UNIVERSITY of STRATHCLYDE
CENTRE FOR ENERGY POLICY

Research Briefing

Network investment and electric vehicle rollout required for 2050 net zero:

The importance of electricity price impacts in driving policy trade-offs

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Research overview

In the context of the UK's 2050 net zero ambitions, electrification of transport in general, and more specifically the transition from conventional to electric vehicles (EVs) in delivering private transportation services, is crucial to the overall national decarbonisation efforts and contribution to global emission reduction.[1] However, the role and magnitude of contribution of EVs to the decarbonisation of transport is dependent on both the nature and extent of large-scale investment required, and the level of rollout/penetration. The latter is enabled by infrastructure investment and affected by availability and affordability of the EVs themselves, both set in the context of the anticipated 2035 UK-wide restriction on sales of new petrol and diesel fuelled vehicles. Combined, these factors will trigger varying absolute and distributional impacts across the economy generally, and specifically on a range of industries and different household income groups, and this is in terms of the likely pathways and timeframes as well as who ultimately pays for required actions.

This research briefing is the first of two generated by a new research project funded by the National Centre for Energy System Integration (CESI) which focuses on addressing the question of '**Who ultimately pays for and who gains from the electricity network upgrade for EVs to support the UK's net zero carbon ambitions?.**[2] This research builds on a body of work[3,4,5] produced through projects funded by CESI, Scottish Power Energy Networks (SPEN), and the Bellona Foundation. Generally, addressing the question of 'who ultimately pays' involves **consideration of a range of indirect, unanticipated and unintended, consequences of network development for EVs through impacts on markets, prices and incomes across the economy**. Our integrated scenario simulation approach reflects consideration of how consumers respond to 'smart charging' capability that in turn determines required levels and timing of investment in different timeframes to support the network upgrades necessary to enable the projected EV rollout, and to realise the sustained expansion of the UK economy that can ultimately be supported. We also consider scenarios where the pace of EV rollout for net zero may not actually be achievable if, for example, there are constraints on EV manufacture at UK and/or global levels both absolutely and/or in different timeframes.

Our initial findings tell us that the projected EV rollout to 2050 and associated investment is likely to trigger positive net wider economy wide gains that are fully realised by 2050. This includes a shift onto a higher trajectory of GDP expansion (reaching +0.15%), accompanied by earning gains (+0.19%) and sustained increases in employment (+ 0.11% or 27,437 FTE jobs). However, this expansion has two key underlying characteristics. First, the required large-scale investment and cost recovery via electricity prices introduces both electricity and wider CPI pressures. Second, while supporting a more sustainable economic expansion – one that is associated with increased labour productivity and higher average wages – any supply constraints in the wider economy will introduce additional cost pressures that put upward pressure on the UK electricity price. This introduces policy challenges and trade-offs in terms of the extent to which the expansion is associated with increased real consumer spending power which, in turn, will raise a range of distributional concerns both in terms of direct electricity cost and how real household income and expenditure are impacted as the economy adjusts.

This research briefing begins by explaining our research focus, approach and simulation strategy, before providing an overview of key initial results in terms of the net impacts of enabling and realising a relatively rapid EV rollout on the UK wider economy. We close with a summary of conclusions.

1. Research focus, approach and scenario simulation strategy

The research questions we begin to address here are:

- How might the **full rollout of EVs required to meet the UK 2050 net zero target** impact the economy-wide picture of who ultimately pays and gains from enabling and realising this decarbonisation pathway?
- How might this picture further **change if the projected rollout overestimates the actual pace of uptake** in different interim timeframes and overall, for example if the manufacture of EVs (at UK and global levels) cannot meet the implied demand?

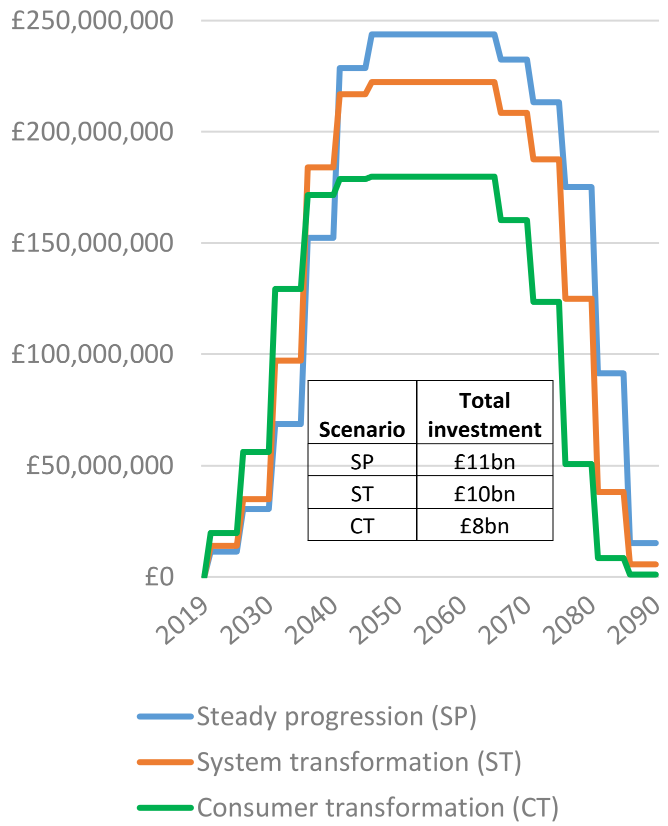
In order to address the research questions, we conduct scenario simulations using our economy-wide computable general equilibrium (CGE) model (UKENVI), informed by UK energy system (TIMES) analyses of the levels and timings of investment cost for network upgrades, the EV rollout and associated efficiency changes in delivering private transport services. We set scenarios in the context of the CEP Net Zero Principles Framework[6] that we have developed for application across the net zero policy space. This involves considering two distinct but interacting stages for any net zero action:

1) Enabling stage: focusing on the large-scale investment spending for network upgrade to enable the EV rollout. In the scenarios reported here, only one-third of the total investment spending is made within the UK, focused on construction (and associated supply chain) activity. While this in itself is a source of wider economy expansion, the crucial constraints are that: (i) the total investment costs need to be recovered through energy bills, spread over the lifetime of assets created; (ii) constraints on the availability of capital and labour across the UK economy trigger more general price increases across the economy.

2) Realising stage: focusing on the impacts of actually realising EV rollout and uptake as EVs replace conventional vehicles and change in fuelling from petrol and diesel to electricity. While efficiency in terms of miles travelled per £ of spending plays a role, the greater reliance on fuelling that involves drawing on strong domestic UK electricity supply chains triggers a wider economic expansion. While households share in real income gains, demand-driven expansion triggers cost pressures in all sectors, feeding through to increased CPI pressures, including electricity prices faced by all consumers.

Drawing on National Grid's Future Energy Scenarios (FES)[7] – used to directly inform our initial energy system analysis in TIMES - we focus on electricity network investment required to support a full capacity EV penetration reaching 100% EV rollout by 2050. Figure 1 shows the evolution/pattern of the spread of the network investment cost to 2050 and repayment (cost recovery) activity or programme to 2090 for each of three FES scenarios, where the total network upgrade investment cost required to enable the projected EV rollout ranges from £8bn (Consumer Transformation) to £11bn (Steady Progression.

Figure 1. TIMES model outcome: evolution of total investment for Steady Progression, System Transformation and Consumer Transformation FES scenarios to enable 100% EV rollout by 2050



In refining the energy system outcomes to inform our economy-wide analysis, all three scenarios are represented in Figure 1 on the basis of the assumption that investment spending is incurred over planning period blocks or per price control periods of 5 years. However, the total investment costs are recovered through bills over a 45-year time (i.e. asset lifetime). As noted, we assume that only one-third of this is spent in the UK, on construction activity. The remaining component of the investment spend (i.e. two-thirds) occurs abroad. However, UK consumers will repay the total investment cost via higher electricity bills.

In the results presented and discussed here, we focus initially on the Consumer Transformation scenario (£8bn). This requires consumer behavioural changes in their consumption patterns to support the delivery and speed of decarbonisation[8]. Compared to the Steady Progression and System Transformation scenarios, this equates to relatively high early/upfront investment up to 2035, thereafter smoothing out to 2065 (post end of investment), with subsequent reduction as consumers begin to respond to smart charging capability alongside their adoption of EVs

2. Key initial results: net impacts of a relatively rapid EV rollout on the wider UK economy

From the discussion above, we would anticipate three main mechanisms determining outcomes in our economy-wide model.

a). The enabling stage investment will stimulate the economy, here through the primary conduit of spending in the UK construction industry. However, the outcome will not be a straightforward 'multiplier' operating through indirect supply chain linkages and induced household spending. This is due to the presence of a lasting constraint on the size of the working population and labour supply, which will introduce wage pressures in the economy. There are also transitory constraints on capital, which will be relaxed through investment activity, but with this introducing further price pressures.

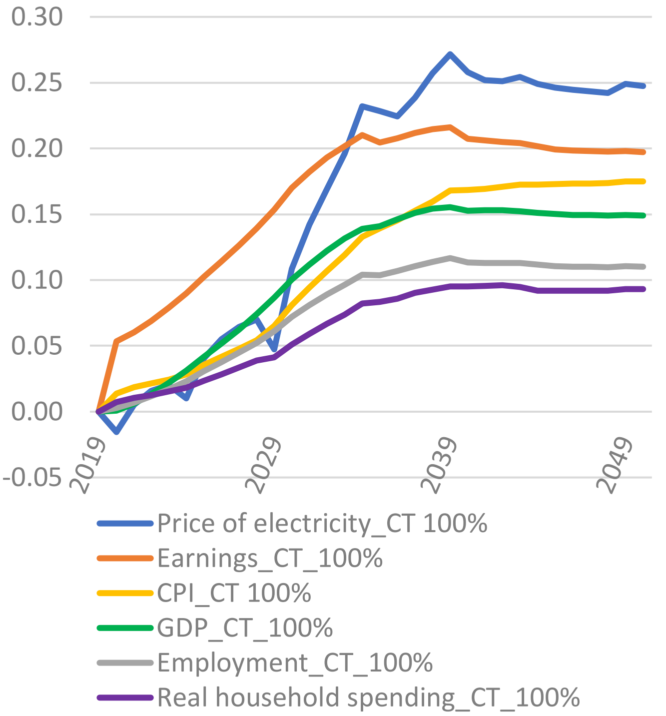
b). The expansion will be further constrained due to the fact that the total costs of electricity network upgrade investment need to be recovered through consumer bills, albeit over a 45 year timeframe. This will act to drive a wedge between real household income and real household spending power as the price of electricity in the consumption basket rises.

c). Households adopting EVs and switching to the use of electricity to fuel them provides the main source of expansionary power. This is due the stronger and relatively high value added/high value wage domestic supply chain content relative to petrol/diesel supply chains. However, as with transitory enabling stage expansion, lasting supply constraints feed through to electricity and other consumer prices. But now this acts to drive a sustained wedge between real household income and expenditure.

2.1 Scenario 1: £8bn investment and 100% EV rollout

Figure 2 shows how the network investment and the projected 100% EV rollout combine to impact key indicators in our scenario simulations. Notice that the net impact is to trigger positive and sustained wider economic gains on GDP, earnings and employment across all timeframes up to 2050. The quality of GDP expansion is reflected in the gap over employment gains, reflecting labour productivity gains. Earnings also grow faster than both GDP and employment with a shift to higher average wage employment.

Figure 2. Net impacts on wider economy of £8bn required spending on network upgrades and 100% EVs roll-out by 2050 (consumer transformation scenario)



However, the trajectory of increased real household spending, which grows at a slower rate than employment, trails the wider expansion of the UK economy. This is reflected in the emergence of a marked gap between GDP and real household spending. The key underlying driver of this outcome is the fact that the rapid EV rollout equates to greater reliance on domestic sourced fuel-electricity. While this is what powers the expansion, increasing demand introduces cost pressures across the economy, including in the electricity industry, resulting in higher electricity prices and consumer bills. The pathway of the increasing electricity price in Figure 2 reflects both the recovery of electricity network upgrade investment costs through consumer bills, and sustained cost pressures across the economy that occur as greater domestic demand drives a constrained wider economy expansion.

The outcome is that the cost of the household 'consumption basket' generally increases, with higher cost electricity accounting for a larger share of spending. Moreover, the price of electricity rises at a higher and faster rate than earnings or other sources of income.

In fact, under the 100% EV rollout scenario, over time there is a 40% sustained household demand increase for electricity, where, in the UK context, the price of electricity is already relatively high and may be further exacerbated if/when reliance or demand increases for purposes beyond the electrification of transport.

2.2 Scenario 2: £8bn investment and 50% EV rollout

In Figure 3, we consider a case where the investment paths and levels are the same as in the 100% EV rollout case (Figure 2), but where we simulate only half (50% rollout) the projected EV rollout. That is, the created capacity is not fully utilised. This may come about, for example, if some people in some household groups (e.g. low income) cannot or choose not to adopt an EV (e.g. for affordability or availability reasons, in new or second-hand markets). Another issue may be that production and/or supply chain conditions are such that it is not technically and/or economically feasible for manufacturers to supply EVs to meet the demand implied by the projected rollout. In either case, if the actual EV rollout is slower and/or smaller than the projected one that network upgrade investments have been planned around, the outcome is one of both excess capacity and reduced expansionary power through the realising stage. The key implication is an emerging trade-off.

Figure 3.Net impacts on wider economy of £8bn required spending on network upgrades and 50% EVs roll-out by 2050 (consumer tranformation scenario)

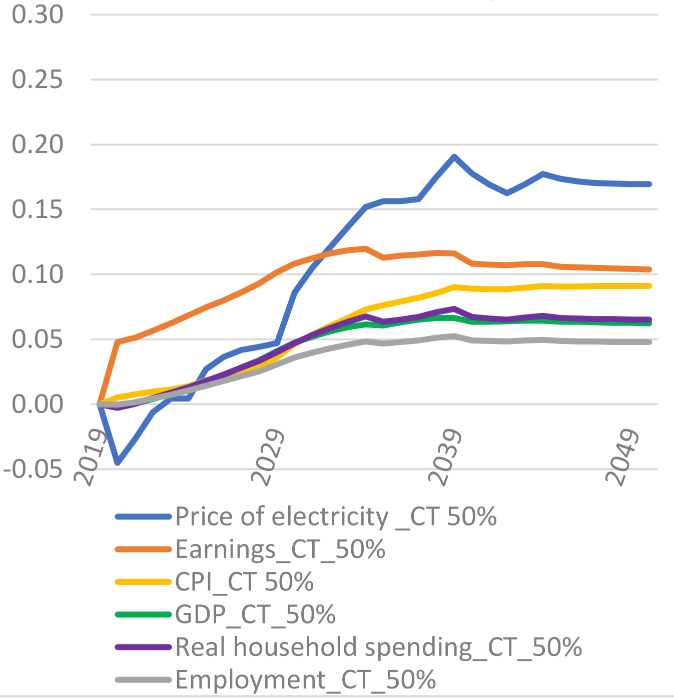


Figure 3 shows that if the pace and extent of the EV rollout were – as an illustrative case – only 50% of the projected one, the trajectory of GDP, earnings and employment expansion is reduced compared to what is reported in Figure 2. Moreover, the pace of GDP over employment expansion reduces so that labour productivity gains in particular are reduced. On the other hand, with less demand pressure driving constrained wider economy expansion our results show that the gap between the trajectory of expansion in GDP and real household spending will narrow. This includes reduced electricity demand pressure, with the sustained increase in the share of electricity in the UK household consumption basket reducing to 20%.

Thus, the nature of the trade-off crystallises, this is in terms not only of the extent but the nature of the 'quality' of GDP expansion, where policymakers are likely to have dual policy aims to realise increases in both labour productivity *and* real consumer spending power. Our findings, as reflected in Figures 2 and 3 suggest that the former will be maximised the greater the extent of electrification in private transport, but that the growth in real household spending power will be constrained where this puts sustained upward pressure on production and consumer costs across the economy, including electricity prices. Moreover, in comparing the outcomes in the 100% and 50% EV rollout cases it must be remembered that the latter does not simply involve doing and delivering less. Both cases involve the same total, £8bilion, level of investment spending, and the same spread of this spend and associated cost recovery over time. This point is emphasised if we consider the wider economy returns per £1million of spending that is ultimately incurred by bill payers. For example, in the 100% EV rollout case, 3.4 full-time equivalent (FTE) jobs are sustained over the long term per £1 million of spending. This drops to 1.5 in the 50% case.

3. Conclusions

Some key challenges for policymakers and regulators, and for the political economy narrative emerging around enabling or supporting the UK EV rollout, are implied by the results of the initial analysis reported above. Crucially, while electricity pricing is of course subject to regulatory decisions in the UK, our scenario modelling demonstrates the nature of interacting market pressures on electricity and other prices that are likely to emerge if and when the EV rollout - and required electricity network upgrades, along with other 'enabling' investments - move forward in a complex and constrained wider economy landscape.

The price pressures emerging in our scenario simulations are twofold: 1) user bill increases mapping directly to repayment/payback of the total investment cost 2) market-driven cost pressures on the price of electricity and other goods and services as the due to increased domestic demand for production across the UK economy. That both occur in a context where both network investment and the EV rollout provide expansionary power to the UK economy is what delivers wider economy gains from enabling the EV rollout. The fundamental trade-off is that this inevitably involves a range of cost and price pressures. The challenge for policy decision makers is in identifying and considering the wider economy consequences of electrification as a decarbonisation pathway and how these feedback to impact different consumers and sectors. The analysis presented here demonstrates how such consequences may emerge in the context of private transportation.

Ultimately, any findings of processes driving increases in electricity add other consumer prices, and the resulting gaps between real income and expenditure gains, will be of concern to regulators in particular and public policymakers more generally. This is particularly important given the potential of such forces to widen real income inequalities and increase fuel and other forms of poverty. Thus, the next stage of our project will focus on drilling down into the impacts on different household groups. This will allow fuller consideration of who is most and/or less likely to benefit from the near term and sustained economic-wide gains for the cost of upgrading the power network to facilitate EV rollout consistent with the UK's 2050 net zero carbon ambitions.

Future publications and contact information

A second research summary will be published in early spring 2021 to report on the next stage of this CESI project. Further non-technical policy briefs will also be published in the weeks following the release of the research summaries. We invite direct engagement with the team. Please contact oluwafisayo.alabi@strath.ac.uk and/or cep@strath.ac.uk.

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About the authors

Professor Karen Turner is Director of the Centre for Energy Policy (CEP), Principal investigator and research lead on this CESI project and others at CEP. She is currently a member of the Scottish Government's Just Transition Commission. She also served on the Royal Society of Edinburgh's enquiry into 'Scotland's Energy Future' in 2018-19, and the Committee on Climate Change's Advisory Group on the Costs and Benefits of Net Zero during the preparation of the 2019 advice to the UK national and devolved governments.

Dr Oluwafisayo Alabi, CESI co-investigator, economy-wide modeller and researcher on the crucial question of 'Who Ultimately Pays for low carbon solutions and the transition to a low carbon future'.

Dr Antonios Katris, CESI co-investigator, economy-wide CGE modeller and researcher on various UKRI and other projects considering the wider economy impacts of net zero and energy policy actions.

Dr Christian Calvillo, CESI co-investigator, TIMES energy systems modeller and formerly Scottish Government ClimateXChange (CXC) fellow on 'Energy System Impacts of Energy Efficiency' project.

Endnotes

[1] Committee on Climate Change (CCC) 2019. Net Zero-The UK's contribution to stopping global warming. Available at https://www.theccc.org.uk/publication/net-zero-the-uks-contribution-to-stopping-global-warming/

[2] A research briefing outlining our project aims is available at https://strathprints.strath.ac.uk/72954/.

[3] Our research on who ultimately pays for and who gains from the electricity network upgrade for EVs? https://doi.org/10.17868/67741.

[4] Scottish Power Energy Network (SPEN) funded research : Can the electrification of private transport lead to economic prosperity https://doi.org/10.1016/j.esr.2020.100497

[5] Bellona funded research : Laying the foundation for a net zero society: principle and the infrastructure for a climate resilient and economically sustainable recovery https://doi.org/10.17868/72953

[6] CEP principle framework on net zero https://doi.org/10.17868/71580

[7] National Grid. (2020) Future Energy Scenarios. Available at https://www.nationalgrideso.com/document/174541/download

[8] See page 26 of endnote #7

Other relevant CEP papers

Alabi, O., Turner, K., Figus, G., Katris, A., & Calvillo, C. (2020). Can spending to upgrade electricity networks to support electric vehicles (EVs) roll-outs unlock value in the wider economy?. *Energy Policy*, *138*, 111117. https://doi.org/10.1016/j.enpol.2019.111117. Full research paper linked to endnote #3

Calvillo, C. F., & Turner, K. (2020). Analysing the impacts of a large-scale EV rollout in the UK–How can we better inform environmental and climate policy?. *Energy Strategy Reviews*, *30*, 100497. https://doi.org/10.1016/j.esr.2020.100497. Further research paper linked to endnote #3