Assessing the Impacts of Large EV Penetration in the UK

Analysis of Network Investments and Changes in Fuel Use

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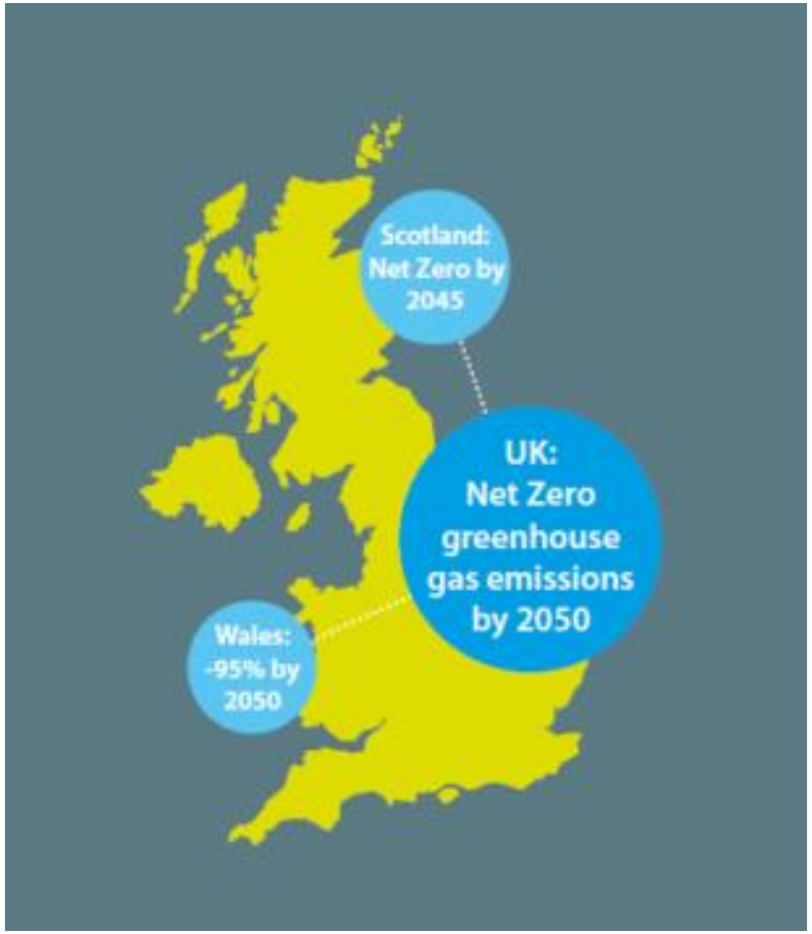
Introduction

UK AND SCOTLAND POLICY CONTEXT

The UK and Scottish policy context

The UK Committee on Climate Change (CCC) recently published the report ´Net Zero – The UK's contribution to stopping global warming´ (CCC, 2019).

- ´The UK can end its contribution to global warming within 30 years by setting an ambitious new target to reduce its greenhouse gas emissions to zero by 2050´



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The UK and Scottish policy on EVs

The UK Government has set the target of all new cars and vans to be effectively zero direct emission by 2040 (UK Government, 2018).

- However, the CCC is recommending to move this date forward.
- The Scottish Government has set the same target to 2032.

National Grid (the British TSO) expect an overall EV penetration of 90% by 2050 (National Grid, 2018).

BUSINESS INSIDER

Scotland will ban new petrol and diesel cars 8 years earlier than the rest of the UK

Shehab Khan, The Independent Sep. 5, 2017, 11:34 AM

The Scottish government has pledged to phase out new petrol and diesel cars and vans across Scotland by 2032, eight years ahead of the UK Government target.

Miles Willis / Stringer

Nicola Sturgeon outlined plans to "massively expand" charging points and set up pilot projects to encourage uptake of electric vehicles.

The EV challenge on the energy system

A large penetration of EVs is likely to bring important challenges to the energy system, potentially requiring **new generation capacity and network reinforcements**.

Also, **the timing** (‘smart’ vs ‘dumb’) **and location** (at home vs at a centralised charging point) of EV charging could potentially **increase or mitigate the undesired impacts of the EV roll-out.**

Many studies have been developed to address these challenges.

- However, most of them fail to analyse the implications of a large penetration of EVs outside the power sector;
- Not considering, for example, the changes on fuel use and consumer costs, and other potential impacts on the rest of the energy system and the economy.

The objective of this paper is to provide insight on this issue, using a whole energy system model (UK TIMES).

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The TIMES model

A (VERY) BRIEF DESCRIPTION

The TIMES model
a (very) brief description

TIMES is an energy system-wide bottom-up model that cover all the processes of the energy system.

- Uses linear-programming to find a least-cost future energy system scenario, according to a number of user constraints (including GHG emissions, energy use, etc.).

Due to this holistic approach, TIMES is a widely used tool to analyse decarbonisation scenarios.

Examples of policy questions:

How would the energy system look like in 2050 if we:

- Decarbonise the economy?
- Electrify transport?
- Use hydrogen for heating?
- Improve the energy efficiency of buildings?
- Etc.

What technologies will need to be promoted?

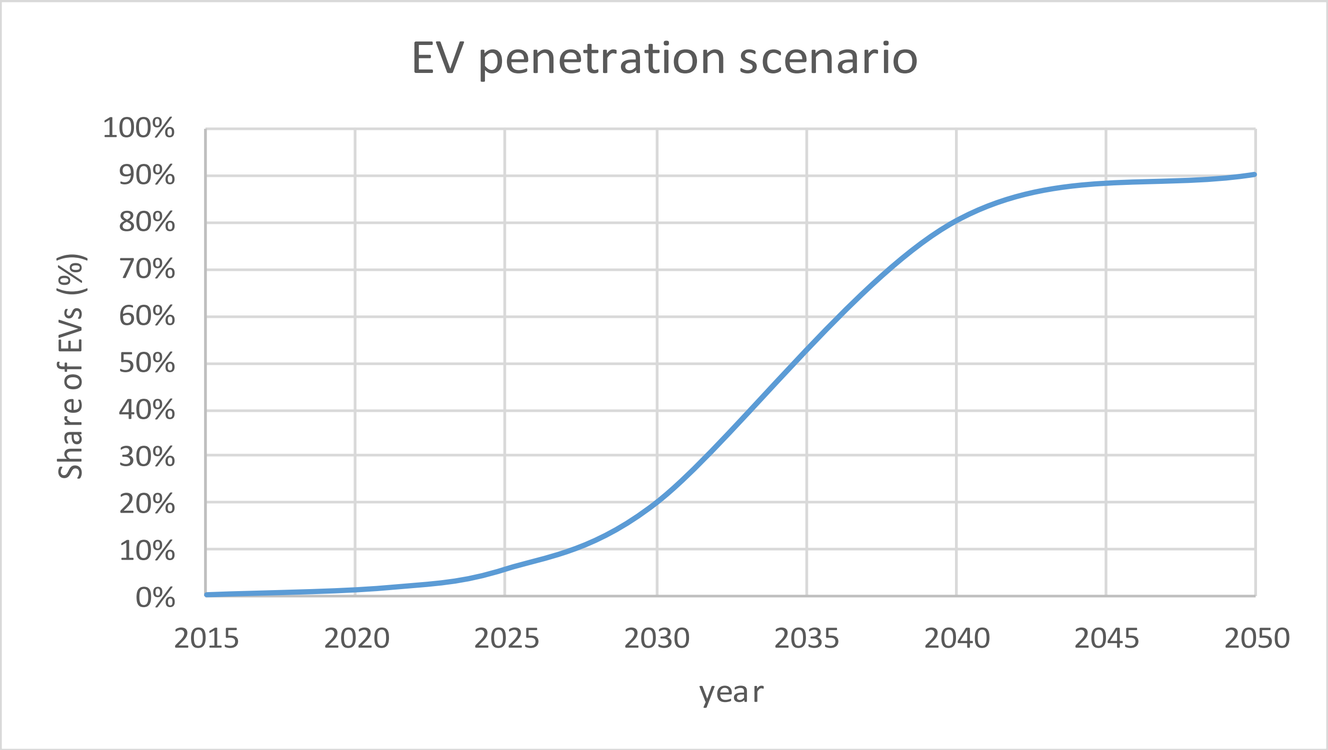
What investments are likely to be made?

Scenario description

AND PARAMETERS

Expected EV rollout in the UK

The expected EV penetration is around 20% by 2030, 80% by 2040 and 90% by 2050 (National Grid, 2018).

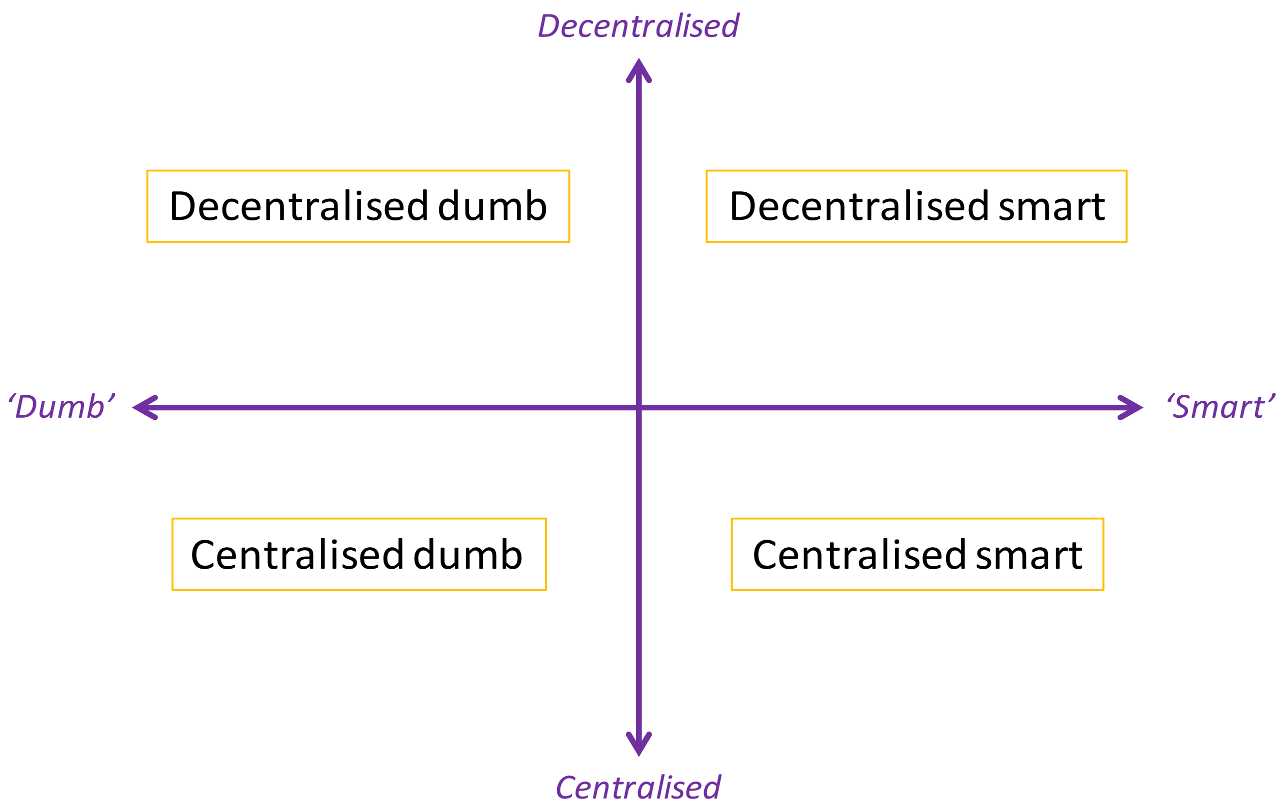


EV charging scenarios

Four different EV charging scenarios

These scenarios are compared with a ‘business-as-usual’ base scenario with no EV penetration.

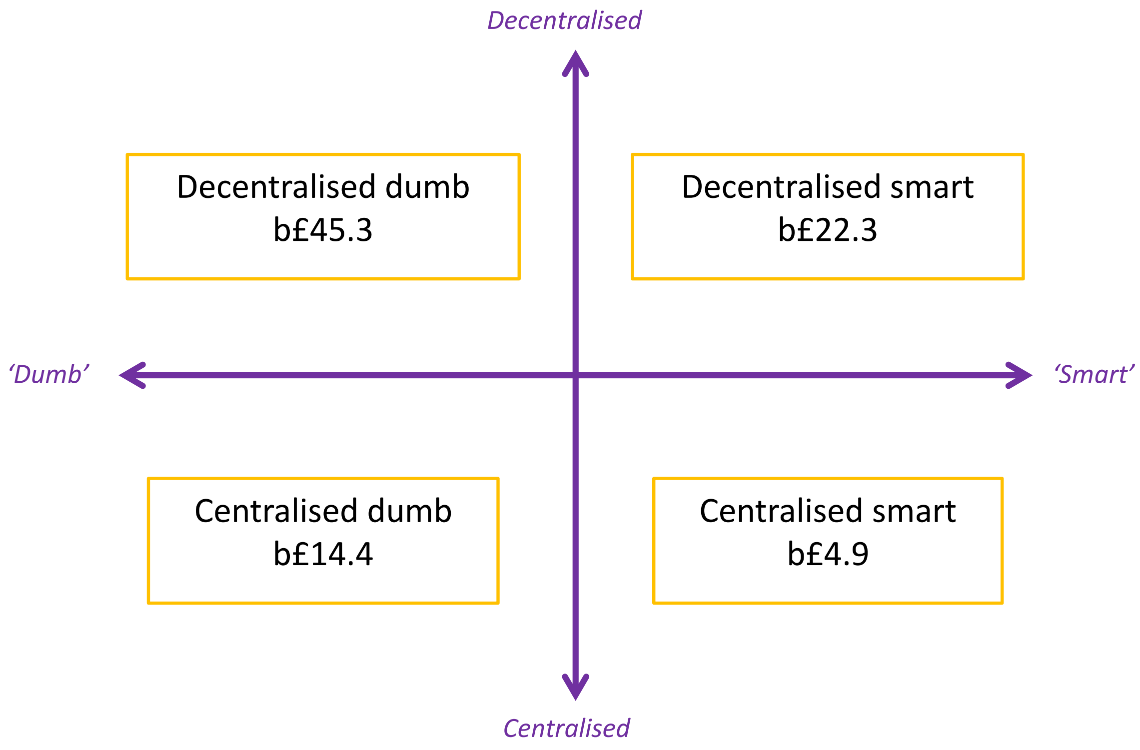
- **Decentralised** charging is assumed to occur at distribution level (i.e. charging is done at home or at work in the city),
- **Centralised** charging is assumed to occur before the distribution level (big parking lots in the outskirts of cities).
- **‘Dumb’** charging consist in charging at peak hours,
- **‘Smart’** charging only occurs when it is cheaper to do so (mostly overnight).

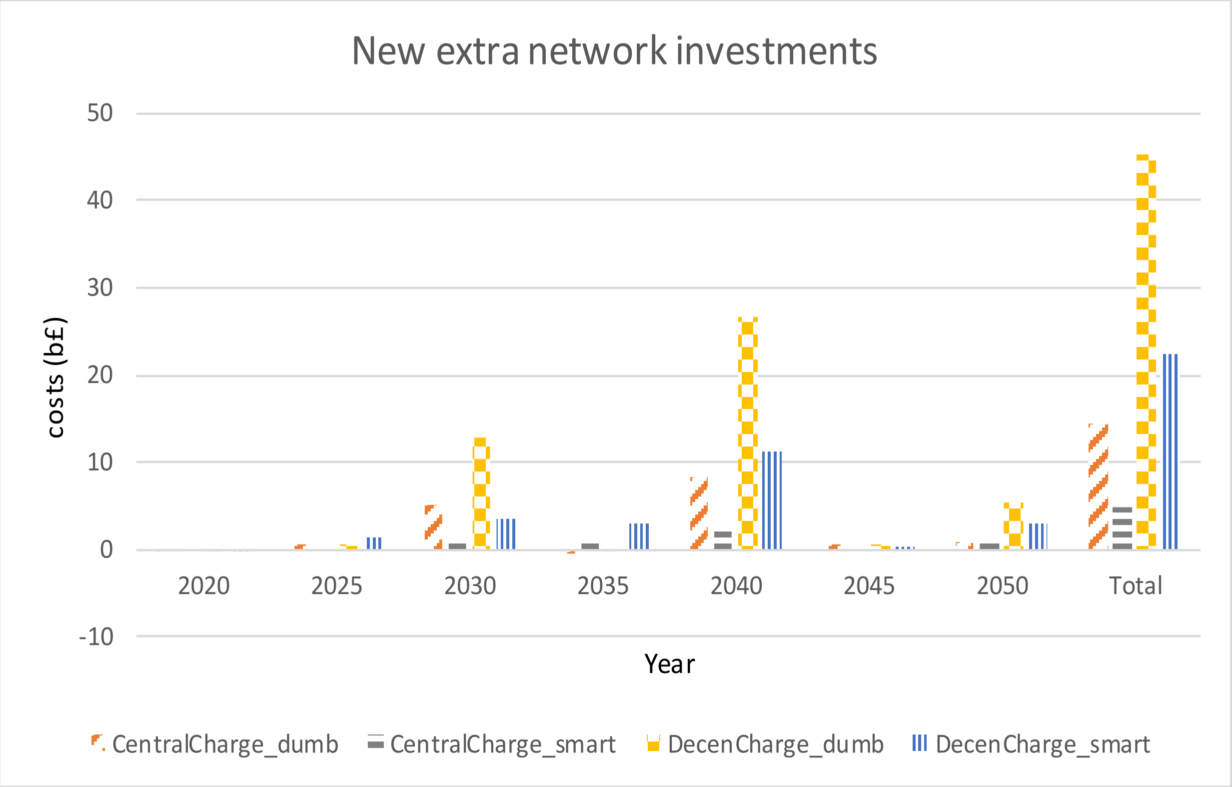


Result analysis

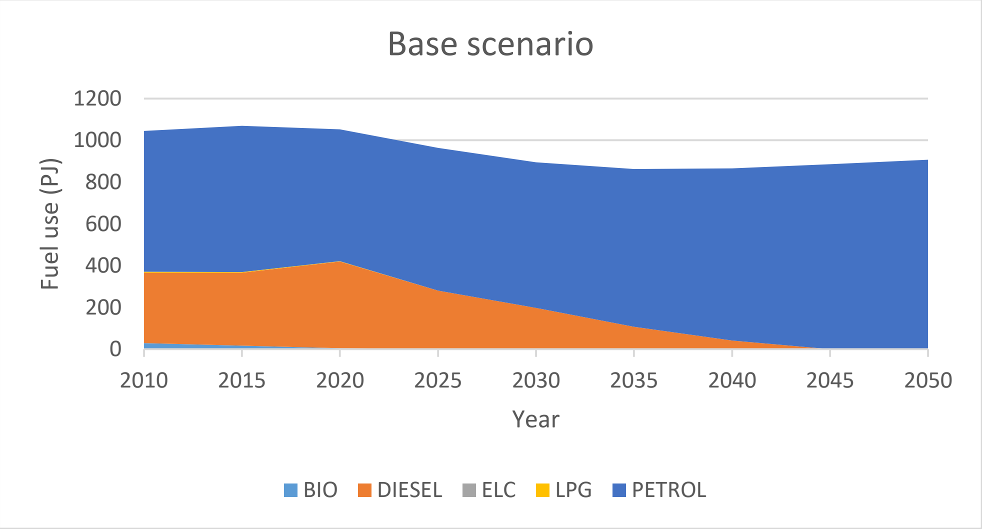
Network investment due to the EV rollout in the UK

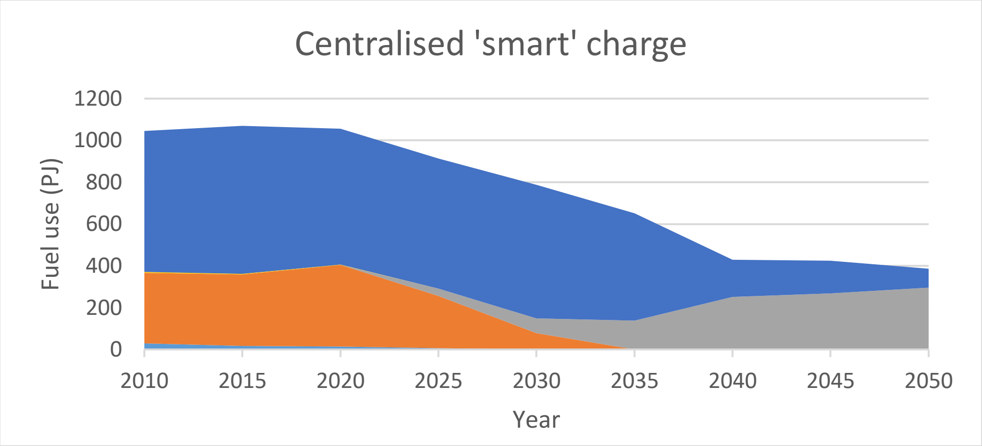
Total network investment per scenario by 2050

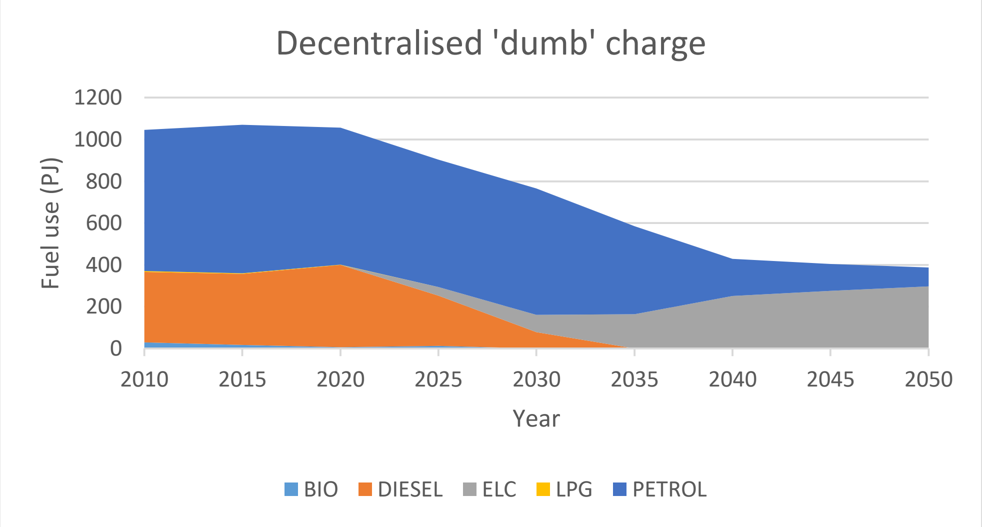




Car fuel use changes

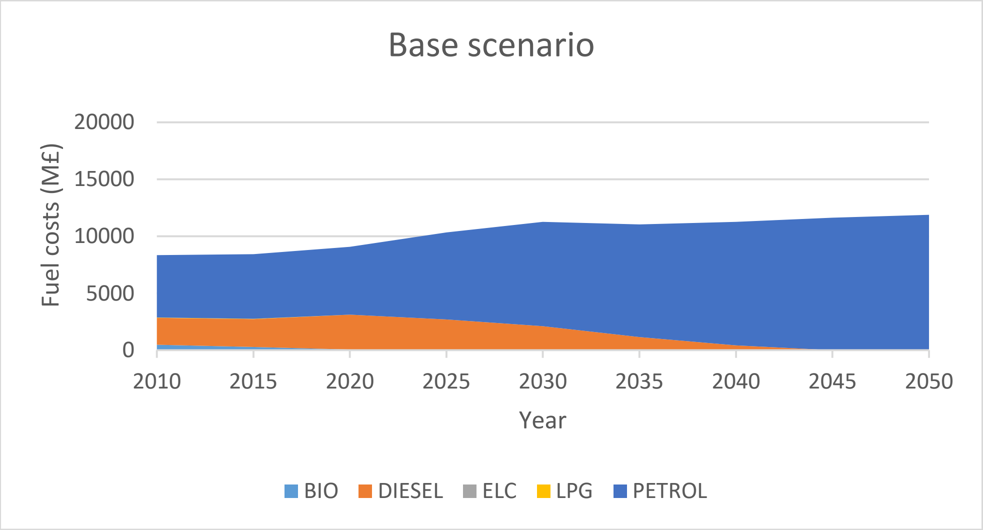


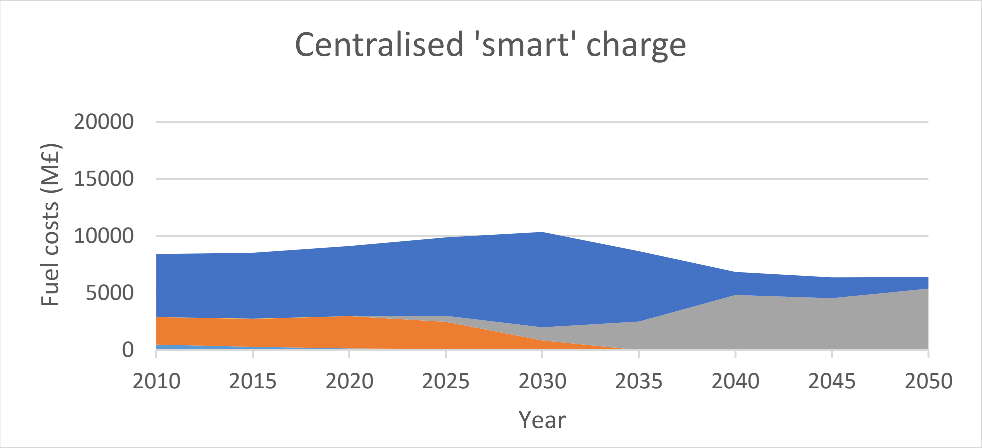


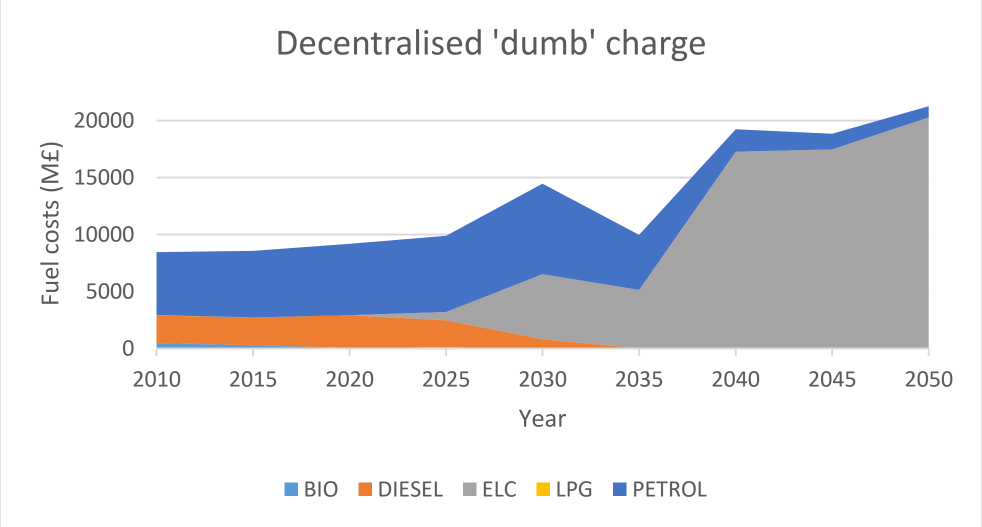


Not a big difference in fuel use between EV scenarios

Car fuel cost changes







Massive difference in fuel cost between EV scenarios

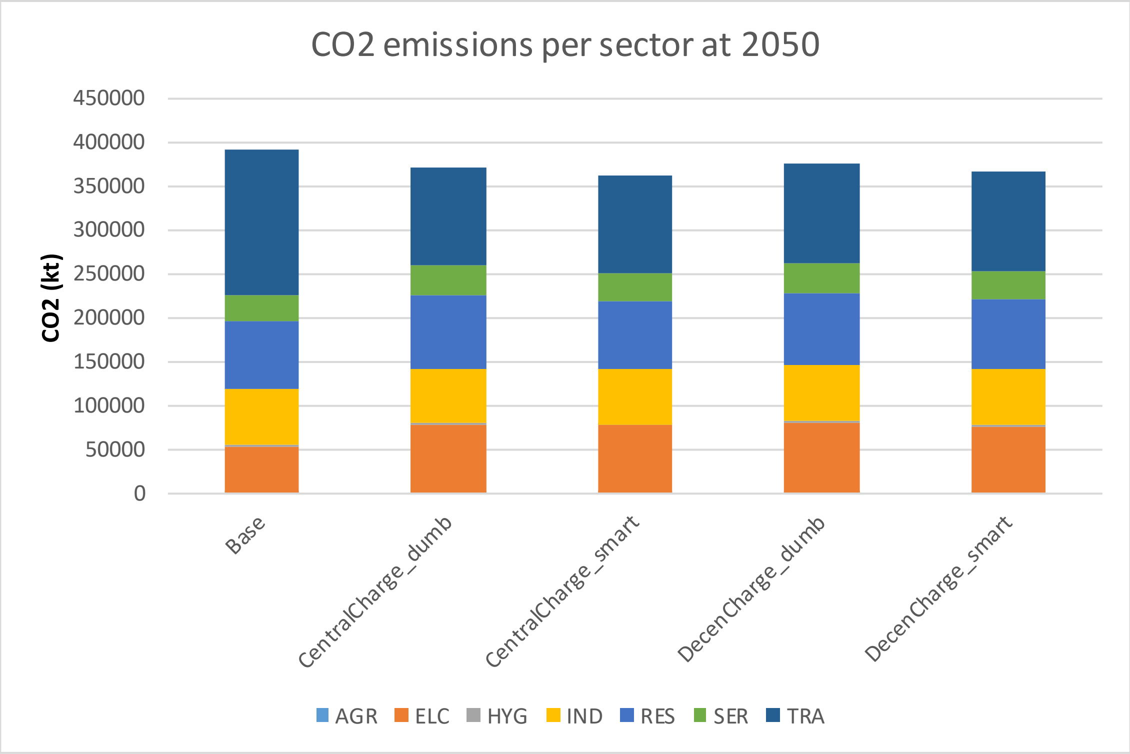
CO2 emissions

Transport related emissions (TRA) decreased approximately 32% relative to the base scenario.

Increase of emissions in the power sector (ELC) in the range of 42 – 48%.

All EV scenarios present a reduction in overall CO_2 emissions relative to the base case, with the 'smart' charging scenarios presenting greater reductions

- -7.5% in CentralCharge_smart
- -6.5% in DecenCharge_smart
- -5.1% CentralCharge_dumb
- -4.3% DecenCharge_dumb.



Conclusions

The results obtained show **the importance of the 'smartness' and location of EV charging** in terms of network reinforcements and fuel costs.

- ´smart´ vs ´dumb´ – 2 to 1 network investment cost reduction
- ´centralised vs decentralised – 3 to 1 network investment cost reduction

Network investment costs are passed to final consumers as an increase in energy marginal costs (energy prices).

We observed a **shift of sectoral emissions** as the power sector, required to generate more energy to meet EV demand.

- A holistic approach is needed.
- Policies that target a particular sector (e.g. promoting EV uptake) need to be accompanied with other policies that ensure that there is no emission transfer to other sectors or 'outsourced' to other countries.

We need to analyse the impact of these changes in the economy.

Future and ongoing work

ECONOMIC ANALYSIS

EV roll-out analysis with CGE and TIMES

Analysis of network investments to accommodate large-scale roll-out of EVs in the UK

- How costs are passed to consumers
- How the economy reacts to these investments
- Who ultimately pays for it

TIMES model for network investment costs

- 20% EV penetration by 2030
- Mixed charging scenario (£2.7bn investment)

CGE model for economic impacts

- Investment spread over 3 years or 12 years
- payback over 45 years

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Research Briefing

Who ultimately pays for the electricity network upgrade for EVs?

Karen Turner, Oluwafisayo Alabi, Christian Calvillo and Ragne Low

Introduction

The UK and Scottish Governments have set ambitious targets for the roll-out of electric vehicles (EVs). The predicted rapid expansion in EV ownership over the next couple of decades will see a shift in demand away from petrol and diesel fuels and towards electricity. The mass roll-out of EVs is likely to require upgrades to the electricity network itself, which will carry significant costs. The Centre for Energy Policy is partnering with SP Energy Networks in a National Centre for Energy Systems Integration (CESI) project that integrates energy and economic system modelling approaches to investigate the crucial question of who ultimately pays for the costs of upgrading the power network to facilitate the intended roll-out of EVs.

What do we mean when we ask 'who ultimately pays?'

We propose three underpinning principles in analysing 'who ultimately pays' **the costs** for the network upgrade required for EVs. *NB. This is prior to any consideration of how EV uptake may offset these costs particularly at aggregate level:*

1. **To fund the necessary investment, costs are passed on to consumers through their bills.** The

across the economy as the construction sector in particular draws in additional labour and capital resources. The nature and extent of any negative impacts will depend on the extent and time period over which the investment activity to upgrade the network takes place.

Focusing on this latter point to start with, our initial analysis suggests that the lowest income households would suffer the least if the economy contracted in this way. This is because lower

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EV roll-out analysis with CGE and TIMES

Investment activity can stimulate and deliver returns to the wider economy

- But low income households not as badly hit as may fear

Particularly where large scale spending is concentrated in short time frames and the costs need to be recovered from consumers, it may cause the economy to contract

Roll-out of increasingly more efficient EV's does deliver net positive outcomes.

- Full cost parity with conventional vehicles (close if not already here)

Key driver is fuelling

- Greater reliance on domestic (UK) supply chains in supporting fuelling of electric rather than petrol and diesel cars.
- Greatest employment gains: electricity sector itself and in public and private service sectors.
- Any net job losses are confined to the manufacture and fuelling of petrol/diesel vehicles and offset in other sectors.

Thank you!

Please get in touch if you want to learn more or collaborate with us!

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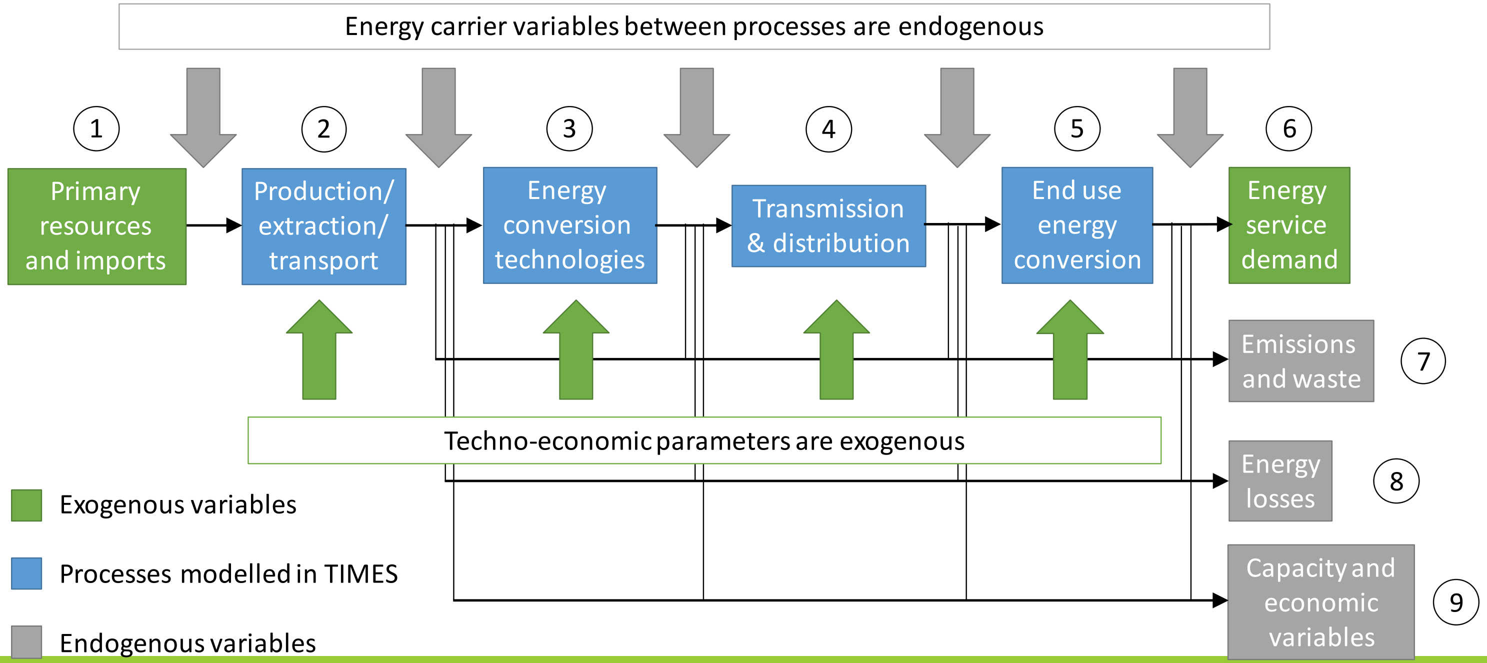
The TIMES model inputs and outputs

The inputs, or exogenous variables of the model, are the data of the supply and demand side (end-use service demand)

The outputs of the model, or endogenous variables, include emissions and waste, energy losses associated to processes, technology capacity planning and different economic variables including energy prices, costs, etc.



The CGE economic model a (very) brief description

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CGE is a multi-sector economy-wide generally top-down model that covers all sectors and markets

Uses input-output tables (National Accounts) as core structural database – SIC classification of industries

For any given policy or industry action, or economic disturbance, solves for supply and demand in all markets simultaneously, under set of condition/constraints for functioning of different markets and macroeconomy

Examples of policy questions:

How would the wider economy and incomes/prices/activity in different production and end consumer sectors look following/during implementation of actions to:

- Improve labour and/or capital productivity in energy supply or other production sectors
- Support increased energy efficiency (e.g. through construction sector activity on retrofitting – break into ‘enabling’ and ‘realising’ stages)
- Support roll out of new low carbon solutions via investment in infrastructure in different sectors

How would exports, imports, employment, investment and GDP be affected in different time frames?

Would energy use reduce across all sectors of the economy?

Which household income groups would enjoy/suffer greatest boosts/reductions in real income and/or spending?

Other parameters

EV parameters

	2010	2020	2030	2040	2050
Lifetime (years)	12				
Technical efficiency (vehicle km/MJ)	1.45	1.62	1.75	1.84	1.89
Vehicle cost* (k£/vehicle)	43.21	22.06	20.92	19.77	18.63
Fixed operation & maintenance cost* (k£/vehicle)	2.93	1.68	1.62	1.55	1.48

Transmission and distribution network reinforcement cost parameters

	Technical lifetime (years)	Investment costs* (m£/GW)	Fixed operation & maint. cost* (m£/GW)
Transmission	40	628.26	6.34
Distribution	25	328.13	12.61