EEA Technical report | No 5/2013

Achieving energy efficiency through behaviour change: what does it take?

ISSN 1725-2237

European Environment Agency

Achieving energy efficiency through behaviour change: what does it take?

European Environment Agency

Cover design: EEA
Cover photo: © Flickr/Mark Florence
Layout: EEA/Henriette Nilsson

Information about the European Union is available on the Internet. It can be accessed through the Europa server (www.europa.eu).

Luxembourg: Publications Office of the European Union, 2013

ISBN 978-92-9213-384-9
ISSN 1725-2237
doi:10.2800/49941

European Environment Agency
Kongens Nytorv 6
1050 Copenhagen K
Denmark
Tel.: + 45 33 36 71 00
Fax: + 45 33 36 71 99
Web: eea.europa.eu
Enquiries: eea.europa.eu/enquiries

Contents

Acknowledgements

The report was prepared jointly by the European Environment Agency (EEA) and Ricardo-AEA. The authors were Anca-Diana Barbu (EEA) and, from Ricardo-AEA, Nigel Griffiths and Gareth Morton.

The authors would like to thank the following experts for their valuable contributions in shaping up the scope and the messages of this report (alphabetical order): Beccy Whittle (Lancaster University), Caspar Tigchelaar (ECN), Dominique Osso (EDF), Guillermo Beltrà (BEUC), Kai Kuhnhenn (German Federal Environment Agency), Karin Widegren (Swedish Coordination Council for Smart Grid), Katarina Jacobson (Swedish Energy Agency), Malgorzata Bednarek (Polish Department of Monitoring and Environmental Information — Chief Inspectorate for Environmental Protection), Paul McAleavy (EEA), Rebecca Whittle (Lancaster Environment Centre) and Ruth Mayne (Oxford University — Environmental Change Institute).

Executive summary

On October 2012, the European Union adopted the Energy Efficiency Directive in reaction to the fact that EU Member States were not on track to reduce primary energy consumption by 20 % by 2020. The implementation of this directive, and other policies that have been adopted in recent years, will require a change in consumer behaviour and energy consumption practices.

Within this context, and related to on-going debates on the same subject, a new European Environment Agency (EEA) report argues that correctly navigating the interface between policymaking and human behaviour is key to achieving sustained reductions in energy consumption. As such, the report provides timely and reliable information and analysis to those involved in designing policy measures to reduce energy consumption which target the end consumer.

A growing body of evidence in academic literature demonstrates that there is potential for energy savings due to measures targeting behaviour as shown in Table ES.1.

There is, however, one issue that has not been covered by previous studies, and which the EEA report directly addresses, namely the distinction between consumer behaviour and consumption practices. Most recent academic literature argues that it is the consumption practices themselves that need careful scrutiny as they tend to lock consumers into patterns that are more and more energy intensive and they involve a wide range of actors. From the energy efficiency policy design perspective, this is relevant because these actors need to be involved from the outset of the policy process.

The report also argues that a whole range of changes need to take place in the way energy markets function and are regulated in order to enable the consumer to actively engage with these markets. The report however does not include a discussion on the socio-economic implications of these structural changes. During 2013, the EEA will launch a survey via social media and its own website to follow up on conclusions of the report. The aim will be to receive society's views on the issues raised.

This EEA report provides a review of available literature on measures targeting consumer behaviour in order to achieve energy savings.

The report focuses on:

- Energy efficiency measures and behaviour change;
- Structural factors — such as the impact of liberalisation and the energy mix and energy tariff structures;
- The rebound effect.

Table ES.1 Potential energy savings due to measures targeting behaviour

Intervention	Range of energy savings
Feedback	5–15 %
Direct feedback (including smart meters)	5–15 %
Indirect feedback (e.g. enhanced billing)	2–10 %
Feedback and target setting	5–15 %
Energy audits	5–20 %
Community-based initiatives	5–20 %
Combination interventions (of more than one)	5–20 %

The report structures advice and analysis into the following topic areas:

Feedback measures

Consumers need appropriate frames of reference in order to determine whether their energy consumption is excessive. In analysing recent and available literature the report highlights that combining direct and indirect feedback from energy suppliers has been, so far, the most successful in changing consumer behaviour and achieve energy savings. Direct feedback could include information received via the consumer's computer, via smart meters combined with in-home displays. Indirect feedback could include more informative and frequent bills containing historical and/or comparative information on energy consumption.

The report suggests that policy makers seem focused more on the instrument itself than on the behaviour and consumption practice that needs to be affected.

Understanding the relationship between feedback measures, demand response measures and energy efficiency programs is important to avoid potential conflicts and ultimately failure to capture the full energy-saving potential available.

Following interaction from feedback measures, setting individual energy-saving targets can also work well particularly if set by the consumers themselves.

Energy audits

Energy audits are a useful tool to provide the information needed to implement energy efficiency measures in a specific environment. The literature reviewed supports the idea that there is a direct link between implementing energy audits and achieving tangible energy savings but is less clear about the extent to which energy audits can trigger real and persistent changes in consumer behaviour. To strengthen the link between energy audits and consumption practices, energy audits should be part of a longer-term programme to improve energy management and not just a one-off activity.

Community-based initiatives

Community based initiatives could lead to long-term behaviour change because they facilitate the introduction of new, pro-environmental social norms. Examples include groups sharing information to facilitate behaviour change.

The literature researched noted that for these types of initiatives to be successful, it is important that they are part of a wider programme that has clear objectives. These could include reducing the environmental footprint or delivering energy savings. A pre-existing relationship between the participants and whether participants share pro-environmental views also contribute to the success of such measures. Such initiatives are likely to be more successful if they involve a role model respected by the selected group.

Structural factors

Dynamic pricing schemes, ie, those which fluctuate at times of high and low demand, can lead to improvements in the efficiency with which energy is delivered by the energy system but also to energy savings for the consumer. Yet, the literature reviewed notes wide variations in such benefits due to the vulnerability of certain consumer groups (e.g. low income households whose lifestyle or lack of real choices make it difficult for them to alter consumption patterns), the need to correctly explain how the pricing schemes work and the relative lack of ability for consumers to negotiate with energy suppliers.

Linking dynamic pricing schemes with data on energy consumption that smart meters could offer makes sense. Yet not all consumers will respond in the same way. While the business sector is largely driven by economic reasoning, households are not. Factors such as education, social norms, age and culture are prevalent.

The rebound effect

The term 'rebound effect' serves to explain how energy efficiency measures can lead to increasing the energy used, thereby minimising the expected impact from initial savings.

Adequately estimate the size of this effect remains a challenge. The literature surveyed addresses the issue of the rebound effect mainly in response to energy efficiency measures involving technological interventions but not necessarily in response to measures targeting behaviour change or changes in consumption practices. This is perhaps because in almost all cases there is no long-term follow up of such measures.

Recent literature argues that the direct rebound effect is less than 50 % for the household sector and much less for the business sector.

The literature reviewed suggests that the rebound effect exists and is to be expected but the ability to accurately quantify the size of the effect remains challenging. In addition it is not sufficient to justify delaying investments in energy efficiency and behaviour change measures. Moreover, the effect is expected to decrease over time as needs are fulfilled.

The report concludes by noting that many factors influence consumer behaviour. These factors can include technological development, considerations of general economic situation, age, social norms, belief systems and cultural traits and marketing strategies.

Energy infrastructure plays an important role in determining consumer behaviour vis-à-vis energy consumption. Such interaction needs to be considered taking into account possible constraints (asymmetric information, unexpected capital costs, trade-offs to reach an optimal solution, etc.) and the ability of the consumer to deal with a new technology defined by cultural traits, level of education and expectations of convenience.

The success of measures targeting a change in consumer behaviour and practices will largely depend on how these expectations are fulfilled.

1 Introduction

1.1 Policy context

The implementation of a number of recent energy policy initiatives could benefit from a widespread roll-out of smart meters across Europe. Some of these initiatives are also crucially dependent on altered consumer behaviour and energy consumption practices in order to achieve their goals. Energy efficiency is one such policy domain.

The Conclusions of the European Council of 8–9 March 2007 emphasised the need for the European Union (EU) to achieve the objective of saving 20 % of primary energy consumption by 2020, compared to projections. The European Council of 4 February 2011 emphasised that the 2020 target must be delivered, but also recognised that Member States are not on track to fulfil this commitment. On 25 October 2012, the EU adopted Directive 2012/27/EU on energy efficiency (known as the Energy Efficiency Directive), a significant milestone in promoting EU energy efficiency objectives.

The Energy Efficiency Directive provides strengthened or new measures to accelerate energy efficiency improvements, and makes clear that an integrated approach is called for to address all aspects of energy supply and demand. The directive also emphasises that cost-effectiveness is critical, given the 'urgent need to restore sustainability to public finances', and concludes that energy efficiency offers a cost-effective approach towards the issue. In the impact assessment accompanying the directive, it is mentioned that 'PRIMES 20 % ([1]) efficiency scenarios assume that measures are successful in changing consumer behaviour with respect to the uptake of energy efficiency solutions' ([2]).

In other words, a full implementation of the Energy Efficiency Directive requirements presupposes that consumers will change behaviour and this will lead to persistent and long-term energy-savings benefits.

The directive includes a wide range of measures:

- a requirement for the Member States to establish a long-term strategy for mobilising investment in refurbishing residential and commercial buildings stock;
- a requirement for Member States to set up energy efficiency obligation schemes for energy distributors or suppliers, or alternative measures, e.g. a carbon tax, financing schemes, regulations or voluntary agreements;
- a requirement to introduce smart metering where proven feasible and financially cost-effective;
- a requirement to base energy billing on real consumption and provide complementary information on historical energy consumption;
- a requirement to identify the potential for the application of high-efficiency cogeneration as well as for district heating and cooling;
- a requirement for Member States to ensure that national energy regulators encourage demand response programmes, and that network tariffs take into account the costs and benefits of energy efficiency measures.

The Energy Efficiency Directive is not the only energy policy to require a change in energy consumption practices by end consumers and whose implementation is likely to be facilitated by the

([1]) The PRIMES Model: http://www.e3mlab.ntua.gr/e3mlab/index.php?option=com_content&view=category&id=35&Itemid=80&lang=en.

([2]) Commission Staff Working Paper, Impact Assessment accompanying the document Directive of the European Parliament and of the Council on energy efficiency and amending and subsequently repealing Directives 2004/8/EC and 2006/32/EC {COM(2011) 370 final} {SEC(2011) 780 final}, Brussels, 22.6.2011, SEC(2011) 779 final. See http://ec.europa.eu/energy/efficiency/eed/doc/2011_directive/sec_2011_0779_impact_assessment.pdf.

Table 1.1 Energy policies with specific references to changing consumer behaviour and/or smart meter roll-out

Energy policy	Reference to consumer behaviour change and/or smart meter roll-out
Directive 2005/89/EC on security of supply	Encourages the adoption of real-time demand management
Directive 2006/32/EC on end-use energy services	Encourages the introduction of smart meters
Third liberalisation package ([a])	Requires transparency in energy billing information and encourages the introduction of smart meters

Note: ([a]) The third liberalisation package entered into force in September 2009 and includes a number of directives and regulations. For details, see the European Commission website http://ec.europa.eu/energy/gas_electricity/legislation/legislation_en.htm.

introduction of smart meters. Table 1.1 summarises the main energy policies with direct relevance for changing consumer behaviour in general and smart meters roll-out in particular.

To the extent that changing consumer behaviour and energy consumption practices lead to real and persistent energy savings, such change will help also other policies (such as climate policies) to achieve their goals. Households and industry sectors in the EU each generate approximately a quarter of energy-related greenhouse gas emissions. In 2010, these sectors were the ones mainly responsible for the emissions increase within the EU (EEA, 2012).

1.2 Aim of the report

There is a growing body of evidence in academic literature which demonstrates that there is potential for energy savings due to measures targeting behaviour change.

Conventional research on the subject points to the fact that the link between measures and behaviour is crucially important because there is evidence to suggest that technical interventions alone have lower impact and are more expensive to implement if carried out in isolation, i.e. without any accompanying programme designed to encourage behaviour change.

However, more recent research within the realm of social sciences (Shove, 2010) calls for the focus to be placed on changing energy consumption practices instead. According to Shove, what people do and what practices they decide to establish and reproduce depend on the active integration of a variety of factors (Figure 2.1 in Section 2.1 demonstrates the interplay between various factors).

One consequence of this is that policies targeting change in consumption practices rather than consumer behaviour alone will need to involve a wider range of actors. Looking at Figure 2.1 for instance, these actors could include those involved in creating opportunities and influencing capacity to undertake positive actions towards energy efficiency, but also those involved in technological and institutional development, and cultural role models.

The available literature mainly considers measures targeting consumer behaviour change rather than practices. The aim of this report, therefore, is to investigate the current level of knowledge on the effectiveness of such measures in achieving energy savings, based on empirical evidence from pilot projects across Europe.

Structural factors significantly influence consumer behaviour and practices (see Section 2.1). Some key structural factors influencing the effectiveness of measures targeting change in consumer behaviour vis-à-vis energy consumption and the rebound effect issue are thus also considered.

As such, this report aims to provide timely and reliable information and analysis for those involved in schemes designed to achieve energy efficiency through behaviour change.

1.3 Scope of the report

The subject of behaviour change vis-à-vis energy consumption is complex and involves a wide range of different possible measures to address it. It was therefore necessary to limit the scope of the present report to measures targeting change in consumer behaviour that appear to be (based on the literature reviewed) among the most effective in delivering energy efficiency benefits (energy savings).

1.3.1 Types of measures reviewed

The list of measures reviewed includes:

- feedback measures:
  - direct feedback — smart meters and in-home displays;
  - indirect feedback — enhanced billing; personal goal setting and feedback;
- energy audits;
- community-based initiatives.

Other measures were also screened, but their impact on reducing energy consumption was not sufficiently proven or was not directly related to changing behaviour, so they were not reviewed in detail. Such measures include:

- building certification and labelling;
- public engagement campaigns;
- financing schemes and subsidies;
- ecodesign.

1.3.2 Residential and non-residential

The design and delivery of behaviour change programmes related to energy efficiency can differ greatly when comparing domestic to non-domestic consumers. Households have a direct connection between their energy efficiency behaviour and monthly or quarterly cost of energy. In the non-domestic sector, initiatives are normally delivered at the organisational or sub-organisational level, and there is no direct link to personal wealth of the individual employees. Motivation for employees to engage in energy efficiency behaviours is therefore very different and must rely on corporate and social responsibility objectives and reinforcing societal norms.

Most of the trials and empirical evidence collected and reviewed relate to the domestic market (Brannlund et al., 2007; Ipsos MORI, 2011; OECD, 2008; Darby, 2001 and 2006; Hodge and Haltrech, 2009). This may be because the potential for savings through behaviour change is thought to be greater in the domestic environment, where there is more direct control over energy consumption. Aecom (Morant, 2012) reference a recent report by the Behavioural Insights team at the Cabinet Office of the United Kingdom, which suggests that people do not behave rationally with respect to energy usage in the workplace. It is worth noting that most employees would not benefit directly from initiatives to reduce energy consumption in a commercial setting, unless incentivised through competitions and provided with regular feedback on progress.

But a cross-over between initiatives can exist. For example, behaviour change measures at work may inspire consumers to act differently at home. There are also some reasons put forward in the reviewed literature as to why people's attitudes are different at home compared to the workplace. For instance, at home consumers are isolated from others. In the workplace, different norms apply.

For these reasons, the report takes into account both domestic and non-domestic consumer behaviour wherever possible.

1.3.3 Heating and cooling vs power monitoring only

Many of the trials on behaviour change in energy efficiency have focused exclusively on electricity use. This may be because, given the current infrastructure in Europe, it is easier to provide feedback on electricity consumption than on gas consumption. It has been pointed out (Brounen et al., 2012) that residential gas consumption is determined principally by structural dwelling characteristics, while electricity consumption varies more directly with household composition and social standing — and thus may be more responsive to behaviour change programmes. Whenever possible, the report considers literature on the effects of behaviour change on space heating demand as well.

1.4 Data collection and data quality

The data collection was carried out based on desk research and expert recommendations following the expert session held on 30 May 2012. With very few exceptions, the literature collected was peer-reviewed and published. The reports reviewed are listed in Appendix 1.

One of the quality issues encountered during the review was related to the fact that the analysis of behaviour change measures was based on limited attitudinal surveys; the projects did not always measure the impact on energy consumption. Some reports did identify measured reductions in energy use, while others investigated only the shift between peak and off-peak demand.

Where energy savings are recorded, this was often carried out over the campaign, with little consideration for results over a more prolonged period (i.e. they record how attitudes have changed over the course of the campaign, but there is no follow-up later). There is generally no assessment of whether any fundamental changes in lifestyle/behaviour have been made as a result of the pilot project. Where follow-up was carried out, this was usually within a maximum of two years after the end of the project. This period may not be sufficient to capture the full picture of long-term changes in consumption patterns and persistency of energy savings benefits. Furthermore, in some cases it was difficult to attribute changes in consumption to the original intervention. The situation is complicated by the existence of similar effects such as the Hawthorne effect and the drawback effect (see discussion in Chapter 4 on the rebound effect).

2 Energy efficiency measures and behaviour change

2.1 Consumer behaviour vs consumption practices

Most energy efficiency measures implemented (or yet to be implemented) in Europe involve technological interventions, but will equally have to rely on people adjusting their energy consumption behaviour. This section provides a short overview of the main factors influencing consumer behaviours and practices.

Behavioural models are necessary to understand what consumers do, and why they do so. Such models tend to vary widely by theory, concepts and applications (Axsen and Kurani, 2012). A simplified model is presented in Figure 2.1.

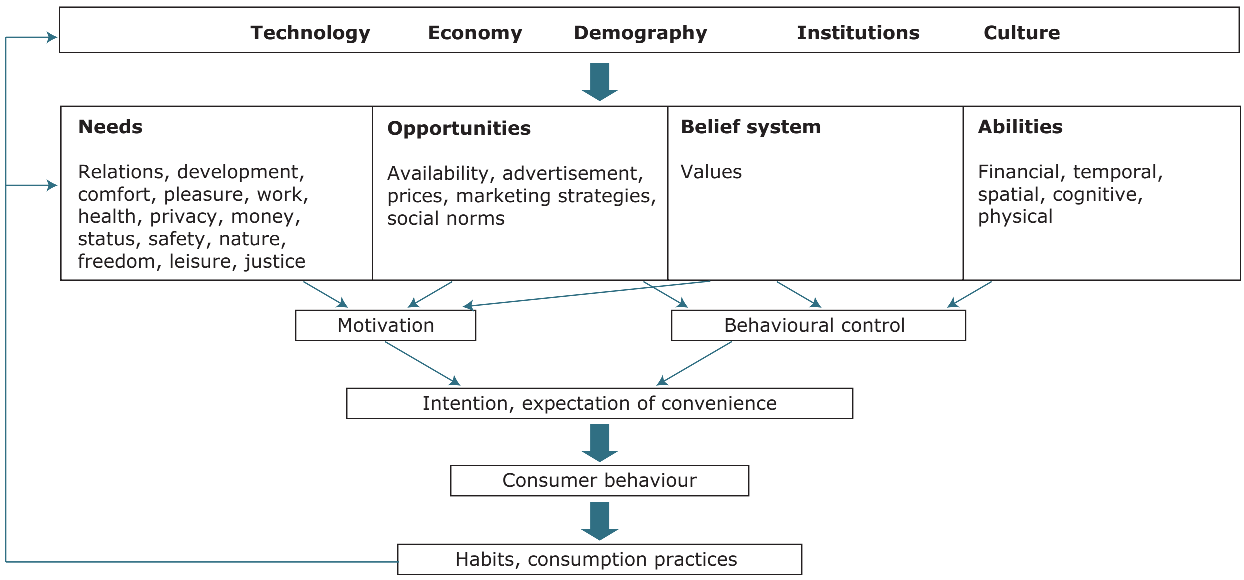
One important message evident in Figure 2.1 is that relationships between various factors that influence behaviour and consumption practices and the human element are dynamic, and not static, as they are assumed to be in a large body of literature on this topic. They change over time, rendering consumer behaviour and the process of consumption practices development somewhat irrational and to some extent unpredictable.

Social science can improve our understanding of individual and societal responses to their surroundings; it has been used to investigate people's relationship with energy, energy use and energy efficiency behaviour change initiatives/measures (for a brief overview of existing theoretical frameworks for consumer behaviour analysis, see Appendix 2).

Recent social science research reveals some of the shortcomings of the work carried out in this field on consumer behaviour over the past decades.

For instance, Elizabeth Shove (Shove, 2003) argues that there is evidence that routine consumption is controlled to a large extent by social norms, and is

Figure 2.1 Main factors influencing consumer behaviour and emergence of consumption practices



Source: Adapted from the NOA model described in Darton 'Methods and Models'.

profoundly shaped by cultural and economic factors (see also Figure 2.1). In her view, not only are habits changing, but they are doing so in a way that often leads to a standardisation of consumption patterns (via commercial interests, more often than not) conducive to an escalation of resource consumption and environmental degradation. In her work entitled *Converging Conventions of Comfort, Cleanliness and Convenience*, Shove challenges the conventional wisdom whereby adoption of more sustainable ways of life depends on the diffusion of 'green' beliefs and actions through society. She demonstrates that current consumption patterns, particularly in energy and water, reflect that we are generally not aware of routines and habits (for more details and examples in this research supporting this, see Appendix 2).

One of the main conclusions stemming from this research is that instead of keeping the focus on individual consumption one should rather concentrate on the emergence and transformation of collective conventions (social norms) as they are key in locking us into consumption patterns with different consequences for resource consumption and the environment.

Shove also argues that there is a close relationship between behaviours and infrastructure (Shove, 2010): energy infrastructure (e.g. smart grids, heating systems, roads and vehicles) plays a very active role in what people consider 'a normal way of life', according to her. While this is true, the interaction with new energy technologies is far from straightforward. Table A.3.1 in Appendix 3 briefly describes four possible dimensions in which to analyse human interaction with technology.

The implications of these more recent findings in social sciences research for policymakers are significant. If one chooses to focus on consumption practices and how these become instilled in society instead of consumer behaviour exclusively (which mainly considers individuals), then a wider range of actors (including those identified in Figure 2.1) should be engaged at the very start of the policy development cycle for energy efficiency. Given the complex interaction between consumers and new technologies, it also seems necessary to gain a better understanding of which conditions most favour technology take-up.

2.2 The measures

Energy efficiency/conservation initiatives use several different types of interventions:

1. communication and engagement:
    - information and promotion, training, personal advice and one-to-one engagement, demonstrations, benchmarking, commitment, goal-setting, labelling, prompts, modelling, feedback;
2. economic incentives and disincentives:
    - subsidies, levies, surcharges, taxes, bonuses, tax differentiations, tax refunds, financial instruments such as interest free loans, rewards and penalties;
3. regulatory:
    - general laws and rules, specific exemptions, covenants and agreements;
    - regulated versus dynamic energy pricing.

Many of the projects in the reports reviewed do not use behavioural factors to develop interventions and programmes, possibly because policymakers and those responsible for implementing energy efficiency measures are focused on the instrument itself rather than on the behaviour or consumption practice which is to be affected. This is an important point for policymakers to consider for future programmes.

Stromback et al. (2011) suggests that a more 'problem-oriented approach' is required to address behaviour in particular target groups. This contrasts with the instrument-oriented approach commonly used in most trials to date. Approaches focused on instrumentation tend to ignore the demographic make-up of the sample group and do not take into account any inbuilt bias in the selection.

The next sections look in detail at the different energy efficiency measures, and examine how they have been used to change behaviour.

2.2.1 *Feedback*

Feedback is an essential element in effective learning: this is equally true in domestic and non-domestic settings. There are a number of different feedback types; the reviewed literature suggests that they have a significant role to play in raising energy awareness and changing consumers' attitudes towards energy consumption.

There are different ways to provide feedback to energy consumers: direct feedback, indirect feedback, inadvertent feedback and energy audits (Darby, 2006). Table 2.1 describes the main types of feedback which can be used to change behaviour. Smart meters, which are of particular interest across Europe, are considered under direct feedback.

Direct feedback covers a range of systems designed to give instant (real-time) access to energy consumption information on a frequent or continual basis. Real time displays (RTDs) and smart meters have key features that are lacking from existing equipment:

- two-way communication with the supplier — enabling dynamic pricing and automated meter reading;
- export metering;
- in-building display of data (e.g. energy consumption, pricing, energy consumption for water heating).

The data to be displayed depend on the intended use. For domestic properties, this may be a relatively simple smart meter that only provides real-time energy costs. Historical information on energy consumption may also be available, and the information may be expressed in terms of energy, costs or CO_2 emissions. Typically this applies across

Table 2.1 Types of feedback on energy consumption

Types of feedback	
Direct feedback — available on demand Learning by looking or paying	• Direct displays • Interactive feedback via a PC • Smart meters - operated by smart cards - two-way (automatic) metering • Trigger devices/consumption limiters • Prepayment meters • Self-meter-reading • Meter reading with an adviser • Cost plugs
Indirect feedback — raw data processed by the utility and sent out to customers Learning by reading and reflecting	• More frequent bills based on meter readings • Frequent bills based on readings plus historical feedback • Frequent bills based on readings plus normative feedback (comparison with similar households) • Frequent bills plus disaggregated feedback • Frequent bills plus offers of audits or discounts on efficiency measures • Frequent bills plus detailed annual or quarterly energy reports
Inadvertent feedback Learning by association	• New energy-using equipment • Distributed renewable energy generation • Community energy-conservation projects and the potential for social learning
Energy audits	• Undertaken by a surveyor on the client's initiative • Undertaken as part of a house sale/purchase or other mandatory survey • Carried out on an informal basis by the consumer

Source: Darby, 2006.

gas and electricity usage. The in-building display is critical for enabling behaviour change; at present, most meters are inaccessible and require manual reading. Smart meters can also identify what time of day is cheaper to run certain equipment, notably white goods, to reduce peak consumption and thus cost. Smart meters can in fact be used for a wide range of network services, apart from just accurate billing, as the example from Denmark shows.

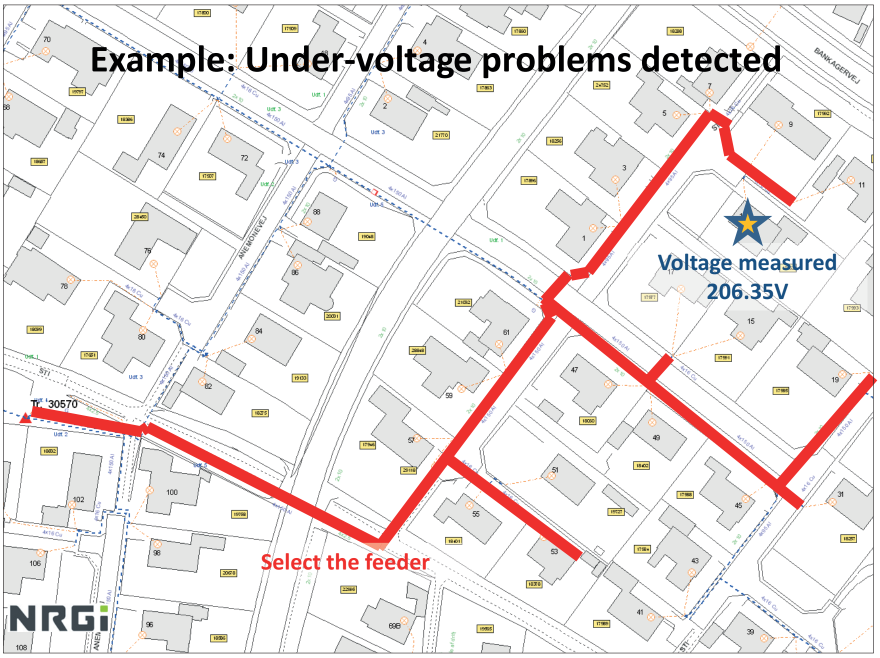
Example: The NRGi smart meter roll-out programme

Between 2009 and 2012, NRGi, a Danish energy company, installed 210 000 smart meters throughout their customer base. The primary objective of the programme was to prepare their service network for the future with better opportunities to spread the load (particularly in view of anticipated increase in the use of renewable energy and electric vehicles) and cheaper ways to maintain the grid (see Figure 2.2). Changing consumer behaviour or achieving energy savings were not factored specifically into the programme. In fact, according to a company representative ([3]), one of the bigger challenges they encountered during the roll-out was explaining to their customers why there is a need for a new meter and why new features are being added. Customers have the option to view their energy consumption via smartphone or the Web (with a delay of six hours), but the company did not observe much interest on the part of the consumers in these feedback options (possibly because the original implementation did not focus on consumer behaviour change).

In the United States, a survey was conducted by the Federal Energy Regulatory Commission (FERC) on the use of advanced metering amongst energy utilities. This revealed that 66 % of the utilities surveyed use advanced metering to enhance customer service, 53 % to detect outage and other line losses, 42 % to improve the quality of electricity supplied, 39 % for asset management, and only 19 % to induce demand response (Ehrhardt-Martinez and Donnelly, 2010).

The picture concerning the implementation of smart meters throughout Europe is patchy. Most Member States have begun trials with smart meters and have committed to roll them out more widely.

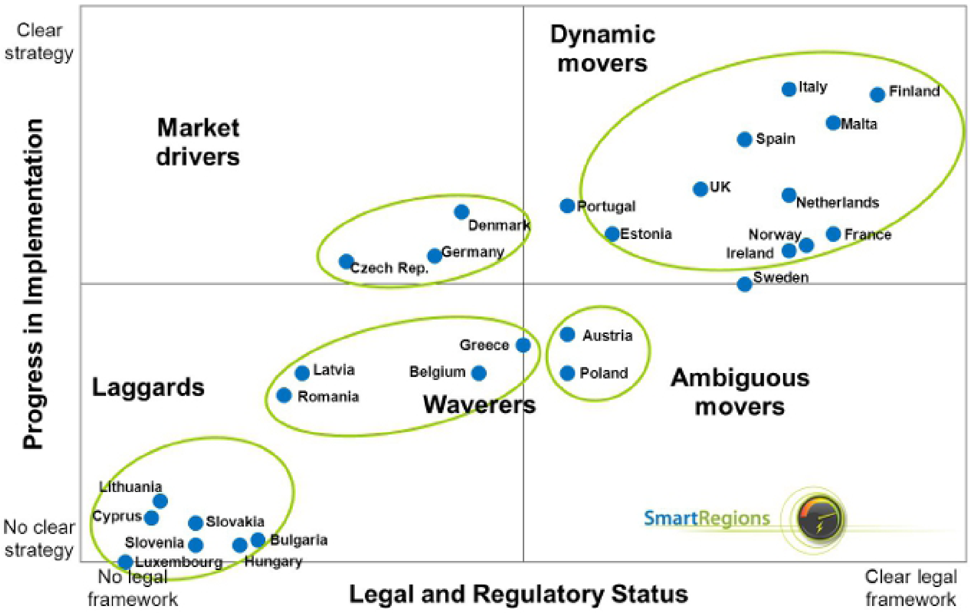
Figure 2.2 Identification of under-voltage problems using smart meters



Note: The figure shows how smart meters can be used to identify grid faults by measuring voltage, current, etc. For smart meters to be used in this way, it is important that the software in the meter and the system software support the desired functions and can be upgraded over time (NRGi) ([4]).

([3]) Based on personal communication with Per Svendsen (NRGi) on 20.11.2012.
([4]) Based on personal communication with Poul Berthelsen, Project manager at NRGi, on 19.11.2012.

Figure 2.3 Progress to date of implementation of smart-metering programmes in Europe



Source: Smart Regions project.

Also there are more smart meters in general in the non-domestic sector than in the domestic sector. Figure 2.3 provides a quick overview of the situation in Europe today with respect to the penetration of smart meters.

Example: The Swedish experience with smart meters (5)

The energy market in Sweden was opened in 1996. The smart meter roll-out programme started back in 2006, and was finalised in 2009 when mandatory monthly meter reading was introduced for all 5.2 million customers throughout the country. As of October 2012, all customers can have hourly readings if they wish, but this granularity is mandatory for customers in tertiary and industrial sectors. In May 2012, the Swedish government appointed the Coordination Council for Smart Grid, whose role is to 'coordinate and stimulate cooperation and knowledge transfer between different actors in the area of smart grid and deliver proposals to accelerate the development of smart grid in Sweden'. In Sweden, electricity billing was the number one reason for complaints, so more accurate billing based on real consumption data (instead of estimates) was the main driver for the smart meter rollout. However, the programme yielded benefits beyond the original scope, like reductions of about 9 % in energy loss in the transmission and distribution system. Based on the Swedish experience, the prerequisites for having more engaged consumers (facilitated by the introduction of smart meters) would include:

- dynamic pricing schemes;
- a clear distinction in the billing information provided to the customer between the various elements that constitute the end-user price (network tariffs, taxes, etc.);
- options to choose between suppliers or between different services offered by the same supplier;
- clear information concerning the impact on electricity cost of shifting consumption (e.g. from peak to off-peak periods).

Smart metering is also a key element of smart grid technology, providing a two-way link between the grid operators at one end, and customers (and suitably equipped home appliances) at the

(5) This section was developed based on the presentation by Karin Widegred, Director of the Swedish Coordination Council for Smart Grid, delivered during the EEA webinar 'Achieving energy efficiency through consumer behaviour: what does it take?' held on 4.9.2012. All relevant documents prepared for the webinar are available at http://ew.eea.europa.eu/eea_energy/webinar-material/eea-draft-reports.

other. The results of smart-metering consumer focus groups in Italy and Belgium indicate that smart metering alone would not deliver significant changes in consumer behaviour on their own, but they do constitute an essential part of wider behaviour change programmes, as they provide information necessary for more informed decision-making on energy use.

Smart meters were presented in the assessed reports as either stand-alone systems, or in research comparing means of presenting consumption information to consumers. There was also a body of research assessing market acceptance for smart meters, where they were typically found to be acceptable to consumers.

A review (Darby, 2006) of 38 different direct feedback projects carried out at various times between 1975 and 2000 demonstrated the potential for energy savings of some types of feedback. Despite challenges in comparing, interpreting and even categorising these studies (as they all contain a different mix of elements), the author concluded that feedback measures (direct and indirect) have a significant part to play in bringing about energy awareness and conservation.

A total of 21 direct feedback projects were studied, covering a range of measures:

- direct displays
- interactive feedback via PC
- smart meters
- trigger devices/consumption limiters
- prepayment meters
- self-meter-reading
- meter reading with an adviser
- cost plugs.

The reported savings are shown in Table 2.2.

The report drew several conclusions:

- direct feedback, alone or in combination with other factors, was the most promising single intervention type, with almost all of the projects that involved direct feedback producing savings of 5 % or more;
- the highest savings — in the region of 20 % — were achieved by using:
  - a table-top interactive cost- and power-display unit;
  - a smartcard meter for prepayment of electricity (coinciding with a change from group to individual metering);
  - an indicator showing the cumulative cost of operating an electric cooker;
- direct feedback in conjunction with some form of advice or information gave savings in the region of 10 % in 4 programmes aimed at low-income households.

Enhanced billing is a type of indirect feedback and can take a variety of forms. Typically, it includes a comparison of the consumer's consumption against a specific average. This can be based on the historical consumption of the dwelling, against a nominal baseline, or an average consumption. Enhanced energy bills can be used to provide feedback to consumers so as to encourage them to change their behaviour. Darby's review (2006) also included 13 indirect feedback projects that considered a range of different measures:

- more frequent bills based on meter readings;
- frequent bills based on readings plus historical feedback;

Table 2.2 Savings achieved by direct feedback studies

	Savings						
	Unknown	**0–4 %**	**5–9 %**	**10–14 %**	**15–19 %**	**20 % of peak**	**20 %**
Direct feedback studies (1975–2000) (n = 21)	–	2	8	7	1	–	3

Source: Darby, 2006.

- frequent bills based on readings plus normative feedback (comparison with similar households);
- frequent bills plus disaggregated feedback;
- frequent bills plus offers of audits or discounts on efficiency measures;
- frequent bills plus detailed annual or quarterly energy reports.

The savings reported by these 13 indirect feedback projects studied are shown in Table 2.3.

The report concluded that as far as indirect feedback measures are concerned, the range of savings achieved tends to be lower than the one reported in direct feedback studies; nevertheless, they may be important and are achievable at relatively low cost. This demonstrates that indirect feedback via better billing can have a part to play in bringing about energy awareness and conservation — if used within a mixture of measures to encourage energy efficiency.

As concerns enhanced billing, there are several ways (Iyer et al., 2006; Roberts & Baker, 2003) to make energy bills more informative, by including:

- charts which visualise households' energy use trends;
- comparisons of energy use (e.g. to the previous month or the same month in the previous year);
- comparisons to selected user groups (such as households in the same street).

A recent British government report (Ipsos MORI, 2011) investigating the most appropriate benchmarks to be included on bills indicated that participants had a range of reactions to the inclusion of a consumption benchmark within their bill, and concluded that an average measure of energy consumption from the local area was the most effective benchmark for participants.

The key is to provide householders with better, more informative bills on how much energy they use and how much it is costing them, either in monetary or environmental terms. More clearly presented bills would also give households an opportunity to see how much gas or electricity they are saving. A report by the Centre for Sustainable Energy (Roberts and Baker, 2003) concluded that feedback and more informative billing could reduce energy consumption by 5 % to 10 %.

In Europe, the Citizens Energy Forum ([6]) was established to facilitate the exchange of good practice in improving consumer information on energy. The Working Group on Billing provided recommendations on possible improvements for energy billing, based on good practices already implemented in Austria, Italy, Norway, Sweden and the United Kingdom, for electricity and gas ([7]). Priority billing items recommended by the working group include:

- supplier details (name and contact details for queries) and contact hours;
- customer name, billing address and supply address (if different);
- customer account reference number;
- date of the bill and when payment is due;
- the period over which the energy shown on the bill has been consumed;

Table 2.3 Savings achieved by indirect feedback projects

	Savings						
	Unknown	0–4 %	5–9 %	10–14 %	15–19 %	20 % of peak	20 %
Indirect feedback studies (n = 13)	3	3	–	6	1	–	–

Source: Darby, 2006.

([6]) See http://ec.europa.eu/energy/gas_electricity/forum_citizen_energy_en.htm. Please check archive for 2009, presentation from J. Minor on billing.

([7]) More details are available from http://ec.europa.eu/energy/gas_electricity/doc/forum_citizen_energy/2009_09_29_citizens_energy_forum_reports_and_materials.zip.

- the energy product (gas/electricity/both) supplied;
- the total cost (for each product);
- the total consumption (kWh);
- if costs excluding VAT are stated, the VAT charged;
- the total amount payable (including VAT);
- the telephone number (and contact hours) customers can call for queries and payment difficulties;
- the telephone number for reporting gas emergencies and/or electricity problems;
- contact information, e.g. client services, for questions and/or complaints;
- identification of point of delivery, i.e. customer switching code, EAN, meter point reference number (MPRN), metering point administration number (MPAN), MPID — as relevant per Member State;
- disaggregation between network and supply price components, if appropriate to national market conditions;
- meter readings used at the beginning and end of the billing period, and the reading date and method used for the reading (e.g. whether actual or estimated);
- name and contact information of network operator (for network issues).

The Energy Demand Research Project (EDRP) was a major project in the United Kingdom to gauge consumer responses to different forms of information about their energy use (Ofgem, Raw and Ross, 2011). Four energy suppliers each conducted trials of the impacts of various interventions (individually or in combination) between 2007 and 2010. The interventions were primarily directed at reducing domestic energy consumption, with a minority focused on shifting energy use away from periods of peak demand. The measures were generally applied at household level, but one supplier also tested action at community level. The project involved over 60 000 households and the installation of 18 000 smart meters. The findings are as follows:

- Interventions using smart meters were often successful and resulted in larger energy savings compared to other measures. This may be in part explained by the process of receiving the smart meter (e.g. the positive effect of getting new technology), but also by the different options available once a smart meter was installed, e.g. more sophisticated real-time displays (RTDs), and more frequent and accurate historical feedback and billing.
- The provision of an RTD was particularly important in achieving savings in electricity consumption. Gas savings could be achieved through installation of a smart meter without further intervention, although evidence of persistence was not as strong as for electricity savings with RTDs.
- Electricity savings can be promoted through provision of advice and historical feedback on consumption but they cannot be relied upon individually; a combination with a direct feedback measure is likely to have higher benefits.
- The combination of smart meters and RTDs consistently resulted in energy savings of around 3 % on average (differences depended on the fuel used, the customer group and the time of use). Providing an RTD with a smart meter is important: savings were generally 2 % to 4 % higher than with a smart meter only (with a full range going up to 11 % for some periods and customer groups).
- Financial incentives and commitment to reduce consumption had either no effect or a very short-term effect.
- The delivery of information through the Web or customers' TVs was not successful.
- Community engagement can also be effective, but may require a higher initial investment and will not necessarily work in all localities.

The project also highlighted that support from the equipment installers may be particularly important for users to learn how to operate the devices in an optimal way. Furthermore, customer surveys on RTDs showed that cost information was used and valued more than unit (kW) information, and electricity information more than gas. Displays of CO_2 emissions were generally not widely noticed, used, or perceived as useful.

There were two further interesting findings from the literature carried out for the ERDP:

- households may find RTDs more useful in confirming savings after attempts to reduce consumption, than when using an RTD to initiate savings;
- RTDs can be used to check that everything has been switched off before going to bed or leaving the house (Ofgem, Raw and Ross, 2011).

To be effective, feedback needs to be continual. For instance, in a Dutch report on 285 respondents' gas consumption, researchers found that feedback displays showing constant or cumulative information on energy consumption resulted in monthly energy savings of as much as 15 % during the report; once feedback was removed, however, consumption increased for all respondents within one year after the initial report (van Houwelingen and van Raaij, 1989).

Several studies on feedback found that the level of households' previous energy consumption can bear upon the effect of the feedback. Researchers (Brandon and Lewis, 1999) found that high- and medium-level energy users are likely to reduce energy use with feedback, while low-level energy users are likely to increase it. The report analysed various forms of feedback on the gas and electricity consumption of 120 households, and found that the level of previous energy consumption had an impact on energy-using behaviour. Following comparative feedback, high-level energy consumers reduced their energy consumption by an average of 3.6 %, and medium-level energy consumers by an average of 2.4 %; low-level energy consumers, however, increased their consumption by 10.7 %.

A recent meta-review of residential feedback programmes concerning electricity consumption in the household sector (Ehrhardt-Martinez and Donnelly, 2010) examined 57 studies worldwide. According to this report, energy savings due to direct feedback generally fall within the range of 5 % to 15 %. Energy savings from indirect feedback can reach 10 %, but success depends on the context and the quality of information delivered to households. Moreover, the higher end of the range tends to be delivered by short-term trials and smaller-scale projects (up to 100 participants). The report also considered the effect of the economic context. Interestingly, it concluded that the level of energy savings due to feedback programmes was higher during the 'energy crisis era' (1974–1995) than during the 'climate change era' (1995–2010). Regional differences were stronger in more recent studies (e.g. energy savings reported in the United States were somewhat lower than those reported in Europe during the 'climate change era'). Finally, the report highlights the clear distinction between demand response programmes and energy efficiency. While demand response programmes tend to focus on reducing peak demand during specific periods of time, energy efficiency measures are more comprehensive and focus on reducing energy consumption across the board. While there may be synergies between these different measures, there may also be potential conflicts. For instance, focusing on peak demand can help identify situations where energy is simply wasted and therefore a demand response programme can be complemented with other energy efficiency measures to eliminate this waste permanently. Also, experience from demand response programmes could have a positive spillover effect on other energy efficiency measures. On the other hand, if customers are paid on the basis of the amount of load they can temporarily reduce when called upon (measured against a business-as-usual baseline), this can create a disincentive to take more permanent energy efficiency measures.

Feedback measures: main messages

Without an appropriate frame of reference, consumers cannot determine whether their energy consumption is excessive. The way in which the feedback is delivered, and whether consumers understand the information and come to believe that they can make a difference are very important. The most successful combination of measures seems to involve both direct and indirect feedback, in order to increase the consumer's awareness on energy consumption and maintain the motivation to actively engage in energy efficiency actions. In addition, the level of energy consumption existing prior to the implementation of the measure/programme can influence the outcome of the measure/programme.

Policymakers seem focused more on the instrument itself than on the behaviour and consumption practice that needs to be changed. A problem-solving approach in lieu of the instrument-oriented approach would allow one to properly account for demographic make-up and other biases of the targeted group, possibly leading to a more successful implementation of behavioural measures.

Smart-meter rollout programmes implemented by energy utilities tend to be driven by the utility's operational concerns (cost reduction and profit enhancement by improving the quality of energy service delivered). Consequently, real opportunities to achieve energy savings may be overlooked in such programmes.

The results reported in the studies surveyed on feedback measures were significantly influenced by the duration of the trial, the sample size and the consumer profile. So when designing nation-wide measures, all these factors need to be accounted for.

Understanding the relationship between feedback measures, demand response programmes and energy efficiency programmes is crucially important in order to avoid potential conflicts, and ultimately to capture the full energy-saving potential available.

Feedback measures cannot operate in isolation from the overall economic context. Attention should be paid to the prevailing driving force (e.g. concerns regarding energy security, climate change, economic recovery) at the time when the measures are being considered, as well as to whether and how these driving forces are likely to change for the lifetime of the measure.

2.2.2 *Feedback and target setting*

Goal or target setting is another method to encourage households to save energy. This measure is often applied on a self-selective basis, i.e. households themselves will define and commit to a certain energy-saving target. This kind of commitment can be effective — in some cases, even more effective than material incentives or rewards in terms of rapid behaviour change — and it can also result in long-term behaviour change (De Young, 1993).

Research (Becker, 1978) found that not only did the level of the target have an influence on how well people perform in energy saving, but that an energy-saving target combined with feedback resulted in higher savings. This indicates that feedback can help households determine how close they are to achieving their goal.

Becker's research looked at the electricity use of 80 families in the United States who were asked to set either an easy (2 %) or a difficult (20 %) energy-saving goal. The sample was further divided into those who received feedback three times a week and those who did not receive feedback. A control group of additional 20 families received neither a goal nor feedback. The results are presented in Table 2.4.

These results are similar to those of another report (McCalley & Midden, 2002) which also found that those who had a self-set target were the most successful in reducing their energy use.

Target setting: main message

Setting up personal goals with respect to achieving energy savings can serve as a successful tool, particularly when self-set by the target group and accompanied by feedback measures.

2.2.3 *Energy audits*

Energy audits have been instrumental in advancing energy efficiency in Europe for many years. More recently, energy audits have been considered in the recast of Directive 2010/31/EC on energy performance of buildings in connection to the

Table 2.4 Savings achieved through goal setting and feedback

Energy-saving target	Energy consumption reduced with feedback	Energy consumption reduced without feedback
20 %	15.1 %	4.5 %
2 %	5.7 %	0.6 %

Source: Becker, 1978.

issuance of building certificates, as well as by the new Energy Efficiency Directive. More specifically, Article 8 of the Energy Efficiency Directive includes recommendations for Member States to promote energy audit activities in the small and medium-sized enterprise (SME) sector and makes energy audits mandatory for large enterprises. In addition, the directive encourages Member States to raise awareness about the benefits of energy audits among households.

Energy audits provide detailed information on energy use and saving potential. An energy audit would normally include an evaluation of the thermal characteristics of the building, its existing infrastructure and the appliances in use. In addition, the audit report documents users' activities and the saving potential, and provides recommendations for investments (Brohman, Cames, Groes, de Best-Waldhober).Therefore energy audits are useful because they provide information tailored to a specific context and actual consumption, which tends to lead to a more successful outcome in terms of improving the energy management than one-size-fits-all energy-saving information (Ball, 2007; Roberts, 2007; Rohr, 2007). Furthermore, energy audits are usually delivered by independent experts, and this independence seems to be valued by consumers.

More often than not however, the energy audit reports do not address behaviour change. Typically, energy audits tend to focus more on measures that require investment in a specific technology. They could, however, be successful in raising awareness about energy issues, a prerequisite for changing behaviour and consumption practices. One example is the Norwegian Industrial Energy Efficiency Network (IEEN).

Example: the Norwegian Industrial Energy Efficiency Network (IEEN)

The IEEN was established in 1989 by the Ministry of Petroleum and Energy in Norway to stimulate energy efficiency measures. The programme was instrumental in identifying and realising the industrial energy efficiency potential in the mid-1990s. A total of 900 companies (two thirds being SMEs) participated in the programme.

At that time, the Norwegian government set up an energy-saving target of 43 PJ/year to be achieved by 2010, out of which 9 PJ/y were expected to be delivered by the industry through energy efficiency measures and switching to renewable energy.

The network members could obtain governmental grants covering a significant part of the costs associated with the energy auditing and energy efficiency measures implemented. In addition, a web-based benchmarking tool was set up to allow participating companies to access information on their own energy consumption compared to the consumption of other companies within the same industrial branch. The tool was based on self-reporting, one of the preconditions for receiving public support being that the network members had to actively engage in filling in the online database. The grant could be accessed in two stages. In the first stage, companies identified the main energy flows and possible energy-saving measures. In the second stage, a more in-depth analysis of possible and cost-effective investments was undertaken.

An independent ex post evaluation of the programme was carried out and the main outcomes were presented in (Modig, 2006). The results suggest that the programme was largely successful.

- Overall, the programme achieved 6 PJ/year of energy savings.
- The average energy savings at company level were about 6 %, with most participants indicating that the measures will last for at least 10 years.
- The deadweight ([8]) was estimated to be in the range of 10 % to 50 %, depending on how the answers to the questionnaire are interpreted.
- The programme was cost-effective: the public cost was EUR 0.03 ¢/MJ ([9]) while the private cost amounted to EUR 0.01 ¢/MJ ([10]). These costs compared well to the average cost of electricity at the time, of EUR 1 ¢/MJ for industrial consumers.
- Only 8 % of the participants failed to deliver agreed outcomes, reflecting high participant motivation (largely sustained by the benchmarking tool) and good programme management by the public authority.

([8]) Deadweight represents companies who would have taken the measures regardless, even in absence of the programme. This should always be accounted for when evaluating the cost effectiveness of any energy efficiency programme.
([9]) The interest rate was 4 %, and the economic lifetime of the project was 10 years.
([10]) The interest rate was 15 %, and the economic life of the project was 10 years.

But the benefits of the programme went beyond pure energy savings and cost effectiveness:

- 85 % of the respondents stated that the main motivation to participate in the programme was to be able to reduce energy costs;
- a great majority of the respondents indicated that the programme resulted in increasing knowledge on energy matters and their ability to carry out such measures in the future;
- communication between actors active within the same industry branch improved, leading to a fruitful exchange of ideas on technological improvements, for compressed air systems, the use of low temperature effluent water, heat pumps, etc.

One important success factor was the fact that the focus of the programme was the SME sector, where capacity to implement proper energy management systems is more limited compared to big, energy intensive companies.

Given the success of the programme, the Norwegian government has implemented a more advanced successor programme where one of the preconditions for receiving public support is good basic knowledge of energy issues. In addition, the programme inspired a pilot project aiming to bring together 11 European countries to identify energy efficiency potential in industry.

In some of the literature reviewed, however, energy audits were assessed in isolation as a means to relate the potential for energy savings directly to a consumer. Energy audits also tended to be seen as part of the solution to upgrade the quality of the building, with energy efficiency being more a consequence of conducting such audits than a driver for doing so. Sometimes, a large number of audits were undertaken as part of a wider assessment of the housing conditions, to identify dwellings eligible for specific funding streams, i.e. those with difficult-to-treat walls or those within a specific demographic (e.g. elderly people in hard-to-treat homes).

Some studies found that people were generally engaged in the process and, where possible, investments were made to improve the energy efficiency of the building. This suggests that energy audits may have a role to play in changing consumers' attitudes vis-à-vis energy consumption.

For example, back in the 1980s, one report showed that households receiving an energy audit (on their energy consumption for heating and air conditioning) used 21 % less electricity compared to a control group (e.g. Winett et al. 1983). Likewise, in Poland, within the framework of a project aiming to convince managers of various industrial facilities of the benefits of energy efficiency, energy audits were carried out in selected facilities with know-how transfer from Ireland and Netherlands. The project seems to have resulted in raising managers' awareness of energy efficiency benefits, of the importance of properly monitored energy consumption, of setting energy efficiency goals, and of adequately planning for energy efficiency investments. In addition, real reductions in energy consumption by implementing no-cost or low-cost measures were observed (energy-cities case report Poland ([11])).

Other studies, however, could not attribute with certainty the contribution of energy audits to energy savings, either in cases where tailored energy advice was delivered in combination with other feedback measures, or when they were stand-alone programmes.

For example, a Finnish report by the Department of Home Economics, VTT Building Technology and Finnish District Heating Association (Martiskainen, 2007) studied 105 district-heated households. Findings showed that following monthly feedback and focused energy-saving advice:

- 54 % of households reduced energy consumption by turning off lighting in empty rooms;
- 27 % lowered room temperatures;
- 27 % dressed more warmly;
- 23 % paid attention to thermostat valves.

The report also found that:

- 68 % considered that economic reasons provided motivation to save energy;
- 20 % considered environmental reasons to be the main motivator;
- 40 % reported that the monthly meter reading feedback on their consumption made them think about their consumption;
- 13 % altered their habits following the feedback.

([11]) http://www.energy-cities.eu/db/poland2_569_en.pdf.

The results showed that households were able to reduce energy consumption (both electricity and heating) without compromising their level of comfort. Heating energy consumption fell by 3 % to 9 % following feedback on consumption, compared to the previous year. Electricity consumption in the treatment groups decreased by an average of 17 % to 21 % following feedback. However, there was little evidence of the result being linked to the advice which was given after feedback.

An evaluation of the Canadian ENERSAVE programme (McDougall, Claxton and Ritchie, 1983) found that there was no difference in the reported energy-saving actions and actual energy use between those who had received tailored information and those who had not, when participants were contacted again two years after the implementation of the programme. A possible explanation is the relatively long time that elapsed between implementation of the intervention and the measurement.

Good practice from the National Energy Efficiency Action Plans (Schüle et al., 2009) cites the Austrian and Irish campaigns and confirms that information supported by energy audits is one effective way to raise awareness on energy efficiency opportunities in the household sector.

Energy audits: main messages

Energy audits are an useful tool for providing the information needed to implement energy efficiency measures in a specific environment. The literature reviewed supports the idea that there is a direct link between implementing energy audits and achieving tangible energy savings, but is less clear about the extent to which energy audits can trigger real and persistent changes in consumer behaviour.

The link between energy audits and changing consumer behaviour is via increasing awareness about energy consumption. To the extent that the energy audit is part of a longer-term programme to improve energy management (i.e. not just a one-off activity where decisions to implement measures are to be taken at a later stage), chances are that it will lead to sustained changes in consumer behaviour and consumption practices.

2.3 Community-based initiatives

Community-based initiatives, being adopted by an increasing number of programmes, are a fairly recent approach to pro-environmental behaviour change. Within the framework of such initiatives, small groups of people gather together and decide on a range of behaviours and attitudes that can be changed either to reduce their overall environmental footprint and/or to increase energy efficiency, in a report group format. The group size varies: from less than 10 people to more than 100, but in some cases reaching 1 000 individuals. The group meets regularly and is given access to reliable information through written material and/or access to a trained expert. The group studies the information available and decides on the range of behaviours to be changed for the purpose of reducing their overall environmental impact and/or reducing energy consumption.

Report groups are usually formed by people from the same neighbourhood, workplace or community of interest such as a faith or a voluntary group. So there is already an established relationship between the members of the group prior to the start of the programme.

The literature reviewed suggests that these types of initiatives appear to be most effective when they are part of a more comprehensive programme that includes feedback measures and/or aims to implement technological interventions to the building envelope.

Primarily targeted at the domestic sector, community initiatives also reinforce positive change in social norms regarding environmental/energy efficiency behaviour and allow sharing of good practice. The fact that the group members are already acquainted may have a positive influence on establishing these social norms. Community initiatives have the potential to establish ownership and responsibility for actions to improve environmental footprint/energy efficiency, even in situations where individuals may otherwise feel that their contribution is insignificant. In other words, it is important that information on the individual impact on the local company delivering the services targeted by the programme (be it the energy utility, the water company, etc.) is clearly communicated.

In most of the studies reviewed, community-based initiatives were considered successful in both motivating change and maintaining this motivation over a prolonged period of time. This is mostly due to the fact that the focus on resources/energy management at the community scale meant that social norms and behaviours were changed, and that people wanted to be in sync with their local community.

Table 2.5 European group- or community-based projects

Project	Description
EcoTeams (United Kingdom and the Netherlands)	The EcoTeams programme is run by Global Action Plan (GAP) both in the Netherlands and in the United Kingdom. British EcoTeams met once a month for five months with set monthly topics. Meetings were facilitated either by GAP employees or by trained volunteers, and attendants were provided with information packs and workbooks, and encouraged to explore, discuss and share information. By 2008, a total of 3 602 British households had participated in EcoTeams, and household consumption data were available for 1 096 households (GAP United Kingdom, 2006 and 2008). The Dutch EcoTeams programme has been extensively assessed in a longitudinal report (where people are studied and restudied over a long period of time) of 153 households through questionnaires and measurement of energy, waste and water use (Staats and Harland, 1995; Staats et al., 2004).
Carbon Rationing/ Reduction Groups (CRAGs)	The CRAG movement is a loose-knit community of people who meet in groups to reduce their carbon emissions. Unlike EcoTeams, there is no specific model for how CRAGs function. Members agreed how to record changes in energy use and emissions, recorded their own meter and odometer readings and shared information at regular meetings. Individual CRAGs chose how often to meet (usually monthly) and participants valued the opportunity to discuss changes and share ideas. CRAGs used an annual accounting system and had no trained facilitators, but groups were supported by information on the CRAG website (Howell, 2009; Seyfang et al., 2007).
Green Streets	A slightly different group-based intervention was conducted by British Gas as part of its Green Streets programme. Eight households were recruited in each of eight streets to form neighbourhood teams with the aim of reducing the emissions of all the households in the team. The team that made the largest reductions won a cash prize. Green Streets households were supported by a dedicated energy advisor and the teams met to discuss and share information. British Gas also provided each group with GBP 30 000 of funding to make improvements to the households, including a mandatory element of renewable energy generation. Green Streets participants were provided with feedback through handheld meters and monitoring of energy consumption through monthly meter readings (Lockwood and Platt, 2009).

The most successful schemes identified in the literature review involved financial incentives for communities to invest in energy efficiency. This typically led to the largest savings and motivated people to maintain behaviour, as there was a tangible financial reward. It also enabled people to learn from others in their surroundings. However, the literature is somewhat scarce on success stories for community initiatives in communities with low-income households or diverse ethnic profiles,

Table 2.6 Savings achieved by group- or community-based projects

Programme	Number of participants	Percent reduction	Percent carbon reduction	Data collection
British EcoTeams	1 096	Electricity: 7 Gas: 21 Water: 15 Waste: 20	17	Meter readings and weights reported by participants
Netherlands EcoTeams	153	Electricity: 7 Gas: 23 Water: 5 Waste: 30	Unreported	Meter readings and weights reported by participants
CRAGs	50	Unreported	27	Meter readings reported by participants
Green Streets	64	Energy: 25	23	Meter readings collected by British Gas

Source: Fisher & Irvine, 2010.

where it may be harder to motivate people to make a change.

Three group- or community-based interventions have been studied extensively:

- EcoTeams (Netherlands and the United Kingdom);
- Carbon Rationing/Reduction Groups (CRAGs) (United Kingdom);
- Green Streets (United Kingdom).

Published evaluations (Fisher & Irvine, 2010) of these group-based interventions have shown average reductions in energy use and carbon emissions of approximately 20 % within a year.

The researchers noted that total reductions in carbon emissions for the Netherlands and the United Kingdom EcoTeams may be higher than those reported here, as savings in transport emissions were not recorded (because they were not included in the programme). It should also be noted that although some of the reductions in the Green Streets programme are attributable to improvements facilitated by the funding provided by British Gas, only about 50 % of the energy savings were attributable to installed measures; the rest were the result of behaviour change.

The reductions in energy use, water use, carbon emissions and waste production found in the interventions were mainly a result of changes in a collection of related behaviours. Dutch EcoTeams report significant changes in 19 out of 38 measured behaviours, and a significant number of British EcoTeams members adopted at least 22 new pro-environmental behaviours. Participants in Green Streets indicated that the households adopted at least 13 pro-environmental behaviours.

All the interventions reviewed here achieved results within one year (British EcoTeams demonstrated results after five months, the Dutch EcoTeams after nine months, and the CRAGs and Green Streets after one year).

Evidence from these programmes suggests that group-based interventions may be best suited to communities already with a high level of awareness on sustainability issues. However, evidence on participants in the semi-facilitated British EcoTeams model suggests that this type of intervention could be applied more widely with training of volunteer facilitators from a wider variety of contexts. The Green Street participants did not start with specifically pro-environmental attitudes, but the funding from British Gas may have encouraged people to get involved with the programme.

In the Netherlands, a follow-up report of EcoTeams households six to nine months after completion of the programme showed further significant reductions. After a further two years, these reductions had been maintained or improved upon. These participants were compared with a sample matched for pro-environmental behaviours from a representative household survey on environmental behaviour conducted annually in the Netherlands. During the first year, the pro-environmental behaviour of EcoTeams participants increased significantly more than that of the control group, despite that fact that the behaviour of the control group improved slightly. Over the following two years, the pro-environmental behaviour of the EcoTeams participants continued to improve, while that of the control group showed no change (Darby, 2010; Fisher & Irvine, 2010), as seen in Table 2.7.

Table 2.7 Behaviour change in Dutch EcoTeams

EcoTeams	Consumption after ETP programme (compared to control group)	Two-year follow up (compared to control group)
Gas use	– 20.5 %	– 16.9 %
Electricity use	– 4.6 %	– 7.6 %
Water use	– 2.8 %	– 6.7 %
Waste	– 28.5 %	– 32.1 %

Note: There are some differences in the data from the research displayed in this and Table 2.6, but overall, the results are broadly similar.

Source: Darby, 2010.

Many of these types of community-based activities have a local 'champion' driving the initiative, often a trusted and well-known figure in the local community.

Community-based initiatives: main messages

Community-based initiatives could lead to long-term behaviour change because they facilitate the introduction of new, pro-environmental social norms, and because within these programmes, participants benefit from a relevant frame of reference for their behaviour (people they know and trust, or who share similar interests or beliefs, etc.).

For these types of initiatives to be successful, it is important that they form part of a wider programme with clear objectives to reduce environmental footprints or increase energy efficiency, and with additional feedback measures and/or investment strategies. Moreover, it appears to be important whether there is a pre-existing relationship between the participants, and whether participants share pro-environmental views. Finally, such initiatives are likely to be more successful if they involve a role model that resonates with the selected group.

2.4 Other measures that could be relevant for behaviour change

The focus of this report has been on measures directly linked to changes in consumer behaviour. This section includes measures that might be relevant from the point of view of improving energy efficiency, but for which the literature reviewed is inconclusive concerning their direct impact on behaviour change (and consequently, they were not studied in depth).

2.4.1 Building certification and labelling

Directive 2010/31/EU on the energy performance of buildings requires Member States to establish a system for certification of energy performance of buildings. However, only buildings owned by public authorities and those frequently visited by the public and with a floor area exceeding 500 m^2 are required to actually display the certificate. For non-domestic buildings, the directive requires that a common, voluntary scheme of certification be established. Currently, certification schemes of buildings around Europe are examining a wider range of issues than just energy performance. Examples are the BRE Environmental Assessment Method (BREEAM) (United Kingdom), the Deutsches Gütesiegel Nachhaltiges Bauen (DGNB) (Germany), the Haute Qualité Environnementale (HQE) (France), VERDE (Spain) and others.

One European project, IDEAL-EPBD (2013), looked into the effectiveness of energy performance certificates (EPCs) in influencing home owners' decisions with regard to energy efficiency. The final report (Tigchelaar, Backhaus, de Best-Waldhober, 2011) indicates that homeowners are generally not aware of the EPC and its recommendations, but that if they were, they would be likely to undertake energy efficiency measures compared to homeowners that do not have an EPC. Having said this, the project could not ascertain with certainty whether an EPC would definitely influence tenants' behaviour towards energy efficiency (as it is also possible that people interested in renovating their homes simply pay more attention to the recommendations in the EPC). To make the EPC more effective, it was recommended to improve their availability, presentation and content.

Other issues to be considered include the fact that people with an understanding of energy-efficient behaviour self-select low-carbon buildings, so the impact of behaviour change measures may be small as the scope for further improvement is limited. It is also possible that tenants will regard the building as sustainable per se, and will therefore not take any further actions in terms of behaviour change.

2.4.2 Economic instruments

There are a number of economic instruments applied to the energy sector. Energy taxation systems across Europe differ due to structural characteristics (existing infrastructure) as well as political choices (revenue raising, protection/promotion of national companies, international competitiveness, etc.) ([12]).

This section, however, focuses only on economic instruments specifically targeting energy efficiency measures and consumers' behaviour change.

([12]) A good discussion can be found in the regular report from Eurogas 'Energy taxation in the European Economic Area' from April 2010 (http://www.eurogas.org/uploaded/Eurogas%20Taxation%20Report%20as%20of%20April%202010_final240610.pdf). For electricity, the Eurelectric publication 'Taxes and levies on electricity in 2011' provides an excellent overview (http://www.eurelectric.org/media/60787/taxes_and_levies_on_electricity_2011_-_final-2012-560-0006-01-e.pdf).

Funding for energy efficiency measures takes place via either central/local government in the form of subsidies for specific investment (usually involving a technical measure), or private investment at the community scale (e.g. utilities).

More recently, there has been some discussion of introducing feed-in tariffs for energy efficiency (Eyre, 2012). The advantage of such a financing mechanism is that it allows the provision of fixed price incentives for energy efficiency measures to a broader range of stakeholders and types of measures. At the same time, one of the main challenges will be to measure with a high degree of certainty the outcomes of the measures, with ex ante estimations being currently perceived as a more efficient option.

The main reason for not focusing in depth on economic instruments in this report is because, more often than not, they involve an investment in technology rather than aim to influence behaviour.

Rewards can be effective if they are designed well; however, research has shown that the effects of rewards and incentives are not always maintained for the long term — in most cases, they last only for as long as the intervention is in place (Martiskainen, 2007).

The recent British trials on energy demand confirmed this point (Ofgem, Raw and Ross, 2011). 'EDRP found no reliable or persistent effect of either financial incentives to reduce energy consumption or general statements of commitment to reduce consumption. The literature provides little substantive evidence on financial incentives to meet a consumption reduction target except for the general (and obvious) point that sufficient incentive will prompt people to reduce consumption, but only for as long as the incentive is kept in place. Three EDRP trials employed financial incentives to reduce consumption but only Scottish Power saw reductions in consumption when the incentives were applied — only in the case of credit customers with smart meters and only for short periods. Raw and Ross conclude that the Hawthorne effect ([13]) is a sufficient explanation of the Scottish Power findings. There are also concerns in the literature that using the financial motive in this way could focus households' attention on financial savings and that this could reduce the chances of seeing long-term savings because other motives to reduce consumption are suppressed by the financial motive.'

The advent of more widespread smart metering may enable a more sophisticated reward structure to be developed (see also Section 3.3 on the influence of smart meters on tariff structures).

2.4.3 Ecodesign requirements

Energy labelling of consumer energy-using products and of buildings themselves contributes towards energy awareness among building occupiers and users. However, while labelling of products plays a part in investment decisions, there is little evidence to suggest that patterns of usage of products or buildings are strongly influenced by it. A recent working paper of the European Commission (SEC(2011) 469 final) on consumer empowerment in the EU elaborated based on interviews with 55 000 consumers revealed that approximately half the consumers surveyed did not have the necessary skills to understand and correctly interpret the information available on labels and logos. These skills depend particularly on age and education level. This may be one reason why labels are not as effective in changing long-term consumer behaviour and consumption patterns.

2.4.4 Public engagement campaigns

Public engagement or communication campaigns targeting specific consumer groups with relevant information cover a wide range of initiatives: mass media campaigns, information centres, training, brochures, etc. They are used to raise awareness about energy consumption, available technologies and energy efficiency potentials. They are run by local municipalities or by other local actors such as the local energy provider (usually targeting regional or national levels) or a housing association, for instance.

Literature reviewed suggests that the success of public campaigns will be partly dependent on several elements: existing national goals for energy efficiency, how progress towards meeting those goals is communicated, and the institutional setting to implement and monitor energy efficiency measures/programmes. A comprehensive survey of Europe's building stock (Economidou, 2011)

([13]) The Hawthorne effect describes a situation where behaviour is dependent to some extent on the awareness of being watched.

indicates that appropriate information for consumers, decision-makers, the energy service sector, architects, distributors, etc. can ensure that the energy efficiency potential is delivered in a cost-effective manner.

However, campaigns are not always documented and/or evaluated well. As a consequence, in many cases the available literature includes estimates of **reported** behaviour change and energy saving/carbon reduction (e.g. via a qualitative survey) rather than **actual** change. Experience from behaviour change campaigns in other fields indicates that actual behaviour change may not be as high as reported behaviour change; therefore, reported results should be treated with caution.

The evaluation of one campaign run by the Energy Saving Trust (EST) in the United Kingdom aimed to identify more generally what worked, what the value for money was, and how the outcomes of the campaign compared to those of other EST activities. The primary method used for the evaluation of the EST's 'Dave' campaign was a random survey of over 1 500 people, door to door, over two to three months after the campaign. Using the identified measures and equipment installations undertaken by people as a result of the advertising, the EST modelled and calculated the actual energy savings generated. The survey also asked what people were planning to do as a result of the advertising, and a proportion of future anticipated impacts were included in the attribution calculation.

It was estimated that the campaign reached 38 % of the British population. Around 1 in 300 people who saw the advert contacted the EST or its website.

From this, it is estimated that campaign benefits included an annual saving of 94 500 tonnes of CO_2 and GBP 26 million in total utility bill savings, outweighing the costs (GBP 1.4 million). Comparing savings from physical measures (e.g. installing insulation) to savings attributed to behaviour change, the evaluation revealed that most savings were in fact achieved as a result of behaviour change. However, this was reported behaviour change rather than actual change (Mikkonen et al., 2010).

A Swedish campaign highlighted that:

- households feel that they experience energy efficiency information overload; they do not know how best to use this information for their own benefit;
- households are often 'energy conscious, but not energy knowledgeable', i.e. people are aware of the importance of low energy use, but they may not know how to carry out energy-saving measures in their homes.

A key issue with public campaigns and energy advice is trust — whether people trust the information source. The credibility of the source of energy information/advice influences the extent to which energy efficiency measures are adopted. A report conducted in the United States on 1 000 households with a high demand for electricity found that a message from a trusted source (e.g. the municipality) was more effective in encouraging both interest in energy conservation and reduction in actual energy use. Practical experience of energy efficiency programmes suggests that personalised energy efficiency advice (i.e. feedback), interpersonal contacts and recommendations count for significantly more than leaflets or labels (Mikkonen et al., 2010).

The Innovative Instruments for Energy Saving Policies (INESPO) project, which reviews policies to achieve energy efficiency in Belgium, looked at the strategies of the Flemish, Walloon and Brussels regions for achieving targeted energy savings by the promotion of rational energy use in buildings. Each region had a complex communication strategy. The actions of the regions are complemented by efforts of the distribution system operators (as part of their public service obligations), the provinces, the communities and various other organisations. The communication activities range from raising awareness (and the relatively important benefits that some relatively minor investments or behaviour changes may bring) to providing tailor-made advice.

The report concludes: 'Current policies and measures concerning lowering energy consumption at the household level heavily rely on promoting energy efficiency. Everything else being equal, increasing energy efficiency will result in energy savings. In reality, however, potential energy savings from efficiency improvements at the household level have to an important extent been offset by unadapted behaviour'. The report also stresses the importance of exemplary leadership from the public sector and the usefulness of energy challenges (De Smet and Bachus, 2011).

Other measures: main messages

There are a number of measures in place in Europe that aim to promote energy efficiency whose success in delivering tangible results depends crucially on consumers to understand the information they receive (e.g. building certificates, labels for buildings and products) and to adapt behaviour and consumption patterns (economic instruments, public campaigns, etc.). Literature reviewed suggests that much more needs to be done to improve the content, the availability and the process associated with the implementation of such measures.

Economic instruments aiming to improve energy efficiency are currently used mainly for technical measures, while changing consumer behaviour and practices is much less, if at all, considered as a viable objective. With adequate monitoring methodologies, such objectives could be useful in the future.

Public campaigns tend to be more successful when they are organised with trusted local partners (the municipality, a housing association, etc.), are accompanied by a good communication strategy specifically tailored to the needs of the targeted consumer group, and are followed up with additional measures (feedback measures, rewards for champions, investment strategies, etc.).

3 Structural factors

The aim of this section is to identify structural factors in the energy supply industry which may either assist in or hinder the delivery and effectiveness of the behaviour change measures identified in Chapter 2. It should be stressed at the outset that this subject is rarely addressed in the literature reviewed.

There is a close relationship between the structure of the energy supply industry and behaviour change measures. The structure of the energy industry may influence the effectiveness of some types of behavioural measures. As discussed in Section 2.1, the energy infrastructure plays an active role in what people consider a 'normal way of life'. On the other hand, behaviour change measures themselves may lead to results across the economy, which when aggregated, have an impact on the supply industry.

3.1 Impact of liberalisation and the energy mix

Liberalised retail energy markets can lead to frequent switching between suppliers. This means that there should be a clear connection between the distribution system operators (DSOs) and the energy supplier, for behaviour measures to work as expected. The proper operation of smart grids will require DSOs to provide (or rather, re-establish) this essential link between the generator and the consumer. They are expected to do this by providing an appropriate level of information to both customers and energy retailers. It has been pointed out that legislation may be required to share the benefits of demand side management (DSM) effectively (Enviros, 2008).

It is also necessary to consider the energy supply mix, which varies between Member States. A country's energy supply and energy mix also determine the kind of energy efficiency outcomes that can be achieved, and hence the measures that should be put in place (Ryan and Campbell, 2012). Moreover, there is a difference between the gas and electricity markets (peak demand in electricity markets being more of an issue) which may have some bearing on the type of measures that can be applied in the heating and cooling sectors compared to electricity consumption.

3.2 Dynamic pricing

The influence of the supply industry structure on consumer behaviour in energy efficiency is largely mediated through the price of energy. In many cases, the price is not related in any way to the time of day or the overall level of consumption. Consequently, the pricing structure at present acts as a barrier to wider engagement of the end consumer through behaviour change. The advent of widespread (planned) smart metering put forth the possibility that dynamic pricing may be introduced more widely. Dynamic pricing essentially allows the market to reflect to the end consumer the actual system costs associated with constant changes between supply and demand, with prices rising in times of high demand and falling when demand is low. Dynamic pricing structures may take several forms: real-time pricing (where prices reflect the system cost in real time), time-of-use pricing (where different prices are set for different periods of time), and peak pricing (where different prices are set for peak time), with some variations to distinguish between peak and critical peak situations.

3.2.1 Dynamic pricing and the household sector

Given the current structure of the energy market in Europe, there is little evidence of a strong link between household energy consumption and the structure of the industry. Supply contracts based on the spot price, for instance, are not widely available; time-of-use pricing is rare.

The introduction of smart meters is likely to facilitate these forms of dynamic pricing, since they can accommodate rapid multiple changes in price over time, but more importantly, because they provide two-way communication between the supplier and the customer. When coupled with an in-home display, smart meters can convey the relevant information in a transparent, understandable and timely manner to the end consumer.

Smart metering may serve either to reduce demand overall (by making consumers more aware of their consumption) or to redistribute consumption to other times of day, in order to reduce peak demand, thereby improving overall system efficiency and producing a net saving for the economy. Smart meters would facilitate the introduction of more accurate and more frequent billing — and by doing so, improve the quality of feedback provided to consumers, in addition to being a prerequisite for a smarter grid.

The *Final Guidelines of Good Practice on Regulatory Aspects of Smart Metering for Electricity and Gas* issued in 2011 by the European Regulators Group on Electricity and Gas (ERGEG) ([14]) recommends that Member States define at national level a list of services that consumers should expect from the energy industry (suppliers, DSOs, meter operators, etc.) associated with the introduction of smart meters. This list should include services considered by ERGEG to be core services. Table 3.1 provides a brief description of these services.

Darby (2006) notes that time-of-use pricing, critical-peak pricing and real-time pricing are major concerns in those parts of the world with summer and winter peaks in demand coupled with supply constraints; she cites evidence of reductions of up to 30 % of peak demand through a variety of measures involving some sort of time-sensitive pricing. However, she points out that domestic customers are not usually enthusiastic about real-time pricing as risk is transferred to the customer. Households in particular have an understandable concern about constantly fluctuating prices, but this need not lead to an increased bill. Indeed, when smart meters are in use and communications are correctly structured, consumers should be forewarned about periods of high prices and have the option to adjust their consumption accordingly.

There is little scope for load-shifting among domestic consumers, particularly in the case of low-income households whose lifestyles or

Table 3.1 Services associated with the introduction of smart meters (considered as core services by ERGEG)

Electricity/gas	Core services
Electricity	• Information on actual consumption and cost, on a monthly basis, free of charge • Access to information on consumption and cost data on customer demand • Easier to switch supplier, move or change contract • Bills based on actual consumption • Offers reflecting actual consumption patterns • Remote power capacity reduction/increase • Remote activation and deactivation of supply • All customers should be equipped with a metering device capable of measuring consumption and injection • Alert in case of non-notified interruption • Alert in case of exceptional energy consumption • Interface with the home
Gas	• Information on actual consumption and cost, on a monthly basis, free of charge • Access to information on consumption and cost data on customer demand • Easier to switch supplier, move or change contract • Bills based on actual consumption • Offers reflecting actual consumption patterns • Remote enabling of activation and remote deactivation of supply • Alert in case of exceptional energy consumption • Interface with the home

([14]) See http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/CEER_PAPERS/Customers/Tab2/E10-RMF-29-05_GGP_SM_8-Feb-2011.pdf.

lack of real choices make it difficult to alter their consumption patterns. By contrast, the ECME (2010) report on the functioning of EU retail electricity markets notes that there may be a benefit in adjusting the price structure to encourage energy saving, and in particular to assist fuel-poor groups. This picture could change as the proportion of demand that is met by building-integrated renewables and distributed generation increases. However, Darby (2006) goes on to point out: 'Electricity tariff structures do not have to be based on time of use in order to have an impact on load: for example, progressive block pricing offers an incentive to conserve and could be combined with informative billing and displays of how close the customer is to reaching a threshold above which the unit cost will be higher.' See also Section 3.3 on the influence of smart meters on tariff structures.

In Italy, smart meters have already been introduced throughout the domestic market; they were primarily intended to support competition and prevent electricity theft (Renner et al., 2011) but they were not designed to include wider feedback and other functions that characterise smart meters installed elsewhere. As these meters do not have user-friendly in-home displays, their impact on behaviour change is limited. Nevertheless, as the principal concern of the DSOs was to reduce peak demand for electricity, the consequent introduction of dynamic pricing has allowed the Italian utility supplier to achieve cost savings of EUR 750 million ([15]). In the broadest sense, this is confirmed by a Dutch report (Gerwen et al., 2006) whose authors note that while at present there are few dynamic pricing contracts available for domestic consumers, smart metering offers great potential to react to periods of high pricing or diminished availability. Vasconcelos (2008) points out that there will also be broader benefits to suppliers (and to the economy as a whole) from smart metering, in terms of reducing network losses. However it is noteworthy that none of these reports address gas consumption, and that the focus has hitherto been placed on electricity and on reducing peak load.

In addition to cost savings, dynamic pricing schemes can lead also to real energy savings. For instance, the German Intelliekon project analysed the effect of the introduction of smart meters and time-of-use (TOU) pricing schemes on electricity consumption in households. Results showed a 3.7 % electricity saving through the introduction of smart meters, and an additional 6.1 % of savings due to the introduction of TOU pricing scheme (European Parliament — ITRE Committee, 2012).

When changing tariff structures due to the introduction of smart meters and dynamic pricing schemes, it is crucially important that consumers understand the change and the implications for their energy consumption and financial outlook, as the example from Ireland shows (CER 11180a, 2011).

Example: Irish trial to assess the potential of smart metering technology in combination with other DSM stimuli to induce measurable gas consumption savings in the residential sector

The pilot project took place from 1 June 2010 until 31 May 2011. From the initial 1 927 volunteers, a total of 1 892 people remained engaged in the programme. The pilot project considered a combination of smart meters with a set of Demand Side Management (DSM) stimuli (including a bimonthly bill plus detailed energy statements, a monthly bill combined with a detailed energy statement, a bimonthly bill combined with an in-home display and a detailed energy statement and finally, a bimonthly bill combined with an energy statement, an in-home display and a variable tariff). The design of the variable tariff included the following features:

- it was meant to be neutral compared to existing rates (so participants were assured that their energy bills would not increase as compared to the bills before the trial);
- the tariff for transmission and distribution was left unaltered;
- all other components of the tariff were seasonally adjusted (higher tariffs for the period from October to May).

The results of the project showed the following.

- The use of additional DSM stimuli led to statistically significant reductions in gas consumption of almost 3 %, with each combination of stimuli leading to comparable results. The highest level of savings was achieved when a combination of bimonthly bill with an energy statement, an in-home display and a variable tariff was used. Also, the level of savings was higher in periods of high consumption

([15]) See http://www.businessweek.com/globalbiz/content/nov2009/gb20091116_319929.htm.

(70 % of the overall reduction achieved) because participants focused on achieving most of the reductions during these periods.

- The trial had a positive impact on increasing awareness, with 36 % of participants reporting a heat source substitution.

- The trial has the potential to lead to persistent behaviour change, since 75 % of the participants continued to use the in-home display after the trial.

However, an interesting finding was that the variable tariff concept was not fully understood. Out of the total number of participants, 57 % did not realise that the tariff had changed, and more than 90 % were not able to provide an estimate of the seasonal unit costs.

3.2.2 *Dynamic pricing and the non-household sectors*

In the non-domestic sector, there may be greater potential for achieving energy savings through the introduction of dynamic pricing, as heavy loads can be shifted through changes in working practices or through other technological solutions. In some Member States, higher tariffs are used to discourage energy use at times of peak demand, and therefore to make the supply system more efficient. For dynamic pricing mechanisms to be effective, the direct link between energy price and energy-using behaviour is a prerequisite. The price elasticity of demand depends on the structure of energy mix as well as the structure of the economy. For instance, in Norway, regions with a high industrial base are more responsive to high prices than regions where the residential and commercial sectors have a highest share.

ECME (2010) notes, that within the commercial sector in Italy, Portugal and Spain, prices also vary according to the intensity of the power supplied to the consumer, i.e. the maximum level of demand rather than the overall level of consumption over a period. In these countries, lower prices (per kWh) are available to consumers who have lower power intensity.

In Sweden, all non-domestic consumers undergo mandatory hourly readings, but this situation has emerged over almost a decade; it started with large energy consumers who were more open to contracts with this high granularity ([16]).

3.2.3 *Real-time pricing and capacity margins*

Real-time pricing deserves special attention because of its possible impact on the current design of the energy market. The absence of real-time pricing may have both short-term and long-term detrimental effects. In the short term, consumers tend to demand more than the optimal quantity of energy at peak times, and less than the optimum at off-peak times. In the long term, producers tend to build a more-than-optimal amount of capacity in order to satisfy the peak demand, which may be higher than it needs to be. In addition, as long as the demand remains inelastic (in the absence of adequate price signals) the energy market becomes very sensitive to small perturbations in the system, which leads to requirements for capacity reserve margins.

This is a relevant issue: one of the current regulatory debates relates to how much capacity reserve will actually be needed in the context of shifting the European energy system to a smart grid system (which involves also higher shares of renewables and distributed generation). Literature is scarce with respect to the impact of real-time pricing and capacity payments, so much more investigation is required before a clear conclusion can be reached. One recent report (Allcott, 2012) explores an extreme case of a system with no capacity market. The report suggests that switching to a system with no capacity market could give an immediate and location-specific signal of scarcity (system is at its peak demand) to both consumers and producers, but the gains from introducing real-time pricing would be somewhat lower and distributed through different channels.

3.3 Energy tariff structures and smart grids

In line with internal energy market rules, all Member States were expected to fully open their energy markets by 1 July 2007. To date, end-user prices remain regulated in 9 Member States for gas, and 17 Member States for electricity (ERGEC, 2007). Network activities (transmission and distribution) remain regulated, being considered natural monopolies, and they can have a significant impact

([16]) Presentation by Karin Widegren, Director Swedish Coordination Council for Smart Grid during the EEA webinar on 4.9.2012.

on the total efficiency of energy pricing. In order to reap the full benefits of smart meters (and ultimately have a more engaged end-consumer in the energy market), tariff structures will have to change, and an alignment between transmission, distribution and retail tariffs needs to be achieved.

European initiatives such as the Smart Regions or ADDRESS projects have already looked at some of these issues, so the aim of this section is to briefly summarise the main characteristics of the current energy tariff designs in Europe, and discuss some of the challenges to make them work in the context of smart grids and a more active demand.

The main regulatory approaches for energy network industries can be broadly split into three main categories with different consequences for improving efficiency in energy delivery (Petrov, 2009). Table 3.2 summarises the main characteristics of each type of regulation and describes efficiency incentives embedded in current regulatory practices.

In Europe, most countries apply either a cap regulation or yardstick competition type of regulation.

It is important to note that most regulatory approaches provide incentives for increasing efficiency in delivering energy services, because the efficiency benchmarking calculation is usually part of the tariff calculation methodology, but not necessarily to curb energy demand.

Ryan and Campbell (2012) and Grayson/Campbell (2012) also point out that improved energy efficiency could help energy providers to offer better energy services while at the same time reducing operating costs and improving profit margins. Both reductions in peak demand and reductions in network losses benefit suppliers as well as the economy (and the wider environment) overall. The Ryan and Campbell (2012) paper asserts that as much as 10 % of the total benefits from energy efficiency measures are likely to accrue directly to energy providers. So a change in tariff structures to create incentives both for increasing efficiency in energy delivery and for real energy savings need not be a scarecrow for energy providers.

To make the best use of smart meters and ultimately engage the end consumer more actively, a number of issues will need to be considered when deciding on the energy tariff structure (Kema, 2009 and 2011; Similä, Koreneff, Kekkonen, 2011).

- How investment and operating costs associated with the mass roll-out of smart infrastructure

Table 3.2 Efficiency incentives embedded in current energy tariffs structures in Europe

Regulation		Efficiency incentive
Type	**Variation**	
Rate of return In this case, the regulator sets the prices in such a way that they cover the company's cost of production and include a rate of return on capital that is sufficient to maintain the investor's willingness to replace and expand the company's assets		Low incentive; the return is fixed so there are no incentives for efficiency improvements, costs can be shifted to customers
Cap regulation Under a cap regulation, either revenues or prices are set in advance by the regulator, usually for a period of three to five years. Under this type of regulation, the company is entitled to retain all or part of the profit arising from increased efficiency gains over the respective period	Revenue cap	Medium-to-strong incentives; profit can be increased by reducing costs or by increasing prices and reducing output; includes a specific factor for expected efficiency improvement
	Price cap	Medium-to-strong incentives; profit can be increased by reducing costs or by increasing output; requires explicit expectations on productivity gains
Yardstick competition In this situation, prices are set by the regulator based on the average cost across the most efficient companies within the industry		Strong incentives; cost/revenues indexed to average cost/productivity improvement of the industry; profits can be increased by reducing costs in terms of competitors

(smart meters, in-home devices, etc.) will be reflected in the tariff regulation.

- In a liberalised market, suppliers operating in a competitive retail business typically use standard load profiles to schedule their energy purchases and network usage. With the implementation of smart grids, real-time data with high granularity (with readings every hour, or even more frequently) will become available, but if standard load profiles continue to be used by the retailers instead, the advantages offered by smart meters will not be realised. This is particularly relevant in the case of dynamic pricing schemes.

- To make the best use of dynamic pricing schemes and real-time energy data, the coordination of the pricing schemes along the value chain is key. For instance, if the tariff structure of the DSO is different from the one for the supplier, there is a risk that distribution tariffs will shift the load, which could pose a significant issue for the energy supplier. However in practice, this is easier said than done. Traditionally, the main goal of the tariff design was the sustainability of the company, while other goals such as economic efficiency, equity and transparency came second. With the introduction of unbundling requirements on the one hand, and the prospect of increased availability of real-time data and accompanying dynamic tariffs on the other, some trade-offs between these objectives will have to be made.

- Conditions for participation in the balancing market may also need to be changed. For example, in Finland, the condition to participate in this market is have at least 10 MW of load and a response time of fewer than 15 minutes. This type of restriction would prevent residential consumers, for instance, from participating in the market, unless they do so via aggregators.

- The expected higher penetration of renewables and electric vehicles may trigger the need for more flexible tariffs, adjustable to reflect actual capacity needs.

Most reports focus on smart metering alone as a behaviour change measure, but Enviros (2008) raises the intriguing possibility of conducting remote energy audits by using the detailed data gathered through smart metering. While no evidence was found to confirm this is already taking place in Europe, such feedback could become commonplace in the near future. But further investigations are needed to draw clear conclusions about conditions under which this can be done for different groups of consumers (household vs non-household sector, vulnerable groups, etc.)

3.4 Other structural issues relevant for changing consumer behaviour and practices

3.4.1 *Dynamic demand control*

In addition to dynamic pricing, there is the potential for further savings if dynamic demand control is introduced. Dynamic demand control would permit appliances such as refrigerators, air conditioners, water heaters and pumps, whose time of use is not critical within reasonably narrow time periods, to be switched off remotely by suppliers at times of peak demand. This would reduce the need for reserve capacity but could also improve the net effectiveness of intermittent renewable generation technologies by making best use of their generation capacity. Baker & White (2008) assert that dynamic demand control could reduce demand more rapidly than a traditional 'spinning reserve' generator can increase its supply.

3.4.2 *Systemic volatility*

The introduction of dynamic prices might lead to instability in the supply industry if not properly managed. If consumers are encouraged to react to price signals, then in theory, a concerted reaction on their part could lead to sudden changes in the aggregate. Also, in theory, increased volatility could lead to a situation where energy storage becomes more important, and thus it would serve the commercial interests of owners of power storage to maintain a high level of volatility in the system. To mitigate such risks, smart metering and dynamic pricing have to be introduced gradually and tariffs adjusted accordingly if there is a risk of increased volatility. In general, the available literature on this subject indicates that there is potential in dynamic pricing to manage and reduce volatility. In the British market, the Triad system ([17]) is designed to penalise consumption by large energy users at times of peak demand. As large users use a warning

([17]) The Triad system is a wholesale demand management system operating in the United Kingdom that operates by increasing the price of energy at times of peak load.

service, they are notified in advance if a period of peak demand is expected, and they can often reduce their demand during these periods and shift the demand peak or eliminate the charge altogether. Similar systems operate in other Member States.

The effects on the gas supply industry are also considered by Enviros (2008), who assert that reductions in peak load in particular may obviate the need for storage. Interruptible supply contracts for power stations or large industrial users are expected to manage peak demand, dampen prices and contribute to the security of supply. The demand for gas is less price-elastic in the short term, so the potential for load-shifting in space heating is greatly reduced. In addition, the existing storage facilities for gas are more effective than those available for electricity.

3.4.3 Impact of distributed generation

Micro-generation could raise awareness of energy consumption within households. People are naturally interested in the new equipment and its capacity to generate power, so they initially become more aware of their energy use. This in itself could reinforce behaviour change (Keirstead, 2007).The amount of energy exported may depend on the structure of subsidies such as feed-in tariffs; a low export tariff coupled with a high generation tariff could act as a disincentive to export to the grid in some circumstances.

Where two-way metering and export tariffs do not exist, or the generation equipment is not connected to the grid, there may be a disincentive to conserve energy, because of the perception that since the energy is renewable and 'free', it matters less whether it is consumed.

While the potential for increased systemic volatility due to increased use of dynamic pricing has been considered above, it is also possible that changes in the quantity of renewable energy exported to the grid may reduce volatility. Firestone and Marnay (2007) conclude that TOU and critical peak pricing (CPP) tariffs do not incentivise generation that serves to stabilise the spot market. This is because TOU pricing is effectively fixed according to predicted rather than actual peaks in demand — so generators are already running. By contrast, real-time pricing (if it is true real-time pricing and not averaged) may trigger marginal generation — especially via CHP — as it becomes more profitable to generate and export electricity to the grid. As this incentivises generation when demand is high, real-time pricing thus helps to stabilise the spot market.

Structural factors: main messages

Dynamic pricing schemes have the opportunity to bring about improvements in the overall efficiency of the energy system but also real energy savings for the end consumer. Despite the stated benefits, not all consumers will respond in the same way to their introduction. Households are less responsive to price signals due to the fact that their consumption practices are to a large extent determined by non-economic factors, which makes their demand rather inelastic. Secondly, household consumers may be less skilled in hedging against high price volatility that might result from the introduction of dynamic pricing schemes, and in negotiating terms with the energy supplier, compared to large industrial consumers who have much better standing in this respect.

The introduction of dynamic pricing schemes must be handled with care, particularly for vulnerable consumer groups, and should be gradual so as to allow all participants in the system time to adjust to the new circumstances. Importantly, the change needs to be clearly communicated so that consumers understand the full implications for their energy consumption and financial outlook.

The introduction of dynamic pricing and smart grid infrastructure will have a significant impact on the design and the operation of the energy markets. They will require a major overhaul of the way the system deals with reserve capacity (and consequently of the incentives to maintain it at current levels) and a revision of the conditions for participating in the balancing markets to include a wider range of participants. It will also require a change in the current structure of energy tariffs to reflect the significant costs associated with the smart grid infrastructure, but also to adjust the relationship between the distribution system operators and energy suppliers in light of the new circumstances. This is likely to be easier said than done. Traditionally, the main goal of the tariff design was the sustainability of the company, while other goals such as economic efficiency, equity and transparency came second. With the introduction of unbundling requirements on the one hand and the prospect of increased availability of real-time data and accompanying dynamic tariffs on the other, some trade-offs between these objectives will have to be made.

There are also other structural issues with relevance for changing energy behaviour and practices that will need to be factored in, such as the scope for demand control, the risk of increasing the volatility in the system if actions of all actors along the energy value chain are not well coordinated, and the expected increase in the share of distributed generation.

Increasing the use of distributed generation could trigger positive long-term changes in behaviour with respect to energy consumption, but only under the condition that the incentives for this type of generation are aligned with the overall objectives of the smart grid.

4 The rebound effect

The rebound effect or take-back effect is the term used to describe the impact lower costs of energy services (due to increased energy efficiency) have on consumer behaviour, both individually and nationally. Put simply, the 'rebound' effect is the extent to which the energy saving generated through energy efficiency measures is taken back by consumers in the form of higher consumption, either by increasing the quantity of energy used (for instance to increase their comfort levels) or due to a higher quality of energy service.

The rebound effect was first posited by Jevons in 1865. He pointed out the existence of the effect for coal as increasing efficiency in machines actually led to an increase in demand for their use, and thus an increase in demand for coal overall; this became known henceforth as the Jevons Paradox.

In the context of this report, the rebound effect is understood as a behavioural effect that reduces the savings attributable to energy efficiency measures. It has been considered within the framework of this report because it needs to be accounted for when assessing the impact of energy efficiency policies.

The recent report from the European Commission (Maxwell et al., 2011) reviews the state-of-the-art knowledge on the rebound effect.

Three types of rebound effect are generally identified:

- **direct rebound effect**, where increased efficiency and associated cost reduction for a product/service results in its increased consumption because it is cheaper;
- **indirect rebound effect**, where savings from efficiency cost reductions enable more income to be spent on other products and services;
- **economy-wide rebound effect**, where more efficiency drives economic productivity overall, resulting in more economic growth, and hence additional consumption at a macroeconomic level.

Most of the literature reviewed concentrates on the measurable or hypothetical rebound effects on energy consumption at the micro or macro scale. What this debate fails to recognise however, is that improved energy efficiency has a range of social, economic and environmental benefits in addition to the immediate reductions in energy use (Ryan and Campbell, 2012). These include (but may not be limited to) the following factors:

- reductions in greenhouse gas emissions;
- increases in internal living temperatures where properties were previously under-heated;
- consequent improvements in human health and associated reductions in the economic costs of health care;
- reductions in fuel poverty;
- downward pressure on energy prices through reduced demand;
- job creation;
- natural resource conservation;
- contribution to energy security;
- strengthening of community cohesion where programmes are delivered at the community level;
- increased asset values;
- positive macroeconomic effects including improved competitiveness.

The rebound effect is normally portrayed as a negative result of energy efficiency, but it will ultimately be necessary to evaluate these positive social, economic and environmental effects, in order to form a balanced view of the overall societal impacts of energy efficiency.

Importantly, measures can be taken to ameliorate the rebound effect. Findings from the Energy Efficiency Watch Analysis (Schüle et al., 2011) note that the continued provision of good quality information can be expected to increase the effectiveness and the long-term impact of most other policy instruments — thereby reducing the rebound effect.

4.1 Direct rebound effect

The direct rebound effect is important because it has the potential to reduce the magnitude of savings attributable to energy efficiency measures, since consumers may be tempted to consume more energy as their total cost of energy drops. The existence of the direct rebound effect is not disputed, but there is — unsurprisingly — disagreement about the size of the effect.

The direct rebound effect varies according to the type of technology under consideration. For example, Geller and Attali (2005) and Greening, Greene and Difiglio (2000) provided an overview of technology-specific effects of the direct rebound effect based on empirical evidence in the United States.

Much of this evidence is in line with what intuitively would be expected. For example, improved efficiency of refrigerators does not lead to their increased use as they operate 24/7 in almost all cases ([18]). By contrast, there is evidence (Milne and Boardman, 2000) that some houses are heated well below accepted comfort temperatures and that temperatures are increased following boiler replacement or thermal improvements to building fabric. It is notable that empirical evidence in the business sector indicates a lower overall average rebound effect — suggesting that drivers for operating times of lighting and equipment are not susceptible to the same factors as those in the residential sector. Once behaviour has been altered in this sector, it is more likely to become institutionalised, and thus less likely to lead to increases in consumption.

Early estimates of the rebound effect such as Khazzoom's (1987) suggested that the direct rebound effect could even exceed 100 %; in other words, the direct rebound effect can offset all the improvement achieved through energy efficiency measures (this effect is called backfire). This view has not been confirmed by the empirical evidence and is not supported by the most recent literature reviewed.

The European Commission report (Maxwell et al., 2011) concludes that in the residential sector, there is evidence for the direct rebound effect in the areas of space heating/cooling, white goods and lighting: it is estimated to be in the range of 10 % to 30 % for developed countries. According to this report, the effect is expected to decline over time as demand reduces (energy needs are satisfied) and income increases. This finding is in line with Geller and Attali (2005), who note that the effect in space heating in particular is expected to decline as the penetration of central heating increases, because in-door temperatures, after an initial rise ([19]), will eventually stabilise. The same holds for improved insulation, which initially could lead to higher temperatures; so, if at the same time, the boiler is replaced with a more efficient one, the replacement would lead to absolute gains with little or no rebound effect.

Table 4.1 Estimated size of rebound effect by technology

Sector	End use	Size of rebound effect
Residential	Space heating	10–30 %
Residential	Space cooling	0–50 %
Residential	Water heating	10–40 %
Residential	Lighting	5–12 %
Residential	Appliances	0 %
Business	Lighting	0–2 %
Business	Process use	0–20 %

([18]) Although refrigerators are getting larger in size due to changing consumer preferences.
([19]) With the penetration of central heating, people tend to warm up rooms that are not being occupied (compared to the situation where each room was heated separately), thus leading to initial increase in energy consumption and comfort take-up. After the initial adjustment however, the indoor temperature preferences tend to stabilise.

On the contrary, in developing countries (and low-income groups in developed countries) the rebound effect may be higher (Sorrell, 2007) but the rebound effect will be expected to decrease over time as basic energy needs are met.

When discussing the direct rebound effect, it is also necessary to consider the ownership of the property. (Madlener & Hauertmann, 2011) find that the rebound effect is much higher in rented properties than in owner-occupied properties. They find also a correlation with the income effect. According to their report, the income level does not significantly alter the magnitude of the rebound effect in owner-occupied properties. The opposite seems to be the case for rented properties, where the income effect appears with properties rented by lower income households having a much greater rebound effect (49 %) than higher income households.

4.2 Indirect rebound effect

The indirect rebound effect describes a situation where reduction in the cost of running energy-using products leads to changes in demand for other goods and services in the economy that also require energy. For example, the cost savings obtained from improvements to a heating system could be spent on overseas travel, but this is particularly difficult to measure as the contribution of cost savings to the decision-making process cannot be evaluated scientifically. There is some evidence to suggest that eco-communities, while having a lower environmental impact locally, travel more and thus have a higher overall footprint (Hodge and Haltrech, 2009). There appears to be no empirical evidence to evaluate the indirect rebound effect, although Druckman et al. (2011) estimate the indirect rebound effect for the household sector to be around 7 %. There is, however, some evidence to suggest that the indirect rebound effect varies significantly by income level (Murray, 2011) — with the effect decreasing as household income increases.

4.3 Economy-wide (macroeconomic) rebound effect

The economy-wide rebound effect arises because improvements in energy efficiency reduce the price of final and intermediate goods in the economy. This, in turn, can contribute towards economic growth and may therefore lead to an increase in energy use in numerous sectors. There are various estimates of the macroeconomic rebound effect. The literature reviewed (Greening, Greene and Difiglio, 2000; Laitner, 2000) suggests that this effect is very small — in the range of 0.5 % to 2 %.

It is, however, necessary to distinguish between short- and long-term rebound effects. It has recently been argued (Jenkins et al., 2011) that the economy-wide rebound effect is still emerging, and the effect will be much larger than observed at present. The report, citing Barker & Foxon, predicts that up to 50 % of energy efficiency savings will be eroded by the macroeconomic rebound effect by 2030. This disparity on the quantification of the macroeconomic rebound effect has yet to be resolved, and may ultimately rest on how boundaries are set for defining energy-consuming behaviour that is relevant or linked in any way to the original intervention.

4.4 Transformational effects

A recent report (Wallenborn et al., 2009) on the Ecodesign programme suggests a fourth category of rebound effect: transformational effects. According to this report, 'energy efficiency is brought through new technologies. These changes in technology operate also at the level of consumer's preferences and transform them. Social institutions are also changed: technology trajectories are path-dependent'. This finding is in line with the analytical framework presented in Figure 2.1. It is, however, difficult to discern whether these transformational effects are positive or negative in terms of energy use.

4.5 Other (related) effects

As defined above, the rebound effect does not include two further effects which may come into play when implementing energy efficiency measures.

- The **drawback effect** is observed when people fall back on old habits after the newness of the experiment wears out.
- The **Hawthorne effect** describes a situation where achievements are not so much a direct result of the experiment in progress, but rather occur because people are aware that they are being watched.

Both these effects need to be taken into account in the evaluation of the effectiveness of energy efficiency behaviour change programmes (particularly in the pilot phase), in addition to the more conventional rebound effect, but further work is necessary to provide adequate estimations of the size of these two effects.

The rebound effect: main messages

Estimating the size of the rebound effect remains a significant challenge. The literature surveyed addresses the issue of rebound effects mainly in response to energy efficiency measures involving technological interventions, but not necessarily in response to measures targeting behaviour change or changes in consumption practices. This may also be because in almost all cases, there is no long-term follow-up of these measures, and consequently there is no empirical evidence of the persistence of this type of measures.

Although there is evidence to suggest that the rebound effect is at play, the most recent literature argues that the direct rebound effect is lower than 50 % for the household sector (with more common ranges of 20 % to 30 %), and much less for the business sector. The indirect rebound effect is estimated at around 7 % while the macroeconomic rebound effect is much lower, in the range of 0.5 % to 2 %.

The difference between the residential and non-residential sectors with respect to the size of the rebound effect is due to the fact that different factors influence the energy consumption patterns for different consumers. This is to be expected: the business sector is economically motivated in general, while the residential sector is driven by a multitude of other factors including education, age, technological development, belief systems and property ownership.

The literature reviewed suggests that while the rebound effect exists, it is not sufficient to justify delaying investments in energy efficiency and behaviour change measures. Moreover, the effect is expected to decrease over time as needs are fulfilled.

Nevertheless, it is important to consider the rebound effect in ex ante evaluations of energy efficiency policies.

Finally, it is also important to bear in mind that energy efficiency has multiple benefits; while the rebound effect may undercut some energy savings achieved, it does not cancel out the wider economic, social and environmental gains that can be achieved through energy-saving programmes.

5 Conclusions

Many factors influence consumer behaviour and practices, as seen in Figure 2.1. Technological developments, considerations of the general economic situation, age, social norms, belief systems and cultural traits, marketing strategies: all play an important role in defining what we consider a normal way of life. A significant part of the literature reviewed tends to consider these relationships as static when they are not. Consumer preferences change over time, and consequently the focus should shift from the consumer behaviour per se (which tends to imply emphasis on individual preferences) to how different consumption practices take hold in the society. Literature on this subject is scarce. The implication from the policy design point of view is that when developing/testing energy efficiency measures or programmes, a wider variety of actors should be involved from the outset.

Energy infrastructure plays an important role in determining consumer behaviour as related to energy consumption. This interaction needs to be considered, taking into account possible constraints (asymmetric information, unexpected capital costs, trade-offs to reach an optimal solution, etc.) and the ability of the consumer to deal with a new technology, defined by cultural traits, level of education, expectations of convenience. The success of measures targeting a change in consumer behaviour and practices will largely depend on how these expectations are fulfilled.

Without an appropriate frame of reference, consumers cannot know whether their consumption is excessive. Meaningful, clearly communicated and continual feedback is therefore essential for a long-lasting change in consumer behaviour. Sometimes communities can be successful in acting as incubators for positive change in social norms and behaviours, because they provide an environment where people explore those changes alongside 'connected' others: neighbours, work colleagues, people of the same faith, etc.

There are different ways to deliver feedback, but the key seems to lie in combining different measures (and the reward can be significant). Literature suggests that up to 20 % of energy savings can be achieved through different measures targeting consumer behaviour. Table 5.1 provides an overview of the main findings from literature reviewed concerning the possible ranges of energy savings from feedback measures.

The estimations with respect to potential energy savings thanks to feedback measures and combinations of measures should, however, be treated with some caution. This is due to significant differences in approaches, project goals and scientific methodology employed in developing the pilot projects presented in the studies reviewed; the results are not always fully comparable. For instance, smart meter rollout

Table 5.1 Summary of likely savings achieved from different interventions

Intervention	Range of energy savings
Feedback	5–15 %
Direct feedback (including smart meters)	5–15 %
Indirect feedback (e.g. enhanced billing)	2–10 %
Feedback and target setting	5–15 %
Energy audits	5–20 %
Community-based initiatives	5–20 %
Combination interventions (of more than one)	5–20 %

pilot projects developed by energy utilities are in a category of their own because they have been driven by operational concerns of the utility, rather than having the aim of changing consumer behaviour and practices. In addition, the amount of estimated savings depends on a number of design features for the project: sample size, length of the project, selection method for the participants in the pilot, demographic make-up, etc. Perhaps most importantly, none of the pilot projects described in the studies reviewed included a long-term follow-up. The projects tend to be carried out over the short term (six months to a year), and if there is any follow-up, it is usually within two years at most after the end of the project. This may not be sufficient to adequately evaluate the persistence of the energy savings benefits and long-term changes in consumer behaviour and practices. It also makes difficult to assess the actual size of the direct rebound effect with a high level of confidence.

Differences between the residential and the business sectors concerning the impact of behaviour change measures are somewhat easier to identify. But it is more difficult to discern whether different approaches should be taken with respect to electricity consumption vs energy consumption for heating and cooling to drive behaviour change and changes in consumption practices. Intuitively, with respect to the latter, the success of behaviour change measures seems highly dependent on the thermal performance of the building envelope, and as such, options to influence behaviour need to be considered in combination with technological interventions. Nevertheless, the example of the CoolBiz and WarmBiz programmes in Japan (Appendix 2) that continue to deliver important energy savings by simply changing the dress code, suggests that there is potential for behaviour changes related to space heating and cooling.

There are a number of energy efficiency measures in Europe whose success depends crucially on consumers to understand the information they receive and to act upon it. Literature reviewed, including work carried out in the context of Energy Citizen's Forum and Consumer empowerment initiatives, however, shows that much work remains to be done. People's skills must be honed to enable them to stay informed and be assertive in taking advantage of opportunities to better manage their energy consumption.

Changing consumer behaviour and practices (including through the implementation of smart meters) will not guarantee the full implementation of energy efficiency policies, because much remains to be done also in adapting the current structure of the business model for the energy industries.

The introduction of dynamic pricing schemes seems essential to take full advantage of the highly granular data on energy consumption that smart meters could offer, but not all consumers will respond in the same way. While the business sector is largely driven by economic reasoning, the household sector is not (other factors play a part here: education, social norms, age, culture, etc.). In addition, the household sector is generally ill-equipped to hedge against the price volatility that may result from the introduction of dynamic pricing schemes and to negotiate terms with the energy supplier.

The introduction of dynamic pricing coupled with smart metering will have a significant impact on the current business models of energy companies and the way energy markets operate. In order to harness the full energy-saving potential, a revision of the current practices regarding capacity reserves, balancing markets and the structure of the energy tariffs will need to take place. In addition, a higher penetration of distribution generation will require some alignment between the current financial support schemes applicable and the overall smart grid concept, if positive behaviour changes related to energy efficiency are to be achieved and maintained over a long period of time.

The literature reviewed seems to agree that a rebound effect is to be expected when implementing energy efficiency policies, but an adequate quantification of the size of the effect remains largely unrealised to date. Most recent literature on the subject suggests that the direct rebound effect in the residential sector is less than 50 % (but differs by technology, with 0 % for appliances, and higher percentages for space heating and cooling), and much less in the business sector. Again this is due to the fact that energy consumption in the residential and business sectors are driven by different forces. The indirect and macroeconomic rebound effects are assumed to be much lower. In summary, the rebound effect exists and should be considered in ex ante evaluations of energy efficiency policies, but is not so significant as to justify delaying the implementation of energy efficiency policies. Furthermore, the multiple benefits of energy efficiency policies should also be accounted for.

Appendix 1 Literature reviewed

Allcott, H., 2012, *Real-time pricing and electricity market design*, New York University, https://files.nyu.edu/ha32/public/research/Allcott%202012%20-%20Real-Time%20Pricing%20and%20Electricity%20Market%20Design.pdf, accessed 17 January 2013.

Ball F., 2007 Interview with Fiona Ball, Head of Environment, BSkyB Ltd. 12.03.2007.

Baker, W., and White, V., 2008, Towards sustainable energy tariffs. *A report for the National Consumer Council by the Centre for Sustainable Energy*, Bristol.

Becker L.,1978, *Joint effect of feedback and goal setting on performance: a field study of residentioal energy conservation,* J Applied Psycholoigy 63, 428–433.

Brannlund, R., Ghalwash, T., and Nordstrom, J., 2007, *Increased energy efficiency and the rebound effect: Effects on consumption and emissions. Energy economics,* 29(1) 1–17.

Brohmann, B., Cames, M., and Gores, S., 2009, *Conceptual framework on consumer behaviour — with a focus on energy savings in buildings*. IDEAL-EPBD Project report for the European Union under the Intelligent Energy Europe Programme (http://www.ideal-epbd.eu/download/conceptual_framework.pdf) accessed 7 January 2013.

Darby, S., 2001, *Making it obvious: designing feedback into energy consumption*, Energy Efficiency in Household Appliances and Lighting 2001, pp 685–696, Springer, Berlin.

Darby, S., 2006, *The effectiveness of feedback on energy consumption — A review for Defra of the literature on metering, billing and direct displays,* Environmental Change Institute, University of Oxford.

Darby, S., 2010a, *Literature review for the Energy Demand Research Project,* Environmental Change Institute, University of Oxford.

Darby, S., 2010b, 'Smart metering: what potential for householder engagement?', *Building Research & Information,* 38(5) 442–457.

Darnton, A., 2008, *Practical Guide: An overview of behaviour change models and their uses*. GSR (Government Social Research Unit) Behaviour Change Knowledge Review, Government Social Research Unit, HM Treasury, London (http://www.civilservice.gov.uk/wp-content/uploads/2011/09/Behaviour-change_practical_guide_tcm6-9696.pdf) accessed 7 January 2013.

De Smet, L., and Bachus, K., 2011, '*Overview of EU directives and Belgian policies and measures regarding energy savings at the household level'*, Research paper in the framework of the INESPO-project (Innovative energy saving policy instruments), Leuven (https://hiva.kuleuven.be/resources/pdf/publicaties/R1422_EU_Directives_and_Belgian_PAMs.pdf) accessed 5 April 2013.

De Young, 1993, *Changing beahviour and making it stick: the conceptualisation and management of conservation behaviour*, 25 (4), 485–505.

Druckman, A., Chitnis, M., Sorrell, S. Jackson, T., 2011 '*Missing carbon reductions; Exploring rebound and backfire in UK households*', *Energy Policy,* 39, 3 572–3 581.

EEA, 2012, *End-user GHG emissions from energy; reallocation of emissions from energy industries to end-users 2005–2010*, EEA Technical report No 18/2012, http://www.eea.europa.eu/publications/end-user-ghg-emissions-energy.

ECME Consortium, 2010, *The functioning of EU retail electricity markets for consumers in the European Union*, Report by European Consumer Markets Evaluation Consortium for DG Health and Consumers (http://ec.europa.eu/consumers/consumer_research/market_studies/docs/retail_electricity_full_study_en.pdf) accessed 5 April 2013.

Economidou, M., 2011, *Europe's buildings under the microscope — A country-by-country review of the energy performance of buildings*, Buildings Performance Institute Europe, Brussels (http://www.europeanclimate.org/documents/LR_%20CbC_study.pdf) accessed 5 April 2013.

EGREG, 2011, *Final Guidelines of Good Practice on Regulatory Aspects of Smart Metering for Electricity and Gas* (http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/CEER_PAPERS/Customers/Tab2/E10-RMF-29-05_GGP_SM_8-Feb-2011.pdf) accessed 18 March 2013.

Ehrhardt-Martinez, Karen; Donnelly, Kat A. and John A. 'Skip' Laitner. 2010. '*Advanced Metering Initiatives and Residential Feedback Programs: A Meta-Review for Household Electricity-Saving Opportunities'*, Washington, D.C.: American Council for an Energy-Efficient Economy.

Enviros Consulting Ltd, 2008, *The potential for behavioural and demand-side management measures to save electricity, gas and carbon in the domestic sector, and resulting supply-side implications*, Department of Energy and Climate Change, London (http://www.niam.scarp.se/download/18.6579ab6011d9b20740f8000648631/1233218171222/decc2008+potential+behavioural+demand+side+management+-save-energy-implications.pdf) accessed 5 April 2013.

European Commission, 2013, *Energy — Single market for gas & electricity* (http://ec.europa.eu/energy/gas_electricity/legislation/legislation_en.htm) accessed 12 March 2013.

European Commission, Commission staff working paper (SEC(2011) 469 final), http://www.google.gr/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CC0QFjAA&url=http%3A%2F%2Fec.europa.eu%2Fconsumers%2Fconsumer_empowerment%2Fdocs%2Fswd_consumer_empowerment_eu_en.pdf&ei=w1VHUZykHYnjOoHKgagI&usg=AFQjCNHDUh7FwJkUJrL5hFdtB1VmbYJAyA&sig2=H9DxT6r6fSMR9ZKIcrgszg.

European Parliament, ITRE Committee, 2012, *Effect of smart metering on electricity prices,* http://www.europarl.europa.eu/document/activities/cont/201202/20120223ATT39186/20120223ATT39186EN.pdf, accessed 12 December 2012.

European Regulators' Group for Electricity and Gas (ERGEG), *Position paper on end-user price regulation*, Ref: E07-CPR-10-03, http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/CEER_PAPERS/Customers/2007/E07-CPR-10-03_E-UPriceReg_0.pdf, accessed 11 June 2012.

Eyre, N., *Energy saving in energy market reform—The feed-in-tariffs option*, EnergyPolicy (2012), http://dx.doi.org/10.1016/j.enpol.2012.07.042.

Firestone, R., and Marnay, C., 2007, 'Distributed generation dispatch optimization under various electricity tariffs', *International Journal of Electronic Business Management, 5*(3), 200.

Fisher, J., and Irvine, K., 2010, *Reducing household energy use and carbon emissions: the potential for promoting significant and durable changes through group participation,* Paper presented at the IESD PhD Conference: Energy and Sustainable Development, Leicester, United Kingdom.

GAP, 2006, *Changing environmental behavior: A review of the evidence from Global Action Plan,* London, Global Action Plan.

GAP, 2008, *EcoTeams evaluation report*, London, Global Action Plan.

Geller, H., and Attali, S., 2005, *The experience with energy efficiency policies and Programmes in IAE countries — Learning from the critics,* International Energy Agency, Paris (http://www02.abb.com/db/db0003/db002698.nsf/ca7e93ab03030d22c12571380039e8fc/0912873430b22467c12571da0032d460/$FILE/The+Experience+With+Energy+Efficiency+Policies+and+Programmes+in+IEA+Countries.pdf) accessed 5 April 2013.

Greening, L.A., Greene, D.L., Difiglio, C., 2000. *Energy efficiency and consumption — the rebound effect — a survey*, Energy Policy. 28(6-7), 389–401.

Heffner, G., Campbell N., 2011, *Evaluating Energy Efficiency Benefits for Energy Providers and Customers*, IEA, Paris.

Hodge, J. and Haltrech, J., 2009, BedZED seven years on — *The impact of the UK's best known eco-village and its residents*, BioRegional Development Group, Wallington. http://www.bioregional.co.uk/files/publications/BedZED_seven_years_on.pdf.

Howell, R., 2009, *The experience of carbon rationingaction groups: Implications for a Personal Carbon Allowances Policy. Final Repor,* Environmenyal Change Institute, Oxford University Centre for the Environment. Available from: http://www.eci.ox.ac/publications/downloads/howell09crags.pdf.

IDEAL-EPBD, 2013, *European project on consumer response to energy labels in buildings* (http://www.ideal-epbd.eu/) accessed 12 March 2013.

Intelliekon, 2013, *Intelliekon in English* (http://www.intelliekon.de/intelliekon-in-english) accessed 10 March 2013.

Ipsos MORI, 2011, *Empowering Households — Research on presenting energy consumption benchmarks on energy bills,* Report by Ipsos MORI for the Department of Energy and Climate Change, London. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48124/2136-empowering-households-research.pdf.

Iyer M., Kempton W. and Payne C., 1998, *Comparison groups as a tool for evaluating energy efficiency programs: an analysis of Energy Star billing comparison groups*, Proceedings, American Council of Energy-Efficient Economy.

Jenkins, J., Nordhaus, T., and Shellenberger, M., 2011, *Energy emergence: Rebound & backfire as emergent phenomena: A review of the literature*, The Breakthrough Institute, Oakland (http://thebreakthrough.org/blog/Energy_Emergence.pdf) accessed 5 April 2013.

Keirstead, J., 2007, '*Behavioural responses to photovoltaic systems in the UK domestic sector*', *Energy Policy,* 35(8) 4 128–4 141.

Laitner, J.A, 2000. 'Energy efficiency: rebounding to a sound analyticalperspective.' *Energy Policy*, 28 (6–7), 471–475.

Lockwood, M., and Platt, R., 2009 *Green streets: Final report to Bristish Gas*, London IPPR.

Madlener, R., Hauertmann, M., 2011, *Rebound Effects in German Residential Heating: Do Ownership and Income Matter?* FCN Working Paper [Vol 2011,2].

Martiskainen, M., 2007, '*Affecting consumer behaviour on energy demand*', Final report to EdF Energy, University of Sussex, United Kingdom.

McDougall, G.H.G., Claxton, J.D., Ritchie J.R., *Residential home audits: An empirical analysis of the EnerSave Program, Journal of Environmental Systems*, 12(3) pa.

Mikkonen, I., Gynther, L., Hämekoski, K., Mustonen, S., and Silvonen, S., 2010, *Innovative communication campaign packages on energy efficiency: WEC-ADEME case report on energy efficiency measures and policies*, Motiva Services Oy (http://www.worldenergy.org/documents/ee_case_study__communication.pdf) accessed 5 April 2013.

Milne, G., and Boardman B., 2000, *Making cold homes warm e: the effect of energy efficiency improvements in low-income homes. A report to the Energy Action Grants AgencyCharitable Trust*, Energy policy, 28(6), 411–424.

Modig, G., 2006, *Evaluation of the industrial energy efficiency network in Norway*, http://www.aid-ee.org/documents/013IndustrialEnergyEfficiencyNetwork-Norway.PDF, accessed 10 January 2013.

Morant, M., 2012, *CEW1005 the performance gap — non domestic building: Final report*, AECOM, Cardiff http://www.cewales.org.uk/cew/wp-content/uploads/Presentation42.pdf.

Murray, C., 2011, *Income dependent direct and indirect rebound effects from 'green' consumption choices in Australia.* MPRA Paper No. 3497 (http://mpra.ub.uni-muenchen.de/34973/3/MPRA_paper_34973.pdf) accessed 5 April 2013.

OECD, 2008, *Household behaviour and the environment: Reviewing the evidence*, Organisation for Economic Co-operation and Development, Paris.

OECD, 2011, *Greening Household Behaviour: The Role of Public Policy*, Organisation for Economic Co-operation and Development, Paris.

OECD, 2012, *Greening Household Behaviour — Overview of survey data*, Organisation for Economic Co-operation and Development, Paris.

Ofgem, www.ofgem.gov.uk/sustainability/edrp/pages/edrp.aspx.

Petrov, K., 2009, *Price regulation methods,* http://www.leonardo-energy.org/sites/leonardo-energy/files/root/pdf/2010/Price%20Regulation%20Paper.pdf, accessed 11 June 2012.

Polish National Energy Conservation Agency, *Energy self-audit scheme*, Penelope Project Good Practice Database, Energie-Cités 2001 — 2002, http://www.energy-cities.eu/db/poland2_569_en.pdf, accessed 10 January 2013.

Raw, G., & Ross, D., 2011, *Energy demand research project: Final analysis*, AECOM, http://www.ofgem.gov.uk/Sustainability/EDRP/Documents1/Energy%20Demand%20Research%20Project%20Final%20Analysis.pdf) accessed 5 April 2013.

Renner, S., Albu, M., van Elburg, H., Heinemann, C., Łazicki, A., Penttinen, L., Puente, F. and Sæle, H., 2011, *SmartRegions — Promoting best practices of innovative smart metering services to European regions.* Österreichische Energieagentur *— Austrian Energy Agency (AEA), Vienna.*

Roberts S (2007) Interview with Simon Roberts, Chief Executive, Centre for Sustainable Energy, 13.05.2007.

Roberts, S., and Baker W., *Towards effective energy information: Improving consumer feedback on energy consumption,* A report to OFGEM, www.cse.org.uk/downloads/file/pub1014.pdf.

Rohr C (2007) Interview with Carsten Rohr, Sustainable Energy Analyst, Division of Climate and Energy, Defra, 15.03.2007.

Ryan, L., and Campbell, N., 2012, *Spreading the net: The multiple benefits of energy efficiency improvements*, International energy Agency, Paris.

Schüle, R (2009), *Energy Efficiency Watch; Final Report on the Evaluation of National Energy Efficiency Action Plans,* Berlin: Wuppertal Institute.

Schüle, R., Höfele, V., Thomas, S., and Becker, D., 2011, *Improving national energy efficiency strategies in the EU framework:Findings from energy efficiency watch analysis* (EEW-Publication Nr. 1/2011). Intelligent Energy Europe (http://www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW2/Improving_National_Energy_Efficiency_Strategies_in_the_EU_Framework_Findings_from_EEW1.pdf) accessed 5 April 2013.

Seyfang, G.,Lorenzoni, I., Nye, M, 2007, *Personal carbon trading : notional concept or workable proposition? Exploring theoretical, ideological and practical underpinnings*. CSERGE Working paperEDM07-03. Available from http://www.uea.ac.uk/env/cserge/pub/edm/edm_2007_03.htm.

Shove, E.,2003, 'Converging conventions of comfort, cleanliness and convenience.' In: *Journal of Consumer Policy*, Vol. 26, No. 4, 12.2003, p. 395–418.

Similä Lassi, Koreneff Göran, Kekkonen Veikko, 2011, *Network tariff structures in Smart Grid environment*, research report No. VTTR0317311, http://www.vtt.fi/inf/julkaisut/muut/2011/VTT-R-03173-11.pdf, accessed 11 June 2012.

Smart Regions project, http://www.smartregions.net/default.asp?SivuID=26927.

Sorrell, S., 2007, *The rebound effect: An assessment of the evidence for economy-wide energy savings from improved energy efficiency*, UK Energy Research Centre.

Sorrell, S., Dimitropoulos, J., and Sommerville, M., 2009, '*Empirical estimates of the direct rebound effect: A review*', *Energy policy,* 37(4) 1 356–1 371.

Staats, H. J and Harland P., 1995, *The EcoTeam program in the Netherlands, study 4: longitudinal study on the effects of the EcoTeam Program on th eenvironmental behaviour and its psychologyal backgrounds*. Centre for Energy and Environmental Research, Faculty of Social and Behavioural Scienbces Leiden University.

Staats, H. J and Harland P., and Wilke, H.A.M, 2004, *Effecting durable change: A team approach to improve environmental behaviour in the household.* Environment and Behaviour, 36,341-367.

Stromback, J., Dromacque, C., and Yassin, M. H., and 2011, *The potential of smart meter enabled programs to increase energy and systems efficiency: a mass pilot comparison*, VaasaETT Global Energy Think Tank (http://www.esmig.eu/press/filestor/empower-demand-report.pdf accessed) 5 April 2013.

Tigchelaar, C., Backhaus, J., de Best-Waldhober, M., 2011, *Consumer response to energy labels in buildings; Recommendations to improve the Energy Performance Certificate and the Energy Performance of Buildings Directive based on research findings in 10 EU countries*, http://www.ideal-epbd.eu/download/pap/Final_WP6_report_findings_recommendations.pdf, accessed 10 January 2013.

The Commission for energy regulation, Information paper no. CER11180a, 2011, *Smart metering information paper; gas customer behaviour trial findings report*, http://www.cer.ie/en/information-centre-reports-and-publications.aspx?article=5dd4bce4-ebd8-475e-b78d-da24e4ff7339 accessed 23 November 2012.

Vasconcelos, J., 2008, *Survey of regulatory and technological developments concerning smart metering in the European Union electricity market*, Policy papers, Robert Schuman Centre for Advanced Studies (RSCAS) *RCAS 2008/1*, European University Institute, Florence (http://cadmus.eui.eu/bitstream/handle/1814/9267/RSCAS_PP_08_01.pdf?sequence=2) accessed 5 April 2013.

van Elburg, H., 2009, *Smart metering and in-home energy feedback; enabling a low carbon lifestyle.* Paper presented at the European Council for an Energy Efficient Economy (ECEEE) 2009 Summer study report proceedings. Act! Innovate! Deliver! Reducing energy demand sustainability, Côte d' Azur, France (http://www.eceee.org/conference_proceedings/

eceee/2009/Panel_8/8.125/paper) accessed 5 April 2013.

van Gerwen, R., Jaarsma, S., and Wilhite, R., 2006, *'Smart metering' briefing paper.*Leonardo Energy (http://www.leonardo-energy.org/sites/leonardo-energy/files/root/pdf/2006/SmartMetering.pdf) accessed 5 April 2013.

Van Houwelingen, J.H., and van Raaj, W.F., 1989, The effect of goal-setting and daily electronic feedback on in-home energy use, Journal of consumer research, 16, 98–105.

Wallenborn, G., Prignot, N., Rousseau, C., Orsini, M., Vanhaverbeken, J., Thollier, K., and Simus, P., 2009, *Integration of standards, ecodesign and users in energy-using products,* Science for a sustainable development, Belgian Science Policy, Brussels (http://www.belspo.be/belspo/SSD/science/Reports/ISEU-Report%20Phase1-DEF.pdf) accessed 5 April 2013.

Winett R.A, Kage J., Battalio R.C. and Winkler R.A.,1978 *The effects orf rebates, feedback and information on electricityconservation*, Journal of Applied Psychology, 63, 72–80.

Appendix 2 The social science research landscape and recent findings

Social science has a role in helping us to better understand individual as well as societal responses to the world, and has been used to investigate people's relationship with energy, energy use and energy efficiency behaviour change initiatives/measures. Various models have been developed to describe and analyse behaviour and change:

- rational choice theory;
- theory of reasoned action;
- theory of planned behaviour;
- ecological value theory and value belief norm theory;
- attitude-behaviour-context model;
- persuasion and social learning theories.

A number of studies (Becker et al., 1981; Brandon and Lewis, 1999) indicate that environmental beliefs and/or socially responsible attitudes do not significantly influence energy consumption; monetary savings, for instance, seem to be better motivators.

Our behaviour is also influenced by social symbols. Symbolic interactionism and symbolic self-completion theories argue that we buy certain goods or 'symbols' (cars, mobile phones, etc.) not only for their practical value but also to construct our identity, and use those goods or 'symbols' for the image they portray of us to the outer world. Some research argues that under the idea of sustainable consumption, our aim should be to move away from using goods as social symbols and for the basis of our identity, towards other, more sustainable, and non-material resources (Jackson, 2005).

Cognitive dissonance theory could be used to encourage energy conservation. In a study of 118 high electricity-use households, individuals who felt that it was their duty as responsible citizens to conserve electricity, were made aware of the discrepancy between their attitudes and their actual electricity consumption. They reduced their consumption more compared to a control group (Kantola et al., 1984). This research concluded that if people are made aware of the difference between their attitudes and their actual behaviour, they are likely to change their behaviour. This will only work if people with these attitudes also possess the means to change their behaviour (e.g. heating thermostats) and the determination to match their beliefs with their actions.

Elizabeth Shove (2003) argues that there is evidence that routine consumption is controlled to a large extent by social norms and is profoundly shaped by cultural and economic factors. She argues that current consumption patterns reflect that we generally remain unaware of routines and habits, particularly when it comes to energy and water consumption.

One example supporting this statement is the housing made 'for' air conditioning that omits important features in naturally ventilated designs (such as verandas, overhanging eaves, space layout, etc.) which was promoted to 'standardise' comfort levels across different climatic regions. Another example is the evolution of the practice of doing laundry. According to Shove, an American household currently washes three times more laundry than it did in 1950. Doing laundry today involves a complex set of decisions about the degree of whiteness, the precision of ironing, the quality of starching, the fragrance, the type of fabric, etc., and consequently there is a constant reliance on interconnected markets that deliver products to satisfy a given combination of desired outcomes. And while water temperatures have plummeted (for instance the quantity of laundry washed at 90 °C has decreased in the United Kingdom over the past 30 years from 25 % to 7 %), the actual number of cycles has increased with changing social norms and perceptions about personal cleanness.

Generally, people aim to compensate for their lack of time and keep up with social norms with ever-increasing expectations of convenience. The ultimate impact on resource consumption and the environment more generally will therefore depend a great deal on how convenience is delivered, according to Shove.

And possibly, nothing is more telling about the power of social norms in changing consumption patterns and creating new habits than the CoolBiz and WarmBiz programmes (http://www.env.go.jp/earth/info/coolbiz) launched by the Ministry of Environment, Japan back in 2005, in an attempt to reduce energy consumption. The WarmBiz campaign promoted a reduction of the indoor temperature during cold months to 20 °C while employees were encouraged to dress more warmly. In contrast, the CoolBiz campaign promoted the increase of the indoor temperature in the summer months beyond which air conditioning is needed to 28 °C, while employees were encouraged to wear lighter clothing and avoid wearing a tie. Households, too, were encouraged to apply the same standards. A whole new fashion trend (and industry) has been created, and the end result was a significant change in the office dress code in Japan. Important energy savings are being still delivered to date.

Appendix 3 Interaction between humans and technology: a proposal for an analytical framework

Many of the energy efficiency measures currently in force or being planned in Europe rely heavily on technology adoption. However, the interaction between humans and new energy technologies remains challenging. Table A.3.1 briefly describes four possible dimensions in which to analyse human interaction with technology.

Table A.3.1 Four dimensions to analyse human interaction with new energy technologies

Dimension	Explanation/examples
Constraints	• Factors which may impede initiatives. For smart grids, these may include: - informed participation of consumers; - barriers to effective feedback mechanisms (i.e. to consumers getting useful and timely information easily); - unexpected capital costs; - an optimal solution may not always be reached due to trade-offs, cost considerations, etc.; - increased gadgetry, which could prevent adequate integrated energy management processes.
Cultural	• Social trends in device proliferation (multiple mobile phones, TVs in every room, dual computer screen use, etc.). • Fear of technology.
Comfort/ convenience	• How easy feedback devices/behaviour change initiatives are to use/implement. • Impact on daily routines (disruptive or negligible). • Location and visibility (e.g. of smart meters). • Human desire to be comfortable (warm/cool). • Overcoming ingrained habits/making current habits less desirable.
Cognitive impact	• The link between delivery of behaviour change initiatives and the consumption activity (too long/infrequent or complicated/difficult) and impact is lost because it becomes irrelevant or it is too hard to apply. For example, the American Energy Star programme included programmable thermostats, but after 10 years of their use, energy consumption had risen. This was attributed to the facts that: - people tended to use the default setting (rather than altering their heating at night or when away); - the design was overcomplicated, making them awkward for people to use (reinforcing the former element). • Feedback needs to be timely, i.e. close to the time of consumption, e.g. a smart meter warning when consumption rises, exceeds or approaches a particular threshold.

European Environment Agency

Achieving energy efficiency through behaviour change: what does it take?

2013 — 52 pp. — 21 x 29.7 cm

ISBN 978-92-9213-384-9
doi:10.2800/49941

TH-AK-13-005-EN-N
doi:10.2800/49941

European Environment Agency
Kongens Nytorv 6
1050 Copenhagen K
Denmark

Tel.: + 45 33 36 71 00
Fax: + 45 33 36 71 99

Web: eea.europa.eu
Enquiries: eea.europa.eu/enquiries

ISBN 978-92-9213-384-9

Publications Office

European Environment Agency