Policy Briefing

Executive Summary

This briefing paper reports on an illustrative analysis of how energy efficiency improvement programmes in the UK may impact across the wider economy. We explore how the implementation of residential energy efficiency actions funded through the Energy Company Obligation, ECO, triggers a range of impacts and interactions in and between different sectors and actors in the UK economy. We then consider how outcomes may differ if alternative funding approaches were to be adopted, with the aim of providing useful insight to a wider stakeholder community concerned with energy efficiency policy.

Supporting household energy efficiency improvements enables households to use less energy and to reduce their spending on energy bills. The **real income gains and changes in spending trigger a process of wider economic expansion** that could be important in justifying public spending to help deliver support for efficiency programmes. Our simulation analyses show that energy efficiency gains will generally trigger expansionary processes, but the nature and extent of impacts on household incomes, GDP and employment depend, among other things, on how we enable efficiency gains.

For example, our results suggest that the retrofitting activity supported by the current UK ECO programme has the potential to deliver a GDP expansion of up to 0.02% above what it would otherwise be and support just under 6,500 full-time equivalent (FTE) jobs. However, these economic gains are temporary and begin to erode after the programme ends. On the other hand, households actually realise energy efficiency gains of 17.2% per beneficiary household, equating to an average of 2.38% energy saving across the household sector. This releases more disposable income to spend on other things, triggering further expansion across the economy. Ultimately, **by enabling energy efficiency gains, we estimate that ECO may ultimately support a sustained GDP boost of up to 0.07% and just over 19,500 FTE jobs across a wide range of sectors in the UK economy.** With approximately £10.9billion spent on ECO, over time (but with only £4.2billion actually going to efficiency improvements) this translates to a societal return of 1.8 jobs and £2.3million of cumulative GDP gains (by 2040) per £million spent.

So is ECO is the best mechanism for maximising residential energy efficiency gains and the economic expansion that results? The key problem is that ECO, as a centralised scheme run through the major energy suppliers, involves several types of non-retrofitting costs. Administrative and search costs increase the total cost passed to consumers, while the potential presence of large economic rent can further reduce the funds directed to the industries and supply chains delivering efficiency improvements.

We consider a second scenario where there is no economic rent present in the ECO system. Here, in the retrofitting stage alone, results suggest that GDP gains could reach 0.04% above the pre-efficiency programme levels, supporting around 11,450 new full-time equivalent jobs. If we introduce consideration of the impacts of households actually realising energy efficiency gains, each beneficiary household still requires 17.2% less energy, but with more funds (8.2billion) directed to efficiency gains, the average improvement increases to 4.64% per UK household. As household spending on energy bills falls, the boost from increased real incomes and reallocated spend can now grow to support a sustained GDP boost of 0.14% and 37,400 FTE jobs. That is, the societal return per £million of ECO spending could ultimately reach 3.4 FTE jobs and £4.4million in additional (cumulative) GDP by 2040.

We also consider whether an alternative type of funding scheme may deliver greater benefits than ECO. The centralised nature of ECO is in itself a source of potential inefficiency. If households seeking energy efficiency gains are able to search for and resource suppliers themselves to implement retrofitting at individual project level, the type of 'leakage' considered above is likely to be reduced, with the implication that more funds can be directed towards achieving more efficiency improvements. In two alternative scenarios, we assume that the total amount spent falls to £9.8billion but is entirely directed to energy efficiency improvements. We consider two ways in which such a decentralised approach may be

resourced. One possibility involves ensuring that households have access to loans. Another is to entirely socialise the costs through grants funded by taxation (here income tax).

By employing either of these funding options each beneficiary household still becomes 17.2% more energy efficient, but now this equates to an average energy saving of 5.66% per UK household. Our simulations suggest that, while in the shorter term taxpayers fund the energy efficiency programme, over time economic expansion driven by greater efficiency allows more than a 1:1 return back to the taxpayer. Thus, socialising the cost via income tax ultimately frees up more household income and delivers the greatest net wider economy gains over the long-term, potentially delivering a sustained 0.25% boost to GDP compared to pre-efficiency programme levels, supporting over 64,700 full-time equivalent jobs. That is, the societal return per £million of spending could ultimately reach 6.6 FTE jobs and £6.7million in additional (cumulative) GDP by 2040. Funding through loans (here, for simplicity, assuming an extreme of zero interest) could also deliver greater gains than ECO, with our scenario simulations suggesting a potential sustained GDP expansion of up to 0.17% associated with just over 45,200 FTE jobs. However, in either case, it is crucial to consider these societal returns in the context of whether the full energy efficiency gains required to deliver them would actually be realised in a decentralised context. If not, the economy-wide gains will be smaller and individual households may suffer net losses in some timeframes.

It is also important to consider distributional impacts. For example, if costs are fully socialised through income tax, lower income households will initially gain at the expense of mid-to-high income groups. The precise nature of distributional impacts also depends on access to funding. For example, the outcomes reported above assume an equal distribution of/access to funds. We reconsider the case where costs are fully socialised, but focus on a scenario where the 20% of households on the lowest incomes receive most (54%) of the grant support and the 20% of households with the highest incomes the least (2%). The outcome is that real income gains to the average household in the lowest income group grow by over £30 per year, but this is at the cost of more constrained macroeconomic gains, and this is associated with around 5,300 fewer FTE jobs sustained into the long term.

Key messages: Trade-offs need to be considered when designing an energy efficiency policy. Some key messages emerging from the analysis are:

- As with any investment activity, **the retrofitting/projects supported by ECO can deliver economy-wide benefits and boost to the incomes of the lowest income households even if no efficiency gains are actually realised.** However, **these will be limited, both over time and relative to the fuller societal returns achievable** from households reducing their energy bills and devoting increased real purchasing power to other goods and services. The magnitude of the gains is dependent on the presence or not of rent. Moreover, search and administrative costs erode the benefits achievable if the same amounts are used for directly improving the efficiency of dwellings.

- Crucially, however, while gains from ECO may be limited relative to alternative funding mechanisms, **our findings strongly suggest that the net impacts of the ECO programme will be positive in all timeframes for lower income households and for the economy as a whole.** This is not so clearly or generally true in the case of either of the alternative funding approaches considered. **Alternative funding mechanisms such as using loans or socialising the cost through income tax may deliver better outcomes in terms of boosting GDP, employment and household incomes.** However, if the efficiency gains are not realised, there is the **potential for transitory but significant economy-wide and net household income losses in some timeframes.**

- **Distributing access to funding equally across all household quintiles enables the best economy-wide results but a tapered distribution can deliver better income boost for the lowest income households.** This is explained simply by the fact that more affluent households consume more and, thus, trigger a greater economic stimulus if they are able to increase efficiency in their energy use.

Thus, **our analysis demonstrates the need to trade off policy objectives and priorities in considering the best means of supporting energy efficiency programmes.** The results of the scenario simulations reported here demonstrate that that there is no single approach that enables both the best sustained economy-wide outcomes and the largest income boost for the lowest income households while ensuring that there is no potential for any negative impacts in any timeframe. **The key 'takeaway' message is the need for policy makers to clearly define and prioritise the goals of energy efficiency policies before selecting the combination of funding approaches and the access distribution therein.**

I: Introduction

In this policy briefing, we report the results of an illustrative analysis of the potential impacts of residential energy efficiency achieved across the UK economy, based on the research by Katris and Turner (2021). We focus specific attention on the real income of UK households. We use a Computable General Equilibrium (CGE) model for the UK, which allows us to capture impacts on GDP and employment across all the sectors of the UK economy driven by a programme that enables residential energy efficiency gains through retrofitting of properties. Some key features of the model we use are detailed in Annex A. We explore a range of different scenarios with the core one being the impact of the Energy Company Obligation (ECO) with and without the presence of economic rent. The alternative scenarios we analyse involve broad resetting to a decentralised programme, where households directly manage and transact efficiency actions. This involves one scenario where loan funding is used and another where costs are fully socialised through the income tax system (both with a varying distribution of access to grant funding).

Our model is based on 2010 UK national statistics arranged in a Social Accounting Matrix, which provides information on the interactions between UK sectors, imports, exports and monetary transfers both within the UK and between the UK and abroad. Key features of the model are detailed in Annex A. Our scenarios are based on the GB energy efficiency projects supported through ECO, as reported in relevant government publications up to 2018 and estimates for the period beyond 2018. We also use data from government publications to estimate the average efficiency improvement per UK household. The funding breakdown in each of our scenarios, along with a summary of the main results, can be found at Annex B. This briefing is structured as follows. In Section II we focus on ECO, the potential impact that ECO-projects can drive and how the outcomes differ if economic rent is present or not. In Section III we consider alternative funding mechanisms to ECO and how their potential outcomes compare to those delivered by ECO. In Section IV, we shift our attention on how different distribution of access to funds can affect the expected results. Section V summarises our conclusions.

II: Modelling the economy-wide impacts of ECO

ECO came into being across the UK in 2013. Since then there have been 4 versions: ECO1; ECO2; ECO Help to Heat (HtH); and the current version ECO3. ECO1&2 lasted for just over 2 years, ECO HtH just over one year and ECO3 is planned to last for 3.5 years.

To date the expectation has been that each round of ECO will be followed by a new one. This is despite the relatively short timeframe of, and time gaps between, the different implementations. This indicates an effective management of expectations around ECO, which is crucial, particularly in the context of supply chain actors servicing energy efficiency programmes. Expectations over the future of the programme govern whether the firms involved in the delivery of ECO measures continue to allocate resources to support new rounds. If industries like Construction lose faith on the future of ECO then they, and their supply chains, could start reallocating their resources towards other activities. For the purpose of the research reported here, we focus on a case where all producers expect a continuing (16-year) ECO to be a standalone programme with no successor past 2028. On this basis, firms do not start to reallocate their resources away from delivery of ECO until near the end of the programme.

Another key characteristic of ECO is the variety of costs associated with the delivery of energy efficiency projects. For ECO3 it is expected that 40% of the funds will cover installation costs, 10% various administrative costs, 12% search costs. According to data provided for this study (Annex A), the other 38% effectively become an economic rent. Here we assume that this accrues to suppliers who can deliver projects at a cost lower than the average price charged.[1] In short, the cost of delivering efficiency gains through ECO is inflated by non-installation costs. Take the search costs, for example. Because delivering efficiency gains through ECO is an obligation for energy suppliers, they need to find appropriate projects to support in order to meet this obligation. This generates search costs that are (as with other costs associated with delivering ECO) passed on to consumers through energy bills. At the same time, there are fixed prices for particular retrofitting activities covered by ECO, regardless of their actual cost. In short, energy companies essentially act as a centralised supplier of energy efficiency measures. Moreover, there is room for significant economic rent. Some of this may be absorbed by activities necessary for the

retrofitting, but which do not improve energy efficiency (e.g. cleaning services after the retrofitting) but can also enable the extraction of large profits by the retrofitters.

How does all this affect the type of wider economy returns that may justify continued public support of a programme like ECO to deliver residential energy efficiency gains? We use a multi-sector economy-wide computable general equilibrium (CGE) model, UKENVI (see Annex A), to explore the impacts of ECO to the UK economy. We do this in two stages to consider two distinct ways in which impacts transpire over time. First, we model the retrofitting activity of ECO, which we refer to as **the enabling stage**. We assume that the enabling stage lasts for a period of 16 years (2013-2028) with a total cost, based on available data and projections, of £10.9billion. Table 1 in Annex A details what we assume about the allocation of these funds.[2]

In summary, approximately £7billion is spent on the output of the UK Construction sector (to cover the actual retrofitting work, but with the potential for rent to be extracted from this amount). A further £1.3billion is spent on purchases of boilers, where 75% of this is spending with UK suppliers. We do not model the production of the other 25% of the boilers that are imported, but we do model spending on them by UK households. Thus in total, we take the direct spending on enabling efficiency gains to be a sum of £8.3billion. The remaining £2.6billion are administrative and search costs. We use data from the 2019 edition of the Household Energy Efficiency Statistics to determine this breakdown. We assume that access to funding is equally distributed across all households throughout the duration of the programme. We consider an alternative approach in distributing access to funding in Section IV of this briefing.

We then consider what we call the **realising stage**. That is, households realising efficiency gains will reduce their energy bills, boosting and freeing up real income to spend on other things.[3] The information regarding the improvement achieved through ECO are taken from the 2019 edition of the National Energy Efficiency Data framework (see Annex A). We use these data to estimate an average efficiency improvement equating to each more efficient household requiring 17.2% less physical energy to run their homes. However, not every household in each quintile will receive an efficiency improvement so

that his equates to, for example, in our first scenario an average energy saving of just 2.38% per UK household (where only 3.6million out of 27.2million UK households receive efficiency improvements). Crucially, depending on the presence of economic rent or not, the number of households receiving an efficiency gain (and, thus, the UK household average energy saving) may fluctuate quite significantly. This is due to the fact that not all spending is directed to actually deliver energy efficiency (which we consider to be the physical amount of energy required to deliver a given level of energy services).

For the scenarios modelled here, with access to funds equally distributed, the data suggest that the projects supported by ECO on average help the UK household sector to use 2.38% (when a large economic rent is present) or 4.64% (when there is no rent) less physical energy to run their homes. This boosts real household incomes and drives a reallocation of spending, which triggers a sustained demand driven expansion across the wider economy. This adds to any time-limited gains realised in the enabling stage (driven by spending on retrofitting and equipment).

The economy-wide impacts of ECO

Here we explain and consider how each (and both) the enabling and realising stages of these residential energy efficiency gains impact across the wider economy due to changes in demand patterns and levels, and real income. We consider the enabling stage first, to isolate the impacts of retrofitting activity and the purchase of boilers. But this then enables the realising stage, where efficiency gains are actually realised and household real incomes are affected through this process. The two stages will unfold alongside one another and this is reflected in our reporting of the realising stage.

We find that **a key factor determining the impact of ECO is what happens in terms of extraction of economic rent**. In the best-case scenario, there is no economic rent. This means that, in enabling energy efficiency improvements, the entirety of the non-admin non-search funds are directed (during the enabling stage) to UK Construction sector and boiler manufacturers, imports of boilers and also sectors that provide inputs necessary to facilitate wall insulation, boilers etc.

Generally, the boost in demand for UK production in enabling energy efficiency improvements will enable a larger expansion

rippling across the wider economy. On the other hand, if this causes prices to rise (i.e. we assume that capacity in labour and capital markets is constrained) there will be some 'crowding out' of some other activity, which will dampen any net gains. For a disturbance of the size considered here, the main impacts of crowding out will be at sectoral rather than macroeconomic level. While investment relaxes the capital constraint over time, we assume a fixed national labour supply. Thus, any boost in overall employment is only possible due to the presence of a pool of unemployed labour. The base year structural data report a 6% unemployment rate but the maximum labour supply expansion from our scenarios only reduces this to 5.76% over the long term, reflecting relatively small pressure on the labour capacity constraint.

The Enabling Stage

It is useful to consider the economy-wide impacts of ECO by building up through the enabling and realising stages, given that these trigger different types of expansionary processes, and only the latter has sustained impacts. Taking the enabling stage first, we estimate that, in the best-case scenario (where no economic rent is extracted) ECO projects themselves (before they deliver any efficiency gains) may trigger a maximum GDP boost of £553million in 2023. This expansion also supports 11,451 additional full-time equivalent (FTE) jobs in the same year. By 2040, the cumulative GDP gains (again, attributable to the enabling stage alone) are £6.6billion. [Note that all monetary values are reported in the 2010 prices of the UKENVI base year dataset – see Annex A].

Conversely, if we assume that a large economic rent is present, the 2023 gains in GDP and employment attributable to the enabling stage will be eroded to £308million (0.02% greater than it would otherwise be) and 6,357 jobs. The cumulative GDP gains by 2040 are eroded to £3.8billion. These results reflect the importance of minimising the presence of economic rent and ensuring that available resources are used to retrofit as many properties as possible. Of course, we do not suggest that the potential for rent can be entirely removed in practice. Rather the aim of our simulation exercises is to indicate just how much potential additional expansion may be gained in the absence of rent extraction. Here the results suggest that rent leads to the potential to lose over half of the potential

economy-wide benefits that could be otherwise achievable.

We emphasise that the gains achieved should be considered in net terms. The implementation of ECO leads to price increases for the energy used by households (i.e. higher energy bills) and, as a result, it directly affects household incomes before any efficiency gains are even considered. Depending on the presence (or not) of rent, there is variation in how different household quintiles are affected (we model from the 20% households on the lowest incomes up to the 20% on the highest incomes). In the worst-case scenario, where 37% of resources leak from spending into economic rent, the lowest and highest income quintiles (HG1 and HG5) are the only ones that do not experience any negative income changes, but for different reasons. HG1 tends to have smaller energy bills in absolute (£) terms. Thus, they cover a smaller share of the costs of ECO. On the other hand, HG5 has much larger energy bills but, at the same time, they own more of the production capital and extract higher wages for labour services. That is, households in HG5 gain more when the economy expands. In our simulations, the retrofitting activity delivers sufficient employment and capital gains to help HG5 offset any negative income changes from the higher energy price. HG2-4 experience net negative income changes but only temporarily. On the other hand, in the absence of economic rent, our simulations suggest that only households in the quintile with the second highest incomes, HG4, will experience temporary (for a single year) net income losses.

Introducing the Realising Stage

So far, we have focussed on the impacts that triggered by the fact that an energy efficiency programme like ECO will involve spending on activities such as retrofitting homes and installing new boilers. This is basically a demand shock to the economy through a form of domestic investment activity, the impacts of which will be time-limited. However, while investment programmes are sometimes used to stimulate the economy, the main purpose of a programme like ECO is to enable energy efficiency gains. The real stimulus to the UK economy comes from the fact that what happens at the enabling stage allows households to use less energy, reduce their energy bills and use any savings and real income gains in spending on other things. This is what ultimately delivers a

sustained boost to the UK economy. It will start to happen concurrently with the enabling stage but will substantially outlast it. In this section we introduce consideration of the impacts this realising stage in combination with those discussed above as attributable to the initial enabling stage.

When we incorporate consideration of the fuller impacts of households actually realising energy efficiency gains, there are important changes to the observed results. **At this realising stage, the boost to the UK economy is triggered by the fact that more energy efficient households have lower energy bills.** Thus, they have increased real income to spend on a range of things. It is this that triggers a second round of demand-driven expansion, but one where the further stimulus may add to price pressures emerging from the first trigger of the enabling stage.

The sustained longer term outcome of the enabling and realising improved energy efficiency is the delivery of net income gains for all UK households, regardless of the presence of rent. These are sufficient to completely offset any negative income changes for HG2-4 associated with the enabling stage, and also help deliver greater income boosts to HG1 and HG5. HG1 experiences the largest percentage long-term income gains, while HG5 experiences the smallest ones. However, the size of the income boosts is linked to the size of the efficiency gains. Therefore, a large economic rent extraction leads to smaller income gains as it restricts the efficiency gains realised.

The energy bill savings and real income gains from the efficiency improvement are what can deliver a sustained expansion to the UK economy. Of course, this requires that households actually spend a significant share of their savings/real income gains on the consumption of UK produced goods and services. Here, we assume that households increase spending in line with their initial distribution of income between savings and spending (i.e. the marginal propensity to save is unchanged). Similarly, we assume that spending on different goods and services expands in line with households' initial allocations, but with the model capturing the impacts of changes in relative prices (on different domestic and imported goods).

The results of our scenario analyses suggest that **in the worst-case scenario UK GDP is bosted by 0.07% above what would be otherwise. A net increase of 19,567 new sustained full-time jobs is observed.** As highlighted above, this is the case where there is significant economic rent. If we consider the employment outcomes against the £10.9billion spent as part of ECO we see that there is a **societal return of 1.8 jobs per £million spent** (see first column of the summary results Table reported for key scenarios in Annex B).

In the absence of economic rent, larger amounts are used directly to retrofit properties. Thus, households realise greater efficiency gains and bigger income boosts, which in turn enable bigger economy-wide benefits. We estimate that such a scenario could be achieved, UK GDP could expand by 0.14% above what it would otherwise be over time. Figure 1 shows the difference that is driven by the presence or not of rent and how the results of ECO compare to the alternatives we consider below (where by definition rent is absent). Overall, the combination of retrofitting and efficiency gains helps deliver (when a large rent is extracted) £25.4billion cumulative GDP gains by 2040. This equates to £2.3million of cumulative GDP gains per £million spent. This is over 6 times the amount delivered by retrofitting activity alone. In the absence of rent, the combination of the enabling and realising stages enable cumulative 2040 GDP gains of £48.1billion, £4.4million in additional cumulative GDP per £million spent and over 7 times the amount delivered by just the enabling stage. These findings emphasise the importance of actually realising energy efficiency gains in delivering a 'return' to the wider economy, but also of simulating scenarios on a case-by-case basis. That is, there is no simple multiplier relationship between investment spending and GDP/employment outcomes).

Considering the employment impacts, our analysis shows that in the absence of economic rent there could be a net increase of 37,410 new sustained full-time jobs. In this case, for the same £10.9billion spent, the societal return, in terms of employment per £million of ECO spending, could ultimately reach 3.4 FTE jobs. This is achieved largely through the economy drawing on the pool of unemployed labour, with only energy supply sectors suffering net job losses (see Figure 2 below).

Figure 1: Comparison of GDP changes under different funding options (enabling and realising, forward-looking producers, equal distribution)
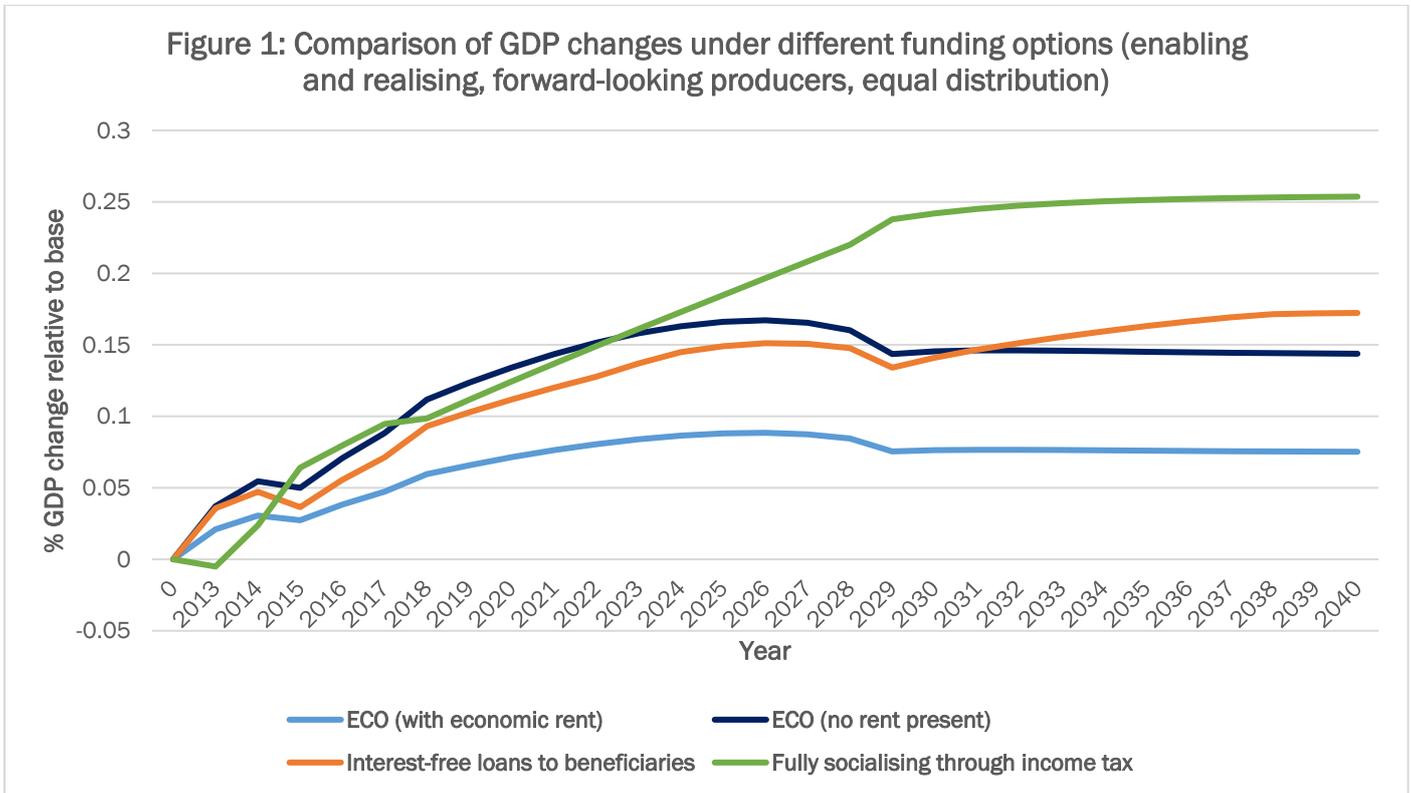
III: Modelling alternatives to ECO

The main challenge for ECO is how both efficiency and other economic gains are limited by the large non-installation costs that inflate the costs passed on to the consumers. Thus, we also consider potential alternative broad funding frameworks to ECO. Both require households to source the retrofitters themselves. In principle, this means that burdens like the search and administrative costs are no longer applicable and the margin for economic rent is smaller as households will look for the retrofitters that can deliver the best value for money. [In practice, we do not have information to actually models issues such as information asymmetries between suppliers and households.]

The first approach we consider involves passing the entire cost of making the efficiency improvements to the beneficiaries. We assume (for simplicity) that these households will have access to interest-free loans with a 10-year repayment period to cover the costs. This gives us an extreme 'framing' case where the maximum gains from a loan approach could be achieved. In reality some interest would be involved (especially where loans are issued by private institutions) and, thus, household real income and economy-wide gains would be more limited (at least in the short term). We also make a 'best case' assumption that all loan funds are taken up by households exclusively the purpose

of increasing energy efficiency. Generally, this allows to consider an upper 'best' case outcome for the loan scenario. We assume that repayments for each household only begin once that household has received the efficiency improvement. This means that the repayments exceed the duration of the enabling project activity.

The other alternative we consider is a reference case where the costs of efficiency improvements are fully socialised via income tax. We label it as a reference case because we model the cost recovery through taxation as fully flexible in a way that would be unlikely in practice. The aim is to consider the difference in impacts when the government can increase tax (here income tax) to raise funds that can be offered to households as grants but then reverse this when the economy gains as a result. Because the grants are issued for a specific purpose, there is a net zero income effect for the households. That is they cannot spend the grant on anything else (i.e. we assume there can be no household 'rent').

In both the 'loans' and 'full socialisation of costs' cases, £8.6billion are allocated to the UK Construction sector and a further £1.3billion to boiler manufacturers (again 75% going to the UK industry). **The elimination of administrative costs[4] leads to a smaller total cost for UK households of over £1billion.** At the same time, because **a larger amount is available for retrofitting (due to the absence of search costs**

and economic rent), larger average efficiency gains can be expected. Again, we focus on scenario where we have an equal distribution of access to funding. But now each of ECO's potential alternatives enables an energy efficiency improvement of 5.66% for each of the household quintiles. This represents a significant difference compared to the efficiency gains that could be realised through ECO, for the same distribution but a different level of funding dedicated to actually enabling energy efficiency improvements.

Economy-wide impact of alternatives to ECO

We begin by considering the enabling stage in isolation. An important thing to keep in mind when considering alternatives to ECO is that both loan repayments and tax payments precede any other payment. That is they must be met before any other spending. This is an important distinction: under ECO households have the option to adjust how they spend their income. That is, where ECO raises energy bills, households do have some choice in terms of choosing to use less energy. This is not an option when households have to meet their loan repayments or their tax payments, which means that their disposable income will be limited due to those payments. As a result, during the enabling stage, we observe potential negative income changes for all household quintiles for both potential alternatives to ECO.

Our analysis shows that, before any energy efficiency gains are realised loan repayments can lead to a net drop in annual income of HG1 of up to £22 per household in 2028, while the maximum annual income drop for any other household is £35 per household in HG5 in 2029. Despite the same loan repayments across all quintiles, more affluent households are also affected by the reduced activity observed across the economy during the enabling stage and suffer greater potential net income losses.

On the other hand, using income tax to socialise the cost of efficiency improvements helps distribute the cost in a more progressive way. Here, in 2014 (the year that most funds are available), HG1 has a maximum drop in income of £7 per household, while households in HG5

lose £136. In fact, as we go up in terms of gross annual income, we also see a larger income drop.

The presence of negative outcomes at the enabling stage highlight the paramount importance of actually realising energy efficiency gains and triggering the household spending driven expansion that delivers sustained positive impacts on household incomes, employment and GDP. This is what helps mitigate, and ultimately offset, any negative income changes resulting from the need to pay for energy efficiency actions (the enabling stage). Indeed, when we consider both the enabling and realising stages together we see net positive income changes for all households across most of the programme timeframe and beyond. With the efficiency gains included in our results, HG1 achieves a maximum sustained income boost of £64.39 per household. This maximum net gain is observed when the costs are socialised using income tax. This is a better outcome in terms of income boost compared to the best-case scenario ECO (£46.58 income boost per HG1 household) and passing the cost to beneficiaries (£56.31 income boost per HG1 household). In fact, within 5 years from the beginning of the efficiency improvement programme and over the long-run, socialising the costs through income tax enables greater income boosts for all household quintiles compared to any other funding approach we consider here.

But it is important to note that a crucial difference between socialising the costs and using loans is due to how we have assumed income tax will adjust in what we have set out as a reference case. In the same way that the government raises the tax to cover the cost of grants, we assume that it maintains a balanced budget by reducing the income tax as soon as there are net positive revenues from the programme. This delivers a bigger boost to the incomes of households, which alongside the larger efficiency gains, leads to better long-term income results for all quintiles. However, those greater long-term income gains also mean temporary negative income changes for every household quintile, apart from HG1, in the short-run and for a maximum of 2 years for HG4 and HG5.

Figure 2: Employment changes in 2028 due to different funding mechanisms by UK sector (forward-looking, compared to ECO, equal distribution)
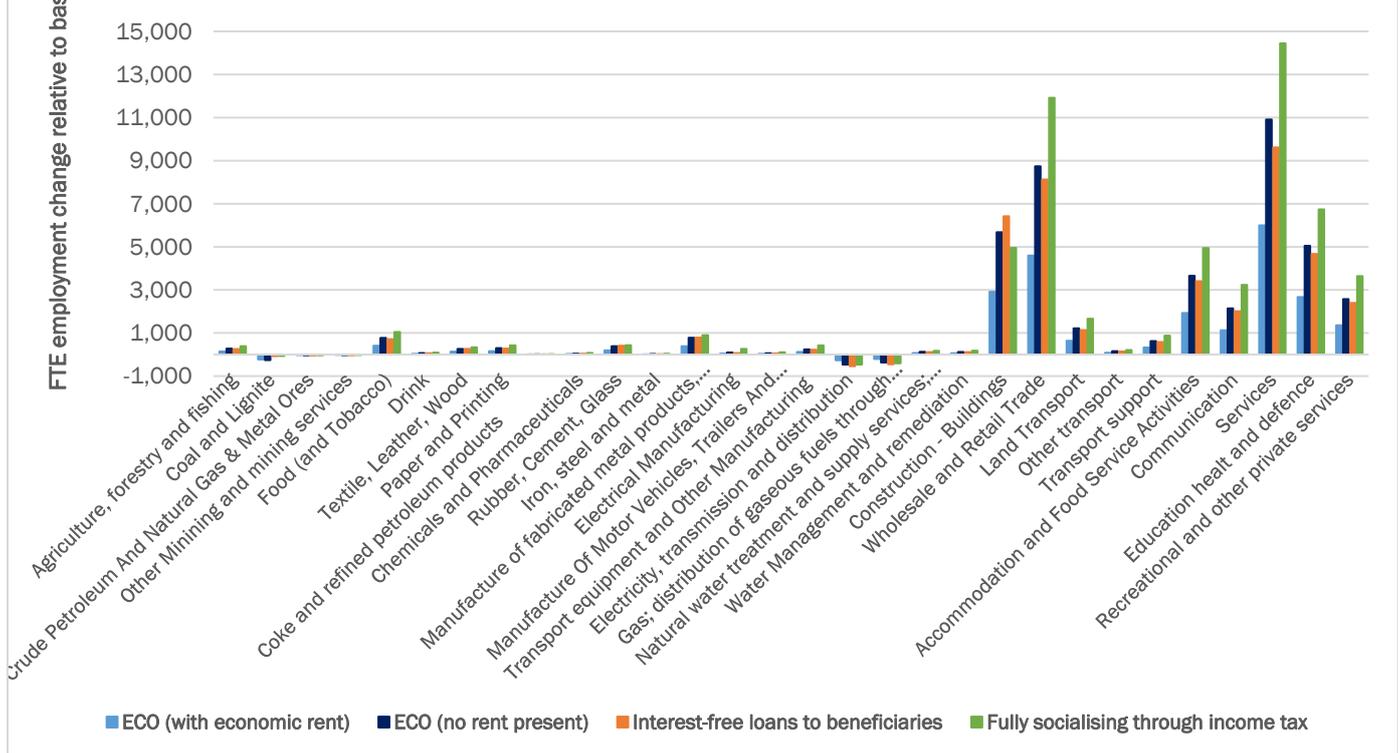
The potential for better household income outcomes from these alternatives of ECO could also translate to a greater economy-wide boost (see Figure 1). **Using interest-free loans to cover the costs could ultimately lead to a maximum sustained GDP expansion of 0.17% relative to what the situation would be with no energy efficiency programme, and a net boost of 45,240 full-time equivalent jobs. Socialising the cost delivers even better results, with a maximum sustained 0.25% GDP expansion over what it would otherwise be, accompanied by a net increase of 64,742 full-time jobs.** In this case where the cost of energy efficiency is socialised via the income tax we observe societal returns that could ultimately reach **6.6 FTE jobs and £6.7million in additional (cumulative) GDP by 2040 per £million of spending.** This is a significant improvement over ECO (event the case when no rent is present).

In considering the sectoral distribution of gains, it is important to consider whether capacity constraints lead to any net crowding out of activity. We find that the 'shock' here is relatively limited without lasting impacts on prices or competitiveness. Only the energy sectors are expected to suffer net losses in output and employment. But this is due to reduced demand driven by efficiency gains, rather than crowding out. On the other hand, the hospitality sectors provide an example of industries that may

experience an increase in output and employment if households opt to spend their boosted real incomes in line with initial spending patterns. The magnitude of the impacts varies with the extent of efficiency gains. Figure 2 demonstrates the different employment impacts in the UK sectors by the end of ECO or any alternatively funded efficiency improvement programme. It is useful to keep in mind here that how the funds are used is also affecting the impact on specific sectors. For instance, ECO funding includes search costs. These are used to employ specialist services to identify projects that could be supported. When loans are used as the funding mechanism, the beneficiaries are required to source the retrofitters and we assume, in the absence of any better information to frame our scenarios and for simplicity, that the search costs are no longer applicable.[5] This underpins the difference between the two mechanisms in the Services sector in Figure 2.

IV: Distributing access to funding

Our focus so far has been on the case where access to funding is equally distributed across all households regardless of which income quintile they fall into. This enables the most positive economy-wide impacts.

Now we consider an alternative approach where, from 2013 to 2017 we continue to assume that

access to funds is equally distributed across all households, while from 2018 onwards, access to funds is distributed in a tapered way. This approach enables the lowest income households to have access to the majority of funds (54%) and, as we move to more affluent households, access is gradually reduced.[6] The efficiency gain per beneficiary household remains 17.2% but the distribution across quintiles changes.

Introducing a tapered distribution changes the nature and magnitude of some of the impacts observed so far. One of the most significant changes is on the potential magnitude of negative income effects. In Section II we noted that if loans are used by beneficiaries to cover the retrofitting cost, there is the potential for income losses of £22 per HG1 household in 2028 at the enabling stage. This could be taken to correspond to a situation where, for some reason (e.g. equipment does not work properly), efficiency gains are not actually realised. A tapered approach could amplify this because it allocates more funds to HG1. That is, these low income households are required to cover higher loan repayments. Thus, if efficiency gains do not follow, the potential HG1 income losses in 2028 increase to £58 per household, while HG5 may experience potential losses up to £18 per household in 2029. In short, the lowest income households may experience greater net income losses under a loans framework. This is in contrast to ECO, where our simulations suggest that, despite the need to pay for efficiency gains that may not yet be fully realised, the lowest income households will not suffer net income losses in any timeframe.

When we consider the realising stage of each efficiency improvement programme, **the difference in access to funding also translates to differences in potential efficiency gains.** Under a tapered approach, using ECO may deliver HG1 efficiency gains equating to a 4.37% reduction in average energy use across the entire quintile (in the presence of significant rent), while the potential HG5 efficiency gains map to just 1.33% savings. When no rent is present, HG1 efficiency gains map to 8.53% savings and HG5 efficiency gains to 2.59%. On the other hand, when we consider the potential alternatives to ECO the HG1 efficiency gains may translate to 10.14% savings across HG1, while the HG5 can reach 3.29%.

Comparing the potential efficiency gains under a tapered approach to the ones enabled through an equal distribution it can be seen that **HG1 is significantly better off in the tapered approach. HG2 may also achieve slightly bigger efficiency gains and energy savings across the quintile while every other household quintile can achieve small gains compared to what is achieved if funds/projects are equally distributed.** The variation in energy savings resulting from efficiency gains translate to differences in the extent of real income boosts for all household quintiles. **Socialising the retrofitting costs through the income tax with a tapered distribution, HG1 gets a greater sustained £94.5 per household boost, over £30 more than if we impose an equal distribution.** See Figure 3. On the other hand, HG3-5 achieve smaller efficiency gains under a tapered approach and therefore observe smaller income gains. As shown in Figure 3 as we move towards households that are more affluent there is a noteworthy gap between the tapered and the equal distribution.

What happens to the macroeconomic impacts? The key point is that while HG1-2 gain most, they consume less. Thus, a smaller demand boost for goods and services is triggered. This translates to smaller economy-wide impacts being observed when a tapered distribution of funding for energy efficiency is introduced. In fact, where the distribution of energy efficiency funding is tapered in favour of low income households and costs are fully socialised via the income tax, a maximum sustained GDP expansion of 0.23% is achieved, accompanied by a net increase of 59,365 new full-time jobs than if the funds are distributed equally. The dampening of economy-wide impacts equates to a GDP gain that is 0.02% points smaller, with 5,377 fewer full-time jobs. The per £million returns fall to 6 full-time jobs, while the cumulative GDP returns are £6.9million in 2040, slightly higher than the equal distribution at this specific point but gradually equal distribution delivers greater per £million cumulative GDP returns (see Table 2 in Annex B). The fact that under a tapered distribution we observe smaller GDP and employment gains, is the reason why HG2 achieves marginally smaller income gains compared to the equal distribution (£95.66 rather than £97.81 per household) despite the larger efficiency gains. However, a tapered distribution helps prevent the net negative income changes suffered by HG2 in the first year of the programme observed in the non-tapered case.

Figure 3: Evolution of HG1,3&5 disposable income when retrofitting costs fully socialised under different funding allocation approaches (forward-looking producers)
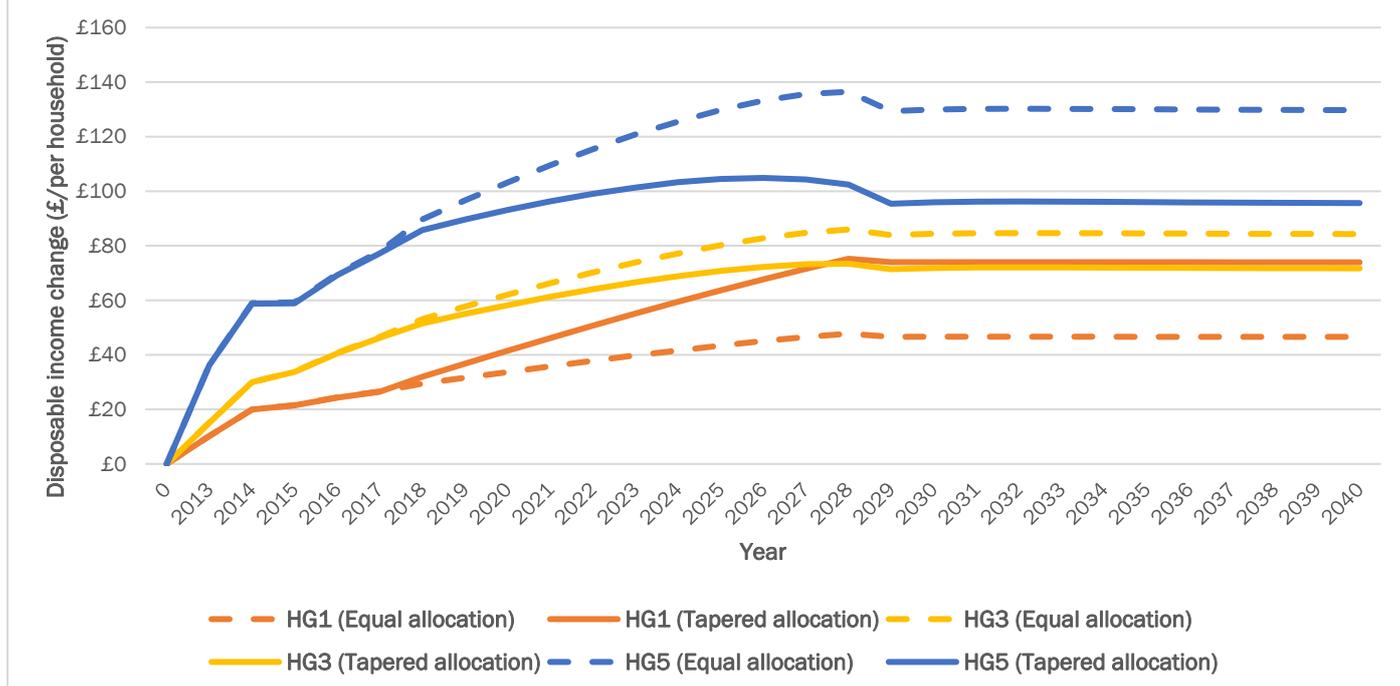
V: Conclusions

Our analysis demonstrates that energy efficiency programmes have the potential to deliver positive outcomes both in terms of an economy-wide boost and how the disposable incomes of households are impacted. **As a funding mechanism, ECO enables these gains to be achieved without the potential for net income losses for the lowest income households at any point.** Our findings indicate that even if ECO did not deliver any efficiency gains, no net negative GDP or employment changes are observed, and any potential net income losses are temporary, short scale and mainly confined at middle and high-income households. **On the other hand, the administrative and search costs, and the potential for substantial economic rent extraction associated with ECO introduce limitations on the extent of efficiency gains – the real source of sustained economic expansion – that can be achieved using the level of funding available.** In short, ECO delivers smaller economy-wide gains compared to what could be possible if the same amount was used exclusively for retrofitting properties.

Of all the funding mechanisms we consider here, fully socialising the cost via income tax delivers the best high-level economic outcomes. This is because, while increased income tax requirements may have negative real income effects in the short to medium term, the economic expansion triggered by enabling energy efficiency gains ultimately allows the tax shock to be reversed, with potential reduction of income tax demands relative to what they were later on. This is what ultimately generates even greater real income boosts to all households.

On the other hand, this outcome must be considered in the context of the temporary net income losses for many households. We find these losses accrue to those in the three highest income quintiles (HG3-5), and also to those in the second lowest quintile, HG2, where access to funds to enable energy efficiency is distributed equally (we do not find any income losses for HG1). Furthermore, if for whatever reason efficiency gains are not achieved as a result of spending, every alternative to ECO that we consider here could potentially drive substantial and long lasting (over 20 years) income losses for all households. At macroeconomic level, this also translates to potential for negative GDP and employment changes.

These are important considerations for policy makers. Is it better to continue with ECO, which, while delivering smaller economy-wide gains, does not ultimately have any net negative impacts on the wider economy and limits any negative income effects to middle and higher income households, for a period of not more than 3 years? Or should they opt for an alternative approach that may deliver better economy-wide outcomes but, unless the efficiency gains are fully realised, may negatively affect both the wider

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economy and real incomes across all household income groups for long periods (potentially exceeding 20 years)?

Our work also highlights how the extent and nature of wider economy and household real income impacts are sensitive to what we assume about how access to funding is distributed across different household income groups (here quintiles). We find that distributing funds equally across different household income groups has the potential to deliver the best economy-wide gains. On the other hand, a tapered approach that provides greater access to funding to the lowest income households has the potential to deliver better real income results for these more vulnerable households, but at the expense of reduced economy-wide gains.

More generally, our work highlights the trade-offs between different funding mechanisms and different distributions of access to funds. We find that ECO is the safer approach as it does not deliver net negative impacts at a macroeconomic level at any point and only causes minimal short-term negative impacts to the incomes of middle and higher households. Greater economy-wide returns can be achieved if households can directly source energy efficiency projects with finance through loans or grants funded through the income tax system. But if households do not actually realise the expected efficiency gains, there is potential for negative economy-wide effects and significant income losses across all households. Similarly, giving all households equal access to funds may enable the largest economy-wide benefits, while tapering the availability of funds in favour of lower income households will deliver greater real income gains to them, but at the expense of smaller economy-wide gains. Thus, a key message from this work is that it is important to clearly identify the goals of energy efficiency improvement policies. Our analysis demonstrates that no combination of the options we considered is clearly better than the others in terms of delivering economy-wide gains at the same time as avoiding real income losses particularly to low income households.

About this project

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Annex A: Brief description of the UKENVI CGE model and data for scenarios

Model and scenario data

In this work we use the UKENVI multi-sector computable general equilibrium, CGE, model of the UK economy. The model is detailed in Katris and Turner (2021) and is based on previous work by Lecca *et al.(* 2014) and Figus *et al.* (2017), where the latter introduces the household disaggregation used here to considered distribution effects. UKENVI is currently calibrated on a 2010 social accounting matrix (SAM) that incorporates an estimated industry-by-industry input-output (IO) table (to be updated when more recent data are published by ONS). Here we explain some key characteristics of the model that are particularly important for the analysis conducted here.

The data on the funding available through ECO are taken from the 2019 edition of BEIS Household Energy Efficiency Statistics (HEES). The information available in this publication detail the ECO spending up until 2018 so for the period 2019-2028 we assume fixed funding availability each year, equal to the amount available in 2018. Through HEES we also obtain information on the number of households that received efficiency improvements. This way we can determine the amount allocated per beneficiary household and through that the number of beneficiary households in the period 2019-2028. Using the number of beneficiary households we can also identify what share of each household quintile is receiving efficiency improvements.

Table 1: Summary of data used to inform scenarios

		ECO (with economic rent)	ECO (no rent present)	Loans to beneficiaries	Fully socialising through income tax
Amount Spend on Constructions (% of total)		3,567.84 (33%)	6,957.29 (64%)	8,569.84 (87%)	8,569.84 (87%)
Amount Spend on Boiler manufacturers (% of total)		644.06 (6%)	1,255.91 (12%)	1,255.91 (13%)	1,255.91 (13%)
Economic rent (% of total)		4,001.30 (37%)	0 (0%)	0 (0%)	0 (0%)
Search costs (% of total)		1,612.54 (14%)	1,612.54 (14%)	0 (0%)	0 (0%)
Administrative costs (% of total)		1,071.28 (10%)	1,071.28 (10%)	0 (0%)	0 (0%)
Total cost paid by consumers		10,897.03	10,897.03	9,825.75	9,825.75
Total efficiency gains when access distributed equally (in %)	HG1-5 (per household quintile)	2.38%	4.64%	5.66%	5.66%
Total efficiency gains with tapered distribution(in %)	HG1	4.37%	8.53%	10.14%	10.14%
	HG2	2.44%	4.76%	5.79%	5.79%
	HG3	1.91%	3.73%	4.61%	4.61%
	HG4	1.85%	3.62%	4.47%	4.47%
	HG5	1.33%	2.59%	3.29%	3.29%

For the efficiency improvement of each more efficient household we use data from the National Energy Efficiency Data (NEED) framework. NEED reports the mean energy savings for a range of implemented retrofitting activities. We use the one reported for 'Condensing Boiler and Cavity Wall Insulation and Loft Insulation' as an indication of the efficiency achieved per more efficient household. The data cover the period 2013-2016 so for the 2017-2028 period we assume that the efficiency gains are the average of the 2013-2016 period. Although there is some variation in the efficiency gains of each beneficiary household in the period 2013-2016, which is reflected on our analyses, the average efficiency gains per beneficiary household across the 2013-2028 period is 17.2%. We use this figure and the share of households in each quintile that receive an improvement to determine the efficiency improvement of the whole quintile. For example, if in 2019 75,750 households in HG1 receive efficiency improvements this is 1.39% of HG1. With each beneficiary household being 17.2% more efficient, this means that the whole quintile is on average 0.24% (17.2% x 1.39%) more efficient. Adding together the efficiency gains of each year gives us the total efficiency gains of the entire programme (see Table 1).

Which sectors are included?

The general equilibrium framework incorporates all sectors of the UK economy. This allows analysis to capture interactions between the different sectors and markets and identify how changes in one sector can spill across the entire UK economy through changes in prices and incomes generated in different markets and the availability of constrained supplies of labour and capital. We aggregate the 103 sectors reported in ONS IO accounts to 30 sectors. This includes five energy supply sectors: coal extraction, crude oil extraction, refined petroleum, electricity and gas distribution sectors. The aggregation (or not) of the other 25 sectors permits key activities impacting or impacted by the response to enabling and realising energy efficiency are distinguished. However, in some cases the IO classification still aggregates some important activities. For example, the 'Manufacture of fabricated metal products, excluding weapons & ammunition' sector (sector 25OTHER in SIC 2007) includes the production of gas boilers. In this work we use a similar aggregation to Figus *et al.* (2017), with the differences being the disaggregation of Manufacture of fabricated metal products, excluding weapons & ammunition' sector from the aggregated 'Iron, Steel and Metal' sector in Figus *et al.* (2017) and the further aggregation of 'Recreational' and 'Other Private Services' sectors.

How is production activity modelled?

Each industry has a production function that incorporates labour, capital, energy and non-energy intermediate inputs. Capital, labour and intermediates are standard input classification in every CGE model, including the one used by HM Treasury. The key difference is that in our model we distinguish between energy and non-energy intermediates. Capital and labour are combined in one nest of a CES consumption function to produce value added before combining with intermediates, dependent on relative prices. Here, we assume a fixed nominal wage and also a fixed (national) labour supply, meaning there cannot be any migration to cover the excess labour demand. The base year data incorporate a small (6%) pool of unemployed labour that responds to additional employment opportunities and through which the labour demand is covered. We assume perfect mobility of employees to other sectors where increased demand for their output also leads to increased labour demand. Capital is also constrained in that it does not instantly reach the desired level. Instead, as detailed by Figus *et al.* (2017), the path of the necessary investment to the desired capital stock is calculated so that it maximises the value of the firms, while taking into account the depreciation of existing capital.

How is consumption modelled?

Our model includes a number of consumers including the government and households. In our model, the government consumption is treated as exogenous meaning that despite any changes in relative prices the government is assumed to maintain the same level of consumption. This affects the budget balance, but in most simulations the government can accumulate savings or deficit. The only scenario where we assume a balanced budget is when we simulate the full socialisation of the cost of efficiency improvements through the income tax. In that case the government still maintains the same level of consumption but adjusts the income tax either up or down to achieve a balanced budget.

The households are disaggregated into 5 quintiles based on their gross income, as detailed in Figus *et al.* (2017). This allows us to study how households with varying income levels differ in their consumption

of goods and services, including energy goods and services. Household income comes from different sources, including labour income, income from capital and transfers from the government. The marginal propensity to consume is assumed to be constant throughout the duration of our analyses. The initial consumption choices of each quintile are informed by the SAM data used as the basis for this model. However, the households respond to changes in the relative price of goods and services, so that they can maximise their utility; subject to budget constraints that fluctuate with every simulated period. This includes the consumption of residential energy, i.e. the energy required for households to run their properties and an efficiency parameter on energy use is shocked in our scenarios. As such our analyses capture any indirect rebound effects driven by a drop in the relative price of residential energy or by a general increase in the disposable income of households which increases the consumption demand of all goods and services.

Are there imports/exports in UKENVI?

UKENVI includes two external regions; Rest of EU (REU) and Rest of the World (ROW). Goods and services from these external regions can be imported for intermediate or final use and similarly UK industries have the option to export their output to these regions. UK goods and services are considered imperfect substitutes to those produced abroad and both import and export demands respond to changes in relative prices. In each simulated period firms can choose to either use domestically produced intermediate inputs or import them from abroad. However, since they are considered as imperfect substitutes, a greater difference in relative prices is required for the UK firms to opt to use imports rather than use domestic goods and services. A similar process applies to consumers, who have the option to meet their needs by using domestic or imported goods and services. The elasticity we assume between domestic and imported goods is in line with the existing literature and is generally accepted as being a reasonable assumption. However, a sensitivity analysis can be conducted by introducing different elasticities to reflect consumers of firms more or less prone to import the goods they need and how export demand does respond to changes in the competitiveness of UK industries.

Annex B: Summary of key results

Table 2: Impact on key macroeconomic variables due to ECO and fully socialising the cost of energy efficiency

	Base values	ECO (with economic rent)		ECO (no rent present		Loans to beneficiaries		Fully socialising through income tax	
		First year	Full adjustment	First year	Full adjustment	First year	Full adjustment	First year	Full adjustment
GDP	£1,305,907m	0.02%	0.07%	0.04%	0.14%	0.04%	0.17%	-0.01%	0.25%
CPI	1	0.06%	0.00%	0.08%	0.00%	0.04%	0.00%	-0.02%	0.00%
Investment	15%	0.04%	0.08%	0.06%	0.15%	-0.03%	0.18%	0.18%	0.27%
Unemployment rate	6%	-0.60%	-1.23%	-1.06%	-2.35%	-1.03%	-2.84%	0.14%	-4.07%
Employment	24,930,573	0.04%	0.08%	0.07%	0.15%	0.07%	0.18%	-0.01%	0.26%
Real wage	1	0.06%	0.00%	0.08%	0.00%	0.04%	0.00%	-0.02%	0.00%
Imports	£452,832m	0.07%	0.08%	0.14%	0.15%	0.13%	0.18%	-0.02%	0.27%
Exports	£452,832m	-0.05%	0.00%	-0.08%	0.00%	-0.07%	0.00%	0.02%	0.00%
Total energy use	£190,271m	-0.09%	-0.22%	-0.10%	-0.42%	-0.04%	-0.51%	-0.07%	-0.43%
Disposable income (excluding savings)	£1,427,453m	0.01%	0.14%	0.03%	0.28%	0.06%	0.33%	0.03%	0.39%
Household total energy consumption	£38,856m	-0.36%	-0.56%	-0.40%	-1.08%	-0.13%	-1.31%	-0.27%	-1.17%
Residential energy consumption	£32,019m	-0.13%	-0.27%	-0.15%	-0.53%	-0.05%	-0.64%	-0.11%	-0.54%
Cumulative GDP per £million spent	0	£0.03m	£4.31m	£0.04m	£8.20m	£0.05m	£9.83m	-£0.01m	£14.10m
Employment per £million spent	0	0.88 FTE	1.80 FTE	1.55 FTE	3.43 FTE	1.66 FTE	4.60 FTE	-0.22 FTE	6.59 FTE

Endnotes

[1] A future focus of our scenario analysis could extend to consider the impact of some of the rent embodied in ECO accruing to households.

[2] Please note that Annex B reports the funding breakdown across the entire period 2013-2028 and includes a mixture of reported and estimated figures. As a result the percentage share of each cost associated with the delivery of ECO is slightly different compared to what is expected for ECO3.

[3] Any direct rebound effect should be captured in the direct energy saving data reported in the National Energy Efficiency Data (NEED) framework, which we use to inform the economy-wide scenario simulations of efficiency gains realised. Any indirect/economy-wide rebound are then captured through our general equilibrium analysis.

[4] It is important to highlight that any alternative funding mechanism may have associated administrative costs that could increase the total cost. However, in the absence of any information we assume that there are no administrative costs.

[5] In future research we aim to incorporate more behavioural features and dynamics into UKENVI. This will potentially include the impact of information asymmetries, but, as with all scenario simulations, what can be modelled is dependent on information available.

[6] Under the tapered approach HG1 has access to 54% of the funds, HG2 21%, HG3 12%, HG4 11% and HG5 2%. This breakdown was provided by our colleagues at BEIS and are the outcome of internal analyses/modelling.

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