

# Policy brief

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# Green Mobility

## The Future of Electric Cars and Low Carbon Transport

A Guide for Policymakers  
in the West of England

**IPR** Institute for  
Policy Research



## Context

The West of England, in common with a number of English regions, now has a new framework of governance. Alongside local authorities and their leaders, and a Local Enterprise Partnership, there is a combined authority, led by a directly elected Mayor – the West of England Combined Authority (WECA). This encompasses Bristol, Bath and North East Somerset, and South Gloucestershire. WECA has devolved statutory duties for planning, transport, housing and economic development. In partnership with local government, business and the community, it has important obligations for developing low carbon economic growth, tackling climate change, and improving the local environment, including reductions in air pollution.

Green transport can form part of an integrated policy framework for meeting these obligations. Mayors of combined authorities should be at the forefront of creating aspirational targets for clean, green environments for their communities. Transport has the potential to contribute to vibrant and sustainable local economies and taking proactive steps to decarbonise transport systems gives Mayors the opportunity to meet their green policy obligations in a holistic way.

In this paper, we set out what research, from the University of Bath, tells us can be done to develop green transport infrastructures and promote environmentally sustainable, low carbon growth in the devolved regions of England.

## Drivers to Green Transport: A Call to Action

The October 2018 IPCC report gave the world 12 years to rectify what will be catastrophic climate change if no action is taken.<sup>1</sup> This has lent a sense of urgency to the 2008 Climate Change Act which saw a commitment by the UK government to reduce emissions of carbon dioxide (CO<sub>2</sub>) and other greenhouse gases (GHGs) by 80% from 1990 levels by 2050. The pathway to achieve this is through the building of a low-carbon economy, as reflected in the 2018 Industrial Strategy. The UK's commitment to the reduction of GHGs was further consolidated by the ratifying of the 2015 Paris Agreement which saw the government commit to keeping the increase in global average temperatures to well below 1.5°C.

Climate change is not the only issue. In May 2018, the UK was referred to the European Court of Justice due to illegal levels of air pollution.<sup>2</sup> Dr Alistair Hunt, an economist from the University of Bath, in collaboration with researchers at the University of Oxford, has produced a report estimating that exposure

to nitrogen dioxide (NO<sub>2</sub>) and small particulate matter (PM<sub>2.5</sub>) pollution is linked to 40,000 deaths a year alongside other preventable illnesses, at an estimated cost of over £6bn a year to the NHS.<sup>3,4</sup>

Transport constitutes a contributor to nitrogen oxides (NO<sub>x</sub>), particulate matter emissions, and GHG emissions, meaning action could be taken to tackle all three sources of emissions within the same policy framework. Such interventions can be incredibly successful: since the introduction of catalytic converters in the early 1990s, emissions of NO<sub>x</sub> from road transport has decreased significantly. However, despite this, road transport is still the largest single contributor to NO<sub>x</sub> and PM<sub>2.5</sub> emissions in the UK, contributing around 1/3 of all emissions. In addition, transport is also the single largest contributor to GHG emissions in the UK.<sup>5,6</sup>

Transport policy has the potential to have a significant impact on the local economy, alongside its ability, if developed appropriately, to address air pollution and climate change issues. Transport is the largest item of (non-housing) expenditure for UK households, if taken to include the purchase of new cars and fuel in conjunction with spending on train, bus and air travel.<sup>7</sup> In addition, the transport sector is a major employer. According to figures from the Society of Motor Manufacturers and Traders, the automotive industry employs around one million people in the UK, and turned over £82bn in 2017.<sup>8</sup>

## Current Policy Responses

On a national level, green transport has the potential to address a number of focus areas outlined in the government's recent Industrial Strategy, including Infrastructure, Clean Growth and the Future of Mobility. The government has committed funding to these areas through investment in Catapult centres, such as the Centre for Transport Systems; the National Productivity Investment Fund, which has £31bn to invest in new projects; and the Future of Mobility Grand Challenge which sees investment for the development of clean technologies for road, rail, aviation and maritime transport systems.<sup>9</sup> The recently published Areas of Research Interest (ARIs) from the governmental departments also illustrate that the focus on transport systems and emissions permeates throughout government policy, whether from the Department for Business, Energy and Industrial Strategy's (BEIS) focus on the networks necessary to support a transfer to electric vehicles, DEFRA's research into the impact of emergent technologies on the environment, or the Ministry of Housing, Communities and Local Government focus on electric car charging points.

The 2018 "Road to Zero" report by the Department for Transport (DfT) outlines how the government aims to deliver cleaner road transport. The approach is multi-faceted and includes reducing emissions from vehicles already on the road, driving uptake of "cleaner" new vehicles, reducing emissions from heavy goods vehicles (HGVs) and improving both the manufacture of electric vehicles and the electric vehicle network around the country.<sup>10</sup> There is a focus on the transport mix, with active transport options, such as walking and cycling, sitting alongside policies for electric vehicles.

The Industrial Strategy includes policies to improve electric vehicle usage through investing £400m in charging infrastructure. The transport plan sits alongside the government plan to tackle air pollution, and specifically NO<sub>2</sub>, with the main aims of:

- Ending the sale of all diesel and petrol cars by 2040;
- Aiming for almost all cars and vans to be zero emission by 2050.<sup>10</sup>

**Currently, electric vehicles and hybrids account for just over 2% of current car sales in the UK**

These are ambitious targets: currently, electric vehicles and hybrids account for just over 2% of current car sales in the UK,<sup>11</sup> and current charging infrastructure is limited in both number and location.

The responsibility for tackling air pollution and enacting local policy falls on local governments and combined authority Mayors. The government has drawn up a National Air Quality Action Plan for (NO<sub>2</sub>) in collaboration between DEFRA and DfT (July 2017), which aims to tackle roadside NO<sub>2</sub> concentrations.<sup>12</sup> As part of this, 28 councils in England, including Bath and North East Somerset, have been told to achieve compliance with NO<sub>2</sub> limits by 2021. The onus is on councils and local authorities to reduce emissions, predominately through the use of Clean Air Zones (CAZ) which dissuade drivers with highly polluting cars to drive through city centres. However, the effectiveness of these measures will depend on integrated transport solutions that are developed in parallel, and ideally in advance of the introduction of the CAZ.

The movement in the UK towards green transport is part of a global trend towards low carbon economies. The Industrial Strategy mirrors the European Commission's three key areas for action for robust reductions in transport related emissions:

- Increasing efficiency of transport systems;
- Low-emission energy sources for transport (fuels);
- Zero emission vehicles.

The report identifies the key role cities and local authorities will play in this transition, as each local authority has a unique set of needs, and will require tailored solutions to what is an incredibly complex problem.<sup>13</sup>

National policies are focusing on the transport mix, including moving people out of cars and onto public transport or making active transport choices, alongside investment in electric vehicles. Personal transport will inevitably move towards fully electric or hybrid, particularly when coupled with the introduction of autonomous or self-driving cars. With the development of new technologies, this movement away from traditional internal combustion engine vehicles is likely only to accelerate, meaning regional mayors need to not only understand the implications of such technological shifts, but also ensure their constituencies are ready to facilitate a smooth transition.

Effective transport planning should consider all users of the system. The implications of electrification of the transport system on rural areas, particularly with current concerns over the range of most electric vehicles, will need to be addressed for the implementation to be successful.

Green transport encompasses a wide range of new technologies, but also needs to include the organisation of transport systems. The policy framework for green transport must include alternative fuels – electricity, hydrogen and biofuels – alongside increased fuel efficiency, whilst also considering the

impact that autonomous and self-driving vehicles will have on the transport landscape. In addition, the wider implications of new technologies must be considered, including the ease of integration into the existing transport system, and infrastructural changes required to accommodate new technologies. In addition, the rise of the “sharing economy” and future availability of autonomous vehicles along with “active transport” options, such as walking and cycling, particularly in urban areas, will also need to be factored into the picture.

## **Cleaner Vehicles**

### **Battery Electric Vehicles (BEVs)**

Promotion of active transport and the use of public transport, through incentives, improved services or discouraging the use of cars are all important contributions in the steps towards green transport. However, car use and ownership will continue to play a major role in the British transport system, and although BEVs are currently leading the field in terms of widespread adoption, there are many ways to meet the ambitious emissions targets set by the government for personal vehicles.

Trends in travel show an overall decrease in both the number of trips and the miles travelled over the past 20 years. The shortest of these journeys, under one mile, are predominately taken on foot (81%). However, for journeys of all other distances, driving dominates. Data from the Department for Transport states that since 1950, the number of vehicles on the road, the amount of traffic, and the miles travelled have increased by at least seven times. Walking and cycling as a means of transport has decreased, and, with the notable exception of London, the use of buses has also decreased.<sup>14</sup>

The use of the car as the favoured mode of transport persists, despite increasing fuel prices, increased traffic on the roads and the documented impacts of noise and air pollution. The reasons for this are multifaceted, but include the fact that the car is often favourably viewed when the user weighs up costs and benefits in comparison to alternative travel modes.<sup>15</sup> Additionally, a lack of public transport or alternative transport options for commuters can have a significant impact.

### **Electric Cars and Hybrids**

The government has made a commitment to BEVs and hybrids through its pledge to end the sale of diesel and petrol cars by 2040. The Industrial Strategy outlines investment into charging infrastructure, along with investment in research into new approaches towards manufacture of electric vehicles through initiatives such as the Faraday Institution. This government funded institute is investigating electrochemical energy storage, with a specific focus on batteries. This is vital as current BEVs are limited by their range, which can vary from 100 miles to over 200, and this is related to the battery technology.

Saiful Islam is Professor of Materials Chemistry at the University of Bath and is a member of the expert panel at the Faraday Institution. He explains that the focus of the research can be broken down into four categories:

- Solid state battery materials, which could increase the energy density – increasing the range of electric vehicles, and will have a significant impact on safety;
- Degradation of batteries, to try and gain insight into how to extend their lifetimes;
- Modelling of materials, both existing battery materials to look at degradation, or to help develop new materials;
- Lifecycle analysis, which investigates recycling and the end of use of battery materials.

Professor Islam emphasises the need to improve the energy density of battery materials, which will improve the available range of BEVs, before we see higher adoption into the market, along with improved recycling techniques. He argues that the lithium ion battery, the battery found in most mobile phones and some electric vehicles, has plenty more scope for improvement, although he stresses it will be incremental, rather than a step-change in terms of efficiency or energy density.<sup>16</sup>

Professor Islam also stresses that although “range anxiety” is a valid concern on long trips, most journeys in the UK are less than five miles, and 80% of car journeys are less than 50 km, so in many cases this anxiety is unfounded. However, these concerns can be mitigated by large-scale investment into a national charging infrastructure, necessary for widespread adoption throughout the UK.

## Green Fuels

Biofuels are fuels that are produced from biomass. They can have similar characteristics to oil-based fuels such as petrol or diesel, and are often lauded for their capacity to be a “drop-in” replacement to oil-based liquid fuels. They are touted as carbon-neutral fuels as their net greenhouse gas emissions are zero, although it is important to consider the emissions associated with their growth and processing, such as the use of fertilisers, transportation and machinery. Additionally, at point of use, biofuels as a vehicle fuel still produce particulate matter and  $\text{NO}_x$ , although in varying amounts dependent on the source and type of biofuel.<sup>17</sup>

Globally, biofuels are already produced on a large scale, around 120 million tonnes per annum. However, this is barely a dent on the surface of global fuel policy, representing the challenges associated with producing enough energy. This ties into one of the largest considerations with the use of biofuels, land use. It is imperative that biofuels are not grown on agricultural land and thereby compete with food production, particularly as the global population continues to rise.

Newer biofuels are based on crop waste or non-food crops, alleviating concerns that they compete with food production. Dr Chris Chuck, Reader in Chemical Engineering at the University of Bath, explains his solution to the food/

fuel nexus. “We have to play to our strengths. Britain has a large coastline and limited agricultural land, that’s why I’ve been investigating algae and seaweed as a potential source of biofuels”.<sup>18</sup>

Using a process called hydrothermal liquefaction, Dr Chuck can produce “crude oil” from seaweed or algae. He has also investigated the integration of this technique with various “service industries”, such as wastewater purification, which can help mitigate the higher cost of a new technology. These studies have shown that it is possible to combine heavy metal waste remediation with the growth and processing of their algae-based biocrude oil.<sup>19, 20</sup>

Regarding biofuels utilisation, Professor Geoff Hammond, of the Department of Mechanical Engineering at the University of Bath, argues that introducing biofuels in small blends to the fuel system could be done without the need for significant infrastructural change, either for the vehicles and or the distribution and processing system. This is supported by Professor Jamie Turner, also based in the Mechanical Engineering Department, and who has many years’ experience working in the automotive industry. He states that the cost of retrofitting vehicles to run from any mix of biofuel and petrol could be as low as £100 per car.<sup>21, 22</sup>

A report by the Committee on Climate Change explained that the government decision to invest heavily into electric vehicles, rather than biofuels, for transport applications was due to the lack of available feedstock for the production of large quantities of biofuels. Rather than being disheartened by this, Dr Chuck sees this as an opportunity, recognising that “different transport systems have different needs”, so rather than focusing solely on the production of petrol replacements, there is scope for applications in aviation fuel, or long distance haulage, both of which are likely always to require liquid fuels, rather than electric power.

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## Hydrogen

Hydrogen is often touted as an “ideal fuel” as it only produces water and energy in a fuel cell or via combustion, unlike hydrocarbon fuels, which produce carbon dioxide at point of use. Professor Tim Mays, Head of Chemical Engineering at the University of Bath, explains that one of the factors holding up widespread adoption of hydrogen as a fuel is storing and transporting it. His research focuses on hydrogen storage in porous materials, which have the potential to be designed to line hydrogen storage tanks to lower the pressures needed to store the gas. Current state-of-the-art technologies involve storage tanks operating under very high pressures, but this requires significant investment to ensure tanks are safe, resulting in high costs. The types of technologies being envisaged by Professor Mays could lower the pressures required for hydrogen storage, therefore reducing the price.<sup>23</sup>

However, storing hydrogen is not the only issue. First, the gas needs to be produced in a sustainable manner. This is a significant challenge, as currently hydrogen is produced by a process called “steam methane reforming” which produces CO<sub>2</sub>, and uses natural gas as a feedstock, so it unsustainable on two counts. Alternative methods of hydrogen production include using renewable energy to electrolyse water, or generating hydrogen from biomass. Both methods offer a potential solution to the storage of hydrogen, but would require significant infrastructural investment to make the economically viable.



# The Future Green Transport Mix

The current road transport landscape includes around 2% electric vehicles. Despite the government aims to have stopped the sale of petrol and diesel cars by 2040, it is clear the road fleet will be a mix of different technologies for years to come. BEVs, hybrids and traditional combustion engine vehicles all show scope for improvements in emissions and fuel efficiencies, and the potential for biofuels and hydrogen to change the transport landscape mean local authorities need to be adaptable and ready for a changing transport landscape. The local investment and infrastructural change required to ensure a smooth transition will be supported by robust policy frameworks and informed policymakers.

New technologies require investment and support which are often nationally led policies, rather than local ones. However, there are small policy changes that can have potentially large impacts. Powertrain engineer Professor Jamie Turner claims that imposing a weight limit on vehicles could have a triple positive impact – lighter vehicles see less brake and tyre erosion, reducing their particulate emissions. In addition, fuel consumption is lower for lighter vehicles, further reducing NO<sub>x</sub> and PM emissions, along with CO<sub>2</sub>. Finally, lighter and smaller vehicles are also safer for urban use, particularly in cities such as Bath, where roads are narrow and pavements are over capacity.

## Facilitating Green Decisions

### Placing Transport in Context

Transport forms part of local, regional and national strategies, and it is important to consider the ways in which such policies overlap. Transport clearly has an impact on local mobility policies, but the impact on growth or regional development should not be underestimated.

Research by Professor Marcelle McManus, Professor of Energy and Environmental Engineering at the University of Bath, has highlighted the importance of considering transport, and specifically electric vehicles (EVs) in the wider context, with a specific focus on energy policy. By modelling projected growth and adoption of the use of EVs, and using existing research on the use of EVs, such as where and when they are most commonly charged, she has mapped the projected demand on the National Grid up to 2050. Despite the lack of tailpipe emissions, the use of electricity from the National Grid, particularly when only 25% of the national energy supply is from renewable resources, calls into question the true level of EV emissions. Professor McManus estimated that this “true” emission can be considerably higher than that of a conventional petrol car, depending on the electricity grid mix, which shows the importance of complete life cycle assessment and systems-level thinking.<sup>24</sup>

Outside of low carbon electricity, the impact of electric cars on the grid is also an important consideration, and shows that coupling transport policy with energy policies can ensure a truly low carbon transport network with the capability to manage the associated increase in demand. Factoring both sectors into policy planning through integrated transport solutions offers a “two-in-one” solution of “greening” the transport network and the energy system with the same set of policies.

These intersections between different sectors exist outside of the transport/energy boundary. Changing transport networks may also cross into local development strategies, particularly in regional manufacturing hubs, and this is an opportunity to be capitalised on by local authorities. Transport also overlaps with town and spatial planning, an area where the unique powers granted to devolved authorities is particularly pertinent, allowing transport strategies to cross regional boundaries.

Advances in computer power have led to developments in spatial strategy planning and mapping. Delivery or public transport routes can now be mapped using advanced algorithms, and can be programmed to prioritise different aspects, such as emissions, timings or to avoid certain routes. Dr Maria Battara and Dr Güneş Erdoğan both work in the School of Management at the University of Bath. Their research focuses on vehicle routing problems, and both have collaborated on large-scale projects in major European cities. Dr Battara stresses that it can be incredibly challenging to make an algorithm that takes into account all of the potential variables, particularly when something like traffic can be so varied. Both she and Dr Erdoğan have worked on bike sharing schemes, and explain that in order for the system to work effectively it requires significant coordination. For this approach to offer a viable alternative to driving, there needs to be a bike available to pick up, but also space to drop it off when the user has finished with it. This involves mapping the use around and across the city, predicting peak flow times, and then coordinating moving the bikes, if necessary, to where there is need. When the numbers were calculated, it was found that if more than 50% of the bikes were in use, the system would be working sub-optimally, highlighting the need for spare capacity in a system.<sup>25</sup>

Their work overlaps with the considerations required for the adoption of self-driving and autonomous vehicles, which the government has pledged to have on the road by 2021. The physical infrastructure needed to deal with such new technology will require local authorities to be flexible and adaptive, not to mention the legal and administrative groundwork needed to ensure safe use.

It can be tempting to rely solely on new technologies to revolutionise transport, but Dr Erdoğan suggests that thinking about the problem more holistically can help break it down into manageable problems. He suggested that advocating flexible working, such as working from home or variable hours, would reduce the volume of traffic on the roads. In addition, staggering the start of school and work days would lead to peak traffic flows being more dispersed throughout the day, easing congestion in city centres.

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## Adoption of New Forms of Transport

Driving has dominated British travel trends for many years, and will likely continue to do so for years to come. Investigating why certain modes of transport are preferred, along with potential drivers for changing behaviour, can help policy-makers when thinking about promoting active or greener transport options.

University of Bath Psychologist Professor Bas Verplanken identifies three main drivers for human behaviour: motivation, opportunity and habit.<sup>26</sup> Motivation, in the context of decision-making, can be broadly classified as the goals, intentions, attitudes and values of the decision-maker. Opportunity refers to the potential barriers to behaviour, and can be further broken down into structural barriers, such as available infrastructure, financial, legislative or personal barriers, such as lack of knowledge or necessary skills. Habit refers to a set of behaviours that are completed “without thinking”, and form a part of a routine. Although we usually think of habits as personal, they can also be found on a societal scale as a set of cultural norms.<sup>27</sup>

Habits are adopted because they work, so when thinking about behavioural change in the context of Green Transport, it is necessary to ensure that any green alternatives work as well, if not better, than current modes of transport. Professor Verplanken explains that it is important to try to understand why a person might choose a particular option, and then weigh up the alternatives against it: Is the infrastructure in place? Is it feasible? Is it comparable to the existing methods?

Professor Verpanken argues that the best time to encourage people to make a change is when their habits are broken, for example after moving house, after starting a new job, or after the introduction of a CAZ. Broken habits offer an opportunity for people to make greener choices, as they have not yet established a “default” mode of transport. These interventions are not a “one size fits all” approach, but there are simple actions that could be implemented, but these are best done in the context of integrated transport policies. As an example, the introduction of a CAZ should sit alongside the introduction of alternative modes of transport, whether improved public transport systems, subsidies for electric vehicles or improved electric car charging infrastructure. Another example, in a broader infrastructural context, would be ensuring there are efficient bus services to new housing developments.

On a more individual level, Professor Verplanken worked with a colleague at Bath, Dr Ian Walker, to investigate the factors that have an impact on an individual when choosing a car. They found that, contrary to previous studies, environmentalism played a very small role in the decision-making process, meaning policymakers and marketing executives will need to consider alternative methods of encouraging the purchase of environmental vehicles.<sup>28</sup>

Economist Dr Lucy O’Shea uses insights from psychology to help frame economic research. She suggests that it becomes necessary to use financial incentives, such as introducing a congestion charge, to “tip” the scales in favour of the environment when making a transport decision. Although introduction of such charges can be politically challenging, she suggests that by reinvesting the congestion charge into public transport, improving the system or reducing the cost, it can make such charges more acceptable to the public and addresses the need for the development of improved transport systems in parallel to changes the introduction of a CAZ. However, she is careful to stress the importance of the wider implications of such programmes, where lower income people can be disproportionately affected by such charges, as well as the need to consider displacement of traffic from CAZ’s to peripheral areas where the environmental problems persist.

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## Economic Drivers

The financial restraints associated with implementing new public policies should be thoroughly scrutinised and justified to the taxpayer. However, the financial burden of not taking action are much less frequently justified, or even calculated, despite the sometimes astronomical costs associated with inaction. A pertinent example is the report produced by Dr Alistair Hunt of the Department of Economics at Bath, calculating the current associated costs from air pollution in the UK from cars and vans. This work reported that previous studies estimated that around 40,000 early deaths, along with thousands of lesser health impacts in the UK can be traced to human exposure to PM<sub>2.5</sub> and NO<sub>x</sub> emissions from all sources, with a combined annual cost of between £22.6bn and £71.3bn.<sup>29</sup> Although not all PM<sub>2.5</sub> and NO<sub>x</sub> emissions are from transport, Dr Hunt has calculated that emissions from cars and vans is accountable for a quarter of the total health costs associated with outdoor air pollution, which is equivalent to 10,000 premature deaths each year, at a cost of £5.9 billion a year, in the UK alone.<sup>29</sup> When calculated per vehicle, the picture is clearer still – the annual health costs associated with a diesel car amount to £258, with £37 for a petrol car. A BEV has associated health costs of just £13 per year. It is clear that these costs should be factored into any discussion around new technologies or policies.

Both Professor McManus and Dr Hunt stress the importance of integrated, lifecycle thinking and analysis across different regions and departments. It can be challenging to justify spending on transport when the savings will be seen in the NHS, but this serves to highlight the need for interdisciplinary, long-term thinking such as that adopted across the University of Bath. A further consideration when performing systems analysis is the cost over time. This can be complicated by relatively short governmental terms, where large initial investments can take longer than the current term before seeing returns.

Dr Hunt also argues that when costing a new policy, it is imperative to consider the broader costs associated with such an action. He argues that it is important to account for health and personal costs, alongside economic ones. This gives a broader picture of the impact of a policy, and can help shape further decisions. In his air pollution study, he chose three different “costs” to take into account in an example where person X takes time off work due to pollution related illness:

- Economic costs (lost work time, corresponding lack of money spent in local region);
- Health costs (costs to NHS – doctors wages, medicines, etc);
- Personal costs (cost of pain and suffering to individual).

Different policies will have different “costs” associated with them, it might be necessary to consider the environmental costs associated with a new policy, factoring in GHG emissions, resource availability (such as water) and any other environmental impacts. Here, again, he stresses the importance of interdisciplinary working, for example working with epidemiologists to factor in the health effect of a given “dose” of pollution. As an economist, Dr Hunt’s job is to “monetise the impact” of a particular output, associating costs with the NHS and lost work time, as well as pain and suffering – this last component often dominating the others.

It is clear from both the work of Professor McManus and Dr Hunt that consideration of the broader financial implications of any new policy must be taken into account from the outset, with the long-term impacts fully accounted for.

## Evaluation of Policy Proposals

There is an increasing focus on the move to a low carbon economy, coupled with a focus on a radical reduction in air pollution and CO<sub>2</sub> emissions. However, this is occurring against a backdrop of rapid technological development, changing economic policies, infrastructure development and industry pressure, all of which have the possibility to have a significant impact on the implementation and success of new policies. Taking the current situation into account, whilst also forecasting for the future can offer valuable insights and help guide policymakers. The concept of Transition Pathways is a technique that offers a multilevel perspective over a complete system, and can help map out different routes to the “end goal”.<sup>30</sup>

Professor Geoff Hammond led a consortium of researchers to draw up a series of transition pathways for the transition from where we are now to a low carbon future for the electricity system. The consortium was made up of engineers, predominantly electrical, policy analysts, economic historians and economic modellers. Professor Hammond specialises in horizon scanning, looking at which technologies might influence electricity or energy systems over the next 50 years. He explains that although there are a number of different ways to develop such models, the transition pathways approach emphasises governance patterns, which support policymakers when considering different pathways. The project saw high engagement from both industry and policy, with Rolls-Royce, Eon and the former CEO of Shell all involved in the project Industrial Advisory Board, along with representatives from within government, including BEIS/DECC, the DfT and the committee on Climate Change. In addition, the academic partners from nine UK universities engaged with the public/private Energy Technologies Institute (ETI).<sup>31</sup>

Ensuring key stakeholders feel that the policy is working for them, and that the solution is tailored to the specific regional needs, can help bring key players on board. Additionally, using a framework to assess potential policy proposals or national or regional strategies can help policymakers identify potential issues before they arise. Transition pathways also put policymakers in contact with experts, facilitating the creation of evidence-based policymaking. This is essential when there is a risk of “lock-in”, where investing in a specific technology represents a long term commitment, as such decisions should not be taken without a thorough understanding of the implications and potential costs.

# Conclusions

It is clear that the transition to green transport will require a range of different strategies, and that a “one size fits all” approach will not be sufficient. Freight and commuter transport will need different solutions from each other, as will urban and rural communities, and what works in the West of England may not work for the North East.

**Meaningful change to the transport landscape will require innovative and bold leadership**

Meaningful change to the transport landscape will require innovative and bold leadership. The devolution of power to combined authorities such as WECA offers a unique opportunity to shape the future of green transport in meaningful ways across regional networks. However, the need for collaborative and interdisciplinary thinking across disparate research fields, areas of expertise and even geographical spaces is more pressing than ever if local authorities want to realise their ambitious commitments to improving conditions for their constituents. In order to succeed, major infrastructural changes are required, which will necessitate robust policy frameworks to support them.

The benefits of moving swiftly to a low carbon economy, and cutting emissions, are clear, but local leaders will have to stand firm to deliver such initiatives, regardless of potential political backlash, as the timescales within which to reduce emissions are short. There are many barriers to policy implementation, but many can be alleviated through strategic planning; for example, financial constraints to investment in public transport could be mitigated through income generated from a CAZ.

The barriers to action for the general public can be addressed through thoughtful policymaking. Despite environmentalism not acting as a driver for individual action, local authorities can mitigate for this in their policies. By ensuring viable alternatives to driving, alongside plentiful electric car charging points, and forward thinking, holistic strategies towards alternative technologies, local authorities can deliver on green transport and help move towards a low carbon economy, whilst at the same time supporting economic development in their constituencies.

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