Multiple benefits of energy efficiency

Literature Review - methodology and preliminary findings

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1. Introduction

This work is the preliminary deliverable from Task 2.1 within the Multiple Benefits for Energy Efficiency (MBENEFITS) project.

The key premise of MBENEFITS is that a multiple benefits approach to energy-efficiency can be persuasive in increasing efficiency investments by organisations, especially firms operating in industrial sectors of the economy. The focus of MBENEFITS is on the decision-making processes for individual firms, projects and investment decisions, rather than at the level of policy (international, national, regional or local).

Task 2.1 aims to bring together the best available evidence to support the contention that a multiple benefits framing can be persuasive in these contexts using evidence from a variety of academic disciplines. These include: organisational decision-making; business strategy and investment decisions; policies and evaluation of programs for energy-efficiency in industry and commercial sectors; communication and negotiation strategies in business. We will explore how this idea has been, and could be, operationalised - looking for innovative approaches that are relevant to the implementation of policies, programmes and projects from across OECD countries. Research includes identifying the range of multiple benefits which may be relevant and strategic for a wide range of businesses by sector, size and energy end-uses. The review will inform the development of other work packages by highlighting existing good practice and promising opportunities for innovative approaches.

This document forms part of the conceptual basis of the M-BENEFITS project. It contains three major strands of work. Firstly there is a preliminary literature review of the multiple benefits of energy efficiency and a discussion on definitions of key words. Secondly, the methodology used to identify key literature - a 'rapid evidence assessment' - is explained. Finally, the results of the searches are presented.

In the final version of this deliverable the literature found will be summarised and synthesised, with key findings highlighted. However, this stage has not yet been completed.

2. Preliminary literature review and working definitions

In this section, we present a brief introduction to multiple benefits, discuss some key words and their definitions, and provide an overview of the general literature on the multiple benefits of energy efficiency. This forms the background against which our more detailed literature review takes place.

2.1 Introduction to multiple benefits

Energy efficiency has featured in national and international policy for more than 40 years. The idea that energy efficiency should be an important part of government energy policy developed in response to the first oil price crisis in 1973, when reducing energy demand was seen as a route to greater energy security in many developed countries (Geller et al, 2006). As political and economic priorities have changed, government justifications for continuing to develop policy on energy efficiency have stressed different benefits, including energy security, affordability of energy, business competitiveness, and reducing greenhouse gas emissions (Mallaburn and Eyre, 2013). Thus, energy efficiency is already understood as a means to reach a variety of ends. Now, the 'multiple benefits' framing of energy efficiency seeks to expand the range of benefits which energy efficiency is recognised to deliver, and thereby to increase its role in policy making.

The multiple benefits framing of energy efficiency proposes that energy efficiency has many environmental, social and economic benefits, such as improved health, new job creation, and increased productivity, and that these are not currently properly understood or taken

account of in decision-making (IEA, 2014). This approach seeks to expand the perspective of energy efficiency beyond the traditional measures of reduced energy demand and lower greenhouse gas emissions by identifying and measuring its impacts across many different spheres. In their influential report, the International Energy Agency (IEA) brought together a wide range of empirical evidence on the benefits of energy efficiency (IEA, 2014). IEA identified fifteen classes of multiple benefits, represented by a 'flower' diagram (Figure 1). The report focused on bringing together evidence in five key areas - macroeconomic development, public budgets, health and well-being, industrial productivity and energy delivery. This report has been a landmark in establishing multiple benefits as a significant development in thinking about energy efficiency.

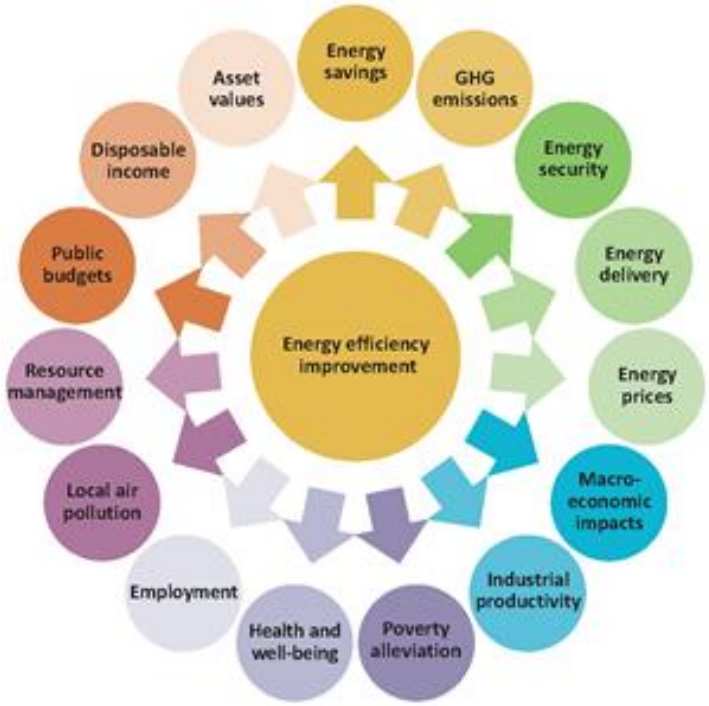

Figure 1: The multiple benefits of energy efficiency improvements (IEA 2014)

2.2 Key definitions

The definitions included here are preliminary. This is primarily created as a resource for consortium partners on the M-BENEFITS project to help clarify our collective use of terminology and to reduce the risk of misunderstandings or ill-founded assumptions. Much of what follows is based on a reading of Catherine Cooreman's doctoral thesis (2010), which includes useful (and extensive) reviews of relevant literature. In some places, other resources have also been used to add new ideas or additional evidence to the arguments presented.

Each section sets out definitions and emerging issues or contested topics related to the term under discussion.

Decision

A decision implies a two-step process. Firstly, there is a choice between multiple options; and secondly a decision implies a commitment to act to make it happen. In other words, a decision is more than a preference or an option; it includes the important element of resources being made available to make the choice a reality.

Strategy/Strategic

Cooremans argues that the term 'strategy' is poorly defined, often tautological, and often so vague as to be of little use. In turn, the word 'strategic' is often used as a close synonym of

'important', but the real meaning of the term is no clearer for that. Many definitions of 'strategy' can be found, for example:

- 'a plan of action designed to achieve a long-term or overall aim' (Oxford online dictionary)
- 'a set of decisions for selecting between means and actions, organising resources in order to achieve a goal'[1] (Thiétart and Xuereb 2005, cited in Cooremans 2010: 201)
- 'the art of committing a firm to a sustainable, long-term path, which allows it to find advantage within the rules of the game and the changing context'[2] (Gervais 2003, cited in Cooreman 2010: 201)
- 'strategy is about being different … to deliver a unique mix of value … [it] is the creation of a unique and valuable position' (Porter 1980, cited in Cooremans 2010: 201)
- 'the long-term orientation of an organisation's activities' (Cooremans, after Porter 1980; 1985)
- 'the direction and scope of an organisation over the long term, which achieves advantage in a changing environment through its configuration of resources and competences with the aim of fulfilling stakeholder expectations' (Johnson, Scholes and Whittington 2008 Exploring Corporate Strategy, Harlow: Prentice Hall, 8th edition: 4)
- the setting of goals and deciding how (best) to achieve them.

Some, but not all, definitions of 'strategy' make explicit reference to a (relatively) long time period. The length of time taken seems to be related to the implicit assertion in many definitions that strategy requires concerted effort and is not easy. Strategy stands in contrast to snap decisions or choices made on a whim, where there is little or no consideration of consequences. Strategy does carry consequences. However, it also seems clear that not all strategies are equally conceived or articulated, and that is at least partly because strategy requires intellectual effort, resources, skills – and time. The long timeframe referred to in some definitions seems to be a function of the serious and complex nature of strategy: the decisions involved require careful thought and judgement, may depend on special resources (research, advice from consultants etc.) and the outcomes of strategic decisions are both unpredictable (risky) and consequential (impactful).

The distinction between strategic and non-strategic decisions is one of degree, not a binary distinction. Cooremans illustrates this point with two extreme examples: the decision to re-stock photocopier paper is mundane and non-strategic; while the decision to build a factory as part of a decision to diversify into new markets is thoroughly strategic. In reality, many decisions will lie between the two extremes, with most having some strategic content.

Desreumaux and Romelaer (2001, cited in Cooremans 2010) make a strong link between what it means to invest and what it means to be strategic: 'in terms of strategy, investing relates to choices about possible future development paths for a business (building, finding new markets, keeping what you have, withdrawing from a market, mergers, partnerships etc)'[3]

Cooremans argues that academic research has tended to treat investment and strategy as two separate activities, each attracting the interest of different disciplines (economics generally being interested in investment; and business studies generally concerning itself with strategy). The calculation of payback predominates in the economics of investment decisions, and is common currency in studies of energy efficiency. However, research with firms suggests that real-life business decisions are based more on the alignment with

[1] 'l'ensemble des decisions concernant le choix des moyens et des actions relatives à l'articulation des ressources en vue d'atteindre un objectif'
[2] 'l'art d'engager durablement l'entreprise dans une voie lui permettant, sur la longue période, de tirer avantage des règles du jeu de l'environnement et de leur évolution'
[3] 'investir, dans le langage de la stratégie, renvoie à des choix de trajectoires de development d l'entreprise (construire, s'implanter, conserver, se retirer d'un marché, absorber, s'allier etc)'

strategic goals than with narrow financial returns of the project in question. In other words, a firm may well choose to invest its own money into a project because the project will help the firm to position itself in a favourable way in relation to markets, competitors, opportunities, regulation, new technology etc. A strategic investment of this kind is not required to 'pay for itself' in a way that can be meaningfully calculated in terms of financial payback. What it does need to do, however, is help the firm achieve its strategic goals. The judgement of whether an investment is worthwhile will of course take account of the cost, but the other elements influencing the decision are value (to the firm; to the strategic objectives) and risk. The decision-making process is therefore rather different from the logic of payback.

An often overlooked (but always limited) factor is time. Decision-makers operate under time constraints and have to evaluate competing priorities, which means that the time dedicated to strategy may prove to be insufficient or sub-optimal in some way. Skills and resources may also be limited, all of which leads to the conclusion that strategy may be very uneven in terms of quality and completeness. Citing Mintzberg (1978), Cooremans argues that strategy is not always clear-cut or well articulated, and that it is always in a dynamic relationship with changing circumstances.

The shortage of time and the contingent nature of strategy can both be perceived in Mintzberg's broad classification of strategy types:

- Deliberate strategy – clearly thought-out and effectively realised
- Unrealised strategy – a plan which has been thought out but not yet put into practice
- Emergent strategy – a plan which does not predate individual decisions, but which co-evolves with those decisions

Where strategy is emergent, Mintzberg defines it as 'a pattern in a stream of decisions' (Mintzberg 1978, cited in Cooremans 2010, p. 200).

Investment

An expenditure of money for the purpose of creating value or benefit of some kind over time. For some authors 'investment' only includes capital expenditure, i.e. equipment. Others broaden the definition to include 'any expenditure which leads to the acquisition or creation of the means to generate value'[4]. This broader definition includes both capital and operational expenditure, e.g. on training, R&D, management systems or staff engagement activities.

Investment decisions can be categorised using three criteria:

- **Investment content** – what kind of equipment or activity does the investment pay for? eg investments for replacement equipment, investments to increase production capacity, to break into new markets, to develop new markets, to satisfy regulatory compliance; investments for marketing, R&D, human resources etc.
- **Analytic characteristics** – what kind of logic does the investment need to follow, and what are the consequences elsewhere? Eg is the decision reversible or not? How much uncertainty or risk is associated with it? What kind of risk(s) are involved? Does the investment address a well-defined problem with a clear development path, or is it more speculative, leading to innovations which cannot be determined at the outset? What are the consequences of the investment succeeding or not? Etc.
- **Strategic content** – to what extent does the decision bear on future priority objectives and their achievement? Eg upgrading database systems

[4] 'toute dépense qui conduit à l'acquisition ou à la constitution d'un actif en vue de créer de la valeur' (Charreaux 1996, cited in Cooremans 2010, p. 51)

> to ensure they comply with new regulation may be necessary but is less strategic than, say, the development of a new product or service.

A key characteristic of all types of investment is the loss of present-day income or profit in the expectation that it will lead to future income or benefit. Investment is therefore inherently uncertain and always carries an element of risk.

In her review of the literature on business strategy and investment, Cooremans (2010) identifies a general disparity between academic theorising and empirical evidence, arguing that much of the research effort to date has been on defining how decisions *should* be taken, with rather little attention being paid to how decisions *are* taken. In the minority of literature based on analysis of real decisions, it seems that the content of an investment decision is of greater importance for practitioners than for academic research; and decision-makers are more holistic in their approach than the theories might suggest. For example, decision-makers pay attention to the core competencies of the firm when assessing investment options, and are also alert to proposals which address multiple objectives simultaneously. These topics are not prominent in academic research.

2.3 Brief review of literature on multiple benefits

Here a very brief review of some of the key issues in the multiple benefits literature is presented. IEA (2014) provides a comprehensive review of literature, with Freed and Felder (2017) exploring the 'non-energy benefits' literature in more detail.

Academic interest in multiple benefits has grown in recent years, although the peer-reviewed multiple benefits literature is relatively small (Fawcett and Killip, 2017). There has not yet been convergence of the language used, an indication that this field is at an early stage of development. Various terms have been used, including: 'multiple benefits' (IEA, 2014; Kerr et al., 2017), 'multiple impacts' (Ürge-Vorsatz et al., 2016), 'non-energy benefits' (Nehler and Rasmussen, 2016; Nosperger et al., 2015) and 'co-benefits' (Balaban and Puppim de Oliveira, 2017; Ürge-Vorsatz et al., 2014). To some extent, research focussed on different sectors and at different scales tends to use different phrases. For example, 'non-energy benefits' research tends to focus on individual or sector level investments in industry, whereas 'co-benefits research' typically includes sectoral, national or international framing (Rasmussen, 2017). This project follows the IEA's use of 'multiple benefits'.

The concept of multiple benefits can be applied at different scales and in different contexts – from the negotiations about energy efficiency targets at EU level, all the way down to individual business investment decisions. Much of the literature is focused on society level benefits – with different benefits in focus depending on the project, programme or policy under consideration. For example, in addition to energy and carbon savings, Liddell et al. (2011) focus on benefits to householders, the installers and the local economy from a housing energy efficiency programme; Balaban and Puppim de Oliveira (2017) focus on health benefits to building users from sustainable buildings; while Zhang et al. (2018) calculate regional air quality benefits from more efficient cement production. From the United States, where some utility energy efficiency programmes include mandatory evaluation of 'non-energy benefits' there is a considerable literature on these benefits for utilities, participants and society (Malgrem, 2013; Skumatz, 2016).

This research project focuses on analysis and communication of the multiple benefits of energy efficiency investments to the organisations making them. Little of the multiple benefits literature focuses at this scale. As Nehler and Rasmussen note: "the concept of industrial non-energy benefits is relatively unexplored, and there is a lack of knowledge regarding their existence in industry." Firm-level benefits can include increased worker productivity, higher capital and rental values for more efficient buildings and reduced industrial maintenance and production costs (Bleyl, 2017; Kluczek and Olszewski, 2017; Nehler and Rasmussen, 2016). Other firm-level benefits could include improved public

image and customer perception and consequential marketing and communication opportunities (IEA,2014).

Within the literature, most attention has been given to quantitative assessments of multiple benefits and methods for extending the range of cost-benefit assessments. These impacts, positive and negative, range from those which are quantifiable with good quality data and agreed methodologies, to those which are intangible and hard to value. Studies using cost-benefit analysis show their value can be higher than direct energy cost savings, with monetised 'non-energy' effects up to several times the magnitude of the energy cost savings (IEA, 2014, Urge-Vorsatz et al., 2015). Work is on-going to improve assessment methodologies – for example to evaluate the multiple benefits of efficiency investments in buildings (Bozorgi, 2015; Dalla Mora et al., 2018). However, robust methodologies for many potential benefits are not yet available, for example, productivity (Chatterjee and Ürge-Vorsatz, 2017) and job creation and macro-economic effects (Blyth et al, 2014). It is widely accepted that more research is needed to provide better evaluation methodologies and evidence for many of the multiple benefits of energy efficiency.

3. Overview of Rapid Evidence Assessment methodology

We have used a rapid evidence assessment (REA) methodology for Task 2.1. This is more systematic than a literature review, and takes more time, but it has the advantage of greater rigour. Plus, because the process for an REA is more detailed than for a literature review, it is easier to share the work between a number of partners.

REAs provide a balanced assessment of what is already known about an issue, by using systematic review methods to search and critically appraise existing research. They aim to be rigorous and explicit in method and thus systematic but make concessions to the breadth or depth of the process by limiting particular aspects of the systematic review process. They are 'rapid' in comparison with 'full systematic reviews' which are expected to take 8-12 months, and can take between 2-6 months (UK Civil Service, 2014). The methodology we have used here is based on current best practice (e.g. Smithers, 2015), but adapted to work within the constraints of time and resources available.

The process of REA we have used is outlined in Figure 2. Each step is described in more detail below. The method includes stages of reflection and going back to repeat earlier steps as necessary.

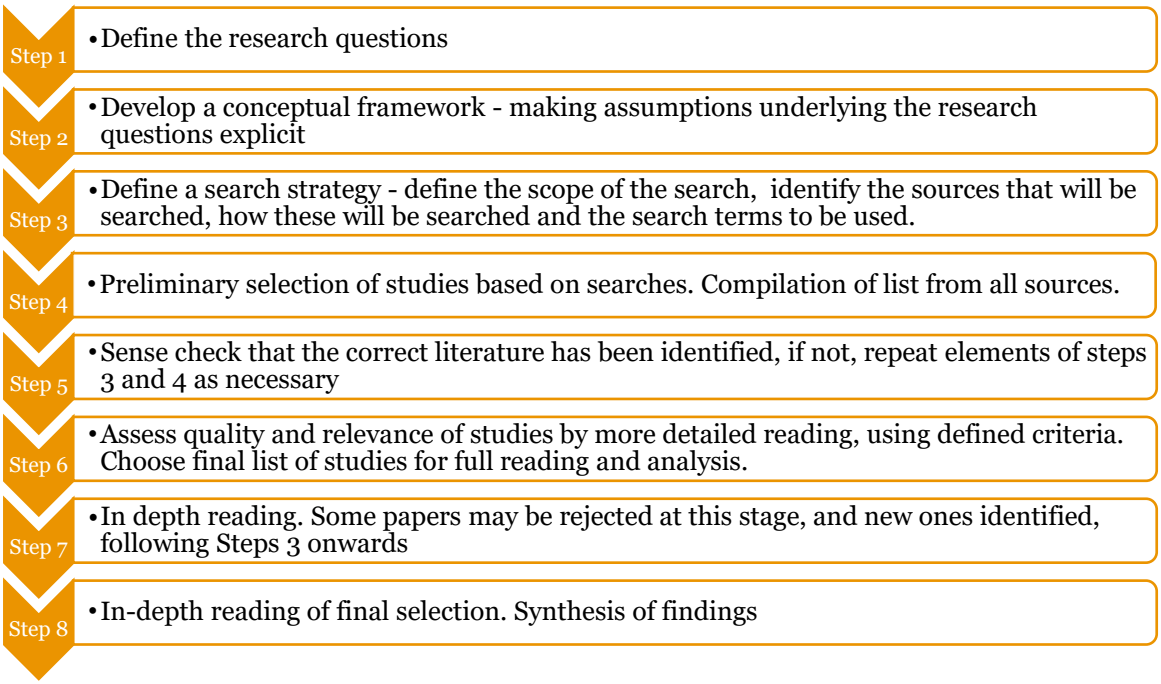

Figure 2: Summary of the Rapid Evidence Assessment method used in this study

3.1 Step 1: Research Questions

Following discussions within the research team, a set of research questions was devised. Several of these questions are closely related, and many of them may be answered by the same literature.

All questions relate only to business organisations and to analysis focused on organisation-level benefits, not benefits at a sector / regional / national level. Q1-4 are based on empirical evidence, Q5&6 are based on theory / commentary.

Q1: How has a multiple benefits approach to energy efficiency been used? What were the effects on investment decisions? Were any strategic benefits of energy efficiency specifically recognised?

Q1a. What examples of good practice or innovative use of a multiple benefits approach exist?

Q1b: What evidence is there of difficulties with implementing a multiple benefits approach (i.e. for instance, interest but lack of reliable figures, or lack of management interest, etc.)?

Q2: Are there contextual factors which seem important to the rate at which MBs are operationalised, making the use of an MB approach more/less likely (e.g. the presence/absence of a strong champion, either within the company or in an external advisory role)?

Q3: For which energy efficiency measures and technologies has the MB approach been used? How do the MBs identified differ between measures and technologies?

Q4. Does use of MB differ by company structure, company size, sector or other organisational characteristics?

Q5: How could a multiple benefits approach to energy efficiency investments in organisations be operationalised?

Q6. How could a strategic understanding of the multiple benefits approach to energy efficiency investments in organisations be operationalised?

In developing these questions, we realised it would be useful to also have agreed definitions of some key words for the project - including 'decision', 'investment' and 'strategic' - as detailed earlier.

3.2 Step 2: Conceptual framework

The conceptual framework which underpins this research can be described as two separate, but related, topics:

1. How organisations make energy-related decisions
2. How organisations make strategic investment decisions

One way of describing the purpose of this project, is that it aims to design and test tools that ensure decisions of type 1, can be included in the type 2 processes. Our hypothesis is that by identifying, quantifying (where possible) and communicating the multiple benefits of energy efficiency in a strategic way, companies will take up more energy efficiency opportunities.

Energy-related decision making

The conceptual framework about how energy-related decisions are made within organisations used here is based on that used in a previous REA investigating energy-related organisational decision-making, in which one of the M-BENEFITS team was involved (Banks et al., 2012). The framework suggests decision-making takes place in a context of social, technical and cultural interrelationships – sometimes called a "socio-technical" landscape. This is a much more complex depiction of the influences on decision-making than a simple 'rational economic decision maker' model.

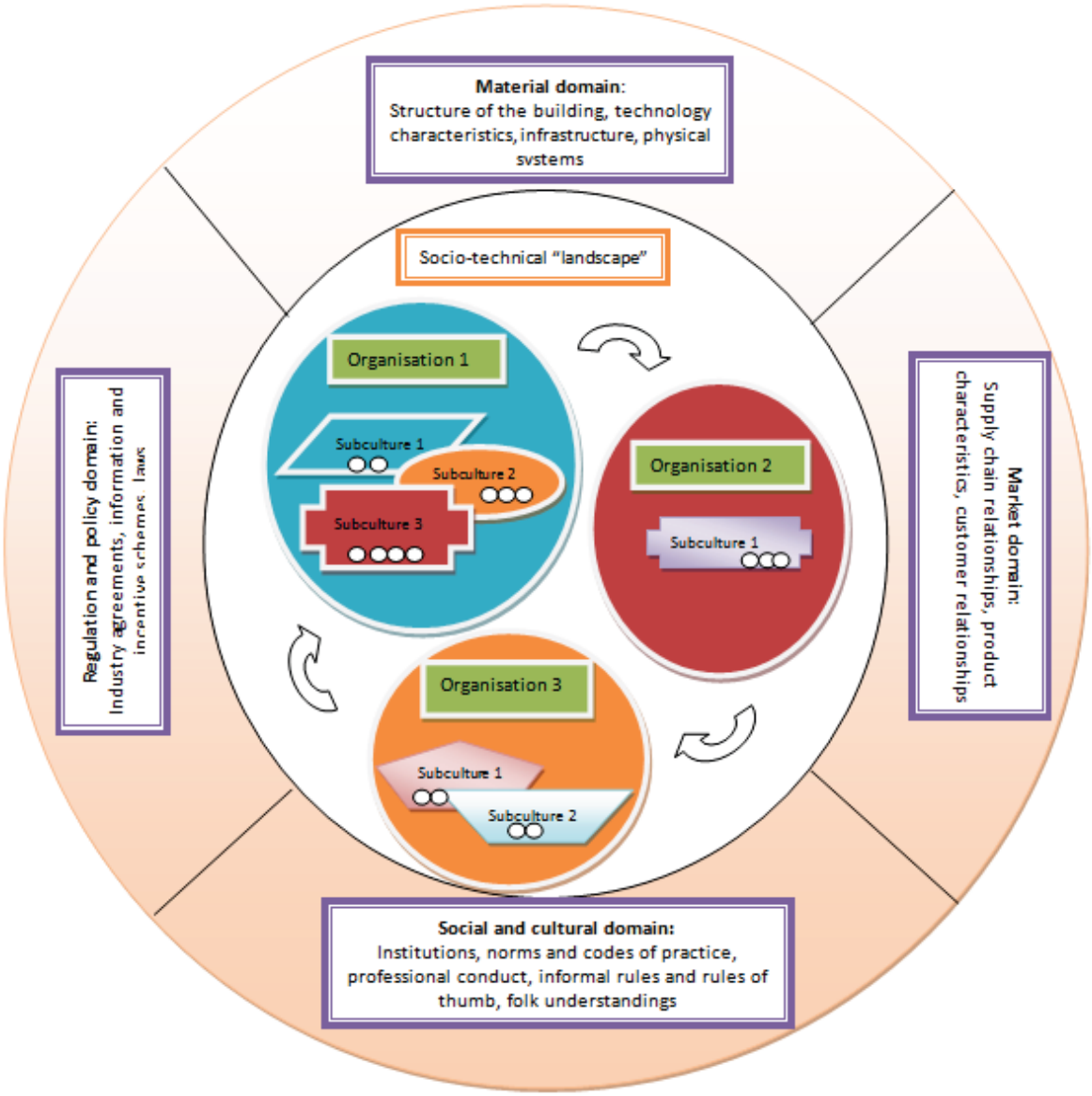

Figure 3: Conceptual framework depicting space within which energy-related decisions are made (from Banks et al., 2012)

This framework suggests that an organisation's energy behaviour is shaped by five levels of activity : 1) the decision-making and activity of individuals; 2) the interactions between the various subcultures within an organisation; 3) the independent "life" of the organisation inscribed in its procedures, history and ethos; 4) the relationships that the organisation maintains with other organisations in its supply chain; and 5) the socio-technical context constructed by the interaction of various types of factor. These are perceived and constructed by stakeholders within the organisation as a kind of "landscape" of possibility and opportunity. The process of decision-making takes place within this context of intersecting drivers and influences (Banks et al., 2012).

Understanding decision-making in this way opens up many routes to change - as well as acknowledging many barriers to change.

Strategic decision-making & competitive advantage

Strategic decisions (as discussed earlier) would be expected to deliver competitive advantage. This concept was theorized more than thirty years ago by Michael Porter (1985). Originally, it was based on the idea that an organization "must deliver greater value to customers or create comparable value at a lower cost, or do both" (Porter, 1996:2). This idea has been developed further by one of the M-BENEFITS team members (Cooremans, 2011). She argues that in the complex and rapidly changing world of today, one cannot consider only the cost of creating value. Risks of creating this value and of bringing it to customers have to be taken into account as well. Therefore, competitive advantage should not be considered as a bi-dimensional but as a tri-dimensional concept, consisting of three interrelated elements: costs, value, and risks (Figure 4). This strategic analysis of the contribution of the multiple benefits of energy-efficiency investment to competitive advantage must be rooted in energy and operational analyses.

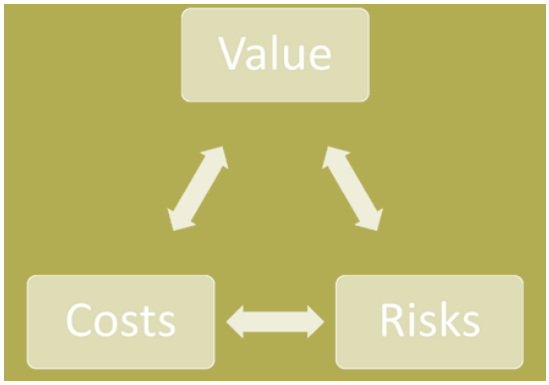

Figure 4: The three dimensions of competitive advantage (Cooremans, 2011)

This conceptualisation of what matters to high-level decision makers in business, underpins the approach to assessing and communicating multiple benefits within this project. Energy-efficiency is no longer relegated to an energy and cost-saving analysis, but rather becomes a source of revenue and a profit centre. The concept of competitive advantage provides a lens through which to analyze and communicate multiple benefits of energy-efficiency investments.

3.3 Step 3: Search strategy

Scope of the research

To carry out our searches, we set clear criteria defining what was within and outside the scope of the project.

Within scope

- All investments in energy efficiency related to the operation of firms, whether defined as innovative or not.
- Investments in energy efficiency technology.
- Energy efficiency improvements which are not physical assets - e.g. energy management programmes, employee behaviour change programmes.
- Publications from 1999 onwards.

Outside of scope:

- An overview of the prevalence of use of MB in decision-making, or a general understanding of organisational decision making.

- The agricultural sector
- The public sector and quasi-public sector (e.g. universities)
- The literature about the energy efficiency of the products and services produced by firms. Only literature about firms' decision-making around the energy use of their own operations should be included.
- The general 'barriers to energy efficiency' literature will not be a focus, unless it specifically concentrates on multiple benefits understandings of energy efficiency. However as this can be difficult to distinguish from titles only, it may be necessary to read abstracts.

Sources of information

Several types of search were carried out in order to provide broad coverage of academic and non-academic literature. These were:

- Expert identification - asking team members and members of the advisory board to identify important and relevant literature
- Database searching – mainly including academic papers in peer-reviewed journals, but also including some conference papers
- Conference proceedings – where the full proceedings of relevant conferences are not indexed in research databases, conference websites have been searched instead
- Snowballing – using the references cited in a paper to generate a new list of items for the literature review.

A description of each is given below, along with the number of relevant documents identified at Step 4 of the REA - a preliminary list of sources.

Expert identification

Expert identification produced an initial list more than 60 documents, which continues to be added to. Some of the documents in this were not found by any of the other search processes, although there was a considerable degree of overlap. Due to constrained time, this was the key way of including grey literature in the process - that is documents not within the academic or conference literature.

Database searching & key words

Three databases have been used to search for literature:

- Scopus - primarily science-based, but includes some social science & business literature
- ABI/GLOBAL Inform - business and management literature
- International Bibliography of Social Science - social science literature

Words in Table 1 were combined to generate a range of searches. Typically, three terms were needed to ensure the results are well focussed - but it depends on the words used and the sources being searched. A range of searches were run to test various synonyms and combinations. A number of these terms were not productive (i.e. did not generate useful references) and were removed after initial testing: energy demand, multiple impacts, ancilliary benefits, strategy / strategic (indicated in italics).

Most searches were conducted with an energy term, but there were some exceptions. For a complete list of all key word searches, and the number of unique papers which were identified, see Appendix 3.

Table 1: Key words used in database searches, by category

Energy terms	Multiple benefits terms	Sector terms	Strategy terms	Investment terms
Energy efficiency	Multiple benefits	Industry / Industrial	*Strategic / strategy*	Strategic investment decision-making
Energy consumption	*Multiple impacts*	Commercial	Core business	
Energy demand	Co-benefits	Business	Competitive advantage	
Energy conservation	Non-energy	Organisation / organization		
Energy management	*Ancillary benefits*	Building		
Energy productivity				

Using a range of key words, these searches have returned 68 unique papers from scanning 4,220 titles. Of those identified, 13 came from the small number of ACEEE and ECEEE conferences which have been indexed and included in the Scopus database. These conferences seem to be a very important source of literature.

Conference proceedings

A very wide range of energy, environment, evaluation and management conferences from across the world from 1999 onwards were searched for relevant papers. This was done by reading titles of conference papers and choosing those which seemed to be likely to answer one or more of the research questions. This was necessary because, with a small number of exceptions, conferences are not indexed by academic research databases. The full list of proceedings search is listed in Appendix 4.

This represents a huge body of literature and thousands of articles scanned for relevance. The conferences were chosen by expert judgement of the WP2 team. In a few cases, proceedings were not publicly available, and so could not be searched.

Snowballing

'Snowballing' is a method of finding new sources of information by looking at all the references in key sources. A snowballing method was trialled with two recent, key references as identified by expert judgement:

- Skumatz, L., 2015. NEBs: The Latest in Results, Applications, and Best Practices for State Cost-Effectiveness Tests, Proceedings of IEPEC conference, Long Beach. Available: https://www.iepec.org/wp-content/uploads/2015/papers/142.pdf
- Rasmussen, J., 2017. The additional benefits of energy efficiency investments—a systematic literature review and a framework for categorisation. Energy Efficiency 10(6) 1401-1418

The references from each paper were then converted into a list. Each list was scanned quickly and a judgement was made on each reference, according to the relevance of the paper title to the research questions of the MBENEFITS project. The lists were grouped in three categories: not relevant; potentially interesting and new; already identified in REA process.

The first paper (Skumatz 2015) had 14 references, none of which seemed useful to pursue further. The second paper (Rasmussen 2017) had 78 references, of which five seemed relevant, interesting and new; and nine had been identified previously by other means. The five new sources were accepted as candidates for inclusion in the literature review, based on their titles only. A second step was then carried out to review the abstract of these five papers. In all five cases, the paper was assessed as not being relevant enough to M-BENEFITS. The end result of this exercise was the addition of zero new papers to the M-BENEFITS database. As a result of this, it was decided not to carry out any further snowball exercises.

3.4 Step 4: Search results

After this process was complete, and the results of various searches were combined and duplicates or near duplicates (e.g. a conference paper and journal article covering the same material) were removed, there was a database of 295 documents (Table 2).

Table 2: Total number of documents found per type of search, with duplicates and near duplicates removed

Search method	Number of documents
Expert identification	42
Database searches	68
Conference proceedings	185
Snowball searches	0
Total	295

As Table 2 indicates, most documents judged to be relevant at this stage came from conference proceedings. Major sources of this initial list are shown in Table 3. The two most important conferences were a European conference focussed on energy efficiency (ECEEE summer conference) and an American conference on evaluation of energy programmes (IEPEC) - both welcome studies from around the world.

Table 3: Major sources of initial literature identified

Key sources	Number
Academy of Management Journal	4
ACEEE buildings conference	11
ACEEE industry conference	27
IAEE conference	9
ECEEE industry conference	19
ECEEE summer conference	42
Energy Efficiency	12
Energy Policy	5
IEA workshops on MB	20
IEECB conference	15
IEPEC conference	30
IEPPEC conference	16
Journal of Cleaner Production	6
Other	79
Total all sources	295

Another interesting feature of the initial literature list is the date distribution, as shown in Figure 5.

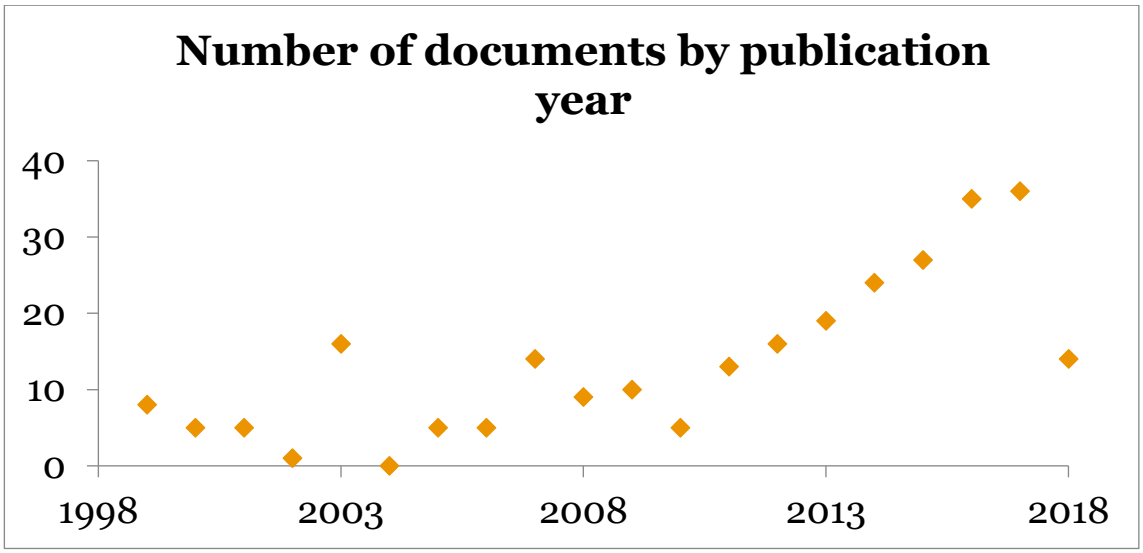

Figure 5: Number of documents in initial list, by publication year

Over half of the documents identified have been published from 2014 onwards. This demonstrates what a new field of enquiry this is (as noted in the Introduction).

3.5 Step 6: Final list of literature

Procedure

Having identified an initial list of 295 documents, the task is then to review this and choose the best 30-40 documents for a detailed reading and inclusion in the literature review. This process is iterative. In Step 6.1, all article titles and abstracts were re-read with reference to the research questions, to choose the most relevant documents. This results in about half of the 295 being discarded.

A set of quality measures were available for Step 6.2, to inform a more detailed reading of remaining papers, to choose the most useful (details in Appendix 4). However, in practice, documents were primarily chosen from a more detailed reading and comparison with the research questions and the aims of the project.

Results

As at 28 June 2018, 37 documents have been identified for full reading, analysis and synthesis. These are listed in Appendix 5. As explained in the REA process, this list may be added to, or documents may be removed, if it becomes clear there are gaps in the literature which could be filled, or if a chosen document does not answer any of our research questions on closer reading.

3.6 Step 7 & 8 - review of final list of literature

This stage of task T2.1 has not been completed. It will be completed by 31 July 2018, and reported in subsequent reports.

4. Preliminary findings

The final step of the REA - actually reviewing the literature found and answering the research questions where possible - has not yet been completed (due for completion by 31 July 2018). Therefore, full conclusions cannot be provided - the following are some thoughts on the process to date, and the types of literature found.

4.1 Selected literature

The list of 37 selected documents shows a predominance of conference papers over other types of document, with four conferences representing the principal discussion forums for the topics and research questions identified in the MBENEFITS project. These are:

- the American Council for an Energy Efficient Economy (ACEEE)
- the European Council for an Energy Efficient Economy (ECEEE) – European 'sister' to ACEEE
- the International Energy Program Evaluation Conference (IEPEC)
- the International Energy Policy and Programme Evaluation Conference (IEPPEC) – European 'sister' to IEPEC.

Taken together, these four conferences represent the publication source for 26 out of the 37 papers selected (70%). Of the remainder, ten out of 37 were papers published in peer-reviewed academic journals (27%) and just one document was a report. The split of the 37 papers by source is summarised in Figure 6.

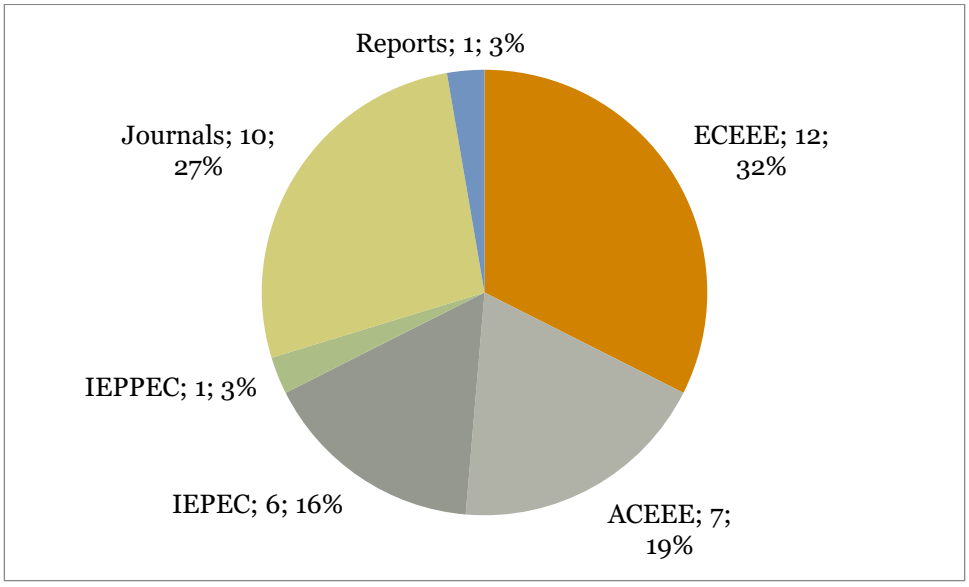

Figure 6: Publication sources/types for the 37 documents identified for detailed literature review

These conferences (ECEEE, ACEEE, IEPPEC, IPEEC) are ones which straddle the conventional boundary between purely academic meetings and purely industry-focused meetings. These are policy-relevant conferences with their own peer-review processes, where the participants represent both the academic and practitioner communities.

Across the 37 papers, most authors or co-authors had contributed to just one document. However, two authors stand out as having contributed disproportionately to this literature – Catherine Cooremans (author on 5 of the 37) and Lisa Skumatz (author on 4). Six other authors had contributed on two of the selected documents: Josefine Rasmussen, Noel Stevens, Pam Rathbun, Nick Hall, Johna Roth, Christopher Russell.

It seems reasonable, therefore, to characterise the topic of investment decision-making for energy efficiency as a topic of minority interest. The majority of that interest and discussion takes place at just four conferences around the world, and a small number of researchers and practitioners have published on this subject more than once.

4.2 Process

The REA process has been successful in generating a manageable body of literature to review in detail, given the project's time constraints. The structure imposed by the REA methodology also gave the team of collaborators in four different countries a clear framework in which to work. The subjective value judgements on the quality and relevance of resources were informed by the process and the discussions among the team.

Within the REA process, the part which seemed most problematic was academic database searching by selection and combination of keywords and search strings. This inevitably has an element of trial and error about it, especially when the search strings contain terms with more than one meaning in more than one context. There is a tension between choosing search terms with wide potential relevance and those which are much more specific: the broad terms may not be used by the authors of documents, precisely because they are rather general; but the more specific terms used instead are harder for the REA team to identify with any reliability or accuracy. This trial and error element is neatly demonstrated by the late introduction of 'energy productivity' as a search string - as suggested by one of the research team who was not undertaking the searches. This term, in combination with others, gave a higher response rate than for other terms. There remains the possibility that the literature contains other documents which would be useful to know about, but which remain hidden, because of the inherent limitations of the process.

The only safeguard that we know of against this problem is for the researchers to have a good understanding of the topic and a good degree of familiarity with the literature: in the case of MBENEFITS, the search string 'energy productivity' was only tried because of a sense among the research team that some of the relevant literature had not been identified with the earlier key word combinations.

Because of time constraints, there was not a full review of 'grey', non-academic literature - and the final list of 37 only containing one report may reflect the lack of grey literature on the long list.

4.3 Literature not found

The methodology we have used means two types of literature are likely to be under-represented:

- Business-oriented literature about including multiple benefits in strategic decision making, which does not focus on energy efficiency
- Most relevant grey literature

Business conferences were included in our search, with little of relevance found, and it may be that there is very little literature in this space. There are related literatures, such as that on corporate social responsibility, which have some connection with this topic - but were not relevant enough in answering our research questions.

There are systematic methods for discovering grey literature - including identifying key organisations and looking at their outputs, expert elicitation and snowballing. The latter two have been tried to some extent, but not thoroughly (e.g. no experts outside of the project team were consulted).

References

Balaban, O., Puppim de Oliveira, J.A., 2017. Sustainable buildings for healthier cities: assessing the co-benefits of green buildings in Japan. Journal of Cleaner Production 163: S68-78.

Banks, N., Fawcett, T., Redgrove, Z., 2012. What are the factors influencing energy behaviours and decision-making in the non-domestic sector? A rapid evidence assessment. Report by Centre for Sustainable Energy and ECI, University of Oxford. Department for Energy and Climate Change, London.

Bleyl, J., 2017. Building deep energy retrofit: Using dynamic cash flow analysis and multiple benefits to convince investors. ECEEE 2017 Summer study on energy efficiency. Belambra Les Criques, Hyeres, France.

Bozorgi, A. (2015) Integrating value and uncertainty in the energy retrofit analysis in real estate investment. Energy Efficiency, 8, pp. 1015-1034.

Blyth, W., Gross, R., Speirs, J., Sorrell, S., Nicholls, J., Dorgan, A., Hughes., N., 2014. Low carbon jobs: The evidence for net job creation from policy support for energy efficiency and renewable energy. UKERC, London.

Chatterjee, S., Ürge-Vorsatz, D., 2017. Productivity impact from multiple impact perspective. ECEEE 2017 Summer study on energy efficiency. Belambra Les Criques, Hyeres, France.

Cooremans, C., 2010. Les déterminants des investissements en efficacité énergétique des entreprises : dimensions stratégique et culturelle de la décision d'investir. Université de Genève. Thèse, 2010. https://archive-ouverte.unige.ch/unige:14997

Cooremans, C., 2011. Make it strategic! Financial investment logic is not enough. Energy Efficiency, 4 (4), pp. 473-492.

Dalla Mora T., Peron F., Romagnoni P., Almeida M., Ferreira M., 2018. Tools and procedures to support decision making for cost-effective energy and carbon emissions optimization in building renovation. Energy and Buildings 167, 200-215.

Fawcett, T., Killip, G., 2017. INBEE Project: D2.4 Intangible benefits of energy efficiency: Final report, Available: http://in-bee.com/project-results/ [Accessed November 2017].

Freed, M., Felder, F.A., 2017. Non-energy benefits: Workhorse or unicorn of energy efficiency programs? The Electricity Journal 30, 43-46.

Geller, H., Harrington, P., Rosenfeld, A.H., Tanishima, S., Unander, F., 2006. Policies for increasing energy efficiency: Thirty years experience in OECD countries. Energy Policy 34(5), 556-573

IEA, 2014. Capturing the multiple benefits of energy efficiency. International Energy Agency, Paris.

IEA, 2016. Energy, climate change and environment: 2016 insights. International Energy Agency, Available: https://www.iea.org/publications/freepublications/publication/energy-climate-change-and-environment-2016-insights.html [Accessed Jan 2018].

IRENA, 2016. Renewable energy benefits: Measuring the economics. International Renewable Energy Agency, Available: www.irena.org/DocumentDownloads/Publications/IRENA_Measuring-the-Economics_2016.pdf [Accessed Feb 2017].

Kerr, N., Gouldson, A., Barrett, J., 2017. The rationale for energy efficiency policy: Assessing the recognition of the multiple benefits of energy efficiency retrofit policy. Energy Policy 106, 212-221.

Kluczek A., Olszewski P., 2017. Energy audits in industrial processes. Journal of Cleaner Production 142, 3437-3453.

Liddell, C., Morris, C., Lagdon, S., 2011. Kirklees Warm Zone: The project and its impact on health and well-being. University of Ulster, Available: http://eprints.ulster.ac.uk/19116/1/KIRKLEES_PROJECT_and_COST_BENEFIT_REPORT.pdf [Accessed March 2016].

Mallaburn, P. S., Eyre, N., 2014. Lessons from energy efficiency policy and programmes in the UK from 1973 to 2013. Energy Efficiency 7, 32-41.

Malgrem, I., 2013. Incorporating Non-Energy Benefits into Cost-Effectiveness Screening: The Vermont Story. Proceedings of the International Energy Programme Evaluation Conference 2013, Chicago.

Nehler, T., Rasmussen, J., 2016. How do firms consider non-energy benefits? Empirical findings on energy-efficiency investments in Swedish industry. Journal of Cleaner Production 113, 472-482.

Nosperger, S., Mazoyer, J.L., Vitt, E., 2015. Making non-energy benefits a real asset and changing professionals' habits: renew the partnership approach through the DECADIESE model, ECEEE 2015 Summer study on energy efficiency. Belambra Les Criques, Hyeres, France.

Porter, M.E., 1985. Competitive advantage. New York: Free Press

Porter. M.E., 1996. What is strategy? Harvard Business Review, November-December 1996: 61-78

Rasmussen, J., 2017. The additional benefits of energy efficiency investments—a systematic literature review and a framework for categorisation. Energy Efficiency 10, 1401-1418.

Skumatz, L. 2016. Non-Energy Benefits / NEBs - Winning at Cost-Effectiveness Dominos: State progress and TRMs. Proceedings of American Council for an Energy Efficient Economy Study on Buildings.

Smithers, R. 2015. SPLICE Phase 1. A methodology for Rapid Evidence Assessments. Report for Defra. Ricardo-AEA. Available: https://www.researchgate.net/publication/306327335_SPLiCE_Phase_1_A_methodology_for_Rapid_Evidence_Assessments [Accessed June 2018]

Ürge-Vorsatz, D., Kelemen, A., Gupta, M., Chatterjee, S., Egyed, M., Reith, A., 2015. Literature review on Multiple Impact quantification methodologies. D2.1 report, COMBI project. COMBI project, Available: https://combi-project.eu/wp-content/uploads/2015/09/D2.1_LR-methodologies.pdf [Accessed January 2018].

Ürge-Vorsatz, D., Kelemen, A., Tirado-Herrero, S., Thomas, S., Thema, J., Mzavanadze, N., Hauptstock, D., Suerkemper, F., Teubler, J., Gupta, M., Chatterjee, S., 2016. Measuring multiple impacts of low-carbon energy options in a green economy context. Applied Energy 179, 1409-1426.

Ürge-Vorsatz, D., Tirado Herrero, S., Dubash, N.K., Lecocq, F., 2014. Measuring the Co-Benefits of Climate Change Mitigation. Annual Review of Environment and Resources 39, 549-582.

Zhang, S., Ren, H.,Zhou, W., Yu, Y., Chen, C., 2018. Assessing air pollution abatement co-benefits of energy efficiency improvement in cement industry: A city level analysis. Journal of Cleaner Production 185, 761-771.

Appendix 1: Database searching methodology

Three databases between them offer a very good coverage of the literature we are interested in.

Scopus

Scopus is the largest abstract and citation database of peer-reviewed literature: scientific journals, books and conference proceedings. Delivering a comprehensive overview of the world's research output in the fields of science, technology, medicine, social sciences, and arts and humanities, Scopus features smart tools to track, analyze and visualize research.

International Bibliography of the Social Sciences

The International Bibliography of the Social Sciences (IBSS) includes over 3 million bibliographic references to journal articles and to books, reviews and selected chapters dating back to 1951. It is unique in its broad coverage of international material and incorporates over 100 languages and countries. It provides cross-disciplinary coverage across the social sciences, focused on four primary subject areas: anthropology, economics, political science and sociology.

ABI/INFORM Global

ABI/INFORM Global™ is one of the most comprehensive business databases on the market, offering the latest business and financial information for researchers at all levels. It includes in-depth coverage from thousands of publications, most of them in full-text. With ABI/INFORM Global, users can find out about business conditions, management techniques, business trends, management practice and theory, corporate strategy and tactics, and competitive landscape. ABI/INFORM Global includes ABI/INFORM Archive, which offers a deep backfile of many of the most important business journals of the last century.

Inclusion of conference proceedings

- Most ACEEE Industry & buildings proceedings are NOT included in Scopus.
- Exceptions are: ACEEE Industry 2005, 2001, 1999; ACEEE Buildings 2000
- Most ECEEE Industry and Summer Studies proceedings are NOT included in Scopus.
- Exceptions are: ECEEE Industry 2016, 2014.
- ACEEE and ECEEE not indexed through ABI/INFORM Global or IBSS (also checked Web of Science - not indexed). ScienceDirect does not search conference proceedings.

Appendix 2: Results of key word searches

The following tables give results of key word searches by database. The key word combinations used are noted, as are the number of possible documents identified by the database, the number read (a maximum of 120 per key word combination, sorted to be the most relevant of those found), the number of relevant papers and finally the number of relevant papers unique to searches in that database. A final step was to merge list of papers from each database, to remove any duplicates. This means the total found across all databases is lower than the sum of those found in each individual database.

Table A2.1 Results of key word searches in Scopus database

Key words				Number of results			
	AND	AND	AND	Total	Scanned	Relevant	Unique
energy efficiency	multiple benefits	Industr*		10	10	0	
energy efficiency	multiple impact*	Industr*		1	1	0	
energy efficiency	co benefit*	Industr*		38	38	2	2
energy efficiency	non energy	Industr*		82	82	19	19
energy efficiency	ancilliary benefit	Industr*		0	0	0	
energy conservation	non energy	Industr*		29	29	5	2
energy conservation	co benefit*	Industr*		25	25	1	
energy conservation	multiple benefits	Industr*		69	69	8	4
energy conservation	multiple impact*	Industr*		2	2	0	
energy demand	non energy	Industr*		225	120	4	3
energy consumption	non energy	Industr*		480	120	3	2
energy management	non energy	Industr*		182	120	7	1
energy demand	multiple benefits	Industr*		2	2	0	
energy consumption	multiple benefits	Industr*		5	5	0	
energy demand	co benefit*	Industr*		246	120	0	
energy consumption	co benefit*	Industr*		539	120	0	
energy efficiency	co benefit*	business		18	18	0	
energy efficiency	co benefit*	commercial		5	5	0	
energy efficiency	co benefit*	building*		31	31	1	1
energy efficiency	co benefit*	organisation		164	120	0	
energy efficiency	non energy	building*		354	120	4	1
energy conservation	non energy	building*		184	120	3	0
energy conservation	multiple benefits	building*		63	63	5	0
energy efficiency	co benefit	strateg*		624	0		

energy efficiency	co benefit	strateg*	industr*	434	120	2	0
energy efficiency	co benefit	strateg*	building	326	120	3	0
energy efficiency	co benefit	core business		1	1	1	1
energy efficiency	non energy	core business		5	5	0	
energy efficiency	multiple benefit	core business		0			
energy conservation	co benefit	core business		0			
energy conservation	non energy	core business		2	2	0	
energy efficiency	co benefit	competitive advantage	11	11	0		
energy efficiency	non energy	competitive advantage	22	22	4	3	
energy efficiency	multiple benefit	competitive advantage	5	5	1	0	
energy conservation	non energy	competitive advantage	12	12	3	0	
energy conservation	co benefit	competitive advantage	3	3	0		
energy	non energy	competitive advantage	25	25	4	0	
energy productivity	industr*			89	89	9	8
energy productivity	business			40	40	2	2
energy productivity	commercial			16	16	1	0
energy productivity	building*			14	14	1	0
energy productivity	building*			371	100	3	1
energy	strategic	investment	decision-making	179	100	8	7
industr*	strategic	investment	decision-making	562	120	4	0
co benefit	strategic	investment	decision-making	4	4	0	0
benefit	strategic	investment	decision-making	322	40	1	0
building	strategic	investment	decision-making	118	118	3	1
commercial	strategic	investment	decision-making	66	66	3	0
business	strategic	investment	decision-making	44	100	5	2
organisation	strategic	investment	decision-making	322	100	3	0
ALL					2573	123	60

Table A2.2: Results of key word searches in ABI/Global Inform database

Key words				Number of results			
	OR	AND	AND	Total	Scanned	Relevant	Unique
energy efficiency	energy conservation	industr*	multiple benefits	84	84	2	2
energy efficiency	energy conservation	industr*	co benefit	250	250	3	1
energy efficiency	energy conservation	industr*	non energy	352	120	4	2

energy demand	energy management	industr*	non energy	268	120	2	0
energy demand	energy management	industr*	co benefit	24	24	0	0
energy demand	energy management	industr*	multiple benefits	40	40	1	1
energy efficiency	energy conservation	industr*	core business	320	120	4	2
energy efficiency	energy conservation	industr*	competititve advantage	1455	120	4	2
energy efficiency	energy conservation	building*	competititve advantage	1132	120	4	1
energy efficiency	energy conservation	building*	core business	270	120	3	0
energy efficiency	energy conservation	multiple benefits	core business	5	5	3	0
energy efficiency	energy conservation	non energy	core business	6	6	2	0
energy efficiency	energy conservation	co benefit	core business	4	4	1	0
energy efficiency	energy conservation	multiple benefits	competititve advantage	17	17	2	0
energy efficiency	energy conservation	non energy	competititve advantage	28	28	2	0
energy efficiency	energy conservation	co benefit	competititve advantage	15	15	2	0
ALL				4270	1193	39	11

Table A2.3: Results of key word searches in IBSS database

Key words				Number of results			
	OR	AND	AND	Total	Scanned	Relevant	Unique
energy efficiency	energy conservation	industr*	multiple benefits	12	12	1	1
energy efficiency	energy conservation	industr*	co benefit	77	77	0	0
energy efficiency	energy conservation	industr*	non energy	110	110	1	1
energy demand	energy management	industr*	non energy	90	90	2	0
energy demand	energy management	industr*	co benefit	24	24	0	0
energy demand	energy management	industr*	multiple benefits	3	3	0	0
energy efficiency	energy conservation	industr*	core business	24	24	1	1
energy efficiency	energy conservation	industr*	competititve advantage	112	112	1	1
TOTAL				452	452	6	4

Appendix 3: List of conference proceedings searched

Table 1. Table A3.1 List of conference proceedings searched

Conference	Years
European Council for an Energy Efficient Economy (ECEEE) - Summer Study	1999 - 2017 (2 yearly)
European Council for an Energy Efficient Economy (ECEEE) - Industrial Study	2012, 2014, 2016
American Council for an Energy Efficient Economy (ACEEE) - Buildings	2000 - 2016 (2 yearly)
American Council for an Energy Efficient Economy (ACEEE) - Industry	1999 - 2017 (2 yearly)
International Energy Programme Evaluation Conference (USA)	1999 - 2017 (2 yearly)
International Energy Policy & Programme Evaluation Conference (Europe)	2010-2016 (2 yearly)
International Energy Policy & Programme Evaluation Conference (Asia)	2017
International Conference on Improving Energy Efficiency in Commercial Buildings (IEECB)	2000 - 2016 (2 yearly)
Behaviour, Energy and Climate Change (BECC) (impossible to search effectively pre-2007)	2007-2017 (yearly)
International Association for Energy Economics (IAEE)	1999 - 2017 (yearly)
International Green Buildings Conference	
International Conference on Energy Production and Management	
IRMBAM-2018 (International Research Meeting in Business and Management)	2018
Academy of Management Conference	
Indoor Air Quality	2011
International Energy Agency Workshops on multiple benefits	2014, 2105 & 2018

Appendix 4: Choosing final documents for detailed analysis

Step 1

These criteria should be able to be applied quickly, needing only the title and abstract of the document to be read.

We propose the following exclusion criteria:

- Where papers with very similar content are published in different journals, exclude either the earlier paper (usually) or the paper from the less prestigious journal (if this judgement can be easily made).
- Where conference papers and journal articles have very similar content, exclude the conference paper.
- Apply the 'topic relevance' criterion from Table 1. This is the key criterion requiring researcher judgement.

Details of how the criteria listed above will be applied are given in Table A4.1.

Table 2. Table A4.1 Criteria to judge exclusion of documents

Criterion	Options	Using criterion	Judging criterion
Multiple versions of same research		Exclude oldest / less prestigious / conference article	Comparative reading of abstracts and publication location
Topic relevance	1 – tangentially relevant, addresses related research questions but not those core to MBENEFITS 2 – Directly addresses one or more of the core research questions	Exclude 1	From reading abstract in conjunction with list of research questions

Probably the 'topic relevance' criterion will exclude the highest number of papers – on the grounds that papers were given the benefit of the doubt for initial inclusion, and a closer reading of abstracts may reveal that they do not meet the standard proposed.

Depending on the number of papers identified, Step 2 may not be necessary as an additional way of reducing the number to be read in full. However, we will still want some judgement on quality - and only to include higher quality papers in the final literature review.

Step 2

Having excluded a number of papers, then intend to use a quality criterion to choose the best remaining papers. This will be done by reading the abstract and methodology section of the document.

This will be difficult to apply in a rigorous way because we are dealing with a very wide range of documents with a variety of research questions and qualitative and quantitative methodologies. The following grid for judging quality was based on extensive discussion in a previous REA project - and is for guidance.

This grid does not seek to provide a basis for all aspects of quality (e.g. transferability, replicability etc). It seeks only to provide indicators for the "trustworthiness" aspect of quality. For example, in many empirical studies trustworthiness is generally a function of

sampling (size and from where the sample is drawn) and the management of investigator bias. The various indicators reflect this. A simple definition of quality is needed so as to reduce the number of studies to a manageable level and guarantee a threshold of quality for papers to be included in the detailed analysis phase.

Table 3. Table A4.2: Base methodological quality criteria for primary research – "trustworthiness"

Study type and notes	1 - poor	2 – limited	3 - good	4 - excellent
Quantitative study type 1: Descriptive study Quantified parameters. Where confidence intervals not stated researcher to make judgement on appropriate sample size and sampling method.	Inadequate sample size (e.g. delivering confidence interval of 10% or greater at 95% confidence level) And skewed or unrepresentative sample	Small sample (e.g. delivering greater than 5% confidence interval at 95% confidence level) And skewed or unrepresentative sample but with procedures to account for this	Medium sized sample (e.g. delivering 5% or less confidence interval at 95% confidence level.) And representative sample	Large sample (e.g. delivering 2.5% or less confidence interval at 95% confidence level) And representative sample
Quantitative study type 2: Modelling Designed to establish "cause-effect" relationships between variables as in a model. Unlikely to be many - if any - papers using this method.	Inadequate sample size - less than 20 cases for each variable modelled. Unclear theoretical model based on poorly reasoned arguments	Adequate sample size - around 20 cases per variable modelled No use of randomised selection procedures (where appropriate) Theoretical model identified but not elaborated	At least 20 cases for each variable modelled. Use of randomised selection procedures (where appropriate) Probability of action calculated Well reasoned theoretical model	Large number of cases for each variable in the model Randomised case selection procedures Monte-Carlo analysis. Sensitivity analysis Well reasoned theoretical model
Quantitative study type 3: Comparisons Test effect of an intervention	Single group single point (post test only) – e.g. testing correlations within group	Non-equivalent control group (with no adjustment in analysis) or use of pre and post intervention design on same sample.	Non randomised controlled trial where comparison groups are demonstrated to be equivalent on important variables	Fully controlled randomised trial with good control

Qualitative study Case studies may be judged on these qualitative criteria	Ill considered data collection method Poorly structured data collection procedures No consideration of sample characteristics. No attempt to account for investigator bias Impacts of data collection methods not accounted for or considered No audit trail	Adequate choice of data collection method (focus groups, diaries, content analysis etc) Adequately structured data collection procedures. Some scope for bias of investigator or the data collection method to unduly influence findings and conclusions Limited diversity of sample if appropriate to research design Limited audit trail	Appropriate choice of data collection method (focus groups, diaries, content analysis etc) Formal procedures in place to structure data collection process and analyse results. Procedures robustly executed Clear evidence of purposive sampling and moderate diversity of sample if appropriate to research design Audit trail	Highly effective data collection methods Formal procedures in place to structure data collection process and analyse results. Procedures to check investigator bias. Transparent methodology and clear discussion of appropriate use of results. Clear evidence of purposive sampling. Wide diversity of sample if appropriate to research design Well referenced and documented audit trail.
Theoretical study	Poorly reasoned and referenced	Solidly referenced and reasoned account but of limited use in model building and application to answering research questions	Well reasoned and referenced. Suggests useful models and means of interpretation of empirical results	Very well reasoned and referenced. Clearly breaking new ground and suggestive of useful models and means of interpretation of empirical results

Appendix 5: List of papers for full review, 28 June 2018

This is the list as agreed on 28 June 2018. Some papers may be removed, and other added, during the process of reading and synthesising material from these articles.

Andrews, R.N.L. and Johnson, E. (2016) Energy use, behavioral change, and business organizations: Reviewing recent findings and proposing a future research agenda. *Energy Research & Social Science,* 11, pp. 195-208.

Bailey, M., Lauman, R., Wickes, G. and Crumrine, B. (2009) Get 'er Done! How to Implement Energy Efficiency Projects by Understanding Organizational Behavior and Decision Making. *ACEEE Summer Study on Energy Efficiency in Industry,* American Council for an Energy Efficient Economy.

Banks, N., Fawcett, T. and Redgrove, Z. (2012) *What are the factors influencing energy behaviours and decision-making in the non-domestic sector? A rapid evidence assessment.* London: Department of Energy and Climate Change.

Bement, D. and Skumatz, L. (2007) New Non-Energy Benefits (NEBs) results in the commercial/industrial sectors: Findings from incentive, retrofit, and technical assistance/new construction programs. *ECEEE Summer Study,* European Council for an Energy Efficient Economy, pp. 1551.

Benn, S., Crittenden, P., Brown, P.J. and Brown, D. (2014) Networks of Practice for Energy Efficiency: a Role for Boundary Objects. *AMPROC,* 2014 (1), pp. 13055.

Bozorgi, A. (2015) Integrating value and uncertainty in the energy retrofit analysis in real estate investment. *Energy Efficiency,* 8, pp. 1015-1034.

Cagno, E., Trianni, A. and Moschetta, D. (2016) Only non-energy benefits when adopting an EEM? Cases from industry. *ECEEE Industrial Summer Study Proceedings,* European Council for an Energy Efficient Economy, pp. 281.

Christiansen, I.S., Dyhr-Mikkelsen, K. and Gudbjerg, E. (2016) New robes for NEB research – open and expanding data. *ECEEE Industrial Summer Study,* European Council for an Energy Efficient Economy, pp. 417.

Cooremans, C. (2015) Competitiveness benefits of energy effciency: a conceptual framework. *ECEEE Summer Study,* European Council for an Energy Efficient Economy, pp. 123.

Cooremans, C. (2014) CAS in energy management: an innovative continuing education program as a tool to market transformation. *ECEEE Industrial Summer Study,* European Council for an Energy Efficient Economy, pp. 677.

Cooremans, C. (2012) Investment in energy efficiency: do the characteristics of investments matter? *Energy Efficiency,* 5 (4), pp. 497-518.

Cooremans, C. (2011) Make it strategic! Financial investment logic is not enough. *Energy Efficiency,* 4 (4), pp. 473-492.

Cooremans, C. and Schönenberger, A. (2017) Energy management: a key driver of energy-efficiency investment? *ECEEE Summer Study,* European Council for an Energy Efficient Economy, pp. 221.

Crittenden, P. (2012) Integrating energy efficiency into core business practices – an institutional work perspective on the implementation of energy management systems. *ECEEE Summer Study on Energy Efficiency in Industry,* European Council for an Energy Efficient Economy, pp. 697.

Fleiter, T., Hirzel, S. and Worrell, E. (2012) The characteristics of energy-efficiency measures – a neglected dimension. *Energy Policy,* 51, pp. 502-513.

Hall, N.P. and Roth, J. (2003) NON-ENERGY BENEFITS FROM COMMERCIAL AND INDUSTRIAL ENERGY EFFICIENCY PROGRAMS: ENERGY EFFICIENCY MAY NOT BE

THE BEST STORY. *2003 Energy Program Evaluation Conference, Seattle*I, nternational Energy Program Evaluation Conference, pp. 689.

Herrero, S.T., Ürge-Vorsatz, D., Arena, D. and Telegdy, Á. (2011) Co-benefits quantified: employment, energy security and fuel poverty implications of the large-scale, deep retrofitting of the Hungarian building stock. *ECEEE Summer Study,* European Council for an Energy Efficient Economy, pp. 1213.

Jakob, M. and Nutter, S. (2011) Marginal costs, cost dynamics and cobenefits of energy efficiency investments in the residential buildings sector. *ECEEE Summer Study,* European Council for an Energy Efficient Economy, pp. 829.

Larsen, P.H., Stuart, E., Goldman, C.A. and Gilligan, D. (2014) Current Policies and Practices Related to the Incorporation of Non-energy Benefits in Energy Saving Performance Contract Projects. *ACEEE Summer Study on Energy Efficiency in Buildings,* American Council for an Energy Efficient Economy, pp. 8-169.

McClain, E., Skumatz, L.A. and Jennings, J. (2007) Commissioning in public sector building – Non-Energy Benefits (NEBs), not savings, are the selling point. *ECEEE Summer Study*European Council for an Energy Efficient Economy, pp. 1073.

McGinley, K., Geary, P. and Dodenhoff, J. (2015) Striking Gold: How Innovations and Productivity Improvements in the Mining Industry Leverage Energy Efficiency Technologies. *Summer Study on Energy Efficiency in Industry,* American Council for an Energy Efficient Economy, pp. 6-1.

Nehler, T. and Rasmussen, J. (2016) How do firms consider non-energy benefits? Empirical findings on energy-efficiency investments in Swedish industry. *Journal of Cleaner Production,* 113, pp. 472-482.

Neves, L.P., Antunes, C.H., Dias, L.C. and Martins, A.G. (2005) Development of multicriteria models to classify energy efficiency alternatives. *ECEEE Summer Study,* European Council for an Energy Efficient Economy, pp. 63.

Newberger, J., Hall, N., Roth, J., Horowitz, P. and Weber, D. (2007) Custom NEBs: Are They Worth It? - Experiences, Challenges, and Directions in Massachusetts. *2007 Energy Program Evaluation Conference, Chicago*International Energy Program Evaluation Conference, pp. 701.

Pye, M. and McKane, A. (2000) Making a stronger case for industrial energy efficiency by quantifying non-energy benefits. *Resources, Conservation and Recycling,* 28 (3), pp. 171-183.

Rasmussen, J. (2014) Energy-effciency investments andthe concepts of non-energy benefits andinvestment behaviour. *ECEEE Industrial Summer Study,* European Council for an Energy Efficient Economy, pp. 733.

Russell, C. (2013) Corporate Protocols for Capital Investment: Implications for Industrial Energy Program Design. *ACEEE Summer Study on Energy Efficiency in Industry,* American Council for an Energy Efficient Economy, pp. 2-1.

Russell, C. (2009) What's in It for Me? The Financial Dynamics of Corporate Energy Management. *ACEEE Summer Study on Energy Efficiency in Industry,* American Council for an Energy Efficient Economy, pp. 2-24.

Sandberg, P. and Söderström, M. (2003) Industrial energy efficiency: the need for investment decision support from a manager perspective. *Energy Policy,* 31 (15), pp. 1623-1634.

Sandberg, T.A. (1998) Promoting and Quantifying Non-Energy Benefits — A Method to Achieve Energy Efficiency in Sweden. *ACEEE Summer Study on Energy Efficiency in Buildings,* American Council for an Energy Efficient Economy, pp. 8.289.

Skumatz, L.A. and Gardner, J. (2005) Methods and Results for Measuring Non-Energy Benefits in the Commercial and Industrial Sectors. *ACEEE Summer Study on Energy Efficiency in Industry*American Council for an Energy Efficient Economy

Stevens, N., Abdou, M., Caron, N., Robinson, J. and Rathbun, P. (2016) Life-Cycle Cost Analysis Provides Powerful Tool for Estimating Non-Energy Impacts of Energy Efficiency Measures in New Construction Programmes. *International Energy Policy & Programme Evaluation Conference,* IEPPEC

Stevens, N., Foley, L., Weber, S., Rathbun, P. and Goldberg, M. (2013) Using In-depth Interviews to Estimate Non-energy Impacts Resulting from Commercial and Industrial Energy Efficiency Measures. *International Energy Program Evaluation Conference, Chicago,* IEPEC

Tolkin, B.M., Blake, W., Titus, E., Prahl, R., Conant, D. and Hoefgen, L. (2009) What Else Does an ENERGY STAR® Home Provide? Quantifying Non-Energy Impacts in Residential New Construction. *International Energy Program Evaluation Conference, Portland,* IEPEC

Weinsziehr, T. and Skumatz, L.A. (2016) Evidence for Multiple Benefits or NEBs: Review on Progress and Gaps from the IEA Data and Measurement Subcommittee. *International Energy Policy and Programme Evaluation Conference.*

Wobus, N., Meissner, J., Barkett, B., Waldman, D., Train, K., Thacher, J. and Violette, D. (2007) Exploring the Application of Conjoint Analysis for Estimating the Value of Non-Energy Impacts. *International Energy Program Evaluation Conference, Chicago*

Woodroof, E.A., Turner, W.C., Heffington, W. and Capehart, B. (2012) Energy Conservation Also Yields: Capital, Operations, Recognition, and Environmental Benefits. *Energy Engineering,* 109 (5), pp. 7-26.