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LEED and BREEAM requirements in building services design process

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<p>The purpose of this bachelor's thesis was to identify the requirements and documentation of LEED (<i>Leadership in Energy and Environmental Design</i>) and BREEAM (<i>Building Research Establishment's Environmental Assessment Method</i>) during the design process of the building services. As environmental issues are great concerns and building regulations are more stringent, building rating systems are becoming popular tools to help property owners and project teams to demonstrate their commitment to greener, safer and more sustainable buildings.</p> <p>Another aim of this project was to create guides for building services designers and engineers, who are to work in LEED or BREEAM projects. The goal was to assist them by provide an overview of all the relevant requirements, documentation and referenced standards. This was seen to be especially important because the rating systems are complex and can be difficult to fully understand. The guides present clear and compact information in a way that information can be easily extracted.</p> <p>The guidelines were implemented in a project which was at an early design phase to provide overlook of the certification process. A survey was also completed by several professionals to provide feedbacks of the guidelines. The results were positive and the guides seemed to be helpful tools that can be used in the future projects.</p>	
Keywords	LEED, BREEAM, green building, building services, guides

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Abbreviations

ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
BOD	Basis of Design
BRE	Building Research Establishment
BREEAM	Building Research Establishment's Environmental Assessment Method
CFC	Chlorofluorocarbon
CO ₂	Carbon dioxide
CxA	Commissioning Agent
EPD	Environmental Product Declaration
FSC	Forest Stewardship Council
FTE	Full-time equivalent
GBCI	Green Building Certification Institute
GWP	Global-warming potential
HVAC	Heating, ventilating, and air conditioning
LCA	Life-cycle assessment
LCC	Life-cycle cost
LEED	Leadership in Energy & Environmental Design
LZC	Low and zero carbon

M&V	Measurement and verification
OPD	Ozone Depleting Potential
OPR	Owner's Project Requirements
REC	Renewable Energy Certificate
USGBC	U.S. Green Building Council
VOC	Volatile organic compound

1 Introduction

Today, it is widely accepted that our planet is becoming warmer. Scientific evidence suggests the climate change is occurring, and human activities are the primary contributor. It is undoubted that global climate change has already had observable effects on our environment, societies and economies. There is no better time to start thinking about our climate than now. Among the human activities, it is estimated that the construction industry causes as much as one third of total global greenhouse gas emissions and consumes up to 40% of all energy [1.]. The immense pressure on the environment means that we need better, greener buildings that are sustainable and reduce the burden on the limited natural resources. It is possibly one of the biggest challenges the construction industry faces today.

While tackling climate change, green building movement is shifting the construction industry towards sustainability [2.]. Green buildings can reduce or eliminate negative impact of buildings on the environment through good design and operational practices [2.]. In order to achieve this, green building rating systems have been created to provide building owners and professionals the tools they need. Mentioned in this paper are the two widely used systems in the world: LEED (United States of America) and BREEAM (United Kingdom). In Finland, these are also the two most popular tools with LEED being a more popular one [3.].

This study was done for Projectus Team Oy, one of Finland's leading companies in the building services sector. The company provides design services of the building's technical systems, such as heating, cooling, air conditioning, electrical, energy, water and building life cycle assessment. The study investigates both LEED and BREEAM systems, focusing on the services that Projectus Team Oy offer, to help the company's designers to understand the certification process, its requirements, documentation and related building standards. The products of this study are the LEED and BREEAM design guidelines, which are not public.

2 LEED and BREEAM rating systems

2.1 LEED for Building Design and Construction

One of the topics of this thesis, the LEED system of Building Design and Construction, is applied to buildings that either being constructed or going through a major renovation. LEED version 4 (LEEDv4) is the latest version of LEED, launched in 2013. However, since the market has requested additional time to prepare for LEED v4 according to the USGBC [4.], the scope of this final project will focus mainly on version 3 (2009) but will also go through what you need to know about the version 4.

2.1.1 Overview

LEED (*Leadership in Energy and Environmental Design*) is an internationally recognised green building certification program developed by the U.S. Green Building Council (USGBC). Started in March 2000, LEED provides a third-party verification tool for high performance buildings and sustainable neighbourhoods that implement best building practices and strategies. The main purpose of LEED is to promote sustainability in the built environment, improving performance and quality of buildings while minimising negative environmental impacts. LEED is designed to cover all types of building, from small residential houses to large commercial and public buildings. [5.]

LEED is a voluntary tool for design and construction professionals that can be integrated into construction projects along with local government building regulations and other incentives. Building owners and operators who wish to measure the sustainability of their building projects can use LEED as a framework for implementing practical green solutions throughout the entire building life cycle – design, construction, operation and maintenance, tenant fit-out and major renovation. All the metrics that matter the most are considered: sustainable site development, energy efficiency, water savings, CO₂ emission reduction, healthy indoor environment qualify for building occupants, stewardship of resources and innovations in design. By achieving LEED certification, building owners can demonstrate the “greenness” of the building projects. [5.]

2.1.2 How LEED system works

USGBC's LEED uses a point system to award projects scores based on how well they perform against a set of criteria [5.]. Most of LEED rating systems generally consist of a maximum of 110 points divided into five main categories and two extra categories for innovative solutions and regional priority [5.]. The categories are shown in table 1.

Table 1. LEED 2009 New Construction sustainability categories and credits. [5.]

Section	Weighting %	Credits available
Sustainable Sites (SS)	24	26
Water Efficiency (WE)	9	10
Energy and Atmosphere (EA)	32	35
Materials and Resources (MR)	13	14
Indoor Environmental Quality (IEQ)	14	15
Innovation in Design (ID)	5	6
Regional Priority	3	4
	100 %	110

LEED building rating system is a standard set of performance-based criteria and, therefore, a flexible system with a wide range of paths to achieve a desired level of certification. Because of this flexibility, a number of project types are covered:

- New Construction (NC)
- Core & Shell (CS)
- Commercial Interiors (CI)
- Existing Buildings Operations & Maintenance (O&M)
- Schools
- Retails
- Healthcare
- Homes
- Neighbourhood Development (ND) [5.]

In order to be eligible for certification under LEED 2009, a project must comply with the Minimum Program Requirements (MPRs) [5.]. These requirements are the elementary

characteristics that make a project appropriate for LEED. According to the USGBC, MPRs were designed to protect the integrity of LEED program and make the LEED certification less complicated. [5.]

Within each category, there is a group of *Credits* and/or *Prerequisites*. Unless the project achieves all of the prerequisites, it cannot be awarded any further credits. There are a total of eight prerequisites in LEED 2009. All credits are worth 110 points, with each credit worth a minimum of one point. To satisfy each credit or prerequisite, the project has to meet one or more requirements to earn points. For example, the first prerequisite of the *Water Efficiency* category requires that a project must reduce the water use by at least 20% compared to the baseline. For more detail, the project team needs to refer to the LEED reference guide to find out how to establish the baseline case and carry out the necessary calculations. [5.]

At the end of the certification process, after all documentation has been approved, a project will be certified according to the amount of points it earns. There are four levels of certification: Certified (40-49 points), Silver (50-59 points), Gold (60-79 points) and Platinum (80+ points). [5.]

2.1.3 LEED certification process

The main mission of the USGBC is to promote green building practices and develop the LEED certification program. The organisation that directly handles the verification for LEED is the Green Building Certification Institute (GBCI), supported by the USGBC. Projects that wish to join the program are registered and certified by the GBCI. All the interactions between the project team and the GBCI occur on the LEED Online, a comprehensive website that contains all the necessary information and tools for the certification process. Through LEED Online, project teams can register their projects, manage project information, complete forms for prerequisites and credits, upload supporting documentation, communicate with the GBCI and ultimately receive LEED certification. [5.]

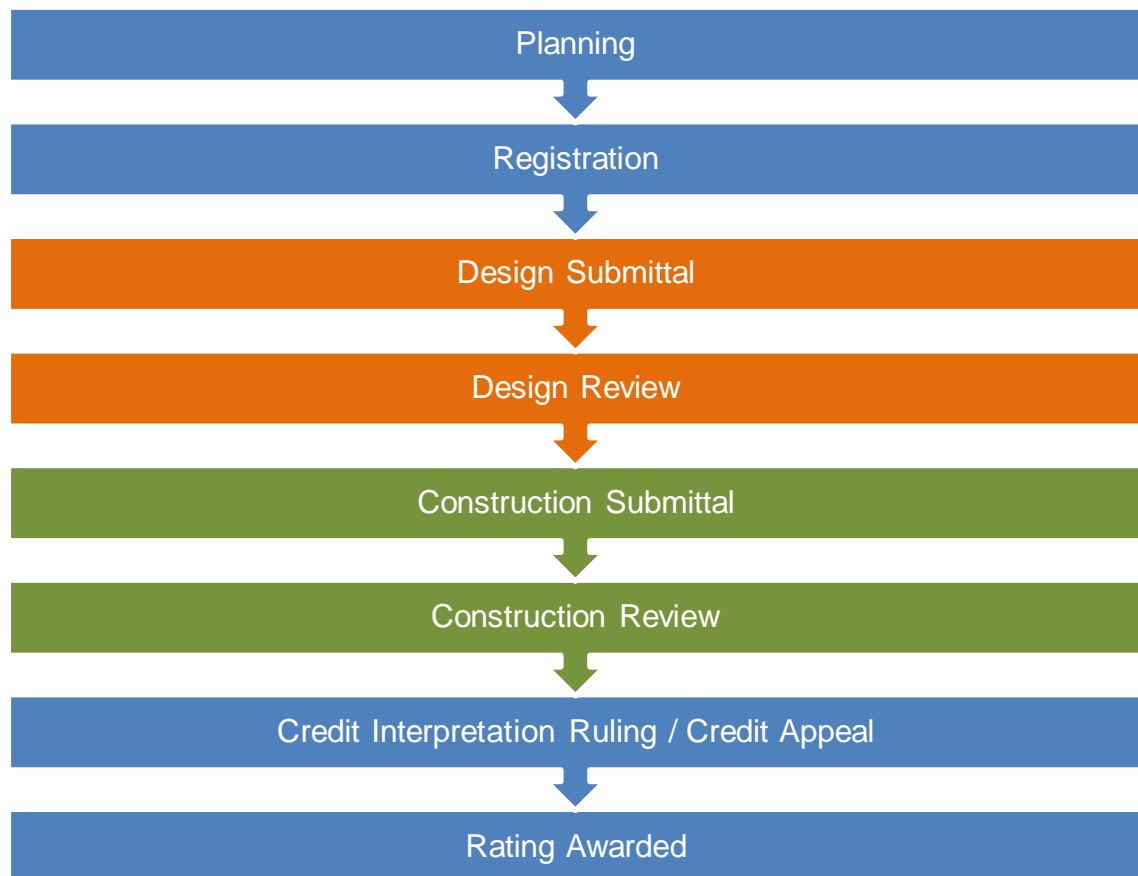


Figure 1. LEED certification process. [5.]

As shown in figure 1, LEED has a streamlined process that most projects can follow. The LEED certification process begins with a LEED Charrette in the planning phase. A Charrette is a workshop where project stakeholders participate and discuss to create a shared vision and to define the LEED goals. A feasibility study is evaluated and strategies are developed so that all the team members have a mutual understanding of the next steps of the project. Participants in the Charrette are everyone who is involved in the projects, such as the owner, architects, engineers, contractors, consultants and commissioning agents. After the Charrette, should a preliminary rating is defined, a first draft of a LEED scorecard is produced, and the roles of each member of project team are known. [5.]

When the owner has decided to select LEED, the project team can register their project through the GBCI's website and pay the registration fees. The registration allows the project team an access to the LEED Online portal where they can start to upload information about the project. LEED Online contains a set of forms that need to be filled out and submitted along with other supporting documentation for review. The project team

can choose between combined or split review . Combined design and construction review means that all the documentation for the LEED project is submitted and reviewed at one time when the construction is finished. A split review allows the project team to provide some of the documentation during the design phase to the GBCI for review and feedbacks of which credits are good to anticipate. [5.]

2.1.4 Main changes in LEED v4

LEED v4 was introduced at the end of 2013 with many changes and new concepts that could potentially shape the industry for years to come. First of all, it is worth to notice that the USGBC has rearranged 2009 ratings systems into five bigger groups in version 4. In fact, new variations of LEED project types have been added to the rating systems such as 'Data Centers', 'Hospitality' and 'Warehouses and Distribution Centers'. [6.]

Secondly, new categories have been added and the change in point allocation within the LEED rating systems has been made. For instance, LEED v4 New Construction includes two categories more than LEED 2009 New Construction, and the number of points for each category is slightly different. As shown in table 2, the new Integrative Process category is designed to bring the team together to produce an early analysis of water and energy-related systems by identifying interrelated synergies and opportunities to design the systems, so that they can be the most effective in terms of performance, costs and environmental goals. This process can be seen as similar to the LEED Charrette, but on a more advanced level. Another new category is Location and Transportation, which pulls several credits from Sustainable Sites category in version 2009. [7.]

Table 2. Changes in LEED version 4. [8.]

Credit categories	LEED 2009 (NC)	LEED v4 (NC)	Point gain/loss
Integrative Process		1	+1
Location and Transportation		16	-
Sustainable Sites	26	10	-
Water Efficiency	10	11	+1
Energy and Atmosphere	35	33	-2
Materials and Resources	14	13	-1

Indoor Environmental Quality	15	16	+1
Innovation and Design Process	6	6	-
Regional Priority	4	4	-

Last but not least, newer standards, concepts and requirements have been adopted in the new LEED. For example, in the single most point-awarding credit *Optimize Energy Performance*, a whole building energy simulation must comply with ASHRAE Standard 90.1-2010 in LEED v4 rather than ASHRAE Standard 90.1-2007 in the previous LEED 2009. Another interesting development occurs in the category *Materials and Resources* where new credits have been introduced to increase the demand for transparency and disclosure of building materials. New terms such as *Life Cycle Analysis (LCA)* and *Environmental Product Declarations (EPDs)* appear in LEED for the first time. These requirements will hopefully increase the demand for environmentally-friendly building materials and products hence challenging manufacturers to be more responsible for their raw material extracting and manufacturing process. [7.]

2.1.5 LEED projects in Finland

According to the article “Top 10 countries for LEED” published in May 2014 by the USGBC [9.], Finland is among the world leaders in gross square meters of LEED certified space. It stands 10th in the list and second in Europe after only Germany. The USGBC has praised Finland’s Sello Shopping Centre, which was the first European shopping centre to receive Gold rating, as an example of outstanding LEED projects around the world. [10.]

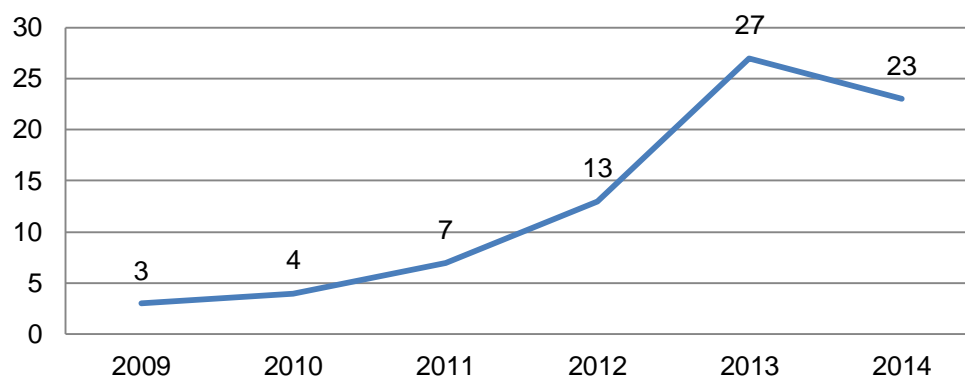


Figure 2. Number of Finland’s LEED certified projects in recent years. [11.]

Figure 2 above demonstrates a trend of an increasing number of LEED projects in Finland. The first LEED-certified project in Finland and apparently in any Nordic countries was the Trio Shopping Centre in Lahti. The project was certified in 2009 and received level 'Certified' under LEED New Construction v2.2 after completing a major renovation and extension of the existing premise. As of February 2015, there are over 80 LEED-certified projects and 72 projects are in progress for certification in Finland. [11.]

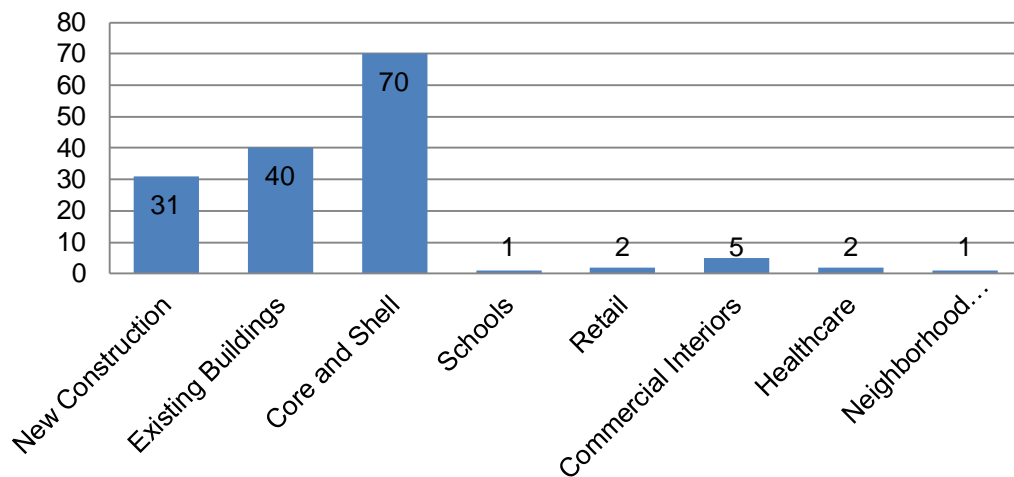


Figure 3. LEED projects in Finland as of Feb 2015 (including registered and certified projects). [11.]

From figure 3, LEED Core and Shell is the most popular LEED system used in Finland with 70 projects, followed by Existing Buildings with 40 projects and New Construction with 31. Over half of the certified projects in Finland achieved Gold rating level, a quarter was Silver, 10% received Certified and 12% was Platinum.

2.2 BREEAM International New Construction

Being the world's oldest building assessment method, BREEAM (*Building Research Establishment Environmental Assessment Methodology*) was first published by the Building Research Establishment organisation (BRE) in 1990. The scheme is most popular in the United Kingdom but has also gained popularity in Europe and many other countries around the world. BREEAM International 2013 (updated in April 2014) is the latest version of BREEAM assessment used in projects outside of the UK and is studied in this paper. [12.]

2.2.1 Overview

BREEAM is internationally recognised as a benchmarking tool for building sustainability measures. According to BRE, a quarter of a million buildings have been certified under BREEAM, including projects in more than 60 countries around the world. Like LEED, BREEAM works to raise the awareness of sustainability approach amongst building owners, designers, occupants and operators. It sets the standard in sustainable design and construction and assists in the adoption of the best practices throughout the entire life cycle of buildings. [12.]

BREEAM is the main rating system in the UK. BREEAM UK version includes 4 large schemes: BREEAM New Construction, BREEAM Communities, BREEAM Refurbishment, BREEAM In-Use, Code for Sustainable Homes and EcoHomes. For international projects, BREEAM International 2013 is currently used to assess new commercial and residential buildings worldwide, while BREEAM Europe Commercial 2009 remains the methodology for assessing all refurbishment or fit-out of office, retail and industrial buildings in Europe and EU member states. For other building types that are not covered, a bespoke process is needed to allow projects to be assessed and certified. Additionally, a number of countries have BREEAM schemes designed specifically for them, including Germany, Netherlands, Norway, Austria, Spain and Sweden. [12.]

2.2.2 How BREEAM system works

BREEAM uses a credit awarding system for verification against a set of sustainability criteria; however the amount of credits available varies depending on types of project. There are 10 environmental sections of sustainability in BREEAM International 2013, which can be seen in table 3. [12.]

Table 3. BREEAM 2013 International New Construction sustainability categories and credits [12.]

Section	Average weighting %	Credits available
Management	12	22
Health & wellbeing	15	10
Energy	19	30

Transport	8	9
Water	6	9
Materials	12.5	12
Waste	7.5	7
Land use & ecology	10	10
Pollution	10	13
Innovation	10	10

One point achieved in BREEAM does not necessarily equal to one point of the entire system, due to section weightings. These weightings are used to show the values of the sections and their contributions to the overall score. The assessment looks at each of the above sections in table 3 and awards credits based on the building performance against specific criteria. In each section, the percentage of the number of credits achieved over number of credits available is calculated. All of the percentages are then multiplied by the corresponding weightings of the sections and make up the overall score. BREEAM rating level is determined on the basis of the overall score, as following:

- Unclassified: <30%
- Pass: ≥ 30%
- Good: ≥ 45%
- Very good: ≥ 55%
- Excellent: ≥ 70%
- Outstanding: ≥ 85% [12.]

BREEAM sets out the minimum standards so that fundamental environmental issues are not overlooked. Unlike LEED where all prerequisites must be achieved for a building to be considered for any of LEED certification, BREEAM applies minimum standards for the specific rating level that the project aims to pursuit. [12.]

Another example of BREEAM's flexibility over LEED is the influence of a project's location on the sections and assessment issues. Climatic, cultural and economic aspects are taken into account in the development of the criteria to ensure a fair assessment. For instance, a project located in a high precipitation zone will be assessed against higher water saving performance benchmark due to the fact that it has a higher opportunity for rainwater recycling than projects in drier zones. [12.]

2.2.3 BREEAM certification process

In order for a building to be assessed against BREEAM, the project client needs to engage a licensed BREEAM assessor preferably early in the project to help achieving the target rating. A BREEAM assessor is a trained, qualified professional who knows the BREEAM criteria in detail so he or she can help the project team to understand what is needed to earn the credits. A BREEAM assessor can determine if the criteria have been met and write a report with evidences provided by the project team to help the project receive the rating it deserves. An assessor carries out the assessment and certification but does not influence the design process of a building. However, he or she can provide consultancy if the client needs it. [12.]

A building can be certified in two stages:

- Design Stage – leading to an Interim BREEAM certification
- Post Construction Stage – leading to a Final BREEAM certification [12.]

For the Design Stage method, a project is assessed and certified when its design has advanced to a stage where it has all the relevant design information that allows a BREEAM assessor to evaluate and verify the building's performance. For the Post Construction Stage, the assessment is done to verify the performance of a completed building using one of the two approaches: post construction review based on the completed interim design stage assessment, or post construction assessment (a full assessment) if an interim assessment has not been done earlier. [12.]

2.2.4 BREEAM projects in Finland

BRE has a tool called *GreenBookLive* which provides a listing of the BREEAM Assessments that have been certified under BREEAM 2008 onwards, except some buildings that cannot be listed due to confidentiality reasons. [13.]



Figure 4. Alberga Business Park, one of Projectus Team Oy's projects [14.]

According to this tool, there are in total 35 BREEAM certified projects in Finland listed. Among these projects, 26 of them were certified under BREEAM Europe Commercial 2009, 3 were under BREEAM International Bespoke and 8 were BREEAM International In-Use buildings. The most common rating level is “Very good” which was achieved by 19 of these projects. Only one achieved the rating of “Excellent”. Offices are the most common type of buildings certified under BREEAM, followed by retail buildings. [13.]

3 Building services in LEED and BREEAM

3.1 Overview of the building services sector

‘Building services’, according to the Chartered Institute of Building Services Engineers (CIBSE), includes everything inside a building which makes it safe and comfortable to be in. It refers to the technical services, systems and equipment that contribute to controlling the internal environment in a safe, functional and efficient manner providing a place where building occupants can live and work. In Europe, Canada and Australia, the term ‘building services engineering’ is often used while in the United States, the field is known as ‘architectural engineering’ or ‘building engineering’. [15.]

In Finland, building services (in Finnish: *talotekniikka*) include technical services, systems and equipment, energy efficiency, environmental impacts as well as building comfort. This chapter deals with the services that are offered by Projectus Team Oy – one of the leading building services companies in Finland, which include:

- Heating, cooling and ventilation
- Energy & indoor climate study
- Renewable energy
- Water, drainage and plumbing
- Electrical systems
- Information and communication (ICT)
- Lighting design
- Life cycle services

The study is carried out to identify the roles of above mentioned services in sustainable building certification, focusing on the two most popular green building certification systems in Finland LEED and BREEAM [3.]. A guidance is created as a result for this project with the purpose to help building services engineers and designers understand the certification process, recognise the building services-related credits and requirements and how to achieve them.

3.2 Building services in LEED

This section is a continuous development of a university project which was done earlier in the spring of 2014 by the author and the Projectus Team Company. The purpose of that project was to investigate the building services related credits in LEED 2009 New Construction. The results show that building services sector accounts for nearly 60% of the total amount of the entire LEED rating system, as seen in table 4. [16.]

Table 4. Building services credits in LEED. [16.]

Category	Credit	Credit Title	Points
Sustainable Sites	SS 7.1	Heat Island Effect, Non-Roof	1
	SS 7.2	Heat Island Effect, Roof	1
	SS 8	Light Pollution Reduction	1

Water Efficiency	WE p1	Water Use Reduction, 20%	Required
	WE 1	Water Efficient Landscaping	2-4
	WE 2	Innovative Wastewater Technologies	2
	WE 3	Water Use Reduction, 30-40%	2-4
Energy and Atmosphere	EA p1	Fundamental Commissioning of the Building Energy Systems	Required
	EA p2	Minimum Energy Performance	Required
	EA p3	Fundamental Refrigerant Management	Required
	EA 1	Optimize Energy Performance	19
	EA 2	On-site Renewable Energy	7
	EA 3	Enhanced Commissioning	2
	EA 4	Enhance Refrigerant Management	2
	EA 5	Measurement & Verification	3
	EA 6	Green Power	2
Indoor Environmental Quality	IEQ p1	Minimum IAQ Performance	Required
	IEQ p2	Environmental Tobacco Smoke Control	Required
	IEQ 1	Outdoor Air Delivery Monitoring	1
	IEQ 2	Increased Ventilation	1
	IEQ 3.1	Construction IAQ Management Plan – During Construction	1
	IEQ 3.2	Construction IAQ Management Plan – Before Occupancy	1
	IEQ 5	Indoor Chemical & Pollutant Source Control	1
	IEQ 6.1	Controllability of Systems, Lighting	1
	IEQ 6.2	Controllability of Systems, Thermal Comfort	1
	IEQ 7.1	Thermal Comfort, Design	1
	IEQ 7.2	Thermal Comfort, Verification	1
	IEQ 8.1	Daylighting & Views, Daylighting	1
IEQ 8.2	Daylighting & Views, Views	1	
Innovation			5
Total			59 + 5

Innovation credits mentioned in table 4 are exemplary performance credits and vary a lot among projects. The Materials category is not included in this section as it has no relation in LEED with the building services.

3.2.1 Sustainable Sites

One of the first decisions to be made in a building project is its site selection, or the area where the building is going to be located. It is also the topic of the first category looked at in LEED. This section of LEED aims to promote sustainable land use and minimisation of building's impacts. The location of a project has great impacts on the building's performance as well as the surrounding ecosystems as damages, caused by construction development, can take an extended time to remedy. [5.]

It is often that site selection and management is of the responsibility of the building owner, main contractor, or head architect. In this category, building services design mainly involves in the credits of heat island effect and light pollution. As the US Environmental Protection Agency explains, the 'heat island effect' occurs when human infrastructure, such as buildings and roads, replace natural open land and vegetation causing urban regions to become warmer than rural surroundings, forming an 'island' of high temperature. [17.]

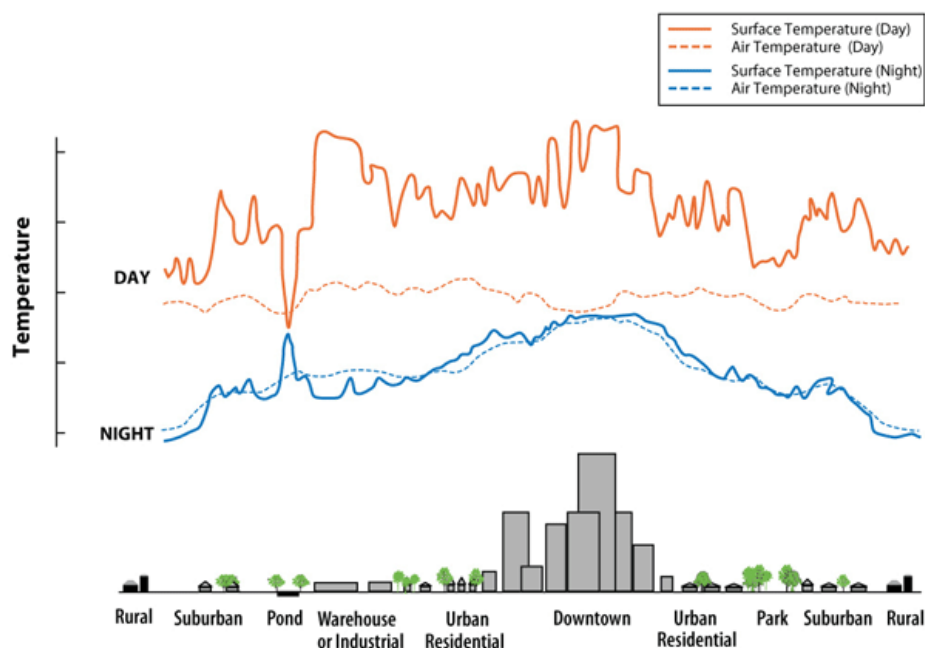


Figure 5. Heat island effect. [4.]

There are two credits for the heat island effect: roof and non-roof. Non-roof surfaces are site hardscape such as roads, sidewalks, courtyards and parking lots. LEED proposes a number of strategies such as using materials with high solar reflectance index (SRI), providing shading for hardscape using trees or solar panels, or simply by reducing hardscape area. For roofs, using coatings with high SRI and vegetation is recommended. [5.]

In Finland, the SRI is not often accounted for in the design of a building's indoor climate. Still, overheating in the summer time is a problem and using roofing materials with high SRI value can be a passive method to consider. With the help of a building simulation program, an energy engineer can provide a sophisticated insight on different roofing solutions and how they affect the building temperature and energy consumption, providing the architect with helpful information on the optimal selection. [18.]

Lighting pollution reduction credit includes both interior and exterior lighting systems. For interior lighting, nonemergency lighting density from the inside of the building to the outside must be reduced by automatic controls from 11p.m. to 5a.m, according to the LEED reference guide. For exterior lighting, power densities must not exceed those in the ASHRAE Standard 90.1-2007 for the specified lighting zone of the project. [5.]

The Finnish building regulations regarding external lighting have no requirements for reducing night time light pollution, but in LEED (and BREEAM) this is an issue. Therefore, it takes extra effort to comply with the requirements. Electrical designers must use computer modelling to design site lighting for proper selection and location of fixtures, and to determine compliance with lighting zone requirements.

3.2.2 Water Efficiency

According to the United Nations, around 2.8 billion people live in water-stressed areas today, and many more are approaching this situation [19.]. Because only 0.5% of the total amount of water on Earth is accessible for the needs of humans and ecosystem, water scarcity is among the main problems that affect every society and continent. As most of the available water is used for agricultural and industrial purposes, just a little over 10% is used domestically. It is very crucial that we are aware of the limited water resource and save water by using it effective and efficiently. The intent of *Water Effi-*

ciency credits in LEED is to reduce the water consumption of buildings by using water conservation strategies. Reducing water usage decreases maintenance and life cycle costs for building operations. Moreover, energy required for the treatment and distribution of fresh water and waste water is also reduced.

In LEED for New Construction rating, there is one prerequisite and three credits relating to building water use which are worth a total of 10 points and they promote the following measures:

- Monitoring of water consumption
- Reduce indoor potable water consumption
- Practice water-efficient landscaping [5.]

The *Water Reduction* prerequisite requires the building to use 20% less water than the water use baseline calculated annually for it. Project teams can establish their water baseline according to the standardised data provided in the LEED reference guide for plumbing fixtures such as faucets, toilets, urinals and showerheads. Data used for plumbing fixtures is regulated by the Energy Policy Act 1992 (EPAAct). Calculations are based on the number of full-time equivalent (FTE) load for all occupants, list of plumbing fixtures and their flow rates provided by the manufacturers. The design case is done in the same way as the baseline case, except for the EPAAct data which is substituted by real design data to determine the percentage of annual potable water savings. There are many water saving strategies that project teams can consider and implement for their projects. Further points are awarded for achieving savings above the 20% level of the prerequisite, as stated below:

- 30% savings = 2 points
- 35% savings = 3 points
- 40% savings = 4 points [5.]

For landscaping irrigation, the credit *Water Efficient Landscaping* awards 2 points for reducing potable water consumption for irrigation by 50% from a calculated mid-summer baseline, or 4 points for using no potable water for irrigation at all. These requirements can be achieved by a number of different strategies, for example rainwater harvesting, wastewater recycling or water treatment. Selecting native or adaptive plants

which require little or no irrigation and fertilisation can also help achieving this credit. [5.]

Building sewage can affect the potable water demand. The credit *Innovation Wastewater Technologies* requires a 50% reduction in potable water used for building black water produced by flush fixtures. It can be accomplished through the use of water conserving fixtures, non-potable water or treating 50% of wastewater on-site. For calculations, most of the work has been done in the Water Reduction prerequisite, except this time flow fixtures are removed from the equation because only flush fixtures are considered. [5.]

Water efficiency closely relates to energy efficiency. Although the supply of fresh water is not a concern in Finland, a considerable amount of heat is consumed through the heating of domestic hot water (DHW). The typical calculation method for estimating DHW use during the design phase, based on energy (kWh/m²) or water (litre/second/person), may not take into account the effect of water efficient fixtures. Therefore, new calculation methods should be implemented. The plumbing engineer is a key position to influence the water efficiency of a building. He or she, working along with the architect and civil engineer, performs the necessary calculations, sizes the equipment, and prepares plumbing system design and documents to help the project meet the LEED qualifications.

3.2.3 Energy and Atmosphere

Buildings use 40 % of the total EU energy consumption and generate 36% of greenhouse gases (GHG) in Europe [20.]. Increased energy use leading to burning of more fossil fuels is linked to global warming and air pollution. Understanding the importance of energy conservation in the building industry, LEED pays great attention to the *Energy and Atmosphere* category, giving it the most credits in the rating system (35 points available). The reason energy and atmosphere are combined is because a significant amount of GHG emissions come from energy sources.

This category looks at energy use in buildings focusing on four key goals:

- Determining building energy performance

- Tracking of building energy performance
- Managing refrigerants to eliminate CFCs
- Using renewable energy [5.]

For new buildings, energy performance depends significantly on the design. The orientation, massing (shape & size), construction methods, materials, envelope, water use, HVAC, and lighting systems all determine how efficiently the buildings perform in terms of energy. About 80% of energy consumption in Finnish buildings is for space heating purposes, accounting for a quarter of the energy consumption in Finland according to 2013 data from Statistics Finland [21.]. Therefore, it is natural to understand that Finnish builders pay great attention to building insulation and the efficiency of building heating and ventilation systems. Energy-efficient buildings create huge savings from operational costs for the owners and reduce the burden on the environment.

Commissioning

Included in the *Energy and Atmosphere* category, there are three mandatory requirements and six optional credits. There are two credits that are related to the commissioning process: the first prerequisite *Fundamental Commissioning of Building Energy Systems* and the credit *Enhanced Commissioning*. Their intent is to verify if the energy related systems are installed, adjusted and perform according to the owner's project requirements (OPRs), basis of design (BOD) and construction documents. The optional credit requires the commissioning authority to be on the project earlier and stay later than suggested in the prerequisite to complete several additional tasks. The systems to be commissioned include: heating, ventilation, air conditioning and refrigeration (HVAC&R) systems and associated controls, lighting and daylighting controls, domestic hot water (DHW) systems and renewable energy systems. The commissioning process is a planned and systematic process which is most effective when it begins at the early stage of the design. [5.]

The main steps in the commissioning process are:

1. Commissioning Authority to be designated
2. Owner to document Owner's Project Requirements (OPRs)
3. Design team to document Basis of Design (BOD)
4. Commissioning Authority to review OPRs and BOD

5. Commissioning Authority to develop and implement Commissioning Plan
6. Commissioning Authority to incorporate commissioning requirements into construction documents (CDs)
7. Commissioning Authority to verify installation and performance of commissioned systems
8. Commissioning Authority to produce summary commissioning reports [5.]

The Commissioning Authority is an individual who organises, leads and reviews the completion of the commissioning process activities. He or she acts as an independent objective advocate for the owner and is the only one who is permitted to perform important verifications and summary reports. Commissioning is essential to a successful delivery of a high performance building as it brings many benefits such as reduced energy use, lower operating costs, and verification that the systems perform as specified in the OPRs. Project team members are encouraged to participate in the commissioning activities. [5.]

Energy Performance

The goal of energy credits is to optimise the building so that the energy consumption is as small as possible while energy systems can perform properly and good indoor environment is maintained. In order to find that balance, project teams need to determine how much energy the building is going to save. The method is to design the project so that it uses less energy by a certain percentage over a comparable building. Prerequisite *Minimum Energy Performance* requires a project to demonstrate a 10% improvement in proposed building design compared to baseline performance, and the credit *Optimize Energy Performance* provides up to 19 points for performance better than the minimum threshold. It is worth to notice that the comparison is based on the total costs of all energy types consumed (as there are normally different prices for different types of energy used in building) rather than on the basis of total energy consumption. [5.]

Although there are three different pathways to achieve the *Optimize Energy Performance* credit, most projects often opt for the option *Whole Building Energy Simulation* because it contains the most credits and also provides more reliable and accurate results of energy performance. Small projects less than 1,858 square meters (20,000 square feet) may follow other options. For the energy simulation option, computer energy simulation software is required to establish a proposed building model, which is

then used as the basis for baseline building in accordance with Appendix G of the ASHRAE Standard 90.1-2007. Any updates (such as size of building and components, orientation, HVAC type and sizing) during the design process in the proposed model should also be reflected in the baseline case. As the proposed model is based on the actual design and the baseline model is dictated by ASHRAE, the total annual costs from energy consumption of both models are expressed in U.S. dollars and then used to calculate the percentage of improvement. The design team should check the energy prices from the utility provider as they may be different from project to project. [5.]

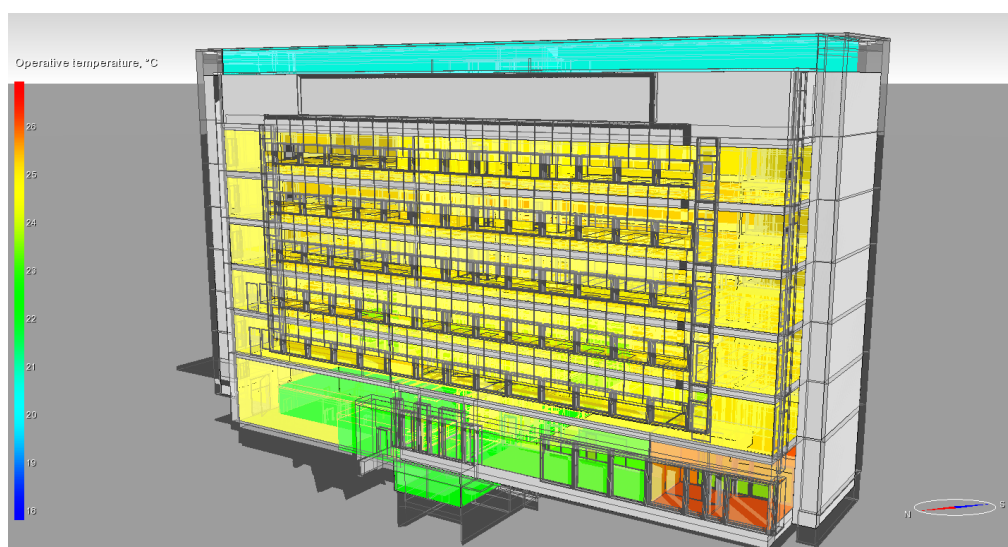


Figure 6. An example of building model in IDA-ICE simulation tool [30.]

Appendix G of the ASHRAE Standard 90.1-2007 is an informative set of requirements that must be met for the calculation of the proposed and baseline building performance. To achieve the credits, the proposed design must meet the following rules:

- Include all energy costs associated with the building project
- Comply with the mandatory provisions (Sections 5.4, 6.4, 7.4, 8.4, 9.4 and 10.4) in Standard 90.1-2007
- Process loads in the baseline building should be modelled as designed. Default process energy cost is 25% of total building energy cost, and justification should be provided if the process cost is lower than 25%. [5.]

Table 5 below is a quick summary of the mandatory provisions in the ASHRAE Standard 90.1-2007 that the proposed building design must comply.

Table 5. Summary of mandatory provisions for building energy modelling in LEED. [22.]

Section	Title	Summary
5.4	Building envelope	Insulation, fenestration & doors, air leakage
6.4	HVAC	Efficiencies, load calculations, controls, insulation
7.4	Service water heating	Efficiencies, load calculations, controls
8.4	Power	Voltage drop
9.4	Lighting	Control, wiring, exit signs, exterior ground lighting and power
10.4	Other equipment	Electric motor efficiency

For the submittal documentation of energy performance credits, a revised EAp2 Section 1.4 Tables spreadsheet must be completed and submitted along with supporting documents such as input and output summaries from energy simulation program, energy and cost reports.

Refrigerant

In buildings, refrigerants are used in HVAC systems for both heating and cooling purposes, as well as fire suppression systems thanks to their thermodynamic properties. Typically, chiller units use refrigerants to produce chilled water that travels to air handling units (or fan coil units) to cool the warm outdoor air entering the building during the summer months. Refrigerants can also be used for heating by practically the same but reversed process using heat pumps so that heat is supplied into the building rather than cooling. There are two types of refrigerants: mechanical refrigerants and natural refrigerants. Natural refrigerants are less effective than mechanical refrigerants as they require more energy to achieve the same amount of cooling. There are two common properties to assess the environmental impact of refrigerants: ozone depletion potential (ODP) and global warming potential (GWP). Natural refrigerants have low ODP and GWP and are usually benign to the earth's atmosphere. The idea is to select a refrigerant that is both effective and has low ODP and GWP when practical. [5.]

In the 20th century, chlorofluorocarbons or CFCs were commonly used because they were very effective refrigerants. However, during the 1980s scientists discovered that CFCs contributed to ozone depletion and global warming and hence they were banned under the Montreal Protocol. For basic refrigerant design in LEED, the intent of prereq-

quisite *Fundamental Refrigerant Management* is rather simple: zero use of CFC-based refrigerants in HVAC and fire suppression systems in new construction projects. However, if existing systems with CFCs as refrigerants are reused, it is possible to achieve this prerequisite by completing a CFC phase-out prior to project completion. [23.]

Beyond this basic design, a credit called *Enhanced Refrigerant Management* (worth 2 credits) provides projects following options to choose:

- Do not use refrigerants at all
- Use only natural refrigerants
- Select refrigerants with low ODP, GWP and leakage rate
- Select HVAC equipment with efficient refrigerant recharge and long service life
- Use halon-free fire suppression systems and fire extinguishers [5.]

The mechanical engineer is responsible for the design document submission for refrigerant credits. Submittal documentation generally includes a narrative describing the CFC phase-out plan when applicable, manufacturer's documentation on the types and quantities of refrigerants used in the building's HVAC systems, any impact calculations required with a narrative explaining the calculations, and confirmation of no CFCs, halons or HCFCs in fire suppression system.

Renewable Energy

Energy production from traditional fossil fuel-based sources significantly contributes to air pollution through the release of pollutants and greenhouse gases such as nitrogen oxide and carbon dioxide. Air pollution causes severe effects on human health, plants and animals on the planet and potentially worsens global warming and climate change. Use of renewable energy reduces the demand for conventional energy sources such as coal, oil and natural gas and its associated environmental impacts. Generation of power from renewable energy sources - such as sunlight, wind, water and geothermal heat is much more sustainable and environmentally beneficial. For LEED projects, renewable energy can come from on-site or off-site sources. [5.]

The use of on-site renewable energy technologies in the credit *On-site Renewable Energy* is a good way for building owners to demonstrate their commitment to reducing the negative environmental impact associated with building's energy use. The energy

produced by on-site renewable system is expressed as a percentage of building's annual energy cost, so that the amount of points is determined. Examples of eligible systems for this credit are photovoltaic system, wind energy system, solar thermal system, bio-fuel based electrical system, geothermal heating system, low-impact hydroelectric power system and wave/tidal power system. To estimate the amount of energy generated, the energy engineer must include the technologies in the building energy model and the simulation results can be used as submittal documentation for LEED. [5.]

Off-site renewable energy or the credit *Green Power* is considered to be beneficial for the environment as it comes from renewable sources with low carbon emissions resulting in less pollution. LEED projects can obtain green power credits by purchasing green power directly or indirectly from power provider or purchasing renewable energy certificates (RECs). The *Green Power* credit requires projects to engage in a minimum 2-year green power contract to provide at least 35% of building's electricity from renewable sources. The annual energy consumption can be obtained from the baseline results in the credit *Optimize Energy Performance* mentioned earlier, and all purchases must be based on quantity of energy consumed, not the cost. [5.]

Measurement and verification

Measurement and verification method provides ongoing accountability of building energy consumption over time. The aim is to continuously monitor building energy consumption to achieve and maintain an optimal performance over the lifetime of the building. The strategy for the *Measurement and Verification* credit is to develop and implement an M&V plan in consistency with the International Performance Measurement and Verification Protocol (IPMVP) Volume III: Concepts and Options for Determining Energy Savings in New Construction (2003). [5.]

3.2.4 Indoor Environmental Quality

A high performance and sustainable building should provide its occupants with a healthy indoor environment to live and work in. According the Finnish Institute of Occupational Health [24.], people in Finland spend between 80% and 90% of their time indoor. Thus, the indoor environment quality (IEQ) is especially important for their wellbeing and productivity. Unfortunately, as the US Environmental Protection Agency [25.]

points out that indoor air can sometimes be 2-5 times more polluted than outdoor air. “Sick building syndrome” is the term used to describe building related health problems and diseases that are a result of poor indoor air quality. IEQ problems can lead to liability issues, poor occupant health, missed work days, loss in employee productivity and costly remedies to repair the problems. [26.]

The factors that affect the indoor environment include:

- Ventilation rate
- Temperature and thermal comfort
- Humidity and dampness
- Freshness of ambient air
- Bacteria, fungi and dust
- Lighting
- Control systems

The intent of the IEQ category is to address building related environmental concerns and provide strategies to ensure the quality of living environment inside the buildings.

Indoor Air Quality

Two prerequisites in the *Indoor Environmental Quality* category represent the minimum efforts to ensure the basic quality of indoor air and they must be achieved before the project can proceed with obtaining credits. The prerequisite *Minimum Air Quality Performance* establishes the minimal air quality performance in compliance with the ASHRAE Standard 62.1-2007. [5.]

Similar to the prerequisite *Minimum Energy Performance* which sets the bar for energy performance, the prerequisite *Minimum Air Quality* makes sure that projects meet the requirements ventilation rate for one of the three ventilating methods:

- Mechanical ventilation: by determining the minimum required ventilation rates using ventilation rate procedure or local code whichever is more stringent. Section 4 through 7 of ASHRAE 62.1-2007 provides such information for this method.

- Natural ventilation: section 5.1 in the ASHRAE standard provides requirements on the location and size of openings in naturally ventilated buildings.
- Mixed mode ventilation: by meeting the requirements for ventilation rates in chapter 6 of the ASHRAE standard using any acceptable engineering calculation method regardless of ventilation mode. [5.]

For submittal documentation, the architects should complete the excel file for minimum ventilation rates, “62MZCal”, provided by LEED that shows compliance with the flow rates specified in the ASHRAE Standard 62.1-2007. For Finnish construction projects, this prerequisite is usually easy to achieve as ventilation rates in the Finnish building code are more stringent than ones in the ASHRAE standard. [27.]

The second prerequisite *Environmental Tobacco Smoke Control* addresses the control of second-hand smoking in buildings. Exposure to second-hand smoking is just as dangerous as smoking itself and is the cause of thousands of deaths of non-smokers in lung cancer every year [28.]. For all projects, the best strategy is to prohibit smoking in the building. Another option is to allow smoking in designated areas in the building. For residential buildings and hospitals, smoking must be prohibited in all common areas of the building. Smoking is also not allowed at all in schools. If allowed on the grounds, smoking area has to be at least 8 meters away from entries, outdoor air intakes or operable windows. The architects or facility managers provide evidence for compliance with above requirements. [5.]

The credit *Outdoor Air Delivery Monitoring* monitors the delivery of outdoor air into the building. The requirement is to install permanent monitoring systems for building ventilation to help the building operator stay informed about the outdoor air delivery. Accompanied by CO₂ monitoring and air flow measuring equipment, an alarm can detect when the system is 15% below or above the design minimum outdoor air rate, as defined in ASHRAE Standard 62.1-2007. The equipment must be able to feed information to the HVAC system or building automation system (BAS) for adjustment. Floor plans and drawings that highlight the location of CO₂ sensors and outdoor airflow measurement devices are sufficient to be submitted to LEED Online. [5.]

The credit *Increased Ventilation* is a step up from the prerequisite *Minimum Air Quality*, as the outdoor ventilation rates to all occupied spaces must be increased by 30% above the minimum rates, defined in ASHRAE Standard 62.1-2007. The intent is to

increase the quality of indoor air. However, an increase in ventilation will raise the energy consumption which negatively affects the building energy performance; therefore better approaches need to be considered such as using a heat recovery method. [5.]

The credits *Construction IAQ Management Plan* cover the management of indoor air quality during construction and before occupancy to promote comfort and well-being of both construction workers and building occupants. During construction, an IAQ management plan needs to be developed and implemented, addressing following actions:

- During construction, project must comply with the control measures of the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guidelines for Occupied Buildings under construction.
- Project must protect on-site stored and installed absorptive materials from moisture damage.
- If permanent installed air handlers used during construction, filtration media must have a minimum efficiency reporting value (MERV) of 8 at each return air grille per ASHRAE 52.2-1999. [5.]

Before the occupancy, either flush-out or air testing must be carried out. A building flush-out is performed by supplying a total air volume of 4000 cubic meters of outdoor air per square meter of floor area, while maintaining internal temperature of 15 Celsius degree and up to 60% relative humidity. The air testing approach, on the other hand, is to confirm that major contaminants stay below acceptable levels before occupancy. [5.]

In addition, pollutants must be prevented from contaminating the indoor environment. The credit *Indoor Chemical & Pollutant Source Control* is designed to minimize building occupant exposure to potentially hazardous particles and chemical pollutants. The following strategies are addressed and applied to regularly occupied building areas:

- Entryway system: to be installed at each outdoor-to-indoor entry to prevent contaminants from entering the building. The system must be at least 3 meters long in direction of travel to capture dirt and particles. Metal grates and walk-off mats can be used at every entrance to remove dirt and contaminants from shoes.
- Isolated and sufficient exhaust systems in areas where hazardous gases and chemicals may be present. Examples of such areas are garages, cleaning and laundry areas, copying and printing rooms, science labs, etc.

- For mechanically ventilated buildings, filters in air handling units must be MERV 13 or higher, for both outdoor supply and return air.
- Closed storage must be provided for off-site disposal of hazardous liquid wastes. [5.]

Mandatory documentation to the LEED Online to support compliance with above requirements includes:

- Floor plans showing entryway system locations and measurements
- Mechanical drawings highlighting location of hazardous gas usage areas, room separations and associated exhaust systems
- Documentation listing MERV ratings for all air handling units installed in the project [5.]

Thermal comfort

In addition to air quality, the comfort of the occupants also plays an important role in the success of good IEQ. Green buildings should be designed to ensure a majority of occupants to have thermal comfort for working and living activities. Thermal comfort indicators include environmental conditions (air temperature, radiant temperature, humidity and air speed) and personal factors (metabolic rate, activity, and clothing factor). To qualify for the credit *Thermal Comfort - Design*, a building's HVAC systems and envelope must comply with ASHRAE Standard 55-2004, Thermal Environmental Conditions for Human Occupancy. In general, the standard requires that the level thermal comfort in occupied spaces must be within the allowed ranges stated in the standard, using the Predicted Percentage of Dissatisfied (PPD) and Predicted Mean Vote (PMV) method. Human metabolic rate, clothing insulation and other factors affecting indoor thermal comfort must also be taken into account for comfort modelling. [5.]

During the design and planning, owner and design team should determine the building's indoor comfort needs based on its type, size, location, nature of operations and local climate conditions. Once defined, designers can use HVAC load calculation methods in sizing and selecting HVAC equipment to meet the thermal comfort goals. This task can be integrated into the energy simulation task because some building energy simulation programs have the ability to also study the indoor climate conditions. Outputs from the load calculation software can be used to submit to the LEED Online

along with supporting documents confirming compliance with ASHRAE 55-2004. During post-occupancy, thermal comfort can be verified by having building occupants fill out a thermal comfort survey, as required by IEQ Credit 7.2 *Thermal Comfort - Verification*. ASHRAE 55-2004 can be referred to as guidance to establish thermal comfort criteria. After the survey, if more than 20% of those who answered are not satisfied with the level of comfort in the building, the design team must develop a plan for corrective actions. Additionally, a permanent monitoring system is needed to ensure that the building performance meets the desired comfort criteria set during the design phase. [5.]

Controllability of thermal comfort

Many conventional buildings do not give the occupants the control over thermal conditions. Nowadays, it is considered to be better when individuals can adjust thermal conditions for a more comfortable environment. IEQ Credit 6.2 *Controllability of Systems – Thermal Comfort* requires that 50% of building occupants should be provided with thermal comfort control, through adjustment of comfort parameters such as thermostats, diffusers (located at the floor, desk, or overhead level) and radiant panels. Occupancy sensors can also be used to automatically turn down the thermostat and reduce air flow when the space is unoccupied, thus reducing energy use. Representative drawings and floorplans that identify thermal comfort controls declared are needed to achieve this credit point. [5.]

Lighting design

Lighting design is at the heart of sustainable building design. There are two types of lights that can be optimised in buildings: electric lighting and daylighting. When properly designed, daylighting can offer significant energy savings by offsetting a portion of the electric lighting load. Besides, numerous studies have shown the positive health effects daylight exposure has on people. For the daylighting credit, designers can, through computer simulation, demonstrate that 75% of all regularly occupied spaces achieve daylight illuminance levels of a minimum of 25 foot-candles and maximum of 500 foot-candles in a clear sky condition on September 21 at 9 a.m. and 3 p.m. Furthermore, building occupants should also be provided with outdoor views. LEED requires a direct line of sight to 90% of the occupants to see the outdoor environment through windows placed between 0.8 meter and 2.3 meter above the finished floor. The glazing design

should also be studied using computer simulation to avoid increased unwanted solar heat gain or heat loss. [5.]

Controllability of lighting

The benefits of daylighting are maximised when both occupancy and lighting sensors are used to control the electric lighting system. For IEQ Credit 6.1 *Controllability of Systems – Lighting*, individual lighting controls must be provided for 90% of the occupants to enable adjustments to suit their needs. Lighting system designs should comply with average illumination levels recommended by the Illuminating Engineering Society of North America. [5.]

3.3 Building services in BREEAM

Moving on to BREEAM rating system, the building services sector also plays an important role. BREEAM International 2013 New Construction credits have been studied and as a result, there are 66 points related to the building services (different projects may have different amount of credits available), accounting for 53% of the total BREEAM system, when taking section weighting into account. The credits are presented in table 6 below.

Table 6. Building services credits in BREEAM.

Category	Credit	Credit title	Points
Management	Man 01	Sustainable Procurement	3
	Man 05	Life Cycle Cost and Service Life Planning	3
Health & wellbeing	Hea 01	Visual Comfort	4
	Hea 02	Indoor Air Quality	4
	Hea 03	Thermal Comfort	2
	Hea 04	Water Quality	1
Energy	Ene 01	Energy Efficiency	15
	Ene 02	Energy Monitoring	1
	Ene 03	External Lighting	1
	Ene 04	Low and Zero Carbon Technologies	2

	Ene 05	Energy Efficient Cold Storage	3
	Ene 06	Energy Efficient Transportation Systems	2
	Ene 08	Energy Efficient Equipment	2
Transport	N/A		
Water	Wat 01	Water Consumption	5
	Wat 02	Water Monitoring	1
	Wat 03	Water Leak Detection and Prevention	2
	Wat 04	Water Efficient Equipment	1
Materials	Mat 01	Life Cycle Impacts	6
Waste	N/A		
Land use & ecology	N/A		
Pollution	Pol 01	Impact of Refrigerants	4
	Pol 02	NOx Emissions	3
	Pol 04	Reduction of Night Time Light Pollution	1
Innovation			10
Total credit points			66 + 10
Total score (with section weighting)			53%

Innovation credits mentioned in table 6 are exemplary performance credits and vary a lot among projects. Building services have little involvement in the Transport, Waste and Land use & ecology categories, and therefore not included in this section.

3.3.1 Management

The BREEAM category “Management” (abbreviated as Man in table 6) deals with the construction site and property management. This section aims to promote the management skills which look into the impact of the construction site on the surrounding environment and neighbourhood, as well as the health and safety of the workers working on-site. Overall, there are 5 credits in this category and the weighting factor is 12% of the entire BREEAM system. Building services contribute in two main areas: commissioning and life cycle cost.

Man 01 – Sustainable procurement (Commissioning, 3 credits)

The *Sustainable procurement* credit is split into three parts: project brief and design, construction and handover, and aftercare. Two commissioning credits for building services systems are included in the latter two, with one is done before the occupancy and the other is post-occupancy. [12.]

For the first commissioning credit, a project team member is to be appointed for the commissioning tasks. The commissioning process includes pre-commissioning, commissioning and, when necessary, re-commissioning of the key building services:

- a. Heating systems
- b. Water distribution systems
- c. Lighting systems
- d. Ventilation systems
- e. Refrigeration systems
- f. Automatic controls
- g. Cold storage [12.]

The main contractor accounts for the commissioning program within the main construction work. Additionally, a specialist commissioning manager must be appointed during the design stage for complex building systems that require more expertise. For an additional point to be awarded, all building services should be included in the commissioning schedule, and commissioning procedure must follow national best practice codes or appropriate alternative guidance. Appointment letter or commissioning responsibilities schedule, relevant section in building specification or contract, main contractor program and commission schedule, wherever relevant, are required by BREEAM as evidence to achieve this credit. [12.]

The second commissioning credit, called 'Seasonal commissioning', demands the commissioning tasks to be done over a minimum of a 12-month period after the building becomes occupied. An external consultant or facilities manager can be responsible for simple systems in naturally ventilated buildings, while testing of complex systems is the responsibility of the specialist commissioning manager. [12.]

Man 05 – Life cycle cost and service life planning (3 credits)

Life cycle cost (LCC) analysis is part of the services offered by Projectus Team therefore; it is discussed in this paper. The European Commission defines LCC as a tool to evaluate the costs of an asset throughout its life cycle [29.]. LCC is based on purely financial valuation in which the costs are expressed in monetary terms. Three points are available for this credit, which aims to encourage life cycle cost and service life planning, in order to offer data for the decisions regarding the design, specification and maintenance and operation of the buildings.

An LCC analysis is conducted in accordance with ISO Standard 15685-5:2008 for three building stages: construction, operation and maintenance. The study period is at least 40 years, ideally 60 years, and shows both real and discounted cash flow terms. A critical appraisal must also be completed at the feasibility stage of building procurement, covering service life estimations and maintenance implications for specific design requirements. Full three points are awarded if an LCC analysis is done at a more detailed strategic system level and updated during design development stage. [12.]

3.3.2 Health & Wellbeing

The health and wellbeing of the building occupants should always be one of the main criteria in green building design. According to the “The Drive toward Healthier Buildings Smart Market Report” from McGraw-Hill Construction, 56% of building owners saw lower rates of absenteeism and 21% reporting improved productivity from the employees working in buildings that have implemented green design features and practices, such as use of daylighting, non-toxic materials, higher indoor air quality and accessibility to outdoor views [30.]. The importance of this issue is shown in BREEAM as this category accounts for 15% of the total rating system, the second highest just after energy efficiency. [12.]

HEA 01 – Visual comfort (4-6 credits)

In order to gain points for the *Visual comfort* credit, one prerequisite must be met. It requires that all fluorescent and compact fluorescent lamps in the building must be fitted with high frequency ballasts (electric ballasts). The advantages of electric ballasts

over conventional ballasts are that they are quieter, more reliable, more energy efficient, offer better control and produce less heat. Another option worth considering is LED lighting. LED lighting is becoming an increasingly popular choice of lighting as LED lights are extremely energy efficient and have a much longer life span compared to other lighting types. [12.]

Up to two credits (commercial buildings) or four credits (residential buildings) are available for the use of daylight. Daylighting can be designed in compliance with the national best practice for daylighting, or the values provided for the average daylight factor, uniformity or illuminance recommendations in the BREEAM manual. [12.]

In regularly occupied building areas, glare is to be controlled via the design so that daylight still can enter the spaces even on cloudy days. Architects should refer to the manual for the appropriate window sizes and openings with a view out. Internal and external lighting must be designed to meet the national best practice lighting guides or BREEAM requirements. [12.]

HEA 02 – Indoor air quality (4 credits)

Asbestos, which is a set of naturally occurring silicate minerals, was commonly used in the 1980s as fire-proofing materials in building thanks to its heat and fire-resistant properties. However, exposure to asbestos has been linked to health problems and risks of cancer. The laws in the U.K. have banned the use of asbestos and the prerequisite of this section also sets the same rule. [31.]

For minimising sources of air pollution, an IAQ plan must be developed to maintain good indoor air quality. National best practice for ventilation should be followed to provide enough fresh air and minimise internal pollutants. After the construction, measurements must be made to ensure that the concentration level of contaminants inside the building is below the allowed limits. [12.]

HEA 03 – Thermal comfort (2 credits)

Similarly to LEED, PMV and PPD metrics are used to determine the level of thermal comfort using thermal modelling simulation. The modelling is done in accordance with ISO standard 7730:2005 taking seasonal variations fully into account. Two full credits

are awarded when a thermal modelling analysis is made to inform the operational manager of the building about the temperature control strategy. [12.]

HEA 04 – Water quality (1 credit)

Fresh drinking water for all occupants is essential in every building. BREEAM requires the water systems to be designed in compliance with the relevant national health and safety best practice to minimise any risk of microbial contamination. Supply of accessible potable water must be adequate on each floor level. [12.]

3.3.3 Energy

One of the first steps to achieving sustainability in buildings is to reduce the energy consumption while still maintain good performance of building systems. The importance that energy efficiency has in a sustainability framework is significant and, as a sign of this BREEAM allocates 26 points in this category. [12.]

ENE 01 – Energy efficiency (15 credits)

The energy performance of the building is calculated from design information using a BREEAM-approved energy modelling software. The estimated energy performance of the assessed building is compared to the performance of an equivalent Notional building designed to meet, but not improve on, the current building energy performance standard. BREEAM 2013 International uses ASHRAE standard 90.1-2010, an updated version of ASHRAE standard 90.1-2007 in LEED 2009, when establishing the baseline and proposed models. BREEAM uses a metric that is unique to this system, called the Energy Performance Ratio for International New Construction (EPRINC), which takes account following parameters:

- Operational energy demand (MJ/m²)
- Primary energy demand (kWh/m²)
- Total resulting CO₂ emissions (kgCO₂/m²) [12.]

Data from the above parameters from actual building (proposed model) and notional building (baseline model), along with the building gross floor area (m²), are essential

for the calculation to determine the score of EPRINC. A number of BREEAM credits is awarded to according to the EPRINC score calculated. A copy of the report from the simulation tool illustrating these results is a necessary submittal document. [12.]

ENE 05 – Energy efficient cold storage (3 credits)

The purpose of *Energy efficient cold storage* credit is to recognise and encourage the installation of energy-efficient refrigeration systems to reduce operational energy use and the resulting greenhouse gas emissions. It is recommended that a suitably qualified engineer to be appointed during the concept design stage for assisting the design and installation of the refrigeration system. According to the BREEAM manual, a number of strategies and requirements proposed by BREEAM are required for controls, components and commissioning with respect to the refrigeration system. [12.]

ENE 06 – Energy efficient transportation systems (2 credits)

Transportation systems in building are lifts, escalators, elevators and moving walks. For *Energy efficient transportation systems* credit, demand and usage patterns must be analysed to determine the optimal number and size of each of these systems. Furthermore, design teams can estimate the amount of energy consumption to specify the strategies that offer greatest potential energy savings. [12.]

ENE 08 – Energy efficient equipment (2 credits)

Equipment and appliances are major energy consuming end-uses within buildings. Making use of energy efficient equipment will reduce the energy usage and create savings for the building owner. For two credits, BREEAM provides a list of equipment and their required specifications so design teams can specify which of them are used in the assessed building and comply accordingly. Additionally, the team should identify which devices are responsible for the majority of equipment energy consumption. [12.]

ENE 02 – Energy monitoring (2 credits)

Energy monitoring within BREEAM aims to recognise and encourage monitoring of operational energy consumption through sub-metering. One credit is achieved when a Building Energy Management System (BEMS) or separate sub-meters are installed for

energy consuming systems such as space heating, domestic hot water, cooling, major fans, lighting and others. Implementing a BEMS or accessible sub-meters, to all tenants or by floor of single occupancy buildings, rewards a second point. [12.]

ENE 03 – External lighting (1 credit)

Projects can earn a point through *External lighting* credit by meeting or exceeding lighting requirements in BREEAM and providing controls, such as time switch or daylight sensors, for light fittings in external areas. [12.]

ENE 04 – Low and zero carbon technologies (2 credits)

In a simply explained way, *Low and zero carbon technologies* credit aims to reward projects that make use of local renewable energy. Projects are to achieve the first point, through a feasibility study conducted at the concept design stage by an energy specialist, to establish the most appropriate on-site low or zero carbon (LZC) energy source for the building. A second point is available when a life cycle analysis (LCA) of carbon impact is included for the chosen LZC system. [12.]

3.3.4 Water

WAT 01 – Water consumption (5 credits)

BREEAM has a particular water calculation tool called “*Wat 01 calculator*” that establishes a water baseline case and allows the input of actual water consumption data for comparison. *Water consumption* credit aims to reduce building’s potable water through the use of water efficient fixtures (WCs, urinals, taps, showers, baths, dishwashers, washing machine) and water recycling systems (greywater and rainwater). The number of BREEAM credits is determined on the basis of the precipitation zone that the project belongs to. [12.]

WAT 02 – Water monitoring (1 credit)

Monitoring the water consumption within a building can contribute to consumption reductions as the building owners and occupants become aware of the amount of water

they use. The credit *Water monitoring* demands project to water meter all incoming water supply to the building and sub-meter all plants or building areas that account for more than 10% of the building's total water demand. Each meter must have the ability to give instantaneous reading and enables connection to Building Management System (BMS). [12.]

WAT 03 – Water leak detection and prevention (2 credits)

Leakage in the water piping system is difficult to notice when it happens and could cause water damage to the building and unwanted rise in water bills. BREEAM provides a credit specific to this issue while it is absent from LEED. Two credit points are available, one for when a leak detection system is in place and another for when flow control devices are fitted in each WC area. [12.]

WAT 04 – Water efficiency equipment (1 credit)

The *Water efficiency equipment* credit aims to reduce the use of potable water for landscape irrigation. The requirements are that projects to implement irrigation controls, reclaimed water, no irrigation at all or only manual irrigation. [12.]

3.3.5 Materials

One credit in this category that belongs within the scope of building services defined earlier is the life cycle impacts of building elements, especially the building systems.

MAT 01 – Life Cycle Impacts (1-6 credits)

This section examines the environmental impacts due to the materials used in buildings during its life cycle, and the allocation of credits accordingly. Projects use a life cycle analysis (LCA) tool to measure the impact of main building elements specified in BREEAM *Mat 01 calculator*. Points are awarded on the basis of the total score achieved from the calculation result. [12.]

3.3.6 Pollution

Three areas of pollution that affect the building services are refrigerants used in building systems, NO_x emissions from heating and hot water plant, and night time pollution of external lighting. [12.]

POL 01 – Impact of refrigerants (4 credits)

Building systems may leak refrigerants, which are greenhouse and ozone depleting gases. To reduce this, BREEAM split this credit into two parts: Ozone Depleting Potential (ODP) and Global Warming Potential (GWP). The former is worth one credit and requires that the refrigerants used within the building must have an ODP of zero, or just no refrigerants at all. Projects which use no refrigerants also automatically achieve full three credits for the second part. Also, projects that use refrigerants must meet the requirements for a metric called “Direct Effect Life Cycle CO₂ equivalent emissions” (DELCO₂e), using the BREEAM *Pol 01 calculator*. [12.]

POL 02 – NO_x emissions (3 credits)

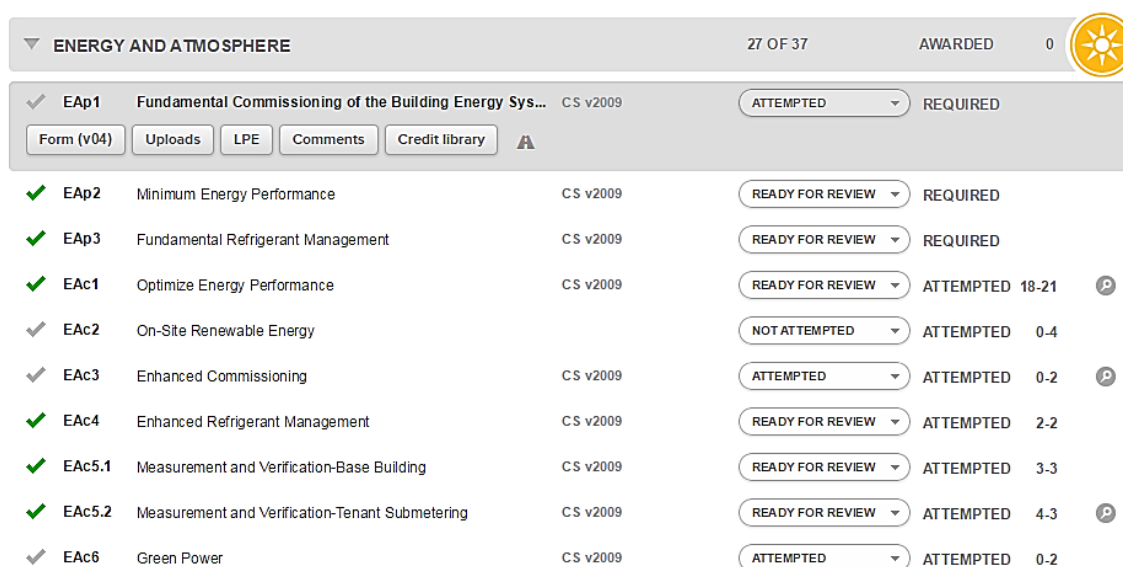
NO_x emissions are a part of the air pollution that leads to health issues in humans and impact local environment negatively. Three credits are allocated for this credit when the installed heating system, that satisfies building’s delivered heating and hot water demand, does not exceed the limits of a dry NO_x emission level stated in the BREEAM manual. [12.]

POL 04 – Reduction of night time light pollution (1 credit)

External lighting, when not designed properly, causes light pollution during night time that affects the wildlife, environment and people, as well as wastes energy and resources. Projects must meet the limits for external lighting set in Section 2.7 of the standard CIE 150-2003 and Table 2 in CIE 126-1997. Lighting fixtures must also be fitted with automatic controls which switch the light off between 23:00hrs and 6:00hrs. However, if for safety and security reasons, projects can comply with recommendations in CIE 150-2003 and CIE 126-1997 during these hours. [12.]

4 Research Methodology

In order to gain a good understanding of the rating systems, the research was started by examining a variety of publications and literature materials available for LEED, BREEAM and related issues. Two very important documents that were used throughout this paper are the “LEED 2009 New Construction reference guideline” and the “BREEAM 2013 International New Construction manual”, which were both available for access from the company’s internal network. Some of the relevant standards such as ASHRAE standard 90.1-2007 were also provided. The LEED guideline was a continuous development from the results of a university project which was carried out in spring of 2014 the author of this paper together with Projectus Team Oy. The project provided information about the building services related credits in the LEED system and the requirements.



ENERGY AND ATMOSPHERE		27 OF 37	AWARDED	0
✓ EAp1	Fundamental Commissioning of the Building Energy Sys...	CS v2009	ATTEMPTED	REQUIRED
✓ EAp2	Minimum Energy Performance	CS v2009	READY FOR REVIEW	REQUIRED
✓ EAp3	Fundamental Refrigerant Management	CS v2009	READY FOR REVIEW	REQUIRED
✓ EA1	Optimize Energy Performance	CS v2009	READY FOR REVIEW	ATTEMPTED 18-21
✓ EA2	On-Site Renewable Energy		NOT ATTEMPTED	ATTEMPTED 0-4
✓ EA3	Enhanced Commissioning	CS v2009	ATTEMPTED	ATTEMPTED 0-2
✓ EA4	Enhanced Refrigerant Management	CS v2009	READY FOR REVIEW	ATTEMPTED 2-2
✓ EA5.1	Measurement and Verification-Base Building	CS v2009	READY FOR REVIEW	ATTEMPTED 3-3
✓ EA5.2	Measurement and Verification-Tenant Submetering	CS v2009	READY FOR REVIEW	ATTEMPTED 4-3
✓ EA6	Green Power	CS v2009	ATTEMPTED	ATTEMPTED 0-2

Figure 7. The LEED Online system. [27.]

The LEED Online system, where project teams can fill the credit forms and submit required documentation, is also a valuable tool for this thesis project. It was possible to access previous projects and go through the documentation to have an understanding of what is to be submitted to obtain the qualification. This information was especially helpful for the making of the LEED design guideline. Unfortunately, when this paper was written, access to the BREEAM online system was not available, and only little information was found regarding this system.

5 Development of the Guidelines

5.1 Description of the guidelines

The task of the final year project was to create design guidelines for both LEED and BREEAM systems focusing on building services related credits. The purpose of the design guidelines is to assist building services engineers to oversee the projects with an understanding of the key sustainability points, the prerequisite and credit requirements that must be met, and documentation that must be produced.

Guidelines were created separately for LEED and BREEAM. However, their structures are identical. Both of them present the main information of the rating systems: credit name and title, amount of points available, general requirements which were studied from the original guidance, a list of the required documentation and referenced standards that the designers can refer too. The guidelines are not published with this paper, but table of content of the BREEAM guideline can be found in the appendix 2. Figure 8 shows an example of a credit in the BREEAM guideline.

HEA 03 – THERMAL COMFORT

(2 credits)

Credit	Requirements	Output documents
One credit	<ol style="list-style-type: none"> 1. Thermal modeling using PPD and PMV in according with ISO 7730:2005 (taking full account of seasonal variations) 2. Local thermal comfort criteria used to determine level of comfort in building (internal winter and summer temp ranges in line with recommendations in ISO 7730:2005). No areas falling within the levels defined as representing local dissatisfaction. 3. Thermal comfort levels in occupied spaces meet Cat B in TABLE A.1 Annex of ISO 7730:2005 4. PMV and PPD reported to BREEAM based on modeling above 	<ul style="list-style-type: none"> • Relevant sections/clauses • Thermal modeling evaluation results with confirmation these are within required limits • PMV/PPD data from design team
Two credits	<ol style="list-style-type: none"> 5. Above achieved 6. A thermal modeling analysis to inform the temperature control strategy. Software used provides full dynamic thermal analysis. Further guidance in CIBSE AM 11 Building energy and environmental modeling 	<ol style="list-style-type: none"> 1. Thermal comfort strategy and software results highlighting the points considered 2. Confirmation that software is BREEAM compliant 3. Relevant sections/clauses 4. Design drawings

Figure 8. Example of one credit in the BREEAM design guideline. [32.]

After the guidelines were completed, feedback was collected from the participants, engineers and professionals from different departments such as energy, HVAC, water, lighting, commissioning, and life cycle services within the Projectus Team Company. The participants agreed to go through the guidelines, answered interview questionnaire regarding the documents, and evaluated the effectiveness and usefulness of the guidelines as well as gave feedback for improvement. Feedback forms were analysed, and the results are presented in Section 6.1 “Results” of this paper.

5.2 Application of tools – Case study “Air Cargo Terminal”

5.2.1 Objectives of the study

The tools were tested on a logistic centre project serving a nearby airport. The building consists of parking areas for vehicles, storage areas with heavy automation systems (cranes) and refrigeration systems, loading areas for trucks and airplanes, and a small office area. The site area can be seen in figure 9.



Figure 9. Construction area where the cargo terminal will be located. [32.]

Due to confidentiality reasons, the identity of the project is not published. At the time this paper was written, the project was still at an early design phase with little information and many uncertainties. The property investor sought to achieve a green building certification for the building, with LEED and BREEAM being the main choices. The main objective of the preliminary study was to compare the LEED and BREEAM requirements and to clarify the opportunities for certification. The results were meant to

help the property owner and the project team to make the decision on the possible rating system, expected level of certification and useable tools.

Assessment tools used were the LEED for New Construction v2009 and BREEAM International New Construction 2013. After the pre-assessment was done, BREEAM turned out to be a more favourable choice between the two. If BREEAM were used, BREEAM Bespoke system would have to be applied because the logistic centre belongs to a non-standard building type. The following is a brief pre-assessment summary of the building services credits in BREEAM for this project.

5.2.2 Case study results

LEED New Construction 2009

In the preliminary study of the project, LEED Silver certification level was defined based on the information available. Silver level requires the project to achieve mandatory requirements for a minimum of 50 points. During the certification process, the number of points that a project can achieved could be changed so a margin of approximately 10% should be taken into consideration. Based on the assessment, the project could reach up to 56 points. The expected score resulted from credits with high feasibility and cost-effectiveness.

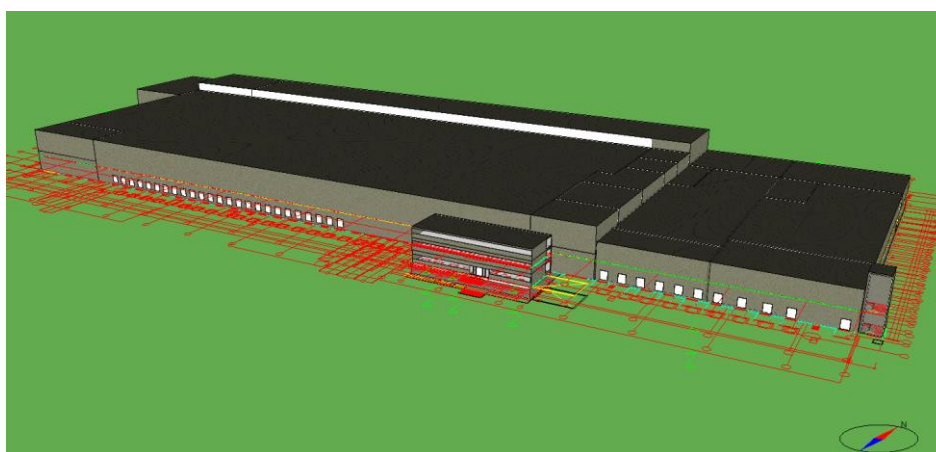


Figure 10. Building energy model of the logistic centre project. [32.]

Below are some significant measures that caught the attention of the design team:

- **Water efficiency credits:** These credit requirements should be taken into account in the selection of water fixtures. Water fixtures (WCs, urinals, sink faucets, kitchen faucets, and shower heads) should be water efficient and, if possible, fitted with sensors or flow control devices. This type of efficient fixtures are often more expensive than conventional designs.
- **Fundamental Commissioning of Building Energy Systems:** The prerequisite requires extra effort of normal administrative work. The commissioning task could be included in the tasks of one of the administrators with the assistance of the automated storage area supervisor.
- **Measurement and Verification:** Whole building energy consumption measurement is required for this credit. In addition, a measurement and verification needs to be drawn up, covering efficiency improvements, in at least one year after the construction finishes. The energy simulation of in the credit *Minimum Energy Performance* should be calibrated as-built in accordance and rechecked about a year after project completion.
- **Green Power:** A minimum of two-year power contract from green electricity provider is required. Alternatively, so-called RECs certificates must be obtained. In both scenarios, the green energy must account for at least 35% of the building's electricity use. The calculation will be done in the credit *Optimize Energy Performance's* annual energy cost estimation.
- **Outdoor Air Delivery Monitoring:** This credit calls for the measurement of all outdoor air ventilation machines and CO₂ monitoring in all areas where large number of people may occupy.
- **Thermal Comfort - Design:** thermal modelling is integrated in energy modelling made by the energy expert.

BREEAM International New Construction 2013

BREEAM pre-assessment indicated the BREEAM level **Very Good** for this project. The Very Good level needs mandatory requirements to be achieved for a minimum of 55% of the total weighted points. The project was expected to reach **66.11%** of the total score. The expected score resulted from credits with high feasibility and cost-effectiveness.

Below are some significant measures that caught the attention of the design team:

- *Sustainable Procurement*: the project team needs to ensure that the commissioning process is adequate and data should be reported on water and energy consumption for 3 years after completion (for exemplary performance).
- *Indoor Air Quality and Thermal Comfort*: Indoor air quality (IAQ) plan must be developed and implemented. Thermal comfort modelling must also be established.
- *Water Consumption*: water-efficient fixtures are used to reduce the water consumption of the building.
- *Energy and Water Monitoring*: both water and energy will be monitored throughout the entire building.

5.2.3 Summary of the case study

The project was preliminarily assessed on the basis of initial information and had the possibility to achieve either a LEED Silver or BREEAM Very Good certification level. Both rating systems contain low-cost and high-cost measures. According to the architect, sanitary equipment are possibly the most cost-intensive and must be included regardless the rating system. In addition, the biggest cost associated with LEED is the commissioning and measurement tasks, while for BREEAM it is the further studies and guidance. Low cost measures in both certification systems focus on the contractor's site management and responsibilities. The total costs for a certification process are approximately the same for both LEED and BREEAM, with regard to the costs of implementing measures, certification expenses and consultant fees.

Table 7 below presents the key points between LEED and BREEAM.

Table 7. Key points of LEED and BREEAM for the case study project

Issues	LEED 2009	BREEAM 2013
Expected level	Silver	Very Good
Minimum score	50 points	55%
Expected score	56/100 points	66.11%
Heat island effect	Avoid overheating in summer	N/A
Water efficiency	Target 35% (3 credits)	Target 25% (2 credits)
Energy efficiency	<ul style="list-style-type: none"> • Building energy simulation 	<ul style="list-style-type: none"> • Building energy simulation

	<ul style="list-style-type: none"> • Possible: 13 points • ASHRAE 90.1-2007 • EPR_{INC} 	<ul style="list-style-type: none"> • Possible: 12 points • ASHRAE 90.1-2010 • Total annual cost
Commissioning	Third party needed for extended commissioning	Possible for current contractor
Renewable energy	Geothermal and solar energy are possibilities	LZC feasibility and carbon study is very likely
Thermal Comfort	Modelling (ISO 7730:2005)	Modelling (ASHRAE 55-2004)
Indoor Air Quality	Not difficult	VOCs and contaminant testing can be challenging
Life cycle studies	N/A	LCC and LCA analysis
Cold storage	N/A	Refrigeration system strategies
Refrigerants	No CFC	ODP, GWP and DELC CO ₂ eq.
Total costs (approximate)	85,000 euro	88,000 euro

At the end, BREEAM was chosen over LEED for a number of reasons. First of all, BREEAM offers the bespoke certification where the rating system is tailored specifically for the project, giving it more opportunities to achieve a better result just like a better fitting shirt over a rather loose one. Secondly, the assessment showed that the project achieved a fairly good BREEAM score with a “safer” score margin over LEED. While the project achieved an estimate of 56 points which was only 6 points clear of falling down to a lower rating, it got a score of little more than 11% better than the minimum required for “Very Good” rating. BREEAM “Very Good” also has a higher minimum score than LEED “Silver”, that is 55% over 50% respectively. Even though BREEAM “Very Good” may correspond to LEED “Silver” when comparing the rating scale, a study on projects that have achieved dual certification indicated that BREEAM levels may be more difficult to achieve than corresponding LEED levels and that may show the extra effort and contribute to the project’s reputation and commitment to sustainability [33.]. Lastly, BREEAM might have been chosen because the owner of this project has not had any BREEAM certified property before, and this could be a good opportunity for that.

BREEAM Bespoke was issued for the project. A brief summary of key points from each category can be drawn here.

Management

Key services are present in the project so it was recommended that the commissioning task to be carried out and to follow the national best commissioning practices. Commissioning of building service systems is a common practice in Finnish building industry and is a part of the building regulations. Seasonal commissioning is also considered likely to be achieved. Life cycle cost (LCC) is a new practice but is not necessarily difficult to be done. These credits should comply with the assessment criteria for non-residential buildings, and no further guidance is needed.

Health & wellbeing

For daylighting design, criteria can be excluded for areas requiring strictly controlled lighting conditions. Since the majority of the building area is an automated storage where little occupancy is present, daylighting requirements do not apply to such areas. Similarly to thermal comfort, operational and storage areas do not need to comply with thermal comfort requirements. Internal and external lighting are specified in accordance with best practice standards. For indoor air quality, materials containing asbestos are completely prohibited. Indoor air quality (IAQ) plan is to be completed; however, testing of contaminant and VOCs is a challenge that requires the contractor to work on such large building area. Natural ventilation is not considered for this building type. Provision of fresh water should be done without any complications.

Energy

Preliminary energy model was made in accordance to ASHRAE Standard 90.1-2010 for the purpose of the pre-assessment. According to the energy engineer who modelled the building, the building's basic geometry was not too complicated but the model had to be updated frequently because of many changes from the architectural design. Building code standard values could not be used because of building type, so it took time to collect real values, such as internal heat loads (people, lighting, equipment) and schedules. There are a number of design uncertainties that could potentially affect the energy consumption and indoor climate of the building. The automation systems such as cranes produce lots of heat, and therefore, the building must be properly modelled to avoid excessive heat during summer months. Additionally, the project contains cold

storage areas for food and medical products which may take advantage of the cold storage credit available in BREEAM. Renewable energy systems may be possible.

Water, materials and pollution

It is difficult to estimate the water consumption at the early design phase until further information of water consuming fixtures becomes available.

According to the architect, life cycle analysis could be feasible to cover the whole building. However gathering of material information and calculation can be laborious and at this point is not yet considered.

Refrigerant containing systems will be installed in the building but since the specific type of system is not yet specified it is not possible to know the impact of refrigerants at this point. Yet this could only just come down to the matter of system selection. Night time external lighting credit is a challenge to meet as the building is designed to be available at all time for the trucks and airplanes to access.

6 Results and discussion

6.1 Results

Feedback was collected from 6 people in different departments with at least one-year experience working with LEED or BREEAM projects. Most of the participants stated that they were, to some level, familiar with LEED and BREEAM requirements, documentation and referenced standards. However, some said they had used the LEED reference guide or BREEAM manual all the time to look for information while others had done that sometimes or hardly ever. One question asked of the participants was what difficulties they faced when working on LEED or BREEAM projects, and some of the answers were:

- “Procurement of initial information.”
- “Documentation, understanding the tasks and using ASHRAE standards.”
- “There are a lot of standards! Documentation requirements can be unclear!”
- “Not easy to remember the requirements and have to go back to reference guide all the time.”
- “The standards can be difficult to understand.”

Most participants agreed that the design guidelines gave them some impression of what to expect of LEED and BREEAM requirements, documentation and standards, and that they would refer to these documents during the design process. An open question was provided at the end of the survey for the respondents to give their opinions and suggestions for improvement of the guidelines. Not everyone completed this part which was not expected; however, one gave a comment that “the guidelines were clear and easy to follow, and would be a good use in the future” and “an index page can be added at the beginning to provide preface information how to use the guideline”. In the near future, when the guidelines are tested in a wide range of projects, more feedback and comments will be gathered for further improvement.

The survey form can be found in the appendix 1 at the end of this paper.

6.2 Discussion

As can be seen from the survey results, documentation and standards appear to be the main challenges for the designers. This is the problem that the design guidelines aim to solve. The question is whether this kind of tool would be useful in LEED and BREEAM projects. The official reference guides are still the most reliable and informative documents to refer to, but it can be laborious to go through them as they contain more than a thousand pages between the two systems.

At a first glance, the response to the guidelines is positive. The guides were said to give the building services designers a general idea of the LEED and BREEAM systems, and that the guides were well organised and easy to read. Hard copies were provided when the interviews were conducted, but it is also possible to use the electronic version for better navigation. Yet the usefulness and effectiveness of the guides can only be fully assessed when they are practically implemented in actual projects.

From the guideline author's point of view, it is believed that the guidelines can be rather helpful for such circumstances when a quick summary of the requirements and documentation is needed, for example during project meetings. Additionally, the guidelines can be used by the LEED coordinator to provide clear and easy to understand information to the designers who are not so familiar with LEED and BREEAM rating systems, and possibly guides them throughout the design process. In order to successfully and uncomplicatedly complete the LEED and BREEAM certification process, it is strongly recommended that the design team have a good understanding of the system preferably as early as possible during the design phases. The earlier the design team can be on the same page the more opportunities there are to produce better design strategies and as a result save time, money and effort.

As for the logistic centre case study project, it is clear that implementing the guidelines at this early stage of the project gave an impression of how the design process can proceed further. The results were still very general and might not necessarily be accurate, but they provided the project team valuable information to make the decision on which rating system would be more advantageous than the other. For whole building energy consumption calculation, BREEAM uses a different approach the LEED, calculating the Energy Performance Ratio for International New Construction (EPRINC) factor. While the comparison of actual building and baseline building in LEED is done us-

ing the total energy costs, BREEAM incorporates CO₂ emissions with the delivered energy and primary energy. Having acknowledged this, the energy designer will know that data for CO₂ emissions is to be gathered to complete the calculation.

Still there are limitations in the guidelines. Because they have to be compact and summarised while still providing enough information, it was a challenge as some important piece of information might have been missed out. The guidelines also cannot contain all the important tables and figures that are present in the official guidance. Further improvements on navigation and the contents must also be made in the future. But in the end, the idea was to create a “mini” version of the official guidance, and the guidelines have fulfilled this purpose.

7 Conclusion

The final year thesis project set out to study the LEED 2009 New Construction and BREEAM 2013 International New Construction building rating systems and to create guidelines to assist the building services designers at Projectus Team Oy. Both systems' issues and some associated standards were carefully examined so that the credit requirements, documentation and standards could be recorded. In the end, the project managed to achieve the goals and received some positive feedback.

The building services sector accounts for 59% of the total amount of credits in LEED and 53% of BREEAM for typical office building. The building service systems can hugely affect the building's sustainability performance through energy consumption, water efficiency, indoor environmental quality and environmental life cycle impacts. That being said, it is important for the designers who are involved in LEED or BREEAM projects to have a good understanding of the systems, and about how to meet the requirements and produce appropriate documentation.

As the building regulations become more stringent in Finland and throughout Europe, sustainability movement must come forward and set the bar higher to create the opportunities for better design and management practices, more advanced and efficient technologies and environmentally-friendly materials. We are constructing buildings that are unlike anything we have built before. Tackling climate change through incorporating sustainability in the construction industry is the task of building engineers today, to "meet the needs of the present without compromising the ability of future generations to meet their own needs", as in the definition of sustainability from the World Commission on Environment and Development's report in 1987[34].

References

- 1 United Nations. United Nations Environment Programme (UNEP) - SBCI [Online]. URL: <http://www.unep.org/sbci/AboutSBCI/Background.asp>. Accessed 1 April 2015.
- 2 Kibert C. Sustainable construction. Hoboken, New Jersey: John Wiley & Sons, Inc.; 2013.
- 3 Zizzo R. Blue and White ... and Green! Finland leads the Nordic Countries with the most LEED certification and BREEAM certified buildings [Online]. 2013. URL: <http://figbc.fi/wp-content/uploads/2013/09/Blue-White-and-Green.LEED-in-Nordics.pdf>. Accessed 1 April 2015.
- 4 US Green Building Council. USGBC Announces Extension of LEED 2009 [Online]. 2014. URL: <http://www.usgbc.org/articles/usgbc-announces-extension-leed-2009>
- 5 U.S. Green Building Council. LEED Reference Guide for Green Building Design and Construction 2009 Edition. Washington, D.C.: U.S. Green Building Council; 2009.
- 6 Coyle T. How to match LEED 2009 rating systems to LEED v4 [Online]. 2014. URL: <http://www.usgbc.org/articles/how-match-leed-2009-rating-systems-leed-v4>. Accessed 1 April 2015.
- 7 U.S. Green Building Council. LEED Reference Guide for Building Design and Construction v4 (2013 Edition). Washington, D.C.: U.S. Green Building Council; 2013.
- 8 Trane. Engineers Newsletter volume 43-1: LEED v4 [Online]. 2014. URL: https://www.trane.com/content/dam/Trane/Commercial/global/products-systems/education-training/engineers-newsletters/energy-environment/ADM-APN050-en_0314.pdf. Accessed 1 April 2015.
- 9 Holmes S. Top 10 countries for LEED [Online]. 2014. URL: <http://www.usgbc.org/articles/top-10-countries-leed>. Accessed 1 April 2015.

- 10 Royal Institution of Chartered Surveyors. Going for Green Sustainable Building Certification Statistics Europe September 2013 [Online]. Frankfurt: Royal Institution of Chartered Surveyors; 2013. URL: http://www.breeam.org/filelibrary/Grun_kommt!_2013.pdf<http://www.usgbc.org/articles/outstanding-projects-around-world>. Accessed 1 April 2015.
- 11 U.S. Green Building Council. Projects [Online]. URL: <http://www.usgbc.org/projects>. Accessed 1 April 2015.
- 12 Building Research Establishment Global Ltd. BREEAM International New Construction Technical Manual SD5075-1.0:2013. BRE Global Ltd; 2014.
- 13 Building Research Establishment Ltd. GreenBook Live: Certified BREEAM Assessments [Online]. URL: <http://www.greenbooklive.com/search/scheme.jsp?id=202>. Accessed 1 April 2015.
- 14 Arkkitehtitoimisto Brunow & Maunula. Alberga havainnekuva ulkoa päivällä [Online]. URL: <http://www.projectusteam.fi/alberga-business-park-espoo/>. Accessed 1 April 2015.
- 15 Chartered Institute of Building Services Engineers. CIBSE - What is Building Services? [Online]. URL: <http://www.cibse.org/building-services/what-is-building-services>. Accessed 1 April 2015.
- 16 Huynh V.P. Innovation project: LEED implementation in the design process. Helsinki, Finland. Unpublished manuscript, Metropolia University of Applied Sciences.
- 17 US Environmental Protection Agency. Heat Island Effect [Online]. 2013. URL: <http://www.epa.gov/heatland/about/index.htm><http://www.cibse.org/building-services/what-is-building-services>. Accessed 1 April 2015.
- 18 Finland's Ministry of the Environment. D2 Suomen rakentamismääräyskokoelma: Rakennusten sisäilmasto ja ilmanvaihto. Helsinki; 2012.

- 19 United Nations. Water scarcity - International Decade for Action 'Water for Life' 2005-2015 [Online]. URL: <http://www.un.org/waterforlifedecade/scarcity.shtml>. Accessed 1 April 2015.
- 20 European Commission. Energy-efficient Buildings (EeB) - Research & Innovation - Key Enabling Technologies [Online]. URL: http://ec.europa.eu/research/industrial_technologies/energy-efficient-buildings_en.html. Accessed 1 April 2015.
- 21 Hakala J. Statistics Finland - Energy consumption in households 2013 [Online]. 2014. URL: http://www.stat.fi/til/asen/2013/asen_2013_2014-11-14_tie_001_en.html. Accessed 1 April 2015.
- 22 American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. ANSI/ASHRAE Standard 90.1-2007 Energy Standard for Buildings except Low-Rise Residential Buildings SI Edition. Atlanta, GA: ASHRAE; 2007.
- 23 United Nations. United Nations Environment Programme - Montreal Protocol [Online]. URL: http://ozone.unep.org/new_site/en/montreal_protocol.php. Accessed 1 April 2015.
- 24 European Commission. Energy-efficient Buildings (EeB) - Research & Innovation - Key Enabling Technologies - European Commission [Online]. URL: http://ec.europa.eu/research/industrial_technologies/energy-efficient-buildings_en.html. Accessed 1 April 2015.
- 25 US Environmental Protection Agency. Basic Information | Air and Radiation | US EPA [Online]. 2012. URL: <http://www.epa.gov/air/basic.html>. Accessed 1 April 2015.
- 26 Burge P. Sick building syndrome. Occupational and Environmental Medicine. 2004; 61(2):185-190.
- 27 U.S. Green Building Council. LEED Online [Online]. URL: <https://www.usgbc.org/leedonline/>. Accessed 1 April 2015.
- 28 Centers for Disease Control and Prevention. CDC - Fact Sheet - Secondhand Smoke - Smoking & Tobacco Use [Online]. Smoking and Tobacco Use. 2015. URL:

- http://www.cdc.gov/tobacco/data_statistics/fact_sheets/secondhand_smoke/general_facts/. Accessed 1 April 2015.
- 29 European Commission. Life-cycle costing - Green Public Procurement - Environment - European Commission [Online]. 2015. URL: <http://ec.europa.eu/environment/gpp/lcc.htm>. Accessed 1 April 2015.
- 30 Bernstein H.M. Smart Market Report: The Drive Toward Healthier Buildings: The Market Drivers and Impact of Building Design and Construction on Occupant Health, Well Being and Productivity [Online]. Bedford, MA: McGraw Hill Construction; 2014. URL: <http://www.aia.org/aiaucmp/groups/aia/documents/pdf/aiab104164.pdf>. Accessed 1 April 2015.
- 31 Bull S. Asbestos General Information [Online]. London, UK: Health Protection Agency; 2007. URL: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/337511/HPA_ASBESTOS_general_information_v1.pdf. Accessed 1 April 2015.
- 32 Huynh V.P. Final year project. Personal photograph. 2015.
- 33 Cheshire D. LEED vs BREEAM: What's best? [Online]. 2012. URL: <http://www.edie.net/library/LEED-vs-BREEAM-Whats-best/6124>. Accessed 1 April 2015.
- 34 Brundtland G. Report of the World Commission on Environment and Development: Our Common Future. Oslo, Norway: Oxford University Press; 1987 p. 16.

Appendix 1 Survey

THESIS SURVEY: LEED & BREEAM REQUIREMENTS IN THE BUILDING SERVICES DESIGN PROCESS

1. Which department/function are you from?
 - a. energy
 - b. life cycle
 - c. hvac
 - d. lighting
 - e. water / plumbing
 - f. commissioning

2. Approximately, how long have you been working with LEED or BREEAM projects?

3. How familiar are you with LEED and BREEAM requirements, documentation and referenced standards?
 - a. Very familiar
 - b. At some level
 - c. Not familiar

4. What are your main challenges when working on LEED/BREEAM projects?
(short answers are ok)

5. How often do you use the LEED reference guide or BREEAM manual to look for information?
 - a. All the time
 - b. Sometimes
 - c. Hardly ever

6. Do the design guidelines give you an idea what to expect of LEED/BREEAM requirements & documentation?
 - a. Yes
 - b. A little
 - c. No

7. Do you think you would refer to the design guidelines during the design process?
 - a. Yes
 - b. Maybe
 - c. No

8. Please provide your feedbacks/suggestions for improvement of the guidelines (even little ones):

Thank you very much for your participation!

Kiitos paljon!

Appendix 2 BREEAM Guideline, Table of content

PROJECTUS TEAM

BREEAM®

DESIGN GUIDELINE

BREEAM 2013 INTERNATIONAL NEW CONSTRUCTION

VERSION 1.0
PROJECT:

APRIL, 2015

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