorsers.

Purcell, D. (2000), The car and the city, *Bulletin of science, technology and society,* (20)5, pp. 348-359.

She, Z.-Y. et al. (2017) What Are the Barriers to Widespread Adoption of Battery Electric Vehicles? A Survey of Public Perception in Tianjin, China, *Transport Policy*, 56, pp. 29–40.

Stead, D. & Meijers, E. (2009), Spatial Planning and Policy Integration: Concepts, Facilitators and Inhibitors, *Planning Theory & Practice*, 10(3), pp. 317–332.

Tomalty, R. and Mallach, A. (2016), *America's urban future : lessons from north of the border, Island Press*, Washington.

Top, H. & Pharoah, T. (1994), Car-free city centres, *Transportation*, 21, pp. 231-247.

Wang, F.-P. et al. (2017), Analysis of the Barriers to Widespread Adoption of Electric Vehicles in Shenzhen China, *Sustainability*, 9(4), pp. 522–522.

Zhang, J. et al. (2022), Does Electric Vehicle Promotion in the Public Sector Contribute to Urban Transport Carbon Emissions Reduction?, *Transport Policy*, 125, pp. 151–163.

6.2 SLR references

Angnunavuri, P.N., Kuranchie, F.A., Attiogbe, F. & Nerquaye-Tetteh, E.N. (2019), The potential of integrating vehicular emissions policy into Ghana's transport policy for sustainable urban mobility, *SN Applied Sciences*, 1(10).

Bakker, S., Maat, K. & van Wee, B. (2014), Stakeholders interests, expectations, and strategies regarding the development and implementation of electric vehicles: The case of the Netherlands, *Transportation Research Part A: Policy and Practice*, 66(1), pp. 52-64.

Barone, G., Buonomano, A., Calise, F., Forzano, C. & Palombo, A. (2019), Building to vehicle to building concept toward a novel zero energy paradigm: Modelling and case studies*, Renewable and Sustainable Energy Reviews*, 101, pp. 625-648.

Brendel, A.B., Lichtenberg, S., Brauer, B., Nastjuk, I. & Kolbe, L.M. (2018), Improving electric vehicle utilization in carsharing: A framework and simulation of an e-carsharing vehicle utilization management system, *Transportation Research Part D: Transport and Environment*, 64, pp. 230-245.

Burkert, A., Fechtner, H. & Schmuelling, B. (2021), Interdisciplinary analysis of social acceptance regarding electric vehicles with a focus on charging infrastructure and driving range in Germany, *World Electric Vehicle Journal*, 12(1), pp. 1-33.

Chen, C.-., Zarazua de Rubens, G., Noel, L., Kester, J. & Sovacool, B.K. (2020), Assessing the socio-demographic, technical, economic and behavioral factors of Nordic electric vehicle adoption and the influence of vehicle-to-grid preferences, *Renewable and Sustainable Energy Reviews*, 121.

Costa, E., Horta, A., Correia, A., Seixas, J., Costa, G. & Sperling, D. (2021), Diffusion of electric vehicles in Brazil from the stakeholders' perspective, *International Journal of Sustainable Transportation*, 15(11), pp. 865-878.

Hasan, S. & Simsekoglu, Ö. (2020), The role of psychological factors on vehicle kilometer travelled (VKT) for battery electric vehicle (BEV) users, *Research in Transportation Economics*, 82.

Hoerler, R., van Dijk, J., Patt, A. & Del Duce, A. (2021), Carsharing experience fostering sustainable car purchasing? Investigating car size and powertrain choice, *Transportation Research Part D: Transport and Environment*, 96.

Huang, Y., Qian, L., Tyfield, D. & Soopramanien, D. (2021), On the heterogeneity in consumer preferences for electric vehicles across generations and cities in China, *Technological Forecasting and Social Change*, 167.

Illgen, S. & Höck, M. (2018), Electric vehicles in car sharing networks – Challenges and simulation model analysis", *Transportation Research Part D: Transport and Environment*, 63, pp. 377-387.

Kanger, L., Geels, F.W., Sovacool, B. & Schot, J. (2019), Technological diffusion as a process of societal embedding: Lessons from historical automobile transitions for future electric mobility, *Transportation Research Part D: Transport and Environment*, 71, pp. 47-66.

Langbroek, J.H.M., Franklin, J.P. & Susilo, Y.O. (2018), How would you change your travel patterns if you used an electric vehicle? A stated adaptation approach, *Travel Behaviour and Society*, 13, pp. 144-154.

Lin, X. & Sovacool, B.K. (2020), Inter-niche competition on ice? Socio-technical drivers, benefits and barriers of the electric vehicle transition in Iceland, *Environmental Innovation and Societal Transitions*, 35, pp. 1-20.

Luna, T.F., Uriona-Maldonado, M., Silva, M.E. & Vaz, C.R. (2020), The influence of e-carsharing schemes on electric vehicle adoption and carbon emissions: An emerging economy study, *Transportation Research Part D: Transport and Environment*, 79.

Marletto, G. (2014), Car and the city: Socio-technical transition pathways to 2030, *Technological Forecasting and Social Change*, 87, pp. 164-178.

Melliger, M.A., van Vliet, O.P.R. & Liimatainen, H. (2018), Anxiety vs reality – Sufficiency of battery electric vehicle range in Switzerland and Finland, *Transportation Research Part D: Transport and Environment*, 65, pp. 101-115.

Mourad, A., Hennebel, M., Amrani, A. & Hamida, A.B. (2021), Analyzing the fast-charging potential for electric vehicles with local photovoltaic power production in french suburban highway network, *Energies*, 14(9).

Pucci, P. (2021), Spatial dimensions of electric mobility—Scenarios for efficient and fair diffusion of electric vehicles in the Milan Urban Region", *Cities*, 110.

Shi, X., Pan, J., Wang, H. & Cai, H. (2019), Battery electric vehicles: What is the minimum range required?, *Energy*, 166, pp. 352-358.

Sovacool, B.K., Kester, J., Noel, L. & de Rubens, G.Z. (2019a), Energy Injustice and Nordic Electric Mobility: Inequality, Elitism, and Externalities in the Electrification of Vehicle-to-Grid (V2G) Transport, *Ecological Economics*, 157, pp. 205-217.

Sovacool, B.K., Kester, J., Noel, L. & de Rubens, G.Z. (2019b), Income, political affiliation, urbanism and geography in stated preferences for electric vehicles (EVs) and vehicle-to-grid (V2G) technologies in Northern Europe, *Journal of Transport Geography*, 78, pp. 214-229.

Sprei, F., Habibi, S., Englund, C., Pettersson, S., Voronov, A. & Wedlin, J. (2019), Free-floating carsharing electrification and mode displacement: Travel time and usage patterns from 12 cities in Europe and the United States, *Transportation Research Part D: Transport and Environment*, 71, pp. 127-140.

Thorgeirsson, A.T., Scheubner, S., Funfgeld, S. & Gauterin, F. (2020), An Investigation into Key Influence Factors for the Everyday Usability of Electric Vehicles, *IEEE Open Journal of Vehicular Technology*, 1, pp. 348-361.

Truffer, B., Schippl, J. & Fleischer, T. (2017), Decentering technology in technology assessment: prospects for socio-technical transitions in electric mobility in Germany*, Technological Forecasting and Social Change*, 122, pp. 34-48.

Zolfagharian, M., Walrave, B., Romme, A.G.L. & Raven, R. (2021), Toward the dynamic modeling of transition problems: The case of electric mobility, *Sustainability (Switzerlan*d), 13(1), pp. 1-23.

6.3. Appendix: overview of SLR articles and recommendations

Author(s)	Year	Policy recommendations
Angnunavuri, P.N., Kuranchie, F.A., Attiogbe, F. & Nerquaye-Tetteh, E.N.	2019	Need for charging bay availability
Bakker, S., Maat, K. & van Wee, B.	2014	Facilitate public charging infrastructure, emphasis on incentives, prevent grid overloading
Barone, G., Buonomano, A., Calise, F., Forzano, C. & Palombo, A.	2019	Integration of EVs into micro-grids
Brendel, A.B., Lichtenberg, S., Brauer, B., Nastjuk, I. & Kolbe, L.M.	2018	Fostering EV integration through the support of EV-sharing systems

Burkert, A., Fechtner, H. & Schmuelling, B.	2021	Need for abundantly available fast charging infrastructure, as well as private charging infrastructure, leading to social acceptance
Chen, C.-., Zarazua de Rubens, G., Noel, L., Kester, J. & Sovacool, B.K.	2020	Need for policy on vehicle to grid (V2G) technology (instead of charging infrastructure)
Costa, E., Horta, A., Correia, A., Seixas, J., Costa, G. & Sperling, D.	2021	Need for fast charging infrastructure
Hasan, S. & Simsekoglu, Ö.	2020	Need for public charging stations, policies against 'rebound effect' causing more VKT
Hoerler, R., van Dijk, J., Patt, A. & Del Duce, A.	2021	Carsharing could be a means towards increased EV use in cities
Huang, Y., Qian, L., Tyfield, D. & Soopramanien, D.	2021	Need for public and private charging locations
Illgen, S. & Höck, M.	2018	Need for public charging infrastructure, penalty taxes on conventional vehicles for sharing system operators
Kanger, L., Geels, F.W., Sovacool, B. & Schot, J.	2019	Focus on societal embedding processes
Langbroek, J.H.M., Franklin, J.P. & Susilo, Y.O.	2018	Policies to prevent induced traffic, public transport investment to provide alternatives for longer trips
Lin, X. & Sovacool, B.K.	2020	Improving public charging infrastructure, fostering social embedding
Luna, T.F., Uriona-Maldonado, M., Silva, M.E. & Vaz, C.R.	2020	Facilitate dedicated EV parking, accept EV sharing as a driver of EV integration
Marletto, G.	2014	Need for investment in charging stations, smart grids and swapping stations (sharing)
Melliger, M.A., van Vliet, O.P.R. & Liimatainen, H.	2018	Facilitate fast charging infrastructure, primary focus on home charging (prerequisite for newly built homes)
Mourad, A., Hennebel, M., Amrani, A. & Hamida, A.B.	2021	Need for grid integration and 'smart' charging stations
Pucci, P.	2021	EV integration policies need to be adjusted to the size of the city

Shi, X., Pan, J., Wang, H. & Cai, H.	2019	Increase service range of charging infrastructure, paying attention to function substitutions
Sovacool, B.K., Kester, J., Noel, L. & de Rubens, G.Z.	2019(a)	Minimize injustice for broad integration
Sovacool, B.K., Kester, J., Noel, L. & de Rubens, G.Z.	2019(b)	Need for EV and V2G policies that target specific subgroups
Sprei, F., Habibi, S., Englund, C., Pettersson, S., Voronov, A. & Wedlin, J.	2019	Introduce free parking for EVs (for carsharing), reduce public transport travel time to prevent mode displacement
Thorgeirsson, A.T., Scheubner, S., Funfgeld, S. & Gauterin, F.	2020	Need for adequate charging infrastructure, both at home and public
Truffer, B., Schippl, J. & Fleischer, T.	2017	Need for fast public charging infrastructure or charging options at home
Zolfagharian, M., Walrave, B., Romme, A.G.L. & Raven, R.	2021	Policies should be adjusted to market segmentation