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LEED Certification: The Difference Between Version 3 and Version 4

Helsinki Metropolia University of Applied Sciences

Bachelor of Engineering

Sustainable Building Engineering

Thesis

11 May 2018

Helsinki Metropolia University of Applied Sciences

Author Title Number of Pages Date	Thanh Dao-Cong LEED Certification: The Difference Between Version 3 and Version 4 22 pages 11 May 2018
Degree	Bachelor of Engineering
Degree Programme	Civil Engineering
Specialisation option	Sustainable Building Engineering
Instructor	Eric Pollock, Lecturer

This bachelor's thesis aimed to provide extensive comparisons between two versions of a popular green building certification LEED: LEED v3 and LEED v4. The project was implemented because of a lack of universal comparison between the two versions, in addition to the detached categories of the older version LEED v3. The purpose was to eliminate all confusion of the certification, while offering a complete package of information about the latest and sole version till date.

The study method included a literature research to combine all official documentations into one easy-to-read paper. The audience of the thesis consists of new people who would like to study LEED, experienced people used to the older version of LEED, and all people in between.

Overall, the thesis established that the current LEED v4 offers much better guidance than the older version. It also adds and updates an amount of credits that account for nearly 90 percent of the total points. However, many credits raise the standards, so it is now harder for projects to achieve similar points as they would have achieved with LEED v3. All in all, LEED v4 is the only possible version to choose for new projects at the moment.

Keywords	LEED, confusion, green building, easy-to-read, guidance

Contents

Abbreviations

ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
BD+C	Building Design and Construction
CFC	Chlorofluorocarbon
CO_2	Carbon Dioxide
HVAC	Heating, Ventilating, and Air Conditioning
ID+C	Interior Design and Construction
LEED	Leadership in Energy & Environmental Design
ND	Neighbourhood Development
O+M	Building Operation and Maintenance
USGBC	U.S. Green Building Council
VOC	Volatile Organic Compound

1 Introduction

Environmental impacts are of major importance in the construction industry nowadays, when sustainability is increasingly emphasized in the real estate and construction sectors. Energy regulations are tightened and buildings are more energy efficient. Therefore, when designing a building, it is important to take into account energy-efficient solutions and practices.

One indicator for energy efficient construction is the LEED certification. LEED (Leadership in Energy and Environmental Design) is a popular green building rating system used all around the world. It is available for various types of constructions and aims to provide guidelines to create environmentally friendly, highly efficient and economical buildings. [1.]

LEED version 3, or LEED 2009, or LEED v3, the most popular version, accounts for more than 40 percent of certified projects in the world, by the 1st of January 2018, calculated on the basis of the USGBC online public project directory. LEED version 4, or LEED v4 was introduced on the 20th of November 2013 [2] and it has been mandatory since 31st October 2016 [3]. It means that from the 31st of October 2016, all new projects had to register and use LEED v4. However, until the 1st of January 2018, only 4 percent of the certified projects version were using LEED v4. The difference rises major confusion, not only for professionals, but also people new to LEED: Is the new version (v4) better? How big is the change?

This study aims to eliminate this confusion. In addition, it is an extensive and user-friendly document for both newcomers and professional people. The research method is literature studies.

2 LEED Certification System

2.1 Overview of Developer of LEED: U.S. Green Building Council

The U.S. Green Building Council (USBGC) was founded in 1993 to promote the sustainable applications in construction industry. The council members jointly develop industry

standards, design guidance and tools. The council also develops training tools that support sustainable planning. The USGBC is best known for developing LEED Certification. USGBC's members include companies, contractors, public corporations, universities and other non-profit organizations. [4.]

USGBC's goal is to support buildings that are environmentally friendly, cost-effective and healthy for living. In addition to efficient energy use, efforts are also being made to foster comfort in buildings and their immediate surroundings. This is done by, for example, planting trees, lawns and other green areas. The task of the council is to increase the level of environmental responsibility and to provide information to operators in the sector. The LEED green building rating system is to help people in this activity. [4.]

2.2 Overview of LEED

In 1993, LEED was created by senior scientist Robert K. Watson. Together with him, early committee members consisted of USGBC co-founder Mike Italiano, Bill Reed, Sandy Mendler, Gerard Heiber, Myron Kibbe and Richard Bourne. LEED began as a tool to promote sustainable, green buildings by creating parameter standards. In addition, from the very beginning, it aimed to raise the awareness of the benefits of sustainable building, and to stimulate and transform the building industry. [5.]

LEED New Construction (NC) v1.0 was the first ever version of LEED certification. It was introduced in 1998 as a pilot version. This version was the fundamental for USGBC to gain knowledge, and introduced LEED NCv2.0 and v2.2 in 2005. [5.] LEED v3 was released in 2009 [5] and became a major hit. According to the USGBC database, by the 1st of January 2018, more than 40 percent of certified projects are of LEED v3. The latest version, LEED v4 only accounts for 4 percent of total certified projects.

LEED covers many types of constructions, from completely new construction to renovation, maintenance or community planning. There are four main construction types in LEED rating systems. [2.]

- Building Design and Construction
- Interior Design and Construction
- Building Operations and Maintenance
- Neighbourhood Development [2.]

Each construction types has several sub-construction types, or rating systems that the project team need to choose appropriately. Selecting the applicable rating systems is very important. USGBC may request the project team to change the project's rating system if the chosen one is not suitable. [2.]

A rating system has several topics that the project goes through. Each topic have credits, which are the tasks that projects need to complete. Every topic has prerequisites, which are the mandatory credits. To achieve any point from the topic, firstly, the construction must complete all the prerequisites in that topic. After that, the construction tries to complete the credits in the topic to gain points. The total amount of points the project achieve defines the rating levels of the project. [2.]

3 Similarities between LEED v3 and LEED v4

Throughout the two versions, LEED assessment follows the following parameters to balance the evaluation between the different topics:

- All LEED credits are worth at least one point.
- LEED points are positive integers.
- All LEED credits receive an equal weight in each rating system; there are no individualized scorecards based on project location.
- All LEED rating systems can reach 100 points, with extra 10 points for innovation process. Total possible points are 110. [6.]

LEED certification can be achieved in four different levels, depending on how much the project has done to improve environmental performance and sustainability, which is indicated by the total amount of points. LEED rating levels are:

- Certified: 40-49 points
- Silver: 50-59 points
- Gold: 60-79 points
- Platinum: 80-110 points [6]

4 Differences between LEED v3 and LEED v4

In this chapter, the third and fourth versions of LEED, or LEED v3 and LEED v4 are compared. Specifically, the changes are from LEED v3 to LEED v4 are listed in their rating systems, topics and credits in each topic.

4.1 Rating Systems

LEED v3 created detached systems. According to Rating System Selection Guidance Version 4, choosing a rating system requires two steps: A choice based on construction type and an option space usage type.

The first step is choosing the construction type. The LEED v3 certification system divides construction in complete construction, core and shell construction, commercial interior construction and limited construction of existing buildings. *Complete construction* is suitable for buildings that are undergoing new construction or major renovation and a complete interior installation. *Core and shell construction* is appropriate for buildings that are undergoing new construction or major renovation on the exterior shell and core mechanical, electrical, and plumbing units but not a complete interior installation. *Commercial interior construction* is applicable for commercial interior spaces that are undergoing a total interior installation of at least sixty percent of the certifying gross floor area. *Existing buildings: limited construction* is suitable for existing buildings undergoing improvement work or little to no construction. [6.] There are several rating systems for each of the four construction types, shown below:

- Complete Construction
    - LEED for New Construction and Major Renovations
    - LEED for Schools
    - LEED for Healthcare
    - LEED for Retail: New Construction and Major Renovations
    - LEED for Homes [6.]
- Core and Shell Construction
    - LEED for Core and Shell [6.]
- Commercial Interior Construction
    - LEED for Commercial Interiors
    - LEED for Retail: Commercial Interiors [6.]
- Existing Buildings: Limited Construction

- LEED for Existing Buildings: Operations and Maintenance [6.]

After choosing construction type, if there are multiple rating systems applicable to the construction type, next step is choosing rating system based on space usage type:

- New Construction and Major Renovations
- Schools
- Healthcare
- Retail
- Homes
- Commercial Interiors [6.]

In LEED v4, the classification is simpler and more intuitive. Table 1 below shows the details of LEED v4 construction types. [1.]

Table 1. Construction Types of LEED v4. [1.]

Building Design and Construction	Interior Design and Construction	Building Operations and Maintenance	Neighbourhood Development
• New Construction • Core and Shell • Retail • Data Centres • Warehouses and Distribution Centres • Hospitality • Healthcare	• Commercial Interiors • Retail • Hospitality	• Existing Buildings • Schools • Retail • Data Centres • Hospitality • Warehouses and Distribution Centres • Multifamily	• Plan • Built Project

LEED v4 divides into four main construction types. Each type may have a similar space usage to the others. In addition, new usage types are introduced in LEED v4: hospitality, data centre, warehouse and distribution centres. [1.]

4.2 Topics

As mentioned above in chapter 2.2, LEED rating systems is divided into several topics. The seven topics of LEED v3 are:

- Sustainable Sites
- Water Efficiency
- Energy and Atmosphere
- Materials and Resources

- Indoor Environmental Quality
- Innovation Design and Process
- Priority Credits [2.]

However, in LEED v4, there are two new topics. *Sustainable Sites* is divided into *Location and Transportation* and *Sustainable Sites*. A new topic, *Integrative Process*, is introduced to encourage early integration and cost-effective application of designs. [7.] The new topic accounts for one or two points.

Table 2. Points Difference in "New Construction" Rating Systems in Two LEED Versions. [7.]

Topic	Version 3	Version 4
Integrative Process	0	0
Location and Transportation	0	16
Sustainable Sites	26	10
Water Efficiency	10	11
Energy and Atmosphere	35	33
Materials and Resources	14	13
Indoor Environmental Quality	15	16
Innovation and Design Process	6	6
Regional Priority	4	4

The distribution of points changes slightly from LEED v3 to LEED v4. In a single topic, the difference in points varies at maximum three points. Table 2 above shows the difference in points of the *New Construction* topic. This trend also applies for other building types. The last two topics, *Innovation and Design Process* and *Regional Priority*, maintain the points. [7.] Their credits remain unchanged.

4.3 Credit Changes

The major credit changes from LEED v3 to LEED v4 can be easily noticed when studying each credit. The changes are listed based on the four construction types in LEED v4. overall, the changes consist of language adjustments, meaning that some requirements and guidance are clarified and some credits renamed, and of separation and addition of credits.

4.3.1 Building Design and Construction

A major change in the *Building Design and Construction* of LEED is the addition of a new credit *Integrative Process*. The new credit is not a part of any topic. The credit awards one point for achieving it, and encourages high performance and cost effectiveness through analysis of energy and water systems at an early project stage. Another change in *Building Design and Construction* was an adjustment in sub-category *Healthcare* where the minimum charrette duration reduces from eight hours to four hours. [8.]

The first topic, *Sustainable Sites* in LEED v3 was divided into two topics in LEED v4: *Location and Transportation* and *Sustainable Sites*. Table 3 below show seven credits in LEED v3 which have been renamed to LEED v4. [8.]

Table 3. Name Changes in Credits from LEED v3 to LEED v4. [8.]

LEED v3	LEED v4
Site Selection	Sensitive Land Protection
Brownfield Remediation	High Priority Site
Development Density and Community Connectivity	Surrounding Density and Diverse Uses
Alternative Transportation - Public Transportation Access	Access to Quality Transit
Alternative Transportation - Bicycle Storage and Changing Rooms	Bicycle Facilities
Alternative Transportation – Parking Capacity	Reduce Parking Footprint
Alternative Transportation – Low-emitting and Fuel-Efficient Vehicles	Green Vehicles

The *Sensitive Land Protection* credit offers up to two points compared with the earlier one point for *Site Selection*. The *High Priority Site* credit offers maximum of three points. It adds two more options on top of brownfield remediation in version 3 to encourage developers to locate projects in areas that have development constraints. The *Surrounding Density and Diverse Uses* credit adds more thresholds for various density levels and amounts of uses. In addition, the points earned from the density and the diverse uses are separate. Warehouse and distribution centre requirements are also added to encourage development near commercial or industrial sites or near transportation infrastructure. [8.]

The several changes were made from LEED v3 to LEED v4. Four *Alternative Transportation* credits from LEED v3 are updated in the version 4. Not only four credits were renamed, but also the requirements were adjusted. The *Access to Quality Transit* credit offers different rewards for various public transportation levels. Moreover, the old metric (radius) has been changed to walking distance. To be awarded in the *Bicycle Facilities* credit, a bicycle-accessible site or bicycle network is required. The minimum reference levels for *Reduced Parking Footprint* credit now follows the Institute of Transportation Engineers' Transportation Planning Handbook. It also removes *No New Parking* option. The credit for *Green Vehicles* now requires that at least three percent of the parking space is reserved for environmentally friendly vehicles. Two percent of the parking spaces need to have refuelling stations. [8.]

One new credit has been added to LEED v4 for *LEED for Neighbourhood Development Location*. This credit serves as an independent credit in the topic, which means that if a project attempts to acquire this credit, they cannot earn points from other credits in the *Location and Transportation* topic. The *LEED for Neighbourhood Development Location* credit encourages projects to find appropriate sites to reduce vehicle travel distance and to encourage physical activities. [8.]

The *Sustainable Sites* is now the second topic in LEED v4, after *Location and Transportation*. All credits in *Sustainable Sites* have been adjusted except for the *Environmental Site Assessment* prerequisite which does not change. The other prerequisite, *Construction Activity Pollution Prevention*, now uses version 2010 of Environmental Protection Agency's Construction General Permit instead of 2003. [8.]

Site Assessment is a new credit in the *Sustainable Sites* topic which rewards projects for an early analysis of construction site conditions to designers. The *Site Development – Protect or Restore Habitat* credit replaces earlier inappropriate requirements with preservation standards and adds a financial support option as the second choice for projects. The old *Site Development – Maximise Open Space* credit is renamed as *Open Space*. More importantly, the new credit adds extra qualification for open spaces that are favourable occupants. Guidelines for turf grass and vegetated roof requirements are also clarified.

Not only are new credits introduced, several credits are combined for simplification without comprising the standard level. *Rainwater Management* is the merge of *Stormwater*

Design – Quality Control and *Stormwater Design – Quantity Control*. It adds site-specific criteria for more frequent, low-intensity events and includes an option for zero-lot-line projects in urban areas. The two *Heat Island Effect – Nonroof* and *Heat Island Effect – Roof* credits in LEED v3 are combined into *Heat Island Reduction* in version 4. The changes include updates for the roof Solar Reflectance Index (SRI) requirement, replacing Solar Reflectance (SR) for a paving materials metric, addition of 3-year old SRI and SR values, and weighted SRI average calculation methodology and parking under cover threshold increment. The *Light Pollution Reduction* credit has also been adjusted. The interior lighting requirements are moved to prerequisite of *Energy and Atmosphere* topic. The blacklight-uplight-glare rating methodology is included as a way to reach the exterior lighting requirements. Lighting Zone 0 is added along with existed lighting zones from 1 to 4. On the other hand, there are some exemptions for exterior lighting requirements. [8.]

Water Efficiency is the third topic to be discussed here. The changes are dramatic since many credits are new or removed. Two of the three prerequisites are new in LEED v4. The credit *Outdoor Water Use Reduction* that requires thirty percent reduction in landscape water with the use of a tool from the Environmental Protection Agency's (EPA) is introduced. The counterpart of this prerequisite is the prerequisite *Indoor Water Use Reduction* which has been renamed from the previous version. It requires a WaterSense label for certain fixtures. A requirement of The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) 189 for basic cooling tower is added. A further prerequisite is *Building-Level Water Metering*. Since this is the prerequisite, the whole building must be able to measure the water use. The specialised prerequisite for "Healthcare", "Minimum Potable Water Use for Medical Equipment Cooling" is removed. [8.]

Outdoor Water Use Reduction and *Indoor Water Use Reduction* are two complementing credits for respective prerequisites. The *Outdoor Water Use Reduction* has been renamed from *Water Efficient Landscaping*. It rewards projects that can reduce the landscape water use by at least fifty percent. The title *Indoor Water Use Reduction* used to be *Water Use Reduction*. It is very similar to the respective prerequisite with WaterSense label for extra fixtures and more thresholds for achievement. [8.]

The further two new credits emphasise the ability to track water usage. *Cooling Tower Water Use* credit encourages projects to analyse their water source and maximize their

water cycles. Points for credit *Water Metering* can be achieved if the project sub-meters at least two water end uses. [8.]

The topic *Energy and Atmosphere* always accounts for most points in a LEED certification assessment. The *Optimize Energy Performance* credit can earn a maximum of eighteen points, more than the *Water Efficiency* topic. Of the prerequisites, the only unchanged one is the *Fundamental Refrigerant Management*. Prerequisite *Building-Level Energy Metering* is a new one that ensures all projects can measure the energy use of whole building. The prerequisite *Fundamental Commissioning and Verification* is renamed from *Fundamental Commissioning of Building Energy Systems*. The content is adjusted to ensure a project meets the Owner's Projects Requirements related to energy, water, indoor environmental quality and durability. New requirements are also included for preparing operations and a maintenance plan. The prerequisite *Minimum Energy Performance* provides major improvements. The standard used is updated to ASHRAE 90.1-2010. In addition, prescriptive option for Advanced Energy Design Guides is updated to fifty percent for *Office*, *Retail*, *Schools*, and *Healthcare* sub-construction types. Requirements for *Data Centres* is included as it is a new building type. The biggest credit, *Optimize Energy Performance* with maximum of eighteen points has similar updates as the prerequisite *Minimum Energy Performance*. The credit *Enhanced Commissioning* has options for monitoring and envelope commissioning. It also adds requirements of how to prepare the building operators for building systems operations. [8.]

Advanced Energy Metering and *Demand Response* are newly introduced credits in LEED v4. Projects that want to acquire "Advanced Energy Metering" must include methods to measure at least ten percent of all energy from end users in total energy consumption. The meters need to connect to the building automation system. *Demand Response* credits encourage the use of demand response technologies and programs that generate and distribute energy more efficiently, decreasing greenhouse gas emission. On the other hand, the credit *Measurement and Verification* is removed. Its requirements are added to the prerequisite *Building-Level Energy Metering* and the credit *Advanced Metering*. [8.]

The credit *On-Site Renewable Energy* in LEED v3 is called *Renewable Energy Production* in version 4. The amount of adjusted points in this credit is significant. In LEED v3, the credit can reward up to seven points. In LEED v4, maximum points for this credit is three. Furthermore, the credit *Enhanced Energy Production* gives more retail-specific

requirements than the old version. The last credit adjustment is done in the *Green Power and Carbon Offsets*. Its title is changed from *Green Power*. The credit is now based on the total building energy usage. The credit requires a contract with green energy distributors, which the duration extends from two to five years. The qualified energy sources should be available on the internet after 1st of January 2005. [8.]

Similarly to the topics discussed above, *Materials and Resources* topic in LEED v4 has gone through many changes. However, some credits remain unchanged, such as:

- Prerequisite *PBT (Persistent Bioaccumulative Toxic) Source Reduction – Mercury*
- Credit *PBT Source Reduction – Mercury*
- Credit *PBT Source Reduction – Lead, Cadmium, Copper* [8.]

On the other hand, many credits of LEED v3 are simplified. They are combined. Two credits in LEED v3, *Building Reuse - Maintain Existing Walls, Floors, and Roof* and *Building Reuse - Maintain Interior Nonstructural Elements* are now *Building Life Cycle Impact Reduction* in version 4. The new credit rewards the reuse historic and blighted constructions in life-cycle assessment of whole project's building, which is from credit *Materials Reuse* of LEED v3. The credit *Materials Reuse* is omitted from LEED v4. [8.]

In the topic *Materials and Resources* of version 4, it is easy to recognise the relation of new credits in titles. Table 4 shows the old credits of LEED v3 and the combined credits in LEED v4. [8.]

Table 4. Credits in LEED v3 and Their Combined Credits in LEED v4. [8.]

LEED v3	LEED v4
Regional Materials	Building Product Disclosure and Optimization – Environmental Product Declarations
Recycled Content Rapidly Renewable Materials Certified Wood	Building Product Disclosure and Optimization – Sourcing of Raw Materials
Regional Materials Building Reuse – Maintain Existing Walls, Floors, and Roof Building Reuse – Maintain Interior Nonstructural Elements	Building Product Disclosure and Optimization – Material Ingredient Reporting

The requirements of the LEED v3 credit *Regional Materials* credit are moved to the LEED v4 credit *Building Product Disclosure and Optimization – Environmental Product Declarations*, which rewards projects that use qualified local products. In addition, the credit is restructured into disclosure and optimisation options. The credit *Building Product Disclosure and Optimization – Sourcing of Raw Materials* in LEED v4 is the combination of the credits *Recycled Content*, *Rapidly Renewable Materials* and *Certified Wood* of LEED v3. The credit *Building Product Disclosure and Optimization – Material Ingredient Reporting* of LEED v4 has a similar structure as the two credits of LEED v4 mentioned above. It emphasises in product selection and material sources with optimised ingredients. [8.]

There are substantial changes in the other prerequisites and credits in the *Materials and Resources* topic. The prerequisite *Storage and Collection of Recyclables* requires that electronic waste is marked and that the top four sources of waste are identified to provide recycling collection. The prerequisite *Construction and Demolition Waste Management Planning* is new. It demands that projects need to set up waste management and waste diversion rate reports. The respective credit in LEED v4 that awards for good handling of waste is *Construction and Demolition Waste Management* which mandates the removal of waste from various materials. In addition, the credit offers an option for a waste reduction strategy. [8.]

For sub-construction type *Healthcare*, there are two credits in the *Materials and Resources* topic in LEED v4: *Furniture and Medical Furnishings* and *Design for Flexibility*. The credit *Furniture and Medical Furnishings* updates standards and criteria from American National Standards Institute (ANSI) for options *Testing and Modeling of Chemical Content* and *Multi-Attribute Assessment of Products*. The credit *Design for Flexibility* renamed from credit *Resource Use – Design for Flexibility* with a change in guidance clarity. [8.]

The changes in the topic *Indoor Environmental Quality* are not as extensive as those in the topic *Material and Resources*. However, the changes that are made are significant. There are still three prerequisites in the topic, but the requirements are extended. The prerequisite *Minimum Indoor Air Quality Performance* requires that outside air delivery is monitored and addresses combustion machines, CO monitors and radon in residential projects. The prerequisite *Environmental Tobacco Smoke Control* in LEED v4 does not allow for a smoking space indoor in any buildings except residential ones. Smoking is

also prohibited everywhere in projects that fall in sub-construction type *School*. The prerequisite is even stricter when reducing the maximum allowable leakage rate for residential houses. The final prerequisite in the topic *Indoor Environmental Quality* is *Minimum Acoustic Performance* which provides better guidelines than those in LEED v3 to coordinate with the standards of the American National Standards Institute (ANSI) and The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE). [8.]

In addition, in *Indoor Environmental Quality* topic, there are five credits that have been moved and combined into other credits shown in table 5 [8].

Table 5. Credits in LEED v3 That Have Been Moved to New Credits in LEED v4. [8.]

LEED v3	LEED v4
Outdoor Air Delivery Monitoring Increased Ventilation Indoor Chemical and Pollutant Source Control	Enhanced Indoor Air Quality Strategies
Controllability of Systems – Lighting	Interior Lighting
Mould Prevention	Thermal Comfort

The credit *Enhanced Indoor Air Quality Strategies* in LEED v4 is a combined credit of credits *Outdoor Air Delivery Monitoring*, *Increased Ventilation*, and *Indoor Chemical and Pollutant Source Control* in LEED v3. The new credit offers an extra option for modelling, additional sensors and mixed mode systems. Furthermore, the credit *Low-Emitting Materials* in LEED v4 is the unified credits of six separate credits in LEED v3: [8.]

- Low-Emitting Materials – Adhesives and Sealants
- Low-Emitting Materials – Paints and Coatings
- Low-Emitting Materials – Flooring Systems
- Low-Emitting Materials – Composite Wood and Agrifiber Products
- Low-Emitting Materials – Furniture and Furnishings
- Low-Emitting Materials – Ceiling and Wall Systems [8.]

The requirements stated in the credit *Low-Emitting Materials* are now based on Volatile Organic Compound (VOC) emissions. Formaldehyde requirements are also adjusted. [8.]

The LEED v4 credit *Indoor Air Quality Assessment* is called *Construction Indoor Air Quality Management Plan – Before Occupancy* in LEED v3. The credit now limits the maximum temperature of exhausted air. Furthermore, more contaminants are to be tested in Option 2. Another credit with a new name in LEED v4 is *Thermal Comfort*. Moreover, the ASHRAE reference standard is updated to ASHRAE 55-2010. There are also two other credits with new names: *Daylight and Views – Daylight* is changed to *Daylight* and *Daylight and Views – Views* is changed to *Quality Views*. From the *Daylight* credit, the prescriptive option is removed. A new option is added for spatial daylight autonomy. The measuring unit is changed from footcandles to lux. The credit *Quality Views* adds a requirement for a quality view which is defined by exemplary performance criteria in LEED v3. [8.]

Acoustic Performance is a new credit in LEED v4. It is applied for all building types except for *Schools* and *Healthcare*. It provides metrics for the design of noise levels, sound insulation, reverberation time, paging, masking and sound reinforcement systems. [8.]

The remaining two topics *Innovation Design and Process* and *Priority Credits* do not have any adjustment in construction type *Building Design and Construction* in LEED v4. The topics do not change in other construction types either. [8.]

4.3.2 Interior Design and Construction

The construction type *Interior Design and Construction* has many similar changes as *Building Design and Construction*. The *Interior Design and Construction* has new *Integrative Process* credit in LEED v4. However, the *Interior Design and Construction* does not have the *Sustainable Sites* topic, but *Location and Transportation.* All credits and changes in *Location and Transportation* are similar to the respective topic in *Building Design and Construction*. [9.]

The topic *Water Efficiency* has been adjusted in the indoor water usage. The prerequisite and credit with the same name *Indoor Water Use Reduction* requires a WaterSense label in fixtures and fittings. The prerequisite uses ASHRAE 189 for basic cooling tower requirements. The credit offers multiple thresholds to earn points. [9.]

The changes in other three topics, *Energy and Atmosphere*, *Materials and Resources* and *Indoor Environmental Quality* are not as great as those in construction type *Building Design and Construction*. All adjustments made in three above topics in construction

type *Interior Design and Construction* are covered in construction type *Building Design and Construction* respective topics that can be checked in chapter 4.3.1. [9.]

4.3.3 Building Operations and Maintenance

The construction type *Building Operation and Maintenance* has slightly different structure compared to the construction type *Building Design and Construction*. The *Building Operation and Maintenance* does not have the credit *Integrative Process*. The topic *Location and Transportation* has been changed in only credit *Alternative Transportation*. The credit adds two options that projects can conduct a survey and implement alternative transportation programmes. [10.]

The topic *Sustainable Sites* in the construction type *Building Operation and Maintenance* is not similar to the topic of the same name in construction types *Building Design and Construction* and *Interior Design and Construction*. It has a new prerequisite *Site Management Policy* that combines the policy requirements of credits *Building Exterior and Hardscape Management Plan* and *Integrated Pest Management, Erosion Control and Landscape Management Plan* in LEED v3. The credit is not optional as it was in LEED v3, but a prerequisite in LEED v4. The respective credit of *Site Management Policy* prerequisite is the *Site Management* in LEED v4. The credit adds performance criteria as well as options for equipment that has environmentally sensitive site maintenance. [10.]

A new credit *Site Improvement Plan* is introduced in LEED v4 to encourage the long-term sustainability of a project site. It requires a five-year improvement plan for hydrology, vegetation and soils. The credit *Joint Use of Facilities* is a specialised credit for sub-construction type *Schools* that encourages common spaces for community. [10.]

The adjustments in topic *Water Efficiency* in the construction type *Building Operation and Maintenance* are the same as in the construction type *Building Design and Construction*. Therefore, the reader is referred to chapter 4.3.1. The topic *Energy and Atmosphere* in the construction type *Building Operation and Maintenance* is also similar to *Building Design and Construction* in LEED v4 that can be checked in chapter 4.3.1. On the other hand, in topic *Energy and Atmosphere*, the credits *Existing Building Commissioning – Implementation* and *Ongoing Commissioning* are modified to closely monitor the current facilities requirements of the project and building operations and maintenance plan. The credit *Emissions Reduction Reporting* is omitted in LEED v4. The changes in

the topic *Indoor Environmental Quality* are almost identical to those in the *Indoor Environmental Quality* in the construction type *Building Design and Construction*. The prerequisite *Green Cleaning Policy* is a unique credit in the construction type *Building Operation and Maintenance* and it requires implementation of green cleaning policy to the projects. [10.]

Unlike the other topics, the topic *Materials and Resources* in the construction type *Building Operation and Maintenance* is totally different from any topic in other construction types. The prerequisite *Ongoing Purchasing and Waste Policy* in LEED v4 is a combination of two prerequisites in LEED v3: *Sustainable Purchasing Policy* and *Solid Waste Management Policy*. *Facility Maintenance and Renovations Policy* is a new prerequisite in LEED v4. Projects must have policies describing procurement, waste management, and indoor air quality for project maintenance and renovations. [10.]

The credit *Purchasing – Ongoing* in LEED v4 was called *Sustainable Purchasing – Ongoing Consumables* in LEED v3. Its requirements incorporate with two old credits *Sustainable Purchasing – Durable Goods* and *Sustainable Purchasing – Food*. The credits *Sustainable Purchasing – Reduced Mercury in Lamps* and *Sustainable Purchasing – Facility Alterations and Additions* of LEED v3 are called *Purchasing – Lamps* and *Purchasing – Facility Maintenance and Renovations*, respectively. In LEED v4, the threshold in the credit *Purchasing – Lamps* is reduced from ninety to seventy picograms per lumen hour. Moreover, the credit *Purchasing – Facility Maintenance and Renovations* in LEED v4 have an added option to encourage projects not to alternate and buy furniture. [10.]

In the construction type *Building Operation and Maintenance*, the topics *Innovation Design* and *Regional Priority* do not change from one LEED version to the other. Those two topics also remain unchanged in construction types *Building Design and Construction* and *Interior Design and Construction* type. [10.]

4.3.4 Neighbourhood Development

The construction type *Neighbourhood Development* has different topics compared to the other three construction types in last three chapters. The adjustments from LEED v3 came from three topics: *Smart Location and Linkage*, *Neighbourhood Pattern and Design* and *Green Infrastructure and Buildings*. [11.]

In topic *Smart Location and Linkage* in LEED v4, the prerequisites and credits that do not have substantive changes are [11]:

- Imperiled Species and Ecological Communities
- Agricultural Land Conservation
- Preferred Locations
- Housing and Jobs Proximity
- Long-Term Conservation Management of Habitat or Wetlands and Water Bodies [11.]

No new credit has been introduced. In the changed credits, the *Wetland and Water Body Conservation* requires reclaimed land prohibition within last twenty years in LEED v4. The prerequisite *Floodplain Avoidance* clarifies and revises terminology, which now follows the industry standards. The *Floodplain Avoidance* also adds ASCE (American Society of Civil Engineers) 24 standard as an option to obtain the prerequisite. [11.]

Two credits *Brownfield Remediation* and *Bicycle Facilities* are adjusted in construction type *Neighbourhood Development* to align with respective credits in construction type *Building Design and Construction*. On the other hand, the requirements of the credit *Steep Slope Protection* in LEED v4 have been revised and simplified for clarity. In both *Site Design for Habitat or Wetland and Water Body Conservation* and *Restoration of Habitat or Wetlands and Water Bodies,* the protection of lands “in perpetuity” is replaced with “for purpose of long-term conservation”. [11.]

Very similarly to the topic *Smart Location and Linkage*, the topic *Neighbourhood Pattern and Design* topic does not have any new credits and have many credits remain unchanged, such as:

- Compact Development (prerequisite and credit)
- Mixed-Income Diverse Communities
- Transit Facilities
- Access to Recreation Facilities
- Visitability and Universal Design
- Community Outreach and Involvement
- Local Food Production [11.]

The prerequisite *Walkable Streets* clarifies the centreline measurement from building height to street. The change also applies to the credit with the same name. The credit *Connected and Open Community* has added requirements that no more than ten percent of the project area can be accessed from a circulation network that is protected by gates. [11.]

The changes in the credit *Mixed-Use Neighbourhoods* are dramatic. In LEED v3, the credit was called *Mixed-Use Neighbourhoods Centres*. The requirements for projects of over forty acres have been deleted. At least a public transport stop is required nearby if the project has a retail component. The credit also removes the prohibition for counting uses on-site. Finally, the thresholds have been simplified, but all point levels have been raised by fifty percent. [11.]

The peak period trip reduction option was omitted from the credit *Transportation Demand Management* and two options for guaranteed ride home programme and flexible work arrangements were added. In the credit *Tree-Lined and Shaded Streets*, the spacing between trees was reduced to a maximum of fifty feet (approximately 15,24 meters). The fourth credit in the construction type *Neighbourhood Development*, *Neighbourhood Schools* requires new schools to be built in the developed area so that schools are opened before a fifty percent occupancy. [11.]

The final topic, *Green Infrastructure and Buildings* has most changes. Once again, there are no new credits. The unchanged credits consist of: [11.]

- Existing Building Reuse
- Solar Orientation
- Infrastructure Energy Efficiency
- Wastewater Management
- Recycled Content in Infrastructure [11.]

The prerequisite *Certified Green Building* in LEED v4 requires a certified building to use a rating system that is verified according to the International Organization for Standardisation (ISO) standard reference. In the prerequisite *Minimum Building Energy Performance*, the requirements are similar to those of the construction type *Building Design and Construction*. The *Minimum Building Energy Performance is* also updated to use

ASHRAE 90.1-2010 as reference. The prerequisite *Indoor Water Use Reduction* requires design performance to reduce domestic water use. [11.]

The credit *Certified Green Buildings* has similar changes as the prerequisite with the same name, as does the credit *Optimize Building Energy Performance whose* prerequisite is *Minimum Building Energy Performance*. Credit points for *Outdoor Water Use Reduction* can only be attempted if the project has at least 2500 square feet (232,3 square metres) of green space. The related credit, *Rainwater Management*, provides additional methods to determine manageable amount of rain. The credit *Solid Waste Management* requires that the amount of reused or recycled asphalt, brick, and concrete must not account for more than 75% of the total diverted waste. [11.]

The topics *Innovation* and *Regional Priority* have not changed between LEED v3 and LEED v4. The distributed points also stay unchanged. [11.]

4.4 “Performance Based” Orientation of LEED v4

A notable update in LEED v4 is its performance orientation. The completed building is expected to operate for a very long time. It is necessary to monitor the building operation during its lifespan. LEED v4 has introduced two credits to encourage the monitoring of indoor environmental quality. The credits are the *Outdoor Air Delivery Monitoring* and the *Water Metering*.

5 Discussion

Almost every credit is changed with LEED v4, regardless of construction type. The changes might be as small as a name change, or as major as adding a new credit or choosing an updated standard as a reference. The LEED v4 User Guide offers comparison charts between LEED v3 and LEED v4 for three types of buildings in three certification construction types. In the construction type *Building Design and Construction*, a comparison is offered for *New Construction*. In construction type *Interior Design and Construction*, a comparison chart is offered for *Commercial Interiors*. In construction type *Building Operations and Maintenance*, a comparison chart is offered for *Existing Buildings*. The charts indicate with colours which credit has no change, which one has minor changes, where the changes are and where a new credit is added. [7.]

All the points for substantial changes or new credits are summed up in the comparison chart for *Building Design and Construction: New Construction* for 54 percent of the whole point distribution. When including both substantial changes or new credits and minor changes in credits, the proportion reaches nearly 90 percent. The proportion for *Interior Design and Construction: Commercial Interiors* and *Building Operations and Maintenance: Existing Buildings* is almost the same. The changes from LEED v3 to LEED v4 are truly major. [7.]

In addition, many changes in credits are changes to higher standards. For example, the credit *Low-Emitting and Fuel-Efficient Vehicles* in LEED v3 is changed to *Green Vehicles* in LEED v4. In addition, five percent of parking spaces are required for green vehicles. An additional two percent of the parking spaces must have refuelling stations, a totally new requirement in LEED v4. [8.]

6 Conclusion

The thesis introduces the differences between LEED v3, the most popular LEED version, and LEED v4, the latest version, to eliminate any confusion between the two. The study also provides an extensive view towards the changes which are difficult to research since all official documents do not combine. The goal is totally achieved in the end.

The current version of LEED, LEED v4, eliminates the weaknesses of the previous version. LEED v4 provides more intuitive categories, with four main construction types, according to their use. In addition, because of that, the guidelines now only combine into four books, instead of a separate document for each construction type and type of use. New construction types are also brought into LEED v4 (*Data Centres, Hospitality*). Many credits are divided and also added to provide deep understanding for project teams.

Moreover, LEED v4 emphasises building performance as the key to sustainable constructions. Several monitoring credits are added such as *Water Efficiency*, *Outdoor Air Delivery Monitoring* and a monitoring tool (Arc) is introduced to enhance the building energy performance. As nearly 90 percent of the available points are changed, it is safe to say that LEED v4 is a major upgrade from its predecessor.

Furthermore, the changes in LEED v4 included the adaption of higher standards, requiring more effort of a project to earn points when using LEED v4. With still more than 21000

on-going LEED v3 projects, compared to more than 4200 LEED v4 projects by 1st of January 2018 [12], the unbalance level between the number of projects is substantial. The transfer to LEED v4 requires adaptation from all team members. Cost efficiency when choosing LEED v3 or LEED v4 is a very interesting aspect to study. However, it is impossible to gather data to examine.

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