RICARDO-AEA

A Comparative Review of Housing Energy Efficiency Interventions

Main Final Report

Report for ClimateXChange

IQ13-2014

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1 Context and aims of the project

This project encompasses a comparative study of energy efficiency interventions to inform the Scottish Government and its work on energy efficiency in the housing sector. In its recent Heat Policy Statement (HPS) describing its priorities for low carbon heat, the Scottish Government announced that it is designating energy efficiency as a National Infrastructure Priority. The cornerstone of this will be Scotland's Energy Efficiency Programme (SEEP) which will provide an offer of support to all buildings in Scotland – domestic and non-domestic – to improve their energy efficiency rating. Understanding how energy efficiency interventions have worked in other countries will help inform this. This will enable the Government to target its efforts most effectively and minimise any negative unintended consequences.

The review includes energy efficiency regulations, schemes, support programmes, incentives and fiscal levers in other European countries, top performing American states and selected countries with relevant experience. The focus of the study is on refurbishment and new-build Building Regulations were therefore excluded. This study was carried out between January and September 2015.

1.1 Methodology

We designed our methodology around two stages of research:

In **Stage 1**, we carried out a high level overview of energy efficiency initiatives in 20 countries/states. These were selected based on their performance on energy efficiency; and experiencing similar conditions and challenges to Scotland – for example GDP, climate, housing types and quality. These included:

- EU countries for which National Energy Efficiency Action Plans (NEEAPS) are available (9 including the United Kingdom (some actions are reported separately for England, Wales, Scotland and Northern Ireland)
- Switzerland, Norway
- Top 5 performing US states (Massachusetts, California, Oregon, Rhode Island, Vermont)

A template was then developed for the Stage 1 data gathering exercise and agreed with Scottish Government. For each country/state all relevant programmes were identified and data was then collected to populate the template. For each of the 20 cases we produced a summary table of the main interventions. This includes:

- Dates of the intervention;
- Type of intervention (e.g. regulation, financial incentives etc.);
- Scope – geographic coverage;
- Technologies supported;
- Cost of the intervention and
- Savings achieved and cost per tonne of CO_2, taking into account the cost effectiveness of both individual measures and the scheme as a whole (where data is available).

The outcome of this work was summarised in an interim report (included in Appendix 1) describing which interventions were put in place in each country, and giving the main characteristics of each. The range of measures considered are shown in Table 2. The results are summarised in Section 3.

Stage 2 involved a detailed assessment of individual energy efficiency interventions in the housing sector for seven countries which the Scottish Government selected for further investigation.

A case study template was agreed to capture the necessary data gathered to populate the template. When data gaps had been identified, key officials in case study countries were identified and contacted. Short interviews were then carried out to address these data gaps and to gain a deeper insight into the key success factors in each case. The case studies were then completed and are presented in Appendix 2 of this report.

A general reason for selection was to pick up countries/states that are less well studied than others. Other reasons for selection are detailed below:

Table 1 Reason for selection of country

Country / State	Reasons for selection at Stage 2
Sweden	Wide range of measures, overarching carbon tax, Municipal level initiatives
Ireland	Similar to Scotland, similar range of schemes, good data
Oregon	Weather most similar to Scotland of US states selected in stage 1, mix of measures, long running initiatives
Netherlands	Broad mix of measures, including an energy tax, a similar climate, web focused, More with Less scheme
Germany	Large fossil fuel component to energy mix, interesting flexible loan scheme
France	Old building stock, range of incentives, some of the measures target fuel poverty, also electricity is largely decarbonised in France and therefore the carbon driver may be less in France than in, say Oregon. Other drivers may come to the fore in the analysis, which might be interesting for Scotland to reflect on as it increasingly decarbonises electricity.
New Zealand	Focus on health, similar climate, an non-EU country level example

The analysis carried out considered how well the interventions work, their cost-effectiveness, marketing and communication/ public acceptability and unintended consequences.

Our analysis drew on a number of sources including:

- evaluations of interventions (commissioned by programme administrators or independent);
- academic literature (e.g. conference papers presented for example at the eceee Summer Study[1]); and
- grey literature (e.g. consultancy reports, working papers).

We also contacted individuals in each of the Stage 2 countries to make sure we captured all of the information available. In our experience, the quality and quantity of published information available differs significantly by country and intervention.

1 Keeping energy efficiency at the top of the agenda, eceee 2015 Summer Study on energy efficiency ttp://www.eceee.org/summerstudy

2 Range of interventions by country/state

A range of different intervention types was considered as part of Stage 1:

- **On-bill Finance Schemes**: On-bill finance provides households with a loan to cover the cost of energy efficiency measures. The loan is paid back through energy bills and usually attached to the property rather than a person.
- **Energy Efficiency Obligations**: Energy Efficiency Obligations oblige energy companies (or a third party) to achieve specific energy savings targets through installing energy efficiency measures at the customer end.
- **Taxation or tax rebates**: Taxation measures put a tax on energy (or carbon) which makes energy services more expensive providing an incentive to reduce energy consumption. Tax rebates provide a reduction of the tax paid for the installation of energy efficiency measures or a financial contribution after energy efficiency measures have been installed (this does not have to be linked to the actual tax paid).
- **Regulation or standards**: Regulations consist primarily of building codes requiring households to achieve a certain energy performance. For existing buildings those requirements usually apply when major alterations of the building are made. Standards apply to the energy performance of energy consuming devices such as appliances and boilers.
- **Grants or subsidies**: Grants and subsidies are financial incentives paid as a contribution towards the cost of energy efficiency measures.
- **Loans**: Loans (often provided at low interest rates) are offered to households to cover the up-front cost of energy efficiency measures. Such loans may be issued by retail banks, energy agencies, and local authorities. They are usually subsidised by public funds.
- **Voluntary agreements**: Voluntary agreements are relatively rare in domestic energy efficiency and may include commitments by bodies such as social housing providers to achieve a certain energy performance improvement.
- **Information and education**: Information and education includes a wide range of measures such as energy labels and specific information campaigns but also feedback on energy consumption.
- **Advice & support**: Advice and support are often provided to help households with understanding the energy efficiency opportunities in their home as well as the funding available to them.
- **Demonstration projects**: Demonstration projects usually focus on innovative high energy performance retrofits to illustrate what is technically possible with the aim of encouraging replication.

Table 2 summarises the spread of housing energy efficiency interventions across countries that were covered in Stage 1 of the project.

Table 2 Summary of range of interventions by country/state

Countries or States	On-bill Finance Scheme	Energy Efficiency Obligation	Taxation or Tax Rebate	Other Rebate	Regulation or Standards	Grant or Subsidy	Loan	Voluntary Agreement	Rating	Information	Demo
									Labelling	Education	
										Advice & Support	
England	✓	✓	✓		✓						
Wales	✓	✓	✓		✓	✓✓	✓				
Northern Ireland			✓		✓	✓✓✓		✓			
Austria					✓	✓✓	✓			✓	
Canada				✓	✓✓	✓✓		✓	✓	✓	
Denmark		✓	✓		✓					✓	
Finland			✓		✓✓	✓✓		✓✓✓		✓	
France			✓		✓		✓✓				
Germany					✓	✓	✓			✓✓	
Ireland		✓	✓		✓	✓✓✓					
Netherlands			✓✓✓✓		✓✓		✓	✓✓✓			✓
New Zealand					✓	✓✓	✓			✓	
Norway			✓		✓	✓✓✓	✓✓			✓	
Sweden			✓✓		✓	✓				✓✓✓	
Switzerland					✓✓	✓					
Massachusetts				✓	✓		✓				

Countries or States	On-bill Finance Scheme	Energy Efficiency Obligation	Taxation or Tax Rebate	Other Rebate	Regulation or Standards	Grant or Subsidy	Loan	Voluntary Agreement	Rating	Information	Demo
									Labelling	Education	
										Advice & Support	
California			✓	✓✓	✓	✓	✓✓				
Oregon	✓		✓	✓✓	✓		✓				
Rhode Island				✓✓	✓						
Vermont				✓✓✓✓ ✓✓✓✓	✓		✓✓				

Note 1: Some interventions assessed in stage 1 incorporate more than one intervention type, for example some schemes may offer grants, loans and information provision. Such interventions are represented by ticks in each of the relevant cells.
Note 2: Each ✓ refers to a type of intervention implemented in a given country as described in stage 1 of the project. So for example three voluntary agreements are described for Finland, so ✓✓✓ is shown above.

Note 3: As the focus of this project is on the refurbishment of existing homes, regulations or standards are only included if they apply to refurbishments.

Note 4: Interventions shown in **BOLD** have been considered in depth in the case studies given below.

3 Phase 2 Case studies: Summary of context and key measures by country

This section describes for each country the policy context, energy costs, demographics and distribution of housing stock. It is intended as an introductory section to the more detailed description of intervention types within Section 4. It is clear that energy efficiency interventions are targeted to deal with a range of different issues so factors such as a country's demographic profile, housing stock and energy price do not map directly between countries and interventions.

The case studies selected for the Phase 2 analysis can be broken down by type of intervention to demonstrate the broad mix of schemes analysed. For Phase 2, it was agreed that up to 4 interventions would be analysed per selected country/state. In some cases there were 4 or fewer interventions covered under Phase 1 and this was used as the basis for selection. Where there were more interventions, the most relevant were selected as recorded under the table for each country below.

Table 3 Most Relevant interventions

	Germany	France	Netherlands	Sweden	Ireland	Oregon	New Zealand
Loans	✓*	✓					✓
On-bill finance						✓	
Grants	✓*			✓	✓✓	✓	✓
Tax rebates		✓	✓	✓	✓	✓	
Energy efficiency obligations		✓			✓		
Regulatory measures and standards	✓	✓	✓	✓			✓
Advice programmes	✓✓		✓				✓
Energy taxes			✓	✓			

* Germany uses a blend of loans and grants in its programme

3.1 Policy context

Article 3 of the EU Energy Efficiency Directive required Member States to set national non-binding energy savings targets for 2020. In this section we describe the policy context for the EU Member States included in the study, together with Oregon and New Zealand, highlighting the targets and policy priorities in each country and region.

Germany

Germany has a target to reduce its final energy consumption to 2259.7 TWh final energy consumption by 2020. This represents roughly a 12% reduction in final energy consumption, relative to 2008 levels.

In its National Energy Efficiency Action Plan in 2012 (updated in 2014), Germany set a target for 2050 to have a building stock that is almost climate-neutral. To achieve this target, the heating requirement is to be reduced by 20% by 2020, with primary energy demand dropping by 50% by 2050.

Fuel poverty has not been a driver of energy efficiency policy in the past.[2] However, more recently fuel poverty has been on the political agenda in Germany and during 2014 the German government reported that 6.9m households live in energy poverty[3], if defined as spending more than 10% of their income on energy (there is no official definition of fuel poverty in Germany). However there is no fuel poverty

2 Rosenow, J. (2013): The Politics of the German CO2 Building Rehabilitation Programme. Energy Efficiency 6(2), pp 219-238
3 http://wdvs.enbausa.de/nachrichten/energiearmut-gruene-fordern-massnahmen-fuer-hoehere-energieeffizienz.html

reduction target, and the only measure addressing low income groups is to encourage low income groups to exchange old refrigerators, in exchange for cash vouchers.

Within the domestic sector the key policy for delivering retrofit is the CO_2 Building Renovation Programme, of which the Energy Efficient Refurbishment or KfW's (German development bank) funding programmes (loans and grants) for new build construction and renovation of existing housing forms a key part.

Country	Interventions identified (at Phase 1)	Phase 2 Selected for case studies
Germany	Energy-efficient Refurbishment (KfW loan and grant programme)	✓ **(Only loan element)**
	Electricity Saving Initiative	✓
	Energy Consumer Advice Centre	✓
	Energy Conservation Regulations	✓

France

France's 2020 target was set at the level of 1,528TWh for final energy consumption. The EU target (20%) covers all emissions sources and uses 1990 as reference year. The national target on greenhouse gas emissions covers emission sources not already included in the European exchange system of emission quotas and uses 2005 as reference year.

The French government set out its National Energy Efficiency Action Plan in 2012 (updated in 2014). Within the domestic sector the key policies for delivering retrofit are Energy Efficiency Obligations (White Certificates), tax rebates (CITE), and loan schemes (Eco-PTZ, and Eco-PLS). New builds are also targeted with stringent building codes (RT2012). As part of the EU Climate and Energy Package Effort Sharing Decision, France has an emissions target of 14% below 2005 levels by 2020.

Country	Interventions identified (at Phase 1)	Phase 2 Selected for case studies
France	CITE	✓
	Eco-PTZ	✓
	Eco-PLS	✓
	Building codes	
	Energy Efficiency Obligations	✓

Building codes were excluded at Phase 2 at these are not a type of intervention programme.

Netherlands

The Dutch government set out its National Energy Efficiency Action Plan (NEEAP) in 2011 (updated in 2014). The Netherlands declared it aims to achieve 1.5% energy savings per year from 2013 to 2020, giving a reduction overall of 10%.The indicative national energy efficiency target for 2020 of 133.9 TWh final end-use efficiency improvements to be achieved in the period 2014-2020; in primary terms this is 186.4 TWh.

The basic principle in the Netherlands is that individuals and businesses have an interest themselves in saving energy, through the cost savings that result and, in the latter case, improvements in competitiveness, and should therefore take responsibility for doing so. This approach has been formalised in the "Energy Agreement for Sustainable Growth[4]" between the government at national and regional levels and organisations representing employers, citizens, environmental interests and other stakeholders. The Government's aim is to create the conditions for economically rational investments to be undertaken and its policies facilitate and encourage third party investment and provide financial and subsidy support where necessary. Measures include information provision/awareness raising, the

4 Summary of the Energy Agreement for Sustainable Growth: http://www.energieakkoordser.nl/~/media/files/internet/talen/engels/2013/energy-agreement-sustainable-growth-summary.ashx

reduction in regulatory burden and fund based financing, especially for the residential sector and municipal councils.

Country	Interventions identified (at Phase 1)	Phase 2 Selected for case studies
Netherlands	Energy Tax	✓
	Green Investment and Finance	
	Green Deal	
	Reduced VAT rate for insulation work	
	Reduced VAT rate on the labour costs for maintenance and renovation of residential buildings	✓
	More with Less: Agreement for energy saving in existing residential and other buildings	✓
	Home Valuation System	✓

Schemes were selected on the basis of those which had best data available – i.e. a measurable impact.

Sweden

Sweden's target was set at the level of 126 TWh of primary energy consumption in 2020. This represents a 20% reduction from 2008 levels. The Swedish government set out a National Energy Efficiency Action Plan in 2014.

Country	Interventions identified (at Phase 1)	Phase 2 Selected for case studies
Sweden	Repair, maintenance, conversion or extension rebate	✓
	Energiaktiv.se (Energy efficiency online portal)	
	Planning and Construction Act (PCA)	✓
	Programme for Buildings with Very Low Energy Use (LAGAN)	✓
	Testing and Trial of Energy Intensive Products	
	Energy and Carbon Tax	
	State Aid for Municipal Energy and Climate Advice	✓

For Phase 2 it was decided to focus on those schemes with good quality data, to exclude products as these have a natural rate of replacement and to retain the Lagan Programme as it included renovation.

Ireland

Ireland's overall national energy efficiency target for primary energy for 2020 is 31.9 TWh. This represents a 20% reduction in primary energy consumption from the 2001-2005 average baseline. This target, along with a commitment to a 33% reduction in public sector energy use, constitute the central pillars of Ireland's national energy efficiency policy.

Country	Interventions identified (at Phase 1)	Phase 2 Selected for case studies
Ireland	Energy Efficiency Obligation Scheme	✓
	Residential Retrofit – Better Energy Warmer Homes	✓
	Residential Retrofit – Better Energy Areas	
	Residential Retrofit – Better Energy Homes	✓
	Energy Efficient Boiler Regulation for Replacement Boilers	
	Home Renovation Tax Incentive	✓

Better Energy Homes, Better Energy Warmer Homes, and the supplier obligation are the three main domestic retrofit interventions in Ireland and so selected as they have had the largest impact.

In February 2015 the Irish Government published a white paper to launch a public consultation on the development of a new Energy Affordability Strategy. The white paper aims to address fuel poverty through three channels: energy efficiency; supporting the income of those in energy poverty, and ensuring energy markets work for consumers. The main tool to deliver the energy efficiency arm of this approach is the Better Energy Warmer Homes scheme.

Oregon

While Oregon does not have state-wide energy targets, the Energy Trust of Oregon, which is an independent not-for-profit organisation focussed on energy efficiency and renewable energy, sets strategic plans. In 2009, it established its strategic plan for 2010-2014, which included the following goals for energy efficiency:

- Between 2010 and 2014, save 256 average megawatts (aMW)[5] of electricity, contingent on adequate funding, through efficiency and conservation
- Save 22.5 million therms of natural gas annually, through efficiency and conservation

Similarly, the Energy Trust of Oregon has set out its 2015-2019 strategic plan, in which the energy efficiency goals are stated as follows:

- save 240 average megawatts (aMW) of electricity
- Save 24 million therms of natural gas annually

State	Interventions identified (at Phase 1)	Phase 2 Selected for case studies
Oregon	Clean Energy Works	✓
	State Energy Loan Program	
	Residential Energy Tax Credit	✓
	Home Energy Solutions for Existing Homes	✓
	Residential Energy Star Appliance Rebate Program	

The products programme was excluded as products have a natural rate of replacement.

New Zealand

Energy efficiency in New Zealand is set by the Energy Efficiency and Conservation Act (2000). The Act established the Energy Efficiency and Conservation Authority (EECA) as the entity to promote energy efficiency across all sectors of the economy. Energy intensity in New Zealand has declined on average by roughly 1% per year since 1990, in large part due to the country's long history of energy efficiency. In the country's energy efficiency strategy (2010), New Zealand set a target to deliver 15.3TWh of energy saving across the economy by 2015, compared to 2010. This equates to approximately 9% reduction in New Zealand's economy-wide energy intensity. New Zealand's government aims to cut carbon emissions 5% below 1990 levels by 2020.

The New Zealand Energy Efficiency and Conservation Strategy 2011-2016 (NZEECS) is focuses on the promotion of energy efficiency, energy conservation and renewable energy. Fuel poverty[6] is a significant public health problem currently estimated to affect 25% of households in New Zealand and the cost of electricity is a key driver.

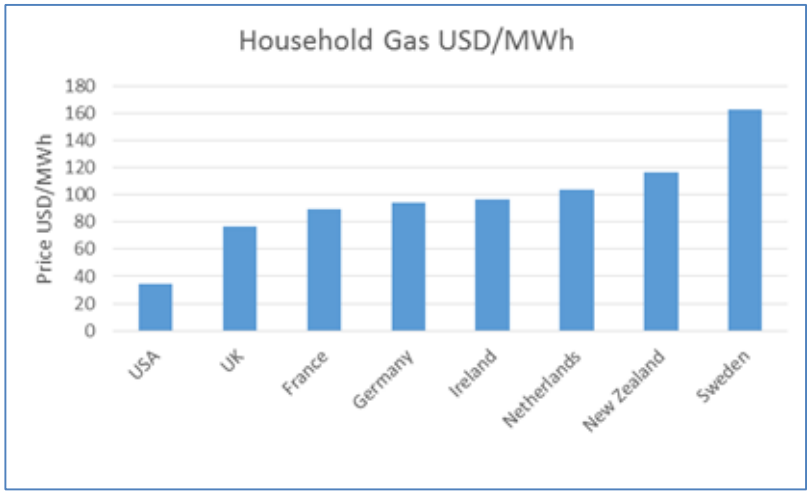
5 Average megawatts relates to the average number of megawatt-hours, not megawatts, over a specified time period.
6 Although Fuel Poverty appears to not have been defined by the New Zealand government, Healthy Housing – He Kainga Oranga – "Evaluation of Warm Up New Zealand: Heat Smart", http://www.healthyhousing.org.nz/research/current-research/evaluation-of-warm-up-new-zealand-heat-smart/ cites the international definition "the inability to acquire adequate household energy services for 10% of household income".

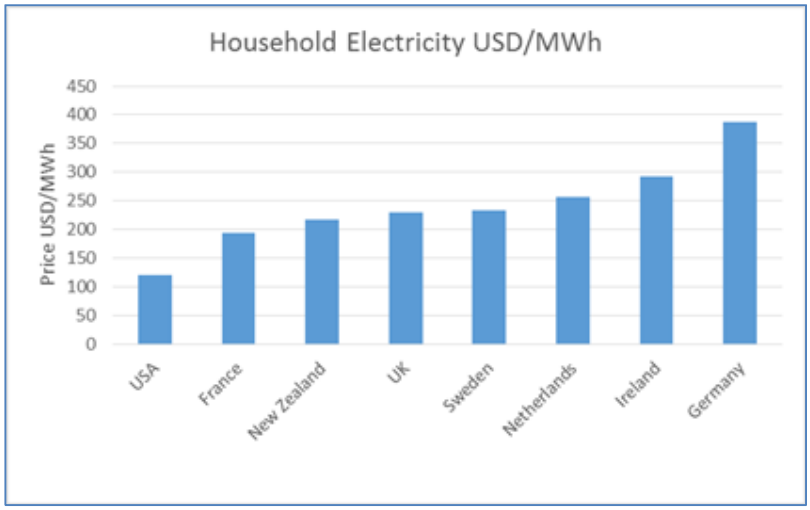
Country	Interventions identified (at Phase 1)	Phase 2 Selected for case studies
New Zealand	Warm Up New Zealand: Heat Smart	✓
	Warm Up New Zealand: Healthy Homes	✓
	Building Regulations	
	Energywise information campaign (not in Phase 1)	✓
	Minimum Energy Performance Standards (not in Phase 1)	✓

Building codes were excluded at Phase 2 at these are not a type of intervention programme.

3.2 Energy cost

The graphs below show household electricity[7] and gas prices in selected countries compared to the UK, in increasing order of cost for the selected countries.





The contribution from tax varies considerably:

7 http://www.iea.org/publications/freepublications/publication/KeyWorld2014.pdf

For gas[8], Sweden (44%) and the Netherlands (41%) have the largest tax component, followed by Germany (24%), France (18%), New Zealand (14%) and the UK at 5%. Data on the US was not found.

For electricity, Germany has the largest tax component (52%), followed by Sweden (36%), France (31%), the Netherlands (27%), Ireland (18%), New Zealand (13%) and the UK (5%).

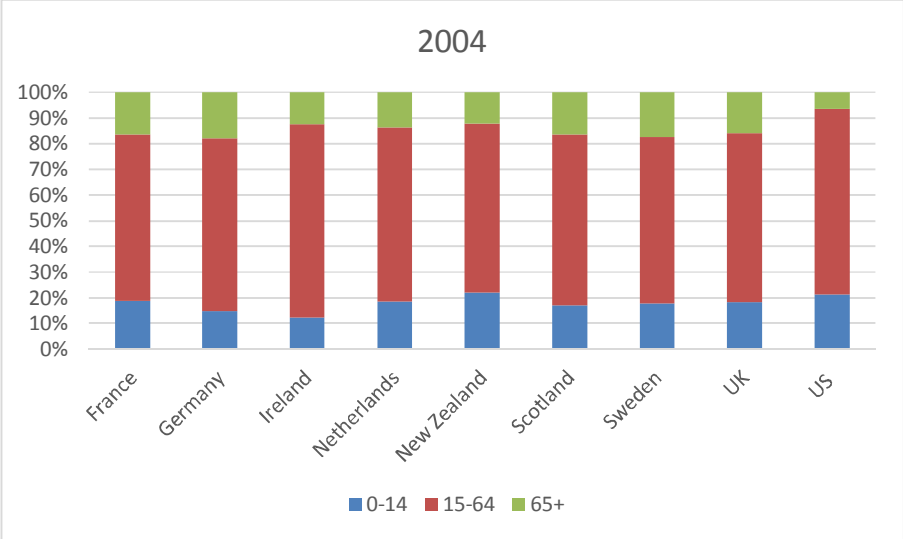
3.3 Fuel Used

The following table shows the forms of fuel used for heating in housing[9,10,11].

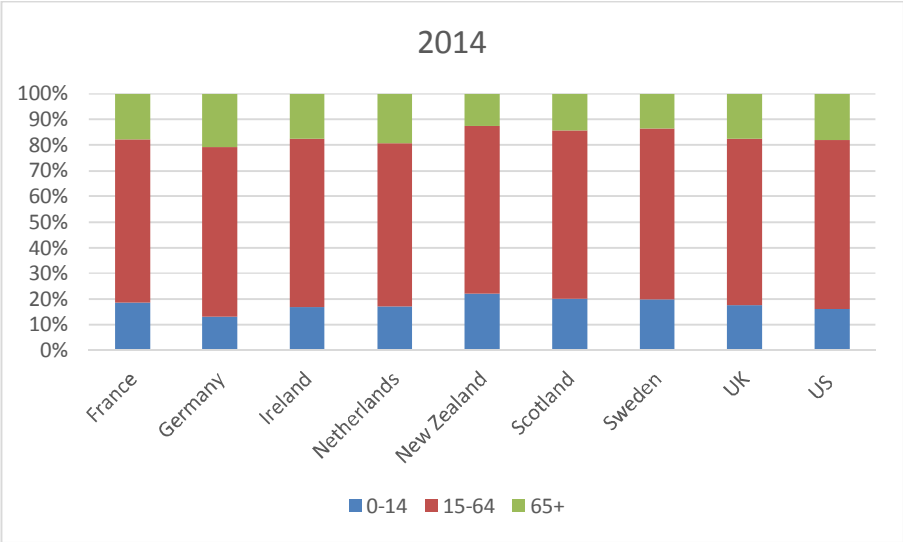
	Coal	Oil	Gas inc LPG/bottled gas	District heating	Electricity	Wood	Other/ None
France	1%	19%	38%	5%	14%	24%	
Germany	3%	26%	43%	9%	2%	17%	
Ireland	23%	43%	26%		5%	3%	
United Kingdom	3%	8%	78%		8%	3%	
Sweden		2%	1%	48%	28%	21%	
Netherlands		1%	89%	4%	2%	4%	
Oregon		7%	42%		49%		2%
New Zealand	3%		18%		52%	24%	4%

3.4 Demographics

The figures below shows the age profile of the countries included, along with that of the UK and Scotland in 2004 and 2014[12]



8 http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do;jsessionid=T3xyyIEdXyVFaKlwyg9oN-PcBOjlwMKoJ9tdKDfrW0acT16rgmgx!-1454260853
9 EU data exported from ODYSEE MURE
10 Oregon data from http://apps1.eere.energy.gov/states/residential.cfm/state=OR
11 New Zealand data from
12 With the exception of the US where the data is for 2012 and 2000.



All show an ageing population, to varying degrees. This is also the case in Scotland, where the number of households headed by people aged 65 and over is projected to increase by almost 54% between 2012 and 2037.

There is a range of urbanisation between the countries investigated:

In the Netherlands 89.9% of the population live in urban areas.

86% of New Zealanders live in urban areas, a trend that is slowly growing – and New Zealand has an ageing population.

In France, 47% of the population live in densely populated areas, 30% in intermediately urbanised areas and 34% in thinly populated areas.

More than 46% of Oregon's population lives in the Oregon portion of the Portland metropolitan area. Oregon's landscape is very diverse, varying from rain forest to barren desert and Oregon is known for being rainy and cloudy for practically nine months out of the year; with dry summers.

Approximately 40% of the Swedish population lives in densely populated (urban) areas, and an additional 30% in intermediate urbanised areas[13] and 20% in sparsely populated areas.

In Ireland, 34% of the population live in densely populated areas, 25% in intermediately populated areas, and 41% in rural areas. It is worth noting that the proportion of lower income residents in rural areas is around twice that in dense urban and intermediate areas. This issue of rurality can present supply-chain challenges when attempting to tackle causes of fuel poverty through energy efficiency installations. This effect has been noted more widely in other countries too, and can be exacerbated when there is 'stop start' funding for support programmes which make it harder for local enterprises to become established.

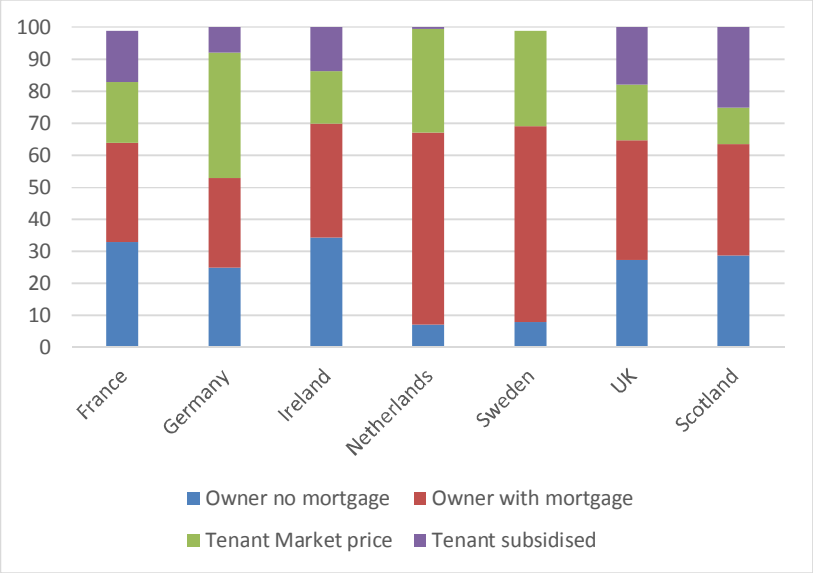
In Germany the population is relatively evenly split by dense, intermediate and thinly populated areas (proxy for rural and urban distribution).

Scotland's population is concentrated in the densely populated central belt of the country, with centres of population around Aberdeen. The Highlands and Islands in particular have population densities of 99 people per square kilometre or less.[14]

13 For definition of area classification: http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Revision_of_the_degree_of_urbanisation
14 Population density map http://www.ons.gov.uk/ons/search/index.html?newquery=scotland+population+density+map

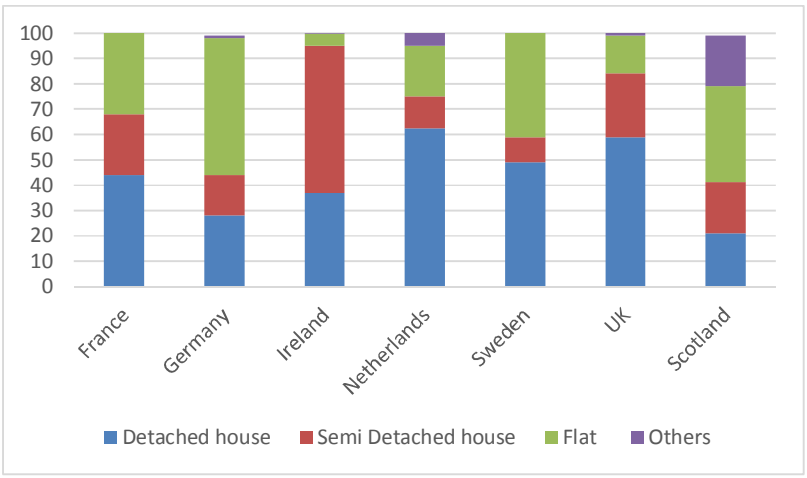
3.5 Housing stock

The chart below illustrates housing tenure for countries in the European Union, including Scottish data[15]:



For the USA 65%[16] of homes are owner occupied a percentage not dissimilar to Scotland. Unfortunately it was not found possible to obtain a breakdown of US data to the level of detail shown above. As can be seen there is a considerable variation between the prevalence of renting and ownership between the different countries. There have also been considerable changes over the last century. There has been an increase in owner occupation across much of Europe, but it has been particularly dramatic in Scotland. Scottish Government statistics show that in 1981, less than 40% of Scottish dwelling stock was owner occupied. By 2008, this had risen to 62% but had fallen back to 58% in 2013, as more people have rented privately or live rent free.

The chart below shows the distribution between types of property[17].



There is also considerable variation between the ages of properties[18]. Ireland has the most recent housing stock with only about 27% built before 1960. In the Netherlands and Germany about half of the country's housing stock was built after 1960, France has a slightly older housing stock whereas the

15 Tenure data from Scottish census 2011, http://www.scotlandscensus.gov.uk/ods-analyser/jsf/tableView/tableView.xhtml
16 http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_13_5YR_B25003&prodType=table
17 Data from Scotland from Scottish Housing Condition Survey, Table 1, http://www.gov.scot/Resource/0046/00465627.pdf
18 http://www.bmwfw.gv.at/Wirtschaftspolitik/Wohnungspolitik/Documents/housing_statistics_in_the_european_union_2010.pdf

majority of Swedish housing was built before 1975.[19] 60% of Oregon's housing stock is more than 50 years old.

In Oregon, roughly 75% of housing units in Oregon are single-family homes, 81% of which are in urban counties[20]. Housing in 'rural' counties tend to be older than in urban counties, with close to half being built before 1969.

The majority of New Zealand housing is occupied detached housing (76%), followed by 17% as flats/apartments/townhouses. The remainder of the housing stock (7%) comprises mostly informal or improvised dwellings.

19 BPIE (2011): Europe's Buildings under the Microscope. Online: http://www.europeanclimate.org/documents/LR_%20CbC_study.pdf
20 Urban/Rural is based on the 2013 USDA Rural-Urban Continuum Codes with those counties in codes 1-3 considered to be urban and all others considered to be rural. http://www.ers.usda.gov/data-products/rural-urban-continuum-codes.aspx

4 Effectiveness of different types of intervention

When considering different types of energy efficiency interventions an understanding of their respective effectiveness and cost-effectiveness is paramount. Effectiveness commonly refers to the extent to which a policy instrument achieves its goals / intended effects. In other words, effectiveness describes whether or not the outcomes are in line with the intervention's expectations. This report discusses effectiveness largely in terms of the energy savings that have been achieved but, where appropriate, also highlights effectiveness related to other policy goals such as reducing fuel poverty. Cost-effectiveness refers to the relative cost involved in delivering the desired outcomes. In the case of energy efficiency, the metric of pence / kWh is a useful measure of cost-effectiveness – and the lower this metric is the better.

Some of the challenges related to analysing the effectiveness of energy efficiency interventions are:

a) **Lack of ex-post evaluations** for individual interventions and intervention types: For most interventions there are no robust evaluations available making it difficult to judge their effectiveness.
b) **Focus on activity/output rather than impact-related indicators**: Often evaluations and government documents provide figures for the amount of money spent and the number of participants rather than the energy savings.
c) **Baseline not defined clearly**: It is often not clear how many energy efficiency measures were installed before and after the programme or what the baseline energy use was.
d) **Inconsistency in terms of methodologies** employed when undertaking evaluations: For example, some evaluations explicitly consider rebound effects, free-riders and the technological performance gap (where a technology delivers less savings than anticipated based on engineering models).

The challenge of comparing different interventions is even more profound for cost-effectiveness if the figures are provided without the underlying assumptions such as energy savings and cost of delivery of the programme.

A recent review by Joanne Wade and Nick Eyre on behalf of the UK Energy Research Centre provides a good overview of the problems encountered when comparing different evaluations.[21] Work by the IEA has also stressed that 'very few thorough evaluations of economic instruments in energy efficiency policy are available that would facilitate benefit-cost ratio comparisons. The available sources do not allow general recommendations on which policies are most effective or efficient.'[22]

Whilst we cannot resolve this challenge of consistently assessing effectiveness, this needs to be kept in mind when discussing specific intervention types. Where possible we provide a quantitative analysis of the impact and cost-effectiveness of the interventions but in some cases the assessment is qualitative only, resulting from a lack of sufficient data, or effectiveness cannot be assessed at all.

We now discuss effectiveness and cost-effectiveness for the following interventions:

- Loans
- On-bill finance
- Grant schemes
- Tax incentives and investment schemes
- Energy efficiency obligations
- Regulatory measures and standards
- Advice programmes

Further information on each of the interventions and how they work can be found in the Appendix to this main report.

[21] Wade, J., Eyre, N. (2015): Energy Efficiency Evaluation: The evidence for real energy savings from energy efficiency programmes in the household sector. UKERC: London
[22] IEA (2012): Mobilising investment in energy efficiency. IEA: Paris

4.1 Loans

Data on the effectiveness and costs of soft loans for energy efficiency is relatively limited but there is some evidence that suggests that loans can be a very effective mechanism to stimulate energy efficiency investments and lever in private capital. This is largely a result of the potentially higher leverage effect of loans compared to other forms of subsidies such as grants and tax rebates as the subsidy is used to buy down the interest rate rather than to cover the investment cost.

4.1.1 France

In France, two loan schemes funded by the government have been operational since 2009, namely the Eco zero-interest loan (Eco Prêt à taux zéro – Eco-PTZ) for owner occupiers and the Eco loan for social housing (Eco Prêt logement social – Eco-PLS for low-rent housing agencies, mixed economy companies and also to municipalities with social housing). The maximum loan for the Eco-PTZ is 30,000 Euros per household and for the Eco-PLS between EUR 9,000 and EUR 16,000 per dwelling.

The Eco-PTZ initially achieved about 70,000 retrofits per year (period 2009) but this has since declined to just about 30,000 properties being retrofitted (2012). The intended effect of Eco-PTZ was to retrofit about 6% of the total housing stock over the period 2009-2015 and another 6% by 2020.[23] In reality, over the period 2009-2012 only 0.7% of the housing stock was renovated with eco-PTZ loans. The drop in the numbers of loans issued has partly been attributed to disallowing the shared funding of renovations by using both the Eco-PTZ loan and the tax rebates[24] for all or part of the costs (depending on the total cost of the renovation) of installing eligible energy efficiency measures (Crédit d'impôt développement durable). However, even after reversing this decision in 2012 for households with an annual income of up to €30,000 the loan volumes did not increase.[25] The impact in the period 2009-2010 has been estimated to be 1,431 MWh of primary energy savings per year and 260,000 tCO2 per year. The cost-effectiveness of the Eco-PTZ appears to be moderate and is equivalent to €0.1 / kWh[26] which is higher than the price of gas but lower than the price of electricity in France.

The Eco-PLS has achieved about 120,000 renovations per year[27] (current activity levels). The Mure database estimates that the energy savings achieved in 2013 equate to 4 TWh i.e. 0.9% of the final energy consumption in the residential sector in 2011.[28] This figure appears to be very high given the relatively low number of loans being issued and should be treated with some caution. No data on cost effectiveness could be identified.

4.1.2 Germany

The best available data was identified for the government funded KfW loan programme for owners of residential buildings in Germany which has been in operation since 2001 and where ex-post evaluations are carried out at regular intervals (usually annually). KfW supports the refurbishment of houses if they meet a specific energy requirement (based on the building codes for new buildings) or install single measures from a list of approved measures, with a third of refurbishments in Germany being supported. Half of all new builds are funded by the KfW to a higher standard than the minimum standards prescribed by the Energy Saving Ordinance. A maximum loan of €100,000 is currently available with an interest rate of 0.75% and the loans are provided through the retail banks. Depending on the level of energy efficiency reached KfW also provides a repayment bonus (a reduction of the loan to be paid back). As an alternative, homeowners have the possibility to apply for a grant route of the programme that currently provides grants of up to €30,000. The loan and the grant route cannot be combined. Currently the German government funds the scheme with €2 billion every year. The exact amount of funding varies depending on demand in a given year.

Take-up of the programme has been very successful once the programme was well-known. In most years the anticipated loan volumes were met or exceeded which is why the funding has been increased

23 ibid
24 A tax rebate needs to be distinguished from tax reductions on energy efficiency installations. While the latter offers only a reduction in the amount of tax payable, a tax rebate provides funding similar to a grant but post-installation. The tax rebate applies even if the individual does not pay any income tax. In effect, the tax credit is independent of the individual's income level and thus all those who can afford to can avail of the offer.
25 MINEFI 2011 quoted in IEA 2012
26 ibid
27 personal communication with Elodie Trauchessec, ADEME
28 http://www.measures-odyssee-mure.eu/public/mure_pdf/household/FRA43.PDF

substantially since 2001. The number of retrofitted properties increased from 30,000 in 2001[29] to around 250,000 in 2012 and 2013[30]. The most recent evaluation estimates that the current rate of refurbishment leads to additional energy savings of 1.8 TWh/year[31] which is 0.3% of final energy consumption in the residential sector[32].

Regarding the cost-effectiveness, we use the high-level programme figures from 2001-2007 based on official evaluations carried out on behalf of KfW by the Bremer Energie Institut. The reason for using this timeframe is that grants were only introduced in 2007 and the data prior to 2007 relates to the loan component only. For data after 2007 it is difficult to specify the total amount of funding used for the purpose of the loan component alone which is why this earlier data has been used. The programme appears to be cost-effective at a cost of about €0.02/kWh (the cost of heating fuels and electricity is significantly above this).[33] However, detailed academic studies have put into question whether the programme is as cost-effective as it appears to be because existing ex-post evaluations do not include many factors such as free-riders (which could potentially be high as research indicates[34]) and the rebound effect and also use modelled savings based on a theoretical energy consumption pre-retrofit. [35][36] Taking those factors into account (except for free-riders) the cost are probably around €0.03/kWh which is way below gas and electricity prices and therefore cost-effective.[37]

4.1.3 New Zealand

New Zealand implemented loans for home retrofits in 2009. The first phase of the programme ran until 2013 when it was replaced with the scheme Warm Up New Zealand: Healthy Homes. This programme offers both grants to low-income households and loans for those homeowners and tenants not eligible for insulation grant under the scheme. Loans are provided through two different routes:[38] [39]

- Banks: certain banks will add the cost of the insulation to a homeowners' mortgage, to be paid back with interest. Associated fees are waved.
- Councils: costs can be added to the council rates, and paid back over a period with interest applied. 10 local councils, representing 56% of the population, have committed to offering households low-cost finance options. Through 'voluntary targeted rates' (VTR), local councils can fund insulation retrofits and progressively recover the cost from the property through rates over a nine- or 10-yearperiod (e.g. in Auckland, costs are paid by via council rates over 9 years, at 7% interest up to a loan volume of $5,000).

Data on the effectiveness of loans provided as part of New Zealand's Warm Up New Zealand: Heat Smart Programme could not be identified. The evaluation of the programme[40] does not analyse loans and focuses entirely on the grant component. In response to a request to clarify this, EECA stated that there is no information available on the cost effectiveness of the loan options, mostly due to the service providers managing this aspect of the programme, which reduced costs to the NZ Government. Hence no conclusions can be drawn regarding the effectiveness and cost.

4.2 On-bill finance

There has been limited experience with on-bill finance programmes to date. The example of Oregon presented below is one of the most well-known programmes.

29 http://juser.fz-juelich.de/record/38005/files/Umwelt_34.pdf
30 https://www.kfw.de/PDF/Download-Center/Konzernthemen/Research/PDF-Dokumente-alle-Evaluationen/Monitoringbericht_2013_05-12-2014.pdf
31 Diefenbach et al. (2014): Monitoring der KfW-Programme „Energieeffizient Sanieren" und „Energieeffizient Bauen" 2013. IWU and Fraunhofer-Institut für Fertigungstechnik und Angewandte Materialforschung
32 http://www.umweltbundesamt.de/daten/energiebereitstellung-verbrauch/energieverbrauch-nach-energietraegern-sektoren
33 Rosenow, J., Galvin, R. (2013): Evaluating the Evaluations: evidence from energy efficiency programmes in Germany and the UK. Energy & Buildings 62, pp. 450–458
34 Rosenow and Galvin (2013)
35 ibid
36 Galvin, R. (2012). German Federal policy on thermal renovation of existing homes: a policy evaluation. Sustainable Cities and Society, 4, 58–66
37 Rosenow, J. (2013): The politics of change: energy efficiency policy in Britain and Germany. Oxford
38 IEA (2012):
39 Association for the Conservation of Energy (2013): Financing energy efficiency in buildings: an international review of best practice and innovation. Online: http://www.wec-policies.enerdata.eu/Documents/cases-studies/Financing_energy_efficiency_buildings.pdf
40 Grimes, A. et al. (2012): Cost Benefit Analysis of the Warm Up New Zealand: Heat Smart Programme

4.2.1 Oregon

Clean Energy Works Oregon (CEWO) and its pilot program Clean Energy Works Portland (CEWP) have been operating as an on-bill financing energy efficiency programme in Oregon since 2009. The programme has been set up and is funded by the Oregon Department of Energy. The loans are provided by lending partners at current interest rates ranging from 3.5% to 7.5%.[41]

CEWO offers loans that customers can repay through utility bills and streamlined installations of energy efficiency upgrades. The non-profit organisation received a $20 million grant provided by the Recovery Act, also known as the Stimulus Plan in 2011.[42]

So far more than 4,300 households have participated in the programme out of approximately 1,516,456[43] households. An evaluation of the years 2010-2011 provides figures on the energy savings.[44] On average, households saved about 2,000 kWh electricity (only electric heating) and around 10,000 kWh of gas (only gas heating). The analysis of gas bills found that savings represented an average reduction in consumption of 32% in 2010 and 31% in 2011. Electricity savings were 17-39% of normalised annual consumption. In summary, the savings have been significant.

However, the evidence on the cost-effectiveness suggests that the programme is likely to be less cost-effective than other programmes in Oregon. A report[45] found that Clean Energy Works' cost to install air sealing was 67% higher than Energy Trust's "standard track," where homeowners simply call a contractor and pay for a specific efficiency measure to be installed. Its cost for various insulation measures was anywhere from 115 -145% higher than the standard track where homeowners simply call a contractor and get a specific efficiency measure installed without on-bill finance.

The reasons for the cost differences are complex and the study analysing the cost data stressed that it was not able to identify a clear cause of the discrepancies. Potential reasons suggested by the study include:[46]

- the broader scope of CEWO projects;
- difficulty segmenting the energy measure costs and distinguishing them from costs of other services in contractor invoicing;
- the quality level to which the work is performed based on consumer preference, wage requirements under the CEWO Track; and
- added administrative burden for CEWO contractors to meet federal reporting requirements under the American Recovery and Reinvestment Act (ARRA).

High-level data on the annual savings and money spent[47] suggests that the costs of the programme is about $0.09/kWh which is just below the current price of residential electricity $0.1/kWh[48] but above the current gas price of about $0.05/kWh[49].

4.3 Grant schemes

4.3.1 Germany

As already mentioned above, Germany offers a grant route to homeowners as part of its KfW programmes on energy efficiency. KfW supports the refurbishment of houses if they meet a specific energy requirement (based on the building codes for new buildings) or install single measures from a list of approved measures, with a third of refurbishments in Germany being supported. Investment grants of up to €30,000 per property are available. (A maximum loan of €100,000 is also available but the loan and the grant route cannot be combined. Applications for grants are made through KfW and the grant is transferred to applicant's account after completion of the refurbishment measures.

41 https://cewo.org/financing/
42 http://energy.gov/articles/oregon-celebrates-launch-statewide-clean-energy-works-program
43 http://quickfacts.census.gov/qfd/states/41000.html
44 Degens, P. (2014): Clean Energy Works Oregon Energy Consumption Analysis, 2010-2011. Energy Trust of Oregon
45 Energy Trust of Oregon (2014): 2013 Report on Energy Savings and Measure Costs of Existing Homes program tracks: Standard, Home Performance, and Clean Energy Works Oregon
46 Ibid.
47 http://www.oregon.gov/energy/Recovery/docs/CEWO.pdf
48 http://www.electricitylocal.com/states/oregon/
49 converted from http://www.eia.gov/dnav/ng/ng_pri_sum_dcu_sor_m.htm

Grant funding varies with the final standard of the refurbishment, as described in detail in Appendices volume, Section 3.3.

The most recent evaluation[50] provides data on the energy savings achieved through the grant route of the programme as well as the cost. In 2013, the grants resulted in 0.5 TWh of energy savings annually. Assuming a 30-year lifetime this amounts to 16 TWh in total. The volume of grants offered in 2013 amounts to €146 million. This equates to €0.009/kWh which is highly cost-effective.

4.3.2 Ireland

Ireland has two grant schemes, Better Energy Warmer Homes and Better Energy Homes. Better Energy Warmer Homes and Better Energy Homes are both part of the Residential Retrofit suite of schemes, under the Better Energy Brand. Better Energy Homes is available to all domestic energy customer, but only covers up to 30% of eligible improvement costs, whereas Better Energy Warmer Homes can cover 100% of costs for eligible applicants as the scheme is targeted at low-income households. The total amount of funding provided depends on the combination of measures. The average grant size awarded under the Better Energy Warmer Homes programme was €1223 per home treated (data from 2000 to 2014).[51] Under the Better Energy Homes about €1,100 was spent per house (based on data from 2009 to 2014).[52]

We now discuss the effectiveness of each programme in turn.

Better Energy Warmer Homes

By the end of 2014, the scheme had upgraded more than 112,000 fuel poor homes since it was launched in 2000, with an overall spend of almost €137 million[53]. The International Energy Agency's *Energy Policies of IEA Countries* review for Ireland in 2012 states that 80,000 homes were treated at a total spend of €80 million, and estimated related annual[54] energy savings to be 171 GWh.[55] Applying the same proportionality to the DCENR's figures for the end of 2014 would give an estimated annual energy savings in the range 239-293 GWh.

The cost-effectiveness of the programme is high at a cost of about €0.02 per kWh (based on the figures above assuming a lifetime of the measures of 30 years).

Better Energy Homes

The SEAI website provides statistics on the productivity of the scheme from its start in 2009, up to 1st March 2015.[56]More than 400,000 measures have been installed since 2009. Our analysis of this data results in an estimated energy saving, not including solar thermal installations, of just over 1,000 GWh per year. Note that this calculation does not include interaction effects between the different measures installed.

Assuming lifetimes of 30 years for insulation and 15 years for heating system related measures this gives a total lifetime savings of more than 26,000 GWh. The cost-effectiveness is very high with 0.06 €/ kWh. It is not surprising that the cost-effectiveness for the Better Energy Homes programme is higher than for the Better Energy Warmer Homes programme as the latter focuses on fuel poverty where rebound effects are significantly higher and the contribution required to the total investment cost of energy efficiency measures is greater. The combination of those factors lower the cost-effectiveness.

4.3.3 Netherlands

The More with Less programme is a joint initiative of the National Government, housing corporations, building companies, the installation sector and the energy companies for energy saving in existing buildings. It takes the form of a voluntary agreement (covenant). The More with Less programme, Meer

50 Diefenbach, N., Stein, B., Loga, T., Rodenfels, M., Gabriel, J., Fette, M. (2014): Monitoring der KfW-Programme „Energieeffizient Sanieren" und „Energieeffizient Bauen" 2013
51 Department for Communications, Energy and Natural Resources, Towards a New Affordable Energy Strategy for Ireland, January 2015. http://www.dcenr.gov.ie/NR/rdonlyres/1045379C-F07C-4D78-BFE1-7674FA3AFF67/0/AffordableEnergyConsultationPaper.pdf
52 personal communication Jim Sheer, SEAI dated 01/07/2015
53 Department for Communications, Energy and Natural Resources (2015): Towards a New Affordable Energy Strategy for Ireland, January 2015.
http://www.dcenr.gov.ie/NR/rdonlyres/1045379C-F07C-4D78-BFE1-7674FA3AFF67/0/AffordableEnergyConsultationPaper.pdf
54 We assume the energy savings figures are annual as the report presents annual figures for the other programmes in Ireland.
55 IEA (2012): Energy Policies of IEA Countries – Ireland, 2012.
http://www.iea.org/publications/freepublications/publication/IRELAND2012_free.pdf
56 SEAI, Better Energy Homes Statistics, March 2015
http://www.seai.ie/Grants/Better_energy_homes/Better_Energy_Statistics/Website%20Stats.pdf

met Minder in Dutch, means more quality of living with less energy and housing costs. The initiative centres on an action plan to promote energy efficiency and key to its implementation is a website which aims to provide information on how to conserve energy.

The More with Less programme included a grant component. From 2010-2011 a total of €15 million was allocated to home owners that implemented energy saving measures and improved their home's energy efficiency label band, with each receiving a grant of €300-750. This assistance ended in 2011.

Ex-post monitoring reports indicate that the effect of the measures was to improve the efficiency of about 1.2 million homes by 20-30% over 2008-2012, which is in line with the target.[57] This equates to about 4,000-6,000 GWh in total.[58] Note that the More with Less programme not only consisted of grants but also advice and facilitation. It is not possible to assess the effectiveness or cost-effectiveness of the grants separately.

4.3.4 New Zealand

Warm Up New Zealand: Heat Smart was in operation from 2009 to 2013. The programme provided grants for the installation of energy efficiency measures and heating systems in homes built prior to 2000. It was targeted at both owner occupiers, and landlords. The level of government grant funding received depended on the income of the household, and the kind of efficiency measure implemented:

- All income levels: 33% of the costs of installing ceiling and under-floor insulation up to a maximum of £550 were covered
- Low income levels: Up to 60% of the total cost of insulation and £500 towards a clean heating appliance, provided the home was first insulated. Landlords whose tenants were low-income earners could also receive the 60% subsidy, however only £210 was supplied towards a clean heating.

From an initial target of 188,500 homes, 235,000 were insulated under the programme: 15% of all homes in New Zealand. An evaluation[59] of the programme's impacts shows that the measures installed under the programme lead to a 0.96% reduction in average annual household electricity use as a result of receiving an insulation retrofit under the programme and 0.66% reduction in annual total metered energy used. The energy savings are low and one could conclude the programme has been ineffective. However, a large share of Warm Up New Zealand: Heat Smart focused specifically on low-income households which means that a lot of the savings are taken back as comfort (rebound effect).

The cost of providing the measures were about £1,200 per household i.e. £280 million in total over the 5 years the programme has been in operation. This equates to about £5.9-8.6 / kWh which is not cost-effective if only the energy cost savings are considered.[60]

However, another evaluation[61] shows that the other benefits in the form of health improvements of the residents by far outweigh the energy cost savings and result in the programme having positive net benefits.

4.3.5 Sweden

The Programme for Buildings with Very Low Energy Use (LAGAN) is funded by a £ 4.2 million grant for stimulating energy-efficient new buildings and conversions (40% funded by the Swedish Energy Agency). At the time of writing 1 SEK is equivalent to about 0.1 €, and this corresponds to 561,660 €.

An evaluation which is to be released in the Autumn of 2015[62] states that most grants have not enabled new or "unplanned" projects (even without the grant many projects would probably still have been completed). However grants have enabled projects to increase their ambitions, deepen their analyses, increase their scope of the project or increase their dissemination of the project's results. There are currently no data available that would allow an assessment of the scheme's cost-effectiveness.

57 AgentschapNL (2012): Energie besparingsmonitor 2010-2011
58 based on http://www.indicators.odyssee-mure.eu/benchmarking.html
59 Grimes et al. (2011): Warming Up New Zealand: Impacts of the New Zealand Insulation Fund on Metered Household Energy Use
60 Assumed 30 year lifetime.
61 Grimes et al. (2012): Cost Benefit Analysis of the Warm Up New Zealand: Heat Smart Programme
62 personal communication with Roger Eriksson, Swedish Energy Agency

4.3.6 Oregon

The Home Energy Solutions programme is offered by the Energy Trust of Oregon since 2002 and is financed by public funds collected through energy bills. For single family homes, the programme provides cash incentives for energy efficiency and renewable energy measures approved by the programme. The amount of grants offered depends on the combination of measures and is relatively modest with most homes unlikely to receive more than €1,000 based on current rates.[63]

Data on the Home Energy Solutions for Existing Homes (HES) programme is limited and the only evaluation identified is now dated. According to this evaluation from 2007-2008 45,716 homes were refurbished using the grant incentives provided. The associated energy savings were 10 GWh of electricity and 15 GWh of gas.

There is no data on the cost of the programme which would allow a calculation of the cost-effectiveness.

4.4 Tax incentives and investment schemes

There are several varieties of tax incentives for energy efficiency including tax deductions, tax credits, and tax rebates.[64] In principle tax incentives have a similar effect as grants as they lower the cost of investing in energy efficiency measures, although they require households to have the finance in place to fund the measures upfront. 6 of the 7 countries studied in Stage 2 provide grants or loans to help meet part of all of this upfront cost except the Netherlands. However, tax incentives are often in place for longer periods of time providing more stability to the energy efficiency market and investors.[65]

4.4.1 France

The French tax credit scheme called Crédit d'impôt développement durable (CIDD) had been in place since 2005 and was replaced in 2014 by the Crédit d'Impôt Transition Energétique (CITE). Initially, the scheme was supposed to support primarily low-cost measures but in 2012 the focus shifted towards deeper retrofits. The programme is state-funded and every year the budget for CITE is voted on in parliament and thus terms and conditions can fluctuate year by year. To apply to the scheme, individuals having carried out eligible works will only recover their tax credit in the following year. The rebate covers 30% of the refurbishment costs (excluding labour costs, subject to exceptions), with an upper limit of €8,000 for a single person, or €16,000 for a couple under joint taxation. This amount is increased by €400 per dependent.[66]

4.2 million households benefited from measures promoted through CIDD scheme between 2005 and 2008 which represents 13% of the French housing stock. Most of the beneficiaries were higher-income earners with a very small share of low-income households participating (only 1.6% of the lowest 20% income quintile compared to 9.1% of the highest income quintile) as an official evaluation has shown.[67]

Energy savings have been calculated by two different models, the SceGES model developed by the Ministry of Ecology, Sustainable Development and Energy as well as the Menfis model developed by the French Environment and Energy Agency ADEME. Primary energy saved until 2020 through CIDD scheme implemented between 2008 and 2012 compared to a situation without the CIDD available are estimates to be 17.1-19.2 TWh.[68] Note that those figures do not account for free-riders and rebound effects which means they are probably overstating the savings. Free-rider effects have been estimated independently to be very high, exceeding 50%.[69]

Figures on the cost-effectiveness are not readily available. The cost per tonne of CO_2 saved through CIDD from 2005 to 2012 is estimated to be €93/t CO_2.[70] Assuming that the energy savings were

63 http://programs.dsireusa.org/system/program/detail/2426
64 For a detailed description see IEA 2012.
65 WEC (2011): Policies for the future: 2011 assessment of country energy and climate policies
66 http://vosdroits.service-public.fr/particuliers/F1224.xhtml.
67 MEDDTL (Ministère de l'Ecologie,du Développement Durable, des Transports et du Logement) et al. (2011): Synthese de l'évaluation du credit d'impot développement durable", Rapport du comité d'évaluation des dépenses fiscales et des niches sociales – Annexe D, Ministère de l'Economie, des Finances et de l'Industrie, Paris
68 MEDDTL et al. (2011)
69 Nauleau, M.L., (2014): Free-riding on tax credits for home insulation in France: An econometric assessment using panel data. Energy. Economics 46, 78–92
70 MEDDTL et al., (2011)

delivered in proportion to the heating fuel mix in France[71] using standard conversion factors for electricity[72] and other fuels[73] this equates to €0.013 / kWh which is highly cost-effective.

4.4.2 Ireland

The Irish tax credit scheme called the Home Renovation Incentive (HRI) provides for tax relief by way of an Income Tax credit at 13.5% of expenditure on repair, renovation or improvement works carried out on a main home or rental property by qualified contractors. It is not purely an energy efficiency scheme but supports home renovation more generally. The scheme has only been in place since October 2013 which makes an assessment of its effectiveness difficult given that most interventions require some time (often several years) to be fully operational at scale.

Up to April 2015, The HRI had received registrations for over 20,000 home retrofits from 4,700 contractors, with a value in excess value in excess of €385 million.[74]

Formal cost benefit analysis of the scheme is difficult as cost and/or energy savings figures from installed measures are not reported on. When applying the credit award figure of 13.5%, the qualifying works value of €385 million translates to a cost to the exchequer of €51.975 million in tax forgone for the scheme up to April 2015. With 20,000 qualifying works registered on the online scheme, this leads to a subsidy of €2,598 per individual job.

However, not all of the works are energy efficiency related as the HRI covers also non-energy efficiency technologies such as construction works and landscaping. Without cost figures for the energy efficiency related expenditure and the energy savings estimates it is not possible to assess the cost-effectiveness of the scheme.

4.4.3 Netherlands

In the Netherlands a reduction of the VAT rate from around 20% to 6% applies to renovation and refurbishment of residential buildings, the fitting of insulating material and the labour component for the fitting of glass. There has been no evaluation of the effects of the measure which makes it difficult to assess its effectiveness. Other similar VAT reductions in the Netherlands have not led to significant uptake of demand which suggests the tax reduction in itself is unlikely to provide a significant stimulus but it does support the other policies in that it makes their delivery less costly and financially more attractive.

4.4.4 Sweden

In Sweden, property owners have the opportunity to receive a tax reduction of 50% of the costs of work to repair, maintain, convert or extend their property for single family houses (houses, condominiums and privately owned flats). The maximum rebate is SEK 50,000 per owner per annum, (currently equivalent to 5,196 €) and some of these measures are related to energy efficiency (e.g. a property with two owners could have up to SEK100,000 capped by the amount paid in taxes).

It must be noted that this measure was not singularly aimed at incentivising energy efficiency retrofits. For this reason, no specific evaluation of the energy impacts has been done. The Swedish National Board of Housing, Building and Planning and the Swedish Energy Agency prepared a report in 2014 on the national strategy for investment in renovations to improve energy efficiency, in which they estimate the impact of various energy efficiency programmes. However, no disaggregated assessment exists that would allow and analysis of the effectiveness of the tax breaks.

4.4.5 Oregon

Oregon's Residential Energy Tax Credit (RETC) has been in place since 1978 and is anticipated to run at least until 2018. From 1998 to 2007 almost 300,000 measures were supported by the programme.[75] 90% of the measures were energy efficiency appliances. The annual savings generated have been estimated to be 0.14 TWh per year (electricity and natural gas) which equates to about 0.4% of final

71 ADEME, 2011. Batiment Edition 2011 Chi res cles. Agencede l'Environnement et de la Maitrise de l'Energie, Centrede Sophia Antipolis
72 IEA, 2012. CO2 emissions rom uel combustion Highlights(2012 edition). International Energy Agency, Paris.
73 http://www.energysavingtrust.org.uk/content/our-calculations
74 15. The Office of Revenue Commissioners (2015): Annual Report 2014, April 2015
75 Brown, M. (2010): State Tax Policies to Encourage Energy Efficiency

energy consumption in homes in Oregon. Assuming a 10 year lifetime this implies lifetime savings of 1.4 TWh.

The cost-effectiveness has not been evaluated formally but based on a total spend in the form of tax credits of $45 million the cost per kWh was about $0.03 which is significantly below current electricity prices of $0.1/kWh[76]. According to an evaluation of the economic impacts for the years 2007 and 2008 the administrative cost of the programme was just 3% of the total subsidy cost.[77] This figure suggests that RETC was highly cost-effective. It is not clear whether or not the energy savings include free-rider effects (i.e. energy savings that would have happened even in absence of the programme[78]) and rebound effects. A free-rider effect would occur if a tax credit was received for something the householder would have done anyway. However, the evaluation of the economic benefits of RETC assumes that only 20% of beneficiaries were free-riders. Note that most of the measures delivered under the scheme are appliances which are very cost-effective but where additional savings are now much harder to achieve due to higher penetration levels.

4.5 Energy Efficiency Obligations

An Energy Efficiency Obligation (EEO) is a regulatory mechanism that requires obligated parties to meet quantitative energy savings targets through implementing cost-effective end use energy efficiency initiatives. EEOs usually put an obligation on energy suppliers and/or distributors to save a set amount of energy at the customer end through a range of defined energy efficiency measures. The cost of implementing the measures is passed through to the customers via a surcharge on energy. EEOs of a significant scale only started operating relatively recently which means that there is limited evidence on the effectiveness of EEOs in terms of countries where they have been in place for many years. The EEOs analysed as part of Stage II this report have been operational for only a few years so far.

Longitudinal data exists, however, for the UK where EEOs have been in place since the early 1990s. In the following section we provide also a detailed analysis of the effectiveness of EEOs in the UK.

4.5.1 France

The white certificates scheme (certificats d'économies d'énergie – CEE) was first introduced in 2005. CEE is currently running in its third triannual period. The scheme obliges energy providers to meet the set targets for triannual energy savings. Obligated parties include energy suppliers of electricity, LPG, domestic heating oil, gas, and transport fuels. They are allowed to buy and sell CEE certificates between them. Savings can be achieved across all sectors including the residential sector, which has historically been the most important sector in terms of savings.

For the first triannual period (1st July 2006 to 30th June 2009), the national objective was set to 54 TWh (lifetime) in savings. In the first period, energy savings were higher than expected: 65.3 TWh (lifetime) were produced. The energy breakdown was as follows: 86.7% from the residential sector. Also in the second period of CEE most of the savings (almost 90%) have been achieved in residential buildings.

In the first period, ADEME estimated associated costs for the energy companies at €210 million corresponding to €0.0039 /kWh.[79] There is no public evaluation available on the total expenditures for the second period, however the cost per kWh cumac has been estimated at €0.0037.[80] These figures indicate a very high cost-effectiveness. The scheme is currently in its third period and no results are yet available.

4.5.2 Ireland

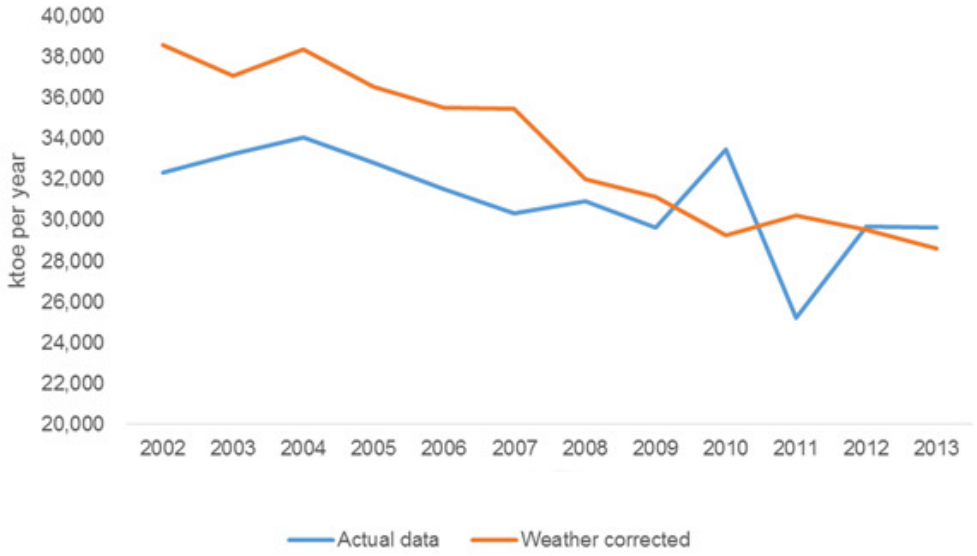
In the case of Ireland EEOs only started in 2014 after a voluntary scheme and the Sustainable Energy Authority of Ireland (SEAI) only recently analysed the data of the first year of the EEOs but this is not yet available in the public domain.

76 http://www.electricitylocal.com/states/oregon/
77 ECONorthwest (2009): Economic Impacts of Oregon Energy Tax Credit Programs in 2007 and 2008
78 Rosenow, J., Galvin, R. (2013): Evaluating the Evaluations: evidence from energy efficiency programmes in Germany and the UK. Energy & Buildings 62, pp. 450–458
79 http://www.developpement-durable.gouv.fr/Principes-du-dispositif.html
80 ENSPOL (2015)

4.5.3 Example of EEOs in the UK[81]

The UK has the oldest EEOs in the EU starting in 1994 which makes the UK a good case for evaluating the evidence on the impact of EEOs on energy consumption.

From 1990 to 2004 gas (the main fuel used for heating in the UK) consumption increased by 32% (not corrected for weather). This was largely a result of increasing indoor temperatures and floor space. From 2005 to 2012 gas consumption decreased by 13% (not corrected for weather) and 25% (corrected for weather).



Source: DECC 2014, Energy consumption in the UK. London, DECC and DECC 2014, Energy trends section 7: weather. Online: https://www.gov.uk/government/statistics/energy-trends-section-7-weather

The change in consumption since 2005 has been driven by a range of factors including energy efficiency improvements. In 2005 the target of EEOs was doubled (compared to the previous EEO scheme, the Energy Efficiency Commitment 2002-2005). Also, from 1 April 2005 gas boilers were required to be condensing type boilers. Together, the policy changes resulted in significant energy efficiency improvements.

Analysis by the Centre for Economics and Business Research carried out on behalf of British Gas[82] in 2011 investigated the drivers behind the reduction of gas consumption in the period 2006-2009. The analysis considered factors such as:

- households, population and income;
- temperature;
- energy efficiency measures; and
- other factors e.g. government initiatives, increasing environmental awareness and climate change concerns

The analysis concluded that the largest impact on the reduction of gas consumption resulted from the installation of energy efficiency measures such as cavity and loft insulation and condensing boilers. About 2/3 of the decline of gas consumption of 4.9% per annum was attributed to energy efficiency measures (3.3%) of which 36% was due to insulation (1.2%).

As a large share of the insulation measures were promoted by EEOs one would expect that EEOs were the primary driver of savings resulting from insulation measures. A bottom-up analysis of the Carbon Emissions Reduction Target (CERT) which ran from 2008 to 2012 suggests that annual savings of around 1% of final consumption in the household sector were achieved in the period 2008-2012.[83]

[81] Please note that this is an extra insertion, not part of the project scope but known to the authors and added to give additional insight.
82 Centre for Economics and Business Research 2011, British Gas Home Energy Report 2011. An assessment of the drivers of domestic natural gas consumption. London, Centre for Economics and Business Research
83 Own calculations based on personal communication with Prof Nick Eyre and Dr Eoin Lees and three independent calculations using the official impact assessment and the final report provided by the regulator.

Alongside CERT ran the Community Energy Savings Programme (CESP), another EEO with a focus on area-based approaches to delivery and higher cost measures such as solid wall insulation. CESP had a target equivalent to about 10% of CERT. Therefore, together, EEOs in the UK in the period 2008-2012 delivered about 1.1% savings of final energy consumption in the household sector. This is in line with the analysis by the Centre for Economics and Business Research.

To conclude, the evidence from the UK suggests that EEOs have achieved about 1.1% savings of annual final consumption in the household sector. Note that the CERT and CESP schemes were replaced by the Energy Company Obligation in 2013 that has much reduced energy saving targets.[84]

4.6 Energy taxes

All EU Member States have to apply a minimum tax on energy. On the basis of this principle, the Energy Taxation Directive sets minimum rates of taxation for a range of fuels including heating fuel and electricity. The levels of taxation applied by Member States may not be lower than the minimum rates set in the directive. A recent evaluation of the implementation of the Energy Efficiency Directive shows that 12 Member States use energy taxes for the purpose of complying with Article 7 of the Directive which sets an annual 1.5% energy consumption reduction target.[85]

4.6.1 Netherlands

The Regulating Energy Tax was introduced in 1996 and is a measure by the Dutch Ministry of Finance. The aim of the tax is to encourage the efficient use of energy. It is applied as a levy on the use of electricity and gas for household use and also in certain commercial sectors.

The levy amounts are divided into tiers. For example in 2014 the tax for most households was € 0.1185 per unit of electricity (usage between 0 – 10,000 kWh) and €0.1894 per unit of gas (up to 170,000m^3).[86] The tax is significantly higher than the minimum tax rates set by the EU Energy Taxation Directive.

No recent evaluation or documentation on the results of the Energy Tax on the energy use of households can be located.

4.7 Regulatory measures and standards

4.7.1 Germany

Germany's Energy Savings Ordinance (EnEV) provides minimum requirements for the energy performance of the building envelope and systems for new buildings and major renovations of existing buildings (affecting more than 10% of the building fabric).

There is an ex-ante evaluation of the CO_2 savings of the 2013 Ordinance but this does not provide a disaggregated analysis of new and existing and residential and non-residential buildings. An independent paper assessing the effectiveness of the EnEV for home renovations suggests that the requirements are not economic because the standards are going beyond the cost-effective levels and are too stringent.[87]

4.7.2 New Zealand

New Zealand introduced minimum energy performance standards (MEPS) for appliances in 2002: these specify performance requirements for the appliances, limiting the amount of energy they consume performing specified operations. According to the EECA annual report, these limits on energy use of residential products is estimated to have saved 2,389 GWh of energy since it started in 2002, worth $230 million. In 2013/14 MEPS resulted in 528 GWh of energy savings.

Information has not been found on costs to enable the cost effectiveness to be estimated.

84 Rosenow, J., Eyre, N. (2015): Re-energising the UK's approach to domestic energy efficiency. In: Proceedings of ECEEE Summer Study 2015
85 Rosenow, J., Forster, D., Kampman, B., Leguijt, C., Pato, Z., Kaar, A.-L., Eyre, N. (2015): Study evaluating the national policy measures and methodologies to implement Article 7 of the Energy Efficiency Directive. Study for the European Commission
86 https://www.ser.nl/en/publications/publications/2013/energy-agreement-sustainable-growth.aspx
87 Galvin, R. (2010): Thermal upgrades of existing homes in Germany: The building code, subsidies, and economic efficiency. Energy and Buildings 42 (6), pp. 834-844

4.7.3 Sweden

In 2012 minimum energy performance requirements were introduced for modifications to homes. There are detailed requirements which depend on the size of the alteration and capability of the building. An alteration may be changing a window, and in that case the replacement must be as energy efficient as those required for new buildings. When it comes to remodelling the building regulations applies fully.

No specific review of this intervention has been found that would allow an explicit assessment of its effectiveness. A 2014 report on the national strategy for investment in renovations to improve energy efficiency looks at the minimum energy requirements, along with several other instruments, and it was not possible to isolate the evaluation of individual measures.

4.8 Advice programmes

4.8.1 Germany

We assessed two advice related programmes, namely the Energy advice at the premises of the consumer programme (Vor-Ort-Beratung) and the Electricity Saving Initiative (Stromsparinitiative).

Energy advice at the premises of the consumer programme

The Energy advice at the premises of the consumer programme has been operating in different formats since 1998. The scheme provides households with independent information on retrofit options and finance programmes available. The service is subsidised by the Federal Ministry for Economic Affairs and Energy charges for advice are between €5-45.

In 2009 more than 30,000 households used the advice programme but this dropped by 50% in 2012 and there are concerns around the effectiveness of the programme. An evaluation by the Federal Office of Economics and Export Control[88] estimates that each household that participated in the programme saved about 6,000 kWh per year which is a significant saving. However, the evidence on the causality of the energy advice programme triggering the reduction is relatively thin and it could well be that the savings are at least partially independent of the programme.

The cost of the programme in 2012 were €4.9 million of which 23% were administrative cost. The cost per kWh saved per year was 0.14 €. Assuming a lifetime of 30 years the cost for the lifetime savings are 0.005 € / kWh which is highly cost-effective.

Electricity Saving Initiative

An evaluation by CO2 Online[89], a consulting firm, provides data on the impact of the programme. Until the end of 2013 43,394 households used the advice offering. Of those 20,960 participated in a deeper advice offering. For those who participated in the deeper advice offering 64% changed their behaviour regarding energy consumption and 46% purchased new appliances to save energy. In total, the effect of those changes is estimated to be 6.3 GWh per year. However, only about 15% of the participants stated that the advice programme had a significant effect on their energy saving behaviour and purchasing decisions. If only those participants are considered the savings would be 0.9 GWh.

The cost of the programme for setting up the online website were €600,000 until mid-2013. Assuming no further resources were spent in 2013 the cost per kWh would be €0.06 assuming a 10-year lifetime for the appliances. This would be very cost-effective. However, we could not identify more recent cost data and the cost may well be higher.

4.8.2 New Zealand

New Zealand has implemented a range of instruments providing advice and increasing awareness including the ENERGYWISE Information Campaigns and Websites, ENERGY SPOT television series, ENERGY STAR appliance endorsement mark, RightLight consumer efficient lighting campaign and the EECA corporate and business websites.

It is not possible to provide figures on the effectiveness in terms of energy savings as the advice programmes help facilitate the other energy efficiency programmes – they act as a gateway referring

[88] Federal Office of Economics and Export Control (2014): Evaluation der Energiesparberatung vor Ort
[89] CO2 Online (2013): Evaluation StromCheck BMU Stromsparinitiative

people to other programmes offering funding for energy efficiency retrofits. Other metrics for effectiveness are used instead.

Awareness of the ENERGYWISE brand is very high at 65%. In 2010, the ENERGYWISE™ website won the 2010 Internet Industry Awards in New Zealand, as the website was recognized for having the most 'Positive Societal Impact'.[90] The Energy Spot has been on air since 2009 and has been viewed by around 2.4 million New Zealanders, with 41% saying they have taken action to reduce energy use as a result.[91] In 2013/14 39% of viewers took action as a result of seeing the episodes, practically achieving the EECA target of 40%. Actions taken ranged from turning off appliances and lights when not in use, to installing energy efficient light bulbs or draught stopping in winter.

Due to the lack of data on energy savings cost-effectiveness cannot be calculated.

4.8.3 Sweden

The Swedish Energy Agency[92] estimated that the overall effect of the Swedish advisers' activities aimed at households is in the range 0.48 to 1.04 TWh / year. There is significant uncertainty, however, and the authors acknowledge that it is very difficult to express the impact of advisors activities on energy savings on a TWh basis.[93]. There are 250 advisors (approximately) who support 290 municipalities. The energy and climate advice is targeted at a number of target groups and areas including industry, transport and homeowners. The advice offered includes technology neutral advising on "energy" issues – e.g. energy efficiency interventions to the home, for example, or which kind of heat pump to use, or insulation to adopt. It also includes "climate" advice, to support the decreased use of fossil fuels.

30% of homeowners in Sweden say they have contacted energy advisors. Of these, 70% state that the advice had an impact on their actions. Those who approach advisors are usually already engaged in the subject, having done some preliminary research and requiring impartial advise as to which technology (for instance) to choose. It is not clear how many of those would have undertaken energy efficiency improvements also in absence of the advice.

The cost of the programme is about £10 million[94] which equates to a cost-effectiveness of 0.03-0.07 pence / kWh assuming a 30-year lifetime of the measures installed as a result of the advice. This indicated an extremely high cost-effectiveness.

4.9 Summary and comparison

The purpose of this analysis is to identify specific interventions that have been more or less effective and why. No single intervention type is superior to others – it depends very much on the policy design and the context whether an intervention achieves a significant impact.

Notably all of the effective schemes were supported by a high level of public subsidy, either through general taxation (for example in Germany and France), government grants (Oregon), or through energy bills (Ireland and EEO example from the UK). We did not identify a policy instrument that delivered large amounts of savings purely through providing a framework for the market to function in (which has been the intention of the Green Deal which clearly failed to deliver at scale[95]).

Overall, we conclude that:

- **Loans**: Loans can be very effective as the case of Germany shows where the programme received a large amount of funding through general taxation and has been in place over a long period of time now. The programme is generous and offers attractive financial conditions to households. However, even if the financial conditions are attractive uptake can be hampered by rushed policy changes as in France where demand has declined despite a 0% interest rate. If delivered through retail banks the evidence suggests that engaging with the banks is crucial so that they promote the loans to their customers.

90 http://www.eeca.govt.nz/news/energywise%E2%84%A2-website-wins-award-its-positive-impact-new-zealand-society
91 http://www.eeca.govt.nz/eeca-programmes-and-funding/programmes/homes
92 Swedish Energy Agency (2013): Implementering av artikel 7 i energieffektiviseringsdirektivet – Energimyndighetens beräkningar och förslag, ER 2013:04
9393 Personal communication Hans-Olof Karlsson Hjorth, National Board of Housing Building and Planning
94 ENSPOL (2015): Energy Saving Policies and Energy Efficiency Obligation Scheme - D3.1: Report on Alternative schemes to Energy Efficiency Obligations under Article 7 implementation, March 2015
95 Rosenow, J., Eyre, N. (2015): Re-energising the UK's approach to domestic energy efficiency. In: Proceedings of ECEEE Summer Study 2015

- **On-bill finance**: Due to the relatively short experience with this type of interventions there is a lack of evidence on on-bill finance programmes. Contrary to expectations, evaluations of programme in Oregon cast doubt on effectiveness of on-bill finance schemes compared to other programmes largely resulting from the intervention being more complex than alternative schemes.
- **Grant schemes**: Our analysis shows that grant schemes can work well and at scale as experience from Ireland shows.
- **Tax rebates**: Overall tax rebates appear to perform consistently well and also over long periods of time as they are not subject to budgetary fluctuations as much as grants and loans. This provides long-term stability to the market. Tax rebates are not only available to those paying tax (depending on the design) but often to any household regardless of whether or not they pay tax. It is unlikely that tax rebates fund deep renovations as the funding is usually release after the retrofit leaving the household with the upfront cost.
- **Energy efficiency obligations**: Energy efficiency obligations can be very effective as emerging evidence shows. Because of their focus on low-cost measures[96] they are effective and cost-effective too. It is, however, hard to see how obligations could be applied to more capital-intensive measures including solid wall insulation[97] given the distributional effects.
- **Advice**: Advice programmes are often used to facilitate other energy efficiency programmes. An excellent example is New Zealand's ENERGYWISE website which acts as a gateway to funding from all the programmes.

4.9.1 Comparison of effectiveness

The analysis above treats each intervention individually. Table 4 shows the effectiveness of all interventions analysed in comparison.

Table 4: Comparison of effectiveness of different types of interventions

	Germany	France	Netherlands	Sweden	Ireland	Oregon	New Zealand
Loans	✓++	✓--					X
On-bill finance						✓-	
Grants	✓++		✓++	X	✓++	✓+	✓-
Tax rebates		✓++	X	X	X	✓++	
Energy efficiency obligations		✓++			X		
Advice programmes	✓+			✓++			✓+
Regulation	✓+			X			✓+
Energy taxes			X				

Data availability on effectiveness:

✓: data on effectiveness available

X: no data on effectiveness available

If data available:

++: highly effective

+: effective

-: not very effective

--: very ineffective

Based on the analysis provided above the cost-effectiveness figures are compared in Table 5. The comparison suggests that:

- the advice programmes achieve the highest cost-effectiveness;

96 There are a variety of reasons for this. First, energy companies deliver their targets through the cheapest routes i.e. focus on low-cost measures. Second, EEOs usually deliver standardisable measures and not complex retrofits. Third, it is more difficult to get a significant contribution from households for high-cost measures. Finally, the disruption and hassle makes complex high-cost measures a more difficult sell.
97 This was tried in the UK but soon reversed, see Rosenow and Eyre 2015

- the rebates and EEOs are also particularly cost-effective;
- the loans analysed are not more cost-effective than grants; and
- on-bill finance in Oregon is not more cost-effective than conventional loans or grants in other countries.

The order of cost-effectiveness by instrument type generally in line with expectations with one exception: Loans are usually attributed with higher leverage than grants (because the subsidy is used to reduce the interest rate rather than paying for part of the cost and allows households to overcome the barrier of up-front capital cost). The data derived in this analysis does not support this assertion.

However, the results should be treated with caution because a) the sample size is small and b) the basis for their calculation is not the same (different methodologies for calculating the energy savings in the programme evaluations for example). Also, the assumptions made around the causality of specific programmes and the decision to renovate a property are uncertain to some extent as the degree of free-ridership is often unknown.

Table 5: Cost-effectiveness of different schemes in €/kWh

	Loans	On-bill finance	Grants	Rebates	EEOs	Advice
Ireland			Programme 1: €0.06 Programme 2: €0.02	N/A	N/A	
France	€ 0.10			€ 0.01	€ 0.004	
Oregon		€ 0.08	N/A	€ 0.03		
Germany	€ 0.03		€0.009			Programme 1: €0.005 Programme 2: €0.06
New Zealand			(€8-€11 ,outlier)			N/A
Sweden			N/A	N/A		€0.0004-€0.001
Netherlands			N/A	N/A		

4.9.2 Interaction of policy instruments

The analysis above concerns the effectiveness of individual instruments rather than their interaction with other policies. We have not carried out a systematic assessment of instrument interaction and the role of the policy mix. A forthcoming paper by one of the authors explicitly analyses the role of the policy mix for building energy efficiency.[98]

More generally, the literature[99] [100] [101] [102] suggests that combinations of policies fulfilling the same function (for the same technology and target group) are more likely to be counter-productive than combinations which accomplish different functions.

However, in many cases policy instruments address multiple goals and are used to mitigate unintended effects of another policy instrument (for example financial instruments can be used to support low-income households to comply with building minimum standards). In other words, it may be legitimate to combine policy instrument types even if the overall effect on energy savings is diminishing. Hence the goal is not to always avoid such combinations where the overall effect is diminishing but to assess in which circumstances interaction between policy instruments is acceptable or unacceptable.[103]

Three instruments that are often combined are grants, loans and tax rebates.[104] Recent work on energy efficiency finance by the Energy Efficiency Financial Institutions Group (EEFIG)[105] suggests that

[98] Rosenow, J., Fawcett, T., Eyre, N., Oikonomou, V. (submitted to Building Research & Information): Energy efficiency and the policy mix
[99] Gunningham, N., Sinclair, D. (1999): Regulatory Pluralism: Designing Policy Mixes for Environmental Protection. Law & Policy 21, pp. 49–76
[100] Kosonen, K. and Nicodeme, G. (2009): The role of fiscal instruments in environmental policy. Taxation Papers. Working paper No. 19 2009. Luxembourg: Office for Official Publications of the European Communities
[101] Lee, W.L., Yik, F.W.H. (2004): Regulatory and voluntary approaches for enhancing building energy efficiency. Progress in Energy and Combustion Science 30, pp. 477–499
[102] Sorrell, S., Smith, A., Betz, R., Walz, R., Boemare, C., Quirion, P., Sijm, J., Konidari D M P, Vassos, S., Haralampopoulos, D. and Pilinis, C., 2003. Interaction in EU climate policy, SPRU, Sussex
[103] ibid.
[104] see also forthcoming paper by Rosenow et al. cited above
[105] EEFIG (2015): Energy Efficiency – The First Fuel for the EU Economy: How to Drive New Finance for Energy Efficiency Investments

blending of loans and grants can help increase the uptake of energy efficiency significantly and points out the following best-practice approaches:

- single, streamlined application and approval process through multiple retail facing outlets with clear criteria and a swift response (as opposed to multiple channels with separate application and operating procedures and agents);
- increased grant component, lower interest rates and/ or public support for ambitious levels of, and verifiable, energy savings;
- structural incorporation of an independent energy (or technical) advisor who delivers trust and confidence into the process for both client and investor, provides programme outreach and can help scope and manage the project; and
- the provision of project development assistance to build investment project pipelines.

5 Key themes

This section provides an analysis of key themes such as:

- drivers (those explain why some countries might adopt specific intervention types);
- critical success factors (those explain why the interventions worked);
- barriers (those explain which barriers the intervention faced);
- co-benefits (other benefits besides the energy savings); and
- unintended consequences (effects encountered but not anticipated).

For each of the themes we identify where we found those and how often. However, the data presented below is based on a relatively small number of interventions per country and it is likely that this is not representative of the whole energy efficiency policy package. Hence where a country has not been linked to a specific theme this does not mean it is completely absent.

5.1 Drivers

The drivers of specific interventions are very different from country to country. The discussion below relates to the selection of interventions rather than the policy landscape in each country as a whole. It is possible that other drivers are relevant but not so relevant for the interventions we analysed and/ or that the drivers were simply not discussed in the evidence we reviewed.

We found that the multiple benefits of energy efficiency are reflected in the drivers across the cases:

- **Fuel poverty alleviation**: In 3 out of the 7 countries we found this to be a major driver for the interventions we analysed.
- **Health**: Only the interventions in one country were directly linked to health issues. In New Zealand health is clearly a major driver of energy efficiency.
- **Climate change policy**: Whilst all interventions have an effect on carbon reduction only some interventions are explicitly linked to climate change policy. Climate change policy has been an important driver in Germany indicated by the name of the KfW programme CO_2-Building Rehabilitation Programme.
- **Job creation**: Most of the programmes we analysed are linked to job creation with some of them deliberately set up during the recession to help the struggling construction industry.
- **Preference for self-regulation**: Not an important driver overall this applies only to the Netherlands where the More with Less programme reflects the spirit of self-regulation.
- **Preference for market-based solutions**: Of those interventions we reviewed the Swedish energy tax is the only intervention that is based on a preference for market regulation.

Table 6 shows all drivers by country providing a specific example of interventions where this driver was particularly relevant.

Table 6: Comparison of drivers across countries analysed

	Germany	France	Netherlands	Sweden	Ireland	Oregon	New Zealand
Fuel poverty		Eco-PLS			Energy Efficiency Obligations Better Energy Warmer Homes		Warm Up New Zealand Heat Smart
Climate change policy	KfW programmes	CITE	More with Less		Energy Efficiency Obligations (EED driven)		
Job creation	KfW programmes	CITE	Repair, maintenance, conversion or extension rebate		Better Energy Homes	Clean Energy Works	
Preference for self-regulation			More with Less				
Preference for market-based solutions		White certificates		Energy tax		Residential Energy Tax Credit	
Health							Warm Up New Zealand Heat Smart

5.2 Critical success factors

Critical success factors describe those features that increased the programmes' ability to deliver successfully. Identifying success factors is important for replicating or up-scaling similar programmes as important lessons can be learned on how to design programmes in a way that they perform effectively.

The most important success factors in terms of frequency are:

- **Clarity and simplicity**: If programmes are transparent and sufficiently simple from the households' perspective they are more likely to achieve their intended impacts. A good example is Ireland's Better Energy Warmer Homes programme which has a simple one-page application process.
- **Trusted intermediaries**: Experience shows that trusted intermediaries play a key role for the successful delivery of energy efficiency programmes. For example, in New Zealand the Energy Efficiency and Conservation Authority manages a range of energy efficiency programmes in a consistent way making sure all programmes are well-aligned.
- **Engagement and partnerships with actors involved**: Successful delivery of energy efficiency programmes requires early and ongoing engagement and partnership with the actors involved such as trade associations, community groups, energy companies, charities etc. A good example is the Clean Energy Works (CEWO) programme in Oregon. During the pilot, CEWO partnered with Craft3, a nonprofit community development financing institution, to provide low-interest, long-term financing that participants could repay through their heating utility bill.

- **Effective communication**: Especially new programmes require effective communication to make them known to the public. Probably the best example of this is New Zealand's ENERGYWISE website which acts as a gateway to all the energy efficiency programmes. Awareness of the website in New Zealand is very high which is clearly a success of effective communication.
- **Engagement with low-income rental sector**: The low-income rental sector can often represent a segment of the housing stock that is easier to engage with because the pressures to keep the rents low (especially relevant to social housing) are more prevalent than in other sectors. The success of the Eco loan for social housing (Eco Prêt logement social) in France is partly attributed to this.

Other success factors we found include:

- **Staged approach**: When introducing new programmes a staged approach can help avoid some of the pitfalls that can negatively impact on a programme such as poor workmanship, lack of buy in from stakeholders, and an ineffective delivery architecture. The staged approach can involve an initial phase at a smaller scale, testing the delivery approach or simply a scoping phase allowing for the identification of the most suitable target groups etc. A good example is the Irish Energy Efficiency Obligation which was 'tested' during a voluntary phase prior to its obligatory phase.
- **Increasing scope and flexibility**: Most energy efficiency programmes are limited to specific technical interventions (e.g. insulation). As the programme develops and the potential for some measures declines or if the uptake has been limited increasing the scope of the measures supported can improve effectiveness. Examples of this can be found in Germany where loans also support single measures after initially only supporting packages of measures. The intention was to make the scheme available to a wider audience.
- **Attractive financial proposition**: The financial proposition needs to be effective in any case in order to achieve sufficient uptake. In Germany and France the low-interest loan schemes and the possibility of blending loans with grants and tax rebates has been a success factor we identified.[106]
- **Combination with professional energy advice**: If combined with professional energy advice energy efficiency programmes can be more effective because they a) increase the confidence in the programme from the householders' perspective, b) reduce complexities (e.g. consultant deals with the paperwork), and c) ensure programme resources are spent appropriately. A good example is the German 'Vor-Ort-Beratung' a scheme which provides energy advice from start to finish and is obligatory for those households participating in the loan programme.

The table below provides a summary of all the success factors across the countries analysed. The number of tick marks represents the number of programmes where we found this success factor to be important. The success factors are ranked in the order of prevalence with those most widespread coming first.

Table 7: Comparison of success factors across countries analysed*

	Germany	France	Netherlands	Sweden	Ireland	Oregon	New Zealand
Clarity and simplicity	✓		✓		✓✓✓	✓	✓✓
Trusted intermediaries	✓✓			✓	✓✓✓		✓✓
Engagement and partnerships with actors involved			✓	✓	✓	✓✓	✓✓✓
Effective communication		✓	✓	✓		✓	✓✓✓
Engagement with low-		✓				✓	✓✓

[106] Note that in France the blending of tax rebates and loans is only possible for low-income households.

	Germany	France	Netherlands	Sweden	Ireland	Oregon	New Zealand
income rental sector							
Attractive financial proposition	✓	✓	✓				
Combination with professional energy advice	✓						✓
Staged approach					✓	✓	
Increasing scope	✓	✓					

5.3 Barriers

Barriers in the energy efficiency literature are usually discussed as barriers from the customer perspective (bounded rationality, imperfect information etc.). We discuss barriers in this report as obstacles to programme delivery i.e. factors which made the programme more difficult to deliver. Similar to success factors, this information enables future programmes to be designed in a way that addresses those barriers from the outset. Across all schemes we identified barriers to delivery of the programmes analysed. The most prevalent barriers are:

- **Budgetary constraints**: Programmes that depend on annual budgets (e.g. as part of the national public budget, federal stimulus programmes or utility funding programmes) often suffer from the limited funds allocated to them. Once the funds are exhausted this can lead to an unhealthy start-stop cycle with significant impacts on industry. We found that this barrier was particularly important in Germany, France, Ireland, Oregon and New Zealand.
- **Lack of long-term certainty**: Long-term investments into the energy efficiency industry require long-term certainty. Programmes that are at risk of being affected by funding cuts or even terminated do not provide this long-term certainty and confidence to investors.[107] Similarly, programmes that depend on a set target of energy savings to be reached (such as EEOs) can suffer from frequent changes to the target which has repercussions for the industry as well.
- **Lack of buy-in from actors involved**: Particularly in the early stages of a new programme scepticism and lack of buy in from stakeholders can severely limit the uptake of the programme. Examples of this include the resistance from banks in Germany to promote the KfW programmes for energy efficient retrofits because they deemed their profit margins unattractive. Similarly, banks in France appeared to have been too stringent in terms of the eligibility criteria for loans. Our analysis of the Irish grants programmes shows that a lack of buy-in across the supply chain can limit the effectiveness of the programme (although this was addressed in the Irish case).

Additional barriers include:

- **Supply chain constraints**: If a programme increases the levels of activity in the market for energy efficiency retrofits very quickly this can sometimes be constrained by the capacity of the supply chain to deliver. We found this to be an issue in Ireland where waiting times between application and installations were up to 9 months, although this is an outlier case and most households received the measures more quickly.
- **Limited potential for low-cost measures**: With increasing take-up the potential for low-cost measures gets depleted. This means that the finance model requires adjustments allowing for more capital intensive measures to be supported. In Ireland the reduced potential for cavity wall insulation that remains has been identified as a potential concern and a need to refocus the programmes.

107 Investor confidence was recently highlighted as a key issue in a high-profile report by EEFIG (2015).

- **Complex application procedures**: If the application process is burdensome and not transparent demand for support from the programme is likely to be limited or at least remain beyond what it could be. A good example is the Clean Energy Works (CEWO) programme in Oregon which simplified the loan application process by using bill payment history as a proxy for credit instead of burdensome credit checks by the banks, allowing more homeowners to be eligible for the loans due to their timely bill payments, although this change only happened recently and we are not aware of any evidence available that would confirm how effective it has been.
- **Complex administrative procedures**: In addition to the application procedures from the perspective of the applicant there can be tedious and complex administrative procedures for the other actors involved. For example, as part of the Irish Energy Efficiency Obligation QA procedures were found to be a hurdle when delivering the programme. SEAI lost some installer 'buy-in' when tightening the QA process once already into the delivery of the scheme. Careful consideration and clear communication of QA expectations and procedures at the outset of any scheme would go a long way to avoiding this 'buy-in' barrier.
- **Cost of contribution from consumers**: Most energy efficiency programmes providing finance require a customer contribution which can be high (for the able to pay sector) or low (for those on low incomes). We identified the ability to pay as a potential barrier for programmes such as the German energy advice programme which requires a customer contribution that potentially detracts potential applicants.
- **Geographical coverage**: National energy efficiency programmes sometimes suffer from incomplete geographical coverage, particularly because remote and rural areas are more difficult to reach. Evidence from Germany suggests that its 'Vor-Ort-Beratung', an energy advice service, was not offered in all regions to the same extent. This can potentially lead to some regions being left out.
- **Quality of the workmanship**: Poor quality of workmanship can create a bad reputation of a programme which will be difficult to rectify. An example where this was an issue is Oregon's Home Energy Solutions for Existing Homes (HES) programme. Some participants were dissatisfied by the quality of contractors, indicating that there is a need for the Energy Trust to provide additional training or contractor screening.

The table below provides a summary of all the barriers across the countries analysed. As before, the number of tick marks represents the number of programmes where we found this barrier to be important. The barriers are ranked in the order of prevalence with those most widespread coming first.

Table 8: Comparison of barriers across countries analysed

	Germany	France	Netherlands	Sweden	Ireland	Oregon	New Zealand
Budgetary constraints	✓	✓✓			✓✓	✓	✓
Lack of long-term financial certainty	✓	✓✓		✓	✓✓	✓	
Lack of buy-in from actors involved	✓				✓✓	✓	
Complex application procedures		✓		✓	✓	✓	
Complex administrative procedures		✓	✓		✓	✓	
Cost of consumers' contribution	✓✓			✓✓			

	Germany	France	Netherlands	Sweden	Ireland	Oregon	New Zealand
Geographical coverage	✓			✓			
Limited potential for low-cost measures					✓✓		
Quality of the workmanship						✓	
Supply chain constraints					✓		
Enforcement gap	✓						

5.4 Co-benefits

Co-benefits to energy savings are often intentional as they increase the net-benefit of a programme but also address other policy goals. We found these co-benefits, based on the evidence available:

- **Health benefits**: Energy efficiency programmes are known to potentially lead to significant health improvements, particularly households who under heat their homes can benefit from increased comfort levels. The Warm Up New Zealand: Healthy Homes programme is an excellent example of this and evaluations found the health benefits to exceed energy cost savings by far, making improvements in health the most important benefit of the programme.
- **Employment and economic benefits**: Investing in energy efficiency compares very favourably with investing in other energy sectors in terms of job creation impacts (both direct and indirect). Energy efficiency programmes are often part of a wider stimulus programme (examples can be found in the US and Germany). A well-researched example is the German KfW programme for energy efficiency retrofits where significant employment impacts have been found and are evaluated on a regular basis as part of the ongoing programme evaluation.[108]
- **Fiscal benefits**: The costs of energy efficiency programmes are to some extent offset by additional tax receipts, savings in unemployment benefits payments, and other revenue streams generated as a result of the activities promoted under the programme. This effect can even lead to subsidies becoming self-financing. We identified this effect for Germany where it is explicitly considered and measured for the KfW loan and grant programmes for energy efficiency.[109]
- **Fuel poverty alleviation**: Improving the energy performance of low-income households in particular can help with fuel poverty alleviation. Programmes in Ireland are explicitly focused on fuel poverty alleviation with sub-targets within the Energy Efficiency Obligation to target fuel poor households.

Table 9: Comparison of benefits across countries analysed

	Germany	France	Netherlands	Sweden	Ireland	Oregon	New Zealand
Health benefits					✓✓		✓✓
Employment and economic benefits	✓✓				✓✓		✓✓
Fiscal benefits	✓✓						
Fuel poverty alleviation		✓	✓		✓✓✓		✓✓

108 Kuckshinrichs, W., Kronenberg, T. and Hansen, P. (2010): The Social Return on Investment in the Energy Efficiency of Buildings in Germany. Energy Policy, 38(8), 4317-4329.
109 Ibid.

5.5 Unintended consequences

Unintended consequences are often detected at a late stage of delivery of energy efficiency programmes and can include a wide range of issues such as poor workmanship and its effects on properties, inappropriate measures installed in some properties, perverse incentives etc.

We found the following unintended consequences:

- **Gaming**: Gaming can occur when scheme participants find loopholes which they use for their own benefit. In France anecdotal evidence exists that some professionals inflate their prices when they notice that their clients are recovering costs from tax rebates which is not the intention of the scheme and increases cost of delivery.
- **Regressive effects for low-income households**: Depending on how funds are raised and benefits distributed low-income households can proportionally be disadvantaged. Evidence suggests that to some extent this is the case in Germany where those benefitting from the KfW programmes are likely to be on higher incomes whereas the cost are shared by all households..

6 Conclusions for policy development in Scotland

Improvements in the energy efficiency of homes can have multiple benefits including carbon reduction, fuel poverty alleviation, economic stimulus, and health benefits, the latter if targeted. In this review we have analysed a wide range of interventions aimed at increasing the energy performance of existing buildings from across the world.

Our review shows that:

- No single type of intervention is superior to the others and it depends on the context and policy design how effective they are.
- Long-term stability of interventions is important. This relates to the consistency of funding as well as short-term policy changes which can potentially undermine the intervention's success.
- Schemes that work well and at scale are usually supported by high levels of public subsidy (whether through general taxation or surcharge on energy bills).
- A staged approach when implementing a new programme prevents substantial policy failure by piloting and testing approaches before they are up-scaled.
- All interventions have an impact on a wide range of issues and contribute to multiple policy goals. Assessing those multiple benefits of energy efficiency and linking them explicitly to other areas helps to develop an integrated approach rather than policy silos.
- Overly complex interventions consequently suffer from a lack of demand and buy-in. Successful programmes keep the complexity to a manageable level whilst ensuring the robustness of the intervention at the same time.
- Interventions need to address many of the non-financial barriers if they are going to be effective – an attractive financial proposition on its own is not enough to generate sufficient demand.
- Trust and intermediaries are crucial for the successful delivery of a programme. This will generate demand, encourage buy-in across the supply chain, and ensure effective delivery of the intervention.
- Good evaluations can help to understand a programme's impact and identify potential modifications where needed. Currently there is a lack of data on effectiveness and different interpretations of what effective means (homes renovated, energy saved, fuel poor households helped etc.).

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