SUSTAINABLE ENERGY AUTHORITY OF IRELAND

Changing energy behaviour – what works?

Sustainable Energy Authority of Ireland

SEAI is Ireland's national energy authority investing in, and delivering, appropriate, effective and sustainable solutions to help Ireland's transition to a clean energy future. We work with Government, homeowners, businesses and communities to achieve this, through expertise, funding, educational programmes, policy advice, research and the development of new technologies.

SEAI recognises the need to address the human and psychological factors that influence the uptake of sustainable energy solutions. Behavioural science indicates that people's decisions about energy use are often determined by the unique characteristics of human cognition.

SEAI's Behavioural Economics Unit was established in 2017 to identify testable and scalable solutions to encourage sustainable energy behaviours in Irish households, businesses, and communities.

Executive Summary

Interventions to encourage behaviour change have the potential to generate significant energy savings in Ireland.

To increase the probability of success, the choice and design of these interventions should be informed by the best available evidence.

In order to identify the best strategies for activating behaviour-related energy savings in Ireland, SEAI performed an extensive analysis of international best practice.

The key findings of this analysis are as follows:

- Providing households with regular feedback on their energy use and encouraging them to set energy saving commitments in public can generate energy savings.
- Providing households and businesses with free independent energy audits may spur investment in energy efficiency measures and this approach should be further investigated.
- Early evidence from other countries suggests that a community based social marketing approach may be effective for encouraging retrofits and the uptake of energy efficient technologies. This warrants further investigation.
- This review indicates that incorporating behaviourally informed interventions into the design of future energy policy in Ireland will strengthen Ireland's ability to transition to a low-carbon economy.
- Following discussion with relevant stakeholders, a number of behaviour change interventions will be designed and trialled to increase sustainable energy behaviours among households and businesses.
- It is important that any behaviour change interventions trialled in Ireland are evaluated using the most robust methods available. Energy savings programmes should be evaluated by comparing changes in energy use to a control group, using experimental methods, and collecting objective data such as meter readings.

Contents

1.1 // Introduction

CLIMATE CHANGE PRESENTS a unique set of challenges for Ireland. Changing weather patterns are likely to result in an increase in the intensity and frequency of storms affecting the country. Warmer summers with less rainfall may lead to water shortages in the summer months. The risk and scale of river and coastal flooding is also likely to grow (Gleeson, McGrath & Treanor, 2013). The international community has a limited window during which it can take action to ensure that current and future generations can live sustainably in a low-carbon and climate resilient world (Department of Communications Climate Action & Environment [DCCAE], 2017).

There is an urgent need to encourage more sustainable energy behaviours across society in order to reduce the risks associated with climate change. Sustainable energy behaviours include increased energy efficiency, increased use of sustainable energy sources, and a shift towards low-carbon behaviours such as increasing the use of public transport.

Encouraging more sustainable energy behaviours among households, businesses, and communities will also realise multiple benefits across society (International Energy Agency, 2014). The retrofitting of homes will improve the health of homeowners and their families, and increase warmth and comfort levels. Similarly, the installation of energy efficiency measures and technologies will help homeowners and businesses to save on their energy bills. The adoption of sustainable clean energy sources will increase energy security (Dineen et al., 2016; Winzer, 2012) and improve air quality, again generating health benefits for the people of Ireland.

There is clear recognition at national level that realising this ambition will require significant behaviour change. To this end, energy and climate policy must be informed by the most robust evidence available on how individuals and organisations make energy-related decisions.

This review assesses the international evidence on what works for encouraging sustainable energy behaviours, and recommends a number of behaviour change interventions that should be trialled in Ireland in order to strengthen the evidence base for behaviourally informed policymaking.

// There is an urgent need to encourage more sustainable energy behaviours across society in order to reduce the risks associated with climate change //

1.2 // Potential Savings from Behavioural Measures

PREVIOUS ANALYSIS CARRIED out by SEAI identified a range of technical and behavioural measures with the potential to improve energy efficiency and save energy in Ireland. This analysis estimated that medium term potential savings (from 2015 to 2030) equated to a €1 billion improvement in the Government's balance sheet due to increased economic activity (Scheer, 2015). According to the analysis, improvements in energy efficiency based on the implementation of behavioural measures could enable Ireland to avoid 6.5 TWh of energy consumption in 2020 (Scheer, 2015) — this is equal to approximately 5% of the total energy consumption across the economy in 2015 (Howley & Holland, 2016).

It is worth noting that this figure of 6.5 TWh potential energy savings from behavioural measures identified in the above analysis does not include home retrofit measures, which are classified as 'technical' in the report. Therefore, the potential figure for behaviourally informed energy saving across the economy is likely to be greater than the estimated 6.5 TWh by 2020 as a range of different behavioural factors influence households' decisions to invest in energy saving technologies.

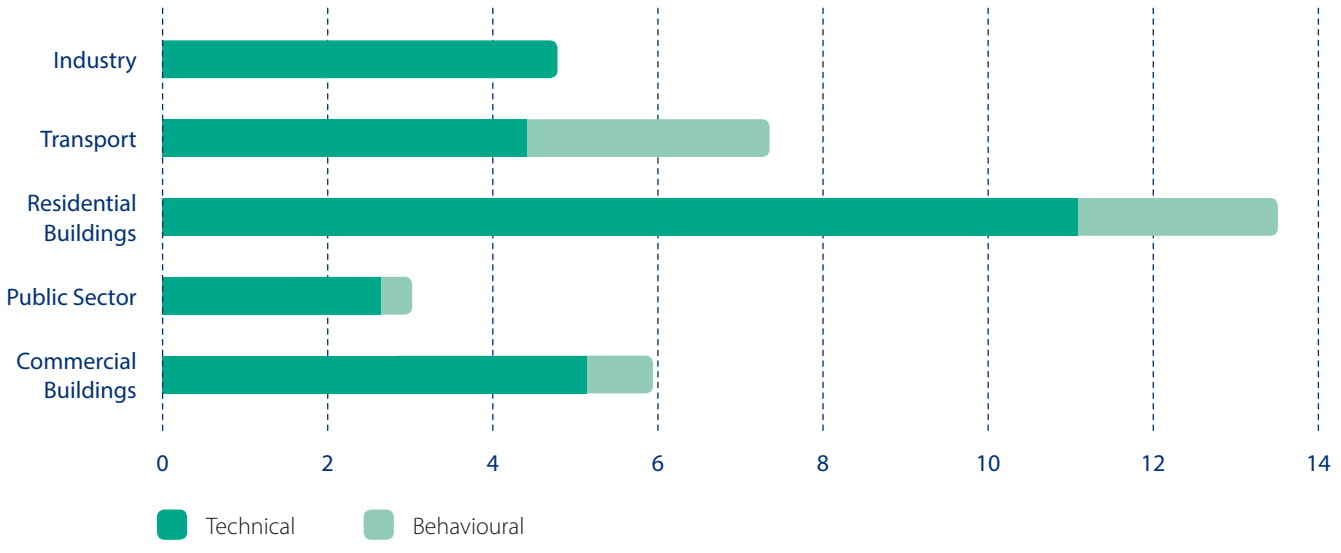
Figure 1.2.1 shows a breakdown of the potential energy savings by 2020. The savings are categorised as industry, transport, residential buildings, public sector and commercial buildings. Because the successful uptake of technical solutions often relies on behaviour change, the distinction here between technical and behavioural measures underplays the role of behaviour. For example, the full energy saving potential of heating, ventilation, and air conditioning (HVAC) systems can only be realised through the use of correct settings and maintenance (Skumatz, 2012), and there is strong evidence to suggest that the installation of home retrofit measures is influenced by a range of behavioural drivers and barriers (Klöckner & Nayum, 2016). As a result, the potential behavioural savings presented by Scheer (2015) represent a low-end estimate. A rebound effect of 36% is assumed for savings in the residential sector.

A recent review of behaviour change techniques by Andors and Fels (2018) shows that techniques such as feedback, social comparisons, and goal setting can reduce household energy use. The savings associated with these techniques differ based on the context in which they are applied but range from 2% to 10% on average.

It is clear that for policy to succeed in supporting these potential energy savings, it will need to be underpinned by a strong understanding of human behaviour.

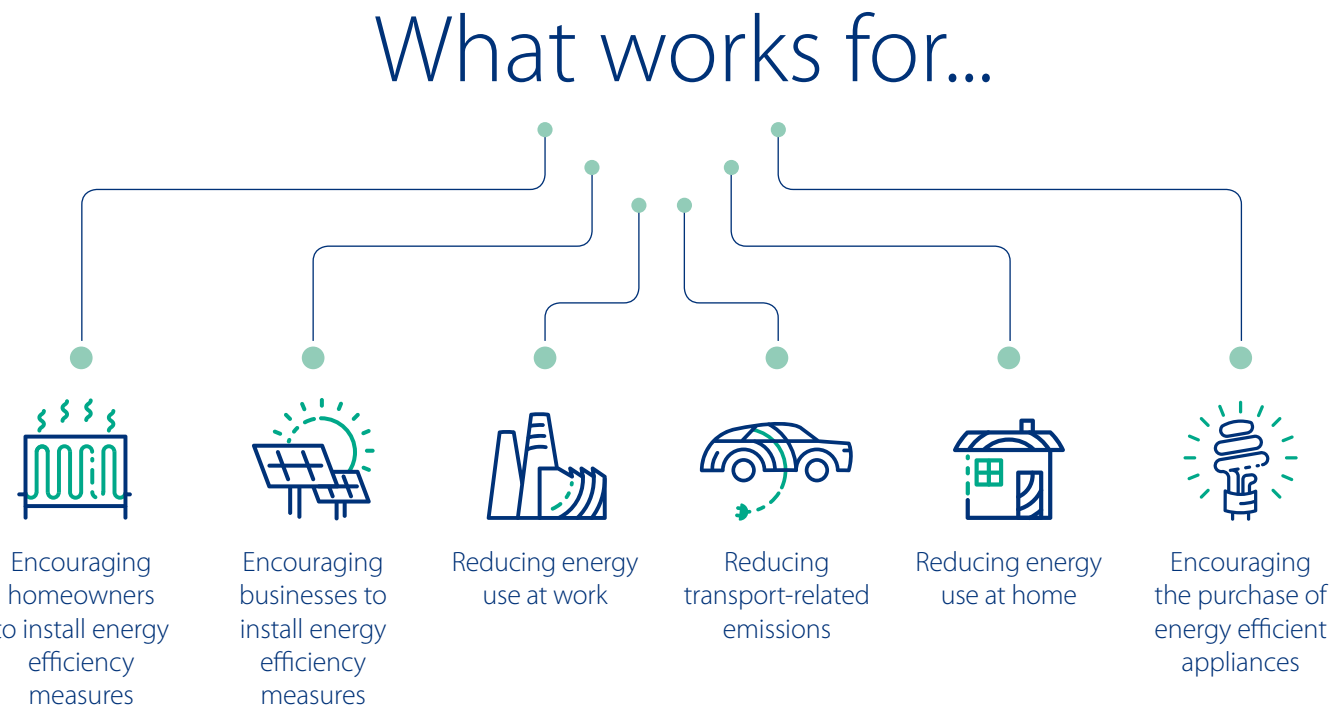
The application of Behavioural Economics will help to improve the uptake of existing energy efficiency schemes. SEAI's Behavioural Economics Unit is working to develop, test and scale targeted behaviour change strategies that will help to achieve the energy and emissions targets associated with Ireland's low-carbon transition.

Figure 1.2.1: Potential Energy Savings in 2020 from both Technical and Behavioural Efficiency Measures (Scheer, 2015)



1.3 // Focus of the Review

Figure 1.3.1: The review focuses on identifying what works for encouraging a number of sustainable energy behaviours



THIS REVIEW ASSESSES international evidence on what works for encouraging sustainable energy behaviours, and recommends a number of behaviour change programmes that should be trialled in Ireland. It identifies potential behaviour change strategies to complement the delivery of SEAI's current objectives and programmes. Figure 1.3.1 shows the main behaviour changes targeted by SEAI.

An extensive search of journals, relevant websites, and grey literature was conducted to identify studies that utilised experimental methods. These studies were used to estimate the energy savings generated by various behaviour change interventions. Using a pre-determined analysis template to summarise the findings of each study, 176 relevant studies were identified and reviewed in detail.

Research questions requiring further investigation

- What works for encouraging households and businesses to conduct energy audits?
- What is the most effective intervention for encouraging households and businesses to follow the recommendations provided by energy audits?
- What are the most effective methods for encouraging households and businesses to invest in energy efficiency measures?
- What is the likely impact on energy savings of conducting a community based social marketing campaign to encourage households to invest in energy efficiency measures (e.g. insulation) or energy saving technologies, such as light-emitting diodes (LEDs), in Ireland?
- What is the likely impact of providing a one-stop shop to assist households and businesses to invest in energy efficiency measures?
- What is the most effective method for increasing applications to free home upgrade schemes?
- What are the most effective methods to reduce abandonment among households who apply to grant-funded energy upgrade schemes?
- What works for encouraging households to electrify their heating source?
- What works for reducing the consumption of oil and other non-metered fuels, such as coal, peat, and wood?
- What works for encouraging households to change the way they use their existing heating systems?
- What are the real-world savings associated with the various smart heating control products available on the Irish market?

2.2 // Findings

THIS REVIEW IDENTIFIED a number of findings relevant to the programmes currently operated by SEAI.

2.2.1 Reducing Household Energy Use

Home energy reports that provide detailed and comparative feedback on household energy use may not be cost effective in Ireland.

The provision of home energy reports was the most common household energy saving intervention identified by this review.

Home energy reports summarise household energy use in an easy-to-understand format and compare it with the energy usage of their neighbours. This provides the householder with a frame of reference for their consumption and motivates occupants to reduce their energy consumption in comparison with their neighbours.

A large number of studies have suggested that such home energy reports deliver energy savings of about 1-3% in the United States (Allcott & Rogers, 2014). Recent evidence suggests that these reports may have less of an impact in European climates, which do not heavily rely on air conditioning, and may not be cost-effective due to European energy supply mixes (Andor et al., 2017). Andor et al. explain that because European countries, such as Germany, tend to have a cleaner energy supply than the United States, the monetary savings associated with home energy reports in European countries are lower, making them less cost-effective.

Providing Irish households with feedback on their energy use through in-home displays and enhanced billing is likely to lead to savings of up to 3% of electricity use.

Multiple studies show that providing feedback to households on their energy use is effective. Feedback is most effective when:

- It is delivered in real time with appliance-specific breakdowns by time-of-use (Asensio & Delmas, 2016);
- The energy use is communicated in broadly understood units (like euros instead of kwh), along with tips on how to save energy (Schleich, 2013);
- Households are frequently prompted to check their energy use over a long time period.

Indeed, findings from the Irish Smart Meter Trial (2011) performed by SEAI, the Commission for Regulation of Utilities and other partners, showed that households saved the most energy when they were provided with in-home displays, enhanced billing frequency, and feedback on how their energy use changed over time. The savings from the Irish Smart Meter Trial represent the best estimate compared to the international literature and activities reviewed, as it was conducted as a randomised control trial with a large representative sample and an appropriate measurement period. The reported energy savings associated with providing feedback to households ranges from 1% to 13% but is most likely to be closer to 2.9% based on results from the Irish trial.

Encouraging households to set realistic energy saving goals, and asking them to publicly commit to these goals, could reduce electricity use by approximately 10% in the short term.

Setting energy saving goals and making public commitments to save energy have also proved successful in reducing household energy use. Energy saving goals are most effective when households:

- Publicly commit to saving energy (Pallak, 1976);
- Set realistic targets of between 10% and 15% (Harding & Hsiaw, 2014);
- Receive energy saving tips (Abrahamse et al., 2007);
- Are provided with regular feedback showing how they are doing in relation to their goal (Seligman, 1978).

Goal setting and commitments can produce savings of between 4% and 22% of private household energy use, but, based on estimates shown by Andors and Fels (2018), average savings are more likely to be in the region of 10%. More work is needed to determine whether these savings persist in the long term.

Providing free home energy audits that supply homeowners with energy saving technologies (such as LEDs) and a summary report of energy saving measures appears to spur energy savings and investment in energy efficiency measures.

Preliminary evidence suggests that providing households with energy audits can reduce their energy use and increase the likelihood that they will invest in energy efficiency measures likely to produce long term energy savings. For example, a study by Alberini and Towe (2015) showed that a one-hour home assessment can generate energy savings of between 2.7% and 5.5%. The assessment consists of a professional visit to assess insulation levels, air leakage, heating and cooling systems, windows and doors, lighting and appliances, and water heating equipment. A report comprising findings and energy saving recommendations is then provided to the homeowner. Equipment and supplies, such as compact fluorescent light bulbs, tap aerators, efficient-flow showerheads, water pipe insulation or water heater tank wraps, are offered while in the home.

Providing home energy audits with simple reports seems to be most effective in reducing energy use when they are provided for free (Alberini & Towe, 2015), and when the person who is performing the home energy audit has been trained on how to explain the results to householders in simple and salient language (Gonzales, Aronson & Costanzo, 1988). The effectiveness of home energy audits is increased by having energy saving devices installed during the visit (Winnet et al., 1982).

Financial incentives may encourage some households to reduce their energy use but can produce negative effects when offered to people who would have been willing to save anyway.

A number of papers offered households financial incentives to reduce their energy use. The evidence in this area is mixed and some suggest that offering financial incentives may crowd out altruistic energy saving, i.e. energy saving motivated by good intentions rather than financial gain (Pellerano et al., 2017). Notwithstanding, based on the evaluation of the evidence, it would seem that financial incentives are most effective when households are provided with feedback on their energy consumption, provided with energy saving tips, and when the financial reward is not delayed (in relation to when the energy is saved). Group based competitions that offer financial rewards should be designed with provisions to ensure that households do not get demotivated by falling too far behind (Alberts, 2016).

Time-of-use tariffs (which provide information to customers on when energy is expensive/inexpensive to use and charge for energy use in accordance with high/low demand periods) appear to either encourage households to use less energy or to shift their use to off-peak times. Increases in the peak tariff do not seem to lead to additional savings.

Time-of-use tariffs charge for energy according to demand, and keep customers informed about prices. A number of studies reviewed the impact of providing homes with smart meters, in-home displays, time-of-use tariffs, demand–response programmes or a combination of these. There is mixed evidence as to whether providing homes with a time-of-use tariff without additional information results in energy savings. Several studies have found evidence of energy savings (Aigner & Lillard, 1984) while others have shown that households simply shift their energy consumption to less expensive times but do not reduce their overall energy use (Charles River Associates, 2005).

The customer behaviour trials run in 2011 by SEAI, the Commission for Regulation of Utilities and other partners, to assess the savings associated with time-of-use tariffs, smart meters, and in-home displays, provided the most reliable evidence for the Irish context. The results showed that participants changed their energy use during different peak periods, but did not further reduce their energy use when peak prices increased. Energy savings were largest when consumers received in-home displays in combination with energy-use statements and time-of-use tariffs. This combination yielded average energy savings of 3.2%, and reductions in energy use of 11.3% during peak periods.

Time-of-use tariffs appear to be most effective in encouraging energy savings when:

- They are simple to understand (e.g. they have one peak period and one non-peak period);
- Households have in-home displays highlighting when it is expensive to use energy (Jessoe et al, 2014);
- Householders are given automated technology that can reduce demand at peak times (Harding & Lamarche, 2016);
- Householders receive prompts to reduce their energy use during peak periods (Ito, Ida & Tanaka, 2014);
- Households are auto-enrolled into time-of-use tariffs with the option to opt-out (Fowlie et al., 2017).

Community based approaches are likely to be highly effective at increasing the installation of energy saving technologies and energy efficiency measures and are most effective when following a community based social marketing framework.

A study by Fowlie et al. (2015) showed that by following a community based social marketing approach (including home visits, sign-up assistance events, and local media advertising), Chicago's free weatherisation programme increased completions in contacted households (from 1% to 6%).

Two studies by Schultz et al. (2012 and 2015) that examined the impact of using community based social marketing approaches to encourage households to save energy by installing energy efficient lighting were reviewed. In both studies, the authors designed community based social marketing campaigns that sought to minimise the barriers associated with installing LED lightbulbs. The campaigns used initiatives such as providing LEDs at a discount, running in-store information events, and distributing flyers, door hangars, and leaflets to raise awareness for the programme. The approach was highly effective, increasing sales of LEDs by 876% (compared to control stores in similar areas). The authors did not report statistically significant energy savings, but this may be due to the difficulty of collecting follow-up information from households.

2.2.2 Reducing Business Energy Use

By setting energy saving goals, assigning energy champions, and providing employees with feedback on how their energy use compares to that of their colleagues, businesses can reduce their electricity use by 10%.

The review found that the most effective interventions for encouraging employees to save energy in the short term are energy saving competitions and providing publicly visible feedback comparing their energy consumption to the energy use of their colleagues. The impact of these interventions ranges from 4% to 30%, with typical savings more likely to be around 10% – as estimated by robust randomised evaluations with lengthy follow-up periods. The most effective workplace campaigns contained the following features:

- Goal setting (a target of 10–15% has been shown to be realistic) (Nilsson, Andersson & Bergstad, 2015);
- Competition with frequent public ranking and handicapping (Handgraaf, Van Lidth de Jeude & Appelt, 2013);
- Comparative feedback across meaningful units (teams, departments, buildings, etc.) (Siero et. al., 1996);
- Frequent (e.g. weekly) feedback communications that include energy saving tips (Klege et al., 2018);
- Weekly elected energy leaders who take responsibility for encouraging others to save energy for a particular week, and who are empowered to take energy saving actions like turning lights off (Klege et al., 2018).

Providing businesses with free independent energy audits appears to increase investment in energy efficiency measures.

There is some evidence to suggest that independent energy audits encourage businesses to invest in energy efficient technologies, but there have been very few large scale randomised field evaluations of interventions such as these.

2.2.3 Reducing Transport Emissions

Providing businesses with eco-driving programmes can reduce fuel use by between 3.5% and 7%.

A number of choice based experiments were initially identified for review. These were experiments that required participants to choose between two or more options, and analysed the responses in order to better understand the factors driving behaviour. They were excluded from the final review because they relied on hypothetical choices. The remaining transport studies focused on encouraging people to drive more efficiently by delivering eco-driving programmes. Eco-driving programmes seem to be most effective when they:

- Provide commercial drivers with advice on how to drive more efficiently (Siero et al., 1989);
- Include a savings target (Siero et al., 1989);
- Offer non-financial rewards (Schall & Mohnen, 2015);
- Make management responsible for drivers meeting targets (Siero et al., 1989).

The savings associated with eco-driving programmes range from 3.5% to 7%.

3.1 // Measuring Energy Savings

Best Practice for Evaluating Energy Saving Programmes

In order to accurately estimate the savings associated with an energy saving programme, it is recommended that, where feasible, future evaluations and energy-related behaviour change interventions meet the following criteria:

- Measure actual changes in energy use using objective data from meter reads or billing information;
- Measure changes in energy use for all relevant energy sources including electricity, gas, and non-metered fuels (particularly oil);
- Include a baseline and follow-up measure of energy use of at least 12 months, preferably two years;
- Use Heating Degree Days to account for changes in the weather;
- Randomly assign, or encourage, participation in the energy saving programme;
- Include a control group and a no-contact control group where appropriate;
- Conduct power analyses and recruit a sufficiently large and representative sample of the population of interest.

THE MAJORITY OF evaluations of behaviour change interventions rely on modelled estimates of energy savings when calculating programme benefits. For example, many evaluations calculate programme savings by looking at the uptake rate of efficiency measures and multiplying the number of installed measures by a modelled savings estimate, such as an improvement in a Building Energy Rating (BER). Modelled estimates usually include a number of assumptions about human behaviour. For example, that the heating system will be used efficiently and that the homeowner won't do things like leave windows open when trying to heat a room.

While all models rely on a set of assumptions, recent evidence has shown that there are large differences between modelled estimated savings and real-world savings observed in randomised field evaluations. By using engineering modelling data and billing analysis from SEAI's Home Energy Saving programme, Scheer et al. (2013) have shown that there is a difference of approximately 36% (±8%) between modelled potential savings and measured savings. **Given this large difference, it is important that monitoring and verification activities are performed to measure the actual savings associated with the installation of energy efficiency measures in order to prove their efficacy.**

It is also common to use simple before/after comparisons to calculate the energy savings associated with energy saving programmes. This involves collecting meter or billing data for a period before the energy saving programme and comparing it with similar data afterwards.

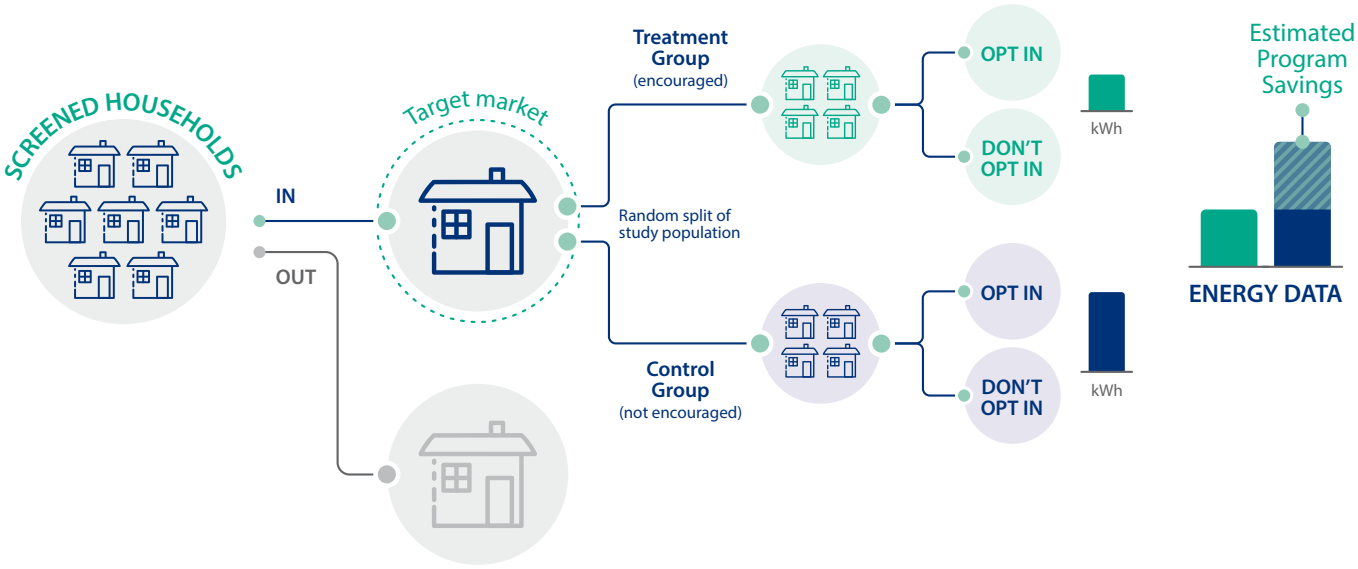
While this may be appropriate for the monitoring and verification of savings at a single site, or for a single project, it is not a reliable method to estimate the impact an energy saving scheme will have if it is rolled out to a wider audience.

This is usually because of selection bias. If people are free to self-select into energy saving programmes, and are not randomly encouraged/assigned, those who self-select are likely to have higher levels of motivation in terms of saving energy than the 'average' person. Thus, it can be difficult to tell if the energy savings associated with the programme are due to the effects of the programme or the specific characteristics of the people involved. **More randomised field evaluations of energy saving programmes are therefore required for an accurate estimate of the energy savings generated.**

While it may be costly to randomly assign certain energy efficient technologies, for example smart heating controls, to a large representative sample of the population to assess their impact, a randomised encouragement design can provide a similarly robust measure of energy savings at a lower cost.

This principle is further explained by Figure 3.1.1, a graphical representation of a randomised encouragement design whereby a target market of households is selected and either actively encouraged to join the programme or not. For example, a targeted group of households may be selected to be encouraged to apply for the SEAI Better Energy Homes scheme. All households are free to join the programme if they wish, but the encouraged group will receive intensive encouragement, such as door-to-door visits, telephone calls, or other prompts to join the program. A reliable estimate of savings attributable to the programme can then be estimated by comparing the energy savings recorded

Figure 3.1.1: Randomised encouragement design – households are randomly assigned to either receive encouragement to join the programme or not



in the encouraged group (shown in green in the figure) versus the energy savings recorded in the not-encouraged group (shown in blue). This arrangement can be used to inform cost-benefit analyses and determine if changes to the programme are needed in order to deliver greater savings.

A large number of evaluations of energy saving programmes rely on participants to report how much energy they have saved or the number of energy saving behaviours they have engaged in. This is problematic for measuring the energy savings associated with energy saving programmes as there can be large discrepancies between self-reported behaviours and actual behaviours. For example, a study by Kua and Wong (2012) shows that only 60% of participants who reported making behavioural changes actually reduced their energy consumption. **As a result, there is a need to include objective measures of changes in energy use, such as meter reads, in the assessment of energy saving programmes.**

In addition, testing and piloting energy saving programmes before they are rolled out creates additional benefits for policymakers. Implementation issues can be identified and addressed, reducing the risk of rolling out policies that may not be effective. When conducted correctly, testing and piloting facilitate cost-benefit analyses, which allow policymakers to identify the policies that will provide the best value for money.

Figure 3.1.2 Different evaluation methods have advantages and disadvantages, but randomised field experiments provide the best estimate of the savings attributable to an energy saving programme/technology.

Before/After Measures of Energy Use

Advantages
- Can be simple to collect
- Simple to analyse
- Based on actual metered energy use

Disadvantages
- Overstates/understates savings
- Hard to generalise results
- Cannot attribute changes in energy use directly to energy saving programme

Modelled Energy Savings

Advantages
- Quick to estimate
- Easy to apply to different house types and across programmes
- Used internationally

Disadvantages
- Overstates energy savings
- Ignores behaviour
- Ignores context
- Can be inaccurate if relying on self-reported behaviour change

Measured Savings from Randomised Field Experiments

Advantages
- Best estimate of real-world energy savings
- Can allow for generalisation of results
- Accounts for human behaviour
- Allows for accurate cost-benefit analysis
- Can analyse impact of programme on different recipients

Disadvantages
- Lengthy follow-up times required
- Planning and rollout require management
- More difficult to analyse

4.1 // Conclusions and Recommendations

THIS REVIEW AIMED at identifying and assessing international evidence on what works for encouraging sustainable energy behaviours, to recommend a number of behaviour change interventions to be trialled in Ireland. A large number of research studies were successfully identified and analysed. The analysis revealed a number of behaviour change interventions that have proven successful in changing energy-related behaviours in Ireland and other countries.

Providing households with frequent, specific, and comparative feedback on their energy use can encourage them to reduce their energy use. Similarly, encouraging households to set specific energy saving goals and publicly commit to them can motivate them to save energy. Providing households with financial incentives (monetary rewards) or disincentives (time-of-use tariffs) may encourage them to change when they use energy, but may not lead to reductions in energy use.

While providing households with feedback, goals and incentives can alter their energy behaviour in the short term, it is likely that encouraging them to install energy efficiency measures, such as insulation, will lead to more persistent savings over the medium to long term. Based on the evidence assessed as part of this review, providing free independent energy audits to households and businesses may spur investment in energy efficiency measures, but further investigation is warranted. More research is required to identify the optimal strategy for encouraging households and businesses to engage with energy audits and install the measures they recommend.

Providing free home energy audits that supply homeowners with energy saving technologies and a summary report of energy saving measures appears to spur energy savings and investment in energy efficiency measures.

One emerging strategy that may be effective in spurring investment in energy efficiency measures among households and businesses is the community based social marketing approach. The early evidence seems to suggest that community based social marketing campaigns that reduce the barriers to, and emphasise the benefits associated with retrofitting, may successfully increase the number of households and businesses upgrading their properties.

A list of potential behaviour change interventions to be trialled in Ireland has been compiled and is currently under internal review. Following discussion with relevant stakeholders, a number of behaviour change interventions will be designed and trialled to increase sustainable energy behaviours among households and businesses.

// Initial evidence seems to suggest that community based social marketing campaigns that reduce the barriers to, and emphasise the benefits associated with, retrofitting, may successfully increase the number of households and businesses upgrading their properties //

Based on the recommendations of the studies analysed for this review, it is important that any behaviour change interventions trialled in Ireland are evaluated using the most robust methods available. As highlighted above, where possible, future behaviour change interventions should be evaluated using randomised field experiments or quasi-experimental methods.

Appendix A // Number of Studies by Broad Category of Behaviour

	No. of Papers Identified (A)	No. of Papers Excluded After Detailed Review (B)	Final No. of Papers Included in Review of Evidence (A–B)	Year of Publication Range	Range of Confidence Assessments
Commercial and Industry	15	6	9	1979 – 2015	Somewhat weak to somewhat strong
Community Programmes	3	1	2	2015 – 2016	Somewhat weak to somewhat strong
Efficiency Measures	18	9	9	1982 – 2018	Somewhat weak to somewhat strong
Public Energy Behaviour	2	2	0	2012 – 2016	Somewhat weak to average
Household Energy Behaviour	95	23	72	1975 – 2017	Weak to strong
School Programmes	15	2	13	1979 – 2018	Weak to average
Smart Meter / Demand Response / Time-of-Use Tariffs	20	5	15	1984 – 2017	Weak to strong
Transport	8	2	6	1996 – 2016	Weak to somewhat strong
Total	**176**	**50**	**126**	**N/A**	**N/A**

1 = weak; 2 = somewhat weak; 3 = average; 4 = somewhat strong; 5 = strong

Appendix B // Number of Studies by Broad Area of Behaviour and Intervention Type

	Incentives	Contests	Make It Easy	Committments	Social Modelling	Social Norms	Education	Feedback	Prompts	Cognitive Dissonance
Commercial and Industry	1	2	1	2	0	3	1	5	0	0
Community Programmes	0	1	0	0	1	0	1	0	0	0
Efficiency Measures	0	0	1	0	1	0	8	1	1	0
General Behaviour	0	0	0	0	0	0	0	0	2	0
Household Energy Behaviour	27	9	9	13	8	16	39	87	20	2
School Programmes	2	3	0	0	0	3	4	4	5	0
Smart Meter / Demand Response / Time-of-Use Tariffs	6	0	0	0	0	0	0	13	1	0
Transport	1	0	1	0	0	1	4	3	1	0
Total	**37**	**15**	**12**	**15**	**10**	**23**	**57**	**113**	**30**	**2**

NB: Please note that each study may have contained multiple interventions and so the results of this table may not tally with the 'No. of papers identified' column in Appendix A above.

Appendix C // Search Methodology

In order to ensure that as many relevant studies as possible were reviewed, similar search strategies to those followed by Andors and Fels (2018) and the Department of Energy & Climate Change (DECC) (2013) were used.

Structured searches were conducted in relevant journals and scientific databases. Experts in behavioural science and energy policy in Ireland were also asked to recommend relevant papers[1]. Finally, previous meta-analyses, policy reviews from other countries, and websites that were likely to contain relevant studies were searched.

A list of inclusion and exclusion criteria defined the types of studies that were included in the review. The criteria were designed to identify behaviour change interventions that had previously been shown to reduce energy use in real-world field trials based on objective, measured data. This was important to ensure that the interventions recommended by this report had been previously shown to produce energy savings in real-world contexts.

Studies were deemed relevant if they were conducted after 1970, included a control group, included an objective measure of energy use, and were published in an academic journal or grey literature sources. Studies were excluded if they were conducted in laboratory settings, relied on hypothetical decision making, relied on before/after measurements of energy use, or did not include a control group. As a result, case studies or theoretical papers were not included, and the review instead focused on experimental or quasi-experimental evidence.

Following the search, the titles of all the studies were reviewed. Studies deemed to be irrelevant based on their titles were removed. The abstracts of the remaining studies were reviewed and studies that were not consistent with the inclusion criteria were removed.

In this way, 176 studies were successfully identified for detailed reading and coding. Using a standardised template, similar to that used by DECC (2013), studies were reviewed and summarised by members of the SEAI Behavioural Economics Unit. Finally, after discussing the main themes identified in the studies reviewed, the SEAI Behavioural Economics Unit identified a number of behaviour change interventions for piloting – those which appeared to offer the greatest potential for delivering energy savings in Ireland.

1 One expert provided us with a Microsoft Excel based library of environmental behaviour change studies, which we also searched for relevant papers.

Appendix D // Search Results

Of the 176 studies identified for detailed reading and coding, 50 were subsequently excluded from the final review, leaving 126 studies. As can be seen from Appendix A, the majority of these examined behaviour change techniques affecting household energy use. Appendix B shows that the most common behaviour change technique applied to changing energy-related behaviours is feedback. These trends reflect previous evidence reviews, which have also found that the majority of energy behaviour change research tends to focus on household energy behaviour and that feedback is one of the most commonly used behaviour change techniques.

A large number of the included studies examined the impact of providing households with feedback (via home energy reports, in-home displays, smart meters, or other methods), education, incentives, or energy saving goals. There was a lack of robust experimental studies focussing on successful methods for encouraging households, communities, and businesses to conduct energy audits or invest in energy efficient measures and technologies. Only one study fell into this category – a randomised field study examining the impact of a large scale, community based social marketing campaign on the uptake rate of a free weatherisation programme in Chicago (Fowlie et al., 2015).

However, it is important to note that the review criteria likely excluded a large number of non-experimental studies investigating the effectiveness of different policy measures to increase investment in energy efficiency technologies. For example, a number of papers referring to school based and community based interventions were excluded from the review because they were evaluated using self-reported measures of behaviour, and/or failed to measure the impact of the intervention compared to a control group. Relying on self-reported measures of behaviour is considered problematic as it inflates energy saving estimates. Similarly, energy saving estimates are biased upwards when they are calculated using before/after methods rather than including a control group.

Bibliography

Abrahamse, W., Steg, L., Vlek, C. & Rothengatter, T. (2007). 'The effect of tailored information, goal setting, and tailored feedback on household energy use, energy-related behaviors, and behavioral antecedents,' *Journal of Environmental Psychology.* https://doi.org/10.1016/j.jenvp.2007.08.002

Aigner, D. & Leamer, E. (1984). 'Estimation of time-of-use pricing response in the absence of experimental data: An application of the methodology of data transferability'. *Journal of Econometrics.* https://doi.org/10.1016/0304-4076(84)90018-6

Alberini, A. & Towe, C. (2015). 'Information v. energy efficiency incentives: Evidence from residential electricity consumption in Maryland,' *Energy Economics.* https://doi.org/10.1016/j.eneco.2015.08.013

Alberts, G., Gurguc, Z., Koutroumpis, P., Martin, R., Muûls, M. & Napp, T. (2016). 'Competition and norms: A self-defeating combination?' *Energy Policy.* https://doi.org/10.1016/j.enpol.2016.06.001

Allcott, H. & Rogers, T. (2014). 'The Short-Run & Long-Run Effects of Behavioral Interventions: Experimental Evidence from Energy Conservation,' *American Economic Review.* https://doi.org/10.1257/aer.104.10.3003

Andor, M., Gerster, A., Peters, J., Schmidt, C. (2017). 'Social Norms and Energy Conservation Beyond the US,' *Ruhr Economic Papers.* http://dx.doi.org/10.4419/86788833

Andor, M. & Fels, K. (2018). 'Behavioral Economics and Energy Conservation — A Systematic Review of Non-price Interventions and Their Causal Effects,' *Ecological Economics.* https://doi.org/10.1016/j.ecolecon.2018.01.018

Asensio, O. & Delmas, M. (2016). 'The Dynamics of behavior change: Evidence from energy conservation,' *Journal of Economic Behavior & Organization.* https://doi.org/10.1016/j.jebo.2016.03.012

Charles River Associates (2005). *Impact Evaluation of the California Statewide Pricing Pilot.* https://www.smartgrid.gov/files/Impact_Evaluation_California_Statewide_Pricing_Pilot_200501.pdf

Commission for Energy Regulation (2011). *Gas Customer Behaviour Trial Findings Report.* Dublin. https://www.ucd.ie/t4cms/Gas%20Customer%20Behaviour%20Trial%20Findings%20Report.pdf
Department of Communications, Climate Action & Environment (2017). National Mitigation Plan. Dublin. https://www.dccae.gov.ie/documents/National%20Mitigation%20Plan%202017.pdf

Department of Energy & Climate Change (2013). *What Works in Changing Energy-Using Behaviours in the Home? A Rapid Evidence Assessment.* Dublin. http://webarchive.nationalarchives.gov.uk/20130103044334/http://www.decc.gov.uk/assets/decc/11/tackling-climate-change/saving-energy-co2/6921-what-works-in-changing-energyusing-behaviours-in-.pdf

Dineen, D., Howley, M., Holland, M. & Cotter, E. (2016). *Energy Security in Ireland: A Statistical Overview. 2016 Report.* Cork. https://www.seai.ie/resources/publications/Energy-Security-in-Ireland-2015.pdf

Fowlie, M., Greenstone, M. & Wolfram, C. (2018). 'Do Energy Efficiency Investments Deliver? Evidence from the Weatherization Assistance Program,' *The Quarterly Journal of Economics.* https://doi.org/10.1093/qje/qjy005

Fowlie, M., Wolfram, C., Spurlock, A., Todd, A., Baylis, P. & Cappers, P. (2017). 'Default Effects and Follow-On Behavior: Evidence from an Electricity Pricing Program,' *NBER Working Papers.* http://www.nber.org/papers/w23553

Gleeson, E., McGrath, R. & Treanor, M. (2013). *Ireland's climate: the road ahead.* Dublin. https://epic.awi.de/34010/1/IrelandsWeather-13092013.pdf

Gonzales, M., Aronson, E. & Costanzo, M. (1988). 'Using Social Cognition and Persuasion to Promote Energy Conservation: A Quasi-Experiment,' *Journal of Applied Social Psychology.* https://doi.org/10.1111/j.1559-1816.1988.tb01192.x

Handgraaf, M., Van Lidth de Jeude, M. & Appelt, K. (2013). 'Public praise vs. private pay: Effects of rewards on energy conservation in the workplace,' *Ecological Economics.* https://doi.org/10.1016/j.ecolecon.2012.11.008

Harding, M. & Hsiaw, A. (2014). 'Goal setting and energy conservation,' *Journal of Economic Behavior & Organization.* https://doi.org/10.1016/j.jebo.2014.04.012

Harding, M. & Lamarche, C. (2016). 'Empowering Consumers Through Data and Smart Technology: Experimental Evidence on the Consequences of Time-of-Use Electricity Pricing Policies,' *Journal of Policy Analysis and Management.* https://doi.org/10.1002/pam.21928

Howley, M. & Holland, M. (2016). *Energy in Ireland 1990-2015. 2016 Report.* Cork. http://www.seai.ie/resources/publications/Energy-in-Ireland-1990-2015.pdf

International Energy Agency (2014). *Capturing the Multiple Benefits of Energy Efficiency.* Paris. http://www.iea.org/publications/freepublications/publication/Multiple_Benefits_of_Energy_Efficiency.pdf

Ito, K., Ida, T. & Tanaka, M. (2018). 'Moral Suasion and Economic Incentives: Field Experimental Evidence from Energy Demand,' *American Economic Journal.* https://www.aeaweb.org/articles?id=10.1257/pol.20160093

Jessoe, K. & Rapson, D. (2014). 'Knowledge Is (Less) Power: Experimental Evidence from Residential Energy Use,' *American Economic Review.* https://www.aeaweb.org/articles?id=10.1257/aer.104.4.1417

Klege, R., Visser, M., Datu, S. & Darling, M. (2018). 'The Effectiveness of Competition and Responsibility Assignment in Saving Energy: A Non-Residential example of the Power of the "Nudge"', *ResearchGate.* https://www.researchgate.net/publication/323258372_The_Effectiveness_of_Competition_and_Responsibility_Assignment_in_Saving_Energy_A_Non-Residential_example_of_the_Power_of_the_Nudge

Klöckner, C. & Nayum, A. (2016). 'Specific Barriers and Drivers in Different Stages of Decision-Making about Energy Efficiency Upgrades in Private Homes,' *Frontiers in Psychology.* https://doi.org/10.3389/fpsyg.2016.01362

Kua, H. & Wong, S. (2012). 'Lessons for integrated household energy conservation policies from an intervention study in Singapore,' *Energy Policy.* https://doi.org/10.1016/j.enpol.2012.04.009

McKenzie-Mohr, D., Lee, N., Schultz, W. & Kotler, P. (2012). *Social Marketing to Protect the Environment: What Works.* Sage. New York. http://sk.sagepub.com/books/social-marketing-to-protect-the-environment

Nilsson, A., Andersson, K. & Bergstad, C. (2015). 'Energy behaviors at the office: An intervention study on the use of equipment,' *Applied Energy.* https://doi.org/10.1016/j.apenergy.2015.02.045

Pallak, M. & Cummings, W. (1976). 'Commitment and Voluntary Energy Conservation,' *Personality and Social Psychology Bulletin.* https://doi.org/10.1177/014616727600200105

Pellerano, J., Price, M., Puller, S. & Sánchez, G. (2016). 'Do Extrinsic Incentives Undermine Social Norms? Evidence from a Field Experiment in Energy Conservation,' *Environmental & Resource Economics.* https://ideas.repec.org/a/kap/enreec/v67y2017i3d10.1007_s10640-016-0094-3.html

Schall, D. & Mohnen, A. (2015). 'Incentives for Energy-efficient Behavior at the Workplace: A Natural Field Experiment on Eco-driving in a Company Fleet,' *Energy Procedia.* https://doi.org/10.1016/j.egypro.2015.07.348

Scheer, J., Clancy, M. & Ní Hógáin, S. (2013). 'Quantification of energy savings from Ireland's Home Energy Saving scheme: an ex post billing analysis,' *Energy Efficiency.* https://link.springer.com/article/10.1007%2Fs12053-012-9164-8

Scheer, J. (2015). *Unlocking the Energy Efficiency Opportunity.* Dublin. https://www.seai.ie/resources/publications/Unlocking-the-Energy-Efficiency-Opportunity-Main-Report.pdf

Schleich, J., Klobasa, M., Gölz, S. & Brunner, M. (2013). 'Effects of feedback on residential electricity demand – Findings from a field trial in Austria,' *Energy Policy.* https://doi.org/10.1016/j.enpol.2013.05.012

Schultz, W., Colehour, J., Vohr, J., Bonn, L., Bullock, A. & Sadler, A. (2015). 'Using Social Marketing to Spur Residential Adoption of ENERGY STAR® – Certified LED Lighting,' *Social Marketing Quarterly.* https://doi.org/10.1177%2F1524500415577429

Seligman, C. & Darley, J. (1977). 'Feedback as a means of decreasing residential energy consumption,' *Journal of Applied Psychology.* http://dx.doi.org/10.1037/0021-9010.62.4.363

Siero, F., Bakker, A., Dekker, G. & Van Den Berg, M. (1996). 'Changing organizational energy consumption behaviour through comparative feedback,' *Journal of Environmental Psychology.* https://doi.org/10.1006/jevp.1996.0019

Skumatz, L. (2012). 'Measuring the Impacts of Behavior Change Programs: Filling in the Blanks.' http://aceee.org/files/proceedings/2012/data/papers/0193-000123.pdf

Winnett, R., Love, S. & Kidd, C. (1982). 'The effectiveness of an Energy Specialist and Extension Agents in Promoting Summer Energy Conservation by Home Visits,' *Journal of Environmental Systems.* http://dx.doi.org/10.2190/B4DN-N9H8-A57Y-2JDG

Winzer, C. (2012). 'Conceptualizing energy security,' *Energy Policy.* https://doi.org/10.1016/j.enpol.2012.02.067

Purcell, K., O'Callaghan, A., Bohacek, M. & Hemmingway, P. (2018). *'Changing energy behaviour - what works?', SEAI.*


CO_2

SUSTAINABLE ENERGY AUTHORITY OF IRELAND

Sustainable Energy Authority of Ireland
Wilton Park House, Wilton Place, Dublin 2, Ireland D02 T228

t +353 1 808 2100 | e info@seai.ie | w www.seai.ie

Ireland's European Structural and Investment Funds Programmes 2014-2020
Co-funded by the Irish Government and the European Union

European Union
European Regional Development Fund