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Advancing the concept of windows of opportunity to explore the dynamics of the sustainability transition: The development of the EV market in the UK

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Abstract

In this study, we seek to understand the interplay between industry and policy, to explain how and why the UK shifted from the promotion of low-emission road transportation, to policy based on zero tailpipe-emission electric vehicles (EVs), as part of its evolving net zero ambitions. For this, we unify the Multi-Level Perspective, Multiple Streams Framework, and Multi-Level Governance into a synthetic model—the Multi-Level Governance and Strategy model. Within this, we identify distinct windows of opportunity (WoO) that relate to each of the technology, policy, and market factors that needed to come together to put the UK automotive industry on a specific trajectory. Utilizing (pragmatist) grounded theory to analyze our extensive interview and documentary data, we find that this trajectory resulted from the interplay of technology innovators and policy entrepreneurs in different WoO, to achieve the ultimate goal of a functioning market for EVs.

KEYWORDS

electric vehicles, policy entrepreneurs, problem brokers, sustainability transition, technology innovators, windows of opportunity

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1 | INTRODUCTION

In recent years, the UK government has sought to promote the decarbonization of road transport, as a major source of the country's greenhouse gas (GHG) emissions. In the context of private personal mobility a major focus was, first, on promoting low emissions vehicles. Over the period 2016–2020, however, the Government released five decarbonization strategy documents that shifted the focus from "low" emissions vehicles to "zero" emissions vehicles (ZEV), cars with zero tailpipe emissions. Alongside the technical and policy dimensions embedded in this shift, the economic ambition was to create a significant, self-sustaining market in such vehicles. In this research, we seek to analyze the dynamic interplay between stakeholders involved in the multiple industries that enabled electric vehicles (EVs) as zero emission vehicles, with particular focus paid to the actors who engaged with and enabled the policymakers to shift their focus, all the while working to establish a market for EVs.

Different aspects of this shift have been explored, utilizing different theoretical frameworks that reflect, in particular, technical and policy dimensions, but also recognizing that the human dimension and consumer acceptance are a *sine qua non* for a successful sustainability transition. One group of studies exploring this draw on socio-technical transitions (STT) frameworks, notably the Multi-Level Perspective (MLP), for example, Mazur et al. (2015), Figenbaum (2017), Hussaini and Scholz (2017), Geels (2018), and Skeete (2019). The MLP framework emphasizes the importance of radical innovations in the STT process, while recognizing the complexity of the interaction between technological and social factors, and also economic and political factors.

Another group of scholars has focused more on the policy agenda-setting dimension of the transition, drawing in particular on the Multiple Streams Framework (MSF). This is adept at handling ambiguity and uncertainty in policy processes, considering how three streams—problems, policies, and politics—can interact over time. Only at certain points of alignment—windows of opportunity—is an issue recognized as a problem, for which a policy solution is promoted, and where the political climate is conducive to the problem and policy solution entering the political agenda (Kingdon, 1984). This is driven by a process of policy entrepreneurship, which emphasizes the central role of agency and individuals in policy change through the coupling of the three streams—although it is important to distinguish between the process and those individuals who drive it (Ackrill & Kay, 2011).

A further dimension of policymaking is captured by the concept of Multi-Level Governance (MLG) developed by Marks (1992) and Hooghe (1996). The sustainability transition seeks to address a systemic global challenge, but policy action, technical responses, and social impacts can vary across multiple levels—from the global, through the regional, to the national and local. The concept of MLG can help in studying sustainability transitions as it allows scholars to explore the impact of institutional structures at different levels of governance and capture both the agency of societal actors and state actors (Ehnert et al., 2018).

Drawing these ideas together the MLP can also accommodate policy dimensions, while the MSF has been extended to include a technological stream, while both can be extended through the incorporation of MLG. As discussed in detail in the following sections, however, there are limitations to analyzing the sustainability transition when utilizing just one of these frameworks. This problem is compounded in the current research, given the unprecedently detailed data collected and analyzed. To overcome these theoretical limitations, in this research we develop a synthetic model which we call the Multi-Level Governance and Strategy (MLGS) model. The collective utility of considering these lenses jointly can provide a more nuanced

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understanding of complex phenomena (Van der Heijden, 2013) given the data, the challenges of developing and applying synthetic theories notwithstanding (Cairney, 2013). The benefits of such a model are discussed in Section 2.

A further rationale for synthesizing the theories in this research is rooted in the research method employed. The research reported below utilized pragmatist grounded theory (GT), where some of the concepts were included deductively, but then confirmed and further refined inductively. The model grounded in the data thus reflects the complexity of decision-making processes used by key stakeholders during the sustainability transition to EVs in the UK. It is capable of explaining the dynamic and two-way linkages between technology and policy agenda-setting processes, particularly in relation to technology-centric issues, such as the decarbonization of transport, where the delivery of policy goals across multiple levels requires successful technological innovation and implementation, while recognizing its social context.

Within the MLGS, reflecting the design features of both the MLP and MSF, windows of opportunity are central. In the MLP literature, they are associated with the process of transitioning innovations from the technological niche level to the socio-technical regime level, which ultimately can lead to the establishment of a new ST regime (Geels, 2002). The MSF literature, as noted, sees WoO as determining the timing of agenda setting activity—which we refer to below as a policy window (pWoO). The MLGS adopts windows as key building blocks, but also incorporates other types of windows: technological windows of opportunity (tWoO), and market windows of opportunity (mWoO). Together, tWoO, pWoO, and mWoO allow us to break down the transition process in stages, highlighting the sequential, interactive relationship between technology and policy. This allows us to identify the key stakeholders, clarify the multiple activities undertaken by them, and define policy entrepreneurship as a set of activities in the transition process.

In what follows, the key stakeholders are shown to act as technology innovators (TIs), policy entrepreneurs (PE), and policymakers. Analyzing stakeholders' roles through GT also led us to identify an additional set of stakeholders' activities—problem brokers. The interplay between key stakeholders performing multiple activities, along with the resulting outcomes, in different types of WoO, underlies the dynamic interactive relationship between technology and agenda-setting. This is fundamental to a sustainability transition process that, ultimately, creates a sustainable and fully functioning market for EVs. It also shows the benefit of the synthetic MLGS model over any one pre-existing framework in analyzing this transition.

Given the significance of the "windows of opportunity" concept and the key stakeholders associated with it, this study aims to address the following research question: How can we advance the concept of windows of opportunity to explore the dynamics of the sustainability transition? In the rest of the paper, as we seek to answer this question, we start with a discussion of the literature that allows us to develop our MLGS model. We then reflect on the methodological approach adopted, which provides information on the particular data collection and data analysis methods used. Section 4 explores in detail the primary and secondary data underpinning our chosen concepts, justifying their inclusion in the analysis. Section 4 also presents a visual representation of the MLGS model. In Section 5, consistent with the GT approach, we compare the findings of the research with the existing literature, in particular that involving the MSF and MLP. Here, we bring together the concepts of multiple WoO, PE, problem brokers, and TIs, as well as the linkages between the policy, the technology and, ultimately, the creation of a self-sustaining market for EVs in the UK. From this, we are able to answer our research question. Section 6 concludes.

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2 | THEORETICAL REFLECTIONS

The global energy transition to net zero requires systemic thinking, to identify the required policy goals and instruments to deliver on them while also seeking technological innovation to enable those goals to be met. In the relevant literature, there are a number of frameworks that offer insights into these processes. In the present research, however, we argue that while some of them appear at first sight to offer the breadth to accommodate and integrate both policy and technology, they offer only a relatively superficial consideration of key aspects of the sustainability transition. These limitations also constrain the scope of the analysis of the data collected, discussed in Section 3. First, we explain the choices made regarding the different frameworks introduced above, focusing in particular on what the MSF adds to the understanding of policy in the MLP, and what the MLP adds to the understanding of technology beyond what is possible within the MSF. While each of these can incorporate issues of multilevel governance, bringing that concept into our synthetic model strengthens that dimension of the analysis given the nested actions required, of policymakers and of multiple relevant industries, in the sustainability transition.

The MLP has become "the central pillar" of analysis of STTs (Geels, 2019, p. 187). This literature analyses changes not only in technology, but also changes in other ST configurations such as regulation, policies, industrial networks, infrastructure, markets, user practices, and symbolic meaning or culture (Geels, 2002). Of these, the present paper focuses on technology, regulations, policies, infrastructure, and automotive industry markets, but does not address explicitly the cultural and behavioral elements of the ST regime mentioned by Geels (2004). Within the MLGS, the shift of EV *technology* from the niche level to the incumbent level is associated with a shift of EVs from a niche *market* to a sustainable and competitive mainstream market. The cultural and behavioral dimensions are thus reflected indirectly, via buyers' EV purchasing decisions that enable the EV market to attain critical mass. Based on the above, the MLP offers an extensive and flexible accommodation of multiple factors required in analyses of the sustainability transition—although tractability means accommodating some elements of the MLP only implicitly.

Equally, the MSF incorporates multiple elements into its exploration of the early stages of the policy process, notably agenda setting (Kingdon, 1984). This occurs through the interaction of three principal streams, coupled by PE in WoO (Zahariadis, 2014), as described above. Recently, it has been extended to include a technology stream (Goyal et al., 2019). With the present paper focusing on the dynamic interplay between policy and technology in the energy transition, this raises the issue of whether we can simply incorporate policy into the MLP, or incorporate technology into the MSF. We argue that the complexity of the sustainability transition in general, but especially the level of detail in our analysis of the transition from low to zero emissions vehicles, warrants the use of a synthetic model that exploits their key complementarities. This enables a more robust analysis of both STTs and the evolution of policy, rather than risking concept-stretching, by drawing on just one. It also allows for a clearer incorporation into the analysis of the idea that stakeholders can take on different roles (TI, PE, problem broker, etc.) at different points in the process, in different theoretical locations within the model—as illustrated later.

Just as the MSF is uniquely well-placed to address issues of ambiguity in policy processes, so the language of niche, incumbent, and governance levels in the MLP are ambiguous in their meanings: when, for example, does a technology cease to be niche and become the incumbent? Following (Cairney, 2013, pp. 2–3), we argue that both frameworks are consistent with the constructivist ontology underpinning the present research. This is also consistent with the

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processes of (pragmatist) GT used in the development of the MLGS model, giving a common epistemological foundation. Cairney (*op cit*) identifies three approaches to combining theories—synthesis, complementary, and contradictory. The MLGS model is, as noted above, synthetic in its design, although this is facilitated by the complementary nature of key elements of the MLP and MSF, notably WoO (inter alia, Kern & Rogge, 2018).

The MLGS then applies these ideas in distinct, but mutually reinforcing, ways. Considering first the MLP, it refers to WoO enabling niche technologies to shift from the niche level to the incumbent (or regime) level and thus become a mainstream technology. Interestingly in the current context, the founder of the MLP has applied it to the automotive industry in both the UK (Geels, 2018) and the USA (Geels, 2005). In these analyses, WoO open through (1) the emergence of new technologies at the technological niche level; (2) the existence of a problem at the regime level; (3) the emergence of new policies, or changes in consumer preferences, changes in the economy, demographics at the landscape level which put pressure on the regime level; (4) decreasing resistance of incumbent actors at the regime level to the technology at the niche level, which enables niche technologies to break through into the regime level (Geels, 2005).

That said, the MLP literature discussing the process of EV transitions in the UK is not clear on when the window of opportunity within the MLP context was opened for EVs and what the role of the policy agenda was in this process. Furthermore, the STT to EVs, involves not one but three distinct industries: the automotive industry, but also the energy supply industry (to deliver electricity generated from renewable sources) and the energy storge industry (to deliver the batteries required for EVs).

Turning to the MSF, the standard three-stream version focuses in particular on policy agenda setting, although solutions to a problem in the problem stream can take not only the form of policies but also technologies, or other means of addressing the problem (Lipson, 2007). The MSF has been extended to include a technology stream (e.g., Goyal & Howlett, 2018; Goyal et al., 2019, 2021). The technology stream depicts "the context and activities that contribute to technology innovation, such as research, prototype development, patenting and licensing, the establishment of a business venture, market creation, and technology transfer" (Goyal et al., 2021, p. 1022). Therefore, just as the original three streams focus on the early stages of the policy process, so the main activity undertaken by "technology innovators" in the technology stream is research and development (Goyal et al., 2019). TIs can also protect, nurture, and empower innovations (Raven et al., 2016) by shaping policy and regulatory developments. Thus, TIs are responsible for linking the technology narrative with the sociopolitical agenda (Smith & Raven, 2012). Policies can drive innovations which, in turn, can lead to an increasing number of policy activities (Goyal et al., 2021). Thus, the authors recognize the two-way linkages between the policy agenda and technology development, but only hint at how individuals can take on multiple roles in the transition.

Notably, the MSF does not operate with the concepts of niche and regime level technology; and does not provide tools for analyzing the shift of technology from one ST level to another. Further, the present case highlights a particular feature of the systemic nature of the sustainability transition—that of multiple industries being involved. If zero-emission vehicles are to play a significant role in decarbonization efforts, then parallel technological shifts are needed in energy generation and storage. One area where the MSF can complement MLP research, therefore, is that the former provides information on the agenda-setting process within the STT, as well as the actors and their agency within a window of opportunity related to technology-related policy specifically—that which we call a tWoO.

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From this, we argue that trying to use just one of the MLP and MSF, and the concept-stretching that would thus be required, justifies the development of a synthetic model—a conclusion that is reinforced by the level of detail that the data acquired for analysis has provided. We are able to explore the temporal interplay between technology and policy, where there is no a priori basis for assuming that technology either leads or lags policy. Moreover, as a result, we can see that there is likely to be back and forth between stakeholders in the context of the sustainability transition. Policymakers may need to look beyond current technologies as they scan the horizon to define long-term policy goals; while TIs have practical and commercial interests that they may seek to protect by lobbying for certain types of policy, a certain pace of policy change, and so forth. Moreover, given the timescale of the shift to net zero in general, and a predominance of EVs in particular, this interaction will not simply be a one-shot game, but will be iterative as each tries to move forwards promoting their own interests, while recognizing the strategic interactions at play between them.

Another extremely important dimension to this interaction between stakeholders is, as noted, that different individuals can take on different roles at different points in time, in different locations within the MLGS model. One example of such an actor in the extant literature is the CEO of EV infrastructure company Better Place, who has been involved in promoting EVs in Israel through collaborations with bureaucrats, politicians, and lobbyists (Cohen & Naor, 2013). In this case, the EV was presented as a technological solution to the problem of reducing the oil dependence of the country (Cohen & Naor, 2017). The CEO of Better Place worked as a TI while developing battery-swapping stations and integrating battery technologies with powertrains; then as a PE when presenting a new policy for electric transportation to the government within a pWoO (Cohen & Naor, 2013).

In sum, therefore, within the technology stream literature, the role of technology in WoO still requires further clarification. Moreover, in the case of sustainability transitions, there can be multiple technological solutions, and they may be interrelated—especially when, as in the present case, more than one industry is active in delivering the technological solution (EVs), as a key means of decarbonizing road transport. With multiple innovations potentially influencing the policy agenda process, whether or how each of them should be included in the technology stream needs to be carefully parsed.

To clarify this, the MLGS adapts the elements of ST regimes used in the MLP literature. In this way, the technology streams are not considered only as the activities contributing to technology innovations. Rather, they broadly encompass the evolution of technologies contributing to the revenue streams of the TIs' enterprises operating in the different types of markets—niche market or mass market; and different levels of the ST system—technological niche or incumbent levels—respectively. This broader conceptualization—of (multiple) technology streams—allows us to trace the shift of technologies from the niche level to the incumbent level and the two-way impact of this shift with policy agenda setting. Furthermore, it can help to link multiple industries into one system. The MLP literature uses the term "trajectory" to explain the changes in niche-innovations and landscape levels (Geels, 2018) and the emergence of the trajectory of electric mobility (Dijk et al., 2013). Turnheim et al. (2015) discussed the dynamics of the regime trajectories, while Yolles and Fink (2013) and Cooke (2018) use this term to explain historical development in the industry of interest. Drawing upon the concept of "technology streams," we utilize the concept of "industry trajectories."

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3 | METHODOLOGY

GT provides a systematic approach to constructing conceptually dense theory using qualitative data (Denzin, 1994; Timonen et al., 2018). Canonical GT (Glaser & Strauss, 1967) suggests entering the research process without any preconception of the phenomenon under investigation, nor using the concepts from established theories. Later interpretations of GT are more flexible in this regard, notably pragmatist GT. We adopt this version of GT, given that "innovative insights arise precisely from someone seeing things differently, based on a different set of preconceptions, and not because they have no preconceptions" (Bryant, 2017, p. 150). In order for the theory to be practically useful for industry practitioners and academics, we strive not to substitute well-known concepts with new ones. Rather, a novel view of the phenomenon is represented using familiar terminology, where possible. Thus, preconceptions and pre-established theory play important roles in this study.

In applying pragmatist GT, we employ abductive reasoning, where we try to find the most plausible explanation for the observed data and phenomenon (Charmaz, 2006). Aligned with the pragmatist approach, the initial theory was scrutinized against the literature to refine it and enhance its explanatory power, leading to the final version presented herein. In the final stage of theory development and application, the theory was validated by the participants (Corbin & Strauss, 2015) by follow-up communication.

Data collection consisted of multiple interviews with stakeholders, combined with and triangulated against archival data obtained via a Freedom of Information request, undertaken over the period 2018–2021. Interview data consisted of 30 semistructured elite interviews and 18 comments. The semistructured interviews lasted about 45 min and included five questions and typically three follow-up questions; the comments focused on one or two specific questions with an average duration of 5–10 min. The comments were provided mostly during the industry networking events listed in Appendix S1, but two arose from Email communications.

The initial sample of potential interviewees was selected using purposive sampling, focusing on individuals knowledgeable about the decision-making processes underlying the UK government's Industrial Strategy (HM Government, 2017). This was complemented by snowball sampling. The coding of the initial interviews provided the basis for the second round of sampling—theoretical sampling (Charmaz, 2014) aimed at individuals who could clarify properties and dimensions of the theoretical codes derived from the initial and follow-up interviews. This approach is key for building GT and is used in all interpretations of GT for the purpose of conceptual development (Bryant, 2017). Data analysis was carried out in parallel with data collection, with each new interview being used to clarify issues that arose during the analysis of data collected in the previous interview.

The majority of participants were involved in Low Carbon Vehicle Partnership (LowCVP) meetings, with six participants being active members of the Electric Vehicle Energy Taskforce (EVET) convened by LowCVP. LowCVP, now known as the ZEMO (zero-emissions mobility) Partnership, a name-change itself reflecting the shift in the government's policy focus, is the main organization in the UK automotive industry bringing together carmakers, energy companies, academics, and other stakeholders to make proposals to the government to accelerate sustainability transitions in the UK in the sphere of low, and now zero, emission vehicles. Appendix S2 provides information about the participants, within the limits permitted by research ethics considerations. Ten interviews were conducted in the pilot stage, 20 in the main stage, with 18 individuals providing comments.

The archive data requested via a Freedom of Information Request related to the EVET steering group meetings, to deepen our understanding of the information presented in the interviews. This enabled us to identify the specific roles of individuals during the transition in focus from low-to-zero emissions vehicles, and locate these details within the MLGS model. The archival data included minutes, presentations, and reports from the 15 EVET steering group meetings, 117 documents in total (Appendix S3). Consistent with the earlier discussion of pragmatist GT, the analysis of these documents also facilitated the selection of some participants during the coding, memo writing, and theory building stages.

4 | REPRESENTING THE MLGS MODEL

In GT research, the presentation of findings and the process of theorization are closely related (Corbin & Strauss, 2015). This involves explaining the relationships between substantive and theoretical codes grounded in the data which leads, ultimately, to the construction of a model that can explain the phenomenon or phenomena under investigation.

In the present research, 1621 open codes were identified during the coding stage. These were grouped into theoretical codes that correspond to the names of the structural elements of MLGS, as well as actors and their agency associated with a specific element of the model. Sections 4.1 and 4.2 below are structured according to the names of the theoretical codes, to explain the interactions between them. The coding was carried out in NVivo. A detailed hierarchy of codes and a code grid are provided in Appendix S4. These relate to the different elements of the MLGS model over time.

Following the abductive research process, theoretical codes comprising the MLGS were derived both deductively and inductively. The deductive theoretical codes were linked with the MLP, MSF, and MLG, while the inductive theoretical codes emerged from the analysis of the interviews and archival data. The deductive theoretical codes include problem, policy, and politics streams, governance levels, incumbent level, and technological niche levels. Inductive theoretical codes supplement deductive codes and expose the novel relationship between them. Examples of inductive codes include automotive, energy supply, energy storage trajectories, tWoO, and mWoO. Both deductive and inductive theoretical codes consist of lower-level substantive codes that were identified inductively and serve to clarify characteristics of theoretical codes, in line with pragmatist GT.

The MLGS model includes six layers. The first three—the automotive industry trajectory, energy supply trajectory, energy storage trajectory—capture the dynamics of the three constituent industries in the EV transition, and are consistent with the MLP. These industry trajectories reflect the evolution of technology within the elements of the EV ecosystem required for the EV to become a mass market product. The MSF is represented by the three streams: problem, policy, and politics.

These contextualize the agenda setting process underlying the policy change captured in the industry trajectories. These six elements represent the six layers in Figure 1. Each of the layers is then split into technological niche (pink), incumbent (light green), and governance (blue) levels. Time is captured in the third dimension. The streams and trajectories, coupled with WoO and tipping points associated with developments in the streams and trajectories, facilitate an analysis of the process that led to the creation of a sustainable and competitive market for EVs in the UK. These connections are captured by the cross-sections connecting the layers vertically.

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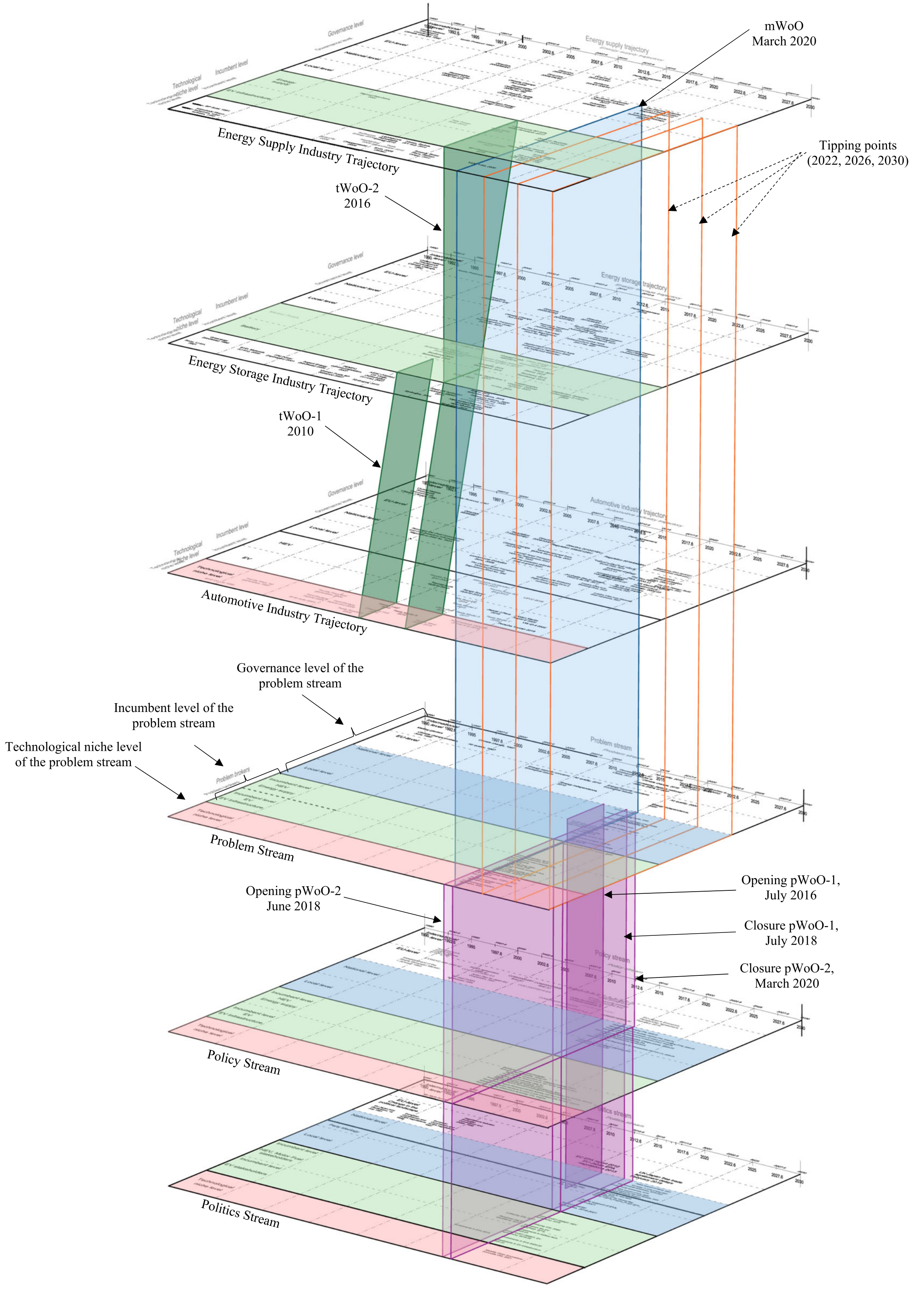

FIGURE 1 Perspective view of MLGS.

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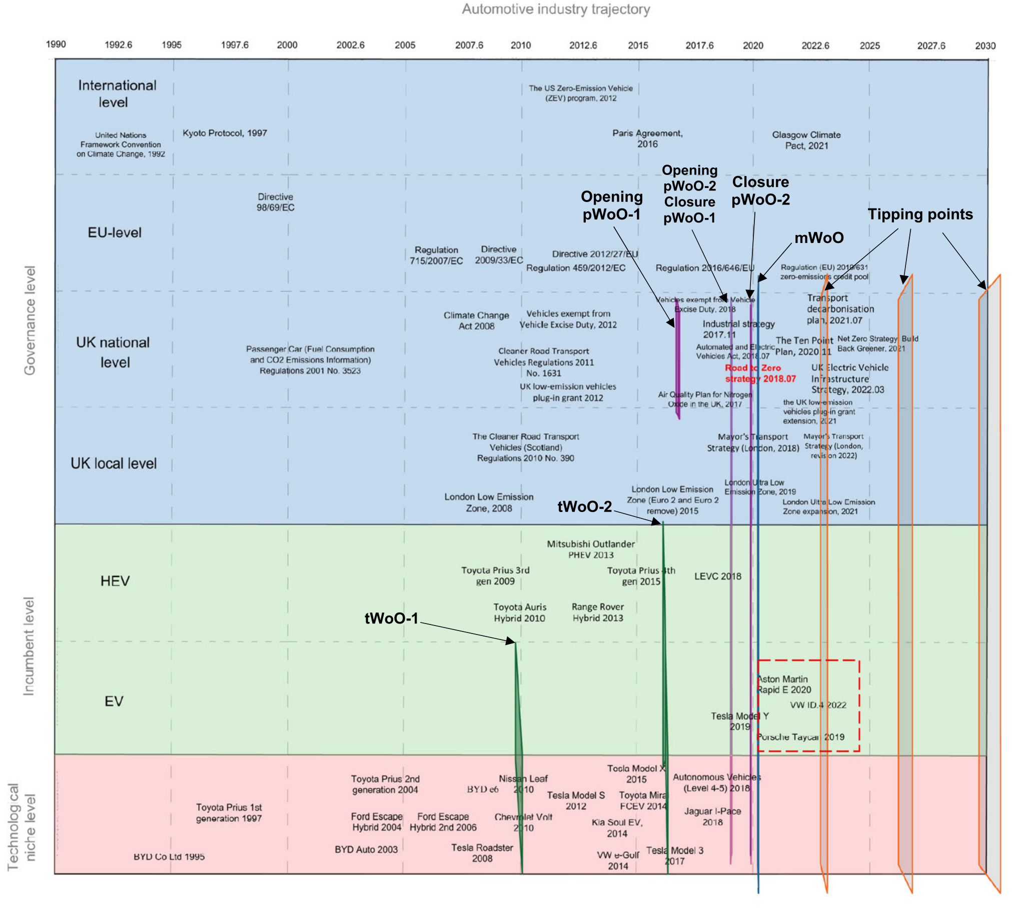
Figure 1 displays a perspective view of MLGS model, with structural elements presented in isolation in Figures 2–5; and Appendices S5–S8. These elements are discussed below in more detail, to illustrate how the model can be applied not only to this case, but also to other complex policy-technology trajectories in the sustainability transition. In Section 4.1, we analyze the three industry trajectories, followed in Section 4.2 with the MSF streams. This visualization of the MLGS model was undertaken in 3D AutoCAD.

4.1 | Technological windows of opportunity

This section focuses on the concept of tWoO, specifically those labeled tWoO-1 and tWoO-2 in the figures above and below. We start by outlining the levels of industry trajectories coupled with tWoOs, followed by a discussion of the processes of opening tWoO-1 and tWoO-2 in Section 4.1.2. Section 4.1.3 provides information on the role of TIs within the industry trajectories in relation to tWoO-1 and tWoO-2. In this section, for conciseness and clarity we



Note: technological windows of opportunity (tWoO-1, tWoO-2), policy windows of opportunity (pWoO-1, pWoO-2), market window of opportunity (mWoO)

FIGURE 2 Automotive industry trajectory, top view. Technological windows of opportunity (tWoO-1, tWoO-2), policy windows of opportunity (pWoO-1, pWoO-2), market window of opportunity (mWoO).

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present a detailed analysis only of the automotive industry trajectory layer. The energy supply and energy storage layers, structurally the same as this, are presented in Appendices S5 and S6, respectively.

4.1.1 | Levels of industry trajectories

Figure 2 illustrates the arrangement of the automotive industry trajectory layer. Specific events are assigned to the niche, incumbent, or governance level on the basis of the data analysis. The incumbent level of trajectories represents the evolution of technologies and services of incumbent level actors. The technological niche level signifies technological development in technological niche markets, where technological niche innovators operate.

Up to 2019, the EV technology and the models associated with it were located at the technological niche level (Figure 2, pink area). The year after, EV technology moved into the mainstream. From that latter year, new EV models can be found at the incumbent level of the automotive trajectory (as shown in Figure 2 by the red dashed square). The transition of the niche technology to the incumbent level is, ceteris paribus, associated with the shift of EVs from a small, niche level, market to a fully functioning sustainable, and competitive market. This can be seen in an increase in EV market share and the adoption of this niche technology by incumbent actors. The process of the shift of technology from the niche level to the incumbent level will be discussed in more detail below.

The *governance level* includes policies that influence industry trajectories, as mentioned by participants, identified in EVET data, and clarified during the literature review matching stage. This level is split into international, EU, national and local levels and reflects the different pressures on industry trajectories from multiple levels of decision-making. The governance level is, therefore, one of the main drivers of technological change and has shaped the development of the automotive and related industry trajectories (Int. 26). In the case of the transitions of EVs in the UK over 2016–2020 such policies include, for example, the Paris Agreement (UNFCCC, 2015) at the international level (Int.22), Regulation 2016/646 (European Commission, 2016) at the regional (EU) level (Int.12), the Road to Zero Strategy (Department for Transport & OLEV, 2018) at the UK national level (Int.27), and The Mayor of London's Transport Strategy (Mayor of London, 2018) at the UK local level (Int.12, 26).

4.1.2 | Opening of technological windows of opportunity

Perpendicular to the industry trajectories and streams there are dark green areas (tWoO-1, tWoO-2) coupling streams or trajectories (shown in Figures 1–3). These areas are related to tWoO or trajectory coupling points, where complementary developments in all three of the energy storage, automotive, and energy supply industries facilitated the shift of EVs to the incumbent level. The developments in these industries enabled advocates of EVs to argue for the capability of this technology to address environmental problems. In the UK, this was associated with the significant decarbonization of well-to-wheel processes of EVs, which evaluate the complete process of energy flow starting from energy generation and storage, through to the energy consumption of EVs (Woo et al., 2017). This, therefore, required not only EVs and the batteries to power them, but also the decarbonization of the electricity supply to charge them.

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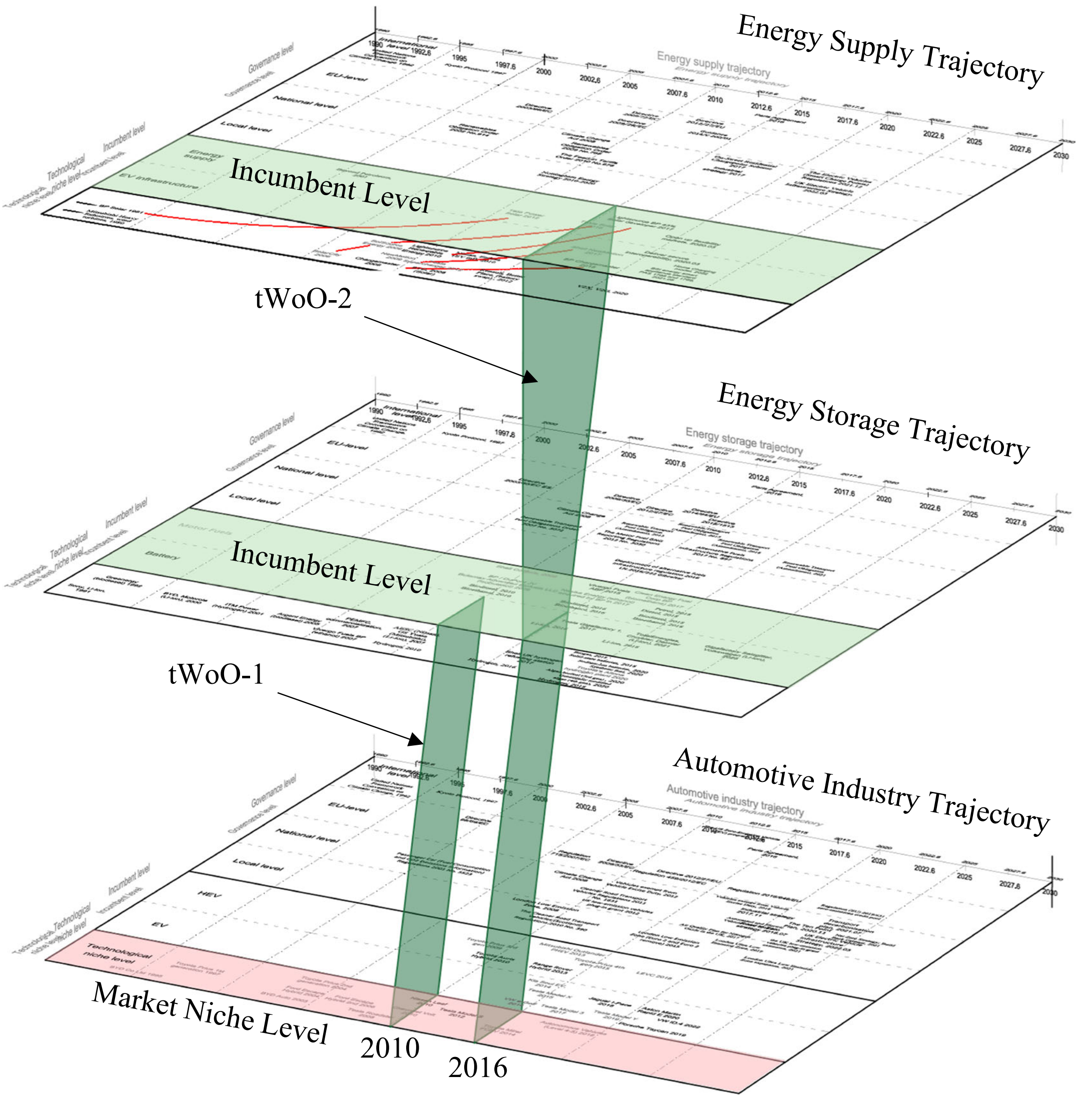

FIGURE 3 MLGS perspective view, focus on industry trajectories and tWoOs.

The first technological window of opportunity (tWoO-1) related to the production of the first mass market-oriented EV, the Nissan Leaf, and it was opened in the technological niche level of the automotive industry trajectory.

> In terms of first opening [WoO] I think it was the early 2010s, so the 2010-2011. It really the first time there was a vehicle that potentially more people could buy, it was probably the Nissan Leaf. In about 2014 we started to see it more out there [UK]. (Int.27)

That said, while the Leaf represented the first potential mass market EV, it still represented a niche level technology at that time, as it "was not affordable to most of the public" (Int.25). The annual registration of EVs in 2011 and 2012 was 1.2k and 1.68k vehicles, respectively

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(Department for Transport, 2023b). Li-ion batteries used in EVs were the mainstream market product in 2010, benefiting from economies of scale. Their development was one of the most important drivers for the widespread adoption of EVs, with economies of scale driving down prices by a "factor of five or six" from 2010, allowing EVs to become affordable to "at least some" of the public from then on (Int. 25). The aforementioned limitations notwithstanding, the Nissan Leaf thus represents the first potential mass market EV. tWoO-1 is shown in Figures 1–3, and depicted by the dark green area coupling the automotive and energy storage industries. Note, however, that the third industry, energy generation, is still dominated by fossil fuels in 2010. EVs therefore are not yet capable of realizing their potential to decarbonize private personal road transport.

Given the continued dominance of fossil fuels in energy generation still in 2010, the second technological window of opportunity (tWoO-2) for EVs is then critical (Int. 22). This opened in 2016 in the energy supply trajectory, was highlighted in interviews (Int. 25) and confirmed by official statistical data. At the time of tWoO-1, in 2010, wind and solar generated only 10 TWh, or 2.6% of total energy generation in the UK, while coal generated a substantial 108 TWh or 28.2% of the total. By 2016, the figures were, respectively, 47 TWh/13.7% for wind and solar, 31 TWh/9% for coal (Office for National Statistics, 2022), the first year when the energy generation from wind and solar exceeded coal. The significance of this, as emphasized by interviewees, saw renewable energy (RE) moving in 2016 from the niche level to the incumbent level, positively impacting the well-to-wheel performance of EVs.

The trajectories were then coupled sequentially. The automotive and energy storage industry trajectories had coupled by tWoO-1 in 2010. This was followed by the coupling of the automotive and energy generation trajectories in tWoO-2, in 2016. Since the trajectories were not decoupled after tWoO-1 (2010) and tWoO-2 (2016), the coupling of industry trajectories was cumulative. This is represented in Figure 3 by tWoO-2 connecting all three trajectories—automotive, energy storage, and energy supply—shown as the second dark green "slice."

The decarbonization of well-to-wheel processes ultimately enabled EVs to become an appropriate technology to address emissions challenges that, in turn, favored its development to becoming a fully functioning market. The coupling of industry trajectories in tWoO-2 paved the way for the shift of EVs from the market niche level to the incumbent level, as environmental problems in the transport sector became answerable by EVs at this moment. However, even by 2016, this did not of itself constitute EVs becoming the self-sustaining stand-alone market that stakeholders subsequently sought. Below, we discuss both the pWoO and mWoO that were important elements of this transition process.

4.1.3 | Role of technology innovators within the industry trajectories

Analyzing EVET data allowed us to identify individuals who worked outside the formal governmental system—carmakers' officials, senior managers of energy engineering companies or entrepreneurs—and held positions such as project managers, product development managers, regional development managers, and CEOs. Such individuals were classified as *Technology Innovators*.

The role of TIs within industry trajectories is focused on developing innovations and facilitating the transition of these innovations from the niche to the incumbent level. This can occur with the advancement of techno-economic parameters of the niche technology, its integration with complementary incumbent level technology within the same ecosystem, and

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harmonizing the development of niche and incumbent level technologies. In the case under investigation, this ultimately led to the improvement of well-to-wheel processes of the niche technology—EVs—via not only improved battery technologies (Li-ion batteries) but also the decarbonization of electricity generation.

Within tWoO-1 in 2010, the coupling of trajectories was made by an EV carmaker—Nissan—and those who supplied Li-ion packs to Nissan and other carmakers, who were also conceptualized as TIs. The involvement of TIs in developing technologies in both the energy storage and automotive industries can be associated with efforts to couple the automotive industry trajectory with energy storage industry trajectory. Apart from the development of EVs using Li-ion batteries to advance the energy storage technology, TIs were responsible for the development of EV infrastructure technology and the widespread establishment of the charging network in the UK. This initiative aimed to couple energy supply with the automotive industry trajectory. The second industry coupling point/technological WoO (tWoO-2) was associated with the intensification of decarbonization of the EV energy supply in the UK in 2016. The coupling of the energy supply trajectory with the automotive industry trajectory took place through electricity providers generating a growing share of electricity from renewable sources. These energy providers acted as TIs within the energy supply trajectory. Moreover, and as a side-bar to our central analysis, tWoO-2 led to EVs overtaking other alternative means of reducing emissions from cars.

> The CO2 of the grid [at night] … frequently dips below 100 [grams of CO2 per kilowatt hour]. So at these CO2 figures for electricity, [EVs] pretty much, that's the only option in town… Whatever you think about biofuels, whatever you think about hydrogen, they can't compete with those CO2 figures. (Int.22)

The coupling of the trajectories can occur not only through the battery suppliers or electricity providers, but also through initiatives of carmakers via vertical integration or diversification strategies. In this case, TIs operate in multiple industries, which allows them to develop complete technical solutions to anticipated environmental problems. That said, interviewees argued that this strategic option is not affordable and feasible for the majority of carmakers.

> Tesla, again, is probably indicative of the way forward by providing a complete energy solution, which is the power wall, the solar roof and now energy supply as well. They are effectively able to power your entire home and that is a very interesting move. (Int.22)

EVET, as noted, facilitated the EV transition and reinforced the link between the industry trajectories. Significantly, some companies participating in EVET were involved in coupling trajectories using vertical integration and diversification strategies. The suggestion is, moreover, that this will become more common over time.

> Looking at the investments the carmakers are making this [diversification into mobility-as-a-service and energy sectors and vertical integration with battery and digital industries] is already happening e.g. VW/Elli, Volvo/Lynk&Co, Geely/CaoCao, BMW/DriveNow, and it's also happening the other way i.e. the energy

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> industry investing in automotive technology e.g. BP Ventures/Ryd in the news today. And then I agree within 5 years [in 2025] this will be the norm. (Int.24)

Incumbent level TIs play an important role, not only in coupling the trajectories, but also in the shift of technology within the trajectory. For example, in January 2018 EV charging was a niche level market, with just 7211 charging devices across the UK (Department for Transport, 2023a). BP—an incumbent actor who works within the energy supply trajectory—acquired a stake in Chargemaster, an EV charging company, in June 2018. Subsequently, other incumbent actors entered the UK market, for example, EDF Energy acquired Pod Point in 2020, and Shell acquired Ubitricity in 2021. Nowadays, BP Pulse (formerly BP Chargemaster) is the third largest Charge Point Operator (CPO) in the UK, following Pod Point and Ubitricity. These three incumbent level actors account for 7.2%, 11.8%, and 15.6% of the total 37,055 installed charge points in 2023, respectively (Zap Zap, 2023). Since 2018, the number of installed charging devices has increased by a factor of 4.45.

> Generally, the strategy of BP was always if you cannot beat let's join and therefore whatever new innovations will develop in the market, they were always there... it's not a surprise that Chargemaster was a natural step for them to acquire because that is a mood in the market and obviously if the electric vehicles would be one of the parts of the automotive industry, certainly BP should have a stake on these things. (Int.1)

It was not only startups and incumbents from the automotive and energy supply trajectories that were involved in coupling the trajectories. There are examples of TIs in the energy storage industry using forward vertical integration coupled with automotive industry trajectories. For instance, BYD started out as a battery manufacturer in 1995 at the market niche level and now operates in the automotive industry (Int.28) at the incumbent level.

4.2 | Policy windows of opportunity

In this section, the concept of pWoO is discussed, with a specific focus on pWoO-1 and pWoO-2. Section 4.2.1 outlines the levels of the streams coupled within pWoOs, followed in Section 4.2.2 by an analysis of the processes of opening and closing pWoO-1 and pWoO-2. The next section provides information on the role of PE within pWoO-1 and pWoO-2. The final section concentrates on the problem brokering activities by TIs and their relationship with policy windows.

4.2.1 | Levels of streams

The streams derived from the MSF as the industry trajectories, are also divided into technological niche, incumbent, and governance levels. This division was conceptualized inductively based on the analysis of interview and archival data. The timeline of the streams indicates the specific date when the policy idea, problem, and/or political event was identified in the data. For example, in the case of the shift of policy agenda from low emission targets to zero emission targets between 2016 and 2020, the period which includes pWoO-1 and pWoO-2

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in the UK, the governance level of the problem stream (the blue area in Figure 4) comprises conditions that were framed as social problems at all of the international, EU, national, and local levels. This condition, according to the interview and archival data, affected the agenda-setting process.

Considering the problem stream, for example, the issue of climate change (UNFCCC, 2015) refers to the international level (text in red in Figure 4). Air quality (Int.12) and energy independence (Int.16) issues in the EU in 2019 relate to the EU level problems. Air quality in the UK (Department for Transport & OLEV, 2018) and energy security in the UK (Department for Transport & OLEV, 2018) associated with national UK level issues. Air quality in cities/towns in 2019 (Int.20) corresponds to the local level of the problem stream within the UK. The incumbent and technological niche level problems then concern the advancement of incumbent level and niche level technologies. To illustrate, in 2020 a lack of interoperability in EV charging, or the cost of fuel-cell electric vehicles (FCEV), can be considered incumbent level and technological niche level problems respectively. Further, because the MLGS includes the time dimension, problems at different levels of the problem stream can change over time.

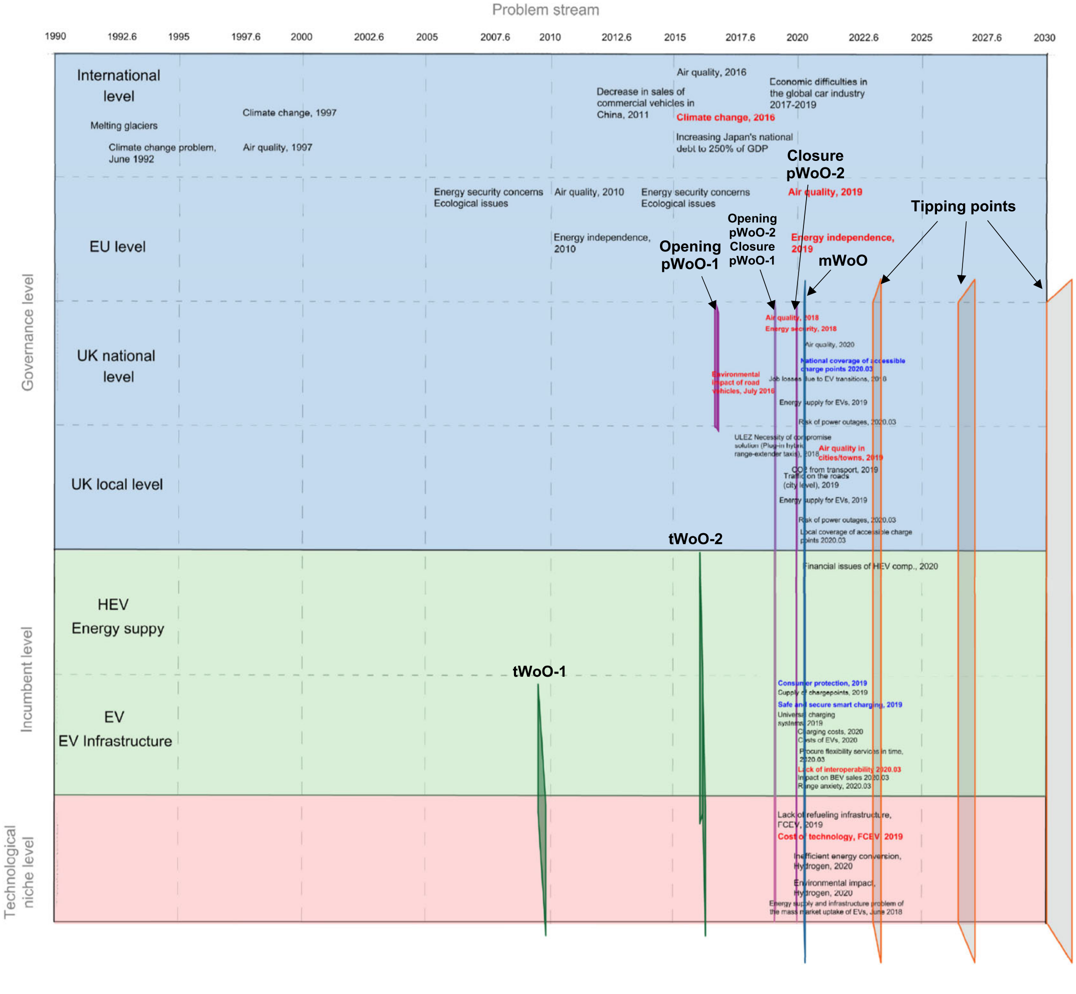

FIGURE 4 Problem stream, top view.

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Turning to the policy stream, the governance level of the policy stream (see Appendix S7) is again divided into international, EU, national and local sublevels, where policy ideas can be adapted and included into the final policy papers referenced below at various governance levels of the industry trajectories. For instance, at the UK national level of the policy stream, a 46-point policy plan (text in red in Appendix S7) informed by the Transport Energy Model (TEM) between 2016 and 2018 (Department for Transport, 2018; LowCVP, 2018) was included in the Road to Zero Strategy (Department for Transport & OLEV, 2018). This is a national level strategic policy document that set the target for ZEV uptake up to 2040, at the national level of the automotive industry trajectory (text in red in Figure 2). At the time, the UK's approach to climate change impacted by the policy ideas of the EU level and international level (Int.12, FOI 33, FOI 38, FOI 74, FOI 81, FOI 103 -105). As an example, at the EU level of the policy stream this includes COM(2018) 773 "A Clean Planet for all"; COP23 in 2017 pushing for a limit to global warming at international level; and a further ambition agreed at COP24 in 2018.

The incumbent and technological niche levels of the *policy* stream then encompass policy ideas in response to technology-related problems that are included in the incumbent and technological niche levels of the *problem* stream. Some of these ideas could be incorporated into one or multiple policy papers captured in the governance level of the industry trajectories. The policy ideas (policy proposals) at the incumbent level of the policy stream are thus industry-focused. For example, within pWoO-2 (Appendix S7) they related to data accessibility and data sharing (FOI 106) discussed in Section 4.2.4, below.

The politics stream (Appendix S8) captures the events indicating government, public or industry stakeholders support, or resistance, relevant to the case under investigation. The events that reflect the government's attitude or public perception toward EV transitions can also come from the global, EU level, national and/or local levels. The events that indicate the attitude of incumbent actors or technological niche actors influencing EV transitions, are portrayed at the incumbent and technological niche levels. For instance, the international level includes UN Climate Change Conferences (COP 24 and 25) in 2018–2019, the EU level includes EU-level surveys of public perceptions toward EVs, the UK level involves political events associated with pro-EV political candidates at elections (e.g., Boris Johnson in 2019) or public support based on national surveys (YouGov, 2018b, 2018a). Incumbent level political events involve participation in EVET by incumbent actors in 2018, lobbying for EVs in 2019 (Int.8), or alternatively, lobbying for hybrid EVs in 2019 (Int.1). Political events at the niche level are associated with advocacy of EVs by technological niche level players. In addition, the incumbent and technological niche level events of the political stream are associated with the support or rejection of the policy ideas by the industry stakeholders in EVET.

4.2.2 | Opening and closing of policy windows of opportunity

Earlier, it was shown that tWoO-2 opened in 2016 with a significant shift in the balance of fossil and renewable contributions to electricity generation. Turning to the policy elements of the MLGS model, data analysis revealed that the government was responsible for opening policy window pWoO-1 in July 2016 and pWoO-2 in June 2018 (Figure 5). That is to say, the policy shift only happened once the industry conditions were right. More formally, the shift of policy agenda from low emission goals to zero-emission goals in the UK automotive industry took place after the first policy window of opportunity, pWoO-1, had opened in July 2016, then closed with the release of the Road to Zero strategy in July 2018. pWoO-1 is thus associated

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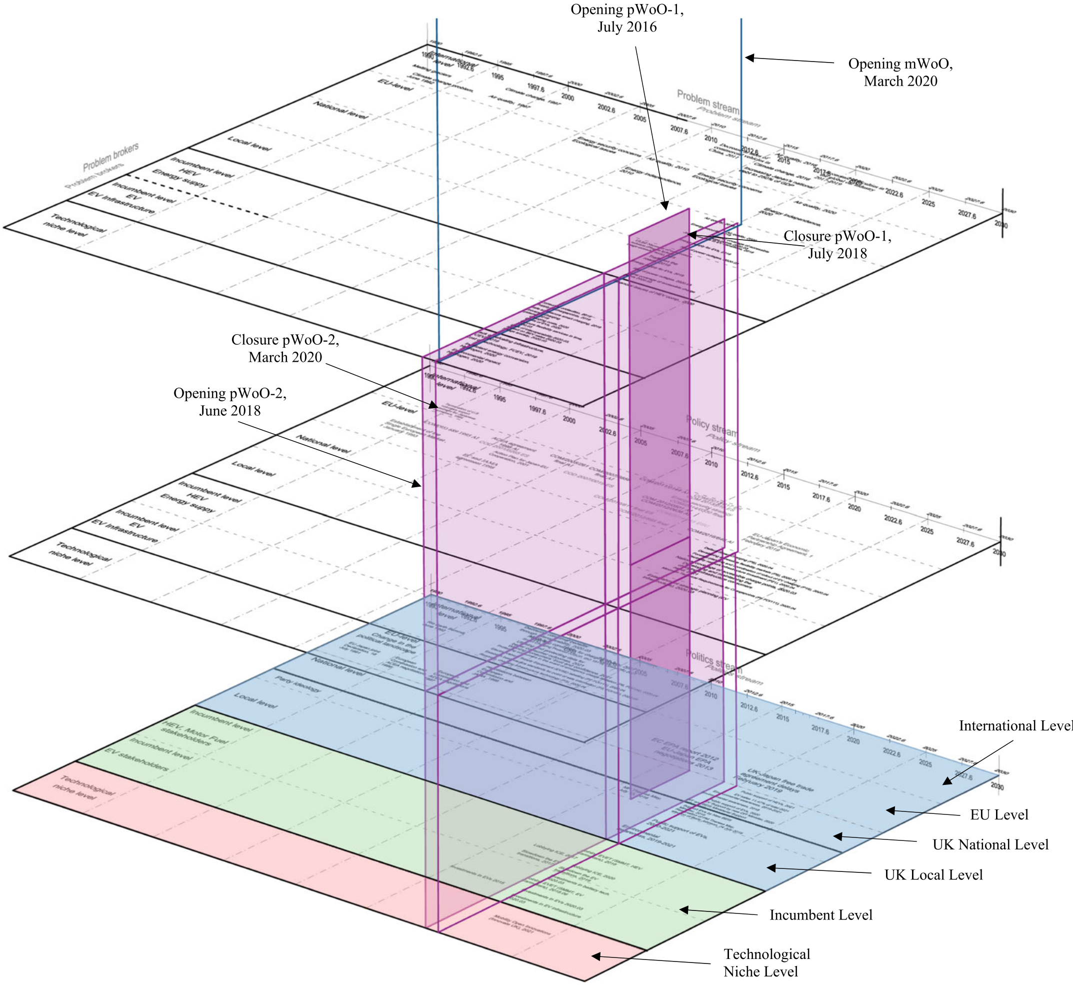

FIGURE 5 pWoO-1, pWoO-2, and mWoO.

with the work initiated by the Department for Transport (DfT) in July 2016, in response to the problem of "the environmental impact of road vehicles" (Department for Transport, 2018, p. 4)—even though the emissions issue would have been known about long before being formally identified as a policy problem later.

This problem was clarified in the Road to Zero strategy and was linked with both air quality and energy security problems (Department for Transport & OLEV, 2018). Within the MLGS, these sit at the national level of the problem stream that opened pWoO-1 at the national level. Work on the Road to Zero strategy and TEM, discussed below, was supported by the government and UK Prime Minister Theresa May, who was appointed on July 13, 2016. This suggests that within pWoO-1, the national level of the politics stream was coupled with the problem stream.

In July 2016, DfT initiated work on the TEM to understand the relative environmental performance of different fuels and types of vehicles using the well-to-wheel approach (Department for Transport, 2018). This model then underpinned the policies set out in the Road to Zero strategy (Department for Transport, 2018), which was developed by the Office for

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Low Emission Vehicles (OLEV). The work on the TEM and Road to Zero continued over 24 months from July 2016 to July 2018, when the Road to Zero was released. Over this period, DfT consulted with industry stakeholders, academia, trade associations, consultants, and other Government Departments, who were able to contribute to the model and policy plan. This signifies the coupling of the problem stream with the national level of policy stream within pWoO-1 (Figure 5).

Analyzing the TEM documentation, it was found that LowCVP prioritized EVs as potentially net-zero in respect to well-to-wheel analyses (Department for Transport & OLEV, 2018, p. 122). The fact that EV technology was coupled with energy storage and an energy supply trajectory within tWoO-1 and tWoO-2 simplified the task of PEs seeking to couple the technology with the policy stream. This is because, within tWoO-1, EV powertrains were equipped with battery storage technology that compared well to motor fuels of conventional internal combustion engine (ICE) vehicles, including those fuels into which biofuels were blended, serving as a more environmentally friendly energy storage medium. As noted in Section 4.1, tWoO-2 opening in 2016 saw a shift of renewable energy from the niche level to the incumbent level, enabling all three industry trajectories—automotive, energy storage, and energy supply—to be coupled. This made EVs a viable environmental solution for the air quality problem. Within pWoO-1, which then opened in 2016, the well-to-wheel processes of EV were seen objectively to be more effective than other technologies. This was the argument that was used by PEs when coupling the EV technology with the EV policy solution, within the policy stream (as seen in multiple interviews and EVET documents).

Another example of pairing the EV technology solution with a policy solution is the inclusion of the 46-point policy plan in the Road to Zero that prioritized EV technology within the strategic policy document. This plan set the targets to end sales of new conventional petrol and diesel cars and vans by 2040 where the majority of cars will be ZEV (Department for Transport & OLEV, 2018). It also includes the point of establishing EVET "to plan for future electric vehicle uptake and ensure the energy system can meet future demand in an efficient and sustainable way" (Department for Transport & OLEV, 2018, p. 5). EVET focused on providing industry-specific policy proposals that informed industry-specific policy instruments. Our analysis therefore presents the establishment of EVET as opening the second window, pWoO-2, in June 2018—actually 1 month before pWoO-1 closed with the release of the Road to Zero in July 2018. That said, they can be viewed as part of the same key moment, when the government ended its stance of technological neutrality, and initiated the shift in policy agenda from low emissions to zero emission goals. It is therefore clear that technology played a critically important role in the shift of the policy agenda, while the concept of multiple WoO, to include tWoO-1, tWoO-2, and pWoO-1 before the opening of pWoO-2, can explain both the sequence of stages in this process and where within the technology-policy milieu the key events occurred.

This second policy window, pWoO-2, was opened at the national and technological niche levels of the problem stream, in response to air quality and energy security concerns, and linked with the energy supply and infrastructure problem of the mass market uptake of EVs. There was uncertainty within government about the problems that incumbent level stakeholders may face during EV uptake, and it was unclear what kind of solutions to these problems could be used. The opening of pWoO-2 corresponded to the month when the problem was formalized and EVET created (within the policy stream) to provide policy proposals facilitating the EV transition. The context of that event was the government's prioritization toward a specific

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technology—EVs—and the ripeness of the policy stream for a macro/national level policy solution—the Road to Zero.

The coupling of pWoO-2 with the politics stream at the national, local, incumbent, and technological niche levels can be associated with the government support of EVET at the national level, and the participation of local authorities and incumbent level actors from all three industries (automotive, energy storage, and energy supply). In total 138 companies were involved in EVET work packages (WPs). Further, in 2018 the national mood toward EVETs objectives was largely positive, as indicated by national surveys. In October 2018, 33% of 2957 British adults surveyed were in favor of a ban on petrol and diesel earlier than 2040, with 15% supporting a ban around 2040 (YouGov, 2018a). Separately, 31% of 4130 adults were found to be "very concerned" about climate change, with 43% "somewhat concerned" (YouGov, 2018b). The general public support on decarbonization targets in transport reinforced the coupling of the problem, policy, and politics streams.

In Figures 1 and 5, it is possible to see that pWoO-1 coupled the national levels of the streams. This related to the fact that Road to Zero policy was developed at the national level by OLEV (later renamed OZEV) but did not involve the creation of EVET. This strategic policy document set national targets for ULEV uptake and was not intended to include detailed technology and industry specific recommendations. These were made afterwards in the policy documents released within or after pWoO-2.

In pWoO-2, it can be seen that the governance level and incumbent levels are adjacent. This is because, in the EVET data, industry specific recommendations addressing energy supply problems (located in the incumbent level of the problem stream) and focusing on the technological aspects of EV transitions, are included in broader recommendations aimed at solving national level problems. For example, incumbent level recommendations/policy proposals of the policy stream on *using roaming technology in charging stations, delivering consumer benefits through interoperability* and *winning consumers' trust and confidence* (italics indicates that these were codes used in the analysis), were targeted to solve the incumbent level problems in the problem stream such as *lack of interoperability*, *consumer protection*, *safe and secure smart charging*. These incumbent level policy proposals are components of the national level policy proposal to *set default smart charging regulation* (national level of the policy stream) that address the *national coverage of accessible charge points* problem (national level of the problem stream) and more broadly the *air quality* issue (EU and UK national levels of the problem stream). The above-mentioned problems and policy proposals are highlighted in blue in the corresponding levels of streams (Figure 4, Appendix S7).

The closure of pWoO-2 came with the completion of EVET WPs in March 2020, or as described in EVET documents, the completion "EVET 1.0" (FOI 107). We thus conclude that the width of pWoO-2 for proposing policy ideas to the government was 22 months (see Figure 5, Appendices S7–S8), starting in June 2018 and closing in March 2020. The result of pWoO-2 was the implementation of policy ideas, formulated during this period, into policy documents such as the Electric Vehicles (Smart Charge Points) Regulations (HM Government, 2021) and the UK infrastructure strategy (Department for Transport, 2022a). It is, however, noteworthy that not all EVET proposals were included in the final policies, or else they were further modified, as the final decision on the inclusion of policy proposals was made by the government, specifically the Ministers of the Department for Transport or the Department for Business, Energy & Industrial Strategy.

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4.2.3 | Policy entrepreneurs

In the present analysis, Senior Managers of LowCVP were confirmed as PE who coupled the problem, policy, and politics streams. LowCVP (renamed ZEMO in 2021—in what follows we use time-appropriate names, either LowCVP or ZEMO), undertook a series of activities to accelerate the shift to zero emissions vehicles via: (1) the creation of communities with shared goals, (2) undertaking evidence based research, (3) influencing policy and information, and (4) accelerating progress toward the EV market (LowCVP, 2020). As early as 2014 the DfT, in collaboration with LowCVP, established the Transport Energy Task Force to help meet renewable transport fuel targets (LowCVP, 2014). Between 2014 and 2017 it was responsible for updates to the Renewable Transport Fuel Obligation (RTFO), in which directors of LowCVP took an active role. The importance of LowCVP, via the Transport Energy Task Force, in policymaking and its influence on the process, can be seen in multiple sources, including the UK Parliament.

> The DfT's Transport Energy Task Force (TETF), made up of Government representatives and a wide range of stakeholders including Ensus, reported in March 2015 with agreed policy recommendations. These, together with the policy changes required by the "ILUC (Indirect Land Use Change) Directive" published in September 2015, will allow the UK to move towards the 10% energy target for transport. However, even if policy changes are implemented with ambition, full compliance will remain challenging. (UK Parliament, 2020)

In the context of MLGS, the senior managers of LowCVP who were responsible for providing policy recommendations to the national level policies are identified as national level PE. Within pWoO-1 (Figure 4–5, Appendices S7–S8), LowCVP organized industry-specific events aimed at generating policy ideas related to the decarbonization of transport. In addition, LowCVP's Transport Taskforce informed DfT concerning fuel decarbonization. Over the period July 2016–November 2017 (17 months) LowCVP contributed to consultations regarding TEM, that informed the government about the impact of various types of vehicles and fuels (Department for Transport, 2018). The evaluation of the environmental performance of different vehicle technologies and fuels was made based on well-to-wheel analysis (Department for Transport & OLEV, 2018). The output of the model then underpinned the policies set out in the Road to Zero Strategy (Department for Transport, 2018). In 2018, LowCVP was also invited to update the assumptions incorporated into TEM, where senior managers were able to consult the government. However, later in 2021 TEM was phased out (OZEV, 2021) closing this channel of communication and influence.

The Road to Zero strategy included a summary of TEM, confirming that LowCVP even then prioritized EVs as potentially net-zero with respect to well-to-wheel analysis (Department for Transport & OLEV, 2018, p. 122). This can be considered as coupling a technology solution with a policy solution and problem frame, when EVs were coupled with an energy supply trajectory, and renewable energy technologies (wind and solar) shifted to the incumbent level. Another example of LowCVP being involved in coupling technology solutions with policy solutions and problem frames is the development and inclusion of the 46-point policy plan in the Road to Zero (LowCVP, 2018). As noted previously, this plan set the targets to end sales of new conventional petrol and diesel cars and vans by 2040 (Department for Transport & OLEV, 2018).

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The main government body responsible for the development of the national strategy paper—Road to Zero—was OLEV. LowCVP within pWoO-1 (July 2016–July 2018) worked at the national level. In the next stage of transition, LowCVP was more focused on industry-specific policies and policy recommendations. Within the MLGS, this is visualized as the second policy window (pWoO-2), which includes not only the national level of the policy stream, but also technological niche and incumbent levels in Figure 5. In pWoO-2, in June 2018, EVET 1.0 was established for the purpose of providing policy proposals regarding energy supply for EVs, as then outlined in the Road to Zero. The secretary functions of EVET were undertaken by the LowCVP manager, who had previously taken the same role and led the Transport Taskforce while providing policy proposals for RTFO amendments (LowCVP, 2014). The foregoing therefore represents key events in a series of salami tactics, breaking down a big task into multiple smaller tasks to manage complexity, build momentum, and overcome resistance (Ackrill & Kay, 2011).

One interviewee suggested that carmakers can be PE.

> Someone like Richard Branson is a good example of someone who is a highly successful entrepreneur but also a highly successful political operator both in terms of understanding where the opportunities are and also quite often making the weather. It is a good example in a way that the chief executive of [names an OEM] is far more traditional. Anytime I need to talk to the President [of the State] I can pick up the phone and he has talked to me because I employ X thousands people. (Int.8)

There is no evidence from our data that, in the UK case, carmakers' officials send policy proposals directly to policymakers at the national level, via Emails or by phone. Rather, all of the evidence we have indicates that they worked through EVET to frame problems within the incumbent level of the problem stream. This could then be discussed at the EVET WP meetings, where a potential solution could be suggested and included in the draft of the WP report. After that, the WP draft would be reviewed by the PEs and either modified or, though unlikely, presented unchanged to the government. Crucially, this sees carmakers working collectively on a shared agenda, through the formal channel established by the government.

4.2.4 | The role of problem frames within the policy windows of opportunity

So far we have focused on TIs and PE. In this section we reflect on the problem brokering activities by TIs, their relationship with policy windows, and how this led to the inclusion of specific policy ideas in the final policy, the UK electric vehicle infrastructure strategy (Department for Transport, 2022a). *Problem Brokers* (PB) are individuals who work outside the formal governmental system and frame problems within the problem stream based on their values, emotions, and knowledge (Wildavsky, 1979; Baumgartner & Jones, 2010; Kingdon, 2014; Knaggård, 2015). Our data analysis revealed that the PB role can be characterized as one specific subset of activities that TIs undertake. This activity was undertaken within the problem stream when pWoO-2 was open.

In the EVET meetings, problem frames were formulated at the incumbent level of the problem stream, in the form of questions that focused on industry-specific problems. For example, during the fifth WP meeting, a TI asked:

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> How could sharing of data (e.g., around demand forecasting) help the energy sector better meet the energy impacts of EVs? (FOI 32)

In the next step, this problem frame was reformulated by PEs in the context of national-level problems—such as the stability of the UK electricity system.

> This [shift to EVs] would represent an increase in energy to be delivered by the UK electricity system over current levels of between 20% and 40% by 2040. Given that the electricity system has very limited headroom at certain locations at times of peak demand, the key question is at what time of day and where will this additional energy will be delivered? Answering this question (and ensuring that EV charging occurs at times of lower demand) will be crucial to meeting the energy impacts of EVs. (FOI 106)

In response to this question, five proposals were provided by PEs to the government and industry stakeholders. These proposals were discussed with TIs at WP meetings and with PEs in EVET steering group meetings. The priority of proposals was set by PEs using the MoSCoW prioritization as "should have" and "must have" priorities in the short, long, and medium terms. MoSCoW stands for, in order of priority, *Must have, Should have, Could have*, and *Won't have* (FOI 103). Thus, in our case, the PE used MoSCoW to set the urgency of specific requirements and the problems associated with them.

After the presentation of policy proposals by the PEs to the Secretary of State for Transport and members of the House of Lords, the policy proposal was included in the final policy paper—the UK electric vehicle infrastructure strategy (Department for Transport, 2022a) which was published in March 2022, 2 years later after the closure pWoO-2 in March 2020. In response to the example question quoted above, the final policy paper included data-sharing arrangements in the action plan.

> We are addressing barriers to data sharing which can impede decision making. (Department for Transport, 2022a, p. 62)

> We will consider the potential sharing of private chargepoint location and energy data with specified parties to support network planning. We will aim to consult on additional measures to ensure we are taking a systems-wide approach for a safe and secure transition to smart charging. (Department for Transport, 2022a, p. 73)

Based on this analysis, we see that TIs participated in the policy process by framing the problems at the incumbent level of the problem stream, through questions that were later used by PEs. The PEs' role focused on coupling incumbent level problems with national problems within the problem stream, prioritizing policy solutions within the policy stream, and presenting those potential policy solutions to the government. This way, PEs coupled policy, problem, and politics streams at the incumbent and national levels.

4.3 | Market windows of opportunity

The concept of the mWoO was derived inductively based on the interviews with the Head of OLEV (Int.27) and further analysis of EVET data. During Interview 27, *tipping points* were

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mentioned that can trigger a mass market for EV uptake. The question was: "When did the window of opportunity open for the widespread adoption of electrical vehicles?"

> I think we're at the moment [December 2020] in another key tipping point where there's more [EV] models available and it's getting all mainstream, last month it was nine percent of new vehicle sales in the UK were full battery electric which is extraordinary. (Int.27)

> Then there should be again another tipping point as we really start to trigger that mass market, but I think that will be in the future so I'm not sure there'd be one point, but I think there's been several interesting bits as we've been going through. (Int.27)

According to Gladwell (2010, p. 12) "the tipping point is the moment of critical mass, the threshold, the boiling point", while innovation diffusion has been characterized as following an S-shape, with slow start-up, followed by "accelerating growth (the 'tipping point') and finally a flattening of demand (and a potential 'tripping point')" (Whittington et al., 2019, p. 325). That said, in terms of the decarbonization of road transport, it is highly unlikely that a tripping point will occur. Rather, as Interviewee 27 suggested, the mass market might be more something that emerges more steadily, rather than there being a single point.

Even so, further analysis of the EVET data indicated that the members of EVET operated the concept of EV Market Development in "preparing the GB energy system for the mass take up of electric vehicles" (FOI 107). The processes of the development of EVET proposals, government actions, and the development of the EV market, are interrelated and sequential. The first stage—the development of EVET proposals (the "innovation" stage in FOI 111)—included identifying the necessity of actions, prioritization of recommendations/policy proposals, and the development of an action plan to deliver the policy measure. The second stage pertained to the government actions or "implementation" stage (FOI 111), suggesting the implementation of policy measures. The third stage implied market development or the "impact" stage (FOI 111).

Both the concept of "tipping point" and the "impact" stage underlie the concept of the mWoO and the ultimate aim of the period under analysis—the creation of a market for EVs with sufficient critical mass for it to be self-sustaining, as a crucial phase in the long term ambitions around net zero. The mWoO corresponds to the first tipping point mentioned in Int.27 and is associated with the shift of the focal technology—EVs—to the incumbent level, recalling also that this involves the coupling at the incumbent level of not one but three industry trajectories—automotive, energy storage and energy supply. This is the point when EV technology became mainstream.

To ascertain when the EVs started to become a mainstream market product, interviews, EVET data, and statistical data were scrutinized. The EV mWoO partly opened in September 2019, evidenced by a 141% jump in vehicle registrations (Department for Transport, 2022c, 2022b). The mWoO fully opened in March 2020 (Figure 6), coming after the closure of pWoO-2. At this juncture, EV registrations had increased significantly, for the second consecutive year, by 184% in 2020 (Department for Transport, 2022b). That was a successful year for *all* EV models, with 71% of EV registrations attributed to models other than Nissan and Tesla (Department for Transport, 2022b). The percentage of total UK car sales accounted for by EVs increased significantly, from 0.67% in 2018 to 6.59% in 2020, and

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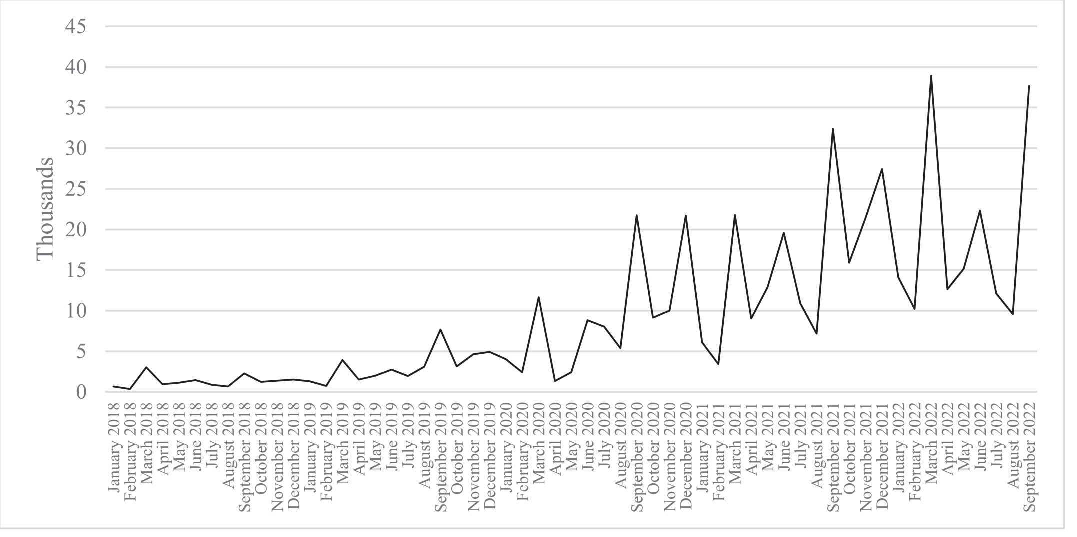

FIGURE 6 BEV registered for the first time in Great Britain, January 2018–September 2022. Source: Department for Transport (2022b).

has continued to grow since then (Department for Transport, 2022b). At this point, the mWoO is fully open, indicating the significant widespread adoption of EVs and their shift to the incumbent level.

Returning to Figure 1, the mWoO is shown as a blue rectangular area that couples the governance level (national and local sublevels), incumbent level, and market niche level of the problem stream and industry trajectories. The coupling of national and local sublevels of the governance level within mWoO signifies the links between the multiple levels of decision-making and the market dynamics within the automotive market in the UK.

In turn, coupling the mWoO of industry trajectories and the *problem* stream underscores the fact that the mass take up of EVs may cause problems across multiple levels of the problem streams and impact not only technological and policy development within the automotive industry but also the energy supply and energy storage industries. The problems with the widespread adoption of EVs could be associated with excessive electricity demand and the risk of power outages (FOI 103). This will require the reduction of peak demand and the development of smart charging (FOI 103), which will impact the incumbent level of the energy supply trajectory, as incumbent actors will need to response to this problem. At the time of writing, this represents an unknown future, but it also offers an important issue for future research.

An example of a positive effect of mass EV uptake could be the impact of increased demand for batteries on incumbent level actors of the energy storage industry trajectory. If EV market growth continues, then the tipping points discussed earlier can be connected to earlier EVET interventions to maintain this momentum. It is expected that these interventions will progressively accelerate the EV transition (FOI 60 cf, FOI 67 cf). In Figure 1, tipping points are depicted as three orange frames in 2022, 2026, and 2030,preceded by mWoO in 2020. The specific tipping points dates were identified based on the analysis of FOI 60 cf and FOI 67 cf.

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As a final observation we note that, consistent with the GT approach, we presented our model and findings back to the stakeholders involved in the data collection activities, and other experts, as part of "model validation." Aspects of the research were presented at international academic conferences, where positive feedback was received. Feedback was also obtained directly from six of the earlier participants in the research.

5 | DISCUSSION

Following the GT method, once the theoretical framework or model has been developed; and answers to the research question given, the results are compared with the literature to identify similarities and differences, to locate theory within the larger body of theoretical knowledge (Bryant, 2017; Corbin & Strauss, 2015). The results of the study are thus now compared with the literatures that embrace the concept of WoO, MSF and MLP specifically, focusing on the dynamic two-way linkages between policy and technology within the context of sustainability transitions in the automotive industry.

In the research, we have found that following a series of WoOs, specifically tWoO-1 (2010), tWoO-2 (2016), pWoO-1 (open 07-2016, closure 07-2018), pWoO-2 (open 06-2018, closure 03-2020), and the shift of the policy agenda to net-zero goals, mWoO (03-2020) opened, signifying the shift of the focal technology, EVs, to the incumbent level. The challenge in implementing the standard GT process in the present case is that no previous research has distinguished these different types of WoO. The literature that has some parallels with the present research considers other European countries, but not the UK: Werner and Onufrey (2022)—Sweden; Kulmer et al. (2022)—Austria; and Derwort et al. (2022)—Germany.

The present research also extends this existing literature by identifying the sequential and dynamic relationships between technology, policy, and market uptake. The transition process started with technological developments by TIs within tWoOs, that improved the well-to-wheel processes of a niche technology; followed by a coupling of this niche technology with a policy solution by PEs within pWoOs, through the subsequent release of strategic policy and industry specific policy instruments. This sequence of events led to a shift of the niche technology to the incumbent level within mWoO.

Of the other studies cited, the closest research to the present study is Derwort et al. (2022), who analyzed policy change toward sustainability in Germany's energy sector over the period 1970–2018. The authors used both the MLP and MSF in their analysis, arguing that political decisions trigger ST change and protect innovative technologies from market pressure. After that, these technological advances provided new solutions to the policy stream "feeding back into the political agenda" (Derwort et al., 2022, p. 693). Thus, these authors also find two-way linkages between the technology and policy agenda. They also confirm that the concept of policy entrepreneurship can shed light on the role of individual agents in ST systems.

The main difference is that the present research has found that the advancement of technology and follow-up activities of PEs led to a significant shift in the policy agenda (from low to zero emissions vehicles). Thus, we argue that the role of individuals is crucial in the policy shift, within tWoO as well as pWoO, with our data enabling us to identify key individuals in this process. Additionally, our research has shown that in the UK case, the pWoOs opened by the government, DfT specifically, were endogenous, planned events; while Derwort et al. (2022) associate opening WoO with exogenous focusing events, such as oil crises or nuclear incidents that influenced the policy system. Both of the research studies, however, agree that

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the technology at the moment of pWoO opening needs to be advanced enough to be capable of solving the policy problem.

In the literature that discusses the agenda-setting processes in UK transport-related studies, the following actors have been identified as PEs: Friends of the Earth (Carter & Jacobs, 2014), Mayor of London Sadiq Khan (Maltby, 2021), Transport for London (Cooper-Searle et al., 2018), Carplus, the Waste & Resources Action Programme (Cooper-Searle et al., 2018) and the Ellen MacArthur Foundation (Cooper-Searle et al., 2018).

Having analyzed the data from EVET meetings, we also identify LowCVP as a PE. Further, LowCVP was found to be involved in multiple pWoO, which ultimately led to EV market uptake and the opening of the key mWoO. As multiple pWoO are linked with the issues of the same solution—EVs—the strategy PEs adopted can be described as salami tactics. The first split of policy moves was associated with the development of strategic policy proposals—the Road to Zero—presenting these proposals during pWoO-1. The second policy move related to work undertaken on the industry-specific policy proposal for policy instruments within pWoO-2.

In the present research, we have also expanded on the foregoing to clarify the role of TIs in the policy agenda setting process—in so doing, clarifying the linkages between the contributions of the MLP and MSF to our unifying MLGS model. In line with Goyal et al. (2019), we found that TIs are responsible for the development of technological solutions in the automotive industry, but also in critically-important related industries. In the context of the MLGS and its visual representation, it is easier to show the links between the multiple technologies and functions represented by the elements of the MLP and MSF, as the STT and policy processes move between the multiple layers of the MLGS.

It was also confirmed that TIs promoted technological solutions to a policy problem. Within EVET, TIs were able to link an industry-specific problem, such as a lack of EV charging interoperability and data sharing, with national level problems such as air quality. This activity can be labeled specifically as problem brokerage. In the UK context, given its bureaucratic procedure, TIs did not provide written policy recommendations directly to policymakers, but rather worked through the structures of EVET and its WP meetings. That said, the details of these discussions and recommendations did not always find expression in the final WP reports, as these were mediated by the PEs in this process—LowCVP Senior Managers, which do not always reflect the earlier individual verbal interventions made by TIs. The fact that TIs can potentially act as PEs (Cohen & Naor, 2013), was thus only partly confirmed in our data and empirical case.

From the foregoing, we are now able to reflect on our research question: How can we advance the concept of WoO to explore the dynamics of the sustainability transition, with a particular focus on the development of the electric vehicle (EV) market in the UK? In this, we are interested in particular in the creation of the technological conditions, in multiple related industries, to enable EVs to constitute a solution to multiple policy ambitions set at multiple governance levels, notably climate change, decarbonizing road transport, and reducing air pollution. Meanwhile, both industry and policy interests have a profound interest in EVs becoming a self-sustaining commercially viable market in the long-term.

The answer to our research question therefore draws on, first, the MLP and its ability to locate technologies at different levels of market maturity. Second, there is the MSF and its framing of problems, policies, and politics, to explore when policy change occurs—and which, in the MLGS model, can also be located within the niche, incumbent, and governance levels. Third, systemic challenges such as the sustainability transition require

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changes at multiple levels of governance, from the global to the local, which can be framed using MLG located across the six layers (industry trajectories and streams) of the MLGS model. Finally, the goal of the research has been to analyze the dynamic shift in stakeholders' focus, from low to zero emissions vehicles in the UK, which finds its ultimate expression in the creation of a self-sustaining mass market for EVs.

This has been framed utilizing the concepts of WoO, as a key concept shared by the MLP and MSF. WoO are particularly useful in exploring what happens when it does (with the opening of a window), and when a particular phase of transition is over (as the window closes). In our analysis, and reflecting the above discussion, we have identified three types of WoO, capturing developments in technology (tWoO), policy (pWoO), and markets (mWoO). The first technological window of opportunity (tWoO-1) opened in 2010 at the technological niche level of the automotive industry trajectory. This saw the coupling of the niche level technology—the EV mass market-oriented powertrain—with the incumbent level technology—Li-ion batteries—within the automotive and energy storage industry trajectories, respectively. This resulted in the production of the first mass market-oriented EV—the Nissan Leaf.

The second technological window of opportunity (tWoO-2) was associated with the shift of RE technology to the incumbent level in 2016. The shift in the balance of electricity generated from coal to renewables marked a turning point in the decarbonization of the electricity supply industry, thus improving the emissions performance of EVs in general. Within the synthetic model—MLGS—this was conceptualized as coupling the niche level technology (EVs) with incumbent level technology—renewable energy (mainly solar and wind) of the automotive and energy supply industry trajectories, respectively. It is worth clarifying that, at this point, the EV market was not fully mature and the Nissan Leaf represented only a niche technology. That said, the tWoOs were not only sequential but also cumulative, given the decreasing cost of batteries and the expanding network of EV charging infrastructure over time.

This series of tWoOs resulted in increased efficiency of well-to-wheel EV processes, as well as their market potential, making it possible for PEs to justify promoting the use of EVs as a solution for environmental problems. After the coupling of automotive, energy supply, and energy storage trajectories, EV technology was paired by the PEs as a strategic policy solution for the environmental problem. This happened in the first pWoO-1 over the period July 2016–July 2018, when work on the TEM and Road to Zero took place. Over this period, the PEs contributed to the TEM, where they were able to prioritize EVs as potentially net-zero with respect to well-to-wheel analyses. In addition, PEs contributed to the inclusion of the 46-point plan in the Road to Zero strategy, an initiative ending the government's stance on technological neutrality. The policy plan favored EVs by setting targets for EV uptake and phasing out petrol and diesel vehicles (and, later, hybrids). The shift in the policy agenda from low emission to zero-emission vehicles happened after the release of the Road to Zero strategy in 2018—although the window for this shift starts in 2016, when the relevant work that went into the Road to Zero began.

The key stakeholder roles, and those who took on those roles, are identified as follows.

Policymakers, individuals, or groups involved in formulating, developing, or amending policy, included Government Ministers, Secretary of State for Transport, Secretary of State for Business, Energy and Industrial Strategy, and Head of the Government's Office of Low Emission Vehicles.

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PE, with a purposive and reputational interest in the acceptance of policy proposals, were found to be individuals who worked within pWoO at the national, incumbent, and market niche levels of policy stream by coupling policy, politics, and problem streams. Key PEs were the directors of LowCVP, who contributed to the TEM and the Road to Zero, as well as providing secretariat functions for EVET, and thus who had control of what went into the final EVET reports making recommendations to government.

TIs operate within technological WoO in technological trajectories across the three key industries—carmakers, battery makers, and energy generators/suppliers. One group of key TIs were carmakers' officials who developed technological solutions. Within the technological WoO, TIs were able to release an innovative product that was complementary to innovations in related industries. They released the first mass-market BEV in 2010 and enhanced the range of EVs from 2016, when the second tWoO was opened. In addition, during the second tWoO, TIs intensified the expansion of the EV charging infrastructure. These individuals were also found to act as problem brokers within the EVET WPs, but the PEs identified above had final say over the content of the WP reports.

Regarding the other two industries in the technology space, TIs in the energy supply industry delivered an ongoing diversification of EV energy supply away from fossil fuels and toward renewables; while TIs in the energy storage trajectory improved the energy and cost efficiencies of Li-ion batteries. These activities, jointly, made EVs a viable technological solution to the multiple policy problems. Policymakers established EVET within the policy stream in response to the technological niche-level problem of the problem stream—a lack of widespread adoption of EVs.

Analyzing EVET data, it was found that pWoO-2 was opened by DfT and BEIS and conveyed by OLEV in June 2018 (FOI 107). EVET provided opportunities for TIs who acted as problem brokers to frame problems in the form of questions at the incumbent level of the problem stream, for example by raising a question regarding the "sharing of data around demand forecasting to help the energy sector better meet the energy impacts of EVs" (FOI 32). This problem was then discussed at the WP meetings, where the problem solution was suggested and included in the draft of the WP by PEs. After that, the WP draft was further scrutinized by PEs. Following modifications, policy proposals were presented to the government, specifically the Secretary of State for Transport and members of the House of Lords (FOI 89, FOI 102). The final decision on the inclusion of policy proposals in the final policy, as agreed and implemented, was made by government ministers.

After the initiation of the EVET WPs in June 2018, the mWoO began to open in September 2019. This is evident from the increase in registration of EVs by 141% compared with the previous year (Department for Transport, 2022b, 2022c). However, the number of EVs registered for the first time, in proportion to the total number of vehicles registered for the first time in the UK, was relatively small, accounting for 1.64% in 2019 (Department for Transport, 2023b). The market WoO fully opened in the following year, March 2020, with the completion of EVET 1.0 WPs and the closure of pWoO-2 in the same month. During this time, the model range of EVs expanded significantly, and the market continued to grow by 184%, accounting for 6.59% of total registered cars for the first time in the UK in 2020 (Department for Transport, 2022b). This signified the shift of EVs to the incumbent level and, as the ultimate goal of all that had gone before, the beginning of the mass market uptake of EVs.

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6 | CONCLUSION

How can we deepen our understanding of systemic change, in the context of the sustainability transition? In this research, we have argued that because such change involves multiple stakeholders and industries working interactively over time, analysis of such processes risk concept-stretching were individual existing analytical frameworks to be deployed. To avoid this, and to enable a clearer analysis of systemic change involving multiple stakeholders and their interactions, we have unified the MLP, MSF, and MLG frameworks into a single, unified MLGS model. This approach is not without its dangers (Cairney, 2013), but we have argued that with due consideration given to the underlying ontological and epistemological contexts of these frameworks, we have avoided the potential downsides that Cairney identifies.

A key part of justifying the synthesis of these particular frameworks has been developing the concept of WoO, which is integral to both the MLP and MSF. Additionally, synthesizing the MLP, MSF, and MLG has enabled us to bring greater clarity to the different roles played by stakeholders in these complex systemic processes. In the present research, this was especially important given the uniquely detailed primary and secondary data sources we gained access to.

Our empirical application has focused on the UK's shifting ambitions for EVs, linked to the wider sustainability policy goals that this technological shift could deliver. Specifically, our primary focus has been on the period from 2016 to 2020, during which time the UK moved from promoting low emissions vehicles while maintaining technological neutrality, to the abandonment of this position on technology when EVs, as zero (tailpipe) emissions vehicles, came to be seen as a viable means of delivering on multiple climate and environmental goals.

That said, the process of getting EVs to this point began somewhat earlier than 2016. With three key industries identified as needing to contribute to this aspect of the sustainability transition, the interplay of those industries had to progress to the point where EVs could indeed offer wider societal benefits. Those three industries reaching those points represented the necessary and sufficient condition for EVs to be able to offer those benefits. At this point, 2016, policymakers could then focus their attention on EVs as a means to deliver on their own ambitions. That said, this process was characterized by policymakers recognizing the need for help from others, hence the creation of EVET. This also provided the means by which those operating outside of government, but especially representatives of key industries, could work either as problem brokers or as PE, to inform and influence the final policy process. In this way, the technology and the policy enabled the creation of EVs as a mature, self-sustaining market.

MLGS represents a viable means of synthesizing complementary theoretical frameworks. The streams of the MSF are embedded as separate layers. Other layers represent the multiple industries required to deliver on certain systemic aspects of the sustainability transition. In our case, this is three, but that can be adapted as necessary to suit any given empirical context. Embedded in each layer are then key elements of the MLP—niche, incumbent, and governance levels—as well as different levels of governance, through MLG. The third dimension, time, then allows for the incorporation into the different layers of key aspects in the analysis of specific analysis of complex systemic change. Recognition of different, but related, WoO can then connect across the layers, with the visualization of the MLGS model aiding researchers' mental maps of the complexities intrinsic to systemic change.

Taking this work forwards, one direction would be to explore its use in analyzing other events within the automotive transition, or other elements of the wider sustainability transition. This would also allow for the testing of the flexibility of the model in terms of varying the number of industry trajectories/layers, as each empirical case demands. Ultimately,

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systemic transitions are highly complex, with multiple stakeholders and "moving parts." We propose the MLGS as a way of capturing, and visualizing, these transitions, whether in a single model (e.g., as shown in Figure 1), or by focusing in on the detail of individual components. This ability to zoom in and out offers clarity as we seek deeper understanding of the interactions embedded within the sustainability transition.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

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REFERENCES

Ackrill, R., & Kay, A. (2011). Multiple streams in EU policy-making: The case of the 2005 sugar reform. *Journal of European Public Policy*, *18*(1), 72–89. https://doi.org/10.1080/13501763.2011.520879

Baumgartner, F. R., & Jones, B. D. (2010). *Agendas and instability in American politics*. University of Chicago Press.

Bryant, A. (2017). *Grounded theory and grounded theorizing: Pragmatism in research practice*. Oxford University Press.

Cairney, P. (2013). Standing on the shoulders of giants: How do we combine the insights of multiple theories in public policy studies? *Policy Studies Journal*, *41*(1), 1–21. https://doi.org/10.1111/psj.12000

Carter, N., & Jacobs, M. (2014). Explaining radical policy change: The case of climate change and energy policy under the British labour government 2006–10. *Public Administration*, *92*(1), 125–141. https://doi.org/10.1111/padm.12046

Charmaz, K. (2006). *Constructing grounded theory: A practical guide through qualitative analysiso title*. Sage.

Charmaz, K. (2014). *Constructing grounded theory* (2nd ed.). Sage Publications, Inc.

23806567, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/epa2.1216 by University of Sunderland, Wiley Online Library on [09/07/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Cohen, N., & Naor, M. (2013). Reducing dependence on oil? How policy entrepreneurs utilize the national security agenda to recruit government support: The case of electric transportation in Israel. *Energy Policy*, *56*, 582–590. https://doi.org/10.1016/j.enpol.2013.01.025

Cohen, N., & Naor, M. (2017). Entrepreneurial failure in the transition to electric vehicles: A case study of support for sustainability policy in Israel. *Policy and Society*, *36*(4), 595–610. https://doi.org/10.1080/14494035.2017.1369678

Cooke, P. (2018). Evolutionary complexity geography and the future of regional innovation and growth policies. In H. Pinto, T. Noronha, & E. Vaz (Eds.), *Resilience and regional dynamics. Advances in spatial science* (pp. 11–30). Springer. https://doi.org/10.1007/978-3-319-95135-5_2

Cooper-Searle, S., Livesey, F., & Allwood, J. M. (2018). Why are material efficiency solutions a limited part of the climate policy agenda? An application of the Multiple Streams Framework to UK policy on CO2 emissions from cars. *Environmental Policy and Governance*, *28*(1), 51–64. https://doi.org/10.1002/eet.1782

Corbin, J. M., & Strauss, A. L. (2015). *Basics of qualitative research: Techniques and procedures for developing grounded theory* (4th ed.). Sage Publications.

Denzin, N. K. (1994). The art and politics of interpretation. In N. K. Denzin, & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 500–515). Sage Publications, Inc.

Derwort, P., Jager, N., & Newig, J. (2022). How to explain major policy change towards sustainability? Bringing together the multiple streams framework and the multilevel perspective on socio-technical transitions to explore the German "Energiewende". *Policy Studies Journal*, *50*(3), 671–699. https://doi.org/10.1111/psj.12428

Department for Transport. (2018). *Transport energy model*. Accessed June 5, 2023. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/739462/transport-energy-model.pdf

Department for Transport. (2022a). *UK electric vehicle infrastructure strategy*. Accessed December 29, 2022. https://www.gov.uk/government/publications/uk-electric-vehicle-infrastructure-strategy

Department for Transport. (2022b). *VEH0120_GB: Vehicles at the end of the quarter by licence status, body type, make, generic model and model: Great Britain*. Accessed May 22, 2023. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1123735/df_VEH0120_GB.csv

Department for Transport. (2022c). *Vehicles registered for the first time by body type and fuel type Great Britain and United Kingdom VEH1153*. Accessed December 22, 2022. https://www.gov.uk/government/statistical-data-sets/vehicle-licensing-statistics-data-tables

Department for Transport. (2023a). *Electric vehicle charging device statistics*. Accessed April 14, 2023. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1130910/electric-vehicle-charging-device-statistics-january-2023.ods

Department for Transport. (2023b). *VEH1153: Vehicles registered for the first time by body type and fuel type: Great Britain and United Kingdom*. Accessed July 10, 2023. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1162899/veh1153.ods

Department for Transport and OLEV. (2018). *The Road to Zero*. Accessed June 17, 2024. https://www.gov.uk/government/publications/reducing-emissions-from-road-transport-road-to-zero-strategy

Dijk, M., Orsato, R. J., & Kemp, R. (2013). The emergence of an electric mobility trajectory. *Energy Policy*, *52*, 135–145. https://doi.org/10.1016/j.enpol.2012.04.024

Ehnert, F., Kern, F., Borgström, S., Gorissen, L., Maschmeyer, S., & Egermann, M. (2018). Urban sustainability transitions in a context of multi-level governance: A comparison of four European states. *Environmental Innovation and Societal Transitions*, *26*(May), 101–116. https://doi.org/10.1016/j.eist.2017.05.002

European Commission. (2016). *Commission Regulation (EU) 2016/646 of 20 April 2016 amending Regulation (EC) No 692/2008 as regards emissions from light passenger and commercial vehicles (Euro 6) (Text with EEA relevance)*. https://eur-lex.europa.eu/eli/reg/2016/646/oj

Figenbaum, E. (2017). Perspectives on Norway's supercharged electric vehicle policy. *Environmental Innovation and Societal Transitions*, *25*, 14–34. https://doi.org/10.1016/j.eist.2016.11.002

Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case-study. *Research Policy*, *31*(8–9), 1257–1274. https://doi.org/10.1016/S0048-7333(02)00062-8

23806567, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/epa2.1216 by University of Sunderland, Wiley Online Library on [09/07/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Geels, F. W. (2004). From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. *Research Policy*, *33*(6–7), 897–920. https://doi.org/10.1016/j.respol.2004.01.015

Geels, F. W. (2005). The dynamics of transitions in socio-technical systems: A multi-level analysis of the transition pathway from horse-drawn carriages to automobiles (1860–1930). *Technology Analysis & Strategic Management*, *17*(4), 445–476. https://doi.org/10.1080/09537320500357319

Geels, F. W. (2018). Low-carbon transition via system reconfiguration? A socio-technical whole system analysis of passenger mobility in Great Britain (1990–2016). *Energy Research & Social Science*, *46*(July), 86–102. https://doi.org/10.1016/j.erss.2018.07.008

Geels, F. W. (2019). Socio-technical transitions to sustainability: A review of criticisms and elaborations of the Multi-Level Perspective. *Current Opinion in Environmental Sustainability*, *39*, 187–201. https://doi.org/10.1016/j.cosust.2019.06.009

Gladwell, M. (2010). *The tipping point: How little things can make a big difference*. Abacus.

Glaser, B., & Strauss, A. (1967). *The discovery of grounded theory: Strategies for qualitative research*. AldineTransaction.

Goyal, N., & Howlett, M. (2018). Technology and instrument constituencies as agents of innovation: Sustainability transitions and the governance of urban transport. *Energies*, *11*(5), 1198. https://doi.org/10.3390/en11051198

Goyal, N., Howlett, M., & Chindarkar, N. (2019). Who coupled which stream(s)? Policy entrepreneurship and innovation in the energy–water nexus in Gujarat, India. *Public Administration and Development*, *40*(1), 49–64. https://doi.org/10.1002/pad.1855

Goyal, N., Howlett, M., & Taeihagh, A. (2021). Why and how does the regulation of emerging technologies occur? Explaining the adoption of the EU General Data Protection Regulation using the multiple streams framework. *Regulation & Governance*, *15*, 1020–1034. https://doi.org/10.1111/rego.12387

Van der Heijden, J. (2013). Different but equally plausible narratives of policy transformation: A plea for theoretical pluralism. *International Political Science Review*, *34*(1), 57–73.https://doi.org/10.1177/0192512112453604

HM Government. (2017). *Industrial strategy*. Accessed June 17, 2024. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/664563/industrial-strategy-white-paper-web-ready-version.pdf

HM Government. (2021). *The electric vehicles (smart charge points) regulations 2021*. Accessed April 21, 2023. https://www.legislation.gov.uk/uksi/2021/1467/introduction/made

Hooghe, L. (1996). *Cohesion policy and European integration: Building multi-level governance*. Oxford University Press on Demand.

Hussaini, M., & Scholz, M. (2017). Exploring low carbon transition pathways for the UK road transport sector. *Transportation Planning and Technology*, *40*(7), 796–811. https://doi.org/10.1080/03081060.2017.1340024

Kern, F., & Rogge, K. S. (2018). Harnessing theories of the policy process for analysing the politics of sustainability transitions: A critical survey. *Environmental Innovation and Societal Transitions*, *27*(June 2017), 102–117. https://doi.org/10.1016/j.eist.2017.11.001

Kingdon, J. W. (1984). *Agendas, alternatives, and public policies*. Little, Brown.

Kingdon, J. W. (2014). *Agendas, alternatives, and public policies* (2nd ed.). Pearson Education Limited.

Knaggård, Å. (2015). The multiple streams framework and the problem broker. *European Journal of Political Research*, *54*(3), 450–465. https://doi.org/10.1111/1475-6765.12097

Kulmer, V., Seebauer, S., Hinterreither, H., Kortschak, D., Theurl, M. C., & Haas, W. (2022). Transforming the s-shape: Identifying and explaining turning points in market diffusion curves of low-carbon technologies in Austria. *Research Policy*, *51*(1), 104371. https://doi.org/10.1016/j.respol.2021.104371

Lipson, M. (2007). A 'garbage can model' of un peacekeeping. *Global Governance: A Review of Multilateralism and International Organizations*, *13*(1), 79–97. https://doi.org/10.1163/19426720-01301006

LowCVP. (2014). *LowCVP collaborates with DfT to establish task force to determine future of energy for UK transport*. Accessed July 2, 2023. https://www.zemo.org.uk/news-events/news,lowcvp-collaborates-with-dft-to-establish-task-force-to-determine-future-of_3081.htm

LowCVP. (2018). Building the Road to Zero – Piece by piece. Accessed 2 July 2, 2023. https://www.zemo.org.uk/assets/presentations/Conference_Close_Andy_Eastlake_LowCVP18.pdf

23806567, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/epa2.1216 by University of Sunderland, Wiley Online Library on [09/07/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

LowCVP. (2020). *Zero emission bus workshop Birmingham*. Accessed July 2, 2023. https://www.zemo.org.uk/assets/presentations/1.%20Zero%20Emission%20Fleets%20-%20Chris%20Douglas,LowCVP.pdf

Maltby, T. (2021). Consensus and entrepreneurship: The contrasting local and national politics of UK air pollution. *Environment and Planning C: Politics and Space*, *40*, 685–704. https://doi.org/10.1177/2399654420981609

Marks, G. (1992). Structural policy in the European Community. In A. M. Sbragia (Ed.), *Europolitics: Institutions and Policymaking in the New European Community* (pp. 191–224). The Brookings Institution.

Mayor of London. (2018). *Mayor's transport strategy*. Accessed November 25, 2023. https://www.london.gov.uk/programmes-strategies/transport/our-vision-transport/mayors-transport-strategy-2018

Mazur, C., Contestabile, M., Offer, G. J., & Brandon, N. P. (2015). Assessing and comparing German and UK transition policies for electric mobility. *Environmental Innovation and Societal Transitions*, *14*, 84–100. https://doi.org/10.1016/j.eist.2014.04.005

Office for National Statistics. (2022). *Energy trends: UK electricity*. Accessed December 28, 2022. https://www.gov.uk/government/statistics/electricity-section-5-energy-trends

OZEV. (2021). *Transport energy model review*. Accessed July 2, 2023. https://www.zemo.org.uk/work-with-us/collaborative-initiatives/projects/transport-energy-model-review.htm

Raven, R., Kern, F., Verhees, B., & Smith, A. (2016). Niche construction and empowerment through socio-political work. A meta-analysis of six low-carbon technology cases. *Environmental Innovation and Societal Transitions*, *18*, 164–180. https://doi.org/10.1016/j.eist.2015.02.002

Skeete, J. P. (2019). Concentration of power: A UK case study examining the dominance of incumbent automakers and suppliers in automotive sociotechnical transitions. *Global Transitions*, *1*, 93–103. https://doi.org/10.1016/j.glt.2019.06.001

Smith, A., & Raven, R. (2012). What is protective space? Reconsidering niches in transitions to sustainability. *Research Policy*, *41*(6), 1025–1036.https://doi.org/10.1016/j.respol.2011.12.012

Timonen, V., Foley, G., & Conlon, C. (2018). Challenges when using grounded theory: A pragmatic introduction to doing GT research. *International Journal of Qualitative Methods*, *17*(1). https://doi.org/10.1177/1609406918758086

Turnheim, B., Berkhout, F., Geels, F., Hof, A., McMeekin, A., Nykvist, B., & van Vuuren, D. (2015). Evaluating sustainability transitions pathways: Bridging analytical approaches to address governance challenges. *Global Environmental Change*, *35*(2015), 239–253. https://doi.org/10.1016/j.gloenvcha.2015.08.010

UK Parliament. (2020). *Written evidence submitted by the Ensus UK Limited (HAT0036)*. Accessed July 2, 2023. https://committees.parliament.uk/writtenevidence/66690/html

UNFCCC. (2015). *Paris agreement*. Accessed June 17, 2024. https://unfccc.int/sites/default/files/english_paris_agreement.pdf

Werner, V., & Onufrey, K. (2022). If electric trucks are the solution, what are the problems? A study of agenda-setting in demonstration projects. *Energy Research & Social Science*, *91*, 102722. https://doi.org/10.1016/j.erss.2022.102722

Whittington, R., Regnér, P., Angwin, D., Johnson, G., & Scholes, K. (2019). *Exploring strategy, text and cases*. Pearson Higher Education & Professional Group.

Wildavsky, A. B. (1979). *Speaking truth to power*. Transaction Publishers.

Woo, J., Choi, H., & Ahn, J. (2017). Well-to-wheel analysis of greenhouse gas emissions for electric vehicles based on electricity generation mix: A global perspective. *Transportation Research Part D: Transport and Environment*, *51*, 340–350. https://doi.org/10.1016/j.trd.2017.01.005

Yolles, M., & Fink, G. (2013). Exploring the common roots of culture, politics and economics. *Business Systems Review*, *2*(2), 94–150. https://dx.doi.org/10.2139/ssrn.2185966

YouGov. (2018a). *Currently the government has said it will ban the sale of new petrol and diesel cars after 2040*. Accessed May 21, 2023. https://yougov.co.uk/topics/transport/survey-results/daily/2018/10/19/a9db6/1

YouGov. (2018b). *How concerned, if at all, are you about climate change?* Accessed May 21, 2023. https://yougov.co.uk/topics/politics/survey-results/daily/2018/10/08/d7f9f/1

Zahariadis, N. (2014). Ambiguity and multiple streams. In P. Sabatier, & W. Christopher (Eds.), *Theories of the policy process* (3rd ed., pp. 25–58). Westview Press.

Zap Zap. (2023). *EV charging statistics 2023*. Accessed April 10, 2023. https://www.zap-map.com/statistics/

23806567, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/epa2.1216 by University of Sunderland, Wiley Online Library on [09/07/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

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