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Evaluation of the European assessment method Levels(s) for buildings

a Swedish Level(s) pilot project including a Skanska building

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Summary

Level(s) is a common EU framework of core indicators for the sustainability of office and residential buildings, for measuring the performance of buildings along their lifecycle. The scope encompasses both new and existing buildings at the point of major renovation.

The Level(s) system is now available as a pilot for testing and this report describe the testing performed by using Skanska's residential building Backåkra as a case study. Besides the formal testing and the mandatory reporting template used by all Level(s) testing pilots (given in the annex), this report includes a description on how Skanska Sweden work with sustainability and environmental performance of buildings in Sweden, comments on the current version of the Level(s) system on a general level and in detail comments on individual indicators used in the Level(s)system (given in the annex). Our main interest and use of Level(s), that influence the assessment made, is the use of life cycle assessment (LCA) as a tool and the related indicators that can be used to calculate these values as part of the sustainability indicators covered by Level(s).

There are several aims outlined for the Level(s) system where our concern is that the market will understand the system as tool for comparison and for comparative assertion. However, the system is not developed for such benchmarking. Our suggestion and conclusions are that the system could be further developed as basis for such use, if the calculation is made digital and the following rules and specification are developed:

- Common rules for scenario setting, i.e. from information module A4 to C4 and module D
- Common requirements on data quality; concerning a complete bill of resources (BoR) used for LCA, the mapping of these resources with either generic or specific data, and the inventory scope concerning which life cycle stages and building parts covered.
- A common digital reporting of the result that is compatible with Building Information Modelling (BIM) and documentation of the data quality (Q metadata report).

The evaluation of Level(s) made here takes the latest digitalisation into account that is now rapidly implemented by the market and that creates new opportunities. The digitalisation is referred to as BIM. One shall be aware that the background work of the Level(s) system (named beta v1.0) that now is tested was published in 2017, and therefore did not take this development and its potential into account. The digitalisation of the LCA calculation will decrease the cost to perform an LCA and at the same time achieve a much higher overall quality. We therefore assume that an updated version of Level(s) will take this into account. The digitalisation, potential use of Level(s), and based on current work on LCA for building (EN 15978), could be set as starting point to establish core rules for a common European environmental declaration of buildings, which will contribute to the implementation of LCA on the market.

1 Introduction

1.1 Level(s) framework

Level(s) is a voluntary reporting framework based on existing standards, with the primarily aim to describe and potentially improve the sustainability performance of buildings.

The goal outline that Level(s) shall provide a common EU approach to the assessment of sustainability performance in the built environment. The sustainably performance covered by Levels(s) compose of environmental performance — which is the focus — together with health and comfort, life cycle cost and potential future risks related to the building. This common EU approach enable actions to be taken at building level that can make a clear contribution to broader European environmental policy objectives. Level(s) framework contains of:

- **Macro-objectives**: An overarching set of six macro-objectives for the Level(s) framework that contribute to EU and Member State policy objectives in areas such as energy, material use and waste, water and indoor air quality.
- **Core Indicators:** A set of 9 common indicators for measuring the performance of buildings which contribute to achieving each macro-objective.
- **Life cycle tools**: A set of 4 scenario tools and 1 data collection tool, together with a simplified Life Cycle Assessment (LCA) methodology, that are designed to support a more holistic analysis of the performance of buildings based on whole life cycle thinking.
- **Value and risk rating**: A checklist and rating system provides information on the reliability of performance assessments made using the Level(s) framework (Dodd, N. et al. 2017).

The users of the Level(s) framework will be able to work with data and calculation methods at three defined levels as defined below depending on the purpose of the reporting (summed up text from different part reported found in Dodd et al 2017a):

- **Level 1 The common assessment:**
  The common performance assessment is intended to provide a common reference point for the performance assessment of buildings across Europe. Common units of measurement and basic, reference calculation methodologies are provided. These can be used directly by professionals but are also intended to be readily adoptable by building assessment schemes, investor reporting tools and the public sector.
- **Level 2 The comparative performance assessment:**
  This level is for professionals that wish to make meaningful comparisons between functionally equivalent buildings. The framework lays down rules to support the comparability of results at national level or building portfolio level. This can include the need to fix certain key parameters and the input data used for calculations. This second level requires provision of a reference measurement and reporting method, which could ultimately enable comparison, benchmarking and target setting.
- **Level 3 The optimised performance assessment:**
  This is the most advanced use of each indicator. The framework provides guidance to support professionals that wish to work at a more detailed level to model and improve performance. This detailed calculation includes more object specific data, in order to achieve greater representativeness and precision from calculations, and thereby close the gap between design and actual performance.

The Level(s) framework is therefore designed so that each indicator for an individual building and its impact can be summarized to describe the priorities for sustainability at macro-level for a country or ultimate at the European Union level. The quantitative assessment of the environmental impacts of a building using Life Cycle Assessment (LCA) is recognised at EU level as the best method to achieve this.

1.2 Core indicators

The reporting format includes core indicators and common metrics for measuring the performance of buildings along their life cycle.

The basic reference unit to be used throughout the Level(s) framework is one square metre (m^2) of useful internal floor area. To more accurately measure the resource intensity of an office building may besides this core reference units also 'per area of workspace occupied by each full-time person equivalent' be used. The reference study period to be used for all buildings assessed according to the Level(s) framework is set to 60 years.

This focuses the Level(s) user on a manageable number of essential concepts and indicators at building level that contribute to achieving EU and Member State environmental policy goals. These six macro-objectives and their related performance indicators[1] are listed below. Depending on what level you aim to report, different indicators are used.

1: Greenhouse gas emissions along a building's life cycle
1.1.1 Primary energy demand, kWh/m^2yr
1.1.2 Delivered energy demand, kWh/m^2yr
1.2 Life cycle Global Warming Potential (GWP_{100} GHG), kg CO_2e/m^2yr

2: Resource efficient and circular material life cycles[2]
2.1 Life cycle tools: Building bill of Materials (BoM), 99% of built-in construction reported in kg per Eurostat four material category
2.2 Life cycle tools: scenarios for building lifespan, adaptability and deconstruction as given below,
  2.2.1 Scenario 1: Building and elemental service life planning[3]
  2.2.2 Scenario 2: Design for adaptability and refurbishment[3]
  2.2.3 Scenario 3: Design for deconstruction, reuse and recyclability[3]
2.3 Construction and demolition waste, kg/m^2 useful floor area reported for the construction, demolition and end-of-life stage separately
2.4 Cradle to grave Life Cycle Assessment, 7 LCIA core indicators

3: Efficient use of water resources
3.1 Total water consumption, m^3 of water per occupant per year

4: Healthy and comfortable spaces
4.1.1: Good quality indoor air, parameters for ventilation [rate of air change], CO_2 concentration

[1] It is said in the report that there exist nine "core indicators" but it not possible to sort out which ones these are.
[2] These indicators are also suggested as the following indicators:
Semi-quantitative and LCA based assessment
Design aspect checklist
[3] Dependent on "level" used is the following method and related indicator used;
1. Design aspects, 2. Semi-qualitative assessment, 3. LCA-based assessment.

[ppm] and relative humidity [%]
4.1.2: Target air pollutants, emissions from construction products and external air intake.
4.2 Time outside of thermal comfort range, %
(4.3.1 Light and visual comfort, aspect suggested for future inclusion)
(4.3.2 Acoustic and protection against noise, aspect suggested for future inclusion)

5: Adaptation and resilience to climate change
Scenarios for projected future climatic conditions: Protection of occupier health and thermal comfort, Simulation of the building's projected time out of thermal comfort range for the years 2030 and 2050.

6: Optimised life cycle cost and value rating of reported results
6.1 Life cycle costs, €/m^{2}yr
6.2 Valuation influence and reliability rating of reported results, a checklist approached, or reliability ratings evaluation of selected aspects related to the reported performance.

Two life cycle approached tools are used as support to assess some of these performance indicators. The life cycle approached tools used are:

- Life Cycle Assessment (LCA), with calculation methods defined is defined in the standards ISO 14040/44, EN 15804 and EN 15978.
- Life Cycle Cost Assessment (LCCA), with calculation methods is defined in the standards EN 16627 and ISO 15686-5.

The setting of the LCA system boundaries shall follow the "modularity principle" according to the EN 15978 and Level(s) is therefore designed to make use of Environmental Product Declarations (EPD) for any resource used for a construction works as defined in the core product category rules for construction products EN15804:2012+A2:2013.

LCA can be potentially used as tool to assess the following indicators;

1.1.1 Primary energy demand,
1.1.2 Life cycle Global Warming Potential (GWP_{100} GHG),
2.1 Life cycle tools: Building bill of Materials,
2.2.3 Scenario
3: Design for deconstruction, reuse and recyclability,
2.3 Construction and demolition waste,
2.4 Cradle to grave Life Cycle Assessment.

1.3 Goal, scope and limitations

Skanska’s goal with this test pilot is to evaluate the framework and the reporting tool “Reporting excel v.1.3” by using the sustainability reporting done by a residential building project on the Swedish market.

The building chosen for the evaluation is called Backåkra and is situated in the northern part of Stockholm city. It is a “top of the line”-project when it comes to sustainability with rigorous demands from both the city and the customer regarding sustainability. Information gathering was thus thought to be easily accessible and therefor a suitable prospect for Level(s).

The overall goals of the test pilot are:

- Evaluate how well the Level(s) framework is aligned with Skanska´s and Sweden´s already existing systems and reporting instruments.
- Identify possibilities and risks with the Level(s) system.
- Evaluate the indicators, and specially focusing on indicators using LCA methodology.

The test pilot gives us the possibility to influence the content of Level(s) and make it more relevant for companies in Sweden.

1.4 Methodology and implementation

The test of the framework is dived in two parts, where the first deals with comments and feedback of the framework on an overarching level and the second part handles aspects given per indicator. This means that reflections based on using the framework are given at the same time as proposals for improvements.

Information from the test pilot is used to fill in the reporting tool to see how well the Level(s) indicators can use the information already available. In the first part Skanska describes their internal reporting system and internal LCA work which is done by the project.

1.5 Color Palette™: The Skanska approach for environmental benchmarking

Skanska has an internal framework to describe sustainability for buildings. The Skanska Color Palette™ was introduced in 2009 as our strategic framework and primary communication tool for Green Business. Skanska Color Palette™ is the core of Skanska´s environmental management system. It defines Skanska´s Journey to Deep Green™. The Color Palette™ is Skanska´s definition of "Green" and used as a:

- Strategic planning tool to set goals and develop action plans, thereby driving continuous improvement and Skanska's Journey to Deep Green™
- Measurement and reporting tool to categorize revenue, order bookings and margins in terms of Vanilla, Green and Deep Green
- Communication tool to define project Green objectives and communicate performance, whilst avoiding the overstatement of achievements

The priority opportunities defining Green Business in Skanska are:

- Energy
- Carbon
- Materials
- Water

For each of the four priority opportunities predetermined "stepping stones" across the Green zone define where each project is mapped on the Color Palette™, scaling from Vanilla to Deep Green. The stepping stones can be found on the internal versions of the Color Palette™.

From Vanilla to Deep Green

Vanilla = Compliance. The construction process and product performance are in compliance with applicable laws, codes and standards.

Green = Beyond Compliance. The construction process and/or product performance is beyond compliance, but not yet at a point where it can be considered to have a near-zero environmental impact.

Deep Green = Future Proof. The construction process and our product performance have a near-zero impact on the environment and thereby future proofs our projects.

Different achievements in environmental certifications systems; for example, LEED, BREEAM, Nordic Swan, MB 3.0 are plotted in the Color Palette™ to make it easy for projects to know how Skanska values the achievements. This has been a successful way of measuring sustainability within Skanska. The Level(s) framework, if possible, should be treated the same way.

1.6 The LCA tools used by Skanska in Sweden

Since Carbon is one of the four priority opportunities predetermined in the Color Palette™ Skanska started to calculate CO_2e from buildings and infrastructure in 2008. Skanska concluded then that the amount of data needed for LCA or carbon calculations, demanded a digitalized work flow, using already existing information handled in the building process. The LCA calculation in the Skanska process uses the resource compilation from the cost calculation tool called SPIK as source for the input of construction work data. The source could also be a The Industry Foundation Classes (IFC) file from 3D models. All LCA calculations can be described by references flows (the term used in ISO14040), which means a number of resources that all together capture the bill of resources (BoR) that describes the source information needed for the declared or functional unit related to the specific construction works. The bill of resources (BoR) shall not be mixed up with the more limited bill of material (BoM) that only covers construction products (or likewise). The BoR also include the processes needed in the construction process and their resource need.

The LCA process is based on ISO 14040, -44 and the regulations given in ISO 21930, EN 15804 and EN 15978. Besides these standards the IVL quality (Q) meta-data system is applied in order to verify the quality and representativeness of the LCA and EPD data used. The LCA calculation is fully digital and consists of; SPIK that is a cost calculation tool developed by Skanska and ECO2 that is a BIM applicable LCA tool, and IVL Environmental Construction Database. This database includes LCA data stored as indicator result according to EN 15804 (24 indicators) and some additions. An example of such additions made is that climate impact from greenhouse gases (GWP_{GHG}) separately and not mixed up with biogenic CO_2 to make it easier to understand. In EN 15804 is biogenic CO_2 sometimes mixed and included in a GWP_{total} indicator.

2 General comments on Levels(s)

2.1 Full control of source data is basic for high quality LCA

The outcome from an LCA calculation can never be better than the source data used. The very basic in LCA is therefore to have control over the so-called reference flow, or with other words, all resources used during the life cycle for the assessed construction works. Digitalisation is required to have a full data cover and a good quality of the mapping of these resources used as input and the LCA data used to describe their environmental impact. We regard the data gathered for the cost calculation as currently the most sufficient input for such LCA calculation for a new building before built and includes typically between 5000 to 15 000 items that all together define the bill of resources (BoR) for the construction face (A1-A5). Such cost calculations are made in specialised software's or other BIM applications. Digitalisation is also in an EC context regarded as an essential part of the over-all roadmap for increased sustainability in the construction sector. In 2012, the Commission published a Communication Strategy for the sustainable competitiveness of the construction sector and its enterprises[4]. The document is a part of the Europe 2020 initiative[5]. It focuses on the promotion of favorable market conditions for sustainable growth in the construction sector. The following five areas are addressed:

1. **Financing and digitalisation**: especially for energy efficient investments in the renovation of buildings and for research and innovation in a smart, sustainable, and inclusive environment
2. **Skills and qualifications**: workforce and management training for job creation through up-skilling and apprenticeships to meet demands for new competencies
3. **Resource efficiency**: focusing on low emission construction, recycling and valorisation of construction, and demolition waste
4. **Regulatory framework**: emphasis on reducing the administrative burden for enterprises, and particularly SME
5. **International competition**: encouraging the uptake of Eurocodes and promoting the spread of new financial tools and contractual arrangements in non-EU countries.

Level(s) follows or contributes to the intention of most of these strategies. However, we cannot find anything about digitalisation (No 1 in the list above). Digitalisation and automatization of the EPD and LCA practical work, and how this is implemented in the construction sector processes and tools like Building Information Model (BIM) is only mention twice in the Level(s) documents. When BIM is mentioned in the report it is not described as a promising approach; "… The calculation of the building's environmental profile (added; based on BIM) is much easier but at the same time, they cannot easily control the results and identify any odd assumptions and results." Our experience is the opposite; a manually calculated LCA for a building is far too time consuming and results in poor quality, as several simplifications are made, which lead to LCA results that are

[4] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52012DC0433
[5] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52011DC0021

not suitable to use in public procurements or for comparative purpose. The poor quality is mainly caused by the fact that a complete calculation is not possible without a digital process, and in the absence of a such complete LCA, the result cannot be used for comparisons. Compare with the required cut-off for an EPD for construction products where only a 5% data gap at the most is accepted (EN 15804), and in practice there are rarely any data gaps since proxy data are used when data gap exists. The same cut-off rule is valid for an LCA for any construction works (EN 15978).

The fact that digitalisation is neglected in Levels(s) and even is considered as not working is a critical drawback that affect the entire work, system layout and recommendations. We therefore would like to mention the Indata Group[6] - an organisation that focus on digitalisation of EPD based on the EC approach ILCD[7] that is a digital format for exchange of LCA data. The ILCD works is also referred to in the requirements for Product Environmental Footprint (PEF). This digitalisation of EPD is supported among several EPD Program operators such as IBU, ÖkobauDat, EPD Norway and EPD International. The French approach INIES that have been operational since 2004 now includes more than 3000 digitally available EPDs for construction products[8]. In 2018 it existed more than 5000 EPD based on EN15804[9]. Another approach is Smart CE marking where the declaration of performance (DoP) now goes digital[10]. The commission also have plans to make the EPD to a mandatory environmental declaration part of the DoP, based on the product category rules for construction products EN 15804. In practice, when this will be launched in future, such EPD as part of the DoP will also be digitally available. All these EPD is used as bricks for calculation of an LCA for any construction works and is supported with the BIM development within the sector.

The current most promising digital approach that can generate a full LCA for any construction work is to reuse the result from a cost calculation tool already used in the companies. These kinds of tools generate a bill of resources BoR, i.e. elements, construction products, intermediate products like ready-made concrete, energy use and different constructions services need for the construction and installation process. The BoR also includes the waste generated at the construction site. This approach is the preferred data source for a digital calculated LCA. Such digital LCA calculations (Erlandsson et al 2007, Heikkilä and Erlandsson 2011) have been made by Skanska since 2007 and is also the recommendation for the first generation of digitalised LCA for constructions works suggested by the Swedish research program Smart Built Environment (Erlandson 2017).

In Level(s) is the bill of material (BoM) referred to as a potential output from a CAD application, but this is a limited list only covering the materials that are part of the final construction works. This means that it will never be complete and applicable for a full LCA calculation, since waste, construction services, energy use processes etc is not part of such list. An alternative is instead to use a bill of objects (or elements) from the CAD application. The drawback is that the inherent content of elements content or the recipe (i.e. resources used for the construction and installation process including construction products) is not always accounted for as an integrated part of the element properties (or a BIM object). We do now see several initiatives where CAD and cost calculations tool are integrated as an open BIM tool (such as VICO[11]) that implies that such tools

[6] https://www.indata.network/
[7] https://eplca.jrc.ec.europa.eu/LCDN/developerILCDDataFormat.xhtml;jsessionid=6CA209B2F5617443D509CE19B1E2F2F7
[8] https://www.inies.fr/the-digitised-data-webservice/
[9] https://constructionlca.wordpress.com/2018/02/20/epd-numbers-continue-to-increase/
[10] https://www.construction-products.eu/publications/publications/smart-ce-marking-concept
[11] https://connect.trimble.com/feature/vico-office.html

now can deliver a full BoR applicable for both cost calculations as source information for LCA and LCC for the same construction works.

LCC is related to the macro-objective 6 indicators: Note that the same source data from for instance a construction cost calculation tool and its bill of resources could potentially be used as source data as needed for the LCA calculations as well as the initial data for the LCC. Such combined bill of resources that can be used for both LCA and LCC is not pointed out in the Levels(s) report but in practice this can be used to streamline the indicator approach in level calculated with LCA and LCC.

2.2 General agreed settings supporting high quality LCA in a market context

The current problem with LCA in general for construction works including buildings is that the most ambitious LCA will include more parts of a building and more parts of the life cycle, and therefor also result in a higher environmental impact compared to a less ambitious LCA. In a market competition situation when the LCA and its scope is not considered, this means in practice that the one that provides a full LCA will be punished if the scope and data quality of the calculations are not considered.

A drawback with the Level(s) methodology settings are the flexibility allowed without limits, which is expressed as follows (Dodd et al 2017, p 8, first bullet in Table 1.1) "It provides flexibility in the level of detail at which sustainability aspects can be addressed in the design process". For internal use of results, simplified LCA with flexible rules is acceptable and can be enough in order to make improvements within the limited scope covered For beginners and when the LCA is used internally without external comparisons it is fine not to require a full LCA and that the LCA use commonly established settings for the scenarios (A4, A5, stage B and C and module D). However, as comparative information for market and communication purpose including public procurement, it is required to use the same methodology and common rules for scenarios settings, in order to achieve a fair comparison of different construction works.

Level(s) users will be able to work with data and calculation methods at three defined levels of expertise and comprehensiveness – a common level (Level 1), a comparative level (Level 2) and a performance-optimised level (Level 3) – with each in turn requiring an increased level of competence and expertise in data handling and competent analysis.

Table 1 Requirements for the calculation in order to use the LCA result for; knowledge building, building Improvements or comparison

Aspects to fulfil?	Knowledge building	Building improvements	Comparison
Common LCA methodology	Y	Y	Y
High amount of product specific data is used[2)]	N	Y	Y
No[1)] data gaps on LCA data	N	Y	Y
No[1)] gaps in bill of resources	N	N	Y
Common rules for scenario setting	N	N	Y
Full life cycle covered	N	N	Y
All construction part included	N	N	Y

1) "No" means that the cut-off with maximum 5% cut-off according to EN 15804 and EN 15978 is accepted. Since it is possible to use proxy data for the remaining 5% the data covary can in many cases almost reach 100%.
2) Product specific data means LCA-data representative for the actual product as it is produced including the upstream impact and to be used in the construction work (tender proposals or contract specification), or the construction product that is used in the construction sector. A minimum of 60% is given as a minimum average value by Erlandsson (2018) for improvements and 90% for comparative purpose.

Based on the information in Table 1 an alternative stepwise LCA implementation approach compared to the one outlined in Level(s) can be defined. The stepwise first "level" is when the use of LCA on buildings will be applicable for knowledge learning on how an LCA can be made and what results it generate. Such approach is typically used in the internal learning process and used for hot spot identification within the analysed system and its scope. In this case is the significant requirement that all LCA data used must be founded on the same methodology. Besides this the rules and specification need for this kind of LCA is very limited, but the scope of the inventory will limit what conclusions that can be drawn.

The second level for use of LCA is to make improvements. Most efficient it is often to start with the hot spot identified, such as the materials in the building frame. The aim of this second level is to compare our own building before and after changes performed or evaluated. This use of LCA is in fact what the most common way to implement it in building classification schemes like BREEAM and LEED (and the Swedish system Miljöbyggnad). Since the improvement is made within the boundary settings made by the organisation responsible for the LCA and not used to compare with others, the boundary settings and scenario specifications etc can be very flexible. You can make improvements compared to yourself. This is how LCA is most useful for Skanska at present time.

To be able to do this kind of improvement including product comparisons, representative data for commercially available construction products are needed. This is handled in practice by use of product specific EPD meaning the data is ideally representative for a specific product from a manufacturer and the actual site where it is manufactured. In order to assess the EPD to meet this representativeness, the EPD must be complemented with quality (Q) metadata (see e.g. Erlandsson 2018).

The most sophisticated use of LCA is for comparison and comparative assertion. When a comparison of different designs that fulfils the same requirements (as expressed in the brief) are asked for, is it crusial that the LCA is complet, with a quality that allows comaprison based on common rules for scenario settings etc. These kind of specifications is not part of the scope of Level(s) but it is needed if the goal is to add up the LCA result from individual builings to macro level that is mentioned in the application exampel of the Level(s) system. The state of development on the market is to achieve such rules and boundary settings, but we are only in the beginning of this development.

2.3 Setting the scope defines what the LCA can be used for

"Level" is defined by the regulation (EU) No 305/2011 [1], article 2(6)] as the result of the assessment of the performance of a construction product in relation to its essential characteristics, expressed as a numerical value. It is likely that the market understands the level approach as a common classification system for buildings that allow the user to assess the performance divided in different performance levels like the EC labelling system A to F. In Levels(s), the use of the system is described as follows (Dodd 2017, p 7) "The intention is not to create a new standalone building certification scheme, or to establish performance benchmarks".

The Level(s) framework is therefore designed so that each indicator for an individual building and its impact can be summarized to describe the sustainability performance at macro-level, which can be used for a country or ultimate at the European Union level. The Level(s) framework seeks to address the life cycle environmental impacts of buildings in an integrated way. Level(s) primarily aim is to describe and potentially improve the sustainability performance of buildings. The Level(s) object of a performance assessment is defined by a building including its foundations and all external works within the area of the building site. This imply that the assessed construction project and all its construction works is the target, rather a method that make comparison possible of the 'equal parts' of the building possible that typically will limit the boundary setting. This typically introduce a system boundary that only account for the foundation and the rest of the upper parts of the building excluding the foundation substructure and all earth works, supplementary buildings and other external constructions works etc.

Furthermore, the scope of the Levels(s) system accounts for both new construction or a major renovation. If this, in theory, is combined with an inclusion of building construction phase (module A1-5) and all running projects in Europe was accounted for, such inventory result then describes the environmental impact from that part of the building sector across Europe. Then, we must improve the inventory to fully cover the BoR used A1-5 (see discussion above). Still, the missing part in such inventory will be minor renovation work (not legally needed to report) and maintenance and replacements that take place in the current building stock including work related to building and real estate services and the construction work made by private person (do-it-self) and black work. Based on Swedish LCA calculations on the building sector on the macro level, this data gap would in year 2015 represent about 45% respective 20% of the overall impact from the sector excluding respectively including the energy use (Erlandsson 2019) However, since this is a voluntary system the incitements to for the market to use Levels(s) based on this aim is likely very low if not non-existing.

The fact is that the overarching aim and following design of the system and related boundary setting of the inventory work limits the use of Level(s) for other purposes, namely as basis for a classification system, or to create a common possibility to compare the environmental performance of different buildings in a common way and to create key figures. Since this is a voluntary system and it is not likely that the industry start using Level(s) to contribute to national or European statistics we suggest that Level(s) major design and use should instead be focused on the use as a common European method for building declaration including a set of sustainably indicators. Such European building declaration system (and supported by the EC and based to the CEN standards EN15804 and EN 15978 related to CPR) is currently missing. And since there exist several national systems and these systems decide their calculations rules by them self, the spin-off effect is also that national requirements on construction products is added and will act as a trade barrier for a common European market. It is also noticed that the different national building classification schemes create barriers for contractors from outside their own country.

2.4 Reflections from using the reporting tool

The reporting system and the language used throughout the reporting tool is difficult to interpret. It is hard to see the purpose with some of the indicators. The level of detail is uneven, some indicators are very detailed for example: 2.1 Bill of materials (low) and 4.1 Indoor air quality (high), and even if the test pilot work with external certifications like the Nordic Swan and Miljöbyggnad, the detailed information needed for some indicators were hard to get from the project (see more information in the Annex)How the indicators actually is connected to the macro objectives is not always easy to understand, and there is a risk that it will be very time consuming without adding value for the single project.

If a voluntary reporting system is going to be used, we think it must be much simpler than Level(s). Our experience with the internal system supports the fact that it must be simple, otherwise it will not be used. It has to have fewer and more relevant parameters to evaluate for each project, otherwise the framework will probably only be used as support for the organizations developing criteria in building certification systems.

3 Concluding remarks

Based on the markets interest in environmental performance of all kind of construction works including both building and civil engineering works, the climate impact is the matter that has the most attention to combat. Our evaluation of Levels(s) therefore is focused on climate impact and other LCA related indicators and how the rules to make this methodology operationally running is suggested in the Level(s) pilot reports.

It is within the human nature to compare different alternatives when options exist and especially if it is possible to assess the performance quantitative, then calculated using the same basic method and reported on a common unit is crucial. It is problematic that a system like Level(s) allows such flexibility in boundary settings etc that in practice means that the indicator result based on LCA is not comparable and cannot be used for comparative assertion. This is also outlined in the Level(s) pilot report where it is stressed that the system is not applicable for benchmarking. The problem is that this is likely how the system will be understood by the market and what the market actor seeks. A market driven aim with the Level(s) system would be to specify the methodology and needed system setting so that this is achieved. If this was the aim, the only way to establish such high quality LCA calculation is to facilitate the potential possibility by digitalisation and standardisation.

Our recommendation is therefore to upgrade the current pilot guidance taken this digitalisation into account and develop a pan-European common specification that make the result out of Level(s) comparable. Such development includes common;

1. guidance on how to calculate an LCA based on information that digitally already exist for a quotative take off and the bill of resources (BoR) that is the source data needed for the LCA calculations (A1-5)
2. support the development of the digitalisation needed to facilitate the LCA calculations, including aspects like common format for transformation of BoR from other tools including building information model (BIM), a common dictionary (compare with buildingSMART data dictionary, bSDD) of defined resources used during the construction works life cycle that can be used for generic LCA resources to whom the specific product LCA/EPD data can be mapped to, common identification system for manufacturers specific products (like GTIN or likewise), a common building and building element classification system that allows the result to be split in to building parts etc (compare with CoClass).
3. common scenario settings or default rules for the building's life cycle i.e. stage B, C and D. Such scenario settings can typically be based on EU scenarios like "A Clean Planet for all - A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy" (28/11/2018 - COM (2018) 773) and other policies.
4. The digitalisation work suggested above can be seen as a logic continuation of the current work done by the Smart CE Marking. It is very likely that in the future there will be a mandatory reporting of environmental performance as part of the declaration of performance (DoP) according to the LCA specification as defined in EN 15804. All these initiatives are related to the construction product directive (CPR). The Smart CE Marking is a human and machine-readable digital format and will also be in line with the latest development of product data template, that when they are filled in by a manufacturer becomes a digital product data sheet applicate in BIM (developed by CEN TC 442 as joint venture with ISO).

Annex: Aspects related to specific indicators

LCA related indicators

Indicator 1. Greenhouse gas emissions along a building's life cycle

1.1.1 Primary energy demand, 1.1.2 Delivered energy

Level(s) give two indicators for the building operational energy use, namely primary energy demand and delivered energy demand 1.1.1 Primary energy demand, 1.1.2 Delivered energy demand(kWh/m2yr). Since this metric is given as a separate indicator, we assume that the aim is to be representative for the inherent thermal quality of the building as such (independent of the current use and the tenant's behaviour). This interpretation is supported by the statement in the ingress of framework report (see part 3 p.27): "An important focus of the calculation method is on the thermal performance of the building envelope". If The inherent thermal quality of the building is the Level(s)' aim with this indicator, it is our recommendation to drop this indicator since it doesn't measure that inherent thermal quality. Moreover, the primary energy and global warming already are calculated as a result of the environmental life cycle assessment result based of the intermediate measure delivered energy demand. The primary energy should therefor follow the calculations rules outlined in EN 15804.

The energy demand is calculated based on the same standards all over Europe, but where different national specifications and guidance are used. This imply that primary energy is defined directly according to the energy performance of building directive (EPBP, (EU) 2018/844), and primary energy therefore need to be specified that can be achieved by referring to the harmonised calculation rules for primary energy as outlined in EN 15804. Sweden has a unique building code on operational energy demand, in that respect that the legally performance is the measured energy demand after at least one year in use. This measures then must be corrected to "normal use" and is then used as the proof on the building's thermal performance. But during the last 10 years only a minor part of the new buildings has measured the energy demand in a way that the figures could be used for a proper verification.

It is well known that there is a difference between the calculated energy demand and the in use verified result. The complexity of the calculation tools for energy demand and the difference in methods used for calculations are of relevance. It is also known that the energy demand is a poor indicator to measure the actual thermal performance of a building in use. An alternative for this performance that should be considered by Levels(s) is the heat loss coefficient method (HLC) (see e.g. Iraldo-Soto et 2019) or the heat loss factor at DVUT, a factor derived from HLC and the crucial performance demand in the FEBY energy classification system[12]. While HLC (W/m^{2}K) is not depending on the climate, the heat loss factor (W/m^2) is the product of HLC and the dimensioning winter temperature, (DVUT) and is thus directly correlated to the energy demand for heating.

[12] https://www.feby.se/files/2019-01/kravspecifikation-feby18.pdf

The problem that expected thermal performance as calculated in the design stage is not delivered in practice is noticed in public procurement in Sweden by The National Agency for Public Procurement (Upphandlingsmyndigheten), and they therefore recommend using building energy requirements based on the FEBY heat loss factor, to secure energy efficient buildings[13]. The company Kommentus that is related to the Swedish Association of Local Authorities and Regions (SKL), use criteria based on the FEBY heat loss factor in a procurement bidding project (ramavtal) for preschool buildings. The HLC based methods like heat loss factor[14], is also applicable for existing buildings and therefore also applicable to define the baseline in renovation[15].

Our recommendation is based on the Swedish experience and if the inherent thermal performance of the building is asked for, the selected indicator should be founded on a metric that could be assessed as-built. It's only a verifiable indicator which can be measured as-build that supports that requirements in public procurements shall be followed up, and this principle is also important for other comparative purposes. As a bonus we also recognise that the calculations in the design stage is quite simple and generated without additional work when the energy demand is calculated, which always is asked for by the clients.

The Levels(s) indicator 'Primary energy factor', PEF, is a consensus-based factor to represent a more scientific based calculated primary energy. The PEF is used as to multiply with the energy demand and then an indicative result on the actual primary energy demand. Such scientific based calculation requires for instance a boundary setting between the nature and the technosphere and allocation procedures to handle processes like combined heat and power production etc. The Level(s) framework referrers to requirements in the standards EN 15603 or EN/ISO 52001- 1. The problem is that neither of these standards includes calculation rules that make it possible to calculate a PEF on the same methodology.

The default PEF given in these standards are aimed to represent averages for the EU. However, according the Level(s) framework recommendation; "…it would preferable to use the primary energy factors provided as part of a national calculation method can be used. These would be more representative of the energy mix for the specific country." Such recommendation will make it impossible to add up the result from building level and country level to the European level, since different PEF based on different assumptions are made.

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[13] https://www.upphandlingsmyndigheten.se/hallbarhet/stall-hallbarhetskrav/bygg-och-fastighet/flerbostadshus-nybyggnad/totalentreprenad/byggnadens-maximala-varmeforlusttal----krav-vid-upphandling-efter-att-systemhandlingar-ar-framtagna.-/#bas

[14] https://www.feby.se/files/rapporter/wp2-1-energi-min.pdf

[15] Vesterberg J, Andersson S and Olofsson T, (2016), A single-variate building energy signature approach for periods with substantial solar gain, Energy and Buildings, Vol 122, pp 185-191.
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PEF will have huge different impact in a Swedish perspective for the buildings heating demand, depending on what system boundary that is selected for the electricity produced.

Either average European Primary energy factor, average Nordic value or a country mix. All perspectives are possible to argue for and then represent different 'questions asked for' by the assessment. The choice will completely determine which one of the competing heating systems in Sweden to select; district heating or electricity-based heating (mainly provided by heat pumps).

We see that a potential scientific based approach is to use a common set of European default PEF that then make it possible to add up figures on the European level that follow the same approach. However, our recommendation is to use the basic LCA calculation rules given in the energy directive (e.g. country specific electrify grid should be used) and calculations rules given in EN 15804, in order to not invent the wheel once more. This will consequently result in the possibility to make it possible to calculate the primary energy demand (as a result of the calculation rules selected and not a political decided figure). Following the EN 15804 approach, the use of primary energy will be combined with the use of secondary energy resources where the overall use of primary energy and secondary energy will always lead to an "energy factor" equal or larger than 1. Moreover, the use of primary and secondary energy is then dived in use of renewable and non-renewable resources, that better describes resource efficiency. Another target not handled in Levels is the scenario approach that has to be considered when considering a full life cycle (see below).

Indicator 1.2 Life cycle Global Warming Potential (GWP_{100} GHG)

The assessment of the operational energy use includes several methodology choices. To start with is an attributional LCA methodological used by Level(s), since the standard for building EN 15978 is referred to (and not a consequential system perspective that is only applied in module D). The benefits of this choice — that we indeed support — is that the calculated environmental impact from one year using this methodology will generate the same figure as in national statistic for this year (also referred to as the real-world approach or 100% rule).

For accounting of electricity in an LCA we also need to specify this rule and can then choose between an approach where the national grid is used or a system where specific electricity is used when a certificate of its origin (GO) is used as proof and all other electricity will have to use the residual energy mix[16]. This aspect is not specified in EN15804 why different EPD program operators allow different approaches or both at the same time. We therefore suggest following the calculation rule to use national average as given in directive (EC) 2015/652 as a specification to energy fuel quality directive 98/70/EC.

[16] https://www.aib-net.org/facts/european-residual-mix

Table 2 Historical, current and future GWP for Swedish electricity mix, kg CO_2e/kWh, based on long term energy scenario from the Swedish Energy Agency (2017), historical grid electricity data from Entso-E[17] and LCA data from Gabi[18]. (Erlandsson 2019)

<table>
<tr><th>Year</th><th>2013</th><th>2014</th><th>2015</th><th>2016</th><th>2017</th><th>2035</th><th>2050</th></tr>
<tr><td>Entos-E</td><td>0.049</td><td>0.041</td><td>0.035</td><td>0.042</td><td>0.035</td><td>0.036</td><td>0.022</td></tr>
<tr><td>medelvärde</td><td colspan="2"></td><td colspan="3">0.037</td><td colspan="2"></td></tr>
<tr><td>EcoInvent*</td><td>0.047</td><td colspan="6"></td></tr>
</table>

European commission have commissioned to JRC to calculate national values representative for year 2013 based on this methodology for all European countries. The methodology accounts for national production, national grid export and import and combines these figures with ready-made LCA data on electricity from different energy sources (Moro and Lonza 2018). This approach gives a verifiable result for the electricity without any double accounting. The figures in the JRC report are old and therefore not representative for the current electricity grid. Moreover, when this kind of figure are used in LCA for domestic building energy demand (B6), they should take future changes into account. Such future long-term scenarios must be established for each country. Table 2 shows the figures asked for (as an example) and is valid for Sweden based on this methodology and a future scenario defined by the Swedish Energy Agency given as an illustrative example.

Indicator metric

The impact assessment method used for global warming in the LCA calculation is very much in line with EN 15804:2012+A1:2013 that refers to IPCC 4th Assessment Report with a scope to cover greenhouse gases (GHG) and the integration of radiative forcing over 100 years (GWP100 GHG). The characterisation factors from IPCC is complemented with factors defined by JRC as follows in the table below.

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[17] https://www.entsoe.eu/publications/statistics-and-data/#statistical-yearbooks
[18] http://www.gabi-software.com/databases/gabi-databases-2019-edition/

Table 3 Complementary characterisation factors according to Levels(s) for GWP100 GHG (Dodd et all 2017b), where the missing factor for planting of renewable resources on area that have not been covered previously like afforestation or planting in urban areas.

Substance	Compartment	GWP_{100} GHG
Carbon dioxide, fossil	Air emission	1
Carbon dioxide, non-renewable biogenic	Air emission	1
Carbon dioxide, non-renewable biogenic	Resource from air	-1
Carbon dioxide, biogenic	Resource from air	0e
Carbon dioxide, biogenic	Air emission	0
Carbon monoxide, fossil	Air emission	1.57
Carbon monoxide, biogenic	Air emission	0
Methane, fossil	Air emission	25
Methane, biogenic	Air emission	22.25
Carbon dioxide, land use change	Resource from air	-1
Carbon dioxide, land use change	Air emission	1

The direct oxidation approach of biogenic carbon dioxide applied in Levels(s) will result in a zero balance over the life cycle for all emitted and sequestrated renewable originated resources over the life cycle. This approach also solves the 'landfill biogenic sink problem' as when sequestration is first accounted for as -1 and the emission +1, since this will create a biogenic carbon sink also taken the emission over 100 years into account. Such alternative (to Level(s)) calculation rule creates a significant bonus for landfilling of biogenic products compared to reuse or energy recovery in end-of-life (that most of us think is a misleading methodological specification). This latter alternative is applied for instance by the wooden product category rules, PCR, EN 16485 that is related to EN 15804, the upcoming revised EN 15804 to be published in 2019 as an amendment (A2:2019), and the General Program Instruction from EPD International (GPI, EPD Int. 2017). The problems with these standards are that they conflict with how GWP is reported international under the UN Climate Convention, the Kyoto Protocol and EU regulations.

All public bodies that demand an LCA use GWP_{100} GHG as the indicator, for example the Transport Administration (Trafikverket 2018), National Board of Housing, Building and Planning (Boverket 2018) and the construction industry's environmental calculation tool (Byggsektorns Miljöberäkningsverktyg, BM) (Erlandsson 2017). When the EPD according to the revised EN 15804:2012+A1:2013+A2:2019 is used in future, the GWP indicator GWP100 GHG that is in line with international climate reporting has to be calculated as below:

GWP_{100} GHG = GWP_{total} – GWP_{fossil} + GWP_{LULUC} – BCC·44/12 [kg CO_2e]

Where,

total the emission of greenhouse gases and temporary storage of biogenic carbon within products in technosphere (by this latter definition is landfill sink set to zero in A2, but is still a problem following EN 16485 and GPI from EPD International)

fossil the emission of fossil greenhouse gases

LULUC greenhouse gas emissions and removals from land use, land use change

BCC biogenic carbon content reported as elementary carbon (why it must be converted to carbon dioxide by multiplying with 44/12, based on the molar weight)

We notice that in section 1.2.1.4 'Suggested reporting format' in framework document part 3 is the name 'GWP – over all' used and is equal to what we here name GWP_{100} GHG compered to 'GWP_{total}' according to EN1504 A2 that also included biogenic sequestration, emission and biogenic carbon stored in product, why GWP total cannot be used if the indicator doesn't account for a full lifecycle and the zero balance of biogenic is established, which defiantly limit the practical use of this new EN 15804 A2 indicator.

We are therefore in favour of the more straightforward and, stricter scientific based and commonly applied GWP_{100} GHG indicator that just accounting for greenhouse gases, and not mixed up with temporary storage of inherent carbon stored in products, just creating a more complicated calculation, reporting and most of important interpretation of the indicator result. The only remark we have is that a characterisation factor that support and stimulate negative emissions by planting of renewable resources on areas that have not been covered previously (like afforestation or planting in urban areas) are missing (see reed text in Table 3).

Another positive aspect for using this approach is that no manual calculations has to be done to complete you LCA outside the LCA tool. The only correction that needs to be done (if not already supported by the software provider) is that the characterisation factor described in Table 3 has to be adopted by the set of characterisation factors used to define GWP_{100} GHG.

The indicator inventory settings

The Level(s) scope comprises the evaluation of the building from cradle to cradle and the building boundary settings shall follow the 'modularity principle' according to the building declaration standard EN 15978.

The ultimate scope covered by Level(s) LCA in order to assess a building shall include all parts including its foundations and all external works and landscaping within the curtilage of the building site. However, the "all" scope is directly turned out to be defined as a complementary minimum list of building elements covered by the LCA (see Table 1.1). Moreover, in the case of a residential apartment building, the object of assessment may be a representative sample of the apartment typologies within the building, rather than the whole building. In the same way, for a residential development or catalogue of property types, the objective of assessment may be a representative sample of the residential typologies.

Levels(s) then introduce a cut-off criteria for each building element where at least 99% by weight of the construction products being built in shall be covered in the so called bill of material (BoM) for each element. The verification is unclear. This mass-based cut-off related to each element included is then completed with an overall cut-off rule (that we assume is relevant for A1-5 since it is said that 99% of the total mass of the building is accounted for), defined as given below:

> *"All input flows to unit processes that make up less than 1 % of primary energy usage and 1 % of the total mass input of that unit process. The total amount of excluded input flows per module must not exceed 5% of the total primary energy usage and mass input, or the total GWP impact depending on the complexity of the calculation tools, of that life cycle module."*

It is possible by following the Levels(s) guidance, to define a limited life cycle scope as found convenient by the end-user, as long as it is included in communication of the result. The following two simplified inventory and reporting scope is suggested covering the following modules:

Alternative 1

- The product stage (A1-3)
- The use stage (B4-5, B6)

Alterative 2

- The product stage (A1-3)
- The use stage (B6)
- The end of life stage (C3-4)
- Benefits and loads beyond the system boundary (D)

With this flexible arrangement of the scope we can state that such approach will not in general make it possible to compare the result between two calculations. With such flexible setting of the scope it will not make sense to add LCA result from the building level to a larger geographical scale as aimed as one of the applications with levels(s). It should also be noticed that the result from module D never can be added up since it found on a consequential LCA approach describing the 'what happens if' (and therefore cannot ad up). It's remarkable that it is not motivated the background on how the limited modules to be accounted for is motivated and what such scope can be used for something meaningful.

The starting point for a fair comparison, i.e. the equal treatment rule according to public procurement is the input data for the shall cover all product/materials (i.e. including that will become waste), energy, construction activities and services used to the construction project analysed. The BoM is then a limiting approach to describe the overall resources used since BoM just cover the mass of that part of the construction products that is part of the final construction works excluding the waste and the resources used in the construction process. A more adequate term is Bill of Resources (BoR), that then cover all resource use by the project for a defined information module or modules.

Our recommendation concerning the scope and the boundary settings is that these defections must be made with a certain use of the result in mind. We therefore suggest the application area of the LCA performed for the building assessment (based on Erlandsson 2019) as given in Table 4.

Table 4 System boundary setting of information modules and building part to be included and cut off rules for inclusion of BoR in the LCA calculation.

	Modules included	BoR Cut-off 1)	Building parts included
Comparison of waste handling	D	95%	The materials as they are sorted in the deconstruction and demolition (C1)
Knowledge learning and hot spot identification	Minimum A1-5	80% per life cycle	Minimum; foundation, façade, roof and load bearing structural frame
Improved performance	Minimum A1-5	80% per life cycle	All building parts
Procurement of a building (comparative purpose)	Minimum A1-5	95% per life cycle	Minimum all building parts above the foundation
Procurement of a building, including evaluation of the life cycle (comparative purpose)	A to C	95% per life cycle	All parts of the construction project
For statistical use and country yearly impact follow up	A1-5	90% per life cycle	All parts of the construction project
Zero Emission Buildings	A to C and depth compensation 2)	95% per life cycle	All parts of the construction project

1) The cut of is described as the worst-case figure on cost-% for each individual resource in the BoR. The data-gab is then adjusted for by multiplying the result with the calculated data-coverage. If for instance 80 % of the BoR is covered by the LCA calculation the result will be adjusted by a factor 1.25 (=1/0.8).
2) ZEM approach is not covered by EN 15978 but is more frequently used and referred to. To start with is our suggestion that the impact burden from A to C has to be reported separately from the compensations measures to handle this depth. We then recognise that a common definition of ZEB is needed, but this is temporary solution to introduce a module E for reporting of this part to increase the transparency.

It is noticed in the Level(s) framework that the LCA can be performed at different stages of a building project from design to as-built including its use and occupation, with the primarily intended use as a design tool. The framework does not give any detailed guidance in this matter but is essential if the LCA is used for procurement or other comparative purposes. Also in this context is the verification limited to discussion about the real Bill of Materials and adapted condition of use, but the focus should be the full Bill of Resources (BoR), limited to A1-5, since this is the verifiable part of the LCA. We also recommend that for this calculation should generic data be replaced with EPD from the actual producers of construction products etc.

2.1 Life cycle tools: Building bill of Materials

The classification of building components in the bill of material must follow national practice, otherwise the definitions will be interpreted differently. In Sweden, in cost calculation systems or digital models we don't use Eurostat four material categories. We have to add the categories manually; the quality and the result will most certainly differ depending on the person doing it. For an individual project the value of dividing the BoR into Eurostat material categories is questioned.

2.2.3 Scenario 3: Design for deconstruction, reuse and recyclability

This was not used by the project although the indicator is interesting. Skanska will look more into this indicator.

2.4 Cradle to grave Life Cycle Assessment

Se comments indicator 1.2, and 2.1

2.3 Construction and demolition waste

Comments on the reporting tool:
Part 1: No comments
Part 2: Hazardous/non-hazardous waste is not defined

Other non LCA-based indicator assessed

3.1 Use stage water consumption

Comments on the reporting tool:
Easy to fill out for all Levels (1-3) since Skanska has a similar tool
Information about actual water consumption is possible to get from the owner(s) of the building or the water supplier (Stockholm Vatten och Avfall). Both can deliver m3/occupant/yr

4.1 Indoor air quality (design indoor conditions and target pollutants)

Comments on the reporting tool:
- Design stage 1: the air quality is regulated in the national building code.

- Design stage 2: Difficult to fill in. Time consuming to figure out which VOCs are carcinogenic
- Design stage 3: Humidity in materials are measured to avoid mould and certificates that ensure safe building techniques are demanded during the building process

4.2 Time out of thermal comfort range

A PPD (Predicted Percentage Dissatisfied) is usually made in projects that take thermal comfort into account. These projects are often following a certification.

Comments on the reporting tool:
Part 1 No comments
Part 2 and 3: No data available

5.1 Protection of occupier health and thermal comfort

No evaluation was possible.

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