UNIVERSITY of STRATHCLYDE
CENTRE FOR ENERGY POLICY

Policy Briefing

Who ultimately pays for and who gains from the electricity network upgrade for EVs?

Karen Turner, Oluwafisayo Alabi, Christian Calvillo, Antonios Katris and Gioele Figus

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 decade will shift demand away from vehicles fuelled with petrol and diesel and will require **upgrades to the electricity network** itself. This will carry significant **costs that are ultimately paid by consumers** both through their energy bills and the costs of other goods and services where electricity prices impact production costs. Large-scale investment can also be disruptive to the wider economy. On the other hand, the **net outcome may be positive** due to a broad set of economic benefits, including **up to 3,000 new jobs** associated with 20% EV penetration by 2030**.** The main driver may be **strong UK supply chain activity driven by powering vehicles with electricity**.

The research findings reported here highlight the need to broaden attention from technology and cost considerations associated with low carbon developments. Instead, there is a need to focus on **the potential for an initiative like the EV roll-out to unlock, sustain and increase value in different parts of the economy** as we transition to a low carbon future. Indeed, we may have been **missing a key source of value in terms of how we have fuelled our vehicles in the past**, and need to look beyond the manufacture of vehicles and batteries in considering **opportunities for generating value in the wider economy system**.

The key questions and findings

We focus on electricity network investment required to support 20% EV penetration by 2030

Q1. How are the costs of electricity network investment and payback likely to impact low income households? Low income households may not be expected to be key players in the uptake of EVs, leading to concerns over how they may be impacted by repaying investment costs. If network upgrades are considered in isolation, we find that all households are negatively impacted, both through their energy bills and how the wider economy responds to the required large scale investment over limited time frames. But the **low income households suffer less the more limited the level of investment spending.** In some years the **net impact may even be neutral.** Small positive gains are found if investment activity is concentrated across 3 years, with a maximum gain of 82p per household in 2027. **But the network upgrades enable EV uptake, and the sustained impacts of that must be assessed.**

Q2. How do network investment and the EV roll-out combine to impact the wider economy? Uptake of EVs triggers **positive net wider economy impacts (on employment, GDP etc.)**. Smoother adjustment and more positive outcomes (a sustained GDP boost of up to 0.1%) are likely where network investment supports a mix of **smarter and more centralised charging** scenarios. It is also better when **investment activity can be spread over a longer time frame** (here 12 years), which would cut across several RIIO price control periods. The **increase in UK household spending always trails GDP expansion**, due to the need to repay the investment cost through energy bills.

Q3. What sectors of the economy gain the most and which lose out? The key driver of gains is the **greater reliance on domestic (UK) supply chains in supporting fuelling of electric rather than petrol and diesel cars.** The greatest employment gains are enjoyed in the electricity sector itself and in public and private service sectors. The largest sustained gross employment gains, 3,071 jobs, are set against a gross sustained loss of 115 jobs. The net impact is a gain of 2956 jobs by 2040. **Any net job losses are confined to the manufacture and fuelling of petrol/diesel vehicles and offset in other sectors.**

What scenarios did the research consider?

We used an energy system model (UK TIMES) to simulate scenarios involving electricity network upgrades to support a range of charging scenarios involving different assumptions as to how smart and centralised the system is. The outcomes for required investment costs and efficiency gains realised through using electric vehicles for private transport were then used to inform an economy-wide model. We focus on the **projected EV roll-out to 2030** and associated investment spread across either the immediate 3 years before this (from 2027) or across 12 years (and multiple price control periods) from 2021-2032. Here, we focus on results for a **mixed partially centralised-smart charging system that requires £2.7bn network investment to enable the EV roll-out to 2030.** Only around one-third of this is spent in the UK (mainly construction requirements), but consumers must ultimately repay the total amount, albeit over the 45-year lifetime of the assets.

How does the electricity network investment impact the wider economy?

Investment spending *will* generate additional activity across the economy, here mainly via the construction sector. This will ripple out to wages and household spending, where higher income households will be the owners of/stakeholders in firms and capital. However, the availability of capital, and labour, is constrained, at least in the short term. This **impacts the economy's ability to expand.** Particularly when the investment activity is concentrated in short time frames, it will **cause prices to rise elsewhere in the economy.** Moreover, **the investment costs have to be recovered**, both directly from households, and from commercial users, who can pass the impact on via their own prices. This introduces more negative pressures and distributional effects.

But just what the net overall and distributional impacts are also depends on **how the *results of the investment* impact different areas of the economy.** That is, the benefits of the EV roll-out. We return to this issue later. In the first instance, we consider the impacts of the investment and its repayment on the lowest income households.

Impacts of the investment stage on low income UK households

Figure 1 shows the net change in real per household spending of the 20% of UK households with the lowest annual incomes that results from (i) the investment stimulus to the economy; (ii) the need to repay that investment.

The results suggest if we focus on a case where investment activity is concentrated in the three year period that just allows network upgrades to happen in time for the projected 2030 level of EV demand the negative impacts may be minimal for low income households in the first 2 years. Our results suggest that **the UK's lowest income households may actually experience minimal net short terms gains** in 2027 (82p per household) and 2029 (21p). By the end of the investment period in 2030, average spending will drop by 86pence. By 2040 the drop in spend is more limited to 72p. If the investment is spread across 12 years (2021-2032), the lowest income households suffer a slight net loss from the outset (13p in 2021). By 2027 this grows to 22p. By 2030 losses are limited relative to the case where the investment is condensed in 3 years.[1]

UK households with higher incomes tend to lose more (a maximum of £5.88 per household in the highest income quintile in 2030 in the 3 year investment case). This is due to a larger absolute impact on what are higher energy bills overall, and a greater exposure to changing economic conditions (wage and capital incomes are more important sources of income).

Figure 1. Net change in average annual real spend per UK household in the lowest income quintile resulting from of a £2.7bn electricity network upgrade investment

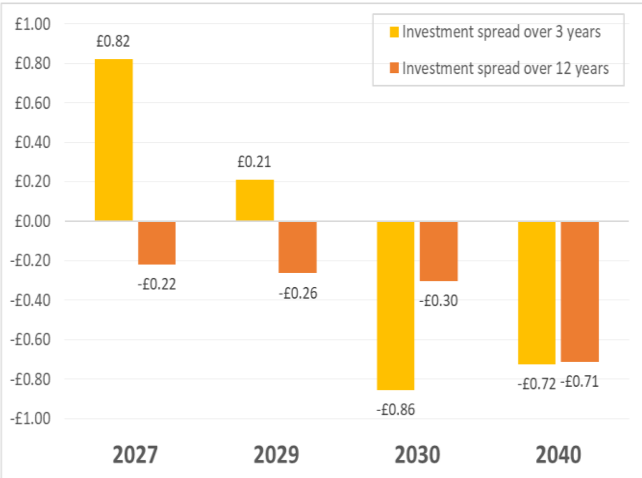
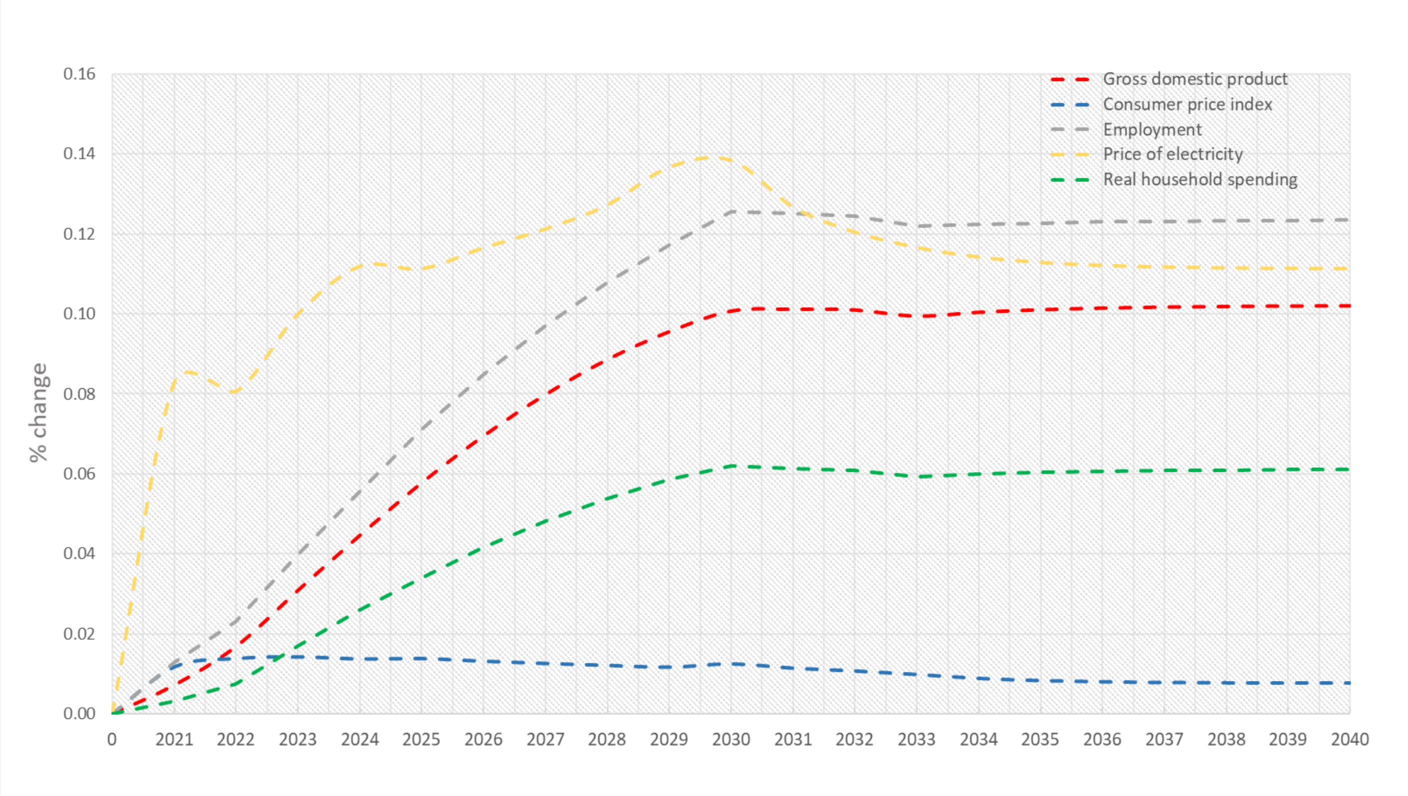


Figure 2. Net impacts on the wider economy of 20% EV penetration by 2030 and required network investment (spread over 12 years, 2021-2032)



How is the wider economy impacted by the combination of network investment over 12 years and the EV roll-out to 2030?

To consider the impact on UK households more generally, and key indicators such as GDP and employment, we **extended our scenario analysis to include the projected EV roll-out to 2030.** Drawing on National Grid's Future Energy Scenarios (FES)[2] and SP Energy Network's RIIO T2 Energy Scenarios[3], we simulate a **20% EV penetration by 2030**. We build the uptake in 2% increments from 2021 from a base of 2%. The TIMES scenarios suggest that **EVs become increasingly more efficient** in using electricity to deliver the same number of miles per physical unit of electricity (20% efficiency gain by 2030).

One source of expansionary impacts on the wider economy from the EV uptake is the efficiency gain in personal transport, which frees up income to spend on other things (including personal transport). But our results suggest that the main source of expansion across the wider economy is shifting to electricity as fuel to run vehicles.

The supply of electricity involves a stronger domestic supply chain than petrol or diesel, where there is greater reliance on imports. We return to this point below. First, Figure 2 plots the trend and impacts on key macroeconomic variables from 20% EV penetration by 2030 and the required investment in network infrastructure upgrade. It is important to note that, despite the expansion in employment outstripping the boost to GDP from the outset, **the boost in real household spending is more limited.** This is because households are repaying the network investment cost via higher energy bills. Moreover, the uptake of EV increases demand for electricity. This puts further upward pressure on prices. The gap between the increases in real GDP and household spending is sustained. This is despite reduced vehicle running costs realised through improved efficiency in using EVs, and an easing of the general upward trend in prices (reflected in the CPI) triggered by the various increased demands.

Which sectors gain the most jobs, and which sectors lose out from network investment and EV uptake?

Figure 3 presents change in full time equivalent (FTE) employment across sectors in the UK economy. We focus on the impacts in four years of particular interest: 2025, 2027 and 2030 (i.e. during the period up to the projected 20% penetration) and 2040, ten years on. Note that when we considered impacts beyond 2030 (and 2032, the end of investment activity), we are still only considering the impacts and economic adjustment in response to the initial phase network investment and 20% EV penetration.

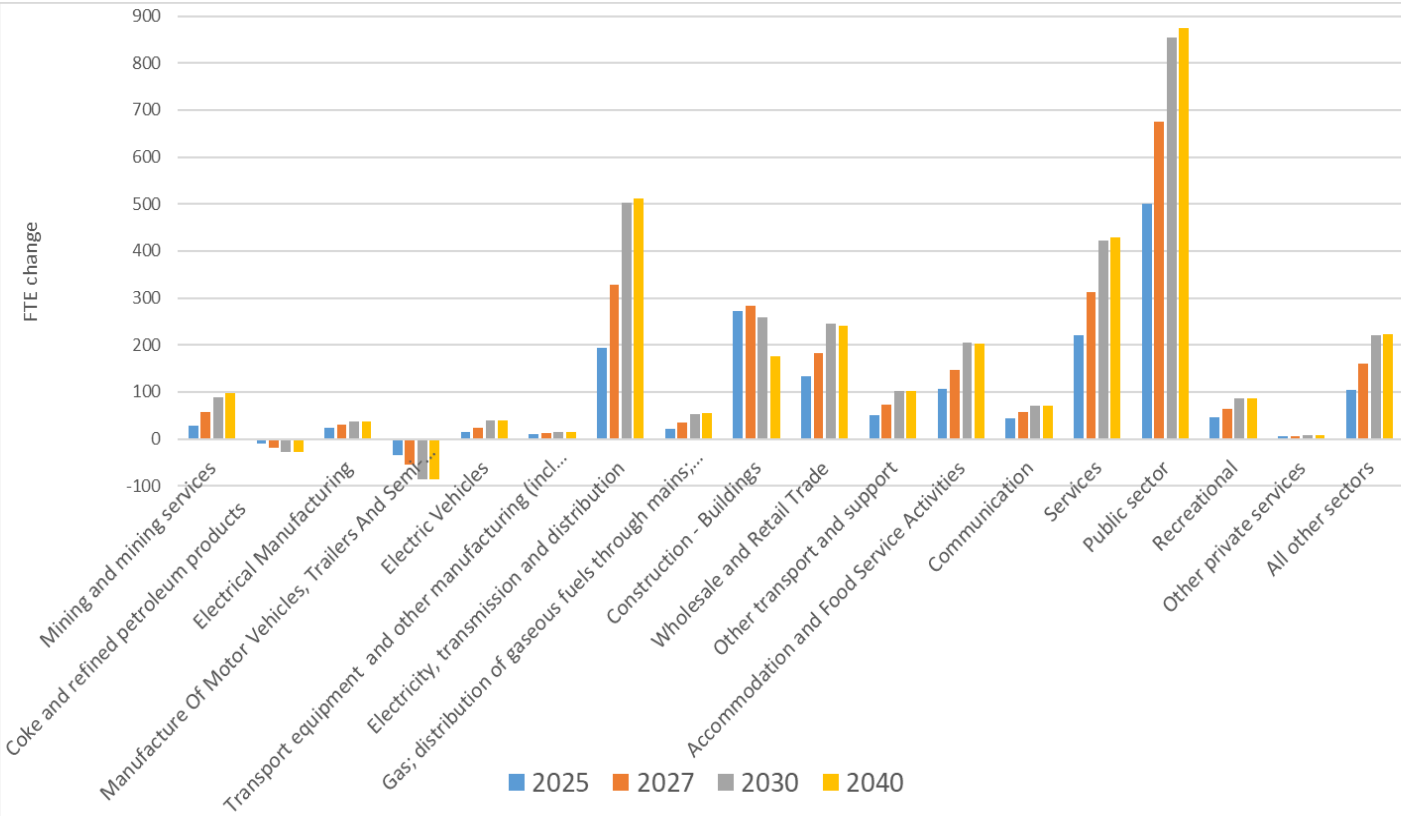
The largest gain in total employment (3071 jobs) is observed in 2040. The biggest employment gains are in the wider public service sector, which includes research, education, health and other public services and gains a sustained increase of 874 jobs by 2040. The electricity generation, supply and distribution industry gains 512 jobs by 2040. The **wider private services sector**, which includes everything from finance/insurance, to legal and real estate activities etc. ultimately gains and sustains an additional 430 jobs.

The number and distribution of net jobs gained demonstrates the strength of the domestic electricity sector's supply chain. This is particularly in terms of the UK electricity industry's (direct and indirect) reliance on UK service activities. This reinforces a key finding from our previous research.[4] The manufacture of vehicles and batteries certainly provides important opportunities for economic gain, but whether this occurs in the UK is subject to many factors. The supply of electricity, on the other hand, is a 'home-based' industry.

The only two net losers are 'Coke and Refined Petroleum' (but only 29 job losses by 2040) and 'Manufacture of Motor Vehicles sectors' (87 job losses by 2040).

More generally, this element of our research findings is important in terms of considering **how EV (and other low carbon) development may be framed not only in terms of delivering climate change objectives, but also economic returns that are valued by society.** This is crucial in the context of the 'Just Transition' framing of policy (which the Paris agreement explicitly sets in terms of national priorities for jobs[5]).

Figure 3. Net impact on sectoral employment of 20% EV penetration by 2030 and required network investment (spread over 12 years, 2021-2032)



In summary, our research highlights and emphasises the need to focus on how a low carbon initiative like the shift to EVs can unlock, sustain and increase value in different parts of the economy as we transition to a low carbon future. In the particular case of EVs, it raises two key questions. First, whether we may have been missing a key source of value in terms of how we have fuelled our vehicles in the past. Second, whether the wider economic benefits of deploying EVs should become a more important factor in policymakers' transportation decarbonisation targets.

A conclusion that can be drawn is for UK policy makers and industry to consider to how to capitalise on the type of returns suggested here. This is both through the ongoing EV roll-out and other low carbon initiatives where domestic capacity can be fully and effectively utilised.

More details of the research can be found in a working paper available for download at https://doi.org/10.17868/67737.

Where does the research go next?

There are a number of directions that future research could take. We identify five potential pathways here.

One immediate area for further development is to extend the range of scenarios simulated to consider a broader set of potential investment time frames, with the aim of identifying how and when wider economy benefits may be optimised.

A second is to introduce consideration of how investment in electricity network upgrades may enable efficiency gains in the supply of electricity. Where improved productivity allows (both commercial and domestic) consumer prices to fall, this provides another trigger for wider economic expansion. In other research (forthcoming in The Energy Journal) we have already begun to research how both economic and climate policy objectives may be met where policy actions enable and support consumers switching to electric systems in the delivery of their heat and/or transport needs. (Please contact us for further details of this research.[6])

A third is to extend the analysis reported here to network investment and EV roll-out beyond 2030. This should involve investigating how the EV uptake is likely to differ across different household income groups, and, thus, further impact both the extent of economic expansion, and how it is distributed across different kinds of households and sectors of the economy. It should also consider scenarios involving an accelerated roll out of EVs, as recommended by the Committee on Climate Change in May 2019.[7]

A fourth area not considered at all here is how tax revenues from fuelling vehicles may be impacted under different scenarios regarding both the EV uptake, different charging infrastructure and system etc.

A fifth is to extend this type of analysis to other low carbon initiatives that require large up-front investment. Some may be interdependent. For example, as noted above, electricity infrastructure upgrades will also be required to support electrification of heat.

Contact

For more information on the research reported here, and to discuss potential future research, please contact Professor Karen Turner, Director of the Centre for Energy Policy at the University of Strathclyde, or other members of the CEP project team at cep@strath.ac.uk.

About the project

The questions addressed in this research originated from a collaboration between the Centre for Energy Policy at the University of Strathclyde, and SP Energy Networks. It was primarily funded through the EPSRC National Centre for Energy Systems Integration (CESi) (EPSRC grant ref: EP/P001173/1). Christian Calvillo's input was funded by the Scottish Government ClimateXChange programme.

The project integrates energy and economic system modelling approaches to investigate the distribution of costs and benefits of upgrading the power network to facilitate the intended roll out of EVs.[8,9] It also builds on previous research funded under EPSRC Hydrogen and Fuel Cell Research Hub research programme (Grant ref. EP/J016454/1), particularly a paper published in the journal Energy Policy in 2018.

About the authors

- Professor Karen Turner, Director of the Centre for Energy Policy (CEP). Principal investigator and research lead on this project and others at CEP. Member of the Scottish Government's Just Transition Commission, the Royal Society of Edinburgh's 'Scotland's Energy Future' inquiry.
- Dr Christian Cavillio, Co-investigator, TIMES energy systems modeller and Scottish Government, ClimateXChange (CXC) fellow on 'Energy System Impacts of Energy Efficiency' project.
- Dr Oluwafisayo Alabi, Co-investigator, hands-on modeller, researcher on economy-wide modelling on 'Who Ultimately Pays' for low carbon solutions under different economic conditions.
- Dr Antonios Katris, Co-investigator, economy-wide CGE modeller and researcher on UKERC-funded project: 'The Impact of Multi-level Policymaking on the UK Energy System'.
- Dr Gioele Figus, Co-investigator, economy-wide CGE modeller and collaborator with Scottish Government Centre for Enterprise on project titled 'Integrating Different Large Scale Modelling Techniques for the Analysis of Energy Efficiency and Climate Change Actions'.

---

[1] Concerns over how large network investments condensed in short timeframes ahead of projected need – i.e. a 'just in time' approach – are reflected in the Committee on Climate Change's May 2019 report, where the following statement is made on p.182, ''Many networks will need to be upgraded in a timely manner and future-proofed to limit costs and enable rapid uptake of electric vehicles and heat pumps''. The report is available at https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-The-UKs-contribution-to-stopping-global-warming.pdf.

[2] National Grid. (2018) Future Energy Scenarios. Available at http://fes.nationalgrid.com/media/1363/fes-interactive-version-final.pdf

[3] Scottish Power Electricity Network (SPEN). (2018). RIIO T2 Energy Scenarios Consultation. Available at https://www.spenergynetworks.co.uk/pages/riio_t2_energy_scenarios_consultation.aspx

[4] Turner, K., Alabi, O., Smith, M., Irvine, J., and Dodds, P., (2018). 'Framing policy on low emissions vehicles in terms of economic gains: Might the most straightforward gain be delivered by supply chain activity to support refuelling?' Energy Policy, [online] 119, pp.528-534. Available at https://doi.org/10.1016/j.enpol.2018.05.011

[5] United Nations Framework Convention on Climate Change (UNFCCC). (2015). Paris agreement. Available at https://unfccc.int/sites/default/files/english_paris_agreement.pdf

[6] Our research on the productivity impacts of UK electricity network upgrades, due to be published in the Energy Journal in September 2019, was funded by the EPSRC (Grant ref. EP/M00760X/1) and the Scottish Government ClimateXChange programme.

[7] See p.198 of the Committee on Climate Change report published in May 2019 (see Endnote 1).

[8] Working papers are available underpinning the CGE modelling (https://doi.org/10.17868/67737) and TIMES simulations (https://strathprints.strath.ac.uk/id/eprint/67545).

[9] The economic system model used here is UKENVI, a multi-sector economy-wide computable general equilibrium (CGE) model. For details of the model variant used here, see:
* Figus, G., Turner, K., McGregor, P., & Katris, A. (2017). Making the case for supporting broad energy efficiency programmes: Impacts on household incomes and other economic benefits. Energy Policy, 111, 157-165. Available at https://doi.org/10.1016/j.enpol.2017.09.028
* Figus, G., Swales, J.K. and Turner, K. (2018) Can private motor vehicle augmenting technical progress reduce household and total fuel use?, *Ecological Economics*, 146, 136-147, 2018. Available at https://doi.org/10.1016/j.ecolecon.2017.10.005