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**Insights from psychology about the design and implementation of energy interventions using the Behaviour Change Wheel** (Wilson, C & Marselle, M.R) Energy Research & Social Science (2016), pp. 177-191 DOI information: 10.1016/j.erss.2016.06.015

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## **Abstract**

Improving the design and implementation of interventions to encourage end-use energy efficiency has the potential to contribute a substantive reduction in carbon emissions. A plethora of behaviour change frameworks is available to guide policymakers and designers but none have been found to be comprehensive or well-used. A new framework – the Behaviour Change Wheel (BCW) – purports to be a useful aid for developing all types of behaviour change interventions. This paper assesses whether the BCW comprehensively describes programmes attempting to reduce energy consumption. To do this, components of behaviour change programmes as identified in four EU guidance documents were mapped onto the BCW. Most of the components discussed in the guidance could be readily coded to the BCW framework. The main energy policy under-represented in the BCW was energy price. Based on our work in this paper, we believe that the BCW offers a useful aid for the systematic design and development of behaviour change around end-use energy efficiency. We also propose that it may support development of a common lexicon for activities that can be rather vaguely described currently in energy efficiency guidance.

## **Keywords**

Energy; consumption; behaviour; intervention; policy.

## **1 Introduction**

End-use energy efficiency is generally seen as the most cost-effective way to reduce CO<sub>2</sub> emissions [1,2]. It offers potentially the largest reduction opportunity [3]. The gap between what savings are possible, and what are currently being realised, warrants the identification of effective strategies to

seize this opportunity [4,5] . As such, changing energy demand and improving energy efficiency is now key to helping the UK and the EU meet obligations to reduce carbon emissions (e.g. UK Climate Change Act 2008, Directive 2012/27/EU). Some interventions to alter consumption levels operate above the level of the end-user (e.g. market regulation), whilst others depend on altering end-user choice or practice. Efforts to reduce emissions in the early 2000s were dominated largely by ideas from the economics and engineering disciplines, ignoring the promise offered dimensions such as the sociological and psychological [6]. Specifically, much energy research has downplayed the role of the human dimension and choice [7].

Coordinated sets of activities designed to alter usage choices and practices can be understood as behaviour change interventions [8]. New models of behaviour change are now emerging in the energy literature, based on multi-disciplinary work [9], but these are not yet widely used in practice[10]. Further, many existing frameworks either analyse only limited aspects of behaviour, or are not reliable in leading to successful interventions [11].

A recent review of the energy studies field concluded that it needed to reach out to other disciplines for useful insights [7]. Insight is potentially available from the Behaviour Change Wheel (BCW), a framework for the systematic design and development of behaviour change interventions. The BCW is drawn from psychologically-rooted guidance about behaviour change in a range of situations, including energy efficiency. The BCW promises much. Its architects propose that it can be applied to “every intervention that has been, or could be, developed” ([8]:3). However, to date, the application of the recently published BCW to energy efficiency is limited [12]. This paper will assess whether the BCW can be recommended for use as a design and evaluation aid for future energy efficiency interventions, and to identify any limitations and concerns. This work contributes to the academic literature by investigating whether, as ambitiously proposed above, the BCW can be used to describe every energy efficiency behaviour change intervention that has been, or could be, developed. This would be a sensible precursor step in order to justify trialling its use in preference to existing behaviour change frameworks – some of which may appear more immediately relevant to the field of energy behaviour [13,14].

This work engages with current social science debates in three ways. Firstly, it contributes to the quest to discover what types of activity are most effective in what circumstances [7], by investigating issues like trust, persuasion, the quality of information and mode of communication. Secondly, by examining a framework designed to help deliver effective behaviour change appropriate to local context, it also relates to the understanding of *how* to introduce behaviour change. The BCW framework claims to offer guidance on the production of a holistic intervention which is more likely to be effective [12]. Finally, it discusses the extent to which the BCW goes beyond a reliance on the attitudes, behaviours

and choices of the *individual*, which has been a criticism of the social science contribution to changing consumption patterns thus far [15].

### **1.1      *Background to the Behaviour Change Wheel***

The BCW was developed from an identification of need. In a systematic review of 19 behaviour change frameworks, Michie, van Stralen and West [8] found that no theories, frameworks or guidance covered the full range of behavioural determinants and intervention types available; in that behavioural determinants or interventions important to one framework were not covered by another. Michie et al.[8] identified that while individual theories explained potentially important variables to influence behaviour [e.g.10,11], they were flawed in their capacity to offer comprehensive guidance – an argument also found in the energy literature [15,18–20]. Many frameworks and guidance documents which offer advice on the implementation of behaviour change interventions were also found to be insufficiently comprehensive [8]. For example, one of the 19 reviewed frameworks – the influential MINDSPACE report from the UK Institute for Government [21] – was found to have a checklist of influences on behaviour without a similarly comprehensive checklist of potential interventions [8].

The BCW was developed from these 19 behaviour change frameworks (see Appendix A). Common features of the 19 frameworks were synthesised and linked to a model of behaviour [12]. It should be noted that two of the frameworks [13,14] specifically address pro-environmental behaviours such as energy efficiency. In this way, the BCW is indirectly informed by key literature and theories of behaviour change of relevance to supporting energy efficient actions [e.g. 18–20].

The BCW has its roots in psychology, and follows an established tradition of focussing on underlying determinants such as motivation, opportunity and capability, when trying to prompt behaviour change [e.g. 21]. The BCW is not just focussed on the individual. The architects of the framework designed it to accommodate all possible “conditions internal to individuals *and in their social and physical environment*” (emphasis added, [8]:9). Economic instruments, such as energy price increases or financial incentives, can be reliable ways to alter energy behaviour [18]. Literature focussing on economic theory is also included in the frameworks which informed the BCW [e.g. 16]. The BCW thus purports to offer a comprehensive set of ideas about factors involved in bringing about behaviour change. At the same time – drawing as it does on existing guidance and ideas about how to alter choices and practices of individuals – it is reflective of the current dominant paradigms of economics and psychology [15]. The extent to which, assembled as it has been from existing frameworks, the BCW incorporates other possible analyses of the problem will be discussed as part of our investigation.

## 1.2 The Behaviour Change Wheel

The BCW has three layers (see Figure 1). At its centre are three key factors that interact to determine behaviour: capability, opportunity and motivation (COM-B). These determinants help understand “what needs to change” ([12]:57). By placing behavioural determinants at its core, the BCW starts from an understanding of the factors most likely to bring about a change in behaviour. Each behavioural determinant is further subdivided into two categories (see Figure 1). Surrounding the six behavioural determinants on the wheel are nine intervention functions (middle layer) and seven policy categories (outer layer). Definitions and examples of determinants, interventions functions and policy categories in the BCW can be found in Table 1.

<<insert Figure 1 about here>>

The operation of the components is not linear. There can be relationships among components both *within* and *between* layers of the BCW. Michie et al. ([8]:6) state “components within the behaviour system interact with each other as do the functions within the intervention layer and the categories within the policy layer.” Furthermore, the architects of the BCW [12] identify links between behavioural determinants and intervention functions most likely to be appropriate and effective for bringing about the desired change, as well as the policy categories most likely to support these interventions. These linkages between layers of the BCW are to be used to direct intervention designers to the optimum package of interventions and policies to change a behaviour [12] (see Table 3).

Context is addressed in the BCW in two ways. First, context is considered prior to the BCW in order to fully understand the problem and specify the target behaviour [12]. Second, context is addressed within the BCW. The architects of the BCW [8] state “one of the strengths of this framework is that it incorporates context very naturally” ([8]:8) through the ‘*opportunity*’ behavioural determinant.

The BCW can be applied “at any level from individuals to groups, sub-populations and populations” ([12]:20). When using the BCW at the level above the individual, the components of the BCW are construed in terms of aggregate parameters such as the proportion of the target population who report a specific motivation or engage in a certain behaviour [12]. Application of the BCW at the level of organisations is incorporated through the *physical* and *social opportunity* determinants [12].

The BCW has multiple claimed uses. It can be used for intervention design, intervention evaluation and theory development; it also provides a systematic way of characterising interventions [12]. It is this latter purpose for which we will use the BCW. We will assess whether the BCW comprehensively characterises the full range of interventions and policies aimed at influencing end-use energy efficiency behaviour. Previous researchers have used the BCW in this way to systematically

investigate whether the framework comprehensively characterises public health interventions. Jackson et al. [26] assessed whether the core of the BCW could classify behavioural determinants within the public health sub-domain of medication adherence. Michie et al. [8] used the BCW to characterise the interventions and policies in UK guidance on obesity and tobacco use. The latter publication has formed the starting point for a growing number of investigations in health-associated literature as a means to create more effective interventions. This current paper uses the mechanism by which it has been introduced into the health domain to verify whether it appears a *prima facie* fit to the domain of end-use energy efficiency behaviour.

<<insert Table 1 about here>>

### 1.3 Applying the Behaviour Change Wheel to energy efficiency

It is proposed that the BCW “is applicable to behaviours across all domains, for example environmental sustainability...” ([12]: 14). Before now, this claim has been largely untested. To our knowledge, one study has applied the BCW to this domain. Determinants of the BCW have been used to evaluate why a campus recycling intervention failed [27]. Interviews explored the capability, opportunity and motivation to recycle. The results provided information about determinants of recycling behaviour which had not been addressed, offering insight into why the original intervention was unsuccessful [27]. The use of the BCW in energy efficiency is also limited. The determinants of the BCW were used to classify an organisation’s household energy efficiency interventions [28], with the finding that the organisation’s household energy efficiency interventions relied too much on providing rational information to increase capability (*psychological capability*) and motivation (*reflective motivation*), whilst neglecting emotion (*automatic motivation*) and other determinants (e.g. *social opportunity*). Similarly, the BCW was used to evaluate the comprehensiveness of a range of CO<sub>2</sub> reduction initiatives [12]. The evaluation found that the initiatives concentrated on behavioural determinants, but largely ignored intervention functions and policies [12].

In order to recommend use of the BCW as a tool to design behaviour change programmes, work is needed to uncover whether it is fully applicable to the domain of energy efficiency. This paper responds to a call by the architects of the BCW to uncover if it is truly comprehensive [8] by investigating whether the BCW can characterise behaviour change interventions encouraging people to use energy efficiently. It does this by first assessing whether the BCW classifies energy efficiency behaviour change interventions, and then further assesses whether the linkages between layers in the BCW correspond with how they connect in this domain. Thus, this paper has two research questions:

1. Does the BCW define and characterise behaviour change interventions associated with energy efficiency?

2. Do the identified linkages between layers of the BCW correspond with those found in the energy behaviour domain?

These two questions are an essential step in assisting those involved in planning behaviour change interventions focussed on end-use energy efficiency in deciding whether the BCW might have application in this domain.

## **2 Methods**

### **2.1 Procedure**

In order to assess whether the BCW can comprehensively classify all of the intervention types associated with end-user energy efficiency, we sought out guidance documents offering a comprehensive review of the current field. The factors associated with energy efficiency in the guidance documents were identified and then mapped to the BCW. This methodology has been used by previous authors [8,26]. Specifically, we followed the procedure for applying the BCW to characterise behaviour change interventions created by Michie et al. ([8]:Additional files 1 & 8).

### **2.2 Literature selection**

The procedure used requires assessment of pre-existing guidance on policies and practices to encourage behaviour change. There is a wealth of advice from different sources about how to influence energy efficiency behaviour. Search terms were used to identify appropriate energy behaviour change guidance. These terms were generated after consulting the energy behaviour change literature. Appendix B details search terms used and databases searched.

Intervention guidance was included if it met the following conditions: it was comprehensive (i.e. described a range of energy efficiency behaviours (not limited to a single topic, such as travel) and covered all three levels of the BCW in order to assess linkages); avoided general exhortation; published after 2005; written in the English Language; and emanated from the EU. The EU was selected as it offered shared overarching legislation and policy drivers. A detailed literature search was conducted with this criterion in place.

Four energy behaviour change guidance documents were used to map onto the BCW. Brohmann et al. [29] reviewed results from programmes in several EU countries to identify the most effective ways to overcome barriers and to change behaviour around energy efficiency in buildings. Dahlbom et al. [30] drew on lessons from an evaluation of 41 EU energy behaviour change programmes, combined them with insights from theory, and created guidelines to develop and implement successful policy interventions. The European Environment Agency (EEA) [31] reviewed available literature on

measures targeting energy efficiency behaviour in order to achieve energy savings. MECHANisms (<http://mechanisms.energychange.info/>) is an online toolkit promoting change in energy use including guidance for practitioners, a database of 100 projects, meta-analysis of 27 case studies, interviews with 24 intermediary organisations, feedback from 170 energy practitioners, and six pilot projects.

As with the frameworks which guided the construction of the BCW, our chosen guidance documents also reflect current approaches to changing behaviour. While this is dominated by attitude-behaviour theories, other viewpoints are represented. The EEA ([31]:9) document acknowledges that current literature “considers measures targeting consumer behaviour change rather than practices.” Dahlbohm et al. [30] similarly adopts a behavioural approach. However, the other two guidance documents capture wider perspectives. The Brohmann et al. [29] guidance draws from economics, psychology, marketing, sociology and other interdisciplinary research. It considers the impact of socio-technical systems, and acknowledges the need to change institutions and systems which surround the individual. MECHANisms [32] guidance argues for a contextualised understanding of energy end-users, and critique of overly dominant techno-economic and psychological approaches. Therefore, the four guidance documents reviewed in this paper reflect current dominant behavioural approaches, but also incorporate alternative conceptualisations of the barriers to behaviour change around energy consumption [e.g. 11,28,29]. The selected guidance documents are thus informed by the academic literature on energy efficiency behaviour, and were preferred to use of academic literature directly. As has been found by other scholars [22], academic literature frequently insufficiently specifies interventions for this type of purpose.

### **2.3      *Coding***

Instructions on how to code the content of the energy behaviour change guidance documents to the BCW were created based on Michie et al. [8]. The first step in the coding instructions was to ‘familiarize yourself with the definitions of the determinants, intervention functions and policy categories’ of the BCW (see Appendix C). However, as we started coding the first guidance document, we found definitions and examples of components of the BCW by Michie et al. [8] were vague. Consequently, it was difficult to code energy reduction interventions found in the guidance documents to the BCW. That it was not simple to categorise terms and concepts from energy guidance into the BCW highlights that the BCW, in its original form, was not readily adapted for use in the energy efficiency domain. In order to further understand what each component of the BCW measured, we added new definitions and examples using current BCW literature [12]. Definitions and examples from the guidance documents which were appropriate to an energy context were also added through the coding process. The end result was definitions and examples of the BCW components more

specific to the energy conservation domain, which enabled easier coding. Table 1 shows our amended definitions and examples of the BCW.

Using the coding instructions (see Appendix C) and our amended Table 1, each author independently coded the behaviour change interventions found in the four energy behaviour change guidance documents against the components of the BCW. We then presented our coding for each energy behaviour change guidance document. Similarities and differences in coding were identified. Differences were readily resolved through discussion.

## **2.4      *Identifying linkage correspondence***

To assess whether the identified linkages between layers in the BCW [12] correspond with those found in the domain of energy efficiency behaviour, each author independently noted links between behavioural determinants and intervention functions, and links between intervention functions and policy categories in the four guidance documents. When, as a result of this coding exercise, new linkages were found, these would be considered for inclusion when they occurred in at least three of the four guidance documents. This would indicate sufficient examples in the energy behaviour change discipline for their inclusion to be justified.

# **3      Results**

## **3.1      *Testing the comprehensiveness of the BCW in an energy behaviour context***

Results of the coding exercises can be found in Appendix D. The final coding of the determinants, intervention functions and policy categories of the four energy behaviour change guidance documents was achieved with the following inter-rater agreements: 94% for Brohmann et al. [29]; 89% for Dahlbom et al. [30]; 94% for EEA [31]; and 95% for MECHANisms [32]. Michie et al. [8] achieved an inter-rater agreement of 88% and 79% when coding two UK health guidance documents onto the intervention function and policy categories of the BCW. The higher inter-coder reliability in this paper is thought to be due to the amendments made in Table 1. This made it easier for energy-specific behaviour change components to be coded.

All of the BCW categories were readily found in the guidance documents (see Table 2). However, a few categories of the BCW were coded less frequently than others. The determinant *psychological capability* was the second most frequently occurring determinant in the guidance documents, whilst *physical capability* occurred the least. *Physical capability* might be more typical in the health field (e.g. technique to take blood sample), than in the domain of energy behaviour. *Reflective motivation* occurred most frequently in the guidance documents, more than twice as many times as *automatic*



*motivation* (see Table 2). This may reflect a difference in the scope for emotion to be a factor in energy consumption, compared to personal health, in that there is reduced scope for emotive injunction to adopt energy behaviour (climate change concerns excepted). *Physical and social opportunities* appear more relevant to energy behaviour, occurring almost equally. At the individual level, devices that offer improved monitoring of consumption afford the *physical opportunity* to make a change (see also section 4.3 for further ways in which devices offering feedback can be categorised).

**<Add Table 2 approx here>**

The most and least common intervention functions discussed in the energy efficiency guidance are detailed in Table 2. *Education* occurred most frequently in the energy guidance documents. *Restriction* occurred least frequently in the guidance. Similarly, the intervention function *coercion* did not feature frequently. This may be because it would be unpopular in a community of countries where individuality is prized and the public is generally less deferential towards authority [35].

The most common policy category was *communication/marketing*, which is unsurprising considering *education* was the most frequent intervention function. The least common policy category was *fiscal measures*, despite energy price being identified as a factor likely to determine consumption [29,36]. This was because the definition of *fiscal measures* in the BCW is limited to the tax system only, and as such was unable to be used to categorise energy price. Thus, non-tax related monetary policies were coded using the policy category *environmental/social planning*, contributing it to being the second most frequently coded policy.

### 3.1.1 Applying the BCW to energy guidance documents

The architects of the BCW state that a limitation of the framework may prove that whilst it is designed to “characterise interventions, it is possible that it may prove difficult to use” ([6]:9). This section addresses this potential limitation as a result of attempting to apply the BCW to the energy guidance. Two types of problem were observed: when there was a lack of detail in the guidance documents and when there was a lack of detail in the BCW. Each will be discussed in turn.

A lack of clarity was found in the guidance documents, contributing to the difficulty in applying the BCW. The guidance documents occasionally discussed an intervention involving *motivation* without specification of its type; for example, “charts which visualise household’s energy use” ([31]:18). This lack of clarification in the guidance documents meant that both determinants *automatic motivation* and *reflective motivation* were coded. “Empowerment” ([29]:8) was insufficiently explained in the guidance documents to indicate which determinants were targeted by its use. Likewise, the discussion

of engagement failed to reveal which intervention function it would address (i.e. is it *training*? Will it provide *education* or *modelling*?). This resulted in it being unable to be coded against the BCW.

A lack of clarity was also found in the BCW. Trust and values are not clearly defined. This is a problem as trust is described as a “key issue” for energy advice ([31]:29) (see also Section 1 of this paper). Based on the evidence of how trust is invoked in the BCW, we categorised trust as most matching the definition of *automatic motivation* (see Table 1). Values are frequently identified as a determinant of behaviour change by much of the energy literature [31]. However, the only time values are clearly associated with *reflective motivation* is when the BCW is related to another behaviour change framework, unrelated to this paper, which raises values as a factor [12] (See Table 1).

The guidance documents highlighted that *physical opportunity* can be restrictive, as well as enabling. Yet, this distinction was not mentioned in the BCW. We amended Table 1 to reflect these two aspects of *physical opportunity*. Restrictive opportunity refers to the lack of physical opportunity in the environment, such as taxes and fees [30], levies and surcharges [31], lock-in to existing systems of provision [29], or inadequate provision of appliances and infrastructure [29]. Enabling opportunity refers to the existence of physical opportunity afforded by the environment, such as provision of subsidies [29,30] or availability of products in shops [30].

A lack of distinct definitions was found for some interventions of the BCW. The threshold separating the intervention functions *education* and *training* from *enablement* is undefined in the BCW. As such, these cannot be easily distinguished. For example, the provision of “tailored advice” ([29]:6) to reduce energy use could have been classified as *education* (increasing knowledge) or *training* (offering the subject of the advice more skill) depending on the nature of the advice. However, with the addition of ‘tailored’, the advice could be argued to become *enablement* because the recipient of the personalised advice has increased their capability. Related issues in coding with these three intervention functions were also found for “support” ([29]:12) and “one to one engagement”([31]:13). Similarly, the difference between intervention functions *incentivisation* and *enablement* was not straightforward to distinguish. For example, the provision of “funding for energy efficiency measures...in the form of subsidies” ([31]:28) could be classified as either an *incentive* (creating an expectation of reduced cost) or *enablement* (increasing means/reducing barriers to increase opportunity) according to the means of the targets of the intervention. As is acknowledged above, difficulties in coding could also be due to the poor description of the interventions in the guidance documents, making their functions difficult to determine.

Making a voluntary commitment is a common energy behaviour change intervention [29,37]. Households may, for example, make a voluntary commitment to achieve a certain energy saving target [31]. They are also defined as programmes in which individuals, households or organizations

make a voluntary commitment to join [32]. In the BCW [12], commitment is a technique associated with intervention functions *incentivisation*, *coercion*, and *enablement* [12]. The relation of commitment to these three intervention functions would not be immediately clear to a programme designer.

Policy categories *guidelines* and *regulation* in the BCW are blurred. *Guidelines* are documents that recommend or mandate practice (see Table 1). *Regulation* is defined as establishing rules of behaviour using the example ‘voluntary agreements’ (see Table 1). The problem here is that both these categories suggest adherence could be voluntary. Energy behaviour instruments were often described as ‘voluntary’ or ‘agreements’ in the guidance documents: “voluntary forms of regulatory instruments” ([30]:31); “covenants and agreements” ([30]:31); “voluntary” schemes of certification ([31]:27). Due to the ambiguity in definitions and examples, both policy categories were used to code the above.

Finally, timing was another factor not explicitly featured in the BCW. As such, interventions targeting lifestyle at the point of fundamental life change – such as moving house – were unable to be categorised ([29]:9-10). The architects of the BCW argue issues such as timing are addressed *before* using the BCW, when specifying the behaviour to be changed [12].

### **3.2      *Linkages between determinants, intervention functions and policy categories in an energy context***

The second research question was to assess whether the linkages between interventions and determinants, and between policy categories and interventions identified by the architects of the BCW [12] correspond to those found in the energy efficiency domain. These relationships are reproduced in this paper, with our amendments, in Table 3.

#### **3.2.1    Linkages between determinants and intervention functions**

There was agreement with the determinants-intervention linkages identified by the architects of the BCW and the energy guidance documents. However, five new determinants-interventions linkages were also found (see Table 3). These are discussed below.

**<Add Table 3 approx here>**

*Psychological capability and persuasion* – Psychological capability is defined as having the necessary knowledge as prerequisite to performing a behaviour – such as understanding the impact of CO<sub>2</sub> on the environment [12]. When an externally organised intervention is proposed (as opposed to a person themselves seeking out information in order to adjust their behaviour), information will be considered by the individual according to whether it is engaging, or persuasive. This suggests that increasing the

psychological capability (or knowledge) of individuals as a method of energy reduction behaviour is supported with information which consumers find persuasive. The relationship between knowledge and persuasive information has been highlighted by Hovland and colleagues' persuasion theory, which "assumes that attitude change occurs through the assimilation and comprehension of the persuasive information" ([23]:106). Climate change communication strategies suggest that climate science information will be absorbed by audiences if it is communicated with persuasive techniques such as appropriate language, visual imagery, metaphor, framing, narrative storytelling, and experiential scenarios [38,39]. Persuasive information has been shown to contribute to greater knowledge; people retained more factual information about climate change after viewing a presentation using persuasive information (i.e. vivid imagery and personal accounts) than a presentation using information alone ([38]:17).

Michie et al.([8]:109-110) give the example of capacity to engage in the necessary thought processes triggered by use of persuasive information: "A message such as 'Please make sure you use soap when washing your hands – just rinsing them is not enough to kill the bacteria that cause nasty stomach bugs', can serve to improve knowledge but also with words such as 'nasty' it can evoke emotions in a way that goes beyond this to persuasion". This linkage between psychological capability and persuasion was identified in three of the four guidance documents ([29]: 7, 12, 13; [30]: 27;[31]:13, 17, 18, 19, 28). For example, the EEA guidance ([31]:13) suggests "to make energy bills more informative is to include charts which visualise household's energy use". Brohmann et al. ([29]:12) highlight the relationship between persuasive information and psychological capability as a pre-requisite of behaviour change: "... it is important to adapt the households' perception of their energy friendliness *before* they can make the appropriate changes" (emphasis added).

*Psychological capability and modelling* – Bandura's [40] social learning theory describes how we learn behaviour through exposure to models. *Modelling* is defined as "providing an example for people to aspire to or imitate" ([8]:7). In the energy domain, examples of *modelling* include comparative feedback, goal setting or energy audit where one's past energy use is a comparator for the amount of energy that could be saved (see Table 1). Comparative feedback uses other people's energy consumption as a model as an example for ones' own future behaviour. As above with persuasive information, the comparative information is used to educate the user on their energy use. One example of comparative feedback is an energy audit. Energy audits provide detailed information on energy use and savings potential by evaluating the thermal characteristics of the building, its existing infrastructure and the appliances in use. An energy audit report details the users' activities, the saving potential and recommendations for investments [29]. Thus, an energy audit uses one's past

energy use as an “anti-role model” ([23]:110) to provide information on the amount of energy that could be saved.

The linkage between *psychological capability* and *modelling* was found in three of the four guidance documents ([29]:13; [31]:17, 20, 21; [32]). For example, “metering and feedback (e.g. informative billing) instruments provide end users with more detailed, *comparable* and comprehensible information on their energy use...” [32] (emphasis added). EEA ([31]:20) inform: “Several studies on feedback found that the level of household’s previous energy consumption can bear upon the effect of the feedback...the level of the previous energy consumption had an impact on energy-using behaviour”. Brohmann et al. ([29]:13) state, “The knowledge about the (comparative) level of consumption and the amount of costs provides the motivation for a change towards more efficient energy use”. Thus, comparative feedback provides users with an understanding of their energy use, which can then motivate a change in energy conservation behaviour (see the reflective motivation – modelling link below).

*Reflective motivation and modelling* – Reflecting and making deliberate evaluations and plans about energy consumption also lends itself to models which illustrate the consequences of behaviours and how to re-align them. In the guidance documents, examples of *reflective motivation* linking with *modelling* are related to feedback and goal setting techniques. For example, “the knowledge about the (comparative) level of consumption and the amount of costs provides the motivation for a change” ([29]:13), and “...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” ([31]:21). The connection between *reflective motivation* and *modelling* was found in all four guidance documents. ([29]:13; [30]: 27; [31]:17, 18, 20, 21; [32]).

*Physical opportunity and incentivisation* – The determinant *physical opportunity* is defined as “opportunity afforded by the environment involving time, resources, locations, cues, physical affordance” (see Table 1). In energy efficiency, examples of physical opportunities include access to energy usage monitoring devices, subsidies, grants or loans. *Incentivisation* is an intervention to create an expectation of reward or a reduced cost. Examples of incentives from energy guidance documents include an energy audit, reduced tax on energy efficient products, or as subsidies, grants and loans for altering one’s home or business to be more environmentally friendly (see Table 1).

The linkage between *physical opportunity* and *incentivisation* was found in three of the guidance documents ([29]:4; [30]:27, 31, 34; [31]:13, 21, 22, 25). The relationship between *physical opportunity* (the external context) and *incentivisation* is highlighted by Brohmann et al.:

“...consumer behaviour is based on individual decisions, but largely depends on external factors, such as economic incentives, supply side measures and an appropriate infrastructure” ([29]:4).

Similarly, Dalhbohm et al. state: “economic instruments affect the cost and benefits of the choices available” ([30]:31). Examples of economic incentives (and disincentives) include: “subsidies, levies, surcharges, taxes, bonuses, tax differentiation, tax refunds, financial instruments such as interest free loans, rewards and penalties” ([31]:13) as well as “transferable emission allowances or certificates, deposits as securities and various forms of grants and subsidies” ([30]:31).

*Social opportunity* and *education* – Social learning has been identified as important for energy conservation behaviour [29]. People learn through social interaction [39]. Our social networks are a source of new information. For example, a work colleague or friend recounts a news story that increases our understanding. According to social learning theory, we learn most effectively from other people who are attractive, socially influential or who we identify as ‘like us’ ([23]:13). In the domain of marketing and advertising, this aspect of social learning has led to the creation of stealth marketing techniques – such as word of mouth and peer group recommendation [41] – and celebrity marketing campaigns [23].

The linkage of *social opportunity* to *education* was supported in three of the guidance documents. ([29]:4, 15; [30]:27; [31]:22). Brohmann et al. [29] highlight that information has to fit the perceived *social opportunity* – educative interventions should reflect social and culture norms to be effective. *Education* can also be defined as in peer education. The EEA guidance discusses community-based initiatives in which “the group meets regularly and decides what information they need to help them alter their behaviours” ([31]:24). Information about influential others’ approval is also discussed by Dalhbohm et al. [30] as an educative tool.

### 3.2.2 Linkages between intervention functions and policy categories

There was agreement with the intervention-policy linkages identified by the architects of the BCW and the energy guidance documents. However, two additional interventions-policy linkages were found in the energy guidance documents (see Table 3). These are discussed below.

*Incentivisation* and *environmental/social planning* – *Incentivisation* is an intervention to generate an expectation of reward or a reduced cost, such as subsidies, grants, loans for altering one’s home or

business to be more environmentally friendly. *Environmental/social planning* is a policy for “designing and/or controlling the physical or social environment” (see Table 1). *Environmental and social planning* policies can support *incentivisation* interventions through Government subsidies, grants or loans (e.g. Green Deal) or supply side policies (e.g. energy ratings, Economy 7 heating). As stated in section 3.1, non-tax related monetary policies were coded as environmental/social planning due to the restrictive definition of *fiscal measures* in the BCW relating to the tax system only.

This linkage was found in three of the guidance documents [29,31,32]. The EEA guidance discusses the effect of financial policies to incentivise behaviour: “Funding for energy efficiency measures takes place via either central/local government in the form of subsidies for specific investment...or private investment at the community scale” ([31]:28). The relationship between financial incentives and policy is also discussed in MECHAnisms: “Financial instruments and subsidies...promote energy efficient technological and measures by reducing the investment costs.” Examples of financial policies include: “governmental grants covering a significant part of the costs associated with energy auditing and energy efficiency measures implemented” ([31]:22) and “feed-in tariffs for energy efficiency...allows the provision of fixed price incentives for energy efficient measures” ([31]:28).

*Environmental restructuring and service provision* – The linkage highlights the importance of service provision in the creation of physical objects or social programmes to change the physical/social context. The intervention *environmental restructuring* involves “changing the physical or social context” (see Table 1) and this is achieved in the energy domain by adding objects to the environment (e.g. energy monitoring devices, web-based benchmarking tools) or the establishment of community schemes. *Service provision* policy – defined as delivering a service – facilitates this intervention with provision of the above-mentioned tools or providing support for community schemes. For example, the UK government has a commitment to install 53 million smart meters in homes and small businesses by 2020 [42]. To facilitate this intervention, a company provides a data and communications service linking the smart meter in the home/business with the systems of energy suppliers, network operators and energy service companies [42].

The relationship between environmental restructuring and service provision was found in three of the guidance documents ([29]:17; [31]:19, 22, 24; [32]). For example, Brohmann et al. list “provision of appliances, products [and] services” ([29]:17) as factors influencing energy behaviour. In MECHAnisms, informative billing interventions involves service provision of “detailed, comparable and comprehensible information on their energy use”, and “two-way communications that allow the supplier to communicate directly with end-users.” With regards to community schemes, the service provision includes the organising of regular meeting sessions, the creation of a handbook with reliable information, or the access to a trained expert ([31]:24), as well as the training of volunteers who

facilitate the meetings, and the creation of activities, games or exercises to do during each meeting [43].

## 4 Discussion

The work undertaken in this paper has addressed two questions. The first is whether the BCW can define and characterise behaviour change interventions associated with emission-related behaviours associated with energy. Included in this aspect of our inquiry is whether the framework, which has so far mostly been trialled in the health domain, is suitable to be appropriated to the domain of energy efficiency. The second question investigates whether the identified linkages between layers of the BCW corresponds with those found in the energy behaviour domain. We respond to these questions in turn. We then reflect on whether the framework can be recommended for trialling by those working in the field of energy efficiency and on its value, based on the work described in this paper.

### 4.1 *Does the BCW define and characterise behaviour change interventions associated with energy efficiency?*

To our knowledge, this is the first study to test the comprehensiveness of the BCW to characterise behaviour change interventions for energy efficiency. From our work on this, we feel that the BCW, as amended in Table 1, sufficiently characterises the current range of interventions focussed on energy behaviour to be a potentially useful tool to help devise future programmes in this sector. This is because all factors of the BCW mapped onto the energy behaviour change guidance documents (see Table 2) and the identified linkages between the layers of the BCW correspond with those found in the energy guidance documents (see Table 3).

The issues raised in the results point to a model applied largely to health behaviours, which needs small-scale adaptations in order that it is easy to interpret for energy behaviours. Further work is needed to the BCW to improve clarity for ease of use in this latter domain. For example, trust and values – important determinants of behaviour for energy conservation interventions – are not clearly defined in the BCW. Trust was not associated with any behavioural determinant in the BCW, whilst values were related to *reflective motivation* only when the determinants of the BCW were compared to another behaviour change framework [12].

Improving definitions of intervention functions in the BCW could also benefit its use in an energy efficiency context, as the lack of clarity in some intervention functions hinders the application and ease of use of the BCW to address energy efficient behaviour. The definitions for intervention functions *education*, *training* and *enablement* did not have clear boundaries to prevent overlap. Subsidies or funding to introduce energy efficiency measures into the home are recurrent energy behaviour interventions. However, these can be categorized as either *incentivisation* or *enablement*.



Similarly, making a voluntary commitment is identified as a factor associated with energy behaviour change. Within the BCW [12], commitment is a behaviour change technique associated with three different intervention functions: *incentivisation*; *coercion*; and *enablement*.

Further clarification of the policy categories is needed before the BCW can be considered a comprehensive model for energy conservation behaviour. The under-specification of energy price in the policy categories in the BCW is potentially the most problematic as it is a significant factor in energy consumption. The means to adjust the cost of energy can take many forms: regulation, subsidies, levies, taxes, interest free loans and other rewards and penalties [31]. However, the BCW *fiscal measures* policy category is limited to tax-related measures only. As such, all non-tax related financial instruments were coded to the policy category of *environmental/social planning*. Clarification is also needed in the BCW policy categories *guidelines* and *regulation* to reduce confusion.

Context is missing as a specified element of the BCW illustration in Figure 1. As set out in section 1.2, the architects of the BCW [8] claim its strength is that it incorporates context through the ‘*opportunity*’ behavioural determinant. However, we found that context variables – such as timing, existing systems and cultural preferences – do not map directly onto a single determinant. This finding is supported by Jackson et al. [26] who found contextual factors of medication adherence did not map onto a single behavioural determinant. The lack of explicit specification of contextual factors in the BCW may fail to prompt designers to fully interrogate or design for these features. In contrast to the BCW, the MECHANisms guidance does specify a more complete guide to context. This is illustrated by the number of times MECHANisms text is categorised as unclassified in the analysis (see Appendix D).

The architects of the BCW warn that a limitation of the framework is that it may prove difficult to use in practice. On certain occasions, we did find the BCW difficult to use (see 3.1.1). In our view, this was due to a lack of specification in the BCW. Resolving of these issues may follow from repeated use of the BCW in an energy behaviour setting and also from further monitoring of how behaviour change interventions using the framework in other sectors start to taxonomise behaviour change projects [44]. The examples highlighted in the current section identify issues for planners and policymakers to be aware of. We also acknowledge an alternative view, which is that the lack of specificity in the BCW presents an opportunity to interpret the guidance using different viewpoints of contextual issues, such as the kind of barrier presented.

A further question is whether the BCW is comprehensive enough to accommodate differing conceptualisations of the challenges involved in reducing energy use? Section 1.1 noted that the framework follows the dominant behavioural approach to resolving behaviour change challenges.

The Brohmann et al. [29] guidance drew from wider domains, including sociological and other interdisciplinary research, and it should be noted that its material was all fairly straightforward to code using the BCW. For instance, social practices are coded as being affected by *social opportunity*. Considerations of systems of provision are coded as *physical opportunity*, possibly requiring policies that operate above the level of the individual, such as *environmental restructuring* or *fiscal measures*. The MECHAnisms guidance also offered a more contextualised understanding of energy end-users. We were able to code relevant factors such as finance (*physical opportunity*), lack of integration between energy efficiency and other policies (*physical opportunity*), values of society (*social opportunity*), availability of supportive policy framework (*physical opportunity*), and social pressure (*social opportunity*). Thus our guidance documents reflect current dominant approaches but also incorporate alternative conceptualisations of the barriers to behaviour change around energy consumption.

#### **4.2      *Do the identified linkages between layers of the BCW correspond with those found in the energy behaviour domain?***

There was good agreement with the linkages between layers of the BCW identified by its architects and those found in the energy guidance documents. Moreover, an additional five determinant-intervention linkages and two intervention-policy linkages were also found in the energy guidance. As such, Table 3 is now a more useful aid for future energy efficiency intervention and policy planning.

Table 3 highlights that a single behavioural determinant can be addressed by multiple interventions, and an intervention can be addressed by multiple policy categories. The level of multiple-linkages would appear to identify where use of the BCW would be helpful to ensure energy efficiency programmes are sufficiently multi-faceted to have optimum chance of success. As the architects of the BCW point out, the framework reminds policy makers and programme planners of the full range of intervention and policy opinions available [8].

#### **4.3      *Can the framework be recommended for use to address energy behaviour? What is its value?***

In the conduct of this work we have identified aspects of the BCW which offer value to the domain of energy efficiency. The key value of the BCW is as a tool to encourage better specification of interventions and work towards a common lexicon for activities that can be vaguely described currently in energy behaviour guidance. The BCW appears to have useful value as a tool to help policymakers and practitioners identify the clear process of change that interventions will support. For example, the lack of detail in the energy guidance documents made *automatic motivation* and *reflective motivation* difficult to distinguish. This was resolved when the guidance made explicit which type of motivation was targeted ([29]:3). Similarly, policymakers and practitioners could

specify clearly what they mean by use of terms such as trust to ensure easier alignment with the determinants of the BCW. Trust in the source of messaging has been found to act as a cue to thoughtful reflection [45] pointing to the potential for trust to be categorised within the BCW as *reflective motivation* or *automatic motivation*, according to context. Policymakers and practitioners, when designing programmes, should identify this context to ensure the type of trust invoked is clarified and the kind of *motivation* specified.

This clarity offered by using the BCW is also useful for dissecting frequently used interventions in the energy efficiency domain. Feedback is an example of a tool which could gain increased clarity via analysing through the BCW framework. The BCW allows designers and policymakers to break down the features feedback will comprise, such as comparison of behaviour with others or one's own previous behaviour. A smart meter is a key feature of a feedback intervention, based on how frequently it was discussed in the guidance documents. As the MECHAnisms guidance points out, many different technical concepts for metering and feedback exist. Smart meters can have the following features: two-way communication with the supplier to enable dynamic pricing; and real-time display of data [31]. The exact function of a smart meter was coded in the BCW according to its accompanying description. Thus, the BCW can help designers and policymakers identify what components need to be provided alongside the meter itself for such an intervention to offer *physical capability*. Does a display alone provide the physical ability to do something not possible before? What further features would ensure enhanced *psychological capability* to reduce energy consumption? Smart meters with real time displays implicitly offer *education*, *persuasion* and *incentivisation* through expectation of rewards or reduced costs. BCW helps designers be explicit about what is needed.

We noted in the introduction that the application of the recently published BCW in the energy efficiency domain is limited<sup>1</sup>. To illustrate how the BCW *might* operate, we have drawn three examples of energy efficiency behaviour change interventions from the guidance documents. We have retrospectively coded these three interventions according to the BCW (see Tables 4-6). The examples are provided here purely as an illustration of how the framework might be used to identify the types of interventions and policies expected to change a given behaviour. The tables illustrate how key components from each layer of the BCW are all identifiable and are in congruence with identified linkages between each layer. Table 4 describes a Norwegian<sup>2</sup> intervention that led to an average

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<sup>1</sup> The architects of the BCW have produced a listing of peer-review publications and presentations referencing the BCW [12]. An up to date list can also be accessed by searching 'Behaviour Change Wheel' at [www.scholar.google.co.uk](http://www.scholar.google.co.uk)

<sup>2</sup> Although Norway is not a member of the European Union (EU), it is closely associated through its membership of the European Economic Area

company energy saving of 6% [31]. Table 5 describes an example from the Netherlands in which an intervention resulted in household savings of 7% of annual consumption [30]. The architects of the BCW might argue that this success is in congruence with these example interventions being characterised by a co-ordinated set of activities designed to tackle specific behavioural determinants relevant in each context. Table 6 is included as it illustrates how a community – rather than individual-focussed initiative – can also be coded under the BCW.

**<Add Tables 4, 5 and 6 approx here>**

## **5 Conclusions**

End-use energy efficiency has a crucial contribution to the reducing of CO<sub>2</sub> emissions, and is frequently dependent on adjusting consumption choices and practices. As interventions in this sphere to date have resulted in variable levels of success [46], new tools to improve the choice of effective methods have a clear value.

The value of this paper is that we have established that the Behaviour Change Wheel (BCW) does sufficiently define and characterise behaviour change interventions associated with energy efficiency to warrant further investigation in the domain of energy efficiency. Using guidance documents on the best practice for interventions in this domain, we have amended the definitions and examples of components of the BCW. The value of Table 1 is that it now makes application of the BCW easier for use in the context of energy efficiency behaviour.

This paper also found the linkages that its architects identified between the different layers of the BCW – such as which determinants most likely link to interventions and interventions to policies – also hold in the energy behaviour domain. We identified and added seven additional linkages to better reflect activity in the energy efficiency domain. In this way Table 3 becomes a useful tool to help select interventions and policies to tackle specific energy behaviours. We argue that this examination of the BCW's capacity to describe the full range of energy behaviour change activity is an essential precursor step in justifying use of the BCW in a live programme. In Tables 4 to 6, we further assist this process by illustrating (albeit in retrospect) the BCW in practice. We provide examples of successful energy reduction programmes which are examined using the BCW and found to be in congruence with its specifications.

Our work has also revealed further potential value of the use of the BCW:

- There is a lack of common terminology to enable functional descriptions of behaviour change programmes which would provide a shared understanding for all stakeholders. The BCW can encourage use of a common terminology for actions, so that engagement, empowerment and information provision, for instance, are fully developed and specified activities.

- Interventions can be broken down into constituent parts using the BCW, to assist in making explicit the path to change. Feedback is an example of an intervention type which benefits from being examined using the BCW. Specifying the features of a feedback package helps achieve clarity about the determinant targeted: a real time display is just a screen on a phone, PC or wall without the additional motivational triggers of relevant information, guidance and clarity about how to use it. The BCW can help make this explicit.
- Education was the most frequently coded intervention function in the energy guidance reviewed. However, this intervention is notoriously weak at instigating behaviour change used in isolation. As such, use of the BCW can remind policy makers and programme planners of the full range of intervention opinions available beyond, and in addition to, education.
- Use of the BCW framework has potential to steer programmes away from an acknowledged weakness of energy programmes, which is that they currently focus too much on the individual. Energy needs are not constructed only by energy users, but also by producers of energy-using equipment and energy providers, indeed the whole supply chain [15,34,47]. Despite being forged from existing behaviour change frameworks, dominated by a focus on the individual, the BCW calls attention to interventions and policies which can direct planners towards systems operating above the level of the individual. An example was offered in section 1.3, with the BCW used to evaluate the comprehensiveness of a range of CO<sub>2</sub> reduction initiatives and found that these ignored intervention and policy options above the level of the individual [12]. However this open-ended capacity to incorporate a wide range of factors is also problematic, as discussed below.

We also find that there are outstanding problems attached to use of the BCW:

- Contextual factors are less explicitly referenced in the BCW than in energy efficiency guidance. This is a potential limitation or opportunity. Its opportunity might be to create an entry point to the BCW being universally applicable. We endorse the advocacy by the architects of the BCW that the framework be used alongside formative research to explore the impact of contextual variables such as existing systems, timing and cultural preferences [12]. However, for a more comprehensive guide to the contextual variables to interrogate in such formative research, policymakers and designers of energy behaviour interventions may also need to cross-refer to other energy-focussed literature and guidance [e.g. 28].
- Policy makers and practitioners who decide to trial the BCW should also be aware, when reviewing existing policy and developing new policies and interventions, that *physical opportunity* can be enabling or restrictive. Being locked-in to an existing system of provision is, for instance, a restriction to opportunity. This restrictive aspect of the component is not made clear in the original BCW.
- The role of price at the policy level is not clearly located. This may be because price is a bigger factor in changing energy behaviour than in health behaviour. At this stage, the BCW is not ideally suited as a framework for a programme in which measures such as tariffs, subsidies, bonuses, loans, fees and surcharges are likely to play a central role.

A limitation of this paper is that, although using an established methodology to make an initial assessment of the suitability of the BCW to be used in energy efficiency, it relies on its selected guidance documents to themselves be comprehensive. No mention is made, for instance, of split incentives around energy efficiency [48], which would have presented the opportunity to discuss this

as an important contextual issue. We also detected, despite arguments discussed in section 2.2 about issues above the level of the individual being addressed in the reviewed guidance, the consumer was referenced far more frequently than other actors in the supply chain such as manufacturers or retailers of electrical goods. The work is also limited to a focus on the EU. By limiting scope to work within Europe, we were able to address the applicability of the BCW to consumption reduction guidance from multi-country experiences. However, further work is needed in other continents, political groupings of countries or at country level. Researchers in those countries may also be able to identify literature in other languages as part of the development of a truly comprehensive guide to the existent literature available. This would help bring together guidance for the sector which appeared to us to be much more fragmented and less clearly indexed compared to the health sector.

This paper opens up four clear avenues for further work. First, practitioners should trial the use of the BCW in the planning, monitoring and evaluation of an energy behaviour change intervention programme, using insights about its strengths and limitations highlighted in this paper. Second, future studies could extend the work into other behaviours relevant to cutting carbon emissions, including transport and food use. Third, further work could assess the usefulness of the BCW over and above the wealth of other conceptual models suggested for the energy efficiency domain. While the wealth of literature informing the energy behaviour domain is represented in two ways already in this paper (it underpins at least two of the frameworks used to create the BCW, and it underpins the four guidance documents used for the secondary analysis in this paper) further work might review the BCW's benefits against further alternative conceptual models devised to specifically address energy savings (e.g. [49]). This further work might resolve whether the BCW's lack of specification makes it flexible enough to accommodate a comprehensive range of approaches to solving the problem of energy over-consumption, beyond those focussing on the attitudes and choices of individuals. Or, it may be found that, it has the opposite effect of locking in options around the existing policy landscape. Finally, future work could explore the main policy feature which the authors felt was under-represented both at the intervention level and policy levels: energy price. Analysis of specialist economic guidance on limiting energy consumption is recommended to help further clarify the BCW framework for optimum use to address energy consumption. In this way practice and research can work together to confirm whether the BCW is a framework to help those in the domain of energy efficiency to drive down carbon emissions associated with end-use energy consumption.

## **Acknowledgements**

The authors would like to thank Dr Christine Broughan (Coventry University) and Dr Caroline Davey (University of Salford) for comments which led to improvement of this paper.

The authors intend no criticism of any of the guidance documents. They were used in this manuscript for the purpose of assessing whether the BCW can be applied to the energy sector. Investigation of their alignment to the BCW does not reflect on the extent to which they fulfilled their original intended purpose.

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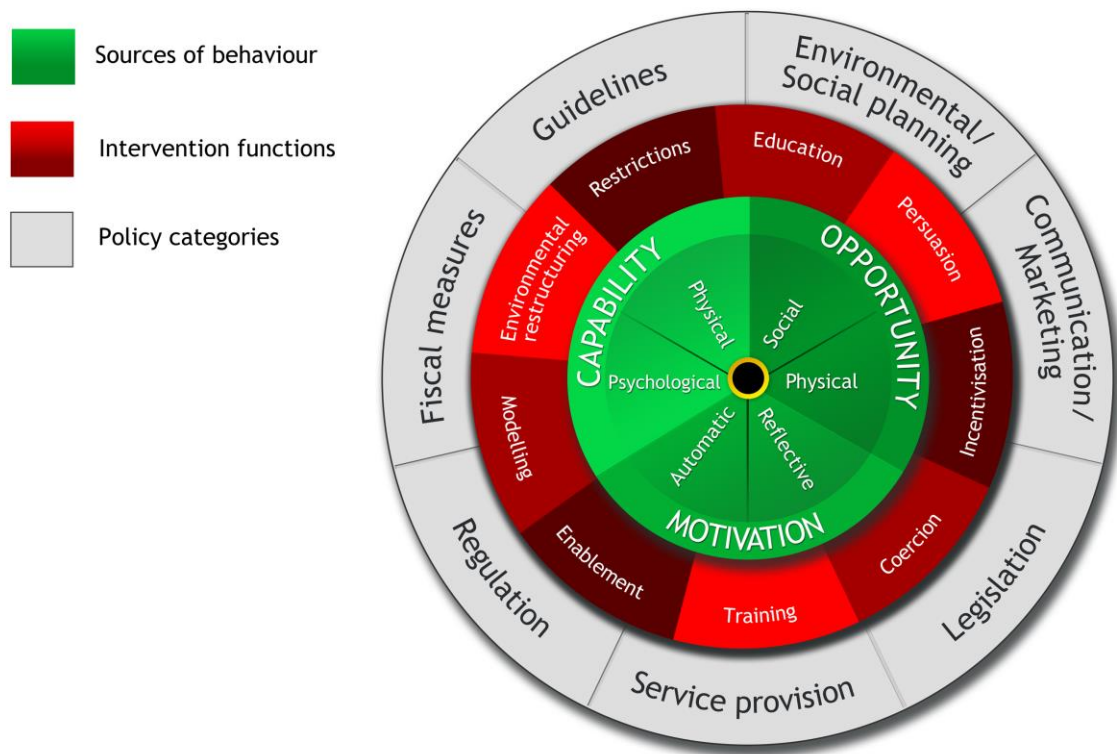
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**Figure 1.** The Behaviour Change Wheel by [Michie, van Stralen & West \(2011\)](#) is licensed under the [Creative Commons Attribution License 2.0](#).

**Table 1. Original definitions and examples of BCW determinants, intervention functions and policy categories, with additional examples from other behaviour change frameworks and energy efficiency documents.**

Determinants	Original BCW Definition	Original BCW Examples	Examples linking BCW to other behaviour change frameworks or techniques	Energy efficiency examples
Capability	The individual's physical and psychological capacity to engage in the activity concerned. It includes having the necessary knowledge and skills <sup>1</sup>			
Physical capability	Physical skill, strength or stamina	Having the skill to take a blood sample		<i>Perceived behavioural control – the individual's perception of their ability to perform the behaviour</i>
Psychological capability	<ul style="list-style-type: none"> <li>• Knowledge or psychological skills, strength or stamina to engage in the necessary mental processes</li> <li>• Capacity to engage in the necessary thought processes—comprehension, reasoning <i>et al.</i><sup>1</sup></li> </ul>	Understand the impact of CO <sup>2</sup> on the environment	Knowledge; memory, attention, decision processes; behavioural regulation <sup>2</sup>	
Opportunity	All factors that lie outside the individual that make the behaviour possible or prompt it <sup>1</sup>			
Physical opportunity	<ul style="list-style-type: none"> <li>• Opportunity afforded by the environment involving time, resources, locations, cues, physical 'affordance'.</li> <li>• <i>Enabling physical opportunity – existence of physical opportunity afforded by the environment</i></li> <li>• <i>Restrictive physical opportunity – lack of physical opportunity afforded by the environment</i></li> </ul>	Being able to go running because one owns appropriate shoes	<ul style="list-style-type: none"> <li>• Environmental context &amp; resources<sup>2</sup></li> <li>• Infrastructure; objects; time &amp; schedules<sup>4</sup></li> </ul>	<ul style="list-style-type: none"> <li>• <i>Convenience of behaviour</i></li> <li>• <i>Enabling opportunity</i></li> <li>• <i>Access to subsidies, grants</i></li> <li>• <i>Availability of products in shops</i></li> <li>• <i>Access to feedback</i></li> <li>• <i>Restrictive opportunity</i></li> <li>• <i>Taxes, levies, surcharges</i></li> <li>• <i>Inadequate provision of appliances or infrastructure</i></li> <li>• <i>Lock-in to existing systems of provision leaving little or no choice on vendor or way of doing things</i></li> </ul>
Social	Opportunity afforded by interpersonal	Being able to smoke in the house of	Social influence <sup>2</sup>	<ul style="list-style-type: none"> <li>• <i>Social practices, social</i></li> </ul>

opportunity	influences, social cues and cultural norms that influence the way that we think about things (e.g. words and concepts that make up our language)	a Smoker, but not in the middle of a boardroom meeting		<i>norms, or social capital</i> <ul style="list-style-type: none"> <li>• <i>Social pressure on family members or co-workers to recycle, turn off computers, etc.</i></li> </ul>
Motivation	All those brain processes that energize and direct behaviour, not just goals and conscious decision-making. It includes habitual processes, emotional responding, as well as analytical decision-making <sup>1</sup>			
Automatic motivation	<ul style="list-style-type: none"> <li>• Automatic processes involving emotional reactions, desires (wants and needs), impulses, inhibitions, drive states and reflex responses.</li> <li>• Emotions and impulses that arise from associative learning and/or innate dispositions<sup>1</sup></li> </ul>	Feeling anticipated pleasure at the prospect of eating a piece of chocolate cake.	<ul style="list-style-type: none"> <li>• Reinforcement; emotion<sup>2</sup></li> <li>• Habit<sup>4</sup></li> </ul>	<ul style="list-style-type: none"> <li>• <i>Routine</i></li> <li>• <i>Trust</i></li> </ul>
Reflective motivation	<ul style="list-style-type: none"> <li>• Reflective processes involving plans (self-conscious intentions) and evaluations (beliefs about what is good and bad)</li> <li>• <i>Commitments</i></li> <li>• <i>Engagement (defined as a state of mental willingness)</i></li> </ul>	Intention to stop smoking	<ul style="list-style-type: none"> <li>• Goals; intentions; professional/social role &amp; identity; optimism; beliefs about consequences or capabilities<sup>2</sup></li> <li>• Values; Attitudes; cost/benefits<sup>4</sup></li> </ul>	<ul style="list-style-type: none"> <li>• <i>Payback time for investment into energy efficient improvements in the home</i></li> <li>• <i>Responsibility and ownership</i></li> </ul>
<b>Interventions</b>	<b>Original BCW Definition</b>	<b>Original BCW Examples</b>	<b>Examples linking BCW to other behaviour change frameworks or techniques</b>	<b>Energy efficiency examples</b>
Education	Increasing knowledge or understanding	Providing information to promote healthy eating		<ul style="list-style-type: none"> <li>• <i>Feedback on own consumption and/or norms</i></li> <li>• <i>Labelling schemes (e.g. Energy Performance Certificate)</i></li> </ul>
Persuasion	Using communication to induce positive or negative feelings or stimulate action	Using imagery to motivate increases in physical activity		<ul style="list-style-type: none"> <li>• <i>One-to-one engagement</i></li> <li>• <i>Tailored information or advice about energy use</i></li> <li>• <i>Feedback visualisation</i></li> <li>• <i>Information/media</i></li> </ul>

<i>campaigns</i>				
Incentivisation	<ul style="list-style-type: none"> <li>• Creating an expectation of reward</li> <li>• <i>Creating an expectation of reduced cost</i></li> </ul>	Using prize draws to induce attempts to stop smoking	<ul style="list-style-type: none"> <li>• Feedback on behaviour<sup>3</sup></li> <li>• Commitment<sup>3</sup></li> <li>• Discrepancy between current behaviour &amp; goal<sup>3</sup></li> </ul>	<ul style="list-style-type: none"> <li>• <i>Energy audit</i></li> <li>• <i>Reduced tax on energy efficient products</i></li> <li>• <i>Incentives, subsidies, loans, grants</i></li> </ul>
Coercion	Creating expectation of punishment or cost	Raising the financial cost to reduce excessive alcohol consumption	<ul style="list-style-type: none"> <li>• Feedback on behaviour<sup>3</sup></li> <li>• Commitment<sup>3</sup></li> <li>• Discrepancy between current behaviour &amp; goal<sup>3</sup></li> </ul>	<i>Market instruments (e.g. UK WEEE Regulations place take-back obligations on retailers &amp; other distributors who sell electrical &amp; electronic equipment)</i>
Training	Imparting skills	Advanced driver training to increase safe driving	<ul style="list-style-type: none"> <li>• Demonstration and instruction on how to perform a behaviour<sup>3</sup></li> <li>• Feedback on behaviour<sup>3</sup></li> </ul>	<i>Community schemes</i>
Restriction	Using rules to reduce the opportunity to engage in the target behaviour (or to increase the target behaviour by reducing the opportunity to engage in competing behaviours)	Prohibiting sales of solvents to people under 18 to reduce use for intoxication		<i>Limit power of vacuum cleaners/hairdryers</i>
Environmental restructuring	Changing the physical or social context	Providing on-screen prompts for GPs to ask about smoking behaviour	Adding objects to the environment <sup>3</sup>	<ul style="list-style-type: none"> <li>• <i>Infrastructure</i></li> <li>• <i>Availability of technology, e.g. real time displays</i></li> <li>• <i>Subsidies, loans, grants</i></li> <li>• <i>Community schemes: small groups of individuals gather to reduce carbon footprint.</i></li> </ul>
Modelling	<ul style="list-style-type: none"> <li>• Providing an example for people to aspire to or imitate</li> </ul>	Using TV drama scenes involving safe-sex practices to increase condom use	Demonstration of behaviour <sup>3</sup>	<ul style="list-style-type: none"> <li>• <i>Comparative Feedback – own energy consumption is compared with an alternative consumption pattern (e.g. to the</i></li> </ul>

				<p><i>previous month/year; to others). This may also be known as enhanced billing.</i></p> <ul style="list-style-type: none"> <li>• <i>Goal-setting or energy audit where one's past/current energy use is used as a source of comparison as movement toward goal, or comparison for the amount of energy that could be saved.</i></li> <li>• <i>Role models</i></li> </ul>
Enablement	Increasing means/reducing barriers to increase capability (beyond education and training) or opportunity (beyond environmental restructuring)	Behavioural support for smoking cessation, medication for cognitive deficits, surgery to reduce obesity, prostheses to promote physical activity	<ul style="list-style-type: none"> <li>• Goal setting<sup>3</sup></li> <li>• Problem solving<sup>3</sup></li> <li>• Action planning<sup>3</sup></li> <li>• Commitment<sup>3</sup></li> <li>• Discrepancy between current behaviour &amp; goal<sup>3</sup></li> </ul>	<ul style="list-style-type: none"> <li>• <i>Subsidies, loans, grants</i></li> <li>• <i>Simple and easy application, programme administration</i></li> <li>• <i>Market transformation</i></li> </ul>
<b>Policies</b>	<b>Original BCW Definition</b>	<b>Original BCW Examples</b>	<b>Examples linking BCW to other behaviour change frameworks or techniques</b>	<b>Energy efficiency examples</b>
Communication/ marketing	Using print, electronic, telephonic or broadcast media	Conducting mass media campaigns		
Guidelines	Creating documents that recommend or mandate practice. This includes all changes to service provision	Producing and disseminating treatment protocols		<ul style="list-style-type: none"> <li>• <i>Governance; policies</i></li> <li>• <i>Standards and voluntary agreements</i></li> </ul>
Fiscal Measures	Using the tax system to reduce or increase the financial cost	Increasing duty or increasing anti-smuggling activities		
Regulation	Establishing rules or principles of behaviour or practice .	Establishing voluntary agreements on advertising		
Legislation	Making or changing laws	Prohibiting sale or use		<ul style="list-style-type: none"> <li>• <i>EU legislation on the</i></li> </ul>

			<i>power of hairdryers</i> • <i>EU Directives</i> • <i>Permits</i>
Environmental/ social planning	Designing and/or controlling the physical or social environment	Using town planning	• <i>Subsidies, grants, loans</i> • <i>Economic incentive</i> • <i>Creation of group-based community schemes to reduce carbon footprint</i> • <i>Supply side measures (e.g. Economy 7 heating; energy ratings)</i>
Service provision	Delivering a service	Establishing support services in workplaces, communities etc.	• <i>Support for community schemes</i> • <i>Electronic metering</i> • <i>Enhanced billing</i>

*Note.* All statements, except where otherwise stated, from Michie, Atkins & West (2014), Table 1.3 (p. 63), Table 2.1 (p. 111) and Table 2.7 (p.135)

<sup>1</sup> Michie, van Stralen & West (2011), p. 4 & Table 1

<sup>2</sup> Michie Atkins & West (2014) Box 1.15, p. 94

<sup>3</sup> Michie, Atkins & West (2014) Table 3.3, p. 151-155

<sup>4</sup> Michie, Atkins & West (2014) Table 5.5, p. 226-231

Text in italics is added by current authors.



**Table 2. Number of times BCW factors were coded in each of the four guidance documents, and total number of occurrences across all documents.**

	Guidance documents				TOTAL
	Brohmann et al.	Dahlbom et al.	EEA (2013)	MECHAnisms	
<b>COM-B Determinants</b>					
Psychological capability	24	12	16	10	62
Physical capability	1	6	2	3	12
Reflective motivation	32	4	24	13	73
Automatic motivation	21	2	4	2	29
Physical opportunity	21	8	10	15	54
Social opportunity	29	8	7	5	49
<b>Intervention Functions</b>					
Education	21	7	17	12	57
Persuasion	11	3	8	7	29
Incentivisation	7	3	11	9	30
Coercion	2	2	4	0	8
Training	2	6	5	6	19
Restriction	1	2	1	0	4
Environmental restructuring	11	4	8	5	28
Modelling	4	6	11	3	24
Enablement	1	1	3	5	10
<b>Policy categories</b>					
Communication/marketing	5	2	6	9	22
Guidelines	4	3	2	2	11
Fiscal	4	3	1	1	9
Regulation	8	5	1	1	15
Legislation	3	3	3	3	12
Service provision	1	0	10	9	20
Environmental /social planning	5	2	7	2	16

**Table 3. Links between layers of the BCW: links between COM-B determinants and Interventions, and links between Intervention Functions and Policy Categories.**

COM-B Determinants						Intervention Functions	Policy Categories						
Physical capability	Psychological capability	Physical Opportunity	Social Opportunity	Automatic Motivation	Reflective Motivation		Communication/Marketing	Guidelines	Fiscal Measures	Regulation	Legislation	Environ./Social planning	Service Provision
	✓		✓ <sup>1</sup>		✓	Education	✓	✓		✓	✓		✓
	✓ <sup>1</sup>			✓	✓	Persuasion	✓	✓		✓	✓		✓
		✓ <sup>1</sup>		✓	✓	Incentivisation	✓	✓	✓	✓	✓	✓ <sup>1</sup>	✓
				✓	✓	Coercion	✓	✓	✓	✓	✓		✓
✓	✓	✓		✓		Training		✓	✓	✓	✓		
		✓	✓			Restriction		✓		✓	✓		
		✓	✓	✓		Environmental Restructuring		✓	✓	✓	✓	✓	✓ <sup>1</sup>
	✓ <sup>1</sup>		✓	✓	✓ <sup>1</sup>	Modelling	✓						✓
✓	✓	✓	✓	✓		Enablement		✓	✓	✓	✓	✓	✓

*Note.* Table modified from *The Behaviour Change Wheel: A guide to designing interventions* by S. Michie, L. Atkins and R. West, 2014, Great Britain: Silverback Publishing. Copyright 2014 by Susan Michie, Lou Atkins and Robert West. Reprinted with permission. ✓<sup>1</sup> = New links added by current authors.

**Table 4. Example from EEA (2013) coded retrospectively according to the BCW**

	<b>Determinants</b>	<b>Interventions</b>	<b>Policy</b>
<p><i>Example: The Norwegian Industrial Energy Efficacy Network (IEEN)</i></p> <p>The IEEN was established in 1989 by the Ministry of Petroleum and Energy in Norway to stimulate energy efficiency measures:</p>			
<ul style="list-style-type: none"> <li>The network members could obtain governmental grants covering a significant part of the costs associated with the energy auditing and energy efficiency measures implemented.</li> </ul>	<p>A grant opportunity presents an opportunity for <b>reflective motivation</b> as it allows re-evaluation of the worth of an action. An energy audit is a <b>physical opportunity</b> in that it offers a new resource guiding effective action</p>	<p>A grant is a <b>financial incentive</b> offers the prospect of a reward. The energy audit presents <b>enablement</b> as its findings offer the support to realise new efficiency opportunities.</p>	<p>This is an example of <b>Environment/social planning</b>, in that the provision of a grant provides the economic incentive to take energy efficiency measures.</p>
<ul style="list-style-type: none"> <li>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.</li> </ul>	<p>The web-based tool presents a further <b>physical opportunity</b> in that it provides a new tool to use to assess energy performance. The participation of other companies is a <b>social opportunity</b> in that it provides cues to the norms that operate in other companies operating in the same sector</p>	<p>Increasing knowledge is an example of <b>education</b>, and an opportunity for participants to revise their social context, which is an example of <b>environmental restructuring</b>. Providing examples of what other companies provides alternative <b>models</b> of behaviour to aspire to.</p>	<p>Establishing a new means of supporting altered behaviour is an example of <b>service provision</b>.</p>
<ul style="list-style-type: none"> <li>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.</li> </ul>	<p>Both grant stages provide two separate opportunities for <b>reflective motivation</b> in that they engage companies in greater consciousness of their energy consumption and promote the evaluation of alternatives.</p>	<p>Cost-effective investments represent <b>incentivisation</b>, with the creation of expectation of reduced long-term cost.</p>	

**Table 5. Example from Dahlbom et al (2009) coded retrospectively according to the BCW**

	<b>Determinants</b>	<b>Interventions</b>	<b>Policy</b>
Measuring Is Knowing, Milieu Centraal, Netherlands. The campaign was introduced in part of the Netherlands in the period 2005-2007			
<p>The core of the campaign was a digital plug-in energy metering device with which the consumer can monitor the energy use of his household appliances. The campaign was based on studies that indicated that feedback, combined with goal setting, is very effective. Energy use for heating is the largest part.</p> <p>Households kept the metering device for three weeks and then gave it to another household. The people were reached by the website of Milieu Centraal and their helpdesk, by articles in news media and by advertising material. The website contains also all kinds of information on how to save energy in homes.</p>	<p>The provision of a device offers a <b>physical opportunity</b> – a new tool to guide action. Handing the meter on to other householders presents a social opportunity for interpersonal influence, with householders likely to discuss energy consumption as they pass on the meter.</p>	<p>The provision of feedback is an example of <b>incentivisation</b> and also of <b>training</b>. By the provision of goal setting it is also an example of <b>enablement</b> in that it has the potential to increase householder capability around energy efficiency. The website, news media and advertising are examples of <b>education</b> and <b>persuasion</b> to support use of the meters.</p>	<p>This campaign is an example of the combined use of <b>service provision</b> and <b>communication and marketing</b>.</p>

**Table 6. Example from EEA (2013) coded retrospectively according to the BCW**

	<b>Determinants</b>	<b>Interventions</b>	<b>Policy</b>
<i>Example: Community based initiatives</i>			
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... The group meets regularly and is given access to reliable information through written material and/or access to a trained expert	A small group forming a community provides a facility for improved <b>psychological capability</b> via the opportunity to gain new knowledge via information and training. It also provides an opportunity to trigger <b>reflective motivation</b> , such as formulating new plans and intentions. The physical meetings of the community group provide a <b>physical opportunity</b> in that meetings create a time to engage with the issue of energy, as well as the opportunity for training. <b>Social opportunity</b> comes from the group format, which used interpersonal influences to change attitudes and behaviour.	This type of activity can be typified as providing several intervention functions. Its outputs are <b>education</b> , through written material and in that knowledge and understanding are increased due to the expertise shared. It is also <b>training</b> from an expert facilitates new skills (such as how to install loft insulation or measure a carbon footprint) being learnt. It is <b>environmental restructuring</b> , in that the group format changes the social context through social norms, social support, social influence etc.	Via a re-design of the social environment, this is an example of <b>environmental/ social planning</b> .  It is also categorized as <b>service provision</b> in that the initiative establishes a support service in the community.
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	Interacting with others presents a <b>social opportunity</b> to share and to question existing social practices and become aware of alternatives. This creates new social norms that change the way	As well as further indicators of <b>environmental restructuring</b> around the use of pre-established networks to tackle introduction of supportive sharing of good practice, there is evidence of <b>modelling</b> in	The community initiatives, such as small groups, is an example of <b>environmental/ social planning</b> .  It is also categorized as <b>service provision</b> in that the initiative establishes a support service in the

establishing these social norms.	the individual thinks about things.	that participants have an opportunity to review social norms around their own energy use compared with others'.	community.
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	<p><b>Reflective motivation</b> is evidenced in participants evaluating the value of their efforts and by the establishment of ownership and responsibility for actions.</p> <p><b>Psychological capability</b> are implied here in that the individuals have the knowledge to understand ones' environmental footprint and its environmental impact</p>	The community initiative, which changes the social context, is an example of <b>environmental restructuring</b> .	<p><b>Environmental/ social planning</b> is evidenced through the community initiative.</p> <p><b>Service provision</b> in that the initiative establishes a support service in the community.</p>
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 award.	<p><b>Reflective motivation</b> is triggered by the tangible reward of the incentive, and consequences of behaviour.</p> <p>The financial incentive to invest in energy efficiency is a <b>physical opportunity</b>. Aiming at the community level cements this initiative's <b>social opportunity</b>.</p>	An initiative such as this is <b>incentivisation</b> when the expectation of a financial reward is a feature.	

## Appendix A. The 19 Frameworks which informed the BCW

Framework	Author	Description
<b>1. Epicure taxonomy</b>	West (2006)	Taxonomy of approaches designed to influence behaviour patterns
<b>2. Culture capital framework</b>	Knott <i>et al.</i> (2008)	Framework of knowledge about culture change, offering practical tools for policymaking
<b>3. EPOC taxonomy of interventions</b>	Cochrane Effective Practice and Organisation of Care Review Group (EPOC) (2010)	Checklist to guide systematic literature reviewers about the types of information to extract from primary studies
<b>4. RURU: Intervention implementation taxonomy</b>	Walter <i>et al.</i> (2003)	Taxonomy covering a wide range of policy, practice and organisational targets aimed at increasing impact of research
<b>5. MINDSPACE</b>	Institute for Government and Cabinet Office (2010)	Checklist for policy-makers aimed at changing or shaping behaviour
<b>6. Taxonomy of behaviour change techniques</b>	Abraham <i>et al.</i> (2010)	Taxonomy of behaviour change techniques grouped by change targets
<b>7. Intervention mapping</b>	Bartholomew <i>et al.</i> (2011)	Protocol for a systematic development of theory- and evidence-based interventions
<b>8. People and places framework</b>	Maibach <i>et al.</i> (2007)	Framework that explains how communication and marketing can be used to advance public health
<b>9. Public health: ethical issues</b>	Nuffield Council on Bioethics (2007)	Ladder of interventions by government, industry, organisations and individuals to promote public health.
<b>10. Injury control framework</b>	Geller <i>et al.</i> (1990)	Heuristic framework for categorising and evaluating behaviour change strategies aimed at controlling injuries
<b>11. Implementation taxonomy</b>	Leeman <i>et al.</i> (2007)	Theory-based taxonomy of methods for implementing change in practice
<b>12. Legal framework</b>	Perdue <i>et al.</i> (2005)	Conceptual framework for identifying possible legal strategies used for preventing cardiovascular diseases
<b>13. PETeR</b>	White (in prep.)	Comprehensive and universally applicable model or taxonomy of health interventions.
<b>14. DEFRA's 4E model</b>	DEFRA (2008)	Process model for policy makers aimed at promoting pro-environmental behaviours in accordance with social marketing principles
<b>15. STD/ HIV framework</b>	Cohen and Scribner (2000)	Taxonomy to expand the scope of interventions that can be used to prevent STD and HIV transmission
<b>16. Framework on public policy in physical activity</b>	Dunton <i>et al.</i> (2010)	Taxonomy aimed at understanding how and why policies successfully impact on behaviour change
<b>17. Intervention framework for retail pharmacies</b>	Goel <i>et al.</i> (1996)	Framework that presents factors that may affect retail pharmacy prescribing and strategies for behaviour change to improve appropriateness of prescribing
<b>18. Environmental policy framework</b>	Vlek (2000)	A taxonomy of major environmental problems, their different levels and global spheres of impact, and conceptual modelling of environmental problem- solving
<b>19. Population Services International (PSI) framework</b>	PSI (2004)	A conceptual framework to guide and help conduct research on social marketing interventions

*Note:* Text modified from Michie, Atkins & West (2014). Appendix 1: Behaviour change frameworks contributing to the Behaviour Change Wheel. Found in: The Behaviour Change Wheel: A guide to designing interventions. Silverback Publishing.

## **Appendix B - Inclusion criteria used to select literature and literature selected.**

### **Search terms:**

‘multiples of ‘guide’+ ‘communication’ +‘energy’ intervention’

‘demand side’+ ‘energy reduction’ +‘intervention’

‘demand side’+ ‘efficiency techniques’

‘communication’ + ‘intervention’ + ‘strategies’ + ‘energy sector’

**Databases** (i.e. Google, google Scholar, Science Direct), plus in-text citations of literature already known to the search team and of literature found in above search.

### **Inclusion Criteria**

An initial inclusion criterion was drawn up to discover literature that responded to the brief outline in the manuscript. The initial inclusion criteria were that the candidate guidance must:

- Published after 2005;
- Written in English; and
- Emanating from the EU.

Additional inclusion criteria required guidance documents to be comprehensive, specifically:

- Acknowledge and cover all three levels of the BCW (i.e. determinants, intervention functions and policies);
- Contain specific advocacy for several situations and contexts and not be confined to a very limited range of energy behaviours (e.g. recycling); and
- Avoid general exhortation.

### **Guidance chosen:**

#### **The Make Energy Change Happen Toolkit (MECHAnisms<sup>3</sup>)**

(<http://mechanisms.energychange.info/>) was produced by the CHANGING BEHAVIOUR project, funded by the 7th Framework Programme of the European Commission. It was created as guidance for practitioners following an analysis of the literature, a database of 100 projects, a detailed meta-analysis of 27 case studies, interviews with 24 intermediary organisations, feedback from 170 energy practitioners, and six pilot projects. The CHANGING BEHAVIOUR project involved numerous

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<sup>3</sup> In the cases of MECHAnisms, INESPO, IDEAL IPBD and BEHAVE, more than one candidate document was reviewed. The same criteria were applied to documents, which were part of a series as to all other literature, resulting in the choices listed above.



countries and was coordinated by National Consumer Research Centre (NCRC), Finland, reporting in 2010.

1. The following two documents on the MECHAnims Toolkit website were selected for analysis:  
Forcefield analysis tool (<http://mechanisms.energychange.info/templates-checklists/17>)
2. Instruments to Promote Energy Savings  
<http://mechanisms.energychange.info/backgrounds/11>

**Achieving energy efficiency through behaviour change – what does it take?** (EEA, 2013) provides a review of available literature on measures targeting consumer behaviour in order to achieve energy savings. It was published by the European Environment Agency (EEA).

**Conceptual Framework on Consumer Behaviour - With a focus on energy savings in buildings** (Brohmann et al, 2009) was produced as part of the IDEAL EPBD project to analyze the effects of consumer barriers on improving energy efficiency in buildings. It reviewed results from programmes in several EU countries to identify the most effective ways to overcome consumer barriers and to change consumer behaviour.

**Changing Energy Behaviour: Guidelines for Behavioural Change Programmes** (Dahlbom et al, 2009) is a product of the BEHAVE project co-funded by the European Commission as part of the Intelligent Energy for Europe programme. The project drew on lessons from an evaluation of 41 energy behaviour change programmes from all over Europe, combined them with insights from theory, and created guidelines to develop and implement successful policy interventions aimed at consumers.

## **Appendix C - Applying the Behaviour Change Wheel to characterise intervention strategies: Coding Materials**

1. Familiarise yourself with the definitions of the Determinant, Intervention and Policy categories. See Table 1 below.
2. Establish the target of the intervention strategy (whose behaviour is being changed).
3. For each intervention and policy, establish the agent of change (who is enacting it).
4. Statements of general exhortation that do not specify an Determinant, Intervention or Policy should be coded as U.
5. Code the Determinant first, followed by the Intervention, and then the Policy. Identify which Policies are (a) specified and (b) would be needed in order to enact the Interventions.
  - a. Example: the strategy 'Remove tobacco products from display in shops' could only be enacted by the Policy of Legislation (even though this is not stated)
  - b. If it is unclear what policy is being proposed or if many could be used, code U.
6. Do not infer beyond what is directly implied.
  - a. Example: a strategy which involves 'Encourage' would definitely involve 'Persuasion', but may not involve 'Education'.
7. Where a change or improvement is proposed to an existing Intervention or Policy, code for the original Intervention or Policy.
  - a. Example: If an intervention strategy involves putting more resources into a given service provision to enable a behaviour, code as 'Enablement' and 'Service Provision'

*Note:* Text modified from Michie, van Stralen & West (2011). Additional File 1: Applying the Behaviour Change Wheel to characterise intervention strategies: Coding materials. Found in: The Behaviour Change Wheel: A new method for characterising and designing behaviour change interventions. *Implement. Sci.* 6, 42

## Appendix D: BCW classification of four Energy Conservation Guidance Documents

### Coding sheet for: Brohmann et al 2009, Conceptual Framework on Consumer Behaviour

(Based on Additional file 8 of Michie et al, 2011)

#### Coding Key:

**Determinants:** Psychological capability (C-Ps), Physical capability (C-Ph), Reflective motivation (M-Re), Automatic motivation (M-Au), Physical opportunity (O-Ph), Social opportunity (O-So)

#### Interventions

Education E, Persuasion P, Incentivisation I, Coercion C, Training T, Restriction R, Environmental restructuring V, Modelling M, Enablement/resources N, Unclassifiable U

#### Policies

Fiscal F, Communication/marketing C, Service provision S, Legislation L, Regulation R, Guidelines G,

Environmental/social planning E, Unclassifiable U

**Agreement:** The table shows the number of agreed determinants, intervention function(s) and policy category(ies), along with the number for which there was agreement and disagreement.

page	Activity description	Determinants	Intervention function	Policy category	Agreement (n)	Disagree (n)
4	<i>3. Conceptualising consumer behaviour: research approaches</i>					
4	...consumer behavior is based on individual decisions, but it largely depends on external factors such as economic incentives, supply-side measures and an appropriate infrastructure	O-Ph	I, V	E	4	0
4	Furthermore, the socio-political framing has to be considered, e.g. if systems of emissions trading or eco-labels exist.	O-So	E	E, R	4	1 <sup>4</sup>
4	... the context of beliefs, norms and values that have to	C-Ps M-Re			2	0

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<sup>4</sup> We couldn't agree whether systems of emissions trading was Guidelines.

	be taken into account to understand energy consumption.					
4	...in the energy sector, the view has to be broadened to the physical context (e.g. systems of provision, buildings, or infrastructure), social practices (e.g. everyday routines) and to the political and economic framework (e.g. subsidies, tax reduction)...	M-Au O-Ph O-So	V, I	E,F	7	0
	...between the perspectives of individual rationality, habit or routines and culturally or socially determined practices	M-Re M-Au O-So			3	0
	... consumer ... behavior results from “a diverse and interdependent mix of roles as citizen, market participant, employee and as member of a household or family...”	M-Re O-So			2	0
6	3.2 Psychology					
6	Information is a key variable in the explanation of energy efficiency behaviours. Although many other variables are influential as well, if individuals have no knowledge of energy efficiency whatsoever they are unlikely to have any attitudes or motivation that can be converted to behavior. ...interest and orientation as well as social capital and a higher financial satisfaction have a strong impact on individual preferences.	C-Ps M-Re O-So	E		4	0
6	Specifically applied to residential energy efficiency, factors such as knowledge about choices and costs, comparative feedback, tailored advice .... trust ... Attitude-behavior models ... knowledge in combination with social pressure such as norms and behavioral intentions.	C-Ps M-Re M-Au O-So	E, M, T, P		8	1 <sup>5</sup>

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<sup>5</sup> Disagree on Enablement; does giving people information, knowledge about choices, helping me with energy use enabling people to change their behavior; goal setting; problem solving [talking point boundaries are not defined well]

	...attitudes ... individual's beliefs about a behavior as well as an evaluation of its outcomes...					
	How incentives affect behavior is often hypothesized as being influenced by peoples' motivation or value preference ... People who value maximizing joint outcome seem to have stronger pro-environmental beliefs and are more willing ... than people who value maximizing own outcome	M-Re	I		2	<b>0</b>
	<i>3.3 sociology</i>					
7	... in early research on energy issues ... the focus was on demographic and lifestyle aspects... and other factors such as household size, cultural conventions or systems of provision.	O-So			1	<b>1<sup>6</sup></b>
	Lifestyles and identity management with regard to energy consumption have been an issue of research...	M-Re M-Au O-So			3	<b>0</b>
	The meaning of personal identity and aspects of motivation to behave in a pro-environmental manner ...	M-Re			1	<b>0</b>
	...the drivers of increasing energy use: how new 'needs' are constructed and how expectations of comfort and convenience evolve.	M-Re M-Au			2	<b>0</b>
	...new technologies themselves serve as change agents...	O-Ph	V		2	<b>0</b>
	consumption as a form of communication and a way to express and underline social status	O-So			1	<b>0</b>
7/8	Summary table					-
	Budget	O-Ph			1	<b>0</b>
	Preferences	M-Re, M-Au			2	<b>0</b>
	personality	U			1	<b>0</b>

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<sup>6</sup> Disagreement M-Au. Social convention. A convention is a habit; if I do an action because it is a social norm this action is habitual and automatic. Is what point is a habit purely self-defined or socially-defined?

	Family	O-So			1	0
	Demographics	U			1	0
	Lifestyles	M-Re M-Au O-So			3	0
	Norms and roles	O-So			1	0
	Marketing	U <sup>7</sup>	P	C	3	0
	consumption as symbolic communication	M-Au, M-Re, O-So			3	0
	Lock-in to existing systems of provision	O-Ph <sup>8</sup>			1	0
	Prices of products	O-Ph			1	0
	• Macro-economic conditions influencing consumer income and propensity to spend vs. save	O-Ph			1	0
	• Conventions	O-So			1	0
	• Social interaction	O-So			1	0
	• Socio-technical systems (e.g., urban structure)	O-Ph	V	E	3	0
	Low prices of natural resources and energy	O-Ph			1	0
	Technological development	O-Ph			1	0
	Prices of products	O-Ph			1	0
	Information and advice	C-Ps	E		2	1 <sup>9</sup>
	Market transformation		N		1	0
	Internalising externalities			U	1	0
	Providing public good or regulating the use of public goods		R	R	2	1 <sup>10</sup>
	Information and persuasion	C-Ps	E,P		3	0
	Empowerment		U		1	0
	• Targeting the social system surrounding the individual	O-So	V		2	0
	• Changing institutions		V	E	2	0

<sup>7</sup> Not specific enough; the BCW is highlighting how we need to be more specific when asking for ‘marketing’; simply saying ‘marketing’ does not specify which determinant you are going to hit.

<sup>8</sup> We are using O-Ph both positively and negatively. Here we are highlighting the lack of physical opportunity.

<sup>9</sup> Disagreement: M-Re. Is Advice related to reflective motivation? Or is advice education?

<sup>10</sup> Disagreement: Service provision. Is ‘providing a public good’ delivering a service?

	and infrastructures					
	•Via products, e.g. standards and voluntary agreements				0	2 <sup>11</sup>
	•Via markets, e.g., increased transparency			U	1	0
	•Via consumption by providing ‘software’ (information) and ‘hardware’ (infrastructures)	C-Ps O-Ph	E, V		4	0
9	4. Factors of influence....					
	The hampering influences on the individual level include aspects such as transaction costs, limited budgets, lack of information and motivation or a missing of knowhow and awareness. Furthermore an inadequate provision of appliances and infrastructure plays an important role...	C-Ps M-Re M-Au O-Ph	V <sup>12</sup>		5	0
	· lack of knowledge (by owners, installers, advisers, consumers), · lack of financing mechanisms (economic barriers), · lack of capacity by installers, · tradition, less flexibility and · large number of actors involved (decision makers, ownership).	C-Ps C-Ph O-Ph O-So			4	0
	...three barriers to be the most important: · cultural aspects – visions of a good life are connected to big and well-equipped homes; · economic aspects – consumers expect a short payback time (3-5 years); · informative aspects – information not only on what and how, but on when.	C-Ps M-Re O-So			3	0

<sup>11</sup> Disagreement: The definitions of Guidelines and Regulation need to be improved. At the moment, an example of Regulation includes “establishing voluntary agreements on advertising” which suggests that voluntary agreements are Regulation. The other coder disagrees.

<sup>12</sup> See earlier note about positive/negative attribution.

	...the lack of knowledge at different actor groups as one of the main barriers ... the perceived energy efficiency does not match the present situation of the household	C-Ps			1	0
	a general lack of trust in installers	M-Au			1	0
	... residents are most likely to realize energy savings if these are both visible and contribute positively to his/her symbolical communication with others.	O-So M-Re			2	0
	...long payback time is currently one of the main barriers to energy efficient improvements in the domestic sector...	M-Re			1	1 <sup>13</sup>
	...another is the principal agent problem where the owner who should make the investment does not necessarily benefit from it in the operation phase.	M-Re			1	0
	A survey...on the implementation of energy labeling in Finland brought up the observation that professionals have very little motivation to use the label.	M-Re M-Au	E		3	0
10	<i>5 Influential context factors</i>					
	They can be defined as a context factor or a framework condition. Other influencing factors might already be incorporated in the design of instruments or measures to promote energy efficiency. They could include aspects of timing, social practice (and marketing) or transaction costs of gaining information to overcome internal or external barriers against inefficient (energy consuming) routines.	M-Re M-Au O-Ph O-So	P	C	6	0

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<sup>13</sup> See earlier note about positive/negative attribution. Should the lack of an incentive be coded as an Intervention?



	Everyday routines and lifestyle patterns of the consumer (including habits)	M-Au O-So			2	0
	· Socially determinants of individual behavior (including values and beliefs)	M-Re O-So			2	0
	· Given technology (e.g. age of appliances, standards and costs of infrastructure)	O-Ph			1	0
	· ...the tax system or an existing governance regime.			F, G	2	0
	Other – socio-psychological – models (Jackson 2005) divide these determinants into two groups: the internal factors (attitudes, beliefs, norms) and the external factors (regulations, institutions).	M-Re O-Ph O-So		R	4	0
	.. the report discusses economic factors (e.g. energy prices, employment), social factors (e.g. role models, government), policy factors (e.g. regulations, law) and physical factors (e.g. infrastructure, availability of technologies).	O-Ph O-So	M, V	R, L, E	7	0
	For efficiency behavior, one has to take into consideration the (symbolic) meaning of different products and the different purchasing situations as well as lifestyles and life events	M-Au O-So			2	0
11	it is difficult for consumers to change their habits in everyday life – even if they are well informed and motivated	M-Au M-Re C-Ps			3	0
	the importance of timing for the successfulness of energy policy programs... there is a lack of conceptualization of timing in the context of program planning so far	O-Ph	U		2	0
11	6 intervention instruments					
	legislative and regulatory instruments,			L, R	2	0
	<input type="checkbox"/> <input type="checkbox"/> market-based instruments,		C, I		2	0
	<input type="checkbox"/> <input type="checkbox"/> agreement and incentive based Instruments and		I		1	0

	□□information and communication based Instruments.		E, P		2	<b>0</b>
	While interventions in general ... – can be categorized into judicial (e.g. regulations), economic (e.g. incentives or subsidies) and communicative instruments (e.g. information or campaigns), they target different determinants of behavior. ECN et al. (2008) group the determinants as follows:		E, P, I	R, C	5	<b>0</b>
	interventions aim at the macro context of energy related decisions of households or organizations and usually address judicial or economic mechanisms			L, F	2	<b>0</b>
	The micro level. interventions of this kind address the attitudes, motivation and preferences of households, individuals or organizations and are mainly covered by communicative instruments.	M-Re M-Au	P	C	4	<b>0</b>
	Antecedent interventions which encompass inter alia information, workshops, mass media campaigns and audits · Consequence interventions which include feedback systems and rewards.		E, P, T, I	C	5	<b>0</b>
12	build up consciousness and increase awareness for the energy efficiency improvement options, through spreading information and support. ... knowledge about choices and costs as strongest internal determinants of behaviour	C-Ps	E		2	<b>0</b>
	well-informed consumers are more receptive to implement energy efficiency improvement measures	C-Ps	E		2	<b>0</b>

	it is important to adapt the households' perception of their energy friendliness before they can make the appropriate changes. Furthermore, the implementation of streamlined routines in activity patterns of households can reduce energy requirement and can promote attention to energy saving	C-Ps M-Au	P		3	<b>1</b> <sup>14</sup>
13	<i>6.1.3. metering and feedback</i>					
	The instruments of metering and feedback have different fields of application. In general they aim to provide consumers with more detailed, comparable and comprehensible information on their energy use.	C-Ps	E		2	<b>0</b>
	The knowledge about the (comparative) level of consumption and the amount of costs provides the motivation for a change	C-Ps M-Re	M		3	<b>0</b>
	the aspect of individual control by the consumers through informative metering and feedback, which gives an important impulse - when the information is linked with concrete action items, such as interactive tools	C-Ps M-Au O-Ph	E, P		5	<b>0</b>
	cultural differences – as indicated through the reactions on feedback systems and preferences in different countries	O-So			1	<b>0</b>
13	<i>6.1.4 labelling</i>					
	the political aim of labels is to influence products by enabling consumers to choose the environmentally better ones. Related to energy	C-Ps M-Re	E	R, G	5	<b>0</b>

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<sup>14</sup> Disagreement: C-Ph. For an activity pattern to change, it must have involved either physical or psychological capacity change, and as we do not know which it is, one reviewer feels both should be included. In the same way, as it is not always possible to distinguish the difference of M-Re/M-Au; it is not always able to tell the difference in C-Ps/C-Ph (e.g. to change behavior did one just need information or did they need information and a skill acquired?).

	behavior there are different label schemes in place: one can find mandatory as well as voluntary systems.					
14	the information provided in the energy performance certificate (EPC) may impact on consumers' decision to improve their property	C-Ps M-Re	E		3	<b>0</b>
14/1 5	6.3 Procedural instruments, voluntary programmes and commitments		U		1	<b>0</b>
15	The formulation of targets is highly instrument-specific. Negotiated agreements usually involve such commitments and are signed by the participants, while voluntary programs are open to different actors and individual organizations. With respect to participatory mechanisms Coenen (2004) reports that they facilitate awareness rising and increase commitments towards environmental issues.	C-Ps M-Re	U		3	<b>3<sup>15</sup></b>
15	increase awareness and engagement of the actors involved, thus stimulating potential behavioral changes. Through their participation, individuals develop active citizenship skills and greater understanding for sustainability problems	C-Ps M-Re	E		3	<b>0</b>
15	commitment-based activities ... This instrument type is seen as a complementary measure under the umbrella of a communication program or initiative <sup>16</sup>		U	C	2	<b>3<sup>17</sup></b>

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<sup>15</sup> Disagreement. The BCW does not specify 'commitments'. As commitments are an important intervention, MM the Book was investigated to find out which interventions relate to 'Commitments'. Relating the BCT to the BCW one finds that commitment as a BCT is related to Incentivation, coercion and enablement.

<sup>17</sup> See earlier footnote about Commitments.

15	Evidence from successful groups...indicates the importance of networks and social learning, a tailored communication and measurement and feedback as a source of motivation	M-Re O-So	E, P, V, M		6	0
17	Figure: Factors influencing Energy Behaviour					
	Social factors: values, norms, roles	M-Re O-So			2	0
	Attitude: beliefs, coping, locus of control	C-Ps M-Re			2	0
	Affects:emotions	M-Au			1	0
	Societal discourse, common goals	O-So			1	0
	Energy prices, taxes			U <sup>18</sup> , F	2	0
	Regulation, governance			G, R	2	0
	Provision of appliances, products, services	O-Ph	V	S	3	0
	Provision of information standards	C-Ps	E	G	3	0
	Intermediaries; knowledge	C-Ps	E		2	0
	Intention/motivation	M-Re M-Au			2	0
	Habits, everyday routines	M-Au			1	0
<b>TOTALS</b>					229	15
<b>Percentage</b>					94% 229/244	6% 15/244

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<sup>18</sup> Energy price, *the* thing to change people's energy use, is not covered as an Intervention or Policy in its own right in the BCW. It is not clear which of the categories it would fall into. This may be because health behavior is not price driven.

## Coding sheet for: Dahlbom et al (2009)

(Based on Additional file 8 of Michie et al, 2011)

### Coding Key:

**Determinants:** Psychological capability (C-Ps), Physical capability (C-Ph), Reflective motivation (M-Re), Automatic motivation (M-Au), Physical opportunity (O-Ph), Social opportunity (O-So)

### Interventions

Education E, Persuasion P, Incentivisation I, Coercion C, Training T, Restriction R, Environmental restructuring V, Modelling M, Enablement/resources N, Unclassifiable U

### Policies

Fiscal F, Communication/marketing C, Service provision S, Legislation L, Regulation R, Guidelines G,

Environmental/social planning E, Unclassifiable U

**Agreement:** The table shows the number of agreed determinants, intervention function(s) and policy category(ies), along with the number for which there was agreement and disagreement.

page	Activity description	Determinants	Intervention function	Policy category	Agreement (n)	Disagree (n)
<b>Chapter 3: Practical Guidance for Programme Development</b>						
<b>Step 2 – Analysis of determinants and target groups</b>						
<b>Guidance note 1: Types of influencing factors of behaviour</b>						
27	<b>Motivating factors</b> are individual, internal drivers of behaviour. These factors are awareness, knowledge, social influence, attitude, perceived capabilities and intention. For people to intentionally change their energy behaviour, they must become aware of their energy use, pay notice to it, and be informed about the consequences. And, they must be motivated to use the available information and instruments to control their energy use.	C-Ps C-Ph M-Re O-Ph O-So			4	1 <sup>19</sup>
27	<b>Enabling factors</b> are the	C-Ph	I, V, T	L	6	0

<sup>19</sup> Are instruments physical affordances? Disagreement

	external constraints on behaviour. These factors allow new behaviour to be realized. Factors involve external financial, technical, organisational and judicial resources. Examples of instruments that influence these factors are subsidies, availability of products in shops, and the availability of specific advice. New skills may have to be acquired to realise the desired behaviour.	O-Ph				
27	<b>Reinforcing factors</b> are those consequences of actions that give individuals positive or negative feedback for continuing their behaviour. These include information about the impacts of past behaviour (e.g., lower energy bill), feedback of peers, advice, and feedback by powerful actors.	C-Ps M-Re M-Au O-So	E, P, M		6	1 <sup>20</sup>
<b>Step 3 – Design of the Intervention: Choosing the matching instruments</b>						
31	<b>Regulatory instruments</b> are controls in the form of prohibitions or requirements, issued by political or administrative bodies that are mandatory in nature. The controls may be quantitative (emission conditions, limit values etc.) or technical. Regulations issued under the environmental framework code often form the basis of a country's environmental policy. Regulations governing the energy efficiency of buildings are another administrative policy measure.		R	R, L	3	0
	Covenants and agreements are a more voluntary form of regulatory instruments			G, R	0	2 <sup>21</sup>
31	<b>Economic instruments</b> affect the costs and benefits of the choices available to	O-Ph	I, C	F	3	1 <sup>22</sup>

<sup>20</sup> Disagreement over explicit nature of Persuasion

<sup>21</sup> See other footnotes about g and r (brohmann?)

<sup>22</sup> Disagree O-Ph as a physical opportunity. Agree leave in.

	parties concerned. They consist of taxes and fees, transferable emission allowances or certificates, deposits as securities and various forms of grants and subsidies					
31	<b>Communicative instruments</b> are used for knowledge transfer, or to persuade, convince or encourage people to the desired behaviour. ... In general we can say the more tailor-made the communication, the better the effect on influencing behaviour will be.		E, P	C	3	1
31	<b>Infrastructural provisions</b> are changes in infrastructure and new technical solutions. Examples are the road-bumps to prevent speed driving, or thermostats and timer switches.		V	E	2	0
32	In most situations, more than one instrument affects the influencing factors and, therefore, we often choose an instrument mix to formulate an intervention strategy made up of various instruments.		U		1	0
34	<b>Guidance note 5 – Instruments</b>					
34	1.1 Laws and Regulations			L,R	2	0
34	1.2 Specific Permits		R	R	2	0
34	1.3 Covenants and agreements			G, R	0	2 <sup>23</sup>
34	2.1 Subsidy	O-Ph	I		1	1 <sup>24</sup>
34	2.2 Levy		C	F	2	0
34	2.3 Financing constructions			F	1	1
34	3.1 Knowledge transfer	C-Ps	E		2	0
34	3.2 Modelling	O-So,	M		2	0
34	3.3 Stimulating communication	M-Re, M-Au	P	C	4	0
34	3.4 Training	C-Ps, C-Ph	T		3	0
34	3.5 Coaching	C-Ps, C-Ph, O-Ph	T, N		5	0

<sup>23</sup> G&R see above

<sup>24</sup> See footnote 4



34	3.6 Personal Advice		T		1	0
34	3.7 Label	C-Ps	E		2	0
34	3.8 Demonstration		T, M		2	0
34	3.9 Benchmarks	O-So		G	2	0
34	3.10 Feedback	C-Ps, M-Re	E,		3	0
34	4.1 Infrastructural provisions	O-Ph	V	E	3	0
34	4.2 Technical steering of behaviour		V		1	0
34	<b>Guidance notes 5 - Determinants (Enabling Factors)</b>					
34	Motivating Factors:					
34	Importance of instruments		U		1	0
34	Awareness	C-Ps,	E		2	0
34	Knowledge	C-Ps,	E		2	0
34	Social influence	O-So			1	0
34	Attitude	C-Ps, M-Re			1	1 <sup>25</sup>
34	Perceived capabilities	C-Ps, C-Ph			2	0
34	Enabling Factors:					
34	Financial resources	U			1	0
34	Technical resources	O-Ph			1	0
34	Organisational resources	O-Ph			1	0
34	New skills	C-Ph, C-Ps	T		3	0
34	Reinforcing Factors:					
34	Feedback of peers	O-So	M		2	0
34	Feedback of experts	O-So	M		2	0
34	Feedback of authorities	O-So	M		2	0
<b>TOTALS</b>					87	11
<b>Percentage</b>					89%	11%
					(87/98)	(11/98)

<sup>25</sup> Disagree over C-Ps. BCW unclear. One coder referring to book argued against C-Ps as ‘attitude’ predominantly seen as M-Re. Depends how defining attitude? (see TPB)

## Coding sheet for: EEA 2013

(Based on Additional file 8 of Michie et al, 2011)

### Coding Key:

**Determinants:** Psychological capability (C-Ps), Physical capability (C-Ph), Reflective motivation (M-Re), Automatic motivation (M-Au), Physical opportunity (O-Ph), Social opportunity (O-So)

### Interventions

Education E, Persuasion P, Incentivisation I, Coercion C, Training T, Restriction R, Environmental restructuring V, Modelling M, Enablement/resources N, Unclassifiable U

### Policies

Fiscal F, Communication/marketing C, Service provision S, Legislation L, Regulation R, Guidelines G,

Environmental/social planning E, Unclassifiable U

**Agreement:** The table shows the number of agreed determinants, intervention function(s) and policy category(ies), along with the number for which there was agreement and disagreement.

page	Activity description	Determinants	Intervention function	Policy category	Agreement (n)	Disagree (n)
<b>Chapter 2: Energy efficiency measures and behaviour change</b>						
<i>The measures</i>						
12	Figure 2.1. Main factors influencing consumer behaviour and emergence of consumption practices	ALL			1	0
13	communication and engagement: • information and promotion, training, personal advice and one-to-one engagement, demonstrations, benchmarking, commitment, goal-setting, labelling, prompts, modelling, feedback	C-Ps M-Re O-So	E, P, I, C, T, V, M, N	C	12	0
13	economic incentives and disincentives: • subsidies, levies, surcharges, taxes, bonuses, tax differentiations, tax refunds, financial instruments such as interest free loans, rewards and penalties	M-Re O-Ph	I, C, N	F	6	0

13	regulatory: <ul style="list-style-type: none"> <li>• general laws and rules, specific exemptions, covenants and agreements;</li> <li>• regulated versus dynamic energy pricing.</li> </ul>		R	L,R	3	0
<i>Feedback</i>						
14	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: <ul style="list-style-type: none"> <li>• two-way communication with the supplier — enabling dynamic pricing and automated meter reading;</li> <li>• export metering;</li> <li>• in-building display of data (e.g. energy consumption, pricing, energy consumption for water heating).</li> </ul>	C-Ps M-Re O-Ph	E, V		5	0
17	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.	C-Ps M-Re	E, P, M	S	6	0
18	There are several ways (Iyer et al., 2006; Roberts & Baker, 2003) to make energy bills more informative, by including:	-	-	-	-	-
18	<ul style="list-style-type: none"> <li>• charts which visualise household's energy use trends</li> </ul>	C-Ps M-Re	E, P		4	0
18	<ul style="list-style-type: none"> <li>• comparisons of energy</li> </ul>	C-Ps	M		3	0

	use (e.g. to the previous month or the same month in the previous year)	M-Re				
18	<ul style="list-style-type: none"> <li>comparisons to selected user groups (such as households in the same street)</li> </ul>	M-Re O-So	M		3	0
19	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.	C-Ps M-Re M-Au O-Ph	E, V	E, S	7	1 <sup>26</sup>
19	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.	C-Ps M-Re	E, V, T	S, C	7	1 <sup>27</sup>
19	Financial incentives and commitment to reduce consumption had either no effect or a very short-term effect.	M-Re	I, C		3	0
19	The delivery of information through the Web or customers' TVs was not successful.	C-Ps M-Re	E,P	C	5	0
19	Community engagement can also be effective, but may require a higher initial investment and will not necessarily work in all localities.		U	S	2	0
20	The project also highlighted that support from the	C-Ps	T	S	4	0

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<sup>26</sup> Service is woolly. This appears to be an example of something which can be described as both E and S. Coders disagree.

<sup>27</sup> Coders disagreed over Enablement and extent to which this is explicitly different to training (clarity over boundaries). Consequently, Enablement was not included as an Intervention Function.

	equipment installers may be particularly important for users to learn how to operate the devices in an optimal way.	C-Ph				
20	Several studies on feedback found that the level of households' previous energy consumption can bear upon the effect of the feedback... 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	C-Ps M-Re	E, M		4	0
<i>Feedback and target setting</i>						
21	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	M-Re	M, I, C		3	2 <sup>28</sup>
21	Research (Becker, 1978) found ... 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	C-Ps M-Re O-Ph	E, I, M,		6	0
<i>Energy audits</i>						
22	Article 8 of the Energy Efficiency Directive [Directive2010/31/EC] 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....[and] encourages Member States to raise awareness ... among households.		E, M, I	L, G	5	0
22	Energy audits provide detailed information on energy use and saving potential....[such as an]	C-Ps M-Re O-Ph	E, P, I		6	0

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<sup>28</sup> One coder originally added N due to Michie et al (2014) book



24	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... The group meets regularly and is given access to reliable information through written material and/or access to a trained expert	C-Ps <sup>29</sup> M-Re O-Ph O-So	E, T, V	E, S	8	1
24	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.	O-So	V, M	E, S	5	0
24	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	C-Ps <sup>30</sup> M-Re	V	E, S	4	1
25	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 award.	M-Re O-Ph O-So	I		4	0
<i>Other measures that could be relevant for behaviour change</i>						
<i>Building certification and labelling</i>						

<sup>29</sup> In discussion we agreed this was an item where C-Ps was explicit along with M-Re, because community gave the facility to enhance capacity.

<sup>30</sup> As footnote 4. But this time coders disagreed the text was sufficiently explicit

27	Directive 2010/31/EU on the energy performance of buildings requires Member States to establish a system for certification of energy performance of [publically owned or used] buildings. ... For non-domestic buildings, the directive requires that a common, voluntary scheme of certification established.		E	L ,G, S	4	1 <sup>31</sup>
27	...homeowners are generally not aware of the EPC and its recommendations. ... To make the EPC more effective, it was recommended to improve their availability, presentation and content		E, P	C	3	0
<i>Economic instruments</i>						
28	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).		I	E	2	1 <sup>32</sup>
28	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.		I	E	2	0
<i>Ecodesign requirements</i>						
28	Energy labelling of consumer energy-using products and of buildings themselves contributes towards energy awareness among building occupiers and users. ... A recent working paper of the European Commission (SEC(2011) 469 final) on consumer empowerment in	C-Ps	E		2	0

<sup>31</sup> Coders disagreed over whether guideline or regulation. Agreed guideline 'voluntary' but another e.g. of lack of boundary between two policy categories.

<sup>32</sup> Lack of agreement over whether this was enablement as well as incentive. Agreed to exclude



	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.					
<i>Public Engagement Campaigns</i>						
28	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.	C-Ps M-Re M-Au	E, P, T	C	6	1 <sup>33</sup>
29	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.	M-Re M-Au	P	C	3	1 <sup>34</sup>
<b>TOTALS</b>					<b>151</b>	<b>10</b>
<b>Percentage</b>					<b>94%</b> <b>(151/161)</b>	<b>6%</b> <b>(10/161)</b>

<sup>33</sup> Coder 1 could not see M-Au explicit here but discussion over whether communication hits both automatic and reflective motivations. Agree to leave in.

<sup>34</sup> Trust text more explicit here therefore one coder added M-Re. Previously M-Au.

**Coding sheet for: MECHAnisms toolkit web tool: ‘forcefield analysis template’ followed by webpage ‘instruments to promote energy savings’**

**(Based on Additional file 8 of Michie et al, 2011)**

**Coding Key:**

**Determinants:** Psychological capability (C-Ps), Physical capability (C-Ph), Reflective motivation (M-Re), Automatic motivation (autmot), Physical opportunity (O-Ph), Social opportunity (O-So)

**Interventions**

Education E, Persuasion P, Incentivisation I, Coercion C, Training T, Restriction R, Environmental

restructuring V, Modelling M, Enablement/resources N, Unclassifiable U

**Policies**

Fiscal F, Communication/marketing C, Service provision S, Legislation L, Regulation R, Guidelines G,

Environmental/social planning E, Unclassifiable U

**Agreement:** The table shows the number of agreed determinants, intervention function(s) and policy category(ies), along with the number for which there was agreement and disagreement.

page	Activity description	Determinants	Intervention function	Policy category	Agreement (n)	Disagree (n)
	<i>Forcefield Analysis</i>					
2	Public awareness of the problem	C-Ps O-So			2	0
2	Target group's & stakeholders' competency	C-Ps C-Ph			2	0
2	Current and future price of energy	M-Re O-Ph	U	U	4	1 <sup>35</sup>
2	Availability of finance	O-Ph			1	0
2	Current legislation and state support	O-Ph		L	2	0
2	Future legislation and state support	O-Ph		L	2	0
2	Environmental concern of target group and stakeholders	M-Re			1	0
2	Social concerns of target group and stakeholders	M-Re O-So			2	0
2	Values related home/work	M-Re			1	0

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<sup>35</sup> Disagreement. One coder feels price is a physical opportunity.

2	Availability of suitable applications for your problem	O-Ph			1	0
2	Availability of services and support	O-Ph	N	S	3	0
2	Public controversies /doubts	M-Re O-So			2	0
2	Existing practical examples	O-Ph			1	0
	<b>Webpage</b>					
	<b>Financial instruments and subsidies.</b> These promote energy efficient technologies and measures by reducing the investment costs ...	O-Ph	I, N	E	4	0
	Fiscal incentives. These aim to reduce the tax on energy efficient measures		I	F	2	0
	Contextual factors: availability and quality of technologies, ability to inform end-users about subsidies and fiscal measures, demography, energy prices, integration between energy efficiency policy and other sectoral policies, etc.	O-Ph	U	U	3	0
	Programme characteristics: adequate information for end-users, easy and short application procedures, focus on investments with long payback time and high efficiency gains or innovative technologies, subsidies on energy audits, etc.	C-Ps M-Re O-Ph	E, I, N		6	0
	Design factors: good combination of financial and informational incentives (if needed in combination with technical and organisational support), fit to decision making process of end-user, etc.	M-Re O-Ph	I, P	S	5	0
	Process factors: simple and easy administration of the programme.	U	N		2	0
	<b>Information and education campaigns...</b> aim for different effects (raising awareness, education and providing knowledge, influencing and maintaining behaviour, etc). They mostly target curtailment behaviour focussing on motivation and	C-Ps M-Re	E, P	C	5	0

	capacity to undertake long lasting behaviour changes in energy consumption. They can also trigger efficiency (investment) behaviour. Factors influencing the success of information and education campaigns include:					
	Contextual factors: use of topic that is positively valued in society, connection to other similar projects to increase mutual collaboration and repetition of message via different channels, etc.	O-So	P	C	3	0
	Programme characteristics: simple, fun and easy message, a mutually reinforcing programme including attention for messenger, goals, design of message, approach of end-users, choice and use of communication channels, etc.	C-Ps M-Re	P	C	4	1 <sup>36</sup>
	Design and process factors: design should be based on theories of human behaviour and communication on different levels, the right marketing mix of products, prices, placement and promotion, etc.		P	C	2	0
	<b>Metering and feedback</b> (e.g. informative billing) instruments provide end-users with more detailed, comparable and comprehensible information on their energy use. They target routine, habitual and unthinking types of behaviour and are most effective over longer periods of time (or even continuously). Metering and feedback are related to energy audits and energy advice. Many different technical concepts for metering and feedback exist, ranging from automated meter reading to smart meters	C-Ps M-Au O-Ph	E, M, V	C, S	8	1 <sup>37</sup>

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<sup>36</sup> Disagreement: M-Au. Reviewer 1 thinks M-Re and M-Au are on an indecipherable continuum. Reviewer 2 thinks M-Au not explicit.

<sup>37</sup> Disagreement: M-Re. Reviewer 1 thinks that reflective motivation is required for one to change his or her mind.

	with bi-directional communication and full in-house communication between meter and appliances and more advanced concepts with two-way communication that allow the supplier to communicate directly with end-users (e.g. via internet or television)  Factors influencing the success of metering and feedback include:					
	Contextual factors: existing systems of energy metering and billing, innovative utilities, existing payment system, legal requirements, use of smart meters, status of metering markets, cultural differences in preferences for presenting information, etc.	U	V	L	3	0
	Programme characteristics: informative billing and metering for residential customers and businesses, related to actual consumption, comparative standards, etc.	C-Ps M-Re	E, V, M	C, S	7	0
	Design factors: (interactive) media and mode of presenting energy use information, written material, electronic meter or interactive tools via internet, timing and control of information, etc.		E, P	C, S	4	0
	Process factors: frequency of feedback, combined feedback with incentives or targets for energy saving, link to individual activities of consumers, etc.		E, I	C	3	0
	<b>Energy audits</b> Energy audits consist of on-site inspection of existing infrastructure and the activities of the customer by the auditor (energy rating) followed by an identification of saving potential. These are	C-Ph O-Ph	E, P, T, I	S	7	1 <sup>38</sup>

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<sup>38</sup> Disagreement over Environmental Restructuring. Reviewer 1 felt energy audits were an example of environmental restructuring.

	translated into personalised advice for the customer about most cost-effective saving measures including recommendations for investments written down in an audit report. The advice can differ in scope and thoroughness. Energy audits primarily target investment behaviour (curtailment behaviour is only a secondary target) and are mostly provided by third parties (like ESCOs and energy agencies) and sometimes by NGOs. Factors influencing the success of energy audits include:					
	Contextual factors: availability of impartial and qualified auditors, supportive policy framework, subsidies and refunds for investments, etc.		V, I	G	3	0
	Programme characteristics: most feasible for larger energy users (organisations), including subsidies for audit costs, 'one-shop-stop' (auditor providing multiple services), etc.		I, N	S	3	0
	Design factors: training and certification of auditors, standardised process, etc.	U	T		2	0
	Process factors: communication and involvement end-users, identification of target group and their needs, marketing efforts, evaluation of outcomes, etc.	U			1	0
	<b>Energy advice</b> Energy advice aims to provide end-users with skills and solutions for energy related problems. It is personalised guidance which can be provided to end-users via different means (telephone, internet, on platforms, in real or virtual groups, visits, workshops, written materials, etc). It always involves some interaction with the customer. Energy advices mostly target	C-Ps C-Ph M-Re	E, T	C	6	0

	curtailment behaviour although raising awareness and increasing motivation to invest in efficiency measures as an element in the behavioural change is often part of the advice as well. Factors influencing the success of energy advices include:					
	Contextual factors: availability of local (impartial) institutions for advice, supportive policy framework, etc.	O-Ph	V	G	3	0
	Programme characteristics: impartial expertise, technology independent advisors, grounding in clients needs, integrated and single issue advice, etc.		E, T	S	3	0
	Design factors: multiple benefits to clients, personalised advice, communicative and technical skills of advisers with social and market knowledge, etc.	U	E, T	S	4	0
	Process factors: tailoring advice, reaching customers at right time, develop right partnerships, effective adviser training and continuous updating of knowledge, bridging gap between information and implementation, etc.	C-Ps O-Ph	E, T		4	0
	<b>Voluntary programmes and negotiated agreements</b> Voluntary programmes and negotiated agreements are systematic instruments that primarily aim to raise awareness of habitual behaviour and to increase people's sense of responsibility for changing their behaviour. Voluntary programmes target individuals, households or organizations which voluntarily make a commitment to join a programme. Negotiated agreements aim for energy	C-Ps M-Re M-Au	E	E	5	3 <sup>39</sup>

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<sup>39</sup> Disagreement: Commitment could be coded as I, C, N as per the BCW book [see EEA]

	savings through bargaining between public authorities and industry (or sectors). These instruments are often combined with other instruments like energy audits. Factors influencing the success of voluntary programmes and negotiated agreements include:					
	Contextual factors: social pressure or systems of social control, etc.	O-So			1	0
	Programme characteristics: including supporting instruments and regulations, positive incentives combining goal-setting with feedback, etc.	M-Re	I, M	R	4	0
	Design factors: target setting must be open and transparent, clarity on commitments on both sides, adoption of new roles and responsibility, impartial intermediaries are relevant, good communication, networks among participants, support a long-term change process, etc.	U			1	0
<b>TOTALS</b>					132	7
<b>Percentage</b>					95% 132/139	5% 7/139