Agency and Agents in Multiple Windows of Opportunity: Decarbonising the Automotive Industry in the UK

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Abstract

In this paper, we present an initial analysis of work that seeks to understand, through a novel combination of concepts, the processes that are driving the UKs decarbonisation strategy for the automotive sector. We undertake extensive fieldwork interviews and documentary analyses that allow us to explore, in fine-grained detail, the interlinkages in a context where policymakers seek to create a significant, sustainable new market (cars with zero tailpipe emissions) via policy incentives, where the basic technology exists (e.g. batteries), but where investment in technological development must come from the private sector, indeed from several related industries within the automotive ecosystem. Moreover, those private sector actors have considerable self-interest in the shape of that policy. We draw upon, notably, the multiple streams framework and the multi-level perspective, to understand how technology, market and policy factors have worked jointly to put the UK automotive industry on a specific trajectory. Adopting a grounded theory approach, we find this has come about through the interplay of different groups of actors: technology innovators, policy entrepreneurs, problem brokers and bricoleurs. They all have agency in different parts of the ecosystem whilst operating across and interacting within different fields of specialism – technology, market and policy. Moreover, our research reveals multiple distinct types of windows of opportunity, with different actors operating in different windows, to achieve the ultimate goal of a functioning market for electric vehicles. This paper aims to answer three interrelated research questions. What is the relationship between technological, policy and market windows of opportunity with industry trajectories and multiple streams? Who are the key agents that are in play inside each WoO? What does windows of opportunity mean for the relevant actors and their interrelations within a particular window?

Key words: Policy entrepreneurs, Problem brokers, Technology innovators, Bricoleurs, Multiple streams framework, Multiple windows of opportunity, Technology stream, Automotive industry

1. Introduction

Over the period 2017-2020, the UK Government released five decarbonisation strategy documents relating to mobility in the sustainability transition. These documents show a recent shift in policy from "low" emissions vehicles to "zero" emissions vehicles, a move which has already had a significant impact on the automotive industry. Despite the significance of this, a number of issues remain underexplored regarding the role of policy entrepreneurs (PE) in this process.

First, including Technology Innovators (TI) and Problem Brokers (PB) is important as they can frame problems in the problem stream that can open a policy window of opportunity (WoO), so how can we define and distinguish between PE, TI and PB in the sustainability transition? Second, do only PEs join streams together in a WoO? If PBs or other agents can, we need to distinguish clearly and carefully, both theoretically and empirically, between PEs, PBs and other agents, such as Bricoleurs and Knowledge Brokers (KB). NB we define all of these terms, with examples of individuals or roles that they can represent on the basis of our fieldwork, below in Section 4. Third, in this research, we distinguish between four types of windows: policy, problem, technological, and market. The first two types are the familiar windows from the multiple streams framework (MSF), which opens in the problem or politics stream, whereas the other two open in industry trajectories. Thus, what is the relationship between technological, policy, problem and market windows of opportunity with industry trajectories and multiple streams? Who are the key agents that are in play inside each WoO? What does 'windows of opportunity' mean for the relevant actors and their interrelations within a particular window? These are our three research questions.

Grounded Theory is used to construct conceptually-dense theory about the role of TIs, PEs, PBs and other agents in coupling streams in multiple WoOs, in the context of the UKs electric vehicle transition. Forty-eight participants were interviewed, from government organisations, and the automotive and related industries. We also analysed minutes, presentations and reports from the 15 steering group meetings of the Electric Vehicle Energy Taskforce (EVET), over 2018-2020. The EVET is the main organisation in the UK bringing together policymakers, carmakers and energy companies, to accelerate, but also influence the shape of, sustainability transitions in the automotive industry.

We find that working together, Bricoleurs, TIs who act as PEs and PBs are successful at the national level. TIs who act as PBs frame problems in the problem stream. In addition, they mobilise expert opinion at industry-specific events and conferences and couple industry trajectories in multiple industries in the technological WoO. Technological WoOs allow carmakers to produce

technological solutions to anticipated problems, which can then be coupled with the problem stream when a problem WoO is open. If TIs problem frame and technological solution is included in a Bricoleur's policy proposals then industry trajectories are coupled with politics, problem and policy streams, wherein the work of TIs can be viewed as PEs. The subsequent policy change leads to change in industries' trajectories and opens market WoO for the specific technological solution. This ultimately facilitates the technological solution to become a mainstream product.

The examples of PEs at the national level in the UK include Senior Managers of Carmakers. Bricoleurs can be, for example, government researchers, the Chair of the EVET, or the Senior Manager of Low Carbon Vehicle Partnership (now called the "ZEMO Partnership"). Problem brokers' functions can be linked with NGOs (Maltby, 2021) or individuals who can frame condition as a public problem (Knaggård, 2015) have preference to a specific solution and can mobilise public opinion. Examples of TI include Senior Managers of Carmakers. Knowledge brokers are associated with the numerous scientists cited in policy proposals.

These findings introduce a clearer conception of agency around policy entrepreneurs, in conjunction with TIs, problem brokers and bricoleurs, around the problem and policy streams and industry trajectories, in a context where the development of policies and markets, through technology innovations, are mutually dependent and mutually reinforcing.

In what follows, we start with a discussion of the methodology, before exploring in detail the literature that allows us to piece together our analytical framework. In so doing, in the next section we identify with reference to the interview data the key concepts that emerged from this engagement with stakeholders, consistent with grounded theory. Sections 3 explore in detail the primary and secondary data underpinning our chosen concepts, justifying their inclusion in the analysis. In addition, section 3 presents a visual representation of the framework, the Multi-Level Governance and Strategy model (MLGS), followed by answers to the first research question. We seek answers to second and third research questions in Sections 4 and 5. Section 6 concludes.

2. Methodology

Grounded Theory is one of the most widely used methods that provide a systematic approach to constructing conceptually dense theory using qualitative data (Denzin, 1994; Timonen et al., 2018). As the research is particularly interested in the participants' action/interaction strategies, the use of well-described theoretical/coding paradigms focused on this aspect of the phenomenon is especially important. In this regard, the Strauss and Corbin (1998) coding approach will be applied. The

present study uses a constructivist interpretation of the grounded theory (GT) approach, whilst applying Strauss and Corbin's (1998) coding paradigm to facilitate the coding process (Charmaz, 2006).

The research draws on multiple sources of interview and archival data. Interview data include 30 semi-structured elite interviews and 18 comments from senior managers and specialists of the government, high profile groups, carmakers, consulting organisations, academia, transport planning organisations, government funding organisations, automotive fuel and energy supply companies, infrastructure companies and digital sector organisations. Forty participants are related to the automotive industry in terms of work background, education, work and research tasks. Thirty-eight participants have senior managerial positions and are involved in sustainable transitions in the UK through the development of policies, strategies, research, equipment and consulting services. Eight participants outside the government or industry participated in the study on the issues linked to the development in the related industries. A list of participants is presented in Appendix 1.

Archival data were obtained via a Freedom of Information Request and include minutes, presentations and reports from the steering group meetings of the EV Energy Taskforce convened by The Low Carbon Vehicle Partnership. This is the main organisation in the UK automotive industry bringing together carmakers and energy companies to make proposals to the government to accelerate sustainability transitions in the UK in the sphere of low emission vehicles.

3. What is the relationship between technological, policy and market windows of opportunity with industry trajectories and multiple streams?

Before proceeding to explain the relationship between multiple types of windows of opportunity, it is necessary to define the technology stream and industry trajectories.

Technology stream

In order to understand the impact of technological change on the policy process, the analysis uses the concept of technology stream (Goyal et al., 2021; Voß, 2007). 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). The likely actors involved in technology development and diffusion are technology constituencies (Goyal et al., 2021; Goyal & Howlett, 2018). Members

of technology constituencies can be technologists, manufacturers, suppliers, service providers, users, lobby groups, political actors, and academics who can also be members of epistemic communities in the problem stream, instrument constituencies in the policy stream, and advocacy coalitions in the politics stream (Goyal et al., 2020, 2021). According to Goyal et al. (2020) entrepreneurial activities in the technology stream focused on promoting "a technological solution to a societal "need" or a policy problem" and can be associated with the activities of technology innovators. In addition, a technology innovator can promote the innovation by coupling "a technology narrative with a socio-political agenda" (Goyal et al., 2020; Smith & Raven, 2012). It is noteworthy that the technology stream can be coupled with problem, politics and policy streams and that the activities of technology constituencies can shape technological trajectories (Goyal et al., 2021). In the analysis, we are using the concept of industry trajectory, that includes technological niche innovations as well as incumbent-level technologies. We find that industry trajectories of related industries can be included in the technology stream since the entrepreneurial activities of technology innovators are linked with multiple industry trajectories and multiple technological levels and can be considered as activities within the technology stream.

Industry trajectory

The importance of communication between related industries was highlighted by interviews 12, 17, 18, 19, 22, 25, and 27 (Appendix 1). Technological and strategic actions of stakeholders related to the transformation of the automotive industry were conceptualised under the term 'industry trajectories'. This concept is not used in the MSF literature, but it is mentioned in the MLP literature, mainly in terms of the historical development of a particular industry (Cooke, 2018; Yolles & Fink, 2013). Also, industry trajectories were associated with the socio-technical dimension of the MLP, such as the socio-technical regime level (Gee & Uyarra, 2013; Karltorp & Sandén, 2012). The list of elements of the socio-technical regime is quite extensive and includes institutional norms (Geels, 2004), incumbent actors and technologies (Holtz et al., 2008). According to Kemp et al. (1998) the regime can be associated with 'the whole complex of scientific knowledge, engineering practices, production process technologies, product characteristics, skills and procedures, and institutions and infrastructures that make up the totality of a technology'.

During the analysis of the data, the participants repeatedly mentioned the development and transformation of the related industries. In the case of the transformation of the automotive industry, the related industries are associated with energy supply and energy storage technologies for vehicles.

In the case of hybrid vehicles, fossil fuels and biofuels are the main energy sources and energy storage medium to which the fuel industry is linked (Int. 1, 2). In the case of electric vehicles, the source of energy mentioned by interview participants (Int. 18, 22) is renewable energy, and the main storage technology is batteries (Int. 15, 23, 30). The related industries include the renewable energy industry (energy generation) and the battery industry (energy storage). The battery industry trajectory has been merged with the fuel industry trajectory, as both petrol/diesel fuel and batteries can be seen as the mediums for energy storage while transforming the automotive industry, petrol/diesel fuel for internal combustion engines, batteries for electric vehicles. Renewable energy has been merged with oil and gas industry, as both provide energy supply for electric vehicles and conventional internal combustion vehicles (Figure 1).

Industry trajectory (Figure 2) includes governance level, incumbent level and technological niche level. The governance level shows the result of coupling problem, policy and politics streams - policies that were released and can affect the development of the specific industry trajectory. Governance level itself split on global, regional, national and local levels where global level include international agreements; regional, national and local levels indicate policies released on different levels of governance.

The incumbent level in the automotive industry includes the development associated with internal combustion technologies, mainly hybrid vehicles. The technological niche level corresponds to the development of electric vehicles. The inclusion both of these levels indicates the transition from hybrid vehicles to electric vehicles, which is related with both the publication of policies and the production of new models of electric vehicles by incumbents. The inclusion of governance level, incumbent level and technological niche level is linked with the socio-technical regime and niche-innovations level of the multi-level perspective framework (Geels, 2011) and represent policy and technology aspects of the sustainability transitions.

Policy, problem and politics streams

Policy, problem and politics streams (Figure 1) correspond to structural elements of the MSF (Kingdon, 2014). The politics stream consists of the public mood, financial institutions mood, pressure group campaigns, election results, partisan or ideological distributions in Parliament (Kingdon, 2014). The problem stream includes “various conditions that policy makers and citizens want to be addressed” (Zahariadis, 2014, p. 32). The developed model complements the MSF by the fact that the problem stream also includes problem brokers activities (problem frames) at the

level of incumbents and technological niches (Figure 3). This addition is included for analytical purposes to keep track of the problem frames of technology innovators (who act as problem brokers) that were included in policymakers' policy papers, and the linkage with the industry trajectory dynamics. The policy stream comprises policy ideas/solutions which specialists try out in a variety of ways – "bill introductions, speeches, testimony, papers, and conversation" (Kingdon, 2014, p. 19) and which are selected by an "environment of technical feasibility, value congruence, budgetary implications and political support" (Ackrill et al., 2013, pp. 879–880). It is also worth noting that according to Lipson (2007) solutions can also be specific technologies.

Technological window of opportunity

Interviewees 15, 17, 19, 22, 24, 25, 26 and 27 talked about windows of opportunity for hybrid and electric vehicles. Technological windows of opportunity (tWoO) are associated with the development of breakthrough technology in related industries, which contributes to the development of the technology of interest (Figure 1-3). In addition, tWoO relates to standardisation of infrastructure required for a specific technology, reduction of costs and decarbonisation of energy supply (Int 25). In the case of electric vehicles, the technological window of opportunity was linked with the development of microelectronics and software in the electronics sector, which was subsequently adapted to transport (Int. 17, 19); decarbonisation of electricity resulting from the development of renewable energy; development of communication protocol between electric vehicles and charge stations; the development and reduction of costs of energy storage technologies - batteries, both for renewable energy and for electric vehicles – was of great importance (Int. 23, 15). The coupling energy storage trajectory (battery industry) and the automotive industry trajectory allowed for the first mass market electric vehicles (EVs) to be released in 2010 (Int. 19, 25).

Who is responsible for coupling industry trajectories (IT) within tWoO? Based on interview data it was found that the main agents in industry trajectories are technology innovators (Project Managers, Senior Project Developer, Senior Engineers, CEOs) and technology innovators are responsible for coupling ITs. Technology Innovators are also responsible for opening tWoO via R&D activities in the streams.

> "They [Tesla] were forced to develop a battery company, to develop a car company and to develop a charging infrastructure company simultaneously, they had no choice on that" (Int.25). "Tesla had no choice but to put a charging network in place, because if they didn't, then nobody could buy their cars, so they were forced to do" (Int.25).

> "[Managers of Tesla] were first movers and they wanted to get market share, and the only way to do that was to build the charge stations themselves" (Int.17).

> "We are not going to get into charge point solutions, we're not gonna have [interviewee's car brand] chargers dotted around the place, we have done some in the past but that was about pump-priming the industry" (Int.26)

The subsequent decarbonisation of electricity generation has made it possible to reduce emissions at the EV production stages as well as on the road (Int. 22). Further reductions in the cost of the most expensive part of EV – batteries – make EVs more accessible to the mass market. The deployment of a network of charging stations as well as standardisation has made electric transport more convenient to use (Int. 25).

The second technological WoO for EVs was opened in 2015 (Int. 25) in energy supply and energy storage industry. At this time there were a significant drop in usage of coil and shift toward renewable energy in energy generation (Table 1). This way energy supply for EVs was decarbonised. In addition, the cost of batteries dropped from 290 to 82 USD/kWh, almost by 55%, from 2011 (Table 2) showed that electric vehicles could be cost effective technology available to the mass market (Int 17, 21, 25).

Table 1 Electricity generated by fuel in the UK 2005 to 2021, TWh

Generator type	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Coal	135	108	108	143	130	100	76	31	23	17	7	5	7
Oil	5	5	3	3	2	2	2	2	2	1	2	2	2
Gas	153	176	146	100	96	101	100	143	137	131	132	111	123
Nuclear	82	62	69	70	71	64	70	72	70	65	56	50	46
Hydro (natural flow)	5	4	6	5	5	6	6	5	6	5	6	7	5
Total wind	3	10	16	20	28	32	40	37	50	57	64	76	65
Onshore wind	[x]	7	11	12	17	19	23	21	29	30	32	35	29
Offshore wind	[x]	3	5	8	11	13	17	16	21	27	32	41	36
Shoreline wave / tidal	[x]	0	0	0	0	0	0	0	0	0	0	0	0
Solar	[x]	0	0	1	2	4	8	10	11	13	12	13	12
Bioenergy	10	12	13	15	18	23	29	30	32	35	37	39	40
Other fuels	4	3	3	3	3	4	5	6	5	6	6	7	7
Pumped storage	3	3	3	3	3	3	3	3	3	2	2	2	2
Total all generating companies	398	382	368	364	358	338	339	339	338	333	324	312	309

Source: Office for National Statistics, 2022

Table 2 Average pack price of lithium-ion batteries and cathode material cost 2011 to 2021, USD/kWh

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021e
Cathode material	32.6	25.1	29	21.9	12.6	13	29.8	31.6	26.4	21.1	28.7
Other cell cost	601.4	473	440.4	390.5	250.6	207.6	128.8	102	86	83.4	72.3
Pack cost	290	227.9	214.7	194.4	130.2	82	66.9	51.6	48.5	35.9	31

Source: IEA, 2022

Both the development in EV energy supply (renewable energy) and energy storage (battery) industries make it possible to offer EVs as a viable technological solution to environmental problems when the problem window of opportunity is open.

Problem window of opportunity

The problem window of opportunity opens in the problem stream and triggers the search for possible solutions to the problem (Zahariadis, 1996). "A "problem window" can open when an indicator worsens substantially [for example unemployment rate or emissions level] or when a crisis or feedback focuses attention on a specific problem" (Herweg et al., 2022, p. 208). Wherein the problem stream includes the conditions "that can turn into problems, which the political system then may have to deal with" (Herweg et al., 2022, p. 207). Technology innovators (TI) can couple industry trajectories with problem stream withing problem WoO and link a technological solution to a problem (Figure 1-3). In this case TI work as problem brokers (PB).

> "[In 2018] there was a lot of arguing between the ministers and between the car industry and the transport department, and [LEVC] company was one of the only companies because they only make range extended vehicles, so plug-in vehicles, that was like a compromise, "No, no, we're okay, we don't wanna argue, we just want you to actually do the strategy" (Int 24).

In 2018 LEVC coupled its technological solution (plug-in hybrid range-extender electric vehicle) with the problem stream (CO2 emissions in London) and is currently the third taxi fleet in London (LEVC, 2022b) that can be used in London's Low Emission Zone and is exempt from the scheme (LEVC, 2022a).

Linking a technology solution with a problem stream does not guarantee the policy change. For this reason, industry trajectories and the problem stream need to be coupled with the policy and politics

streams in a policy window of opportunity (Figure 1-3). If this happens, technology innovators operate not only as a problem broker but also as policy entrepreneurs. Bricoleurs provide a platform for PEs to compete wherein they recombine and present to policymakers PEs' problem frames and technological solutions that contribute to solving the policy problem.

Policy window of opportunity

The policy window of opportunity (pWoO) opens by cause of events within the politics stream or problem stream. In the politics stream, such events can be a change in the government or shift in national mood; within the problem stream, these can be the emergence of problems that become visible through focussing events (Kern & Rogge, 2018; Kingdon, 1995). The pWoO allows policy entrepreneurs to advocate policy solutions for the appropriate pWoO in order to be selected by policymakers, whilst policy entrepreneurs are not involved in the opening of the window (Ackrill & Kay, 2011; Kingdon, 1995). A pWoO which opens in the problem stream can be missed if there is no appropriate and well developed policy solution being offered (Kern & Rogge, 2018). If a pWoO is opened in the politics stream, then a solution can be selected first and only then the problem identified (Kern & Rogge, 2018; Zahariadis, 2014).

In the case under investigation the policy window of opportunity (pWoO) opened after the tWoO and problem WoO were opened, wherein the condition was framed as a problem, and a technological solution was identified and explained to the public.

> "There are a lot of incredibly difficult things that you need to do if you are going to meet net zero. Doing some of the ones, like moving to zero emission vehicles where there is technology solution and it is an option and you can do it, makes that more of a sort of no-brainer" (Int.27).

> "I think technologies are quite good at solving issues so they can almost come of need of public consensus but it's very iterative. You can shift the public opinion if the technology is helping, you can help them [technologies], you can shift the political thing if the public opinion changes and it is all needs to be iterative. If I was to pick one first it needs to be the sense that there is a problem that needs to be solved" (Int.27).

The pWoO led to policy change in the automotive industry and ultimately facilitate the specific technological solution to become a mainstream product.

Market window of opportunity

Ning, Sutherland and Fu (2017), Wei et al. (2020), and Lema, Fu and Rabellotti (2020) talk about the important role of the government in the emergence of a green market. Wei et al. (2020) frame this idea using the concept an institution-led market, that was partly confirmed by this research. In

the institution-led market, the government is concerned not only with an institutional/policy WoO, which refers to legislation, state procurement, resource provision, and administrative control, but also a market WoO, when the government uses mechanisms such as demand creation, resource allocation and regulation of market orders (Wei et al., 2020). The authors conclude that an institution-led market has a positive effect on the probability of newcomers becoming leaders, in the case of changes in the market and transitions to alternative technologies.

The link of government with a market window of opportunity is supported by empirical evidence. For example, the government creates conditions for increasing the demand for BEV through the announcement of plans to ban ICEs, infrastructure development, plug-in grants, or feed-in tariffs to reduce the cost of BEV ownership. In Table 3 it is possible to see a sharp increase in sales of BEV in 2020 following the release of decarbonisation policies such as the Road to Zero (Department for Transport, 2018) strategy and The ten point plan for a green industrial revolution (HM Government, 2020).

At the same time, it is worth mentioning that findings in the socio-technical transition literature identify three distinct government (policy) approaches: hands-off, enabling facilitator, and interventionist director. In the *hands-off* approach, firms do not experience tightly regulated markets; when acting as an *enabling facilitator*, the government becomes more involved in the functioning of the economic system; in the case of an *interventionist director* approach, the government directs innovation through public investment (Schmidt, 2002). According to Wesseling (2016), Kanger et al. (2019) and Sovacool et al. (2019) the regulatory environments for electric vehicles between 2008-2014 in the UK can be classified as *hands-off*. We note also that starting from 2017, after the publication of the Industrial Strategy (HM Government, 2017), the government's approach can be classified as interventionist director, when the government started to direct innovation via a more activist industrial policy. In 2018, the government then convened the Electric Vehicle Energy Taskforce, one of the key objectives of which was to bring together stakeholders from the automotive industry and energy sector and make proposals to the government. Later in 2019, a new Prime Minister took office, under whose leadership the most ambitious plan was released to ban the sale of petrol and hybrid vehicles from 2030 and 2035 respectively. The ten point plan for a green industrial revolution (HM Government, 2020) accelerated the transition to EVs.

Table 3, Vehicles registered for the first time by vehicle type in Great Britain 2005 to 2021, Percentage of total

Type of Vehicle	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Petrol	63	53	48	48	49	48	49	49	53	62	66	61	54
Diesel	37	46	50	51	50	50	48	47	42	31	26	18	11
HEV	0.22	1.09	1.21	1.22	1.28	1.49	1.68	1.91	2.83	3.69	4.72	10.13	15.69
PHEV	0.00	0.00	0.00	0.02	0.03	0.27	0.66	0.99	1.29	1.78	1.51	4.09	6.87
Battery electric	0.01	0.01	0.06	0.08	0.12	0.27	0.38	0.39	0.55	0.67	1.64	6.59	11.47
Range extended electric	0.00	0.00	0.00	0.03	0.02	0.06	0.07	0.07	0.10	0.09	0.01	0.00	0.00
Fuel cell electric	0	0	0	0	0	0	0	0.001	0.001	0.002	0.003	0.004	0.001
Gas vehicles	0.022	0.007	0.006	0.004	0.001	0.002	0.002	0.001	0.001	0.004	0.001	0.048	0.141
New fuel technologies and steam	0.001	0.004	0	0	0	0	0	0	0	0	0	0	0
Zero emission	0.01	0.01	0.06	0.08	0.12	0.27	0.38	0.39	0.55	0.67	1.64	6.59	11.47

Source: Department for Transport, 2022

Multi-level governance and strategy framework

In order to take a comprehensive look at transformation of the automotive industry in the UK, we developed the Multi-level Governance and Strategy (MLGS) model: Figure 2. MLGS syntheses the multiple streams framework, multilevel perspective framework, multi-level governance theory and multiple windows of opportunity identified through grounded theory. MLGS can be used as a tool in strategic planning and at the agenda setting and evaluation stages of policymaking.

In the MLGS model the window sees coupling not only of the problems, policies, politics streams, but also industry level trajectories (Figure 1-3). Perpendicular to the industry trajectories described above are technological windows of opportunity (green frames), problem windows of opportunity (red frames), policy windows of opportunity (blue frame) and market windows of opportunity (orange frame) identified in the interviews. Industries associated with energy supply, energy storage and vehicle manufacturing, selected in accordance with interview data, are the renewable energy industry (energy supply), fuel industry (energy storage) and automotive industry. Each of the trajectories includes information about the policies related to the industry, as well as the strategic and technological actions of key industry stakeholders. Information related to policies (the result of coupling streams) is located at the governance level, which in turn is divided into global, EU, national and local levels (Figure 2-3). Information related to the actions of stakeholders is located at the incumbent level, which includes strategic actions and technological actions of incumbent actors. Niche innovations are located at the technological niche level.

The policies and politics streams refer only to the governance level of industries' trajectories and correspond to MSF logic (Figure 1, right view). The problem stream is divided into two parts, one part includes focusing events and is linked with the governance level of industries trajectories (Figure 3). The second part includes the actions of problem brokers and is linked to the incumbent level and the technological niche level of industry trajectories. This arises from the analysis of the interviews and FOI data, which indicated that BEV technology innovators acted as problem brokers, framing events as social problems and linking them with their technological solutions in order for bricoleurs and policymakers to accept these frames and include them in policy proposals and, subsequently, policies.

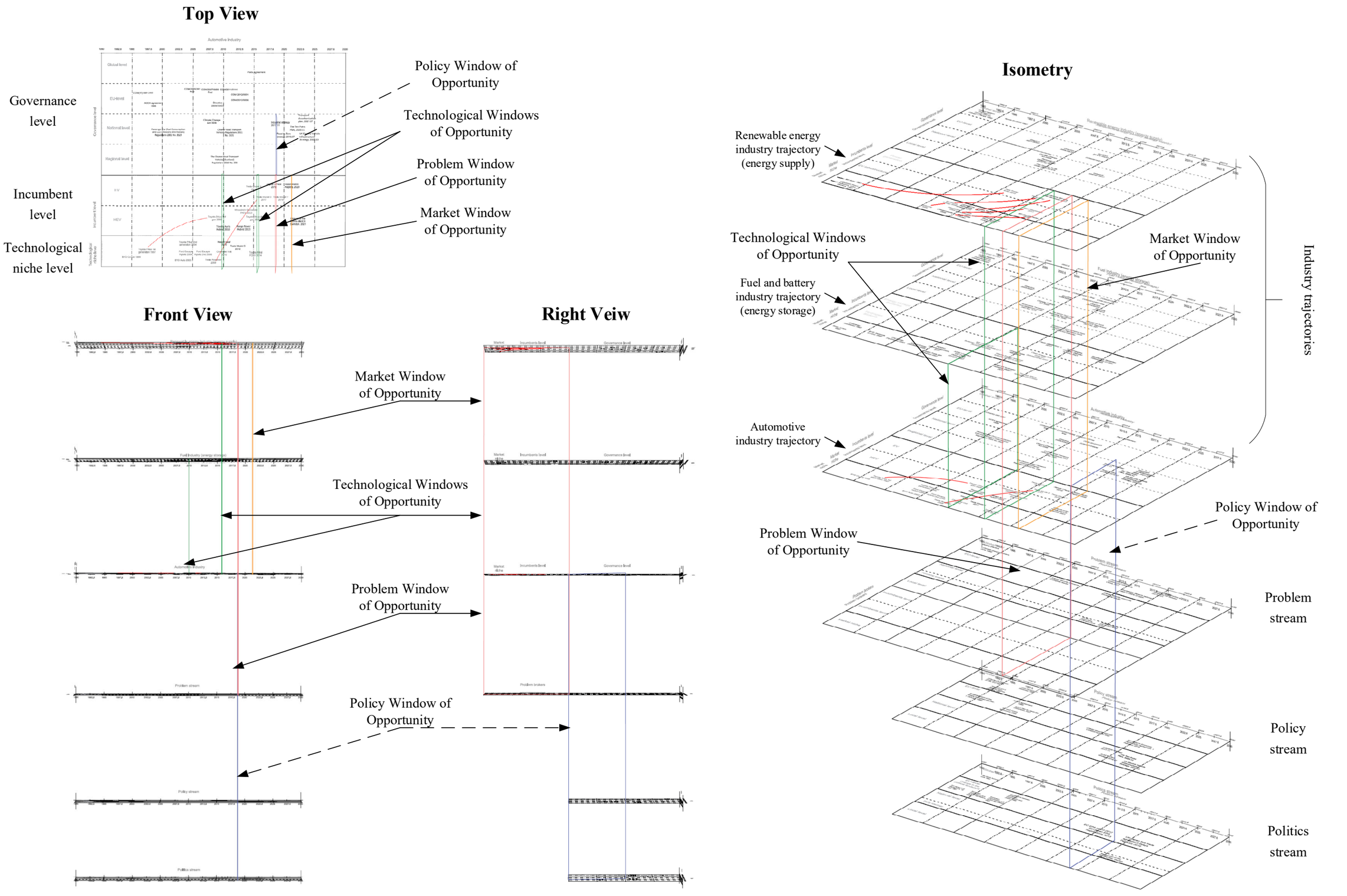

Figure 1 Multiview projection and isometry of MLGS

Automotive industry trajectory
Top view

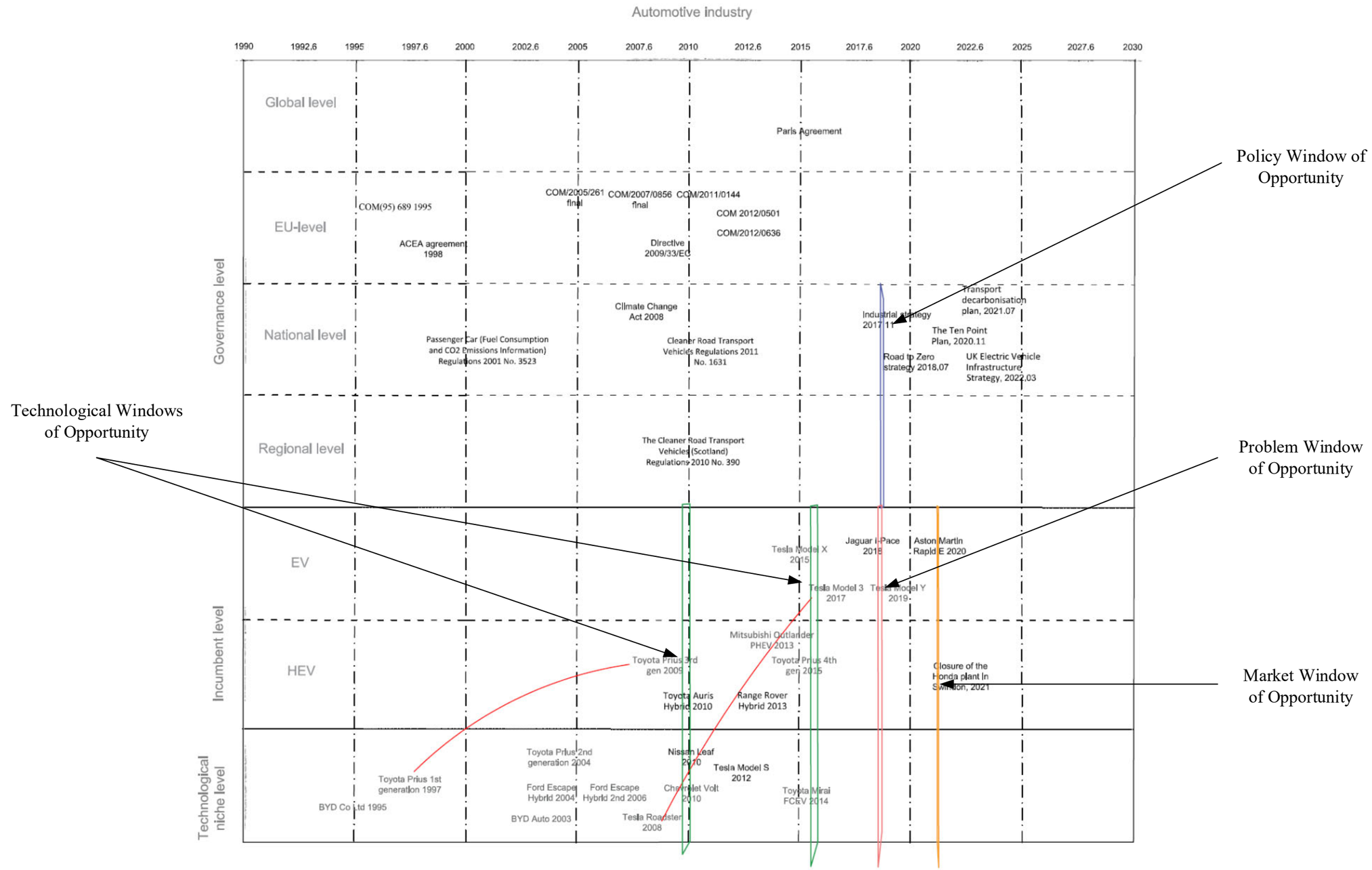

Figure 2 Automotive industry trajectory, top view

Problem stream
Top view

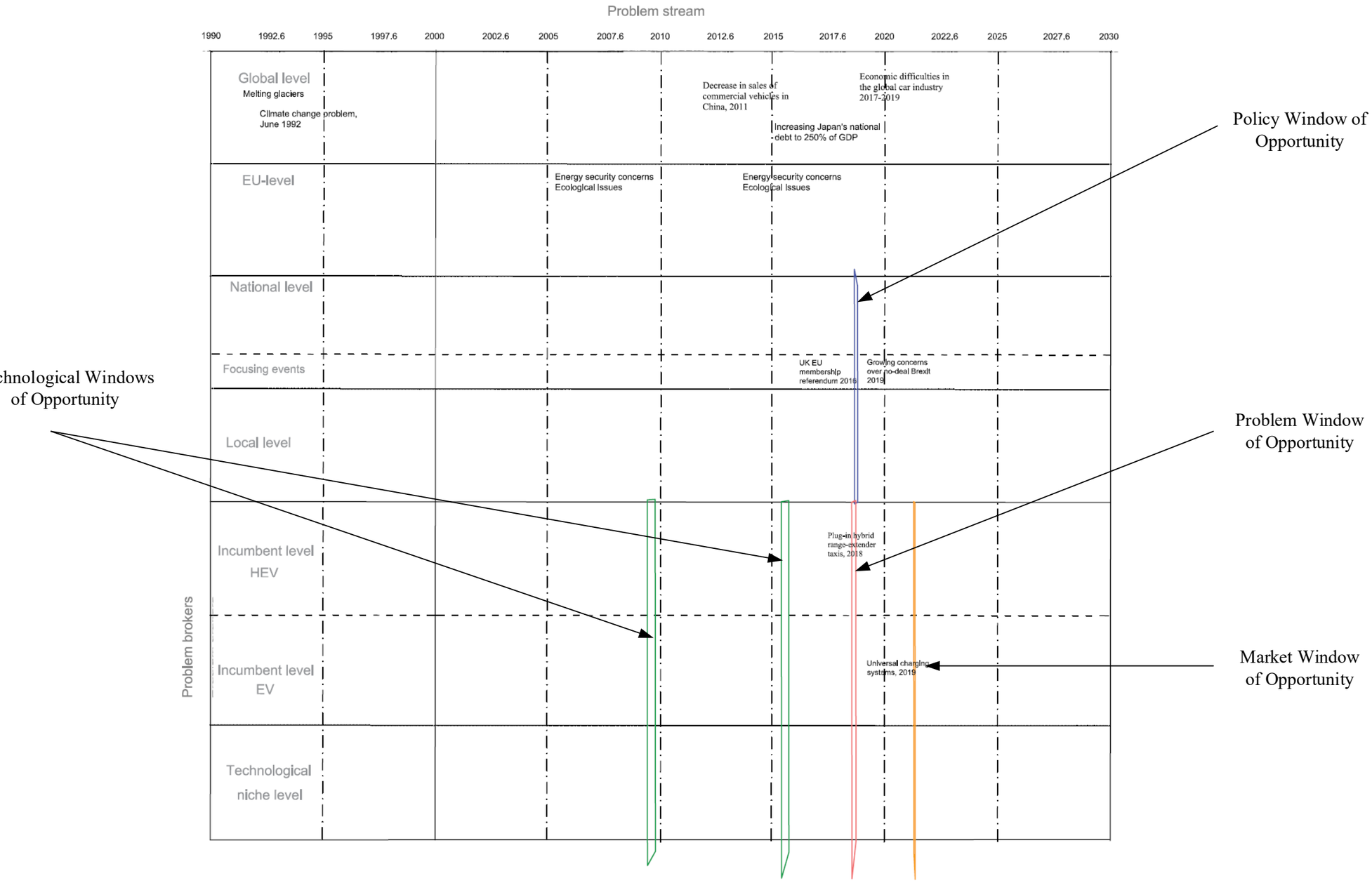

Figure 3 Problem stream, top view

4. Who are the key agents that are in play inside each WoO?

Analysing 48 interviews, as well as minutes, presentations and reports from the 15 steering group meetings of the Electric Vehicle Energy Taskforce (EVET), over 2018-2020, the following agents were identified:

- Policymakers;
- Policy entrepreneurs at the national level (Policy WoO);
- Bricoleurs at the national level (Policy WoO);
- Knowledge brokers;
- Problem brokers;
- Technology innovators (Technological WoO, Market WoO).

Below we provide definitions of each agent-type based on the literature review and the analysis of primary data.

Policymakers – individual or group of individuals involved in formulating, developing or amending policy, for example, Head of the Government High-Profile Group (Head of Office for Zero Emission Vehicles), Ministers of Government (Secretary of State for Transport)

Policy entrepreneurs at the national level (PE) – individual or group of individuals who work outside the formal governmental system to introduce, translate, and implement innovative ideas into public sector practice (Roberts & King, 1991). Policy entrepreneurs couple problem, politics and policy stream within window of opportunity (WoO) opened in problem stream (problem WoO) or politics stream (politics WoO). PE can set proposals to the government and they have a clear policy preference on how to solve the problem. They can include for example, Senior Managers of Carmakers (Government Affairs & Relations Manager, Senior Project Developer).

Bricoleurs at the national level (BN) – individuals or group of individuals who work inside or outside the formal governmental system. Bricoleurs make suggestions for particular policies based on their knowledge, knowing which policy ideas the policymakers are ripe to, wherein they recombine policy ideas into bespoke policy solutions that fit a specific problem and which are capable of solving it. Bricoleurs couple problem and policy streams within the problem WoO by formulating a bespoke policy solution (Deruelle, 2016). Bricoleurs can be for example, government researchers, the Chair of Taskforce, or the Senior Manager of Low Carbon Vehicle Partnership.

Knowledge brokers (KB) – work outside the formal governmental system and frame knowledge in order for it to be understandable in the political world (Zohlnhöfer & Rüb, 2016). They supply the concise evidence that is most relevant to understanding the problem (Cairney, 2018) and tend to be

neutral toward the problem, without partisanship (Pielke Jr, 2004). Litfin (1994) associated KB mainly with scientists. For example, knowledge brokers can be numerous scientists cited in policy proposals. Knowledge brokers do not couple the streams.

Problem brokers (PB) – individuals or group of individuals who work outside the formal governmental system and frame the problems within the problem stream based on their values, emotions and knowledge (Baumgartner & Jones, 2010; Kingdon, 2014; Wildavsky, 1979). Problem brokers avoid acting as policy entrepreneurs (Angervil, 2021; Knaggård, 2015) and do not set policy proposals directly to the government . They do not couple the politics and policy streams themselves but prefer to work closely with policy entrepreneurs, who are capable of doing so and who set policy proposals to the government. Problem brokers can facilitate opening problem WoO and couple a specific technological solution with a specific problem. For example, problem brokers can be NGOs.

Technology innovators (TI) – individuals or group of individuals who work outside the formal governmental system and who are involved in creating innovations withing the industry trajectory; for example, carmakers' officials or entrepreneurs. TI couple industry trajectories in multiple industries within the technological WoO. This allows TI to produce technical solutions to anticipated problems. In the case of the development of the UK electric vehicle infrastructure strategy, the technological window of opportunity (tWoO) was associated with the development of microelectronics and software in the electronics sector, which was subsequently adapted to transport (Int. 17, 19); decarbonisation of electricity resulting from the development of renewable energy; development of communication protocols between electric vehicles and charge stations; and the development of energy storage technologies - batteries (Int. 23, 15). If TI work as problem brokers, then they can frame a condition as a problem, they have a clear technological preference on how to solve the problem, and then they can couple the technological trajectory with the problem stream when the problem WoO is open. Problem WoO can be open for example by some focusing event, such as an energy crisis or the publication of environmental statistics. Examples of TI include Senior Managers of Carmakers (Project Managers, Senior Project Developer, Senior Engineers, CEOs).

It is important to outline who were policymakers and what policies they developed. The case under investigation focuses on the period 2017-2022, where most of the archival data and interviews were collected. During this time multiple policies were released which outlined the government's shift from low emission vehicles to zero emission vehicles. Such policies include the Industrial Strategy (HM Government, 2017), the Road to Zero Strategy (Department for Transport, 2018), The Ten

Point Plan for a Green Industrial Revolution (HM Government, 2020) and the UK Electric Vehicle Infrastructure Strategy (Department for Transport, 2022b). Policymakers responsible for the development of a specific policy, as well as policy priorities, are depicted in Table 4 and Table 5.

Table 4 Policymakers and policy papers

Date of release	**Title of policy paper**	**Secretary of State**	**Department**
27 November 2017	The UK's Industrial Strategy	Rt Hon Greg Clark MP (Conservative Party)	Business Energy and Industrial Strategy (BEIS)
9 July 2018	Road to Zero Strategy	Rt Hon Chris Grayling MP (Conservative Party)	Department for Transport (DfT); and Office for Low Emission Vehicles (OLEV)
18 November 2020	The Ten Point Plan for a Green Industrial Revolution	The Rt Hon Alok Sharma MP (Conservative Party)	Business, Energy and Industrial Strategy
25 March 2022	UK Electric Vehicle Infrastructure Strategy	Rt Hon Grant Shapps MP (Conservative Party)	Department for Transport

Table 5 Policy priorities

Policy paper	**Policy priority linked with transformation of the automotive industry**
The UK's Industrial Strategy	"support electric vehicles through £400m charging infrastructure investment and an extra £100m to extend the plug-in car grant", making "25% of all cars in the central government department fleet ultra-low emission by 2022" (HM Government, 2017, pp. 50, 128)
Road to Zero Strategy	"put the UK at the forefront of the design and manufacturing of zero emission vehicles, and for all new cars and vans to be effectively zero emission by 2040" (Department for Transport, 2018, p. 2)
The Ten Point Plan for a Green Industrial Revolution	"end the sale of new petrol and diesel cars and vans from 2030", "allow the sale of hybrid cars and vans that can drive a significant distance with no carbon coming out of the tailpipe until 2035" (HM Government, 2020, p. 14)
UK Electric Vehicle Infrastructure Strategy	installing a minimum of 300,000 public chargepoints by 2030, "but there could potentially be more than double that number" (Department for Transport, 2022b, p. 44)

In the archival data (shown below), DfT, BEIS and OLEV are constantly referred to as the Government, which can support the assumption that these stakeholders can be considered as policymakers.

> "Government updates: OLEV & BEIS update; XXX provided an update for OLEV" (FOI 15 Minutes 28 Apr 2020).

> "EVET [Electric Vehicle Energy Taskforce] was convened by the Office for Low Emission Vehicles (OLEV) in 2018, at the request of ministers from BIES and DfT, with the objective of making proposals to Government and Industry on 'how to ensure the GB energy system is ready for and able to best exploit the mass take up of electric vehicles?'" (FOI 13 Project Proposal Mart 2020).

The next agents that were identified are bricoleurs. Based on primary data we found that in the case of the transformation of the UK automotive industry, bricoleurs work outside the formal governmental system in the policy hub. In particular there is the Electric Vehicle Energy Taskforce (EVET), whose work is supported and led by senior representatives of bodies such as the Low Carbon Vehicle Partnership (now ZEMO Partnership) and the Energy Systems Catapult (Energy Systems Catapult, n.d.).

In 2002, a public-private partnership, the Low Carbon Vehicle Partnership (LowCVP), was established "to accelerate the shift to low carbon vehicles and fuels" (Zemo Partnership, 2022). Before 2018 the LowCVP focused on low emission technologies such as hybrid vehicles, renewable energy and biofuels. The organisation was effective with its roles as, despite the total number of licensed vehicles increasing by 27%, overall emissions fell by 19% from 2002 to 2021 (Department for Transport, 2021; National statistics, 2021). In 2020 LowCVP was renamed Zemo Partnership "to show raised zero emissions ambition " (Zemo Partnership, 2022). This has proven to be a very important body, and conduit for conveying information, analysis and policy ideas directly into government. The new Chair Philip Sellwood was named in 2020 to work closely with the government and the widest range of stakeholders "to deliver progress in the transition to net zero in road transport" (LowCVP, 2020). The previous Chair Darran Messem in his congratulations mentioned the following

> "Since I became LowCVP's Chair, the UK has made significant progress in the decarbonisation of transport, particularly in the moves to more efficient new vehicles, electrification and increased use of lower-carbon transport modes. Delivering change in transport is a team effort, and while LowCVP cannot take all the credit for this progress it certainly has played a vital part… I'm confident LowCVP will continue to play an important part" (LowCVP, 2020).

Before publication the Road to Zero strategy in 2018 the UK Government were technologically neutral however after publication Road to Zero strategy the specific solution was chosen.

> "As part of that [Industrial Strategy], our UK Plan for Tackling Roadside Nitrogen Dioxide Concentrations … and Clean Growth Strategy will cut exposure to air pollutants, reduce greenhouse gas emissions and improve our energy security. Now we want to go further still … and to put the UK at the forefront of the design and manufacturing of zero emission vehicles" (Department for Transport, 2018).

Moving on to the analysis of interview data with Head of the government office it is possible to say that the official has a clear preference on how to solve the problem.

> "I think we're at the moment [late 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).

In the steering group minutes (FOI 15 28 Apr 2020) officials from OLEV and BEIS were presented. The following record were made in the government perspective section - "Noted that the new DfT Minister…is very keen on electrification of transport." (FOI 15 28 Apr 20). This is another indication that the government official has a clear preference on how to solve the problem. It also reaffirms the importance of having key individuals in key roles to push forward the relevant agenda for reform. Assuming that the goal of the policymaker at national level was not only to reduce emissions from transport, but also shift to electric vehicles, organisations that recombine policy ideas into bespoke policy solutions and help the government to achieve its goal can be seen as bricoleurs.

In 2018, the Taskforce was established to publish "a comprehensive set of proposals to Government and industry to ensure the electricity network is ready for the mass take up of electric vehicles" (Zemo Partnership, 2020). The policymakers have a clear goal to shift from ICE to EV and the Taskforce have to make suggestions for particular policies based on their knowledge, knowing that policymakers are ripe to EVs. Thus recombining policy ideas into bespoke policy solutions that fit to the problem of shift toward net zero technologies and are capable of solving it, are likely to be very positively received. It is a problem solving agent that does not focus on one specific policy solution but rather on combination of policy solutions suggested by EV stakeholders. Thus it is possible conclude that the Taskforce acted as an external bricoleur, outside of the government system.

In confirmation of this, consider the quote from Taskforce Work Package 2 (WP2), below. WP2 was presented to policymakers (OLEV and BEIS) by a senior Taskforce official on 16th March 2020 (FOI 13 Minutes 16 March 2020)

> "The definition of public chargepoint under the Alternative Fuel Infrastructure Regulations excludes networks that are for the drivers of a particular vehicle brand or company (for instance Tesla's Supercharger network). However, Work Package 2 would encourage the development of a universal [charging] system in time, for the benefit of all EV drivers" (FOI 13 WP2).

It is possible to see that not all of the technological solutions that were coupled with the problem stream by technology innovators were included in the Taskforce policy proposals. In this way, Taskforce members recombine policy ideas into policy solution that can be accepted by policymakers. It is worth noting that three major EV carmakers were members of the core group in WP2. WP2's statement on the development of a universal charging system indirectly indicates the contribution of two of these OEMs, that themselves do not have their own dedicated charging network. The example of Taskforce policy proposals to the government shown below.

> "PROPOSALS:
>
> 1. The Government must set clear annual targets (or scenarios) for EV adoption (and associated infrastructure), in accordance with transport policy
>
> 2. The Government (or delegated body) must track and openly publish monthly data on EV adoption (and associated infrastructure)" (FOI 14 WP4).
>
> "Proposal 8: OLEV (and any agency established to oversee cyber security for smart charging) should conduct a review based around international standards and identify a 'preferred' option that receives support…" (FOI 14 WP3).

The next agents identified are policy entrepreneurs. Following Cohen & Naor (2013), the CEOs of EV companies can act as policy entrepreneurs, which means that they are directly involved in policy making and are capable of coupling the politics, policy and problem streams. In the interview data there is a statement showing openness of the government official in OLEV for cooperation and the possibility of carmakers to interact with policymakers.

> "I really thinking about how they [carmakers] can work with government because there's a lot of will to do this and that means they have quite a lot of leverage so if they want to ask for things they have that ability to. So, I think that they should be not looking to slow things down and lean into it and this is what we need in order to make this [decarbonisation] happen and they are increasingly doing that I hasten to add" (Int.27).

An expert from the government Innovative fund Innovate UK, also suggested that carmakers can be policy entrepreneurs.

> "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)

Analysing minutes, reports and interviews this study cannot confirm that in the UK case carmakers' officials send policy proposals directly to policymakers at the national level, via emails or by phone. They rather act through the Taskforce and coupled technological solutions with policy problems

and framed the problem associated with the transition to technology in the Taskforce documents. Later Taskforce policy proposals were presented to policymakers by a senior member of the Taskforce.

The significance of having OEMs in the WPs can be seen in several ways. For example, in Work Package 4, an official from one major EV OEM contributed to the question on "How can data help remove barriers/ease access to getting a connection for EV charging infrastructure (and help inform EV infrastructure investment decisions)?" (FOI 13 WP3). In addition, several carmakers' representatives were members of the core group in Work Package 2 (FOI 5 WP2) – "Engaging EV users in smart charging and energy services". In the EVET meeting of July 2019, based on personal observation, it was confirmed that carmakers can frame the problem and address them to the members of the Taskforce, who then included these in their work packages.

In this way, the issues associated with using the protocols of communication between EVs and charging stations discussed in the meeting, and later, were included in the proposal of work package 3 (FOI 13 WP3). Based on archival data, interviews and personal observation it is possible to conclude that carmakers work as technology innovators, problem brokers and policy entrepreneurs at the EVET meetings contributing to policy proposals. In this case the PE's policy ideas were included in work package, presented to policymakers and included in the policy paper. Thereby carmakers are seen to act as policy entrepreneurs, coupling the problem, policy and politics stream via bricoleurs using the EVET platform.

Scientist and academics participated in Taskforce meetings (FOI 13 WP1, FOI 13 WP2, FOI 13 WP4), but also there were numerous scholars cited in the Taskforce WPs. Scientists who frame knowledge in order to be understandable in the political world (Zohlnhöfer & Rüb, 2016) and are neutral toward the problem (Pielke Jr, 2004) are classified as knowledge brokers. Scientist and academics who frame a condition as a problem by connecting *emotions, values* and scientific *knowledge* (Baumgartner & Jones, 2010; Kingdon, 2014; Wildavsky, 1979) are classified as problem brokers.

5. What does it mean for the relevant actors and their interrelations within a particular 'window?

The discussion below reflects the idea that a distinction can and perhaps should be drawn between policy entrepreneurs as individuals, and policy entrepreneurship as a process, "allowing us to isolate different facets of entrepreneurial activity" (Ackrill & Kay, 2011, p. 74).

In Figure 4 we depict a policy entrepreneurship process that leads to coupling problem, politics and policy streams by policy entrepreneurs and bricoleurs. Technology innovators work within the technological stream and couple industry trajectories in order to produce technological solutions. Technology innovators can act as problem brokers if they frame a condition as a problem and link their technological solution with this problem. Where technology innovators go further and include a technological solution into EVET's policy proposal to the government, they will be acting as policy entrepreneurs.

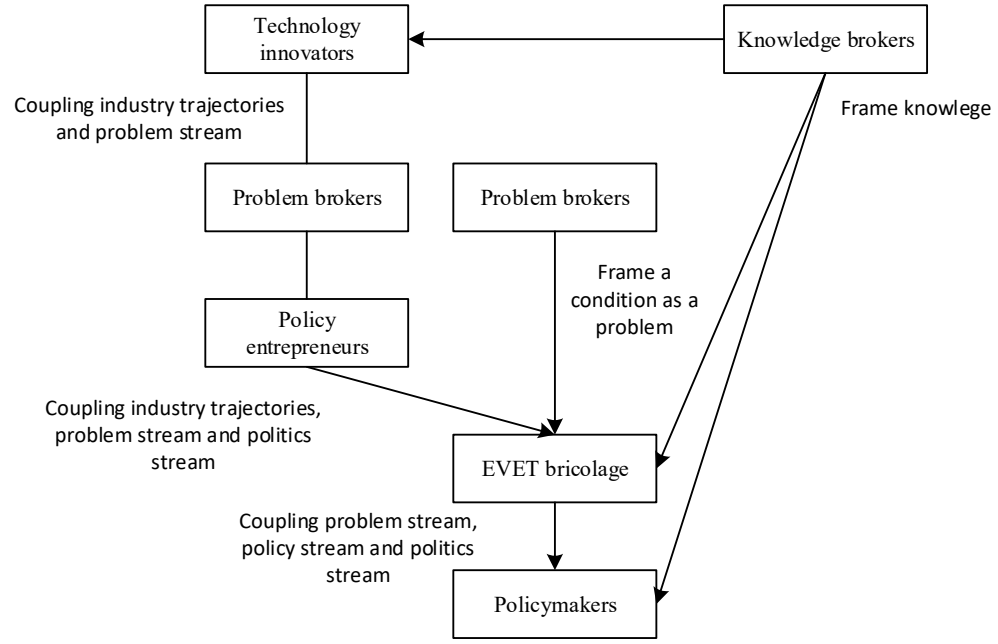

Figure 4 Policy entrepreneurship process during the transformation of the automotive industry in the UK over the period 2018-2020

EVET provides a platform for PEs, where a policy idea offered by the PE is included in EVET Work Package, presented to policymakers and included in a policy paper. Then the problem, politics, policy streams and industry trajectories are being coupled. Table 6 summarises the characteristics of agents identified in the case and their interaction in a particular window.

Table 6 Summary of agents identified in the case

Agent	**In which window couple streams**	**What streams couple**	**In which stream work**	**Inside or outside the government systems**	**Type of leadership**	**Preference to a specific solution**	**Type of solution – technological or policy**
Policy entrepreneurs at the national level	Problem, Politics	Policy, problem, politics and industry trajectories	Problem, Policy, Industry Trajectories	Outside	Appointed leadership, senior managers of carmakers	Has preference	Technological and policy solution
Bricoleurs at the national level	Problem, Politics	Policy, problem, politics	Policy	Outside	Appointed leadership	Preference ripe to policymakers	Technological and policy solution
Knowledge brokers	na	na	Frame knowledge	Outside	na	No preference	na
Problem brokers	na	na	Problem	Inside and outside	Appointed leadership	Has preference	Policy and technological solution
Technology innovators	Technolo-gical	Industry trajectories	Industry trajectories	Outside	Appointed leadership	Has preference	Technological solution

Bricoleurs at the national level work within the policy stream and couple the policy, politics and problem streams when a problem or politics window of opportunity opens in the problem stream or politics stream, respectively. Policy entrepreneurs work within policy stream and couple policy, politics and problem stream. In addition, policy entrepreneurs who act as TI couple industry trajectories within a technological window of opportunity when they produce an innovative technological solution. Technology innovators who do not act as PE only produce technological solutions. Problem brokers do not couple the politics and policy streams, but they can frame conditions, as a policy problem in the problem stream, then facilitate opening a problem WoO and couple their technological solution with the problem. Knowledge brokers do not work in any of the streams but frame the knowledge to make it easier for technology innovators, bricoleurs and policymakers to understand it.

PEs routinely act as problem brokers. Indeed, identifying an issue as a problem is a key role assigned to PEs in their acting as a PE. Given the earlier definitions of, and distinctions between, PEs and PBs, however, PEs then go on to propose/promote particular policy solutions. Knaggård (2015), Maltby (2021), Eckersley & Lakoma (2021) and Wikström, Eriksson and Hansson (2016) write specifically about PEs acting as PBs. Based on the empirical data we elaborate the PB concept a little bit further. We find that PB can work with technology innovators (TI) or as TI who couple the problem stream with the technology stream under a problem WoO. The PB role can be thought

of as one specific subset of activities that the PE or TI undertakes, and it remains strictly a PB role only if the MSF actor just engages in problem brokerage.

However, PBs play an important role in policy change as their actions can facilitate opening a problem WoO and framing the problem around technological solution, or coupling the technological solution with a policy problem. Later this technological solution can be included in policy proposals by bricoleurs or PEs. In our empirical case, this led to the policy proposal reaching the top of the agenda of policymakers (DfT), that led to the release of the policy paper with PE's policy idea included in it. For example, the idea of the development of a universal charging system was reflected in strategic vision of "fairly priced and inclusively designed public charging" in the UK wherein "most EVs can now be charged at all devices on the UK public network due to increased standardisation of connectors" (Department for Transport, 2022b, pp. 5, 26).

In the case under investigation, the technological WoO opens first, then the problem WoO and policy WoO, then finally the market WoO, which ultimately facilitates the technological solution to become a mainstream product.

6. Conclusion

Analysing interview data, archival data and secondary materials, the answers to the three research questions can now be provided provided.

RQ1: What is the relationship between technological, policy and market windows of opportunity with industry trajectories and multiple streams?

Technological windows open in a related industry and are associated with the development of a breakthrough technology in related industries that complement the automotive industry, standardisation of fuel/energy infrastructure required to specific technology, reduction of battery costs, and decarbonisation of the energy supply. An open technological window couples industry trajectories, which subsequently leads to the development of a prototype/demonstration fleet. Coupling industry trajectories with the problem stream mobilises expert opinion and frames the technology as a solution to the policy problem. This technological solution could later be included in the EVET policy proposal by bricoleurs and reach the top level of the agenda of policymakers.

In this case by technology innovators work as problem brokers and policy entrepreneurs. For example, the idea of the development of a universal charging system was reflected in the strategic vision of a "fairly priced and inclusively designed public charging" in the UK wherein "most EVs

can now be charged at all devices on the UK public network due to increased standardisation of connectors" (Department for Transport, 2022b, pp. 5, 26). With the policy change towards specific technology solutions, the market WoO is opened, contributing to an increase in the market share of a specific technology and making the technological solution a mainstream product.

RQ2: Who are the key agents that are in play inside each WoO?

In the case of transformation the automotive industry in the UK between 2017-2022 the following agents were identified:

- Policymakers;
- TI and PB who work as policy entrepreneurs in problem of politics WoO;
- Bricoleurs at the national level who operate within problem of politics WoO; ,
- Knowledge brokers do not work in any of streams;
- Problem brokers do not couple the streams;
- Technology innovators who operate within technological WoO; ,

RQ3: What does windows of opportunity mean for the relevant actors and their interrelations within a particular window?

Agents identified in each window have different agency:

- TI and PB work as policy entrepreneurs at the national level, coupling policy, politics and problem streams where their policy idea was included in EVET policy proposal;
- Bricoleurs at the national level recombine policy solutions and couple policy, politics and problem streams;
- Knowledge brokers frame the knowledge make it easier for technology innovators, bricoleurs and policymakers to understand it;
- Problem brokers frame conditions as a policy problem in problem stream, can facilitate opening problem WoO and couple technological solution with problem stream;
- Technology innovators carmakers officials who do not act as PE and PB, and only produce technological solutions.

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Appendix 1 List of participants

Table 1 List of participants in the pilot study

Int. No	Data collect. stage	Industry	Position classifier	Position name
10	Pilot Study	Consulting in auto industry (C)	Specialist	Technical Specialist
9	Pilot Study	Transport planning (TP)	Specialist	Transport Planner at government organisation
8	Pilot Study	Research funding (Fn)	Manager	Regional Manager at government research funding organisation
7	Pilot Study	Automotive (A)	Specialist	Product Specialist of a carmaker
6	Pilot Study	EV infrastructure (I)	Manager	Project Manager at electric vehicle infrastructure company
5	Pilot Study	Biotech (B)	Manager	Business Development Manager at engineering company (brewing and biotech)
4	Pilot Study	Automotive (A)	Specialist	Engineer at multinational engineering company
3	Pilot Study	Academia (R)	Specialist	Researcher, Civil Engineering
2	Pilot Study	Oil and Gas (F)	Senior manager	Senior Manager at Oil and Gas company
1	Pilot Study	Academia (R)	Head	Vice-Dean at a University

Table 2 List of participants in the second round of interviews

Int. No	Data collect. stage	Industry	Position classifier	Position name
30	Second round	Battery recycling (BR)	Specialist	Engineer at battery recycling company
29	Second round	Automotive (A)	Manager	Manager, carmaker
28	Second round	Research funding (Fn)	Manager	Manager, government research funding organisation in auto industry
27	Second round	Policymaker (P)	Head	Head of Government Office
26	Second round	Automotive (A)	Senior manager	External and Government Affairs Manager, carmaker
25	Second round	Automotive (A)	CEO	CEO of engineering company in auto industry, consulting company
24	Second round	EV infrastructure (I)	Senior manager	Policy Director in EV infrastructure company

Int. No	Data collect. stage	Industry	Position classifier	Position name
23	Second round	Battery (Li)	Head	Head of department in battery cell manufacturing company
22	Second round	Energy (E)	Head	Head of department in energy engineering company
21	Second round	Transport planning (TP)	Manager	Decarbonisation Programme Manager at government transport planning organisation
20	Second round	Transport planning (TP)	Senior manager	Chair of the Sustainable Transport Panel at government transport planning organisation
19	Second round	Consulting in auto industry (C)	CEO	CEO of strategic planning and management consulting company in auto industry
18	Second round	Consulting in auto industry (C)	CEO	Co-founder vehicles, renewable energy and project management consulting company
17	Second round	Consulting in auto industry (C)	Head	Head of innovation hub for technology companies
16	Second round	EV infrastructure (I)	Senior manager	Senior Director European Policy at electric vehicle infrastructure company
15	Second round	Battery (Li)	Manager	Account Manager within the Battery Materials business
14	Second round	Academia (R)	Senior manager	Senior Research Associate at a University
13	Second round	Consulting in auto industry (C)	Specialist	Sustainability consultant
12	Second round	Consulting in auto industry (C)	Specialist	Industrial waste and sustainability consultant
11	Second round	Academia (R)	Specialist	Researcher, Green hydrogen production for maritime transport

The Conference on Policy Process Research 2023

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Agency and agents in multiple windows of opportunity: decarbonising the automotive industry in the UK

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Policymakers and policy papers linked with transformation of the automotive industry in the UK between 2018-2022

Date of release	Title of policy paper	Secretary of State	Department
27 November 2017	The UK's Industrial Strategy	Rt Hon Greg Clark MP (Conservative Party)	Business Energy and Industrial Strategy (BEIS)
9 July 2018	Road to Zero Strategy	Rt Hon Chris Grayling MP (Conservative Party)	Department for Transport (DfT); and Office for Low Emission Vehicles (OLEV)
18 November 2020	The Ten Point Plan for a Green Industrial Revolution	The Rt Hon Alok Sharma MP (Conservative Party)	Business, Energy and Industrial Strategy
25 March 2022	UK Electric Vehicle Infrastructure Strategy	Rt Hon Grant Shapps MP (Conservative Party)	Department for Transport

Policy priority in policy papers creating a market for zero tailpipe emissions vehicles in the UK

Policy paper	**Policy priority linked with transformation of the automotive industry**
The UK's Industrial Strategy	“support electric vehicles through £400m charging infrastructure investment and an extra £100m to extend the plug-in car grant”, making “25% of all cars in the central government department fleet ultra-low emission by 2022” (HM Government, 2017, pp. 50, 128)
Road to Zero Strategy	“put the UK at the forefront of the design and manufacturing of zero emission vehicles, and for all new cars and vans to be effectively zero emission by 2040” (Department for Transport, 2018, p. 2)
The Ten Point Plan for a Green Industrial Revolution	“end the sale of new petrol and diesel cars and vans from 2030”, “allow the sale of hybrid cars and vans that can drive a significant distance with no carbon coming out of the tailpipe until 2035” (HM Government, 2020, p. 14)
UK Electric Vehicle Infrastructure Strategy	installing a minimum of 300,000 public chargepoints by 2030, “but there could potentially be more than double that number” (Department for Transport, 2022, p. 44); standardisation of connectors of all devices on the UK public network (Department for Transport, 2022, pp. 5, 26).

Agents identified in the case of transformation the automotive industry in the UK between 2018-2022

Policymakers – *senior officials of the Department for Transport (DfT), Office for Low Emission Vehicles (OLEV), Department for Business, Energy & Industrial Strategy (BEIS);* individuals involved in formulating, developing or amending policy

Policy entrepreneurs at the national level – *senior officials of carmakers*; individuals who work from outside the formal governmental system to introduce, translate, and implement innovative ideas into public sector practice (Roberts and King, 1991)

Bricoleurs at the national level – *senior representatives of bodies of the Electric Vehicle Energy Taskforce (EVET);* individuals who make suggestions for particular policies based on their knowledge, knowing which policy ideas the policymakers are ripe to, wherein they recombine policy ideas into bespoke policy solutions that fit a specific problem and which are capable of solving it (Deruelle, 2016)

Knowledge brokers – *scientist;* individuals who frame only knowledge in order to be understandable in the political world (Zohlnhöfer & Rüb, 2016)

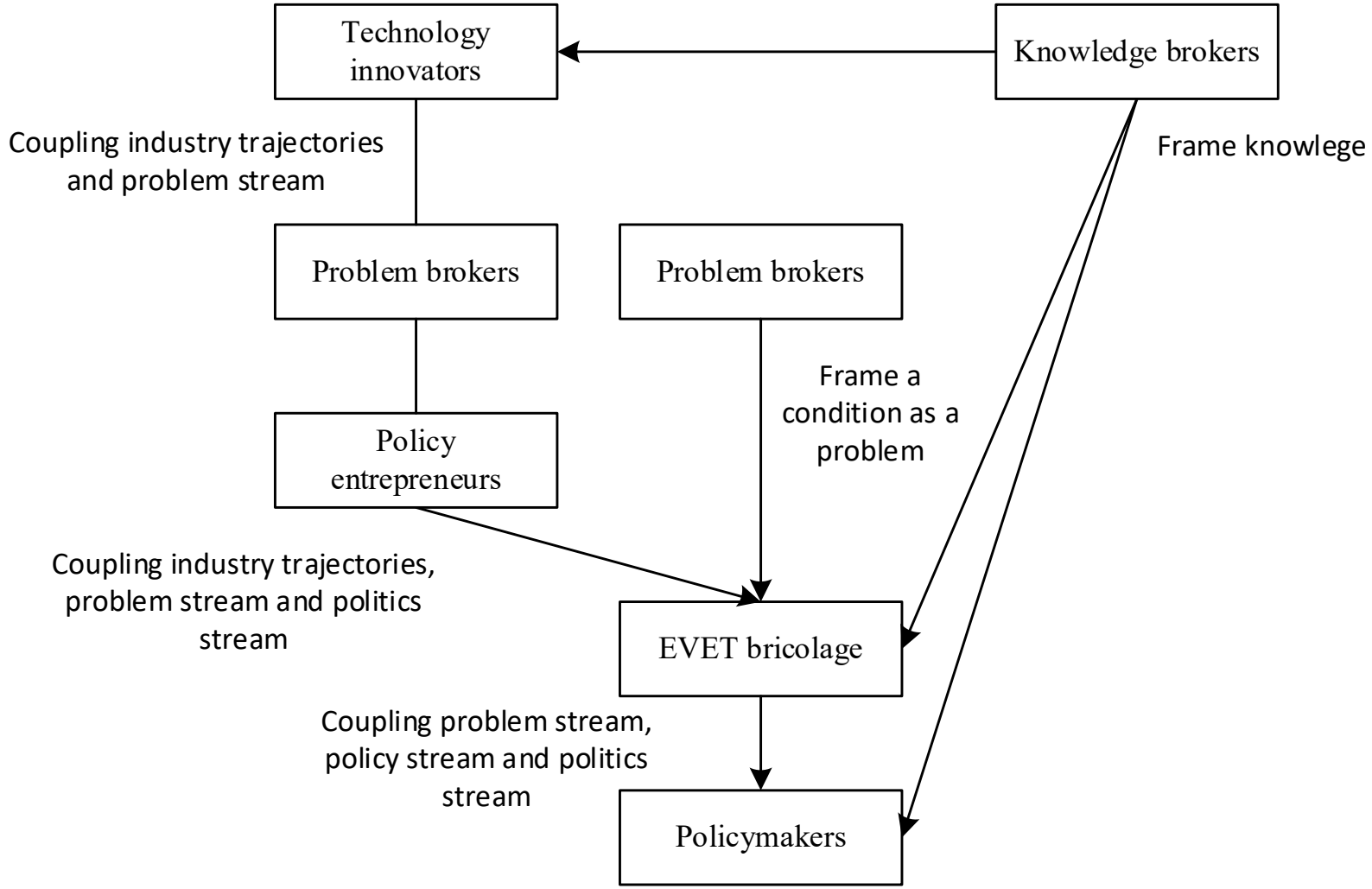
Problem brokers – *senior officials of carmakers, scientist;* individuals who operate by connecting values, emotions and knowledge in order to frame a condition as a problem (Knaggård, 2015)

Technology innovators – *senior officials of carmakers;* individuals whose entrepreneurial activities related to the technology stream and focusing on the promotion the innovation by coupling "a technology narrative with a socio-political agenda" (Goyal, Howlett and Chindarkar, 2020)

Interrelations in multiple windows of opportunity, multiple streams and industry trajectories

Agent	**In which window couple streams**	**What streams couple**	**In which stream work**	**Inside or outside the government systems**	**Type of leadership**	**Preference to a specific solution**	**Type of solution – technological or policy**
Policy entrepreneurs at the national level	Problem, Politics	Policy, problem, politics and industry trajectories	Problem, Policy, Industry Trajectories	Outside	Appointed leadership, senior managers of carmakers	Has preference	Technological and policy solution
Bricoleurs at the national level	Problem, Politics	Policy, problem, politics	Policy	Outside	Appointed leadership	Preference ripe to policymakers	Technological and policy solution
Knowledge brokers	na	na	Frame knowledge	Outside	na	No preference	na
Problem brokers	na	na	Problem	Inside and outside	Appointed leadership	Has preference	Policy and technological solution
Technology innovators	Technolo-gical	Industry trajectories	Industry trajectories	Outside	Appointed leadership	Has preference	Technological solution

Policy entrepreneurship process during the transformation of the automotive industry in the UK over the period 2018-2022



Agency within multiple types of windows of opportunity

Agency within Technological Window of Opportunity

- Agent - Technology Innovators
- Coupled trajectories – energy supply (renewable energy, EV charging), energy storage (battery), and automotive industry trajectories
- Outcome – production cost effective mass market EVs capable of using universal charging system
- Year - 2015

Agency within Problem Window of Opportunity (problem WoO was a reason for opening policy WoO)

- Agent - Technology Innovators who act as Problem Brokers
- Problem – Intensify the shift to EVs
- Coupled streams and trajectories - energy supply (renewable energy, EV charging), energy storage (battery), and automotive industry trajectories
- Outcome - the need to use a universal charging system for the EV uptake; the need for UK Electric Vehicle Infrastructure Strategy
- Year - 2020

Agency within multiple types of windows of opportunity

Agency within Policy Window of Opportunity

- Agent - Technology Innovators who act as Policy Entrepreneurs and offering policy ideas; Bricoleurs who recombine of policy ideas of Policy Entrepreneurs into bespoke policy solution
- Policy proposal - UK Electric Vehicle Infrastructure Strategy that focusing on universal charging system
- Coupled streams and trajectories - energy supply (renewable energy, EV charging), energy storage (battery), automotive industry trajectories, problem stream, politics and policy stream
- Outcome – policy proposal that was present to the government; UK Electric Vehicle Infrastructure Strategy which include policy ideas of Policy Entrepreneurs was released in 2022
- Year – 2020

Agency within Market Window of Opportunity

- Agent - Technology Innovators, Policymakers
- Coupled trajectories – energy supply (renewable energy, EV charging), energy storage (battery) and automotive industry trajectories
- Outcome – intensify market uptake by EVs using universal charging system
- Year – 2022

Visualisation of Multi-level Governance and Strategy (MLGS) model

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