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Assessing and comparing German and UK transition policies for electric mobility

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ABSTRACT

This paper presents a novel policy assessment approach for sustainable transitions using insights from the multilevel perspective (MLP). An analysis of current German and UK policies for sustainable transport is conducted to illustrate its application. For both cases a potential transition pathway, that can satisfy environmental protection and industrial competitiveness goals, is derived from archetypal transition pathways. These are then put in relation to current policies, discussing whether these measures support these pathways. In the UK case, where emission reduction goals and industrial development are pursued together, current policies of promoting the diffusion of electric vehicles as well as industrial niches are supporting the emergence of a reconfiguration pathway. Replacing foreign suppliers, the local automotive industry shall become a significant part of the future regime. In contrast to that, Germany focuses on a careful transformation and conservation of its automotive industry where none of the current actors is left behind.

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1. Introduction

The aim of this paper is to present a novel approach that allows policy makers to assess whether their policies are actually supporting transitions that satisfy their policy goals. While the case of electric cars has been chosen as an illustrative example, the approach can be utilized to discuss other cases of sustainable transitions as well.

The private car transport sector has been taken as example as it is currently in a transition towards electric cars, mainly driven by significant economic and environmental pressures (IEA, 2010; IPCC, 2007; WEC, 2011). Alike other sustainability transitions this will induce significant changes to the current structure of the (automotive) industry, making it for some national governments a question of industrial policy as well as of energy and environmental policy. These energy and environmental policy goals are largely similar across European countries, however, industrial policy goals can be expected to reflect the particular structure and strategy of national industries and therefore vary more significantly. This hypothesis is supported by the fact that recent policies aimed at promoting electrification of road transport have taken somewhat different forms in different European countries (Elzen and Wieczorek, 2005; Huétink et al., 2010; Santos et al., 2010; Stern, 2007; van den Hoed, 2007).

The question policy makers pose themselves is, what policies are most appropriate in order to reach their transition goals? The traditional way of answering the question would be by measuring the results that they have produced so far, in terms of both the uptake of electrified vehicles and of industrial competitiveness. However, given the policies were introduced only recently and vehicle uptake numbers are still low, such an assessment would be characterized by a high degree of uncertainty. Therefore we propose in this paper an alternative approach to assess policies for transitions that are intended to happen, or are at a very early stage. For that we use insights that are based upon recent research on transitions of socio-technical systems.

Whilst the role of innovation in driving economic growth and industrial competitiveness has been noted by economists since early in the 20th century, many early works (Schumpeter 1934) focused on technological innovation on its own. However, since then, and over some decades, innovation theory has evolved greatly, leading to the investigation of innovation processes from a system perspective. This has brought more complexity into innovation theory, suggesting that attention needs to be paid also to the societal and institutional system in which an innovation is happening and spreading, leading to research on transitions of socio-technical systems.

Looking at those aspects, a number of strands, including transition management (Rotmans et al., 2001), strategic niche management (Kemp et al., 1998), and the multi-level perspective (MLP) on socio-technical transitions (Geels, 2005b; Rip and Kemp, 1998) have been developed (among others) since the 1990s. The MLP is a framework that has significantly contributed towards the understanding of past transitions. Moreover, analysing historical transitions using the MLP, Geels and Schot (2007) have identified a set of stereotypic transition pathways that have been used to describe possible pathways for current sustainability transitions (Foxon et al., 2010; Van Bree et al., 2010; Verbong and Geels, 2010). Strategic niche management focuses on the management of transition experiments (on the niche level) to support niches in breaking existing regimes to initiate transitions. Transition management examines the policy process around the transition itself in a more general manner, including experiments and learning (Lachman, 2013; Markard et al., 2012).

Although these strands have provided many new insights into sustainable transitions, they are however not yet providing specific insights into what policies are appropriate to reach specific transition targets for the system. In the literature much focus is on the niche level. In particular, Markard et al. (2012) and Meadowcroft (2009) outline that these approaches do not provide insights on decisive policies such as the target-oriented allocation of scarce resources among various alternatives.

To address this, and to show the suitability of research on sustainable transitions for policy making, this paper proposes a novel approach that can be used to assess policy making for transitions, especially in the early stage of transitions. It is based upon the MLP approach, and especially a set of stereotypic transition pathways. The approach is applied to the case study of two European governments that have been introducing policies to support the electrification of vehicles: the UK and Germany. Previous work (Mazur et al., 2012) provided a brief comparison of road transport electrification policy making in the UK and Germany from a transition science and transition management point of view. However, with the help of this newly developed approach the present work goes significantly further. It now uses insights from transition science in a more formalized way in order to develop a methodology to evaluate the current policies in terms of compatibility with their intended goals.

In Section 2 key concepts from transition theory and their relevance to this policy analysis are outlined. The notion of socio-technical systems and different types of possible transition paths are also introduced. These concepts are then formalized in Section 3 into an assessment framework. In section 4 this methodology is then systematically applied to the UK and Germany to assess their current policies for transport. This is then followed in Section 5 by a conclusion where we also outline how the approach can be further used.

2. Theory

2.1. Socio-technical systems and the MLP

Innovation literature (Geels, 2005b; Rip and Kemp, 1998) clearly points out that a successful transition involves overcoming barriers that go far beyond pure technical and economic dimensions; and that infrastructural, institutional and societal dimensions are just as important. In the case of electric mobility the transition directly affects a number of actors such as car manufacturers and suppliers, providers of infrastructures (such as oil, gas and utility companies/suppliers) and owners of the vehicles. All of them form a so called a ‘socio-technical system’ (Geels, 2005b).

The MLP describes transitions as an interaction between these different dimensions. For that purpose it classifies the various components of the system into three distinct but closely related levels: regime, niche and landscape.

Socio-technical regimes are relatively stable configurations of the system and their rules, practices and networks determine the development and use of technologies (Rip and Kemp, 1998). In the case of transportation, the regime is defined by aspects such as the type of fuel, the type of vehicle power train, corresponding production infrastructures as well as beliefs and habits of the relevant actors. In contrast, niches are seedbeds for change and are normally a relatively protected market or technological domain, where new systems and practices appear. The landscape incorporates the environment in which regime and niches exist. It describes external factors, such as demographic shifts or cultural changes. Niche and regime actors experience changes in the landscape as external pressures and respond to them accordingly. In the case of electric mobility such pressures can be climate change, rising oil prices and related policy measures (Geels, 2002; Kemp and Loorbach, 2003; Schot and Geels, 2007; Smith et al., 2005; Tukker and Butter, 2007).

2.2. Stereotypic transition pathways

Based upon historical observations of transitions, Geels and Schot (2007) have proposed a variety of pathways that are common for transitions. Their typology of transition pathways (cf. Table 1) is based upon the nature and timing of interactions between the landscape, the niches and the regime.

The typology differentiates between a landscape that is reinforcing the regime, and a landscape that is disruptive towards the regime. The typology also differentiates between a niche and regime relationship that is either competitive or symbiotic. The timing of the interaction plays also an important role and describes the ‘readiness’ or ‘competitiveness’ of the niche based upon its development.

With the help of these criteria Geels and Schot (2007) differentiate 4 standard transition pathways that have been observed in the past (see Table 1). A *Transformation* path is given for a case of a moderate landscape pressure, where no potential niche is strong enough to fill the gap. In such a case the whole regime with all its actors has sufficient time to adapt, for example by an adjustment of its focus or just by slow adaption of knowledge from existing niches. The case where pressures from the landscape have been large enough (e.g. ‘avalanche’) to lead to a significant erosion (de-alignment) of the regime and to a slow emergence (re-alignment) of an alternative niche among many, is called a *De-alignment and re-alignment* pathway. In contrast to these two pathways, in the case of a *Technological substitution* pathway a potential niche (e.g. a radical alternative innovation) already exists. Through a shock, induced for example by the landscape, the niche knocks off the destabilized regime. The fourth type of

Table 1
Typology of transition pathways.

Transition pathways	Nature of interaction		Timing of interaction	Characteristics of transition and main actors involved in transition
	Landscape pressure (Yes/No)	Niche-regime relation (competing or symbiotic)	Developed niche available? (Yes/No)	
Reproduction (no transition)	No	Not relevant	Not relevant	Stabile regime that slowly reproduces itself
Transformation	Yes (moderate)	Competing or Symbiotic	No	Regime actors adjust to adapt regime to pressures from regime outsiders
Reconfiguration	Yes (moderate)	Symbiotic	Yes or No	Regime actors adapt to new alternatives from new suppliers that replace old ones
De-alignment and re-alignment	Yes (strong or shock)	Competing	No (not initially)	Strong pressure destabilizes regime. Leads to appearance of new niches. Dominant niche replaces old regime.
Technological substitution	Yes (strong or shock)	Competing	Yes	Strong pressures destabilizes regime that gets replaced by new firms

Adapted from Geels and Schot (2007).

pathways, the *Reconfiguration* pathway is at first glance similar to the *Transformation* pathway, as also here innovations from niches are taken up by the regime. However if these may involve multiple innovations, or rapid and significant changes of the regime structure, affecting many technical elements of the system (e.g. changed behaviour and infrastructures through a change towards electric mobility) then one speaks of a *Reconfiguration* pathway. In such a case certain regime actors are replaced by new ones while the main regime actors survive the transition.

A case where the regime is stable and no transition of the system happens is called *Reproduction*.

Apart from defining four key transition pathways, the typology also outlines the main actors involved and the types of interactions.

This typology is the basis for the approach that is presented in Section 3. The transition paths outlined by Geels and Schot (2007) are widely accepted and have already been used as a basis to create possible future scenarios for the transition towards sustainable mobility (Foxon et al., 2010; Van Bree et al., 2010; Verbong and Geels, 2010).

3. Methodology

This paper proposes a novel approach to analyze transition policies from the point of view of transition science. Unlike past works (Van Bree et al., 2010) that create transition futures based upon transition theory, in our policy assessment we do not intend to determine what transition outcomes could result from current polices. Instead we propose to carry out an *ex-ante*, qualitative policy assessment based upon the existing visions of policy makers. In other words, this work presents an approach to assess current governments' policy making with respect to their communicated goals.

As transitions, such as the electrification of transport and introduction of electric vehicles, affect many domains (technological, social, economic, etc.), transition theory is the analytical framework of choice for our analysis, due to its improved ability to capture all the key dimensions of a transition process when compared to other approaches. A number of previous studies (Geels, 2005a, 2012; Ieromonachou et al., 2007; Nykvist and Whitmarsh, 2008) have already applied methods from this domain to discuss transitions in road transport from a historical point of view.

The methodology applied in this paper is motivated by recent work in the literature (Van Bree et al., 2010). Van Bree et al. (2010) develop possible transition scenarios for the future automotive transport, focusing mainly on the introduction of hydrogen and electric vehicles. For that, their study uses the Multi-level perspective (MLP) (see Section 2) to formalize the characteristics of today's automotive transport system. It then introduces a set of possible triggers (such as policies) that challenge today's system. These triggers lead to different transition pathways that then lead to different future technology scenarios. The pathways are chosen from the typology of standard transition pathways (see Table 1) that have been derived from observations of past transitions (Geels and Schot, 2007).

In comparison, this paper also draws upon insights from transition science, but unlike former work (Foxon et al., 2010; Van Bree et al., 2010; Verbong and Geels, 2010), it does not try to provide a set of possible future scenarios or pathways as the result. Instead, the proposed approach aims to provide a means that can assess whether governmental policies do actually support a specific pathway that has been derived from the government's policy goals. The approach involves the following steps, which will be discussed in the next sections in turn:

1 Analysis of the current system and regime.
2 Identification of a future regime based upon policy targets.
3 Identification of a compatible transition pathway.
4 Assessment of whether current policy making supports the proposed transition pathway.

3.1. Analysis of the current system and regime

The first step consists of describing the state of the current socio-technical system with its functions, rules and existing pressures. Furthermore, the system structure is analyzed based on the MLP, and the current regime with its main regime players is described. This is then the basis for the identification of pathways that can link the current and future regime.

For instance, the case study in Section 4 explores the automobile system. It focuses on environmental as well as industrial aspects, with an emphasis on the automotive industry, the vehicle type, production system and to a smaller extent, the infrastructure and market (or consumer behaviour), as these are the aspects that describe the current regime. Information such as the type of typical vehicle, national vehicle sales, and the national economic indicators on the automotive sector is taken as a basis for this description.

3.2. Identification of a future regime based upon policy targets

Having identified the attributes that describe the current regime, the second step involves the identification of the policy makers' vision of the future system and hence the future of those attributes. For that the current communicated goals of the respective countries are taken as a basis and the inferred future vision for the regime that is currently favoured by policy makers is formulated.

Published government communications or regulations are considered as a good source to get a picture of governments' long-term targets.

3.3. Identification of a compatible transition pathway

Once the current and future regimes have been defined, the next step is the identification of a transition pathway that can link those two states – assuming any compatible transition path exists.

For that, this study draws on the typology of standard transition pathways (Geels and Schot, 2007) that were already discussed in Section 2.2. Table 1 illustrates those pathways and outlines the criteria by which they are distinguished – namely whether any landscape pressure exists, how the niche and regime affect each other (both describe the nature of the interaction), whether a strong niche exists (timing of interaction) and, in a broader context, the actors through which the transition is characterized. In order to identify compatible transition pathways for each specific case studied, we analyze those states and compare them with these stereotypic pathways. The purpose is to determine whether the future policy vision can be linked to the current state by means of one of the archetypal pathways previously discussed.

3.4. Assessment of whether current policy making supports the proposed transition pathway

In the final step the current policies are assessed by analysing whether they support the identified transition pathway.

For that, the current policies in the observed country need to be reviewed and then compared to the specific conditions and requirements of the transition pathway that has been chosen in the third step.

4. Case study: assessing policy making for low emission vehicles in the UK and Germany

In this section the application of the proposed methodology is presented. A case study approach is taken and policies supporting low emission vehicles in Germany and the UK are assessed. We do not take modal changes into account but instead, focus on the change away from internal combustion engine vehicles (ICEVs) towards vehicles with electric power trains, such as hybrid electric (HEVs), plug-in hybrid electric (PHEVs), battery electric (BEVs) and hydrogen fuel cell electric vehicles (FCEVs).

Germany and the UK have been chosen for this study due to their characteristics and good availability of data, as well as the fact that they are both bound by the same EU energy and environmental policy targets (landscape), which provides the context for these countries' electric mobility policies. To get a good picture of both countries, information provided by respective national statistics agencies, relevant government departments, and vehicle associations have been analyzed. The two case studies are discussed in the following sections; these are structured according to the four steps outlined in the methodology Section 3.

4.1. Analysis of the current regime

4.1.1. Today's private car sector in the UK

There are about 29.5 million cars in the UK. These contribute 12.6% of the country's total energy-related CO_2 emissions. In 2012, 2.04 million new vehicles were registered in the UK, making it Europe's third biggest automobile market (15% of total European registrations). Of those, only 1262 were BEVs and 25,370 hybrid vehicles, while most cars on the market are conventional combustion vehicles. While there are some battery re-charging stations, most of the energy is still provided through liquid fuel stations (IEA, 2011a, 2011b; SMMT, 2012, 2013).

While most of the vehicles sold are supplied by foreign brands, the automotive industry still plays an important role in the UK. The local automotive industry exports 83.7% of the vehicles manufactured in the UK leading to a significant export value of £29 billion – or 11% of UK's total exports (SMMT, 2012, 2013).

Vehicle output has increased over the last decades, from below 1 million in the 1980s to nearly 2 million at the end of the 1990s, followed by a steady growth over the last 10 years until, due to the financial crisis in 2008/09, the output dropped to below 1 million vehicles. Since then output has been rising again (in 2011 more than 1.3 million vehicles were produced), with Nissan, Jaguar Land Rover, MINI, Vauxhall and Toyota being the top five manufacturers among 40 companies that manufacture vehicles in the UK. This is 1.8% of the total passenger car production worldwide. Apart from that, 2400 component manufacturers operate in the UK. Their output also included the manufacturing of 2.5 million engines in 2011 (IEA, 2011a, 2011b; SMMT, 2012, 2013).

In total, 868,000 people were employed in UK's automotive sector in 2005 but this number had decreased to 737,000 by 2010. The whole sector generated a turnover of £49 billion in 2010 contributing less than 1% towards UK GDP (SMMT, 2012, 2013).

Many of those manufacturers are directly engaged in automotive R&D activities. Jaguar Land Rover, Ford and Nissan all have major R&D centres alongside SMEs such as Lotus Engineering, MAHLE, MEL, Millbrook, Ricardo and Zytek, to name just a few. R&D within these organizations generally also includes some efforts in the domain of electric mobility (SMMT, 2012, 2013).

4.1.2. Today's private car sector in Germany

With a stock of 43 million cars (2012) the passenger car sector in Germany contributed 14% towards total national energy-related CO_2 emissions. 2.9 million new vehicles were sold and registered in Germany in 2012, with German brands having a market share of 70% in Germany. By January 2012 there were 4541 fully electric and 47,642 hybrid vehicles, with an additional 2956 electric and 21,438 hybrid vehicles registered in 2012 (Kraftfahrt-Bundesamt, 2011, 2012a, 2012b).

The automotive sector is crucial for Germany's economy as it generated a turnover of €317 billion in 2010 (20% of German industry). €200 billion was generated in foreign markets. In 2010, 12.7 million vehicles were manufactured by German companies (52% produced abroad) and more than 75% sold abroad. In total, one in six passenger vehicles worldwide were produced by German car manufacturers. This includes major German brands such as Audi, BMW, Daimler (Mercedes) and Volkswagen that provide, together with suppliers such as Bosch, Continental, Schaeffler, etc. more than 5 million jobs (VDA, 2011).

Additionally, the German automotive sector (manufacturers and suppliers) invested €19.6 billion into R&D in 2010, more than 1/3 of all German R&D investments, and employed 89,000 people (VDA, 2011). As a result, most of the German automotive R&D is also based in Germany. Those major players (especially the suppliers) are also involved in the research & development of alternative power train technologies. They cover the technological niche of electric power train technologies. Additionally the German car manufacturers have entered into collaborations with suppliers of alternative technologies, such as Daimler with BYD and Tesla, and BMW with Toyota (Green Car Congress, 2011; Manager magazin, 2010; Spiegel Online, 2009, 2011, 2012).

4.1.3. Today's private car regime in the UK and Germany

Both countries' markets, similar in size, are important markets in Europe. Fig. 1 presents some statistics for both countries' automotive industries.

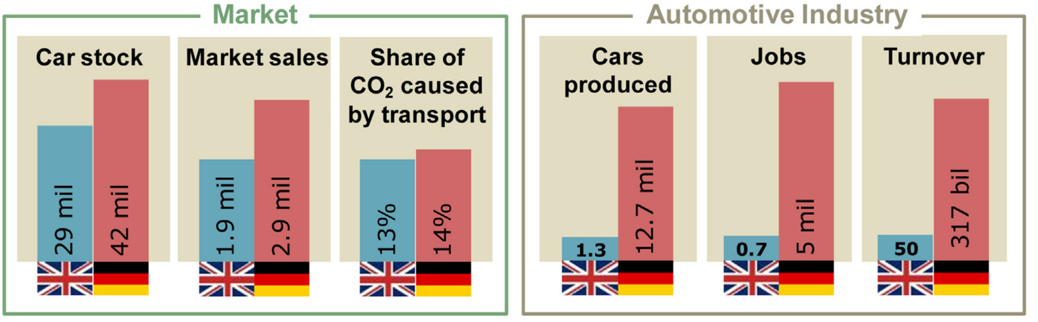

Fig. 1. Comparison of the UK and Germany in terms of vehicle market, automotive industry and its industrial landscapes in 2010.
Sources: Automotive Council UK (n.d.), SMMT (2012), VDA (2011).

Though developments of alternative power train systems are currently being pursued, both regimes are currently dominated by ICEVs – on the roads as well as in the production plants and sales rooms. The uptake of alternative vehicles has been slow so far in both countries as well as the installation of re-charging stations. In summary, the typical vehicle on the market, the infrastructures, as well as usage patterns, are still supporting a regime that is dominated by the traditional internal combustion engine vehicle.

While German vehicle manufacturers are just starting to make their first hybrid and electric vehicles available to the mass market, such as BMW who launched the i-series in July 2013, the current and short-term regime will be still dominated by conventional vehicles with internal combustion engines, and by car manufacturers that offer mainly this type of vehicle, for at least a decade or two. Hence, there are only few electric vehicles on the roads in Germany as well as in the UK (according to sections 4.1.1 and 4.1.2 less than 1% in both cases).

In both cases the current conditions are very similar. The regime is dominated by internal combustion vehicles. However the automotive industry that is providing the passenger car in Germany is bigger and more important for its economy. So the industrial dimensions that could be affected by a transition towards sustainable passenger cars are significantly bigger in Germany than in the UK.

4.2. Identification of a future regime based upon policy targets for the UK and German cases

4.2.1. UK government policy goals for the private car regime

The UK government has legislated in the DECC Climate Change Act 2008 a binding greenhouse gas emission reduction target of 80% by 2050 (relative to 1990) (UK Government, 2008). Additionally the UK has committed itself to the European Energy and Climate Policy Package in 2008, setting a CO_2 emission reduction target of 20% by 2020. For the road transport sector in particular, the UK government aims to achieve close to zero net greenhouse gas emissions by 2050 (see the report 'The carbon plan: delivering our low carbon future' (DECC, 2011)) which implies that all new cars sold in the UK from 2040 onwards have to be zero-emission vehicles. It is therefore clear that CO_2 emission reduction is a key focus of UK road transport policy.

However, the potential that low carbon vehicle technology has for the UK's industrial development is also recognized; as outlined by the briefing paper "Ultra-Low Carbon Vehicles in the UK", jointly published in 2009 by the UK Department for Transport (DfT), the Department for Business, Enterprise and Regulatory Reform (BERR) and the Department for Innovation, University and Skills (now BIS) (page 1):

> "*Our transport system connects people to places and businesses to markets. As such it is fundamental to our economic strength and quality of life. However, the only sustainable future for transport lies in a transformative shift to low carbon. Our ambition must be twofold, to reduce the environmental impact of transport and for UK business to benefit from this transformation.*"

and furthermore:

"*By acting now there is a real potential for the UK to take a lead in this sector*" (UK Government, 2009)

4.2.2. German government policy goals for the private car regime

The German Government initiated a National Electric Mobility Strategy Conference in 2008 that led to the announcement of a strategy paper in 2009: 'Nationaler Entwicklungsplan Elektromobilität' (National Development Plan for Electric Mobility) (German Government, 2009) outlining a set of drivers and targets. While environmental targets also play a role, it is evident that German policy makers are interested in preserving the German automotive sector's role and significance in the world, in order to ensure continued economic activity and employment in Germany. According to that report, the main goal is growing and preserving the automotive industry, as it provides 5 million jobs and generates a €317 billion (20% of the German industry total) annual turnover. Additionally there is a commitment to a 40% GHG reduction by 2020 and an intention to reduce by 80–95% by 2050 (compared to 1990 levels). Furthermore the German government has set the target of 1 million EVs in 2020 and 6 million in 2030 (German Government, 2009).

4.2.3. Potential visions for the future UK and German regimes

At first glance the German and the UK governments seem to have announced similar goals concerning the future regime of their private car transport systems (see Table 3). Both emphasize the reduction of carbon emissions as well as the support of the local automotive industry. Both aim to achieve this through the introduction of alternative vehicle technologies such as electric cars and their respective infrastructures making those technologies the new regime. Both also aim to take advantage of the change towards the electric mobility to support their industry, creating jobs and growth.

However, there are differences. While the UK has legally binding zero carbon emission targets until 2050, German long-term targets are not as strict. Moreover the health of the existing industry in Germany has a much more important role. German policy makers explicitly aim to sustain the role of German manufacturers and suppliers in a future regime. In comparison, the UK considers such a transition to low emission vehicles to be an opportunity for local SMEs to become a more significant part of a future automotive regime by becoming suppliers of alternative technologies.

4.3. Identification of a compatible transition pathway

4.3.1. Potential transition pathways for the UK

Comparing the current state (Table 2) and the future vision (Table 3) of the passenger car regime with the future vision, we infer that there will be a need for a change to the regime that will go beyond a simple *Reproduction* pathway. There will need to be changes in the typical vehicle technology, the recharging (refuelling) infrastructure, as well as the production system. However, as the government favours the development of local suppliers while supporting the existing manufacturers the change will not include an entire replacement of the existing suppliers of passenger cars (manufacturers).

Table 2
Current regimes in Germany and the UK.

System dimensions	Regime today in the UK	Regime today in Germany
Vehicle type on market	Most vehicles sold are internal combustion vehicles, built abroad and imported. Some PHEVs.	Most vehicles sold are internal combustion vehicles; built in Germany or by German manufacturers. Some PHEVs.
Production system	Relatively small automobile industry (mainly controlled by foreign companies) with focus on combustion engines. Some SMEs with focus on electric cars and power trains.	Several big car manufacturers and suppliers form a strong local automotive industry providing millions of jobs. Suppliers providing electric mobility solutions
Infrastructure	Mainly based on fuel stations. Some uptake of charging stations	Mainly based on fuel stations. Some uptake of charging stations

Table 3
Potential visions of future regimes in Germany and the UK.

System dimensions	UK's future regime	Germany's future regime
Vehicle type on market	Electrification of passenger car fleet. Existing vehicle stock and vehicles on the market are electric or zero emission cars.	Electrification of passenger car fleet. Existing vehicle stock and vehicles on the market are electric or zero emission cars.
Production system	There is manufacturing of electric cars and their technologies in the UK. Foreign companies manufacture cars while UK suppliers of electric mobility technologies are important part of the supply chain and also exporting abroad. They provide many jobs in manufacturing and engineering.	There is manufacturing of electric cars and their technologies in Germany The German automotive industry with the current manufacturers and suppliers still exists and is strong. It still develops and produces cars in Germany providing economic growth and jobs to Germany.
Infrastructure	There is an infrastructure for EVs and/or FCEVs	There is an infrastructure for EVs and/or FCEVs

Considering the stability of these multinational car manufacturers implies a *Substitution* or *De- and Re-alignment* scenario is also unlikely (Wells and Nieuwenhuis, 2012). Hence the current regime players will still play a crucial role in the future vision. However, the transition pathway will have to go beyond the transformation of the current manufacturing system and its suppliers. And as the government also favours the development and empowerment of local suppliers of alternative vehicle technologies this infers a *Reconfiguration* pathway. In such a case the suppliers get replaced by new niche players.

The UK has already on the niche level a significant number of British SMEs that manufacture various components for the power trains of electric vehicles, such as Ashwoods, Johnson Matthey, GKN or Yasa, as well as engineering firms (e.g. Ricardo, GMD, Lotus) and one major manufacturer, Jaguar Land Rover, whose primary R&D activities are located in the UK, that are already focusing on this market. Hence a *Reconfiguration* pathway links the current state of the regime with the future vision of the policy makers (see Table 4).

4.3.2. *Potential transition pathways and patterns for Germany*

Comparing the current state (Table 2) and the future vision (Table 3) of the passenger car regime with the future vision shows that there will also be a need for a significant change to the German regime in order to reach the future vision.

There will be a change in the typical vehicle technology, the recharging (refuelling) infrastructure as well as the production system. However, in contrast to the UK, the German government favours the support of the whole existing automotive industry including its big manufacturers and suppliers. This is supported by the stability of the automotive industry as it has established itself in Germany over many decades. It is dominated by a number of car manufacturers (VW with Audi, BMW, Daimler, etc.) and suppliers (Bosch, Continental, ZF, etc.) leading to significant stability and inertia, especially due to existing networks, technologies and infrastructures. Hence to meet the vision, the change must not include a replacement of the existing production structures. Therefore the regime will have to internalize those technologies to reach both environmental and industrial goals. This can be achieved by a *Transformation* pathway (Table 1). Table 4 summarizes the characteristics of the transition with regard to the 4 dimensions for the UK and German case.

4.4. *Assessment of current policy making with regard to its compatibility with a valid transition pathway*

In the previous section it has been outlined that there is a specific pathway that can link the current and future state of the system of both countries. Each pathway occurs under certain conditions or requires certain drivers (see Table 1). In this section the actual policies will be assessed with respect to those pathways and their specific requirements, and whether these policies actually support them – and hence the announced policy targets.

Table 4
Potential transition pathways for the UK and German passenger car regime transition.

	Nature of interaction		Timing of interaction	Characteristics of transition and main actors involved in transition	Transition pathways
	Landscape pressure (Yes/No)	Niche-regime relation (competing or symbiotic)	Developed niche available? (Yes/No)		
UK case	There is moderate to strong pressure from the UK government due to the CO_2 reduction commitment creating pressure on the regime	Symbiotic niche-innovations from SMEs are taken up by regime car manufacturers, such as power train components	Although the existing SME niche players are not strong enough to challenge or substitute the existing actors, they do supply already electric power train technologies to major regime players (Lotus, Zetek)	(New) local UK suppliers provide technologies to existing regime players.	Corresponds with Reconfiguration pathway
German case	There is only moderate pressure from the German government on the automotive industry as its health (growth, jobs) is priority.	Symbiotic niche-innovation is taken up by regime, such as power train components, mainly provided by big German suppliers. Innovative solutions can be acquired or developed by car manufacturers	While there are no small niche providers who could challenge the system, most of the competition is coming from niche technology providers such as Tesla	The current German automotive industry including car manufacturers and suppliers execute the change themselves.	Corresponds with Transformation pathway

Table 5
Policies supporting a Reconfiguration pathway in the UK (Department for Transport, 2012; Department of Trade and Industry, 2006; Mayor of London, n.d., Technology Strategy Board, 2012; UK Department for Transport, 2011).

Drivers	UK measures that support drivers for a Reconfiguration pathway
Moderate policy pressure on the regime	• Creation of a Low Carbon Vehicle Public Procurement Programme (LCVPP) that provides funding to support the trial of over 200 electric and low emission vans in a range of public fleets. In Nov 2011, further funding of up to GBP1.7m was made available for any public fleet buyers to purchase a further 500 low carbon vans from the procurement framework. • Transport for London offers 100% discount for hybrid and pure electric vehicles on the London Congestion charge leading to savings of up to £2000 per annum for London's drivers. London is important arena for the UK.
Support of regime players in executing the transition	• Creation of an ultra-low carbon vehicle demonstrator programme that resulted in around 340 new innovative cars on the road in locations all over the UK, and is believed to be Europe's largest co-ordinated real-world trial of low carbon vehicles (£25m).Within the frame of the Technology Strategy Board's 'Low Carbon Vehicles Innovation Platform' which was founded in 2007 by the Departments of Transport, of Business, Innovation and Skills, the Technology Strategy Board and the Engineering and Physical Sciences Research Council. • Support of alternative vehicles through the Office for Low Emission Vehicles (OLEV), formed by the Department for Energy and Climate Change, the Department for Transport and the Department of Business, Innovation and Skills: - Plug-in vehicle grant: 25% subsidy (up to £5000) for a new Ultra-low Emission Vehicles, with a total budget of £300 million. - Favourable tax regimes and exemption from Vehicle Excise Duty and Company Car Tax for Ultra-low Emission Vehicles. - £30 million match funding for Plugged-in Places (recharging stations).
Support of new suppliers that replace old ones	• Creation of the Integrated Delivery Programme, an investment programme, jointly financed by Government and business that "aims to maximize the benefit to UK-based businesses of the rapidly-developing low carbon vehicles market, and to help accelerate the adoption of low carbon vehicles in the UK." The Programme co-ordinates the UK's low carbon vehicle activity from initial strategic research through collaborative research and development, leading to the production of demonstration vehicles (£250m of joint government and industry investment). • UK government created CENEX (Centre of excellence for low carbon and FC technologies) which is supported by the Department of Business, Innovation and Skills (BIS). Its aim is to catalyze innovation to enhance UK industries' overall capabilities using strategies focused on knowledge transfer and technology demonstration. Founded in 2005. The tasks include, Identifying and communicating emerging technologies, deploying fleet-scale demonstrators, coordinating academia, suppliers, car manufacturers, etc.

4.4.1. Assessment of low carbon vehicle policies in the UK

In the previous section it has been outlined that a *Reconfiguration* pathway can link the current state of the system with the policy makers' vision of the regime. This translates into 3 requirements for policies in this case study. It requires some moderate to strong pressure (and possibly also incentives) from policies on the landscape level that makes the regime adopt new symbiotic niche-regime innovations. However, this must be done whilst not destabilizing the main regime players (especially the car manufacturers that produce in the UK). It also requires policy makers to support niche suppliers in order to replace the current suppliers. Table 5 presents different policies that do support these three drivers and hence a Reconfiguration pathway.

The main pressure on the existing regime is being already created by EU emission limits for vehicles. Therefore, the UK's efforts to create additional strong pressure in this way are unnecessary. The UK has a procurement programme for low emission vehicles and there are low emission zones within cities where low emission vehicles do not have to pay certain charges.

In terms of supporting the regime in achieving the change, the UK government has introduced more extensive measures. Through the creation of the Office for Low Emission Vehicles (OLEV) it has provided more than £400 m funding for the development and deployment of ultra-low emission vehicles, providing consumer incentives, supporting recharging infrastructure and research, development and demonstration programmes. Although these measures also put pressure on the regime, they do not endanger the current regime players but instead provide incentives to adapt. A possible result of such an incentive may be the decision of Nissan to build the BEV Leaf at their existing location in Sunderland UK (The Guardian, 2010; The Telegraph, 2010).

Measures that support the uptake of new local or national niche suppliers have also been employed by the UK government. For instance, the variety of RD&D programmes directed towards UK-based businesses that offer low carbon technologies, the investments into infrastructures and especially investments into recharging stations and the choice of niche actors for demonstrator projects, all have the potential to nurture the local niche industries that then can grow and become a part of a bigger solution.

In summary, the application of the proposed approach shows that the UK government has introduced policies that support a transition pathway (Reconfiguration) that is compatible with environmental and industrial goals.

4.4.2. Assessment of low carbon vehicle policies in Germany

In the previous step it has been outlined that a *Transformation* pathway links the current state of the system with the policy makers' vision of the regime. This translates into 3 targets for policy makers.

Pressures on the regime should be low so that it can adopt new innovations and does not get replaced by another regime. This also means that in a future regime the current regime players, and especially the German manufacturers and suppliers, should still exist. Hence it will require policy makers to create only enough pressure to help and incentivise German industry to achieve a change towards electrification of transport without destabilizing it. This might require policy actions that decrease pressures if they might challenge Germany industry too much. Furthermore the support of a general transition in infrastructure is necessary. Table 6 presents different policies that do support these three drivers and hence a *Transformation* pathway.

As mentioned before, the main pressure on the existing regime is driven by EU emission limits for vehicles. However, this could threaten the health of the German automotive industry, which produces vehicle fleets with average carbon emissions that are well above the limits that are being discussed at the EU level. As a result the German government has tried to weaken those targets. Germany's role during the EU negotiation on vehicle emission targets reflects this protective behaviour (Spiegel Online, 2008). “Merkel has fought energetically for months to get the proposed regime weakened”, (The Guardian, 2008).

This does not mean that Germany is opposing the transition. It invests in infrastructure, provides limited incentives for electric cars and funds demonstrator programmes - purchase grants have not been considered though (Handelsblatt, 2012).

The main goals of German policies appear therefore to be the preservation of its automotive sector by supporting the German automotive industry's transition towards the electrification of their products. Germany provides extensive R&D programmes supporting major German-based car manufacturers and suppliers to conduct research in the area of electric mobility, production technologies and demonstration projects supporting already existing regime actors and hence their transformation.

There are significant investments into the technological competitiveness of its own automotive industry and the cost efficient manufacturing of power train components. Both measures imply a strategy that leaves enough time for the German car manufacturers to adapt and start selling EVs in Germany as well as elsewhere. The absence of a purchase grant is probably to limit the ability of foreign car manufacturers to increase their market share in Germany through subsidized PHEV or EV sales before German car manufacturers are ready.

Table 6
Policies supporting a Reconfiguration pathway in Germany (German Government, 2009).

Drivers	German measures that support drivers for a Transformation pathway
Only low pressure on the regime	• Loosen emission limit targets during negotiations on EU level as well as slowing down introduction of limits • Adaptation of vehicle taxation system in 2009, so that the tax is now based upon both the engine size and CO_2-emissions. • Electric vehicle owners do not pay any vehicle tax for the first 10 years.
General support of transition	• Research on Grid and system integration - Cooperation of Ministries of Economics, Technology, Environment and Nature - Change of energy system and execution of smart grids, fleet tests and demonstrations, introduction of norms and standards, education of specialists, ensuring supply of resources • Launch of a support programme for electric mobility (Förderprogram Elektromobilität of Ministry for Environment BMU) - 2009–2011 Provision of €600 million within the framework of an economic growth programme to promote fleet tests of cars, vans, hybrid buses - 2011 - end of legislation: extension of the programme with an additional €1 billion. - In 2012 a Display of Electromobility, an additional demonstration programme with €180 million (plus €180 million match funding from industry) has been launched (called Schaufenster Elektromobilität). • Electric vehicles get access to special parking and may use bus lanes • Public Procurement of Electric vehicles for Ministry vehicle fleets
Support of current German car industry regime players in executing the transition	• Creation of a National Platform for Electric Mobility by the federal government, with 7 Workgroups for the topics: propulsion, batteries, charging and grid integrity, standards and certification, materials and recycling, training and education and framework creation. This network involves all big manufacturers, suppliers, utility providers, car clubs and associations, universities, research institutes and the public sector, hence all actors that are along relevant for the system. • Creation of Joint Unit for Electric Mobility (Gemeinsame Geschäftsstelle Elektromobilität – GGEMO) of the German Federal Government • Creation of Research alliance for Lithium-ion batteries - €60 million from Ministry of Education & Research, €360 million from industry (2009–2015) - €35 million from Ministry of Economics and Technology for battery research to make Germany a producer of batteries (2009–2012) • Support of Research for vehicle technologies - Ministry of Economics and Technology concentrates on electric power and drive train and provides €30 million (2005–2010) - Ministry of Education Research (€100 million) initiated German Alliance for Automotive Electronics (€ 500 million)

In summary, German policies are consistent with its policy targets as the policies support a Transformation pathway that satisfies these targets.

5. Conclusions

This paper has presented a novel approach to assess policy making for transitions of socio-technical systems with respect to policy goals. To show the application of this method, two case studies (electric mobility in the UK and Germany) are discussed.

The methodology draws insights from transition science, using the multi-level perspective (Geels, 2005b; Rip and Kemp, 1998) and common pathways of transitions (Geels and Schot, 2007) that have been observed in history. First it involves the translation of policy makers' targets into a vision for the future regime. Then a pathway is identified that can reach such a future. In the last step the actual policy making is assessed by its compatibility with the proposed transition pathway.

A review of the current state as well as of the respective policy goals has been conducted. It shows that in the UK and Germany, policy makers have targets that are motivated by environmental and industrial goals: a decrease in GHG emissions (hence a fast introduction and diffusion of low emission vehicles) and simultaneously the development or preservation of their automotive industry and its competitiveness.

In the case of the UK, the main drivers are the government's announcement of the 2050 emission reduction goals, the conservation of the current foreign owned manufacturing, as well as an establishment of a local automotive industry (mainly from the niche level) that can take advantage of the change towards electric vehicles.

In the German case, although environmental targets exist too, industrial goals play a more important role, driven by the fact that Germany is economically highly dependent on its automotive industry (current regime actors) and this is threatened by a global transition from a fossil fuel based transport towards electric mobility, if it does nothing.

The differences in these two cases are illustrated by the proposed pathways that have been identified for both cases. The UK transition problem could be satisfied by a Reconfiguration pathway while in the German case a Transformation is more suitable. While there are many similarities in both cases, there are differences in terms of the role of the automotive industry. While the UK wants to develop a new local industry in the domain of electric mobility (suppliers), German policy makers favour the preservation of the existing German automotive manufacturers and suppliers making the extent of the transition less disruptive.

In order to achieve their specific goals, the governments of both countries have introduced a variety of measures. In contrast to the UK, where a significant amount of the budget is allocated to a low emission vehicle purchase grant as well as to the support of niches, the German government did not introduce a purchase grant. Instead, Germany directs funding mainly towards R&D, especially focusing on technology development within the current industry regime. The UK has introduced measures that support a pathway that can lead to a move away from CO_2 emitting vehicles towards a future where cars are electrified. Furthermore it can allow the UK industrial environment to take advantage of such a change, providing jobs and prosperity.

In Germany the government has announced emission reduction targets as well as the industrial health of its automotive industry as main drivers for its policy making. Their actual policies actually imply that a bigger focus is put on the latter one supporting a Transformation pathway and therefore a controlled transformation of the German automotive industry.

Hence in both cases our methodology shows that policy makers are applying policies that support pathways that lead to transition outcomes that satisfy policy targets.

However, there are limitations in the approach proposed here. While the approach allows us to assess whether policies support the proposed pathways, it does not provide insights as to whether the policies are sufficient to achieve the targets on time. In the case of Germany for example, while a *Transformation* pathway would correspond with the attempt to give the industry enough time to adapt, it might not meet national and international road transport emission targets, especially as a significant amount of vehicles that are sold in Germany are of German make. Such a pathway might not be even sufficient in the current world wide race towards electric cars, assuming that other countries (China or Japan) might execute their transition in a faster way, and Germany might jeopardize its automobile industry's role (ifo Schnelldienst, 2008).

To summarize, we have presented here a method that can provide insights on policies for transitions. While we have chosen the case of electric cars as an example, the approach can be as well utilized to discuss other cases of sustainable transitions where policies are implemented to reach certain goals. Examples can be the decarbonisation of energy production, the change of manufacturing towards 3D printing or the introduction of autonomous transport means. The approach just requires that there are policies targeting the transition that is to be assessed.

Furthermore additional research on more precise pathways as well as the quantification of further aspects could lead to more a more extensive analysis. However, that would decrease the easy applicability of the proposed approach which provides a simple way to assess whether transition policies are consistent with policy targets.

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