How do Companies Certified to ISO 50001 and ISO 14001 perform in LEED and BREEAM Assessments?

Abstract:

Energy and environmental standards, like ISO 50001 and ISO 14001, have a significant influence on the sustainable performance of companies worldwide, while international sustainable building rating systems are often the chosen method to quantify and benchmark performance. This research aims to comprehensively evaluate and assess the performance of these standards in relation to both the LEED and BREEAM assessments. Based on a clearly defined methodology, each standard topic and assessment criteria are comprehensively evaluated and discussed in detail. The main outcome of this research is that through a combination of these standards, a minimum of a LEED Gold or a very good, four-star BREEAM certification is achievable. Furthermore, the highest potential areas for improvement in companies with mature standards are highlighted as well as recommendations for companies with less mature standards and projects in the design and planning phase.

Keywords:

- ISO 50001
- ISO 14001
- LEED
- BREEAM
- Energy and Environmental Standards
- Green Building Certification

1. Introduction:

International standards and certifications are often major driving factors for quality, effectiveness and performance improvements across industries (Orji 2019). These documents layout the foundations for efficient performance and highlight areas of significant value and importance to achieve the goal of improved development and operation of the systems they influence. This can have a substantial effect on a countries overall energy use as well as their potential to meet emissions targets (Vandyck et al. 2018). The industrial sector accounted for 38% of global total final energy use in 2016 (OECD/IEA 2018). The same sector in Ireland accounted for approximately 21% of total final energy use in 2017 (Howley et al. 2018), further emphasising the value of improving performance in this area. Energy and environmental standards are especially valuable throughout the full lifecycle of a building, development or industrial network. The structured and defined layout from planning and design phase, through construction and operations can be vital in ensuring structures are designed, operated and eventually deconstructed or re-purposed in the most resource and environmentally friendly way (Doan et al. 2017). Significant benefits can be achieved by implementing energy and environmental management systems, from reducing energy consumption and CO_2 emissions (Marimon and Casadesús 2017) to the reduction of resources used and cost benefits associated with this (Systems 2001). Furthermore, by following the structured format of these documents many organisations can improve their awareness and develop more effective energy consumption methods and future plans (Laskurain et al. 2017).

The Technical Committee of the International Organisation for Standardisation (ISO) initially released a document to standardise the formulation and use of an environmental management system (EMS) in 1996. This document was revised in 2004 and again for re-release in 2015 presenting the standard "Environmental Management Systems – Requirements with guidance for use" (ISO 14001) (CEN I.S. EN ISO 2015). The aim of this document is to outline a defined procedure to design, implement and continually improve a company's EMS. Detailed within the document is a structured and well defined "Plan-Do-Check-Act" (PDCA) cycle, which is used to ensure a highly performing system is upheld throughout its operation (Comoglio and Botta 2012). By guiding the user through setting up an EMS, the standard ensures the potential for continued improvement and further benefits throughout its lifecycle. The main motivations for ISO 14001 certification include reduction in CO_2 and other environmentally harmful emissions, overall reduction and more effective use of resources, economic gains both short and long term as well as a stronger connection with all stakeholders (Raines 2002). The proactive approach of this standard ensures decisions made are in the best interests of all involved and will maintain the overarching goal of continual improvement (Systems 2001). This standard assumes a particularly all-encompassing role as it aims to optimise the balance between the three pillars of sustainability, the environment, society and economy. As such it has been developed to accommodate any project, regardless of size across a multitude of aspects throughout its life from planning to operation and eventual decommissioning (CEN I.S. EN ISO 2015). Through regular re-evaluation and procedural auditing, the goals of this standard can be consistently achieved. Thus, ensuring the continual improvement of environmental performance across all areas.

In Ireland the first energy management system (EnMS) standard developed to ensure that energy management was integrated into organisational business structures was I.S. 393:2005 (Solutions 2009) following on from the first European standard released in Denmark, DS 2403: 2001 (Laskurain et al. 2017). These were superseded by the European Standard EN 16001:2009 (Laskurain et al. 2017) as the main industry standard promoting the implementation of an EnMS. Until 2011, when the ISO compiled a comprehensive document called "Energy management systems – Requirements with guidance for use" (ISO 50001). This was later superseded by an updated version of the same in 2018 (CEN I.S. EN ISO 2018). The aim of the ISO 50001 standard is to present a universally adoptable framework for companies, building operators and small businesses alike to implement and achieve energy savings and emissions reductions (Science et al. 2018). By categorically guiding the user through the implementation of an effective EnMS, the standard creates a strong platform for further work. Based on these developed foundations, emphasis is heavily placed on maintaining an ethos of continual improvement and stakeholder engagement. Therefore, ensuring savings and value are extracted throughout the entire lifecycle of the project (Marimon and Casadesús 2017). The document aims to fully evaluate and continually improve all aspects of performance, from energy use, efficiency and optimised consumption (CEN I.S. EN ISO 2018). In practice, this standard follows a systematic and data-driven approach to setup, operation and improvement, similarly to ISO 14001 it is based on a well-defined and structured PDCA cycle. This ensures all actions are thoroughly evaluated, fully accountable and easily scaled and repeated across a project (CEN I.S. EN ISO 2018), as transparent and effective monitoring of energy systems is integral to the continued development and

improvement of energy performance (Javied et al. 2018). The standardisation of this process and well-documented protocols within this standard present a valuable asset to the continued energy performance of all buildings, companies and projects around the world.

As the push for sustainability and energy efficiency measures increases year upon year many large companies are making the effort to lead this development (Brem et al. 2020). In Ireland, commitment to the environment is slowly becoming the norm with trends showing increased responsibility across companies in relation to defined policies, practices and performance (Ireland 2014). Statistics show that even companies without certifications, like ISO 14001, are putting schemes in place to ensure their systems are run at a high environmental standard (Ireland 2014). This is driven by the significant environmental and economic gains being achieved by companies who have achieved ISO certifications (Marimon and Casadesús 2017)(Bansal and Bogner 2002). In addition to the clear environmental benefits and recorded cost savings of over 20% (Jovanović and Filipović 2016), the Irish government has encouraged the largest energy consumers, the Large Industry Energy Network (LIEN) (Sustainable Energy Authority of Ireland 2017), to improve their performance. This is done through initiatives to support the implementation of the EU Directives, like the "Energy Efficiency Obligation Scheme" (Ireland 2017). Other significant multinational companies bolster their commitment to sustainability through self-driven declarations and performance schemes. There is an abundance of examples available of large companies demonstrating their self-imposed commitments to exceptional environmental and social performance (Solutions 2019). As a result, many large corporations develop their own in-house or company specific sustainable energy best practices (SEBP's) as a guideline for all areas, like the management of boilers, chillers, compressed air, motors and pumps, air handling, lighting and on-site generation as well as management practices and continuous improvement. These best practice guidelines are generally maintained and distributed for reference within the defined structures of the specific company. Thus, ensuring a high level of energy and environmental performance is consistently achieved across all aspects within their control. This defined structure guarantees that all projects, both new and existing have an approved guideline to work to, consequently maintaining the company's overall commitment to excellence in energy and environmental performance.

Additional certifications have been developed over time to assess and quantify the performance of projects and buildings around the world. In 1998 the U.S. Green Building Council (USGBC) launched their first version of the Leadership in Energy and Environmental Design (LEED) rating scheme (Doan et al. 2017). This assessment protocol has continually advanced to meet the demands of today's environment as demonstrated by the various updates and resources available on their website (USGBC 2019). As a result, this protocol has become one of the leading programs for building assessments across their lifecycle, from initial design to construction and continued maintenance and operation (Mattoni et al. 2018). The diversity from its market driven New Construction (LEED NC) (Wallhagen et al. 2013) to its expansive Existing Building Operation and Maintenance (LEED EB:O&M) (Shiuh et al. 2010) versions ensure it is relevant and accessible for all project stages, regardless of whether it is industrial, commercial or residential. The rating system is divided into 4 categories; Certified 40-49 credits, Silver 50 – 59 credits, Gold 60 – 79 credits and Platinum 80+ (Choi et al. 2015). Thus, creating an achievable entry level while also encouraging continual improvement and exceptional performance to achieve higher levels of certification. While this program has a relatively broad scope it ensures its assessment integrity by segmenting its criteria into 8 specific topic headings; Location and Transportation, Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, Innovation and Regional Priority (Champagne and Aktas 2016). In this way, every project is equally assessed across all areas integral to its environmental performance. Finally, to ensure the overall quality of a buildings performance and the accuracy of the certification, minimum standards or mandatory prerequisites are also ingrained in the assessment procedure (Sun et al. 2018). This guarantees that any certified project reaches an acceptable level in all areas rather than just exceptional performance in one to the detriment of the rest.

Another well-known sustainable building rating system is the Building Research Establishment's Environmental Assessment Method (BREEAM), which was first developed in the UK in 1990, making it the longest standing of the most prominent assessment methods (Nguyen and Altan 2011). As a result, many of the subsequently produced rating systems are based on this benchmark to some extent (Doan et al. 2017). The BREEAM rating system covers a significant number of topics throughout the entire lifecycle of a building or project; from design and planning to in-use and even retrofitting (Mattoni et al. 2018). This in addition to tailoring its application to its native UK and the global market with specific international documents (BREEAM 2016), ensure its provides an all-encompassing assessment program for any application. To guarantee equality and the integrity of testing

the scheme is divided into specific categories evaluating the projects sustainability across 71 different criteria (Bernardi et al. 2017). These topics are weighted between the sections titled; Management, Health and Wellbeing, Energy, Transport, Water, Waste, Land Use and Ecology and Pollution with additional credits for exceptional innovation (Suzer 2019). A projects' final score is calculated as a percentage total of each of the topics based on their designated weighting values. The eventual certification level will then be based on where this value lies on their rating scale; Unclassified (≤ 30 points), Pass (< 45 points), Good (< 55 points), Very good (< 75 points), Excellent (< 85 points) and Outstanding (≥ 85 points) (Mattoni et al. 2018) with an adjusted scale and additional Acceptable rating exclusively for their In-Use scheme. By encouraging sustainability and rewarding exemplary performance, this standard aims to reduce the environmental impact and lifecycle cost of projects around the world.

The remainder of this paper is broken down into four further sections. Section 2 presents the methodology employed throughout the study including justification of the standards and processes selected. A descriptive analysis accompanies the graphical results of this research in section 3. Section 4 presents a discussion of the certification results, output recommendations and significant learnings from this research. Finally, section 5 offers conclusions and potential areas for future work.

2. Methodology:

Often in the industrial sector, there can be a large divide between top management and teams or personnel implementing projects or maintaining certifications. Unfortunately, this can lead to inefficient or redundant use of time or resources (Marimon and Casadesús 2017). As the proliferation of certifications and rating systems continues, companies and individual sites get to a stage where multiple schemes may be targeted or already in place. This can be particularly common in large multi-national companies where sites are located in different jurisdictions or countries. In such cases, each site may be required to gain certification or achieve a rating consistent with the remainder of the company's portfolio. As a result, it is valuable for the stakeholders to evaluate these schemes and establish if crossovers exist on site to minimise the associated time and resource costs, optimise the intrinsic benefits and maximise their rating or certification achievable (Rebelo et al. 2015).

2.1. Selection of Standards:

The standards chosen for this evaluation aim to provide an accurate representation of those used for energy and environmental management in Ireland and industries around the world. ISO 50001 is widely considered the norm in energy management (Javied et al. 2018) and has gained such worldwide recognition that it can be considered the global reference meta-standard to adopt an EnMS (Laskurain et al. 2017). In 2017, there were 21,501 ISO 50001 certifications across 93 countries worldwide (International Organisation For Standardization 2019a). Ireland is a relatively small country but it still maintained the positive growth in annual certifications seen across all regions, climbing from 36 in 2012 up to 178 by the end of 2017 (International Organisation For Standardization 2019a). Although this certification remains voluntary, its ongoing value and global prominence can be easily highlighted. ISO 50001 has an average of over 112 certifications per country worldwide, with the considerable implementation rates shown in Table 1 demonstrating the performance of the leading country for certifications across each continent (International Organisation For Standardization 2019a).

Continent	**Country**		**Total Certifications**		**Continental %**		**Worldwide %**	
	ISO 50001	ISO 14001	ISO 50001	ISO 14001	ISO 50001	ISO 14001	ISO 50001	ISO 14001
Asia	China	China	1,567	165,665	44.73	74.11	7.29	46.15
Europe	Germany	UK	8,314	17,559	47.09	16.09	38.67	4.89
N. America	USA	USA	77	5,251	60.63	64.64	0.36	1.46
C & S America	Brazil	Columbia	49	2,954	37.12	28.68	0.23	0.82
Oceania	Australia	Australia	23	3,938	100	92.9	0.11	1.1
Africa	Egypt	South Africa	40	1,230	65.57	39.9	0.19	0.34

Table 1. Continental breakdown of the most certified countries and associated statistics.

ISO 14001 is one of the most widely used systems for managing corporate environmental aspects and processes (De Oliveira et al. 2016) and was selected as it has been adopted by significantly more companies than its competitors like EMAS (Comoglio and Botta 2012), with only 13,205 sites certified in September 2018 (European Commission 2018). ISO 14001 is also a voluntary standard (Bansal and Bogner 2002), which has grown significantly in prominence year upon year since its inception. From 13,994 certifications in 1999, this figure has steadily grown to 358,953 across 179 countries by the end of 2017 (International Organisation For Standardization 2019b). This can be attributed to the significant benefits associated with achieving this certification. In addition to the considerable international prominence shown in Table 1, the number of certifications in Ireland is quickly approaching 1,000 (International Organisation For Standardization 2019b), ensuring this standard had to be included in any evaluation of industrial performance.

The corporate SEBP's were included as they were found to be the most suitable method of compiling company's diverse and extensive in-house quality and sustainability guidelines. As these policies and documented protocols have become increasingly common throughout industry (Finnerty et al. 2018b) but remain company specific and so are not necessarily externally regulated as the standards would be, it was necessary to include them as an example to maintain a valid assessment. The LEED and BREEAM certifications were selected as they are two of the oldest, most common and broadest green building ranking schemes available, making up almost 60% of the Green Building rating market in 2017 (Bernardi et al. 2017). At the beginning of 2019, LEED had over 2 million square feet certified with more than 90,000 projects across 165 countries and territories worldwide (USGBC 2019). While BREEAM were also present in over 80 countries around the world with over 560,000 certifications across over 2.2 million registered buildings (Ltd 2019), clearly demonstrating their significant presence worldwide. The specific LEED EB:O&M and BREEAM In-Use International standards were selected as they both focus on the actual operation, utilisation and maintenance of the building as part of their sustainability assessment. This ensured a valid evaluation and comparison between the ISO standards and rating systems could be drawn without the ambiguity of company and building specific certifications.

2.2. Evaluation Matrix:

To generate the most value from this evaluation it was important to develop a method of comprehensively assessing each of these standards, ISO 50001, ISO 14001 and the SEBP's in relation to the LEED and BREEAM rating systems. Each of the ISO standards are based on a defined standard of verbal forms to ensure conformity across documents. As such, any standard requirements are indicated by "shall" statements, whereas recommendations are assigned "should", possibilities "can" and permissions with "may" statements. The evaluation matrix was formed by assessing each standard in isolation and incorporating each of the key requirements for compliance, highlighted by the "shall" statements (CEN I.S. EN ISO 2018)(CEN I.S. EN ISO 2015), for example "The organisation shall determine external and internal issues that are relevant to its purpose" (CEN I.S. EN ISO 2015). Each of these requirements were independently documented along with their associated clause number to ensure a quick reference to the specific area of the standard was available. The clause reference was then used to show compliance and account for coverage of a topic when evaluating overlaps with the LEED or BREEAM rating system. Within the matrix, the rating system being evaluated is illustrated under its own determined topic and section headings in addition to its own credit or marking system to allow for an accurate assessment.

Each rating system topic was then evaluated individually, with the areas covered under each standard, ISO 50001, ISO 14001 and an example of an organisation's SEBP's represented by the corresponding standard clause. Additionally, any prerequisites or minimum performance requirements were noted and assessed to ensure a complete evaluation was performed. Once an evaluation of the rating system had been completed, the total credits or marks achievable could be calculated. Thus, presenting a good initial indicator before the results are illustrated graphically to further demonstrate their performance. By visualising this, it was possible to gain a deeper insight into each standard and further understand which areas they are particularly strong or not so prominent in. The detail of these results creates a strong platform from which to discuss and draw conclusions about the relevant performance of each of the standards being evaluated.

2.3. Justification of Evaluation Methodology:

An important factor throughout the creation and use of this evaluation matrix was ensuring a valid representation of each standard was achieved. As such it was vital to gain an understanding of each aspect and how their relative performances can be affected, particularly by their standing on relevant maturity models

(Jovanović and Filipović 2016)(Finnerty et al. 2018a)(Antunes et al. 2014)(Frehe et al. 2014) (Inoue et al. 2013). The methodology chosen draws on the experience of these works and bases the evaluation on the levels of maturity defined by the SEAI (John 2013). As a result, each standard is evaluated at the highest level, Level 5, to eliminate any ambiguity and ensure a fair representation is achieved. Furthermore, the 2011 version of ISO 50001 and the 2009 version of LEED EB:O&M were included in the evaluation to offer a comprehensive illustration of the performance of existing companies that may already be certified. Hence, outlining the areas necessary to improve or gain certification to an updated standard.

The methodology for this evaluation was based on a decision gate process (Ameri Sianaki et al. 2017), as shown by the ISO 50001 example in Figure 1. This defined process ensured a repeatable and fair evaluation of each standard was achieved. To demonstrate this process, Ongoing Commissioning, an Energy & Atmosphere topic from LEED 2018 which is designated 3 credits (U.S. Green Building Council 2018) can be used as an example. This topic was found to have a significant number of ISO 50001 “shall” statements relevant too it. Once each of those was recorded, the maturity model was used to assess the relative performance and conclude that all three credits were achievable in this case. Alternately, another topic also from LEED 2018, LEED Accredited Professional for one credit in the innovation section, does not have any relevant ISO 50001 “shall” statements and was marked as not applicable and awarded zero credits.

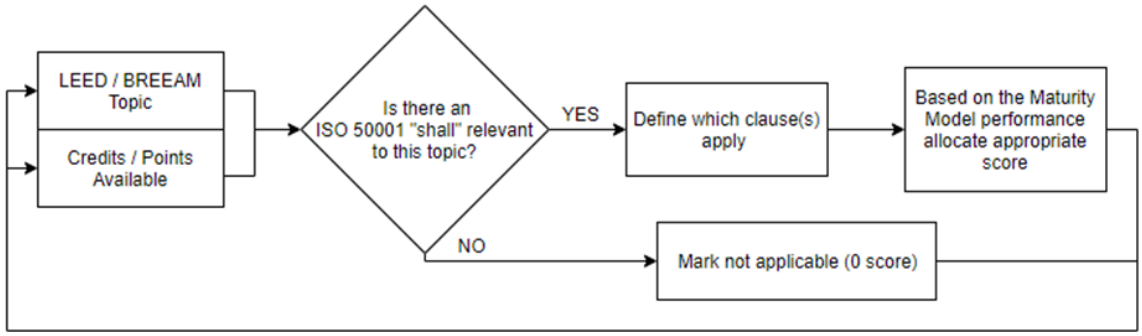

Fig. 1 Flow diagram of methodology decision process

The BREEAM In-Use International technical manual was used as the basis for the evaluation of BREEAM certifications (BREEAM 2016). This outlines the defined requirements and marking scheme allowing the research to be completed. As the Energy Model used for certain specific calculations was not freely available, the technical specifications and guidance of this document were used to formulate an accurate marking figure. As these guidelines are detailed to form the basis of a standard BREEAM, assessment it was deemed acceptable to use the estimated figure in place of the restricted Energy Model output for this evaluation.

3. Results:

3.1. LEED EB: O&M 2009

The scoring mechanism of this certification was based on a ranking of 0 to 110 credits (U.S. Green Building Council 2009). These credits were awarded for achieving the defined performance requirements of each topic. The assessment was divided between the 7 topics; Sustainable Sites, Water Efficiency, Energy & Atmosphere, Materials and Resources, Indoor Environmental Quality, Innovation in Operations and Regional Priority Credits (U.S. Green Building Council 2009). Figure 2 illustrates the performance of each standard in relation to these topic areas, giving a general overview before delving into the actual points achievable. From this graph, it is clear that each of the standards perform strongly in the Energy & Atmosphere category. While the ISO 14001 standards perform particularly well in Materials & Resources and the aggregated corporate guidelines, SEBP’s, offer the best performance in Indoor Environmental Quality and Water Efficiency.

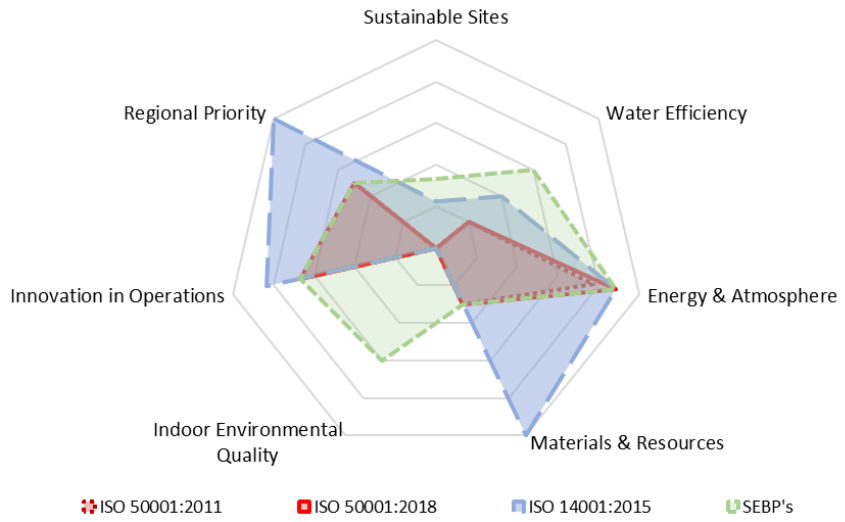

Fig. 2 Performance of each standard in relation to the topic areas in the LEED EB:O&M 2009 Certification standard

By further evaluating each topic in terms of the actual points achievable, a more detailed depiction of each standards performance capabilities can be highlighted. Figure 3 displays the relative performances of each standard in terms of the minimum and maximum points achievable in a LEED EB:O&M 2009 assessment. The headings are the same as in Figure 2 but are now adjusted to account for the specific points awarded within the LEED marking scheme. Each standard again performs very strongly in the Energy & Atmosphere section, with the potential to achieve more than 90% of the available points. The significance of ISO 14001's performance in the Materials & Resources and Regional Priority Credits categories is also brought into context with these sections offering 10 and 4 credits respectively. Figure 3 also demonstrates the substantial effect of the 3 to 15 credits available for Alternative Commuting Transportation within Sustainable Sites, as ISO 14001 shows exemplary performance here relative to the other standards. Finally, the value of the SEBP's attaining up to 9 credits in Indoor Environmental Quality is also highlighted as a standout achievement.

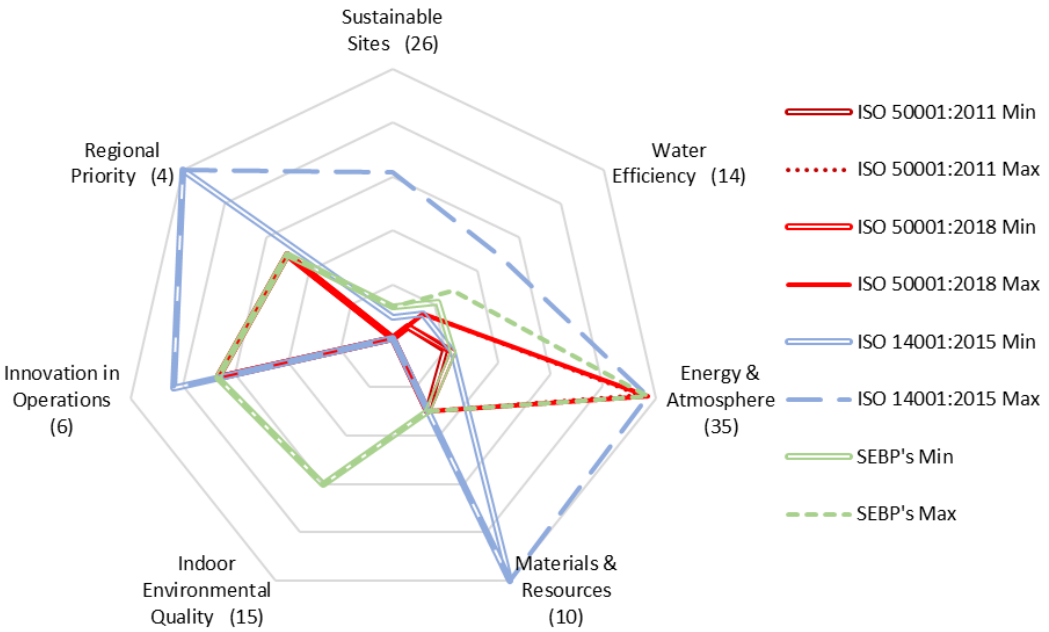

Fig. 3 Minimum and maximum points achievable per standard in relation to the LEED EB:O&M 2009 Certification Standard

A clear illustration of the potential of a company with a combination of the three mechanisms and standards is shown in Figure 4. This demonstrates the potential to satisfy the minimum compliance requirements of the certification and achieve 42 credits in a LEED assessment at the minimum, level 3, maturity. Up to a total of 85 points were achievable based on exemplary performance, level 5 maturity, in each of the areas covered. As

shown, the Energy & Atmosphere section has the most significant impact on potential ratings. This is largely due to its points weighting but also the inherent emphasis on ensuring a very high standard of performance in this area.

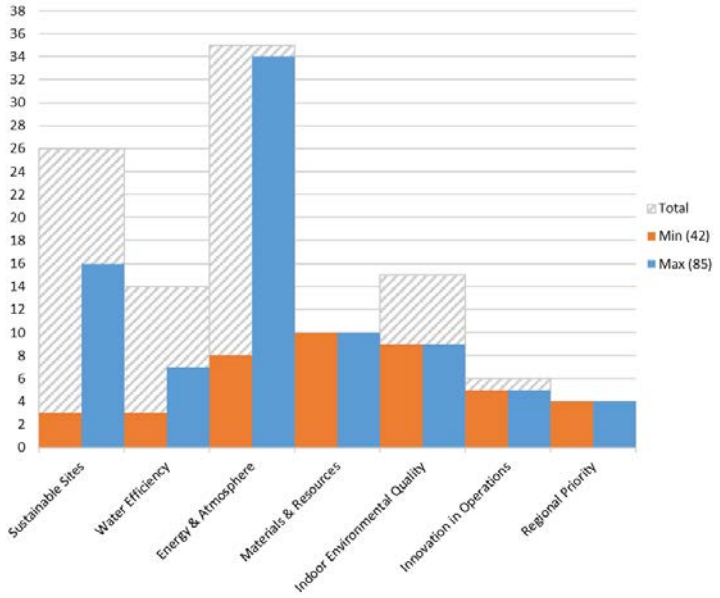

Fig. 4 Minimum and maximum points achievable for a combination of the three standards in relation to the LEED EB:O&M 2009 Certification standard

3.2. LEED EB:O&M v4 2018

The LEED v4, released in 2018 is an evolution of the previous certification with strategic changes to certain aspects ensuring it remains relevant (U.S. Green Building Council 2018). This iteration maintains the 0 – 110 scoring system but divides these marks into 8 categories rather than the 7 of the previous version. Location and Transportation is marked as a standalone topic in addition to the 7 established topics. As expected, each of the standards again perform particularly well in the Energy and Atmosphere topic shown in Figure 5. In this version the innovation and regional priority credits appear more of a challenge to attain, thus encouraging quality work in these areas to achieve higher ratings.

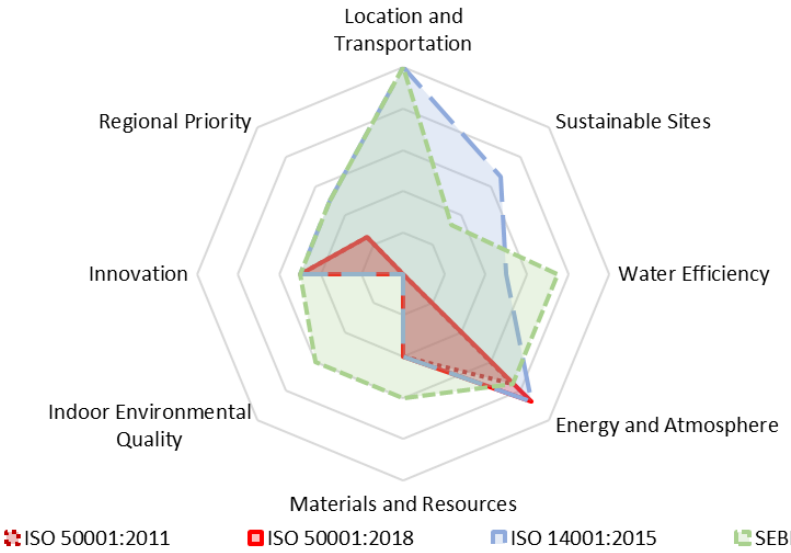

Fig. 5 Performance of each standard in relation to the topic areas in the LEED EB:O&M v4 2018 Certification standard

In addition to the added topic, the marks allocated to each section were also redistributed to maintain the applicability of the certification. Figure 6 shows how points previously awarded for Sustainable Sites, Water Efficiency and Materials and Resources have been redistributed between Energy and Atmosphere and Indoor

Environmental Quality. This evaluation shows the potential to achieve higher performance in the updated Sustainable Sites category, albeit for fewer marks. Similarly, the overlap between ISO 14001 and the SEBP's is much stronger in the updated Water Efficiency topic, demonstrating the current value of efficient water use. More stringent regulations around the efficient use of materials and resources have made it more difficult to achieve high marks in the Materials and Resources area, Figure 6. The Indoor Environmental Quality section remains an area outside the scope of the ISO standards, with the only overlap coming from the SEBP's. Finally, in keeping with the strong ethos of continual improvement instilled in each of these standards the innovation credits remain as potentially very achievable credits under each of the standards assessed.

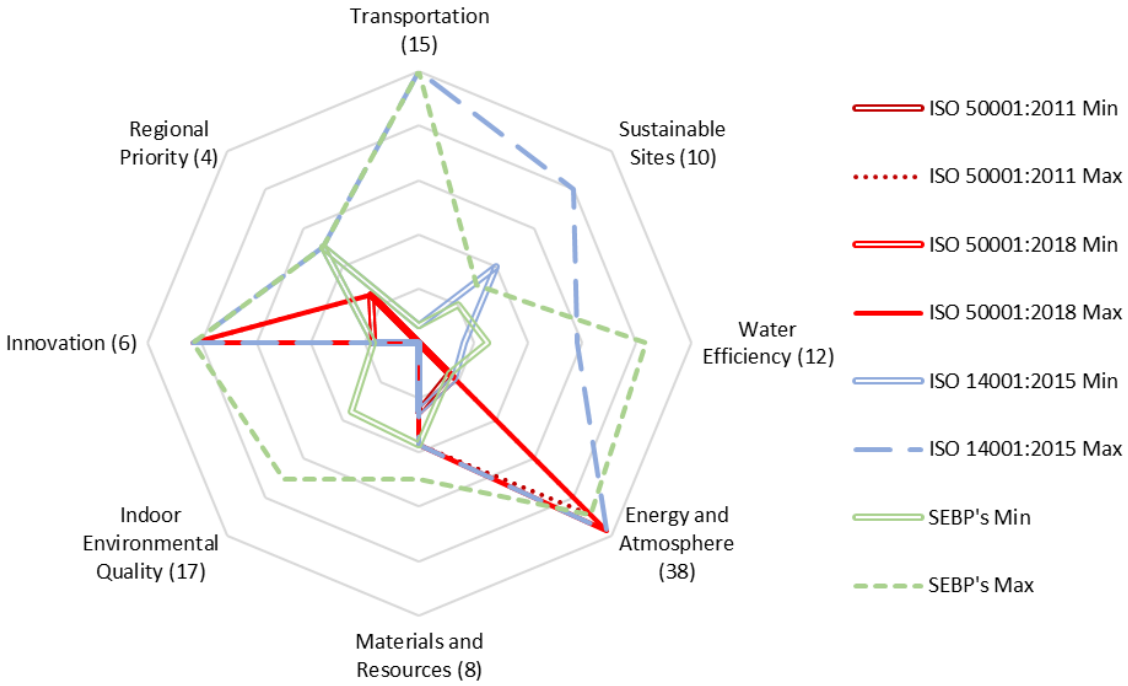

Fig. 6 Minimum and maximum points achievable per standard in relation to the LEED EB:O&M v4 2018 Certification standard

The potential performance of a company compliant to each of the three mechanisms and standards is portrayed in Figure 7, where again this combination satisfies each of the prerequisites for this certification. However, it also presents a much more drastic range from a minimum, level 3 maturity, of 27 points up to an exemplary maximum, level 5 maturity, of 93 points. This increase in potential is partly due to the reallocation of points in the rating scheme but is also affected by more stringent assessment criteria and higher performance requirements. The growth in the range from min to max compared with the previous, 2009 rating scheme, clearly demonstrates the evolution of the rating system itself and the development of emphasis on striving for continual improvement. The 15 points available for Location and Transportation is also a considerable variable as it is largely affected by the company's geographical location.

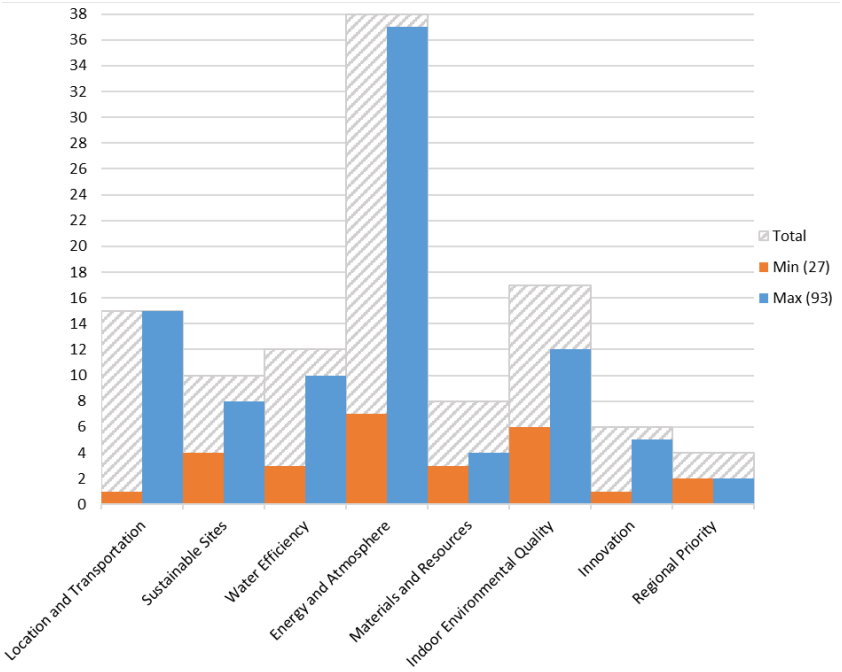

Fig. 7 Minimum and maximum points achievable for a combination of the three standards in relation to the LEED EB:O&M v4 2018 Certification standard

Using this evaluation, an appropriate baseline and input from the maturity model it was possible to quantify a company's performance. In this case, a combination of each of these standards demonstrates the potential to achieve 70 credits and therefore a LEED Gold Certification, Figure 8. Considering projects still in the planning phase but intending to design and implement each of the aforementioned standards to the highest level, a similar evaluation was conducted of the LEED v4 2018: BD+C: New Construction and Major Renovation Checklist. Employing the same evaluation methodology, it is clear that the combination of these standards is less significant than for the operations and maintenance standard. In this case only achieving 60 credits, right on the lowest band of a Gold rating. This result is likely impacted by the ISO standards heavier focus on operations and continual improvement rather than on planning and design specifics.

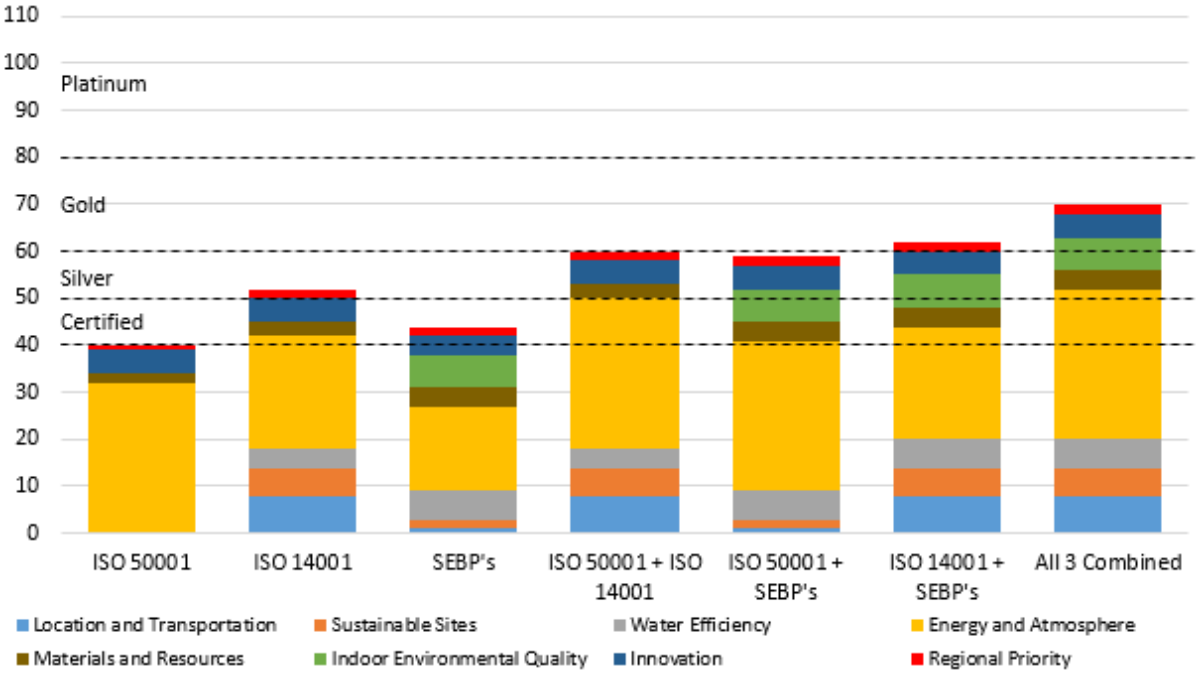

Fig. 8 Performance of each standard individually and combined in relation to the LEED EB:O&M v4 2018 Certification standard

3.3. BREEAM In-Use International:

BREEAM assessments are broken down into three parts, Part 1 Asset Performance, Part 2 Building Management and Part 3 Occupier Management (BREEAM 2016), with a recommendation to combine parts 2 and 3 for a more accurate indication of performance. Based on this, Figure 9 illustrates the performance of each of the standards in relation to a BREEAM assessment. The significantly broad and all-encompassing nature of this assessment makes the contribution of ISO 50001 appear relatively minor, although it demonstrates class leading performance in the Energy section, especially in Part 3. The SEBP's provide adequate cover in the majority of sections, achieving a passing performance to potentially good certification ranking, Figures 9. The ISO 14001 standards demonstrate the most consistent performance when all sections are considered, only receiving lower marks then the SEBP's in the Part 2 evaluation. Overall, it is clear that a BREEAM certification is achievable with at least one or a combination of the standards evaluated.

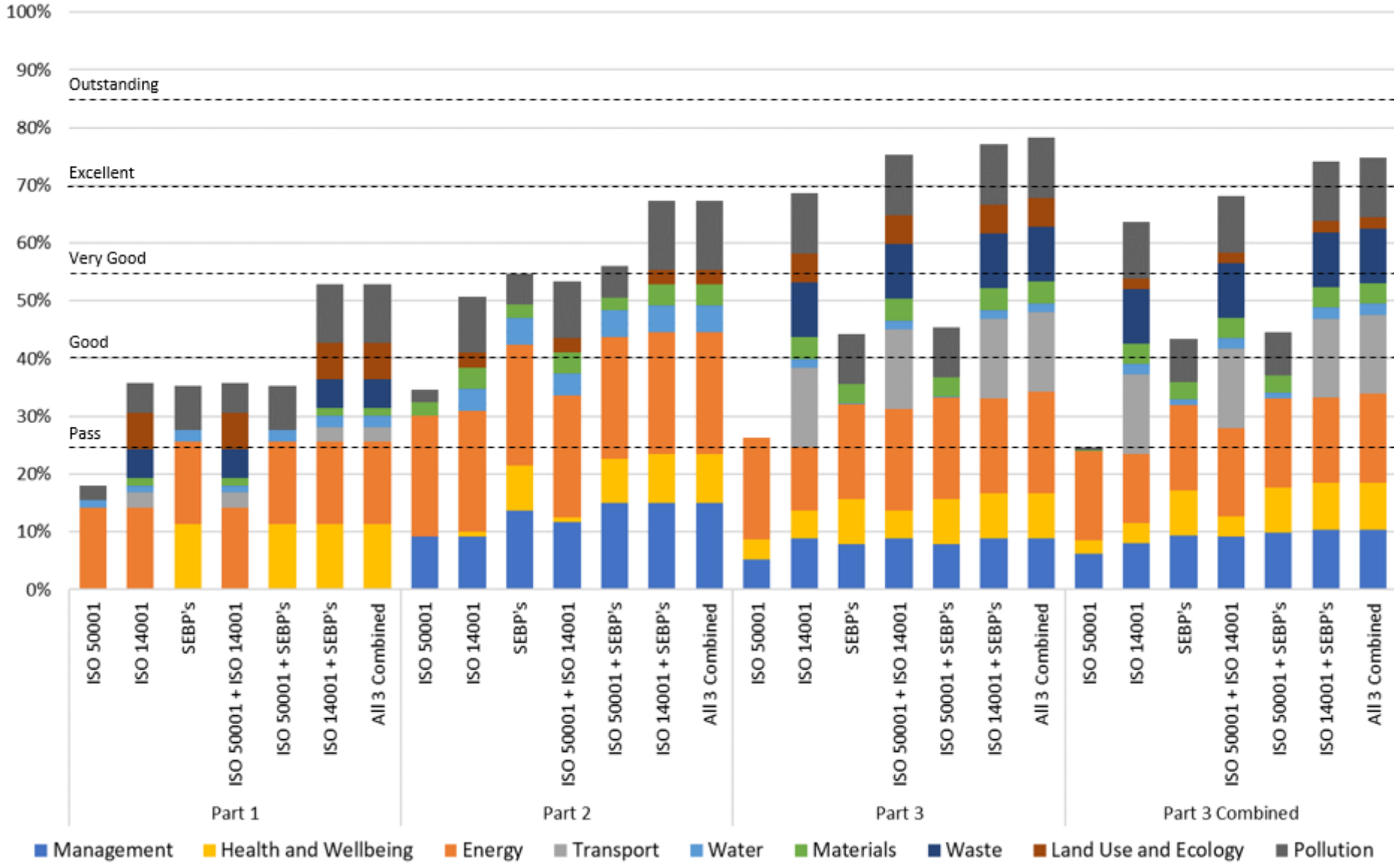

Fig. 9 Performance of each individual and combination of standards in relation to the sections of a BREEAM In-Use International 2015 Certification

4. Discussion:

4.1. Significant Insights:

For certain companies or projects there can often be significant pressure to achieve certifications or meet benchmarks with minimal resources. For companies just starting in this area it may not be feasible to target more than one standard at a time. As such, if the main indicator of their performance is their certification rating it is clear that ISO 14001 would be preferable to target first. This is largely due to its much broader and more all-encompassing scope, ensuring it covers more of the topics in a LEED or BREEAM assessment. As such, it would be easier for the company to validate its performance and justify the work put in to achieving compliance with this standard. This does not discount the value of the ISO 50001 standard though, as there remains significant performance improvements to be gained in this area. While energy, the focus of ISO 50001, is only one aspect of both rating systems it is the most heavily weighted area, accounting for 34% of the points in a LEED assessment. Thus, ensuring there is value in striving for exemplary performance in this area to improve the company's rating as well as the inherent efficiency and economical savings associated with this standard. Naturally, there are significant overlaps between the two ISO standards who both operate the PDCA cycle. This can be attributed largely to the fact that they were designed with the intention of eventually being integrated. This vision of a combined system is increasingly considered to be the optimal way of ensuring a company operates in the most environmentally and energy efficient way possible (NQA 2019).

An additional benefit to these crossovers between ISO standards and the rating schemes are the time and resource costs saved after the initial expenditure. Taking the empirical outputs from an embedded study in three large manufacturing companies the resource days required to implement each aspect of ISO 50001 were found (Bruton et al. 2018). Conducting reviews, baselining and formalizing opportunities and action plans are some of the most labour intensive aspects of implementing and maintaining an ISO standard. These aspects were found to take between 20 to 30 resource days each to formalize and implement the process (Bruton et al. 2018). Using their experience, sites attempting to achieve additional certifications are well placed to optimize their subsequent implementation process and procedures. Thus, reducing the resource days required for each task and maximizing benefits and continual improvement. Additionally, the significant crossovers between standards and rating systems give conforming sites a considerable advantage and reduces the time required for them to complete rating assessments. This is largely due to the time intensive measurement and verification procedures required by the standards, a process that can take 10 to 15 resource days (Bruton et al. 2018). Already having these in place, allows the site to quickly demonstrate and quantify performance levels required by the rating schemes. Saving a considerable amount of time and resources through existing structures rather than having to formalize and implement these structures during the assessment, hence lengthening the timeframe. Furthermore, the most time consuming aspect, opportunities and action plans, attributed with up to 30 resource days of work (Bruton et al. 2018), provides more optimisation potential. This continual improvement structure offers considerable crossover with innovation and other optimisation credits available in the rating schemes. As such, even more time and resource days can be saved through the overlaps between the various schemes.

An interesting observation arising from this research is the difference in emphasis between the ISO standards and the LEED and BREEAM assessment methodologies. The ISO standards present a very detailed approach, where companies are encouraged to follow the PDCA cycle to optimise their systems. Initially, during the planning phase, the company must conduct energy or environmental reviews to establish a baseline and define performance indicators. These are then used to create a comprehensive policy that ensures commitment to the continual improvement objectives and targets. Once these structures are in place, action plans are used to ensure projects and opportunities are implemented. The checking stage ensures performance indicators are monitored and measured, thus ensuring all performance is recorded. Finally, the act stage ensures continual improvement opportunities are highlighted and implemented as appropriate. The LEED EB:O&M assessment follows a more defined beginning to end structure. Once an assessment has been initiated, a project team must be assembled with individuals assigned to specific tasks throughout the duration of the assessment. This aspect along with further time, resource and application expenses can result in achieving LEED certification being very costly. The project team must define the project scope, ensure the application meets the minimum program requirements and develop the LEED scorecard. Once the application and all performance periods are complete, a quality assurance review must be conducted before certification can be achieved. The BREEAM certification follows a similar assessment methodology but with some more explicit requirements. Similarly to LEED, at least one dedicated individual is required throughout the duration of the assessment further adding to the cost associated with achieving this certification. There is also little emphasis placed on internal and external

communication within the LEED and BREEAM assessment criteria. In contrast to the significant value placed on this throughout the ISO standards. Both ISO 50001 and ISO 14001 place considerable importance on well-documented communication channels and comprehensive stakeholder engagement throughout the certification lifecycle (CEN I.S. EN ISO 2018)(CEN I.S. EN ISO 2015).

Although these standards and certifications remain distinct in their own right, it is clear that there are commonalities and aspects that are driving towards the same objective. A significant crossover between ISO 50001 and the two rating systems is demonstrated in the energy performance section. The purpose of ISO 50001 targets a continual improvement plan for energy efficiency and performance. Critical aspects of this process are also directly called out within the building rating schemes. LEED credits for optimizing energy performance, building-level energy metering and ongoing commissioning and implementation analysis demonstrate the significant overlap in emphasis and similarities of the purpose and objectives of these schemes. Equally, specifically called out LEED credits for site development – protect or restore habitat and BREEAM topics for pollution prevention, environmental policies and sustainable procurement each align considerably with the ISO 14001 standard. It is these crossovers and a shifting of emphasis towards overall sustainability and continually improving performance that demonstrate the common purpose and direction of each of these systems.

One of the major difficulties for certain companies to achieve the highest marks in either a LEED or BREEAM assessment can arise from their geographical location. If an existing company intends to apply for one of these certifications and they are situated in an unsuitable location, with relocating out of the question, it can be difficult to perform strongly in certain areas. The Location and Transportation aspect of LEED and Land Use and Ecology topic of BREEAM are particularly affected by the company's geographical location, as each of these heavily emphasize the reduction of single-occupant commuting in conventional automobiles. Achieving reductions in this area can be severely hampered in locations where there is a lack of public transport infrastructure and walk/cycle ways or the company is located a significant distance from any additional amenities. This can restrict a company's ability to achieve marks in these areas and limit their potential maximum results. Equally, companies that base their LEED or BREEAM applications purely on the ISO standards or have particularly minimal best practices in place may encounter problems satisfying the minimum compliance requirements and prerequisites of these ratings. The Environmental Tobacco Smoke Control credit is mandatory for each of the LEED assessments but with nothing explicitly mentioned in the standards, a site would require their own regulation of this to achieve any rating. The extent to which a site records water consumption may also limit their ability to achieve the minimum requirements of a BREEAM assessment and so particular consideration should be taken in this area. Furthermore, the Indoor Environmental Quality aspect of LEED and Health and Wellbeing section of BREEAM assessments are scarcely covered by the ISO standards. This area is the next largest limitation of maintaining these two standards in isolation by some distance. As such, a company would be required to implement an additional standard or their own form of best practices to ensure the marks available in these areas were achievable.

4.2. Output Recommendations:

Through careful analysis of each standard, both individually and combined, it was possible to refine our understanding of their performance in relation to the green building certifications. Both of the ISO standards performed very strongly in the innovation categories, particularly highlighted in Figure 6. This reinforces the emphasis placed on continual development and improvement ingrained in these standards. One area that stands out in both LEED and BREEAM assessments is the lack of emphasis and coverage of water consumption and efficiency. For highly performing companies this would appear to be an area worth focusing on to increase overall performance as well as gain additional points to improve their rating. The Materials and Resources section of the LEED assessment would also offer further point gains to well established companies. Similarly, this area is not as comprehensively covered by these standards. As such, a relatively straight forward improvement in the companies rating could be achieved by developing and maintaining suitable indoor and outdoor water use protocols or ensuring suitably defined waste management schemes are implemented across their site. For very mature and highly performing companies these small aspects can offer additional areas of improvement that may be the difference between gaining the top honours or class leading performance. Equally, these areas are worth focusing on for developing companies, as it will help to quickly improve their overall site performance and potentially fast track their way to better, more representative certification ratings.

4.3. Achievable Certifications:

A significant finding from this research is that a company certified to ISO 50001 and ISO 14001 with a high level of maturity and their own form of SEBP's can achieve a certification without any further action. For these companies a high gold or even platinum LEED certification is achievable under the current and previous rating system as well as a very good or four-star BREEAM rating depending on their maturity level. Once the systems and protocols have been setup and are appropriately maintained it is only a matter of demonstrating the performance in accordance with the specific standards assessment criteria. There are many examples in Ireland of indigenous and multinational companies achieving both ISO 50001 and ISO 14001 certification. DePuy Synthes Cork is a prime example in the medical device manufacturing sector, Dell EMC Cork in the technologies sector (Dell Technologies 2019) and Gas Networks Ireland from a utilities perspective (Gas Networks Ireland 2018). The value of these structures can be particularly prominent during the implementation and development of these management systems while companies are in the beginning phase or lower end of the maturity model scale. As they have the potential to make substantial gains in performance, which in turn will be clearly illustrated by the improved rating achievable. The value of having an easily comparable benchmark, provided by these rating systems, is not exclusive to the operations and maintenance of sites either. The prioritisation of these standards has a positive effect throughout the full lifecycle of any company. This is clearly demonstrated as the combination of these standards achieves a gold rating, 60 points and over, in both the design and planning phase, New Construction and Major Renovation, and throughout its use, Existing Building Operations and Maintenance. Each of these standards further emphasise the preparation for decommissioning and reduction of waste, thus ensuring a high performance is maintained through the entire lifecycle.

4.4. Case Study:

To demonstrate the applicability and performance of this evaluation methodology, a case study was carried out on a representative company. Using the experience and information collected from a manufacturing site in County Cork, Ireland the evaluation methodology was trialled for this company assessing its performance to the LEED EB:O&M v4 2018 Certification standard. This company has maintained ISO 50001 and ISO 14001 certification for a number of years and therefore was deemed to be at level 5 maturity, in addition to employing its own comprehensive SEBP's. By maintaining these standards and practices it was found that this company is capable of achieving 70 points, demonstrating the performance across each topic required to achieve a Gold LEED Certification, Figure 10. For this company to improve its rating, potentially up to LEED platinum, it was recommended that they develop processes within Water Efficiency and Materials and Resources as these areas are clearly highlighted as having significant improvement potential.

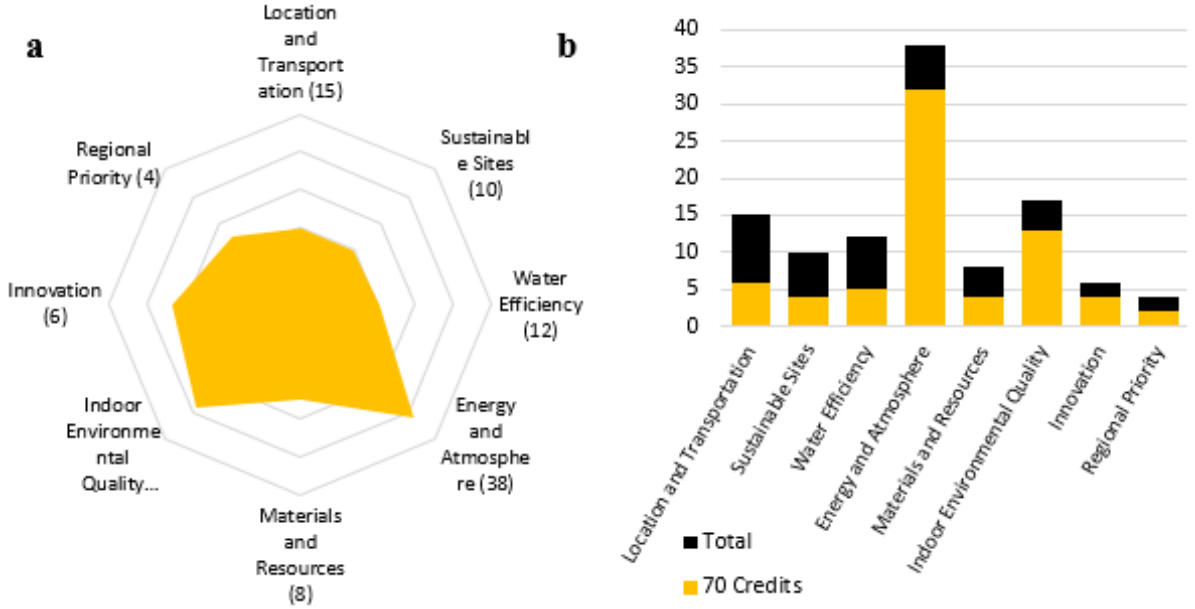

Fig. 10 a Radar diagram illustrating the overall performance, **b** Bar chart demonstrating the achieved performance in each topic compared to the total points available

5. Conclusions and Future Work:

The significant outcome of this research is a clear answer to the question, How do Companies Certified to ISO 50001 and ISO 14001 perform in LEED and BREEAM Assessments? As discussed, a single well developed or combination of ISO standard certifications can provide a direct route to LEED or BREEAM certification. There is clear potential for companies at the top end of the maturity model scale to achieve at least a gold LEED certification or very good, four-star BREEAM certification with a combination of these standards. Equally, companies that are less advanced on the maturity model scale with a combination of these standards still maintain the performance to achieve a passing LEED or BREEAM certification. Overall, it is clear that through the implementation and commitment to these standards or some form of sustainability measure companies are more likely to achieve better energy and environmental performance and higher sustainability ratings.

For highly performing companies, it is clear that Water Efficiency and Materials and Resources are particular areas worth developing as they offer the most improvement potential. Whereas for early phase projects, ISO 14001 demonstrates the more effective route to LEED or BREEAM certification of the two ISO standards. This is largely due to its broader scope with significantly more overlap with the rating schemes assessment criteria. Finally, it was found that the location selected for a site in the planning phase can have a substantial effect on its future rating. This is due to the large amount of credits designated to its location and transportation performance, particularly in LEED assessments, which can be incredibly difficult to enact retrospectively.

By continuing development of this evaluation matrix, there is the potential to create an evaluation tool to assist companies in evaluating their LEED or BREEAM performance. This has significant potential to reduce the time taken for companies to consider attempting these certifications and the work required to highlight the most effective target areas. To further the understanding of this area there may be value in applying the same evaluation methodology to other less common sustainable building rating schemes. Obtaining further insights from more niche assessment standards or illustrating the differing influences of geographical location on other international standards offers huge potential to grow the knowledge base in this topic. Performing further case studies of performance over each level of the maturity model scale would also increase the accuracy of evaluation and resulting outputs. Additionally, through conducting these case studies it would be valuable to investigate these standards and certifications further, with a view to quantifying their actual lifetime value in practice. This would further increase the potential for this research to aid decision making for policy makers and implementers alike. Thus improving energy and environmental performance and reducing the impact of companies around the world.

References:

Ameri Sianaki O, Masoum MAS, Potdar V (2017) A decision support algorithm for assessing the engagement of a demand response program in the industrial sector of the smart grid. Comput Ind Eng 115:123–137. doi: 10.1016/j.cie.2017.10.016

Antunes P, Carreira P, Mira da Silva M (2014) Towards an energy management maturity model. Energy Policy 73:803–814. doi: 10.1016/j.enpol.2014.06.011

Bansal P, Bogner WC (2002) Deciding on ISO 14001: Economics, institutions, and context. Long Range Plann 35:269–290. doi: 10.1016/S0024-6301(02)00046-8

Bernardi E, Carlucci S, Cornaro C, Bohne RA (2017) An analysis of the most adopted rating systems for assessing the environmental impact of buildings. Sustain 9:1–27. doi: 10.3390/su9071226

BREEAM (2016) BREEAM In-Use International, Technical Manual ; SD221-2.0:2015– Version: 2

Brem A, Adrita MM, O'Sullivan DTJ, Bruton K (2020) Industrial smart and micro grid systems – A systematic mapping study. J Clean Prod 244:118828. doi: 10.1016/j.jclepro.2019.118828

Bruton K, O'Donovan P, McGregor A, O'Sullivan DDTJ (2018) Design and development of a software tool to assist ISO 50001 implementation in the manufacturing sector. Proc Inst Mech Eng Part B J Eng Manuf 232:1741–1752. doi: 10.1177/0954405416683427

CEN I.S. EN ISO (2015) ISO 14001:2015 - Environmental Management Systems - Requirements with guidance for use

CEN I.S. EN ISO (2018) ISO 50001:2018 - Energy Management Systems - Requirements with guidance for use

Champagne CL, Aktas CB (2016) Assessing the Resilience of LEED Certified Green Buildings. Procedia Eng 145:380–387. doi: 10.1016/j.proeng.2016.04.095

Choi JO, Bhatla A, Stoppel CM, Shane JS (2015) LEED credit review system and optimization model for pursuing LEED certification. Sustain 7:13351–13377. doi: 10.3390/su71013351

Comoglio C, Botta S (2012) The use of indicators and the role of environmental management systems for environmental performances improvement: A survey on ISO 14001 certified companies in the automotive sector. J Clean Prod 20:92–102. doi: 10.1016/j.jclepro.2011.08.022

De Oliveira JA, Oliveira OJ, Ometto AR, et al (2016) Environmental Management System ISO 14001 factors for promoting the adoption of Cleaner Production practices. J Clean Prod 133:1384–1394. doi: 10.1016/j.jclepro.2016.06.013

Dell Technologies (2019) Policies & Positions. In: Dell Inc. https://corporate.delltechnologies.com/en-ie/social-impact/reporting/policies-and-positions.htm#tab0=2. Accessed 13 Aug 2019

Doan DT, Ghaffarianhoseini A, Naismith N, et al (2017) A critical comparison of green building rating systems. Build Environ 123:243–260. doi: 10.1016/j.buildenv.2017.07.007

European Commission (2018) EMAS - Statistics & Graphs. In: Environment. http://ec.europa.eu/environment/emas/emas_registrations/statistics_graphs_en.htm. Accessed 8 Mar 2019

Finnerty N, Sterling R, Coakley D, Keane MM (2018a) An energy management maturity model for multi-site industrial organisations with a global presence. J Clean Prod 167:1232–1250. doi: 10.1016/j.jclepro.2017.07.192

Finnerty N, Sterling R, Contreras S, et al (2018b) Defining corporate energy policy and strategy to achieve carbon emissions reduction targets via energy management in non-energy intensive multi-site manufacturing organisations. Energy 151:913–929. doi: 10.1016/j.energy.2018.03.070

Frehe V, Stiel F, Teuteberg F (2014) A Maturity Model and Web Application for Environmental Management Benchmarking. Proc Twent Am Conf Inf Syst (AMCIS 2014) 1–14

Gas Networks Ireland (2018) Sustainability in Action 2018

Howley M, Dineen D, Holland M (2018) ENERGY IN IRELAND 2018 Report. Dublin

Inoue E, Arimura TH, Nakano M (2013) A new insight into environmental innovation: Does the maturity of environmental management systems matter? Ecol Econ 94:156–163. doi: 10.1016/j.ecolecon.2013.07.014

International Organisation For Standardization (2019a) 04. ISO 50001 - Data per Country and Sector - 2011 to 2017. https://isotc.iso.org/livelink/livelink?func=ll&objId=18808772&objAction=browse&viewType=1. Accessed 8 Feb 2019

International Organisation For Standardization (2019b) 02. ISO 14001 - Data per Country and Sector - 1999 to 2017. https://isotc.iso.org/livelink/livelink?func=ll&objId=18808772&objAction=browse&viewType=1. Accessed 8 Feb 2019

Ireland B in the C (2014) MAKING CONSISTENT IMPACT : ENVIRONMENTAL TRENDS , BEST PRACTICE AND SUPPORTS

Ireland SEA of (2017) Energy Efficiency Obligation Scheme (EEOS). https://www.seai.ie/energy-in-business/energy-efficiency-obligation-scheme/. Accessed 31 Jan 2019

Javied T, Bakakeu J, Gessinger D, Franke J (2018) Strategic energy management in industry 4.0 environment. 12th Annu IEEE Int Syst Conf SysCon 2018 - Proc 1–4. doi: 10.1109/SYSCON.2018.8369610

John OS (2013) ISO50001 Ireland Conference

Jovanović B, Filipović J (2016) ISO 50001 standard-based energy management maturity model - Proposal and validation in industry. J Clean Prod 112:2744–2755. doi: 10.1016/j.jclepro.2015.10.023

Laskurain I, Ibarloza A, Larrea A, Allur E (2017) Contribution to energy management of the main standards for environmental management systems: The case of ISO 14001 and EMAS. Energies 10:. doi:

10.3390/en10111758

Ltd BRE (2019) BREEAM. https://www.breeam.com/. Accessed 8 Mar 2019

Marimon F, Casadesús M (2017) Reasons to adopt ISO 50001 Energy Management System. Sustain 9:1–15. doi: 10.3390/su9101740

Mattoni B, Guattari C, Evangelisti L, et al (2018) Critical review and methodological approach to evaluate the differences among international green building rating tools. Renew Sustain Energy Rev 82:950–960. doi: 10.1016/j.rser.2017.09.105

Nguyen BK, Altan H (2011) Comparative review of five sustainable rating systems. Procedia Eng 21:376–386. doi: 10.1016/j.proeng.2011.11.2029

NQA (2019) Making the Move from ISO 14001 to ISO 50001. In: NQA. https://www.nqa.com/en-gb/resources/blog/may-2015/iso-14001-to-iso-50001. Accessed 14 Aug 2019

OECD/IEA (2018) Industry - Tracking Clean Energy Progress. https://www.iea.org/tcep/industry/. Accessed 11 Feb 2019

Orji IJ (2019) Examining barriers to organizational change for sustainability and drivers of sustainable performance in the metal manufacturing industry. Resour Conserv Recycl 140:102–114. doi: 10.1016/j.resconrec.2018.08.005

Raines SS (2002) Implementing ISO 14001 - An international survey assessing the benefits of certification. Corp Environ Strateg 9:418–426. doi: 10.1016/S1066-7938(02)00009-X

Rebelo M, Santos G, Silva R (2015) Integration of Standardized Management Systems: A Dilemma? Systems 3:45–59. doi: 10.3390/systems3020045

Science C, Technology I, Science C, et al (2018) Development of Energy Management Standards. 185–189

Shiuh TJ, Shigeru U, Ling LC (2010) 1st LEED certified green building for existing building operation and maintenance for semiconductor industry. IEEE Int Symp Semicond Manuf Conf Proc 1–3

Solutions AE (2009) I.S. 393:2005 Energy Management Systems Standard. In: EngineeringSolutions.ie. http://engineeringsolutions.ie/page/art/26/is3932005-energy-management-systems. Accessed 11 Feb 2019

Solutions F (2019) Best Practices in Sustainability. In: Best Pract. Sustain. https://firstcarbonsolutions.com/resources/newsletters/december-2015-best-practices-in-sustainability/best-practices-in-sustainability/. Accessed 31 Jan 2019

Sun X, Gou Z, Lu Y, Tao Y (2018) Strengths and weaknesses of existing building green retrofits: Case study of a LEED EBOM gold project. Energies 11:1–18. doi: 10.3390/en11081936

Sustainable Energy Authority of Ireland (2017) Large Industry Energy Network. https://www.seai.ie/energy-in-business/lien/. Accessed 28 Feb 2019

Suzer O (2019) Analyzing the compliance and correlation of LEED and BREEAM by conducting a criteria-based comparative analysis and evaluating dual-certified projects. Build Environ 147:158–170. doi: 10.1016/j.buildenv.2018.09.001

Systems M (2001) Cost Benefit Analysis for Implementation. 766–768

U.S. Green Building Council (2018) LEED v 4 for Building Operations and Maintenance

U.S. Green Building Council (2009) Leed 2009 for Existing Buildings Operations and Maintenance Rating System

USGBC (2019) Leadership in Energy and Environmental Design (LEED). In: U.S. Green Build. Counc. https://new.usgbc.org/leed. Accessed 1 Feb 2019

Vandyck T, Höhne N, Sha F, et al (2018) Are the G20 economies making enough progress to meet their NDC targets? Energy Policy 126:238–250. doi: 10.1016/j.enpol.2018.11.027

Wallhagen M, Glaumann M, Eriksson O, Westerberg U (2013) Framework for Detailed Comparison of Building Environmental Assessment Tools. Buildings 3:39–60. doi: 10.3390/buildings3010039