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The potential impacts of Brexit on Energy Efficiency Scotland funding

Working paper

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Executive Summary

Energy Efficient Scotland (EES) is a large scale energy efficiency improvement programme to be implemented in Scotland. Over a 20-year period, currently scheduled to start in 2020, an amount in excess of £10billion is planned to be directed to the improvement of the energy efficiency in domestic and non-domestic buildings. Funding for energy efficiency projects will come not only from the Scottish Government but also private interest-free and low interest loans as well as the successor(s) to the Energy Company Obligation (ECO). Aside from directing investment funds to the Scottish economy, promotion and support of energy efficiency through programmes such as EES, is one of the few instruments at the Scottish Government's disposal to conduct energy policy, especially on the energy demand side.

However, EES is considered to be more than an energy/climate change policy by the Scottish Government. For example, the stated goals of EES include the alleviation of fuel poverty among the lowest income Scottish households. On this basis, funding mechanisms such as government issued grants, are exclusively available to the lowest income households. More generally, energy efficiency has been identified as a 'national infrastructure priority' in the EES Route Map document published in May 2018, and the Scottish Energy Strategy published in December 2017 considers how energy efficiency actions may impact upon key economic indicators such as GDP and employment across the wider economy.

EES was officially announced in May 2018 with the publication of the EES Route Map. At that time the UK was already in the process of leaving the European Union: commonly referred to as Brexit. Brexit, regardless of its final shape (which is currently unknown), is expected to affect policies in multiple ways including limitations to EU funds, skilled labour movement restrictions and increased import prices to name a few examples (among the potential impacts highlighted by different studies, reported in a 2018 Institute for Government report[1]). The magnitude and the exact nature of any impacts will be affected by the exact form that Brexit will have. In this shifting socio-economic landscape, EES will undoubtedly be affected in a range of ways.

In the research presented in this working paper, in the first instance we focus attention on the funding limitations that Brexit could introduce to EES. Specifically, we identify two EES funding mechanisms that are likely to be affected; government-issued grants and privately-provided loans. For different reasons, these mechanisms are of paramount importance in order to achieve the EES goals as specified in the EES Route Map.

First, Government grants are key to delivering the fuel poverty alleviation goal as it is a way for the government to contribute towards energy efficiency improvement projects for the lowest income households without those households being required to repay the costs of those improvements in the years to come. Restricted access to EU funds, regardless of whether they come from the European Investment Bank (EIB) or

[1] The report by Tetlow and Stojanovic can be found here: https://www.instituteforgovernment.org.uk/publications/understanding-economic-impact-brexit

the European Structural and Investment Funds (ESIF), could limit the Scottish Government's ability to offer the originally planned amount of grants.

Second, private loans, whether in interest-free or low-interest form, are in practice the main mechanism to fund EES projects, particularly for those households not eligible to receive grants. On this basis, the current plan is that private loans would constitute the largest source of contributions towards EES projects. However, uncertainty around Brexit and the future relationship between the UK and the EU has already begun to affect the availability of investment capital for loans, as highlighted by Froggat et al in a 2017 Chatham House report. Thus, it follows that reduced availability of loan finance could undermine the achievement of the energy/climate change goals as fewer households are likely to opt to implement energy efficiency improvement projects.

These arguments provide the basis for our development of a range of scenarios that look at the differences in the outcomes of EES in the event that funding availability is in fact restricted. We compare the results of simulating these scenarios against a central 'No-Brexit' case. Our findings show that the impacts of Brexit need to be examined on a case by case basis. However, there are some general lessons from the research reported here:

- **Maintaining the originally-planned funding level is key**. The level of funding determines the magnitude of the anticipated EES outcomes, especially the long-term ones that are driven by realising efficiency gains in energy use by Scottish households. For example, our 'No-Brexit' analysis for EES suggests that the lowest income households could ultimately achieve a 4.02% reduction in the energy required to run their homes. But a reduction of 10% in the amount offered as grants could reduce the extent of efficiency gains and energy savings to 3.74%, which may be further reduced to 1.21% if no grants are offered.

- **The options used to bridge any funding gaps need to be carefully considered.** In particular, where a funding gap emerges in the provision of government grants, it is important to carefully design the mix of options used to raise the necessary funds and/or fill that gap. Otherwise, gains in the disposable income of the lowest income households could be eroded, from a potential 0.7% in the 'No-Brexit' case to 0.3% where no grants are provided. Moreover, it is likely to be at least 10 years after the beginning of EES before any positive effects can be observed, in contrast to the 'No-Brexit' case where positive effects are observed from the outset of EES.

- **The continued availability of private loans is crucial for the overall success of EES.** Private loans are the dominant source of contributions towards EES projects. A 10% reduction in the availability of private loans will impact upon both employment gains and energy savings across the wider economy. Our 'No-Brexit' analysis suggests that EES could generate sustained employment gains of almost 5,000 new FTE jobs across the economy and 1.07% reduction in total energy use by 2050. But a 10% reduction in the availability of private loans limits the jobs gains to approximately 4,700 and erodes energy savings to 1%. Of course, the availability of funds or the cost of the loans is outside the direct control of the Scottish Government. Nonetheless, it is crucial to use any available

instruments to ensure that both the funding level and the cost of loans remains as close as possible to the originally-planned levels.

The key ‘take home’ messages emerging are, first that the Scottish Government should aim to keep EES funding as close to the original level, and, second it needs to carefully consider how this may be done in the context of an uncertain Brexit.

1. Introduction

The UK's withdrawal from the European Union (EU) – commonly referred to as Brexit - has been a key point of discussion among various research communities and the general public since the 2016 referendum. Attempts to estimate the potential effects of Brexit are hampered by the many uncertainties that still surround Brexit outcomes.

Almost 2 years after the Brexit referendum, the Scottish Government published the route map for its Energy Efficient Scotland (EES) programme. EES is a major energy efficiency improvement programme, with particular, but not exclusive, focus on households and residential energy use. It is planned to run for a 20 year period between 2020 and 2040 (although at present there is a process of consultation seeking wider views on a number of topics including whether the delivery of the programme needs to be accelerated). This means that if the UK leaves the EU at any point within the next few years, most of the project-related activity around EES would take place after Brexit. Yet, our previous work exploring the potential economy-wide impacts of EES (Turner *et al.*, 2018), as is the case with the majority of the research evaluating the potential economy-wide impacts of energy efficiency policies, has assumed a static policy environment, with little consideration of whether the planned EU exit will alter that environment.

Brexit will remove a layer of governance hitherto provided by the EU, leaving the policy environment less certain, at least in the short-term. At the same time the uncertainty regarding the final form of the future UK-EU relationship is already having a profound destabilising effect on the political and economic landscape. The changes in the nature of the future UK-EU relationship could contribute to significantly different outcomes generated by EES. It is crucial then to explore how the removal of a governance level and the associated uncertainty regarding the future UK-EU relationship, including how access to various EU policy funding mechanisms is affected, could influence the anticipated impacts of EES.

In this working paper, we explore how Brexit may affect the goals of the Scottish Government's energy efficiency improvement projects under EES, with a specific focus on how changes to funding availability impact upon the wider economy effects of the programme. The EES Route Map identifies three main funding streams. The first is government grants targeted at the least affluent households. The second is contributions through energy suppliers under the Energy Company Obligation (ECO) scheme or any of its potential successors. The third is interest-free or low interest loans, provided by private institutions or the Scottish Government. The broader economic uncertainties associated with the UK leaving the EU generate risks for the availability of private loans, and at the same time, the Scottish Government might find it difficult to offer grant funding once EU funding streams end. The only funding option that is likely to be relatively unaffected (at least directly) by Brexit is ECO.

Reduced funding availability would be a crucial change in the economic environment for EES. As with any retrofitting/intervention project, the amount of funds that can be allocated for a certain purpose is a key determinant of the potential level of activity and anticipated impacts. In that sense, the Scottish Government may have to make some important decisions. Would it accept that funding is more restricted and therefore the goals of EES will need to be revisited to reflect the new circumstances? Or will it seek

to fill the potential funding gap through taxation, provision of additional government-backed loans and/or other potential options? And how can we expect changes to the availability of funding to affect the outcomes of the EES programme? These are the questions we explore in this working paper.

The working paper is structured as follows. In Section 2, we outline current Scottish energy efficiency policies and set out their EU dimension, with a particular focus on EU funding and the availability of finance. We identify a number of pathways, including potentially restricted access to European funds and the challenges of securing alternative funding streams within Scotland. In Section 3 we describe the central 'No-Brexit' case that is the base line against which we will compare our scenarios in this working paper.

Section 4 presents the scenarios we model in relation to reduced provisions of grants by the Scottish Government. We explore scenarios in which availability is partially restricted and ones in which there are no grants available for a certain period of time. We also explore potential options that can be employed to cover the losses in grants. Our analysis shows that maintaining the funding level is key to achieve similar energy savings to the ones possible under the original EES planning. We also find that if interest-free loans are the only means to bridge the funding gap then there is the potential for negative impacts on the disposable income of the lowest income households.

In Section 5 we shift our attention to privately issued loans and the impacts of restricted availability due to investors' reluctance to provide the same amounts of capital. We find that this would erode not only the energy savings achieved across the Scottish economy but also the employment opportunities driven by EES activity and energy bill savings. In fact the impact from reduced employment opportunities affects the entire spectrum of Scottish households, albeit to varying degrees.

Finally, in Section 6 we provide a summary of the key messages coming out of this work, the additional ways in which Brexit can affect EES, and suggest further research steps.

2. Scottish Energy Efficiency policies and Brexit

The EU has made key contributions to improving energy efficiency in all member states since 2012 through the setting of targets to reduce energy demand and increase energy efficiency standards. The 2012 EU Energy Efficiency Directive set binding measures to help the EU reach its target of a 20% improvement in energy efficiency by 2020. These EU targets leave considerable discretion to national governments to formulate their policy approaches to help them achieve their share of the target.

2.1 Current Scottish energy efficiency policies

Within the UK, energy policy and the regulation of the gas and electricity markets are the responsibility of different governing bodies. Energy policy is almost wholly devolved in Northern Ireland, while the Northern Ireland Utility Regulator is responsible to regulate the energy sector. On the other hand in Great Britain, the regulation of the gas and electricity markets is reserved for a GB-wide authority, Ofgem, while energy policy is mainly conducted by the UK government.

The devolved governments of Scotland and Wales have responsibility for promoting energy efficiency, including through supporting and funding projects intended to reduce energy demand and improve the energy efficiency of residential and commercial buildings. In Scotland, the devolved government has identified energy efficiency as a national infrastructure priority since 2015 (as highlighted in the EES route map), resulting in significant attention and funding directed at delivering more energy efficient buildings. The EES is the delivery programme intended to implement that priority, starting in 2020 and following the completion of a transition programme between the existing energy efficiency improvement measures and EES.

As the International Energy Agency highlights (IEA, 2014), the objectives underpinning energy efficiency actions can span multiple policy fields; they do not need to be considered exclusively as energy and climate change policy tools. The Scottish Government seems to share this view. The main goals identified for EES are to remove energy inefficiency from the drivers of fuel poverty and to reduce greenhouse gas (GHG) emissions (alongside the decarbonisation of heat). It is evident, then, that EES has both social and environmental priorities in relation to climate change and fuel poverty. In order to achieve these goals, it is crucial that energy efficiency improvement measures can be accessed by the widest number of households possible; especially those households that are currently considered as fuel poor[2]. According to the 2017 Scottish House Condition Survey[3], 613,000 Scottish households are estimated to be in fuel poverty, with 174,000 of them in extreme fuel poverty.

[2] There are different definitions of which households are considered to be in fuel poverty. The DEFRA definition for England and Wales contained in the Energy Conservation Act 2000 states that “A fuel poor household is one which needs to spend more than 10% of its income on all fuel use and to heat its home to an adequate standard of warmth”. A less strict version was introduced in 2014. The Scottish definition was contained in the Housing (Scotland) Act 2001, while there is a new definition in the Fuel Poverty (Target, Definition and Strategy) (Scotland) Bill stating “Households should be able to afford the heating and electricity needed for a decent quality of life. Once a household has paid for its housing, it is in fuel poverty if it needs more than 10% of its remaining income to pay for its energy needs, and if this then leaves the household in poverty”.

[3] The main outcomes of the survey can be found here: https://www.gov.scot/publications/scottish-house-condition-survey-2017-key-findings/

Yet, a substantial upfront investment is necessary in order to install many efficiency improvement measures. This is something that fuel poor, and less affluent households in general, may find difficult. Accordingly, the EES includes provisions for government grants targeted specifically to those households that struggle to fund the improvements on their own or even to repay interest-free or low-interest loans that would enable them to do so.

2.2 Funding and the changing EU context

How will the government grants, and EES as a whole, be funded? The EES Route Map highlights a number of existing energy efficiency programmes that will support the delivery of EES. Box 1 highlights some of the key programmes that will be used. These programmes range from low and interest-free loans, to direct contributions by the Scottish Government to Household Energy Efficiency Programmes for Scotland (HEEPS) schemes that include a multitude of grants and household contributions.

For the loan schemes in Box 1 there is an expectation that the recipients will eventually repay the loan within a fixed time period that largely depends on the specific requirements of each scheme. For instance, the district heat loans are repayable between 10 to 15 years, whereas the SME loans have an 8-year repayment period. On the other hand, schemes like HEEPS provide grants as part of the overall support provided to households to improve the energy efficiency of their properties - household contributions may also be necessary.

Box 1: Energy efficiency programmes to support the delivery of EES

- **Low Carbon Infrastructure Transition Programme** (LCITP) provides financial support to low carbon energy generation projects for a range of technologies. £40 million of funding has been offered since March 2015 to 16 low carbon demonstration projects and supported over 30 proof of concepts for proposals.
- **District Heating Loan Fund** supports district heating schemes through low interest unsecured loans with 10 or 15 year repayment terms. £15 million has been lent to over 50 projects in Scotland since 2011.
- **SME Loan Scheme** offers businesses loans of up to £100,000 at low or no cost for efficiency measures and renewable technologies through Resource Efficient Scotland (RES). Over 800 projects have been financed through the scheme since 2008.
- **Home Energy Scotland (HES) Loan Scheme** provides energy efficiency and renewable technology interest-free loans of up to £35,000 through the Energy Saving Trust (EST). It was launched in 2017 and 1,325 loans have been offered with a total value of £3.4 million.
- **Home Energy Efficiency Programmes for Scotland (HEEPS)** includes four programmes: Area Based Schemes, Warmer Homes Scotland, Home Energy Scotland Loan Scheme, and Equity Loan Pilot Scheme.
- **Renewable Heat Incentive (RHI)** (GB-wide) provides payments for domestic and non-domestic heat generated from renewable energy and is promoted by the Scottish Government. The scheme's uptake is relatively high in Scotland (pro-rata at 20% of total Great Britain accreditations).

The funds for HEEPS are provided by the Scottish Government, and part of the funding required for programmes like the LCITP comes from the European Union and specifically the European Structural and Investment Funds (ESIF). ESIF is a significant source of investment funds for Scotland and the UK as a whole, for low-carbon economy and climate adaptation programmes. A 2017 Chatham house report[4] highlighted that for the 2014-2020 period a total of €5.5billion was allocated to the UK for such programmes: €2.9billion for low-carbon economy and €2.6billion for climate adaptation. In Scotland, the total amount available through ESIF, in the same 2014-2020 period, is €941million[5] and is directed in a number of areas of policy interest including the transition to a low-carbon Scotland and tackling poverty. It is fair to say then that ESIF is a significant funding stream for Scottish policies and one that may be at risk following the UK's withdrawal from the EU.

ESIF is not the only EU funding source that may be at risk following Brexit. The Chatham House report also highlighted that a total of £2.5billion per annum is allocated to the UK for energy investments by the European Investment Bank (EIB). Assuming a proportional distribution based on each devolved nation's GDP, with Scottish GDP being approximately 10% of UK's GDP, Scotland receives approximately £250million per annum for energy investments. Given that this is the total amount invested, it is not exclusively allocated on energy efficiency projects but covers a wide array of energy related investments.

However, a 2018 European Union (EU) directive[6] set targets regarding the ways in which greenhouse gas (GHG) emission savings will be achieved by 2030. It highlighted that EU aims to achieve 32.5% of its GHG emission savings through energy efficiency improvements. Assuming that this decision affects how the EIB funds are distributed, this equates to a total amount of £81.25m to be provided to Scotland for energy efficiency projects until 2030, i.e. just under £8m per year.

We do not yet know what form Brexit will take. If the UK leaves with a deal, we can assume that EU funding sources will still be accessible to the UK during the transition period. A close UK-EU relationship thereafter could still permit access to some EU funds, but it is reasonable to assume that structural and investment funds designed to help the EU meet its strategic objectives will no longer be available to the UK. This risks generating a funding gap for EES. The Scottish Government would, of course, be free to finance energy efficiency projects from its own revenues and the UK Government may decide to replace the EU's structural and investment funding with its own scheme. However, energy efficiency improvements compete alongside other significant policy items for a share of a finite pool of public funds and energy efficiency is not the only area that may face a funding gap as a result of EU exit. This could lead to funding being reduced, potentially shaping the projected outcomes of EES.

[4] The report can be found here: https://www.chathamhouse.org/publication/staying-connected-key-elements-uk-eu27-energy-cooperation-after-brexit

[5] According to the Scottish Government's website: https://www.gov.scot/policies/european-structural-funds/

[6] Energy Efficiency Directive – Directive 2018/2002/EU, OJ L 328/210, 21 December 2018. Can be found here: https://eur-lex.europa.eu/eli/dir/2018/2002/oj

EES projects will not be exclusively funded through grants. The programmes to support the implementation of EES (see Box 1) include several low or interest-free loan options, while the Energy Company Obligation (ECO) is embedded in the funding of HEEPS. Among the different funding mechanisms for EES, ECO and its potential successor(s) seems to be the least likely to be affected by Brexit. It is possible that a future obligation scheme may spread the cost differently across the customer base of UK energy suppliers, but this is a change associated with domestic policymaking rather than the direct effects of Brexit. Similarly, for any government-backed interest-free loans provided to the lowest income households, it is not unrealistic to assume that the Scottish Government will opt to keep the amount available at the originally planned levels, given that the receiving households are required to repay the loans. This way the government will ultimately recover the amount offered, albeit with reduced purchasing power.

However, for the provision of non-government-backed loans, the Scottish Government relies on private investors to support the efficiency improvement projects of Scottish households. Brexit, as a whole, has introduced uncertainties regarding the future of the UK and Scottish economies. In this economic environment, investors may be reluctant to, or at least less interested and/or confident in, providing funding. The 2017 Chatham House report argues that following the EU withdrawal referendum, the availability of investment capital was reduced by 10% compared to the period prior to the referendum (Froggatt et al, 2017, pp. 30). One of the main challenges of the Scottish Government will be to address any concerns on behalf of the investors and ensure that the funding availability is at the originally anticipated/desired levels. The extent to which the Scottish Government will be able to address investors' concerns will largely determine the availability of private funding for households looking to participate in EES.

Of course, the potential impacts of Brexit on EES are not limited to restrictions on the funding availability for retrofitting projects. There are also likely impacts associated with new limitations in recruiting skilled labour from the EU, and/or the possible tariffs on EU goods and services in the UK and vice versa. However, these impacts are outwith the scope of this working paper. Here we focus only on the funding limitations and how these, and the potential options to overcome them, may affect the anticipated outcomes of EES. We disuss how the estimated labour and price impacts could be explored in future research in the final section of this working paper.

3. The central 'No-Brexit' case

The work that we discuss in this working paper builds on and updates previous work we have conducted on the potential economy-wide impacts of the residential energy efficiency gains more generally, and of the Energy Efficiency Scotland (EES) programme in the Scottish Economy particular. For the latter see the (Turner *et al.*, 2018) policy briefing that was published on the day of the publication of the EES route map in May 2018. In this working paper, we update that analysis with a Computable General Equilibrium (CGE) model based on more recent data (calibrated on a Scottish social accounting matrix, SAM, for 2013). This model includes all the sectors in the Scottish economy and actors such as the wider government, households etc. It allows us to study how a change, for example the improvement of household energy efficiency, drives a number of economy-wide impacts in areas such as GDP and employment. To keep the main body of this working paper accessible to a wider audience we include the description of the model used in Appendix A. Our consideration of how energy efficiency programmes in the residential sector may impact across the wider economy, in particular set in the context of the case for public support, builds on an existing body of work conducted at the University of Strathclyde and in the wider energy economics literature.

There is an issue in that much of the research on the economic impacts of energy efficiency improvements has been concentrated on energy rebound effects (i.e. with a focus on how economic responses may lead to an erosion of technically possible energy saving and after that a wider range of, for example, employment and GDP impacts). On the other hand, consideration of economy-wide rebound is instructive as it indicates the size of positive income effects emerging as a result of efficiency gains. This literature is reviewed in Turner (2013). The applied economy-wide modelling approach adopted here with application for the Scottish and UK economies has been developed through a range of papers, initially with focus on industrial energy efficiency (e.g. see Allan *et al.*, 2007; Hanley *et al.*, 2009) and more recently, with attention to residential energy use (see Lecca *et al.*, 2014; Figus *et al.*, 2017, 2018).

3.1 What are the main results of the central 'No-Brexit' case?

EES will be funded using a mixture of funding sources and support programmes. The EES Route Map identifies a number of loan schemes, grants and other programmes that use a range of funding streams to support energy efficiency improvement measures, and which will have a role in the implementation of EES from 2020 onwards. However, the exact mixture is currently unknown. For our central case, we assume that the entire EES will be implemented using a funding model similar to the one used in the nationally-managed Warmer Homes Scotland programme, which is part of Home Energy Efficiency Programmes for Scotland (HEEPS). HEEPS is one of the programmes currently in place that are being used by the Scottish Government to promote energy efficiency improvements, and is exclusively focused on domestic buildings. HEEPS is also part of the transition phase until the implementation of EES formally begins in 2020 and is also, as shown in Box 1, part of the set of programmes that are expected to be used to implement EES.

Energy efficiency improvements supported via Warmer Homes Scotland use a number of funding mechanisms: government grants, ECO contributions, contributions by

households themselves, and finally contributions in kind from Scottish Gas Networks in the form of reduced or no-cost connections to the gas network. The latter accounts for an equivalent value of approximately 20% of the total funds available, but for the purposes of our work it has been excluded from consideration. This is due to the absence of data that we could use to model contributions in kind. Thus, for our central case we focus on £8billion of funding for EES projects, rather than the total £10billion suggested in the EES Route Map. We assume that the total funds available from all sources will be made available and utilised evenly across the 20-year time frame, enabling equal average increments to the energy efficiency of Scottish households in each year, but with the lowest income quintile making greater gains due to the enhanced funding targeted at and available to them. The breakdown of funding available for EES in our central case is summarised in Table 1.

Table 1: Summary of EES funding provided in central 'No-Brexit' case

	Lowest income households (1st quintile) - per year	**All other households -per year**	**Total (across all households and 20-year EES programme)**
Government grants	£78m per year	No government grants	£1,560m
ECO contributions	£13.99m per year	£46.01m per year	£1,200m
Government - backed loans	£18.22m per year	No government-backed loans	£364.41m
Private loans	No private loans	£243.78 per year	£4,875.59m
Total funding available	£110.21m per year	£289.79m per year	£8,000m
Energy efficiency improvement (incremental per year)	0.66% per year	0.43% per year	
Total Energy Efficiency improvement	13.20%	8.67%	

The information in Table 1 reflects the funding accessibility limitations imposed by the EES Route Map. For example, government grants are available only to the lowest income households. We assume that interest-free loans enable households to contribute their share of the costs of retrofitting their properties. These take the form

of government-backed loans in the case of the lowest income quintile, with all other groups relying on funding via private institutions. Thus, ECO is the only funding mechanism open to every household regardless of income, but which must be repaid through the energy bills of all consumers.

So how does EES impact the wider economy? It does so via two triggers and two routes, which we refer to as 'enabling' and 'realising' stages. In the first instance the funding availability affects the magnitude of the retrofitting activity. This is what we refer to as the 'enabling' stage of an energy efficiency programme, i.e. the period during which the retrofitting activity takes place. We assume that it takes the form of spending in the Scottish 'Construction' sector. Regardless of whether any efficiency gains are actually realised, activity throughout the enabling stage will impact the wider economy via what is a significant mid-range boost to activity in Scottish Construction and other Scottish industries via supply chain 'multiplier effects'.

We estimate that the enabling stage of the residential energy efficiency element of EES has the potential to deliver a cumulative (undiscounted) boost of £2.5billion to Scottish GDP over the next 30 years (in 2013 prices that relate to our model's database). Of course, this enabling stage, just like any economic expansion occurring in the presence of even short term constraints (in the availability of labour and capital), will cause price pressures and have some short term 'crowding out' effects (we assume that labour and capital constraints relax over time due to migration of workers and investment in capital). Nonetheless, our results suggest that the peak of a period of increased employment associated with the enabling state is reached with a net gain of 4,246 additional jobs in the sixth year of the twenty-year programme.

The point that there is a peak is an important one to note. Following this, despite still having fourteen years to run, the wider economic boost from the enabling stage alone loses power. This is partly because an increasing number of Scottish households are paying back the loans that finance their contributions and also paying indirectly for the ECO contribution through their energy bills. This in turn limits the 'multiplier' effect of increased wage income and the household spending that it supports.

However, the main reason the economic boost wanes after a peak is that the enabling stage does not really outlive the projects. Indeed, as the 20-year period of spending on retrofitting draws to a close, producers will begin to make other plans for their equipment and workers, with the process of reallocation potentially triggering a gross contraction in economic activity for a few years at the end of the enabling stage.

But, these negative impacts are offset by gains from the simultaneous positive impacts of actually realising energy efficiency gains. This is the second, and ultimately more important, trigger for wider economic expansion generated by an energy efficiency programme like EES. The lasting legacy of the enabling stage is that it enables the 'realising' stage, by facilitating energy efficiency gains. It is the efficiency gains in energy use that permit households to access the same energy services (e.g. heating homes to the same temperature for a given period of time) at reduced cost. This will in turn reduce energy bills and, thus, increase disposable income for recipient households to spend on other things.

It is the impact of this increased spending power, and the shift and boosted nature of spending that enables sustained expansion across the economy. In any one time

period during the adjustment process even households that have not benefitted from energy efficiency gains will realise real income gains through boosted wage incomes and, for higher income households, returns to investment/ownership of capital as the economy expands. Moreover, given that the efficiency improvement enables a lasting change in how households use energy, the trigger effect on household incomes and spending power through reduced energy bills is a lasting one.

One key point to note, in considering how wider expansionary effects further impact upon the real incomes of Scottish households, is that the group of most concern to policymakers (low income households) gain less via this route. This is because employment and ownership of capital do not constitute a major part of the incomes of the lowest income households. Thus (as investigated in some detail by Figus et al., 2017), the direct impacts of the energy efficiency gains on bills and spending power are a much more important source of gain for the lowest income quintile on which we focus our attention here.

In terms of the combined results for our central 'No-Brexit' case, the funding set out in Table 1 ultimately enables a 23.66% energy efficiency improvement per retrofitted property, which is the average estimated improvement from Warmer Homes Scotland projects[7]. However, as the funds are not sufficient to retrofit every household in each income quintile, the overall efficiency of each quintile improves proportionately by less than this. This is the annual incremental efficiency improvement reported in Table 1. The funds available for the lowest income quintile are sufficient to improve the quintile's energy efficiency by 13.2% at the end of the 20-year programme. In the same timeframe, those available to the remaining four quintiles are sufficient to make each one 8.67% more energy efficient. The difference in efficiency gains between the lowest income quintile and the remaining four quintiles is directly linked to the extent of funds available in each. The lowest income quintile has approximately £110million per year available for retrofitting projects. The remaining quintiles have to share around £290million each year, i.e. £72.5million per quintile per year (assuming an even distribution of the funds across the quintiles).

For our central case we combined all the funding mechanisms available to the different quintiles and the efficiency gains supported by the funding available to each household. We obtained the following headline results regarding the potential impact of the residential energy efficiency element of EES on the Scottish Economy.

- A cumulative GDP gain of £5.6billion by the end of the programme in 2040 and £7.5billion in the 30-years following the beginning of the main phase of EES (i.e. by 2050)

- A sustained GDP expansion of 0.2% compared to pre-EES

- Approximately 6,300 net additional full-time (FTE) jobs by the end of the programme in 2040 and just under 5,000 net sustained FTE jobs by 2050, with the 'realising' rather than the 'enabling' stage being key to these gains over the longer term

[7] The estimates are based on the EPC certificates of properties before and after retrofitting them using Warmer Homes Scotland funding.

Moreover, and associated with the focus of this working paper, we found that under the central 'No-Brexit' case, by 2050:

- The lowest income households enjoy an average 0.73% increase in their disposable income. Crucially their disposable income is higher compared to the pre-EES levels across the entire duration of the programme

- The lowest income households achieve a 4.02% reduction in the energy required to run their homes (referred to here as residential energy use). Across the economy total energy use drops by 1.07% (including industrial energy use)

4. The potential impacts of restrictions in the provision of government grants

Our central case results reflect what the potential EES impacts to the Scottish economy could be if Brexit left the socio-economic landscape somewhat unaffected (and EES is deployed as set out). But, a large political development like Brexit should be expected to affect the potential impacts of any policy in multiple ways, so the focus of this study is revisiting our central case scenario to begin consideration of this.

In this section we focus on how the potential impacts of EES could be affected if the Scottish Government is no longer able to offer the originally planned amount of grants due to Brexit. Grants are a significant part of the total funding of EES and the fact that they are exclusively available to the lowest income households renders grants a key tool in achieving the social goals of EES, namely the alleviation of fuel poverty. The UK's withdrawal from the EU could lead to restricted access to EU funds and EIB loans[8], specifically for energy efficiency projects and/or more general policies that up until now were supported by the EU. One potential outcome then could be that the Scottish Government will have a smaller pool of funds available to offer as grants to the lowest income households.

However, in evidence submitted by the E3G climate change think tank to the House of Lords EU Financial Affairs sub-committee's enquiry 'Brexit: the European Investment Bank'[9], it is assumed that the negative impact on capital funding should be temporary. Post-Brexit, the UK could reach an equivalent level of funding for energy-related projects (including energy efficiency improvement) 10 years after the withdrawal from the EU[10]. In the interest of simplicity we assume that the UK will leave the EU in 2020, the same year that the main body of EES begins. In this case there will be funding restrictions until 2030 (year 10), before the UK manages to raise the equivalent level of lost EU funds and therefore the Scottish Government is once again able to offer the originally planned annual amount of grants for EES projects.

Based on the information we presented so far, we developed a number of scenarios, which we have organised in two sets based on the size of the restrictions that we anticipate on the availability of funds for grants. The first set focusses on the scenarios where there is a partial restriction in the funding available for grants, while the second set explores scenarios where there is no funding available for grants. In each set, we explore what the impacts would be if the Scottish Government opts or not to restore the funding levels to the ones originally planned and how the method used to restore the funding level could influence the anticipated outcomes.

[8] Although these funds are not directly allocated to the Scottish Government (SG), it is likely that SG may have to provide support to projects that rely on EIB loans

[9] See the 25th Report of Session 2017-19, HL Paper 269 available here: https://publications.parliament.uk/pa/ld201719/ldselect/ldeucom/269/269.pdf

[10] Please note that the evidence focus on lending levels matching those provided by EIB. However, in the absence of any other useful information we generalise this assumption to cover the entire funds, not only the ones provided by EIB loans.

4.1 Scenarios Set 1: Restricted provision of government grants

Based on the previous analysis we assume that there will be a reduction of £8million per year in the amount of funds available for government grants, i.e. approximately 10% of the annual amount, which will last until year 10 of our simulations and then recover to the original levels. We have then developed the following scenarios:

A. **The government decides not to raise funds in any other way so there are fewer government grants offered until year 10**. This means that for the first 10 years of EES the amount available for government grants is reduced to £70million per year.

B. **The government decides to match the original level of funding available to low income households by offering more via government-backed loans.** In this case, until year 10, the amount available for grants is £70million per year but the amount available through loans increases by £8million per year. There are implications then due to the increased repayment requirements.

C. **The government foresees the upcoming reduction in European funds and decides to raise half of the necessary funds by other means**. Here we consider that this may be through budget neutral options (i.e. making use of whatever external funds are available), with the other half through income tax. Starting from the point of year 11 (2031) after Brexit and until the end of EES' 'enabling' stage the government still raises funds for grants through the income tax. The total amount available for grants remains at the original levels, £78million per year, across the entire duration of the programme, but this time the outcomes are affected by the fluctuations of income tax. A key point to highlight here is that income tax does not remain permanently high. Instead, we assume an endogenous income tax adjustment, which means that as soon as there are budget savings, as a result of EES, the government lowers the income tax to return the savings back to the households.

The scenarios of Set 1 are summarised and compared against the central case in Table 2.

Table 2: Summary table of Scenarios Set 1 assumptions against central case (No-Brexit)

	Central case (No-Brexit)	Scenario 1.A	Scenario 1.B	Scenario 1.C
Government grants available (Until Year 10)	£78m/year in government grants	£70m/year in government grants	£70m/year in government grants	£39m/year in government grants raised through income tax increase; £39m/year in government grants raised from external funding
Government grants available (Year 11 until Year 20)	£78m/year in government grants	£78m/year in government grants	£78m/year in government grants	£78m/year in government grants raised through income tax increase
ECO contributions available (Year 1 until Year 20)	£13.99/year in ECO contributions	£13.99/year in ECO contributions	£13.99/year in ECO contributions	£13.99/year in ECO contributions
Interest-free loans available (Until Year 10)	£18.22/year in interest-free loans	£18.22/year in interest-free loans	£26.22/year in interest-free loans	£18.22/year in interest-free loans
Interest-free loans available (Year 11 until Year 20)			£18.22/year in interest-free loans	
Assumption on income tax	Exogenous	Exogenous	Exogenous	Endogenous

Given that in Scenarios Set 1 our focus is on the government grants provided to the lowest income households, it is reasonable to also focus on the social side of EES and how it is affected by Brexit. In our model, the lowest income households are represented by the lowest income quintile. Some key characteristics of these households are that they are usually in fuel poverty[11], hence the main target of the social aspect of EES, but also they often extract little income from the economy, i.e. from additional employment opportunities, capital gains etc. The latter implies that as the economy grows those households benefit less compared to other household groups and similarly when the economy contracts the suffer less.

Based on those observations we believe that the key performance indicators (KPIs) regarding the effectiveness of the social side of EES are (a) the disposable income of the lowest income households and (b) their residential energy use, i.e. the energy required to run their dwellings. These are two key factors impacting fuel poverty so delivering beneficial changes to those variables can be associated with alleviation of fuel poverty. Therefore, we focus our attention on these, but identify the GDP and employment impacts at the start of each set to provide a wider economy context, particularly where employment impacts may impact real income levels.

In this first Scenarios Set 1, our analysis shows that if the EES funding is reduced compared to the central case, as is the case in scenario 1.A, the cumulative GDP gains are eroded. Indeed, instead of £5.6billion cumulative GDP gains by 2040 (i.e. by the end of EES), in 1.A we observe cumulative GDP gains of around £5.5billion, i.e. an erosion of approximately £100million. Furthermore, because the economy expands by less, compared to the central case, we observe 60 less full-time equivalent (FTE) new jobs by 2040.

In 1.B, the fact that EES funding level is kept at the originally planned level helps maintain more of the cumulative GDP gains. However, due to the increased loan repayments there is still an erosion of the 2040 cumulative GDP gains of approximately £50million. On the other hand, because the lowest income quintile becomes as energy efficient as it would be in the central case, the number of extra full-time jobs by 2040 is almost identical in the central case and scenario 1.B.

Where we observe the most notably different results is scenario 1.C, where we assume an endogenous tax (i.e. the income tax rate is adjusted to ensure a balanced budget). Here, while initially bridging the funding gap through increased income tax, the government ultimately returns to the households any budget savings it achieves, through reductions of the income tax rate. By the end of EES in 2040, the budget savings due to the increased efficiency and retrofitting activity are sufficient to completely offset any negative effects in the early stages of EES, when income tax had to be increase to raise the funds for grants. As a result the 2040 cumulative GDP gains are around £6billion, over £400million above the central 'No-Brexit' case.

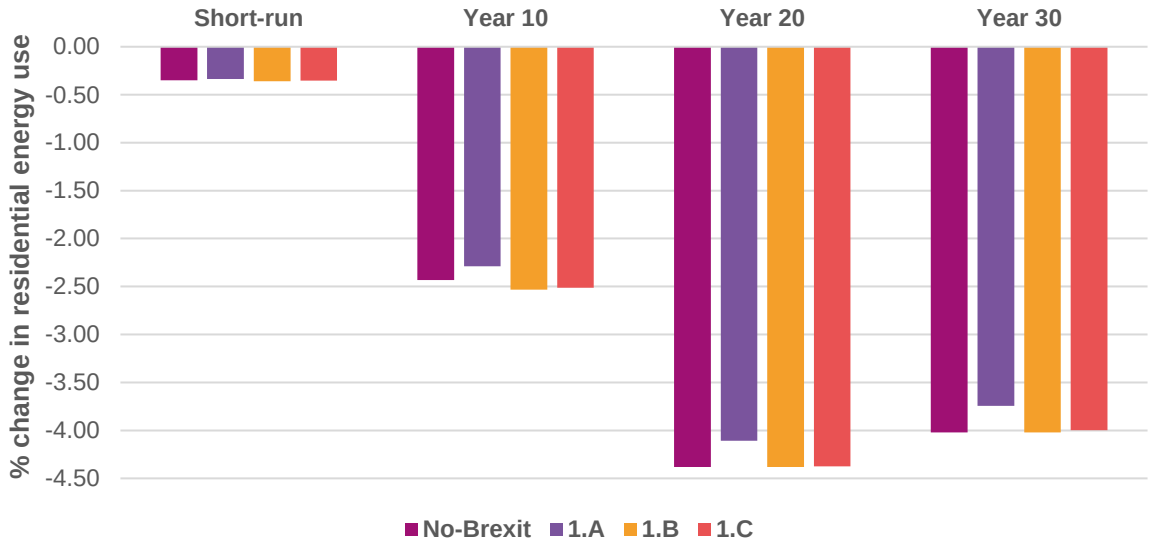
[11] According to the 2017 Scottish House Condition Survey (SHCS), 88% of the households with weekly income, before housing costs, under £200 and 51% of the households with weekly income between £200 and £300 are in fuel poverty. Our lowest income quintile consists of households from these two income groups. The key findings of the 2017 SHCS can be found here: https://www.gov.scot/publications/scottish-house-condition-survey-2017-key-findings/

Furthermore, in the same year there are over 400 more full-time jobs are created relative to the central case scenario.

Differences in residential energy use

Our central focus is how the changes in residential energy use and disposable income are affected by the Scenarios in Set 1 and how they compare to the central 'No-Brexit' case. Impacts on energy use in the lowest household income quintile in different years and across the four scenarios are presented in Figure 1.

Figure 1: Potential EES-driven changes in residential energy use of the lowest income households for different scenarios regarding availability of government grants (Scenarios Set 1)



Given that the aim of EES is to improve the energy efficiency of households, it is encouraging that the residential energy use of the lowest income households drops in every scenario of Set 1 and in the central case. However, there are some small differences that can be observed. The outcomes of the 'realising' stage of EES depend primarily on the level of efficiency improvement achieved, which in turn is affected by the funding availability for efficiency improvement projects. As a result, in scenarios 1.B and 1.C the overall funding level is kept fixed, the lowest income quintile becomes 13.2% more energy efficiency, which is the same energy efficiency gains observed in the central case. On the other hand in scenario 1.A, the reduced funding availability means that the lowest income quintile becomes 12.24% more energy efficient.

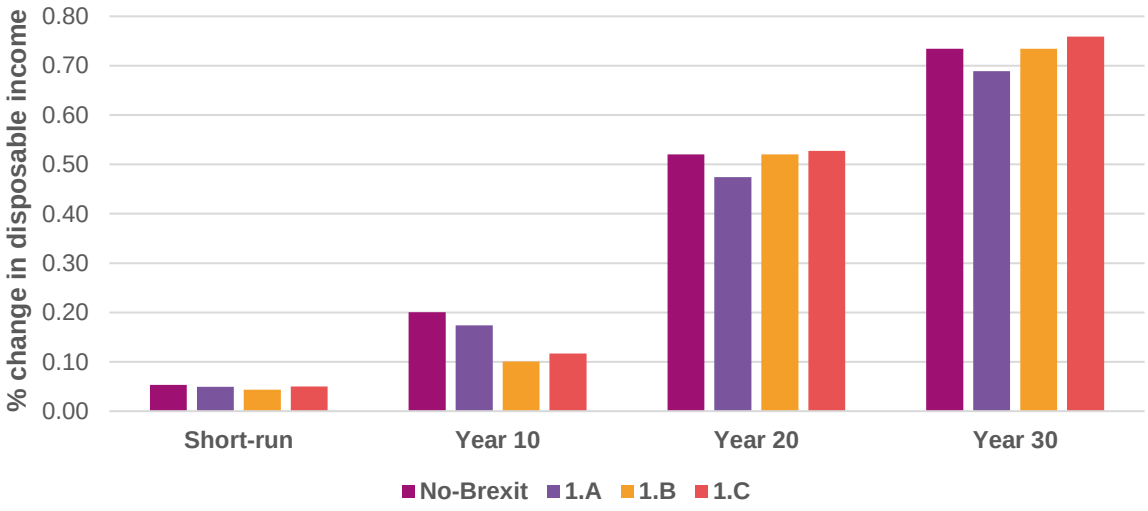
The differences in energy efficiency gains under the different scenarios are the initial and core drivers underpinning the outcome of different residential energy use savings. Because the efficiency gains are identical in the central case and scenarios 1.B and 1.C, we see that by the end of EES in 2040 the lowest income households achieve the same residential energy savings of around 4.38%. Furthermore, as shown in Figure 1, because in scenario 1.A the lowest income quintile becomes less energy

efficient, its residential energy savings in 2040 are eroded to 4.11%. It is useful to highlight that the relationship between the efficiency gains and the residential energy savings is not linear. In scenario 1.A a 7% drop in efficiency gains leads to a 6% erosion of the residential energy savings. The 2040 residential energy savings though are the largest achieved by EES. As can be seen in Figure 1, following the end of the 'enabling' stage of EES, the residential energy savings are eroded in every scenario and the central case, indicating the presence of a 'rebound effect' driven by income effects associated with the 'realising' stage of EES.

Differences in disposable income

So what disposable income impacts are associated with these patterns of variation in efficiency gains and energy savings? Figure 2 compares the different scenarios of Scenarios Set 1 to the central 'No-Brexit' case.

Figure 2: Potential EES-driven changes in the disposable income of the lowest income households for different scenarios regarding availability of government grants (Scenarios Set 1)



An immediate observation from Figure 2 is that under every scenario in Set 1, the lowest income households are better-off in terms of disposable income compared to their pre-EES status, as is the case with the central case. Indeed, even in what turned out to be the worst case scenario (1.A) the lowest income households observe a 0.47% increase in their disposable income in year 20, which continues to grow even 10 years after the end of EES. That the income gain is smallest under scenario 1.A, is driven by the smaller energy efficiency gains achieved. As households are becoming more energy efficient they need to spend a smaller portion of their income on energy to run their dwellings. With smaller energy bills, these households can now acquire more goods and services with the same income, i.e. they have a higher purchasing power. Simultaneously, there are some income increases associated with the increased

employment opportunities created by EES. But this is a limited source of income gain for the lowest income households due to the fact they tend to mainly rely on transfers from the government rather than labour income.

From a social policy perspective, the increased disposable income is a desirable outcome, which, combined with the results presented in Figure 1, indicates that fuel poverty is alleviated, at least under the DEFRA definition of energy efficiency, even where Brexit impacts the funding for EES. However, in considering Figure 2 we can see that the disposable income impacts vary across scenarios. For example, under Scenario 1.A by year 30 the disposable income of the lowest income households increases by less compared to the central case (0.69% against 0.73% in central case). This is due to the fact that reduced funding leads to reduced realised energy efficiency and as a result fewer income benefits for the households. The fact that the funding gap is not covered in 1.A explains why the gap in potential income gains between the central case and 1.A never recovers.

On the other hand, Scenarios 1.B and 1.C introduce some rather interesting outcomes under different timeframes. For the first 10 years of the 'enabling' stage the income gains for the lowest income households are even lower than those in Scenario 1.A where the funding is not covered. The driver behind this result is the higher payment requirements that have to be made by households. In 1.B they face larger annual loan repayments, which precede the fulfilment of any other need, while in 1.C households have to pay higher income taxes[12] to raise part of the funds required for government grants. The difference between 1.B and 1.C in year 10 reflects the fact that using the tax system to raise funds has least impact on the incomes of the lowest income households.

Generally, bridging the funding gap is particularly important for achieving the long-term policy goals of EES. When funding is kept at the originally planned levels, we can see that by the end of the 'enabling' stage (year 20) and thereafter, the household incomes match the central case results. This indicates that achieving the originally anticipated efficiency level, which is linked to the total amount available for EES projects, is sufficient to completely offset any losses in potential income gains observed in the first half of EES. In fact, if the gap is bridged using an endogenous tax process then by the end of the 'enabling' stage there are sufficient budget savings to allow a reduction of the income tax compared to the pre-EES level. The households then achieve not only savings in terms of their residential energy spending, but are also paying less income tax. This is the reason why 1.C delivers better long-term disposable income results compared to every other scenario in set 1 and the central 'No-Brexit' case. The energy savings though are eroded compared to the central case and by 2050, 1.C delivers a 4% reduction of residential energy use instead of the 4.02% reduction achieved in the central case.

It is important to set different gains in context. For example, because of the greater disposable income gain in 1.C we see smaller savings in residential, and total, energy use. That is, there is more rebound, but is rebound a 'bad' thing for low income households? Figure 1 shows that long-term residential energy use falls by less in

[12] In our model, all the households have to pay income tax. As a result, all the households are affected when the tax is increased or decreased. However, the income tax is progressive meaning that the lowest income households need to pay less income tax whereas the more affluent one have to pay more.

scenario 1.C compared to the central case, despite the fact in both cases the same number of households has received an energy efficiency improvement. This outcome is driven by the greater disposable income gains that scenario 1.C delivers. Due to the increased disposable income available, the households of the lowest income quintile can meet their energy needs in a better way, meaning they can use more energy to run their properties. This shows the rebound enables the necessary 'comfort taking' for the low income households.

The positive impacts of scenario 1.C are not only observed in the case of the lowest income households. The long-term reduction in income tax benefits all the households, just as all the households are contributing through their taxation to raise the funds for EES grants. The outcome of the long-term reduction in the income tax is income being freed-up for all the households to spend on goods and services. Hence, the larger cumulative GDP boost by 2040 in scenario 1.C compared to the central case, and the associated difference in full-time jobs. In fact, the gap between scenario 1.C and the central case grows in the years following the end of EES. The cumulative GDP gains in scenario 1.C grow to £8.5billion by 2050, compared to £7.5billion in the central case, while there are over 1,250 more full-time jobs. However, this GDP expansion comes at the expense of additional economy-wide energy needs, meaning that the total energy savings of 1.07% in the central case are eroded to 1% in scenario 1.C.

4.2 Scenarios Set 2: Exploring major impacts on the government grants availability

Scenarios Set 1 assumes that in the 2020-2030 period Scotland will have some access to European funds. However, the final nature of Brexit is yet to be determined and as a result this key assumption of Scenarios Set 1 might vary significantly, especially in the event of a 'no deal' Brexit. In an extreme case, Scotland could lose access to EIB funds and/or other European funds. This would put the entire funding availability for government grants at risk, at least until 2030 (year 10 of EES) when we assume that UK funding would be matched through alternative sources. This risk, and some of the options that could be used to deal with it, is the focus of our following scenarios:

A. **The government does not offer any grants**. In this case the entire amount of £78m per year that was proposed to be offered as grants is lost.

B. **The government opts to maintain the EES funding levels through the use of interest-free loans**. This means that there are no grants offered and instead the amount available as government-backed interest-free loans is increased by £78 million per year. This way the amount of EES funding remains in line with what was initially proposed but there are significantly larger instalments to be paid by households during the first 10-years of the project.

C. **The government raises funds for grants through income tax until year 10**. This is a similar scenario to 1.C described above, but requires that the government uses taxation exclusively to raise funds for grants for the first 10 years of the programme. After that point the grants are provided through the use of alternative funding sources. Similarly to 1.C the increase of income tax is not permanent and once there are budget savings the government reverses the income tax increase, returning the savings back to the households.

The scenarios of Set 2 are summarised in comparison with the central 'No-Brexit' case in Table 3.

The results of Scenarios Set 1 show that a relatively small reduction in the annual availability of government grants is sufficient to limit but not completely offset the gains that can be expected by EES. But, if there are no grants available, at least temporarily, the effect on the KPIs could be sufficiently large to jeopardise the entire social side of EES. Furthermore, if the Scottish Government opts to bridge the funding gap then it is key to decide the optimal way to do it as Scenarios Set 1 indicates that the approach used affects the anticipated outcomes. Figure 3 presents the differences in residential energy use changes under each of the scenarios in Set 2 and the central case.

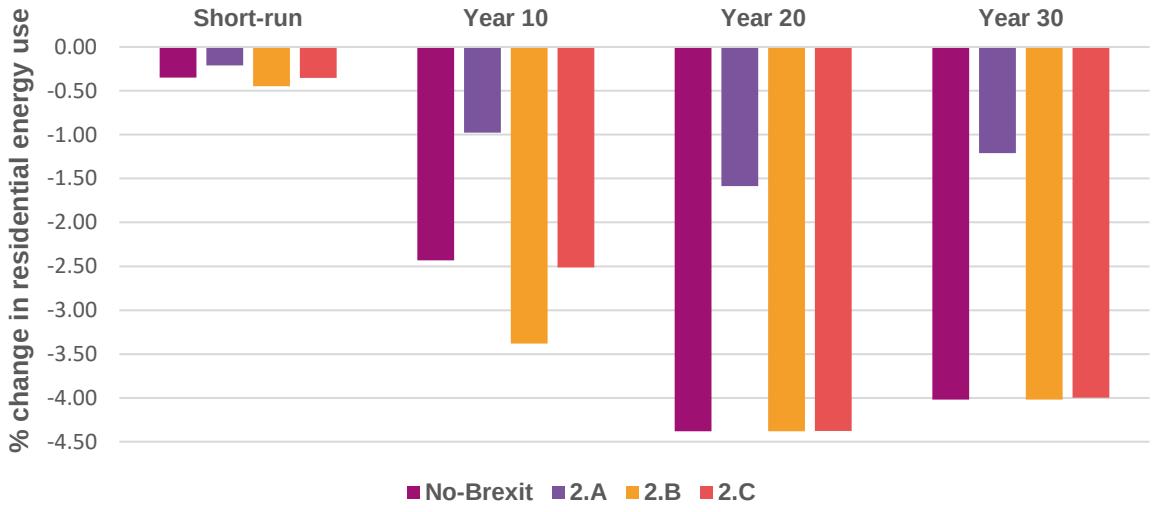
An important observation from Scenarios Set 1 is that when the funding gap is not bridged, the largest erosion in cumulative GDP gains is observed. This outcome is magnified in scenario 2.A where the absence of grants for 10 years leads to approximately £800million less cumulative GDP gains by 2040, or £4.8billion in 2.A against £5.6billion in the central case. Furthermore, 635 fewer full-time jobs are created, and the reduced funding for energy efficiency projects enables the lowest income quintile to become only 3.86% more energy efficient instead of 13.2% in the central case.

As we showed with scenario 1.B, bridging the funding gap helps mitigate the losses in cumulative GDP gains and jobs creation. As a result, in scenario 2.B we see that the erosion of cumulative GDP gains by 2040 is in the region of £500million, or £5.1billion in 2.B instead of £5.6billion in the central case. The loss in potential new jobs is dramatically reduced, with only 23 less full-time jobs created. Moreover, bridging the funding gap means that the lowest income quintile becomes 13.2% more energy efficient, which is the same as the central case and also scenario 2.C. However, this is the only similarity in the outcomes of scenarios 2.B and 2.C. The use of endogenous tax in 2.C leads to cumulative GDP gains of around £6.6billion by 2040, approximately £1billion more than the central case, and almost 1,300 more new full-time jobs.

Table 3: Summary table of Scenarios Set 2 (Extreme scenarios) assumptions against central case (No-Brexit)

<table>
<tr><th></th><th>Central case (No-Brexit)</th><th>Scenario 2.A</th><th>Scenario 2.B</th><th>Scenario 2.C</th></tr>
<tr><td>Government grants available (Until Year 10)</td><td>£78m/year in government grants</td><td>No government grants</td><td>No government grants</td><td rowspan="2">£78m/year in government grants raised through income tax increase</td></tr>
<tr><td>Government grants available (Year 11 until Year 20)</td><td>£78m/year in government grants</td><td>£78m/year in government grants</td><td>£78m/year in government grants</td></tr>
<tr><td>ECO contributions available (Year 1 until Year 20)</td><td>£13.99/year in ECO contributions</td><td>£13.99/year in ECO contributions</td><td>£13.99/year in ECO contributions</td><td>£13.99/year in ECO contributions</td></tr>
<tr><td>Interest-free loans available (Until Year 10)</td><td rowspan="2">£18.22/year in interest-free loans</td><td rowspan="2">£18.22/year in interest-free loans</td><td>£96.22/year in interest-free loans</td><td rowspan="2">£18.22/year in interest-free loans</td></tr>
<tr><td>Interest-free loans available (Year 11 until Year 20)</td><td>£18.22/year in interest-free loans</td></tr>
<tr><td>Assumption on income tax</td><td>Exogenous</td><td>Exogenous</td><td>Exogenous</td><td>Endogenous</td></tr>
</table>

Figure 3: Potential EES-driven changes in residential energy use of the lowest income households for different extreme scenarios regarding availability of government grants (Scenarios Set 2)



The results in Figure 3 share some similarities to the ones presented in Figure 1 for Scenarios Set 1. In both cases, matching the originally proposed funding level leads to similar long-term residential energy use savings to the central case. There are more significant differences between the central case and 2.A than between the central case and 1.A. This is because under 2.A there are no government grants available for a 10-year period (until 2030), significantly reducing the number of retrofitted households and therefore the final efficiency improvement of the entire quintile of the lowest income households.

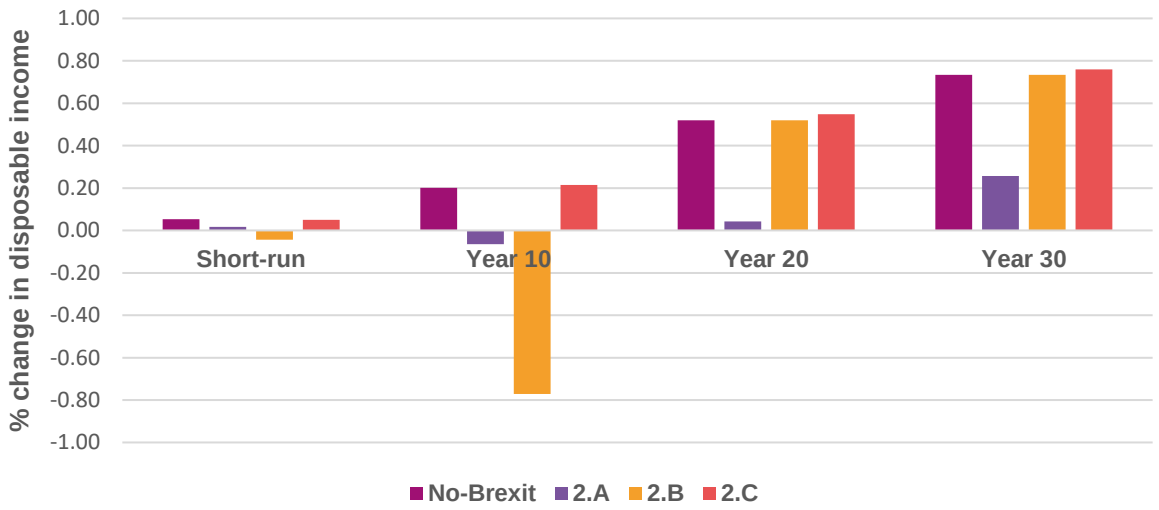
A rather interesting finding is the considerable difference in residential energy use savings between the central case and scenario 2.B in year 10. Bridging the funding gap through the use of more government-backed interest-free loans means that the lowest income quintile is becoming more energy efficient at the same pace both in the central case and in 2.B. Yet, in year 10 there are significantly larger residential energy savings in scenario 2.B compared to the central case. The trigger for this outcome is the disposable income impacts associated with the use of interest-free loans as the way to bridge the funding gap in 2.B. The disposable income impacts for Set 2 are presented in Figure 4 below.

Indeed, in year 10 (2030) under scenario 2.B, we observe a significant drop of 0.77% in the disposable income of the lowest income households. The fact that the funding gap is assumed to be entirely covered via the provision through government-backed interest-free loans means that households have to pay higher annual loan repayments. As the repayments, like other commitments such as income tax, are assumed to precede any other consumption expenditures, the amount available for households to spend on their wider basket of spending is negatively affected. This affects spending on both energy and non-energy goods and services and is the reason we observe greater residential energy use savings at the same time. The reduced disposable income forces households

to reduce their overall consumption, including reduced spending on residential energy by 3.38%. Moreover, the erosion of new full-time jobs that we observe in scenario 2.B further suppresses the lowest income quintile's disposable income but the effect of reduced employment is smaller than the effect of greater loan repayments.

Ultimately, however, the benefits from realising energy efficiency improvements completely offset any earlier negative impacts in all the scenarios in Set 2. By the end of the 'enabling' stage in 2040 (year 20) we see that the disposable income of the lowest income quintile is larger compared to the pre-EES level under every scenario. But the eventual net gain is small under scenario 2.A. If the initial funding gap is not bridged then the lowest income households achieve only a 0.04% increase in their disposable income by the end of EES instead of the 0.52% that is possible in the central case, or even scenario 2.B (also a 0.52% increase in disposable income). Despite the disposable income gains in the years to follow, there is always a lag between the gains under 2.A and the central case, similarly to that observed for residential energy use savings. It is thus fair to question whether, in the event that any funding gap is not bridged, the social goal of EES to alleviate fuel poverty would be achieved, and if so to what extent.

Figure 4: Potential EES-driven changes in the disposable income of the lowest income households for different extreme scenarios regarding availability of government grants (Scenarios Set 2)



Interestingly, when income tax is used to cover the funding gap no negative impacts are observed at any point. Using income tax essentially socialises the cost of energy efficiency improvements for the lowest income households, placing a smaller burden on those households and a higher one on the more affluent ones. In fact, the disposable income changes observed under scenario 2.C are comparable to the ones initially observed in the central 'No-Brexit' case. Moreover, by employing an endogenous income tax process it is possible to achieve better income outcomes for the lowest income households (as in scenario 1.C), albeit at the expense of reduced residential and total economy-wide energy use savings.

5. The potential impacts from reduced availability of private loans (Scenarios Set 3)

The breakdown of the EES funding sources in Table 1 demonstrates that private loans play a key role in implementing EES and achieving the goals set by the Scottish Government. It may be expected that, due to the large amount of funds involved compared to the other funding instruments, any impact on the availability and/or the costs of private loans will have a significant effect on the magnitude of impacts we could anticipate from EES to the Scottish economy. As with government-backed loans, for simplicity, we have assumed that private loans are also interest-free. Thus, in this set of scenarios we only focus on changes in their availability rather than the cost in terms of changing interest. We examine the following two scenarios based on the reduction in capital availability reported in the Chatham House report:

A. **There is a permanent 10% reduction in the amount available for private interest-free loans**. This means that a reduced number of households from groups 2-5 can borrow money to retrofit their properties and as a result there is suppressed construction activity and reduced energy efficiency gains.

B. **The 10% reduction in private loans availability is temporary and lasts 5 year following Brexit (until 2025)**. Following that it recovers at a pace of 1% per year until it reaches the originally planned levels by year 15 (2035).

We summarise Scenarios Set 3 in Table 4 and compare them against the central case assumptions. Note that in this Scenarios Set we only focus on the funding available to income quintiles 2-5. The funding available to the lowest income quintile (which only source loans from the government) is assumed to be unaffected. Therefore, the funding breakdown for the lowest income quintile which is presented in Table 1 applies here as well.

Despite the fact that privately issued loans directly contribute only on the climate/energy goals of EES, still maintaining access to the originally planned amounts is key for the overall success of EES. Private loans are planned to contribute almost 61% of the total funding available for EES projects. Losing then a significant part of these funds will severely undermine the ability of EES to deliver its goals. The main issue/difference though between private loans and the funding mechanisms available to the lowest income households is that the Scottish Government has no direct control on the capital availability to support energy efficiency projects. As such, there is no direct way in which the Scottish Government can secure the continuous provision of privately-issued loans at the quantity and cost that has been originally planned. The only intervention that can be made from the government side is to try and maintain confidence among investors that funding energy efficiency projects in Scotland is a viable, profitable and secure investment.

Table 4: Summary table of Scenarios Set 3 assumptions against central case (No-Brexit)

	Central case (No-Brexit)	Scenario 3.A	Scenario 3.B
ECO contributions available (Year 1 until Year 20)	£46.01/year in ECO contributions	£46.01/year in ECO contributions	£46.01/year in ECO contributions
Interest-free loans available (Until Year 5)	£243.78/year in interest-free loans	£219.4/year in interest-free loans	£219.4/year in interest-free loans
Interest-free loans available (Year 6 until Year 15)			Gradual 1% recovery of amount available for private interest-free loans until the originally planned amount reached
Interest-free loans available (Year 15 until Year 20)			£243.78/year in interest-free loans

Impact of reduced private loans

In our central case analysis we find that, in the absence of any Brexit effects, EES can deliver cumulative GDP gains of £5.6billion by 2040, which increase to £7.5billion by 2050, i.e. 10 years after the end of the 'enabling' stage. When the availability of private loans is restricted, the 2040 cumulative GDP gains are eroded to £5.3billion in scenario 3.A and £5.5billion in 3.B. The erosion gains pace by 2050, when, instead of the £7.5billion cumulative GDP gains, scenario 3.A shows gains of £7.1billion and scenario 3.B £7.3billion.

Alongside the erosion of cumulative GDP gains, there is an erosion of full-time job creation. By 2040, there are 300 less full-time jobs created in 3.A and 200 less in 3.B, compared to the 6,300 created in the central case. In both cases, the percentage erosion in cumulative GDP gains is almost identical to the percentage erosion in additional employment. This finding indicates that there is an erosion on the number of new jobs across all sectors, with the average 'quality' not impacted. Similarly to the cumulative GDP, as we move beyond the end of the 'enabling' stage and into the 'realising' stage, when the impacts are dominated by the energy efficiency gains achieved, the gap in employment between the central case and 3.A and 3.B widens. However, the difference is in the tens rather than hundreds of new full-time jobs.

Table 5: Summary of changes in key EES macroeconomic variables due to Scenario Set 3

	Short-run (2020)			Year 20 (2040)			Year 30 (2050)		
	No-Brexit	**3.A**	**3.B**	**No-Brexit**	**3.A**	**3.B**	**No-Brexit**	**3.A**	**3.B**
GDP (in % change)	0.10	0.09	0.09	0.23	0.22	0.22	0.20	0.18	0.19
Cumulative GDP (in £m)	**115**	**108**	**108**	**5,604**	**5,338**	**5,511**	**7,497**	**7,135**	**7,337**
Employment (in % change)	0.17	0.16	0.16	0.29	0.27	0.28	0.23	0.21	0.22
Number of FTE jobs	**3,718**	**3,504**	**3,507**	**6,302**	**6,004**	**6,176**	**4,987**	**4,673**	**4,838**
Total energy use (in % change)	**-0.03**	**-0.03**	**-0.03**	**-1.19**	**-1.11**	**-1.16**	**-1.07**	**-1.00**	**-1.03**
Disposable income (excluding savings, in % change)	0.10	0.09	0.09	0.15	0.15	0.15	0.12	0.11	0.11
Lowest income quintile real income (in % change)	0.05	0.05	0.05	0.52	0.52	0.52	0.73	0.73	0.73
Residential energy consumption (in % change)	-0.25	-0.25	-0.25	-3.39	-3.17	-3.30	-2.93	-2.74	-2.84
Residential energy consumption of lowest income quintile (in % change)	-0.35	-0.35	-0.35	-4.38	-4.38	-4.38	-4.02	-4.02	-4.02

Especially after 2040, the observed gaps in cumulative GDP gains and full-time employment are associated with the differences in energy efficiency gains achieved. In the central case, each of the income quintiles 2 to 5 becomes 8.67% more energy efficient by 2040. In 3.A, where the reduction in private loan availability is permanent, the energy efficiency gains of each household are eroded to 7.95%, while if the reduction in loan availability is temporary, like in 3.B, then the efficiency gains are eroded to 8.33%. Apart from the GDP and employment impacts that this erosion of efficiency gains has, it also affects the energy savings across the Scottish economy. Indeed, while in the central case we see total energy savings of 1.07% by 2050, in 3.A they are eroded to 1% and in 3.B to 1.03%. This shows that a permanent 10% reduction in private loans could lead to 6% less total energy savings, while a temporary reduction to 3% less total energy savings, highlighting the importance of maintaining the loan availability as closely as possible to the original levels if EES is to achieve its climate/energy goals.

6. Final remarks and future research focus

In this working paper we have presented some key insights from our work focusing on how the potential outcomes of the EES programme could be affected by Brexit. Specifically, we have focused on potential ways in which Brexit could affect some of the main funding mechanisms available for households to retrofit their properties: government grants and privately-provided interest-free loans. In light of continued Brexit uncertainties, we have used existing published material as a guide to develop a number of scenarios to analyse how funding limitations, and the options to overcome those limitations, could lead to different potential EES outcomes. We then compared the results of the different scenarios against our central 'No-Brexit' case.

Our findings show that changes in the socio-economic landscape after Brexit can be expected to generate different outcomes compared to the central case. The differences may be observed in the long-term results reflecting a sustained outcome or could be temporary. It is important to use a case by case approach in order to identify the nature, permanent or temporary, of certain differences as well as their magnitude. However, there are some key lessons to be learned from the work we have conducted.

- **It is important to keep the overall funding as close as possible to the originally proposed levels.** EES, like all energy efficiency improvement programmes, consists of two intertwined conceptual stages, the long lasting effects are delivered via the 'realising' stage. The magnitude of the benefits delivered by the 'realising' stage greatly depends on the number of households that manage to realise an energy efficiency improvement and this depends on the funding available. If the overall amount is kept close to the originally-planned levels, the long-term effects will also be close to what was originally estimated, despite any temporary adverse effects that may be observed.

- **The option(s) used to maintain the level of funding are crucial.** As was demonstrated by our simulations, interest-free loans are a useful tool to support EES projects but they should be used with caution. Relying exclusively on interest-free loans to cover the lack of government grants could negatively affect the disposable income of the lowest income households. These negative income effects could last up to 15 years before the gains from the efficiency improvements are sufficiently high to offset the negative effects. On the other hand, using an endogenous income tax approach to raise the necessary funds for government grants spreads the cost across all households, minimising the impact on the lowest income households. Following this approach the efficiency gains are sufficient from the outset of EES to cover any negative income effects from the increased taxation.

- **Private loans are crucial for the overall success of EES**. The Scottish Government has indicated that there is a key role to be played by private institutions to facilitate energy efficiency improvements in the more affluent households. However, both the availability and the cost of those loans will need to remain close to the originally-estimated levels. If either the availability reduces or the cost increases, less households will opt to get a loan and therefore we will observe smaller gains from EES compared to what would be possible otherwise. However, more expensive loans will also place larger

restrictions on the disposable income of the households that do get a loan, further eroding the benefits from EES. It is key, then, that the government uses any tools in its disposal to try and ensure that this will be the case.

However, the scenarios explored here are not the only ways in which EES might be affected by Brexit. A couple of other factors in which Brexit could affect the outcomes of EES would include the following:

- **Increased prices for imported intermediate goods.** A large number of Scottish sectors rely on imports to enable their production (as intermediate inputs). Any increased cost(s) associated with importing intermediate goods (e.g. insulating material, more efficient heating equipment, more efficient light bulbs) would affect the EES outcomes in multiple ways. First, where the supply chains for energy efficiency delivery face higher costs, this could increase the cost of energy efficiency improvements faced by households, meaning that fewer households would receive efficiency improvements with the existing funds (a key factor affecting the benefits from the 'realising' stage of EES). Second, increased cost of imported intermediate goods would more generally increase the production cost, and therefore the price, of Scottish goods and services. This would not only limit the demand-driven expansion of the UK economy but would also harm the competitiveness of Scottish exports.

- **Limitations in the availability of skilled labour.** In this working paper we have assumed that the sectors involved in the delivery of EES (in the 'enabling' stage) can handle the task. However, due to Brexit it will be increasingly difficult and costly to source skilled labour from the EU. Therefore, it may not be possible to deliver the desired volume of retrofitting projects within the 20-year period of EES, due to lack on the necessary labour force. Or delivery may come at an increased cost leading to the issues described above.

A potential focus for future work could be how each of the other two factors described here could further affect the potential outcomes of EES. Another is that the analysis would benefit from the introduction of bottom-up data to better inform the economy-wide model of households' energy consumption and provide additional details on how each fuel is used to provide different services. This is a recommendation from the International Energy Agency in their 'Capturing the Multiple Benefits of Energy Efficiency' (IEA, 2014) publication on how economy-wide analysis could be improved and one that we are seeking to address in future research projects.

Data Statement

This study uses data that are publically available from the University of Strathclyde at the following website: https://doi.org/10.15129/38c90098-3e67-4c93-9b74-a77d6fdc54d9. No new data were created during this study.

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Appendix A: The model and data used

A.1 The CGE model

Our model is based on the AMOS ENVI CGE model used by Figus et al. (2018) to explore the usefulness of energy efficiency as a regional policy tool. Because the model focuses on a regional economy, we assume a flexible labour supply which is positively related to the differences between the log of the regional and the national real wages, while being negatively related to the difference between the log of the regional and national unemployment rate. However, rather than using a wage curve to determine the real wage, we assume that the nominal wage is fixed. As described by Figus et al. (2018) we represent production using a nested constant elasticity of substitution structure (CES), where labour and capital are nested together while energy and non-energy intermediates are nested together. Domestically-produced and imported goods and services are assumed to be imperfect substitutes using an Armington assumption (Armington, 1969).

A key difference is that instead of a single representative household, in our model we have five household income quintiles. This allows us to simulate scenarios where different income groups have access to different funding mechanisms, which is the case with EES. For each of the household groups we model their behaviour to maximise their discounted intertemporal activity subject to a wealth constraint. Solving this optimisation path then gives us the optimal consumption path for each household group, consisting of energy and non-energy goods, domestic and imported, which are also considered imperfect substitutes (Armington, 1969).

Modelling ECO

A key point of focus is how the different funding mechanisms are modelled in our CGE model. Starting off with ECO there are two main elements that need to be considered. The first involves the funds provided by energy companies to energy efficiency improvement projects and the other is associated with the way in which energy companies recover the funds. For the allocation of funding we assume that the Scottish 'Construction' sector will be the one delivering the retrofitting. Therefore, we model the ECO funds as an increase in the final demand for the outputs of Scottish 'Construction' sector. The cost of ECO on the other hand is passed on to the entire residential consumer base of energy companies, not just those receiving the efficiency improvement. To reflect then the necessary increase in energy bills to cover the cost of ECO, we have re-specified the energy price paid by households as follows:

$$P_{ene} = P_{enemc} \times (1 + \theta) \quad [1]$$

P_{enemc} is the price of energy in a perfectly competitive market, while θ is a mark-up and P_{ene} the price of energy paid by households. The difference between the price paid by households and the competitive market price is the marginal profit of the energy companies.

$$mp = P_{ene} - P_{enemc} \quad [2]$$

If the marginal profit is then multiplied to the total revenue of the energy companies, the product needs to be equal to ECO.

$$\overline{ECO} = mp(P_{ene} \cdot Q_{ene}) \quad [3]$$

With ECO being exogenously determined and having functions for all the other endogenous variables, we can solve equations [1] to [3] for the mark-up required so that energy companies recover the cost of ECO through their residential customers.

Modelling household interest-free loans

Another funding mechanism to be used for EES is the provision of loans, either interest-free or low-interest ones, backed either by the government or issued by private institutions. For ease of modelling, in our work we assume that the loans across the board, regardless of the provider, will be interest free. The key differentiating point is the amount available for each household group and therefore the repayment cost for each group.

In terms of how the household loans are modelled, we follow a rather simple approach. The loans themselves are modelled as an increase of final demand for the output of the Scottish 'Construction' sector. As is the case with ECO, we assume that this increase of final demand is exogenous, fixed and lasts for the entire duration of EES. The repayments are assumed to last 10 years, starting from the year that retrofitting takes place. Therefore, a household that receives the retrofitting in year 5 will repay the loan by year 15 and as a result the repayment period exceeds the duration of EES itself. An important point to keep in mind is that loan repayments are assumed to be the top priority of households. This means that first they cover the cost of their instalments and then, with the remaining disposable income, cover the rest of their needs. The result coming from this assumption is that consumption is suppressed compared to what could have been in the absence of the loan repayments.

Modelling government grants

The final funding mechanism we consider is government grants. Grants are modelled as an increase of the government, as a type of final consumer, purchases from the Scottish 'Construction' sector that is delivering the retrofitting projects.

The increased government purchases though have an impact on the government budget balance. There are two ways in which we assume the necessary funds for grants are raised. The first is to allow for an increased budget deficit. In this case the government is allowed to spend more that its revenue, assuming that the funds are coming from a source exogenous to the Scottish economy, be it contributions from the UK Government,

EU funds or any other sources external to the Scottish Government. Moreover, when the funds for grants are raised through budget deficit we assume that the income tax is exogenous.

The alternative way to model government grants is through the use of taxation to raise the necessary funds. In this case we assume the income tax to be endogenous and the Scottish Government is obliged to have a balanced budget. Therefore, as the government's demand for the output of Scottish 'Construction' increases, the income tax rate increases as well to ensure that there is no budget deficit. A key point to highlight here is that once the retrofitting activity and the energy efficiency start delivering budget savings, the income tax rate is reduced returning the budget savings to the households.

A.2 The data

The baseline data that provide us with the structure of the economy come from the 2013 Scottish Social Accounting Matrix (SAM)[13] developed by the Fraser of Allander institute at the University of Strathclyde. The Scottish industrial sectors are aggregated into 29 groups, with the energy sectors – coal, crude oil and gas extraction, oil refinement, electricity generation and distribution and gas distribution – being more disaggregated. Furthermore, the SAM includes a series of economic agents; the government, five household groups, corporate sectors, while it accounts for imports and exports to the rest of UK and the rest of the world. The underlying assumption is that prior to the energy efficiency improvements, and the associated retrofitting activity, the Scottish economy is in a steady-state equilibrium, therefore our model is calibrated to reflect this assumption.

Regarding the EES-specific data, we assume that EES will be implemented by a mechanism similar to the one used for the nationally managed Warmer Homes Scotland (Warmhomes) scheme and therefore the funding breakdown follows similar patterns. There are three funding options we consider: government grants, ECO and loans (government-backed or private). The contributions in kind by the Scottish Gas Networks were not considered in our simulations. The total value of retrofitting projects, across all household groups, is assumed to be £400million per annum. For the government grants we assume an indicative amount of £78million per year, directed towards only the lowest income group HG1. From that amount we estimate the total value of projects for HG1 to be approximately £110million per annum, with the remaining £32million split between ECO contributions and government-backed loans which are assumed to be interest-free.

The remaining approximately £290million per annum is the value of retrofitting projects in the remaining household groups and is broken down into ECO contributions and private loans, which are again considered to be interest-free. The overwhelming majority

[13] The SAM used is publically available at this address: https://doi.org/10.15129/38c90098-3e67-4c93-9b74-a77d6fdc54d9

of the funding is provided through loans in line with the government's view of the important role that private institutions have to play in the implementation of EES and the somewhat limited value of the existing ECO contributions.

The total amount to be spent across the duration of EES is £10billion, with our work focusing on the £8billion delivered through grants, ECO and loans. We estimate that over 237,000 low income (HG1) households and over 718,000 households from the other groups would benefit initially. The average efficiency improvement per retrofitted property is 23.66% and is taken by data provided by the Energy Saving Trust. This efficiency improvement reflects the average energy cost savings achieved through Warmhomes, as estimated through the Energy Performance Certificate measurements taken from properties retrofitted via Warmhomes. The efficiency improvement figures are then scaled to reflect the efficiency improvement of the entire household group and through that we estimate that by the end of the programme HG1 will be 13.2% more energy efficient, while each of the other groups will be 8.67% more energy efficient, compared to the pre-EES circumstances.