Economic and policy analysis in support of a revised EEOS for Ireland 2021-2030

Final report

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Abbreviations and acronyms

ACA	Accelerated Capital Allowance
AM	Alternative Measure
BEC	Better Energy Communities
BEH	Better Energy Homes
BER	Building Energy Rating
BEV	Battery Electric Vehicle
BEWHS	Better Energy Warmer Homes Scheme
BRP	Building Renovation Passport
CAP	Climate Action Plan
CBA	Cost-Benefit Analysis
CHP	Combined Heat and Power
DEC	Display Energy Certificate
DECC	Department of the Environment, Climate and Communications
ECA	Economic Consulting Associates
EED	Energy Efficiency Directive
EEOS	Energy Efficiency Obligation Scheme
EP	Energy Poor
ESRI	Economic and Social Research Institute
ETS	Emission Trading Scheme
EU	European Union
EV	Electric Vehicle
FE	Final Energy
GWh	Gigawatt-hours (1 million kWh)
ICE	Internal Combustion Engine
HGV	Heavy Goods Vehicles
HLI	Heat Loss Indicator
kWh	Kilowatt-hours
LGV	Light Goods Vehicles
LIEN	Large Industry Energy Network
LPG	Liquid Petroleum Gas
M&R	Monitoring and Reporting
M&V	Monitoring and Verification
NGR	Net to Gross Ratio
NTA	National Transport Authority

OP	Obligated Party
PHEV	Plug-in Hybrid Electric Vehicle
PV	Present Value
RAP	Regulatory Assistance Project
SEAI	Sustainable Energy Authority Ireland
SME	Small and Medium-sized Enterprises
TWh	Terawatt-hours (1,000 GWh)
VRT	Vehicle Registration Tax

Glossary

Alternative Measure co-funding	Relates to financial support being provided to a consumer through an Alternative Measure *in addition to* support from an OP under the EEOS
Alternative Measure contribution	The estimated contribution of an Alternative Measure towards Ireland's Energy Efficiency Directive Article 7 target
Aggregate subsidy	The total level of financial support provided to a consumer for an energy efficiency measure from the EEOS and/or an Alternative Measure
Cost per kWh-saved	The cost of saving one kilowatt-hour of energy (typically relates to investment subsidy portion as identified in text)
Cost per kWh-sold	The cost to an OP of meeting their EEOS target divided by volume of energy sold in kilowatt-hours
Energy saving credit	The credit provided to an OP for each kilowatt-hour of energy saved through their support to consumers
OP credit costs	The cost to an OP through subsidy support to consumers of generating energy saving credits (equivalent to cost per kWh-saved when looking solely at OP subsidy costs)
Subsidy component	The share of subsidy in total investment cost of an energy efficiency measure
Subsidy costs	The subsidy provided to end consumers to incentive uptake of energy efficiency measures
Total investment cost	The full investment cost of undertaking an energy efficiency measure inclusive of the consumer contribution and all subsidies
Total subsidy	Aggregate level of subsidy provided to all consumers by OPs or through Alternative Measures as identified in text
Weighted average cost per kWh of energy saving credits across the EEOS	Weighted average of cost per kWh-saved for generating energy saving credits across residential, energy poor and non-residential sectors

Executive summary

Introduction

Article 7 of Directive 2018/2002 (the "Energy Efficiency Directive" or "EED") represents a major component in delivering on the European Union's overall energy efficiency objectives. There is, however, flexibility in how it is implemented with various design choices regarding both the types of policy instruments used and specifically, the design of any Energy Efficiency Obligation Scheme (EEOS).

For the 2014-2020 period, Ireland adopted a mix of an EEOS and so-called "Alternative Measures" (AMs) to deliver on its energy saving obligation. The 2021-2030 target is both longer in duration and larger in terms of annual savings than that for 2014-2020. In cumulative terms it is estimated to equate to 60,707 GWh. Meanwhile some of the AMs adopted for the 2014-2020 period are considered no longer eligible due to revised criteria and the heightened baseline set by EU legislation.

Concurrent with the transposition of the requirements of Directive 2018/2002, Ireland intends to define and implement a series of actions targeted at reductions in Greenhouse Gas (GHG) emissions as laid out in the Climate Action Plan (CAP). The policy response to EED Article 7 needs to align with and support the actions and objectives of the CAP.

This report has therefore investigated:

- What potential mix of AMs may be selected by Ireland for contributing towards its Article 7 obligation in a manner consistent with the CAP.
- Design options regarding a potential forthcoming EEOS, including the threshold for the obligation, sectoral ring-fencing, eligibility criteria (in consideration of consistency with the CAP), and overall scheme costs.

Alternative Measures

A review was undertaken of the potential contribution from AMs towards Ireland's 2021-2030 target covering both existing AMs and potential new AMs[1] in alignment with the CAP. This review found that:

- For the current period (2014-2020), AMs are expected to contribute approximately 45% of Ireland's EED Article 7 target.
- For the forthcoming period (2021-2030), an initial estimate is that the suite of AMs considered to be eligible can deliver approximately 40% of the cumulative target exclusive of projects co-funded by the EEOS.

[1] A "new" AM could be an existing policy which has previously not been considered for contributing to the Article 7 obligation. In this case, it is necessary to ensure that the calculation methodology for estimating energy savings attributed to the measure, as well as the monitoring and verification processes for it, are consistent with the requirements of EED Annex V.

- This would leave 60% of the forthcoming target to be met through the EEOS, including co-funded projects[2].

- There is, however, significant uncertainty both in the calculation of these figures and the policy pathway on which they are based.

The estimated breakdown in AM contribution by year is shown in the following table.

Table 1 Summary of estimated energy savings contribution from AMs

AM	New annual energy savings (GWh)										Cumu.[1]
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	
Carbon tax	569	667	651	736	802	858	906	947	980	1,008	8,123
Home retrofits[3]	30	30	30	45	45	45	45	45	45	45	2,070
Industrial & commercial	57	57	57	57	57	57	57	57	57	57	3,135
Public sector	46	46	46	46	46	46	46	46	46	46	2,541
EV incentives	23	31	42	56	71	88	102	119	136	155	3,291
Modal shift	44	66	88	110	132	154	176	198	220	220	6,018
Total											**25,178**

Source: ECA estimates

Note 1: The cumulative total is calculated based on the assumed lifespan of the underpinning measures. Where these are assumed to all be at least 10 years in length, new savings continue to contribute each year after implementation. Where shorter lifespans are evident (only during the year of application in the case of carbon tax) contributions "drop out" prior to 2030 and hence the cumulative total is lower.

EEOS – threshold level and structure

Ireland applies an annual sales volume threshold for its EEOS, below which entities are not obligated. All entities with annual sales volumes above the threshold, currently set to 600 GWh, then have their EEOS target allocated in proportion to their share of the aggregate sales volume. The purpose of the threshold is to ensure the associated costs of implementing an EEOS (particularly the fixed administrative costs) do not present an unreasonable barrier to entry for new firms, reducing market competitiveness. It also avoids unnecessary administrative complexity arising from having to manage obligations for a large number of small parties.

[2] Consumers are permitted to receive support for a particular energy efficiency project from both an energy supplier through the EEOS and from another support scheme (such as SEAI grants). This approach is particularly prevalent in the energy poor sector where the large majority of credits for the current period (2014-2020) were generated in this way. Such projects in this report are termed "co-funded".

[3] This represents only a subset of the total Irish objective outlined in the CAP of 500,000 retrofits to at least BER level "B2"by 2030 due to the specific eligibility limitations imposed by the requirements of EED Article 7 and also exclusion of that portion co-funded by the EEOS.

An analysis was undertaken on the threshold level and structure to assess its appropriateness in terms of its potential for market distortion. This found that:

- The current threshold of 600 GWh covers the vast majority of market sales volume in both the dual fuel (electricity and gas) and liquid fuel markets.
- Should the Irish electricity and gas markets experience a similar upheaval from new entrants to that observed in Great Britain in recent years then it is possible the EEOS coverage will fall resulting in increased risk of some market distortion. Even in this situation, however, 600 GWh is considered likely to be low enough to ensure well over 90% of the market remains covered. 600 GWh represents approximately 1.3% of current total dual fuel sales, a figure that is only likely to decline as heat and transport become increasingly electrified.
- The current threshold structure which allocates the target based on an entity's total sales volume creates a substantial cliff-edge at the point at which an entity crosses the threshold to become obligated. This could represent a barrier to growth for small firms and act as a deterrent for new entrants.
- Introducing a "Free Allowance" whereby only marginal sales above the threshold are counted towards the target allocation could mitigate the cliff-edge effect.
- Under the assumption that the total EEOS target is allocated in proportion to Obligated Party sales on a kWh basis regardless of fuel type[4], the Free Allowance approach is estimated to enable the threshold to be lowered to 400 GWh without loading disproportionate costs onto smaller entities.

EEOS – sectoral ring-fencing and scenarios

The current EEOS has three ring-fenced targets:

- At least 5% of the Obligated Party's target must be achieved with consumers designated "energy poor".
- At least 25% of the Obligated Party's target must be achieved within the residential sector (inclusive of the energy poor target).
- The remaining 75% of the target may be met in the non-residential sectors (although surplus savings from the residential sector target may be used to meet the non-residential target).

Activity in energy poor households typically requires a substantially greater subsidy from the Obligated Party to initiate activity than across the general population (sometimes termed "able-to-pay"). In turn, savings in the residential sector typically require a greater subsidy than in the non-residential sector, even though the net present value in economic/social welfare terms of

[4] An alternative approach would be to allocate aggregate targets by sector or fuel type, for example as with current split between transport and non-transport Obligated Parties, before allocating the individual entity targets within each sub-group relative to their respective sales volumes. Provided the aggregate targets remain broadly in line with that group's share of total final energy consumption this will not materially affect the results presented in this analysis.

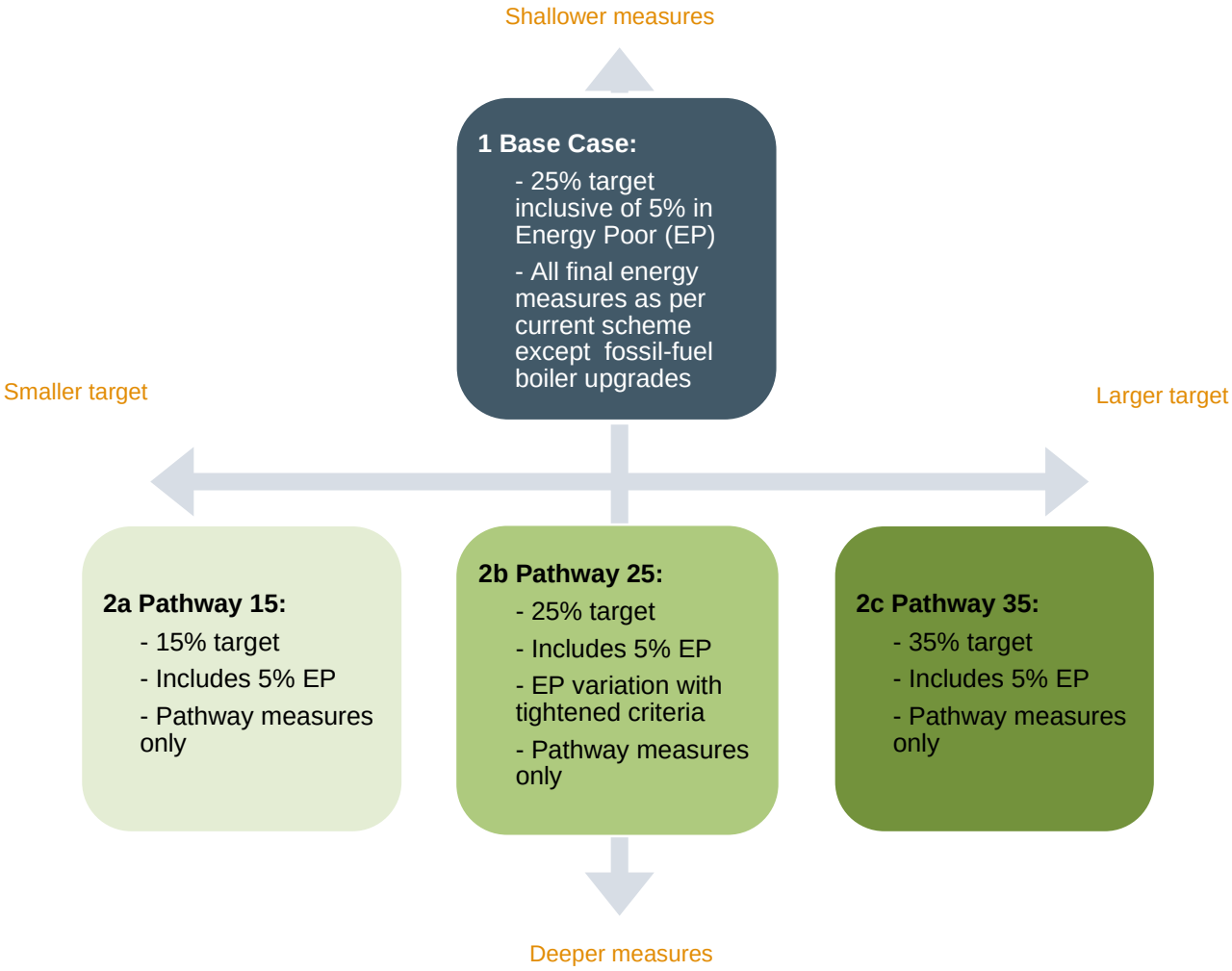
a residential action may be higher. Therefore, without ring-fencing, activity is likely to focus on the cheaper credits available in the non-residential sector.

Furthermore, Ireland's CAP outlined ambitious objectives for the electrification of heat and transport as well as deep retrofits. Supporting such measures is expected to remain less cost-effective in simple Euros per kWh-saved terms within the period of the obligation (2021-2030) than so-called shallow measures such as simple insulation, fossil fuel boiler upgrades, lighting, and heat controls. There is particular concern regarding incentivising such shallow measures where they do not form part of a longer-term package to maximise the energy efficiency performance of a given home.

Residential sector – target size and eligibility criteria scenarios

A **Reference Scenario** has been developed whereby the EEOS follows the same structure and eligibility as at present with the only changes being denominating savings in final energy terms and amending the deemed energy savings for measures with a lifetime of less than 10 years by a factor equivalent to the assumed lifetime divided by ten. Under this Reference Scenario activity would, however, be expected to focus on fossil fuel boiler upgrades with integrated heating controls. There are additionality concerns with this outcome while it is also not consistent with the objectives of the CAP.

Four **alternative scenarios** have therefore been selected for evaluation and comparison to the Reference Scenario based on the size of the residential sector target and the continued eligibility of shallow measures as illustrated in the following figure.



The **"Base Case"** (Scenario 1) represents the same approach as for the Reference Scenario with the exception that no credits are provided for fossil fuel boiler upgrades. All other individual measures remain admissible under the EEOS provided they target final energy consumption savings, irrespective of whether they form part of a pathway towards the declared CAP objective of achieving at least Building Energy Rating (BER) B2 status. A 25% overall residential sector target is retained but for modelling purposes the target is treated as if it were 20% with the 5% energy poor ring-fenced target considered independently. This implicitly assumes energy poor activity will always cost more than residential sector activity and hence there is no incentive to generate excess energy poor credits for use towards the general residential sector target.

The "**Pathway**" scenarios (Scenarios 2a to 2c) cover different levels of 'ring fencing' of the residential sector and seek to tie the EEOS target more firmly to the CAP objectives regarding cost optimal retrofit and the upgrading of homes to BER B2/cost optimal equivalent level by 2030. This involves limiting eligible measures to (1) building fabric packages that meet a "**heat pump readiness**" criterion of a Heat Loss Indicator (HLI) no more than 2.0 W/m^{2}K and (2) concurrent or subsequent **heat pump** installation (with control) that meets at least BER B2 rating. Three variants have been modelled with the **residential sector target** set to **15%, 25%, 35%** respectively. In each case the energy poor target remains a subset of this at 5%

and is treated separately leaving the able-to-pay targets modelled at 10%, 20%, 30% respectively.

The results of the analysis for the **Reference Scenario** and **Base Case** are:

- In the **Reference Scenario** the EEOS largely follows current structures (with an adjustment to the energy saving calculation methodology for measures with lifetime of less than 10 years; notably heating controls). Under the Reference Scenario, Obligated Party credit costs (cost per kWh-saved) are expected to remain at a similar level to current residential sector credits, around €0.12/kWh-saved in final energy terms, due largely to higher efficiency **fossil fuel heating system** deployment. There are additionality concerns regarding this approach (see below) while it is also not aligned with CAP objectives given the ongoing support for fossil fuel heating system installations.

- Under the **Base Case**, Obligated Party residential sector credit costs are estimated to rise by around 60% as compared to the Reference Scenario reaching around €0.18/kWh-saved. This increase could alternatively be met through the scaling-up of AM co-funding.

- Activity would be focused on the remaining cavity wall insulation (in early years), further roll-out of heating controls and heat pump installation. The higher costs relative to those for similar credits under the current scheme are largely due to the deemed credits being reduced by 50% for heating controls to reflect their shorter lifespan.

The analysis of the Reference Scenario and Base Case use the current SEAI energy savings credit table[5] for deemed energy savings attributable to each individual measure, with a factor applied to all measures with a lifespan shorter than 10 years equivalent to their assumed lifespan divided by ten. Changes in marketplace products and the penetration levels of energy efficiency measures since the credits were devised may negatively affect the level of additionality of the energy savings for some measures as compared to a situation with no EEOS. This issue is most likely to negatively affect measures such as fossil fuel boiler upgrades and heating controls where high levels of market penetration have already occurred. Additionality requirements of the EED would strictly necessitate that changes in additionality, if sufficiently evidenced, be incorporated into calculations of progress vis-à-vis Article 7 targets[6]. For reasons elaborated in the main body of the report it is expected this issue will be of greatest concern with respect to the deemed energy savings values for fossil fuel boilers which are anyhow excluded from the Base Case calculations.

The results of the analysis for the **Pathway** scenarios are:

- Changing the ring-fenced target size impacts on costs both due to:

- The decrease or increase in the target itself meaning the weighting of able-to-pay residential sector credits in the overall subsidy cost of the EEOS decreases or increases proportionately; and

[5] https://www.seai.ie/publications/Energy_Saving_Credits_Table.pdf
[6] See Page 123 of https://ec.europa.eu/energy/sites/ener/files/documents/c_2019_6621_-_annex_com_recom_energy_savings.pdf

- on a per kWh-saved basis due to variation in the marginal cost of achieving new energy savings in each sector (a steeper cost curve will result in an increase in the target size having a disproportionate increase in overall subsidy costs of the EEOS).

- Under the 15% residential / 10% able-to-pay target level (Scenario 2a) subsidy cost per kWh-saved for residential energy saving credits (to be met by either Obligated Parties and/or AMs) is estimated to be broadly equivalent to the Base Case.

- Under the 25% residential / 20% able-to-pay target level (Scenario 2b) the subsidy cost per kWh-saved for residential energy saving credits is estimated to be around 20% higher than for the Scenario 2a.

- Under the 35% residential / 30% able-to-pay target level (Scenario 2c) the subsidy cost per kWh-saved for residential energy savings credits is estimated to be around 40% higher than for the Scenario 2a.

These results are summarised in Table 2 below.

Table 2 Residential sector results: annual average impact per year (2021-2030)

Scenario	Sector savings (GWh)	Total subsidy[1] (€M)	Cost per kWh-saved (€c/kWh-saved)	Number of homes retrofitted[2]
1. Base Case[2]	130	23.9	18	72,000
2a. 10%	65	10.2 - 12.1	16 - 19	3,000 - 3,500
2b. 20%	130	23.9 - 31.4	18 - 24	5,000 - 8,000
2c. 30%	195	40.1 – 52.3	21 –27	6,500 – 11,000

Note 1: Calculated based on subsidy component equivalent to 30% of investment costs

Note 2: For Base Case refers to number of individual measures

Energy Poor – Eligibility criteria scenarios

The same Reference Scenario, Base Case and Pathway scenarios as modelled for the residential able-to-pay sector have been modelled for the energy poor sub-sector, in each case with the energy poor target remaining at 5%. An additional variant of the Pathway scenario has also been modelled which limits eligible homes to those with initial BER rating of E or poorer. This is estimated to equate to around 200,000 eligible homes.

The key results of the analysis are:

- Under the **Reference Scenario** whereby the scheme largely follows current structures, Obligated Party energy poor energy saving credit costs are expected to remain at a similar level to the estimated cost to Obligated Parties of current energy poor credits, around €0.26/kWh-saved with deployment dominated by shallow measures, notably higher efficiency **fossil fuel heating systems**. This is inconsistent with the CAP objectives.

- Under the **Base Case** the average cost to Obligated Parties is estimated to increase to around €0.40/kWh-saved with activity focused on the remaining cavity wall insulation potential and heating controls.

- A "**Pathway – standard criteria**" scenario has been modelled following the same eligibility criteria for measures as those described for the able-to-pay residential sector. Under the current energy poverty target level (5%) the cost per kWh-saved for energy poor credits faced by Obligated Parties are estimated to approximately double as compared to the Reference Scenario unless there is a relative increase in the AM contribution[7].

- Under the "**Pathway – enhanced criteria**" variation scenario, confining eligible homes to those of BER level E or poorer, the cost per kWh-saved for the energy poor credits are expected to approximately triple in the absence of a relative terms increase in AM contributions. This results in a notable impact on overall EEOS subsidy costs, rising by around 30% as compared to the Reference Scenario.

These results are summarised in Table 3 below.

Table 3 Energy poor sector results: annual average impact per year (2021-2030)

Scenario	Sector savings (GWh)	Total OP subsidy[1] (€M)	Cost per kWh-saved (€c/kWh-saved)	Number of retrofitted homes[2]
1. Base Case[2]	32.5	12.9	40	11,000
2b. Pathway	32.5	13.5 – 19.1	42 –59	1,000 - 1,500
2b. Enhanced	32.5	21.0 – 27.0	65 –83	1,200 - 1,300

Note 1: Calculated based on two-thirds of required subsidy being met by EEOS

Note 2: For Base Case refers to number of individual measures

Non-residential sectors

Non-residential sectors constitute the balance of the total EEOS target and thereby in effect act as a third category although surplus residential credits may be used towards meeting the target. This is currently equivalent to 75% of the overall EEOS target but should the residential (including energy poor) target be amended to 15% or 35%, it would adjust accordingly to 85% or 65% respectively.

Simple cost curves have been developed for Obligated Party support for each of Transport, Commercial Buildings, and Industrial and Commercial Processes. Scenarios have then been modelled including a Base Case without any further changes to EEOS design and a specific ring-fence for the transport sector proportionate to the sector's share in final consumption. No separate Reference Scenario has been developed for the non-residential sector as was

[7] The split used in calculations is two-thirds of subsidy met by Obligated Parties and one-third by AMs. This undervalues the actual contribution of AMs both within the current scheme and in the projections, however additional AM contributions above the one-third level are assumed to be offset by overall costs being higher than calculated under the least cost assumptions underpinning the modelling for this report. This is largely because of the multiple objectives of AMs.

provided for the residential sector due to it being entirely synonymous with the Base Case. For the Base Case the effective target has been modelled at each of 85%, 75% and 65% to reflect the balance of the overall EEOS target after considering the different residential sector scenarios (15%, 25% and 35% respectively).

The key findings are:

- Adopting a **final energy** target has an effect on the relative attractiveness (compared with the current EEOS) of common non-residential measures for Obligated Parties, **favouring heating over lighting** in particular. It may also limit the absolute size of the annual market in lighting measures for Obligated Parties.

- Under the **Base Case** with no change to the sub-sectoral targets, Obligated Party costs per kWh-saved are estimated to remain approximately as at present, around €0.05/kWh-saved. If the non-residential target is expanded to 85% to allow for a 15% residential sector target (inclusive of energy poor) then this is estimated to rise to around €0.06/kWh-saved. There is, however, a high level of **uncertainty** associated with this result with both figures being particularly sensitive to assumptions regarding the size of the annual market for heating measures.

- Modelling suggests any shortfall in savings available in commercial buildings or processes may need to be substituted by incentives for **EV purchase**. This is an unproven measure under an EEOS and costs for Obligated Parties are especially difficult to discern.

- **Transport** constitutes over 40% of final energy consumption. Should the sector have a **ring-fenced target** consistent with this share then costs are expected to increase markedly. This is due to having to offer higher incentives for EV take-up. In this case the transport energy savings are estimated to cost an average of €0.26/kWh-saved with overall non-residential sector credits (including the ring-fenced transport component) costing an average €0.15/kWh-saved. However, there are very large uncertainties regarding the future cost trajectory of new EVs and the level of subsidy OPs would be required to offer in order to incentive additional investments.

These results are summarised in Table 4 below.

Table 4 Non-residential sector results: annual average impact per year (2021-2030)

Scenario	Sector savings (GWh)	Total OP subsidy (€M)	Cost per kWh-saved (€c/kWh-saved)
Base Case (65%)	422.5	16.1	3.8
Base Case (75%)	487.5	22.4	4.6
Base Case (85%)	552.5	33.1	5.8
Transport ring-fenced (40%)	260	66.5	25.6

EEOS overall scheme costs by scenario

Three “combined scenarios” have been modelled with variations regarding EEOS design across each sector as follows:

- **Base Case:** as per Base Case described within each sector with current ring-fenced targets retained of 25% residential of which 5% must be energy poor. EEOS continues largely in its current guise but with switch to a final energy target, adjustments for measures with <10-year lifespan and exclusion of fossil fuel boiler upgrades as an eligible measure.
- **Pathway and Enhanced Energy Poor:** Combination of Pathway 15% scenario for the residential sector, Pathway scenario with enhanced criteria for the energy poor sector, and Base Case (85%) for the non-residential sector.
- **Pathway, Enhanced Energy Poor and Transport:** As per above but with additional ring-fence around transport at 40% (approximately equivalent to share of final consumption).

The results are presented in Table 5, which includes the respective estimates of cost per kWh of energy sold.

Table 5 Annual impact by combined scenario (average impact per year 2021-2030)

Scenario	Sector savings (GWh)	Total OP subsidy[1] (€M)	Cost per kWh-saved (€c/kWh-saved)	Cost per kWh sold[2] (€c/kWh-sold)
Base Case	650	59.2	9	0.045
Pathway and Enhanced Energy Poor	650	64.3 – 72.2	10 – 11	0.049 – 0.055
Pathway, Enhanced Energy Poor and Transport	650	107.7 – 115.6	17 – 18	0.081 – 0.087

Note1: Assumes full 30% subsidy component for residential sector investments is met by OPs

Note 2: Assumes 97% of all fuel consumption falls under Obligated Parties’ sales with costs allocated proportionately, based on consumption trajectory

Overall energy savings summary

Combining the above findings in relation to AM and EEOS cumulative savings over the period 2021-2030 yields the sectoral breakdown shown below in Table 6. This is based on the Pathway 15 scenario for the apportionment of sectoral targets within the EEOS – namely 15% residential sector target with 5% of that designated as energy poor. No ring-fencing of transport is included.

Table 6 Estimated energy savings apportionment between AM and EEOS

Sector	Policy measure	AM savings	EEOS savings	Total
Cross-sectoral	Carbon tax	8,123		8,123
Residential	AM-driven home retrofits	2,070		2,070
	EEOS able-to-pay		3,575	3,575
	EEOS energy poor		1,788	1,788
Industrial and Commercial	All	3,135	25,975	29,110
Public	All	2,541		2,541
Transport	Incentives for EV deployment	3,291	3,586	6,877
	Modal Shift	6,018		6,018
	Other EEOS		826	826
Total		**25,178**	**35,750**	**60,928**

Source: ECA calculation

While no EEOS savings are attributed to the public sector (following experience in the current scheme whereby only a very small share of targets is achieved in this sector), EEOS activity is permitted and cost-effective opportunities are available should current obstacles be overcome. This is particularly the case in public buildings including education and health centres.

1 Introduction

At the request of the Department of Environment, Climate and Communications (DECC), the Sustainable Energy Authority of Ireland (SEAI) is supporting the development of policy for compliance with Article 7 of the revised EU EED, Directive 2018/2002. To assist with this objective, Economic Consulting Associates Ltd (ECA) is providing economic and policy advice in the development of relevant policies.

The requirements of EED Article 7 for the 2021-2030 period can be summarised as:

- Ireland must achieve cumulative end-use energy savings equivalent to new savings each year from 1 January 2021 and 31 December 2030 of 0.8% annual final energy consumption, averaged over the three-year period to 1 January 2019. **For Ireland this is currently estimated to result in a cumulative target of 60,707 GWh**.

- The requirements of Article 7 must be achieved through the implementation of an EEOS, eligible "Alternative Measures (AMs)", or a mixture of both.

- These policy measures must instigate end-use energy savings in line with additionality and materiality criteria given in Annex V of the EED and elaborated within the European Commission's Recommendations[8], as well as being sufficiently measurable and verifiable.

The 2021-2030 EED Article 7 obligation is the successor to a similarly formed obligation for the period 2014-2020, which Ireland has sought to meet through a combination of an EEOS and specified AMs. The target for the new period is larger in equivalent annual terms (due to the removal of allowed exclusions) and longer in duration. Meanwhile some policy measures that are contributing substantially to the 2014-2020 target are no longer eligible for the 2021-2030 period and/or face lower cost opportunities becoming increasingly saturated.

Concurrent with the transposition of the requirements of Directive 2018/2002, Ireland intends to define and implement a series of actions targeted at a reduction in Greenhouse Gas (GHG) emissions as laid out in the recently published CAP[9]. The policy response to EED Article 7 needs to align with and support the actions and objectives of the CAP.

The challenge is therefore substantial. This report seeks to describe a potential scenario for how Ireland may meet its requirements under the revised EED Article 7, the policy measures which can be used to elicit sufficient eligible savings, and the future design and role for Ireland's EEOS within that mix.

The remaining sections are structured as follows:

- **Section 2** describes the findings of a review of ongoing or planned policy measures in Ireland, how they may meet the end-use energy savings

[8] Available at https://ec.europa.eu/energy/en/topics/energy-efficiency/targets-directive-and-rules/energy-efficiency-directive#content-heading-2
[9] Available at https://www.dccae.gov.ie/en-ie/climate-action/publications/Pages/Climate-Action-Plan.aspx

requirements of EED Article 7, and their potential contribution as eligible **AMs** towards meeting the EED Article 7 targets.

- **Section 3** covers the design of the **EEOS** including specific analysis on the threshold for obligation and sectoral ring-fencing.
- **Section 3.4** provides **conclusions** from the analysis.
- **Annex A1** provides further details on the calculation approach for estimating the contribution of the AMs described in Section 2.
- **Annex A2** describes in the input data and sources for the modelling of the EEOS design in Section 3.
- **Annex A3** describes an analysis of the social costs and benefits of the EEOS design options.

All numbers presented in this report related to policy design are used for demonstration purposes to estimate the implications of various policy design options. Unless otherwise stated, they do not reflect agreed policy decisions nor the consultant's recommendations. Furthermore, analysis has required input from a large array of pre-existing data sets, together with assumptions and approximations drawn from the consultant team's extensive experience in the energy efficiency field. Limitations inherent in the available data, as well as the extent of original analysis that could be undertaken lend considerable uncertainty to the results presented. Key areas of uncertainty are discussed where appropriate throughout the report, noting that such uncertainty is generally considered to be greater when referring to absolute values rather than the relative results between scenarios.

2 Alternative Measures

Summary of section

- Under the EED Article 7, Ireland has been set an end-use (final) cumulative energy savings target for the period 2021-2030 estimated to equal 60,707 GWh.
- The annual equivalent target for the period 2021-2030 represents a 22% increase on the corresponding target for the current period (2014-2020) while certain AMs considered for the current period are no longer eligible for the next period under the revised EED.
- For the current period (2014-2020), AMs are expected to contribute approximately 45% of Ireland's EED Article 7 target.
- A review was therefore undertaken of the estimated energy saving contribution from existing AMs that are considered to remain eligible for the next period as well as potential additional AMs not considered in the current period.
- Following this review an initial estimate is that the suite of AMs considered here can deliver approximately 40% of the cumulative target for the 2021-2030 period exclusive of projects co-funded by the EEOS.
- In the absence of the introduction of further measures, this would leave 60% of the target to be met through the EEOS, including co-funded projects.

2.1 Scoping and selection of AMs

As with the current period (2014-2020), Ireland intends[10] to meet its revised EED Article 7 target for the next period (2021-2030) through a combination of an EEOS and eligible AMs. These AMs include both measures which are (or were) earmarked to contribute towards the current period target, as well as further measures considered eligible but not currently calculated for Article 7 purposes.

AMs can act both in parallel to and in combination with the EEOS. Where an AM operates in conjunction with the EEOS for a specific intervention, care must be taken to avoid "double counting" the derived energy savings. The expected scale and contribution of these measures over the period and the extent to which they operate in conjunction with the EEOS will therefore help define the corresponding size of the EEOS target for Obligated Parties. Furthermore, the combined delivery from AMs and the EEOS should be consistent with the objectives of Ireland's CAP.

As a starting point, this analysis therefore:

[10] Minister's Decision Paper from June 2020.

- Reviews existing AMs with respect to:
  - The expected energy savings to be delivered over the course of 2021-2030
  - Their eligibility under the revised EED for contributing towards the Article 7 obligation
  - Their interaction with the EEOS
- Reviews the CAP to identify:
  - Additional proposed policies that may act as AMs
  - The expected savings that these policies may deliver over the period 2021-2030
  - Their potential interaction with the EEOS

2.1.1 Review of existing AMs

For the current period of 2014-2020 Ireland notified the European Commission of its intention to report savings from nine AMs[11]. Comments regarding the potential role of all nine of these AMs for the 2021-2030 are provided in Table 7.

Table 7 Review of existing Alterative Measures

Alternative Measure	Contribution to 2014-2020 target[A]	Notes	Considered as AM for 2021-2030 target?
SME Programme	1%	Programme set to continue during 2021-2030 period	Yes
Large Industry Energy Network (LIEN)	6%	Programme set to continue during 2021-2030 period	Yes
Building Regulations Conservation of Fuel and Energy Dwellings (Part L) to 2020	29%	Will not be eligible as a contributory measure to 2030 target unless (a) driven by policy measure or (b) goes above and beyond requirements of Directive 2018/844 (the revised Energy Performance of Buildings Directive)	No
Energy Efficiency Boiler Regulation for Replacement Boilers	3%	Raised baseline for 2021-2030 period (set by Ecodesign for local space heaters, mandatory as from January 2018 – marginal savings above baseline remain eligible)	No
Smart Meters	Not used	Lack of additionality to Directive 2009/72/EC in 2021-2030 period	No

[11] After aggregating four sets of incremental improvements in Building Regulations

Alternative Measure	Contribution to 2014-2020 target[A]	Notes	Considered as AM for 2021-2030 target?
Accelerated Capital Allowance (ACA)	Not used	Need to address lack of data granularity to monitor and avoid double counting with other policy measures	Yes
VRT/Motor Tax	7%	Potential double counting with grants for Electric Vehicle uptake if both AMs are used for period 2021-2030	Yes (within wider EV incentives)
Home Renovation Tax Incentive	Not used	Possible reintroduction	Possible
CO_2 Tax	Not reported to date but may contribute	Requires development of compliant assessment on elasticities	Yes

Note A: Contribution rates based on expected annual contribution in 2020 as per latest Annual Report for Ireland to the European Commission

Details of each of the existing AMs considered for the 2021-2030 period and their estimated contribution towards Ireland's EED Article 7 target are provided in Section 0 below.

2.1.2 Review of Climate Action Plan

The CAP represents the Government of Ireland's overriding strategy for the decarbonisation of Ireland's economy by 2050. Energy efficiency policy therefore represents a major pillar of this strategy and aims to be aligned with the objectives outlined within it.

A brief review of the CAP was undertaken to identify actions and objectives that are relevant to end-use energy efficiency and which may either contribute to EED Article 7 targets or be delivered in part by the EEOS. The review was undertaken on a sectoral basis and is summarised in Table 8 below.

Table 8 Summary of CAP review with respect to EED Article 7

Policy area	CAP actions	Relevant notes
Cross-cutting policies		
Carbon tax	**Action 8:** Planned to reach at least €80/t by 2030 from current level of €20/t (€26/t for some fuels)	Proposed as an AM under previous period Requires development of compliant assessment on elasticities to support calculations Care must be taken on double counting risk Plans for significant increase in tax rate could make it a major contributor subject to above
Electricity		
Energy saving assessments for households	**Action 16:** Require suppliers to provide details on energy	Principally a promotional and technical assistance enabler of direct energy efficiency

Policy area	CAP actions	Relevant notes
	savings potential to households	investment delivery measures rather than a direct delivery measure in itself Within the EEOS detailed assessments may form the basis for a prescribed path (potential to adopt IGBC[12] "passport" approach – see box on Page 34)
Enterprises		
Industrial and SME energy efficiency initiatives	Actions 34, 35, 37 and 38: Collection of actions among enterprises focused on continuation and expansion of existing EXEED, LIEN and SME programmes	LIEN has been an AM in previous period Particular scope for expansion of efforts in SME sector EXEED to be expanded and operate in support of and alongside other programmes
Built Environment		
BER and DEC initiatives	**Actions 44 to 46:** Increase homes and premises with BER/DEC and link commercial rates to BER	Increasing coverage of BER/DEC is a potential AM but has potential to double count with subsequent actions Principally a stimuli of investment action in direct energy efficiency delivery measures rather than such direct delivery measures Linkage of rates is a potential AM albeit with quantification and verification difficulties
Building retrofits	**Actions 47 to 49, 52 to 54:** Delivery of retrofits, adopting one stop shop approach and with focus on financing options for deep retrofits	Significant interaction between current AMs and EEOS Need to consider how to treat shallow measures To consider ability of EEOS to deliver deeper measures
Heating system upgrade	**Action 62:** Phase out of fossil fuel heating systems	Can be considered a sub-component of deep retrofits To consider effect on EEOS and allowance of credits for fossil fuel boiler systems
Transport		
Support for EV transition	**Actions 72, 78, 79, 82, 83:** Relate to suite of incentives covering grants, tax and regulation to accelerate EV take-up and supporting charging infrastructure	No significant role in current period but a major component of Ireland's 2030 CAP strategy Ambition to reach full market penetration by 2030 Possible EEOS role but interaction with government support schemes over period needs consideration
Support for modal shift	**Actions 88 to 91 and 95 to 100:** Cover a wide range of initiatives to support modal shift to public transport and cycling	No role in current period but together form a major area of activity within CAP Challenges in estimation and verification of attributable savings

[12] Irish Green Building Council

Policy area	CAP actions	Relevant notes
Public transport decarbonisation	**Actions 85 to 87 and 92 to 93:** Concern the reduction in carbon emissions of public transport through electrification of buses and trains	
Public sector		
Public sector energy efficiency	**Actions 145 and 146:** Relate to a 30% reduction target for the public sector and improving both incentives as well as monitoring and reporting activities to achieve this	Public sector initiatives have not made widespread use of EEOS to date but are expected to engage more in the next period This may represent a new AM
Agriculture		
General abatement strategy	**Action 101:** Enacting policies to implement the report on "*An Analysis of Abatement Potential of Greenhouse Gas Emissions in Irish Agriculture 2021-2030*"	Emissions in agriculture are largely unrelated to energy demand Some specific energy efficiency measures identified, notably in dairy industry Potential "fishing ground" for EEOS

As can be seen in Table 8, a number of the actions listed within the CAP represent general objectives which current AMs and the EEOS (either separately or jointly with AMs) can assist in supporting, rather than additional independent AMs. Other proposals require further scoping and definition before a commitment can be made regarding any contribution to the EED Article 7 target (for example the application of minimum BER thresholds for rental properties).

However, the following general objectives have important relevance for Article 7 and alignment with these should be priority of the policy mix (including the EEOS):

- The commitment to a very significant increase in the carbon tax
- Focus on deep retrofits and objective of upgrading 500,000 homes to BER B2 level
- Phasing out of fossil fuel heating systems and objective of installing 400,000 heat pumps (comprising both retrofit and newbuild installations)
- Reach 100% of all new car and van sales by 2030 being Electric Vehicles (950,000 on the road) and strong support for modal shift from passenger cars
- The commitment to firming up public sector action and target compliance

The additional specific AMs not included for the current period, but which are proposed for inclusion in the next period, are:

- Building retrofits supported through SEAI grants but not co-funded by an EEOS Obligated Party

- Incentives for EV take-up (incorporating the current AM on VRT and motor tax but extended to encompass wider grant support and subsidies) and major modal shift initiatives
- Public sector energy efficiency programme (including Monitoring & Reporting) for achievement of the 30% target

2.1.3 Summary of selected Alternatives Measures

Bringing together the above reviews provides the final proposed suite of AMs given in Table 9. A summary description of each AM and the expected approach to monitoring and verification of energy savings is provided in Annex A1.

Table 9 List of proposed Alternative Measures for 2021-2030 period

	Type of measure	Sector
SME Programme	Financial/Promotional	Enterprises
LIEN	Information/Promotional	Enterprises
ACA	Financial	Enterprises
CO_2 Tax	Taxation[1]	Cross-sectoral
Building energy retrofits	Financial	Built environment
EV incentives	Financial	Transport
Modal shift	Promotional	Transport
Public sector programme	Promotional	Public

Note 1: "Taxation" is used here as in the revised EED to refer to energy savings derived solely through elasticity of demand with respect to energy or carbon taxes, rather than tax relief schemes

Estimated contribution towards EED Article 7

Following the selection of AMs, the next step is to estimate their contribution in energy savings over the obligation period of 2021-2030. The following data sources have been used for the purpose of deriving expected volumes of energy savings:

- Historical trends
- Analysis of measures undertaken by the SEAI Modelling Group in 2017
- Adjustments to final energy terms from primary energy terms
- CAP targets
- Discussions with SEAI, DECC and Department of Transport, Tourism and Sport

The primary focus is on identifying and quantifying actions which deliver measurable and verifiable energy efficiency/savings outcomes of a sufficient scale to be useful contributors to the EED Article 7 target. However, it is not appropriate to ignore many other upstream actions

which act as enablers of these 'end of pipe' or front-line actions – although it makes sense to attribute energy savings to the latter and not the former. Examples of enablers include energy audits, the BER system and advisory report, smart meters, any information/promotional campaigns, training of professionals and trades, and establishment of service infrastructure such as one stop shops. Also, in cases such as EVs where multiple incentives may apply, the composite impact can be readily quantified even if attribution of savings across the individual support factors is difficult.

Estimates have been made at the sectoral level to reduce the risk of double counting between AMs that reinforce or overlap each other in support of specific projects (eg through both promotional measures and financial contributions).

A number of AMs also currently act in combination with the EEOS via co-funding of projects and are expected to continue to do so in the next period. The EEOS design currently attributes the full energy savings credit to an Obligated Party for a particular project where a measure is implemented in combination. Assuming this approach is retained, to avoid double counting any new EEOS target needs to be fully inclusive of savings achieved through combination actions. Therefore, in this section only projects expected to be undertaken through an AM independent of the EEOS are considered. Co-funding is then discussed further in Section 3.

Table 10 summarises the assumptions made regarding the volumes and energy savings attributed under each measure group.

Table 10 Assumptions for calculating AMs' contribution

Policy measure	Relevant assumptions
Carbon Tax	A full description of the basis for the calculation is provided in Annex A1. Due to the lack of robust elasticity estimates that are compliant with the requirements of the EED in sectors other than the residential sector, only savings within the residential sector are currently considered.
ACA	Current data on the ACA scheme lack details on individual installations. Estimations regarding overlap with another AM or the EEOS are therefore highly uncertain. For this reason, a conservative approach has been taken of not including any contribution from the ACA as a stand-alone measure in the Article 7 policy mix. Rather savings are assumed to be captured through the contributions of LIEN and EEOS non-residential credits.
Home energy retrofit	This considers home energy retrofits undertaken through SEAI grant schemes. In line with CAP, deeper retrofits than the current average have been assumed with each delivering an average 100 kWh/m^2 real final energy saving improvement to homes averaging 100 m^2 floor area. This AM refers to SEAI grants towards projects not in receipt of OP co-funding; estimated to support 3,000 homes for years 1-3 and 4,500 homes for years 4-10 independent of the EEOS. Remaining homes in receipt of SEAI grants are assumed to be co-funded by the EEOS

Policy measure	Relevant assumptions
LIEN	LIEN members have a base annual final energy consumption of approximately 18 TWh per annum. During 2005-2015 the average annual sectoral energy savings equated to 1.3%. For 2021-2030 annual improvements of 1% of this final energy consumption (ie 180 GWh) have been assumed. This is to account for an element of slowdown due to the most cost-efficient measures having already been achieved. 30% of the total saving is attributed to the LIEN programme independent of EEOS intervention. The remaining 70% of savings are assumed to be met either in conjunction with the EEOS or via the EEOS alone.
SME Programme	This programme serves the sector of both commercial and industrial SMEs and is under review. Previous programmes have delivered up to 16 GWh Primary Energy savings per annum in the past. But subject to the outcome of the current review of policy interventions in the sector, a conservative estimate is adopted with year on year annual saving of 6 GWh assumed and 50% of this having a material OP contribution.
Public Sector Energy Efficiency Programme	Based on a final energy consumption of approximately 5 TWh and annual energy savings equivalent to 1% year on year over the decade (within a CAP targeted energy efficiency improvement of 30%). This includes potential in Irish Water. While previous savings were predominantly delivered independent of EEOS support, it is expected and assumed that 30% of future savings will entail an OP contribution (the potential for the EEOS to support the public sector is discussed further in Section 3.3.3).
Incentives for EV deployment	Aggregate assessment of EV deployment through combined effects of grants, excise/VRT relief, motor tax relief, Benefit in kind support, tolling incentives, and charging infrastructure roll-out. Final energy savings based on 60% saving per EV (combined BEVs and PHEVs) deployed each with 17,000 km per annum and a lifetime of 10 years. 8,000 total EV sales supported by either AM or AM in combination with EEOS in 2021, rising to 55,000 by 2030 (total of 291,000 over period). 80% of all supported sales assumed to be exclusive of EEOS support.
Incentives for modal shift	Augmentation of public transport, cycling and walking infrastructure, cutting car usage and congestion. DART Expansion, Metro Link, commuter rail capacity (carriages), BusConnects Programme including 200 km of new cycling network. Relative on a marginal basis to a notional “Business-As-Usual” baseline, over the period 2021 to 2030, daily displacement (5 days per week) of 40,000 to 200,000 daily car journeys saving an average of 10 km with net elimination of 4.5 litres/100 km. Back-loading of delivery is assumed with the majority of measures contributing only in the second half of the decade.

Based on the above assumptions, a central estimate of the contribution of all AMs, exclusive of co-funded projects with the EEOS, is provided in Table 11 below.

Table 11 Summary of estimated energy savings contribution from AMs

AM	New annual energy savings (GWh)										Cumu.[1]
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	
Carbon tax	569	667	651	736	802	858	906	947	980	1,008	8,123
Home retrofits	30	30	30	45	45	45	45	45	45	45	2,070
Industrial & commercial[2]	57	57	57	57	57	57	57	57	57	57	3,135
Public sector	46	46	46	46	46	46	46	46	46	46	2,541
EV incentives	23	31	42	56	71	88	102	119	136	155	3,291
Modal shift	44	66	88	110	132	154	176	198	220	220	6,018
Total											**25,178**

Note 1: For most AMs the cumulative total is calculated by assuming new annual savings for each year continue to deliver at the same level through to 2030. However, for the carbon tax savings are only calculated for the year of application and hence the cumulative total is a straight summation of the 10-year period.

Note 2: Encompasses LIEN, SME Programme and EXEED

From Table 11, independently acting AMs are therefore estimated to be able to contribute **approximately 40% of Ireland's Article 7 cumulative energy savings obligation** for 2021-2030 of 60,707 GWh. This would leave the balance of 60% for the EEOS (including where it acts in combination with AMs). By way of comparison, for the 2014-2020 period the EEOS is expected to contribute 55% of the total target and 63% of contributions for the year 2020 (due to the uplift of the EEOS target over the duration).

As noted above, EED Article 7 and Annex V provides a set of requirements regarding how attributed energy savings must be calculated, monitored, and verified. While the selected AMs should theoretically be capable of meeting these requirements, steps do need to be taken regarding:

- Data deficits flowing from the ACA (should this be included as an independent AM) whereby volumes of specific equipment which has taken advantage of the allowance are currently not visible to SEAI.

- For the carbon tax: robust references regarding short-term elasticity values on energy prices outside of the residential sector.

There is significant uncertainty associated with the estimates provided in Table 11. This includes uncertainty regarding the policy pathway and uncertainty in the calculation estimates. For example, the contribution from the carbon tax could substantially fall should the tax rate not increase in line with the projections, or substantially increase subject to a review of estimated elasticities in sectors other than the residential sector. It is estimated that these

factors could lead to a change in the contribution of the designated AMs in the region of +/- 30% of the central estimate provided in Table 11.

3 Energy Efficiency Obligation Scheme

3.1 Setting the target

Ireland's cumulative final energy saving obligation under EED Article 7 for the period 2021-2030 is set at 60,707 GWh.

Section 2 found that AMs are estimated to have the potential to deliver just over 40% of the Article 7 obligation for 2021-2030, independent of the EEOS. This leaves a balance of around 60% to be delivered either by the EEOS or by projects supported by both the EEOS and an AM[13].

As in the current scheme, the default approach assumed here is that Obligated Parties within the EEOS will be accredited with the full energy savings attributed to a specific project even where that project receives additional support through an AM. This means that, while the EEOS target would need to be set to deliver the full 60% balance, the subsidy support to end consumers needed to meet that target will be split between Obligated Parties through the EEOS and the Irish State through AMs.

Due to the cumulative nature of the target, early action is particularly beneficial; provided it has a lifetime of at least 10 years, a measure implemented in 2021 contributes ten times the energy savings towards Article 7 targets as the same measure implemented in 2030. Nevertheless, consideration of supply chain capacity, cash flow, and the impact on retail bills supports an even distribution of effort over the duration of the obligation.

The net Article 7 target after consideration of AMs is estimated at approximately 36,000 GWh. Assuming all measures to have at least a 10-year lifetime and delivering the target linearly, results in an annual EEOS target of around 650 GWh. These figures are purposely rounded to avoid implication of unjustified accuracy in the AM calculations. The full calculation is shown in Table 12 below.

Table 12 EEOS target and proposed contribution to Article 7 (GWh)

Year implemented	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Sum
2021	650	650	650	650	650	650	650	650	650	650	**6,500**
2022		650	650	650	650	650	650	650	650	650	**5,850**
2023			650	650	650	650	650	650	650	650	**5,200**
2024				650	650	650	650	650	650	650	**4,550**
2025					650	650	650	650	650	650	**3,900**
2026						650	650	650	650	650	**3,250**
2027							650	650	650	650	**2,600**

[13] In many cases this will entail co-funding but in theory may also refer to material support through promotional or technical assistance means

Year implemented	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Sum
2028								650	650	650	**1,950**
2029									650	650	**1,300**
2030										650	**650**
Cumulative											**35,750**

While it is likely that some measures will have a lifetime of less than 10 years, it is considered that this is easiest dealt with via adjustments within the calculation of accredited savings per year for these measures, rather than increasing the overall target.

3.2 Selection of Obligated Parties and threshold

Summary of section

- The current threshold of 600 GWh of annual final energy sales covers the vast majority of both the dual fuel (electricity and gas) and liquid fuel markets.
- Should the Irish electricity and gas markets experience a similar upheaval from new entrants to that observed in Great Britain in recent years then it is possible the EEOS coverage will fall with the risk of some market distortion. Even in this situation, however, 600 GWh is likely to be low enough to ensure well over 90% of the market remains covered. 600 GWh represents approximately 1.3% of current total dual fuel sales.
- The current threshold structure which allocates the target based on an entity's total sales volume creates a substantial cliff-edge at the point an entity crosses the threshold to become obligated. This could represent a barrier to growth for small firms and act as a deterrent for new entrants.
- Introducing a "Free Allowance" whereby only marginal sales above the threshold are counted towards the target allocation could mitigate the cliff-edge effect.
- Under the assumption that the total EEOS target is allocated in proportion to Obligated Party sales on a kWh basis regardless of fuel type[14], the Free Allowance approach is estimated to enable the threshold to be lowered to 400 GWh without loading disproportionate costs onto smaller entities.

[14] These results will hold of allocating sectoral targets prior to individual Obligated Party targets provided the aggregate targets remain broadly in line with that group's share of total final energy consumption.

3.2.1 Selection of energy types to be obligated

The current EEOS obligates all energy types including:

- Networked energy (electricity and natural gas)
- Liquid fuels
- Solid fuels

Spreading the obligation across all fuel types reflects the fact that energy efficiency is a cross-sectoral goal and has advantages in spreading the cost impact as well as encouraging innovation in the identification and delivery of energy saving opportunities. It also restricts the potential impact of fuel substitution between those fuels with retail prices bearing the obligation and those fuels without.

In the current EEOS period (2014-2020) an initial disaggregation of the target is undertaken with 5% being allocated to transport energy suppliers and 95% of the target to the remaining sector energy suppliers/retailers above the threshold sales level. Within each disaggregated group, the target is then allocated in proportion to the sales volume of each energy supplier or retailer that meet the threshold, known as Obligated Parties.

The specialist treatment of transport reflects the allowance provided by the EED within the current period to exclude final energy consumption within transport from calculation of the national target[15]. For the next period of 2021-2030, however, no such reduction is allowed on the minimum end-use savings obligation, equivalent to 0.8% of annual final energy consumption.

In the subsequent analysis it is therefore assumed that the EEOS remains cross-sectoral and that the aggregate annual target is allocated to all entities that meet the threshold sales volume in straight proportion to their energy sales volumes without prior disaggregation of the target. An alternative approach would be to allocate aggregate targets by sector or fuel type, for example as with current split between transport and non-transport Obligated Parties, before allocating the individual entity targets within each sub-group relative to their respective sales volumes. Provided the aggregate targets remain broadly in line with that group's share of total final energy consumption this will not materially affect the results presented in this analysis.

3.2.2 Background and purpose of a minimum sales threshold

For the current EEOS (2014-2020), energy retailers have been obligated when they surpass a minimum energy sales volume threshold of 600 GWh per annum. The aggregate annual EEOS target for all such Obligated Parties is then allocated proportionately (within the transport / non-transport split as discussed in Section 3.2.1 above) to total energy sales.

[15] It is noted that this does not prevent energy savings undertaken within the transport sector from contributing towards the national target.

The purpose of the threshold is to ensure the associated costs of implementing an EEOS (particularly the fixed administrative costs) do not present an unreasonable barrier to entry for new firms, reducing market competitiveness. It also avoids unnecessary administrative complexity arising from having to manage obligations for a very large number of very small parties.

Conversely the threshold should not be so high as to create significant market distortion or create perverse incentives for energy supplier firms near to the threshold level such as notable delay to growth plans. Combating the former means that the obligation should cover the large majority of total sales' volumes, while mitigating for the latter involves avoiding an unreasonable "cliff-edge" above which costs are suddenly imposed at a significant scale.

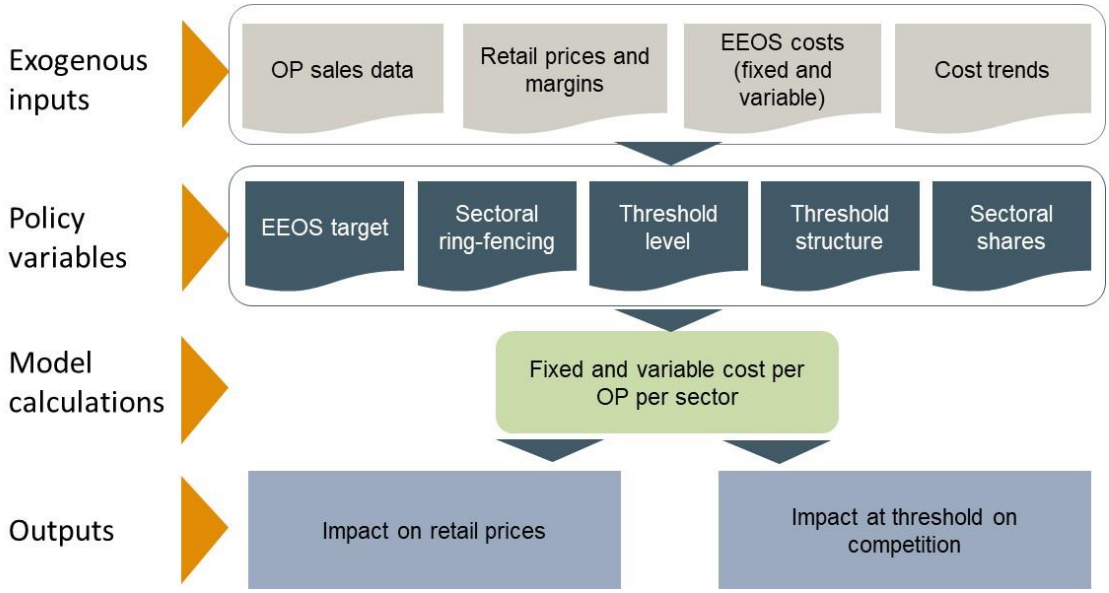
The purpose of this analysis is therefore to assess the appropriateness of differing threshold levels as well as structures with respect to the impact on retail market competition. Three facets are considered in the evaluation:

- The estimated proportion of the market within each sector and each year of the EEOS that will be captured as the threshold is varied. This is a function of the market landscape (concentrated or disparate).
- How material the market distortion is around the threshold level with respect to the impact on energy bills and retailer margins.
- Whether an alternative structure to the application of the threshold will reduce such distortions (eg provision of a free allowance by considering only those sales volumes above and beyond the threshold when allocating targets).

3.2.3 Approach to modelling

The general approach to the model is described in Figure 1.

Figure 1 Approach to modelling



Input sources for each of the exogenous inputs are listed in Annex A2.

3.2.4 Scenarios for threshold structure and level

The results presented here are all under a **"Reference Case"** scenario for EEOS design components other than those directly related to the threshold level. These are:

- The overall target is set to approximately 60% of the total EED Article 7 target, equivalent to an annual target of 650 GWh each year 2021-2030, after considering the potential contribution of AMs.

- The EEOS share of the Article 7 target is allocated to all Obligated Parties above the threshold in proportion to their sales volumes. Unlike in the current scheme there is no prior disaggregation to the transport and non-transport sectors assumed. As previously noted, should any such prior allocation be made then the result will hold to the extent this allocation is in proportion to the share of each sector in final energy consumption.

- Sectoral ring-fencing remains as at present with 5% energy poor and 25% residential (inclusive of energy poor) sub-targets. The remaining 75% can be met via eligible activity in any end-use sector.

- Variable installation costs are set to the weighted average cost to Obligated Parties per kWh of primary energy saved of €0.057 as reported by the Commission for Regulation of Utilities (CRU) in 201716. This has been converted into final energy using a conversion factor of 1.36 (representing the weighted average conversion rate for consumption across households, industry and services), yielding €0.076/kWh-saved of final energy[17]. This level is assumed to remain constant in real terms through the course of the obligation for 2021-2030.

Three threshold levels were tested – 600 GWh, 400 GWh, and 200 GWh. For each threshold level, two threshold structures were also tested. These were:

- **Total Sales:** This involves continuation of the current approach whereby the full sales volume of all Obligated Parties above the threshold are considered in allocating the individual entity targets on a pro-rata basis. This creates a cliff-edge at the point of the threshold as once an entity becomes obligated it is immediately liable for an EEOS savings target calculation in proportion to its total sales, i.e. inclusive of sales below the threshold level. The entity therefore faces not only the

[16] CRU (2017), "*Energy Supply Costs Information Paper*", https://www.cru.ie/wp-content/uploads/2017/10/CRU17291-RFI-Information-paper.pdf - value has been converted to 2019 Euros

[17] We note that costs are likely to diverge from their historic levels due to saturation of cheaper measures and potential changes to scheme design. This issue is analysed further in Section 3.3 but is not expected to have a significant impact on the issue of market distortion around the threshold level.

fixed costs of scheme establishment but also the variable costs of implementing the associated target.

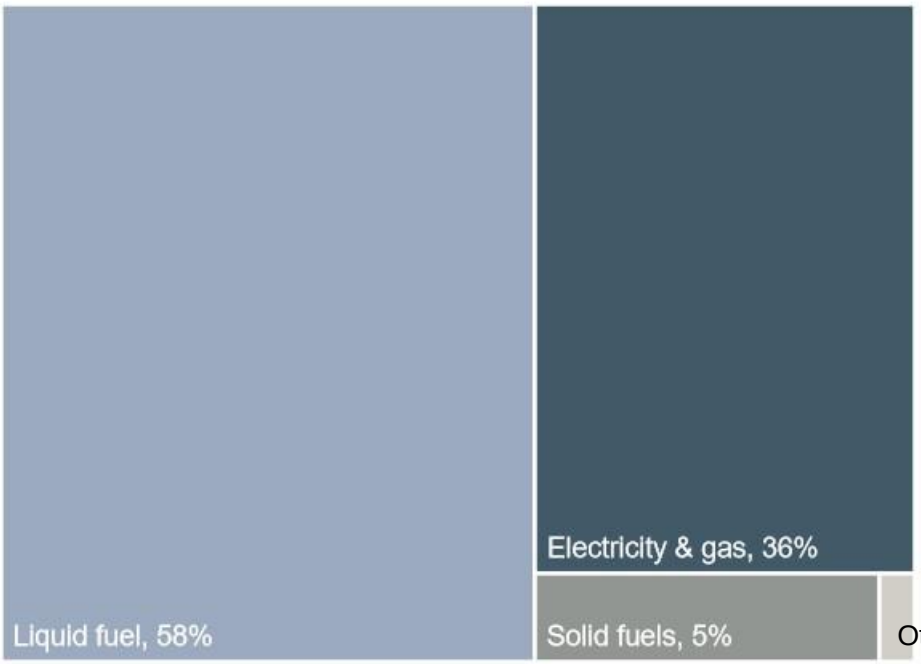
- **Free Allowance:** Under this approach all sales below the threshold are discounted prior to allocation of the EEOS target and hence only fixed costs will be incurred at the point an entity becomes obligated. There are no immediate variable costs since only marginal sales above the threshold contribute towards the calculation of the EEOS target allocation.

3.2.5 Results

Market coverage

Oil products, electricity and natural gas together dominate end-use energy consumption in Ireland as shown in Figure **2**. Solid fuel (encompassing coal, peat and biomass), by contrast, accounted for around 5% of final consumption in 2019 with coal and peat use projected to fall by around half by 2030 due to the changing nature of Ireland's fuel mix. The wider distortion to the energy market of partial coverage of the EEOS for solid fuels will therefore be marginal[18].

Figure 2 Share of final energy consumption by fuel type in 2019



Notes: "Other" includes renewable and non-renewable waste, solar thermal and ambient heat while biomass, biodiesel/bioethanol and biogas are included under "solid fuels", "liquid fuels" and "electricity and gas" respectively

[18] There are some minor discrepancies between consumption and sales figures due to a small percentage of fuel being for own-use and hence not traded. Nevertheless, this is not deemed to be of an extent that will affect this conclusion.

Source: Energy Balance of Republic of Ireland, 2019

For reasons of fair competition and minimising market distortion it is also desirable to ensure a significant majority of the market per fuel type is covered by the EEOS obligation.

For electricity and gas (treated in aggregate), based on 2018 energy sales a significant majority of market sales (>98%) are covered by the EEOS regardless of whether the threshold level is at 600 GWh, 400 GWh, or 200 GWh. This is due to a scarcity of energy suppliers recording 2018 sales volumes within the 200 to 600 GWh range. A few entities were noted as having annual sales between 50 and 200 GWh indicating that with reasonable growth the numbers within the 200 to 600 GWh range could grow with repercussions for the share of market players and final sales covered by the EEOS should the threshold be held at 600 GWh.

It is possible that the supplier mix will change over the course of 2021-2030 with greater market competition and an increased number of smaller players, resulting in the share of sales above the threshold reducing. Of possible relevance here is the example of the market in Great Britain where before 2013 the “big 6” suppliers each had an electricity supply market share of at least 10% and all other suppliers together a meagre 1%. Rapid market upheaval has resulted in almost 30% of the market being held by players outside of the traditional big 6[19]. Of these 8% is accounted for by “small suppliers” with less than 1% market share each and a further 21% by medium-sized suppliers with between 1% and 5% market share. A very similar picture is observed for natural gas given the predominance of dual fuel suppliers.

The current threshold of 600 GWh in Ireland equates to approximately 1.3% of total electricity and gas sales. Should the Irish market see similar changes to that observed in Great Britain then the coverage could fall below the 98% level currently observed. It is likely, however, that even in this case it would remain above the 90% mark. Furthermore, due to much larger absolute size of the market in Great Britain, it is considered unlikely that the Irish market would sustain such a large number of smaller players further diluting any impact.

For liquid fuels all recorded entities have sales volumes in excess of the current threshold of 600 GWh per annum[20]. While the share of liquid fuels in overall consumption is expected to fall over the obligation period with the gradual electrification of transport, it is considered unlikely that this would significantly change the market coverage results.

Comprehensive sales data for solid fuels were unavailable for the analysis. With a 600 GWh threshold, the coverage of solid fuels is weak with data for 2017 indicating the aggregate sales volume above the threshold level is equivalent to only 18% of final energy consumption. Due to a level of own-use the percentage of total sales as opposed to total consumption that are above the sales threshold will be somewhat higher but remain a minority share of the full market. Reducing the level to 400 GWh or 200 GWh would increase coverage substantially with the equivalent share of final energy consumption being 31% and 38% respectively.

[19] https://www.ofgem.gov.uk/data-portal/electricity-supply-market-shares-company-domestic-gb
[20] We note that Fuels for Ireland anyhow currently operates a voluntary pooling of the obligation among liquid fuel entities that in effect ensures a comprehensive arrangement and negates the impact of the threshold

Market distortion

Cost components

The costs to Obligated Parties of meeting their EEOS obligations include:

- **Variable direct costs:** these are costs directly incurred through subsidising energy efficiency measures for end-use consumers. For most Obligated Parties they represent by far the largest cost component of delivering on their EEOS target.

- **Variable administrative costs:** these are costs associated with operating call centres to manage the delivery of measures. They scale with the number of installations.

- **Fixed administrative costs:** these are non-scalable costs to Obligated Parties for the staffing, software, and processes associated with securing and delivering measures compliant with an EEOS obligation. They are split into one-off set-up costs and recurring costs.

In the absence of robust data on the Irish EEOS we have adopted estimates for administrative costs from those provided in the impact assessments for the Energy Company Obligation (ECO) scheme in the United Kingdom. The ECO scheme applies to the residential sector only, with a very strong focus on low income households. Furthermore, some administrative costs designated as “fixed” may be partially variable when considering entities (and therefore targets) of greatly different scales. The estimates regarding ongoing administration costs also vary substantially between the original ECO scheme impact assessment and the latest iteration for ECO3 with the latter substantially lower but with less detail provided on the underlying breakdown by task. Figures used in this analysis have therefore been guided by both documents and adjusted to the Irish context. All input figures and sources are provided in full in Annex A2.

Two related issues affect the extent of market distortion around the threshold level itself:

- There is an **economy of scale** effect for all parties above the threshold as the fixed costs can be spread over a larger volume of sales reducing the cost per kWh-sold[21]. Lowering the threshold level intensifies this effect by obligating smaller entities to recover fixed costs over a smaller volume of sales. This could encourage smaller entities to stay below the threshold or, alternatively, would encourage them to accelerate growth once the threshold is exceeded. In any case it acts as a barrier to entry of new suppliers.

- **Threshold structure:** If the obligation for each entity is calculated on the basis of total sales, then at the point of the threshold an Obligated Party is immediately liable to the variable costs of supporting energy efficiency measures associated with their sales up to the threshold. Combined with the fixed costs, this exaggerates the cliff-edge effect. The alternative approach is to allow all Obligated

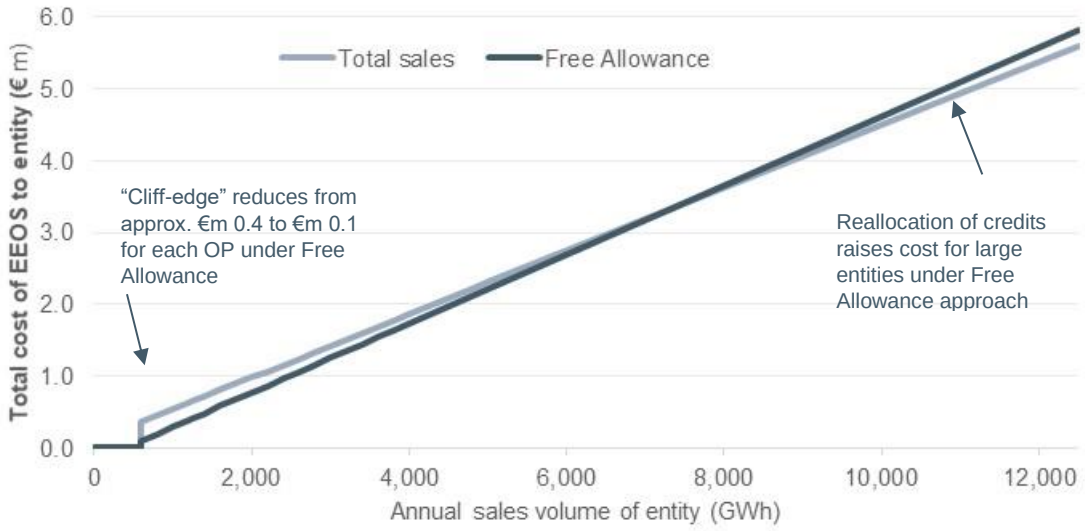
[21] There is potentially also scope for greater purchasing power of energy efficiency solutions from contractors

Parties a free allowance and to place an obligation in relation to sales above the free allowance.

Impact of threshold level and structure at various entity sizes

These points are illustrated in Figure **3** which presents the cost curve for a 600 GWh threshold under each threshold structure.

Figure 3 Impact of changing threshold structure (600 GWh threshold example)

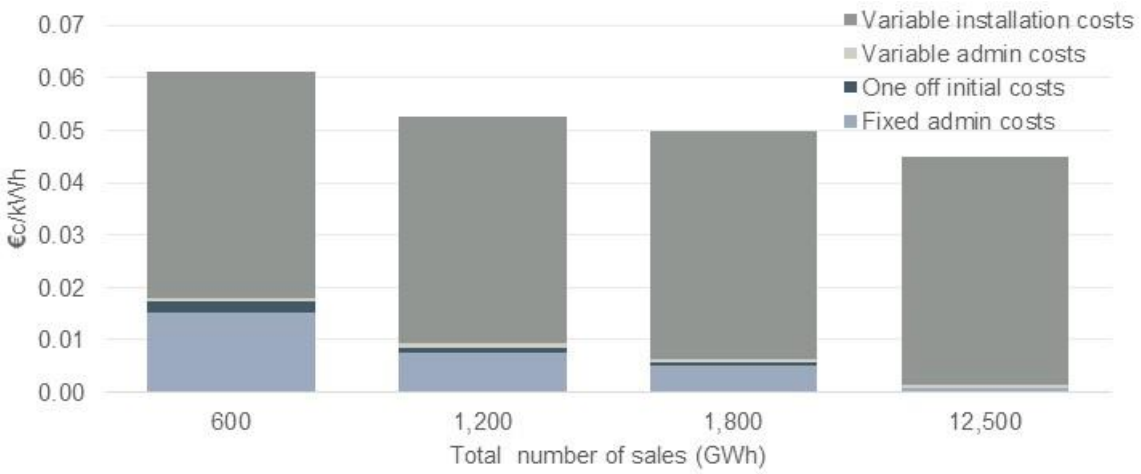


Source: ECA calculation

In both approaches, a vertical line to the cost curve is apparent at the threshold. However, the vertical component is significantly larger for the Total Sales approach as it relates to both the fixed costs of operating a scheme, and the variable costs associated with sales below the threshold. At 600 GWh, these variable costs are estimated to account for approximately 60% of the costs of obligation delivery. This is illustrated in Figure 4 below which estimates the impact on retail prices per kWh of energy sold for entities with a variety of annual sales volumes[22]. The lower cost for a large entity (illustrated by the 12,500 kWh annual sales volume case) reflects the economy of scale effect of spreading fixed costs across a larger sales volume.

[22] This calculation assumes the EEOS overall target is allocated pro rata to the sales volume in kWh terms of all entities above the threshold level, irrespective of the sector and fuel type.

Figure 4 Impact on retail price - Total Sales / 600 GWh threshold

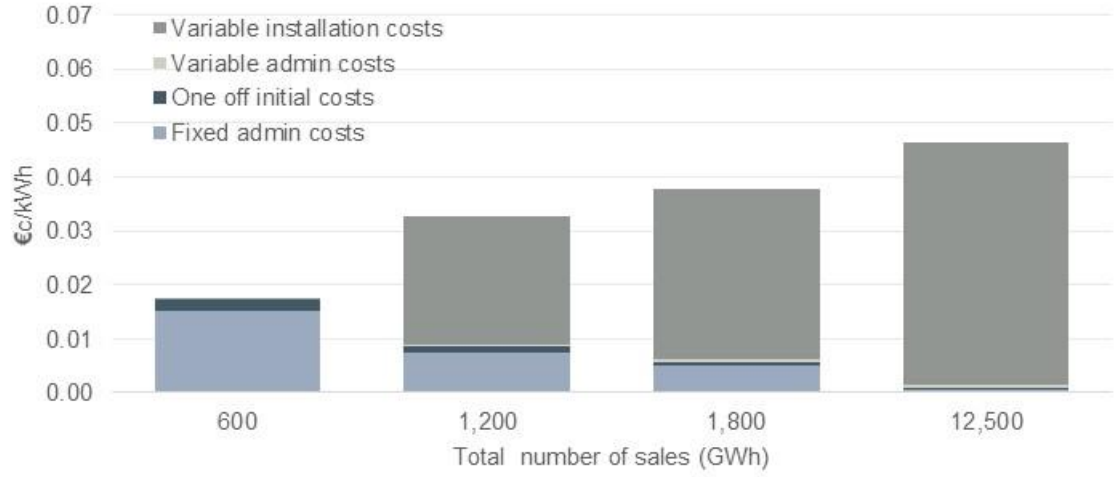


Source: ECA calculation

Reducing the threshold to 400 GWh or 200 GWh while retaining this structure will increase the differential. In the 200 GWh case, an entity just over the threshold level is estimated to have a retail price impact approximately three times that of an entity with 12,500 GWh annual sales.

For the Free Allowance threshold structure the height of the vertical component is equivalent only to the fixed costs incurred. Hence at 600 GWh the change would have an important impact for an entity just crossing the threshold, reducing the immediate impact by an estimated 30% as illustrated in Figure 5.

Figure 5 Impact on retail price – Free Allowance / 600 GWh threshold

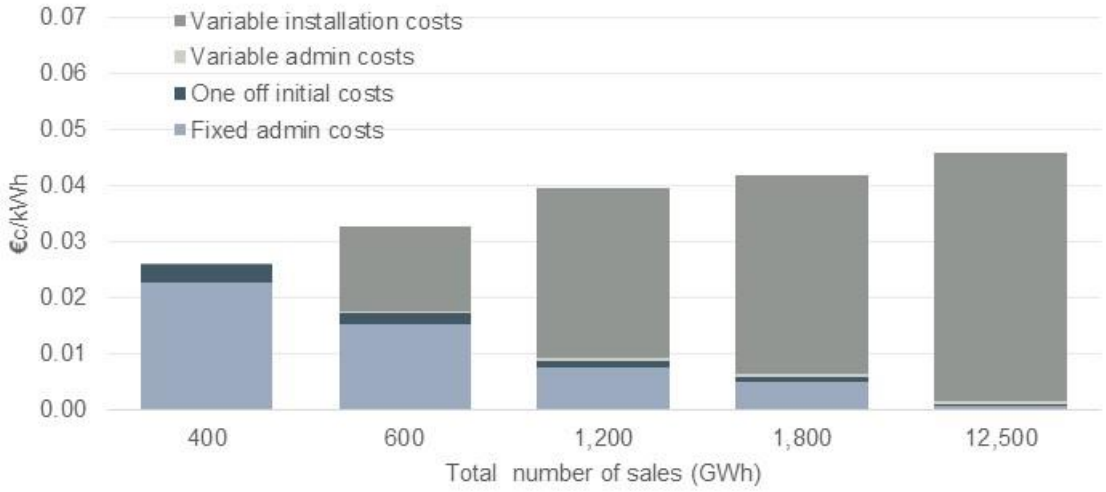


Source: ECA calculation

Indeed, the net result is that the per kWh-sold cost impact on retail prices is reversed with the reallocation of costs meaning a generic large entity with 12,500 GWh annual sales faces notably higher retail price impact than an entity just over the threshold at 600 GWh annual sales.

Reducing the threshold level to 400 GWh or 200 GWh in the Free Allowance case dilutes this effect as shown in Figure 6 and Figure 7 respectively. In the case of the 200 GWh threshold, the trend is estimated to actually reverse again with the smaller entities facing a higher impact on the cost per kWh-sold. This result is sensitive to the assumptions regarding the fixed costs.

Figure 6 Impact on retail price – Free Allowance / 400 GWh threshold



Source: ECA calculation

Figure 7 Impact on retail price – Free Allowance / 200 GWh threshold

Source: ECA calculation

The full results for each of the six permutations are given in Table 13. These results do not take account of any greater buying power larger entities have in generating credits.

Table 13 Estimated cost of EEOS scheme per kWh-sold by entities of various size

Structure	Threshold Level (GWh)	Annual energy sales of entity (GWh)								
		199	200	399	400	599	600	1,200	3,000	12,500
Total Sales	600	-	-	-	-	-	0.061	0.053	0.047	0.045
	400	-	-	-	0.069	0.061	0.061	0.052	0.047	0.044
	200	-	0.095	0.069	0.069	0.060	0.060	0.052	0.047	0.044
Free Allowance	600	-	-	-	-	-	0.017	0.033	0.042	0.046
	400	-	-	-	0.026	0.033	0.033	0.040	0.044	0.046
	200	-	0.052	0.048	0.048	0.047	0.047	0.046	0.045	0.045

Source: ECA calculations

3.3 Sectoral ring-fencing and scenarios

Summary of section

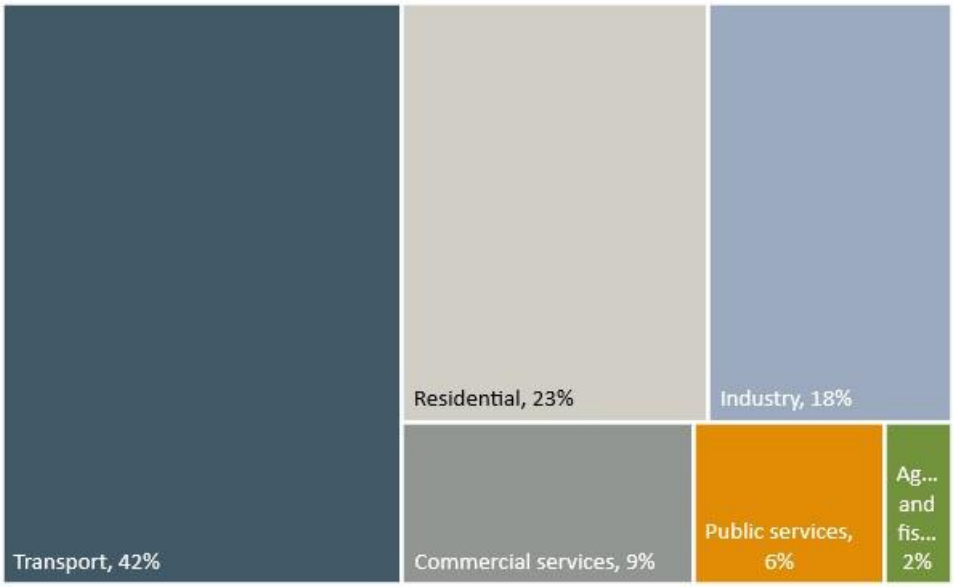
- An EEOS target at 60% of Ireland's overall Article 7 target (set at 60,707 GWh for 2021-2030) equates to an annual **final energy target** of approximately **650 GWh per annum**. This represents a **substantial increase** in ambition from the primary energy target of 700 GWh per annum (equating to approximately 515 GWh final energy) for the EEOS in 2019 and 2020.
- A **Reference Scenario** has been developed for comparison purposes. This scenario involves the continuation of the scheme largely in its current format but with deemed energy credits converted to final energy terms and an adjustment made for measures with lifetimes less than 10 years. Sectoral allocation remains at 25% residential ring-fencing of which at least 5% must be delivered to energy poor households. It does, however, have likely issues regarding additionality with respect to requirements of Article 7 of the EED and is not aligned with the CAP objectives. Hence it is not included as a viable option for the 2021-2030 period.
- A **Base Case Scenario** has then been modelled for the residential sector which adopts the same approach as the Reference Scenario without the option of fossil fuel boiler upgrades (as support for such a measure runs counter to CAP objectives as well as additionality concerns). Under this scenario activity is expected to focus mainly on **heating controls**, the remaining cavity wall insulation potential and, to a lesser extent, heat pump installations. Residential energy saving credit costs are estimated to be around 60% higher than the Reference Scenario at around €0.18/kWh-saved.
- For the **non-residential sector**, the **Base Case** sees no change to measure eligibility. The measure mix is nevertheless forecast to change from that seen under the current scheme as the switch to final energy terms both **reduces the cost-effectiveness and annual market size of lighting relative to heating** upgrades for Obligated Parties.
- Holding the non-residential share at 75%, the **Base Case** results estimate non-residential credit costs may remain similar to present levels (once converted to final energy terms). However, results also indicate the market for cheaper measures may be close to its maximum with significant upside potential to costs should it become more quickly exhausted than expected or the non-residential target be increased to 85%. There is therefore a **high level of uncertainty** associated with the results.
- A **Pathway Scenario** has been modelled for the residential sector which seeks to focus activity to contribute to the twin CAP objectives of retrofitting building stock to BER B2 and phasing out fossil fuel heating systems via **restricting eligible measures to retrofit packages** that meet minimum criteria.
- For able-to-pay **residential energy saving credits** maintaining a **20% target** under the Pathway scenario is expected to **increase** the cost to Obligated Parties of delivering energy savings by **around 75%** on a per kWh-saved basis as compared to the Reference Scenario. For a **10% target** the estimated increase is instead estimated to be **around 50%** on a per kWh-saved basis by focusing on lower cost dwellings.

- Similar criteria have been applied for **Energy Poor** households with an additional variation that the baseline for such households must be **no better than BER level E**. These tightened criteria are estimated to approximately triple per kWh energy saving credit costs in the energy poor sector as compared to the Reference Scenario unless AM co-funding contributions see an increase in relative terms.
- When combining the **Pathway 15 scenario** (10% residential able-to-pay and 5% energy poor) with the **enhanced criteria** variant for the energy poor sub-sector, overall EEOS per kWh-saved costs (weighted average with the non-residential sector) are estimated to **increase by around 50%** compared to the Reference Scenario.
- **Transport** constitutes **over 40%** of final energy consumption in Ireland, yet in 2017 only 7% of EEOS non-residential savings (5% of overall EEOS savings) were delivered in the sector. Under the Base Case this share is not expected to vary significantly.
- This is because transport measures are either deemed to be limited in market size or estimated to remain relatively expensive, particularly the potential **complementary support for EV roll-out**. This means that should a ring-fenced transport sector target be designated in approximate proportion to final energy consumption at 40%, then costs may rise sharply.
- It is estimated that a **40% ring-fenced transport target** could result in the cost of energy saving credits for this sector being around five times that of other non-residential sector credits. When combined with the Pathway and Enhanced Energy Poor scenarios this is estimated to increase overall EEOS costs up to approximately **three times current levels**. The scope of costs and opportunities associated with transport measures are, however, particularly uncertain due to the lack of historical activity for most measures.

Background

The current share of final energy consumption by end-use sector in Ireland is illustrated in Figure 8.

Figure 8 Breakdown of final energy consumption in Republic of Ireland



Source: Energy Balance of Republic of Ireland, 2019

The current EEOS has three ring-fenced targets:

- At least 5% of the Obligated Party's target must be achieved with consumers designated "energy poor".
- At least 25% of the Obligated Party's target must be achieved within the residential sector (inclusive of the energy poor target).
- The remaining 75% of the Obligated Party's target can be achieved within the non-residential sector.

Activity in energy poor households typically requires a substantially greater subsidy from the Obligated Party to initiate activity than across the general population (sometimes termed "able-to-pay"). In turn, savings in the residential sector typically require a greater subsidy than in the non-residential sector.

Excess credits from the energy poor sector may be used to meet the residential sector target while excess credits from the residential sector target may contribute towards the non-residential target.

There are a number of reasons for such ring-fencing:

- The EEOS obligation is paid for by all consumers. Without ring-fencing it is likely the vast majority of activity would take place in the non-residential space due to lower relative costs.
- Access to capital and information asymmetry, key market failures to justify the intervention of an EEOS, are more acute in the residential sector.

- The EEOS is potentially regressive due to energy bills being a greater share of expenditure for poorer households. Ring-fencing savings within the energy poor can help mitigate this effect.

- To align with broader social policy objectives.

The extent of such ring-fencing is a trade-off between the above considerations, the level of energy savings achieved, and the cost to consumers.

Furthermore, Ireland's CAP outlined ambitious objectives for the electrification of heat and transport as well as deep retrofits. Supporting such measures remains less cost-effective on simple Euros per kWh-saved terms within the period of the obligation (2021-2030) than so-called shallow measures such as simple insulation, fossil fuel boiler upgrades, lighting, and heat controls. There is particular concern regarding incentivising shallow measures which do not form part of a longer-term package to maximise the energy efficiency potential of a given home.

The degree to which shallow measures should be eligible for being accredited with energy savings under the revised EEOS is therefore a further variable for assessment. Scenario variations have been devised so as to align with the delivery of packages of measures that will deliver at least the CAP BER B2 rating and in many cases substantially better.

General approach

This section therefore presents different scenarios regarding the size and definition of the ring-fenced targets. Modelling incorporates the development of cost curves for energy efficiency measures under each scenario and the resultant cost to Obligated Parties as well as the estimated impact on retail prices.

In order to provide better clarity regarding the effect of varying the rules in relation to a specific sector, each sector is addressed in turn while keeping other sectors under constant assumptions. The estimated combined effect of specific combinations of policy design proposals are then considered at the end.

To do this, an estimated disaggregation of the CRU reported average cost per kWh-saved under the current scheme has been taken with the following representative costs (including conversion to final energy terms):

- €c20.0 per kWh-saved for energy poor activity = an estimated **€c27 per kWh-saved** in final energy terms

- €c10.0 per kWh-saved for residential (able-to-pay) activity = an estimated **€c13.6 per kWh-saved** in final energy terms

- €c3.5 per kWh-saved for non-residential activity = an estimated **€c4.8 per kWh-saved** in final energy terms

3.3.1 Residential sector (able-to-pay)

Summary of section

- In the **Reference Scenario** the EEOS largely follows current structures (with an adjustment to the energy saving calculation methodology for heating controls), which is not consistent with CAP objectives. Under this scenario, Obligated Party residential energy saving credit costs are expected to remain at a similar level to current residential sector credits, around €0.12/kWh-saved, due largely to **higher efficiency fossil fuel heating system** deployment.
- Under the **Base Case Scenario** which does not allow fossil fuel boiler upgrades, Obligated Party costs rise to around 60% as compared to the Reference Scenario with activity focused on the remaining cavity wall insulation (in early years), further roll-out of heating controls and heat pump installation. The higher costs relative to those for residential credits under the current scheme are largely due to the deemed credits being reduced by 50% for this measure to reflect their shorter lifespan.
- A set of additional scenarios termed the "**Pathway scenarios**" have been modelled, intended to better align with the CAP objectives of reaching BER B2 rating, performing deep retrofits, and phasing out fossil fuel heating systems.
- The Pathway scenarios limit eligible measures to (1) building fabric packages that meet a "**heat pump readiness**" criterion of a HLI no more than 2.0 W/m^{2}K and (2) concurrent or subsequent **heat pump** installation (with control) that achieves at least BER B2 rating.
- Three Pathway variants have been modelled with the **residential sector target** set to **15%, 25%, 35%** respectively. In each case the energy poor target remains a subset of this at 5% and is treated separately, leaving the **able-to-pay** targets modelled at **10%, 20%, 30%** respectively.
- Changing the ring-fenced target size for the able-to-pay residential sector impacts on costs both due to the decrease or increase in the target itself and also on a per kWh-saved basis as the larger the target, the higher the marginal cost of achieving savings.
- Under the current target level (25% with 20% able-to-pay) subsidy costs for residential energy saving credits (to be met by either Obligated Parties and/or AMs) are estimated to rise by between 60% and 100% as compared to the Reference Scenario to between €0.18/kWh-saved and €0.24/kWh-saved.
- Reducing to a 15% residential / 10% able-to-pay target level subsidy cost per kWh-saved for residential energy saving credits is estimated to be between €0.16/kWh-saved and €0.19/kWh-saved, around 20% lower than when retaining the current target level.
- The 25% target level under the Pathway scenario is projected to deliver retrofits to between 50,000 and 80,000 individual homes over the period 2021-2030, while the 15% target level delivers an estimated 30,000 to 35,000 individual home retrofits[23]. Both scenarios represent a narrower but much deeper approach than under the Reference Scenario.

[23] This represents only a subset of the total Irish objective outlined in the CAP of 500,000 retrofits to at least BER level "B2"by 2030.

Approach for residential sector (able-to-pay)

The same model as used for the threshold analysis described in Section 3.2 has been applied to analyse different scenarios for the residential sector target but with the addition of estimating the cost curve for common energy efficiency measures within the residential sector. Building the cost curve involved the following steps:

- **Identification of common measures:** A set of the most common residential energy efficiency measures were identified from the SEAI's EEOS energy saving credit table.

- **Cost data:**

  - For building fabric and heat pump measures, the consultant team has used a mix of in-house data and data held by SEAI to derive estimates. Costs are tailored to eleven default dwelling types representing the residential building stock of Ireland.

  - For fossil fuel heating systems and controls, cost data was taken from Ireland's Report on the Development of Cost Optimal Calculations and Gap Analysis for Buildings in Ireland under Directive 2010/31/EU on the Energy Performance of Buildings (RECAST).

- **Energy saving accreditations (Reference Scenario and Base Case only):** The deemed savings included within the EEOS energy saving credit tables were applied to the dwelling types based on whether they are houses or apartments. An adjustment was made to accredited savings for measures with lifetimes of under 10 years. These have been factored by the measure lifetime in years divided by ten. For example, for heating controls which have a lifetime of 5 years this results in an effective halving of the accredited savings as compared to the current deemed credits. No adjustment has been made where heating control upgrades are integrated in the replacement of fossil fuel boilers with either higher efficiency boilers or heat pumps. No adjustment has been made for updated assumptions regarding the level of free riders and additionality of savings (see discussion in main text on Base Case results).

- **Co-financing:** As discussed in Section 2, many AMs act in collaboration with EEOS support on a particular project. The level of funding available from AMs will impact on the necessary level of funding from Obligated Parties and hence on retail prices. For all the residential sector cases presented here we estimate the aggregate subsidy required based on the above-mentioned leverage rates. This could be provided through AMs and EEOS in conjunction.

- **Leverage:** The share of costs met by Obligated Parties was based on reference to current and previous administrative grant schemes and set to[24]:

[24] These leverage factors are deemed applicable to the able-to-pay residential sector only. Energy poor households are deemed to require full grant funding and have been treated separately in this analysis. They are estimated average rates of subsidy across all measures and consumers

- 15% for fossil fuel boiler upgrades (Reference Scenario only – fossil fuel boiler upgrades not included as eligible under other scenarios)
- 30% for all other measures

The differential results from fossil fuel boilers being supported at the time of natural replacement and hence only the additional cost for improved energy efficiency performance needing incentivising.

- **Number of dwellings:** SEAI data was also used to disaggregate Ireland's 1.5 million pre-2011 dwellings into the eleven dwelling types. The number of energy poor homes (estimated at 410,000 – see Section 3.3.2) was then subtracted from this total.

- **Market penetration of measures to date:** Ireland's BER database was used to estimate the market penetration to date of each measure and applied uniformly across dwelling types.

- **Suitability for measure:** Not all houses within a given dwelling type will be suitable for a particular measure (eg cavity or solid wall insulation), while other measures are mutually exclusive (eg natural gas, oil and LPG boilers). The stock within each building type were therefore factored by estimates of the relative prevalence/suitability of the stock for each measure.

- **Non-reachable:** Once a measure reaches close to saturation point the last remaining households can prove exceptionally difficult to reach and the necessary subsidy to incentivise action will rise beyond the above assumptions. As an approximation of this effect, we have therefore made a generic assumption that 10% of the housing stock net of those deemed energy poor are "unreachable" for the Obligated Parties across all measures and building types.

- **Annual rates of deployment:** The annual market for uptake of specific measures or packages will be limited both on the supply side by supply chain constraints and on the demand side by the frequency of consumer investment decisions. Rates assumed for demand depend on the type of measure and have been guided by lifetimes and decision frequency studies undertaken by SEAI[25]. On the supply side, to ensure volumes remain reasonable with respect to historical norms, we have assumed no more than 5% of the total dwelling stock should receive the same individual measure within the same year. Further detail is provided in Annex A2.

(excluding the energy poor modelled separately). Actual levels available will not be fixed and will likely vary by measure, OP and customer as well as over time.

[25] Behavioural insights on energy efficiency in the residential sector

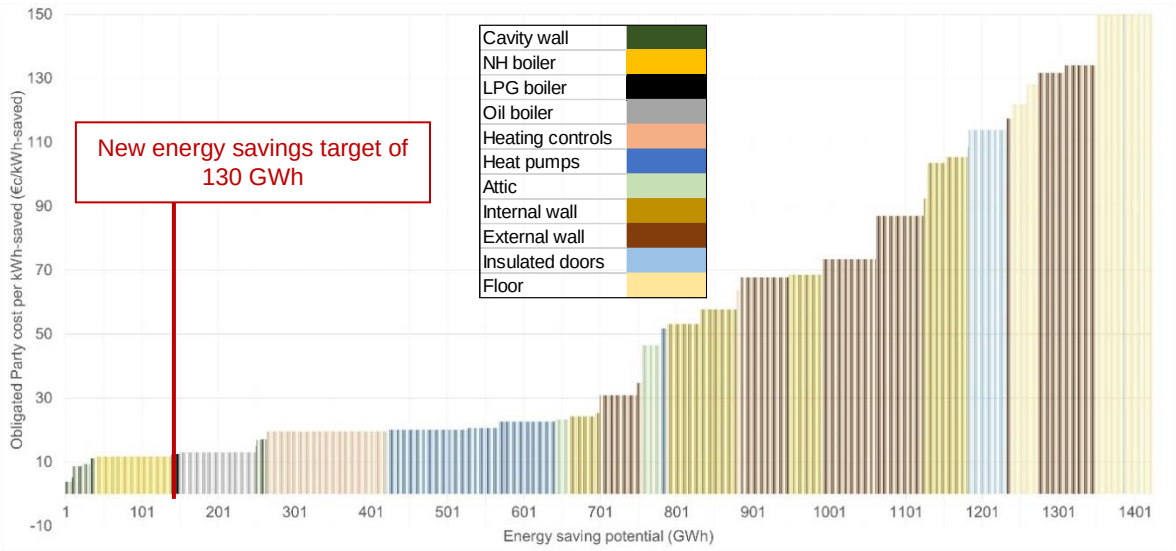
Selection of scenarios

Reference Scenario

A **Reference Scenario** has been modelled as a means of understanding how costs under the current scheme design would be expected to develop in the period 2021-2030 transferred to a final energy rather than primary energy savings approach[26]. The Reference Scenario has additionality concerns (discussed further in results section) and is not consistent with the CAP due to its continued support for upgrading fossil fuel heating systems. The Reference Scenario also does not directly support the declared CAP objective of transforming dwellings to at least BER B2 status. Costs to Obligated Parties under this scenario are expected to remain broadly at the same levels as under the current scheme following conversion to final energy terms (see "General approach" above) at an average of around €0.12/kWh-saved. Deployment would be expected to be dominated by upgrades to fossil fuel boilers with fully integrated heating controls. Results are not separately reported for the Reference Scenario but rather used as a point of comparison for the alternative scenarios described in the following text.

An illustration of the full range of measures considered and the modelled cost curve for Obligated Parties in the first year - 2021 - is given in Figure 9.

Figure 9 Residential sector cost curve (Reference Scenario, 2021)



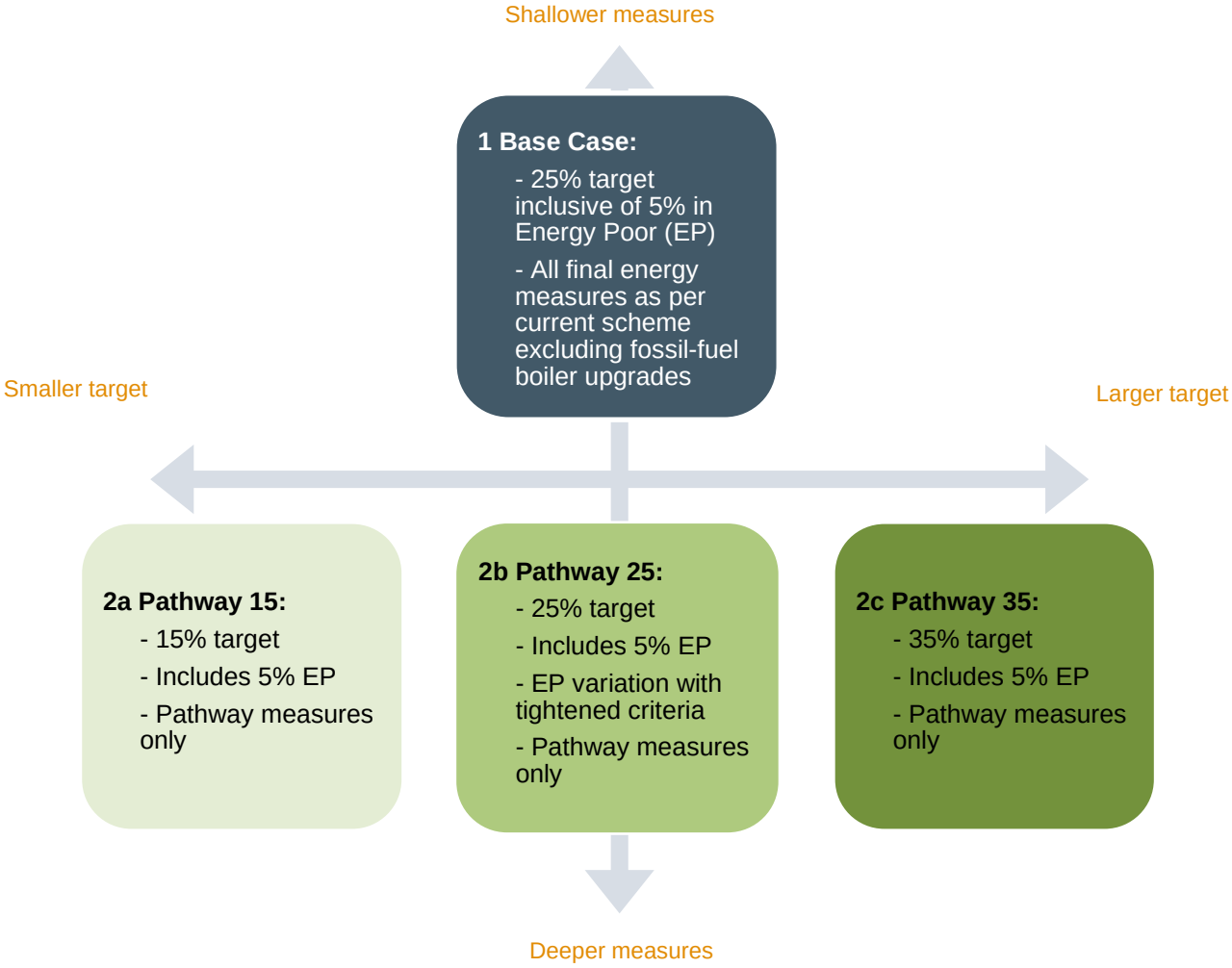
Source: ECA calculations

[26] The deemed energy savings credits for measures with lifetimes of under 10 years have also been downgraded under the Reference Scenario from current levels by a factor of assumed lifetime divided by 10. Measures which do not target final energy consumption are also excluded.

Alternative Scenarios

Four alternative scenarios for future scheme design have then been selected for evaluation based on the size of the target and the eligibility of shallow measures. These are set out in Figure **10**.

Figure 10 **Model scenarios for residential sector**



The **"Base Case Scenario"** (Scenario 1) is as per the Reference Scenario but does not give credits for fossil fuel boiler upgrades. This is intended to prevent it contradicting the CAP although the scenario still does not directly support CAP objectives around delivering dwelling upgrades to BER B2 status. The scenario retains the 25% residential sector target (inclusive of the energy poor target set at 5%). For modelling purposes, the target is treated as if it were 20% with the 5% energy poor target treated independently. This implicitly assumes energy poor activity will always cost more than residential sector activity and hence there is no incentive to generate excess energy poor credits for use towards the general residential sector target. However, the total investment cost (consumer, AM and Obligated Party) of delivering energy savings is assumed to remain the same between able-to-pay and energy poor homes.

The "**Pathway**" scenarios (Scenarios 2a to 2c) cover different levels of 'ring fencing' of the residential sector and seek to tie the EEOS target more firmly to the CAP objectives regarding

deep retrofit and the upgrading of homes to BER B2 level by 2030. This involves limiting eligible measures to (1) building fabric packages that meet a "**heat pump readiness**" criterion of a HLI no more than 2.0 W/m^{2}K and (2) concurrent or subsequent **heat pump** installation (with control) that achieves at least BER B2 rating. Three variants have been modelled with the **residential sector target** set to **15%, 25%, 35%** respectively. In each case the energy poor target remains a subset of this at 5% and is treated separately leaving the able-to-pay targets modelled at 10%, 20%, 30% respectively.

This approach follows the fabric first principle, under which SEAI applies the above heat pump readiness criterion prior to being eligible for support for heat pump installation. Installing a heat pump in a dwelling prior to upgrading of its building fabric risks over-sizing the necessary heating system, incurring unnecessary cost and lowering efficiency, as well as increasing the risk of failing to meet demand and deliver comfort on severely cold days. Furthermore, the higher cost of electricity relative to other heating fuels can mean that an over-sized system actually increases operating costs for the household and risks exacerbating any energy poverty conditions.

Base Case (Scenario 1)

Results

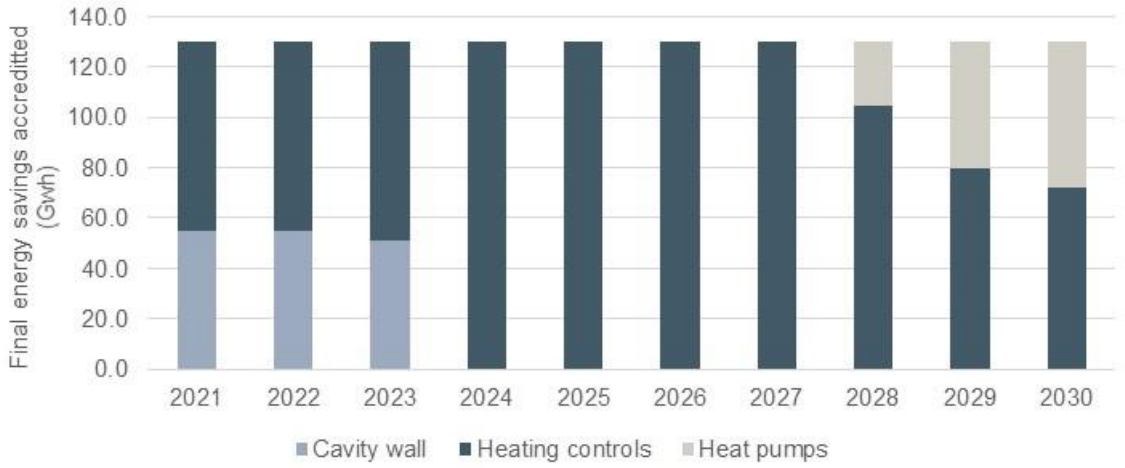
Under the Base Case, 20% of the EEOS target is expected to be met through the able-to-pay residential sector (5% being met via energy poor residential actions considered separately). This therefore defines the flat rate annual delivery of 130 GWh of new energy savings as per Table 14.

Table 14 Final energy savings in the residential sector excluding energy poor

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
GWh	130.0	130.0	130.0	130.0	130.0	130.0	130.0	130.0	130.0	130.0

As can be seen in Figure 11, measure delivery under the Base Case is expected to be dominated by further roll-out of heating controls and, to a lesser extent, the remaining reachable potential for cavity wall insulation as well as heat pump installation.

Figure 11 Fulfilment of residential sector target by measure type (Base Case)



Source: ECA calculation

The estimated total cost, subsidy necessary from Obligated Parties by year and cost per kWh-saved for the Base Case are presented in Table 15. While some contribution from AMs (notably SEAI grants) would be expected, for modelling purposes the conservative assumption is made that such contribution will likely be towards less cost-efficient measures than those included in Figure 11, negating any cost-benefit to Obligated Parties. Nevertheless, should additional AM contributions be available, the cost to Obligated Parties will reduce proportionately.

Table 15 Estimated cost and subsidy requirement for residential energy efficiency credits (Scenario 1: Base Case)

	Annual average (2021-2030)	Total
Able-to-pay sector savings (GWh)	130	7,150[1]
Total subsidy – EEOS plus any available AM contribution (€M)	23.9	239
Residential energy saving credit cost (€/kWh)[2]	0.18	
Number of individual measures[3]	72,000	725,000

Source: ECA calculation

Note 1: Energy saving totals presented are cumulative in nature

Note 2: Calculated based on entire subsidy requirement being met by EEOS

Note 3: For the Base Case Scenario, only the estimated number of measures rather than homes is presented. Some houses may receive more than one measure although it is considered likely that the majority will only receive a single measure.

Under the Base Case Scenario, activity focuses on heating controls with some additional activity in heat pump installations. Due to the proposed reduction in creditable energy savings for heating controls the cost of energy saving credits (subsidy provided per kWh-saved) in the residential sector are estimated to rise by around 60% as compared to the Reference Scenario and current scheme.

The impact on retail prices will be the result of the costs of activity not only in the residential sector but also in the non-residential sector. Assuming that the energy poor and non-residential costs remain constant in real terms (see introduction to Section 3.3 of the report under "General approach"), the estimated weighted average cost per kWh-saved in the Base Case Scenario is shown in Table 16. Also included in this table is the estimated impact on energy prices per kWh-sold.

Table 16 Weighted average cost per kWh final energy saved and sold – Residential sector (Scenarios 1: Base Case)

Parameter and scenario	Annual (2021-2030)
€/kWh-saved	0.09
Average €c/kWh-sold[1]	0.042

Source: ECA calculation

Note 1: Assumes 97% of all fuel consumption falls under Obligated Parties' sales with costs allocated proportionately, based on consumption trajectory

Additionality

"Free riders" are consumers who receive support but would have undertaken the measure even in its absence, while "free drivers" relates to the market acceleration benefit through consumers who are not direct recipients of subsidy but respond to wider awareness and market availability of energy efficiency products and services. Where possible, the extent of such effects should be estimated and incorporated into deemed energy saving values as per the requirements of EED Article 7[27]. The combined effect is sometimes called the Net to Gross Ratio (NGR) which adjusts the "gross savings" that do not account for such effects to "net savings" that do.

The consultants have not undertaken an analysis or update of the SEAI deemed energy saving values when modelling the Reference Scenario and Base Case. It is considered likely, however, that fossil fuel boiler upgrades and heating controls are the two residential sector measures most likely to be negatively affected by any application of NGR estimates. This is based on previous work by:

[27]See Page 123 of https://ec.europa.eu/energy/sites/ener/files/documents/c_2019_6621_-_annex_com_recom_energy_savings.pdf

- Lees (2008), who found that technologies with a market penetration of greater than 30-40% do not need to be financially incentivised as the share of free riders becomes excessive[28];

- Alberini *et al* (2014) who found free riders to account for 100% of uptake of energy efficient boilers (i.e. zero additionality) under the Italian tax incentive scheme[29]; and

- Winskel M. and Kerr N. (2018) who found that additionality is substantially improved for "supplementary measures" such as insulation as compared to "replacement measures" such as boilers[30].

- The Economic and Social Research Institute (ESRI) of Ireland who estimated free riders to constitute 60% of recipients of Better Energy Home heating control grants[31]. In contrast ESRI found that only 7% of recipients of boiler (with heating control) upgrade grants were free riders although it is the consultants' understanding that this is based on a counterfactual of no retrofit implying that the existing boiler could continue to operate without replacement.

Drawing on the above references a significant risk is noted that the deemed energy saving credits for these measures could be reduced following application of NGR estimates in line with the Commission Recommendations for EED Article 7 and result in a commensurate cost increase for Obligated Parties to meet their targets. In the case of heating controls such a downgrading may be partially or fully offset by the reduction in deemed credits due to their shorter lifetime[32].

Pathway scenarios (Scenarios 2a, 2b and 2c)

Deep retrofit packages

In order to model the Pathway scenarios, a set of three packages of measures (termed "P1", "P2" and "P3" in Table 17) has been formed and applied to each of the eleven dwelling types. Each of the dwelling-package combinations is further subdivided by the applicable type of wall insulation – cavity, internal or external. Only package and dwelling type combinations that meet the above criteria regarding HLI and BER rating respectively are then deemed eligible for Obligated Party support. The packages are described in Table 17 below.

[28] Cited by Du Can S. (2014). Design of incentive programs for accelerating penetration of energy-efficient appliances Energy Policy, 72, 56–66
[29] https://www.climatexchange.org.uk/media/3146/cxc-epe-evidence-review-full-report.pdf
[30] Ibid.
[31] https://www.sciencedirect.com/science/article/abs/pii/S0301421518301897?via%3Dihub
[32] Energy credits for heating controls have been downgraded by 50% reflecting their 5-year lifetime. However, assuming installation is staggered linearly over 2021-2030, the cumulative contribution for Article 7 purposes will substantially exceed 50% of the eligible savings of an equivalent measure with a 10-year lifetime. The extent of downgrading therefore is reflective of the relative lifetime energy saving contribution but in excess of that strictly necessary for Article 7 compliance.

The applicable form of wall insulation included as part of the package is denoted by the letter (c = cavity, i = internal, and e = external).

Table 17 Packages of residential sector measures (colour indicates measure included in package) (Pathway scenarios)

	P1c	P1i	P1e	P2c	P2i	P2e	P3c	P3i	P3e
Attic insulation									
Cavity wall insulation									
Internal wall insulation									
External wall insulation									
Insulated doors									
Double glazing									
Triple glazing									
Demand-controlled ventilation									
Air source heat pump									
Heat controls									

These packages clearly do not constitute the full range of permutations available and indeed deeper activity is possible. However, they are intended to be representative of relatively cost-efficient options facing households for reaching the BER B2 threshold.

Table 18 summarises the package-dwelling type combinations deemed to meet the HLI and BER renovation criteria, including those (types 7 and 11) which are already deemed to be "heat pump ready" without need for prior fabric upgrading. Full details of the calculated HLI, primary energy and final energy values are provided in Annex A2.

Table 18 Summary of lowest cost compliant packages for each modelled dwelling type

Dwelling type	Building description	Floor area (m^2)	Start BER	Heat pump ready	P1c	P1i	P1e	P2c	P2i	P2e	P3c	P3i	P3e
1	Bungalow	100	E2										
2	Detached 2 storey house (small)	126	C3										
3	Detached 2 storey house (large)	280	D1										
4	Semi-detached (small)	95	E2					See Note 1					
5	Semi-detached (insulated)	126	C2										

Dwelling type	Building description	Floor area (m^2)	Start BER	Heat pump ready	P1c	P1i	P1e	P2c	P2i	P2e	P3c	P3i	P3e
6	Semi-detached (uninsulated)	126	E1										
7	Semi-detached (large)	160	C2										
8	Terrace 2 storey	100	D2										
9	Apartment (small)	54	E1										
10	Apartment (duplex)	84	D2										
11	Semi-detached 2 storey house	111	C1										

Source: ECA calculation (elaborated in Annex A2)

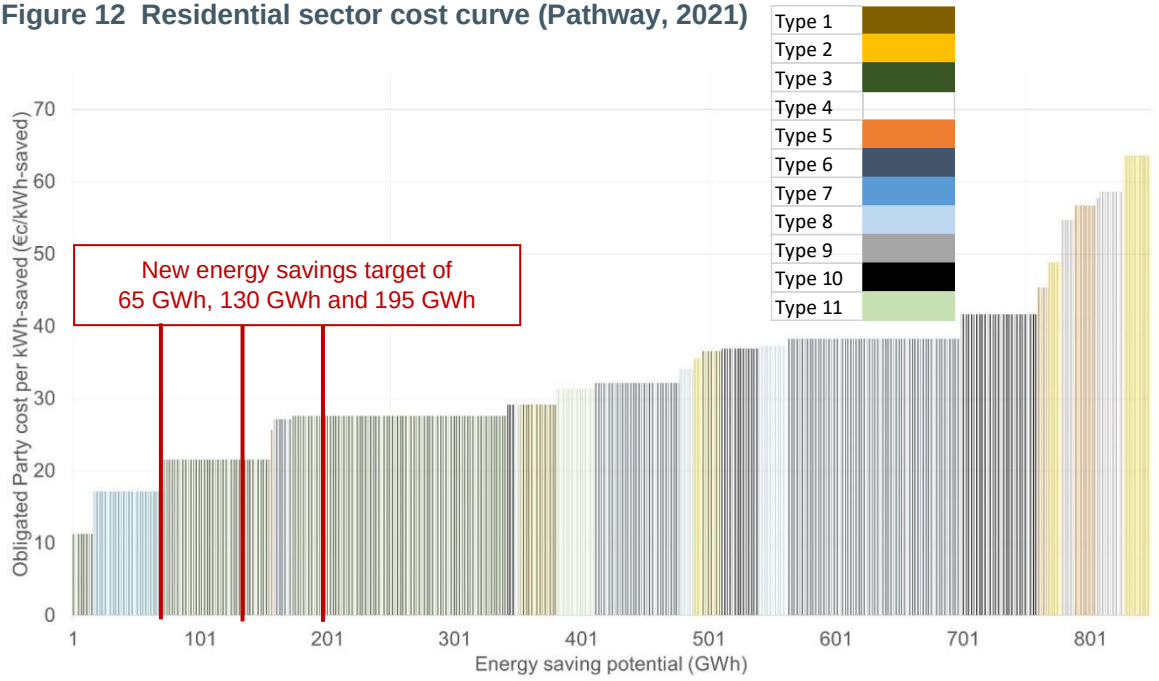
Note 1: None of the identified packages are estimated to be sufficient to bring Dwelling Type 4 to an HLI of 2.0 of less. While a more extensive package could be devised, it will be out of merit on a cost per kWh-saved basis and hence not affect the results presented here.

For modelling purposes, the stock of dwellings within each dwelling type are first factored by the assumed applicable form of unexploited wall insulation (7% cavity, 31% internal, 62% external[33]).

It is then assumed that for a given dwelling & wall insulation type, the most cost-effective package able to reach the minimum performance criteria is applied. The resultant cost curve facing Obligated Parties for 2021 is illustrated in Figure 12.

[33] Figures based on consultant approximations given breakdown of housing stock by age, known characteristics, and BER database records of market penetration to date

Figure 12 Residential sector cost curve (Pathway, 2021)



Source: ECA calculations

Energy saving estimates

In modelling these packages, it is considered inappropriate to use the EEOS deemed savings credits as the BER will be issued on the basis of a more refined assessment of the particular dwelling type in question. The energy savings estimates have therefore been tailored to each dwelling type based on SEAI data to provide the necessary added granularity.

Dwelling types 7 and 11 are deemed to have representative HLIs capable of immediate installation of a heat pump without the need for prior fabric upgrades. Together they are estimated to constitute approximately 122,000 homes out of the estimated 1,115,000 able-to-pay homes.

For all other dwelling types, heat pump & control packages are only eligible for support subsequent to or in conjunction with the fabric upgrades designated in Table 17.

Staging of retrofits

The *Selection of scenarios* sub-section above noted the staging of retrofits into firstly fabric upgrades and then secondly heating system upgrades. The option could be provided for Obligated Parties to split installation of packages along these lines. The model results did not include splitting installation in this way due to the greater cost efficiency of the heating system part of the package meaning it was always deemed preferable to undertake the full retrofit in a single step. However, this does not take into consideration any increased demand for such staging due to the reduction in upfront capital investment required.

Assessment criteria for permitting such partial upgrades and ensuring households remain on the pathway to BER B2 or better rating will require further elaboration. One option is that for fabric only packages to be undertaken independently a further criterion be applied that the dwelling could theoretically achieve BER B2 through installation of a high efficiency fossil fuel heating system with heating controls (with the latter works undertaken independent of the EEOS). The fabric upgrade side for some of the package and dwelling type combinations identified as eligible in Table 18 would not meet this additional criterion. Therefore, should it be applied, in these cases additional fabric upgrade works would have to be included in order for the breakpoint to be permitted.

Disaggregation into additional steps may be possible with the support of independently assessed roadmaps to BER B2 compliance such as the passport system being developed by the Irish Green Building Council, elaborated on in Box 1 below. Indeed, this approach is referenced within the Energy Performance of Buildings Directive as amended (2018/844/EU) Article 2 which notes "policies and actions to stimulate cost-effective deep renovation of buildings, including staged deep renovation, and to support targeted cost-effective measures and renovation for example by introducing an optional scheme for building renovation passports"[34].

Box 1: Building Renovation Passports

Disaggregation of the packages into stages (and potentially into individual steps) may potentially be supported by Building Renovation Passports (BRP) system being developed by the Irish Green Building Council.

Data reporting and verification of savings in this sector can be relatively straightforward, being significantly facilitated by the BER system. The application of ex-post BER assessments by registered assessors, in conjunction with a schedule of works (and costs) to enable inference of the relevant ex-ante BER assessments, have the effect of quantifying the level of energy efficiency improvement in kWh/m^2 of primary energy and confirming the resultant BER (which could be readily extended to include carbon intensity for CAP reporting purposes). It is therefore appropriate that this practice, which has applied under current SEAI grant schemes, should continue to apply for EED Article 7 purposes – for which computation of energy savings in final energy terms is straightforward. The cost of this BER service will typically be in the range of €100-200 per home.

The BRP concept goes a step further, building on the BER platform. A BRP is a diagnostic document outlining a long-term (up to 15-20 years) step-by-step roadmap to achieve deep renovation for a specific building. It supports building owners with customised advice on their renovation options and clarifies the renovation stages for all involved parties. In conjunction with the BER, this enhanced composite service enables implementation and accreditation of incremental upgrades that avoid precluding further upgrading opportunities in the future. The composite cost is provisionally estimated to be in the range €400-600 per home (inclusive of BER), and hence this facilitation of both staged renovation and robust M&V potentially represents a significant transaction cost. However, it can be foreseen that such a service can form part of the one stop shop service which may be subsidised by either State grant schemes or the EEOS.

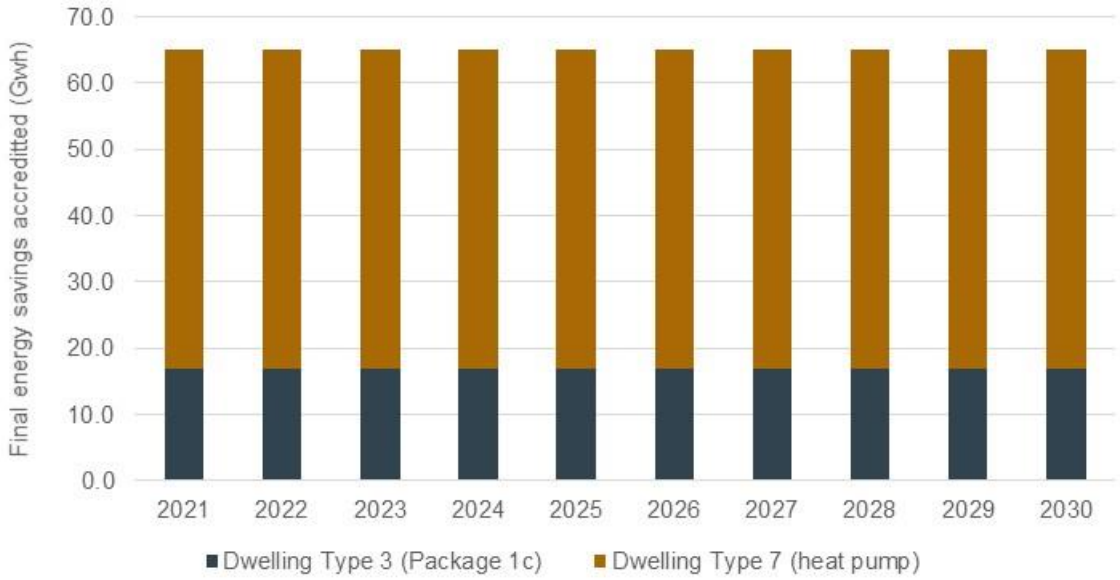
[34] https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-performance-of-buildings/energy-performance-buildings-directive

Results

Under the Pathway scenario, Obligated Parties would be expected to focus on the most cost-efficient combinations of dwelling type and package among those described above that meet the heat pump ready and subsequent BER B2 rating criteria.

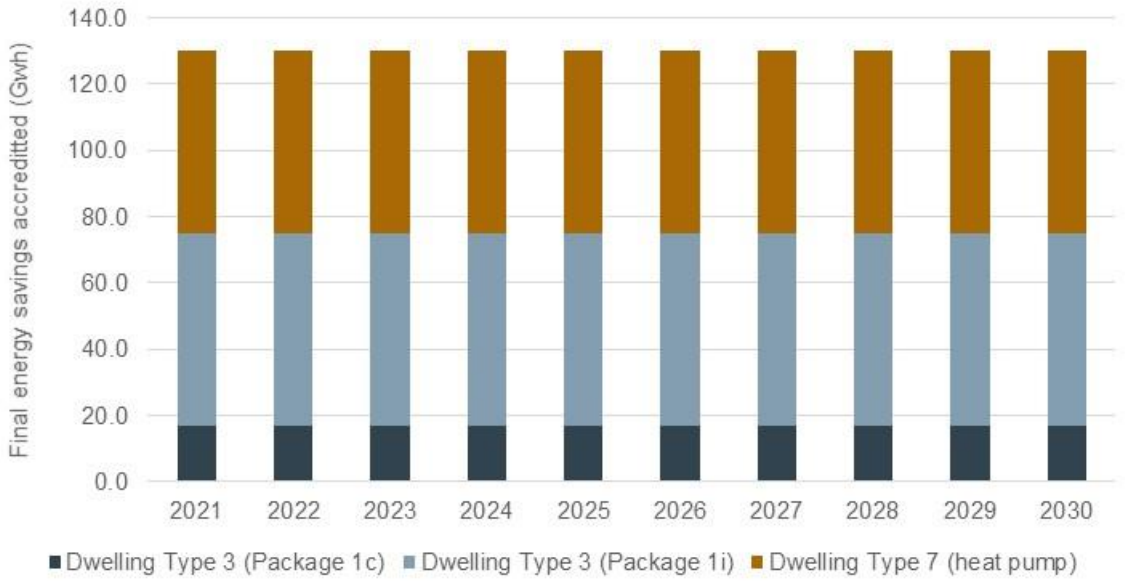
Figure 13, Figure 14 and Figure 15 present the estimated energy savings to be delivered by each such combination for each year 2021-2030 under each scenario – 15%, 25% (current level) and 35% (Scenarios 2a, 2b and 2c respectively). The results exclude the 5% of each target that is ring-fenced for energy poor activity, which is considered separately in Section 3.3.2.

Figure 13 Fulfilment of target by measure type (Scenario 2a: Pathway 15%)



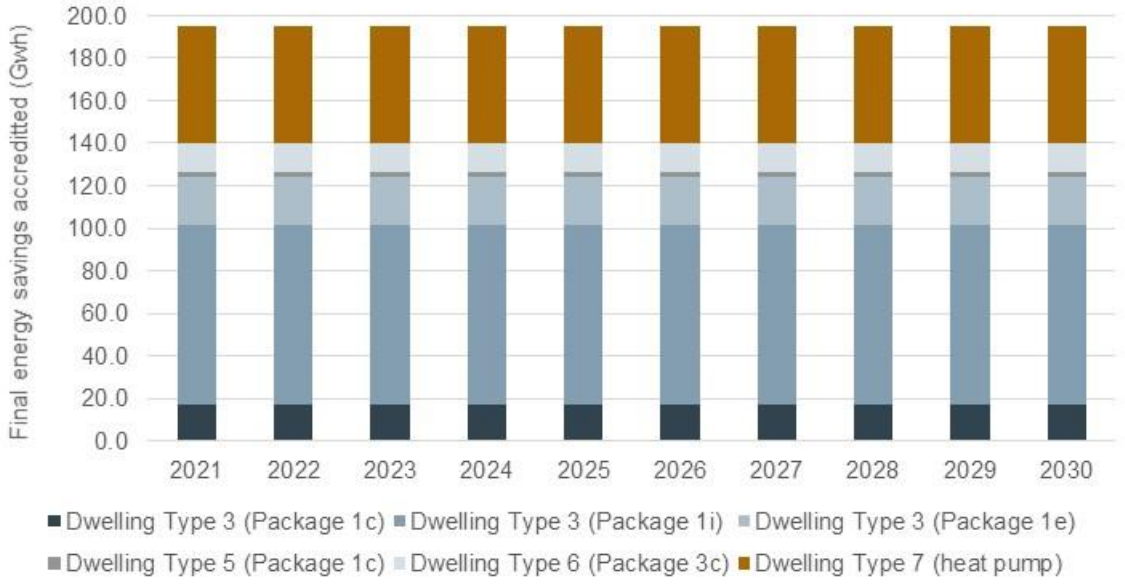
Source: ECA calculation

Figure 14 Fulfilment of target by measure type (Scenario 2b: Pathway 25%)



Source: ECA calculation

Figure 15 Fulfilment of target by measure type (Scenario 2c: Pathway 35%)



Source: ECA calculation

As can be seen, under the 15% and 25% target scenario, activity is expected to be split between installation of heat pumps and controls in “heat pump ready” homes, and fabric plus heating system packages for Dwelling Type 3. In the 35% target scenario, due to the limitation on assumed annual demand by dwelling type, a portion of the target is required to be met through dwelling types 5 and 6 also.

Dwelling Type 3 represents large detached dwellings with a mean floor area of 280 m^2. As its composition is an outlier across the full cohort, a sensitivity check under each target level has been undertaken with this dwelling type removed from the model, pushing activity into a more diverse range of smaller dwelling types.

Table 19 presents the range of estimated costs per annum under each of the residential target scenarios with the higher end of the range representing the sensitivity case of excluding Dwelling Type 3. As the model assumes only 5% of homes per annum within each dwelling type will consider a retrofit, during the period of evaluation (2021-2030) no dwelling type reaches saturation point and hence the mix remains constant across the period.

Table 19 Estimated subsidy requirement for residential energy efficiency credits (Scenarios 2a to 2c: Pathway 15%, 25%, 35%)

	Annual (2021-2030)	Total
Able-to-pay sector savings (GWh)		
15%	65	3,575[1]
25%	130	7,150[1]
35%	195	10,725[1]
Total cost of measures including consumer contribution (€M)		
15%	33.9 – 40.4	339 - 404
25%	79.6 - 104.7	796 - 1,047
35%	133.7 – 174.2	1,337 – 1,742
Total subsidy – EEOS plus any available AM contribution (€M)		
15%	10.2 - 12.1	102 - 121
25%	23.9 - 31.4	239 - 314
35%	40.1 – 52.3	401 - 523
Residential energy saving credit cost (€/kWh)[2]		
15%	0.16 - 0.19	
25%	0.18 - 0.24	
35%	0.21 – 0.27	
Number of houses retrofitted		
15%	3,000 - 3,500	30,000 - 35,000
25%	5,000 - 8,000	50,000 - 80,000
35%	6,500 – 11,000	65,000 – 110,000
Number of individual measures[3]		

	Annual (2021-2030)	Total
15%	4,000 – 5,000	40,000 – 50,000
25%	8,500 – 18,000	85,000 – 180,000
35%	15,000 – 27,000	150,000 – 270,000

Source: ECA calculation
Note 1: Energy saving totals presented are cumulative in nature
Note 2: Calculated based on entire subsidy requirement being met by EEOS
Note 3: Heat pumps and controls package counted as a single measure.

The residential energy saving credit cost is calculated exclusive of any contribution from AM co-funding. AM co-funding may lower the cost to Obligated Parties. However, the multiple objectives and different scheme design of AMs (e.g. deeper retrofit targets beyond BER B2) means that for each Euro spent under an AM the reduction in cost to Obligated Parties will likely be less than a Euro.

Without any such co-funding, the estimated cost to Obligated Parties per kWh-saved in the Pathway 25% (Scenario 2b) is estimated to average around 60% to 100% higher than under the Reference Scenario. Under the Pathway 15% scenario (Scenario 2a), the increase relative to the Reference Scenario is instead estimated to be between 35% and 60%. Under the Pathway 35% scenario (Scenario 2c) this rises to between 75% and 125% the Reference Scenario and possibly higher than the current buy-out price for residential credits.

Furthermore, given residential sector energy savings are more costly than non-residential sector savings, the higher the residential sector target the higher the overall scheme costs. Assuming that the energy poor and non-residential costs remain constant in real terms (see "General approach" in the introduction to Section 3.3), the resulting weighted average cost per kWh-saved for each Pathway scenario by year is shown in Table 20.

Table 20 Weighted average cost per kWh final energy saved and sold – Residential sector Pathway scenarios

Parameter and scenario	Annual (2021-2030)
€/kWh-saved	
15%	0.07 - 0.07
25%	0.09 - 0.10
35%	0.11 – 0.12
Average €c/kWh-sold[1]	
15%	0.034 – 0.036
25%	0.042 – 0.048
35%	0.052 – 0.061

Source: ECA calculation

Note 1: Assumes 97% of all fuel consumption falls under Obligated Parties' sales with costs allocated proportionately, based on consumption trajectory

When the residential sector target is set to 15% (10% able-to-pay), the weighted average cost of energy savings is estimated to remain broadly in line with the Reference Scenario at €0.07/kWh-saved. With the residential target set to the existing (under the current EEOS) 25% of the overall target (20% able-to-pay), the increase in costs under this approach has a notable impact on overall scheme costs lifting the weighted average price to €0.09 - €0.10 per kWh-saved.

Under the 15% residential target (10% able-to-pay), the Pathway approach is estimated to retrofit between 30,000 and 35,000 houses, dependent on the mix of dwelling types that transpire. Retaining the current 25% residential target (20% able-to-pay), this rises to between 50,000 and 80,000 houses. Under the 35% target (30% able-to-pay) this rises again to between 65,000 and 110,000. The number of individual measures to which this is estimated to correspond varies from 40,000 to 50,000 in the 15% residential target (1-% able-to-pay) scenario, 85,000 to 180,000 in the 25% residential target (20% able-to-pay) scenario, and 150,000 – 270,000 in the 35% target (30% able-to-pay) scenario. Again, the wide variation reflects the uncertainty over of the mix of dwelling types, the resulting number of fabric upgrade measures needed to be designated heat pump ready, and the average size of dwelling retrofitted.

3.3.2 Energy poor

Summary of section

- Under the **Reference Scenario** whereby the scheme largely follows current structures, Obligated Party costs per kWh-saved are expected to remain at a similar level to the estimated cost to Obligated Parties of current energy poor credits, around €0.26/kWh-saved with deployment dominated by shallow measures, notably **higher efficiency fossil fuel heating systems.** This is inconsistent with the CAP objectives.
- As for the able-to-pay residential sector, under the **Base Case** activity reverts to heating controls as well as the remaining cavity wall insulation, increasing the estimated average cost to Obligated Parties to around **€0.40/kWh-saved**.
- A "**Pathway – standard criteria**" scenario has been modelled following the same eligibility criteria for measures as that described for the able-to-pay residential sector. Under the current target level (5%), per kWh-saved costs for energy poor credits faced by Obligated Parties are estimated to approximately double as compared to the Reference Scenario unless there is a relative increase in the AM contribution.
- The impact on the weighted average per kWh cost of energy saved across the EEOS, assuming no real terms change to able-to-pay residential or non-residential credits, is estimated to be an increase of around 15% as compared to the Reference Scenario.
- A variation scenario termed "**Pathway – enhanced criteria**" that limits eligible homes for energy poor credits to those at BER level E or worse has also been modelled, constituting around 200,000 homes.
- Under this scenario, per kWh-saved costs for the energy poor are expected to approximately triple in the absence of a relative terms increase in AM contributions (i.e. AM contributions providing a greater share of total investment costs than under the current EEOS). This results in a notable impact on overall EEOS subsidy costs, rising by around 30% as compared to the Reference Scenario.

Approach to assessment

The modelling of the energy poor ring-fenced target follows the same approach as that described for the residential sector more broadly with two key amendments:

- **Number of applicable homes:** The current scheme allows for installations to be deemed creditable towards the energy poor sub-target when the recipient is a privately owned or social housing household in receipt of:
  - Fuel Allowance
  - Working Family Payment
  - Job Seekers Allowance for over six months and have a child under seven years of age

- One-Parent Family Payment
- Domiciliary Carers Allowance
- Carers Allowance and live with the person you are caring for

There is substantial overlap between the above groups and hence estimating an absolute number of homes which fall into one or more category is difficult. The most extensive individual criterion – fuel allowance – has therefore been taken to represent the complete stock of households eligible for activity under the ring-fenced component. There are an estimated 410,000 such households.

- **Leverage:** It is typical that the full capital cost of measures is necessary to be met by subsidy in the energy poor sector. The only measures where this has not been assumed are those for efficient fossil fuel boilers. Here the same approach has been used as for the able-to-pay residential sector of assuming half the rate of other measures (in the case of energy poor that is 50%) is met through subsidy.

- Typically, in the current EEOS financial support for energy poor credits is done through **co-financing** via an Obligated Party and an AM, primarily through local authorities, public housing bodies and SEAI grants. The approach here is to first establish the total subsidy costs and then to allocate these between the EEOS and AMs before estimating the impact on retail prices.

Selection of scenarios

The same Reference, Base Case and Pathway scenarios as modelled for the residential sector and described in Figure 10 in Section 3.3.1 have been modelled for the energy poor sub-sector, in each case with the target remaining at 5% of the overall EEOS target, equivalent to new savings each year of 32.5 GWh.

An additional variant of the Pathway scenario has also been modelled which limits eligible homes to those with initial BER rating of E or poorer. Other than income level and energy prices, BER rating is considered to be the main driver of energy poverty in households. Four of the typical dwelling types described in Table 18 have representative BER ratings within the E-G range[35]. Assuming a uniform share of houses are in receipt of fuel allowance across all dwelling types equates to approximately 186,000 homes being both in receipt of fuel allowance and in BER bands E-G.

The intention of this variant is to ensure better alignment with the requirement of EU Member States to address fuel poverty through EED Article 7 and report on the impact of the policies enacted in alleviating the prevalence of energy poverty. By raising the standard of the dwelling to a BER B2 level, the probability of the residing household being in energy poverty is markedly reduced.

[35] While all four dwelling types have a representative BER of E1 or E2, each dwelling type represents a spectrum of conditions that will include many houses of F and G level also.

Base Case

Results

The results for energy poor homes mirror those of the "can pay" residential sector, factored up to account for the lack of ability to leverage end-consumer's own finances. If one-third of the subsidy costs were met through AMs[36] (resulting in two-thirds to be met by the Obligated Parties – see discussion below for more detail) then the resultant estimated cost per kWh-saved is reported in Table 21.

Table 21 Estimated cost and subsidy requirement for energy poor energy efficiency credits (Scenarios 1: Base Case)

	Annual average (2021-2030)	Total
Energy poor sector savings (GWh)	32.5	1,787.5[1]
Total subsidy – EEOS plus any available AM contribution (€M)	19.3	239.3
AM contribution (€M)	6.4	64.4
Energy poor energy saving credit cost (€/kWh)	0.40	
Number of individual measures[2]	11,000	110,000

Source: ECA calculation

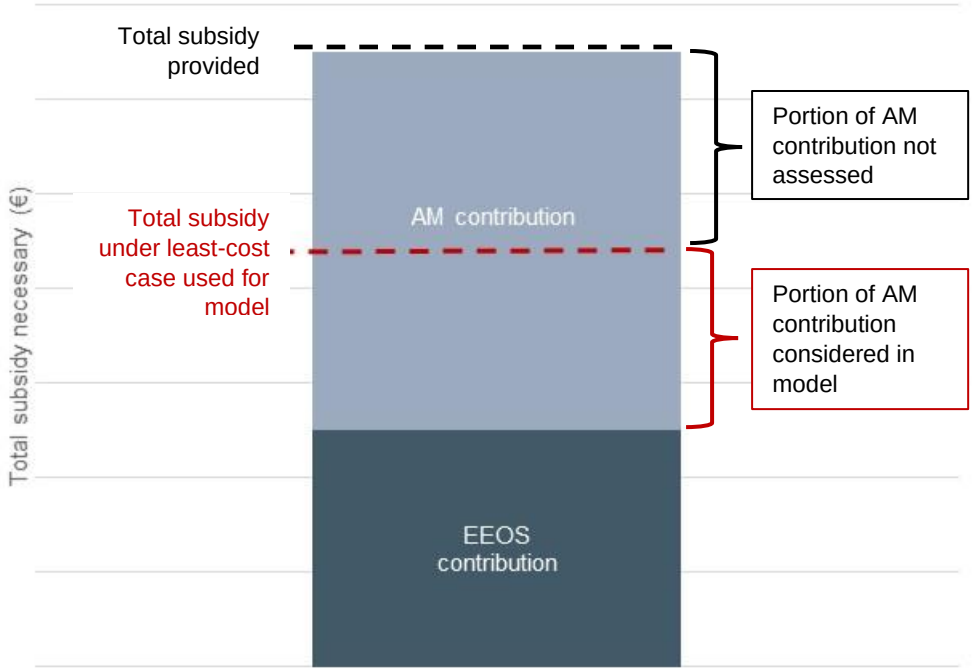
Note 1: Energy saving totals presented are cumulative in nature

Note 2: For the Base Case Scenario, only the estimated number of measures rather than homes is presented. Some houses may receive more than one measure although it is considered likely that the majority will only receive a single measure.

To a greater degree than with the able-to-pay segment of the residential sector, these results represent a simplification of the likely outturn as the allocation of AM grants follows multiple objectives other than simple cost efficiency. The total subsidy required (combined EEOS plus AM) will therefore likely be higher than provided in Table 21 and the contribution of the AMs correspondingly larger as illustrated in Figure 16. This will also have the effect of giving greater heterogeneity to the mix of measures realised given AMs may not only target least cost measures.

[36] This share in costs is likely lower than the current average contribution from AMs, however AM contribution will in part be additional to the least cost case for the mix of measures assumed here

Figure 16 Schematic illustration of modelling approach for AM contribution in Energy Poor sector (not to scale)



Note: Not to scale

Analysis suggests that as in the able-to-pay residential sector, under the Reference Scenario substantial scope for relatively low-cost measures (more efficient fossil fuel boilers and heating controls) remains. In the able-to-pay residential sector, the Reference Scenario estimated that the cost per kWh-saved is not expected to deviate substantially from those encountered in the current EEOS period (2014-2020). If the net effect of AM contributions on the cost of energy poor credits also remains broadly as per the current period, then a similar result relative to the able-to-pay sector may be expected – namely that energy poor energy saving costs will remain broadly as at present. This logic has guided the selection of a nominal one-third AM contribution. Results are therefore best evaluated in relative terms with those from the alternative scenarios.

Similar to the able-to-pay residential sector, excluding fossil fuel boiler upgrades under the Base Case approach is estimated to increase the cost of energy poor energy saving credits by approximately 60% relative to the Reference Scenario due largely to the reduction in deemed credits for heating controls.

Additionality

Similar to the able-to-pay residential sector, NGR estimates accounting for free rider and free driver effects of measures have not been considered in the above assessment. There are little data regarding the magnitude of such effects specifically for the energy poor sector. Given timely replacement of appliances is less likely and access to capital issues are more acute in the energy poor sector, it is considered reasonable to expect the level of free riders would be lower than in the able-to-pay sector.

Pathway Scenarios (Scenario 2b)

Results – standard criteria

By the same approach and criteria as for the Pathway scenarios in the able-to-pay residential sector reported in Section 3.3.1, an analysis was undertaken of the cost of action in the energy poor sector. This involves allowing packages of work to be undertaken that meet: (1) improving the dwellings to a HLI of 2.0 W/m^{2}K or lower and (2) installation of a heat pump system (modelled with heating controls) to reach at least a BER B2 (and usually substantially better). The same combination of dwelling type and packages as shown in Table 18 are permitted in these scenarios for the Energy Poor sector, giving the results shown in Table 22. Where a range is indicated, the higher figure represents the results excluding the cheapest dwelling type, in this case Dwelling Type 1.

Table 22 Estimated subsidy requirement for energy poor energy efficiency credits (Pathway – standard criteria)

	Unit	Annual (2021-2030)	Total
Target (Energy poor)	GWh	32.5	1,788[1]
Total cost (Energy poor)	€M	20.2 – 28.7	202 – 287
Total subsidy necessary	€M	20.2 – 28.7	202 – 287
Assumed AM contribution	€M	6.7 – 9.6	67.5 – 95.7
OP energy poor energy saving credit cost	€/kWh-saved	0.42 – 0.59	
Number of homes retrofitted		1,000 - 1,500	10,000 - 15,000
Number of individual measures[2]		2,200 – 6,500	22,000 – 65,000

Source: ECA calculation

Note 1: Energy saving totals presented are cumulative in nature

Note 2: Heat pumps and controls package counted as a single measure.

As with the Reference Scenario and Base Case this assumes a least cost selection of measures. This is a simplification given the multiple objectives taken by the co-funding AMs in selecting projects.

As with the residential able-to-pay sector, here the Pathway scenario represents a lesser volume but much deeper approach to retrofitting than under the Base Case.

The impact of the increased cost under this scenario on overall EEOS costs is estimated in Table 23. This assumes residential (able-to-pay) and non-residential credits remain at the assumed current prices (see “General approach” at start of Section 3.3) in real terms throughout the obligation period.

Table 23 Weighted average cost per kWh final energy saved and sold – Pathway (energy poor, standard criteria)

Cost indicator	Annual (2021-2030)
€/kWh-saved	0.08 - 0.09
€c/kWh-sold[1]	0.041 – 0.045

Source: ECA calculation

Note 1: Assumes 97% of all fuel consumption falls under Obligated Parties' sales with costs allocated proportionately, based on consumption trajectory

While the impact on energy poor per kWh-saved costs of switching to the Pathway approach is substantial (estimated to rise to an average of approximately €0.50/kWh-saved), the small share of the energy poor sector in the overall EEOS target means that the overall cost impact is expected to remain muted.

Results – enhanced criteria (Scenario 2b variation)

The same analysis was also repeated with an amended criterion that the house must be at a BER grade E or worse prior to implementation of the measures.

Activity in this case is expected to be concentrated on dwelling types 1 and 6 relating to poorly insulated bungalows and mid-sized houses. The results are provided in Table 24.

Table 24 Estimated cost to Obligated Parties for energy poor energy efficiency credits (Pathway – enhanced criteria)

	Unit	Annual (2021-2030)	Total
Target (Energy poor)	GWh	32.5	1,788[1]
Total cost (Energy poor)	€M	31.5 – 40.5	315 – 405
Total subsidy necessary	€M	31.5 – 40. 5	315 – 405
Assumed AM contribution	€M	10.5 – 13.5	105 – 135
OP energy poor energy saving credit cost	€/kWh-saved	0.65 – 0.83	
Number of homes retrofitted		1,200 - 1,300	12,000 - 13,000
Number of individual measures[2]		6,300 – 7,900	63,000 - 79,000

Source: ECA calculation

Note 1: Energy saving totals presented are cumulative in nature

Note 2: Heat pumps and controls package counted as a single measure.

Due to the tightened criteria, the cost per kWh-saved rises substantially when compared to the Pathway - standard criteria case and Base Case and up to three times that in the Reference

Scenario (where costs remain broadly as at present after conversion to final energy terms). The higher end of the range is also close to the current buy-out price for this sector. This is sufficient to have a notable impact on the weighted average cost of the EEOS across all sectors even in the event residential (able-to-pay) and non-residential energy savings are achieved at no increased cost from current estimates, as shown in Table 25.

The number of homes and individual measures actually increases under Enhanced Scenario as the focus shifts to multi-measure packages for smaller dwellings. This latter factor is in part an artificial result, stemming from the necessary grouping of dwellings into a limited set of typologies.

Table 25 Weighted average cost per kWh final energy saved and sold – Pathway (energy poor, enhanced criteria)

Cost indicator	Annual (2021-2030)
€/kWh-saved	0.10 - 0.10
€c/kWh-sold[1]	0.047 – 0.051

Source: ECA calculation

Note 1: Assumes 97% of all fuel consumption falls under Obligated Parties' sales with costs allocated proportionately, based on consumption trajectory

3.3.3 Non-residential sectors

Summary of section

- Adopting a **final energy** target has an effect on the relative attractiveness of common non-residential measures for Obligated Parties, **favouring heating over lighting** in particular. It may also limit the absolute size of the annual market in lighting measures for Obligated Parties.
- Under the **Base Case** with no change to the sub-sectoral targets, Obligated Party costs per kWh-saved are estimated to remain approximately as at present, around €0.05/kWh-saved. If the non-residential target is expanded to 85% to allow for a 15% residential sector target (inclusive of energy poor) then this is estimated to rise to around €0.06/kWh-saved. There is, however, a high level of **uncertainty** associated with this result with both figures being particularly sensitive to assumptions regarding the size of the annual market for heating measures.
- Modelling suggests any shortfall in savings available in commercial buildings or processes may need to be substituted by incentives for **EV purchase**. This is an unproven measure under an EEOS and costs for Obligated Parties are especially difficult to discern.
- **Transport** constitutes over 40% of final energy consumption. Should the sector have a **ring-fenced target** consistent with this share then costs are expected to increase markedly again. This is due to having to offer higher incentives for EV take-up. In this case the transport energy savings are estimated to cost an average of €0.26/kWh-saved.

Surplus residential sector credits may contribute towards the non-residential sector targets that currently constitute the remaining 75% of the overall target. However, due to energy savings credits being comparatively cheaper in the non-residential sector than for the residential sector, least cost delivery would mean that such transfer of credit is relatively rare.

This section has developed simple cost curves for Obligated Party support for each of the following: Transport, Commercial Buildings, and Industrial and Commercial Processes. At the end of the section they are brought together to estimate a full non-residential sector cost curve under two scenarios: with and without a specific ring-fence for the transport sector proportionate to the sector's share in final consumption. A brief discussion is also included regarding potential activity in the public sector. No separate Reference Scenario has been developed for the non-residential sector as was provided for the residential sector due to it being entirely synonymous with the Base Case.

There is substantial uncertainty in relation to a number of the input values used, in particular the lack of information regarding the share of Obligated Party funding in total measure costs. Results therefore are principally of interest in identifying relative changes in cost between scenarios and the current scheme, identifying risks associated with each approach, and illustrating the potential shares of each measure type within the mix.

Transport

Transport delivered approximately 7% of non-residential EEOS savings (5% of all EEOS savings) in 2017. However, at over 40% of final energy consumption and with transport energy use no longer subtractable from the Article 7 target (as was the case for the 2014-2020 period), specific attention has been paid to opportunities for increasing the sector's contribution.

Modelling assumptions for Electric Vehicles

Electric vehicle (EV) and modal shift promotion were outlined in Section 2. EV sales at present are eligible for substantial government subsidy and amounted to approximately 3% of new vehicle registrations in the 6-month period to November 2019 with hybrid vehicles accounting for a further 7% [37].

There are a number of forces favouring increased EV uptake including the available State subsidy, commercial price reductions, improved technology (e.g. vehicle range), and improved charging infrastructure availability. To meet additionality criteria, accreditation of any Obligated Party support should be for sales that would not have occurred in the absence of their contribution as a result of these other drivers. However, as with other sectors, it is assumed that co-funding from State grants and tax relief with Obligated Party finance is admissible within the EEOS. This is very likely a necessity as the cost-effectiveness of subsidising EV take-up in the absence of such co-funding from the State will be highly unattractive from a cost per kWh-saved perspective when compared to alternative energy efficiency measures.

This raises a question of materiality and when an Obligated Party contribution may be deemed material to a purchase decision. In the absence of detailed survey results on willingness to pay, it is considered that benchmarking with typical contribution rates in other sectors is the most reasonable approach. A grant of €1,000 represents around 3% of an assumed purchase price of €30,000 for a new vehicle (net of government subsidies). This is towards the lower end of the typical share of Obligated Party support for measures in other sectors but considered within the current range for non-residential credits.

The current price differential in purchase cost (rather than total cost of ownership) between similar models of mid-range electric and internal-combustion engine (ICE) vehicles in Ireland is estimated at around €15,000. VRT relief and SEAI grants contribute €10,000 leaving an estimated remaining gap of €5,000 for the consumer. The willingness of consumers to pay for this gap will depend on the consumer segment in question. Various international surveys have been undertaken that identify the interest of consumers in EVs and their willingness to pay a premium, but few have addressed the extent of purchase price premium necessary to initiate purchase decisions by different consumer segments.

A recent AAA survey[38] in the United States found that approximately one-quarter of Americans are willing to pay a purchase premium of over USD 4,000 (approximately €3,500), almost half are willing to pay up to USD 4,000, and two-thirds are willing to pay some premium. Guided by

[37] https://statbank.cso.ie/px/pxeirestat/Statire/SelectVarVal/saveselections.asp
[38] https://newsroom.aaa.com/2019/05/why-arent-americans-plugging-in-to-electric-vehicles/

these results as well as the present level of sales under current subsidy offering, for modelling purposes the Irish market has been split as follows:

- 12.5% of the annual market in vehicle registrations is assumed to require no more than the current €10,000 subsidy to initiate an EV purchase decision.
- A further 12.5% of the annual market is assumed to require an additional €1,000 subsidy (leaving a €4,000 premium for the consumer).
- A further 25% of the market is assumed to require an additional €2,000 subsidy (leaving a €3,000 premium for the consumer).
- A further 25% of the market is assumed to require an additional €3,500 subsidy (leaving a €1,500 premium for the consumer).
- The remaining market (25%) is assumed to require purchase price parity (ie an additional €5,000 and no premium for the consumer).

EV costs will very likely fall over the course of the obligation period to 2030. However, the availability of State support is expected to likewise fall in line with such cost reductions. Hence the net position faced by Obligated Parties is assumed to remain unchanged from that described above until such time that no State support remains available. After this point the available market size for lower levels of Obligated Party subsidy will rise, although so will the portion of the market that needs no subsidy to initiate a purchase decision.

Estimates of the rate of price reductions vary widely. As the modelling is concerned with additional sales to what would occur in the absence of support, the conservative assumption has been made to hold the above assumptions constant through the full obligation period of 2021-2030.

Modelling assumptions for other transport measures

No contribution from Obligated Parties is assumed for modal shift[39], the other transport AM identified in Section 2. Three further potential transport measures were identified from other European EEOS as being of interest for modelling purposes and are detailed together with calculation assumptions in Table 26 below. As with other non-residential sector measures, the Obligated Party funding contribution has been set to 5% for all measures with the exceptions of:

- Fuel additives where in the absence of additional drivers a figure of 50% has been assumed.
- Support for private passenger cars where a subsidy of 30% has been assumed reflecting the dynamics observed in the residential building sector.

[39] This may, however, be possible with robust accreditation processes.

Table 26 EEOS transport measures and assumptions

Policy measure	Relevant assumptions
More efficient movements & behaviours in road transportation of goods ("eco-driving")	Behavioural/ logistical/ technological. Efficient driving arising from eco driver training integration into annual safety courses, including training of trainers and covering private and public sectors. For commercial vehicles applied to 100 Heavy Goods Vehicles (HGV) fleets at 30 vehicles per fleet p.a. (7% of overall HGV energy usage) and 100 Light Goods Vehicles (LGV) fleets at 100 vehicles per fleet (4% of overall LGV energy usage) with 5% fuel saving for HGV and 4% fuel saving for LGV lasting 2 years. In vehicle Monitoring & Reporting (M&R) devices. For private cars, up to 14,000 vehicles per year based on one-fifth of new drivers each year availing of the option. 4% savings on average mileage of 17,000 km per annum and baseline 6-litres per 100 km usage. For private cars measurement and verification challenges remain with difficulty in installing and monitoring with appropriate telemetry.
Deployment of fuel additives	200 GWh baseline diesel use in rail transport. Continuous deployment of cleaning additives over 280 ppm yielding energy saving of 2% (Austrian guidance indicates 2.6%), equating to 4 GWh p.a. energy saving. Similarly applied to 1000 GWh segment (about 3%) of annual road transport fuel use at 2% energy saving is computed to yield annual saving of 20 GWh. For private vehicles it is assumed up to 3% of cars select the additive option at fuelling stations with 1.5% fuel saving for each. This measure could alternatively be an AM should policies dictate.
Fuel saving tyres	Behavioural/ logistical/ technological. Complementing eco-driving training, targeted at 100 HGV fleets at 30 vehicles per fleet p.a. (7% of overall HGV energy usage) with 1% fuel saving and 2 year lifespan. Deemed savings based on independent testing.

Selection of scenarios

The following scenarios are modelled for the transport sector:

- No ring-fencing as per the current EEOS design (effectively equal to 85%, 75%, or 65% of the overall target dependent on the residential sector target scenario)
- Transport treated independently whereby a ring-fenced target is implemented proportionate to the sector's share of final energy consumption. This target is assumed to be applied to all Obligated Parties regardless of the sector they operate in.

Industrial and commercial sector

The industrial and commercial sector contributed the remaining 93% of the non-residential sector share of EEOS energy savings (comprising primary energy savings credits) in 2017. The leading measures undertaken in 2017 were:

- Lighting: 37%
- Processes: 24%
- Combined Heat and Power (CHP): 16%
- Boilers: 7%
- Refrigeration: 3%

CHP credits are not eligible under EED Article 7 for the period 2021-2030. A switch to final rather than primary energy as the metric for EEOS target setting will also impact on the relative cost-effectiveness of the other measures listed and hence their attractiveness for Obligated Parties to support.

Modelling has been based on derivation of cost curves for:

- **Commercial buildings**: covering lighting, space heating and building fabric upgrades.
- **Processes:** including process integration and heat recovery, motor efficiency, and refrigeration.

It is noted that many of the measures cited for commercial buildings are similarly applicable for public buildings (indeed are comparatively attractive for schools and health care facilities). This potential has not been included here to avoid double counting with the contribution of the public sector target identified in Section 2 as an AM. Historically there has been very low EEOS activity in the public sector. This may change in the next period and the approach outlined here should not be taken to indicate that public sector actions are not permitted in contributing towards Obligated Party targets. Nevertheless, it should be borne in mind that any activity in this area needs to either be additional to the assumed contribution of the public sector as an AM or compensated by additional savings under a different AM.

Commercial buildings

Building the cost curve for commercial buildings has followed the same process as described for the residential sector with the following steps:

- **Identification of common measures:** A set of the most common non-residential building energy efficiency measures were identified based on historic EEOS data. For new and replacement heating systems, only heat pumps were considered eligible.

- **Cost and energy saving data:**
    - Building fabric cost and energy saving data for six building types were taken from Ireland's Report on the Development of Cost Optimal Calculations and Gap Analysis for Buildings in Ireland under Directive 2010/31/EU on the Energy Performance of Buildings (RECAST).
    - For lighting and heating system measures, the consultant team has used in-house data cross-checked with that held by SEAI to derive estimates. Fossil fuel boilers are not deemed permissible as an individual measure.
- **Leverage:** The share of costs met by Obligated Parties was set to 5% for all measures based on historic costs for non-residential sector credits.
- **Number of buildings:** Numbers of industrial and commercial buildings are taken from the SEAI report "Extensive survey of the commercial buildings stock in the Republic of Ireland"[40]. This dataset has been applied to the non-residential building types used in the Cost Optimal report referenced above. Full details are provided in Annex A2.
- **Market penetration of measures to date:** Little information was available regarding market penetration to date. The Cost Optimal calculations are intended to reflect the building stock at the time of analysis in 2019 and hence should represent the outstanding potential. Nevertheless, there will be significant variation around the reference buildings. A blunt estimate has been applied that 50% of the market is of sufficiently poor quality to be available for upgrades to lighting, windows and cavity wall insulation (where applicable).
- **Suitability for measure:** The suitability of the building stock for insulation measures are split between "cavity wall" and solid wall/metal frame. Similarly, only 50% of the stock is deemed suitable for heat pump installation.
- **Annual rates of deployment:** As for residential buildings, supply chain constraints and trigger points for investment decisions will limit the maximum annual uptake of any given measure. Upgrading of 5% of stock per annum has been assumed.

The above indicates an absolute aggregate potential across all measures included in the modelling of close to 3 TWh. This compares to an estimate in the 2015 SEAI report "Unlocking the Energy Efficiency Opportunity" of around 6 TWh[41]. Some of the gap with the earlier report may be attributed to its inclusion of behavioural measures and appliances which are not modelled here. Extensive activity, particularly in lighting upgrades, has also occurred in the interim. The remaining gap may be considered attributable to the conservative assumptions regarding market penetration and availability for upgrades noted above.

[40] https://www.seai.ie/publications/Extensive-Survey-of-Commercial-Buildings-Stock-in-the-Republic-of-Ireland.pdf
[41] https://www.seai.ie/publications/Unlocking-the-Energy-Efficiency-Opportunity-Main-Report.pdf

Processes

The model has adopted the energy savings potential described in the industrial sector cost curve provided in the above-mentioned SEAI report, “Unlocking the Energy Efficiency Opportunity” with the addition of refrigeration potential identified under the commercial and public buildings section (as this was not included in the tertiary buildings analysis above).

As this report was published in 2015, the values provided have been discounted by 30% to approximately reflect reported and projected delivery across the EEOS and LIEN for the current period 2015-2020.

The cost curve included within the SEAI report is relatively flat with little variation in cost per MWh saved between measures. The current cost of non-residential sector credits for Obligated Parties is estimated at €c3.5/kWh-saved (primary energy). This has been converted to €c4.76/kWh-saved in final energy terms. Given the largely flat cost curve and in the absence of more granular data on Obligated Party costs in this area, the same cost per kWh-saved has been assumed to remain constant in real terms through the obligation period 2021-2030.

10% of industrial entities are assumed to be prepared to consider an investment decision for each measure within a specific year to approximately align annual saving potential with the 1% per annum estimate for industrial and commercial sectors described in Section 2.

Public sector

Section 2 on AMs estimated an improvement in energy efficiency in the public sector in the region of 1% of final energy consumption is realistic. 70% of such savings (0.7% of current final energy consumption) was attributed to AMs yielding an estimated cumulative saving over 2021-2030 of 2,541 GWh.

To date EEOS activity within the public sector has been very low as a proportion of overall non-residential activity, due in part to concerns over compatibility with public procurement processes and regulations.

For this reason, potential measures within the public sector have not been included as part of the non-residential sector EEOS modelling reported here. Nevertheless, it is noted that substantial opportunity exists, particularly within public buildings, for involvement by Obligated Parties should these issues be overcome.

The 2015 SEAI report, “Unlocking the Energy Efficiency Opportunity” found potential savings in public buildings of around 2.5 TWh in primary energy terms, with the largest contributors being measures in lighting, heating and building fabric. Undertaking such measures in schools, health centres and public sector offices (constituting approximately 10,000 buildings) are expected to be cost competitive for Obligated Parties with similar measures in commercial buildings. This provides some headroom to the potential opportunity identified above in other non-residential sectors.

Results – non-residential sectors

Base Case – no ring-fencing

The Base Case non-residential scenario assumes no further sectoral ring-fencing. The estimated share of measures over the period 2021-2030 assuming the 25% residential sector target (leaving 75% for the non-residential sector) is shown in Figure 17.

Figure 17 Fulfilment of 75% target by measure type (Base Case – non-residential)

Source: ECA calculation

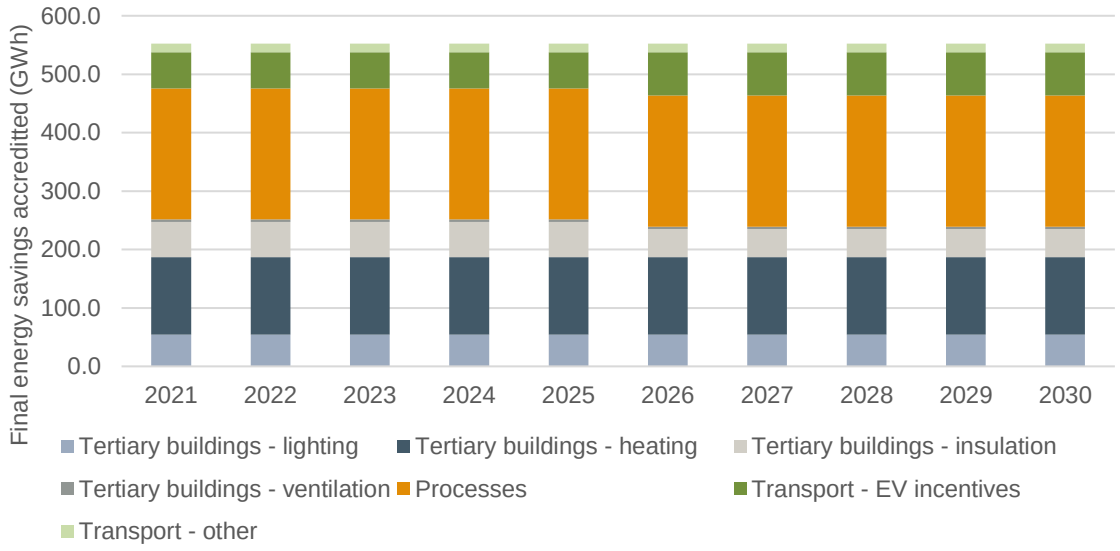
Assuming a target denominated in final rather than primary energy terms improves the relative cost efficiency (from an Obligated Party perspective) of heating as compared to lighting solutions. It also limits the absolute size of the assumed annual market in lighting solutions. These two effects drive the results in Figure 17 that show heating overtake lighting as the primary individual measure. It is noted, however, that in final energy terms costs of heating and lighting measures are considered comparable and should the annual lighting market prove larger than estimated, a more even split is possible. Furthermore, this calculation only considers capital costs with a uniform funding share from the Obligated Party. Heat pumps have an impact on operating costs (due to fuel switching) and therefore these results do not necessarily reflect the “merit order” of energy efficiency measures from a lifetime cost efficiency perspective. This may affect the level of demand and necessary contribution to stimulate activity.

Industrial processes aggregate to around 225 GWh energy savings per annum. This is in line with historical data from 2014-15 of the current EEOS but is higher than that for 2017 when lighting increased its dominance of the non-residential sector. Should the annual potential prove lower than estimated, then activity may shift into less tested and potentially significantly more expensive areas such as incentives for EVs in transport.

Transport measures are dominated by EV incentives despite this being the most expensive among transport measures due to the assumed small energy savings potential estimated for eco-driving, tyre pressure management and fuel additives measures. The low annual contributions from these “other” transport measures is in a large part due to the consideration of their short lifespans and resultant factoring down of accredited annual savings.

Should the residential sector target (inclusive of energy poor) be set to 15% (leaving 85% for the non-residential sector), then the estimated share of measures over the period 2021-2030 is as shown in Figure 18.

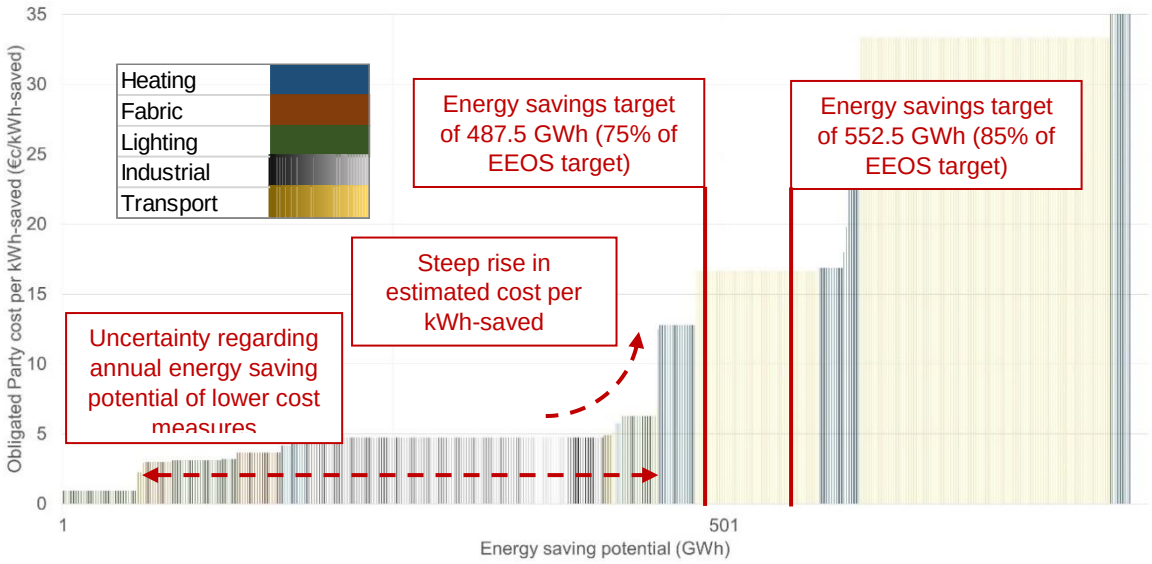
Figure 18 Fulfilment of 85% target by measure type (Base Case – non-residential)



Source: ECA calculation

The additional target is met through EV incentives as the modelled marginal cost measure. It is noted that this result is particularly sensitive to assumptions regarding the annual energy saving potential of heating and lighting measures in commercial buildings and from energy efficiency in industrial processes. As shown in the measure cost curve in Figure 19, should these hold greater annual opportunity than modelled then the marginal cost to Obligated Parties could be substantially lower.

Figure 19 Non-residential sector estimated cost curve (2030)



Note: For viewing purposes x-axis has been truncated; additional energy saving potential, predominantly from EVs, was included in the model at higher costs.

Source: ECA calculation

Table 27 indicates the estimated cost to Obligated Parties per kWh-saved in the sector based on these results.

Table 27 Estimated cost to Obligated Parties for energy efficiency credits (Base Case - non-residential)

	Annual (2021-2030)	Total
Target energy savings credits (Non-residential) (GWh)		
65%	422.5	23,238[1]
75%	487.5	26,813[1]
85%	552.5	30,388[1]
Total subsidy necessary (€M)		
65%	16.1	162
75%	22.4	224
85%	33.1	331
OP non-residential energy saving credit cost (€M)		
65%	0.038	
75%	0.046	
85%	0.058	

Source: ECA calculation

Note 1: Energy saving totals presented are cumulative in nature

These findings suggest little change from current costs under the 75% target with heating system replacement opportunities filling in for the reduced scope for lighting. They are, however, vulnerable to the assumptions made over absolute market size and outturn costs may ramp-up as indicated by the 85% target results should:

- The opportunity in heating system replacement and/or lighting for tertiary buildings be smaller and/or more expensive than estimated. This may be because a smaller share of buildings is deemed suitable for heat pump installation and/or demand is lower due to the lower cost efficiency from a lifetime savings perspective than for lighting solutions.

- The annual market for industrial process measures be smaller than estimated.

In particular, the modelling suggests any deficiency in contribution from the above-mentioned measures may need to be substituted by markedly increased incentives for EVs (as this is the next measure up the merit order). It is important to stress that incentives for EVs by Obligated Parties are an untested measure with substantial uncertainty attached to the incentive rates assumed within the model. Moreover, should costs reduce at the rate envisaged in more aggressive forecasts then the scope for additionality over business-as-usual may narrow substantially in the latter half of the decade at a time cheaper measures are becoming saturated.

Conversely, should the opportunity for lower cost measures in commercial buildings and industrial processes be larger than estimated, and/or incentives for EVs be cheaper to provide than estimated, then the difference in the energy saving credit cost estimates between the 75% and 85% targets may be narrowed considerably.

The impact on the weighted average cost of the EEOS across all sectors is considered in the combined scenario results reported in Section 3.3.4.

Transport ring-fencing

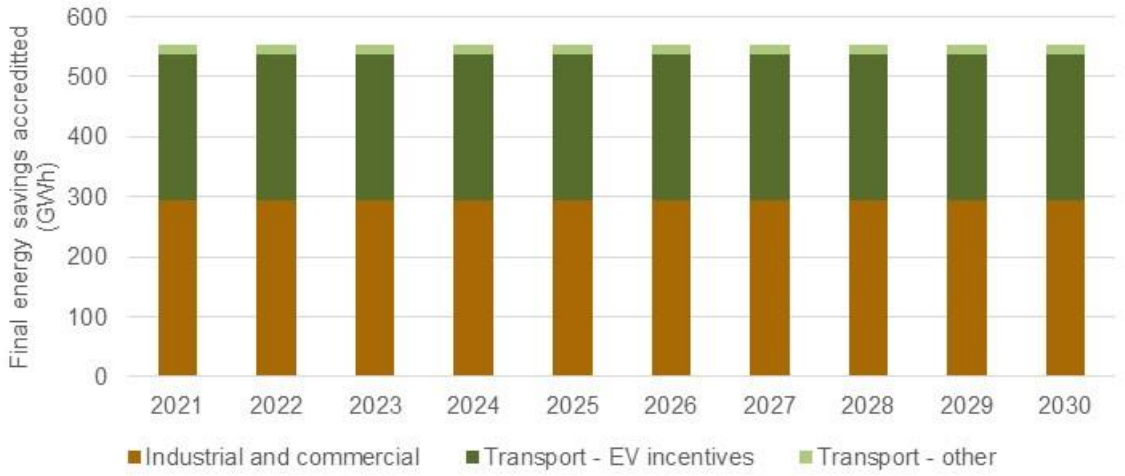
According to the 2017 energy balance of Ireland, transport constituted 43% of final energy consumption. As shown in the above results, leaving freedom of choice for undertaking measures in the non-residential sector will likely result in only a small proportion of the target being met through activity in the transport sector. This is due to the higher estimated cost of energy saved in the transport sector. If additional activity in this sector is desired this may therefore require a specific additional ring-fenced target. This section seeks to estimate the implications of such a target, set to 40% of the total EEOS (i.e. approximately equal to the share of transport in final energy consumption).

Due to the higher costs, this is considered in the context of the lower residential target (15% inclusive of energy poor). Hence, a ring-fenced transport target rounded to 40% leaves 45% for industrial, commercial and public actions. This yields the results shown in Figure 20 and Table 28, with EEOS per kWh-saved costs estimated at €0.26 per annual kWh-saved.

The key result is that transport activity moves into consumer segments for EVs that are estimated to require higher subsidies before committing to purchase decisions. This raises the overall weighted average cost of the EEOS. Should Obligated Parties be restricted to their

own sectors this would be expected to result in a far higher cost per kWh energy saving for transport than other sectors.

Figure 20 Fulfilment of target by measure type (transport ring-fenced – non-residential)



Source: ECA calculation

Table 28 Estimated cost to Obligated Parties for energy efficiency credits (Transport ring-fencing - non-residential)

	Unit	Annual (2021-2030)	Total
Target energy savings credits (Transport)	GWh	260	14,300[1]
Total subsidy necessary	€M	66.5	665
Obligated Party transport energy saving credit cost	€/kWh-saved	0.256	

Source: ECA calculation

Note 1: Energy saving totals presented are cumulative in nature

3.3.4 Combined scenario results

Selection of combined scenarios

In the results for each of Section 3.3.1 to Section 3.3.3, costs associated with those sectors not under investigation were held constant in real terms in order to ease comparison of scenario results.

This section therefore brings the results together under selected composite scenarios designed to provide a representative range of results dependent on choices for scheme design. These are:

- **Base Case:** adopting the Base Case results for residential and energy poor with sectoral targets remaining as at present (i.e. no further ring-fencing within non-residential sector)

- **'Pathway 15' and Enhanced Energy Poor:** This includes:

  - A 15% residential sector target (inclusive of energy poor) under the pathway eligibility criteria provided in Section 3.3.1

  - A 5% energy poor target with the enhanced energy poor eligibility criteria provided in Section 3.3.2

  - The balance of the target (85%) being unallocated and hence open for the non-residential sector

- **Pathway 15, Enhanced Energy Poor and Transport:** This is as above but with a specific ring-fenced target on the transport sector equivalent to its share (40%) in final energy consumption.

Results – combined scenarios

The three sets of results are compared alongside each other in Table 29 below. The ranges provided under the combined scenarios which include the Pathway 15 approach in the residential sector are calculated on the cases of including and excluding the cheapest dwelling type from the model (see Section 3.3.1) to illustrate the sensitivity of results, rather than being an indication of an uncertainty envelope to a stipulated confidence threshold.

Table 29 Estimated cost of EEOS scheme to Obligated Parties under different combination scenarios

	Annual average (2021-2030)	Total
Total savings (GWh)		
All scenarios	650.0	35,750
Total cost to Obligated Parties (€M)[1]		
Base Case	59.2	592
Pathway 15 and Enhanced Energy Poor	64.3 – 72.2	643 – 722
Pathway 15, Enhanced Energy Poor and Transport	107.7 – 115.6	1,078 – 1,156
Energy saving credit cost (€/kWh-saved)		
Base Case	0.09	
Pathway 15 and Enhanced Energy Poor	0.10 – 0.11	
Pathway 15, Enhanced Energy Poor and Transport	0.17 – 0.18	
€c/kWh-sold[2]		

	Annual average (2021-2030)	Total
Base Case	0.045	
Pathway 15 and Enhanced Energy Poor	0.049 – 0.055	
Pathway 15, Enhanced Energy Poor and Transport	0.081 – 0.087	

Source: ECA calculation

Note 1: Assumes full 30% subsidy component for residential sector investments is met by OPs

Note 2: Assumes 97% of all fuel consumption falls under Obligated Parties' sales with costs allocated proportionately, based on consumption trajectory

As noted throughout Section 3, these estimates are based on numerous assumptions and approximations of costs, contributions, volumes, and markets. There is therefore very substantial scope for outturn values to differ markedly from those presented here. Nevertheless, the results provide some guidance on the potential (absolute and relative) impacts both in the expansion of the EEOS target and in refining its sectoral targets and eligibility rules.

3.4 Overall summary

Combining the findings of Section 2 and Section 3 yields the sectoral breakdown shown in Table 30. This is based on the Pathway 15 scenario for the apportionment of sectoral targets within the EEOS – namely 15% residential sector target with 5% of that designated as energy poor. No ring-fencing of transport is included.

Table 30 Overall summary of estimated energy savings by sector and policy measure

Sector	Policy measure	AM savings	EEOS savings	Total
Cross-sectoral	Carbon tax	8,123		8,123
Residential	AM-driven home retrofits	2,070		2,070
	EEOS able-to-pay		3,575	3,575
	EEOS energy poor		1,788	1,788
Industrial and Commercial	All	3,135	25,975	29,110
Public	All	2,541		2,541
Transport	Incentives for EV deployment	3,291	3,586	6,877
	Modal Shift	6,018		6,018
	Other EEOS		826	826
Total		**25,178**	**35,750**	**60,928**

Source: ECA calculation

As discussed in Section 3, while no savings are attributed to the public sector under the EEOS, activity is permitted and cost-effective opportunities are available should current obstacles be overcome.

ANNEXES

A1 Further details on calculation of AMs contributions

A1.1 Summary descriptions for AMs

Carbon tax

Ireland applies a carbon tax to consumers not covered by the EU Emission Trading Scheme (ETS) for the purchase for direct use of carbon emitting fuels. The current rate is €20/tonne, due to rise to €26/tonne in May 2020 and in gradual increments to €80/tonne by end 2030. The contribution of carbon taxes to meeting Article 7 objectives must be estimated using the principles outlined in Annex V Paragraph 4 of the EED. Full details of the calculation included within this report are provided in Annex A1.3 below.

Accelerated Capital Allowance (ACA)

The ACA is a tax incentive scheme that promotes investment in energy efficient products and equipment. The scheme allows a business that pays corporation tax in Ireland to deduct the full cost of the equipment from their profits in the year of purchase (rather than over an 8-year period). As a result, tax payable in that year is reduced by 12.5% of the value of capital expenditure. Over 20,000 eligible products in 52 technologies under the scheme are registered on the Triple E register maintained by SEAI[42] (this is also the reference for Green Public Procurement).

Home Energy Retrofit

This is a composite of front-line SEAI support programmes delivered to address energy poverty and social housing ('can't pay) sectors plus the 'able-to-pay' sector. It covers successors to existing Better Energy Warmer Homes and local authority/ social housing retrofit initiatives, the home component of the Better Energy Communities scheme and the Better Energy Homes subsidy scheme. These programmes can have numerous supporting initiatives (BER advisory reports, minimum BER for rentals, standards, skills initiatives, renovation passports etc.).

Large Industry Energy Network (LIEN)

Continuation of the ongoing SEAI LIEN programme, this is essentially a voluntary energy agreement and support system. It is facilitated by upstream measures such as energy audits, the EXEED (energy efficiency design) system, and Energy Management Systems framework,

[42] https://www.seai.ie/business-and-public-sector/triple-e-register-for-products/

notably through ISO 50001. The LIEN has an intrinsic monitoring and annual reporting requirement for participants.

SME Programme

SEAI-led programme including financial, information and advisory, and training support. For the next EED Article 7 period, this is assumed as a new or revised programme(s) aimed at stimulating and supporting investments in energy savings and energy management in the most energy intensive sub-sectors and across the commercial sector in general.

Public sector energy efficiency programmes

This is a combination of SEAI, Office of Public Works' Optimising Power at Work Programme, and other programmes, including Energy Management System commitments and annual monitoring and reporting obligations. It can include retrofit upgrades to central government buildings (towards also meeting the requirements of EED Article 5) as well as wider public sector buildings, as well as major public facilities such as Irish Water, and is open to including ESCOs / energy performance contracting projects as applicable.

Incentives for EV deployment

Ireland offers a range of stimulus for EV take-up including grants and excise /vehicle registration tax relief, annual motor tax relief, 'benefit in kind' tax treatment, tolling incentive, and charging infrastructure. These may also be supported by a proposed car scrappage scheme.

Modal shift measures

These measures consist of augmentation of public transport and other actions, cutting car usage and congestion. Composite measures to include elements of: cycling and walking infrastructure (including 200 km of new cycling network), DART rail expansion, Dublin Metro Link, commuter rail capacity (carriages), BusConnects Programme, smart ticketing, parking fees, parking restrictions, bike hire schemes, web apps.

A1.2 Monitoring and Verification considerations for AMs

The revised EED Article 7b requires Member States to put in place "measurement, control and verification systems under which documented verification is carried out on at least a statistically significant proportion and representative sample of the energy efficiency improvement measures put in place by the participating or entrusted parties". Such verification has proven difficult for some of the AMs that were proposed for the current period of 2014-2020. Table 31 below therefore provides a brief summary of potential processes for monitoring and verifying the proposed AMs for 2021-2030.

Table 31 Monitoring and verification of AMs

AM	M&V process	Current capacity to quantify and verify	Future potential to quantify and verify
Carbon tax	Economic analysis of impact based on EU guidance concerning use of short-run elasticities, differentiated by fuel type and end-use sector	Robust short-run elasticity estimates are only currently available for the residential sector.	May be improved via the development of additional compliant studies investigating other end-use sectors
ACA	Based on Revenue Commissioners claims data, technology mix and derived engineering calculations. Applying EMEEES guidance	Limited. Lack of data on specific technologies. Currently relies on generic engineering assumptions. Needs more specific granular data to be gathered by Revenue Commissioners and/or surveyed by SEAI.	Compliance with EED requirements could be achieved via additional data granularity gathered by Revenue Commissioners or by SEAI sampling surveys of business sector. Would need to identify potential double counting with other AMs and EEOS
Home Energy Retrofit	Activity and impact data gathered from BER and other data collected on grants database/s - deemed savings plus engineering calculations (applying EMEEES guidance)	High. Evaluation and inspection regimes on incentive programmes enable impact assessment. Attribution to individual measures could be assessed by user surveys.	High. Attribution to enabling measures may be difficult, but the primary issue is the impact of the suite of measures/ initiatives
LIEN	Intrinsic M&R conditions of scheme enable performance improvements to be tracked and reported annually	High. Approximately half of LIEN members operate within framework of ISO 50001 certification or similar Energy Management System (EMS) and all undertaking annual reporting to SEAI. Reporting based on equivalised energy intensity improvements.	High. Within framework of an EMS
SME and commercial sector actions	Depends on the nature of the policy interventions applied, e.g. grants or tax relief databases, energy efficiency product sales data, surveys	Currently limited due to lack of established data channels and survey results where needed.	Can be established

AM	M&V process	Current capacity to quantify and verify	Future potential to quantify and verify
Public sector energy efficiency programmes	Intrinsic M&R conditions of schemes enable performance improvements to be tracked and reported annually	High (as per indicated process).	High
Incentives for EV deployment	Activity and impact data gathered from sales volumes and mix of vehicle types collected on grants database/s relative to counterfactual - deemed savings plus engineering calculations based on official standardised fuel economy data	High. National vehicle registration authority and SEAI databases provide data platforms to assess composite impact. Attribution to individual measures could be assessed by user surveys.	High
Modal shift measures	Based on National Transport Authority (NTA) models and subordinate data sources from local authority traffic data and records from public transport service providers, commuter research data and capacity increases	Medium to high. NTA data can provide a balanced composite picture as well as counterfactual/ BAU projections against which to assess EE impact.	Medium to high. As current. Possibly supplemented by user surveys and EMEEES and methodologies identified in Austrian EEOS

A1.3 Contribution of the carbon tax as an AM

Summary

- Ireland's CAP proposes Ireland's carbon tax to increase from the current level of €20 per tonne to €80 per tonne by 2030.
- The trajectory is not yet defined but a linear increase is assumed over the period.
- Ireland intends to include its carbon tax as an AM for achieving the EED Article 7 obligation.
- Only the taxation rate specifically identified as a carbon tax and above and beyond the minimum rates set by Directive 2003/96/EC is considered for EED Article 7 energy efficiency credits purposes.
- To avoid double counting with other contributing measures, short-run elasticities are adopted for the entire obligation period as per the EU Commission's recommendations.
- A 2016 peer-reviewed study by the ESRI of Ireland has been used as reference for appropriate short-run elasticities to cover all fuel sources within the residential sector.
- International meta-analysis has been used to derive illustrative figures for the commercial, public, industrial and transport sectors – these are not applied to the estimated AM contribution at this stage. Irish specific figures may be sought at a later stage.
- The resulting cumulative energy saving estimate derived from the carbon tax within the residential sector and eligible for contributing towards the Article 7 obligation is approximately 8.1 TWh or 13% of the target.

Context

Action 8 of the CAP for Ireland is to implement a carbon tax rate of at least €80 per tonne by 2030. The Budget 2020 set in motion the first necessary increase to €26 per tonne, already in force for automotive fuels and to apply to all fuel sources from 1 May 2020. The trajectory to € 80 per tonne by 2030 is yet to be specified and "will have regard to considerations on the social and environmental impact" (CAP Annex of Actions, Page 10).

Carbon taxes are an eligible AM for contributing towards Ireland's cumulative end-use energy savings obligation for 2021–2030 as transposed under Article 7 of the revised EED; Directive 2002/2018. Specific requirements apply for taxation measures as set out in Annex V Paragraph 4 of the Directive 2002/2018:

- Credit shall be given only for energy savings from taxation measures exceeding the minimum levels as determined by the EU of taxation applicable.
- Price elasticities for the calculation of the impact of the (energy) taxation measures shall represent the responsiveness of energy demand to price changes

and shall be estimated on the basis of recent and representative official data sources.

- The energy savings from accompanying taxation policy instruments, including fiscal incentives or payment to a fund, shall be accounted separately.

Ireland is required to notify the European Commission of its proposed methodology for operating and reporting on its AMs. In the case of taxation measures the notification should include:

- The target sectors and segment of taxpayers
- The implementing public authority
- The savings expected to be achieved
- The duration of the taxation measure
- The calculation methodology, including the price elasticities used and how they have been established.

This sub-section seeks to outline items 3 and 5 from the above list in order to estimate the likely contribution the proposed carbon tax can have as an AM for achieving Ireland's Article 7 obligation.

Approach to calculation and data sources

Annex IV of the EU Commission's recommendations on transposing the energy saving obligations under the EED is dedicated to the calculation of taxation measures.

Difference between Member State's taxation level and minimum levels under EU Law

As the trajectory for the carbon tax increase to €80 per tonne is yet to be defined, we have assumed a simple linear development from €26 per tonne in 2020 to €80 per tonne in 2030.

The non-carbon component of excise duty applied by Revenue in Ireland exceeds the minimum thresholds set by EU Directive 2003/96/EC for all propellants with the exception of Liquified Petroleum Gas (LPG) where the total rate inclusive of carbon is listed as €96.45 per 1,000 litres. This appears less than the minimum level of €125 per 1,000 litres.

For non-propellants, excise duty on the non-carbon component applied by the Revenue Commissioners in Ireland exceeds the minimum thresholds set by EU Directive 2003/96/EC for all mineral oils. However, no non-carbon component is applied for natural gas and coal and hence the minimum levels set by Directive 2003/96/EC must be subtracted from the carbon tax prior to estimation of its attributable energy savings for EED Article 7. These rates are:

- **Natural gas** at € 2.6 per GJ gross calorific value when used as a propellent, € 0.15 and € 0.30 per GJ gross calorific value when used for heating for business and non-business use respectively, and € 0.3 per GJ gross calorific value for specified other commercial uses. The current Irish Excise Duty rate for natural gas

when not used as a propellent consists solely of a carbon tax component and is set at € 3.70 per MWh gross calorific value, equivalent to approximately €1.03 per GJ. Hence, the contribution above EU minimum rates is €0.73 per GJ gross calorific value for domestic use and €0.88 per GJ for business heating purposes.

- When used as a propellent the rate consists of € 5.66 per MWh non-carbon component and € 3.70 per MWh carbon component. The combined rate is therefore € 9.36 per MWh which is equivalent to € 2.6 per GJ and hence has no eligible margin above and beyond the EU minimum level.

- **Coal and coke** at € 0.15 and € 0.30 per GJ gross calorific value when used for heating for business and non-business use respectively. The Irish Excise Duty rate consists entirely of a carbon component at € 52.67 per tonne, equivalent to approximately € 1.77 per GJ gross calorific value. Hence the contribution above EU minimum rates is € 1.47 per MWh gross calorific value for domestic use and € 1.62 per GJ for business heating purposes.

Article 2 of Directive 2003/96/EC makes specific exception for peat for heating purposes from the minimum levels and hence no minimum threshold is deemed necessary for subtraction. A summary of the calculated eligible carbon tax based on the 2020 level for contributing towards Article 7 obligation is provided in Table 32 below.

Table 32 Eligible carbon tax component by fuel

Fuel	EU minimum rate (€)	Irish non-carbon rate (2020) (€)	Irish carbon rate (2020) (€)	Ineligible component of carbon rate (€)	Effective subtraction to carbon price (€)
As a propellent					
Unleaded petrol	359 / kl	542 / kl	60 / kl	0 / kl	0 / t
Gas oil / diesel	302 / kl	426 / kl	69 / kl	0 / kl	0 / t
Kerosene	302 / kl	426 / kl	51 / kl	0/ kl	0 / t
LPG	125 / kl	64 / kl	33 / kl	61 / kl	39 / t
Natural gas	2.6 / GJ	1.6 / GJ	1.0 / GJ	1.0 / GJ	20 / t
For heating					
Gas oil / diesel	21 / kl	47 / kl	55 / kl	0 / kl	0 / t
Heavy fuel oil	15 / kl	47 / kl	55 / kl	0 / kl	0 / t
Kerosene	0 / kl	0 / kl	51 / kl	0 / kl	0 / t
LPG	0 / kl	0 / kl	33 / kl	0 / kl	0 / t
Natural gas (business)	0.15 / GJ	0 / GJ	1.0 / GJ	0.15 / GJ	2.9 / t
Natural gas (non-business)	0.30 / GJ	0 / GJ	1.0 / GJ	0.3 / GJ	5.8 / t
Coal & coke (business)	0.15 / GJ	0 / GJ	1.8 / GJ	0.15 / GJ	1.7 / t

Fuel	EU minimum rate (€)	Irish non-carbon rate (2020) (€)	Irish carbon rate (2020) (€)	Ineligible component of carbon rate (€)	Effective subtraction to carbon price (€)
Coal & coke (non-business)	0.30 / GJ	0 / GJ	1.8 / GJ	0.3 / GJ	3.3 / t
Electricity (business)	0.5 / MWh	0.5 / MWh	0 / MWh	0 / MWh	0 / t
Electricity (non-business)	1.0 / MWh	1.0 / MWh	0 / MWh	0 / MWh	0 / t
Peat briquettes	NA	0 / t	37 / t	0 / t	0 / t
Milled peat	NA	0 / t	18 / t	0 / t	0 / t
Other peat	NA	0 / t	27 / t	0 / t	0 / t
Other end-uses as specified in Directive 2003/96/EC					
Gas oil / diesel	21 / kl	47 / kl	55 / kl	0 / kl	0 / t
Kerosene	21 / kl	0 / kl	51 / kl	21 / kl	8.3 / t
LPG	41 / kl	0 / kl	33 / kl	33 / kl	26.3 / t
Natural gas	0.30 / GJ	0 / GJ	1.0 / GJ	0.3 / kl	5.8 / t

Sources: ECA calculations based on data drawn from Directive 2003/96/EC and Revenue.ie

Approach to selecting elasticities

The EU Commission's recommendations suggest one of the following approaches be adopted:

- The impact of the taxation measure is assessed using only short-term elasticities across the entire obligation period (2021 – 2030) and estimates for the impact of other policy measures is accounted for separately using bottom-up approaches; or
- A gradual shift from short-term to long-term elasticities is estimated over the course of the obligation period with estimated savings from other policy measures affecting the final energy use to be taxed subtracted from the results.

Our recommendation for reasons of simplicity, capability of available models, and due to the relative contribution of other policy measures expected to exceed that of the carbon tax, is to adopt the first of these approaches.

Data sources for elasticities

For the residential sector we have adopted the short-run elasticities found in the 2016 ESRI paper, "*Analysing Residential Energy Demand: An Error Correction Demand System Approach for Ireland*" by Curtis and Stanley (2016)[43]. This found the following values by fuel type:

[43] The Economic and Social Review, Vol 47, No 2, Summer, 206, pp 185-211

Table 33 Residential sector short-term elasticities

Fuel	Elasticity used
Solid fuels	-0.12
Oil	-0.30
Natural gas	-0.25
Electricity[1]	-0.20

Note 1: No carbon tax is applied for electricity in Ireland as it is addressed within the EU ETS

Source: Curtis and Stanley (2016)

For other sectors, no figures specific to the Irish context and compliant with the EU Commission's recommendations were identified. For illustrative purposes, we have provisionally adopted the findings of the meta-analysis undertaken by Labandeira *et al* (2017, 2015)[44][45]. They are deemed an appropriate initial estimate while elasticities for the Irish specific (or a suitable alternative market that is considered adequately representative, such as the United Kingdom) are sourced. Due to the very significant uncertainties associated with how representative they will prove of the Irish situation, the resulting energy savings calculated from these have not been included in the estimated contribution of the carbon tax as an AM in the main text of this report.

The adopted figures are summarised in Table 34.

Table 34 Non-residential sector short-term elasticities

Fuel	Elasticity used
Gas non-households	-0.18
Electricity non-households	-0.126
Petrol	-0.293
Diesel	-0.153
Oil use for industrial purposes	-0.166[46]

Source: Labandeira *et al* (2017, 2015)

Counterfactual energy consumption

The counterfactual energy consumption figures provided have been derived from the SEAI's National Energy Projections model excluding the effect of the carbon tax.

[44] Labandeira et al (2017) as referenced by Rosenow and Scheuer (2019), *Closing the loopholes: Assessment of the potential impact of tax measures on energy savings claimed under Article 7 of the EED*, Regulatory Assistance Project

[45] Labandeira et al (2015), *A meta-analysis on the price elasticity of energy demand*, Economics for Energy, ISSN no 2172/8437

[46] The figure provided by Labandeira (2015) is a sector-wide figures covering all fuel sources applied here to oil

Estimated contribution

Based upon the above methodology, our estimated eligible energy savings attributable to the carbon tax by fuel and sector is provided in Table 35.

Table 35 Estimated contribution of Ireland's carbon tax to EED Article 7 targets (TWh)

Sector	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Cumulative
Residential only	0.6	0.7	0.7	0.7	0.8	0.9	0.9	0.9	1.0	1.0	8.1

Source: ECA calculation

A2 Input sources and values for EEOS design modelling

A2.1 Inputs for threshold analysis

Table 36 Energy demand projections 2021-2030 (GWh)

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	30,407	33,088	34,218	35,115	35,856	36,383	37,085	37,798	38,658	39,709
Gas	21,405	21,416	21,332	21,274	20,859	20,433	19,935	19,491	19,090	18,726
Oil	79,486	79,530	78,923	77,831	76,507	75,774	74,973	74,053	72,899	71,351
Coal & Peat	4,856	4,630	4,431	4,251	4,085	3,932	3,788	3,651	3,521	3,396

Source: SEAI

Table 37 Administrative cost assumptions (2020 Euros)

Variable administrative costs	Call centre cost per installation	€10.8
Fixed administrative costs	Average salary cost	€39,000
	Number of Full-Time Employees	2.0
Set-up costs	Software	€5,400
	Internal schema process	€83,400
	Familiarisation for staff	€3,200
	Discount rate applied over 10 years	6%

Source: ECA estimates informed by Final Stage Impact Assessment for the Green Deal and Energy Company Obligation, http://www.legislation.gov.uk/uksi/2012/1660/pdfs/uksifia_20121660_en.pdf and Final Stage Impact Assessment: ECO3 http://www.legislation.gov.uk/ukia/2018/145/pdfs/ukia_20180145_en.pdf

A2.2 Inputs for sectoral analysis

Inputs for residential sector and energy poor analysis

Table 38 List of measures considered, assumed investment costs and deemed savings attributed for Base Case scenarios

Measure	Dwelling type	Investment cost (€)	Deemed savings (kWh/yr)
Cavity Wall insulation	House	384 - 15,079	3,250
	Apartment	143 - 302	2,050
Internal wall insulation	House	3,639 – 15,829	5,000
	Apartment	1,353 – 2,861	3,200
External wall insulation	House	5,459 – 23,743	5,900
	Apartment	2,029 – 4,291	3,750
Roof insulation (floor)	House	862 – 2,541	1,300
	Apartment	490 – 762	800
Roof insulation (rafters)	House	4,023 – 11,858	1,171
	Apartment	2,287 – 3,557	457
External doors insulation	House	1,881	495
	Apartment	1,588 – 1,881	186
Improved glazing	House	4,849 – 16,909	700
	Apartment	1,667 – 6,057	450
Natural gas boiler	House	3,200	4,117
	Apartment	2,900	2,617
LPG boiler	House	3,450	4,117
Oil boiler	House	3,570	4,150
Heat pump (air source)	House	7,500 – 9,000	11,946
	Apartment	6,500	3,772
Heat controls	House	1,000	3,083 (factored by 50%)
	Apartment	1,000	942 (factored by 50%)[1]

Source: ECA calculations based on SEAI data

Note 1: In modelling deemed credits for heat controls are factored by 50% to account for a lifespan of 5 years (see main report for explanation)

Table 39 Dwelling types and characteristics

Type	Description	Floor area (m^2)	Number of dwellings
Type 1	Bungalow	100	285,697
Type 2	Detached 2 storey house (small)	126	149,783
Type 3	Detached 2 storey house (large)	280	171,973
Type 4	Semi-detached (small)	95	269,055
Type 5	Semi-detached (insulated)	126	77,388
Type 6	Semi-detached (uninsulated)	126	51,592
Type 7	Semi-detached (large)	160	29,125
Type 8	Terrace 2 storey	100	212,193
Type 9	Apartment (small)	54	87,374
Type 10	Apartment (duplex)	84	52,701
Type 11	Semi-detached 2 storey house	110	138,375

Source: SEAI

Table 40 Application of deep retrofit packages to dwelling types

Building type (floor area)	Unit	Package								
		1c	1i	1e	2c	2i	2e	3c	3i	3e
Type 1 ($100m^2$)										
Initial BER	Band	E2	E2	E2	E2	E2	E2	E2	E2	E2
Initial HLI	W/m^2K	3.84	3.84	3.84	3.84	3.84	3.84	3.84	3.84	3.84
Fabric HLI improvement	W/m^2K	1.17	1.50	1.50	1.48	1.80	1.80	1.61	1.91	1.91
Post-fabric HLI	W/m^2K	2.67	2.34	2.34	2.36	2.04	2.04	2.23	1.93	1.93
FE saved	kWh	12,353	20,883	25,651	17,686	26,216	30,985	22,431	30,961	35,729
Resultant BER	Band	C1	B2	B3	B3	B2	B3	B3	B2	B2
Cost per kWh-saved	€/kWh	0.32	0.76	1.33	0.70	0.95	1.46	0.94	1.10	1.57
Type 2 ($125m^2$)										
Initial BER	Band	C3	C3	C3	C3	C3	C3	C3	C3	C3
Initial HLI	W/m^2K	2.41	2.41	2.41	2.41	2.41	2.41	2.41	2.41	2.41
Fabric HLI improvement	W/m^2K	0.33	0.51	0.51	0.47	0.64	0.64	0.54	0.70	0.70
Post-fabric HLI	W/m^2K	2.08	1.90	1.90	1.94	1.77	1.77	1.87	1.71	1.71

Building type (floor area)	Unit	Package								
		1c	1i	1e	2c	2i	2e	3c	3i	3e
FE saved	kWh	12,954	28,261	36,818	20,276	35,583	44,139	25,217	40,524	49,081
Resultant BER	Band	B2	B1	B1	B2	B1	B1	B1	B1	B1
Cost per kWh-saved	€/kWh	0.77	1.63	2.12	1.18	2.02	2.51	1.46	2.28	2.76
Type 3 (280m²)										
Initial BER	Band	D1	D1	D1	D1	D1	D1	D1	D1	D1
Initial HLI	W/m²K	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22
Fabric HLI improvement	W/m²K	0.65	0.87	0.87	0.81	1.01	1.01	0.88	1.07	1.07
Post-fabric HLI	W/m²K	1.57	1.35	1.35	1.41	1.21	1.21	1.34	1.15	1.15
FE saved	kWh	15,633	31,207	39,912	34,233	49,806	58,512	41,516	57,090	65,795
Resultant BER	Band	B1	B1	B1	B1	B1	B1	B1	A3	A3
Cost per kWh-saved	€/kWh	0.38	0.72	0.92	0.80	1.12	1.32	0.96	1.27	1.47
Type 4 (95m²)										
Initial BER	Band	E2	E2	E2	E2	E2	E2	E2	E2	E2
Initial HLI	W/m²K	3.87	3.87	3.87	3.87	3.87	3.87	3.87	3.87	3.87
Fabric HLI improvement	W/m²K	1.14	1.46	1.46	1.46	1.76	1.76	1.55	1.83	1.83
Post-fabric HLI	W/m²K	2.73	2.41	2.41	2.41	2.11	2.11	2.32	2.04	2.04
FE saved	kWh	11,227	19,093	23,491	18,124	25,991	30,388	23,024	30,890	35,288
Resultant BER	Band	C1	B3	B3	B3	B3	B3	B3	B2	B2
Cost per kWh-saved	€/kWh	0.51	0.85	1.04	0.81	1.13	1.32	1.02	1.33	1.52
Type 5 (125m²)										
Initial BER	Band	C2	C2	C2	C2	C2	C2	C2	C2	C2
Initial HLI	W/m²K	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10
Fabric HLI improvement	W/m²K	0.25	0.39	0.39	0.40	0.53	0.53	0.47	0.60	0.60
Post-fabric HLI	W/m²K	1.85	1.71	1.71	1.70	1.57	1.57	1.63	1.50	1.50
FE saved	kWh	12,342	22,463	28,121	19,664	29,785	35,442	24,605	34,726	40,384
Resultant BER	Band	B1	B1	B1	B1	B1	B1			
Cost per kWh-saved	€/kWh	0.86	1.51	1.89	1.33	1.97	2.34	1.64	2.26	2.63

Building type (floor area)	Unit	Package								
		1c	1i	1e	2c	2i	2e	3c	3i	3e
Type 6 (125m²)										
Initial BER	Band	E1	E1	E1	E1	E1	E1	E1	E1	E1
Initial HLI	W/m²K	3.38	3.38	3.38	3.38	3.38	3.38	3.38	3.38	3.38
Fabric HLI improvement	W/m²K	1.05	1.35	1.35	1.29	1.57	1.57	1.40	1.66	1.66
Post-fabric HLI	W/m²K	2.33	2.03	2.03	2.09	1.81	1.81	1.98	1.72	1.72
FE saved	kWh	12,342	22,463	28,121	19,664	29,785	35,442	24,605	34,726	40,384
Resultant BER	Band	B3	B2	B2	B3	B2	B2	B2	B2	B2
Cost per kWh-saved	€/kWh	0.47	0.82	1.03	0.73	1.07	1.28	0.91	1.24	1.44
Type 7 (160m²)										
Initial BER	Band	C2	C2	C2	C2	C2	C2	C2	C2	C2
Initial HLI	W/m²K	1.91	1.91	1.91	1.91	1.91	1.91	1.91	1.91	1.91
HLI criterion met without fabric upgrade hence results relate to heat pump and controls installation only										
FE saved	kWh					16,347				
Resultant BER	Band					B2				
Cost per kWh-saved	€/kWh					0.61				
Type 8 (100m²)										
Initial BER	Band	D2	D2	D2	D2	D2	D2	D2	D2	D2
Initial HLI	W/m²K	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03
Fabric HLI improvement	W/m²K	0.70	0.90	0.90	1.03	1.22	1.22	1.14	1.32	1.32
Post-fabric HLI	W/m²K	2.33	2.13	2.13	2.00	1.81	1.81	1.89	1.71	1.71
FE saved	kWh	10,771	14,352	16,353	17,668	21,249	23,251	22,568	26,149	28,150
Resultant BER	Band	B3	B2	B2	B2	B2	B2	B2	A3	A3
Cost per kWh-saved	€/kWh	0.62	0.80	0.91	0.97	1.14	1.24	1.21	1.36	1.47
Type 9 (54m²)										
Initial BER	Band	E1	E1	E1	E1	E1	E1	E1	E1	E1
Initial HLI	W/m²K	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24
HLI improvement	W/m²K	0.17	0.31	0.31	0.30	0.43	0.43	0.41	0.53	0.53

Building type (floor area)	Unit	Package								
		1c	1i	1e	2c	2i	2e	3c	3i	3e
Resultant HLI	W/m²K	2.07	1.93	1.93	1.94	1.81	1.81	1.83	1.71	1.71
FE saved	kWh	8,946	10,277	11,021	10,780	12,111	12,854	14,494	15,824	16,568
Resultant BER	Band	B2	B2	B2	B2	B1	B1	B1	B1	B1
Cost per kWh-saved	€/kWh	1.63	1.82	1.95	1.92	2.11	2.24	2.54	2.71	2.83
Type 10 (84m²)										
Initial BER	Band	D2	D2	D2	D2	D2	D2	D2	D2	D2
Initial HLI	W/m²K	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11
HLI improvement	W/m²K	0.16	0.29	0.29	0.38	0.51	0.51	0.48	0.61	0.61
Resultant HLI	W/m²K	1.95	1.82	1.82	1.73	1.60	1.60	1.63	1.50	1.50
FE saved	kWh	9,421	12,235	13,809	16,083	18,898	20,471	20,827	23,641	25,215
Resultant BER	Band	B2	B2	B2	B1	B1	B1	B1	B1	B1
Cost per kWh-saved	€/kWh	0.97	1.23	1.39	1.61	1.85	2.00	2.05	2.27	2.43
Type 11 (110m²)										
Initial BER	Band	C1	C1	C1	C1	C1	C1	C1	C1	C1
Initial HLI	W/m²K	1.91	1.91	1.91	1.91	1.91	1.91	1.91	1.91	1.91
HLI criterion met without fabric upgrade hence results relate to heat pump and controls installation only										
FE saved	kWh	8,107								
Resultant BER	Band	B2								
Cost per kWh-saved	€/kWh	1.22								

Source: ECA modelling

Inputs for non-residential analysis

Table 41 Commercial building types and characteristics

Description	Floor area (m²)	Number of dwellings
Offices (2-storey naturally ventilated)	250	37,800
Offices (6-storey air conditioned)	1,000	4,200
Hotels	750	4,000
Mixed use	250	56,000
Warehouses	750	7,000

Source: ECA estimates guided by SEAI/Element Energy report “Extensive survey of the commercial buildings stock in the Republic of Ireland”

Table 42 List of measures considered for tertiary buildings, assumed investment costs and deemed savings attributed

Measure	Building type	Modelled cost efficiency (€/kWh-saved)	Aggregate savings potential (GWh)	Assumed maximum annual market (GWh)
Cavity wall insulation (U-value 0.31)	Office Natural Ventilation (NV)	2.4	23.2	4.6
	Mixed use (inc retail)	0.9	34.3	6.9
	Warehouse	3.6	7.9	1.6
	Hotels	1.0	3.8	0.8
Solid wall/cladding insulation (U-value 0.15)	Office NV	4.8	66.2	6.6
	Office Air conditioned (AC)	32.8	9.0	0.9
	Mixed use (inc retail)	8.9	70.0	7.0
	Warehouse	13.6	18.4	1.8
	Hotels	5.4	21.0	2.1
Roof insulation (U-value of 0.2 or less)	Office NV	0.8	79.4	7.9
	Office AC	53.1	2.7	0.3
	Mixed use (inc retail)	0.9	122.5	12.3
	Warehouse	11.3	32.8	3.3
	Hotels	2.7	2.3	0.2
Window upgrade (U-value of 1.4 or less)	Office NV	3.4	178.6	17.9
	Office AC	12.5	5.4	0.5
	Mixed use (inc retail)	27.0	264.6	26.5
	Hotels		11.9	1.2
Heat pump (air source)	Office NV	0.6	371.2	37.1
	Office AC	0.6	114.2	11.4
	Mixed use (inc retail)	1.3	272.9	27.3
	Warehouse	4.0	23.2	2.3
	Hotels	0.2	567	56.7
Lighting efficiency	Office NV	0.6	132.3	13.2
	Office AC	0.7	34.2	3.4

Measure	Building type	Modelled cost efficiency (€/kWh-saved)	Aggregate savings potential (GWh)	Assumed maximum annual market (GWh)
	Mixed use (inc retail)	0.7	294.0	29.4
	Warehouse	0.6	52.5	5.3
	Hotels	0.6	30.0	3.0

Source: ECA estimates guided by Ireland's Report on the Development of Cost Optimal Calculations and Gap Analysis for Buildings in Ireland under Directive 2010/31/EU on the Energy Performance of Buildings (RECAST)

Table 43 List of measures considered for transport, assumed investment costs and deemed savings attributed

Measure	Market segment	Cost (€)	FE saving (kWh/yr)	Lifetime	Accredited savings (kWh/yr)
Eco-driving training	LGVs	200	2,197	2	439
	HGVs	2,000	10,169	2	2,034
	Private cars – new driver training	100	415	2	83
Tyre pressure measures for HGVs		240	2,033	2	407
Fuel additives in goods vehicles		18.4	1,783	1	178
Fuel additives in private cars		2.1	155.6	1	15.6
Incentives for Electric Vehicles	Customer segment 1	15,000	6,003	10+	6,003
	Customer segment 2	15,000	6,003	10+	6,003
	Customer segment 3	15,000	6,003	10+	6,003
	Customer segment 4	15,000	6,003	10+	6,003

Note: Assumptions supporting values presented are contained in main text

Table 44 List of measures considered for industry, assumed investment costs and deemed savings attributed

Measure	Market segment	Assumed gross savings potential (GWh)
Motor efficiency		770
Process integration and heat recovery	Low Temperature	1,085
	High Temperature	63
More efficiency refrigeration	Industry	245

Measure	Market segment	Assumed gross savings potential (GWh)
	Commercial buildings	21
More efficient compressed air system		217
More efficient steam system		91

Source: ECA estimates informed by SEAI/Element Energy report, “

A3 Overview of costs and benefits of EEOS design options

A3.1 Introduction

The main text looked at the estimated costs to Obligated Parties (OPs) of fulfilling their EEOS targets under various scheme design options. To assess the broader impact of the design options for society a cost benefit analysis (CBA) must be undertaken. This section therefore contains a high level CBA of the design options. It does not extend to an assessment of the AMs themselves as (a) many AMs are committed initiatives irrespective of the needs of EED Article 7, hence the scope of the main report only extended to estimating their realistic contribution to the national target, and (b) there are a lack of data regarding the cost-effectiveness of the various AMs upon which to base such an assessment.

The Regulatory Assistance Project (RAP) categorised the costs and benefits of Energy Efficiency Obligation schemes in the paper “Costs and Benefits of Energy Efficiency Obligations: A Review of European Programmes” from May 2017[47]. The main factors from that paper together with additional benefits and costs identified by the consultant team are summarised in Table 45.

Table 45 Description of benefits and costs of EEOS

Benefit / Cost	Description
Benefits	
Direct participant benefits	Direct benefit from recipient of energy efficiency measures in terms of energy bill savings and/or increased comfort
Market acceleration benefits[A]	Energy bill saving benefits by consumers who are not direct recipients of subsidy but respond to wider awareness and market availability of energy efficiency products and services
Energy system benefits	Benefits accruing from reduced energy infrastructure costs such as reduced line losses
Other societal benefits	Benefits accruing to society such as reduced emissions not captured in the other listed benefits
Costs	

[47] https://www.raponline.org/wp-content/uploads/2017/04/rap-rosenow-bayer-costs-benefits-energy-efficiency-obligations-2017-may.pdf

Benefit / Cost	Description
Direct programme costs	Costs to OPs for incentivising energy efficiency measures by end consumers
Co-funding subsidy costs[A]	Relates to grant and tax relief subsidies provided by AMs where co-funding with EEOS support (full description on elements considered provided in Section A3.3)
Indirect programme costs[A]	Covers taxation losses through fuel switching as well as the shadow price of public funds which accounts for the deadweight loss caused through the distortionary effects of taxation (due to the unique funding environment of the EEOS which does not flow through general taxation, this is only considered as a sensitivity case)
Direct participant costs	Costs incurred by participating consumers for undertaking energy efficiency measures
OP administrative costs[B]	Includes costs on lead generation, internal administration, reporting, and monitoring and verification
Scheme administration costs	Costs to scheme administrator

Source: RAP, 2017, "Costs and Benefits of Energy Efficiency Obligations: A Review of European Programmes" and consultant proposals

Note A: Consultant team addition, not included in RAP study

Note B: RAP include OP administrative costs within the programme costs

The various costs and benefits are discussed in turn in the following sub-sections with quantification where considered possible. For ease of reading all costs are provided in negative terms (identified using accounting practices with red text and bracketed figures).

These costs and benefits are assessed from a societal level without consideration of any impacts on inequalities. Hence financial transfers between households, enterprises and government are considered neutral with the exception of a sensitivity run regarding the shadow cost of public funds.

Analysis is undertaken for the three "combined scenarios" from Section 3.3.4 of the main text as follows:

- **Base Case:** represents a continuation of the current EEOS design with adjustments to setting targets in final energy terms, restricting measures to those that target end-use efficiency, applying a scaling factor to measures with lifetimes of less than 10 years, and excluding the option of receiving energy savings credits for fossil fuel boilers (due to additionality concerns and in line with the CAP objectives). No further restrictions on measure eligibility are made with regards to whether they form part of a pathway towards the declared CAP objective of achieving at least BER B2 status. Current deemed energy savings credit values are used for modelling purposes, converted to final energy terms[48].

- **'Pathway 15' and Enhanced Energy Poor:** Seeks to tie the EEOS target more firmly to the CAP objectives regarding deep retrofit and the upgrading of homes to BER B2 level by 2030. This involves limiting eligible measures to (1) building

[48] Energy credits for heating controls are also factored by 50% to represent an assumed 5-year lifespan

fabric packages that meet a “heat pump readiness” criterion of a HLI no more than 2.0 W/m^{2}K and (2) concurrent or subsequent **heat pump** installation (with control) that meets at least BER B2 rating. For the Energy Poor sector an additional variation is applied, confining eligible homes to those of BER level E or poorer. Energy saving estimates for retrofit packages have been tailored for eleven different representative dwelling types based on SEAI data. The residential sector ring-fenced target is set to 15% of the overall EEOS target, inclusive of a 5% energy poor sub-target.

- **Pathway 15, Enhanced Energy Poor and Transport:** This is as above but with a specific ring-fenced target on the transport sector equivalent to its share (40%) in final energy consumption.

In all combined scenarios, the annual equivalent final energy savings target for the scheme is set to 650 GWh. In cumulative terms over the 10-year period this equates to approximately 60% of Ireland’s EED Article 7 target. For reference Table 46 summarises the key measures by sector per combined scenario.

Table 46 Summary of main contributing measures by combined scenario

Scenario	Sector	Main contributing measures
Base Case	Residential	Heating controls
	Energy Poor	Remaining cavity wall Heat pumps
	Non-residential	Heat pumps for commercial buildings Lighting upgrades
Pathway 15 and Enhanced Energy Poor	Residential	Retrofit packages involving mix of insulation and heat pumps
	Energy Poor	
	Non-residential	As for Base Case with some additional EV incentives
Pathway 15, Enhanced Energy Poor and Transport	Residential	As for Pathway 15 and Enhanced Energy Poor Scenario
	Energy Poor	
	Non-residential	Incentives for EVs Heat pumps for commercial buildings Lighting upgrades

Throughout this CBA a range is provided for the Pathway 15 and Enhanced Energy Poor combined scenarios (i.e. with and without transport ring-fencing). As discussed in more detail in the main report the higher end of this range reflects the exclusion from the modelling of the most cost-efficient dwelling type. This is because that dwelling type is an outlier among the full cohort and to include it could have the potential for results to be biased by unrealistically assuming activity can be concentrated on this dwelling type.

Wherever a range is given, for consistency the left-hand figure refers to the case where all dwelling types are included in the modelling, while the right-hand figure refers to the case excluding the most cost-efficient dwelling type. It is stressed that the range shown does not represent any specific confidence interval about a central estimate but rather a “best estimate

range" within which all values are considered for the purpose of the analysis to have equal likelihood of occurrence. It is possible, with an unquantified degree of uncertainty, that the actual outturn values will fall outside this range. Key uncertainties are discussed further in the summary section of this report.

A3.2 Benefits

Direct participant benefits and market acceleration benefits

Direct participant benefits can be quantified by the savings on energy bills through reduced demand for each year of the lifetime of the measure. These future benefits must therefore be discounted to estimate the total benefit in present value (PV) terms. This is done using an assumed real terms social discount rate of 4%[49]. The following lifetimes are assumed:

- For heating controls: 5 years
- For residential insulation measures: 30 years
- For deep retrofits: blended lifetime of 20 years
- For non-residential measures: blended lifetime of 10 years

The fuel prices used are listed in Table 47 below. These include applicable carbon costs (from the EU ETS and Ireland's domestic carbon tax) as appropriate at the prevailing rates in 2019. Planned future rises in these costs (and hence benefit gained through their avoidance) has been considered separately in the societal benefits section below.

Table 47 Fuel prices for modelling

Fuel	Price (€c/kWh)		Source
	Domestic	Non-domestic	
Electricity	23.3	15.5	https://www.seai.ie/publications/Domestic-Fuel-Cost-Comparison.pdf and https://www.seai.ie/publications/Commercial-Fuel-Cost-Comparison.pdf
Natural gas	7.2	5.0	
Heating oil[A]	7.9	7.1	
LPG	11.5	11.3	
Solid fuels[B]	5.9	5.9	
Petrol	14.8		https://statbank.cso.ie/multiquicktables/quickTables.aspx?id=cpm04_cpm12 (average values for 12 months to February 2020 taken)
Diesel	12.6		

Note A: Kerosene price taken as proxy for heating oil

[49] This follows the suggested Test Discount Rate for cost-benefit analyses in public sector projects identified by the Department of Public Expenditure and Reform, , https://www.gov.ie/en/publication/public-spending-code/

Note B: Low smoke coal price taken as proxy for solid fuels

For individual measures where electricity is not the only end-use fuel type being saved, the assumed share of existing fuel usage by measure is described in Table 48.

Table 48 Estimated share of originating fuel type for selected measures

Scenario	Fuel	Share of heating (%)	Source[A]
Residential heating (able-to-pay and energy poor) except heat pump packages	Electricity	9%	https://www.seai.ie/publications/Energy-in-the-Residential-Sector-2018-Final.pdf
	Natural gas	35%	
	Heating oil	37%	
	LPG	5%	
	Solid fuels	13%	
Residential heating (able-to-pay and energy poor) heat pump packages	Electricity	9%	As per above but with amendment to reflect expected focus on dwellings off the natural gas grid. This is in line with the Marginal Abatement Cost Curve of the CAP.
	Natural gas	12%	
	Heating oil	60%	
	LPG	5%	
	Solid fuels	13%	
Non-residential heating (Hotels)	Electricity	18%	https://www.seai.ie/publications/Extensive-Survey-of-Commercial-Buildings-Stock-in-the-Republic-of-Ireland.pdf
	Natural gas	18%	
	Heating oil	60%	
	LPG	0%	
	Solid fuels	5%	
Non-residential heating (Office – naturally ventilated)	Electricity	50%	https://www.seai.ie/publications/Extensive-Survey-of-Commercial-Buildings-Stock-in-the-Republic-of-Ireland.pdf
	Natural gas	8%	
	Heating oil	30%	
	LPG	0%	
	Solid fuels	13%	
Non-residential heating (Office – air conditioned)	Electricity	100%	https://www.seai.ie/publications/Extensive-Survey-of-Commercial-Buildings-Stock-in-the-Republic-of-Ireland.pdf
	Natural gas	0%	
	Heating oil	0%	
	LPG	0%	
	Solid fuels	0%	
Industrial measures (share of end-use energy indicated)	Electricity	28%	Energy Balance of Ireland 2019
	Natural gas	42%	
	Heating oil or petroleum coke	14%	
	LPG	2%	

Scenario	Fuel	Share of heating (%)	Source[A]
	Solid fuels or non-renewable waste	14%	
Transport (share of end-use energy indicated)	Diesel	65%	Approximation on share of sales
	Petrol	35%	

Note A: Shares are approximations based on charts provided in the source materials

Both heat pumps and EVs involve fuel switching from other fuel sources. As electricity is generally more expensive than alternative fuel sources, the difference in cost per kilowatt-hour (kWh) between fuel types for the remaining fuel usage post measure implementation must also be considered. The additional cost is equal to the final energy consumption post measure implementation multiplied by the difference in unit price between electricity and the weighted average price of the fuels being substituted. These costs are considered in conjunction with the energy bill savings from reduced fuel use for each year of the lifetime of the measure using the same assumptions as listed above giving a net savings on energy bill expenditure for scheme participants.

Based on these assumptions, the estimated resulting PV of monetary savings (in 2020 Euros terms) from participant energy bills are provided in Table 49. These estimates do not account for any potential free riders (discussed further below). The lower benefits noted in the Pathway 15 and Enhanced Energy Poor (with and without Transport ring-fencing) are partly because these scenarios are more heavily weighted towards fuel switching measures where the additional cost of electricity relative to the replaced fuel reduces the overall savings on energy bills.

Table 49 Estimated direct participant benefits by combined scenario (2021-2030)

Scenario	Sector	PV (2020) of energy bill savings (€M)	Number of measures / homes retrofitted[A]
Base Case	Residential	898.6	722,570
	Energy Poor	252.7	108,012
	Non-residential	3,092.0	
	TOTAL	**4,243.4**	
Pathway 15 and Enhanced Energy Poor	Residential	243.8 - 221.2	31,864 - 36,120
	Energy Poor	207.7 - 199.4	13,142 - 12,610
	Non-residential	3,626.5	
	TOTAL	**4,077.9 - 4,047.0**	
Pathway 15, Enhanced Energy Poor and Transport	Residential	243.8 - 221.2	31,864 - 36,120
	Energy Poor	207.7 - 199.4	13,142 - 12,610
	Non-residential	3,987.3	
	TOTAL	**4,438.8 – 4,407.9**	

Note A: For Base Case this refers to the number of individual measures. More than one measure may be installed in a home although given the narrow focus on a few highly cost-efficient measures such incidences are likely to be limited. For Pathway scenarios the figures refer to number of homes retrofitted with each retrofit constituting a package of measures (see main report).

Effect of additionality and market acceleration benefits

"Free riders" are consumers who receive support but would have undertaken the measure even in its absence, while "free drivers" relates to the market acceleration benefit through consumers who are not direct recipients of subsidy but respond to wider awareness and market availability of energy efficiency products and services. Where possible, the estimated extent of such effects should be estimated and incorporated into deemed energy saving values as per the requirements of EED Article 7[50]. The combined effect is sometimes called the **NGR** which adjusts the "gross savings" that do not account for such effects to "net savings" that do.

The consultants have not undertaken an analysis or update of the SEAI deemed energy saving values when modelling the Base Case. It is considered likely, however, that fossil fuel boiler upgrades and heating controls are the two residential sector measures most likely to be negatively affected by any application of NGR estimates. This is based on previous work by:

- Lees (2008), who found that technologies with a market penetration of greater than 30-40% do not need to be financially incentivised as the share of free riders becomes excessive[51];
- Alberini *et al* (2014) who found free riders to account for 100% of uptake of energy efficient boilers (i.e. zero additionality) under the Italian tax incentive scheme[52]; and
- Winskel M. and Kerr N. (2018) who found that additionality is substantially improved for "supplementary measures" such as insulation as compared to "replacement measures" such as boilers[53].
- The ESRI of Ireland who estimated free riders to constitute over 33% of recipients of Better Energy Home heating control grants[54]. In contrast ESRI found that only 7% of recipients of boiler (with heating control) upgrade grants were free riders although it is the consultants' understanding that this is based on a counterfactual of no retrofit, implying that the existing boiler could continue to operate without replacement.

Fossil fuel boiler upgrades are not permitted under the Base Case. In the case of heating controls for able-to-pay residential consumers an **NGR of 0.67** is assumed to reflect the

[50] See Page 123 of https://ec.europa.eu/energy/sites/ener/files/documents/c_2019_6621_-_annex_com_recom_energy_savings.pdf
[51] Cited by Du Can S. (2014). Design of incentive programs for accelerating penetration of energy-efficient appliances Energy Policy, 72, 56–66
[52] https://www.climatexchange.org.uk/media/3146/cxc-epe-evidence-review-full-report.pdf
[53] Ibid.
[54] https://www.sciencedirect.com/science/article/abs/pii/S0301421518301897?via%3Dihub

findings of ESRI[55]. For all other measures an **NGR of 1.0** has been assumed. This effectively assumes the free rider and market acceleration effects cancel out and is broadly consistent with estimates calculated for various energy efficiency programmes in the United States[56].

All the above findings are focused on the broader residential sector and may not apply to low income households where timely of equipment replacement is less likely. An NGR of 1.0 has therefore been applied for all measures in the energy poor sector, including for heating controls.

Free riders, at least in the residential sector, are expected to be low within the residential sector for the Pathway 15 and Enhanced Energy Poor combined scenario due to the focus on deep retrofits and heat pump installation with low levels of penetration to date. With transport-ring-fencing, in the non-residential sector early years are likely to have low levels of free riders due to low market penetration of EVs but this may quickly change through the course of the decade.

It is possible that the focus on low market penetration measures in the Pathway 15 and Enhanced Energy Poor scenarios (with and without transport ring-fencing) could yield a higher NGR in these cases due to **market acceleration benefits**, or "free drivers". The use of incentives to accelerate the process of early and mass adoption is a well-established rationale for policy intervention. It is particularly relevant where system-change is being targeted and large-scale uptake is dependent on the availability of wider supporting infrastructure.

Given the Base Case concentrates on relatively mature products the multiplier benefit from market acceleration is likely to be lower than in the alternative combined scenarios which have the explicit intent of helping drive structural change in the market. This is particularly relevant for the increased uptake of heat pumps and EVs. The importance of market transformation through electrification is a key objective of Ireland's CAP. Assessment of this benefit is therefore considered qualitatively with respect to the alignment of each combined scenario with the CAP in Table 50. A check on the sensitivity of the Pathway approach in the residential sector using an NGR of 1.25 is also reported below.

Table 50 Qualitative summary of market acceleration benefits by combined scenario

Scenario	Notes regarding alignment with CAP
Base Case	**Loosely aligned:** Activity in the Base Case Scenario is expected to remain concentrated on shallow measures including heating controls and the remaining potential for cavity wall insulation. Some increased activity is, however, expected regarding heat pump installation but little overall support for progress towards BER B2 standard objectives.
Pathway and Enhanced Energy Poor	**Largely aligned:** The Pathway approach for the residential sector ensures activity aligns with the CAP objectives of heat pump roll-out, deep renovation, and the delivery of dwellings to BER B2 standard. The "Enhanced" criteria for Energy Poor households

[55] This NGR is not additional to the downgrade of 50% to the deemed energy saving credits applied in the main model in order to reflect their 5-year lifetime. Rather this CBA considers the present value of the actual estimated additional savings over the 5-year period following installation.
[56] See https://www.energytrust.org/wp-content/uploads/2017/07/FR_Spillover_170206.pdf and http://www.synapse-energy.com/sites/default/files/NTG-Research-14-053.pdf for a discussion on calculation approaches for NGR and example values from the United States

Scenario	Notes regarding alignment with CAP
	additionally aligns with the objective of moving dwellings out of energy poverty.
Pathway, Enhanced Energy Poor and Transport	**Fully aligned:** This combined scenario builds on the Pathway and Enhanced Energy Poor approach by also seeking to support the transition of passenger cars towards EVs.

The amended table for net participant benefits inclusive of market transformation effects is given in Table 51 below.

Table 51 Estimated net participant benefits (inclusive of market transformation effects) by combined scenario (2021-2030)

Scenario	Sector	PV (2020) of energy bill savings (€M)	Number of measures / homes retrofitted[A]
Base Case	Residential	683.7	722,570
	Energy Poor	252.7	108,012
	Non-residential	3,092.0	
	TOTAL	**4,028.5**	
Pathway 15 and Enhanced Energy Poor	Residential	243.8 - 221.2	31,864 - 36,120
	Energy Poor	207.7 - 199.4	13,142 - 12,610
	Non-residential	3,626.5	
	TOTAL	**4,077.9 - 4,047.0**	
Pathway 15, Enhanced Energy Poor and Transport	Residential	243.8 - 221.2	31,864 - 36,120
	Energy Poor	207.7 - 199.4	13,142 - 12,610
	Non-residential	3,987.3	
	TOTAL	**4,438.8 – 4,407.9**	

Note A: For Base Case this refers to number of individual measures. More than one measure may be installed in a home although given the narrow focus on a few highly cost-efficient measures such incidences are likely to be limited. For Pathway scenarios the figures refer to number of homes retrofitted with each retrofit constituting a package of measure (see main report).

A sensitivity case with an NGR of 1.25 applied to all measures in the residential sector under the Pathway 15 approach is estimated to raise the PV of participant benefits under the lower cost case from €243.8 million to €408.8 million.

Energy system benefits

RAP defines energy system benefits as benefits accruing from reduced energy infrastructure investment and operations costs. Care should be taken when identifying the proportion of such benefits that are additional to those already captured within the energy bills savings estimate. Retail bills are an aggregation of the supply chain. For electricity this includes generation, transmission, distribution and retail costs together with participant margins while for solid fuels

it is extraction, processing, shipping, distribution and retail (with margins). In the above estimate of direct participant benefits static real terms energy prices were assumed.

However, as demand reduces so the marginal supplier which sets the wholesale price for a given trading period will change. There are also changes in the capacity requirements and level of losses faced by transmission and distribution networks. To estimate this effect for electricity (including any impact on reserve requirements) would require dispatch and power flow modelling of the Integrated Single Electricity Market (I-SEM) of the island of Ireland. This has not been undertaken as part of this study, but any impact is expected to be minor as compared to other benefits discussed here. For imported fossil fuels the impact on the marginal cost of supply is likely to be negligible.

Societal benefits

Societal benefits include externalities not captured through current energy bills[57]. This includes environmental emissions costs above and beyond those imposed through the EU ETS and Ireland's carbon tax, as well as health and other benefits from improved energy efficiency. The above assessment of direct participant benefits assumed no real terms increase in the price of each fuel type and thus implicitly assumed the cost of carbon also remains constant in real terms. The 2019 Department of Public Expenditure and Reform paper on Valuing Greenhouse Gas Emissions in the Public Spending Code[58] provides price trajectories for considering the social cost of emissions to 2050 by Irish authorities. Separate trajectories are provided for sectors covered by the EU ETS and non-ETS sector and have been used in this analysis as follows:

- **Sectors covered by the EU ETS:** This is assumed to cover all electricity savings from EEOS measures. It remains constant at €23.6/t until 2025 before rising to €33.5/t by 2030 and on to €50/t by 2040, then €88/t by 2050. Only the increase above the 2019 level of €23.6/t is applied to avoid double counting with the energy bill saving benefits estimated above. As the lifetime of some measures installed in later years of the scheme may extend beyond 2050, the rate for 2050 is applied to all subsequent years.

- **Non-ETS sectors**: This trajectory reaches €100/t by 2030, €163/t by 2040 and €265/t by 2050. Again, only the differential in price above the level for 2019 (€20/t) has been applied. SEAI emissions factors have been used[59] except for electricity where a linear trajectory is assumed from 375 gCO_2/kWh in 2018 down to 135 gCO_2/kWh in 2030 and then again between 2030 and 38 gCO_2/kWh in 2050 (necessary due to lifetime of measures extending beyond 2030). All values for 2050 are then held constant for subsequent years.

Applying the above calculations yields the results shown in Table 52. The high financial/ economic benefit from savings achieved in the residential sector relative to the estimated tonnage of carbon savings is due to this sector having a smaller share of electricity supply for

[57] The effect of the forecast increase in Ireland's Carbon Tax on future energy prices has not been considered in the energy bill savings estimate.
[58] https://igees.gov.ie/wp-content/uploads/2018/11/Valuing-Greenhouse-Gas-Emissions.pdf
[59] https://www.seai.ie/data-and-insights/seai-statistics/conversion-factors/

which the EU ETS price has been assumed to be fully captured by the retail price of energy bills. Calculations include application of the NGR rates described above.

Table 52 Estimated carbon emission avoidance benefits by combined scenario (2021-2030)

Scenario	Cost / benefit	PV (2020) of benefit of savings from new measures (€M)	Annual carbon savings in 2030 (t)
Base Case	Residential	171.1	268,873
	Energy Poor	50.1	88,103
	Non-residential	351.0	792,033
	TOTAL	**572.2**	**1,117,009**
Pathway 15 and Enhanced Energy Poor	Residential	185.5 – 186.1	194,317 – 195,861
	Energy Poor	90.3 – 90.5	90,194 – 91,291
	Non-residential	440.5	1,009,456
	TOTAL	**716.3 – 717.2**	**1,293,967 – 1,262,887**
Pathway 15, Enhanced Energy Poor and Transport	Residential	185.5 – 186.1	194,317 – 195,861
	Energy Poor	90.3 – 90.5	90,194 – 91,291
	Non-residential	557.0	1,326,881
	TOTAL	**832.7 – 833.6**	**1,611,392 – 1,614,033**

The carbon impact varies between combined scenario due to the differences in emissions factors of the fuels being saved under the portfolio of measure types. However, under all combined scenarios carbon savings in excess of 1 Mt per annum are forecast by 2030 as a result of the new measures implemented in the period 2021-2030 by the EEOS.

There are potentially further societal benefits which have not been estimated here. Notable among these are wider macroeconomic benefits including the impact on employment. Ascertaining the net benefit on employment is a non-trivial exercise but previous labour market analyses elsewhere in the EU have noted the net positive effects of energy efficiency financing programmes on public budgets[60].

A3.3 Costs

Direct programme costs

Estimations of direct programme costs were the key focus of analysis covered in the main report. These costs were estimated under different scenarios for each of the residential (able-

[60] https://www.kfw.de/migration/Weiterleitung-zur-Startseite/Homepage/KfW-Group/Research/PDF-Files/Energy-efficient-building-and-rehabilitation.pdf

to-pay), energy poor, and non-residential sectors. They have been based on the modelled roll-out of energy efficiency measures over the ten-year period in each sector, ranked based on cost-effectiveness subject to the constraints applied. Further details regarding the cost calculations are provided within the main report.

Summary estimates of the total subsidy cost under each "combined scenario" are replicated in Table 53 below.

Table 53 Estimated direct programme costs by combined scenario (2021-2030)

Scenario	Sector	PV (2020) of costs (€M)
Base Case	Residential	(192.4)
	Energy Poor	(103.0)
	Non-residential	(180.7)
	TOTAL	**(476.2)**
Pathway 15 and Enhanced Energy Poor	Residential	(82.5) – (98.3)
	Energy Poor	(170.6) – (219.0)
	Non-residential	(268.0)
	TOTAL	**(521.1) – (585.3)**
Pathway 15, Enhanced Energy Poor and Transport	Residential	(82.5) – (98.3)
	Energy Poor	(170.6) – (219.0)
	Non-residential	(620.9)
	TOTAL	**(873.9) – (938.2)**

As identified in the main report, the total subsidy requirement is lowest in the Base Case. This is because the other scenarios impose tighter restrictions on eligible measures and hence by design lower the cost efficiency on a straightforward subsidy per kWh-saved basis.

Indirect programme costs

Excise duty, VAT and Motor Tax foregone

Fuel switching to electricity for EVs has a cost to the exchequer from the relatively lower taxation on electricity. These encompass:

- **Excise duty:** Current excise duty rates are €425.72/1,000 litres for diesel and €541.84/1,000 litres for petrol. No excise duty is applied for electricity.
- **VAT:** diesel and petrol are charged at a rate of 23% following application of all other taxes as opposed to 13% for electricity.
- **Motor Tax:** Electric cars are categorised as A0 band and incur an annual payment of €120. The counterfactual benchmark assumes an average A4 band

for diesel cars with annual motor tax rate of €200 and an average B2 band for petrol cars with annual motor tax rate of €280.

The resulting additional cost to the non-residential scenarios is summarised in Table 54.

Table 54 Estimated taxation revenue foregone by combined scenario (2021-2030)

Scenario	Sector	PV (2020) of costs (€M)
Base Case	Residential	(0.0)
	Energy Poor	(0.0)
	Non-residential	(30.8)
	TOTAL	**(30.8)**
Pathway 15 and Enhanced Energy Poor	Residential	(0.0) – (0.0)
	Energy Poor	(0.0) – (0.0)
	Non-residential	(543.2)
	TOTAL	**(543.2) – (543.2)**
Pathway 15, Enhanced Energy Poor and Transport	Residential	(0.0) – (0.0)
	Energy Poor	(0.0) – (0.0)
	Non-residential	(1,974.9)
	TOTAL	**(1,974.9) - (1,974.9)**

Shadow price of public funds

In undertaking an economic appraisal of public expenditure in Ireland, the parameters of the Public Spending Code should be applied[61]. These include the "shadow price of public funds" which is applied to account for the deadweight loss caused through the distortionary effects of taxation. The current rate applied in Ireland is **130%**. In the EEOS the subsidies are recovered through energy bills rather than taxation. As the shadow price of public funds is dependent on the tax rate and structure the suitability of the 130% rate for the EEOS is uncertain. Nevertheless, the socialisation of EEOS costs across energy bill payers is likely to incur some distortionary impact.

A sensitivity case where the 130% factor is applied to EEOS subsidy costs as well as administration costs, has therefore been tested and reported in the summary below. The same factor has not been applied to co-funding subsidies from AMs in order to ensure this CBA remains focused on the costs and benefits of the EEOS as opposed to the package of policy measures. In this sensitivity case taxation foregone as a result of fuel switching as discussed above is discounted by the same 130% factor for consistency.

[61] https://www.gov.ie/en/publication/public-spending-code/

Direct participant and co-funding costs

Direct participant costs reflect the balance of investment costs other than the EEOS subsidy. These are met either by the consumer or by co-funding through an AM. Additional operating costs due to fuel switching measures were accounted for in the estimation of direct participant benefits discussed above. Other variations in operating and maintenance costs have not been accounted for in this analysis.

For pure energy efficiency measures (measures with the sole utility of improving end-use energy efficiency such as cavity wall insulation) the balance of investment costs amounts to the difference between total investment cost and EEOS subsidy provided. For other investments, such as EVs and heat pumps, using the full investment cost would not be appropriate. This is because their sole utility is not energy efficiency. Rather, by assuming purchase at the time of natural replacement[62] there will in many cases be an avoided cost of the equivalent new "inefficient" product. Only the additional cost relative to the counterfactual should be considered. This additional cost is therefore a combination of the cost of the energy efficient product relative to the equivalent inefficient product with an uplift to cover purchases where in the counterfactual case there would have been further delays to replacing the old inefficient product despite it having reached the end of its design life. To calculate this:

- For **EVs** the additional cost equates to the difference in investment cost of the EV against that of an equivalent specified ICE car. For the modelling undertaken in the main report this was estimated for a typical car to be €15,000 per car. The consumer base was separated into "willingness to pay" bins dependent on the contributions assumed to be necessary by an OP to initiate an investment decision. Excluding consumers who are deemed willing to pay without any support from an OP (and hence not additional to business-as-usual), contributions of between €1,000 and €5,000 per car were assumed.

  These contributions were deemed to be additional to any support through VRT relief and SEAI grants which are assumed to decline from €10,000 in 2020 by €1,000 per year to reach zero by 2030. This is assumed to match a cost reduction trajectory equivalent to €1,000 per year meaning that by 2030 the EV premium is reduced to €5,000 per car with no VRT/grant support available. This means the net position faced by consumers and OP contributions remains constant over the 2021-2030 period.

  It is further assumed that in all cases, were an EV not purchased, the equivalent ICE counterfactual would still have been purchased (i.e. the subsidy does not in this case also incentivise early replacement).

- For **residential heat pumps (with integrated heating controls)** half the investment cost of an equivalent efficient new fossil fuel boiler (with adjustment to account for different lifespans of the technologies) has been assumed as the counterfactual. This is to account both for the lower price of an inefficient fossil fuel boiler and the expectation that the availability of subsidies will likely drive a

[62] In this case the materiality condition requires that the incentive provided results in purchase of a more energy efficient product than would have been purchased in a counterfactual case

degree of early replacement of boilers even among those at the end of their design life[63].

- For **non-residential sector heating systems,** a conservative approach has been taken where the full investment cost has been taken. This is to be consistent with the estimation of energy savings in the main report for non-residential uses that take the existing reference buildings as the baseline for calculation, rather than the marketplace average of new products.

A summary of consumer investment costs and co-funding based on the above calculations by combined scenario is provided in Table 55.

Table 55 Estimated direct participant and co-funding costs by combined scenario (2021-2030)

Scenario	Sector	PV (2020) of Consumer Costs (€M)
Base Case	Residential	(432.4)
	Energy Poor	(51.5)
	Non-residential	(2,484.4)
	TOTAL	**(2,968.3)**
Pathway 15 and Enhanced Energy Poor	Residential	(137.7) – (167.4)
	Energy Poor	(62.7) – (87.8)
	Non-residential	(3,252.3)
	TOTAL	**(3,452.7) – (3,507.5)**
Pathway 15, Enhanced Energy Poor and Transport	Residential	(137.7) – (167.4)
	Energy Poor	(62.7) – (87.8)
	Non-residential	(3,923.9)
	TOTAL	**(4,124.3) – (4,179.1)**

Energy Poor consumers are assumed in all scenarios to have their additional costs to be met entirely by subsidy in all cases and hence there are no direct participant costs. The residential (able-to-pay) sector sees participant costs increase under the Pathway scenario due to the higher cost of measures implemented than in the Base Case. Ring-fencing transport increases costs again for the same reason as for direct programme costs – the tighter restrictions on eligible measures forcing activity further away from where the most cost-efficient savings (from a direct investment cost per unit energy saved perspective) can be found.

[63] While 10-15 years is typically considered the natural lifetime of fossil fuel boilers, a UK government survey found that up to 45% of households had not replaced their boiler in the previous 15 years, that only 58% expected to replace it every 15 years, and that waiting for a system breakdown was the most common trigger for an investment decision https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/191541/More_efficient_heating_report_2204.pdf

Obligated Party administrative costs

These include the fixed and variable administrative costs borne by the OPs in delivering their targets. These were estimated at the entity level as part of the main report. The level of aggregate costs will depend on the number of OPs (as fixed costs do not scale with target size). Using data from 2018 and applying an annual energy sales threshold of 400 GWh together with the "Free Allowance" approach (see main report) yields an annual average OP administration cost across all combined scenarios of **(€2.6) Million per year**.

It is recognised that the additional complexity (including perhaps in business model for delivery of measures) that will be imposed by the Pathway and Enhanced Energy Poor scenarios may raise these administration costs for OPs. This effect has not been quantified here.

Scheme administration costs

These have not been estimated in bottom-up manner as part of this analysis. Based on previous analyses by RAP of European EEO schemes, such costs should represent less than **1% of total programme costs** (Direct programme costs and OP administrative costs). For the Base Case, which most closely reflects the schemes analysed in the RAP study, this would result in costs of approximately **(€0.5) Million per year.** As for the OP administrative costs**, c**hanges in EEOS design will impact on the scheme administrator's workload and associated costs, however these are not expected to scale linearly with the increase in direct programme costs. Therefore, given the approximations in the above calculation, the same cost has been applied to all three combined scenarios.

A3.4 Cost benefit summary

Summary by benefits and costs

For benefits and costs where quantification was undertaken the above calculations are summarised in Table 56 excluding any uplift for the shadow price of public funds. Summary net benefit values have been rounded to nearest €100 Million to avoid implying unjustified accuracy.

Table 56 Summary of estimated net benefits (no shadow price of public funds)

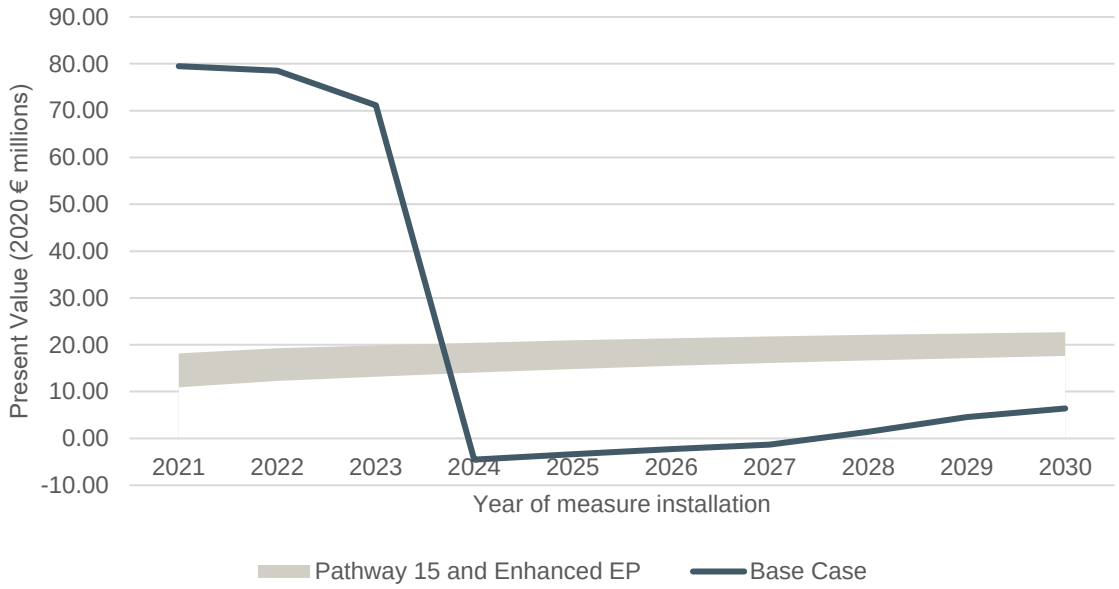
Scenario	Benefit or Cost		PV (2020) costs and benefits (€M)
Base Case	Benefits	Direct participant benefits (net)	4,028.5
		Societal (carbon) benefits	572.2
		Gross benefit	**4,600.7**
	Costs	Direct programme costs	(476.2)
		Indirect programme costs	(30.8)

Scenario	Benefit or Cost		PV (2020) costs and benefits (€M)
		Direct participant and co-funding costs	(2,968.3)
		OP administrative costs	(21.1)
		Scheme administrative costs	(4.1)
		Gross cost	**(3,500.5)**
	NET BENEFIT		**1,100**
Pathway 15 and Enhanced Energy Poor	Benefits	Direct participant benefits (net)	4,077.9 - 4,047.0
		Societal (carbon) benefits	716.3 – 717.2
		Gross benefit	**4,794.2 – 4,764.2**
	Costs	Direct programme costs	(521.1) – (585.3)
		Indirect programme costs	(543.2) – (543.2)
		Direct participant and co-funding costs	(3,452.7) – (3,507.5)
		OP administrative costs	(21.1)
		Scheme administrative costs	(4.1)
		Gross cost	**(4,542.2) – (4,661.2)**
	NET BENEFIT		**300 – 100**
Pathway 15, Enhanced Energy Poor and Transport	Benefits	Direct participant benefits (net)	4,438.8 – 4,407.9
		Societal (carbon) benefits	832.7 – 833.6
		Gross benefit	**5,271.5 – 5,241.5**
	Costs	Direct programme costs	(873.9) – (938.2)
		Indirect programme costs	(1,974.9) - (1,974.9)
		Direct participant and co-funding costs	(4,124.3) – (4,179.1)
		OP administrative costs	(21.1)
		Scheme administrative costs	(4.1)
		Gross cost	**(6,998.3) – (7,117.4)**
	NET BENEFIT		**(1,700) – (1,900)**

The Base Case results and the Pathway 15 and Enhanced Energy Poor scenario both show an overall positive net benefit. The Base Case has by a margin the highest net benefit although this result is sensitive to small changes in the assumed measure mix for non-residential sector credits in the Pathway 15 and Enhanced Energy Poor combined scenario (see below for full discussion on cost curve sensitivities).

It is also informative to show the results for these sectors by year of measure installation. This is shown in Figure 21 and Figure 22 below.

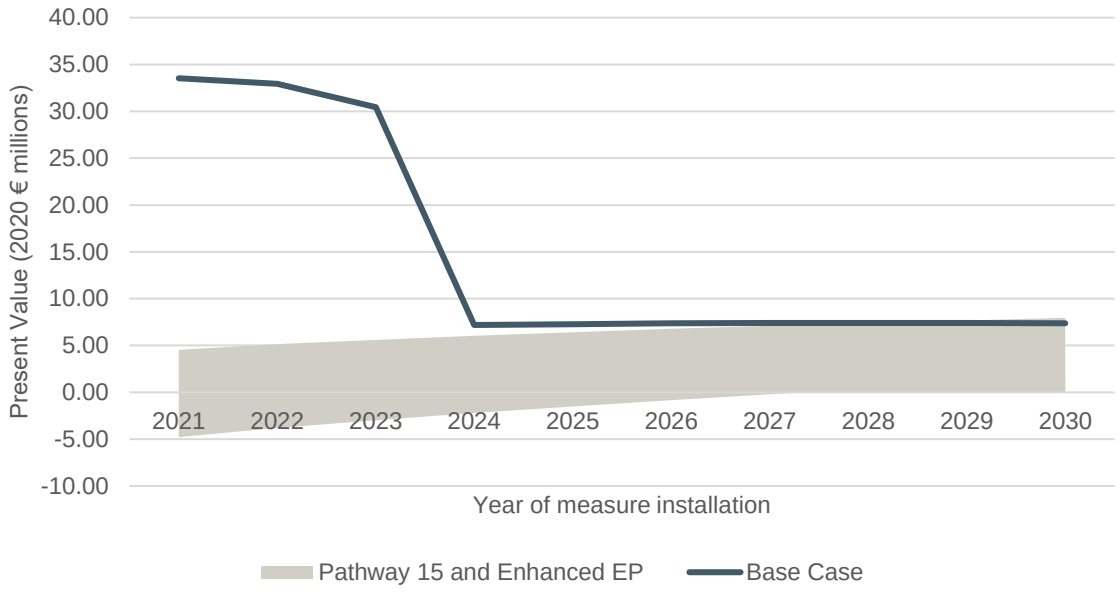
Figure 21 Residential (able-to-pay) sector estimated PV of annual installations



Source: Consultant estimates

The residential sector results demonstrate that PV of the Base Case for the residential sector is entirely driven by the modelled deployment of the remaining cavity wall insulation potential in the first 3 years of the scheme (2021-2023 inclusive). From 2024 to 2030 the Base Case target is largely met through heating controls during which the net benefit of the Pathway 15 scenario is expected to be substantially superior.

Figure 22 Energy poor sector estimated PV of annual installations



Source: Consultant estimates

For the energy poor sector the profiles for each scenario are similar to the residential (able-to-pay) sector but with a substantial offset between the lines meaning that even post 2024 the Base Case is estimated to provide at least as high a net benefit as the "Pathway 15 and Enhanced EP" scenario. This is due in part to the higher additionality assumption for heating controls in the energy poor sector. The "Enhanced" criteria (requiring homes to be of BER level E or poorer prior to intervention) may be associated with a net cost at least in the early years, indicating it may have an equivalent cost of carbon slightly beyond that assumed in the Marginal Abatement Cost Curve.

Summary by sector

Summarising instead by sector yields the results shown in Table 15. These results do not include OP and scheme administration costs which are cross-cutting across all sectors.

Table 57 Summary of estimated net benefits by sector (no shadow price of public funds)

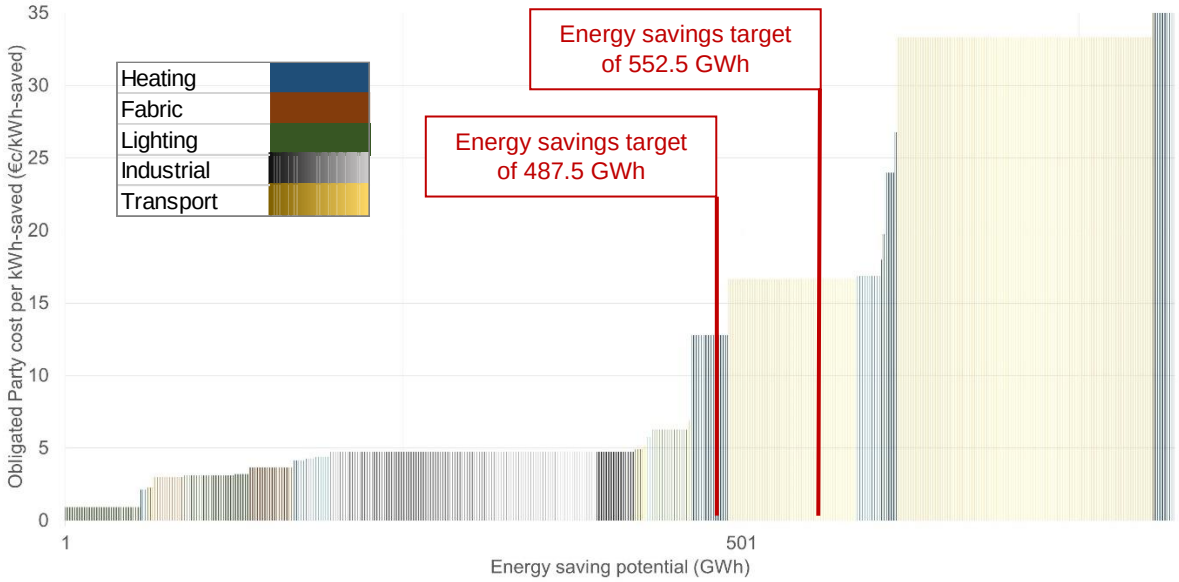
Scenario	Sector	PV (2020) of net benefits (€M)
Base Case	Residential	230.0
	Energy Poor	148.3
	Non-residential	747.1
Pathway 15 and Enhanced Energy Poor	Residential	215.7 – 148.2
	Energy Poor	74.2 – (13.6)
	Non-residential	3.5

Scenario	Sector	PV (2020) of net benefits (€M)
Pathway 15, Enhanced Energy Poor and Transport	Residential	215.7 – 148.2
	Energy Poor	74.2 – (13.6)
	Non-residential	(1,975.4)

Sensitivity to cost curves

Results are sensitive to the underlying sectoral cost curves estimated for the analysis. This is particularly true for the non-residential sector where an allocation of 75% or 85% equates to an aggregate final energy savings target of 487.5 GWh per year or 552.5 GWh per year respectively. Figure 23 and Figure 19 provide the non-residential sector cost curve estimated to be available to OPs (given annual deployment limits discussed in the main report) for 2021 and 2030 respectively, indicating the annual target. As can be seen, it is estimated that the proposed targets sit near a potential inflection point in the curve where lower cost measures – particularly in heating and lighting upgrades to commercial buildings – become saturated. It is recognised that the energy saving potential estimates underpinning these cost curves are subject to significant uncertainty and hence the marginal cost of energy efficiency for the non-residential sector target may differ substantially from that shown. This is reinforced by the additional uncertainty associated with the necessary level of incentives for EV uptake given the lack of historical precedent for this measure (see main report for full explanation).

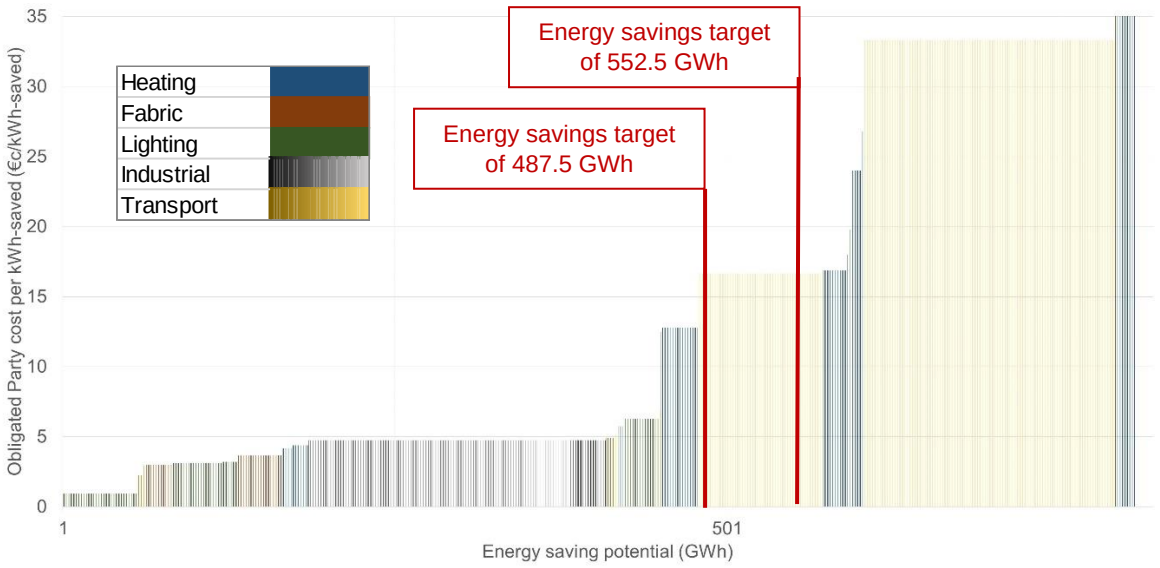
Figure 23 Non-residential sector cost curve (2021)



Note: For viewing purposes x-axis has been truncated; additional energy saving potential, predominantly from EVs, was included in the model at higher costs.

Source: ECA calculations for main report

Figure 24 Non-residential sector cost curve (2030)



Note: For viewing purposes x-axis has been truncated; additional energy saving potential, predominantly from EVs, was included in the model at higher costs.

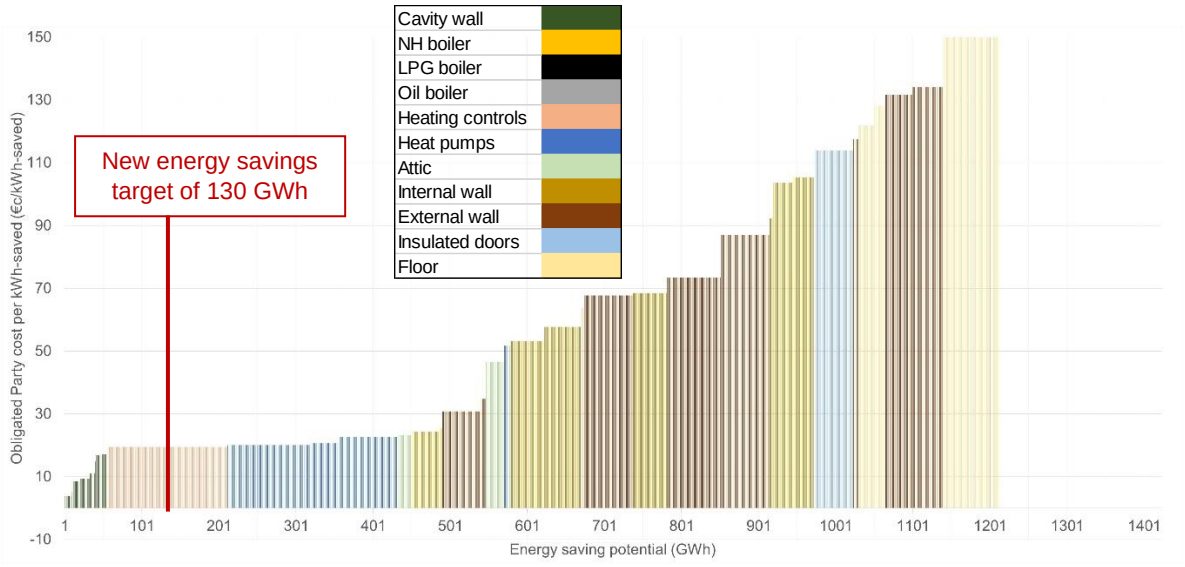
Source: ECA calculations for main report

The difference between the 487.5 GWh target and 552.5 GWh target is met almost exclusively in the model through such incentives for EVs. However, these incentives are judged to only be marginally more attractive to OPs than further residential sector activity above the 15% ring-fenced target (€c16.7/kWh-saved versus €c17.2/kWh-saved)[64]. As these are general estimated costs, in practice activity could easily fall in either direction. Furthermore, due to the higher consumer contribution for EVs as well as the indirect costs from fuel and motor tax losses, the net economic benefit as indicated in Table 56 and Table 57 is estimated to be substantially lower when supporting EVs rather than residential retrofits. The above CBA results for the Pathway 15 and Enhanced Energy Poor combined scenario (no transport ring-fencing) are therefore considered conservative with respect to the non-residential sector.

The equivalent cost curves for the Base Case and Pathway Scenario for the residential (able-to-pay) sector for 2021 are shown in Figure 25 and Figure 12 respectively. In the aggregate residential sector the new energy savings target is 130 GWh with a 25% ring-fenced target and 65 GWh with a 15% ring-fenced target. Energy saving credits have not been adjusted to reflect the NGR of different measures.

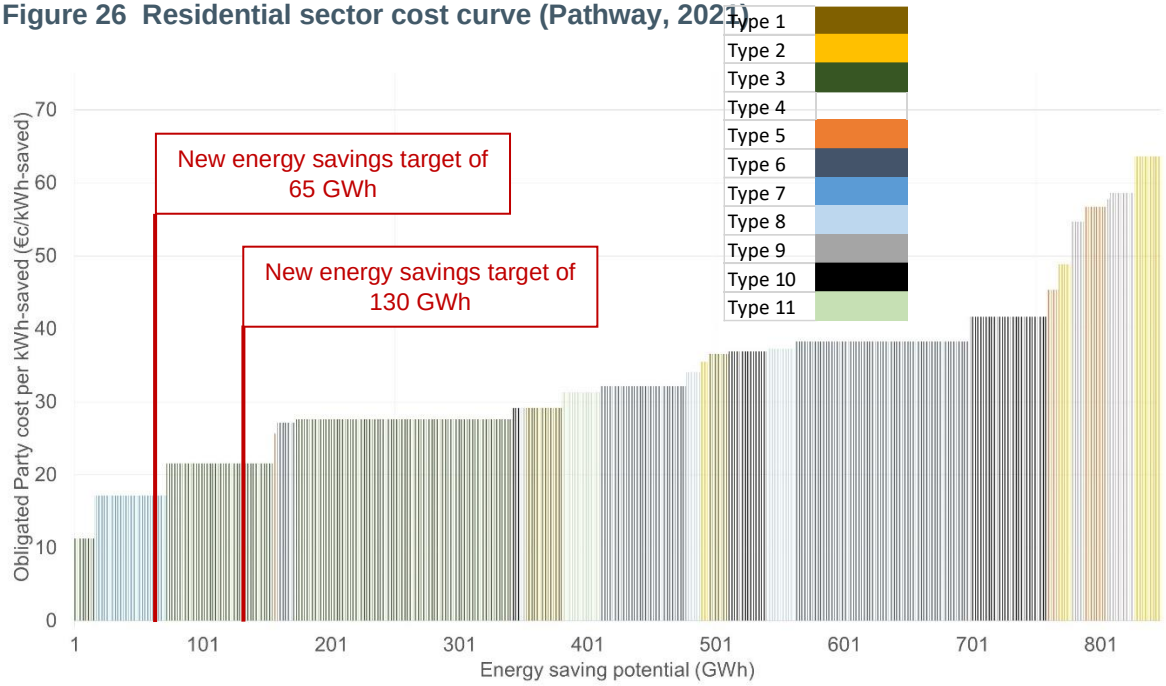
[64] Surplus residential sector credits may be used to meet the overall EEOS target of an OP and hence contribute towards the non-residential allocation indicated here.

Figure 25 Residential sector cost curve (Base Case, 2021)



Source: ECA calculations for main report

Figure 26 Residential sector cost curve (Pathway, 2021)



Note: "Type" refers to dwelling types. Details on characteristics of each dwelling type and package are provided in the main report.

Source: ECA calculations for main report

As can be seen in the Pathway scenario, activity is focused on the cheapest dwelling types. Figure 12 includes all dwelling types as options for the model and hence represents the lower end of the range of results provided in this CBA. The higher end of the range reflects the same model excluding Dwelling Type 3 as a relative outlier.

Uncertainties

As stressed throughout this analysis there are very substantial uncertainties associated with various inputs as well as the potential for unidentified costs and benefits. It is not deemed feasible to undertake a quantitative analysis of these uncertainties but rather to note qualitatively the key elements:

- The NGR rate to account for additionality and market acceleration (spill-over and transformation) effects. This effect was discussed in qualitative terms in the direct participant benefits and market acceleration section with adequate evidence only deemed available for applying an adjustment to heating control upgrades. Further analysis of other measures may indicate additional effects sufficient to alter the relative attractiveness of the results. This is particularly relevant for the increased uptake of heat pumps and EVs.

- The assumed subsidy levels by measure are based on limited data regarding typical leverage rates of EEOS schemes, the cost of energy savings credits observed to date in Ireland, and government run energy efficiency subsidy schemes. These estimates could be substantially refined should data enable more granular measure-by-measure assumptions, differentiated across the consumer base.

- No account has been made for potential “lock-in” effects whereby consumers who avail a relatively light retrofit are reluctant to consider further refurbishments for a substantial period subsequently. This could be an issue for the Base Case where individual insulation measures are permitted.

- A gradual reduction in the premium purchase price for an EV has been assumed equating to €1,000 per year for a typical car and reaching a premium of €5,000 by 2030, down from €15,000 for 2020. This trajectory is relatively conservative with respect to some industry forecasts. Should the price drop at twice this rate (thus actually seeing an EV at a €5,000 discount to an ICE equivalent by 2030) then the **Pathway 15 and Enhanced Energy Poor** combined scenario is estimated have a significantly higher net benefit at around **€1,200 Million**, while the **Pathway 15, Enhanced Energy Poor and Transport** combined scenario is estimated to yield an overall small net benefit rather than cost of approximately **€200 Million**. This result does not account for any resulting changes in the necessary mix of measures delivered by OPs in response to EV price drops, nor in issues of additionality that are likely to ensue from the rapid market penetration that would result.

- Should OPs provide additional residential retrofits rather than incentivise EVs even to achieve the ‘non-residential target’ under the Pathway 15 and Enhanced Energy Poor scenario then this is estimated to increase the overall **net benefit to a similar level to the Base Case**. This is because of the much lower indirect costs from lost taxation as well as the lower consumer contribution levels.

- No value has been attributed to the relative impact on inequalities of the different combined scenarios.

The results shown in Table 56 must therefore be interpreted in conjunction with these qualifications as well as the general uncertainties regarding the estimated cost of measures discussed in the main report.

Application of shadow price for public funds

The application of a shadow price of public funds has been modelled as a sensitivity case given the uncertainty regarding its suitability for the funding design of the EEOS. This is shown in Table 58. The same general conclusions as in the case with no shadow price can be drawn with the Base Case and Pathway 15 and Enhanced Energy Poor combined scenarios retaining a significant positive net benefit.

Table 58 Summary of estimated net benefits (with shadow price of public funds)

Scenario	Benefit or Cost		PV (2020) costs and benefits (€M)
Base Case	Benefits	Direct participant benefits (net)	4,028.5
		Societal (carbon) benefits	572.2
		Gross benefit	**4,600.7**
	Costs	Direct programme costs	(619.0)
		Indirect programme costs	(23.7)
		Direct participant and co-funding costs	(2,968.3)
		OP administrative costs	(27.4)
		Scheme administrative costs	(5.3)
		Gross cost	**(3,636.2)**
	NET BENEFIT		**1,100**
Pathway 15 and Enhanced Energy Poor	Benefits	Direct participant benefits (net)	4,077.9 - 4,047.0
		Societal (carbon) benefits	716.3 – 717.2
		Gross benefit	**4,794.2 – 4,764.2**
	Costs	Direct programme costs	(677.4) – (771.4)
		Indirect programme costs	(417.9) – (417.9)
		Direct participant and co-funding costs	(3,452.7) – (3,481.7)
		OP administrative costs	(21.1)
		Scheme administrative costs	(4.1)
		Gross cost	**(4,573.2) – (4,696.2)**
	NET BENEFIT		**300 – 100**
Pathway, Enhanced	Benefits	Direct participant benefits (net)	4,438.8 – 4,407.9
		Societal (carbon) benefits	832.7 – 833.6

Scenario	Benefit or Cost		PV (2020) costs and benefits (€M)
Energy Poor and Transport		**Gross benefit**	**5,271.5 – 5,241.5**
	Costs	Direct programme costs	(1,136.1) – (1,219.6)
		Indirect programme costs	(1,519.1) - (1,519.1)
		Direct participant and co-funding costs	(4,124.3) – (4,179.1)
		OP administrative costs	(21.1)
		Scheme administrative costs	(4.1)
		Gross cost	**(6,804.7) – (6,943.0)**
	NET BENEFIT		**(1,500) – (1,700)**