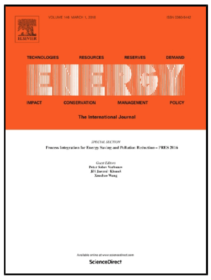
Title	Defining corporate energy policy and strategy to achieve carbon Emissions reduction Targets via energy MANAGEMENT in non-energy intensive multi-site manufacturing organisations
Author(s)	Finnerty, Noel; Sterling, Raymond; Contreras, Sergio; Coakley, Daniel; Keane, Marcus M.
Publication Date	2018-03-14
Publication Information	Finnerty, Noel, Sterling, Raymond, Contreras, Sergio, Coakley, Daniel, & Keane, Marcus M. (2018). Defining corporate energy policy and strategy to achieve carbon Emissions reduction Targets via energy MANAGEMENT in non-energy intensive multi-site manufacturing organisations. Energy. doi: https://doi.org/10.1016/j.energy.2018.03.070
Publisher	Elsevier
Link to publisher's version	https://doi.org/10.1016/j.energy.2018.03.070
Item record	http://hdl.handle.net/10379/7215
DOI	http://dx.doi.org/10.1016/j.energy.2018.03.070

Accepted Manuscript



Defining corporate energy policy and strategy to achieve carbon Emissions reduction Targets via energy MANAGEMENT in non-energy intensive multi-site manufacturing organisations

Noel Finnerty, Raymond Sterling, Sergio Contreras, Daniel Coakley, Marcus M. Keane

PII:	S0360-5442(18)30479-1
DOI:	10.1016/j.energy.2018.03.070
Reference:	EGY 12528
To appear in:	*Energy*
Received Date:	13 November 2017
Revised Date:	12 March 2018
Accepted Date:	13 March 2018

Please cite this article as: Noel Finnerty, Raymond Sterling, Sergio Contreras, Daniel Coakley, Marcus M. Keane, Defining corporate energy policy and strategy to achieve carbon Emissions reduction Targets via energy MANAGEMENT in non-energy intensive multi-site manufacturing organisations, *Energy* (2018), doi: 10.1016/j.energy.2018.03.070

DEFINING CORPORATE ENERGY POLICY AND STRATEGY TO ACHIEVE CARBON EMISSIONS REDUCTION TARGETS VIA ENERGY MANAGEMENT IN NON-ENERGY INTENSIVE MULTI-SITE MANUFACTURING ORGANISATIONS

Noel Finnerty[1,2,3], Raymond Sterling[1,2], Sergio Contreras[1,2], Daniel Coakley[1,2] & Marcus M. Keane[1,2]

[1] Informatics Research Unit for Sustainable Engineering, Department of Civil Engineering, National University of Ireland, Galway, Ireland.

[2] Ryan Institute, National University of Ireland, Galway, Ireland;

[3] Boston Scientific Corporation, Ballybrit Business Park, Galway, Ireland.

Corresponding Author: raymond.sterling@nuigalway.ie

Abstract

Research on the characteristics of long-term energy policy and associated strategies in multi-site manufacturing organisations is limited. Non-energy intensive multinationals do not face the environmental regulations required by their energy intensive counterparts, leading to missed opportunities and further widening the energy efficiency gap. This work investigates the development of a **long-term energy policy and supporting strategy** to close the energy efficiency gap focused on the inherent barriers found for non-energy intensive multi-site organisations. A systematic literature review identifies the essential components and the associated barriers/drivers to energy management. Highlights include (i) a review of energy policy guidelines and standards, (ii) an analysis of the decision-making practices, (iii) the influence of the non-energy benefits of energy-related investments and (iv) a study of six leading sustainable global organisations to identify best energy management practices. Subsequently, this work proposes a methodology to formulate a 'corporate energy policy and an associated strategy' in support of non-energy intensive multi-national manufacturing organisations by focusing on their specific characteristics and barriers. A case study is presented with findings on initial deployment in a Fortune 500 multinational corporation. Finally, conclusions are drawn and future work is proposed.

Keywords: energy policy, energy strategy, energy management, non-energy intensive, multinational, multi-site industry, corporation, carbon emissions, reduction, global energy management system

1 INTRODUCTION

1.1 Carbon emissions and energy management in industry

Carbon emissions reduction are primarily achieved either when imposed by a regulatory framework because of environmental concerns (Almutairi and Elhedhli, 2014), or when the economic and financial benefits associated with reduced emissions are clearly presented and understood by decision makers (Cooremans, 2012; Ouyang and Shen, 2017). Garrone et al. (2017) point out how stakeholders' and public's opinion can better relate to the positive effects of carbon emission reductions as opposed to an equivalent impact from resource efficiency. In any case, the most effective way for industry to achieve carbon emissions reduction, is through the implementation of energy efficiency measures, energy management and energy management systems (Costa-Campi, García-Quevedo and Segarra, 2015). In literature, these terms are sometimes used interchangeably, thus a clear definition is provided as follows

(Finnerty *et al.*, 2016) Figure 1:

- Energy Management (EM) is the systematic monitoring and control of energy related activities (Kanneganti *et al.*, 2017);
- Energy Management System (EnMS) is the procedure or strategic steps put in place to achieve effective energy management (e.g. ISO 50001 (ISO, 2011), GEMS ((Finnerty *et al.*, 2015);
- Energy Efficiency Measure (EEM) is the implementation of actions aimed at improving the efficient use of energy (Bunse *et al.*, 2011) (e.g. improve the ratio of useful output vs energy input (Herring, 2006)) under the governance of the EnMS and aligned with the pursuit of EM.

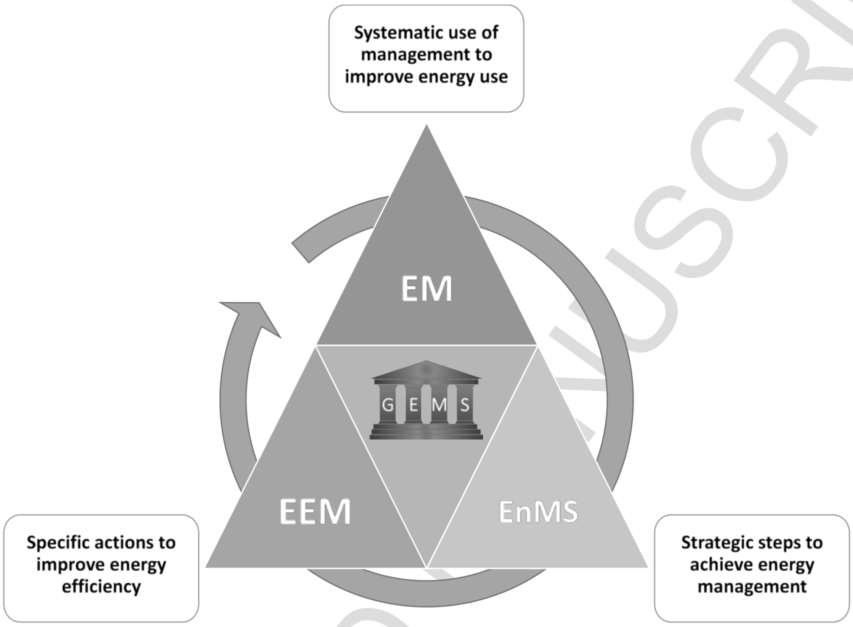


Figure 1. Energy management vs. energy management system vs. energy efficiency measure.

Recognizing energy as an asset that is managed rather than a utility that is paid for, is key to the successful implementation of systematic energy management (Sterling, 2015), (May *et al.*, 2016) leading to carbon emissions reductions and improving energy security and financial performance (Böttcher and Müller, 2014; Martí-Ballester, 2016; May, Stahl and Taisch, 2016; Sáez-Martínez *et al.*, 2016; Bergmann *et al.*, 2017).

However, even with the recognition in industry that better carbon and energy performance is linked to better financial performance, organisations still struggle to make positive investment decisions on energy efficiency measures. This remains a reality even when such measures are financially viable, contribute to lessen their impact on the environment and provide additional non-energy benefits (Contreras *et al.*, 2017). This sub-optimal performance level is referred to in literature as the "energy efficiency gap" (Thollander and Ottosson, 2010). It is a result of the interaction between energy efficiency barriers and drivers that affect a organisation's decision-making processes.

1.2 Energy management in the manufacturing sector

The manufacturing sector alone accounts for more than 98% of direct industrial green-house gases emissions (Fischedick *et al.*, 2014) and 36% of total industrial CO_2 emissions (direct and indirect) (Bunse *et al.*, 2011). Empirical research shows that carbon reduction through energy efficiency in the manufacturing sector faces barriers that affect small, medium and large organisations alike. The impact of those barriers on non-energy intensive[1] organisations is greater than on the energy intensive ones (Trianni, Cagno and Farné, 2016). This is because energy costs are a small fraction of the overall production costs in non-energy intensive organisations, leading to energy efficiency being given less importance (Yeen Chan and Kantamaneni, 2015). Moreover, as energy may not be closely related to the core business activities, energy management may not be deemed strategic, leading to a lack of senior management commitment, competition for funding with other "more important" investments, limited resources and an unstructured decision making process (Cooremans, 2011).

In implementing effective EM in organisations, international standards (e.g. ISO 50001) require the implementation of an energy policy and associated energy strategy, which may be defined as:

- Energy Policy is the documentation of the organisation's long-term vision, justification and commitment to improve its environmental performance through EM;
- Energy Strategy is the systematic approach and roadmap to achieve the targets set-out in the energy policy.

The standards, however, do not provide a clear indication on how to implement an energy strategy or policy in multi-site organisations (Finnerty *et al.*, 2015).

1.3 Energy management in non-energy intensive multi-site manufacturing organisations

For this research work, non-energy intensive multi-site (and/or multi-national) manufacturing organisations (MMO) are an interesting focus group in terms of pursuing carbon reductions through energy management because:

1. Non-energy intensive MMO rarely face the same carbon emissions environmental regulations in comparison to energy intensive industries (which have frameworks or guidelines to which organisations must align to for compliance) (Faure and Peeters, 2008). Non-energy intensive *multi-nationals* typically have several manufacturing sites spread across different countries in which they operate, and may have no legal obligations or targets to reduce CO_2 emissions;
2. Carbon emissions, in non-energy intensive MMO, are produced primarily by burning fossil fuels to generate the energy required for production (Almutairi and Elhedhli, 2014). However, given the non-strategic nature of energy in these organisations, achieving significant carbon emissions reductions through EEMs requires the focus to be outside of the production area and on the facilities infrastructure;
3. There is an opportunity for MMO to look beyond site-focused EEM's and to leverage the most suitable locations across their portfolio to maximise their carbon reduction potential (e.g. conversion to renewables matching regional limitations (Fitzpatrick and Dooley, 2017)), thus limiting the environmental impact associated with their production globally[2];
4. Due to the size and revenue volumes[3] of MMO, they are subject to higher public exposure than small to medium enterprises through corporate sustainability rankings

[1]In non-energy intensive organisation, energy costs are < 2% of the turnover or <5% of production costs (Rohdin and Thollander, 2006; Trianni, Cagno and Farné, 2016).

[2] In fact, several multi-nationals have already pledged their commitment to the Paris Agreement on Climate Change (UNFCCC, 2016) (Tabuchi and Fountain, 2017).

[3] According to the NGO Global Justice Now, in 2016, 69 of the world's 100 top economies are corporations (Green, 2016). The value of the top 10 corporations reached \$285tn, \$5tn more than the value of the bottom 180 countries (Inman, 2016). Hence, corporations (like MMO) do have more resources than most countries and their impact can be even bigger in terms of environmental sustainability given that they control the highest share of world's resources (Fitzpatrick and Dooley, 2017).

(i.e. DowJones Sustainability Index, Corporate Knights). These ratings are increasingly directing investors towards high ranked organisations. This adds incentive for these organisations to use their financial position to improve their environmental performance (i.e. reduce energy intensity, offset or emit less carbon dioxide) as part of Corporate Social Responsibility and Corporate Sustainability programmes (Martí-Ballester, 2016).

5. Multi-nationals, through corporate governance, can more efficiently achieve carbon emissions reductions when compared to geographical clusters of companies. The latter face barriers such as not having a common 'energy' language (Finnerty *et al.*, 2017) and passive participation. These barriers prevent the generation of a common problem statement (Palm and Backman, 2017) thus failing to implement effective policies.

1.4 Overview of the paper

This paper identifies the essential components of a corporate energy policy and proposes an approach to formulate the supporting energy strategies that enable non-energy intensive MMO meet global energy and carbon reduction goals. This work will contribute to further diminish the energy efficiency gap in a sustainable way as part of an overall approach to energy management, without compromising core-business operations.

The paper is structured as follows. The literature review focuses on identifying the main barriers and drivers for implementing energy management in MMO and how they are impacted by the decision-making processes. It analyses key aspects affecting non-energy intensive organisations such as, the need for highlighting non-energy benefits and the support from international standards. The literature review concludes with a summary of the gaps identified which leads to a systematic process to implement an energy policy and associated energy strategy to achieve carbon emissions reductions. The paper then proceeds to detail a methodology for the definition, implementation and continuous improvement of the energy policy and strategy. A case study is presented for a MMO. Finally, conclusions are drawn, and future work is proposed.

2 LITERATURE REVIEW

A systematic approach to the literature review has been adopted to ensure results are consistent, transparent, un-biased and replicable[4] (Tranfield, Denyer and Smart, 2003), (Schulze *et al.*, 2015). The process has been detailed in the Appendix (see section 10.1)

Peer reviewed literature on corporate energy policy and supporting energy strategies to achieve carbon emissions reductions in MMO proved scarce, especially for interventions *not involving production area*. Thus, our literature review focused on:

1. Previous empirical research on barriers, drivers and decision-making procedures that affect how MMO invest in energy management. This provides a context and background that helps tackle the main reasons for the energy efficiency gap;
2. Non-energy related benefits that need to be included in the decision-making process to create a business case around achieving carbon reductions from energy management. Since energy may not be strategic for non-energy intensive MMO, it was deemed necessary to understand how a business case can be built around energy management to engage senior management;

[4] **Databases**: ScienceDirect (Elsevier), Web of Science (Elsevier, Springer, Wiley), EBSCO. Search string: **TITLE**(energy OR sustainability OR carbon) *AND* **TITLE-ABSTR-KEY**((strategy OR strategic OR management OR policy) *AND* (industry OR industrial OR manufacturing OR corporate OR corporation OR firm OR enterprise) *AND* (efficiency OR conservation OR reduction) *AND* (factors OR barriers OR drivers))

3. International standards and *corporate literature*. Guidelines given by international standards on energy management such as ISO 500001 (ISO, 2011), Energy Star™ (US EPA, 2013) and Superior Energy Performance (SEP) (US Department of Energy, 2012) are reviewed. *Corporate literature* (including best practices) about energy policies and/or strategies already in place in a sample of manufacturing organisations revealed that in many cases, energy management is part of environmental sustainability and corporations are beginning to become aware of the need to reduce carbon emissions which is then disseminated to the public in their *sustainability reports*. Understanding the different ways that industrial leaders deal with energy management and implement international standards serves to identify the main strengths and weaknesses of the different models for achieving carbon emissions reductions.

2.1 Barriers, drivers and decision making for carbon reductions through energy management

The topic of barriers and drivers to energy management in industry has started to receive attention from the research community in recent years and a comprehensive review of papers have been published (Lee, 2015; Schulze *et al.*, 2015; May *et al.*, 2016). The focus of this research work is on identifying the key aspects that may influence MMO. Main findings are summarized below.

2.1.1 Main barriers to energy management implementation

A barrier in this context is defined as "*a postulated mechanism that inhibits investments in technologies that are both energy efficient and (apparently) economically efficient*" (Rohdin and Thollander, 2006). We have visited the main studies since 2000 on barriers for energy efficiency in the manufacturing sector (energy intensive and non-energy intensive). A summary of the barriers found in literature can be seen in the Appendix (see section 10.2). From this literature review some patterns in the barriers arise:

- Low capital availability is a recurring and relevant economic obstacle for energy efficiency investments. In large organisations (e.g. MMO), however, this low availability is mainly due to the low priority of energy efficiency. This low priority reveals organisation's strategic view on energy efficiency (Cooremans, 2012). In fact, while access to external funding and lack of own capital are reported as causes for this barrier in SME's (Cagno and Trianni, 2014)(Trianni *et al.*, 2013), opportunity costs and allocation of capital to other non-energy projects might be the reason in large enterprises (Timilsina, Hochman and Fedets, 2016).
- Risk of production disruptions are regarded as a critical barrier in both non-energy intensive (Rohdin and Thollander, 2006) (Hasanbeigi, Menke and du Pont, 2010) and energy intensive organisations (Thollander and Ottosson, 2008).
- Lack of awareness, lack of governmental initiatives (e.g. policies or financial incentives) and time to implement energy efficiency are also identified barriers (Hasanbeigi, Menke and du Pont, 2010), (Trianni, Cagno and Farné, 2016), (Cagno and Trianni, 2014), (Timilsina, Hochman and Fedets, 2016).

The way in which barriers are perceived is determined by the characteristics of the organisations, especially size (number of employees) and energy intensity. For instance, small enterprises perceive barriers more strongly than medium and large enterprises (Trianni, Cagno and Farné, 2016), because the latter tend to allocate financial and human resources more easily to energy management and energy efficiency issues (Trianni *et al.*, 2013). With respect to the energy intensity of the company, in general non-energy intensive SME and LE experience higher barriers than energy intensive counterparts (de Groot, Verhoef and Nijkamp, 2001; Trianni, Cagno and Farné, 2016). This is attributable to the higher ratio of energy costs to overall production costs in energy intensive production processes, which may lead to a higher priority of energy efficiency issues in the energy intensive organisations when compared to non-energy intensive industries.

For organisations that have overcome the identified barriers and operate with maximum energy efficiency, achieving further carbon emissions reductions, or even carbon neutrality, becomes the next strategic goal. However, different barriers arise which are linked to "*the broader regional and global society, in particular the dominant neo-classical economic system"* (Fitzpatrick and Dooley, 2017). In effect, once the energy efficiency is optimized on site, further advances on CO_2 reductions is dependent on external factors and barriers outside the organisation's direct control e.g. fuel used to produce grid electricity or the availability of renewable sources of energy. With regards to specific barriers for energy efficiency in MMO, there is a research gap in the literature reviewed where no empirical study focused on this type of company.

2.1.2 Main drivers to energy management implementation

Drivers are internal or external mechanisms that stimulate organisations to invest in energy efficiency. Drivers vary according to size and energy intensity of the company. AS with the barriers we have studied the main research in the area since 2000. Drivers to energy management implementation found in literature are summarised in the Appendix (see section 10.3).

Internal drivers are repeatedly identified in literature:

- Reduction of energy costs is perceived as the most important driver for energy efficiency. However, if energy is given a low-priority within the organisation, energy cost reduction alone may not be provide sufficient motivation to adopt energy conservation measures (Cooremans, 2012), (de Groot, Verhoef and Nijkamp, 2001). An appropriate business case or alignment of the energy efficiency measure with the core business of the organisation will achieve better perception from senior management (Bergmann *et al.*, 2017; Sa, Thollander and Cagno, 2017) resulting in implementation of the measure and ultimately leading to increased financial performance (Martí-Ballester, 2016);
- The existence of a long-term energy strategy and ambitious people within an organisation is one of the key drivers for adoption of energy efficiency measures (Rohdin and Thollander, 2006), (Thollander and Ottosson, 2008), (Rohdin, Thollander and Solding, 2007). Ambitious people driving change in energy behaviour within the organisation (albeit little researched so far) can be considered a cornerstone in successfully implementing long-term energy strategies (Andrews and Johnson, 2016);
- Awareness of the non-energy benefits (see description in section 2.2) related to an energy efficiency investment and including them in the evaluation can lead to more favourable assessments (Worrell *et al.*, 2003). Energy efficiency projects can be successfully *sold* to management if, rather than the usual financial approach, a strategic approach is taken (Cooremans, 2012) by using non-energy benefits to emphasise energy's contribution to enhance a company's competitive advantage.

External factors to the organisation were identified in literature:

- Energy prices and regulatory stringency are the most significant drivers as concluded by Garrone (2017). Interestingly, the environmental alertness of society (apart from a market pull) was not yet deemed to have a significant effect according to Garrone's study;
- The demand for eco-friendly products (market pull) is a societal driver to implementing energy efficiency (Sáez-Martínez *et al.*, 2016).
- Availability of cheap, cleaner technology (technology push, e.g., cheaper renewable

energy sources) is also one important external factor for environmental sustainability in the manufacturing industry (Sáez-Martínez *et al.*, 2016) (Horbach, Rammer and Rennings, 2012) (Rennings and Rammer, 2011).

Drivers and barriers are closely interlinked, and it is often the decision-making process and the accounting of non-energy benefits that defines whether an element can be a barrier or a driver. The next section highlights the findings in the literature about the typical decision-making practices in organisations.

2.1.3 Decision-making practices in manufacturing organisations

A decision-making process is the series of steps that enables organisations to determine whether to proceed with a given investment proposal. This process starts "*once the need for an investment in energy efficiency is identified*" (Nehler and Rasmussen, 2016) and finishes with decision.

The investment decision process plays a definitive role in the selection and implementation of energy efficiency measures in manufacturing organisations (Contreras *et al.*, 2017), (Cooremans, 2012), (Trianni, Cagno and Farné, 2016), however, "*profitability plays an important but not decisive role in investment decision-making*" (Timilsina, Hochman and Fedets, 2016). Decision-making practices are also influenced by diverse **internal factors** such as (i) the evaluation process (e.g. criteria selection), (ii) the financial assessment (e.g. fiscal rules on payback period and methods used) and (iii) the investment parameters (e.g. categorisation, strategic nature, size and complexity). In addition, **external and idiosyncratic factors** including (i) company culture, (ii) knowledge of non-energy benefits and (iii) lack of awareness (e.g. third-party contracts with suppliers) shape the decision-making processes.

Currently, a gap exists with the lack of a systematic decision-making framework and the variety/dispersion of information sources that influence it. Addressing this gap, within an effective energy strategy, embedded within the organisations policy, will lead to an increased acceptance of energy-related improvement measures.

2.2 Non-energy benefits of energy management

Non-energy benefits can be related to positive impacts on productivity (e.g. lower maintenance costs), improved public image and business continuity (May *et al.*, 2016). The list of non-energy benefits encountered in literature can be found in the Appendix (see section 10.4).

Recent research (Contreras *et al.*, 2017), is now making a strong case for understanding how non-energy benefits may drive energy management implementation as industry "*do not seem to have yet acknowledged how relevant non-energy benefits are to promote energy efficiency measures adoption*" (Trianni, Cagno and Farné, 2016), and "*lack of knowledge of how these [non-energy benefits] should be quantified and monetised*" (Nehler and Rasmussen, 2016) if the manufacturing sector is going to effectively contribute to global carbon reduction targets.

Benefits such as reduced labour and maintenance costs can be monetised to construct compelling business cases with higher savings and better financial metrics than those accounting for lower energy consumption alone (Pye and McKane, 2000). Non-energy benefits can also impact financial metrics of energy investments such as the average payback period which can be significantly reduced when the contribution of productivity related benefits is monetised (Worrell *et al.*, 2003). Non-energy benefits are considered as essential components to the business case and profitability of energy efficiency investments. Two main reasons are identified. First, improving a company's competitive advantage by connecting non-energy benefits and their contribution to core business (Cooremans, 2012), (Worrell *et al.*, 2003). Second, the potential of non-energy benefits to increase the profitability of energy efficiency projects (Worrell *et al.*, 2003), (Pye and McKane, 2000). Both lead to making energy investments strategic.

In fact, a consensus is emerging among researchers that organisations pursuing systematic and continuous EM have stronger financial performance. Sáez-Martínez (2016) conclude that establishing a corporate energy policy allows organisations to realise the full economic potential by identifying "*cost saving potentials, fostering the introduction of new cleaner production systems and other green innovations* (Horbach, 2008)". Martí-Ballester (2016) highlights how organisations implementing policies to systematically reduce carbon emissions develop new knowledge and resources that give them a competitive advantage thus opening new markets and attracting new customers which translate into short- and long-term financial performance improvements. Bergman (2017) highlights the productivity boost achieved from the implementation of energy efficiency investments which is directly associated with monetary benefits. Böttcher (2014) goes one step further by stating that there is "*no trade-off between carbon and economic performance, but that improved carbon performance leads to improved economic performance*" and that such improvements are stronger in organisations with a certified management system in place.

Despite the consensus, quantification of non-energy benefits is not a simple task. Worrell et al. (2003) highlight three main difficulties:

1. Uncertainty on the monetary value due to difficulties in evaluating non-energy benefits, especially for benefits not directly related to productivity enhancements (e.g. improving public image);
2. Lack of data at a facility level to estimate potential productivity impacts because of energy efficiency measures;
3. The existence of negative impacts related to energy efficiency projects which may be similarly difficult to quantify and could exceed the estimated benefits (i.e. production interruption during implementation).

In helping to create a business case for carbon reductions through energy management a more systematic and strategic approach to help decision makers reach positive decisions on energy efficiency measures is needed. Examples of this are given by Fleiter et al. (2012) and by Contreras *et al* (2017). While Fleiter proposes a qualitative approach that lacks a link to the impact on the core business of non-energy benefits, Contreras proposes a quantitative decision support framework for multi-site organisations. It is intended as a systematic tool to provide senior management with all relevant data to complete informed decisions.

2.3 International standards and corporate literature

2.3.1 Energy policy guidelines from international standards

For the implementation of an EnMS, standards such as ENERGY STAR™ (US EPA, 2013), ISO50001 (ISO, 2011) and SEP (US Department of Energy, 2012) offer the best available support to an individual site energy manager. The three standards closely follow the plan-do-check-act (PDCA) cycle for continuous improvement. A comparative table on how energy policy and strategy is addressed in the standards can be found in the Appendix (see section 10.5.1).

The standards recognise that energy policy is fundamental to set the direction and drive energy performance improvement through the implementation of energy management systems. These standards converge in defining energy policy as senior management's official commitment to improve energy performance in an organisation. Since SEP™ is built around ISO 50001, the energy policy requirements included in these two standards are similar. In addition, SEP™ and ISO 50001 requirements are more detailed than those provided by ENERGY STAR™. However, as such, standards present only a generic process for dealing with energy management across a broad range of industries but guidance on implementation of different aspects (e.g. energy policy and associated strategy) for certain sectors such as the non-energy intensive multinational manufacturing organisations This is a gap that this research fills.

2.3.2 Industry best practices on corporate energy policy and strategies

Multi-national organisations now consider climate change as part of normal management practices. According to the Carbon Disclosure Project (CDP), whilst integrating climate change issues into management activities was a leading behaviour in 2010, it is now a standard practice (CDP, 2015). Measurement and reduction of environmental footprint is presently a priority for the majority of senior managers in large organisations (PwC, 2016). Organisations address climate change as part of corporate sustainability and, according to specialised consultants, motivational drivers are reduction of energy use, improved reputation for sustainability and alignment with corporate goals and values (Bonini and Görner, 2011). Other motivations include customer reaction, investors' attraction, access to corporate insurances and securing positions in supply chains (PwC, 2016).

Organisations voluntarily participate in sustainability ranking processes via surveys (Corporate Knights, 2014; CDP, 2015; RobecoSAM, 2016a) aimed at recognition as leading performers in sustainability. The outcome of these rankings is followed by investors that direct resources towards top ranked enterprises (Corporate Knights, 2014; Newsweek, 2016; RobecoSAM, 2016b). Top ranked sustainable organisations are a source of best practices in energy performance improvement since part of the ranking criteria relate to energy performance and carbon emissions Six non-energy intensive corporations were studied as part of the present work. They are recognised leaders in sustainability within their industrial sector and include: Unilever plc.; Roche Holding AG; Biogen Idec Inc.; Abbott Laboratories; Agilent Technologies Inc.; Johnson & Johnson. An analysis of the energy policy practices that are being applied by the afore mentioned corporations, including information found in the Carbon Disclosure Project, is used to identify best practices on energy policy. Findings include (for dull details please refer to the Appendix in section 10.5.2):

- **Hierarchy within the organisation:** Embedded into or dependent on the Corporate Sustainability Policy.
- **Justification:** Alignment to relevant climate change efforts (e.g. Paris Agreement (UNFCCC, 2016));
- **Carbon emission scope covered by energy policy:** Scopes 1, 2 or 3 of the Green House Gas Protocol (WBCSD; WRI, 2004);
- **Duration:** Two main deadlines identified: 100% renewable energy sources (RES) for electricity by 2020; 80%-100% emissions reduction by 2050;
- **Targets:** Separate energy from CO_2 targets:
  - o Energy: Source all electricity from RES (medium term) and all energy from RES (long term);
  - o Carbon: Carbon positive or Carbon neutral;
- **Target setting methods**: 'Scientific based'.
- **Common strategies for achieving targets:** Promotion of energy efficient manufacturing; Use of renewable energy; Dedicated budget for energy and carbon reduction projects; Monetary reward for managers linked to targets' achievement; and Membership to industry advocacy initiatives.
- **Other strategies:** ISO 50001 implementation, favourable ROI requirement for energy/carbon reduction projects, operation in 'green' certified buildings, new facilities aligned to high energy efficiency standards.

At the time this review was completed, none of the six top ranked corporations used an internal price for carbon to drive investments in energy performance improvements that reduce carbon emissions. Other leading organisations in sustainability outside the MMO sector such as Walt

Disney (Carbon Disclosure Project, 2016) and Microsoft (Microsoft Corporation, 2013), do use an internal carbon pricing to provide a monetary value on the impact of carbon reductions associated with energy management. In addition, only one corporation uses carbon offsets to compensate its global carbon emissions and another has set a goal to reach a carbon positive state.

2.4 Summary of gaps for energy policy and associated strategy implementation in non-energy intensive manufacturing organisations

According to Cooremans (2011), it is expected that an energy strategy helps to create, maintain, or develop a company's competitive advantage by increasing value, reducing costs and reducing risks associated with energy issues. However, research about essential components and characteristics of such a corporate strategy are rare. For Thollander (2010) an energy strategy establishes senior management's direction regarding energy issues in the long-term and emphasizes senior management's support to energy management. It contains goals such as reduction of energy use and energy costs, in addition to the implementation of energy management systems. Furthermore, these authors surveyed the duration of long-term energy strategies in Sweden's biggest industrial energy users. They found that most of the studied organisations either did not have an energy strategy or had a short-term one (less than 3 years), even though those organisations were energy intensive. Brunke (2014), analysed energy management practices in the Swedish iron and steel industry and found that large organisations are more likely to have long-term energy strategies (> 3 years). From Cheung (2017) a parallel can be drawn between the country's leader and its government with that of a company's chief executive officer and senior management team whereby leadership (e.g. people's ambitions), political stance (e.g. climate change ideology), clear targets and policies, political stability (e.g. agreement regardless of change of governance body), and economic conditions (e.g. capital availability) determine the country's/organisation's approach to greenhouse gases emissions reductions.

None of the works reviewed so far, however, provide a clear indication on how to implement an energy strategy or policy. The literature review presented in this research work has highlighted some clear issues or gaps that need to be addressed for organisations to fully benefit from implementing carbon reduction measures. Table 1 summarises such gaps and indicates how they will be addressed through the methodology presented in Section 3 (via an Energy Policy, an Energy Strategy or both – see section 1.2 for definition).

Table 1. Summary of issues or gaps to be addressed by the methodology

Type	Issues or gaps identified	Addressed by	
		Policy	Strategy
Barrier	Low capital availability	●	●
	Low priority of energy efficiency	●	●
	Risk of production disruptions		●
	Lack of awareness	●	●
Driver	Reduction of energy costs		●
	Ambitious people	●	
	Identification of non-energy benefits		●
Decision making practice	Lack of a systematic approach to decision making		●
Non-energy benefits	Difficult quantification of non-energy benefits		●
	Lack of approach for leveraging non-energy benefits		●
International Standards Industry best practices	Generic guidelines for policy formulation and associated supporting strategies	●	●

3 METHODOLOGY

The literature review has established that 'greener' organisations have improved economic performance (*Why* do it), leading to an increased demand for improved energy related carbon performance (*What* to do).

This section proposes a methodology (*How* to do it) for the definition of a corporate energy policy and the development of an associated corporate energy strategy to achieve improved carbon and economic performance. The methodology emphasises the appropriate environment for communicating, disseminating and creating awareness of all the benefits from energy management. It can be a catalyst for organisations to become proactive and even leaders in energy management rather than reactive to regulations or public pressure.

The methodology here presented does not intend to replace the application of single-site efforts but to rather complement it with structured support from top management. The methodology, albeit theoretically applicable to any type of organisations of any size, highlights and tackles the specific barriers for non-energy intensive and multisite organisations as presented in Table 1. The most important issues that this methodology addresses, which are typically not evident in single-site energy intensive manufacturing organisations are:

- Lack of clearly defined decision-making process for energy investments: in energy intensive organisations, energy investment is at the same level as core-business investment and would have a structured decision making;
- Identification, quantification and evaluation of non-energy benefits: in energy intensive organisations, the non-energy benefits would have a much lower weight in presenting the business case for energy efficiency measures.

3.1 Corporate Energy Policy

Bottcher (2014) noted "*To systematically improve energy and carbon efficiency companies need to integrate energy management into their overall strategy, organisational structure and daily operations.*" A policy document addresses this need. In fact, the corporate energy policy should be part of the organisation's sustainability policy or plan to improve environmental performance which in turns reflects the company's mission statement and core values.

An energy policy establishes senior management's direction regarding energy issues in the long-term, emphasizes senior management's support to energy management and contains goals such as reduction of energy usage and implementation of energy management systems (Thollander and Ottosson, 2010).

The energy policy will document the justification (*Why* do it) for pursuing performance improvements and will ensure organisation's top-level commitment to achieve carbon emissions reduction targets. The policy should remove the barriers and build on the drivers identified in Section 2.1.

Based on the identified best-practices (see Section 2.3.2), Figure 2 summarises the process for developing and implementing a corporate energy policy.

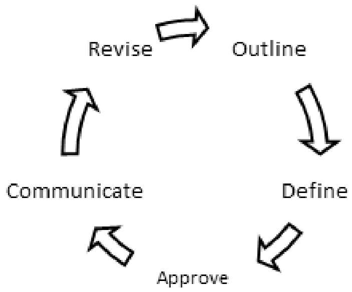


Figure 2. Energy Policy Process.

- **Outline**: a single, easy to read yet comprehensive statement is needed to outline the corporate energy policy. This statement is the first commitment of the organisation towards improving its performance and is also a key communication piece for disseminating the policy. The statement must at least show a clear performance improvement goal and deadline for achievement (e.g. carbon neutrality by 2030).
- **Define**: the next step is to define the constitutive elements of the corporate energy policy. The corporate energy policy must meet the following requirements (minimum):
    - Be aligned with the organisation's nature and strategic direction of the corporate sustainability plan;
    - Reflect the organisation's long-term vision in energy performance and carbon emissions (e.g. Alignment with global climate change efforts such as the Paris Agreement (UNFCCC, 2016));
    - Clearly define what is within the scope of the performance targets set as defined by the Greenhouse Gas Protocol (WBCSD; WRI, 2004);
    - Engage and commit senior management to the implementation of the vision;
    - Commit to the development of a roadmap to achieve the long-term vision (Corporate Energy Strategy Section 3.2);
    - Establish performance improvement as a priority and align individual sites to it;
    - Reflect the commitment to provide the necessary resources to achieve the vision;
    - Be documented;
    - Commit to internal and external communication of its goals and achievements;
    - Enact a periodic review and update process.
- **Approve**: since the energy policy presents a clear and sometimes aggressive commitment to achieving improved performances, it is paramount that it is approved, endorsed and (if possible) championed by senior management.
- **Communicate**: the energy policy must articulate and disseminate, through a common language, its commitment to employees, shareholders, the community and (internal/external) stakeholders.
- **Revise**: revise the energy policy document periodically to ensure its alignment with the corporate sustainability plan and updated global performance improvement efforts.

3.2 Corporate Energy Strategy

The corporate energy strategy should define the objectives, roadmap and enablers required deliver the long-term vision committed by the policy. In this sense, the development and implementation of a corporate energy strategy can follow the PDCA (plan-do-check-act) continuous improvement cycle. The energy strategy needs to:

1. **Plan**: define the targets to be achieved in the medium and long term;
2. **Do**: implement the roadmap and define the appropriate enablers to achieve the targets;
3. **Check**: implement metrics and continuous monitoring to verify the progress of the energy strategy implementation is aligned with the timeframe set in the plan phase;
4. **Act**: raise awareness and disseminate the strategy to involve all the organisation's stakeholders (internal and external) to provide the full support in the implementation of the strategy.

These four steps are presented in Figure 3 and defined in the following sections.

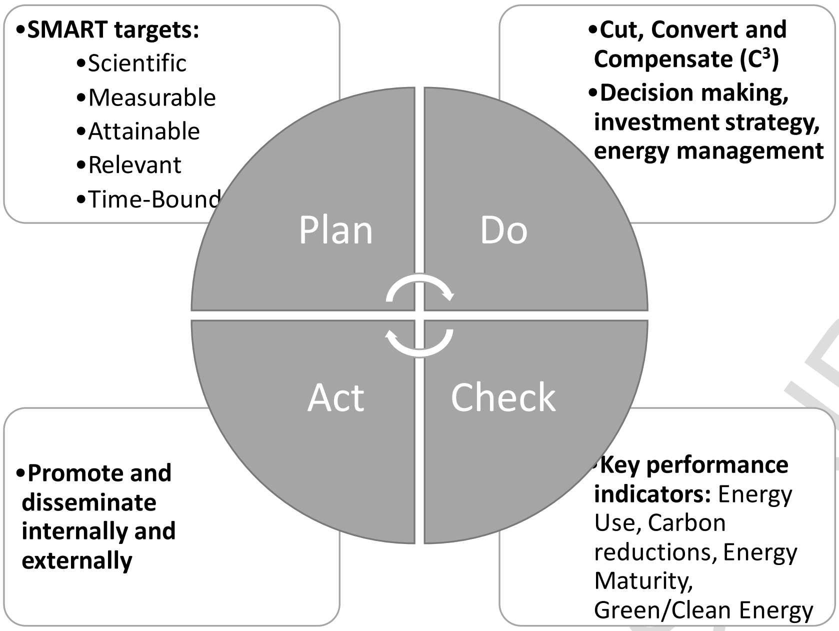


Figure 3. Implementing the energy strategy via PDCA approach

3.2.1 Plan - Set 'SMART' Targets

While the policy defines the long-term vision and associated boundary conditions (e.g. GHG protocol), best practice indicates that a staged approach to reaching the vision through long term target setting is optimal. Definition of targets is suggested to follow the 'SMART' approach (Doran, 1981): **S**cientific based, **M**easurable, **A**ttainable, **R**elevant and **T**ime bound. It is recommended to separate energy and carbon targets as follows:

- Target % renewable electricity in the medium term;
- Target % renewable energy in the long-term;
- Target % $CO_{2\text{-eq}}$ reduction in the medium term;
- Carbon neutral/positive in the long term.

It is important that exact dates are defined for the 'medium-term' and 'long-term' periods since this may then be used during the decision-making process for energy-related carbon reduction projects (Contreras *et al.*, 2017).

3.2.2 Do - Energy Strategy Roadmap

The proposed roadmap is referred to as C^3. It stands for **C**ut, **C**onvert and **C**ompensate. It is aligned to the long-term target performance requirements.

- **Cut** energy use (Bergmann *et al.*, 2017): a continuous pursuit of increased energy efficiency at a site level through EEM's (Energy Efficiency Measures). An energy audit to ASHRAE Level 2 or 3 is recommended.
- **Convert** to renewables (Fitzpatrick and Dooley, 2017):
    - o Pursue on-site generation projects where possible, owned or partnership (e.g. PPA) with Renewable Energy Certificates (RECs)[5] directly owned, negotiated into the contract or purchased elsewhere. There is the added benefit of 'engagement' from employees and local community when site based;
    - o Consider a larger-scale off-site project to cover multiple sites, e.g. large wind-

[5] 1 REC = environmental attributes of 1 MWh of renewable energy generation, also known as Environmental Attribute Certificates (EACs) or Guarantees of Origin (GOs).

turbine project. This caters for energy use where on-site is less feasible, or where the scale of on-site generation is too small;
    - Deploy a procurement strategy for acquiring/retiring Renewable Energy Certificates to make up any difference. Strategy will depend on amount needed and geographic distribution. RECs can only be used for Scope 2 emissions.
- **Compensate** unavoidable CO_2 emissions (to fully harvest non-energy benefits (Sáez-Martínez *et al.*, 2016): purchase 'Carbon offsets' (voluntary market that required 3rd party verifiers). Examples include community projects, reforestation and forest protection. 'In country or in region' projects can help with employee and local community engagement. Carbon Offsets can be used for Scope 1 or Scope 2 emissions.

It is worth noting whilst all three strands of the roadmap can be developed in parallel it is envisaged that the implementation of 'Compensate' commences when the 'Cut' & 'Convert' initiatives are mature. This is done to maximise the direct environmental impact of energy strategy implementation.

3.2.3 Do - Energy Strategy Enablers

To advance the C^3 roadmap and meet the targets outlined ultimately requires investment. The literature review highlights the gaps that currently exist in the ad-hoc decision-making practices, chiefly the lack of awareness on the full range of benefits from energy efficiency measures. To ensure optimal investment in energy efficiency, a 'Decision Support Framework' implementation (Contreras *et al.*, 2017), will allow senior management unbiased visibility to all potential EEM's from any site (Finnerty *et al.*, 2016).

The C^3 roadmap is underpinned by several enablers that provide critical inputs from management teams. The following paragraphs outline the key areas supported by enablers;

- **Decision making process**: requires defining the project selection criteria to use (e.g. financial, sustainability and business continuity criteria) and the appropriate mechanism to quantify (monetise if possible) all associated non-energy related benefits. The strategic input is from senior management and it is fed into the decision support framework. Assigning a value to 'non-energy related benefits' needs to include the impact to the sustainability targets (e.g. using carbon pricing) as well as those related to improved business reliability and reduced maintenance. Such approach helps formulate a compelling business cases by effectively communicating the link between energy improvement projects and core business activities. This is a vital stage in the process of 'levelling the playing field' between energy and other company investments. Firstly, as defining the selection criteria enables energy projects to compete independently from other business-related projects. Secondly, if there is no dedicated energy budget it is imperative that all non-energy benefits are accounted to optimise the business case. Further research on the topic of decision making for industry can be found in (Contreras *et al.*, 2017).
- **Investment Strategy**: senior management and the finance department are key players. Ideally a dedicated budget is set-aside for C^3 implementation. Even if this is not always feasible, an investment roadmap is required to deliver the strategy and policy targets. Direction is needed on the preferred company funding mechanism (e.g. own company capital vs. power purchase agreements) and on financial rules relating to payback parameters such as net present value, internal rate of return, and return on investment. The strategy needs to recognise the special features that typical energy projects exhibit (e.g. long payback times). It is recommended to fix future energy forecasting based on a set period of past performance for each site in the network. Agreement on the financial equivalent of a production disruption period (recommended one hour) is required to monetise the potential impact or improvement on business continuity associated with an EEM. Establishing accountability and links between management remuneration and

energy performance targets is also recommended to incentivise individuals.

- **Energy management system support**: The presence of an overarching energy management system that includes support for strategic initiatives is critical to achieving unbiased energy management decisions. Examples of strategic initiatives include: energy audit frequency and intensity level, energy management maturity models and yearly progression targets, alignment to independent certification bodies (e.g. LEED and ISO 50001) to ensure best practices, alignment to industry advocacy initiatives (e.g. CDP and RE100) for recognition of progress / achievements and communication of strategies (internal and external).

3.2.4 Check - Verify: Metrics and monitoring

Key performance indicators are required to track performance at an individual site and organisation level to meet policy targets. These indicators are designed to capture both quantitative (e.g. energy usage) and qualitative (e.g. energy management maturity) metrics.

3.2.5 Act - Promote and disseminate the strategy

Investment in EEM is improved by effectively communicating the link between EEM and core business activities. Alignment of policy and strategy reporting to the 'Global Reporting Initiatives' (Global Reporting Initiative (GRI), 2006) is recommended to facilitate benchmarking and sustainability mapping from organisation's sustainability reports.

4 CASE STUDY

GEMS (Global Energy Management System) (Finnerty *et al.*, 2016) is a joint industrial and academic collaboration between Boston Scientific Corporation (BSC) and the National University of Ireland, Galway (NUIG) aimed to develop a methodology that guides multi-site industrial organisations meet energy and CO_2 reduction targets. GEMS has been deployed in BSC's global network of sites and complements each individual site's energy management system. The GEMS methodology featured in Boston Scientific's 2016 Corporate Sustainability and Social Responsibility Report (Boston Scientific Corporation, 2016). BSC is a non-energy intensive multi-national manufacturing corporation in the life sciences industry.

4.1 GEMS Introduction

Over the last decade, Boston Scientific has met or exceeded established sustainability goals. The 1st set of goals were developed in 2009 and subsequently updated in 2014. In this time BSC had delivered 32% reduction in GHG emissions (Boston Scientific Corporation, 2016). Through GEMS, BSC now recognises the need to become a global leader in sustainability for non-energy intensive multi-national corporations.

The GEMS methodology (Finnerty *et al.*, 2016) results in a simplified, understandable, systematic, repeatable and scalable decision support framework that delivers optimum network performance whilst addressing the complexities unique to decision-making on capital investments in global multi-site organisations. The GEMS methodology is based on three foundation elements and four pillars as outlined in Figure 4. It is ideally positioned to implement a corporate energy policy (foundation) and associated energy strategy (pillar) as outlined in section 3.

In 2017, BSC became a climate change leader for the medical device industry by committing to carbon neutral manufacturing operations, with a goal to achieve it by 2030 underpinned by the GEMS Methodology. The announcement coincided with climate week (18-24/09/2017) and was launched at the Climate Action Group Conference in New York[6].

---

[6] https://www.theclimategroup.org/ClimateWeekNYC

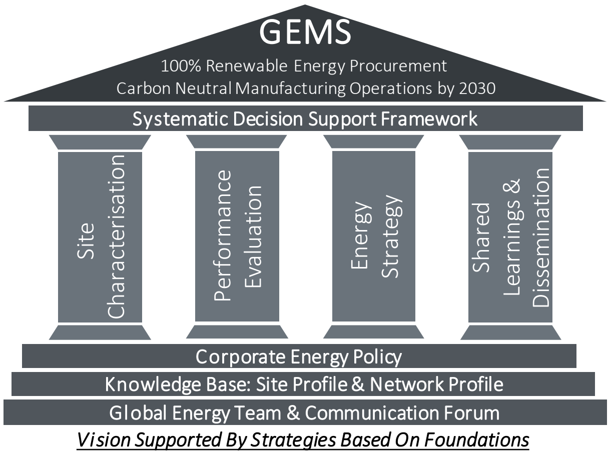


Figure 4. GEMS overview

4.2 GEMS Energy Policy foundation

BSC (GEMS) energy policy represents senior management's commitment to drive and fund optimal network energy performance and reduce carbon emissions across all its sites in support of global efforts aligned to the Paris Agreement on climate change (UNFCCC, 2016). The policy was outlined and defined by the global energy manager and has been approved by senior management.

The policy document was created following the methodology outlined in Figure 2.

- **Outline**: single page, easy to read and understand. Clear goal and timelines defined as:

Boston Scientific believes that leading environmental, health and safety performance contributes to our competitive strength and benefits our communities, customers, shareholders and employees as well as the environment. Boston Scientific is a climate change leader for the medical device industry by committing to carbon neutral manufacturing operations; it is our goal to achieve it by 2030 through our GEMS Methodology.

- **Define**: the policy document meets all the criteria outlined in the methodology stating that: *To achieve this goal the company will:*
  - *Embed our Energy Policy into the organization's corporate sustainability plan;*
  - *Align with the United Nations Framework Convention on Climate Change (UNFCCC) COP21 also known as the Paris agreement on climate change.*
  - *Agree the boundary conditions for Carbon neutrality performance targets to be Scope 1 and Scope 2 emissions as defined by the Greenhouse Gas Protocol;*
  - *Engage and commit senior management to the implementation of the vision;*
  - *Commit to the development of an energy strategy with a roadmap;*
  - *Establish performance improvement as a priority and align individual sites to it;*
  - *Provide the necessary resources.*
- **Approve**: the policy document was reviewed, approved, endorsed and championed by Vice President Global Real Estate, Facilities & EHS.
- **Communicate**: the policy document is clear and concise. It is suitable for dissemination to employees, shareholders, the community and (internal/external) stakeholders. The key elements of the policy will feature on targeted communications such as social media, company web site and individual site premises at strategic locations.
- **Revise**: the policy will be reviewed annually and updated as necessary to ensure its alignment with the corporate sustainability plan and global performance improvement efforts.

Through the policy formulation on carbon neutrality commitments BSC identified 3 main targeted stakeholders;

- **Internal:** aimed to boost employee engagement, talent acquisition and pride in the company:
- **External**: to respond to investors & customers who consider sustainability in decision-making;
- **Industry:** BSC will be a climate change leader for the medical device industry, its commitment will encourage others to follow.

4.3 GEMS Energy Strategy pillar

4.3.1 Plan - 'SMART' Targets

BSC has set the following target:

- 50% renewable electricity by 2021 (short term);
- 100% renewable electricity by 2024 (medium term);
- 90% renewable energy by 2027 (long term);
- Carbon neutral manufacturing operations by 2030 (long term).

As outlined in the policy document the boundary conditions for Carbon neutrality performance targets relate to Scope 1 and Scope 2 emissions as defined by the Greenhouse Gas Protocol (WBCSD; WRI, 2004). In the 2017 Carbon Disclosure Project report BSC recorded the following emissions as a baseline for the new targets:

- 30704 $tCO_{2\text{-eq}}$ Scope 1 emissions;
- 77990 $tCO_{2\text{-eq}}$ Scope 2 emissions.

4.3.2 Do - Energy Strategy Roadmap

Using GEMS as the framework, the 'Energy Strategy' pillar navigates the roadmap to carbon neutrality using the C^3 approach.

- **Cut** energy use: under the governance of GEMS, in 2016 alone BSC invested over US$5 million into strategic energy infrastructure yielding US$2.25 million in long term operational annual savings and reducing CO_2 emissions by over 4% (3,866t of $CO_{2\text{-eq}}$ emissions avoided).
- **Convert** to renewables: 2.5GWh of solar energy generated on site via installations in Marlborough and Quincy, Massachusetts. Further solar projects are under review in two separate locations. Kerkrade facility (Netherlands) sources all electrical power from European wind farms via REC's, resulting in net zero carbon. In addition, BSC is currently reviewing all existing energy provider contracts to assess potential for supply from renewable sources.
- **Compensate** unavoidable CO_2: BSC will review implementation of Carbon off-set projects when the 'Cut' and 'Convert' initiatives are mature.

For energy intensive organisations the business case for improving energy efficiency is obvious and directly relates to core business and revenues. For non-energy intensive organisations such as BSC this is not the case since the direct impact of EEM is of less magnitude which reduces the possibilities to creating a compelling business case unless non-energy benefits are accounted for. Here is where C^3 is necessary. We transform energy efficiency issues into carbon related issues and propose an approach to reduce and quantify carbon emissions reductions via EEM that do not require any intervention in the core business but still deliver the desired effect.

4.3.3 Do - Energy Strategy Enablers

- **Decision-making process:** under GEMS, BSC implemented a decision support framework as the cornerstone of the decision-making strategy where operation savings, sustainability targets and business continuity are part of the assessment criteria (Contreras, 2016). It is worth noting the NPV on a high impact EEM (Tri Generation plant) increased by 40% when all the non-energy benefits were accounted for. These included cost avoidance of CO_2 emissions, reduced running costs (including maintenance) of exiting HVAC equipment and business continuity improvements. The impact of a specific EEM on the overall company and site sustainability target is listed in the decision support framework results despite being already implicit in the financial outputs; such is the qualitative nature of the carbon emissions performance.
- **Investment strategy**: BSC has proposed a dedicated fund to support their long-term goals (calculated as internal carbon pricing times their carbon emissions times multiple year payback periods). This creates good practice and aligns to the 'Cut' phase of the C^3 roadmap. In addition, individual sites have the added incentive to aggressively reduce carbon footprint as after 2024 they will be charged for carbon allocation costs (via internal carbon pricing). Company capital and PPA are both used in their strategy, with PPA model typically used for longer term returns. NPV and IRR are fundamental financial metrics for project assessment. Future energy forecasting is based on the associated sites previous 5-year historical trends (unless exceptional circumstances apply). Production disruption period of 1hour is agreed on a site by site basis proportional to the overall value of the site value of production.
- **Energy management system Support:** The GEMS methodology provides the overarching energy management support to enable the energy strategy implementation:
  - Audits & Maturity Model: The GEMS energy audit and energy maturity level parameters (Finnerty *et al.*, 2017) are set by the Global Energy Management Team.
  - Independent Certifications: BSC has eleven LEED certified buildings including platinum for their global headquarters. BSC main distribution centre in Quincy, US, is ENERGY STAR certified. In 2016, the 'Newsweek Green Ranking' listed BSC in 21st position in the US, an improvement of 8 places from 2015.
  - Advocacy Initiatives: BSC is aligned to the CDP and is currently reviewing membership of RE100 to support its renewable electricity targets.

4.3.4 Check - Verify: Metrics and monitoring

GEMS utilises six enterprise level key performance indicators to track yearly performance (at an individual site and corporate level) and to disseminate the progress of the Energy Policy implementation (see Table 2)) (Boston Scientific Corporation, 2016).

Table 2. BSC Six enterprise level key performance indicators for 2016 (comparison against 2015 benchmark.

Indicator	**Definition**	**Value**
Energy Use	Tracks the total energy consumed annually to manufacture products.	367 GWh
Energy Management Maturity	An energy management maturity model to establish where in the "energy journey" each manufacturing site resides (Finnerty *et al.*, 2017)	+11%
Green Real Estate	Real estate that is independently certified for energy efficiency by industry-leading bodies.	+28%
Carbon Footprint	Total amount of scope one and scope two greenhouse gas emissions that are emitted into the atmosphere.	108,000 $tCO_{2\text{-}eq}$
Green Energy	A subset of renewable energy sources and technologies that provide the highest environmental benefit such as hydro, solar or wind.	+18%
Cleaner Energy	Energy produced from fossil fuels, but based on high-efficiency technologies such as combined heat and power (CHP)	+7%

4.3.5 Act - Promote and disseminate the strategy

GEMS utilises a dedicated pillar to perform all aspects of 'shared learning and dissemination' (Figure 4) including the communicating the energy strategy. Investment in EEM is improved by effectively communicating the link between EEM and core business activities. The communication strategy is divided in internal and external communications.

- **Internal communications** include a company-wide department newsletter annually and display screens at strategic location such as the main lobbies, which show site and global information such as the six performance indicators described in Section 4.3.4.
- **External communications** include social media, conferences and alignment of strategy to the 'Global Reporting Initiatives' (Global Reporting Initiative (GRI), 2006) to facilitate benchmarking and sustainability mapping from organisation's sustainability reports. Under the governance of GEMS, BSC submitted its first CDP Climate Change survey in 2017, aligned with the announcement of Carbon Neutrality by 2030, during Climate Week. These activities lead to inclusion in corporate sustainability rankings which in turn boosts the non-energy benefits from the implementation of energy-related carbon improvement measures by ensuring proper awareness of BSC climate related initiatives to the investment community.

5 DISCUSSION

As shown in the previous sections, the methodology is currently under a pilot study in a non-energy intensive MMO. Since the implementation and the value of EEM is not obvious (lack of awareness) for non-energy intensive MMO, these organisations might feel lost in implementing EEM. We complement energy management standards like ISO50001 with the step-by-step guide (which can also be perfectly followed by all types of organisations) that creates a business model around carbon reductions brought by the EEM and highlights the need to account for the non-energy benefits and to structure the decision-making process.

Initial results show the positive impact of coordinating energy-related carbon reduction efforts within an EM framework (GEMS) that is underpinned by policy and strategy. These include:

- Increased awareness of all the benefits associated with an EEM (especially including non-energy benefits) leads to a better business case, especially for projects that would normally not be considered given their long pay-back period and apparent low connection with core business;
- Through the systematic decision support framework and continuous improvement process it was demonstrated that energy-related projects reduce the risk of production disruptions by increasing energy security and forcing periodic assessment of the systems involved (Coffey *et al.*, 2016). This comprises another non-energy benefit;
- The presence of ambitious people in key positions within the organization, who are committed to contributing to sustainability and climate change but that are also aware of the non-energy benefits of the energy-related carbon reduction measures was key;
- Definition of metrics for a proper measurement and verification process to take place for improving the tracking of corporate and site targets;
- Enterprise-level performance indicators allow the corporation and the individual sites to understand the real impact of the energy efficiency actions and how it relates to the company's ethos;
- Making the energy strategy easy to understand to all stakeholders within and outside the company is fundamental for the successful support of everyone involved in achieving the long-term goals such as Carbon Neutrality (e.g. C^3);
- Once the commitment to become Carbon Neutral is in place it becomes strategic at corporate and individual site level. This enables the allocation of appropriate resources to

meet the medium and long-term targets (e.g. the creation of a fund to finance projects that have significant impact on GHG emissions);

- The successful implementation of GEMS within BSC transformed energy into an organization-wide priority in a corporation that otherwise would not have deemed it strategic.

6 CONCLUSIONS

There is a general trend of organisations willing to become more environmentally sustainable. However, despite this growing interest and efforts to increase businesses' responsibility, most organisations fail to effectively impact energy use and global warming.

Literature has begun to emerge on how business organisations are dealing with energy related issues. There is a growing body of knowledge that supports the positive link between increased carbon performance and a company's corporate financial performance (Böttcher and Müller, 2014; Martí-Ballester, 2016; Sáez-Martínez *et al.*, 2016; Bergmann *et al.*, 2017). This is expected to greatly improve the penetration of research and help focus the efforts required to reduce the energy efficiency gap in the long term. As stated by Bergman *et al.* (2017): "*This win-win situation also entails even more energy and non-energy related benefits and is further known as a form of low-hanging fruit*". Nevertheless, more research is still needed in this area, especially around policy initiatives that actually support organisations as opposed to produce lock-down effects (Andrews and Johnson, 2016)

A variety of different drivers stimulate enterprises to find and execute investments in energy efficiency. These drivers can be internal or external to the company and include reduction of production costs, compliance with environmental regulations on energy efficiency and CO_2 emissions or an improved sustainability record (Williamson, Lynch-Wood and Ramsay, 2006).

One of the main barriers for MMO is the lack of clear structured energy-related decision-making process that allows for an objective approach that avoids the influence of cultural or idiosyncratic factors in energy-related issues. In non-energy intensive MMO, addressing this barrier requires the creation of a link between core production and energy. This is achieved in the methodology presented in this research work, by highlighting the so called non-energy benefits of energy improvements which include reduction of maintenance costs, improved indoor air quality conditions, improved worked morale, improved worker safety, enhanced business continuity, etc.

Drivers are ineffective to overcome drivers unless MMO practice continuous energy management and have the appropriate energy management systems (Thollander and Ottosson, 2010; Trianni, Cagno and Farné, 2016) for the un-biased implementation of EEM aimed to reduced carbon emissions (Böttcher and Müller, 2014). For MMO, EM standards fail to provide clear indication on how to successfully implement EM, resulting in ad-hoc approaches typically used up to now. This leads to reduced environmental performance for MMO due to the lack of systematic approaches (e.g. decision-making processes) that efficiently articulate the organisation's efforts to become more environmentally sustainable.

The methodology presented in this research work addresses this issue since it contains the key components of a long term corporate energy policy and strategic roadmap to address the barriers and support the drivers in the implementation of EM and EnMS in MMO. The energy strategy helps reduce the gaps identified in the literature around decision making practices and the non-energy benefits. Both policy and strategy build on best practices identified from recognised leaders (within their industrial sector) in sustainability. A potential limitation in the methodology presented in this research work lies in the generic approach taken where we suggest what should be done but not how to do it. This could stop implementation of energy policies and associated strategies from organisations due to the lack of a 'recipe' for implementation. An example is that we suggest a carbon pricing is established but not what such pricing should be. An approach to quantify non-energy benefits is presented in (Contreras *et al.*, 2017).

7 FUTURE WORK

Future work will focus on analysing the long-term impact of the current pilot study under the GEMS framework. Additionally, it is foreseen to evolve the methodology to enable deployment in other MMO. The systematic decision support framework that supports the energy policy and strategy is on-going (Contreras *et al.*, 2017) and will concentrate the short-term efforts of this research work.

8 ACKNOWLEDGEMENTS

This publication has been supported in part by a research grant from Science Foundation Ireland (SFI) under Grant Number SFI/12/RC/2289 through a TP agreement between the SFI Centre for Ireland's Big Data and Analytics Research, ZuTec Inc. Ltd and Boston Scientific Corporation. The authors would like to acknowledge Boston Scientific Corporation for enabling this industrial and academic collaboration. Special thanks to Paul Donhauser, VP of Global Real Estate and Facilities, Boston Scientific Corporation.

9 REFERENCES

Almutairi, H. and Elhedhli, S. (2014) 'Modeling, analysis, and evaluation of a carbon tax policy based on the emission factor', *Computers & Industrial Engineering*. Elsevier Ltd, 77, pp. 88–102. doi: 10.1016/j.cie.2014.09.003.

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. doi: 10.1016/j.erss.2015.09.001.

Bergmann, A. *et al.* (2017) 'Hang the low-hanging fruit even lower - Evidence that energy efficiency matters for corporate financial performance', *JOURNAL OF CLEANER PRODUCTION*, 147, pp. 66–74. doi: 10.1016/j.jclepro.2017.01.074.

Bonini, S. and Görner, S. (2011) *The business of sustainability. McKinsey Global Survey results*.

Boston Scientific Corporation (2016) *2016 Corporate Sustainability and Social Responsibility Report*. Available at: https://www.bostonscientific.com/content/dam/bostonscientific/corporate/citizenship/sustainability/Boston_Scientific_CSSR_Report_2016.pdf.

Böttcher, C. and Müller, M. (2014) 'Insights on the impact of energy management systems on carbon and corporate performance. An empirical analysis with data from German automotive suppliers', *Journal of Cleaner Production*. doi: 10.1016/j.jclepro.2014.06.013.

Brunke, J.-C., Johansson, M. and Thollander, P. (2014) 'Empirical investigation of barriers and drivers to the adoption of energy conservation measures, energy management practices and energy services in the Swedish iron and steel industry', *Journal of Cleaner Production*, 84, pp. 509–525. doi: http://dx.doi.org/10.1016/j.jclepro.2014.04.078.

Bunse, K. *et al.* (2011) 'Integrating energy efficiency performance in production management - Gap analysis between industrial needs and scientific literature', *Journal of Cleaner Production*. Elsevier Ltd, 19(6–7), pp. 667–679. doi: 10.1016/j.jclepro.2010.11.011.

Cagno, E. and Trianni, A. (2014) 'Evaluating the barriers to specific industrial energy efficiency measures: an exploratory study in small and medium-sized enterprises', *Journal of Cleaner Production*, 82, pp. 70–83. doi: http://dx.doi.org/10.1016/j.jclepro.2014.06.057.

Carbon Disclosure Project (2016) 'Climate Change 2015 Information Request Walt Disney Company'.

CDP (2015) *CDP Global Climate Change Report 2015*.

Cheung, G. and Davies, P. J. (2017) 'In the transformation of energy systems: what is holding Australia back?', *Energy Policy*, 109, pp. 96–108. doi: https://doi.org/10.1016/j.enpol.2017.06.056.
Coffey, R. *et al.* (2016) 'Assessing Capital Investment on Energy Improvement Projects from a Global Energy Management Perspective : A Tri-generation Case Study', in *Proc. of 9th International Conference Improving Energy Efficiency in Commercial Buildings and Smart Communities (IEECB&SC'16)*. Frankfurt, Germany, pp. 1–9.
Contreras, S. (2016) *A multi-criteria decision method to prioritise energy improvement projects using sustainability criteria*. National University of Ireland, Galway.
Contreras, S. *et al.* (2017) 'A Systematic Decision Support Framework and Prioritization Method for Energy Projects in Industrial Organisations', in *10TH International Conference on Sustainable Energy and Environmental Protection*, pp. 17–29. doi: https://doi.org/10.18690/978-961-286-051-6.2.
Cooremans, C. (2011) 'Make it strategic! Financial investment logic is not enough', *Energy Efficiency*, 4(4), pp. 473–492. doi: 10.1007/s12053-011-9125-7.
Cooremans, C. (2012) 'Investment in energy efficiency: do the characteristics of investments matter?', *Energy Efficiency*, 5(4), pp. 497–518. doi: 10.1007/s12053-012-9154-x.
Corporate Knights (2014) *Global 100 Key performance indicators*. Available at: http://www.corporateknights.com/reports/2014-global-100/key-performance-indicators-13903955/ (Accessed: 18 September 2016).
Costa-Campi, M. T., García-Quevedo, J. and Segarra, A. (2015) 'Energy efficiency determinants: An empirical analysis of Spanish innovative firms', *Energy Policy*, 83, pp. 229–239. doi: 10.1016/j.enpol.2015.01.037.
Doran, G. T. (1981) 'There's a S.M.A.R.T. way to write management's goals and objectives', *Management Review*, 70(11), pp. 35–36.
Faure, M. G. and Peeters, M. (2008) *Climate Change and European Emissions Trading: Lessons for Theory and Practice*. Edward Elgar Publishing.
Finnerty, N. *et al.* (2015) 'Development of a Global Energy Management System for non-energy intensive multi-site industrial organisations: A methodology', *Energy*. Elsevier Ltd, 136, pp. 16–31. doi: 10.1016/j.energy.2016.10.049.
Finnerty, N. *et al.* (2016) 'Development of a Global Energy Management System for non-energy intensive multi-site industrial organisations: A methodology', *Energy*, (Forthcoming). doi: http://dx.doi.org/10.1016/j.energy.2016.10.049.
Finnerty, N. *et al.* (2017) 'An energy management maturity model for multi-site industrial organisations with a global presence', *Journal of Cleaner Production*. Elsevier B.V., In Press. doi: 10.1016/j.jclepro.2017.07.192.
Fischedick, M. *et al.* (2014) *Industry*, *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, United Kingdom and New York, NY, USA. Available at: http://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_chapter10.pdf.
Fitzpatrick, J. J. and Dooley, P. (2017) 'Holistic view of CO2 reduction potential from energy use by an individual processing company', *Renewable & Sustainable Energy Reviews*, 77, pp. 336–343. doi: 10.1016/j.rser.2017.04.038.
Fleiter, T., Hirzel, S. and Worrell, E. (2012) 'The characteristics of energy-efficiency measures – a neglected dimension', *Energy Policy*, 51, pp. 502–513. doi: http://dx.doi.org/10.1016/j.enpol.2012.08.054.
Garrone, P., Grilli, L. and Mrkajic, B. (2017) 'The energy-efficient transformation of EU business enterprises: Adapting policies to contextual factors', *Energy Policy*, 109, pp. 49–58. doi: https://doi.org/10.1016/j.enpol.2017.06.054.
Global Reporting Initiative (GRI) (2006) *Sustainability reporting guidelines*. Available at:

https://www.globalreporting.org/resourcelibrary/G3.1-Guidelines-Incl-Technical-Protocol.pdf.

Green, D. (2016) *The world's top 100 economies: 31 countries; 69 corporations*, *From Poverty to Power*. Available at: https://oxfamblogs.org/fp2p/the-worlds-top-100-economies-31-countries-69-corporations/ (Accessed: 4 October 2017).

de Groot, H. L. F., Verhoef, E. T. and Nijkamp, P. (2001) 'Energy saving by firms: decision-making, barriers and policies', *Energy Economics*, 23(6), pp. 717–740. doi: 10.1016/S0140-9883(01)00083-4.

Harris, J., Anderson, J. and Shafron, W. (2000) 'Investment in energy efficiency: a survey of Australian firms', *Energy Policy*, 28(12), pp. 867–876. doi: http://dx.doi.org/10.1016/S0301-4215(00)00075-6.

Hasanbeigi, A., Menke, C. and du Pont, P. (2010) 'Barriers to energy efficiency improvement and decision-making behavior in Thai industry', *Energy Efficiency*, 3(1), pp. 33–52. doi: 10.1007/s12053-009-9056-8.

Herring, H. (2006) 'Energy efficiency - A critical view', *Energy*, 31(1 SPEC. ISS.), pp. 10–20. doi: 10.1016/j.energy.2004.04.055.

Horbach, J. (2008) 'Determinants of environmental innovation-New evidence from German panel data sources', *Research Policy*, 37(1), pp. 163–173. doi: 10.1016/j.respol.2007.08.006.

Horbach, J., Rammer, C. and Rennings, K. (2012) 'Determinants of eco-innovations by type of environmental impact - The role of regulatory push/pull, technology push and market pull', *Ecological Economics*. Elsevier B.V., 78, pp. 112–122. doi: 10.1016/j.ecolecon.2012.04.005.

Inman, P. (2016) 'Study: big corporations dominate list of world's top economic entities', *The Guardian*, 12 September. Available at: https://www.theguardian.com/business/2016/sep/12/global-justice-now-study-multinational-businesses-walmart-apple-shell.

ISO (2011) 'ISO 50001:2011 - Energy management systems — Requirements with guidance for use', p. 16.

Kanneganti, H. *et al.* (2017) 'Specification of energy assessment methodologies to satisfy ISO 50001 energy management standard', *Sustainable Energy Technologies and Assessments*. Elsevier, 23(August 2016), pp. 121–135. doi: 10.1016/j.seta.2017.09.003.

Lee, K.-H. (2015) 'Drivers and Barriers to Energy Efficiency Management for Sustainable Development', *Sustainable Development*, 23(1), pp. 16–25. doi: 10.1002/sd.1567.

Martí-Ballester, C.-P. (2016) 'Sustainable energy systems and company performance: Does the implementation of sustainable energy systems improve companies' financial performance?', *Journal of Cleaner Production*. doi: 10.1016/j.jclepro.2016.12.015.

May, G. *et al.* (2016) 'Energy management in manufacturing: From literature review to a conceptual framework', *Journal of Cleaner Production*. Elsevier Ltd, (December), pp. 1–26. doi: 10.1016/j.jclepro.2016.10.191.

May, G., Stahl, B. and Taisch, M. (2016) 'Energy management in manufacturing: Toward eco-factories of the future – A focus group study', *Applied Energy*, 164, pp. 628–638. doi: 10.1016/j.apenergy.2015.11.044.

Microsoft Corporation (2013) *The Microsoft carbon fee : theory & practice*.

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. doi: 10.1016/j.jclepro.2015.11.070.

Newsweek (2016) *2016 Newsweek Green Rankings: FAQ*. Available at: http://europe.newsweek.com/2016-newsweek-green-rankings-faq-464496?rm=eu.

Ouyang, J. and Shen, H. (2017) 'The choice of energy saving modes for an energy-intensive manufacturer considering non-energy benefits', *JOURNAL OF CLEANER PRODUCTION*, 141, pp. 83–98. doi: 10.1016/j.jclepro.2016.08.142.

Palm, J. and Backman, F. (2017) 'Policy network creation as a driver of energy-efficient industry', *INTERNATIONAL JOURNAL OF ENERGY SECTOR MANAGEMENT*, 11(1), pp. 143–157. doi: 10.1108/IJESM-10-2015-0004.
PwC (2016) *17th Annual Global CEO Survey. Business success beyond the short term: CEO perspectives on Sustainability*. Available at: http://www.pwc.com/gx/en/sustainability/ceo-views/assets/pwc-ceo-summary-sustainability.pdf.
Pye, M. and McKane, A. (2000) 'Making a stronger case for industrial energy efficiency by quantifying non-energy benefits', *Resources, Conservation and Recycling*, 28(3–4), pp. 171–183. doi: 10.1016/S0921-3449(99)00042-7.
Rennings, K. and Rammer, C. (2011) 'The Impact of Regulation-Driven Environmental Innovation on Innovation Success and Firm Performance', *Industry & Innovation*, 18(3), pp. 255–283. doi: 10.1080/13662716.2011.561027.
RobecoSAM (2016a) *RobecoSAM ' s Corporate Sustainability Assessment Companion*.
RobecoSAM (2016b) *The Sustainability Yearbook 2016*.
Rohdin, P. and Thollander, P. (2006) 'Barriers to and driving forces for energy efficiency in the non-energy intensive manufacturing industry in Sweden', *Energy*, 31(12), pp. 1836–1844. doi: http://dx.doi.org/10.1016/j.energy.2005.10.010.
Rohdin, P., Thollander, P. and Solding, P. (2007) 'Barriers to and drivers for energy efficiency in the Swedish foundry industry', *Energy Policy*, 35(1), pp. 672–677. doi: http://dx.doi.org/10.1016/j.enpol.2006.01.010.
Sa, A., Thollander, P. and Cagno, E. (2017) 'Assessing the driving factors for energy management program adoption', *Renewable and Sustainable Energy Reviews*, 74, pp. 538–547. doi: https://doi.org/10.1016/j.rser.2017.02.061.
Sáez-Martínez, F. J. *et al.* (2016) 'Drivers of sustainable cleaner production and sustainable energy options', *Journal of Cleaner Production*, 138, Part, pp. 1–7. doi: https://doi.org/10.1016/j.jclepro.2016.08.094.
Schulze, M. *et al.* (2015) 'Energy management in industry – a systematic review of previous findings and an integrative conceptual framework', *Journal of Cleaner Production*. Elsevier Ltd, 112, pp. 3692–3708. doi: 10.1016/j.jclepro.2015.06.060.
Sterling, R. (2015) *Self-aware buildings: an evaluation framework and implementation technologies for improving building operations*. National University of Ireland, Galway.
Tabuchi, H. and Fountain, H. (2017) 'Bucking Trump, These Cities, States and Companies Embrace Accord', *The New York TImes*, 2 June, p. A12. Available at: https://www.nytimes.com/2017/06/01/climate/american-cities-climate-standards.html.
Thollander, P. and Ottosson, M. (2008) 'An energy efficient Swedish pulp and paper industry – exploring barriers to and driving forces for cost-effective energy efficiency investments', *Energy Efficiency*, 1(1), pp. 21–34. doi: 10.1007/s12053-007-9001-7.
Thollander, P. and Ottosson, M. (2010) 'Energy management practices in Swedish energy-intensive industries', *Journal of Cleaner Production*, 18(12), pp. 1125–1133. doi: 10.1016/j.jclepro.2010.04.011.
Timilsina, G. R., Hochman, G. and Fedets, I. (2016) 'Understanding energy efficiency barriers in Ukraine: Insights from a survey of commercial and industrial firms', *Energy*, 106, pp. 203–211. doi: http://dx.doi.org/10.1016/j.energy.2016.03.009.
Tranfield, D., Denyer, D. and Smart, P. (2003) 'Towards a methodology for developing evidence-informed management knowledge by means of systematic review *', *British Journal of Management*, 14, pp. 207–222. doi: 10.1111/1467-8551.00375.
Trianni, A. *et al.* (2013) 'Barriers to industrial energy efficiency in foundries: a European comparison', *Journal of Cleaner Production*, 40, pp. 161–176. doi: http://dx.doi.org/10.1016/j.jclepro.2012.08.040.
Trianni, A., Cagno, E. and Farné, S. (2016) 'Barriers, drivers and decision-making process for

industrial energy efficiency: A broad study among manufacturing small and medium-sized enterprises', *Applied Energy*, 162, pp. 1537–1551. doi: http://dx.doi.org/10.1016/j.apenergy.2015.02.078.
UNFCCC (2016) *The Paris Agreement - United Nations Framework Convention on Climate Change*. Available at: http://unfccc.int/paris_agreement/items/9485.php (Accessed: 27 October 2016).
US Department of Energy (2012) 'Superior Energy Performance Certification Protocol', *SEP resource*.
US EPA (2013) *ENERGY STAR Guidelines for Energy Management Overview*. U.S. Environmental Protection Agency.
WBCSD; WRI (2004) *The Green House Gas Protocol: A Corporate Accounting and Reporting Standard*. Available at: http://www.ghgprotocol.org/files/ghgp/public/ghg-protocol-revised.pdf.
Williamson, D., Lynch-Wood, G. and Ramsay, J. (2006) 'Drivers of environmental behaviour in manufacturing SMEs and the implications for CSR', *Journal of Business Ethics*, 67(3), pp. 317–330. doi: 10.1007/s10551-006-9187-1.
Worrell, E. *et al.* (2003) 'Productivity benefits of industrial energy efficiency measures', *Energy*, 28(11), pp. 1081–1098. doi: 10.1016/S0360-5442(03)00091-4.
Yeen Chan and Kantamaneni, R. (2015) *Study on Energy Efficiency and Energy Saving Potential in Industry and on Possible Policy Mechanisms*. Available at: https://ec.europa.eu/energy/sites/ener/files/documents/151201 DG ENER Industrial EE study - final report_clean_stc.pdf.

10 APPENDIX

10.1 Literature review process

A systematic approach to the literature review has been adopted to ensure results are consistent, transparent, un-biased and replicable (Tranfield, Denyer and Smart, 2003), (Schulze *et al.*, 2015). The process followed during the literature review is presented in Figure 5.

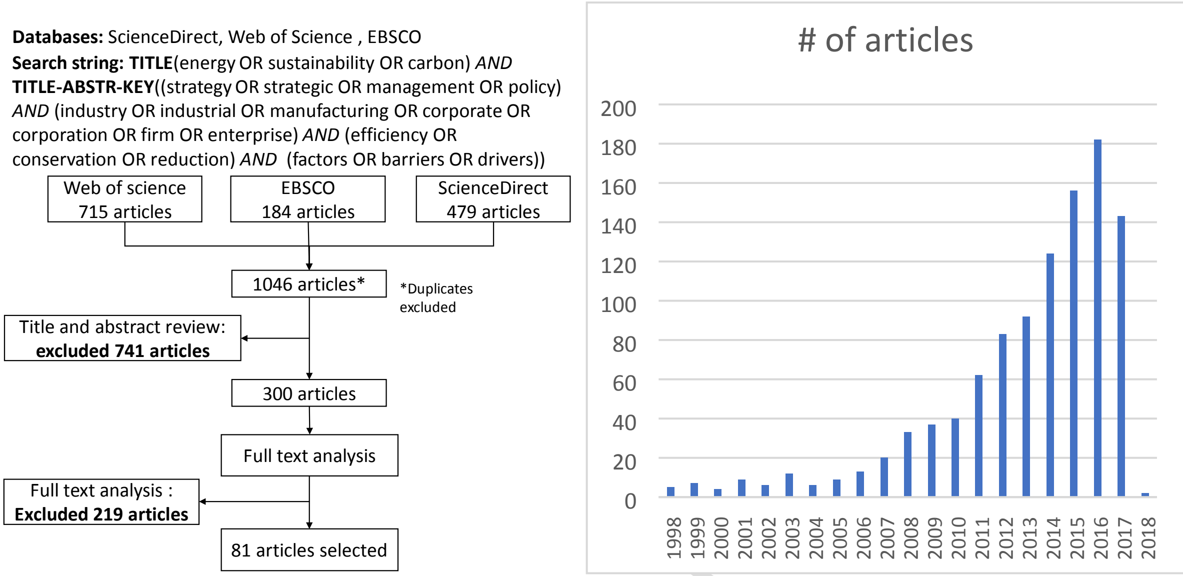


Figure 5. Systematic literature search - Process summary and number of articles per year.

10.2 Barriers

Since 1998, empirical studies have provided evidence about the barriers that prevent cost-effective energy efficiency projects from being executed in manufacturing organisations. Previous research revealed that barriers vary according to both the characteristics of the organisation (e.g. size, energy intensity and sector) and the energy efficiency measure (e.g. risk of production disruption, implementation and technical requirements). Table 3 highlights the empirical and country-specific studies which mainly focus on energy intensive manufacturing SME and LE (e.g. foundries, pulp and paper), with some exploring non-energy intensive manufacturing organisations (e.g. electronics, textiles).

Table 3. Summary of barriers to energy efficiency projects in manufacturing organisations.

Sample Size	Organisation Type and Country	Year	Principal barriers	Ref
15	Manufacturing of all sizes - Sweden	2017	Access to capital; time and expertise; awareness and uncertainty; practice characteristics; risks; complexity	(Sa, Thollander and Cagno, 2017)
509	Energy intensive Industrial ME and LE & commercial ME - Ukraine	2016	Lack of government policies, high upfront investment, higher cost of capital and higher opportunity costs for energy efficiency projects, need of government permits to deploy energy efficiency.	(Timilsina, Hochman and Fedets, 2016)
222	Manufacturing all sizes - Italy	2016	High investments costs; hidden costs; low ROI; lack of information; lack of awareness;	(Trianni, Cagno and Farné, 2016)

Sample Size	Organisation Type and Country	Year	Principal barriers	Ref
			other priorities	
n/a	Energy intensive metalworking SE - Italy	2014	Other priorities; Implementing the intervention; Lack of time; Low capital availability	(Cagno and Trianni, 2014)
35	Manufacturing and commercial, all sizes - Switzerland	2006/ 2007	Other priorities ("more important investments")	(Cooremans, 2012)
16	Manufacturing SME - Thailand	2008	Other priorities; High investment costs; Cost of production disruption; Lack of government incentives	(Hasanbeigi, Menke and du Pont, 2010)
40	Energy intensive manufacturing SME - Sweden	2007	Risks and costs of production disruptions; Lack of time, Other priorities; High investment costs	(Thollander and Ottosson, 2008)
8	Non-energy intensive manufacturing all sizes - Sweden	2006	Risks and costs of production disruptions; Cost of obtaining information, Other priorities; High investment costs	(Rohdin and Thollander, 2006)
135	Manufacturing and horticultural all sizes – The Netherlands	1998	Other investments more important; Technology can only be implemented after existing technology has been replaced; Energy costs are not sufficiently important; Energy efficiency has low priority	(de Groot, Verhoef and Nijkamp, 2001)
100	Industrial all sizes - Austria	1997	Low ROI; Long payback periods; Auditors assessment inaccurate; Energy Efficiency often overlooked	(Harris, Anderson and Shafron, 2000)

10.3 Drivers

Drivers vary according to size and energy intensity of the company. Table 4 contains a summary of the principal drivers identified in the reviewed literature.

Table 4. Summary of drivers to energy efficiency projects in manufacturing organisations

Sample Size	Organisation type - Country	Year	Principal drivers	Ref
256	Industry in general - EU	2017	External factors: regulations; high energy prices; societal awareness	(Garrone, Grilli and Mrkajic, 2017)
222	Manufacturing SME and LE - Italy	2016	Economic external: Public subsidies, private financing; Economic internal: Energy cost reductions, information about real costs; Regulatory internal: Long-term energy strategy; Informative internal: Knowledge on non-energy benefits	(Trianni, Cagno and Farné, 2016)
16	Manufacturing SME - Thailand	2008	Reducing energy costs; Long-term strategy for energy efficiency; Improving compliance with	(Hasanbeigi, Menke and du Pont, 2010)

Sample Size	Organisation type - Country	Year	Principal drivers	Ref
			regulations; Improving product quality;	
40	Energy intensive manufacturing SME - Sweden	2007	Reducing energy costs; People with real ambition, Long-term strategy for energy efficiency.	(Thollander and Ottosson, 2008)
8	Non-energy intensive manufacturing ME and LE - Sweden	2006	Long-term energy strategy; Increasing energy prices; People with real ambition	(Rohdin and Thollander, 2006)
135	Manufacturing and horticultural ME and LE – Netherlands	1998	Green image for the company	(de Groot, Verhoef and Nijkamp, 2001)

10.4 Non-energy benefits

Table 5 provides a summary of non-energy benefits that have been reported in literature.

Table 5. Summary of examples of non-energy benefits of energy efficiency investments.

Non-energy benefits and categories	Ref
Waste: Use of waste fuels, heat, gas; Reduced product waste; Reduced waste water; Reduced hazardous waste; Materials reduction; Costs of environmental compliance; **Emissions:** Reduced dust emissions; Reduced CO, CO_2, NO_x, SO_x emissions; **Operation & Maintenance:** Reduced need for engineering controls; Lowered cooling requirements; Increased facility reliability; Reduced wear and tear on equipment/machinery; Reductions in labour requirements; **Production:** Increased product output/yields; Improved equipment performance; Shorter process cycle times; Improved product quality/purity; Increased reliability in production; worker safety; **Working environment:** Reduced need for personal protective equipment; Improved lighting; Reduced noise levels; Improved temperature control; Improved air quality; **Other:** Decreased liability; Improved public image; Delaying or Reducing capital expenditures; Additional space; Improved worker morale.	(Worrell *et al.*, 2003) (Pye and McKane, 2000) (Nehler and Rasmussen, 2016)

10.5 International standards and corporate literature

10.5.1 International standards

The ENERGY STAR™ programme was established in the United States in 1992 by EPA. It is focused on the energy efficiency of products, homes, buildings, industrial plants and organisations. ENERGY STAR™ provides a certification based on the achievement of actual energy performance levels for a specific facility and provides guidance as per the steps to take for the development of energy management programs. ISO 50001, released by the ISO in 2011 focuses on an organisation's ability to manage their energy sources and energy use. It provides a framework that enables organisations to improve their understanding of their energy use and consumption and subsequently improve their energy performance and reduce carbon emissions. SEP™ – *Superior Energy Performance*®- is a certification program established by DOE in 2007. SEP™ promotes and verifies superior improvements in energy management and performance in industrial facilities that have already achieved ISO 50001 certification.

Table 6. Comparison of energy policy guidelines in ISO 50001, ENERGY STAR™, and SEP™

ENERGY POLICY	**ISO 50001**	**ENERGY STAR™**	**SEP™**
Description	- An energy policy is the organisation's commitment to achieve energy performance improvement. - It is a driver for implementing and improving an EnMS and energy performance within the scope and boundaries of the organisation.	- An energy policy formalises senior management's support for the organisation's commitment to energy efficiency. - It provides the foundation for setting performance goals and integrating energy management. - It articulates the organisation's commitment to energy efficiency for employees, shareholders, the community and other stakeholders.	- An energy policy is senior management's statement of management's intentions with respect to an organisation's energy performance. - It sets the direction for energy management activities and provide the framework for using energy objectives and targets to achieve energy performance improvements.
Organisational level responsible for approval	Senior management	- CEO or head of the organisation	Senior management
Steps for implementation	- Not provided	- (1) Drafting by Energy Director - (2) Approval	-(1) Drafting -(2) Approval -(3) Communication of the energy policy
Requirements	- (1) Alignment with company's nature. - (2) Commitment to continual improvement in energy performance. - (3) Commitment to provide the information and resources required to achieve targets. - (4) Compliance with legislation and regulations on energy efficiency and energy use. - (5) Framework for setting and reviewing objectives and targets. - (6) Support for purchase of energy	- (1) **State an objective:** Have a clear, measurable objective that reflects the organisation's commitment, culture and priorities. - (2) **Establish accountability:** Institute a chain-of-command, define roles in the organisation, and provide the authority for personnel to implement the energy management plan. - (3) **Ensure continuous improvement**: Include provisions for evaluating and updating the policy to reflect changing needs	- (1) The energy policy must state senior management's commitments to: • achieving continual improvement in energy performance • ensuring the information and resources needed to meet energy objectives and targets • compliance with applicable legal requirements and other energy-related requirements subscribed to by an organisation - (2) The energy policy must support: • the purchasing of energy efficient products and services, and • energy performance improvement in design activities. - (3) The energy policy must appropriate to the nature and extent of the organisation's energy use and consumption

ENERGY POLICY	ISO 50001	ENERGY STAR™	SEP™
	efficient products and services, and design for energy performance improvement. - (7) Documentation and communication of the policy at all levels within the organisation. - (8) Regular revision & update.	and priorities. - (4) **Promote goals**: Provide a context for setting performance goals by linking energy goals to overall financial and environmental goals of the organisation.	- (4) Senior management must take ownership of the energy policy and: • assure the policy is aligned with the strategic direction of the organisation. • approve the policy via signature or recorded meeting decision. • communicate the energy policy to establish energy as an organisational priority. • regularly review and update the policy if necessary.

10.5.2 Corporate literature

Top ranked sustainable organisations are a source of best practices in energy performance improvement. Since part of the ranking criteria relate to energy performance, their sustainability assessments cover energy related issues (see Table 7). Six non-energy intensive corporations were studied as part of the present work. They are recognised leaders in sustainability within their industrial sector. Table 8 presents the MMO investigated with the main findings from corporate sustainability reports issued in 2016.

Table 7. Criteria used in corporate sustainability rankings that relate to energy performance

Ranking	Criteria	Weight on the overall ranking
Newsweek's Green Ranking (Newsweek, 2016)	Combined Energy Productivity	15%
	Combined GHG Productivity (Scope 1 &2)	15%
RobecoSAM (RobecoSAM, 2016b)	Environmental dimension (Operational eco-efficiency, Environmental Policy and Management Systems and others)	10%*
Corporate Knights (Corporate Knights, 2014)	Energy Productivity	8%
	Carbon Productivity (Scope 1 &2)	8%

* For Healthcare industries (Life Science, Healthcare equipment, Biotechnology, Pharmaceuticals)

Table 8. Summary of industrial best practices for non-energy intensive sustainability leading organisations

Company		**Unilever plc.**	**Roche Holding AG**	**Biogen Idec Inc.**	**Abbott Laboratories**	**Agilent Technologies Inc.**	**Johnson & Johnson**
Sector		Personal care / food	Health care	Health care	Health care	Health care	Health care
No. sites worldwide		261	20	4	Not available	16	256
Sustainability Ranking	*DJSI 2016*	Leader Food products	Leader Pharma	Leader Biotechnology	Leader Health Care Equipment	Leader Life Sciences Tools & Services	Health care yearbook
	CNs 2016	22	Not ranked	1	Not ranked	53	18
	NGR 2016	7	25	11	284	Not ranked	19
Organisation Energy policy hierarchy		Part of CS Policy			Aligned with CS	Part of CS Policy	Aligned with CS
Energy Policy justification	*Alignment to COP21*	●					●
	Climate change	●	●	●	●	●	●
	Regulations	●	●			●	●
Carbon emission scope		Scope 1 & 2					
Target setting method				Scientific Based			Scientific Based
Energy related targets	*100% renewables*	Electricity by 2020; Energy by 2030		Electricity by 2020			Energy by 2050
	Reduction of energy consumption		15% by 2025 below 2015			10% by 2024 below 2014 level	
Carbon related targets	*Reduction of carbon emissions*	Carbon positive by 2030	15% by 2025 below 2015	80% by 2020 below 2006 level	40% by 2020 below 2010 level	10% by 2024 below 2014 level	20% by 2020 & 80% by 2050 below 2010
Strategies	*Use of clean energy*	●	●		●	●	●
	ISO 500001 EnMS			●	●		●
	Energy efficient new facilities	●		●			●
	LEED certification			●			●
	Dedicated budget for energy/carbon projects	●			●	●	●
	Lower ROI for energy/carbon projects		●		●		●
	Use of internal price for carbon / carbon offsets	Implicit (no offsets)	None	None (carbon offsets)	None	None	None
	Monetary reward for targets' achievement	Top management & relevant managers	all employees	Relevant managers	Senior Management	Environmental Managers	Top management & relevant managers
	Initiatives Membership	RE100; CDP	CDP	CDP	CDP	CDP	RE100; CDP