# Comparison of Two Different Rating Programs for Sustainable Homes

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by

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Submitted to the Department of Civil and Environmental Engineering on May 13, 2009, in partial fulfillment of the requirements for the degree of Master of Engineering in Civil and Environmental Engineering.

## Abstract

This thesis compares two different rating programs for sustainable homes; The Code for Sustainable Homes in the United Kingdom, and LEED for Homes in the United States. The comparison is both in general and with respect to Icelandic homes. Iceland is a small market that currently does not have its own program to rate sustainable homes, and there is an ongoing discussion on whether a foreign program could be adopted in Iceland. The Code for Sustainable Homes and LEED for Homes are two of the most recognized rating programs in this area, and are therefore both possible candidates for adoption. It is shown in this thesis that both the rating programs in question are quite similar and target much the same areas, even though the emphasis on specific aspects might be different. Both these programs were created to be suitable for use in their home countries and focus on subjects that are important in these countries. This fact makes them less adaptable in Iceland, since Iceland differs in many respects from the United Kingdom and the United States. There are, however, many subjects targeted in these rating programs that do apply to Iceland and would be beneficial to adopt. This thesis is therefore not a decisive document on whether one program or the other, or even neither, could be adopted in Iceland, but could rather be an input in the current discussion on these matters.

Thesis Supervisor: Jerome J. Connor

Title: Professor of Civil and Environmental Engineering

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# 1 Introduction

Sustainable design of buildings is a rapidly growing field in the world. All buildings affect the environment throughout their lifetime. Sustainable building design is about limiting their negative environmental effects and using materials, energy and other resources in a sustainable manner. This involves both environmentally friendly construction practices as well as reducing the environmental impact of buildings after construction, e.g. by reducing energy and water consumption, and also to create people-friendly homes and neighborhoods.

There are different scales in different countries regarding how buildings are evaluated with respect to sustainability. The American rating program Leadership in Energy and Environmental Design (LEED), is the industry's leader and awards qualifying buildings Certified, Silver, Gold, or Platinum standards. The United Kingdom has its own method which is widely recognized, Building Research Establishment's Environmental Assessment Method (BREEAM), which assesses the performance of buildings in 8 areas and then rates them on a scale of pass, good, very good, excellent or outstanding, and awards a corresponding certificate. In this thesis, these two rating programs will be explored with respect to homes. The specific rating systems to be compared are LEED for Homes and The Code for Sustainable Homes which is based on the principles of BREEAM.

Incorporating all the measures required in the rating programs into the design and construction processes, is obviously not going to come for free. In a paper by Kwong (2004), an attempt is made to quantify the benefits of sustainable buildings in general (not just sustainable homes). The author divides benefits into three categories: direct cost savings, indirect gains, and reduced externalities.

Direct cost savings include:

- Initial savings: Some of the requirements in the programs automatically include savings, e.g. by recycling existing asphalt on site.
- Utility savings: Cost savings on energy and water bills.
- Maintenance savings: Buildings complying with BREEAM or LEED might need less maintenance.
- Deferred replacement cost: Using more durable materials decreases future replacement cost.

Indirect gains include benefits that may be hard to quantify in terms of money and lead to better quality of the indoor environment within the building:

- Productivity gain: Productivity increases in good work environment (applies more to office buildings than homes).
- Health care cost reduction: Many of the measures in the rating programs can lead to better health, for example by having better indoor air quality.
- Improved quality of life: Occupants feel better and are healthier.
- Prestige factor: A good rating against a program such as LEED or BREEAM might increase the value of the building.

Reduced environmental externalities include the reduced negative environmental impacts that the building has. That includes less pollution, less emission of carbon dioxide, and overall more efficient use of unsustainable resources and materials. This might not be a direct saving to the owner of the building but it is a definite benefit for the environment and the society.

This analysis indicates that sustainable buildings might require higher initial cost, but some of that cost might come back in future savings and/or better living conditions.

It is interesting to explore how the idea of sustainable buildings affects small markets like Iceland. Due to the size of the country, it may not be practical for Icelanders to construct their own rating program for sustainability of buildings, but rather adopt some other country's method. LEED is of course an obvious choice since it is the most widely recognized, but since Iceland has strong ties with the UK, it might seem sensible for Iceland to use the refined and extensive BREEAM program. It is therefore interesting to compare LEED with BREEAM and find the differences between the programs, and explore which one might be more applicable to Iceland.

This thesis begins with giving an overview of both The Code for Sustainable Homes and LEED for Homes, explaining what the programs constitute of and how buildings are being rated. Then, a general comparison between the two programs will be given and at the end of this paper, both methods will be applied to a specific home in Iceland which represents the majority of homes in Iceland.

# 2 United Kingdom – The Code for Sustainable Homes

## 2.1 About the program

The Code for Sustainable Homes (hereafter referred to as *the Code*) is an environmental assessment method used in the United Kingdom to rate the performance of new homes against specified environmental standards. The Code is relatively new, launched in December 2006, but it is based on an older rating program, EcoHomes by BRE. BRE is an abbreviation for The Building Research Establishment, a British organization committed to bringing sustainability values to the building industry and provides a whole spectrum of sustainability rating programs for different types of buildings. In April 2007, the Code formally replaced EcoHomes as a rating method for new homes in England.

While most rating schemes in the world are based on voluntary participation, rating against the Code was made mandatory for all newly constructed homes in the UK after May 2008. The Code is therefore under the authority of a government body, the Department for Communities and Local Government, but the actual implementation is managed by BRE Global.

## 2.2 The rating process

The Code is divided into nine categories of environmental impacts and each category has a set of related subcategories or issues. Each issue as a specified number of available credits and each category has a weighing factor. That means that the available credits are not equal between categories, but rather have different weighed values. Table 1 is constructed from the Code for Sustainable Homes – Technical Guide, and provides an overview of the main contents of the Code. It shows each category, the issues, the weighing factor of each category and the weighed value of the credits:

Table 1. Overview of The Code for Sustainable Homes (adapted from The Code for Sustainable Homes – Technical Guide).

| Categories | Issues | Available credits | Weighing factors | Weighed values of credits |
|---|---|---|---|---|
| **Energy and $CO_2$ emissions** | Dwelling emission rate (M) | 15 | | |
| | Building fabric | 2 | | |
| | Internal lighting | 2 | | |
| | Drying space | 1 | | |
| | Energy labelled white goods | 2 | 36.4% | 1.26 |
| | External lighting | 2 | | |
| | Low or zero carbon (LZC) technologies | 2 | | |
| | Cycle storage | 2 | | |
| | Home office | 1 | | |
| **Water** | Indoor water use (M) | 5 | 9.0% | 1.50 |
| | External water use | 1 | | |
| **Materials** | Environmental impact of materials (M) | 15 | | |
| | Responsible sourcing of materials - basic building elements | 6 | 7.2% | 0.30 |
| | Responsible sourcing of materials - finishing elements | 3 | | |
| **Surface Water Run-off** | Management of surface water runoff from developments (M) | 2 | 2.2% | 0.55 |
| | Flood risk | 2 | | |
| **Waste** | Storage of non-recyclable waste and recyclable household waste (M) | 4 | | |
| | Construction site waste management (M) | 2 | 6.4% | 0.91 |
| | Composting | 1 | | |
| **Pollution** | Global warming potential (GWP) of insulants | 1 | 2.8% | 0.70 |
| | $NO_x$ emissions | 3 | | |
| **Health and Well-being** | Daylighting | 3 | | |
| | Sound insulation | 4 | 14.0% | 1.17 |
| | Private space | 1 | | |
| | Lifetime homes (M) | 4 | | |
| **Management** | Home user guide | 3 | | |
| | Considerate constructors scheme | 2 | 10.0% | 1.11 |
| | Construction site impacts | 2 | | |
| | Security | 2 | | |
| **Ecology** | Ecological value of site | 1 | | |
| | Ecological enhancement | 1 | | |
| | Protection of ecological features | 1 | 12.0% | 1.33 |
| | Change in ecological value of site | 4 | | |
| | Building footprint | 2 | | |
| | | **104** | **100.0%** | |

(M) denotes that the issue specifies a certain level that is mandatory to reach.

The ultimate goal of the rating process is to reach one of six available levels in the Code. Level 1 is the lowest and Level 6 is the highest. The assessment procedure is mainly in two parts; determining the lowest level reached in all mandatory issues and checking if credits for voluntary issues suffice for that level.

Seven of the issues are mandatory, meaning that they have either one minimum requirement to reach for any level or separate requirements for each level.

The mandatory issues with a single minimum requirement for all levels are:

- Environmental impacts of materials
- Management of Surface Water Runoff from development
- Storage of non-recyclable waste and recyclable household waste
- Construction site waste management

Two issues have minimum standards for each level:

- Dwelling emission rate
- Indoor water use

One issue, Lifetime Homes, has mandatory requirements only for Level 6.

The level awarded will be the lowest level that all the mandatory issues meet, given that awarded credits are adequate. For Level 1, 36 credits are needed, 48 credits for Level 2, 57 credits for Level 3, 68 credits for Level 4, 84 credits for Level 5 and 90 credits for Level 6 (all credits are weighed credits).

The assessment is carried out it two stages; design stage and post construction stage. The assessment has to be performed by a licensed and trained Code assessor.

When the rating process is final, the home is awarded a certificate showing the level that the home achieved. There is not a penalty for not reaching the minimum level, but it is mandatory to include the certificate as information to prospective buyers of the home. If a zero rating is achieved, it might affect the value of the home.

## 2.3 The content of the program

In the following sub-sections, the main features of each category will be explained and the purpose of each goal. This discussion will not be detailed since this paper is not intended to be used in an actual rating process, but rather to highlight the core values of the rating scheme. All information are taken from The Code for Sustainable Homes – Technical Guide (published 2008).

### 2.3.1 Energy and $CO_2$ emissions

The first issue of the category is aimed at reducing the carbon emission rate from energy usage, including heating, hot water and lighting. This is the first of a few mandatory elements of the Code. Building regulations specify a certain Target Emission Rate (TER) as the maximum

permitted emission rate. When rated against the Code, homes are granted credits based on their percentage improvement of emission rate over the TER. The minimum improvement is 10%. The ultimate goal is to achieve a Zero Carbon Home which emits no carbon dioxide from any energy used in the house and has a certain heat loss parameter for all walls and windows to maximize the house's energy efficiency. Constructing a Zero Carbon Home is the only way to receive all the possible credits for this part, which are 15 total. This issue includes more than half of the total credits available for Category 1 (Energy and $CO_2$ emissions), underlining the utter importance of this matter.

Issue number two is titled *Building Fabric*. Its aim is to award credits based on the heat loss parameter of the building, thus serving to promote energy efficiency of buildings.

Internal lighting is the subject of next issue, encouraging homeowners to install fixed energy efficient light fittings. These fittings must be such that they can only fit energy efficient lamps and must be permanently fixed to the walls or ceiling.

Topic four awards one credit if there is a space in the house dedicated to drying clothes. The purpose is to encourage drying of clothes without using a tumble dryer and thus reducing energy consumption.

*Energy Labelled White Goods* is issue number five. White Goods is a term used for large domestic appliances, often fixed in place to some extent. In this category are appliances such as fridges, freezers, washing machines, etc. The energy label referred to in the title is the EU energy label that rates products for energy efficiency and consumption. Credits in this category are awarded based on the extent of usage of such energy labeled appliances.

Issue six, *External Lighting*, is similar to issue three, *Internal Lighting*. Two credits can be obtained if all external lighting fixtures are energy efficient and are controlled by motion detectors and daylight sensors, eliminating unnecessary usage during daylight hours or when no-one is around.

*Low or Zero Carbon Technologies*, issue seven, include devices such as solar (photovoltaic) cells, wind turbines, biomass technologies, or other methods of utilizing renewable energy sources or recycling waste heat. The aim is to provide incentive for homeowners to generate green energy locally and thus reduce total carbon emission and pollution. The reduction in carbon emission by these methods must be at least 10% for credits to be awarded.

The last two issues of this category award credits if the house has bicycle storage room and a facility for a home office, thus reducing car usage.

### 2.3.2 Water

The first issue of this category, *Indoor Water Use*, is the second of mandatory elements in the Code. The minimum requirement is to achieve level 1 where maximum usage of potable water is no more than 120 liters per person a day. Up to 5 credits are available as the consumption of water goes further below 120 l/p/day. Reduction in potable water consumption can be achieved by e.g. using flow restrictors, low flush toilets, and by collecting and recycling rainwater.

One credit can be achieved if consumption of potable water is also reduced outdoors, i.e. by using rainwater instead for potable water in irrigation. That requires installing a system for collecting and storing rainwater.

### 2.3.3 Materials

The third category deals with the usage of materials in the actual superstructure of a building including external and internal walls, roof, floors, windows and other building elements. The first issue, *Environmental Impact of Materials*, is the third mandatory element of the Code and offers up to 15 points, which makes it one of the largest issues of the Code along with Dwelling Emission Rate. To determine the credits awarded in this section, a rating system called the Green Guide is used. The Green Guide is a tool constructed by BRE Global, used to estimate the environmental impact of construction materials and is basically a database with information based on life cycle assessments of materials. The lower the total environmental impact of the materials of the building, the higher the number of credits available.

*Responsible Sourcing of Materials – Basic Building Elements* is the second issue of the category. Up to six credits can be awarded, depending on how much of the construction material comes from responsible sources. Responsibly Sourced Materials is a term that refers to materials that have been certified by a third party to fulfill standards regarding both environmental as well as social and economical issues. In the case of timber for example, it must come from legal sources where the manufacture procedure is in accordance with forest management laws and follows the code of practice in the country of origin. Responsible Sources can also include re-used and recycled materials.

The last issue of the category, *Responsible Souring of Materials – Finishing Elements*, deals with the same principles as issue number two except that the subjects here are finishing elements such as stairs, windows, doors, paneling and furniture, instead of structural elements.

### 2.3.4 Surface Water Run-off

Issue one, *Management of Surface Water Run-Off from developments*, is a mandatory element providing up to two credits. Its aim is mainly to reduce flood risk resulting from rainwater flooding the sewer system, and also to prevent pollution and environmental damage. This

reduction in surface water run-off can be achieved by using what is referred to in the Code as Sustainable drainage systems. It is however not just one system but rather a combination of many smaller measures, such as holding ponds, permeable paving, green roofs, and recycling of rainwater. Peak rates of run-off from the developed site should be no more than peak rates of run-off from the site before development.

The second issue of the category is *Flood Risk*. Two credits can be achieved if the building is situated in an area with low flood risk, and one credit if the building is situated in an area with medium or high risk of flooding, if appropriate measures have been taken to protect the building against flooding and safe access and escape routes are provided. The purpose is to encourage homeowners to be aware of flood risk is their area and rather build in low flood risk areas than medium or high risk, or at least do whatever possible to protect their house against flooding.

### 2.3.5 Waste

This category has three issues and the first two both being mandatory. The first one is *Storage of non-recyclable waste and recyclable household waste*. The minimum level is to provide adequate space to accommodate regular garbage containers. Beyond that, credits are awarded depending on storage space or number of bins for recyclable household waste.

*Construction Site Waste Management* is the second issue of the category. According to the provisions in this issue, it is mandatory to create and follow a so-called Site Waste Management Plan (SWMP) during construction. The main idea behind SWMP is to minimize waste resulting from construction by re-using and recycling materials, and promoting efficient use of materials. Up to two credits can be achieved by minimizing construction waste by reducing total waste generated on site and by sorting and recycling the waste as possible.

Finally, one credit is awarded if the home has a facility to compost household waste.

### 2.3.6 Pollution

*Global Warming Potential (GWP) of Insulants* is the first issue. It deals with the emission of polluting chemicals from foamed thermal and acoustic insulating materials. One credit is awarded if all such materials used in the home have GWP < 5, where GWP = 1 is defined as the global warming potential of one unit of carbon dioxide and all other chemicals are measured relative to that amount.

The second issue of the category, *$NO_x$ Emissions*, aims at reducing the emission of nitrogen oxides to the atmosphere from usage of heating and hot water systems. Boilers emitting low levels of nitrogen oxides or systems producing no nitrogen oxides at all, can achieve all three credits available for this issue.

### 2.3.7 Health and Well-being

Issue one is *Daylighting*. Credits are awarded based on how much daylight can be enjoyed in the dwelling. The purpose is to improve the living conditions in the home by increasing natural light and to reduce the usage of electrical lighting. Amount of daylight in the dwelling depends primarily on the architecture of the house, especially on the sizes and shapes of windows and rooms. A special *average daylight factor* has been created to measure the quantity of daylight indoors. It depends on factors such as areas of windows and rooms, reflectance of room surfaces, dirt, glass transmission and angle of visible sky. The higher the factor, the higher the daylight indoors as a fraction of the daylight outdoors.

The second issue is *Sound Insulation*. Up to four credits are awarded based on how much better sound insulation the dwelling has beyond what is required in building regulations. The intention is to improve quality of life in both the dwelling in question as well as in neighboring apartments.

Next issue, *Private Space*, awards one credit if the home has an outdoor space which is at least partially private.

*Lifetime Homes* is the last mandatory element of the Code. The assessment of this element is based on a scheme called Lifetime Homes. It is based on the idea that a home should be able to adapt to its habitants' change of needs at some point in its lifetime. Lifetime Homes is a list in 16 parts which mainly emphasizes the need for homes to be constructed such that they have the flexibility to adapt to the needs of older and/or disabled people, by e.g. providing adequate space for equipment such as handrails, and providing proper access and space for wheelchairs. The dwelling being assessed, has to comply with all parts of the list which are applicable to that particular home in order to reach Level 6 assessment, and achieving that, it will also be awarded four credits.

### 2.3.8 Management

First issue is *Home User Guide*. Two credits are awarded if the house comes with a user guide explaining operational issues regarding the home (such as design features and how its systems can be operated efficiently) and one credit is awarded if the home comes also with a user guide regarding the site and surroundings (such as local amenities). A guide like this can help ensure that the resources of the home are used appropriately.

*Considerate Constructors Scheme* (CCS) is next issue. CCS is a certification scheme that awards points for good construction practices, such as being considerate to the environment and to people living in neighboring dwellings. For a commitment to meet the requirements of such a scheme or even going beyond that, up to two credits are available.

The purpose of the third issue of this category, *Construction Site Impacts*, is to minimize negative effects of construction on the environment. Credits are awarded for minimizing emission of $CO_2$, minimizing water consumption, minimizing pollution from dust and other factors.

Promoting security of homes is the intention of the last issue of this category, *Security*. *Secured by Design* is a project run by the police in UK. It aims at giving advice to the general public how to design new buildings or refurbish older buildings so that they are more secure against crimes (Secured by Design, 2009). Two credits can be awarded for this issue if an advisor from the local police is consulted in the design of the home regarding how to secure the dwelling against crimes. This can involve many things such as choosing adequate thickness of doors, the right glass in each types of windows and using appropriate locks.

### 2.3.9 Ecology

In the first issue, *Ecological Value of Site*, one credit is awarded is the home is being constructed on a site that is not considered having any ecological importance. The purpose is to limit development on land that is important with respect to wildlife.

Issue two, *Ecological Enhancement*, awards one credit if the ecological value of the developed site is somehow increased. An ecologist should be consulted on how this can be successfully implemented, but recommendations might include a careful selection of plants and taking measures to being considerate to animal life existing on the property.

*Protection of Ecological Feature*s is the third issue. One credit is available if adequate measures are taken to protect the site against environmental damage and interruption of wildlife during preparation for construction and construction work itself.

Next issue is *Change in Ecological Value of Site*. The ecological value of the site is measured before and after construction by comparing the diversity of plant species. A specific calculation procedure is outlined in the Code, which results in a single representative number. This number can be used the evaluate the ecological impact of construction. If the impact is minor negative, one credit is awarded, two for neutral impact, three for minor enhancement and four for major ecological enhancement.

The last issue of the Code is *Building Footprint*. The aim is to protect the ecological value of the site by decreasing the footprint of the building. Houses that have a ratio of floor area versus ground floor area of 2.5 or larger can be awarded one credit, and houses having this ratio of 3 or higher can achieve two credits.

# 3 United States – LEED for Homes

## 3.1 About the program

LEED for Homes is the counterpart of The Code for Sustainable Homes in the United States. It was developed by U.S. Green Building Council (USGBC) which is a non-profit organization working to facilitate incorporation of sustainability values to the construction of new buildings. LEED for Homes is a program specifically designed to promote construction of more environmentally friendly homes in the United States. While rating against the Code is mandatory for new homes in the United Kingdom, LEED for Homes is based entirely on voluntary participation. The program in owned and operated by U.S. Green Building Council and all companies or individuals who provide certification services to LEED for Homes are directly under a contract to USGBC.

## 3.2 The rating process

LEED for Homes is divided into eight categories and each category has sub-issues which have a certain number of available credits. For some categories, the developer can choose between two paths, both providing the same total number of credits but having different approaches on the subject. Table 2 shows the division of the program into categories and issues, and available credits for each issue:

Table 2. Overview of LEED for Homes.

| Categories | Issues | Available credits |
|---|---|---|
| **Innovation and Design Process** | Integrated Project Planning | 4 |
| | Durability Management Process | 3 |
| | Innovative or Regional Design | 4 |
| **Location and Linkages** | LEED for Neighborhood Development | 10 |
| | OR | |
| | Site Selection | 2 |
| | Preferred Locations | 3 |
| | Infrastructure | 1 |
| | Community Resources/Transit | 3 |
| | Access to open Space | 1 |
| **Sustainable Sites** | Site Stewardship | 1 |
| | Landscaping | 7 |
| | Local Heat Island Effect | 1 |
| | Surface Water Management | 7 |
| | Non-Toxic Pest Control | 2 |
| | Compact Development | 4 |
| **Water Efficiency** | Water reuse | 5 |
| | Irrigation System | 4 |
| | Indoor Water Use | 6 |
| **Energy and Atmosphere** | Optimize Energy Performance | 34 |
| | Domestic Hot water Distribution System | 2 |
| | Domestic Hot water Pipe Insulation | 1 |
| | Refrigerant Management | 1 |
| | OR | |
| | Insulation | 2 |
| | Air Infiltration | 3 |
| | Windows | 3 |
| | Duct Tightness | 3 |
| | Space Heating and Cooling | 4 |
| | Domestic Hot Water | 6 |
| | Lighting | 3 |
| | Appliances | 3 |
| | Renewable Energy | 10 |
| | Refrigerant Management | 1 |
| **Materials and Resources** | Material Efficient Framing | 5 |
| | Environmentally Preferable Products | 8 |
| | Waste Management | 3 |
| **Indoor Environmental Quality** | Energy star w/IAP | 13 |
| | Enhanced Outdoor Ventilation | 2 |
| | Enhanced Local Exhaust | 1 |
| | Third-Party Testing | 1 |
| | Better/Best Air Filters | 2 |
| | Indoor Contaminant Control | 2 |
| | OR | |
| | Combustion Venting | 2 |
| | Moisture Control | 1 |
| | Outdoor Air Ventilation | 3 |
| | Local Exhaust | 2 |
| | Distribution Systems | 3 |
| | Air Filtering | 2 |
| | Contaminant Control | 4 |
| | Radon Protection | 1 |
| | Vehicle Emissions Protection | 3 |
| **Awareness and Education** | Education of the Homeowner/Tenant | 2 |
| | Education of Building Manager | 1 |
| | | **136** |

Some of the issues have prerequisites which give no points but must be completed. The final rating is in four levels; Certified, Silver, Gold and Platinum. For the Certified level, 45-59 points are required. For Silver level, 60-74 points are required. Gold level requires 75-89 points and the Platinum level requires 90-136 points. The required number of points for each certification level is adjusted for homes that are below or above average in size with a factor called the Home Size Adjustment.

Homes are rated by Greet Raters, which are individuals who are working for LEED for Homes Providers. LEED for Homes Providers are chosen by USGBC to perform the certification services for the program.

## 3.3 The content of the program

As in the chapter on The Code for Sustainable Homes, the main ideas and principles of LEED for Homes will be stated but specific details kept to minimum since this chapter is merely intended to provide an overview of the program. All information in this chapter come from LEED for Homes – Rating System, published January 2008.

### 3.3.1 Innovation & Design Process

First issue is *Integrated Project Planning*. This issue has the prerequisite that a meeting should be held on early stages involving both the developer and the LEED for Homes Provider where the goals are set, which rating level will be sought after, and the means to achieve that level. Three of the four credits for this issue are given for actively involving different parties of the project in the green design process and delegating the responsibility of achieving the desired credits. One credit is awarded if the building is designed such that it is optimized for solar design, i.e. the building makes the most use possible of the sunlight.

The second issue of the category is *Durability Management Process*. The aim is to make the design team aware of available measures to make the building as durable as possible. There are two prerequisites: A plan for durability should be created, containing an evaluation of all the threats to durability and how they can be prevented, and the contractor shall have a quality management process to ensure that the durability measures are implemented properly. Three credits can be awarded if the durability plan is verified by a Green Rater.

The last issue of the category is *Innovative or Regional Design*. Up to four credits can be awarded for innovative measures taken towards green design that are not specified in the rating system.

### 3.3.2 Location & Linkages

There are two paths possible through this category. The first one includes only one issue, *LEED for Neighborhood Development*. Ten points are available if the building has a LEED for Neighborhood Development certificate. LEED for Neighborhood Development is another certification program by USGBC. Some of its intentions are to create compact mixed-use neighborhoods and reduce urban sprawl (U.S. Green Building Council, 2008).

The second path includes five issues, the first one being *Site Selection*. Two credits can be awarded if the building is not situated on an environmentally critical site, such as a site with high flood risk, a site that is an important habitat for wildlife or close to waters or wetlands.

The second issue of this path is *Preferred Locations*. The intention of that issue is to promote condensation of urban areas, i.e. to encourage developers to build on land that borders previously developed sites or build directly on previously developed sites.

*Infrastructure* is the third issue. One credit is available if the new construction is close to existing water and sewer lines.

Fourth issue is *Community Resources/Transit*. Credits are awarded if the home is situated such that the residents can easily reach several specific community resources by walking, biking or using public transportation. The community resources in question are e.g. schools, grocery stores, gyms, banks etc. The intent is to reduce usage of private cars.

Last issue of this category is *Access to Open Space*. If the home is situated within a half a mile from a public recreational area, such as a park or play area, one credit can be achieved.

### 3.3.3 Sustainable Sites

A minimum of 5 points must be achieved in this category in order to stand a chance of receiving a LEED rating.

The first issue is *Site Stewardship*. Its aim is to limit negative environmental effects that construction might have on the site of construction. This issue has the prerequisite that possible erosion of the site must be researched before construction starts and a plan made of how to limit the damage. The plan furthermore has to be implemented. One credit is awarded if appropriate measures are taken to minimize the disturbance of the site resulting from construction. That involves creating a plan showing clearly which areas of the site shall not be disturbed during construction or designing the footprint of the building such that it covers as little as possible of the site.

Next issue is *Landscaping*. The intention of this issue is to avoid using invasive species in the landscape design and also to facilitate minimization in usage of water and synthetic chemicals. The prerequisite of this issue is not to bring in any invasive plants to the landscape of the site.

National Invasive Species Information Center, a center under the U.S. Department of Agriculture, defines an invasive species as "a species that is 1) non-native (or alien) to the ecosystem under consideration, or 2) whose introduction causes or is likely to cause economic or environmental harm to human health" (National Invasive Species Information Center, 2008). An invasive species can be either a plant or some form of animal. Beyond that, points are awarded for selecting and organizing plants and turf so that irrigation needs will be minimized, for example by using drought-tolerant turf and plants and not using turf in steep slopes.

*Local Heat Island Effects* is the third issue of the category. One point is awarded if local heat island effects are reduced by landscaping. That involves either providing shading for at least 50% of hardscapes (sidewalks, patios and driveways) or using light colored materials for at least 50% of hardscapes. The purpose is to lower the outdoor temperature around the house and thus reducing the need for mechanical cooling.

*Surface Water Management* is the next issue. Credits are awarded for taking measures to decrease erosion and runoff at the site. Creditable measures include making outdoor surfaces permeable (by using vegetation or permeable paving), planting trees, installing stormwater control systems on roofs, and using vegetated roofs.

Fifth issue of the category is *Nontoxic Pest Control*. If the home is designed such that the need for pest control in limited, for example by keeping plants some distance away from the home, limiting exposure of wood to the environment, and sealing all external openings with caulking, up to two credits can be awarded.

The last issue of the category is *Compact Development*. The number of credits increases with increased housing density in the area that the development takes place. The intent is to reward development in dense neighborhoods because that reduces cost of infrastructure, reduces distances and increases walkability, and denser neighborhoods are overall considered more livable.

### 3.3.4 Water Efficiency

This category includes only three issues but a minimum of three points must be achieved in the category. First issue is *Water Reuse*. Points are awarded for measures taken to reduce usage of potable water, especially for irrigational purposes. Four points can be awarded for installing a system that collects and stores rainwater that can be used for irrigation or indoor uses. One point can be awarded if a similar system is installed for collection of greywater (water coming from shower, faucets or clothes washer). If neither of these measures are taken but the home's plumbing is designed such that water for irrigation comes from a municipal recycled water system, three credits can be awarded.

The second issue is on similar notes as the first one and is named *Irrigation System*. Up to four credits are available for using a high-efficiency irrigation system or reducing the total irrigation demand. The purpose is again to reduce the water consumption of the home.

The third and last issue of the category is *Indoor Water Use*. Six credits can be awarded for installing high-efficiency fixtures and fittings that reduce the flow rate of water in showerheads, toilets and faucets. By doing that, the demand for both hot and cold water can be reduced.

### 3.3.5 Energy & Atmosphere

The developer can choose between two pathways through this category. The first one includes mainly one big issue, *Optimize Energy Performance*, which gives a maximum of 34 points. The prerequisite of that issue is to meet the performance requirements of ENERGY STAR for Homes, which is a set of standards set to promote energy efficiency of new homes. It applies to both the superstructure of the home itself as well as the products and appliances used within the home. It includes using effective insulation, high-performance windows, sealing all holes and cracks in the exterior, using energy efficient heating and cooling equipment and energy efficient appliances (U.S. Environmental Protection Agency, 2009). Since meeting these standards is a prerequisite for this issue, no points are awarded for that, but up to 34 points can be awarded for exceeding the performance standards of ENERGY STAR for Homes. The number of points depends on how much the improvement is.

This pathway also shares issues six and ten with the second pathway of this chapter. A discussion will be given on those issues below.

The first issue of the second pathway is *Insulation*. The prerequisite of this issue is that the house must have a basic insulation. Beyond that, two points can be awarded if the home has enhanced insulation. The purpose of this topic is to minimize heat loss from homes and thus make them more energy efficient.

Second is *Air Infiltration* and has the intent of reducing air leakage in and out of conditioned spaces with the associated waste of energy. The rating system defines three categories: reduced leakage, greatly reduced leakage and minimal leakage. The first one is a prerequisite and rewards no points, but two points can be awarded for the second one and three for the third.

Third issue, *Windows*, promotes energy efficiency of windows. As in the previous issue, three categories are defined: good windows, enhanced windows and exceptional windows. As before, the first category rewards no points since it is a prerequisite, the second can give up to 2 points and the third three points.

The next issue, *Heating and Cooling Distribution System*, has a similar rating scale as the preceding ones. Designing the heating and cooling distribution system such that losses through ducts are reduced is a prerequisite, and credits are awarded for greatly reducing it or minimize. This can be done e.g. be limited sizes of ducts, using insulation around pipes and keeping the system entirely within the conditioned space.

The fifth, sixth, seventh and eighth issues of this pathway all lead to the same source; energy efficiency and reduced energy consumption. *Space Heating and Cooling Equipment* awards credits for using energy efficient HVAC systems and therefore reducing energy usage linked to the heating and cooling system. *Water Heating* awards credits for designing the hot water distribution system in an efficient way to minimize energy losses, This applies to both the system design itself as well as the layout of the fixtures. A credit is also awarded for proper pipe insulation. In *Lighting*, credits are available for using interior and exterior lighting that match the energy performance level specified in ENERGY STAR by using ENERGY STAR labeled fixtures or lamps, and using motion sensors for exterior lighting as well. *Appliances* awards points for using energy efficient ENERGY STAR labeled appliances such as refrigerators, ceiling fans, dishwashers and clothes washers. Also, one credit is awarded if the clothes washer is water-efficient.

The tenth issue is *Renewable Energy*. The intent of this issue is to reduce consumption of energy coming from nonrenewable energy sources and instead installing renewable electric generating systems. Such system can include solar cells for example.

The last issue of this category is *Residential Refrigerant Management*. One credit is awarded for using air-conditioning refrigerant that has a minimal contribution towards ozone depletion and global warming.

### 3.3.6 Materials & Resources

This category has three issues and a minimum of two points must be achieved within it. The first issue is *Material-Efficient Framing*. It awards credits for reducing the amount of construction waste associated with the construction of the superstructure of the home. In LEED for Homes, a so-called waste factor is defined as "the percentage of materials ordered in excess of the estimated material needed for construction" The prerequisite of this issue is to limit the waste factor to 10% or less. Credits are available for creating detailed construction documents, making a detailed list prior to construction of timber needed, using off-site fabrication and other smaller efficient framing measures.

*Environmentally Preferable Products* is the second issue. The prerequisite here is that tropical wood should have a FSC certificate. FSC stands for Forest Stewardship Council which is an independent organization that promotes responsible management of earth's forests (Forest

Stewardship Council, 2009). Creditable environmentally preferable products are e.g. made from recycled material, are produced locally, concrete with fly ash or slag, and products that meet emission criteria for volatile organic compounds.

Third and last issue of this category is *Waste Management* which has the intent of reduce construction waste. The prerequisite is to have a plan dealing with construction waste management, e.g. investigate local options of recycling. Three points can be awarded for reducing construction waste beyond what might be called the industry norm.

### 3.3.7 Indoor Environmental Quality

This category is divided into two optional pathways. A minimum of six points must be achieved in the category.

The first issue of the first pathway is *ENERGY STAR with Indoor Air Package (IAP)*. Up to thirteen points can be achieved for this issue if the home's indoor environment and atmosphere is improved by completing the requirements of the ENERGY STAR with IAP program. The program is designed to protect homes from moisture, mold, pests, combustion gases, and other airborne pollutants (U.S. Environmental Protection Agency , 2005). This pathway also shares parts of issues three, four, six and seven of pathway two, and these issues will be discussed within the context of pathway two.

The first issue of the second pathway is *Combustion Venting*. Taking basic combustion venting measures is the prerequisite. It includes using no unvented combustion appliances, having a carbon monoxide monitor on each floor, and heating equipment that involves combustion must be designed such that combustion gases do not leak into occupied spaces. Credits are given for enhanced combustion venting measures, which includes installing either no fireplaces or woodstoves, or design it in accordance with specifications listen in the rating document.

*Moisture Control* is the next issue. One credit is awarded for installing a dehumidification equipment that maintains relative humidity below 60%. The purpose is to decrease the risk of mold.

The third issue of the pathway is *Outdoor Air Ventilation*. Indoor pollutants in the home can be reduced by ventilating with outdoor air. Therefore, three credits are available if the home has enhanced outdoor air ventilation, beyond what might be called basic outdoor air ventilation, which is a prerequisite for this issue. Homes in mild climates can be exempt if ventilation needs can be met by opening windows. The purpose is to provide cleaner and healthier air inside the home.

Next issue is *Local Exhaust*. Basic local exhausts are required in bathrooms and kitchens, and credits are awarded for having enhanced local exhausts in these areas. Such an enhanced

system might include an occupancy sensor, fans running continuously or having an automatic timer, or an humidistat controller. As before, the intent is to limit exposure to moisture and pollutants in these areas.

The fifth issue of this pathway is *Distribution of Space Heating and Cooling*. Credits are awarded for ensuring that every room has adequate flow of air and good space heating and cooling. The prerequisite is to perform room-by-room load calculations and install system or ducts accordingly. Air flow and temperature control can be achieved by using adequate sizes of openings, having flow control valves on every radiator, and having more than one thermostat.

*Air Filtering* is the sixth issue, giving credits for ensuring good quality of indoor air by using filters in the air supply system. Good filters are a prerequisite, and credits are given for having better or best filters.

The last three issues of this category are all on similar notes; ensuring good quality of indoor air. *Contaminant Control* is the seventh issue with three creditable subjects: ducts must be sealed during construction so they won't get filled with contaminants, measures such as walk-off mats, shoe removal and storage space or vacuum system should be used to control indoor contaminants, and the home should be flushed with fresh air prior to occupancy. The ninth issue, *Radon Protection*, promotes using radon-resistant construction techniques to protect occupants against radon gas. The ninth issue, *Garage Pollutant Protection*, awards credits for some measures aimed at reducing flow of pollutants coming from adjacent garage. This can include sealing all shared surfaces between garage and the occupancy area and using an exhaust fan in the garage.

### 3.3.8 Awareness & Education

This is the smallest category with only two issues. The first one is *Education of the Homeowner or Tenant*. The prerequisite of this issue is that the developer shall give the home's occupants an operation and maintenance manual explaining the function of the systems and with guidelines of how to keep the home "green". The purpose is to keep the home running as efficiently as possible and maintain its performance. Credits are awarded for giving the homeowner an enhanced training or promote general public awareness about LEED.

The second issue is *Education of Building Manager*. One point is available if the manager of the building is educated about the operation and maintenance of the building. As in the first issue, the purpose is the keep the building performing efficiently and in the most environmentally friendly way, utilizing all the "green" features of the home.

# 4 Comparison

From the summaries above of both systems, it can be seen that these two rating programs are very similar in numerous ways. They target mostly the same areas and subjects, but the approaches are often different.

The issues of the two rating systems can be divided roughly into 10 topics. Some issues target more than one area but can be categorized according to their main emphasis. The topics are:

1) Conservation of energy and reduced $CO_2$ emission
2) Conservation of water
3) Reduced emission of pollutants
4) Efficient and environmentally friendly use of building materials
5) Preserving and/or enhancing the environment of the site
6) People-friendly, dense neighborhoods and reduced car usage
7) Healthy and comfortable indoor environment
8) Efficient operation of the home
9) Lifetime and safety of the home
10) Other

Subsequent sections discuss further each topic. Numbers in front of issues in the tables indicate the categories of each rating system. In LEED for Homes, there are three categories which have two optional pathways. The first one has one core issue that gives most of the points for that category, while the second one is more detailed with more and smaller issues. Here, only the second pathways are used for comparison since they are more detailed than the first pathways. The result should be the same for either pathway since they target the same subjects.

## 4.1 Conservation of energy and reduced $CO_2$ emission

Table 3. Overview of Topic 1.

| Conservation of energy and reduced $CO_2$ emission | |
|---|---|
| **The Code for Sustainable Homes** | **LEED for Homes** |
| 1 - Dwelling emission rate | 3 - Local heat island effect |
| 1 - Building fabric | 5 - Insulation |
| 1 - Internal lighting | 5 - Air infiltration |
| 1 - Drying space | 5 - Windows |
| 1 - Energy labeled white goods | 5 - Heating and cooling distribution system |
| 1 - External lighting | 5 - Space heating and cooling equipment |
| 1 - Low or zero carbon technologies | 5 - Water heating |
| 8 - Construction site impacts (also in topic 2) | 5 - Lighting |
| | 5 - Appliances |
| | 5 - Renewable energy |

Fossil fuel is the main source of fuel used to generate energy in both the United Kingdom and in the United States. The downside of using fossil fuel is that it is a nonrenewable resource and it emits carbon dioxide when burned, leading to global warming. Homes are large consumers of electricity. Therefore, it is important to promote energy savings in homes and especially in new homes that can be built from scratch with the intent to be as energy efficient as possible. Both The Code and LEED for Homes emphasize this issue heavily. *Dwelling emission rate* in The Code is a large issue, dealing with the energy consumption of the home as a whole, including heating, hot water and lighting. LEED breaks the energy usage into smaller issues such as *Air infiltration*, *Heating and cooling distribution system*, *Space heating and cooling equipment*, *Water heating*, and *Lighting*, but basically these are the same subjects that *Dwelling emission rate* deals with. Both systems also emphasize insulating the home effectively to minimize heat loss. These are the issues *Building fabric*, *Insulation*, and *Windows*. Both systems also give credits for using energy efficient appliances, *Energy labeled white goods* and *Appliances*, and they also give credits for supplementing the regular electricity source with some measures of sustainable energy such as solar panels (*Low or zero carbon technologies* and *Renewable energy*).

What separates these two rating systems in this topic are only small issues. The Code awards credits if the home has a drying space to replace a tumble dryer, and if internal and external lighting fixtures are energy efficient. *Construction site impacts* also awards credits for minimizing energy consumption and $CO_2$ emission during construction. LEED gives credits for using landscaping to reduce local heat island effect and thus reduce cooling needs.

## 4.2 Conservation of water

Table 4. Overview of Topic 2.

| Conservation of water | |
|---|---|
| **The Code for Sustainable Homes** | **LEED for Homes** |
| 2 - Indoor water use | 4 - Water reuse |
| 2- External water use | 4 - Irrigation system |
| 8 - Construction site impacts (also in topic 1) | 4 - Indoor water use |
| | 3 - Landscaping (also in topic 5) |

Another important subject in both rating systems is conservation of potable water. The systems are almost identical in this matter. They both award credits for limiting usage of potable water indoors by restricting the flow rate of water, and for collecting and storing rainwater for irrigational purposes. LEED takes this slightly further and awards credits also for collecting greywater (used potable water, from showers for example), and for using water efficient irrigation systems. LEED assumes that re-used water might be used for indoor uses as well. Also, LEED awards credits in the issue *Landscaping* for selecting and organizing vegetation on the site such that the need for irrigation is minimized. The Code however awards credits for minimizing water consumption during construction in *Construction site impacts*.

## 4.3 Reduced emission of pollutants

Table 5. Overview of Topic 3.

| Reduced emission of pollutants | |
|---|---|
| **The Code for Sustainable Homes** | **LEED for Homes** |
| 6 - Global warming potential (GWP) of insulants | 3 - Non-toxic pest control |
| 6 - $NO_x$ emissions | 5 - Residential refrigerant management |

This topic is rather small and the rating programs target different areas of possible pollution. The Code focuses on polluting chemicals from foamed insulating materials and emission of nitrogen oxides from boilers used for heating. LEED awards credits for not using toxic chemicals to protect the home against pests and for using air-conditioning refrigerants that are not made from chemicals that contribute to ozone depletion.

## 4.4 Efficient and environmentally friendly use of building materials

Table 6. Overview of Topic 4.

| Efficient and environmentally friendly use of building materials | |
|---|---|
| **The Code for Sustainable Homes** | **LEED for Homes** |
| 3 - Environmental impact of materials | 6 - Material efficient framing |
| 3 - Responsible sourcing of materials - basic building elements | 6 - Environmentally preferable products |
| 3 - Responsible sourcing of materials - finishing elements | 6 - Waste management |
| 5 - Construction site waste management | |

Both systems highly emphasize reducing negative environmental impacts resulting from construction and building materials. The Code has an extensive issue, *Environmental impact of materials,* which has the intent to encourage the use of materials with low environmental impact. To estimate the total impact of materials, a so-called Green Guide has been developed. The Green Guide is "[…] a rating system for the embodied environmental impacts of construction products and materials. It is based on extensive quantitative data for materials, which has been translated into simple environmental profiles for building elements" (Department for Communities and Local Government, 2008). The information on materials in the Green Guide is based on life cycle assessment (LCA) which assesses all environmental impact of the material from when it is made until it gets unusable. This issue is also mandatory in the Code, so material usage must be considered for all homes.

LEED for Homes has an issue that also deals with these matters, *Environmentally preferable products*. Credits are awarded for certain measures taken to make materials more efficient, such as using fly ash in concrete, or using recycled materials. The handling of this matter is however rather superficial compared to the Green Guide in the Code. A second part of this issue is using certified tropical wood and that is also one of the requirements set forward in the two *Responsible sourcing of materials* issues in The Code, along with other constraints regarding all materials in general to be responsibly sourced.

*Material efficient framing* focuses on the quantity of materials used. That issue emphasizes efficient material usage by planning carefully ahead of construction how much materials will be needed and minimizing construction waste.

Resulting from this discussion, one can say that the first three issues in The Code and the first two issues in LEED in Table 6, more or less cover the same subject but the handling of them is different in depth. The last two issues, *Construction site waste management* and *Waste management*, also deal with the same matter; minimizing waste from construction.

## 4.5 Preserving and/or enhancing the environment of the site

Table 7. Overview of Topic 5.

| Preserving and/or enhancing the environment of the site | |
|---|---|
| **The Code for Sustainable Homes** | **LEED for Homes** |
| 9 - Ecological value of site<br>9 - Ecological enhancement<br>9 - Protection of ecological features<br>9 - Change in ecological value of site<br>9 - Building footprint | 3 - Landscaping (also in topic 2)<br>3 - Site stewardship<br>2 - Site selection (also in topic 9) |

In this category, the two rating programs cover more or less the same subjects. Credits are awarded for protecting the ecological features of the site, both during construction and on the lifetime of the home. *Protection of ecological features* and *Site stewardship* focus on limiting negative ecological impact of construction. *Ecological value of site* and *Site selection* both award credits for not building the home on a site that is considered having some ecological importance. *Landscaping*, *Ecological enhancement* and *Change in ecological value of site* give points for protecting and/or enhancing the ecological value of the site. *Building footprint* is the only difference between the programs – awards credits for limiting the size of the footprint of the home relative the size of the site.

## 4.6 People-friendly, dense neighborhoods and reduced car usage

Table 8. Overview of Topic 6.

| People-friendly, dense neighborhoods and reduced car usage | |
|---|---|
| **The Code for Sustainable Homes** | **LEED for Homes** |
| 1- Cycle storage<br>1- Home office | 2 - Preferred locations<br>2 - Infrastructure<br>2 - Community resources/transit<br>2 - Access to open space<br>3 - Compact development |

LEED for Homes places an emphasis on reducing urban sprawl and creating neighborhoods that are dense, walkable and provide a comfortable environment for the inhabitants. The Code does not award any credits for such issues, but it awards credits for measures taken to reduce car usage, which is also a positive side effect of reducing urban sprawl. *Preferred locations*, *Infrastructure*, and *Compact development* all aim at encouraging developers to build on sites that border other previously developed sites, preferably where housing density is high, and where it is easy to connect the new home to existing infrastructure. LEED also awards credits if the home has a good access to public transportation and open spaces such as parks. The Code

only awards credits in this category for having a cycle storage and an office in the home, both enabling the habitants to reduce their car usage.

## 4.7 Healthy and comfortable indoor environment

Table 9. Overview of Topic 7.

| Healthy and comfortable indoor environment | |
|---|---|
| **The Code for Sustainable Homes** | **LEED for Homes** |
| 7 - Daylighting<br>7 - Sound insulation | 7 - Combustion venting<br>7 - Moisture control (also in topic 9)<br>7 - Outdoor air ventilation<br>7 - Local exhaust<br>7 - Distribution of space heating and cooling<br>7 - Air filtering<br>7 - Contaminant control<br>7 - Radon protection<br>7 - Garage pollutant protection |

This topic is primarily targeted in LEED for Homes. LEED awards credits for limiting the concentration of polluting and/or harmful chemicals inside the home, and keeping the indoor atmosphere healthy for the residents. Credits are available for venting combustion gases, keeping moisture levels under control, having outdoor ventilation, having local exhausts in kitchens and bathrooms, using filters in air supply systems, protecting ducts from contaminants, protecting against radon and reducing flow of pollutants coming from garages. LEED also has available credits for providing good distribution of air throughout the home, causing good flow of space heating and cooling.

The Code does not award credits for good indoor atmosphere, but rather focuses on making the home comfortable for the inhabitants by requiring good flow of daylight into the house and using proper sound insulation to reduce noise disturbance.

## 4.8 Efficient operation of the home

Table 10. Overview of Topic 8.

| Efficient operation of the home | |
|---|---|
| **The Code for Sustainable Homes** | **LEED for Homes** |
| 8 - Home user guide | 8 - Education of the homeowner/tenant<br>8 - Education of building manager |

Both rating systems give points for educating the residents of the home on how to run the home efficiently so that all its environmentally friendly features can be utilized to the full

extent. Both the Code and LEED specifically mention that an operational manual should come with the home, and LEED also awards credits for giving the residents personal training and a walkthrough of the home.

## 4.9 Lifetime and safety of the home

Table 11. Overview of Topic 9.

| Lifetime and safety of the home | |
|---|---|
| **The Code for Sustainable Homes** | **LEED for Homes** |
| 4 - Management of surface water runoff from developments<br>4 - Flood risk<br>7 - Lifetime homes<br>8 - Security | 2 - Site selection (also in topic 5)<br>3 - Surface water management<br>7 - Moisture control (also in topic 7) |

This topic deals with elongating the lifetime of the home, making it adaptable to the changing needs of the residents, and keeping it safe from environmental and human hazards. Both systems award credits for controlling surface water runoff and therefore reducing flood risk. Both systems also give points for not building the home in areas with high flood risk. LEED also has available credits for controlling moisture in the home and thus reducing risk of mold. The Code emphasizes the adaptability of the home and protecting it against crime.

## 4.10 Other

Table 12. Overview of Topic 10.

| Other | |
|---|---|
| **The Code for Sustainable Homes** | **LEED for Homes** |
| 5 - Storage of non-recyclable waste and recyclable household waste<br>5 - Composting<br>7 - Private space<br>8 - Considerate constructors scheme | 1 - Integrated project planning<br>1 - Durability management process<br>1 - Innovative or regional design |

This group consists of subjects that stand alone and do not belong in categories with other subjects. In the Code, this includes providing storage space for household waste, providing facility for composting, having a private outdoor space and having a considerate constructors scheme, which incorporates the contractor being considerate to the environment and neighbors of the construction. The three issues on the LEED side are all a part of the preparation before designing or constructing the home, regarding setting a goal for LEED rating and how to achieve it.

# 5 Applicability to Icelandic Homes – Case Study

The inspiration for this paper was to try to determine if either of these sustainability rating programs would be suitable to rate new homes in Iceland. The advantage of using a previously existing program is that many of these programs have been developed and refined for years, so they are very direct and know which areas to target. LEED in the United States and BREEAM in the United Kingdom are both feasible programs to adopt given how well they are known and how respected they are. It is interesting however to explore whether either of these programs actually fit the Icelandic reality. In this case study, an actual home will be used as an example. The home is built in the years 2007-2009 and represents is most ways typical Icelandic homes. The home is approximately 6500 sq.ft. and is situated on a piece of land by the ocean. It has a specific name, Marbakki, and will be referred to with its name hereafter. Figures 1, 2 and 3 show Marbakki on construction stage at the beginning of the year 2009. The case study gives a discussion of the relevance of each topic to Marbakki and to the Icelandic building industry in general as well, and issues will be categorized according to their relevance to Marbakki at the end of each sub-section. The relevance is divided into three classes; *Relevant*, *Ambiguous*, and *Not relevant*. The relevance is considered with respect to whether the home will be fairly rated against that issue, i.e. are the demands reasonable considering the Icelandic reality? The first and the last terms explain themselves, but *Ambiguous* means here that it is relevant to Marbakki to some extent but perhaps not in the same way as the rating systems intended it to be or if more information are needed to determine its relevance.

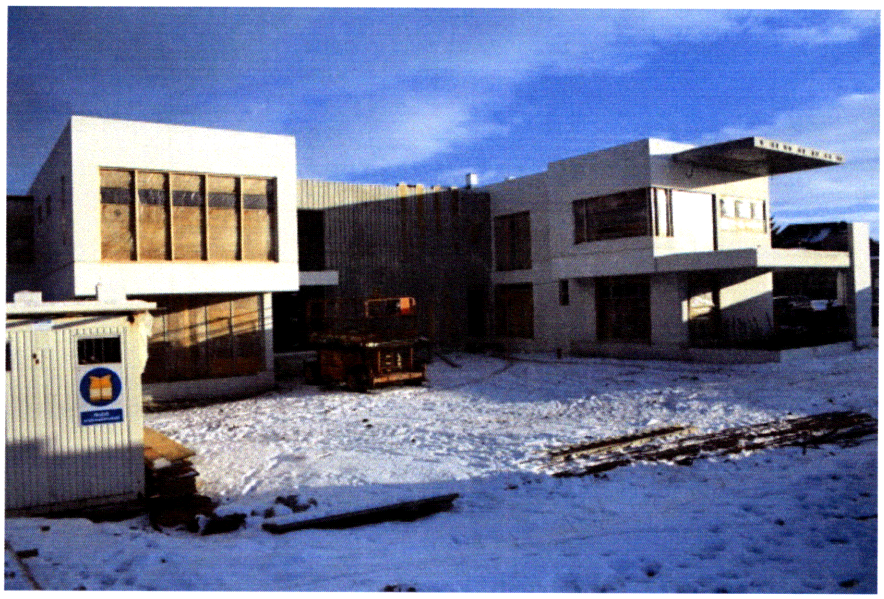

Figure 1. Marbakki (Source: Eysteinn Einarsson)

Figure 2. Marbakki (Source: Eysteinn Einarsson)

Figure 3. Marbakki (Source: Eysteinn Einarsson)

## 5.1 Conservation of energy and reduced $CO_2$ emission

Consumption of electricity per capita in Iceland is the highest in the world (Iceland Trade Directory, 2009). Icelanders are almost wasteful of energy and are usually not actively trying to save energy, at least not on a large scale. One might therefore think that the two rating systems in question here might be even more relevant to Iceland than to the United Kingdom and the United States. There is however a big difference between Iceland and these countries. Virtually all of the country's electricity and heating comes from sustainable sources; hydropower and geothermal power. That means that energy consumption in homes is completely green in this respect and does not stem from use of unsustainable sources nor does it contribute to greenhouse effects. Energy consumption for electricity and heating in Iceland is therefore not quite a matter of environmental impacts, but rather a monetary issue. The advantage of saving energy is a monetary gain of the homeowners, since the energy cost is lower, and a monetary gain of the (publically owned) energy companies, since the existing power plants can serve more people and for longer time if each home uses less energy.

This is the case of Marbakki and almost all other homes in Iceland. It mostly depends on the owner of the home whether he thinks it is financially practical to install some of these measures mentioned in the Code and in LEED, weighing the cost of the measures versus the saving on the energy bill. Some are nevertheless in use in many new homes already; proper insulation and energy efficient windows. This is due to the cold climate and while it does prevent the heat from going out, it also, more importantly, prevents the cold from coming in.

If the owner of Marbakki would decide that he would not be interested in taking any of the extra energy-saving measures stated in the rating programs, the home would get a very poor rating in this category. However, this lack of energy saving actions does not mean in this case that the home can not be environmentally friendly since all the energy consumed in the home is green. This indicates that the rating systems apply poorly in this respect to the Icelandic reality; a home that is green compared to UK or US homes is still receiving a low rating. There is virtually no difference between the Code and LEED for Homes in this respect since they are both very similar in this category.

If all the issues in this category are sorted with respect to relevance to Marbakki, the following table can be constructed:

Table 13. Relevance of Topic 1.

| Conservation of energy and reduced $CO_2$ emission | | |
|---|---|---|
| **Relevance to Marbakki** | **The Code for Sustainable Homes** | **LEED for Homes** |
| **Relevant** | | |
| **Ambiguous** | 1 - Dwelling emission rate<br>1 - Building fabric<br>1 - Internal lighting<br>1 - Drying space<br>1 - Energy labeled white goods<br>1 - External lighting<br>1 - Low or zero carbon technologies<br>8 - Construction site impacts (also in topic 2) | 3 - Local heat island effect<br>5 - Insulation<br>5 - Air infiltration<br>5 - Windows<br>5 - Heating and cooling distribution system<br>5 - Space heating and cooling equipment<br>5 - Water heating<br>5 - Lighting<br>5 - Appliances<br>5 - Renewable energy |
| **Not relevant** | | |

All the issues are in the *Ambiguous* category since they do apply to Marbakki in the sense of cutting cost of energy, but it does not apply in the sense of reducing $CO_2$ emission and protecting unsustainable resources, as is the main intent of the rating programs.

## 5.2 Conservation of water

Clean drinking water is a very precious resource and is limited in many countries. The aim of the Code and LEED for homes in this respect is to promote water savings to protect these limited resources and using them as efficiently as possible. However, just as in the topic before on energy savings, the reality in Iceland is quite different. Iceland has far more pure drinking water than the nation manages to consume each year. According to UNESCO, Iceland is the fourth richest country in the world with respect to drinking water resources (Vatn á Íslandi, 2009). Therefore, there isn't much incentive to conserve water in Iceland. Considering that, this whole

category makes almost no sense with respect to the Icelandic reality. Icelandic homes being rating against The Code or LEED for Homes, would score very low in this category because few people are willing to go the extra mile to conserve water when there is no reason for it. Credits for this topic constitute almost 10% of the total number of credits in The Code, and around 16% of the total credits in LEED for Homes. Losing that large portion of points in this matter would give Icelandic homes far lower rating than they actually deserve. Again, The Code and LEED are almost identical in this category so that it does not make much difference in this respect which system would be used to rate the home.

Table 14 gives the relevance of this topic:

Table 14. Relevance of Topic 2.

| Conservation of water | | |
|---|---|---|
| **Relevance to Marbakki** | **The Code for Sustainable Homes** | **LEED for Homes** |
| **Relevant** | | |
| **Ambiguous** | | |
| **Not relevant** | 2 - Indoor water use<br>2- External water use<br>8 - Construction site impacts (also in topic 1) | 4 - Water reuse<br>4 - Irrigation system<br>4 - Indoor water use<br>3 - Landscaping (also in topic 5) |

## 5.3 Reduced emission of pollutants

Reducing emission of pollutants is a vital issue for all countries in the world. Just as other countries, Iceland should make every effort to decrease its emission of pollutants. Some of the issues targeted in the two rating systems in question apply to Iceland to some extent, while others do not. It is hard to say which types of insulating materials are used in Marbakki, but the contractor should of course consider using insulating materials with global warming potential of less than 5 (see discussion of this issue in chapter 2.3.6). The second issue in the Code in this category concerns nitrogen oxide emission from boilers used for heating and hot water. In Iceland, space heating is achieved by using radiators with geothermally heated water inside of them, and hot water in faucets is also geothermal. Therefore, no boilers are used in homes to heat up water and there is therefore no $NO_x$ emission from such equipments. In Marbakki and some other modern houses, some of the heating comes from systems blowing heated air into the space. The energy used for that is also green – green electricity as was covered in chapter 6.1. For zero $NO_x$ emission, Marbakki would get a full house of points for this issue.

LEED awards credits for using non-toxic pest control in homes. Pests are usually not a concern in homes in Iceland. The climate is cold and the vast majority of homes is built from concrete

instead of wood. Marbakki is cast from concrete and the construction is of high quality so there is no reason to suspect that a pest control will be needed in the home. Secondly, LEED awards credits for using environmentally friendly air-conditioning refrigerant. Marbakki is one of few homes in Iceland that have mechanical air-conditioning. Almost all regular homes just use openable windows for air-conditioning. Those with mechanical air-conditioning should of course not use refrigerants that contribute to ozone depletion.

The outcome is, that one issue in The Code and one issue in LEED in this category, apply to some extent to Icelandic homes, while one in each program do not:

Table 15. Relevance of Topic 3.

| Reduced emission of pollutants | | |
|---|---|---|
| **Relevance to Marbakki** | **The Code for Sustainable Homes** | **LEED for Homes** |
| **Relevant** | 6 - Global warming potential (GWP) of insulants | 5 - Residential refrigerant management |
| **Ambiguous** | | |
| **Not relevant** | 6 - $NO_x$ emissions | 3 - Non-toxic pest control |

## 5.4 Efficient and environmentally friendly use of building materials

This whole category applies to homes in Iceland just as well as it applies to homes in the UK and the US. The two systems are very similar in this respect, except that The Code has a more extensive coverage on the environmental impact of materials and even has a separate rating system for that, the Green Guide, based on life cycle analysis. This category also deals with subjects such as recycling materials, using certified wood and minimizing waste from construction. The relevance of these issues to Icelandic homes is high since most homes are made from concrete. The negative environmental impacts of concrete might be reduced by following the guidelines in these rating programs, for example by using flyash or recycling used concrete. All of this applies to Icelandic homes and Marbakki just as well, but Marbakki would however get a rather poor rating in this category since these issues were not taken into account on the design or construction stages.

Table 16. Relevance of Topic 4.

| Efficient and environmentally friendly use of building materials | | |
|---|---|---|
| **Relevance to Marbakki** | **The Code for Sustainable Homes** | **LEED for Homes** |
| **Relevant** | 3 - Environmental impact of materials<br>3 - Responsible sourcing of materials – basic building elements<br>3 - Responsible sourcing of materials - finishing elements<br>5 - Construction site waste management | 6 - Material efficient framing<br>6 - Environmentally preferable products<br>6 - Waste management |
| **Ambiguous** | | |
| **Not relevant** | | |

## 5.5 Preserving and/or enhancing the environment of the site

This category is very relevant to the Icelandic reality but it depends on each individual home how much its ecological impact is. In the case of Marbakki, it is built on a previously developed site and does not have any significant wildlife or plants on the site. The only vegetation there is grass, so there is not much to preserve. Marbakki would therefore probably score quite high in this category.

This however can be a concern for some homes in Iceland. As urban areas stretch out, it becomes more and more likely that new homes are being built on some ecologically important areas. These issues are therefore pertinent to Iceland in general, even though most homes probably do not have much negative impact on their surrounding ecosystems, mainly because of things like limited wildlife and forests in Iceland.

Table 17. Relevance of Topic 5.

| Preserving and/or enhancing the environment of the site | | |
|---|---|---|
| **Relevance to Marbakki** | **The Code for Sustainable Homes** | **LEED for Homes** |
| **Relevant** | 9 - Ecological value of site<br>9 - Ecological enhancement<br>9 - Protection of ecological features<br>9 - Change in ecological value of site<br>9 - Building footprint | 2 - Site selection (also in topic 9)<br>3 - Site stewardship<br>3 - Landscaping (also in topic 2) |
| **Ambiguous** | | |
| **Not relevant** | | |

## 5.6 People-friendly, dense neighborhoods and reduced car usage

This is a very interesting category and especially in LEED for Homes. LEED encourages construction in densely developed areas where there it good access to infrastructure and public transportation, and people can easily walk and ride their bikes around the neighborhood and do not have to use their private car for every move. As said before, Marbakki is being built on a previously developed site in a rather old neighborhood, and other homes are situated very close to it. There is good access to infrastructure and public transportation. The home has good access to open spaces, both does it have its own back yard and it is also situated closely to a public area near the coast. It does not have a special cycle storage space, but it does have a large private garage that could serve as cycle storage. There is no home office in the house. Marbakki would overall get a good grade in this category, especially when rated against LEED for Homes.

This is however not the case for most new homes. Most new developments are on previously undeveloped sites and the urban areas are increasingly stretching further and further. Sometimes the infrastructure does not keep up with the development and it can take some time to get public transportation and businesses to come to the neighborhood. Most new homes would probably get far worse rating in this category than Marbakki.

Table 18. Relevance of Topic 6.

| People-friendly, dense neighborhoods and reduced car usage | | |
|---|---|---|
| **Relevance to Marbakki** | **The Code for Sustainable Homes** | **LEED for Homes** |
| **Relevant** | 1- Cycle storage<br>1- Home office | 2 - Preferred locations<br>2 - Infrastructure<br>2 - Community resources/transit<br>2 - Access to open space<br>3 - Compact development |
| **Ambiguous** | | |
| **Not relevant** | | |

## 5.7 Healthy and comfortable indoor environment

This is a category of issues that do apply and issues that do not apply to Icelandic homes. Both of the two issues in the Code do definitely apply to Icelandic homes and if complied with, they could lead to significantly better homes. The issues in LEED for Homes are less applicable although they do apply to some extent. Icelandic homes do not use heating equipment that involves combustion and most of them do not need filters in air supply systems since they have no air supply systems. The absence of air supply system makes it unnecessary to seal air ducts

from contaminants during construction but it might be beneficial to use the other measures mentioned in *Contaminant control* to limit indoor contaminants. The condition of having outdoor air ventilation is automatically fulfilled since virtually all homes use openable windows for air-conditioning and venting (although Marbakki uses mechanical air-conditioning as well, it also does have numerous openable windows). In standard homes, radiators are placed under all windows so the requirement of good distribution of space heating is usually automatically fulfilled also. The building code already requires local exhausts to be placed in kitchens and bathrooms if they do not have openable windows (Umhverfisráðuneytið, 1998). Since most homes are cast from concrete, mold is not as big of a problem as in homes made from wood, but mold can still occur and it might therefore be good to take measures to limit the threat of mold by controlling moisture. Radon has only been found in very small concentrations in Iceland (The Icelandic Chemical Society, 2005), so there might not be a reason to take measures to protect homes against radon. *Garage pollutant protection* is probably the most relevant issue to Marbakki and other homes, since Marbakki and most homes do have an adjacent garage.

Overall, the air quality of Marbakki is likely quite good. It should get a rather high score when rated against LEED for Homes, but it might not necessarily be so if the owner is not willing the take the extra measures required if he does not believe are necessary. The home has almost undoubtedly good sound insulation since an acoustic engineer was a part of the design team from beginning. The daylight issue is not so straightforward and too complicated to calculate here, but ensuring good amount of daylight in the home is certainly beneficial an a good idea to take that into account during design.

Table 19. Relevance of Topic 7.

**Healthy and comfortable indoor environment**

| Relevance to Marbakki | The Code for Sustainable Homes | LEED for Homes |
|---|---|---|
| **Relevant** | 7 - Daylighting<br>7 - Sound insulation | 7 - Outdoor air ventilation<br>7 - Local exhaust<br>7 - Distribution of space heating and cooling<br>7 - Air filtering<br>7 - Contaminant control<br>7 - Garage pollutant protection |
| **Ambiguous** | | 7 - Moisture control (also in topic 9)<br>7 - Radon protection |
| **Not relevant** | | 7 - Combustion venting |

## 5.8 Efficient operation of the home

In the case of Marbakki, the owner was fully involved in the whole design process so he knows all the features of the home. Not all owners are involved though, and then homes get sold, so having some kind of a manual regarding the operation of the home might be a good idea. However, it might not be necessary since in the discussion here it has been shown that Icelandic homes do not need the same environmentally friendly features as homes in the UK and US do. It is hard to say therefore, what such a home user manual would constitute of in Iceland.

Table 20. Relevance of Topic 8.

| Efficient operation of the home | | |
|---|---|---|
| **Relevance to Marbakki** | **The Code for Sustainable Homes** | **LEED for Homes** |
| **Relevant** | | |
| **Ambiguous** | 8 - Home user guide | 8 - Education of the homeowner/tenant<br>8 - Education of building manager |
| **Not relevant** | | |

## 5.9 Lifetime and safety of the home

It rarely rains so heavily in Iceland that there's flood risk from surface water run-off. Marbakki however is situated only a few meters from the ocean so that risk of some flooding does exist. That factor was however taken into account in the whole design process, so that flooding should not cause damage to the home. The *Lifetime homes* program in The Code is very interesting and makes homes more adaptable to the changing needs of it habitants. *Security* is another useful program that can help protect the home against crimes but the Icelandic police has no such equivalent program though. In principle though, these two are both something that could definitely apply to Icelandic homes. Marbakki was not designed with any such concerns in mind.

Table 21. Relevance of Topic 9.

| Lifetime and safety of the home | | |
|---|---|---|
| **Relevance to Marbakki** | **The Code for Sustainable Homes** | **LEED for Homes** |
| **Relevant** | 4 - Management of surface water runoff from developments<br>4 - Flood risk<br>7 - Lifetime homes<br>8 - Security | 2 - Site selection (also in topic 5)<br>3 - Surface water management |
| **Ambiguous** | | 7 - Moisture control (also in topic 7) |
| **Not relevant** | | |

## 5.10 Other

Marbakki does have a household waste storage but no separate storage for recyclable waste. It does have a private back yard but no facility for composting. Marbakki does not fulfill any of the other requirements since the home was not designed with the intent to receive a rating against a rating program such as the Code or LEED for Homes.

Table 22. Relevance of Topic 10.

| Other | | |
|---|---|---|
| **Relevance to Marbakki** | **The Code for Sustainable Homes** | **LEED for Homes** |
| **Relevant** | 5 - Storage of non-recyclable waste and recyclable household waste<br>5 - Composting<br>7 - Private space<br>8 - Considerate constructors scheme | 1 - Integrated project planning<br>1 - Durability management process<br>1 - Innovative or regional design |
| **Ambiguous** | | |
| **Not relevant** | | |

# 6 Discussion of Results

From the previous chapter, it can be seen that The Code for Sustainable Homes and LEED for Homes, do apply in many ways to Icelandic homes. The main differences are regarding to energy and water. Energy in Iceland comes from sustainable sources and is not causing carbon dioxide emission. Energy is costly though, which would be an incentive for homeowners to

conserve energy, if they find it economical versus the cost of installing energy efficient equipment. Potable water is however abundant and no rational reason to conserve it. Due to the fact that these two subjects are not relevant or of uncertain relevance to Icelandic homes, it also reduces the need to write up materials or manuals to explain the energy or water conserving features of the home.

This could lead to homeowners not being willing to install some of the features required in the rating systems, simply because they do not see the need. That could in turn lead to Icelandic homes getting worse rating than they actually would deserve when rated against either program. That reduces the applicability of these rating systems in Iceland, which is a shame because many of the items in the programs are very much relevant to Icelandic homes and should absolutely be incorporated into the construction of new homes in Iceland.

Some of the issues in the programs are already fulfilled in Icelandic homes. If a special Icelandic rating system would be created, most of those issues would be left out since they are considered standard in almost all homes. Most homes do easily satisfy the requirements in the rating programs regarding these issues, so including them in the evaluation of Icelandic homes would probably only be beneficial and result in higher rating without much extra effort.

Even though energy in Iceland comes from sustainable sources and drinking water is abundant, both do have some economical value for the nation. Building an hydroelectric power plant is expensive and does have some irreversible environmental impact. Drinking water could be harvested and exported instead on wasting it away. Responsible use of energy and water might therefore be beneficial for Icelanders. Requiring homeowners to conserve energy and water might not be the right end to start at though. The proper channel would be for the nation to discuss these matters first and decide if these resources can be put to better use. The energy and water providers should show people that conserving energy and water does have some beneficial economical impact for the nation as a whole, and only then might it be realistic to start requiring homeowners to conserve energy and water.

# 7 Conclusion

Both of the rating programs in this study serve a very important purpose; to protect unsustainable resources, reduce pollution and create a high-quality home environment. Both of them are respected and serve their purpose well. They are however tailored to the environment that they are created in – i.e. each rating program targets the issues that are relevant to the home country of the program. That can make it difficult to apply them to homes in other countries. As has been shown in this paper, neither The Code for Sustainable Homes

nor LEED for Homes, do perfectly apply to the reality of the construction industry in Iceland. Many issues in both programs would be beneficial do adopt, such as Topic 4, *Efficient and environmentally friendly use of building materials*, and Topic 6, *People-friendly, dense neighborhoods and reduced car usage*. Some of the others are much less applicable however, such as Topic 2, *Conservation of water*. The rating of Icelandic homes might be skewed if either of these programs were used as a rating measure, since many issues simply do not apply.

Icelandic homes are in many ways environmentally friendly as has been discussed. There is a possibility though to do even better. Those issues in the Code and in LEED for Homes that are relevant to the Icelandic reality could perhaps constitute a new Icelandic rating system, shaped specifically to fit Icelandic homes. The best solutions for Iceland would probably be if the BREEAM and LEED programs could incorporate the possibility of homes being fully sustainable with respect to energy and water. If that would be the case, then these programs could very possibly be applicable to Iceland, and would give homes fair and reasonable rating.

This thesis raises many questions regarding the issue of sustainable homes in Iceland. Some of these questions do not have an easy answer and might have to be discussed on a national level before reaching a conclusion. Icelanders have to realize that apart from electricity and water, Icelandic homes do use unsustainable resources and do have some negative impact on their environment. It is their duty, just as everybody else's, to limit these impacts as possible and both these rating programs presented in this thesis do offer various ways to achieve that.

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