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Programme Area: Light Duty Vehicles

Project: Economics and Carbon Benefits

Title: Executive Summary

Abstract:

This project was undertaken and delivered prior to 2012, the results of this project were correct at the time of publication and may contain, or be based on, information or assumptions which have subsequently changed. The Economics and Carbon Benefits project is comprised of three Work Packages. This Executive Summary covers all three Work Packages. 3.1 Scenario Development 3.2 Revenue stream analysis (including the role of value added services) 3.3 Economic sensitivity and carbon offset analysis The purpose of Work Package 3.1 was to agree scenarios and specific questions with the ETI and associated stakeholders for analysis in the Consumers and Vehicles (TR1001) and Electricity Distribution and Intelligent Infrastructure (TR1002) projects. The purpose of Work Package 3.2 was to evaluate and quantify the contribution new revenue streams may make to the financial feasibility of delivering a plug-in vehicle system in the UK. The purpose of Work Package 3.3 was to conduct a comprehensive economic and carbon offset analysis of the plug-in vehicle system and evaluate the viability and sustainability of the various scenarios developed in Work Package 3.1.

Context:

A strategic level analysis of the potential size of the market for plug-in vehicles, the total level of investment needed and the total carbon offset for the UK.

ETI Executive Summary

Programme: Transport – Plug-in Vehicle Economics and Infrastructure

Project Name: Economics and Carbon Benefits (TR1003)

Work Package(s): 3.1, 3.2 and 3.3

Final Deliverable(s): *WS3/ARUP/06, WS3/ARUP/10, WS3/ARUP /13, WS3/ARUP /19 and WS3/ITS/01 and WS3/ITS/02 and WS3/E.ON/03*

Version: *1.0*

Introduction

The Economics and Carbon Benefits project is comprised of three Work Packages. This Executive Summary covers all three Work Packages.

3.1	Scenario Development
3.2	Revenue stream analysis (including the role of value added services)
3.3	Economic sensitivity and carbon offset analysis

The purpose of Work Package 3.1 was to agree scenarios and specific questions with the ETI and associated stakeholders for analysis in the *Consumers and Vehicles* (TR1001) and *Electricity Distribution and Intelligent Infrastructure* (TR1002) projects.

The purpose of Work Package 3.2 was to evaluate and quantify the contribution new revenue streams may make to the financial feasibility of delivering a plug-in vehicle system in the UK.

The purpose of Work Package 3.3 was to conduct a comprehensive economic and carbon offset analysis of the plug-in vehicle system and evaluate the viability and sustainability of the various scenarios developed in Work Package 3.1.

Scenario Development

There are two types of scenario: sensitivity tests and themed scenarios. The variables and scenarios are defined in deliverable WS3/ARUP/10. WS3/E.ON/03 provides the supporting analysis for the definition of electricity costs and electricity CO_2 emissions.

The sensitivity tests were performed to determine sensitivity of the overall results to single variables in the overall system. In some cases, variables were changed together where this was considered to be necessary for the sensitivity test to make sense. 103 sensitivity tests were conducted, split into the following categories depending on the type of variable being tested:

- Vehicle technology tests
- Electricity generation and grid impact tests
- Electricity price tests
- Charging infrastructure and deployment tests
- Consumer behaviour tests

- Government policy tests

Twelve themed scenarios explore plug-in vehicle take-up and carbon emissions under a range of different potential future states.

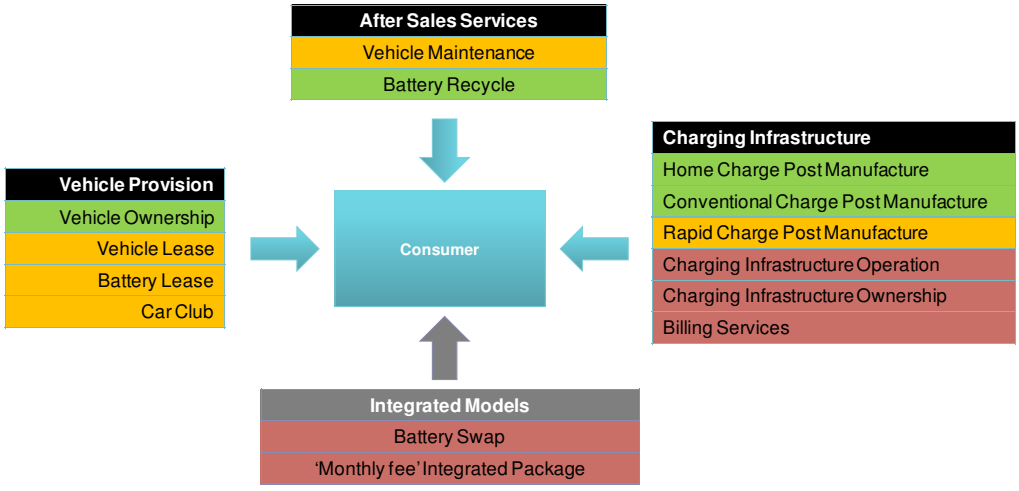
- The Base Case (T0) scenario has all variables set to their most likely values or to a business-as-usual value.
- Five scenarios explore the upper and lower bounds of plug-in vehicle take-up and emissions:
    - All variables are set to be maximally favourable to plug-in vehicle take-up (T1) or minimally favourable to plug-in vehicle take-up (T2); and
    - Government incentives are as announced, but all other factors are maximally favourable to plug-in vehicle take-up (T3) or minimally favourable to plug-in vehicle take-up (T4).
    - Minimum Carbon Emissions (T12) considers the effects of all variables being set to minimise CO_2 emissions in 2050: high commodity prices, low UK GDP growth, high vehicle development, a supportive environment for charge point deployment, consumer attitudes positive for plug-in vehicle take-up, and supportive Government policies.
- High rate of UK GDP growth (T5) and low rate of UK GDP growth (T6), which affects the size of the parc, total vehicle kilometres travelled, electricity base load (all positively correlated with GDP) and consumer sensitivity to prices (negatively correlated with GDP).
- Five scenarios explore the effects of the global economic environment:
    - High (T7) and low (T11) rates of growth in the global economy are assumed to be positively correlated with commodity prices, UK GDP growth, and vehicle development.
    - Medium global growth with a green emphasis (T8) is associated with high commodity prices, low UK GDP growth, high vehicle prices with advanced vehicle attributes, a supportive environment for charge point deployment, consumer attitudes positive for plug-in vehicle take-up, and supportive Government policies.
    - High oil price (T9) and Oil Price Spike (T10) take base values (from scenario T0) for all variables except the price of oil, which is either high or follows the base price curve with a temporary spike in price between 2020 and 2030.

Generic Business Models and Complimentary Revenue Streams

12 components of the business environment were analysed, together with two integrated business models, in deliverable WS3/ARUP/06. The chart below shows a summary of the areas covered and the broad viability of each *(red = very challenging, amber = potentially viable, green = probably viable)*.

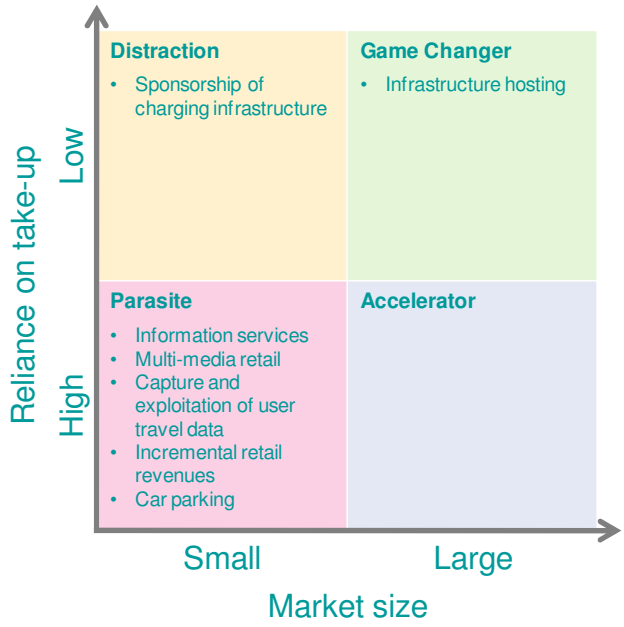
In summary:

- Vehicle provision is made viable by EU Emissions Regulation[1].
- Vehicle lease, battery lease and car clubs are potentially viable, but are inhibited by uncertainty over the potentially uncompetitive residual value of plug-in vehicles.
- Vehicle maintenance is made viable, with manufacturer support for selected locations, as a result of vehicle provision viability. However, it is inhibited by uncertainty as to where vehicles will be bought and maintenance will be required.
- Battery recycling is made viable by the EU Batteries Directive, which puts financial responsibility on the producers. The key issues are uncertainty on the technologies and costs for the battery recycling process, and uncertainty on the value of batteries for second life uses.
- Home charge post manufacture and conventional public charge post manufacture are made viable by a low barrier to entry and an early market supported by Government subsidies.
- Rapid charge point manufacture is potentially viable with support from Government subsidies. The higher barrier to entry makes it less viable than manufacturing other charge points.
- The biggest challenges are in commercial investment in charging infrastructure deployment (without financial support) and the supporting services. These are high risk investments, with unclear return on investment and limited opportunities to manage risk.
- 'Monthly fee' integrated packages are unlikely to offer a sufficiently differentiated service to cause consumers to want to take the risk of adopting a different ownership model.
- Battery swap services maybe suitable for niche applications. Mass-scale use is inhibited by the need for a standardised large battery (affecting vehicle styling flexibility), logistics challenges for the batteries and increased infrastructure/vehicle costs.



[1] *Regulation (EC) No 443/2009 of the European Parliament and of the Council of 23 April 2009 setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO2 emissions from light-duty vehicles; http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0001:0015:EN:PDF*

The scope for complimentary revenue streams to supplement the core business environment was also evaluated in deliverable WS3/ARUP/13. The chart below presents an overview of the range of opportunities considered and their potential contributions.



In summary, hosting other infrastructure, such as wireless internet or mobile phone antennas, could be attractive for single recharge points but is unlikely to significantly enhance viability at system scale. Sponsorship looks attractive in the early stages, but its value will reduce as the market grows making it unlikely to have a significant impact. The other opportunities are reliant on uptake, so may 'feed off' a market but won't drive it.

Economic Sensitivity and Carbon Offset

The results of the economic sensitivity and carbon offset analysis is covered in deliverable WS3/ARUP/19, and supported by detailed analysis in deliverables WS3/ITS/01 and WS3/ITS/02.

The scenario and sensitivity analysis reveals the important market drivers.

- EU regulation is the most significant market driver for change within the automotive industry. Other factors are minor by comparison, but individual government subsidies may be important to secure vehicle deployment in a given country.
- The tank-to-wheel basis of EU regulation drives automotive industry strategy towards electric and hydrogen vehicle power-trains (as they are effectively considered 'zero emission vehicles' – emissions from electricity generation and hydrogen production are not included).
- Significantly improving consumer attitudes towards plug-in vehicles would have the greatest effect on overall uptake, but is a very significant challenge and attitudes could just as easily change against plug-in vehicles.
- Infrastructure deployment has a significant effect on the uptake of plug-in vehicles.

- A revolutionary breakthrough in battery cost would have a significant impact. However, this is very unlikely to occur before at least 2030.

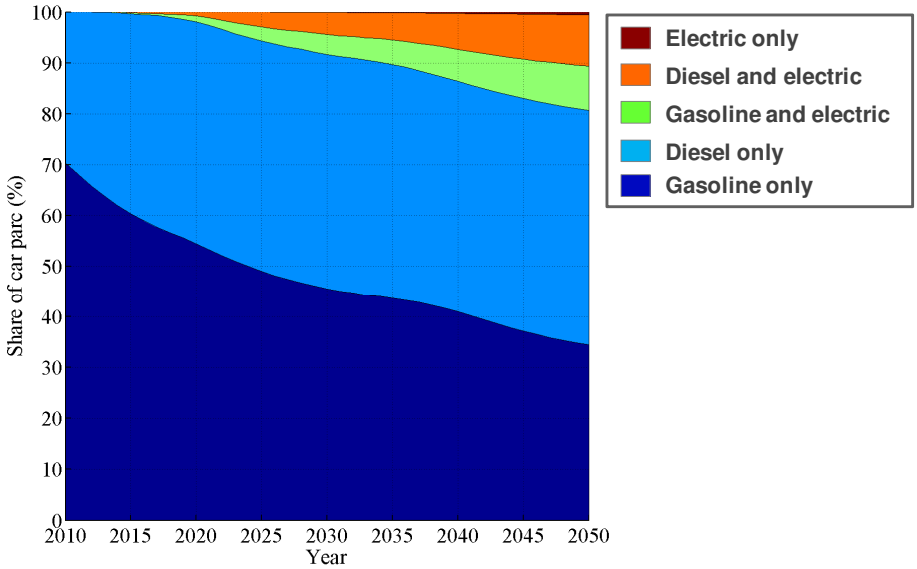
Interestingly, high oil prices (scenarios up to $280 per barrel in 2050 were considered) appear unlikely to have a significant impact on plug-in vehicle uptake. This is partly due to the lower importance most consumers place on running costs relative to outright purchase price and practicality, partly due to conventional vehicle efficiency gains mitigating some of the effect of an oil price rise, partly due to consumer biases relative to conventional vehicles, and partly due to rising electricity costs.

The important market development trends can also be identified.

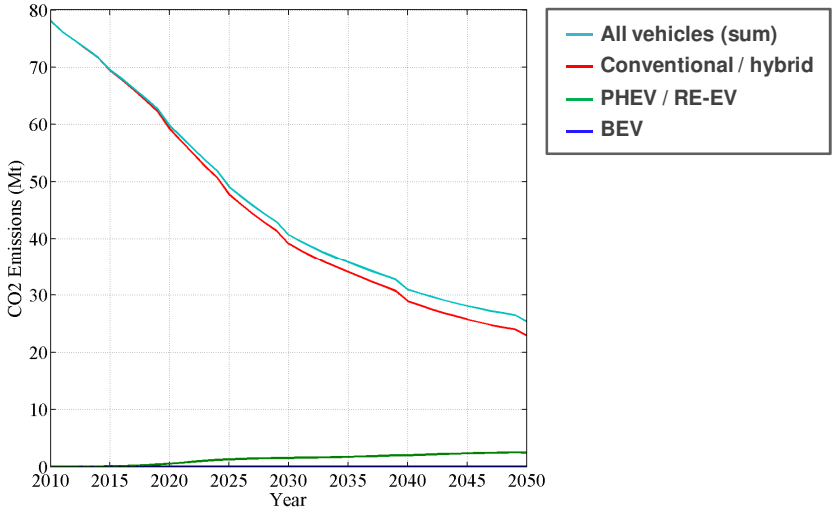
- Conventional vehicle efficiency improvement is likely to be the core contributor to reducing CO_2 emissions.
- PHEVs/RE-EVs are a very probable component of the 2050 UK vehicle parc, with predicted consumer uptake of ~20% or significantly more vehicles in 2050.
- BEV adoption by the UK mass-market is a very significant challenge, with predicted consumer uptake comprising less than 1% of the parc in 2050 unless all factors are especially favourable.
- Conventional vehicle efficiency and vehicle electrification are unlikely to go far enough alone, so other measures will be crucial. These include reducing overall transport demand, maximising the emission reduction from other energy sectors and deploying complimentary technologies such as hydrogen vehicles.

However, it should be noted that over the next few years, BEV uptake may exceed PHEV/RE-EV uptake due to limited product availability for the latter. This is in part due to the strong emphasis of EU regulation towards BEVs. Caution is therefore required in extrapolating market projections from short term data.

The chart below shows the ‘most likely’ scenario for vehicle uptake.



The chart below shows the impact on in-use CO_2 emissions (i.e. excluding production and scrappage) from the vehicle uptake shown above. Both of these charts exclude the role hydrogen vehicles may have. It should also be noted that this is just one of many scenarios and sensitivities evaluated.

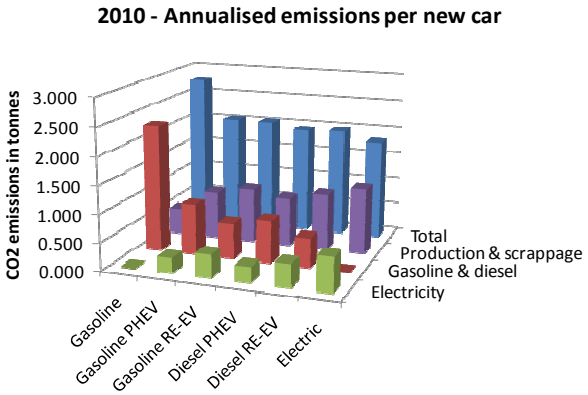


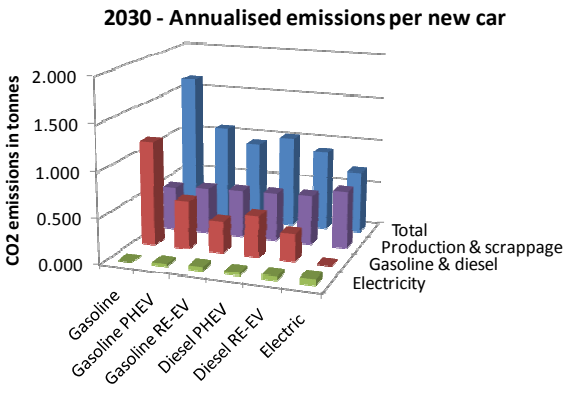
The market share for PHEVs/RE-EVs could be significantly enhanced if any of the market drivers identified above are more favourable. Potentially this could increase the share of PHEVs/RE-EVs in the 2050 parc to make up the majority.

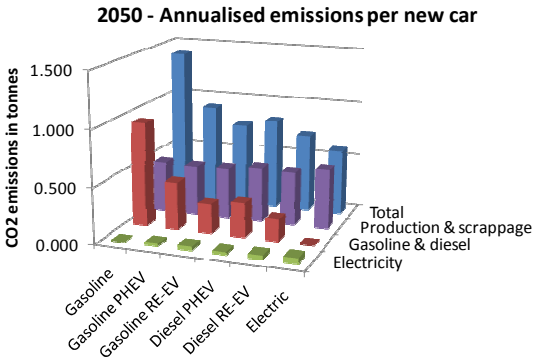
The main factors that could undermine the 'most likely' potential for PHEVs/RE-EVs are a loosening of ambitious government policies for CO_2 emissions reduction or a significant negative shift in consumer attitudes.

The market share of BEVs remains very small unless all factors become especially favourable. The most important factors are the policy environment, advance deployment of infrastructure, reduced battery costs and significantly more favourable consumer attitudes.

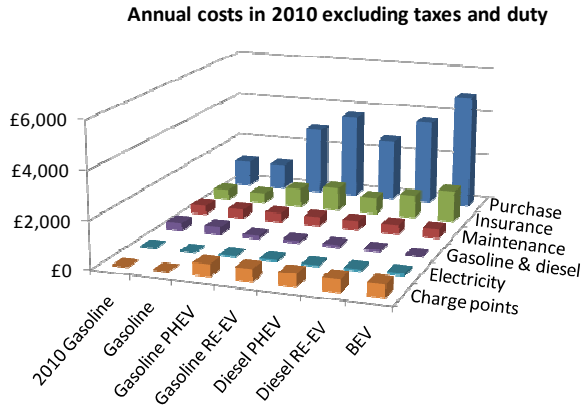
As the in-use emissions of vehicles fall, production and scrappage emissions become an increasingly significant issue. However, production and scrappage emissions are currently treated differently to in-use emissions; emissions are attributed to the producing nation rather than the consuming nation. The charts below show, per vehicle, the split of emissions between in-use and production and scrappage in 2010, 2030 and 2050. Policy measures therefore need to be careful not to negate the benefits of lower in-use emissions by increasing the volume of vehicles in the parc (e.g. through ownership of BEVs as second or third cars for local mileage only).

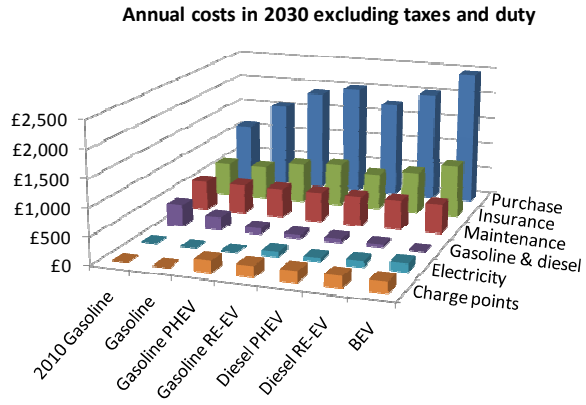


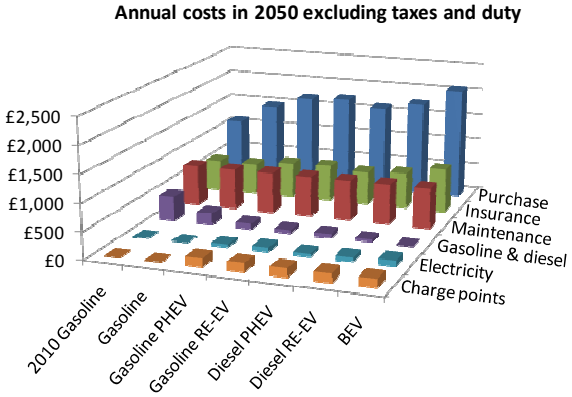




Combining the whole lifecycle carbon emissions per vehicle in the charts above with the annualised costs per vehicle in the chart below gives the carbon abatement cost. This shows that conventional vehicle efficiency has the lowest carbon abatement cost, followed by PHEVs / RE-EVs and then, lastly, BEVs. Further work is required to give sufficient understanding of the infrastructure and energy costs for hydrogen vehicles to enable equal comparison.



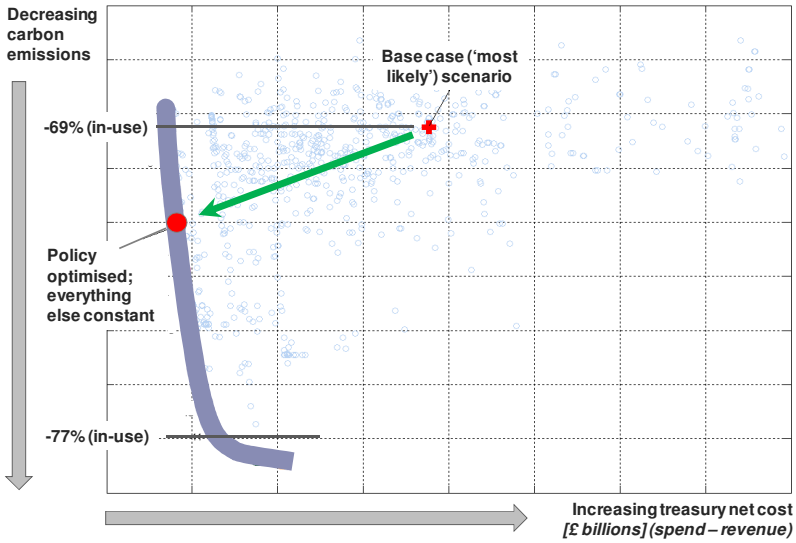




	Carbon abatement cost (£/tCO_2); 2010 gasoline vehicle as baseline.....				
Vehicle type	2010	2020	2030	2040	2050
Gasoline	-	£ 240	£ 364	£ 215	£ 131
Gasoline PHEV	£ 2,304	£ 1,026	£ 575	£ 440	£ 341
Gasoline RE-EV	£ 2,801	£ 1,230	£ 676	£ 463	£ 339
Diesel PHEV	£ 1,756	£ 875	£ 449	£ 303	£ 229
Diesel RE-EV	£ 2,558	£ 1,145	£ 638	£ 430	£ 318
BEV	£ 2,990	£ 1,594	£ 872	£ 671	£ 531

The viability of private sector investment in recharging infrastructure has also been evaluated. There are two different types of operation: schemes for occasional 'insurance' use and those for regular use. The former is more viable, as there can be a large number of customers paying an annual fee for occasional use. The latter is much more challenging, and there appears to be little prospect of profitable operation (in workplaces, public locations, etc) until the plug-in vehicle market is well established. Return on investment is therefore a significant challenge and ongoing Government support is likely to be required.

The chart below shows a wide range of scenarios evaluated (the emissions reduction is shown against the 1990 level). This shows that there are many (largely uncontrollable) factors affecting the reduction in emissions. It also shows that some policy measures are more cost effective than others in terms of reducing carbon emissions.



With all factors other than the policy environment held at the 'most likely' scenario, the resulting optimisation suggests the most cost effective policy package (within the boundaries evaluated):

- Government doesn't subsidise plug-in vehicle sales;
- Government incentivises recharging infrastructure deployment;
- The permissible limits under EU Emissions Regulation continue to decrease;
- Vehicle excise duty is increased, based on whole lifecycle emissions;
- Fuel duty is increased;
- Electricity network reinforcement and system intelligence are incorporated into the electricity system Regulated Asset Base, but investment in recharging points is not; and
- Any revenue preserving taxes (e.g. road user pricing) are based on use not purchase.