SUSTAINABLE ENERGY AUTHORITY OF IRELAND

Unlocking the Energy Efficiency Opportunity

June 2015

Unlocking the Energy Efficiency Opportunity

June 2015

Jim Scheer, SEAI

Emrah Durusut, Element Energy

Sam Foster, Element Energy

With thanks to

The Research Perspective

cambridge econometrics

Baringa

Contents

Figures

Tables

1 Introduction

1.1 Context and project objectives

This report presents a detailed analysis of the potential for energy efficiency improvements across all major energy consuming sectors in Ireland to 2020. This work forms a key evidence base to inform Ireland's national strategy to meet its ongoing obligations with respect to the Recast of the Energy Performance of Buildings Directive (2010) and the Energy Efficiency Directive (2012).

The Irish Government recently released its third National Energy Efficiency Action Plan (NEEAP III), which reinforces its commitment to a national target of a 20 % reduction in primary energy consumption by 2020, including a 33 % reduction in primary energy consumption in the public sector.

This study provides valuable new information for Ireland as it continues to develop its energy efficiency strategy, offering a detailed analysis of the range of measures which could contribute to the target and the variety of policy interventions which could ensure the target is met in the most cost-effective way.

A key objective of this work is to go beyond an estimate of the technical and economic savings potential by incorporating the behaviour and decision-making process of consumers. The aim is to develop realistic estimates of the savings which can be achieved to 2020 under a variety of policy interventions, in order to develop a set of policy scenarios which are successful in meeting the 2020 target and to elucidate the implications of each scenario for the Exchequer.

In addition to this summary report, two further reports will be published describing a series of surveys carried out in the commercial building sector as part of this study. These survey reports provide new and valuable information on the profile of the commercial buildings stock, the energy use in commercial buildings and the behaviour of consumers in the commercial sector regarding energy use and energy efficiency.

1.2 Project scope and methodology

Figure 1-1 below summarises the methodology for the project, which considered the potential for energy efficiency improvements in the following sectors:

- Commercial buildings;
- Public buildings;
- Residential buildings;
- Industry;
- Public utilities;
- Transport.[1]

Process	Key aspects	Key data and tools
Technical energy savings potential	• **Building archetype** generation • National building and vehicle **stock modelling** • Energy savings potential for all **measures**	• Extensive survey of commercial buildings • Building energy models • BER, ND-BER, NCM databases
Economic energy savings potential	• Derivation of **energy efficiency cost curves** • Construction of **energy efficiency packages** (i.e. shallow, medium and deep)	• Costs of measures • Hidden costs • Technology lifetimes • Fuel price forecasts
Investment pathways in Ireland model development	• **'Decision-making processes'** designed for 'Residential', 'Commercial', 'Public' and 'Industry' using **'consumer archetypes'** • Wide range of **policy interventions** modelled	• Survey of consumer behaviour in the commercial sector • Previous consumer behaviour surveys carried out in Ireland and the UK
Economy-wide scenarios meeting the 2020 target	• Economy-wide scenarios constructed with the combination of **sector-level scenarios** (defined with different levels of interventions)	• Investment pathways in Ireland model • NEEAP III estimates for savings already achieved
Exchequer perspective and wider benefits	• Cost to Exchequer • Wider economic benefits	• Investment pathways in Ireland model • Cambridge Econometrics' E3ME model

Figure 1-1: Key aspects of project methodology

For each of these sectors we identified a list of key energy efficiency measures for inclusion. Through a combination of bottom-up stock modelling and scenario development we first derived estimates of the technical energy savings potential of each measure. We then incorporated cost data to calculate the lifetime cost of the energy savings associated

[1] Transport sector in this study includes private cars including alternative fuel vehicles, light duty vehicles, heavy good vehicles and public passenger vehicles.

with each measure. These data, along with the full list of measures modelled, are summarised in the energy efficiency cost curves in Section 2.

The next step was to use these data to develop realistic estimates of the savings which can be achieved to 2020 under a variety of policy interventions. At this stage, we employed two different methodologies according to the sector. For the commercial, public and residential building sectors, and for the industry sector, we developed a detailed model of the consumer decision-making process in order to estimate the uptake of energy efficiency measures under a variety of policy interventions. We populated this model with datasets on consumer decision-making gathered through original fieldwork and through an analysis of existing data. The consumer decision-making model, and the type of input data collected, is described in more detail in Section 3.

As illustrated in the diagram below, the 'Investment Pathways in Ireland' uptake model is the core of our analysis. A significant amount of data on technical, economic and behavioural aspects of energy efficiency, which has been collected throughout the project, was used in this model to construct a set of sector-level scenarios describing the range of savings which could be achieved through feasible policy interventions. The uptake model also includes a set of sector-level scenarios for the transport and public utilities sectors, which were developed off-model based on specific sector-level analysis and literature review.

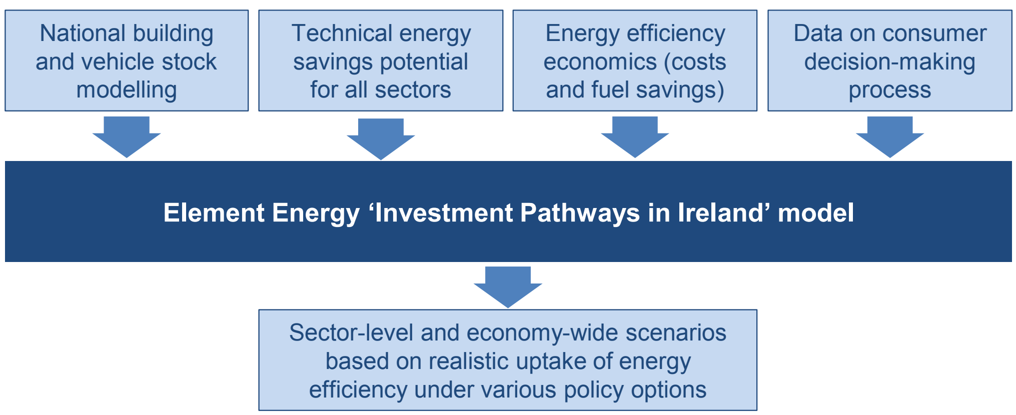


Figure 1-2: 'Investment Pathways in Ireland' model diagram

We then combined the sector-level scenarios to construct a number of economy-wide scenarios meeting the national 2020 target. As described in Section 4, we have compared these economy-wide scenarios in terms of their implications for the Exchequer. For each scenario, we considered the associated cost to the Exchequer; the overall cost-effectiveness and the difficulty of implementation. Furthermore, we assessed the wider macroeconomic benefits associated with each scenario including gross value added, job creation, consumer spending, trade and investment.

Finally, we also considered the 2030 perspective, by estimating the remaining potential beyond 2020 in the commercial buildings, public buildings, residential buildings and industry sectors as described in Section 5.

1.3 Progress on energy efficiency in Ireland

Ireland's 20 % energy efficiency target for 2020 was established in the Government's 2007 Energy White Paper and further detailed in Ireland's first National Energy Efficiency Action Plan (NEEAP) as 31.9 TWh of primary energy savings. The rationale for the 2020 target is explained in more detail in NEEAP III.[2] Additionally, to demonstrate an exemplar role, Ireland has a 33 % energy savings target by 2020 for the public sector, which corresponds to 3.2 TWh of primary energy savings by 2020.

Through a number of National Energy Efficiency Action Plans, Ireland has maintained its commitment to achieving these two targets. Based on the latest NEEAP (III), Ireland has achieved around 12 TWh of primary energy equivalent to 2013 (i.e. end-2012), which corresponds to 39 % of the national target.2 In order to meet the 2020 target, 20 TWh of additional savings should be achieved through an increased level of effort, and a variety of existing and new policy measures.

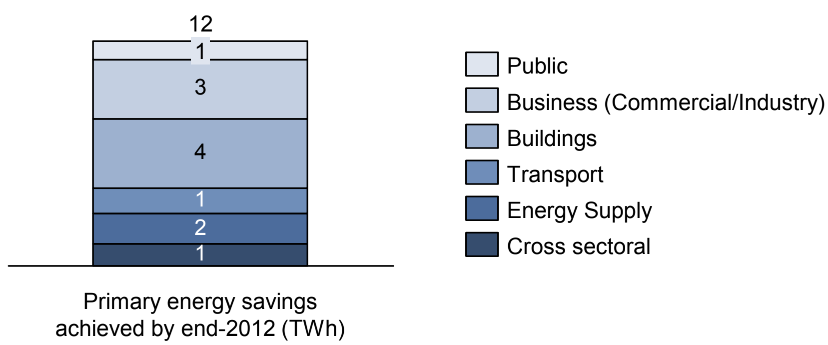


Figure 1-3: Primary energy savings by sector achieved by end-20122

The NEEAP also sets a vision for each of the sectors covered by the Action Plan. The key policy measures for each sector are presented in Table 1-1. All of these policy measures are described in more detail in NEEAP III. Some of the key measures include:

- **The National Energy Services Framework** sets out how an **Energy Performance Contracting (EPC)** process is undertaken. It also provides guidance on routes to project development, together with sources of finance and support available from SEAI to help develop projects in the public and commercial sectors.
- **Energy Efficiency Fund** aims to address the lack of energy efficiency financing in the non-domestic sector by providing structured financing.
- **Energy Efficiency Obligations Scheme** is expected to deliver savings by setting an obligation on suppliers to deliver energy savings in the commercial and residential (including households in energy poverty) sectors to meet annual targets until 2020.
- **Better Energy Financing (BEF)** is a type of Pay-As-You-Save scheme, which is currently under consideration. BEF is intended to overcome the finance barrier in the residential sector by providing accessible finance to householders.

[2] NEEAP I, II and III are available at: http://www.dcenr.gov.ie/energy/energy+efficiency+and+affordability+division/national+energy+efficiency+action+plan.htm.

Table 1-1: Key policies in the National Energy Efficiency Action Plan 3 (NEEAP III)

Sector	Key policy measures	Sector	Key policy measures
Commercial	• Building regulations • Commercial sector retrofit • SME programme • Accelerated Capital Allowances (ACA)	**Public**	• Public sector retrofit incl. Public Sector Programme • ACA
Residential	• Building regulations • Residential retrofit scheme • More efficient boiler regulation • Ecodesign (efficient lighting) • Smart Meter rollout • Better Energy Financing	**Transport**	• VRT/AMT rebalancing • EU mandatory emissions standards • Electric vehicle deployment • More efficient road traffic movements (eco-driving) • Aviation efficiency
Industry	• Large Industry Energy Network (LIEN) programmes	**Power**	• More efficient generation • Reduced T&D losses
Cross-cutting	• Energy supplier obligation • Carbon tax • Energy Efficiency Fund (Public and private sectors)		

From the key policy measures shown in the table above, power supply sector measures and new building regulations are not within the scope of this study.[3] The expected savings from the power sector and the building regulations are estimated in NEEAP III as ~3 TWh and ~2 TWh, respectively. Around 15 TWh of additional primary energy savings are therefore required until 2020 in the 'modelled' sectors as shown in Figure 1-1. In Section 3, 'Energy efficiency investment pathways to 2020,' a number of economy-wide scenarios will be presented achieving at least 15.1 TWh of savings between 2013 and 2020 in addition to the expected savings in the new buildings and power sectors.

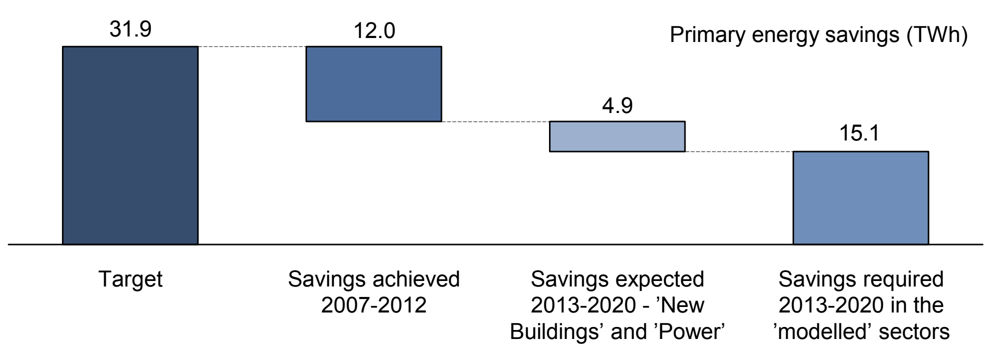


Figure 1-4: Savings required between 2013 and 2020 to meet the 2020 target

[3] Although the building regulations and power supply measures are not modelled explicitly, the impact of these measures on the remaining savings potential is considered. For instance, for the new building regulation savings estimation in NEEAP III, it was assumed that 1 % of the commercial buildings stock is replaced by new buildings annually. This reduces the number of commercial buildings suitable for energy efficiency retrofit. Similarly, due to the power generation efficiency improvement, the primary energy conversion factor for electricity decreases over time.

2 Energy savings potential by sector

2.1 Energy efficiency cost curves

In this section, we present the energy efficiency cost curves derived for each of the sectors modelled. For details on the methodology behind the construction of the cost curves, the reader is referred to the box, ‘Methodology behind energy efficiency cost curves.’

Cost curves are presented for individual energy efficiency measures and for ‘packages’ of measures (described below). The cost curves will be used to highlight measures offering the most significant opportunity for energy savings, and to indicate whether the savings are economic without intervention, or whether intervention is required to render them economic (for the definition of ‘economic’, see the box, ‘Methodology behind energy efficiency cost curves’). As explained below, we will also highlight the cases where promoting the uptake of packages of measures could be a useful mechanism by which to increase, in effect, the economic energy saving potential.

For all cost curves shown here, it should be noted that the actual uptake of measures or packages by 2020 will be lower due to the factors such as decision-making frequency, awareness and engagement, budget limits and willingness to pay. These factors are explained and accounted for in Section 3 where the link is made between the potential for energy savings in the context of Government energy efficiency policy.

Methodology behind energy efficiency cost curves

Energy savings potential shown accounts for the 'suitability' of measures

- *The cost curves present all measures modelled for each sector.*
- *The horizontal axis shows the full technical savings potential in 2020 in units of TWh primary energy, and the individual contribution of each measure.*
- *The technical savings potential of measures was derived using detailed bottom-up stock modelling with archetypes, as described in the accompanying Technical Appendix (Methodology and technical assumptions).*
- *For all measures, the savings potential shown incorporates the 'suitability' of the measure across the stock. For example, the savings potential shown for 'cavity wall insulation' accounts for the fact that the majority of cavity walls in Ireland have already been filled.*
- *For details on the methodology in the Transport sector, please refer to the box 'Methodology behind energy efficiency cost curves for the transport sector'.*

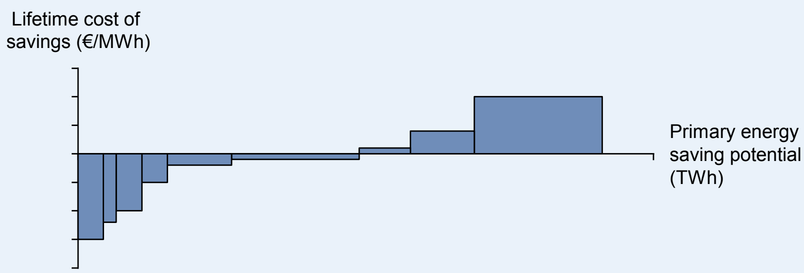


Figure 2-1: Illustrative energy efficiency cost curve

We present cost curves from a 'private' perspective

- *The lifetime cost of the savings attributed to each individual measure is shown on the vertical axis, in units of €/MWh primary energy.*
- *The lifetime cost of measures was calculated against the appropriate counterfactual, including technical capital and operating costs, ongoing fuel and carbon costs, and* ***'hidden' costs*** *(which are included to give a fuller representation of costs associated with deploying each individual measure).*
- *In this section, we present cost curves calculated using a 10% discount rate, reflecting a 'private' perspective. To offer a full Exchequer perspective or societal perspective, wider economic issues such as tax transfers from the purchaser of the fuel to the Government and policy intervention costs should be considered. In Section 4, we consider the full 'Exchequer perspective', and use a public sector discount rate of 5%.*
- *A negative lifetime cost corresponds to economic savings over the lifetime of the measure; measures with a negative lifetime cost are here termed 'economic' or 'cost-effective' (used interchangeably). Measures with positive lifetime cost are termed 'uneconomic'.*

Uneconomic measures may present a significant opportunity for additional savings

- *It is important to note that uneconomic measures should not be deemed unachievable and therefore unimportant. Measures that are uneconomic using a 10% discount rate are likely to be difficult to achieve without additional intervention but could be unlocked with well-targeted support and/or financial incentives.*
- *It should also be noted that implementation of 'packages' (i.e. installing uneconomic measures at the same time as the economic measures) could make the overall investment economic.*

2.2 Energy efficiency measures

We have modelled both 'technical' measures and 'behavioural' measures. Technical measures include building insulation retrofits (wall and roof insulation, high efficiency glazing, draught proofing), heating/cooling system replacements (more efficient boiler, heating controls, more efficient air conditioning, heat pump), more efficient lighting and more efficient office appliances and refrigeration. Behavioural measures include turning off unnecessary lighting (i.e. turning off lights for extra hours), reducing the target room temperature by 1 degree Celsius and reducing unnecessary hot water use. The two types of measure are distinguished on each cost curve.

Note on interaction of measures shown in energy efficiency cost curves

Energy efficiency measures typically 'interact' with each other, and so the order in which measures are applied influences the savings achieved by each individual measure. For example, consider the purchase of a more efficient boiler, which reduces a building's energy consumption by 10%, from 10 MWh per year to 9 MWh per year. The savings potential of the boiler is 1 MWh per year If insulation was installed in the same building, reducing its energy consumption to 8 MWh per year, the boiler would only save 0.8 MWh per year.

There are similar interactions between many other measures in all sectors. It is important that this interaction between measures is captured in the cost curves in order that the savings potential is not overestimated. In the cost curves shown, all interactions are accounted for. It can also be seen that the order in which the measures are applied affects the savings potential attributed to each individual measure. It should be noted that, in the cost curves shown in this section, all technical measures are applied before all behavioural measures. Within each category, measures are applied in order of cost-effectiveness. Applying measures in a different order would yield different results on a per measure basis.

2.3 Energy efficiency packages

In many situations, such as when a building is undergoing a major renovation or when an industrial facility is undergoing a shut-down for maintenance, it may be the case that a 'package' of several energy efficiency measures is implemented at the same time. In order to reflect this, we show cost curves in terms of packages as well as in terms of individual measures. An important finding described in this report, is that promoting the implementation of packages of measures could be a useful mechanism by which to increase, in effect, the economic energy saving potential.

For the commercial, public and residential buildings sectors, and for the industry sector, we have constructed three packages of measures, namely 'Shallow', 'Medium' and 'Deep'. To best reflect reality, packages are defined to group measures on the basis of associated 'decision frequency' and upfront cost. The decision frequency, which is explained in greater detail in Section 3.1, places a limit on the rate at which energy efficiency measures can be taken up. In some cases, such as for heating, lighting or motor systems, this is related to the lifetime of the equipment in question. In other cases, such as for insulation measures, this reflects the frequency with which consumers undertake building renovation or maintenance with a comparable level of disruption. In simple terms, the Shallow package contains measures which are relatively easy to install and have a low upfront cost, and the Deep package contains all measures including the ones which are more difficult to implement and/or have a high upfront cost.

The energy efficiency measures contained within the packages will be described for each sector in turn. We note that behavioural measures are not included in the packages and we do not construct packages for the transport and public utilities sectors.

2.4 Energy efficiency cost curve: Commercial buildings

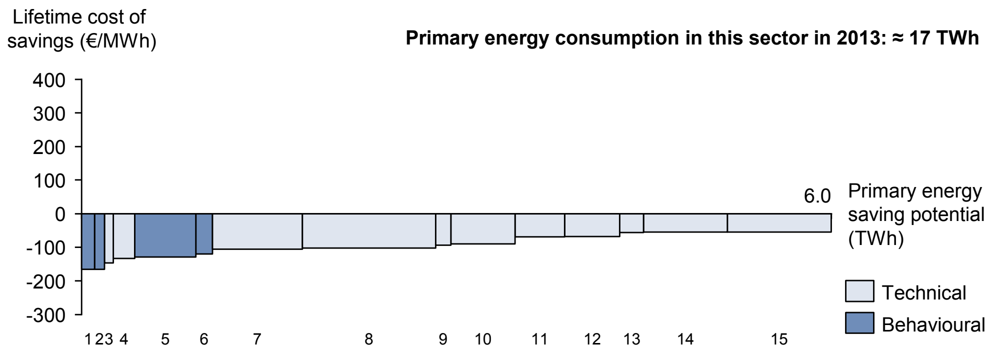
Figure 2-2 shows the energy efficiency cost curve for the commercial buildings sector. The modelling suggests that, for the technologies considered, total primary energy savings potential in the sector is 6.0 TWh, corresponding to around 35 % of the primary energy demand in this sector in 2013, which is estimated to be 17 TWh.[4] The largest savings potential among the technical measures in the commercial buildings sector relates to the installation of energy efficient lighting with lighting controls (1.1 TWh) and heat pumps (0.8 TWh), retrofit with roof insulation (0.7 TWh) and energy efficient glazing (0.7 TWh), and installation of more efficient air-conditioning (0.5 TWh). Of the behavioural measures, reducing the room temperature by 1 degree Celsius has the largest potential of 0.5 TWh.

Behavioural measures are the most cost-effective in this sector.[5] However, all of the savings potential in the commercial buildings sector is cost-effective – that is, all savings carry a negative lifetime cost. The main reason for this is that there is a high fraction of electrical heating in the commercial sector – around two thirds of commercial buildings have an electrical main (primary) heating system. Since electricity is relatively expensive – typically €0.21/kWh for non-domestic consumers[6] – saving energy results in a large economic benefit.

[4] Element Energy and The Research Perspective, 2014, *'Extensive survey of the commercial buildings stock in the Republic of Ireland.'*

[5] We note that in the cost curves shown in this section, we have assumed no cost for the implementation of behavioural measures. In the Exchequer analysis in Section 5, we include a cost for the delivery of behavioural measures.

[6] See the latest commercial fuel cost comparison here: http://www.seai.ie/Publications/Statistics_Publications/Fuel_Cost_Comparison/



Measure	PE saving (TWh)	Measure	PE saving (TWh)
Total technical measures	**5.15**	14. Energy efficient glazing	0.67
3. Energy efficient appliances - Refrigeration	0.07	15. Heat pump	0.82
4. Draught proofing	0.17		
7. Roof insulation	0.71	**Total behavioural measures**	**0.80**
8. Energy efficient lighting with lighting control	1.11	1. Turn off lights for extra hours	0.10
9. Cavity wall insulation	0.12	2. Enable standby features on all PCs and monitors	0.08
10. More efficient air conditioning	0.51	5. Reducing room temperature	0.49
11. More efficient boiler with heating control	0.39	6. Reducing hot water use	0.13
12. Solid wall insulation	0.44		
13. Energy efficient appliances - Office equipment	0.19	**Total**	**5.95**

Figure 2-2: Energy efficiency cost curve for the Commercial sector

The measures contained in the Shallow, Medium and Deep packages for the commercial and public sectors are shown in Table 2-1. Figure 2-3 shows the energy efficiency cost curve for packages for the commercial buildings sector (we note that behavioural measures are not included in the packages). It can be seen that all packages in the commercial buildings sector are cost-effective.

Table 2-1: Measures contained in packages for the commercial and public buildings sectors

Sector	Shallow	Medium	Deep
Commercial and Public	• Cavity wall insulation • Draught proofing • Energy efficient lighting • Heating controls	• **All Shallow measures** • Roof insulation • Energy efficient office equipment • Energy efficient refrigeration • More efficient boiler[7]	• **All Medium measures** • Solid wall insulation • More efficient air conditioning • Energy efficient glazing • Heat pump • Lighting controls

[7] Installation of more efficient boilers is included in the Medium package in the Commercial and Public sectors. Only the archetypes with old boilers (e.g. older than 5 years) were assumed to replace boilers.

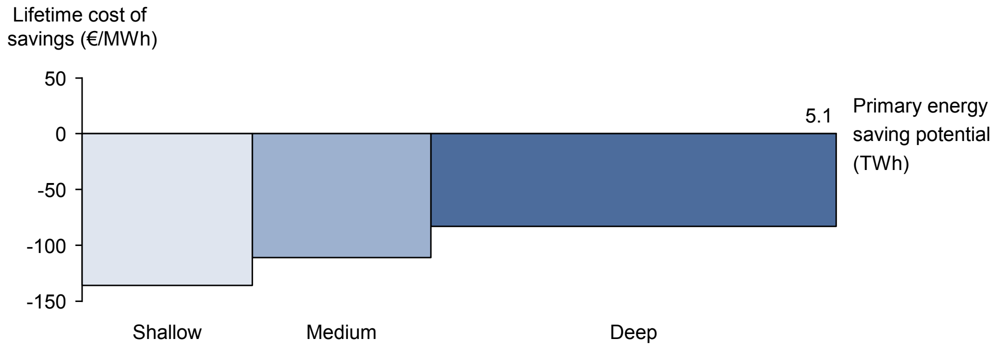
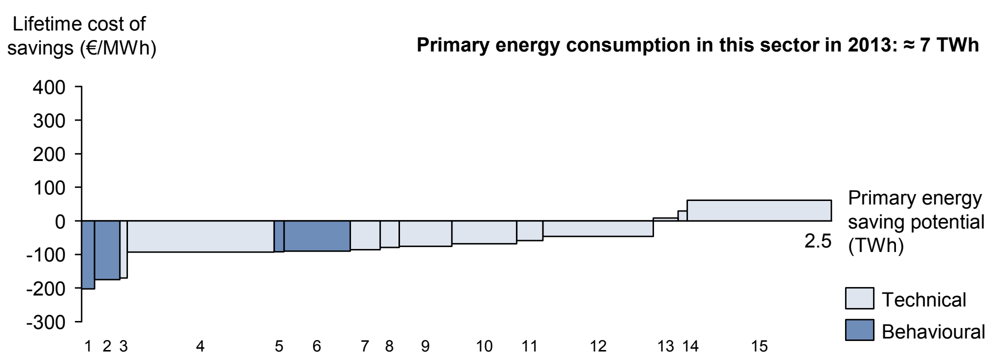


Figure 2-3: Energy efficiency cost curve for the Commercial sector (packages)

2.5 Energy efficiency cost curve: Public buildings

Figure 2-4 shows the energy efficiency cost curve for the public buildings sector. The total primary energy savings potential in the sector is 2.5 TWh, corresponding to around 35 % of the total energy demand in the public buildings sector in 2013 (ca. 7 TWh). The largest technical savings potential in the public buildings sector is available through the installation of energy efficient lighting with lighting controls (0.5 TWh), retrofit with roof insulation (0.2 TWh) and energy efficient glazing (0.5 TWh) and the installation of more efficient boilers (0.4 TWh) and more efficient office appliances (0.2 TWh). Reducing the room temperature by 1 degree Celsius is, as for commercial buildings, the behavioural measure with the largest savings potential (0.2 TWh).



Measure	PE saving (TWh)	Measure	PE saving (TWh)
Total technical measures	**2.09**	14. Heat pump	0.03
3. Energy efficient appliances - Refrigeration	0.03	15. Energy efficient glazing	0.47
4. Energy efficient lighting with lighting control	0.48		
7. Draught proofing	0.10	**Total behavioural measures**	**0.38**
8. Cavity wall insulation	0.06	1. Turn off lights for extra hours	0.04
9. Energy efficient office equipment	0.17	2. Enable standby features on all PCs and monitors	0.08
10. Roof insulation	0.21	5. Reducing hot water use	0.03
11. More efficient air conditioning	0.09	6. Reducing room temperature	0.22
12. More efficient boiler with heating control	0.36		
13. Solid wall insulation	0.08	**Total**	**2.47**

Figure 2-4: Energy efficiency cost curve for the Public buildings sector

The greater prominence of more efficient boiler replacement, as compared with the commercial buildings sector, is due to the higher fraction of oil and gas heating in the public sector. More efficient office appliances are also relatively more important in public buildings, due to the more widespread use of IT equipment in public buildings than in many commercial buildings, such as retail and hospitality buildings.

The majority of the energy saving potential in public buildings is cost-effective. However, it can be seen that savings related to space heating (such as insulation and energy efficient glazing) are rather less cost-effective than in the commercial sector, due to the greater prevalence of oil and gas heating in the public sector. Oil and gas are the main heating fuel for 50 % and 23 % of public buildings respectively, compared with 26 % and 8 % respectively for commercial buildings. Since oil and gas heating are less expensive than direct electrical heating, the economic benefit of energy saving is smaller in the public sector than in the commercial sector.

Figure 2-5 below shows the energy efficiency cost curve for packages for the public buildings sector.[8] It can be seen that all packages in the public buildings sector are cost-effective. It is notable that the Deep package is cost-effective even though it contains a number of measures, including energy efficient glazing, heat pumps and solid wall insulation, which are not cost-effective when installed as individual measures. This demonstrates the utility of promoting the uptake of energy efficiency packages rather than individual measures: if uneconomic measures are installed at the same time as the economic measures, the overall investment may be economic. In some cases – for some consumers – this may increase the uptake of the uneconomic, ‘harder-to-get’ measures without decreasing the uptake of the economic ‘low hanging fruit’.

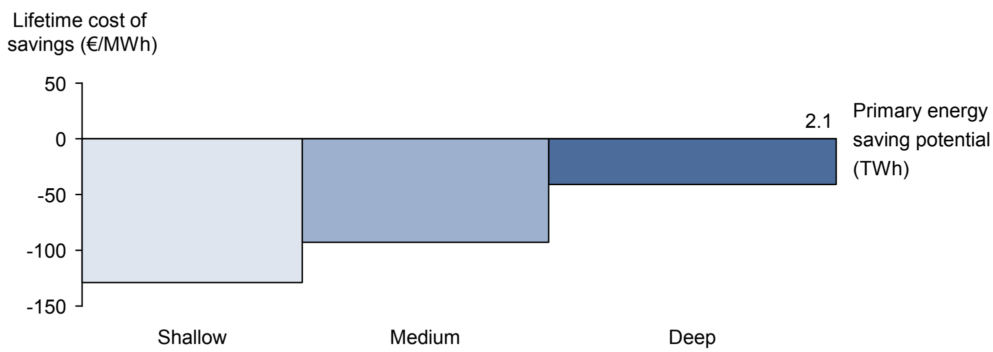


Figure 2-5: Energy efficiency cost curve for the Public buildings sector (packages)

2.6 Energy efficiency cost curve: Public utilities

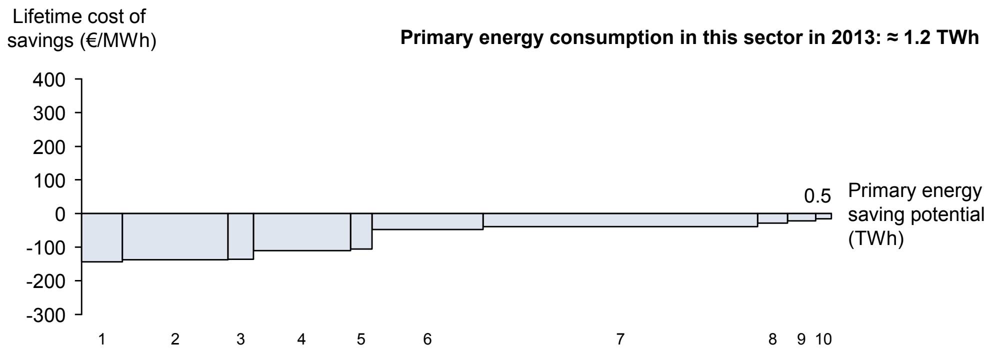
Figure 2-6 shows the energy efficiency cost curve for the public utilities sector (i.e. street lighting and water services). The total primary energy savings potential in the sector is around 0.5 TWh, corresponding to around 40 % of the 1.2 TWh[9] total primary energy demand in the sector in 2013.

We have considered energy savings in public lighting, water supply and wastewater treatment. In public lighting, replacement of lanterns with LEDs and optimised control by a central management system could lead to savings of 0.2 TWh. The measures with the largest potential in the water and wastewater sub-sector include elimination of excess air and retrofit of fine bubble diffused air systems in wastewater treatments plants (0.1 TWh

[8] The measures contained in the Shallow, Medium and Deep packages for the public sectors are shown in Table 2-1 in the previous section. We note that behavioural measures are not included in the packages.
[9] SEAI, 2012, 'Energy Efficiency & Public Lighting Overview' and 'Energy Efficiency & Water Services', overview reports.

each) and higher efficiency pump retrofit at water supply stations (0.1 TWh). It should be noted that water conservation could have an impact beyond these estimates.

All energy saving measures considered for public utilities are cost-effective.



Measure	PE saving (TWh)	Measure	PE saving (TWh)
1. Elimination of parasitic loads in pump house (e.g. heaters)	0.03	7. Replace street lighting by LEDs (including central management system e.g. dimming and trimming)	0.20
2. Elimination of excess air to a level appropriate for plant requirements	0.08	8. Dissolved oxygen control of aeration systems	0.02
3. Optimising operation to best efficiency point through duty & assist control	0.02	9. Retrofit of blowers with VSD	0.02
4. Higher efficiency pump retrofit	0.07	10. Retrofit of high efficiency motors in aeration systems	0.01
5. Install Variable Speed Drive (VSD) instead of throttling	0.02	**Total**	**0.53**
6. Retrofit of fine bubble diffused air systems	0.08		

Figure 2-6: Energy efficiency cost curve for the Public utilities sector

2.7 Energy efficiency cost curve: Residential buildings

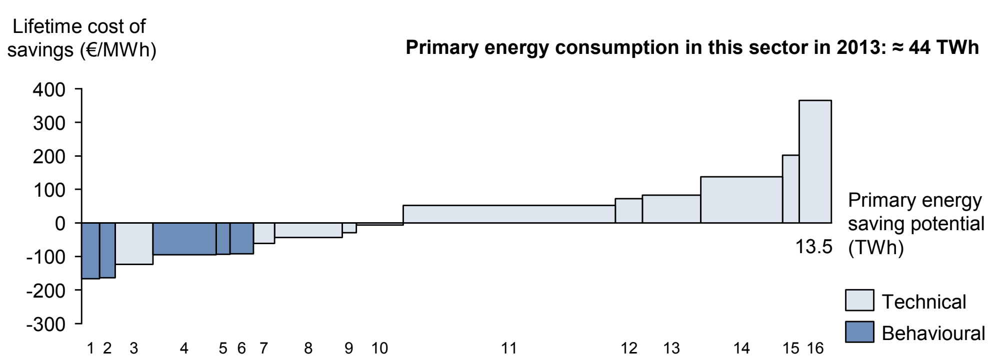
Figure 2-7 shows the energy efficiency cost curve for the residential buildings sector. The total primary energy savings potential (for the technologies considered) in the sector is 13.5 TWh, corresponding to 30 % of the 44 TWh total demand in the sector in 2013.

Technical measures include building insulation retrofits (wall, roof and floor insulation, energy efficient glazing, draught proofing), heating/cooling system replacements (more efficient boilers, heating controls, heat pumps, solar water heating), energy efficient lighting and more efficient household appliances and electronics. Behavioural measures include reducing the target temperature by 1 degree Celsius, turning off heating in unused rooms, turning off lights when not in use, installing a low-flow shower head and air-drying rather than tumble-drying clothes.

The largest savings potential among the technical measures in the residential buildings sector relates to the installation of more efficient boilers with heating controls (3.8 TWh) and retrofit with solid wall insulation (1.5 TWh), roof insulation (1.2 TWh) and floor insulation (1.0 TWh). Reducing the target temperature by 1 degree Celsius has the potential to save 1.1 TWh of primary energy.

According to this study's methodology, approximately half of the technical savings potential in the residential buildings sector is cost effective using a 10 % discount rate. The lower proportion of cost-effective savings compared with the commercial sector is primarily due to 'comfort taking', which is explained in the box 'Comparison of internal and external solid wall insulation

, and the higher prevalence of gas and oil heating in residential buildings, and hence the lower value of energy savings. Key opportunities for large and/or cost-effective savings in the residential sector include the installation of roof insulation and cavity wall insulation, more efficient boilers with heating controls and appliances with higher energy efficiency performance.



Measure	PE saving (TWh)	Measure	PE saving (TWh)
Total technical measures	**11.05**	15. Heat pump	0.30
3. Energy efficient appliances -"Cold" and "Electrical cooking"	0.67	16. Energy efficient glazing	0.57
7. Draught proofing	0.38		
8. Roof insulation	1.21	**Total behavioural measures**	**2.41**
9. Energy efficient lighting	0.26	1. Air dry instead of tumble dry	0.32
10. Cavity wall insulation	0.84	2. Turn off lights when not in use	0.29
11. More efficient boiler with heating control	3.81	4. Reduce room temperature by 1C	1.14
12. Energy efficient appliances - "Wet" and "Consumer electronics"	0.48	5. Turn off heating in unused rooms	0.25
13. Floor insulation	1.05	6. Use efficient shower head	0.42
14. Solid wall insulation	1.47	**Total**	**13.46**

Figure 2-7: Energy efficiency cost curve for the Residential buildings sector

Comfort taking in the Residential sector

'Comfort taking' is an example of the 'rebound effect' in the Residential building sector. It has been shown that the energy savings expected from energy efficiency measures applied in a domestic context are not achieved in full, and that this is due, at least in part, to a change in behaviour of the building occupier. For example, after the installation of insulation measures, the occupier may become accustomed to greater comfort, resulting in them raising the thermostat or heating previously unheated rooms.

We have accounted for comfort taking in the results shown in the residential sector. We apply a fixed factor of 64% in the Residential sector, which corresponds to 36% of the savings being taken in comfort. This estimate is based on a study by Scheer et al., in which the ex-post measured savings achieved through SEAI's Home Energy Saving residential retrofit scheme were compared against ex-ante engineering-type estimates of the savings potential of the measures installed. The total technical potential before applying the effect of comfort taking is therefore 21 TWh, corresponding to nearly 50% savings versus the baseline.

It should be noted that economy-wide rebound effects might also arise from increased economic activity (spending) resulting from increased disposable income resulting from energy savings, which in turn leads to increased demand for energy to service the aggregate demand for goods and services. This could arise outside of Ireland's economy in the form of the embodied energy in imports. Economy-wide rebound effects are not within the scope of this study.

To some extent, rebound effects can be seen as part of the wider benefits of energy efficiency programmes, as set out in the recent report 'Capturing the Multiple Benefits of Energy Efficiency' from the IEA. Direct rebound effects in the form of comfort taking, while offsetting the energy savings, reflect an increase in the welfare of households which can now afford to heat their homes to the desired standards. Where previously under-heated homes are made warmer, physical health benefits also arise.

Performance Gap

Finally, we note that there is an increasing body of work dedicated to understanding the so-called 'performance gap', or the difference between the theoretical thermal performance of a building and the measured performance. We note that the performance gap is, in general, related to issues at all stages of the building life, including imperfect design, construction and handover as well as variations in post-occupancy use (to which the rebound effect typically refers).

The performance gap presents an additional reason to promote deep rather than shallow retrofits. As building thermal efficiency increases (i.e. depth of retrofit increases), energy use in absolute terms becomes less sensitive to variation in internal temperature, as has been shown in Love's 2012 paper 'Mapping the impact of changes in occupant heating behaviour'. In other words, as buildings become better insulated and more efficient, occupant behaviour matters less, and comfort taking is less of a concern.. Any strategy aiming to achieve a fixed and low level of energy consumption should account for this observation.

Comparison of internal and external solid wall insulation

The cost curve in this section shows the savings potential of solid wall insulation. Solid walls may be insulated using internal or external insulation. Here, we describe some of the differences between the two categories of solid wall insulation.

Based on fabric costs (per unit area) published by AECOM [AECOM, 2013], the average installation cost of solid wall insulation for a typical terraced house, including materials and labour, is approximately €4,000 for internal wall insulation and €6,000 for external wall insulation. However, these figures exclude the additional or 'hidden' costs associated with installation. Hidden costs associated with internal wall insulation relate to the loss of internal floor area, the need to store room contents elsewhere during the work, to remove and re-install radiators, pipework and sockets, to re-cut carpets, to replace the kitchen fittings (where relevant) and to redecorate the affected rooms. For external wall insulation, possible hidden costs relate to the need to erect scaffolding, to remove and re-install drainpipes and cabling, to protect the garden, to extend the existing boiler flue, to adjust the door canopy and windows and, where relevant, to create a larger roof overhang [AEA/Ecofys for the CCC, 2008 and Ecofys, 2009].

In both cases, hidden costs can therefore be estimated to be in the range of €5,000-20,000, depending strongly on individual circumstances. For example, if major re-decoration work is already planned, internal insulation may be a more attractive option. Conversely, in a small dwelling where space is at a premium, the loss of internal floor area with internal insulation may be priced very highly.

There are also non-economic advantages and disadvantages to the two options. Internal wall insulation can be attempted one wall at a time, which may make the project more manageable. However, internal insulation is likely more disruptive for the occupier. In addition, internal insulation results in the loss of the thermal mass of the wall, meaning the internal temperature may fall more quickly than before when the heating is off. Since the temperature of the wall fabric will be lower after it has been internally insulated, it may also become prone to problems of damp unless expertly installed.

External insulation brings a number of non-economic advantages such as noise reduction and improved weather protection. It is less disruptive than internal insulation, and also preserves the thermal mass of the wall. Further, as may be relevant for local authorities or housing associations, all dwellings in a terrace or block may be insulated simultaneously. The disadvantages of solid wall insulation are largely economic.

Figure 2-8 shows the energy efficiency cost curve for packages for the residential buildings sector (we note that behavioural measures are not included in the packages). It can be seen that both the Shallow and Medium packages are cost-effective (shown here, as for the other sectors, using the 10 % discount rate) although the Medium package includes a number of measures, which are not cost-effective when installed individually. Cost-effective/economic energy savings potential for technical measures therefore increased from 3.4 TWh to 5.3 TWh.

On the other hand, the Deep package is not cost-effective at a 10 % discount rate. As explained previously, uneconomic measures/packages should not be deemed unachievable as these measures could be unlocked with Government interventions, which will be examined in more detail in Section 3.2.4. The box, 'Making deep retrofit options cost-effective

', also explains a number of ways to make the Deep package cost-effective.

Table 2-2: Measures contained in packages for the Residential buildings sector

Sector	Shallow	Medium	Deep
Residential	• Cavity wall insulation • Roof insulation • Draught proofing • Energy efficient lighting	• **All Shallow measures** • Energy efficient appliances (Wet and Consumer electronics) • Heating controls	• **All Medium measures** • Solid wall insulation • Energy efficient glazing • Energy efficient appliances (Cold and Electrical cooking) • More efficient boiler[10] • Heat pump • Floor insulation

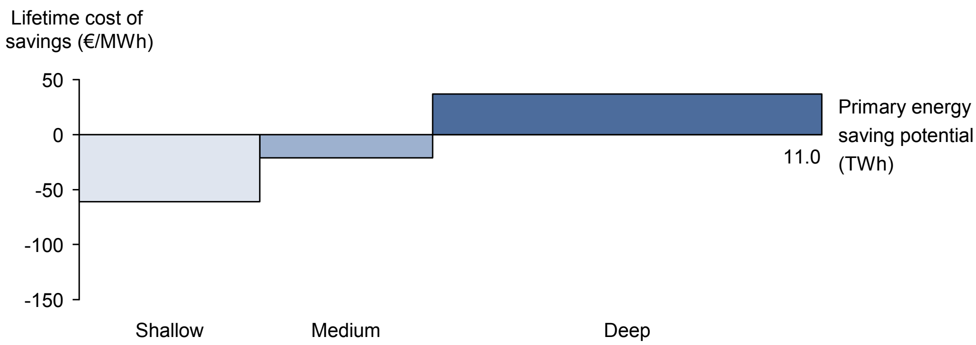


Figure 2-8: Energy efficiency cost curve for the Residential sector (packages)

> ***Making deep retrofit options cost-effective***
>
> *The Deep package in the residential sector includes several energy efficiency measures with significant savings potential such as solid wall insulation, more efficient boiler and energy efficient glazing. However, the uptake of the Deep package, which is estimated to be 'uneconomic' using a 10% discount rate, is likely to be low without additional intervention. Uptake of energy efficiency in the residential sector will therefore require intervention, even more than in other sectors. We have identified a number of potential and existing interventions including regulation, Pay-As-You-Save (PAYS), information campaigns and direct financial support. The potential impact of these interventions will be explained in more detail in Section 3.2.4.*
>
> *The deep package in the residential sector also becomes cost-effective when a lower discount rate (i.e. 5%) is used. This suggests that investment in the Deep package using a commercial loan (i.e. with interest rates of 8%–10%) may not be cost-effective; however, the Deep package can be made cost-effective if low interest rate loans are available for the consumers in the residential sector such as PAYS with lower interest rates.*

[10] Both heat pumps and boilers are included in the packages as it was assumed that heat pumps replace direct electric heating whereas energy efficient boilers replace old oil and gas boilers.

2.8 Energy efficiency cost curve: Transport

Figure 2-9 shows the energy efficiency cost curve for the transport sector. Further details on the transport cost curve calculations are given in the box, 'Methodology behind energy efficiency cost curves for the transport sector

'. The total primary energy savings potential in the transport sector to 2020 is around 7.4 TWh, corresponding to around 17 % of the 43 TWh total demand in the sector in 2013.[11]

Technical measures include the use of more efficient internal combustion engine (ICE) vehicles, the uptake of alternative fuel vehicles (AFVs) – that is, hybrid and electric vehicles – and a shift in the weight class of heavy goods vehicles (HGVs). We note that in terms of the measures in Figure 2-9, the use of more efficient ICE vehicles corresponds to 'EU regulation' and 'VRT rebalancing'. 'EU regulation' refers to EU regulation 443/2009, the mandatory emissions standards imposed upon manufacturers of cars and light-duty vans. 'VRT rebalancing' refers to Ireland's 2008 shift to a Vehicle Registration Tax and Annual Motor Tax system based on carbon emissions rather than on engine size. Behavioural measures include 'eco-driving', a modal shift to public transport, cycling or walking and smaller vehicles.

Measures relating to private cars dominate the transport sector savings potential. The largest potential for savings relates to the use of more efficient combustion-engine cars resulting from EU regulation and VRT rebalancing (3.4 TWh) – measures already in place. Large savings potential is also available through modal shift (1.5 TWh) and a shift to smaller vehicles (0.6 TWh). Across all forms of road transport, eco-driving could save up to 0.8 TWh.

The cost-effectiveness of measures in the transport sector has also been considered (also see the box, 'Methodology behind energy efficiency cost curves for the transport sector

for notes on key assumptions made and data used). It is important to emphasise at this point that, although we find that many of the measures in the transport sector are cost-effective (from the private/consumer perspective), this does not mean that they are easy to achieve. As will be described in Section 3.2.5, many of the measures shown here are deemed unlikely to be achieved by 2020; this includes modal shift, a shift to smaller vehicles and a weight class shift for HGVs.

[11] This figure is based on Energy Balance 2013 estimates, excluding rail, aviation and fuel tourism.

Methodology behind energy efficiency cost curves for the transport sector

Overall approach

- *The technical savings potential of measures was derived through a combination of bespoke analysis and detailed literature review. The detailed assumptions are given in the accompanying Technical Appendix (Methodology and technical assumptions).*
- *For the private car sub-sector, the analysis is based on a detailed stock model including 9 vehicle types.*
- *The lifetime cost of each measure was derived by considering the marginal costs and benefits relative to an appropriately-defined counterfactual.*
- *Operating costs of vehicles are discounted over the vehicle lifetime. For private cars, retirement is based on a scrappage curve from ESRI (Hennessy and Tol, The Economic and Social Review 42, 135, 2011); for HGVs, the lifetime is taken as 12 years; for LDVs, the lifetime is taken as 8 years; for public buses, the lifetime is taken as 12 years.*
- *Fuel prices forecasts were provided by SEAI; petrol prices vary from €0.046/MJ in 2013 to €0.049/MJ in 2030; diesel prices vary from €0.040/MJ in 2013 to €0.042/MJ in 2030.*
- *In the cost curves shown here, a discount rate of 10% is used, reflecting a 'private' consumer perspective.*

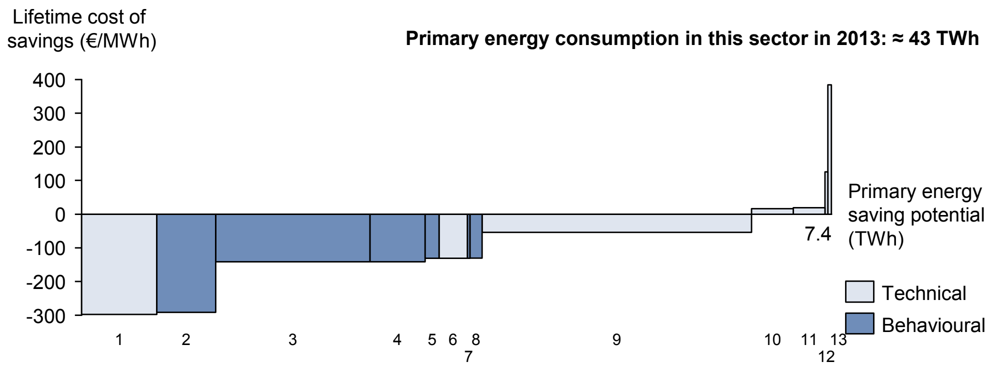
Notes for specific measures

- *Full details of the assumptions for each measure are given in the accompanying Technical Appendix (Methodology and technical assumptions).We also note here a number of important clarifications and key assumptions.*
- *'Modal shift' is treated as a voluntary and unincentivised behavioural measure; we do not include here, for example, the cost to the Exchequer of improved public transport infrastructure. Where this measure is applied, we model a decrease in annual mileage but no decrease in the number or type of vehicles purchased.*
- *'Shift to smaller vehicles' is also treated as a voluntary and unincentivised behavioural measure. This measure does not imply the reversion of a vehicle tax system based on engine size (as was the case before the current emission-based system was implemented).*
- *The cost premium for vehicles due to EU regulation on mandatory emissions standards (versus a pre-2008 efficiency improvement trend) was based on AEA's 2012 report 'A review of the efficiency and cost assumptions for road transport vehicles to 2050'.*
- *We note that the cost to the Exchequer of a national eco-driving scheme is not included in the cost curve, but is included in the later analysis of Exchequer perspective.*

The use of more efficient ICE cars resulting from the VRT rebalancing is found to be highly cost-effective. The dominant effect of the rebalancing was a shift from petrol to diesel cars, due to the higher efficiency of diesel vehicles.[12] In Ireland, diesel is also cheaper than

[12] Rogan et al., 'Impacts of an emission based private car taxation policy – First year ex-post analysis', *Transportation Research Part A,* 2011.

petrol on a per litre basis; this means that the measure has a large, negative associated cost. We note that the strong shift towards diesel may have an impact on the balance between diesel and petrol prices; an analysis of this is not included here.



Measure	PE saving (TWh)	Measure	PE saving (TWh)
Total technical measures	4.45	**Total behavioural measures**	**2.92**
1. Private cars - VRT re-balancing	0.74	2. Private cars - Shift to smaller vehicles	0.58
6. HGVs - Weight class shift	0.28	3. Private cars - Modal shift	1.52
9. Private cars - EU regulation	2.65	4. Private cars - Eco-driving	0.55
10. LDVs - EU regulation	0.41	5. HGVs - Eco-driving	0.13
11. HGVs - Increasing ICE efficiency	0.31	7. Public passenger - Eco-driving	0.03
12. Public passenger - increasing ICE efficiency	0.03	8. LDVs - Eco-driving	0.12
13. Private cars - AFV incentive	0.03	**Total**	**7.38**

Figure 2-9: Energy efficiency cost curve for the Transport sector

Other cost-effective measures include a shift to smaller vehicles (where both capital cost and running costs are reduced), modal shift (where it has been assumed that cars are used less, but still purchased) and eco-driving. We note that the promotional and training cost to the Exchequer of an eco-driving scheme is not included in the cost curves, which reflect the private perspective. The cost to the Exchequer of the eco-driving scheme is included in the analysis of the Exchequer perspective in Section 4. We emphasise that the shift to smaller vehicles and modal shift behavioural measures have been treated as voluntary and un-incentivised; we do not include here, for example, the cost to the Exchequer of improved public transport infrastructure. The use of more efficient ICE cars resulting from EU regulation is cost-effective, albeit less so than the measures listed above. The cost premium on the more efficient vehicles meeting the EU regulation in 2020, amounting to approximately 7 – 10 %, is more than compensated for by the reduced running costs.

Less cost-effective measures in 2020 include the EU regulation for light-duty vehicles (LDVs), where the cost premium for efficient vehicles in 2020 is also around 10 % but the energy efficiency gain is smaller than for cars (and is not compensated for by the higher mileage of LDVs); and higher efficiency HGVs, where the efficiency increase carries a larger cost premium of up to 20 % (also not compensated for by the higher mileage of HGVs).

Primary energy savings due to the uptake of AFVs, which currently carry a high cost premium relative to ICE vehicles, are also less cost effective. However, we emphasise that there is considerable uncertainty around the cost and performance improvements of EVs to 2020, and hence the uptake shown here may be a significant underestimate. In the scenario shown in the cost curve, there are around 25,000 AFVs in the stock by 2020 (the majority being plug-in hybrids, with around 1,500 full battery electric vehicles). The reader is referred to the box, 'Comfort taking in the Residential sector for further discussion of the scenarios considered and comparison with current targets. We also note that EVs bring additional and highly significant benefits to the energy system other than primary energy savings; they also reduce dependence on fossil fuels, are compatible with a zero carbon energy system and offer the potential for grid-balancing services.

Key opportunities in the transport sector, excluding those which have already been implemented (namely EU regulation and VRT rebalancing), include modal shift to public transport, walking and cycling; a shift to the purchase of smaller vehicles; and eco-driving.

Savings potential of electric vehicles to 2020

The Irish Government previously stated a target for 10% of the road vehicle fleet to be electric by 2020. This was recently revised down to 2.5% of the stock, which corresponds to ~50,000 vehicles. The uptake of AFVs was predicted using the ECCo consumer choice model developed by Element Energy for the Energy Technologies Institute, which is based on consumer preference data from a survey of 2,700 new car buyers. ECCo is described in more detail in the accompanying Technical Appendix (Methodology and technical assumptions).

Applying SEAI's existing incentive for AFVs, ECCo predicts the uptake of around 25,000 AFVs in the stock by 2020. Due to the high cost premium of full battery electric vehicles (BEVs) within the model, the great majority of the 25,000 are predicted to be plug-in hybrids (PHEVs), with around 1,500 BEVs. However, there is considerable uncertainty around the cost trajectory of AFVs and therefore around the number of vehicles which will be deployed to 2020. As a result of falling prices and the availability of a wider range of electric options, there has recently been a significant upturn in the number of new BEVs registered in Ireland. Between January and August 2014, 215 new BEVs were registered, compared with 54 in the whole of 2013. With continuing reductions in price and changing public opinion, it may be expected that the uptake of BEVs will accelerate in the years to 2020.

We can estimate the additional savings potential which would be achieved if the revised Government target is met – that is, if there are 50,000 BEVs on the road in 2020. For the purposes of this illustration, we consider the potential savings if (i) the predicted relative share of PHEVs and BEVs remains the same as in the case shown in the cost curve and if (ii) these vehicles are all BEVs. On top of the 30 GWh savings shown in the cost curve, achieving the target of 50,000 AFVs on the road in 2020 would bring an additional primary energy savings of 40 GWh for case (i), and 110 GWh for case (ii).

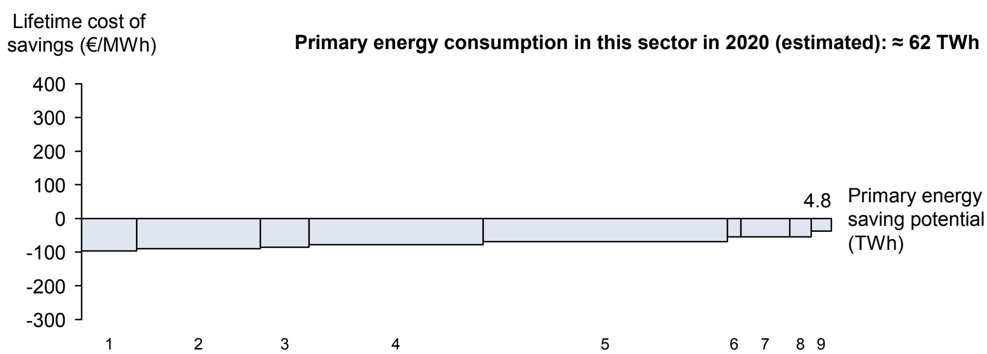
It can be seen that the primary energy savings potential to 2020 of a shift to AFVs is not large compared with the potential of many of the other measures shown. In part, this reflects the modest uptake to 2020 presented above. However, considering only primary energy savings, which is the focus of this analysis, also misses a very important advantage of EVs. EVs offer a pathway to zero emission mobility and are compatible with a low or zero carbon energy system. Provided technology developments and cost reductions for EVs continue, their uptake may accelerate in the period after 2020 making them an increasingly important part of the policy mix in the context of reducing emissions from the transport sector.

2.9 Energy efficiency cost curve: Industry

Figure 2-10 shows the energy efficiency cost curve for the industry sector. The total primary energy savings potential in this sector to 2020 is around 4.8 TWh, corresponding to around 8 % of the 62 TWh total estimated energy demand in the sector in 2020. The fractional savings potential in the industry sector is low compared with the other sectors. This can largely be explained by the fact that by 2020 nearly 60 % of industry final energy consumption is expected to be related to high or low temperature processes, the majority of this in the food and drink, basic metals and non-metallic minerals sub-sectors. Compared with end-use processes such as lighting, refrigeration and motor systems, the savings potential from heating processes, particularly in the basic metals and non-metallic minerals sub-sectors, is relatively small.

We note that Ireland's highly successful energy efficiency programme for large industry, the LIEN[13], which now covers more than half the total industry primary energy demand, claimed nearly 580 GWh in primary energy savings in 2012. As a result, the remaining potential for LIEN members is lower than for non-LIEN members; 'suitability factors' have been developed and applied accordingly.

Technical measures[14] in the industry sector include more efficient motors, refrigeration, compressed air and steam systems, process integration and heat recovery[15], more efficient HVAC (heating, ventilating, and air conditioning) and lighting, and CHP (combined heat and power). The largest savings potential is available through process integration and heat recovery for low temperature processes (1.6 TWh), CHP (0.8 TWh) and more efficient motor systems (1.1 TWh). The remaining measures offer further potential savings of 1.3 TWh.



Measure	PE saving (TWh)	Measure	PE saving (TWh)
1. More efficient refrigeration	0.35	6. More energy-efficient lighting	0.09
2. CHP	0.79	7. Process integration & heat recovery - high T processes	0.31
3. More efficient compressed air systems	0.31	8. More energy efficient steam system	0.14
4. Motor efficiency	1.10	9. More efficient HVAC and ventilation	0.13
5. Process integration & heat recovery - low T processes	1.55	**Total**	**4.76**

Figure 2-10: Energy efficiency cost curve for the Industry sector

[13] http://www.seai.ie/Your_Business/Large_Energy_Users/LIEN/

[14] We note that no behavioural measures have been included in the industry sector, as energy consumption in the sector is dominated by energy-intensive processes.

[15] 'Process integration and heat recovery' refers to the use of design principles and/or technologies enabling previously 'wasted' heat resulting from a certain process to be captured and used as an input to a second process.

We note that no behavioural measures have been included in the industry sector, as there is a dearth of evidence on the potential for such energy savings (although we note that, to the extent that it involves a change in the way systems are designed and operated, 'process integration and heat recovery' can be seen partly as a behavioural measure).

All measures modelled in the industry sector are found to be cost-effective. This reflects the fact that the utilisation of equipment in industry is typically high, meaning that the premium for high efficiency equipment is paid off over a much shorter period than the lifetime of the equipment.

The measures contained in the Shallow, Medium and Deep packages for the public sectors are shown in Table 2-3. Figure 2-11 shows the energy efficiency cost curve for packages for the industry sector. It can be seen that all packages for the industry sector are cost-effective and the lifetime cost of the Deep package is more negative than that of the Medium and Shallow packages. It is worth remembering here that the measures in the Deep package are in the Deep package due to either a high capital cost or a low decision frequency or both; this is not inconsistent with the very negative lifetime cost of savings.

Table 2-3: Measures contained in packages for the industry sector

Sector	Shallow	Medium	Deep
Industry	• Energy efficient lighting	• **All Shallow measures** • More efficient compressed air systems • Process integration and heat recovery – high and low temp. processes • More energy efficient steam system	• **All Medium measures** • More efficient HVAC and ventilation • CHP • More efficient refrigeration • Motor efficiency

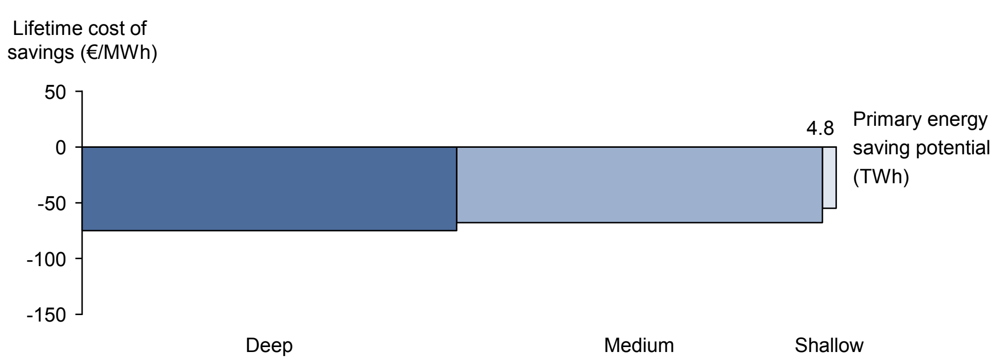


Figure 2-11: Energy efficiency cost curve for the Industry sector (packages)

2.10 Energy efficiency cost curve: all sectors

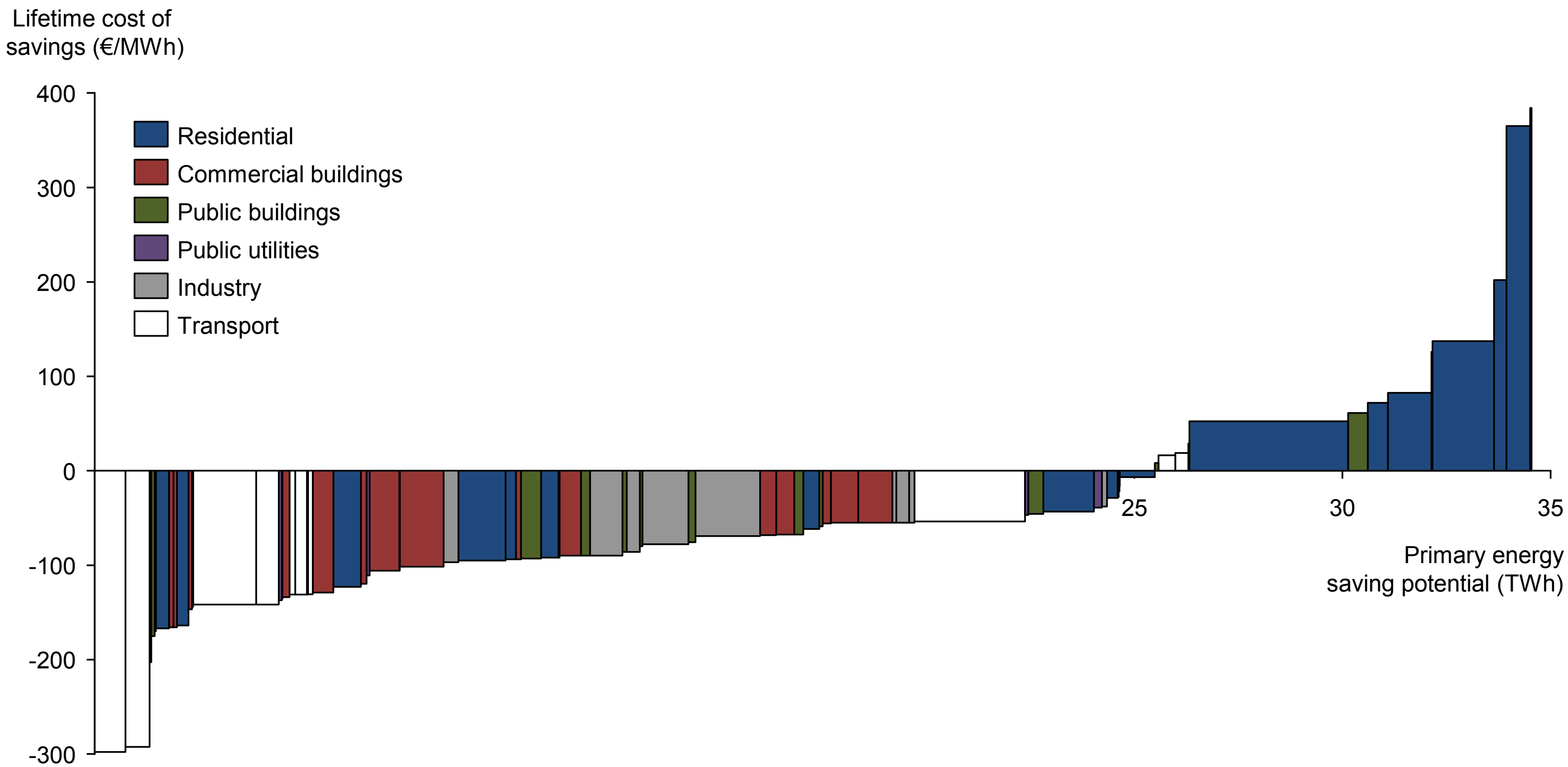
Figure 2-12 presents the energy efficiency cost curve for individual measures across all demand-side sectors in Ireland and Table 2-4 summarises the technical and economic potential[16] in each sector both in absolute terms and as a percentage of the total demand in 2013. Across all sectors studied there remains nearly 35 TWh of technical savings potential to 2020, representing 19 % of the total primary energy demand in 2013.[17] More than 26 TWh of this, corresponding to 15 % of the total demand in 2013, is economic (i.e. below the x-axis).

We emphasise that measures that are uneconomic (i.e. above the x-axis) using a 10 % discount rate are likely to be difficult to achieve without additional intervention, but could be unlocked with well-targeted support and/or financial incentives. Potential Government interventions are examined in detail in the next section. Furthermore, as shown in the above sections, the application of packages rather than individual measures is a powerful way of increasing the fraction of the overall potential which is economic without requiring further support or financial incentive.

The reader is referred to the Appendix, Section 7.1 for a version of the economy-wide cost curve labelled with all measures contained and the associated savings potential.

[16] We define 'economic' to mean a negative lifetime cost at stated the discount rate (in this section, the discount rate used is 10%).

[17] We emphasise that this does not include savings achieved between 2007 and 2012 (amounting to around 12 TWh), and so does not suggest that the 20% target for 2020 cannot be met.



Note: All Energy Efficiency cost curves included in this chapter show measures applied cumulatively in order of cost-effectiveness. In the buildings sectors, behavioural measures are always applied after all non-behavioural measures.

Figure 2-12: Energy efficiency cost curve for Ireland

Table 2-4: Summary of Technical and Economic potential for all sectors[18]

Sector	Measure type	Energy savings potential
Commercial	Technical measures	5.15
	Behavioural measures	0.80
	Total	**5.95**
	As % of Baseline	**35%**
Public buildings, transport and utilities	Technical measures	2.65
	Behavioural measures	0.40
	Total	**3.05**
	As % of Baseline	**30%**
Residential	Technical measures	11.05
	Behavioural measures	2.41
	Total	**13.46**
	As % of Baseline	**30%**
Transport (excl. public transport)	Technical measures	4.43
	Behavioural measures	2.90
	Total	**7.32**
	As % of Baseline	**17%**
Industry	Technical measures	4.76
	Total	**4.76**
	As % of estimated Baseline (2020)	**8%**
All sectors	Technical measures	28.03
	Behavioural measures	6.51
	Total	**34.55**
	As % of Baseline	**19%**

[18] Primary energy savings in 2020 (TWh).

3 Energy efficiency investment pathways to 2020

A key objective of this work is to go beyond the estimates of the technical and economic savings potential described above, and to incorporate the behaviour and decision-making process of consumers to assess which policy interventions could be employed to achieve the 2020 target most cost-effectively. In this section, we describe the construction of several economy-wide scenarios designed to meet the 2020 target.

As described in Section 1.2, we first developed scenarios at the sector-level, describing the range of savings which could be achieved through feasible policy interventions. To achieve this, two distinct routes were followed. For the commercial, public and residential building sectors, and for the industry sector, we have developed a detailed model of the consumer decision-making process in order to estimate the uptake of energy efficiency measures under a variety of policy interventions. In the transport and public utilities sectors, the sector-level scenarios are developed off-model, based on specific sector-level analysis and literature review.

3.1 Consumer decision-making process

Our conceptual framework for the consumer decision-making process is shown in Figure 3-1. The model essentially consists of a series of ‘barriers’ to the uptake of energy efficiency measures. Through the collection of quantitative data relating to each barrier, this approach allows us to directly model the effect of a variety of policy interventions on uptake.

In the sections below, we explain the various aspects of this framework, and the types of policy intervention which can be applied at each stage to affect the level of uptake of energy efficiency measures. A worked example of how annual uptake is derived based on the framework is also included in Figure 3-3..

The quantitative data required to populate this framework were collected through a combination of original field-work and an analysis of existing data including previous surveys deployed in Ireland.[19] A summary of this data set, which is too detailed for presentation in this report, is given in the accompanying Technical Appendix (Methodology and technical assumptions) and in the report for the survey of consumer behaviour in the commercial buildings sector.[20] Subsequent sections describe each element of the consumer decision-making process in more detail.

[19] SEAI reports: 'Retrofit Research: Qualitative & Quantitative Report', 2013 and 'Private Landlord Survey', 2013

[20] Element Energy and The Research Perspective, 2014, 'Survey of consumer behaviour in the commercial sector in the Republic of Ireland'.

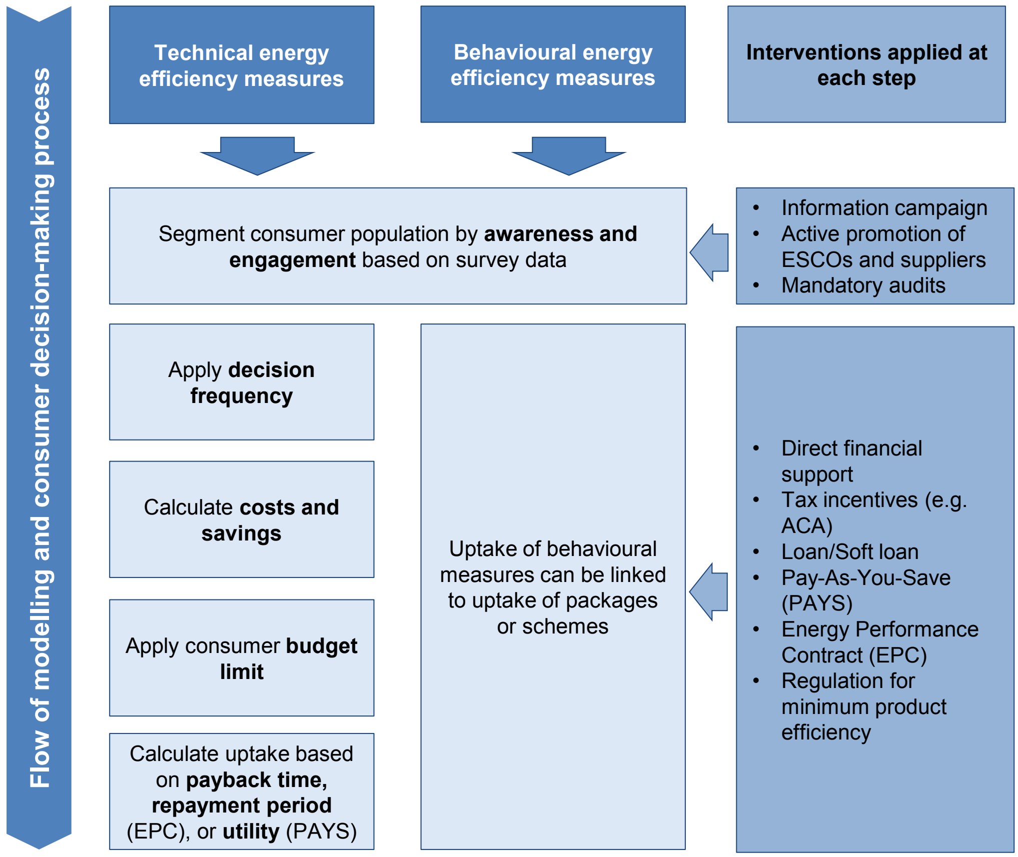


Figure 3-1: Consumer decision-making process in the Commercial, Public, Residential building and Industry sectors

3.1.1 Technical energy efficiency measures

Awareness and engagement

The first aspect of our decision-making process is the segmentation of the consumer population on the basis of 'awareness and engagement.' This segmentation describes whether consumers make decisions (whether positive or negative) related to energy efficiency at all. We have defined four consumer segments:

I. Consumers who do not think they need to reduce energy use as **energy is not a top priority**;
II. Consumers who think they have **already put in place all possible measures**;
III. Consumers who think they can reduce energy use but they **need more information**;
IV. Consumers who **consider energy efficiency options**.

The four consumer segments are treated differently in the subsequent steps of the decision-making process. For instance, consumers in group I (for whom energy is not a top priority), are assumed not to participate in decision-making regarding energy efficiency unless regulation is applied to make this mandatory. Consumers in group II (who think they have already put in place all possible energy efficiency measures) can only be encouraged to participate through either regulation or 'active promotion' interventions, where energy service companies (ESCOs) or energy suppliers present tailored estimates of energy saving potential directly to customers. Generic, 'untargeted' information campaigns are not assumed to change the behaviour of consumers in groups I or II. Consumers in group III (who identify themselves as 'needing more information'), on the other hand, are assumed to participate when an information campaign is undertaken. Consumers in group IV participate even in the absence of interventions. The breakdown of commercial building consumers across the four segments by building activity type is shown below.

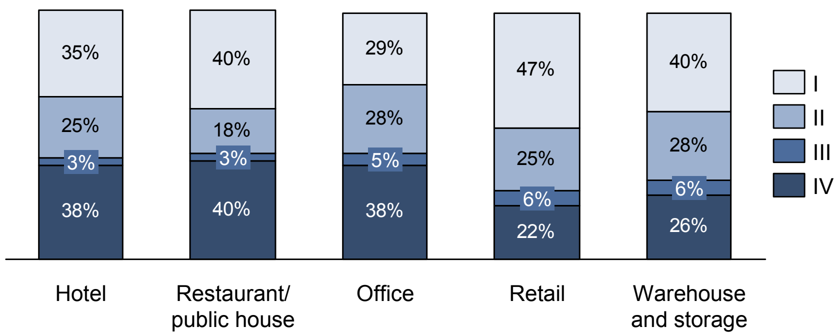


Figure 3-2: Key survey results for consumer awareness and engagement[21]

Decision frequency

The concept of decision frequency was introduced in Section 2.3. The decision frequency is the frequency with which consumers make purchasing decisions (whether positive or negative) regarding their building fabric or equipment, and is thus an important limit to the rate at which energy efficiency measures can be taken up.

The decision frequency is typically related to 'trigger points' at which consumers are most likely to consider making energy efficiency improvements.[22] [23] For a deep retrofit, this might be an end-of-life replacement for a heating system or other major piece of equipment, for the roof or windows, a major building renovation (initially for reasons other than energy efficiency) or major plant maintenance in an industrial facility. For a shallow retrofit such as a loft insulation top-up or draught-proofing, this could be related to a minor renovation such as the redecoration of a room.

Thus, the decision frequency cannot easily be affected, and we do not vary this parameter in the model in response to policy interventions. We note that there are conceivable situations in which the decision frequency could be increased, at least in the short term. For example, if direct financial support were offered for a fixed period of time, this may have the effect of bringing forward renovation work which may otherwise have occurred at a later time. Similarly, a concerted public sector programme to renew existing infrastructure may increase the decision frequency beyond the natural replacement rate of that infrastructure.

---

[21] Element Energy and The Research Perspective, 2014, 'Survey of consumer behaviour in the commercial sector in the Republic of Ireland'.
[22] http://www.rmi.org/retrofit_depot_101_specifying_triggers, accessed 6 December 2014.
[23] Energy Saving Trust (EST), 2011, 'Trigger Points – A Convenient Truth: Promoting Energy Efficiency in the Home'.

Economic criteria

The remaining aspects of decision-making within the framework relate to consumer requirements regarding economic criteria. We consider three main routes to investment in energy efficiency measures:

- **Investments made without a contract (all sectors)**

For consumers' own investments, we account for consumers' budget limit and willingness to pay. The budget limit determines whether the consumer is able to fund each measure without financial assistance. Consumer decision-making in a wide range of contexts can be represented through their willingness to pay, expressed in terms of the fraction of decision-makers willing to purchase a technology for a given simple payback period.[24] In this case, we consider the effect on uptake of policy interventions including direct financial support, a tax incentive and/or a loan.

- **Investments made through an Energy Performance Contract (EPC) with an Energy Service Company (ESCO) (commercial and public sectors, and industry)**

An EPC is a way of allowing consumers in the commercial, public and industry sectors to take up a measure even if the capital cost exceeds their budget limit (see the box, 'Energy Performance Contracting'). For investments made through an EPC, we account for consumers' attitude to the scheme, and for their requirements in terms of repayment time. The repayment time for a project was calculated using a typical rate of return expected by ESCOs. In our model, an EPC may be combined with direct financial support or a tax incentive.

Given that the risk associated with the installation is taken, to a greater or lesser degree depending upon the precise form of the EPC, by the ESCO, it could be also expected that consumers in the commercial sector would accept a longer EPC repayment period than they would accept as a simple payback time for their own investment.

- **Investments made through a Pay-As-You-Save (PAYS) scheme (residential sector)**

A PAYS scheme is a financial model to help consumers in the residential sector to take up a measure even if the capital cost exceeds their budget limit. The cost of the measure is spread over a number of years and the repayments are less than the predicted savings. For investments made through a PAYS scheme, we account for consumers' attitude to the scheme, and the perceived 'utility' of the energy efficiency measure derived from a logit-based consumer choice model.[25] In our model, a PAYS scheme may be combined with direct financial support or a tax incentive.

[24] Simple payback time is defined as (Capital cost) / (Net annual savings).

[25] The model draws on the logit coefficients for PAYS (based on a previous survey deployed in the UK), technology costs, fuel costs, loan length, interest rate, annual repayment amount and source of loan to determine an overall 'utility'. This utility is then used to drive a probabilistic logit equation which predicts uptake of energy efficiency packages for each house type in each year.

Energy Performance Contracting

A growing number of energy efficiency retrofits in the commercial sector are implemented as a result of Energy Performance Contracts (EPCs) between commercial building owners/managers and energy service companies (ESCOs). In simple terms, an EPC involves an ESCO performing an energy audit for the building and, if it finds sufficient potential for energy savings, supplying a loan for the capital cost for the improvement work. The loan is repaid with interest through the savings achieved on the company's energy bill, with the ESCO taking some or all of the savings for the 'repayment period'. In a 'Guaranteed' EPC scheme, the loan is only repaid if the expected savings are achieved. In a 'Non-guaranteed' scheme, the loan must be repaid even if the expected savings are not achieved, but a lower rate of interest is paid to the ESCO to reflect the greater risk borne by the building occupier. An EPC is therefore a way of allowing consumers to take up a measure even if the capital cost exceeds their budget limit. Given that the risk associated with the installation is taken, to a greater or lesser degree depending upon the precise form of the EPC, by the ESCO, it could be also expected that consumers in the commercial sector would accept a longer EPC repayment period than they would accept as a simple payback time for their own investment.

Worked example of decision-making process

A worked example showing how the consumer decision-making process works in our model is presented in Figure 3-3. The figure shows how annual uptake is derived for an illustrative building archetype with 100 buildings. The actual number of consumers making it to the final measure uptake stage in the model varies by cohort.

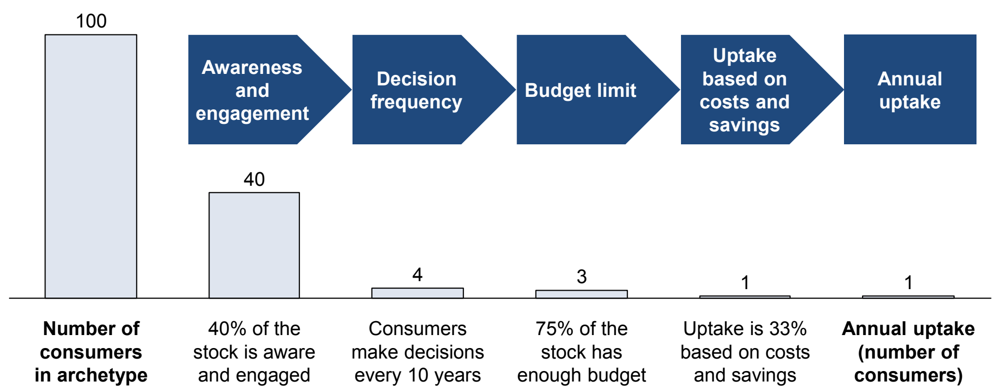


Figure 3-3: Worked example of decision-making process (illustrative)

As discussed above, the number of consumers taking up energy efficiency improvement measures each year can be influenced at the various stages of the decision-making process by appropriately targeted policy.

3.1.2 Behavioural energy efficiency measures

Awareness and engagement

The segmentation of consumers according to awareness and engagement, as described above for technical measures, is performed separately for behavioural measures.

Uptake of behavioural measures

Since the uptake of behavioural measures tends to be limited by a lack of awareness and/or the inconvenience involved, rather than by the cost of the measure (which is typically zero), the remaining aspects of the decision-making process are different from those for technical measures. Evidence collected for DECC[26] shows that information and/or training provided at the same time as the adoption of new technology can act as a stimulus for implementing behavioural measures. The approach taken in the modelling work was therefore to link the uptake of behavioural measures with the uptake of technical measures using an EPC or PAYS scheme, the assumption being that these are opportunities for targeted information on behavioural measures to be conveyed to the consumer. In addition, we have linked the uptake of certain behavioural measures to the rollout in Ireland of smart meters with in-home displays.

3.2 Sector-level scenarios

3.2.1 Approach for developing sector-level scenarios

For each sector, we have identified a list of policy interventions which could be applied in order to encourage the uptake of energy efficiency measures. In the commercial, public and residential building sectors, and for the industry sector, the interventions are shown in Figure 3-1 in terms of their impact in the model of consumer decision-making. In the transport and public utilities sectors, the interventions correspond directly to the implementation of the measures shown in the cost curves in Section 2.

We have assigned each of these policy interventions, at a sector-level, to 'Central', 'High' and, for some sectors, 'Very High' scenarios, reflecting the 'level of effort' entailed. The overall level of effort required to reach the 2020 target is the ultimate goal of each scenario. It is important to note that the Central scenario should not be considered a 'business-as-usual' scenario. It covers existing policy interventions and additional policy interventions where they are deemed to be relatively straightforward to implement and likely to be successful (in particular, those with a low cost to the Exchequer). The High and Very High scenarios include further policy interventions deemed to be more difficult to implement or less likely to be successful, typically involving a greater cost to the Exchequer or additional regulation. The key point regarding the sector-level scenarios is that they have been constructed to cover the full range of savings deemed feasible.

3.2.2 Sector-level scenarios: Commercial buildings

Figure 3-4 shows the energy savings achieved in each of the commercial building sector scenarios, based on the level of uptake predicted by the model. The savings allocated to

[26] 'What works in changing energy-using behaviours in the Home? A Rapid Evidence Assessment', RAND Europe for DECC, 2012.

the commercial building sector in NEEAP III are shown for comparison.[27] It can be seen that the savings from 2007 to 2020 are in all scenarios higher than the savings allocated to the sector in NEEAP III, ranging from 2.5 TWh to 3.2 TWh. It is important to note that the Central scenario includes a number of interventions which are either not currently planned or at least not yet implemented.

Table 3-1 details the energy savings attributed to each intervention between 2013 and 2020 in the commercial sector scenarios. Through 'active promotion of ESCOs', all consumers in groups II (those who think they have already put in place all possible measures) and group III (those who state that they need more information, as defined in Section3.1) are brought in to participate in energy efficiency decision-making over the period 2015 – 2020.[28] As described in our accompanying report on the survey of consumer behaviour in the commercial sector, approximately a third of all companies identify themselves as belonging to group II, and hence this intervention contributes significant energy savings of 0.3 TWh. In addition, mandatory energy audits for all large companies from 2015, in response to the requirements of the Energy Efficiency Directive, will compel all large companies in consumer groups I (consumers who do not think they need to reduce energy use as energy is not a top priority), II and III to assess the potential for energy saving measures in their buildings, and to make a decision on whether to implement them (be that a positive or negative decision). Since approximately another third of all companies identify themselves as belonging to group I, this leads to an additional 0.5 TWh of savings after the impact of other barriers to uptake (budget, pay back criteria etc.) are taken into account. Also included in the Central scenario is regulation to mandate the minimum efficiency of boilers and lighting. While such regulation applies to domestic buildings in Ireland, there is currently no corresponding regulation in the non-domestic sector. The implementation of such regulation saves an additional 0.4 TWh.

A further 0.1 TWh of savings is achieved through behavioural change. In the scenarios presented here, all commercial organisations taking up a Deep package through an EPC undertake additional training of their staff and energy management team to promote behaviour change, and therefore implement each of the behavioural measures shown in Section 3.2.2. There is no assumption that other organisations implement behaviour change. Finally, an information campaign on energy efficiency (for both technical and behavioural measures) leads to a further 3 GWh of savings. The effect of the information campaign is to lead consumers in group III (those who identify themselves as needing more information on energy efficiency) to consider energy efficiency measures. An information campaign acts to promote both 'technical' measures and 'behavioural' measures, based on responses to our survey of commercial consumers. As shown in Figure 3-2, this group represents only a very small fraction of the population, and so the information campaign leads to limited additional savings.

The High and Very High scenarios in the commercial buildings sector include varying levels of direct financial support. We note that this support could be provided by the Exchequer, or it could be provided by energy suppliers as part of the Energy Supplier Obligation, or a combination of the two. It can be seen that providing 30 % of the upfront cost of Deep retrofit packages only (with no support for Shallow to Medium packages), as

[27] The allocation of savings in NEEAP III to the sectors in this study is described in the accompanying Technical Appendix (Methodology and technical assumptions).

[28] In Section 6.2 we will describe the practical implications and recommendations for the key policy interventions listed here.

in the High scenario, leads to 0.3 TWh of savings.[29] Increasing the level of support to 60 % of the upfront cost (of Deep packages only), a further 0.4 TWh is saved. The overall cost implications of this are described in Section 4.

In summary, our analysis shows that the NEEAP III allocation of savings to the commercial buildings sector could be exceeded by 0.2 TWh without the provision of direct financial support, and by up to 0.9 TWh with direct financial support.

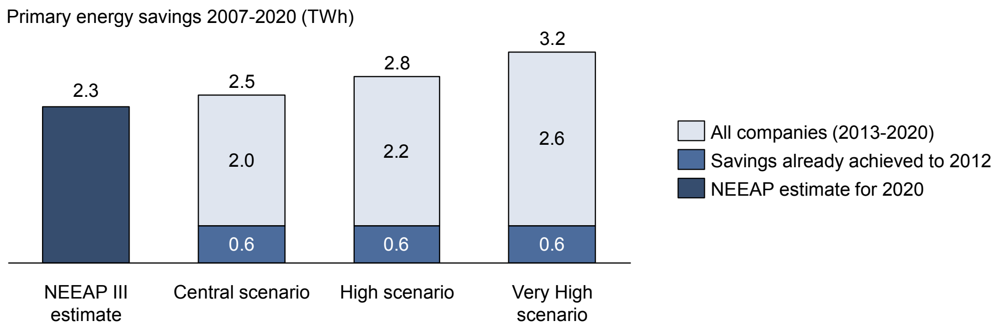


Figure 3-4: Commercial sector scenarios

Table 3-1: Savings attributed to each policy intervention in the Commercial sector scenarios

Category	Intervention	Primary energy savings 2013–2020 (GWh)[30]		
		Central	**High**	**Very high**
All companies	Existing interventions (including ACA and Energy Performance Contracting)	660	As for Central	As for High
	Behavioural change (including targeted and untargeted information)	105		
	Active promotion of ESCOs	275		
	Regulation for minimum boiler and lighting efficiency	440		
	Mandatory energy audit for large companies	480		
	Direct support of up to 30 % of capex (for Deep retrofits)	Not included	265	
	Direct support of up to 60 % of capex (for Deep retrofits)	Not included	Not included	375
Total		**1,960**	**2,225**	**2,600**

[29] In the model, direct financial support can be applied in combination with other interventions, including EPC and PAYS contracts. In each case, the financial support is applied first; the consumer can then make a choice whether to take up the measure using an EPC or a PAYS contract or without a contract.
[30] These savings are additional to those given in the NEEAP for the period 2007 – 2012, but *not* additional to those given in the NEEAP for the period2013 – 2020.

3.2.3 Sector-level scenarios: Public sector (public buildings, public transport and public utilities)

Figure 3-5 shows the energy savings achieved between 2007 and 2020 in each of the public sector scenarios, and the comparison with NEEAP III. We show the combined savings in the public buildings, public transport and public utilities sectors in order to compare the scenarios with Ireland's target for a 33 % reduction in primary energy consumption across the public sector. The Central and High scenarios, which include strong policy interventions to reflect the aggressive 33 % savings target, achieve savings of 3.4 TWh and 3.5 TWh respectively. The savings in both scenarios exceed the 33 % savings target (which amounts to 3.2 TWh), but fall just short of the NEEAP III allocation to the public sector of 3.7 TWh.

Table 3-2 shows the contribution of individual interventions to the overall savings between 2013 and 2020. The Central scenario includes a number of key interventions. In relation to public buildings, EPCs have the potential to unlock large energy savings. In the public sector, this intervention entails less stringent repayment period requirements than for the commercial sector. This reflects longer-term decision-making due to a centralised mandate towards meeting the 33 % savings target. With such repayment requirements, EPCs result in an additional 0.5 TWh of savings, contributing to the 1.0 TWh of savings achieved by all existing interventions. Behavioural change through targeted information in the public buildings sector also carries a large savings potential. With a large proportion of public sector building retrofits being implemented via EPCs, there is a clear opportunity to effect behaviour change through the training of staff and the energy management team. In the scenarios shown here, all public sector organisations implementing Medium or Deep packages with an EPC achieve the implementation of behavioural measures. This leads to an additional 0.6 TWh of savings. Mandatory energy audits for all large public organisations save an additional 0.3 TWh.

The active promotion of ESCOs, which leads all public sector organisations in consumer group II (those who think they have already put in place all possible measures) and group III (those who state that they need more information) to participate in energy efficiency decision-making within two years, achieves a further 95 GWh of savings. In the High scenario, we include direct financial support amounting to 60 % of the upfront cost of Deep retrofit packages only. It can be seen that this leads to an additional 0.1 TWh of savings only. This reflects the fact that the majority of measures in the Public buildings sector are already cost-effective and are therefore already installed in the Central scenario through EPCs, without the need for direct financial support.[31] The remaining unachieved savings are limited more by the finite decision frequency than by the payback period.

As for the commercial sector, the effect of the untargeted information campaign is to lead all public sector consumers in group III (those who state that they need more information) to consider (though not necessarily implement) technical and behavioural energy efficiency measures. As this represents only a small fraction of the population, only 6 GWh of additional savings are achieved.

In public utilities, both the Central and High scenarios include retrofit of water services and upgrade of street lighting, leading to an additional 0.2 TWh of savings. As described in Section 3.1.1, a centrally-driven 'accelerated' retrofit of public utilities could be envisioned,

[31] As described above, direct financial support is applied in combination with an EPC. The financial support is applied first; the consumer can then make a choice whether to take up the measure using an EPC or without a contract.

which would increase the savings that could be achieved to 2020 by (temporarily) increasing the decision frequency.[32] Such an accelerated retrofit is therefore an option available to Ireland should other sectors 'underachieve' in terms of energy savings to 2020. In public transport, both the Central and High scenarios include increasing public bus efficiency and eco-driving, saving 54 GWh.

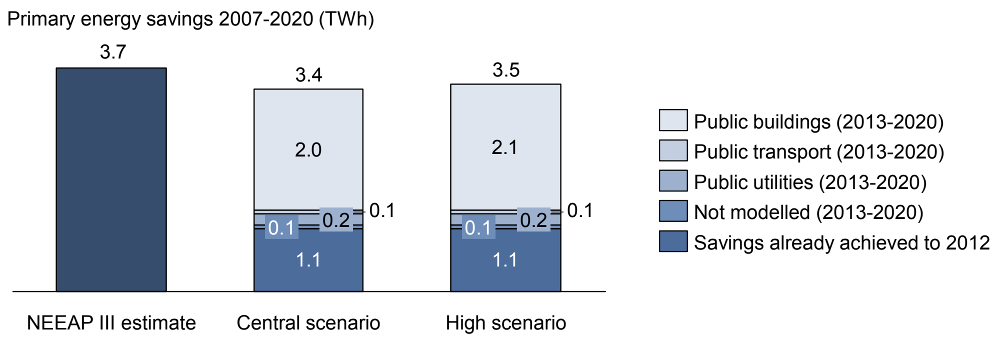


Figure 3-5: Public sector scenarios

Table 3-2: Savings attributed to each policy intervention in the Public sector scenarios

Category	Intervention	Primary energy savings 2013–2020 (GWh)	
		Central	High
Public buildings	Existing interventions (including ACA and Energy Performance Contracting)	970	As for Central
	Behavioural change (including targeted and untargeted information)	615	
	Active promotion of ESCOs	95	
	Regulation for minimum boiler and lighting efficiency	45	
	Mandatory energy audit for large companies	315	
	Direct support of up to 60% of capex (for Deep retrofits)	Not included	95
Public utilities	Street lighting upgrade through ESCOs	65	As for Central
	Water services retrofit through ESCOs	165	
Public transport	Increasing vehicle efficiency and eco-driving	55	
Not modelled		50[33]	
Total		**2,370**	**2,465**

[32] The uptake in the public utilities sector depends on the annual replacement rates of lanterns and water pumps, which are based on their lifetimes. In theory, it might be possible to achieve the whole technical potential by 2020 (e.g. by replacing all existing street lighting). The technical potential in this sector is ~0.5 TWh.

[33] 51 GWh of additional savings are expected from CHP deployment programme in the public sector.

3.2.4 Sector-level scenarios: Residential buildings

Figure 3-6 shows the energy savings between 2007 and 2020 in each of the Residential sector scenarios, and the comparison with NEEAP III. The Central, High and Very High scenarios achieve savings of 4.5 TWh, 5.3 TWh and 5.8 TWh respectively. It can be seen that all scenarios entail lower savings than the allocation to the residential sector in NEEAP III, which amounts to 6.6 TWh.

The contribution of individual policy interventions between 2013 and 2020 is shown in Table 3-3. Several key interventions are highlighted here. Existing interventions (including the regulation for minimum boiler and lighting efficiency) and the PAYS-type residential retrofit support scheme, which is currently under consideration, achieve nearly 1.9 TWh of savings between 2013 and 2020.

We note that the model suggests a relatively low anticipated uptake of the PAYS-type residential retrofit financing schemes, based on an interest rate of 8 %. It is important to note, however, that the interest rate for PAYS in Ireland has not yet been fixed. The box, ‘PAYS with lower interest rates

, describes the potential effect of a modified PAYS-type scheme with a reduced interest rate of 5 %.

In the Central scenario, without direct financial support, the intervention bringing the largest additional savings is behavioural change through smart meter rollout, which is assumed to lead consumers to implement the measures, ‘turn off lights when not in use’ and ‘turn off heating in unused rooms'. This achieves 0.5 TWh of savings assuming full rollout by 2020. This is not included in the ‘existing interventions’ in order to emphasise that these savings carry uncertainty associated with the timing of smart meter deployment. To achieve these behavioural savings, it will be critical to ensure consumers have in-house displays of their energy consumption, and that there is sufficient provision of information on how the smart meter can be used to manage household energy consumption.

The active promotion of PAYS through energy suppliers leads all domestic consumers in consumer group II (those who think they have already put in place all possible measures) and group III (those who state that they need more information) to participate in energy efficiency decision-making within five years, and achieves a further 0.1 TWh of savings. In the scenarios presented here, consumers implementing Medium or Deep packages using PAYS also implement the full range of behavioural measures described in Section 2.7. This is intended to reflect the fact that an uptake of PAYS also presents an opportunity to affect behaviour change through the provision of targeted information to residential consumers on the type and value of behavioural measure savings available to them.

In order to achieve further savings, it is necessary to provide direct financial support for energy efficiency retrofits. We emphasise that this support could be funded by energy suppliers (through the Energy Supplier Obligation, for example) and by the public sector. In the High scenario, direct financial support of up to 60 % of the upfront cost of Medium and Deep retrofits leads to savings of 0.7 TWh. In the Very High scenario, increasing the level of support to 75 % of the upfront cost of Medium and Deep measures leads to additional savings of 0.5 TWh. As explained previously, for each sector, the Central scenario covers existing policy interventions and additional policy interventions with a low cost to the Exchequer. Grants are therefore excluded in the Central scenario.

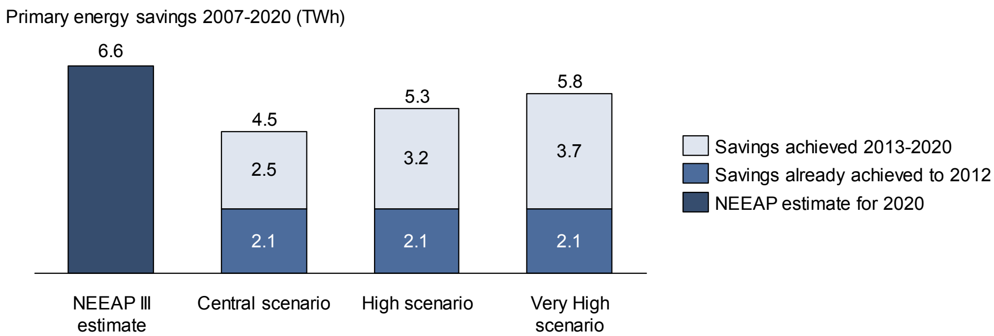


Figure 3-6: Residential sector scenarios

Table 3-3: Savings attributed to each policy intervention in the Residential sector scenarios

Category	Intervention	Primary energy savings 2013–2020 (GWh)		
		Central	High	Very High
All dwellings	Existing interventions (including regulation for minimum boiler and lighting efficiency) and Pay-As-You-Save scheme	1,850	As for Central	As for High
	Active promotion of PAYS	105		
	Behavioural change (including untargeted and targeted information such as smart meter rollout)	540		
	Direct support of up to 60% of capex (for Medium and Deep retrofits)	Not included	715	
	Direct support of up to 75% of capex (for Medium and Deep retrofits)	Not included	Not included	505
Total		**2,495**	**3,210**	**3,715**

PAYS with lower interest rates

A potentially important factor behind the low uptake of the Green Deal – the PAYS-type scheme for residential retrofits in the UK – is the relatively high associated annual interest rate of 7–10%. With the involvement of the Government, more attractive interest rates (i.e. 5% or lower) could be offered to the consumers. In order to test the impact of the interest rate, we have run our model using a reduced interest rate of 5% for PAYS. We find that an additional saving of 0.4 TWh could be achieved by reducing the interest rate from 8% to 5%. The results suggest that lower interest rates encourage uptake of the finance.

3.2.5 Sector-level scenarios: Transport

Figure 3-7 shows the energy savings in each of the transport sector scenarios, and the comparison with NEEAP III. The Central scenario achieves savings of 5.2 TWh, and the High scenario 6.9 TWh. It can be seen that both scenarios achieve greater savings than the 4.5 TWh allocated to the transport sector in NEEAP III.

We note that a large fraction of the savings between 2013 and 2020 in the Central scenario is achieved by policy interventions already in place. The VRT/AMT rebalancing for private cars and the mandatory emissions standards for cars and LDVs together account for more than 3.4 TWh of savings (3.1 TWh. for cars and 0.4 TWh for LDVs). The 'Baseline AFV incentive', which corresponds to the continuation of the level of support provided through the current Electric Vehicle Grant Scheme (and VRT exemption) to 2015, is included in the Central scenario (see the High scenario below for continuing EV support). Also included in the Central scenario is the behavioural measure of eco-driving. Eco-driving schemes in other countries have been successful in reducing energy consumption across the vehicle stock by several percentage points. If Ireland were successful in promoting and sustaining eco-driving practices, this could achieve more than 0.7 TWh of additional savings.

The measures included in the High scenario carry a much greater uncertainty. The measure with the largest savings potential in the High scenario is modal shift from cars to public transport, cycling and walking. While the Irish Government has targets for modal shift for commuters, the overall trend is in the other direction: for travel to work, the share of private car drivers has been rising, while the share of private car passengers, pedestrians and bus passengers has been falling.[34] Therefore, achieving the savings shown here should be considered unlikely. The High scenario includes savings due to increasing HGV efficiency. There are currently no mandatory emissions standards for HGVs. However, earlier this year the European Commission announced a strategy towards regulating HGV emissions. Since this strategy is still in development, and no binding measures have been adopted, the likely savings to 2020 are relatively uncertain. The High scenario also includes the 'High AFV incentive', where the current levels of grant support are kept the same in absolute terms to 2020 (despite the significant decrease in the price of electric vehicles). This brings an additional 42 GWh of savings.

We also note that some of the potential energy savings shown in the cost curve in Figure 2-9 are not included in either the Central or High scenario, as achieving these savings is considered to carry a very high level of difficulty. Measures not included in the scenarios but which have significant savings potential include a shift towards smaller private cars and a shift to higher weight class HGVs. In each case, there is no supporting policy in place, and it is considered very unlikely that these savings will be achieved.

[34] Deduced from census data, Central Statistics Office (1981–2011).

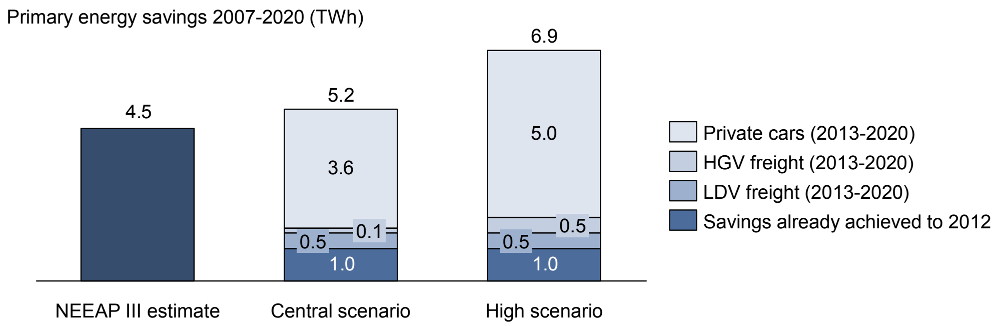


Figure 3-7: Transport sector scenarios

Table 3-4: Savings attributed to each policy intervention in the Transport sector scenarios

Category	Intervention	Primary energy savings 2013–2020 (GWh)	
		Central	High
Private cars	Existing interventions (including EU regulation, VRT/AMT rebalancing, Baseline AFV incentive)	3,090	As for Central
	Eco-driving	500	
	Modal shift	Not included	1,380
	High AFV incentive	Not included	40
HGV freight	Eco-driving	135	As for Central
	Increasing HGV efficiency	Not included	325
LDV freight	Existing interventions (including EU regulation)	350	As for Central
	Eco-driving	110	
Total		**4,185**	**5,935**

3.2.6 Sector-level scenarios: Industry

Figure 3-8 shows the energy savings achieved between 2007 and 2020 in each of the industry sector scenarios, and the comparison with NEEAP III. We disaggregate the savings achieved by Large Industry Energy Network (LIEN) and Non-LIEN companies up to 2020. The Central and High scenarios achieve savings of 5.0 TWh and 5.5 TWh respectively. The allocation of savings to the industry sector in NEEAP III, amounting to 5.3 TWh, falls between the two scenarios shown here.

Table 3-5 shows the contribution of individual interventions in the industry sector between 2013 and 2020. It can be seen that existing interventions, in particular the LIEN Programme for large industrial companies, are already expected to lead to nearly 1.7 TWh of savings between 2013 and 2020. The remaining potential relates to increasing the participation in energy efficiency decision-making of smaller industrial companies. We note that there are approximately 4,000 industrial companies in Ireland, of which around 160 are members of LIEN. Although the industrial organisations, which are members of LIEN, account for over 50 % of the industry primary energy demand[35], increasing the engagement of the Non-LIEN companies could lead to significant energy savings.

In the Central scenario, the 'Active promotion of ESCOs', which leads all Non-LIEN companies in consumer groups II and III to participate in energy efficiency decision-making (be it positive or negative) within three years, saves 0.6 TWh.

In the High scenario, the regulation for mandatory energy audits is extended to all industrial companies, rather than just large companies, as is likely to be the case based on the requirements of the Energy Efficiency Directive. This leads all companies in consumer group I to participate in energy efficiency decision-making from 2015, and saves an additional 0.5 TWh.

It should be noted that the scenarios considered do not include an expansion of the existing LIEN Programme which could potentially induce savings beyond that currently envisaged.

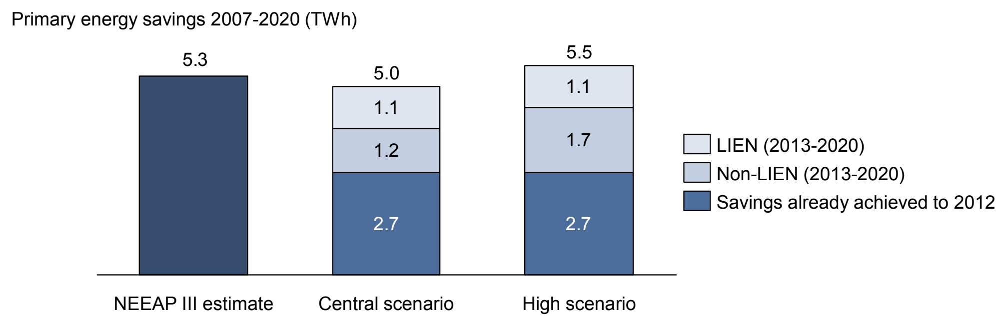


Figure 3-8: Industry sector scenarios

Table 3-5: Savings attributed to each policy intervention in the Industry sector scenarios

Category	Intervention	Primary energy savings 2013–2020 (GWh)	
		Central	**High**
All companies	Existing interventions (including LIEN Programme, ACA and Energy Performance Contracting)	1,655	As for Central
Non-LIEN companies	Active promotion of ESCOs	600	As for Central
	Mandatory energy audit for all companies	Not included	540
Total		**2,260**	**2,800**

[35] The LIEN annual report 2013 is available at http://www.seai.ie/lienreport/report.html.

3.3 Economy-wide scenarios

3.3.1 Central scenarios

As discussed in Section 3.2.1, the sector-level scenarios described above have been constructed to cover the full range of energy savings deemed feasible. The Central scenarios are not business-as-usual scenarios, but contain only interventions considered relatively straightforward to implement and likely to succeed, along with interventions already implemented. The High and Very High scenarios include further policy interventions with higher 'levels of effort'; that is, those deemed to be more difficult to implement or less likely to be successful. Therefore, we first consider whether the target is achieved by implementing only the interventions in the Central scenarios for each sector.

Figure 3-9 shows that, with only the interventions included in Central sector-level scenarios, the 2020 energy savings target is not achieved; there is a shortfall of around 2 TWh. We note that this economy-wide scenario includes no additional direct financial support beyond a continuation of the existing levels of funding, and achieves more than 90 % of the overall 32 TWh target for the full period 2007 – 2020. However, we emphasise that this is not a business-as-usual scenario, but one requiring the successful implementation of the wide range of new interventions described above. To recap, they include:

- mandatory energy audits for all large commercial organisations;
- new regulation on the efficiency of lighting and heating in the non-domestic sector;
- Government activities to promote the ESCO model to reach those organisations currently unaware of, or disengaged in, energy efficiency;
- new financing schemes for residential retrofit;
- the training of energy users in behavioural change when they take up energy efficiency using an EPC or any Government-backed scheme;
- information campaigns to promote building retrofit and more efficient driving practices;
- and the successful rollout of smart meters across all homes.

In order to meet the 2020 target, however, it is necessary to find additional savings from one or more sectors beyond the Central scenarios.

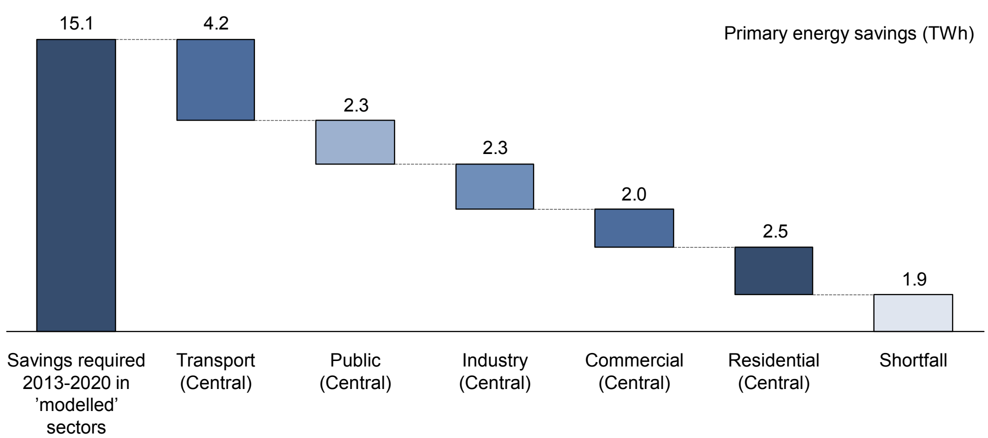


Figure 3-9: Shortfall in savings achieved with Central scenarios

3.3.2 Scenarios to meet the 2020 target

Our first aim is to find out which sets of policy interventions are required in order to achieve the economy-wide 2020 target. To determine this, we have considered all combinations of the sector-level scenarios. Three of the economy-wide scenarios, are found to meet the 2020 target, achieving at least 15.1 TWh of savings between 2013 and 2020. It can be seen that each scenario involves High or Very High levels of effort for at least two sectors among industry, commercial and residential.[36] The economy-wide scenarios are named to indicate the two sectors for which the extra 'push', or level of effort, is required.

Table 3-6: Three economy-wide scenarios meeting the 2020 target (TWh)

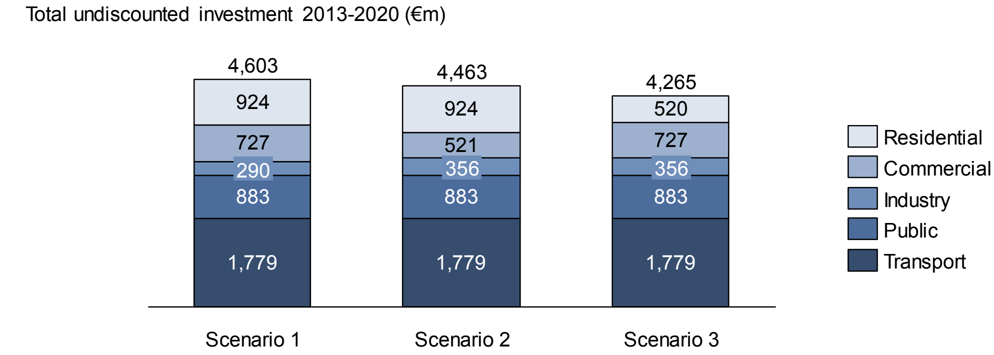
Sector	Scenario 1 – Push Commercial and Residential		Scenario 2 – Push Residential and Industry		Scenario 3 – Push Industry and Commercial	
	Sector-level scenarios	Savings 2013-2020	Sector-level scenarios	Savings 2013-2020	Sector-level scenarios	Savings 2013-2020
Transport	Central	4.2	Central	4.2	Central	4.2
Public	Central	2.3	Central	2.3	Central	2.3
Industry	Central	2.3	High	2.8	High	2.8
Commercial	Very High	2.6	High	2.2	Very High	2.6
Residential	Very High	3.7	Very High	3.7	High	3.2
Total		**15.1**		**15.3**		**15.1**

In Section 4, we present a detailed comparison of these scenarios from the Exchequer perspective including a range of wider (indirect) benefits to the economy. Here, we present a brief comparison of the direct costs and benefits of the three scenarios from a 'consumer' perspective. There are also a number of significant non-energy benefits to energy efficiency, including improved health and wellbeing, and competiveness improvements for business. We note here that these non-energy benefits are likely to have an economic impact beyond the value of the benefits assessed here.[37]

Figure 3-10 compares the total undiscounted investment made in each sector between 2013 and 2020 for the additional policy effort, modelled to close the gap between the 2020 target and the total net present value (NPV) in 2013 of the energy efficiency investments made economy-wide between 2013 and 2020 including both private and public investments (using a 10 % discount rate). The total undiscounted investment ranges from €4.3 bn in Scenario 3 to €4.6 bn in Scenario 3. The NPV of the investments made ranges from €8.0 bn – that is, net *savings* of €8.0 bn – in Scenarios 1 and 2 to €8.2 bn in Scenario 3.

[36] We note that we have excluded the High scenario for transport, reflecting the high risk of failure associated with achieving modal shift. In addition, we have excluded the High scenario for the public sector, since this achieves only 0.1 TWh more savings than the Central scenario, at significant additional cost.

[37] See for example the significant literature on the multiple benefits of energy efficiency collated by the International Energy Agency, 'Capturing the Multiple Benefits of Energy Efficiency', IEA, 2014. Note some of the wider macroeconomic benefits are analysed in the subsequent sections.



	Scenario 1	Scenario 2	Scenario 3
Discounted costs (€bn)	3.3	3.2	3.1
Discounted benefits (€bn)	11.3	11.3	11.2
NPV (€bn)	**8.0**	**8.0**	**8.2**

Figure 3-10: Summary of costs, benefits and NPV in each scenario (10% discount rate)

Table 3-7 compares the number of consumers invested in the energy efficiency packages in the three scenarios. From a Government perspective, Scenarios 1 and 2 both require a push on housing and require substantial numbers of retrofits in residential buildings (ca. 75,000 home retrofits per year in Scenarios 1 and 2, and 50,000 per year in Scenario 3). In Scenario 3, the emphasis is on the industrial and commercial sectors and as a result the total investment required is slightly lower than the other two scenarios.

Table 3-7: Number of retrofit packages installed in the three economy-wide scenarios meeting the 2020 target

Sector	Retrofit package	Number of retrofit packages installed ('000s)		
		Scenario 1 – Push Commercial and Residential	Scenario 2 – Push Residential and Industry	Scenario 3 – Push Industry and Commercial
Residential buildings	Shallow	76	76	90
	Medium	346	346	209
	Deep	24	24	4
Non-residential buildings	Shallow	18	21	18
	Medium	25	28	25
	Deep	26	18	26

4 Exchequer perspective and wider benefits of energy efficiency

Energy efficiency has the potential to provide 'cost-effective' decarbonisation across the economy. The assessment of energy efficiency measures in the previous sections provides evidence on which sectors have the greatest technical and cost-effective potential for energy efficiency. In this section we present an assessment of the macroeconomic implications and the potential implications for the Exchequer.

Energy efficiency also has wider benefits in addition to macroeconomic impacts. The IEA has recently published the report 'Capturing the Multiple Benefits of Energy Efficiency'. In summary it finds fifteen potential benefits of energy efficiency; half of these are addressed (either fully or partly) in this report, while many of the others could be addressed through further analysis of the scenarios developed. This chapter will outline the key results for each of the potential benefits (as identified in the IEA report), which are assessed in this study, namely: macroeconomic impacts, real disposable incomes, energy security, industrial productivity, employment, and Government balances.[38]

At a macro level, the evidence on the cost and benefits of efficiency measures is complex to interpret. Cost-effective energy efficiency measures will lower consumers' energy bills allowing them to spend more on other goods and services. Businesses can benefit from efficiency either through higher profits, or by lowering prices accordingly and seeing increases in volumes of sales, i.e. competitiveness gains. There is also an investment stimulus from investing in the energy efficiency measures, but these measures must be funded either by displacing consumer spending (for households), borrowing (Governments, households or businesses) or increasing product prices or taxes (business or Governments respectively) (see Figure 4-1 and Figure 4-2).

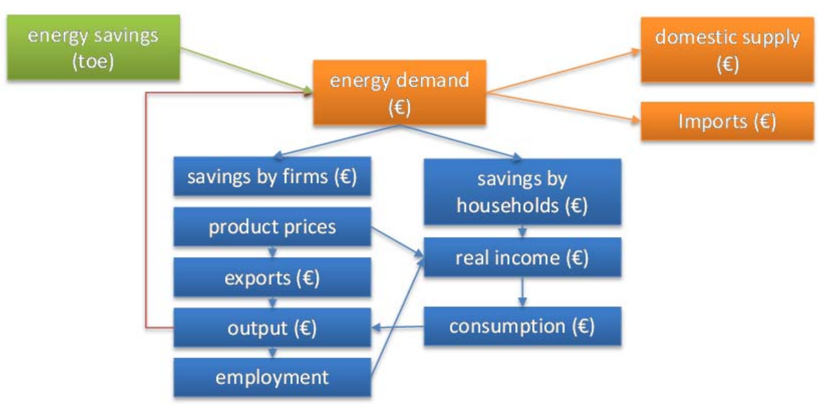


Figure 4-1: Energy savings impacts

[38] Other benefits identified by the IEA, i.e. energy delivery, energy prices, health and well-being, local air pollution, resource management, poverty alleviation and asset values are not assessed in this study. Any valuation of these would be additional to results presented.

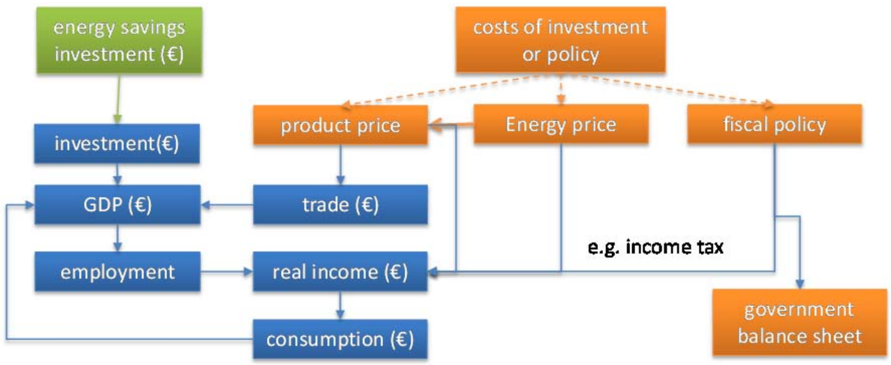


Figure 4-2: Energy savings investment impacts

The extent to which energy efficiency measures lead to economy-wide rebound effects (that come about from changes in incomes, prices and economic structure) should be a major consideration for energy efficiency policy. This will depend on the composition of marginal consumer spending (i.e. what do consumers spend their additional income on, including that raised via energy savings?) and the trade balance and cost structure of energy-intensive industries (i.e. how do energy-intensive industries respond to cost savings?).

Improved energy efficiency will also lead to changes in the structure of the economy away from expenditure on fossil fuels and towards capital expenditure. This changing cost structure affects different sectors in different ways. The construction and engineering sectors are likely to prosper from such a transition, with implications for jobs and incomes. By contrast the electricity, oil, gas, and coal supply chains are likely to see reductions in demand for their products. In Ireland, the combination of these factors could be substantial enough to make energy efficiency measures look more favourable from a macroeconomic perspective, since the construction sector is quite labour intensive (and supplied domestically), while energy (although high value added) is mostly imported. In summary, an energy efficiency measure that had a net present value of zero (i.e. no net cost when future savings are considered) to the party installing it, could still have a positive impact on GDP in Ireland.

4.1 Macroeconomic modelling approach

A scenario-based approach was applied to assess the impact of three energy efficiency programmes (scenarios) on the wider economy (as outlined in Section 3.3). For the economic modelling which was undertaken using the E3ME model (described further below), the inputs to each scenario are:

- Net energy savings by sector (kWh) (after direct rebound effects);
- Capital costs of the energy efficiency measures, by sector;
- Operating costs of the energy efficiency measures, by sector;
- The capital cost supported by Government.

In the economic modelling, the capital costs for the private sector are incurred in the first year. This is a reasonable assumption in the macroeconomic modelling because at the sector-level the investment is relatively small compared to sector-wide investment in all items; and because in each year it allows for a clearer interpretation of the results since the demand-side stimulus to the sectors supplying energy efficiency measures is fully paid for.

Households (consumers) fund the energy efficiency measures by forgoing consumption of other items. Businesses increase prices to recover the investment cost. The public sector borrows in order to support the economy-wide energy efficiency measures and to directly fund energy efficiency measures in the public sector. The public sector financing is therefore assessed and reported separately.

The changes in energy consumption and investment are compared to a forward-looking baseline, or reference, scenario for Ireland's economy over the period to 2030. Each of the three scenarios makes annual primary energy savings of around 15 TWh by 2020, at a total undiscounted investment cost of between €4.2 bn and €4.6 bn. As explained in Section 1.3, the power supply sector measures and new building regulations are not within the scope of this study.

The economic modelling was undertaken using Cambridge Econometrics' E3ME model of energy, economy and environment (E3) interactions for 53 countries across the world. The E3ME model is highly suited to this type of scenario analysis because as a non-equilibrium model it allows for the possibility that cost-effective efficiency options can occur and it has an annual time profile that allows for an evaluation of the impacts as they happen, rather than just the net benefit over a chosen time period.

It also has a full representation of Ireland's economy, based on the CSO national accounts, and energy system (using the IEA's energy balances) and full integration between the two. The behavioural parameters of the model are based on empirical analysis of the economic data for each sector and country and the model includes a full representation of the labour market.

Finally, the model has been extensively used to investigate the impacts of energy efficiency, including in the Impact Assessment of the Energy Efficiency Directive and as part of an assessment of the proposed framework for Europe's 2030 climate and energy policies.

How does E3ME compare to standard macroeconomic (CGE) models?

In terms of basic structure, purpose and coverage, there are many similarities between E3ME and comparable Computable General Equilibrium (CGE) models. Each is a computer-based economic model that considers E3 interactions at the global level, broken down into sectors and world regions. The regional and sectoral disaggregations are broadly similar. Both modelling approaches are based on a consistent national accounting framework and make use of similar national accounts data.

However, it is important to be aware of the substantial differences in modelling approach when interpreting model results. The two types of model come from distinct economic backgrounds; while they are in general consistent in their accounting and identity balances, they differ substantially in their treatment of behavioural relationships.

Ultimately this comes down to assumptions about optimisation. The CGE model favours fixing behaviour in line with economic theory, for example by assuming that individuals act rationally in their own self-interest and that prices adjust to market clearing rates; in this way aggregate demand automatically adjusts to meet potential supply and output levels are determined by available capacity. In contrast, macroeconometric models like E3ME interrogate historical data sets to try to determine behavioural factors on an empirical basis and do not assume optimal behaviour. The model is demand-driven, with the assumption that supply adjusts to meet demand (subject to any constraints), but at a level that is likely to be below maximum capacity.

This has important practical implications for scenario analysis. As the assumptions of optimisation in CGE models mean that all resources are fully utilised, it is not possible to increase output and employment by adding regulation. However, E3ME allows for the possibility of unused capital and labour resources that may be utilised under the right policy conditions; it is therefore possible (although certainly not guaranteed) that additional regulation could lead to increases in investment, output and employment.

In summary, the modelling provides insight into the following outcomes:

- The impact on Ireland's economy from a changing economic structure (supply chains and the composition of spending), arising from the implementation of the additional energy efficiency measures required to 2020;
- Changes in Government balances due to the costs of supporting the implementation of measures, the change in revenue streams and the net impact of improved energy efficiency in the public sector.

4.2 Macroeconomic modelling results

Macroeconomic benefits

The take-up of energy efficiency measures envisaged in each scenario leads to changes in the structure of the economy and an increase in the overall level of GDP. In the short term, this is expected because the energy efficiency measures require an upfront investment (sometimes partly funded by Government), which acts as a stimulus to the construction sector and manufacturers of energy efficiency measures. The net impact of installing the measures is small because they must also be funded (i.e. in the short run, the net savings are small as the capital is repaid. After repaying the capital, then the net impacts increase). Privately funded investment must displace spending elsewhere (households), or lead to businesses charging higher prices or reducing profits. The publically funded component is a direct stimulus to the economy at the expense of public sector finances (in the short term).

In the medium to long term, however, there is a net increase in GDP that persists beyond the period in which the measures are being installed. An increase in GDP alone would not necessarily be beneficial for households if, for example, it represented a shift away from consumption towards investment (over a sustained period), or required a persistent worsening of either Government or household savings. It is therefore important to note that the increased economic activity in the medium to long term leads to increased real disposable incomes and an improvement of the Government balance sheet (both are discussed below).

The long-term benefits arise from the impacts of improved energy efficiency. Households are able to increase spending on all non-energy products (after paying for the up-front investment costs). Output in the sectors that produce these goods and services increases to meet the higher demand. This in turn leads to higher demand for labour, and there is a small increase in average wages. Higher incomes lead to a multiplier effect and further economic benefits. These positive effects more than offset the reduced output in energy supplying sectors, partly because energy is heavily imported and partly because the domestic parts of the supply chains are short, in contrast to newly created supply chains, for example in the construction and energy efficiency retrofit sector.

The changing nature of the impacts over time is reflected in the components of GDP (see Table 4-1) as the 2020 GDP impact is dominated by the investment stimulus, while the 2030 GDP impact is dominated by the increase in real consumer spending. The sectoral composition (see Table 4-2) shows a similar pattern as the short-term impact is dominated by increased output in the construction and manufacturing sectors that supply energy efficiency measures, while the long-term impacts are dominated by sectors that focus on consumers.

Table 4-1: Impact on key macroeconomic indicators (% difference from base)

	2020			2030		
	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
GDP	0.3%	0.3%	0.3%	0.2%	0.2%	0.2%
Consumer expenditure	0.2%	0.2%	0.2%	0.3%	0.3%	0.3%
Investment	0.9%	0.8%	1.0%	0.2%	0.1%	0.2%
Exports	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Imports	-0.1%	0.0%	-0.1%	0.0%	0.0%	0.0%
Consumer price index	0.0%	0.0%	0.0%	-0.7%	-0.7%	-0.7%[39]
Employment ('000)	0.9	0.89	0.8	2.01	1.89	1.94

[39] By 2030 the consumer price index has fallen by 0.7%, representing the change in price inflation directly to consumers (and to the economy more widely) that has come about from the energy efficiency savings.

Table 4-2: Impact on broad sector gross output (% difference from base)

	2020			2030		
	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
Agriculture	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Extraction Industries	0.6%	0.6%	0.6%	-0.3%	-0.3%	-0.3%
Basic manufacturing	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Engineering and transport equipment	0.7%	0.6%	0.7%	0.1%	0.1%	0.1%
Utilities	-3.5%	-3.2%	-3.5%	-2.2%	-2.1%	-2.4%
Construction	0.5%	0.4%	0.4%	0.1%	0.1%	0.1%
Distribution and retail	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
Transport	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Communications, publishing and television	0.0%	0.0%	0.0%	0.2%	0.2%	0.2%
Business services	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Public services & other	0.1%	0.1%	0.1%	0.2%	0.2%	0.2%

The modelling provides an estimate of the impact of energy efficiency measures relative to a reference view in which the measures are not undertaken in the period 2013 – 2020. The model used, E3ME, is a sophisticated macroeconomic model with many features suitable for this particular analysis. However, models can only provide an indication of the likely direction and magnitude of the impacts of a particular course of action, under a given set of plausible assumptions. The results are therefore sensitive to the input assumptions, most notably:

- the scenario inputs, in terms of the relative cost of measures to the resultant energy savings;
- future projections of energy prices.

The relative cost of the measure to the energy savings determines the long-term (sustained) impact of the measures. The lower the cost of the measure (for the same energy savings), the greater the long-term impact on economic output. However the short term impact might be smaller since the stimulus to the installers and manufacturers of the measures would be less. If energy prices were to be lower than the anticipated projections at the time of modelling[40] then the economic results would be diminished, while higher energy prices would increase the economic benefits of energy efficiency.

Real disposable incomes

The average increase in real disposable household income in the scenarios is 0.3 % by 2030, but this will not be distributed equally across all households. Households undertaking energy efficiency measures would benefit disproportionately, as would households with individuals moving from unemployment into work. As a result of the aggregate increase in real disposable income, consumer spending also increases by 0.3 % suggesting that societal welfare (well-being) might have been improved depending on how the increase was distributed across the population.

[40] See the accompanying Technical Appendix (Methodology and technical assumptions) for the fuel price forecasts.

Energy security

Due to the increased energy demand, along with the decline of natural gas and peat production, Ireland's energy dependency on imports has been around 90% for the last decade.[41] Energy efficiency is therefore a key priority to decrease reliance on imported fossil fuels. As explained in the previous section, around 15 TWh of additional primary energy savings are achieved by 2020 in the three scenarios (Around 7, 1, 6 and 1 TWh of demand reduction for electricity, gas, oil and solid fuel, respectively).[42]

Resilience to energy price spikes is also marginally improved. In the baseline a fossil fuel price spike of 20% in 2030 would reduce real disposable incomes in that year by 0.81%; this would be reduced to a reduction of 0.75% following the efficiency measures. Although this appears to be small, it amounts to a saving of around €70 m across Ireland's economy.

Industrial productivity

The energy savings measures lead to lower costs for business. For most sectors the cost impact is small and is often not passed on in full to consumers (it is instead taken in the form of higher profitability) but for energy-intensive sectors there can be more significant impacts. The most notable effects are in the basic metals sector which sees a unit cost reduction of around 2–3% over the period as it is one of the most energy-intensive sectors, and the scenarios have large energy savings for this industrial sector relative to others.

Employment

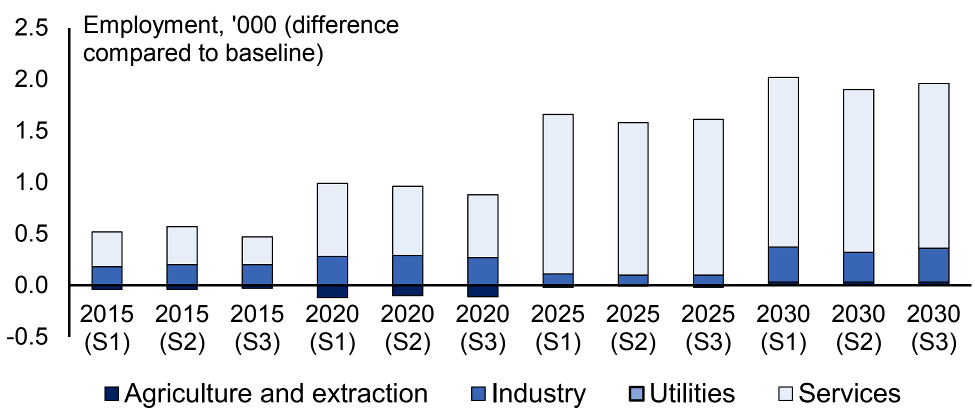


Figure 4-3: Net employment impacts over time, by broad sector

Over time the level of employment is higher in the scenarios than in the baseline. In the long term, around 2,000 extra jobs are created due to the investment, leading to 15 TWh of additional primary energy savings by 2020, mostly in the services sectors in the 2020–30 period. In the 2015–20 period proportionately more jobs are created in the manufacturing and construction sector, as the dominant structural effect of the measures is increased investment in energy efficiency measures, but in the longer term (post 2020)

[41] SEAI, 2011, 'Energy Security in Ireland: A Statistical Overview.'
[42] It should be noted that reduction in energy imports might be lower due to economy-wide rebound effects (i.e. increased demand for energy to service the aggregate demand for goods and services due to increased economic activity), which are not within the scope of this study.

the energy savings impacts start to dominate and the employment impacts are highest in the services sectors (see Figure 4-3). It should be noted that a recent report by SEAI highlighted the potential for Irish-based companies to establish themselves in growing markets for a range of energy efficiency and renewable energy technologies and services.[43] If Irish-based companies can capture more of the supply chain opportunities in strategic sectors, employment figures could increase.

[43] SEAI, 2014, 'Ireland's Sustainable Energy Supply Chain Opportunity'.

Understanding the employment impacts

Many studies assess the jobs impacts associated with energy efficiency measures/programmes. Typically, these studies assess the gross additional jobs generated in the supply chains of the measures and, sometimes, extend this to the jobs associated with higher levels of consumer expenditure on non-energy goods.

These effects are typically disaggregated into three types of jobs:

- *Direct jobs: jobs associated with the installation and operation of energy efficiency measures;*
- *Indirect jobs: jobs associated with the supply chains of energy efficiency measures;*
- *Induced jobs: jobs associated with the impact of the energy savings, allowing consumers to spend money on other goods and services, and businesses to change their pricing structures; and also the jobs associated with the additional spending associated with the additional income generated by the direct and indirect jobs.*

Note that the terminology around direct, indirect and induced jobs is often opaque, and different studies often classify jobs to different categories depending on the scope of the analysis. In contrast to standard jobs studies assessing gross jobs, this study assesses the net impact on the level of employment in Ireland, incorporating the following factors:

- *an increase in jobs created in the construction, services and manufacturing sectors due to an increase in capital investment in installing energy efficiency measures;*
- *an increase in employment in sectors that feature in the supply chains for investment goods;*
- *an induced effect due to higher real disposable incomes and consumer demand for non-energy products and services that drives further increases in employment;*
- *the reduction in jobs associated with the energy supply chains that face lower demand;*
- *a reduction in jobs associated with the displacement of spending on other goods and services by households to pay for the energy efficiency measures;*
- *the net impact of changes in prices in the economy as a result of, (i) higher prices to fund the private investment in energy efficiency measures and, (ii) lower prices resulting from reduced energy costs for businesses;*
- *baseline trends in the ratio between imported supply and domestic supply;*
- *baseline trends in the labour productivity of each sector of the economy;*
- *labour market interactions including changes in relative wage costs, the level of unemployment, and the capacity of the economy and population to supply labour.*

The net jobs figures estimated relate only to the additional work undertaken to reach the 2020 targets in the period 2013 – 2020. They do not include any net increases in employment due to efficiency measures already undertaken, or those associated with measures outside the scope of the study, i.e. building regulations or energy. supply side savings etc.

Government balances

Government balances are improved in discounted terms over the period 2013 – 2030. Figure 4-4 shows the net impact on cash flow over the period, showing that the Government would worsen its balance sheet until 2018/19, after which there would be an improvement to the Government balance sheet. The calculation takes into account the direct public investment costs for energy efficiency measures, foregone tax revenues on energy and carbon, public sector energy savings, and other impacts on the taxes included in E3ME. A discount rate of 5 % is used for aggregating the net impacts over the forecast period.

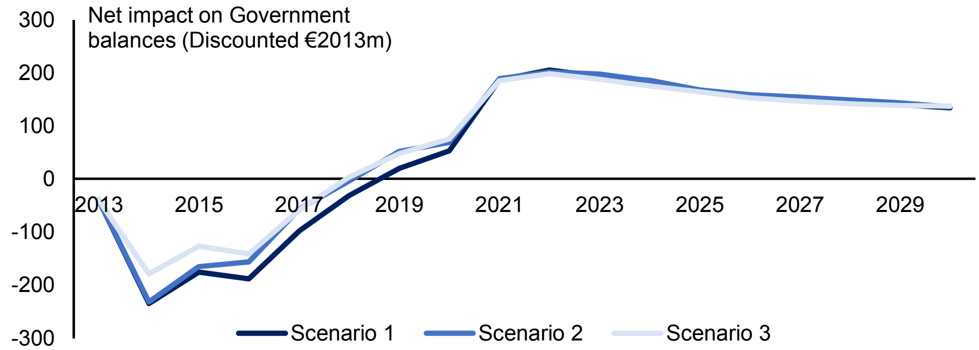


Figure 4-4: Net impact on Government balances

Table 4-3: Real cumulative net impact on Government costs and revenues (€2013 m, discounted) 2013 – 30[44]

	Scenario1	Scenario 2	Scenario 3
Programme support			
Administration costs	-40	-40	-40
Information campaign	-60	-60	-60
Direct grant support	-800	-630	-500
Tax revenue foregone			
Excise duty on fuel	-1,450	-1,450	-1,450
Carbon tax	-520	-530	-510
Increased (net) tax revenue			
Corporation tax	810	810	800
VAT	310	320	290
Social security	260	270	250
Income tax	470	480	440
Energy savings in Government			
Cost of measures	-700	-700	-700
Value of energy savings	2,680	2,680	2,680
Net cumulative impact	970	1,150	1,210

Table 4-3 gives a breakdown of the lifetime undiscounted (real terms) costs and benefits facing the Government in each scenario. Overall, the major benefits to the Exchequer arise from the net benefits of investing in energy efficiency in the public sector. Without realising energy savings in the public sector, the Exchequer would be worse off as

[44] Flows are discounted at 5% pa from 2013 onwards and a minus sign represents a worsening of the Government balances, while a positive number indicates an improvement to Government balances.

increases in economy-wide tax revenues do not outweigh the lost excise duty and carbon tax revenues.

Key results from macroeconomic modelling

As explained, efficiency programmes described by each scenario are similar, with only subtle differences, leading to similar macroeconomic consequences.

For the three main scenarios the following conclusions can be drawn from the analysis:

- Each of the three programmes of energy efficiency measures would lead to a sustained long-term increase in the level of economic output, raising incomes and employment;
- Energy security is improved as a result of lower final energy demand leading to reduced energy imports, and the economy is also more resilient to the impact of energy price volatility;
- Government support for the energy efficiency programmes could be self-financing, particularly if energy savings are realised in public sector services;
- In the long term, the Government balance is improved. This net increase could be transferred back to households, further improving the macroeconomic benefits.

The analysis only considers the impact on Ireland of the efficiency programmes defined in the scenarios. Adopted more widely, perhaps across Europe or globally, ambitious energy efficiency programmes might impact on energy prices directly leading to two quite important effects:

- Reducing the benefit of further efficiency improvements (because energy is now cheaper);
- Bringing financial benefits to all energy consumers.

There could be potential benefits that are not considered within this analysis. The analysis does not consider health benefits that might arise from living in warmer homes. Moreover, the analysis does not consider the impacts of increased asset values from investment in energy efficiency measures. Finally, the analysis does not consider the distribution of the impacts across different socio-economic groups and what the energy efficiency programme might mean for poverty alleviation.

Overall, the economic and fiscal results are encouraging and provide a strong evidence base that supports investment in cost-effective energy efficiency.

5 Remaining potential beyond 2020

5.1 Context: EU's 30 % energy efficiency target for 2030

In July 2014, the EU proposed a new energy efficiency target of 30 % for 2030.[45] Like the 2020 target, this is an EU-wide target, and as yet there are no binding targets for individual Member States.

While the primary focus of this study is the 2020 target, our work is able to provide important insights for the formulation of the 2030 target in Ireland.

In this section, we present:

- The remaining potential for energy savings after 2020 in the three scenarios meeting the 2020 target;
- The energy savings likely to be achieved between 2020 and 2030 through the policy interventions implemented in the three scenarios meeting the 2020 target.

We emphasise that the analysis in this section is, in comparison with the detailed analysis presented in the previous sections, a high-level one. For a brief description of the methodology involved and the associated caveats, the reader is referred to the box, 'Methodology behind remaining potential beyond 2020'.

Methodology behind remaining potential beyond 2020

- *The focus of this study is the 2020 primary energy savings target. However, since we have derived both the full energy efficiency cost curves for Ireland for 2020, and the uptake of those potential energy savings to 2020 under various policy scenarios, this presents an opportunity to consider the remaining potential beyond 2020. This is expected to be of interest with respect to the 2030 energy efficiency target currently being formulated in Ireland.*
- *In comparison with the detailed analysis presented in the previous sections, the analysis in this section should be considered to be high-level.*
- *In particular, the following simplifying assumptions have been made with regard to the calculation of the cost-effectiveness of the remaining savings potential:*
    - *Cost of energy efficiency measures remains constant after 2020 (i.e. no technological learning is applied);*
    - *Fuel prices remain constant after 2020;*
    - *Fraction of consumers in each consumer group (I–IV) remains constant over the full period.*
- *Thus, the analysis presented should be considered an early evidence base for the energy savings potential available beyond 2020. It is highly recommended that further analysis be carried out to better understand how the above factors, and others, will evolve, and the implications for the savings potential available beyond 2020.*

[45] In October 2014, the European Council approved the 2030 Framework for Climate and Energy, proposed by the European Commission, including the objective of an energy efficiency increase of at least 27 %, to be reviewed by 2020, having in mind an EU level of 30 % for 2030.

5.2 Potential energy efficiency savings beyond 2020

Figure 5-1 toFigure 5-4 show the remaining potential (for technical measures, not behavioural measures) in the commercial buildings, public buildings, residential buildings and industry sectors, for the case of Scenario 3 as described in Section 3.3.[46] Across these sectors, nearly 16 TWh of the 23 TWh total primary energy saving potential – that is, 69 % of the total – remains after 2020. However, as described in the following section, achieving these remaining savings is likely to be increasingly challenging.

It can be seen that the fraction of the total potential remaining varies widely, from 35 % in the public sector to 86 % in the residential sector, reflecting the different levels of uptake before 2020 in the Scenario. We note that the fraction of the total potential remaining after 2020 also varies widely across sub-sectors. For example, in the commercial sector, less than half (42 %) of the potential in the hotel sub-sector remains, whereas more than half (58 %) of the potential in the retail sub-sector remains. In the public sector, 32 % of the potential in the education and healthcare sub-sectors remains, and 38 % of the potential in the office sub-sector remains. This suggests that it may be desirable or necessary to target policy interventions towards different sub-sectors at different times in order to stimulate the highest possible uptake of energy efficiency.

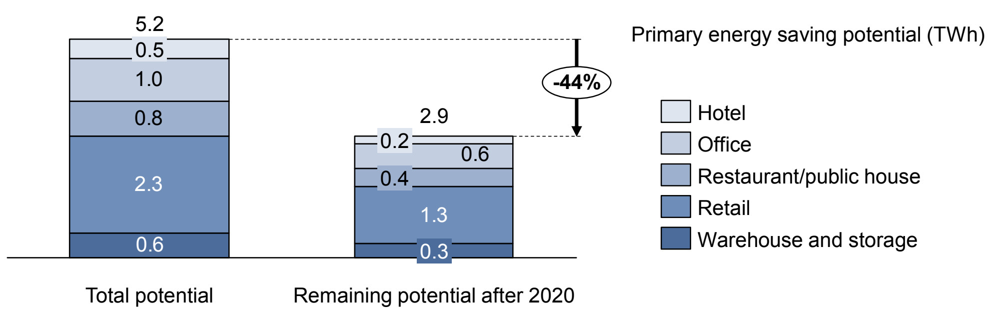


Figure 5-1: Remaining potential by sub-sector in the Commercial sector

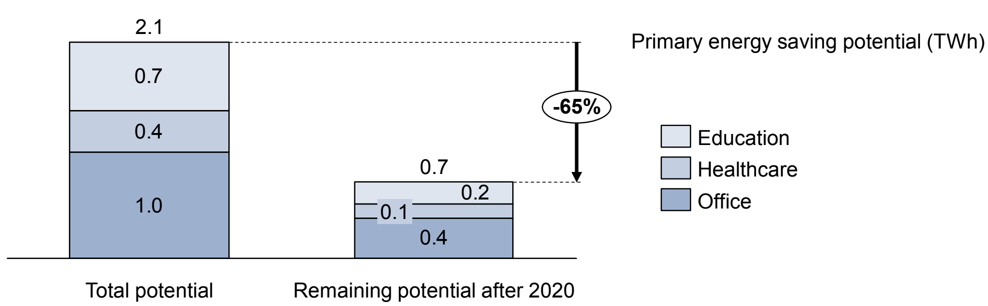


Figure 5-2: Remaining potential by sub-sector in the Public sector

[46] We do not present the remaining potential in the transport or public utilities sectors, since the scenarios developed in these sectors for 2020 do not extend to 2030.

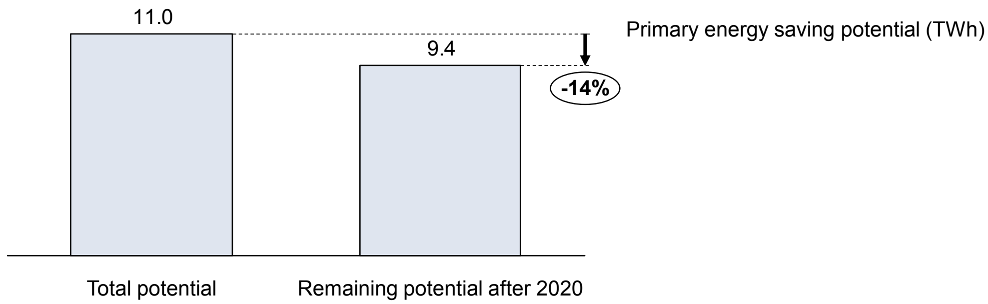


Figure 5-3: Remaining potential in the Residential sector

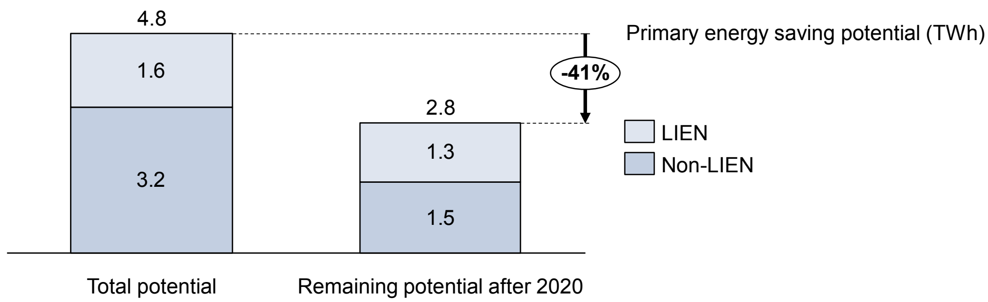


Figure 5-4: Remaining potential by sub-sector in the Industry sector

5.3 Remaining potential beyond 2020: Economic considerations

It has been established above that in the scenarios meeting the 2020 target, more than two-thirds of the technical potential – for technical measures in the commercial, public, residential and industry sectors in the scenarios – remains after 2020. However, to inform the development of an energy efficiency target for 2030, it is important to understand how the cost-effectiveness of the remaining potential compares with the potential already achieved. We emphasise here that, as described in the box, 'Methodology behind remaining potential beyond 2020', the following analysis does not account for technological learning and cost reduction or further fuel price changes beyond 2020.

Table 5-1 compares the cost-effectiveness of the remaining potential after 2020 for Scenario 3 with the cost-effectiveness of the total potential, including all measures presented in the cost curves in Section 2. Differences in cost-effectiveness are due to the fact that, typically, the most cost-effective measures – the 'low hanging fruit' – are implemented first, leaving the less cost-effective measures to be implemented at a later stage. In our model, this corresponds to the fact that a transition from the 'Shallow package installed' state or the 'Medium package installed' state to the 'Deep package installed' state is less cost-effective than a direct transition from the initial state to the 'Deep package installed' state. It can be seen in Table 5-1 that the remaining potential after 2020 is less cost-effective than the total potential in all sectors except for industry, where the cost-effectiveness is almost unchanged (as the Medium and Deep packages are very similar in terms of cost-effectiveness).

Thus, whilst a large fraction of the total potential remains after 2020, it might be expected that the lower cost-effectiveness of the remaining potential – not accounting for reductions in technology cost – could constrain the uptake after 2020, all else being equal.

Table 5-1: Comparison of Total potential and Remaining potential after 2020 in Scenario 3

Sector	Total potential (TWh)	Total potential: cost effectiveness (€/MWh)	Remaining potential: Energy savings (TWh)	Remaining potential: Cost effectiveness (€/MWh)
Commercial	5.1	-83	2.9	-68
Public (buildings only)	2.1	-41	0.7	27
Residential	11.0	37	9.4	52
Industry	4.8	-75	2.8	-75

5.4 Savings to 2030 in the scenarios meeting the 2020 target

To provide further insight regarding the 2030 energy efficiency target, we present here the predicted energy savings to 2030 in the three scenarios achieving the 2020 target, in the case that all policy interventions implemented are applied uniformly to 2030. As above, we present the results from the commercial, public, residential and industry sectors.

Figure 5-5 shows the primary energy savings achieved between 2013 and 2030 in the three scenarios meeting the 2020 target, alongside the total potential. It can be seen that, beyond 2020, the divergence in achieved energy savings between the scenarios is relatively low. In each case, 4.3 – 4.5 TWh of additional savings are achieved to 2030. Comparing this with the 10.6 – 10.7 TWh achieved to 2020, it is clear that the annual uptake of energy efficiency diminishes over time without energy policy change post 2020. In the final five years to 2030, only 1.6 TWh of savings are achieved in each scenario.

This is partly explained by the reduced cost-effectiveness of the energy efficiency measures remaining after 2020. However, the most important factor limiting the uptake of energy efficiency after 2020 is the increasing fraction of the remaining potential accounted for by disengaged consumers. We have found that roughly one-third of the savings potential in buildings lies with consumers in group I: those for whom energy is not a top priority, who are not expected to implement energy efficiency measures. Of the 23 TWh total potential in buildings, these consumers account for roughly 8 TWh – that is, the majority of the potential remaining after 2030.

We note that this analysis does not account for the introduction of new technologies with the potential to improve energy efficiency even further in the segments of the stock which have already implemented the measures included here. It should also be noted that, potential multiplier effects (i.e. a greater societal realisation of the benefits of energy efficiency impacting on decision-making frequency and uptake) are not included. Nonetheless, whilst significant potential remains after 2020, to achieve this potential will require new policy interventions targeted at the least engaged consumer segments.

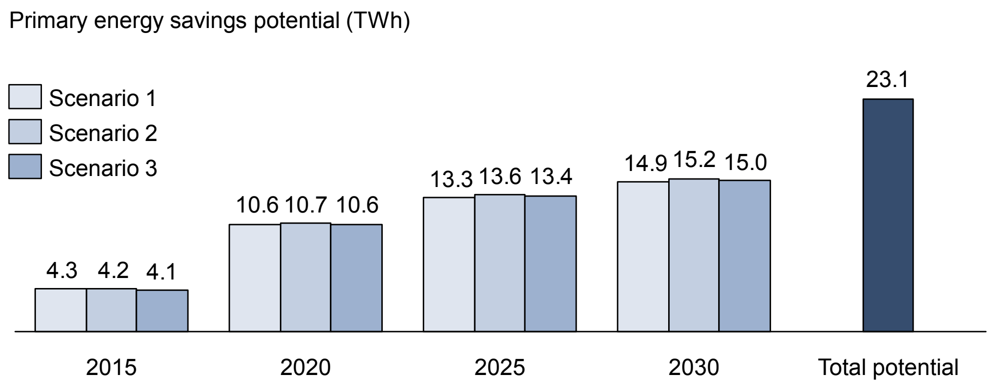


Figure 5-5: Savings achieved to 2030 in the Commercial, Public, Residential and Industry sectors for the scenarios meeting the 2020 target

6 Conclusion and recommendations

SEAI has commissioned Element Energy to undertake a detailed analysis of the potential for energy efficiency improvements economy-wide to 2020.The study provides a detailed analysis of the range of measures which could contribute to the target and the variety of policy interventions which could ensure the target is met in the most cost-effective way possible.

For the commercial, public, residential, industry and road transport sectors, all key energy efficiency measures have been identified. Through a combination of bottom-up stock modelling and scenario development, estimates of the technical energy savings potential of each measure have been derived. The lifetime costs of the energy savings associated with each measure (or packages of measures) have then been calculated by incorporating cost data.

This study goes beyond an estimate of the technical and economic savings potential by incorporating the behaviour and decision-making process of consumers. A detailed model of the consumer decision-making process has been developed in order to estimate the uptake of energy efficiency measures under a variety of policy interventions. The model has been populated with data sets on consumer decision making gathered through original fieldwork and through an analysis of existing data.

Using this model, a set of sector-level scenarios has been constructed describing the range of savings which could be achieved through feasible policy interventions. By combining the sector-level scenarios, a number of economy-wide scenarios meeting the national 2020 target have then been developed. These scenarios have been compared in terms of their implications for the Exchequer, total investment requirements, and some of the associated wider economic benefits. This study also considers the 2030 perspective, by presenting the remaining potential beyond 2020 in the buildings sector and commenting on the challenges to achieving this.

6.1 Key findings

Energy saving potential and the effect of consumer behaviour

- Across all sectors studied there remains nearly 35 TWh of technical savings potential to 2020, with more than 26 TWh of this economic.[47] In absolute terms, the technical potential is largest in the residential buildings sector (13.5 TWh), followed by the transport (7.3 TWh), commercial buildings (5.9 TWh), industry (4.8 TWh) and public (3.0 TWh) sectors.
- The key opportunities for large energy savings in each sector are summarised in Table 6-1. The full list of measures contributing to the energy saving potential can be found in the Appendix, Section 7.1
- Actual uptake by 2020 is highly likely to be lower than the technical and economic energy savings potential due to aspects of consumer behaviour and decision-making including low awareness and engagement, a limited decision-making frequency, finite budget limits and payback period requirements.
- Consumer behaviour varies substantially across the different sectors studied, with important implications for the achievement of the 2020 target. For example, we

[47] i.e. negative lifetime cost using a 10 % discount rate.

find that the decision frequency is typically higher in the commercial sector, at between 6 and 13 years for a deep building retrofit, as compared with around 15 years in the residential sector.[48] As a result of differences such as these, policy must be well targeted; for example, it is critical to explore alternative financing methods for residential retrofit, and likely that greater direct financial support will be required in the residential sector. Even then, the lower frequency of 'trigger points' for retrofit in the residential sector limits the potential contribution the sector can make to the 2020 target.

- A wide range of targeted policy interventions can be applied to address these aspects of consumer behaviour and increase the uptake of energy efficiency measures. Key interventions that may be implemented as part of the effort to achieve the 2020 target are given in Table 6-2.

Table 6-1: Key energy savings opportunities for all sectors

Sector	Key opportunities	Primary energy savings potential in 2020 (TWh)
Commercial buildings	• Energy efficient lighting with controls • Heat pumps • Roof insulation • Energy efficient glazing	1.1 0.8 0.7 0.7
Public buildings, transport and utilities	• Energy efficient lighting with lighting controls • Energy efficient glazing • More efficient boiler with heating controls • Roof insulation • LED street lighting	0.5 0.5 0.4 0.2 0.2
Residential	• Efficient boiler with heating controls • Solid wall insulation • Roof insulation • Energy efficient appliances – 'Cold' and 'Electrical cooking' • Reducing room temperature by 1ºC (behavioural)	3.8 1.5 1.2 0.7 1.1
Industry	• Process integration and heat recovery for low temperature processes • More efficient motor systems • Combined Heat and Power	1.6 1.1 0.8
Road transport (excl. public transport)	• Private cars - EU regulation • Private cars - VRT rebalancing • Eco-driving • Modal shift	2.7 0.8 0.8 1.5

[48] Further details of our findings on consumer behaviour can be found in the accompanying Technical Appendix (Methodology and technical assumptions).

Table 6-2: Key policy interventions for all sectors

Sector	Key policy interventions	Primary energy savings (TWh) 2013–2020
Commercial buildings	• Direct financial support (through grants or supplier obligation)	0.6
	• Regulation for minimum boiler and lighting efficiency	0.4
	• Mandatory audit for large companies	0.5
	• Active promotion of Energy Service Companies	0.3
Public buildings, transport and utilities	• Mandatory energy audit for large companies	0.3
	• Active promotion of Energy Service Companies	0.1
	• Behavioural change through training of staff as part of uptake of EPCs	0.6
Residential	• Direct financial support (through grants and/or supplier obligation)	1.3
	• Residential financing schemes with lower interest rates	0.4
	• Behavioural change (through smart meter rollout, targeted information as part of PAYS uptake)	0.5
Industry	• Active promotion of Energy Service Companies	1.3
	• Mandatory energy audit for all industrial companies	0.5
Road transport (excl. public transport)	• Private cars - EU regulation	2.7
	• Private cars - VRT rebalancing	0.8
	• Eco-driving	0.8
	• Modal shift	1.5

Energy efficiency investment pathways

- Our analysis suggests that continued policy development is required to meet the 2020 target. It is possible to meet the target through a combination of existing, extended and new policy interventions.
- A set of three economy-wide scenarios comprising a variety of policy interventions were constructed to meet the 2020 target. The three scenarios explore the effect of applying a varying level of effort, and financial support, to different sectors.
- Each of the three energy efficiency scenarios, which meet the 2020 target at a total undiscounted investment cost of between €4.2 bn and €4.6 bn, would lead to a sustained long-term increase in the level of economic output, raising incomes and employment.
- GDP is higher in all three energy efficiency scenarios compared to the baseline, by around 0.3 % by 2020 and by 0.2 % by 2030
- There is a net increase in the level of employment of around 2,000 jobs by 2030 beyond those already generated through market development to date.
- Over the period 2015 to 2030, the discounted Government balance sheet is improved by between €970 m and €1,210 m depending on the scenario. This suggests that Government support for the energy efficiency programmes could be self-financing, particularly if energy savings are realised in public sector services.
- While all three scenarios entail a large net benefit both to the Exchequer and to the country as a whole, our analysis suggests that, from the perspective of energy savings achieved, it is more cost-effective to support energy efficiency retrofits in

the commercial and public sectors rather than in the residential sector. This finding is relevant to the allocation of savings in the next NEEAP.

Table 6-3: Summary results for the three scenarios

	Results for the three scenarios
Total costs (discounted,10%, €2013 bn, 2013–2020)	3.1 to 3.3
Total benefits (discounted, 10%, €2013 bn, 2013–2020)	11.2 to 11.3
NPV of investments (discounted, 10%, €2013 bn, 2013–2020)	8.0 to 8.2
Total cost to the Exchequer (discounted, 5%, €2013 bn, 2013–2030)	(-1.0) to (-1.2)
GDP impact in 2030 (% difference from base)	0.2%
Employment ('000)	1.9 to2.0

In addition to these results it is likely that energy efficiency will lead to wider benefits including energy delivery, energy price, health and well-being, local air pollution, resource management, poverty alleviation and increased asset value. These are not assessed in this study and any valuation of these would be additional to the results presented above.

Remaining potential beyond 2020

- In the commercial, public and residential buildings and industry sectors, more than 15 TWh of primary energy savings potential remains after 2020. However, achieving these potential savings is likely to be increasingly challenging, as the most cost-effective measures are expected to be taken up before 2020 (i.e. there is a tendency towards the early uptake of 'low hanging fruit').
- Our analysis demonstrates the importance of promoting the implementation of packages of measures, rather than individual measures. This is an important mechanism by which to increase the effective economic potential, achieving deeper retrofits in the buildings sectors and mitigating to some extent the problem of early uptake of the most cost-effective measures.
- Importantly, however, disengaged consumers (such as laggards) will account for an ever-increasing share of the remaining potential. In the scenarios meeting the 2020 target, there is little uptake beyond 2025, with around one-third of the total potential not taken up. The results suggest that the importance of well-designed regulation and policies to increase engagement will increase after 2020.

6.2 Policy recommendations for Ireland

The following section outlines the key policy recommendations resulting from the detailed analysis presented in this report. They are further informed by a number of previously developed policy documents and analyses developed in the context of Ireland's evolving energy policy. Lessons from international energy efficiency policies have been considered and are summarised further in the Appendix, Section 7.2.

The recommendations are targeted at what are considered the key areas of focus for 2020 target achievement. They are grouped under the following headings:

- Regulation;
- Active promotion of Energy Service Companies;
- Financing residential retrofit;
- Energy Supplier Obligation;
- Direct financial support;
- Achieving behavioural change.

Regulation

Awareness and engagement is a key barrier to energy efficiency investments in the commercial buildings sector; our survey of commercial organisations found that more than one-third do not consider energy reduction to be a top priority. Similarly, in the residential sector, one-third of private landlords stated that they do not plan to install an energy efficiency measure at any point in the future.[49] These consumers are unlikely to participate in decision-making regarding energy efficiency unless regulation is applied to make this mandatory.

A number of regulatory measures have been modelled in this study, including mandatory energy audits for large companies and all industrial sites, and regulation for minimum boiler and lighting efficiency in the non-domestic buildings sector (already in place for the residential sector). With appropriate controls, such regulations force even the most reluctant decision-makers to act on energy efficiency. Modelling showed that together these regulation measures could lead to additional energy savings of 0.9 TWh, 0.5 TWh and 0.4 TWh in the commercial, industry, and public sectors, respectively. These results illustrate the effectiveness of well-designed regulation.

Other additional regulatory measures might also be considered in the residential sector. In the UK, as part of the Energy Act 2011 the Government is mandating a minimum energy performance rating (i.e. similar to BER in Ireland) of E on letting residential and non-domestic buildings by 2018, based on the Energy Performance Certificates rating which runs from A-G. Furthermore, the Government should explore the possibility of introducing 'consequential improvement' regulations for all domestic and non-domestic buildings, whereby building owners undertaking major renovation work would be required to meet a minimum level of thermal efficiency through the simultaneous implementation, where necessary, of additional energy efficiency measures.

[49] Private Landlord Survey, 2013, 'Behaviour & Attitudes' for SEAI.

In the transport sector, additional regulation could include the extension of the carbon-emissions-based VRT system to light-duty commercial vehicles.

Recommendations for Ireland: Regulation

- ***Recommendation 1:*** *Explore options for additional regulation to reach unaware or disengaged consumers, including:*
    - *Minimum boiler and lighting efficiency in the non-domestic sector;*
    - *Minimum thermal efficiency standards in the rented property sector;*
    - *Consequential improvement regulations for all domestic and non-domestic buildings;*
    - *Extension of the carbon emissions-based VRT system to light-duty vehicles.*
- ***Recommendation 2:*** *Ensure that the new regulation for mandatory energy audits for organisations covers the largest feasible fraction of national primary energy consumption.*

Active promotion of Energy Service Companies

Some of the most effective and low cost policy options relate to the promotion of energy efficiency and supporting schemes by the Government. One such option is the active promotion of Energy Service Companies. Our survey of commercial buildings found widespread negative perception of Energy Performance Contracts (EPCs), with more than one-third of companies reporting that they would not consider making use of the mechanism. The Government could improve the perception of the ESCO model by, for example, having an official programme in place to register ESCOs, drawing up example EPC contracts, and developing links between ESCOs and commercial and public building managers. National and local authorities should also assist communities or groups of organisations to come together to 'pool' or aggregate their energy efficiency opportunity; this will be necessary to engage with ESCOs, who typically have high minimum investment thresholds.

Section 3.2 showed that around 1 TWh of primary energy savings could be achieved by 2020 through the active promotion of ESCOs (0.6 TWh, 0.3 TWh and 0.1 TWh in the industry, commercial and public sectors, respectively).

In Ireland, a National Energy Services Framework[50] has been established to help develop the energy efficiency market in the non-domestic sector. The framework sets out the roadmap through which energy efficiency projects, and an Energy Contracting[51] process, are developed. It also explains the process and provides guidance on routes to project development, in addition to the support available from SEAI and sources of finance such as the National Energy Efficiency Fund.[52]

Recommendations for Ireland: Active promotion of Energy Service Companies

- ***Recommendation 3:*** *Increase efforts to promote and develop the ESCO model through registration of ESCOs to an official Government programme and by developing links between ESCOs and commercial and public building managers, including 'pools' of smaller organisations.*

Financing residential retrofit

Pay-As-You-Save (PAYS) is a type of residential retrofit financing scheme currently under consideration in Ireland. A number of research papers were produced examining the PAYS concept, which formed a starting point for the Better Energy Financing project.[53] Better Energy Financing is intended to overcome the finance barrier in the residential sector by providing accessible finance to householders in Ireland.

An important factor behind the low uptake of the PAYS-type scheme for residential retrofits in the UK is the relatively high associated annual interest rates of 7 – 10 %. A similar mechanism in Germany was able to deliver a high number of energy efficiency installations from a previously disengaged consumer market by providing loans with subsidised interest rates. As shown by the results presented in Section 3.2.4, additional saving of 0.4 TWh could be achieved by reducing the interest rate from 8 % to 5 %. The uptake of energy efficiency measures in the residential sector is expected to increase if lower cost finance could be made available.

Other mechanisms which should be explored include employer-based schemes, whereby an employer or a third-party lender provides the capital for an employee's home energy audit and energy efficiency investment, which the employee repays through salary sacrifice. An example of this is the Clinton Climate Initiative's Home Energy Affordability Loan.[54] Home energy suppliers could also be assisted to partner with third-party lenders to provide low interest loans for energy efficiency retrofits, as part of the Energy Supplier Obligation (also see below).

Recommendations for Ireland: Financing residential retrofit

- ***Recommendation 4:*** *Explore potential financing mechanisms to provide consumers with low interest loans (i.e. 5% or lower) for residential retrofit, including:*
  - *PAYS-type scheme with lower interest rate;*
  - *Employer-based schemes to provide employees with low interest loans (such as through 'salary-sacrifice' mechanisms);*
  - *Assisting home energy suppliers to partner with third-party lenders to provide homeowners with low interest loans.*

Energy Supplier Obligation

Article 7 of the Energy Efficiency Directive obliges Member States to achieve energy savings each year to 2020 of at least 1.5 % of the annual energy sales to final customers. The target may be achieved either by imposing the full target on energy suppliers through an Energy Efficiency Obligation Scheme (EEOS), or in part through an EEOS and in part through 'alternative measures'.

[53] Better Energy Financing Project: http://www.seai.ie/Better_Energy_Financing/Project_Documents/
[54] https://www.clintonfoundation.org/clinton-presidential-center/about/heal

Ireland opted to impose part of the target on energy suppliers, who are required to meet an additional 550 GWh of primary energy savings per annum to 2020.[55] The allocation of this target to specific 'sub-sectors' has also been prescribed as 75 % in the non-residential sub-sector, 20 % in the residential sub-sector and a minimum further 5 % to those at risk of energy poverty in the residential sub-sector.[56]

Our analysis has suggested that direct financial support is required in the residential sector – even more so than in other sectors – to unlock a significant fraction of the energy efficiency potential. The EEOS is one effective mechanism through which this support can be provided; however, it should be noted that the additional costs to the supplier associated with the EEOS may be passed onto the consumers through higher energy bills.

In order to meet the obligation, energy suppliers can also provide their consumers with energy efficiency advice to promote cost-effective energy efficiency measures and available funding and financing mechanisms such as PAYS, providing that the savings achieved can be shown to be 'additional'. Through the rollout of smart meters, suppliers will have access to accurate energy consumption data for their customers, which should reinforce their ability to provide energy efficiency assessments.

Recommendations for Ireland: Energy Supplier Obligation

- ***Recommendation 5:*** *Reconsider sub-sectoral targets of the Energy Efficiency Obligation Scheme recognising that energy suppliers can help achieve significant additional energy savings in the residential sector through the provision of direct financial support and energy efficiency advice.*

- ***Recommendation 6:*** *Explore options for providing tailored energy efficiency advice to consumers through energy suppliers, including the innovative use of data acquired through the smart metering rollout. This should raise awareness of both the energy efficiency measures available to the consumer and the variety of mechanisms available to support the financing of retrofits.*

Direct financial support

Although significant savings can be achieved through successful implementation of the low cost policies described above, our analysis suggests that it is not possible to meet the 2020 target without direct financial support. As explained in Section 3.2, the 'High' and 'Very High' scenarios in the commercial and residential buildings sectors include varying levels of direct financial support, which could be provided by the Exchequer, by energy suppliers as part of the Energy Efficiency Obligation Scheme, or a combination of the two. Direct financial support in the residential and commercial sectors could lead to additional savings of up to 2 TWh.

The provision of direct financial support also opens up an opportunity for the Government to influence the depth of the energy efficiency retrofit being implemented. As demonstrated in Section 2, the implementation of packages of several energy efficiency measures is a way of increasing the depth of retrofit that can be achieved cost-effectively. Where the Exchequer is providing direct financial support to a homeowner or business, the

[55] http://www.dcenr.gov.ie/Energy/Energy+Efficiency+and+Affordability+Division/Energy+Efficiency+Obligation+Scheme.htm
[56] www.seai.ie/eeos/

implementation of packages of measures could be strongly incentivised and perhaps even, where appropriate, enforced.

In Ireland, a number of Government-funded direct financial support schemes are already in place including Better Energy Homes[57] and the Electric Vehicle Grant Scheme.[58]

> ***Recommendations for Ireland: Direct financial support***
>
> - ***Recommendation 7:*** *Allocate budget for direct financial support in the residential and commercial sectors through the Exchequer and/or energy suppliers as part of the Energy Efficiency Obligation Scheme, recognising that this will unlock significant potential that may not otherwise be taken up.*
>
> - ***Recommendation 8:*** *Where direct financial support is provided, strongly incentivise (and consider, where appropriate, enforcing) the implementation of packages of energy efficiency measures in order to achieve deeper retrofits.*

Achieving behavioural change

In addition to the 'technical' measures, modelling has identified significant energy savings potential through behavioural change. More than 1.2 TWh of energy savings could be achieved by 2020 through behavioural change in the residential, public buildings and commercial buildings sectors. However, these are unlikely to be achieved with untargeted information campaigns.

Through our survey of consumer behaviour and decision-making in the commercial building sector, we found that only 2 % of small companies, and 4 % of large companies, identified a need for more information on energy efficiency in order to reduce their energy use. This suggests that untargeted information campaigns are unlikely to have a large impact on the uptake of energy efficiency measures. A more targeted approach will be required to capture the disengaged consumer segments, which correspond to around two-thirds of the commercial buildings stock and more than one-third of residential buildings.[59] Evidence collected for DECC[60] shows that information and/or training provided at the same time as the adoption of new technology can act as a stimulus for implementing behavioural measures.

We have identified a number of opportunities where targeted information or training such as this could be provided. For example, when organisations take up an EPC for a technical energy efficiency retrofit, they should also be provided with tailored recommendations on how they could reduce energy use through behaviour change. In the residential sector, a similar opportunity arises when a consumer takes up a PAYS scheme or direct financial support from the Exchequer. In addition, the uptake of certain behavioural measures could be achieved through the rollout in Ireland of smart meters with in-home displays and innovative presentation of an individual household's energy use.

In the transport sector, there is a large energy saving potential related to behavioural measures such as modal shift (1.5 TWh) and eco-driving across all forms of road transport (0.8 TWh). Achieving the savings potential of modal shift is one of the Government's

---

[57] http://www.seai.ie/Grants/Better_energy_homes/
[58] http://www.seai.ie/Grants/Electric_Vehicle_Grant_Scheme/
[59] Private Landlord Survey, 2013, 'Behaviour & Attitudes' for SEAI.
[60] 'What Works in Changing Energy-Using Behaviours in the Home? A Rapid Evidence Assessment', RAND Europe for DECC, 2012.

stated goals in the 2009 Smarter Travel policy document.[61] A significant reduction in the annual vehicle/km driven by private cars is targeted through interventions to focus population growth near centres of employment and to ensure that alternatives to cars are more widely available through an improved public transport system and a plentiful, safe cycling and walking infrastructure. Accordingly, several funding programmes have been introduced towards this goal, including the Department for Transport's Smarter Travel Areas, Active Travel Towns and the National Cycle Network. While a number of public transport improvement projects have been carried out, including Dublin's Luas Cross City extension, the recent economic climate has somewhat constrained investment. As well as ensuring sufficient funding levels for public transport infrastructure to achieve modal shift in the medium and long term, the Government should undertake further analysis to explore how modal shift could be encouraged in the short term through financial incentives and pricing mechanisms.

SEAI has initiated a number of eco-driving programmes by forming partnerships with organisations including Dublin Bus, Bus Eireann and Collins Travel.[62] These schemes demonstrate the significant savings available through eco-driving practices. The Government should consider the implementation of a wide-reaching and prominent national eco-driving programme involving increased emphasis on efficient driving practices in driving school curriculums, the re-education of licensed drivers, financial incentives for the purchase of in-car fuel saving devices and advertising campaigns across a variety of media. A model for this programme is the Dutch 'Het Nieuwe Rijden' scheme[63], a €35 million project that has led to an estimated 2 Mt of avoided CO_2 since 1999.

Recommendations for Ireland: Achieving behavioural change

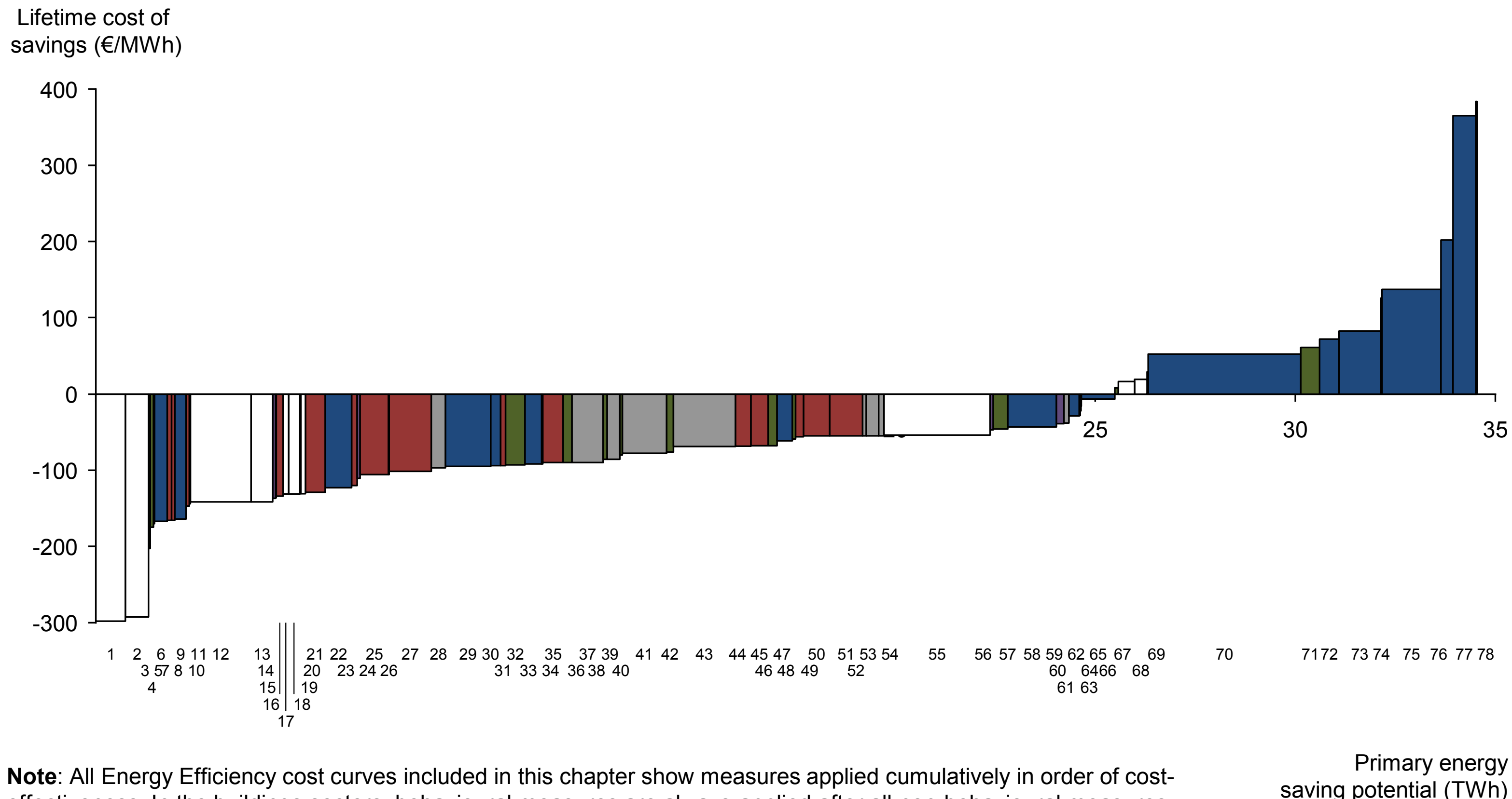
- ***Recommendation 9:*** *Ensure the provision of well-targeted information on individual consumers' potential energy savings and, where appropriate, training on how to achieve those savings. Potential opportunity areas include making such use of the data collected through energy audits during the uptake of EPCs by commercial and public organisations or of PAYS schemes, and of the data that could be collected through the national smart meter rollout.*
- ***Recommendation 10:*** *Carry out further analysis to explore how the energy savings potential of modal shift can be realised in the short term through the use of financial incentives and pricing mechanisms.*
- ***Recommendation 11:*** *Consider implementing a wide-reaching and prominent national eco-driving programme targeting new and existing drivers across all*

[61] 'Smarter Travel: A Sustainable Transport Future', Department of Transport, 2009.
[62] Available at:
http://www.seai.ie/Your_Business/Public_Sector/Collins_Travel_ECODriving_Case_Study.html
http://www.seai.ie/Your_Business/Public_Sector/ECOdriving_at_Bus_Eireann.html
[63] Wilbers and Wardenaar, 'The Dutch national ecodriving programme Het Nieuwe Rijden: A success story', 2007.

[This page is intentionally blank]

7 Appendix

7.1 Appendix: Energy efficiency cost curve with legend



Note: All Energy Efficiency cost curves included in this chapter show measures applied cumulatively in order of cost-effectiveness. In the buildings sectors, behavioural measures are always applied after all non-behavioural measures.

Figure: Energy efficiency cost curve for Ireland

Table: Primary energy saving potential for all sectors (TWh)

	Energy saving (TWh)		Energy saving (TWh)
1. Transport - Private cars - VRT rebalancing	0.74	41. Industry - Motor efficiency	1.10
2. Transport - Private cars - Shift to smaller vehicles	0.58	42. Public buildings - Energy efficient appliances - Office equipment	0.17
3. Public buildings - Turn off lights for extra hours	0.04	43. Industry - Process integration and heat recovery - low T processes	1.55
4. Public buildings - Enable standby features on all PCs and monitors	0.08	44. Commercial buildings - More efficient boiler with heating control	0.39
5. Public buildings - Energy efficient appliances - Refrigeration	0.03	45. Commercial buildings - Solid wall insulation	0.44
6. Residential - Air dry instead of tumble dry	0.32	46. Public buildings - Roof insulation	0.21
7. Commercial buildings - Turn off lights for extra hours	0.10	47. Residential - Draught proofing	0.38
8. Commercial buildings - Enable standby features on all PCs and monitors	0.08	48. Public buildings - More efficient air conditioning	0.09
9. Residential - Turn off lights when not in use	0.29	49. Commercial buildings - Energy efficient appliances - Office equipment	0.19
10. Commercial buildings - Energy efficient appliances - Refrigeration	0.07	50. Commercial buildings - Energy efficient glazing	0.67
11. Public utilities - Elimination of parasitic loads in pump house (e.g. heaters)	0.03	51. Commercial buildings - Heat pump	0.82
12. Transport - Private cars - Modal shift	1.52	52. Industry - More energy efficient lighting	0.09
13. Transport - Private cars - Eco-driving	0.55	53. Industry - Process integration and heat recovery – high T processes	0.31
14. Public utilities - Elimination of excess air to a level appropriate for plant requirement	0.08	54. Industry - More energy efficient steam system	0.14
15. Public utilities - Optimising operation to best efficiency through duty & assist control	0.02	55. Transport - Private cars - EU regulation	2.65
16. Commercial buildings - Draught proofing	0.17	56. Public utilities - Retrofit of fine bubble diffused air systems	0.08
17. Transport - HGVs - Eco-driving	0.13	57. Public buildings - More efficient boiler replacement with heating control	0.36
18. Transport - HGVs - Weight class shift	0.28	58. Residential - Roof insulation	1.21
19. Transport - Public passenger - Eco-driving	0.03	59. Public utilities - Replace street lighting by LEDs (including CMS)	0.20
20. Transport - LDVs - Eco-driving	0.12	60. Industry - More efficient HVAC and ventilation	0.13
21. Commercial buildings - Reducing room temperature	0.49	61. Residential - Energy efficient lighting	0.26
22. Residential - Energy efficient appliances –'Cold' and 'Electrical cooking'	0.67	62. Public utilities - Dissolved oxygen control of aeration systems	0.02
23. Commercial buildings - Reducing hot water use	0.13	63. Public utilities - Retrofit of blowers with VSD	0.02
24. Public utilities - Higher efficiency pump retrofit	0.07	64. Public utilities - Retrofit of high efficiency motors in aeration systems	0.01
25. Commercial buildings - Roof insulation	0.71	65. Residential - Cavity wall insulation	0.84
26. Public utilities - Install Variable Speed Drive (VSD) instead of throttling	0.02	66. Public buildings - Solid wall insulation	0.08
27. Commercial buildings - Energy efficient lighting with lighting control	1.06	67. Transport - LDVs - EU regulation	0.41
28. Industry - More efficient refrigeration	0.35	68. Transport - HGVs - Increasing ICE efficiency	0.31
29. Residential - Reduce room temperature by 1C	1.14	69. Public buildings - Heat pump	0.03
30. Residential - Turn off heating in unused rooms	0.25	70. Residential - More efficient boiler with heating control	3.81
31. Commercial buildings - Cavity wall insulation	0.12	71. Public buildings - Energy efficient glazing	0.47
32. Public buildings - Energy efficient lighting with lighting control	0.48	72. Residential - Energy efficient appliances - 'Wet' & 'Consumer electronics'	0.48
33. Residential - Use efficient shower head	0.42	73. Residential - Floor insulation	1.05
34. Public buildings - Reducing hot water use	0.03	74. Transport - Public passenger - increasing ICE efficiency	0.03
35. Commercial buildings - More efficient air conditioning	0.51	75. Residential - Solid wall insulation	1.47
36. Public buildings - Reducing room temperature	0.22	76. Residential - Heat pump	0.30
37. Industry – CHP	0.79	77. Residential - Energy efficient glazing	0.57
38. Public buildings - Draught proofing	0.10	78. Transport - Private cars - AFV incentive	0.03
39. Industry - More efficient compressed air systems	0.31		
40. Public buildings - Cavity wall insulation	0.06	**Total**	34.55

7.2 Appendix: Lessons from other Member States

The objective of this section is to identify some of the factors affecting the success/failure of the key policy measures included in our energy efficiency investment pathway scenarios based on the lessons from other Member States (mainly Germany and the UK).[64]

7.2.1 Financing residential retrofit (e.g. Pay-As-You-Save)

Pay-As-You-Save is a type of residential retrofit financing scheme, which is currently under consideration in Ireland. A number of research papers were produced examining the PAYS concept, which formed a starting point for the Better Energy Financing project.[65] Better Energy Financing is intended to overcome the finance barrier in the residential sector by providing accessible finance to householders in Ireland.

In this section, similar schemes in Germany and the UK are reviewed to identify the key factors affecting the success of PAYS-type schemes.

The Green Deal in the UK

The Green Deal was initiated in 2013 and stemmed from the 2011 Energy Act, a domestic energy efficiency improvement scheme but with no income bracket target or grants. It is a package which combines accredited energy advice and installation with the provision of finance which is repaid over a period of up to 25 years. Finance for the energy efficiency measures is attached to the property and it is recouped through extra charges on the energy bill of the house concerned. Green Deal is based on a central concept of the 'Golden Rule', whereby the cost repaid on the installations will not exceed the utility bill savings. Therefore responsibility for the repayments rests with the bill-payer in the property, who would have no further liability if they sell or move out of the property. The interest rate on the loan is notably high, between 7.9 and 10 % APR. Key results of the scheme include:

- 98 % of the total measures quoted by DECC (900,000) as 'installed' for its August 2014 update were actually installed through ECO, funded by the energy suppliers – so these would not count as measures installed under the Green Deal scheme. ECO is described in more detail in the 'Direct financial support funded by the energy suppliers' section.
- 300,259 total Green Deal assessments have only resulted in 1,815 'live' plans – a conversion rate of 0.6 % from assessment to completion. DECC's goal for the first 12 months of the scheme alone was 10,000 installations. After seven months and 58,124 assessments, famously only seven households had taken out plans.
- Concentrated peaks of installations and decreasing demand have resulted in one of the main providers, Mark Group, laying off one-quarter of its work force, 670 people.[66]

[64] Whilst country policy comparisons are made, it must be stated that successful policies in one country are not necessarily transposable. The industry data were limited in terms of availability as well as by language, so the comments made are not reflective of the entire industry and all member states.
[65] Better Energy Financing Project: http://www.seai.ie/Better_Energy_Financing/Project_Documents/
[66] http://www.edie.net/news/6/-Hasty-politics--forces-insulation-firm-to-axe-670-jobs/ , 5 September 2014.

Key factors affecting the relatively low uptake of Green Deal:

- **Complexity:** Organising home visits, filling in multiple forms as well as delays in credit checking were identified as key barriers. The timescale for securing the loan is thought to be approximately three weeks.[67]
- **Inaccessibility:** Upfront high property assessment costs (up to £100) made the scheme inaccessible to lower income households and those uncertain of their eligibility for measures. The installation and assessment process has demonstrated a substantial dropout rate, implying delays in plans being proposed to customers, despite many providers waiving the charge upon signing of a plan.
- **High interest rates**: Rates of 7.9 – 10 % APR typically. For example the interest on a typical loan of £5,000 would be £400 in the first year.[68] A high level of interest is paid on an investment in which the benefits are not experienced until the long run – 10 to 25 years.
- **Inability to satisfy the 'Golden Rule'**: Although it was designed to be protective, the Golden Rule is also restrictive as it sometimes deters potential customers from installing measures they need or desire.[69]

The Energy Conservation Act (EnEv) in Germany

EnEv was implemented from 1 February 2002 then amended in 2007 and 2009, replacing the flagship CO_2 Building Rehabilitation Programme. KfW (formerly Kreditanstalt für Wiederaufbau) works in partnership with the German Government, who injects funding into KfW. The Government negotiates the conditions, such as funding levels and interest rates. Germany has a 'three-pillar' approach towards promoting energy efficiency of which this scheme is the first type: limiting demand through legislation and regulation; promoting alternatives; and providing information and advice. In summary, the scheme works as follows:

- As part of EnEv, a low interest loan was available from the public bank KfW for the replacement of the heating and domestic hot water systems of a residence (and ventilation and cooling systems installed earlier than 2009). It can be up to €50,000 with a 10-year repayment period at a fixed interest rate of 1 – 4 %. The energy efficiency improvement must be at least 10 %. Access to loans is by owner occupiers, landlords and new buyers of newly refurbished residential units including individuals, housing companies, housing cooperatives, municipalities, district bodies, community groups and other public or non-profit bodies.[70]
- The goal is to use public policy to refurbish the entire housing stock and all public buildings in Germany by 2030.[71] Between 2004 and 2009, €27 billion was distributed in loans and subsidies, for a total investment in building efficiency of nearly €54 billion.

The initial uptake figures were very promising. Key results of the scheme are as follows:

---

[67] http://www.independent.co.uk/environment/green-living/exclusive-governments-green-deal-energy-efficiency-scheme-is-so-complex-it-deters-homeowners-from-signing-up-8869770.html, 9 October 2013.
[68] Carbon Commentary, 2013, http://www.carboncommentary.com/?s=green+deal
[69] House of Commons Energy and Climate Change Committee, 2014, 'The Green Deal: watching brief'.
[70] UCL Energy Institute, 2011, 'The KfW Experience in the Reduction of Energy Use in and CO_2 Emissions from Buildings: Operation, Impacts and Lessons for the UK'.
[71] 2011, Available at: http://www.electrical-efficiency.com/2011/08/energy-saving-programs-in-germany-an-unsung-success-story/

- **Efficiency**: 1 million old homes were retrofitted and 400,000 new highly efficient homes built (as this is not just a retrofit scheme). Annual energy consumption was reduced by 900 gigawatt hours as well as energy costs of participated companies by €150m per year. Annual greenhouse gas emissions decreased by 545 thousand tonnes overall. Energy efficiency in new buildings has doubled between 2002 and 2009, reducing calculated energy use from 120 kWh/(m^2a) to 60 kWh/(m^2a), while renovation has reduced it to approximately 80 kWh/(m^2a) in existing buildings.[72]
- **Employment**: Promoted investment safeguarding roughly 51,000 jobs, particularly among SMEs. 894,000 jobs were created between 2006 and 2009, mainly in construction and the supply chain.[73]

Table: Summary of PAYS policies[74]

	Green Deal (2013–present)	EnEv (2006–2010)
Interest rate on loan	7.9–10% APR	Publicly subsidised low interest rate (1% – 4%)
Accessibility	Low – high customer dropout rate - 0.6% successful conversion rate	High – extensive marketing campaigns
Main target market	Homeowners	Landlords and public bodies
Total cost of scheme (annual)	Value of investment: €380–€525 m	Average of €1.4 bn. Value of loans and grants: ~€3 bn
Attachment point of loan	Electricity meter	Person or organisation
Outreach	1,815 homes in total	200,000 homes per year
CO_2 emissions savings (Mt CO_2 per year)	0.3 total[74]	19

7.2.2 Promotion of Energy Service Companies

Promotion and development of the ESCO model by the Government by having an official Government programme in place to register ESCOs and specify example contracts, puts ESCOs and public/commercial building managers in touch is a cost-effective way of achieving energy savings.

In Ireland, a National Energy Services Framework[75] has been established to help develop the energy efficiency market in the non-domestic sector. The framework, as shown below, sets out the roadmap through which energy efficiency projects and an Energy

[72] Höhne et al., 2009.
[73] Power and Zulauf, 2011.
[74] Based on a 0.542 kg CO_2 saving per kWh energy consumed and 400 kWh average saving per household. German population approx. 82 m versus UK population 63 m.
Rosenow, J., Eyre, N., Rohde, C. and Bürger, V., 2013, 'Overcoming the upfront investment barrier – comparing the German CO_2 building rehabilitation programme and the British Green Deal' – *Energy and Environment Vol 24, No. 1 & 2.*
UCL Energy Institute, 2011, 'The KfW Experience in the Reduction of Energy Use in and CO_2 Emissions from Buildings: Operation, Impacts and Lessons for the UK'.
[75] http://www.seai.ie/Your_Business/Energy-Contracting/National-Energy-Services-Framework/

Contracting[76] process is developed. It also explains the process and provides guidance on routes to project development in addition to the support available from SEAI and sources of finance such as the National Energy Efficiency Fund.[77]

Figure: National Energy Services Framework in Ireland

The ESCO/EPC market in Germany is reviewed in this section to identify the key insights for Ireland.

ESCO market in Germany

Germany is one of the earliest ESCO markets, emerging in the early 1990s and renowned for its success. Supply contracting (particularly heat delivery services) and operations contracting are offered by the majority of ESCOs in Germany. The number of companies offering services through Energy Performance Contracting is only a fraction of the total of 500 ESCOs. The spread across sectors is approximately 60 % residential, 15 % EPC contracts for the public sector and 20 % industrial and commercial projects.[78]

The two associations which assist with the ESCO sector are the ESCO forum, for large firms (26 members) and the Contracting Forum of the German Electrical and Electronic Manufacturers' Association, for the smaller service suppliers (230 members). The most common model used is the Guaranteed Savings Scheme, where both the customer and ESCO benefit from the savings immediately from the first year – with excess savings shared between the client and the ESCO according to a previously agreed percentage.

Another vital step for the evolution of the ESCO industry was the establishment of standard procedures and documents such as model contracts, an energy performance retrofitting model and contracting guidelines by the federal states of Hessen and Berlin. Besides the large private ESCO sector, Germany is the home of the so-called 'Intracting model' or Public Internal Performance Commitments (PICO). In the PICO model one department in the administration acts as a unit similar to an ESCO in function for another department.

Under the Energy Savings Partnership scheme, buildings are bundled into pools in order to decrease transaction costs. By 2006, 21 pools had been contracted by ESCOs encompassing over 1,300 buildings altogether. Berlin's Energy Savings Programme

[76] http://www.seai.ie/Your_Business/Energy-Contracting/
[77] http://www.seai.ie/Your_Business/Energy-Contracting/The-Energy-Efficiency-Fund/
[78] MED-ENEC – 'ESCO Development in selected countries', 5 December 2012, http://iet.jrc.ec.europa.eu/energyefficiency/sites/energyefficiency/files/events/2012-Istanbul-workshop/2.8-escos_characteristics_istanbul_2012-12-05.pdf

decreased the city's carbon emissions by 19 % in 2004 from its 1990 levels (29–23.5 m tonnes), and 25 % by 2010. By 2012 almost 1,500 public and commercial buildings over 10 years old had been retrofitted, leading to CO_2 reductions of nearly 70,000 metric tons per year and 26 % off the average energy bill.[79]

Limitations of the approach:

- Unwillingness of clients to engage in contracts with pay-back times longer than a few years;
- Reluctance to use ESCOs when the production/manufacturing process is affected;
- Savings need to be verified and measured. This requires an ongoing long-term relationship between the ESCO and the client;
- Increasing issue of insolvency of clients – a guarantee scheme has been proposed in order to overcome this, and life-cycle costs of equipment are taken into account during the initial process of public bidding (plus more transparency of the process).

Key reasons for success in Germany:

- Its ability to pool buildings together as groups encourages energy efficiency investments in large building complexes and reduces transaction costs. With this approach smaller businesses are more likely to participate.
- In addition there is a strong legal framework as well as political will, enforceable standards and independent experts as a base of support. The municipal projects have a strong demonstration effect and act as multipliers among other sectors, most notably the commercial sector.
- The ESCO department organises, finances and implements energy efficiency improvements, allowing larger cost savings and less profitable projects, which would be ignored by a private ESCO. It is not a dedicated Government department but simply receives funding for its projects. The main drawback of this approach is the lack of an energy savings guarantee.

7.2.3 Direct financial support

In Ireland, a number of Government-funded direct financial support schemes are in place including Better Energy Homes[80] and the Electric Vehicle Grant Scheme.[81] Under the recent Energy Efficiency Obligation Scheme[82] in Ireland, energy suppliers must meet specific energy efficiency savings targets. In this section, drivers/factors affecting the success/failure of direct financial support schemes funded by the Government and/or energy suppliers in the UK and Germany are explained in more detail.

[79] 'Berlin Energy Saving Partnership for Energy Efficiency in Buildings', http://ccap.org/assets/CCAP-Booklet_Germany_Berlin.pdf
[80] http://www.seai.ie/Grants/Better_energy_homes/
[81] http://www.seai.ie/Grants/Electric_Vehicle_Grant_Scheme/
[82] http://www.dcenr.gov.ie/Energy/Energy+Efficiency+and+Affordability+Division/Energy+Efficiency+Obligation+Scheme.htm

7.2.3.1.1 Direct financial support funded by the energy suppliers

Energy Companies Obligation (ECO) in the UK:

Launched in January 2013 with an initial end date of March 2015, ECO is entirely funded by energy suppliers, aiming to supply free energy efficiency measures to individuals on Government benefits such as income-based jobseeker's allowance or state pension credit in order to reduce the number of households in fuel poverty. There are three different targets: 20.9 Mt CO_2 savings under the Carbon Emissions Reduction Obligation (CERO); 6.8 Mt CO_2 under Carbon Saving Community Obligation (CSCO); and £4.2 bn in savings under the Home Heating Cost Reduction Obligation (HHCRO).[83] Ofgem ultimately decides which of the energy suppliers have met their obligation, where failing could cost suppliers up to 10 % of their global turnover in fines. Each supplier has varying targets in savings or emissions reductions according to their share in the market of dual fuel customers. The measures offered under the scheme are: boiler repair/replacement, cavity wall insulation, loft insulation and solid wall insulation. Key results are as follows:

- Overall, 891,669 measures have been installed from January 2013 to June 2014. 51 % of the measures installed between April and June 2014 were cavity wall insulation measures and 47 % loft insulation.[84]
- The scheme is funded by energy suppliers with over 250,000 customers. Their customers' bills have increased as a means of funding the programme.

As of December 2013 the targets were revised[85] and the scheme is now extended to March 2017. One of the main reasons for this was to slow the price increase on consumer bills. Any delivery against 2015 targets will be carried over to 2017. The CERO was reduced by 33 %, suggesting that the targets were too ambitious in the first place. The scope for CSCO was extended from the lowest 15 % to the lowest 25 % of areas on the Index of Multiple Deprivation. A minimum of 100,000 measures of solid wall insulation must be delivered by 2017 to encourage more expensive, but longer term savings measures.

Direct financial support funded by the Government

Energiesparservice and the Energy Savings Check in Germany

Energiesparservice started in December 2005 as a collaboration between the Energy Department, Department of Social Services and Caritas Association Frankfurt operating within Frankfurt. Long-term unemployed locals were trained by the leading energy agency Caritas to become energy consultants for energy and water saving techniques. The programme was initially funded by the Energy Department and the Department of Social Services Jobcentre Frankfurt. Low income households are assessed then appropriate energy saving devices are installed free of charge. A second, larger scheme (the Energy Savings Check, 2008 – 2011) was introduced in 2008 to 90 cities using the same programme structure with the Ministry for Environment acting as funder. For this extension

[83] Further information is available at: https://www.ofgem.gov.uk/environmental-programmes/energy-companies-obligation-eco

[84] DECC, 2014, 'Domestic Green Deal and Energy Company Obligation in Great Britain, Monthly Report',https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/346182/Monthly_Statistical_Release_-_Green_Deal_and_ECO_in_GB_21_August_FINAL.pdf

[85] DECC, December 2013, http://blog.decc.gov.uk/2013/12/04/changes-to-the-green-deal-and-the-energy-company-obligation/

of the scheme, 3,000 advisors were trained. The funding duration has been extended until 2015.[86] Key results include:[87]

- 1,500 advisory service customers since the beginning in December 2005 until December 2010.
- Each household saves on average €174 and 303 kg of CO_2 in total per year. People receiving ALG II (support for long-term unemployed people) or *Sozialhilfe* (social welfare) save proportionately €81 in electricity, costs for water and heat energy (56 €/a) are saved by the municipality.
- The savings from the project are an estimated double of the cost.[88]
- The scheme was particularly effective at overcoming any trust issues because the advisors had been in similar positions themselves before their training.

Green Deal Home Improvement Fund (GDHIF) and the Warm Front

The GDHIF was introduced in the UK in 2014 with a fund of up to £120 m to help households improve the energy efficiency of their homes, with a cap of £7,800 per household. This fund included a refund of the assessment fee (typically £100), which was thought to have been an initial obstacle that put many households off. All of the funding was allocated within weeks of opening, a radically better uptake than the original scheme (£120 m budget taken up in less than two months).

The Warm Front scheme, which ended in 2013, was a much more traditional Government-funded grant scheme targeting England, which allocated up to £6,000 for insulation and heating improvements in low-income households as well as for residents aged over 60 years. There were official referral partners for the installation to be outsourced to, such as GB Energy.

7.2.4 Regulation

Most of the regulations in other Member States are Europe-wide, such as the Energy Efficient Buildings European Initiative[89] running from 2009 – 2019. In the UK, as part of the Energy Act 2011, the Government is mandating a minimum energy performance rating (i.e. similar to BER in Ireland) of E on letting residential and non-domestic buildings by 2018, based on the Energy Performance Certificates rating which runs from A-G. Similar to Ireland, the UK also has a minimum of 86 % boiler efficiency[90] for boilers in both new and old dwellings.[91]

Under the Energy Savings Opportunity Scheme (ESOS), approximately 7,500 of the UK's largest firms will have to assess the energy efficiency of their organisation every four

[86] 'Low Carbon South-East Europe', http://www.locsee.eu/uploads/documents/good%20practices/D1%20-%20Electricity%20Saving%20Check.pdf
[87] National Report, 'ACHIEVE', February 2012, http://nep.vitra.si/datoteke/clanki/Case%20studies%20-%20Key%20learning%20for%20ACHIEVE%20D2.1_EU.pdf
[88] May 2009, http://www.managenergy.net/lib/documents/773/original_8-Energiesparservice_Evaluation_EN_final_Bru%C2%A6%C3%AAssel_06-2013.pdf?1373881389
[89] 'Energy Efficiency Buildings: European Initiative – E2BA', http://www.ectp.org/cws/params/ectp/download_files/36D928v2_E2BA_Brochure.pdf
[90] It should be noted that minimum boiler efficiency in Ireland has increased to 90%.
[91] Energy Savings Trust – 'Domestic Heating by Gas', 2008, http://bpec.org.uk/downloads/CE30%20-%20Domestic%20heating%20by%20gas.pdf

years. By a set deadline of 5 December 2015, all corporations must be compliant with ESOS standards. Corporations involved are those with over 250 employees and/or an annual turnover in excess of € 50 m, or a balance sheet exceeding € 43 m. It requires a minimum of 12 months of verifiable data to analyse.

Other Europe-wide schemes (known as Minimum Energy Performance Requirements) include:

- Phasing out of incandescent light bulbs beginning from the 100W bulb in 2009 down to the 60W and 40W from September 2012;
- Phasing out of older gas and oil-fired central heating boilers as of 2015 due to their typically efficiency level of 50 % compared to condensing boilers with heat recovery treatment, which can operate at 97 % efficiency.

7.2.5 Information-based interventions

The scenarios, which were presented in the previous sections, include information campaigns for energy efficiency retrofit measures and interventions for behaviour change (e.g. turn off unnecessary lighting). In Ireland, the Government launched the 'Power of One' campaign to encourage energy efficient behaviour both at home and at work. The campaign was mainly run through TV and radio ads, in addition to flyers included in consumers' bills and billboard ads. In this section, recent information-based interventions in other Member States are presented.

Germany – DENA (German Energy Agency/Deutsche Energie-Agentur)

DENA was founded by the German federal Government, KfW, and three other major German banks in 2000. It sets the standards but does not directly provide advice, deliver projects itself or handle funding for projects. Regional agencies carry out the implementation.

The *Initiative EnergieEffizienz* campaign, which was launched in 2002, encouraged adopting energy efficient approaches and investing in energy efficiency through a central information platform and free advice hotline.

- The site offers energy saving tips and an energy appliance database providing the most energy efficient appliances across the German market.
- It provides corporate decision-makers with technical information and guidance in order to promote the implementation of energy efficiency measures.
- The structure is a public–private partnership project in co-operation with energy supply companies (EnBW Energie Baden-Württemberg AG, E.ON AG, RWE AG, Vattenfall Europe AG) and is supported by the Federal Ministry of Economics and Technology (BMWi).
- There are three campaign modules/targets: private households, industry and production, and the services sector. The campaign's interactive tools help identify energy efficiency potential and suggest suitable measures in, for example, waste heat use, insulation, and lighting.
- Decision-makers in small to medium-sized enterprises are offered extensive information services and tools. The whole budget of the first phase of the

campaign was € 13 million, € 8 million was voluntarily provided by the electricity supply companies and € 5 million by the Government.[92]

- The initial scope focussed on private households reducing losses from equipment on standby, supporting efficient lighting and raising energy efficiency of 'white' household appliances (e.g. refrigerators). The programme was extended to all electricity applications in households (especially the on-mode of ICT appliances and all household appliances) in 2005. As part of the campaign a variety of tools are offered, including a guideline and decision-making toolkit, a dossier highlighting individual aspects of the energy management stages and subsidy options, a beginner's brochure for energy consulting and a cross-sector technologies guide for managers, energy officers and related roles.
- The total CO_2 reduction potential of public relations campaigns, counselling and innovation in the period 2008 – 2012 was estimated at 0.7 million tonnes of CO_2.[93]

European-wide initiative – 'Energy Neighbourhoods'

The Energy Neighbourhoods initiative was piloted in 2008 and originated from a Belgian initiative by IEE (*L'Institut d'Etudes européennes*): styled as a competition, a bet was placed between residents and their municipality to save a specified percentage of energy, typically 9 %, through changes in user behaviour across 4 – 6 months. It was a large scale campaign to raise public awareness. Houses were sent leaflets and handbooks, with an online tool to record their savings daily/weekly/monthly, which took into account the outside temperature during the period. Each entered energy parameters such as their insulation level and their energy carrier. The scheme was advertised through over 800 radio and TV spots, with an additional 160 presentations at events and fairs as well as public support from 32 MEPs.[94]

830 neighbourhoods comprising 8,626 households (22,420 residents) took part and energy savings of 8 % were realised across six months. 80 % of neighbourhoods saved energy compared to their previous year.

Eco-driving in Netherlands

The Eco-driving programme *Het Nieuwe Rijden* in the Netherlands, which started in 1999, encourages the application of energy efficient driving, including private cars, delivery vans and lorries, and the purchase of more energy efficient cars.[95]

The Dutch national eco-driving programme comprises driving school curriculums, re-educating licensed drivers, fuel saving in-car devices, tyre pressure awareness, intelligent purchasing behaviour, communication, evaluation and monitoring, and international cooperation.

The communications strategy highlights safety, comfort, fun and cost savings, and environmental benefits are regarded as a pleasant side effect. The € 35 m project has realised a CO_2 avoidance of 2 Mt.[96] The cost-effectiveness of the programme was estimated to be around €10 per tonne of avoided CO_2 emissions.

---

[92] Mure and Fraunhofer, 2011, available at: http://www.measures-odyssee-mure.eu/public/mure_pdf/household/GER34.PDF

[93] IEA, 2008, 'Promoting energy efficiency investments case studies in the residential sector'

[94] The European Commission – 'Energy Neighbourhoods' - http://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/presentation_of_en2_en.pdf

[95] Wilbers and Wardenaar, 'The Dutch national ecodriving programme Het Nieuwe Rijden: A success story', 2007.

[96] RAC Foundation, 2012, 'Easy on the Gas: The effectiveness of eco-driving'.

Sustainable Energy Authority of Ireland
Wilton Park House
Wilton Place
Dublin 2
Ireland

t +353 1 808 2100
f +353 1 808 2002

e info@seai.ie
w www.seai.ie

@seai_ie