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Life cycle assessment (LCA) in the framework of the next generation Estonian building standard

Building certification as a strategy for enhancing sustainability

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Abstract

Optimizing environmental impacts of buildings, such as energy consumption, CO_2 emissions, water and material use is a must nowadays. Building certification and standards serve as an opportunity to regulate such subjects. This paper investigates how the implementation of a new building quality standard in Estonia can improve the sustainability of buildings by looking into the quantifiable environmental impacts of a construction. The Life Cycle Assessment (LCA) methodology is used to evaluate building certification schemes used within the new standard. The goal is to demonstrate if and how the Standard for Quality and Sustainable Real Estate Lifecycle stands for its name and addresses the life cycle impacts of a construction. This paper could serve as an illustrative example for the future users of the new building quality standard to better understand the aspects of its functioning and differences between certification schemes used within the standard. Furthermore, the results and the suggestions can help to look over requirements of the standard to refine them for a greater sustainability enhancement of the future buildings in Estonia.

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Keywords: Life Cycle Assessment; Green building certifications; Estonian building quality standard

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1. Introduction

Optimizing environmental impacts of buildings is a must in the growing demand of new constructions. There are numerous studies trying to find the best approach for reducing building's environmental impact and various methods aiming to improve sustainability of constructions. Despite of common targets, international and national roadmaps, several countries experience obstacles when putting this knowledge into practice. The motivations and capabilities vary in each country.

This paper analyzes Estonia's current approach of enhancing the quality and sustainability of buildings by implementing a new national building quality standard. The new national Standard for Quality and Sustainable Real Estate Lifecycle (hereinafter referred as "the EVS Standard") defines quality and sustainability of buildings and built environment in the planning, design, construction, and demolition phases. Next to the fulfillment of specific requirements for each building phase, the standard requires using one of four international sustainable building certification schemes or a locally developed one, as part of the standardization process. The accepted schemes in the EVS Standard are the internationally acknowledged certification schemes BREEAM, DGNB, LEED and HQE and the local scheme Rohemärgis. The standard requires fulfillment of BREEAM Good, DGNB Gold, LEED Gold, HQE TP level in at least 7 targets or Rohemärgis The Best level.

In this study, quantifiable environmental impacts of buildings' life cycle are investigated, using Life Cycle Assessment (LCA) methodology. LCA has become very popular method for assessing constructions or its parts ([1]; [2]; [3]; [4], to name few). With an LCA study it is possible to determine the life cycle stage or a material of a

Nomenclature

ADP	Abiotic Depletion Potential includes depletion of non-renewable resources, i.e. fossil fuels, metals and minerals (unit kg Sb-Equiv.).
AP	Acidification Potential is based on the contributions of SO_2, NO_x, HCl, NH_3, and HF to the potential acid deposition, i.e. on their potential to form H^+ ions (unit kg SO_2-Equiv.).
EIA	Environmental impact assessment (EIA) is an analytical process that systematically examines the possible environmental consequences of the implementation of projects, programs and policies.
EP	Eutrophication Potential is defined as the potential to cause over-fertilization of water and soil, which can result in increased growth of biomass (unit kg Phosphate-Equiv.).
EPD	Environmental Product Declaration
GWP	Global Warming Potential is calculated as a sum of emissions of the greenhouse gases (CO_2, N_2O, CH_4 and VOCs) (unit kg CO_2-Equiv.).
LCA	Life Cycle Assessment is a procedure for calculating the lifetime environmental impact of a product or service, compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle (ISO 14040:2006).
LCCA	Life Cycle Cost Analysis is a tool to determine the most cost-effective option among different competing alternatives to purchase, own, operate, maintain and, finally, dispose of an object or process, when each is equally appropriate to be implemented on technical grounds
LCI	Life Cycle Inventory analysis is a phase of life cycle assessment involving the compilation and quantification of inputs and outputs for a product throughout its life cycle (ISO 14040:2006).
LCIA	Life Cycle Impact Assessment, phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product (ISO 14040:2006).
ODP	Ozone Depletion Potential category indicates the potential of emissions of chlorofluorohydrocarbons (CFCs) and chlorinated hydrocarbons (HCs) for depleting the ozone layer (unit kg R11-Equiv.).
PE	Primary energy
POCP	Photochemical Ozone Creation Potential, or photochemical smog, is usually expressed relative to the POCP classification factors of ethylene (unit kg Ethane-Equiv.).

building, which results the biggest burden to the environment and subsequently it is possible to find better solutions for lowering the impact. In an LCA for a building, the product studied is the building itself. Typically, studies looking at entire building life cycle indicate that the stage with the highest environmental impact is the use stage. The use stage of buildings, dominated by the energy demand for heating, is considered the most important life cycle stage for existing and new buildings [5], representing approximately 62-98% of the life cycle total impacts [6], while the construction stage accounts for a total of 1-20% and the dismantling phase represents less than about 0.2-5% [3]. Because of numerous innovations reducing energy use during the operational stage of a building, the embodied energy of building's materials and construction is becoming a larger percentage of a building's total energy over its lifetime [7]. Moreover, when assessing low energy buildings, the embodied energy may be the dominant factor [8].

The EVS Standard targets the quantifiable environmental impacts of a construction through the certification schemes. Therefore, the analysis focuses on the assessment category differences and scoring alterations between the schemes. Using a local reference building for composing three comparable cases, the LCA and energy modeling results enabled an estimation of credit point awarding in the five green building certification schemes used in the EVS Standard.

2. Methodology

To analyze the EVS Standard, and how it is leading to a better result considering environmental burden of a construction, six steps are followed:

- Defining three construction typologies for the case study
- Conducting an LCA for the three construction types with a 10, 50 and 70 years building service life
- Reviewing Estonian environmental data and statistics
- Defining certification scheme criteria, which are reflected in the LCA results
- Estimating credit points for the previously defined criteria
- Comparing the awarded credit points of five certification schemes

Case study Adamsoni 27 building project is used to define three comparable building types for the LCA. The comparison of the assessment results illustrates how after changing the construction materials and energy performance, the construction impacts over its lifespan also change.

One of the three LCAs is based on the actual construction materials of Adamsoni 27 building and two are hypothetical cases (types A and B), respecting the dimensions of the Adamsoni 27 project. For the hypothetical cases mainly the baring structure and insulation materials are changed. The LCA for each building type is observed with building service life 10, 50 and 70 years.

Subsequently, the LCA results are interpreted for the Estonian context. The LCA study environmental impact indicators are given weightings dependent on their significance and importance in Estonian environment by analyzing available environmental data and statistics. By weighting the indicators, it appears how the change in construction materials and energy performance influences the life cycle impact of a building in Estonian context.

Life Cycle Assessment is conducted with an SBS Building Sustainability online-tool, based on the ESUCO database for Estonia. The energy demand input for the LCA is calculated with BV2 open source software, which is developed to provide a tool for calculations of the energy performance certificate under the Energy Performance of Buildings Directive (2002/91/EC) (EPBD), provided by Estonian Ministry of Economic Affairs and Communication.

As a fourth step, for each scheme used within the EVS Standard, the criteria are defined, which are reflected in an LCA study. Following the assessment manuals for each scheme, previously defined criteria are applied to the case study by estimating credit points for the two hypothetical construction types (type A and B), using the actual Adamsoni 27 building as a reference. From the awarded credit points it appears, how significantly each certification scheme evaluates the differences between the LCA results. By analyzing how every scheme encompasses the differences, it is possible to form an opinion over the Standard for Quality and Sustainable Real Estate Lifecycle.

3. LCA study

3.1. The reference building

Adamsoni 27 building is a multi-family 4-storey residential building, holding about 700 square meters living space and 300 square meter large garden. It is located in Kassisaba area, close to Tallinn city center. It is well presenting the most desired building type in Estonia.

The building's baring structure is light concrete hollow block (Columbia block), filled with concrete and steel reinforcement. Wooden façade exterior walls are insulated with a 160 mm mineral wool layer. The roof is a colored copper layer fixed on a steel frame, insulated with a 300 mm mineral wool layer. Windows are triple glazing and wooden framed. The building has natural ventilation and a district-heating system based on natural gas. The building's planned life span is 50 years.

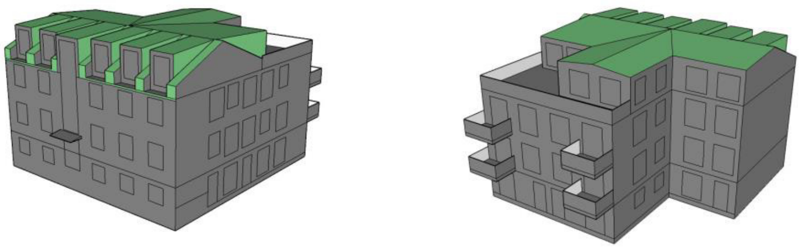


Fig. 1. Adamsoni 27 construction northwest (left) and southwest (right) elevation

3.2. Compared construction types

The construction materials for the first hypothetical case (type A) represent another common material selection for the Adamsoni 27 project, prefabricated concrete as a baring structure and EPS insulation are used. The type B has a timber structure and the rest of chosen construction materials are aimed to be more ecological (where possible) and energy efficient compared to the conventional selection. The selection of the construction materials was for some cases limited by incomplete LCA data for Estonia.

The energy performance indicator, calculated with the BV2 tool, resulted 105,5 kWh/m^{2}y for the Adamsoni 27 building, 102,12 kWh/m^{2}y for the construction type A and 83,81 kWh/m^{2}y for the construction type B.

3.3. Environmental impact categories and functional unit of the LCA

The assessed life cycle impacts for the building types were determined by the software system SBS Building Sustainability, and included following categories:

- Abiotic Depletion Potential (ADP), unit kg Sb-Equiv.
- Global Warming Potential (GWP), unit kg CO2-Equiv.
- Acidification Potential (AP), unit kg SO2-Equiv.
- Photochemical Ozone Creation Potential (POCP), unit kg Ethene-Equiv.
- Eutrophication Potential (EP), unit kg Phosphate-Equiv.
- Ozone Depletion Potential (ODP), unit kg R11-Equiv.
- Water utilization, unit kg
- Overburden and ore processing residues, unit kg
- Municipal waste, unit kg
- Hazardous waste, unit kg
- Primary energy non-renewable, unit MJ
- Primary energy renewable, unit MJ

The selected functional unit of the life cycle model of this case study is the use of the building, with all refurbishment actions considered and the energy consumption for heating and electricity, calculated for one square meter reference over fifty-year life span. This functional unit relates to life cycle stages, such as construction, use stage, refurbishment and demolition.

3.4. Dataset, limitations and system boundaries

The data used for the LCA study is attained from the SBS Building Sustainability tool. The origin of the majority of the data is based on an average of PE INTERNATIONAL, GaBi databases 2006, Ökobaudat, 2000 and Estonian ESUCO 2011/2012 dataset. The data contains expenditures of cradle-to-grave or cradle-to-gate stage, according to EN 15804 and EN 15978 standards. Some of the data is based on literature research and direct assessment of industry; in this case the dataset includes a safety margin of 10%.

The dataset in the SBS Building Sustainability tool does not provide all the construction materials used in Estonia, which is why the choice of the materials was often predetermined by the data availability.

The study integrates 10 construction elements of the building:

- Foundation (and terrace foundation)
- Exterior walls
- Baring interior walls
- Not-baring interior walls
- Ceiling
- Staircase floor and stairs
- Roof
- Terrace roof
- Windows
- Doors

The fittings for interior construction, heating systems, building automation and equipment (sanitation technology, wiring, water pipes etc.) are not considered. Also, the exterior area surrounding the building is not considered. The system boundary includes life stages including production of the materials, refurbishment, use and demolition. Specific stages included to the study after the EN15804 standard are A1-A3, B2-B4, B6, C2-C4 and D.

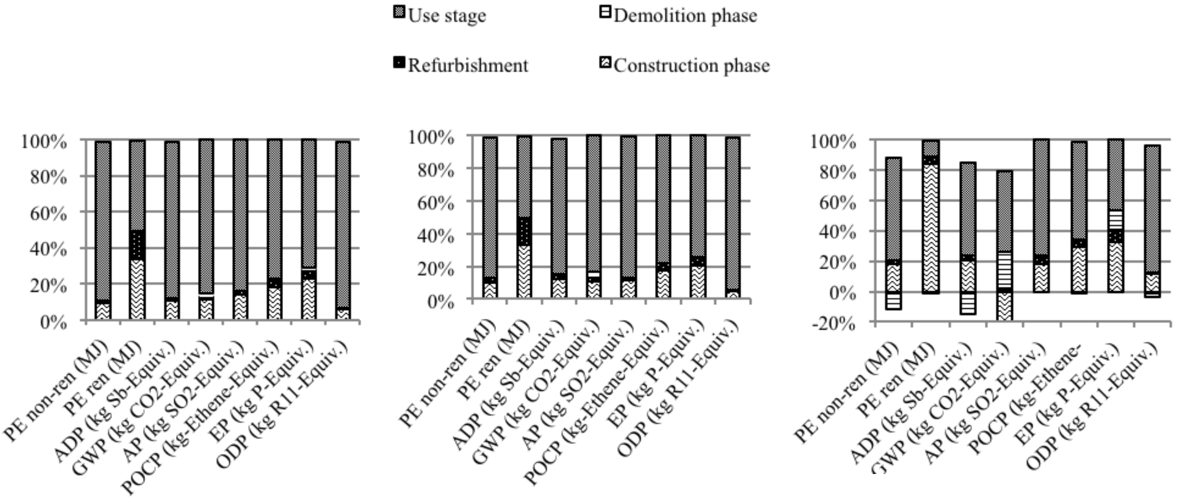
The life span of each product is an average service life value, which is attained from an Excel-based LCA tool, developed by Ingeneurbüro Trinius GmbH, based on the German guide for sustainable building.

3.5. LCA results

Fig. 2 demonstrates relative impact shares of construction life cycle stages for environmental indicators of the three building types over their life cycle of 50 years. As it becomes obvious from the Figures, the environmental impact of the building’s use stage is the most influential. The result for the Adamsoni 27 building (Fig. 1a) is slightly out of the predicted range of 88-98%, presented by Ochsendorf et al [9], showing that the use stage is responsible for 84% of the total CO_2 emissions over the building’s life cycle.

Fig. 3 indicates Global Warming Potential (GWP) for the three types, combined with time dimension. The LCA results are recorded for the service life of 10, 50 and 70 years; the 71st year indicates the impact of a building including its demolition stage.

Fig. 4 shows relative changes of the LCA results in the construction stage, where Adamsoni 27 building is taken as a baseline scenario and service life is 50 years. As it appears, the type B building has much better performance regarding GWP and ADP; on the other hand, the ODP, EP and POCP show worse results. The explanation can be, that the type B uses thicker insulation layer to achieve a higher energy efficiency rate and lower the life cycle impacts over the use stage. There are no big differences between the existing Adamsoni 27 building and the type A. This was also expected as the energy performance and the material selection is very similar for those two types. The building type B shows lower environmental impacts, like several LCA studies confirm [10][11][12], the carbon emissions of the wooden structure are much lower. The GWP is about 50% less if the service life is 70 years (not counting demolition stage).



(a) (b) (c)

Fig. 2. Relative importance of the life cycle stages (a) Adamson 27 building; (b) construction type A (c) construction type B

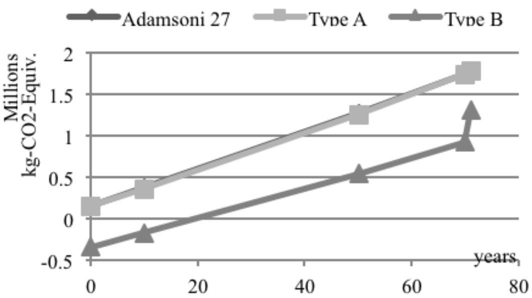


Fig. 3. GWP of three construction types over 70 years of service life to the Adamsoni 27 building

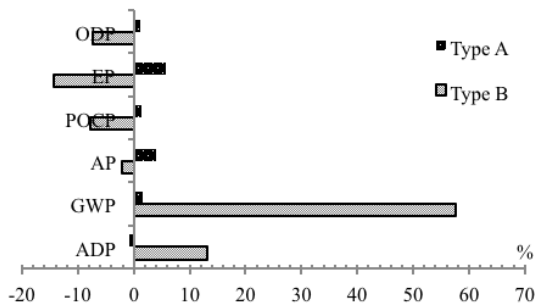


Fig. 4. Type A and B environmental impact change in % compared

3.6. LCA results in Estonian context

As an LCA study is assessing several environmental indicators, it is necessary to make a selection and priority among the investigated parameters in order to define better construction type. To understand the LCA study results in Estonian context, Estonian environmental data and statistics were observed and compared to other European countries. The information was collected for CO_2 emissions per capita, air and water pollution, use of fertilizers and domestic material consumption. Based on the information available, with a rough estimation it is concluded that the GWP, ADP and AP indicators should have higher weightings in Estonian context, when analyzing environmental burden of a product or a service over its life cycle. Applying this estimation, in the Table 2 special weightings are given for the environmental indicators and the construction types A and B are compared to the reference building Adamsoni 27 before and after the environmental impact indicator weighting. The average impact change demonstrates the impact enhancement compared to the reference building.

Table 2. Average impact enhancement compared to reference building before and after weighting environmental impact indicators

	GWP	ADP	AP	POCP	ODP	EP	Average impact change
Type A	1%	0%	4%	2%	1%	6%	2.3%
Type B	30%	27%	-3%	-6%	-5%	-30%	2.2%
Weighting	4	3	2	1	1	1	
Type A	4%	0%	8%	2%	1%	6%	**3.5%**
Type B	120%	81%	-6%	-6%	-5%	-30%	**26%**

4. LCA in the framework of green building certification schemes

This chapter describes the credit awarding in relation to the LCA in the five certification schemes used within the standard. Every criterion of each scheme was observed and determined direct and secondary relations to the LCA methodology. The criteria, which are directly reflected in the LCA results, were investigated into greater detail and credit points were estimated for the case study following the scheme manuals. For the credit estimation the Adamsoni 27 was used as a reference building and credits were awarded for the construction types A and B.

4.1. LCA in the framework of BREEAM

For the analysis BREEAM International New Construction scheme, 2014 issue was used. Two assessment criteria, which were detected to reflect the LCA results, are Energy Efficiency (Ene01) and Life Cycle Impacts criterion (Mat01). The following Table indicates the criteria influence on specific life cycle stages (which were observed for the case study) according to EN15804.

Table 3. BREEAM LCA related criteria assessment scope regarding building life cycle

	Product (A1-A3)	Use (B2-B4)	Operational energy (B6)	End of life (C2-C4)
Ene01			x	
Mat01	x	x		x

For the Ene01 criterion option 1 was selected. The maximum number of credits is 15, which accounts 7,5% of the total assessment. The credits in Energy Efficiency criterion are given depending on the design improvements of the assessed building compared to a reference building. Following the criteria rules and relying on the energy demand calculations, the building type A received 2 and type B 12 credits points.

The Mat01 maximum score is 6 points, which can be achieved by using BREEAM special assessment tool or conducting a whole building LCA with a suitable assessment tool. No specific credit awarding rules are provided when conducting a whole building LCA. Therefore, credit points are given based on the relative improvement of hypothetical building types compared to the reference building. Accordingly, the construction type A receives 1 credit point and the construction type B 6 credit points.

4.2. LCA in the framework of DGNB

In this study the DGNB International CORE 14 scheme is used. The criteria, which are reflected in the LCA results, are Life Cycle Impact Assessment (ENV 1.1) and Life Cycle Impact Assessment - Primary Energy (ENV 2.1). Life cycle stages assessed in the criteria are included in the Table 4.

Table 4. DGNB LCA related criteria assessment scope regarding building life cycle

	Product (A1-A3)	Use (B2-B4)	Operational energy (B6)	End of life (C2-C4)
ENV1.1	x	x	x	x
ENV2.1	x	x	x	x

In the ENV 1.1 criterion it is possible to gain up to 10 evaluation points, which counts up to 7,9% of the total score. The scheme provides reference and relative proportion values for environmental impacts of construction and operation stages. The DGNB uses special weightings for assessed environmental indicators GWP, ODP, POCP, AP and EP. Following the assessment rules, the building type A receives 5,2 points and building type B 6,9 points. Very small difference appears as the DGNB is giving 5 credits for the design that corresponds to the reference building, which suggests that the final score is highly dependent on the reference building.

In the ENV 2.1 criteria three indicators are assessed: non-renewable primary energy demand, total primary energy demand and proportion of renewable primary energy. It is possible to gain up to 10 points, maximally counting for 5,6% of total score. Similarly to the ENV 1.1 criterion, the final score is strongly dependent on definition of the reference building. In this criterion the building type B achieves 4,3 and the type A 6,7 points.

4.3. LCA in the framework of LEED

For the analysis the LEED v4 Building Design and Construction for new constructions and renovations, issue July 1st, 2015 was used. The criteria, which are reflecting LCA results, are Optimized Energy Performance and Building Life-Cycle Impact Reduction criteria.

Table 5. LEED LCA related criteria assessment scope regarding building life cycle

	Product (A1-A3)	Use (B2-B4)	Operational energy (B6)	End of life (C2-C4)
Optimized Energy Performance			x	
Building Life-Cycle Impact Reduction	x	x		x

Optimized Energy Performance criterion enables to gain 1 credit for 6% of improvement up to 18 credits for 50% of improvement. Following the criteria rules, the type A would get no points and type B would receive 8 points.

Building Life-Cycle Impact reduction requires assessment of three environmental impact indicators out of specified five indicators, when using the whole building life cycle assessment option. Using this option, 3 credit points can be achieved. Based on the criteria rules, only building type B would qualify for the 3 credits. The building type A does not reach for any environmental impact indicator the required 10% improvement.

4.4. LCA in the framework of HQE

For the analysis the HQE international scheme from April 2014 for residential buildings was used. Criteria reflecting the LCA results in the HQE scheme are the Environmental Quality of the Materials, Products and Equipment Used (2.2) criterion and the Thermal Design (4.1) criterion. Table 6 indicates the life cycle stages assessed in those criteria.

Table 6. HQE LCA related criteria assessment scope regarding building life cycle

	Product (A1-A3)	Use (B2-B4)	Operational energy (B6)	End of life (C2-C4)
Environmental Quality of the Materials, Products and Equipment Used (2.2)	x	x		x
Thermal Design (4.1)			x	

The HQE criterion 2.2 requests the use of construction products, which are compliant to the ISO 21930 or EN 15804 standards. This means products, which have available environmental impacts information or EPDs. It is possible to achieve up to 3 points, where 1 point equals to B level, 2 points to P level and 3 points to TP level. The HQE does not provide benchmarks or targets to be reached, meaning that by using products with EPDs it is possible to gain level B and by conducting comparative study for the EPDs, the levels P or TP can be reached. Based on the LCA results for the case study, all the building types would receive level B in criteria 2.2, if products with available EPDs would be used. Presuming that the LCA results are acceptable for demonstrating the applicability for levels P and TP, the building type B would receive TP level as it demonstrated improvements compared to the reference building in the environmental performance.

In the criterion 4.1, the level B is applicable for both of the building types, as the both types have annual energy demand lower than 120kWh/m^{2}y. Building type B is close to achieving P level, but exceeds slightly the threshold for energy consumption (having energy performance index of 83kWh/m^{2}y). The TP level in thermal design is not reachable for neither of the building types as the energy consumption exceeds 50 kWh/m^{2}y and no renewable-energy or co-generation installations have been implemented.

4.5. LCA in the framework of Rohemärgis

In the analysis the Rohemärgis scheme version from 2015 was used. The only criterion, reflecting the LCA results, is the Energy efficiency (2.1) criterion, which is assessing the operational energy stage (B6) of a building. The rest of the criteria are not assessable with this methodology.

The criterion 2.1 has three levels: A (the best), B (very good) and C (good). Based on the energy performance indicator calculations, the building type A would receive B level and the building type B an A level.

5. Results

In this chapter, comments on the functioning and possible shortcomings of each scheme assessment process are provided together with a comparison of the schemes and suggestions for the development of the Standard for Quality and Sustainable Real Estate Lifecycle.

5.1. Outcomes and limitations of the assessment process

With respect to the LCA results of hypothetical cases A and B and used reference building, considering environmental impact indicator weightings for Estonian context, the BREAAM and the LEED certification schemes are indicating the most accurately the differences between the building types, having respectively 12,6% and 12,1% of difference in the final score (see Table 7) from the LCA related criteria.

In the BREEAM scheme, with previously demonstrated rough estimation, the building type B would receive predictably about 15 credit points more than the building type A, however, is important to note that 10 point-difference is from the Energy Efficiency criterion, which in BREEAM scheme has the greatest weight. Regarding the assessment process, it is not clear in every step how the credits are awarded, due to specially developed BREEAM tools (e.g. Mat01 calculator), which are not available for open use. Secondly, the Mat01 criterion uses Green Guide for material specification and IMPACT or IMPACT compliant LCA tool for the life cycle impact assessment. The Green Guide examines only the life cycle impact of each building material, the IMPACT compliant tools, however, are required to include life cycle stages like B6 (operational energy use), which is not covered by the Green Guide assessment. Methodologically these two approaches are not directly comparable.

The share of the credit points reflected in the LCA of a construction is the highest in the LEED scheme (20,5 % in total). However, the LEED scheme is giving proportionally more points for the energy efficiency in the operational stage. This can lead to a situation where a highly energy efficient building, but also with a large embodied energy is awarded with a high score.

The DGNB indicates comparably small difference of 4,1 credit points between the two investigated building types. This appears as the DGNB requires a strong reference building and has very high target values. In the analysis, the used reference has similar values to the building type A, so in the DGNB scheme the type A is awarded with about 50% of the possible credits in the investigated criteria. This points out the necessity of developing a strong reference building for the Estonian scene.

The HQE and the Rohemärgis schemes show smaller difference in score between the two building types. It appears, as the relative share of each criterion is difficult to estimate due to their different scoring systems based on levels. However, when assessing the buildings with the Rohemärgis, the final score/level difference between the compared building types cannot be immense, as there are no criteria assessing life cycle impacts of a construction.

The only scheme, which requires completion of an LCA is the DGNB scheme. Compared to the other schemes, the DGNB has the most complete method to select the optimal solution regarding construction life cycle impacts. The BREEAM, LEED and HQE schemes assess the life cycle impact by separating the construction stage from the operational stage. The DGNB is assessing the energy demand of all the life cycle stages of the building, including the construction and refurbishment stage, likewise assessing the construction life cycle impact by including operational energy stage.

In the HQE scheme the credit awarding relies on the use of EPDs, meaning the HQE rewards the contribution by the building products, but not necessarily the LCA results, whereas the DGNB prefers the use of EPDs for the LCA but allows using other generic LCA databases. The BREEAM and LEED schemes do not obligate the assessment of the criteria related to the LCA, apart from the energy efficiency minimum requirements. Regarding the construction materials, the LEED promotes the use of EPD's, whereas BREEAM is using the Green Guide, an LCA based tool, developed by BRE Global Ltd.

The weakest scheme, regarding criteria, which are reflecting an LCA, is the Rohemärgis. The scheme does not have any criteria assessing the quantifiable environmental impacts of a construction. The only criterion related to the LCA is the Energy Efficiency criterion, which can be considered as an economical measure.

5.2. Comparison

In Table 7 the results of the analysis are concluded and the relative importance of the LCA related criteria in each scheme is indicated. Figure 5 illustrates the score difference of investigated criteria for the construction types A and B.

Table 7. LCA in the framework of the certification schemes

Investigated scheme	BREEAM International New Construction (2014)	DGNB Core 14 (2014)	LEED v4 Building Design and Construction (2015)	HQE Residential Buildings Under Construction (2014)	Rohemärgis (2015)
Standard's minimum requirement	Good	Gold	Gold	7 TP targets	The Best
Maximum score	Depending on the type and location of building; 132 weighted points	10 weighted points under every criterion	Depending on the type of building; 110 points	Depending on the type of building; 120 weighted points, 14 targets, 14 stars	3 or 2 levels under every criterion
Criteria reflecting the LCA results	Ene 01 Mat 01	ENV 1.1 ENV 2.1	EA Opt. E. Per. MR LC. Imp. Red	2.2 Env. Qual. 4.1 Therm. D.	2.1 Energy Efficiency
Maximum score of criteria	15(Ene01) 6 (Mat01)	10 (ENV 1.1) 10 (ENV 2.1)	18 (EA Opt. E. Per.) 5 (MR LC. Imp. Red.)	3 (2.2) 3 (4.1)	A (3)
Share of maximum score	7,5% (Ene 01) 6,8% (Mat 01)	7,9% (ENV 1.1) 5,6% (ENV 2.1)	16% (EA Opt. E. Per.) 4,5% (MR LC. Imp. Red.)	4,7% (2.2) 2,3% (4.1)	5%
Type A score in investigated criteria	2 (Ene 01) 1 (Mat 01)	5 (ENV 1.1) 4 (ENV 2.1)	0 (EA Opt. E. Per.) 0 (MR LC. Imp. Red.)	2 (2.2) 1 (4.1)	B (2)
Type B score in investigated criteria	12 (Ene 01) 6 (Mat 01)	7 (ENV 1.1) 7 (ENV 2.1)	8 (EA Opt. E. Per.) 3 (MR LC. Imp. Red.)	3 (2.2) 1 (4.1)	A (3)
Type A points of maximum score	1,0%	6,2%	0%	3,9%	3,3%
Type B points of maximum score	13,6%	9,5%	12,1%	5,5%	5%

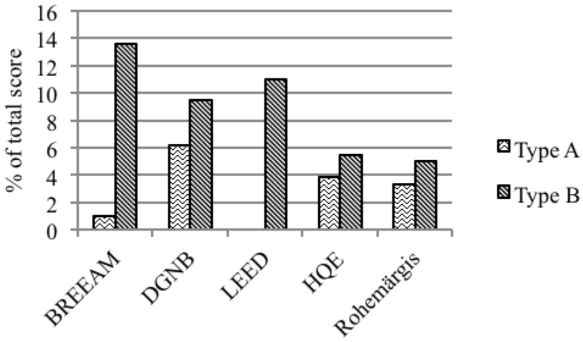


Fig. 5. Share of the investigated criteria in the total maximum score for each scheme

5.3. Suggestions for the EVS Standard requirements

The Standard for Quality and Sustainable Real Estate Lifecycle should stand more strongly for its name and next to Life Cycle Cost Analysis (LCCA), set an obligation for the LCA of the construction and accordingly reference values or benchmarks. Regarding environmental aspects, the standard requires an Environmental Impact Assessment (EIA) pre-assessment, which might lead to a complete EIA. Yet, the EIA is an assessment for the building site, not for the construction itself. The LCA for the construction is required only if it is a requirement within the used certification scheme. The requirement could be set through the certification schemes, by requiring fulfillment of the respective criteria. Yet, this is possible only when using one of the international schemes. The Rohemärgis, as mentioned previously, does not have any criteria assessing life cycle impacts of a construction.

The inclusion of the Rohemärgis in the EVS Standard is not comparable to the international green building certifications used within the standard. Only by looking at the number of criteria, the highest level of the Rohemärgis cannot be compared, for example, to the DGNB Gold (Silver according to the old nomenclature). The procedure's complexity and requirements are not providing the same level of sustainability. The Rohemärgis does not provide requirements for water use, waste management or construction process, which are addressed in all the other green building certification schemes. The criteria for the site selection consider the mobility and service proximity for the future users of the construction, but not the ecological aspects of the site itself. The scheme, however, is being introduced as a tool to assess the three pillars of sustainability of a construction. As a possible solution, the standard itself could set benchmarks and requirements regarding buildings impact over its life cycle, if the Rohemärgis is used.

For all the schemes could be set more specified description of which criteria should be preferably assessed. Especially, the HQE scheme needs more detailed explanation, as the requirement of the EVS Standard (7 levels of Target Performance) is not clear regarding the HQE levels (Pass, Good, Very Good, Excellent, Exceptional). By requiring fulfillment of specific criteria, the standard could maximize the impacts of sustainable design for Estonian scene. Implementing the EVS Standard also requires the establishment of strong reference buildings and defining the building quality standards to be followed when using the international schemes.

6. Conclusion

The quantifiable life cycle impacts of buildings in all green building certification schemes, used within the EVS Standard, appears to be rather insignificant, accounting at most for about 1/5 of the total score. Of course, many environmental aspects of a building are not measurable. The schemes serve primarily as a design and assessment tool to provide a good level of quality and sustainability. It is however important to notice the different approaches and understand the benefits and shortcomings of each scheme for Estonian scene.

The conducted analysis indicates differences between the certification schemes used within the standard and demonstrates how the Standard for Quality and Sustainable Real Estate Lifecycle deals with the quantifiable life cycle impacts of a construction. The example shows some of the functioning characteristics of each scheme and points out the peculiarity of how each scheme deals with an LCA of a building and which criteria are given a higher priority. Regarding the conducted LCA, considering Estonian context, the BREAAM and the LEED certification schemes were indicating most accurately the difference of the life cycle impacts of the investigated building types. The results, however, are highly dependent on the interpretation of the criteria and the reference building.

The only scheme requiring a full LCA of a construction is the DGNB scheme, whereas HQE requires the use of construction materials with available EPDs. The BREEAM and the LEED scheme do not require the LCA and both of the schemes give relatively greater importance for the building's energy efficiency compared to the other schemes. The Estonian scheme, Rohemärgis, does not address the life cycle impact of a construction apart from setting requirements for the operational energy demand. Compared to the international schemes, its requirements regarding sustainability of a construction are much weaker. The EVS Standard should define in more direct ways requirements for the quantifiable life cycle impacts of a construction. For example, by establishing reference and benchmark values for the life cycle imapcts.

The case study, Adamsoni 27, represents a good quality project in Estonia, which nevertheless, does not fulfil the requirements of the EVS Standard. The building has been awarded with the BREEAM Certified level and the EVS Standard requires accomplishment of the BREEAM Good level. Apparently, the jump from current building quality to third party certified projects could be immense.

The Standard for Quality and Sustainable Real Estate Lifecycle provides a springboard to start thinking of construction sustainability aspects in a more systematic way and making the building process more transparent. Yet, establishing national institution for third party certification could turn out to be uneconomical for the small construction market. Adapting one of the international schemes for the local market could be a possible solution. Similar methodology as presented in this paper, could be used to define the most suitable international certification scheme for Estonia.

The comparison in this paper gives an insight into some specifics of the schemes, which should be of interest for the building and the reserch community in Estonia and elsewhere.

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