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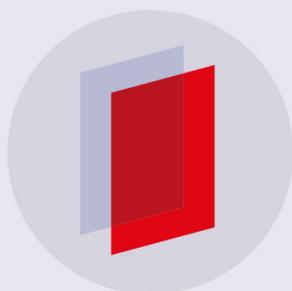
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# Adopting The EU Sustainable Performance Scheme Level(s) In The Danish Building Sector

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**Abstract.** This paper investigates how the EU Level(s) can be adopted in Denmark. The study is limited to life cycle assessment (LCA) requirements within the Level(s) scheme. As a measure for the Danish building sector's LCA practice, the specifications for LCAByg, the official Danish building LCA tool, is used. In 2017, the European Commission's Joint Research Centre has launched Level(s) as a voluntary programme of sustainable building indicators based on existing EU standards and initiatives. Level(s)' original value, beyond the mere aggregation of existing standards, is the selection of the most relevant indicators according to EU and national policies, the graduation of indicators into three levels of comprehensiveness as well as providing original definitions and guidance for their practical application. In the absence of mandatory EU regulation for sustainable buildings, Level(s) is representing a new EU reference for sustainable building performance. The paper presents requirements and criteria given by all LCA-related indicators including building component's environmental impacts, resource use and waste. In general, these definitions are based on international standardisation. In a next step, Level(s) original definitions for procedures, for which no standard definitions exist, are isolated and presented. These extra definitions might conflict with existing schemes and tools such as LCAByg, which are based on the more broad technical standards. Level(s) extra definitions are isolated and presented in order to get an overview on the difference between Level(s) and standardisation in order to develop existing or future initiatives to comply with Level(s). Regarding LCAByg, it shows that the tool may be used for complying with Level(s) LCA criteria. However, if LCAByg and Level(s) shall contribute to a broader use of building LCA in the building sector, a greater integration of guidance and calculation tool might increase feasibility and ease of method. Proposals for deeper Level(s) support in LCAByg are given.

## 1. Introduction

The life cycle assessment methodology constitutes the assessment backbone of the integrated product policy of the European Union [1] and plays a vital role in recent policies on resource efficiency in the building sector [2]. However, EN 15978, the EU standard for conducting life cycle assessments on buildings, provide a wide degree of freedom of definitions when applied in practice [3]. This is leading to a situation, where many EU-member states are establishing environmental funding programmes, guidelines or sustainable building certifications using their individually tailored LCA requirements, which may vary between programmes and countries [4]. Examples of certification schemes with different LCA definitions used in Denmark include DGNB, LEED, BREEAM, Nordic Ecolabel and



ActiveHouse. Consequently, LCA approaches do not align across different schemes within one country or different national policy requirements across the borders [5].

In autumn 2017, the European Commission issued Level(s), a new voluntary reporting framework for a two-year pilot phase. It provides core indicators and common metrics for measuring the environmental performance of buildings along their life cycle [6]. Aiming at defining a general language of sustainability for buildings. The authors seek “to provide a consistent and comparable voluntary reporting framework that works across national boundaries and has a broad potential for use by building sector professionals across the EU” [6].

Among covering topics like environmental performance, health and comfort, cost, value and risk [Table 1], Level(s)' LCA rules and guidance have a significant harmonising potential for the presently scattered national and NGO initiatives and programmes. Two main implications apply, which shall be addressed in two consecutive analyses in this paper.

In the first part analyses, the LCA-based definitions in Level(s) are presented and the original definitions exceeding the information given EN 15978 and related standards are specified. This information can be used for detecting possible conflicts with existing schemes and programmes – which, in turn, also might include different, original definitions beyond the wide frames of the standards in order to make them operable for practical use.

The second part is a case study investigating, to what degree Danish LCA practice comply with Level(s) original definitions and what support measures might be necessary.

## **2. Method**

### **2.1. Level(s) structure**

The Level(s) publications are subdivided by chapters, which reflect the structure of the scheme consisting of macro-objectives, indicators, tools and scenarios. Information on what rules and definitions apply for material LCA are not listed at one location, but are distributed throughout a number of chapters (Table 1). A screening of Level(s) is being conducted resulting in a classification of information relevant for this paper and allowing the sorted list of requirements in the main study (Table 3).

### **2.2. Objectives**

The first research question pursued is, what Level(s)' LCA requirements are and what rules are defined in more detail than EN 15978 and related standards. The technical literature on Level(s), consisting of three parts of the Joint Research Centre's report on Level(s), are studied and compared to standardisation. The second question, to what degree the official Danish tool LCByg complies with those Level(s)'s definitions, which exceed standardisation, is being answered by a description of the tools functions.

### **2.3. Level(s) definitions exceeding standardisation**

The most relevant standard for building LCA in Europe is EN 15978 and related, referenced standards such as EN 15804. The information of interest is, what Level(s) criteria are more restrictive and what definitions more narrow than present standardisation, providing the user with more specific rules and less freedom of choice. This information is Level(s) original and novel contribution related to standardisation – although content is partly inspired by existing certification schemes, initiatives, tools and so on, which are not part of current standardisation.

Here, only requirements for the environmental loads from building components not Use stage energy and water use are treated. Furthermore, only requirements for new buildings are taken into account, not renovations.

A key feature of Level(s) is the division of requirements into three levels of expertise and comprehensiveness in order to either conducting common performance assessments, comparative performance assessment or performance optimisation assessments. Since the paper's aim is discussing Level(s) LCA approach as a whole, the graduated requirements will be noticed, but not be the focus.

#### **2.4. Case study: Level(s) and Danish LCA practice**

The functions given in the official Danish tool LCAByg are taken as a measure for how LCA is used and defined in Denmark. Developed by the Danish Building Research Institute and issued by the Danish Ministry of Climate, Energy and Building in 2014. The tool is regularly adjusted in order to meet changes in standards and the requirements of the Danish building sector and is expected to continue at the base of eventual future national policy [7] other tools and LCA rules exist in the certification schemes named in the introduction, which also contribute to Danish LCA practice.

In the comparative analysis, Level(s) original definitions are taken as the reference and the compliance of LCAByg is described. Compliance means that the LCAByg may be used for conducting LCA in order to meet Level(s) requirements without conflicting methods, functions or misleading guidance. Compliant functions might require supplementary procedures and methods beyond the tool.

Beyond mere compliance, supporting functions are discussed. Support means, that the user is provided most relevant data and guided through procedures securing that Level(s) criteria are met with lesser need for resources from other sources.

### **3. Results and discussions**

Level(s)' LCA requirements are predominantly placed in 6 chapters (Table 1). Chapters 7 on Cradle-to-cradle LCA include most of the definitions for conducting material-related LCA. Level(s) is classifying this chapter as an overarching LCA tool; however, it also defines most LCA measures, being seven environmental impact categories and two resource categories.

together with chapter 1.2 on Global Warming Potential and 2.3 on building waste, these three chapters constitute Level(s)' three chapters with environmental impact measures. Chapter 2.1 describes the bill of materials, which relates to building model definitions and other building scoping rules in chapter 1. The bill of materials is not an effect measure, but provides data for calculating flows and processes at the base of environmental impact measures. Scenarios for lifespan, adaptability and deconstruction provide criteria for making assumptions for post-construction life cycle stages. The function of these scenarios is informing the modelling of the life cycle stages in order to calculate their environmental impact. Finally, chapter 6.2 includes a rating on the quality of all assessment processes and data use and applies for all indicators including LCA-related indicators.

#### **3.1. Minimum building scope**

Level(s) exceeds EN 15987 by strictly defining the entire building with all constituting parts as the minimum building scope in chapter 1.

As there is no guidance in LCAByg for the scope of building parts to be included, LCAByg can be used for LCA complying with Level(s). However, a more rigorous advise for Level(s) compliancy might be achieved by written rules in the user guide or structuring the indata user interface in a way supporting the completeness of an entire building.

**Table 1.** Material LCA requirements in the Level(s) system

Level(s) classification <sup>a</sup>		De facto function <sup>c</sup>	Environmental impact category
Indicators	1.1 Use stage energy performance <sup>b</sup>		
	1.2 Life cycle Global Warming Potential	Impact measure	GWP
	2.3 Construction and demolition waste and materials	Impact measure	Waste (hazardous, non-hazardous, recovery potential)
	3.1 Total water consumption <sup>b</sup>		
	4.1 Indoor air quality		
	4.2 Time outside of thermal comfort range		
	6.1 Life cycle costs		
Tools	2.1 Bill of materials	Building model	
	2.2 Scenarios for building lifespan, adaptability and deconstruction	Building lifetime assumptions	
	7 Cradle to cradle LCA	Impact measure	GWP, ODP, AP, EP, POCP, ADPe, ADPf, renewable biotic resources and non-metallic minerals
	5.1 Scenarios for projected future climatic conditions		
Quality rating	6.2 Value creation and risk factors	Process and data quality measure	

<sup>b</sup> Operational indicators are beyond the paper scope

<sup>a</sup> Potential future aspects are not taken into account in the study

<sup>c</sup> Functions differ between either measuring or supporting the process of calculating environmental impacts

### 3.2. Life cycle stages

The principal system boundary in Level(s) is a cradle-to-cradle perspective including all life cycle stages according to EN 15078 (Table 2, I). This approach is one of the premises of the programme in general, not only for LCA indicators, since “the framework encourages the user to think about the whole life cycle of a building” [8].

However, Level(s) recognises that this wide boundary might be challenging in practice and design professionals may not have the expertise yet [9], why a complete cradle-to-cradle approach would rather represent a future prospect.

As an exception, Level(s) actually widens the standard’s narrow requirements for new buildings allowing “incomplete life cycles”, but requires to include at least the first stages, since they “will have taken place by the completion of the building and may be directly influenced by design decisions”. Stages representing future projections require greater efforts and LCA expertise and might be added with regards to the study objectives and data availability.

Level(s) provides two “Suggested simplified reporting options” [10] (Table 2). Both include the production stage and combinations with other stages. Option 1 (Table 2. II) also includes operational energy and water use and is the simpler of the two. Option 2 (Table 2. III) focusses on the projected service life comprising replacement and refurbishment based on information from the Levels(s) scenario tool 2.2.2.2 Design for adaptability and refurbishment.

The authors do not explain the choice of options nor state whether alternative options are accepted in the scheme. However, classifying them as suggestions indicates that other combinations might be accepted.

This applies to LCByg representing one of these alternative combinations of A1-3 with other modules and would thus comply with Level(s) incomplete life cycle criterion. Beyond the fabrication stages, LCByg includes replacements, energy use and end-of-life processes, table 2. The replacements stage is supported by available official Danish service life values for building products [11], however not including repair and maintenance.

Waste and disposal processes are taken from Ökobaudat with modifications to Danish conditions. Operational energy use follows the calculation rules given by the Building regulation's energy requirements [12].

A better Level(s) support may be achieved by including data sets for other stages available in Ökobaudat. The limited representativeness of using German data in Denmark will remain unchanged, [see 3.7].

As a consequence of extending the system boundary, professionals and clients will have to increase their efforts for making meaningful future assumptions when including stages for building site processes and schedules for building use modules, deconstruction and next product stages. This might, in turn, suggest the need for further support in the tool.

**Table 2.** Life cycle modules, suggested in Level(s) and available in LCByg<sup>a</sup>

	Product fabrication			Building construction		Building operation							End of life				Benefits and loads beyond the system boundary
	Raw material supply	Transport	Manufacturing	Transport	Construction, installation process	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction, demolition	Transport	Waste processing	Disposal	
	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
I																	
II																	
III																	
IV																	

I: Level(s), cradle-to-cradle<sup>b</sup>

II: Level(s), simplified option 1 including projected service life<sup>b</sup>

III: Level(s), simplified option 2 including building material bank<sup>b</sup>

IV: LCByg, version 3.2 (released 2018)

<sup>a</sup> According to EN 15978:2011

<sup>b</sup> Levels, part 3 pp 188-189

### 3.3. Cut-off rules

Level(s) follows the criteria for the exclusion of inputs and outputs in EN 15804. LCByg complies with any cut-off, which the user may calculate manually, but does not include a rule or function. A support for managing cut-offs would be central for more feasible procedures.

### **3.4. Building type**

While EN 15978 is open to all building types, Level(s) is restricted to housing and office use. Level(s) LCA rules do not indicate a specific focus on these building uses, however, other indicators within health and comfort are explicitly targeted to housing and offices and might explain this choice. LCAByg may be used for a number of building types, which include Level(s) scope and thus complies.

### **3.5. Impact categories**

Level(s) follows the suggested in EN 15978, but opens the possibility of considering other categories, if better suited for meeting the objectives of a study. The currently ongoing revision of the standards 15978 and 15804 is expected to result in a different list of impact categories.

LCAByg provides a minor number of resource and impact categories, thus not entirely complying with Level(s) standard categories or optional other categories. Compliance may be achieved if opening access to the missing categories available in the used Ökobaumat database. As for the inclusion of more life cycle stages mentioned beforehand, this decision relates to the trade-off between the number of available choices and the complexity of method and interpretation of the results.

### **3.6. Environmental data types**

Level(s) allows generic data to be used for level 1 assessments. Data used on level 2 and 3 shall be specific and representative in terms of time, geography and technology.

There is no available data complying with the requirements for level 2 and 3 for Danish conditions nor a sufficient number of local EPD's. Being the most representative and complete ready-to-use alternative, Ökobaumat has been translated and adjusted for use in Denmark in line with the adoption of DGNB in Denmark 2014. Ökobaumat comprises a wide range of data source and quality [12]. Using Ökobaumat therefore requires choosing data based on information on type in order to comply to Level(s) requirements interpretation and review.

For the moment being, Ökobaumat is the set of data for building products, which is closest to Danish conditions. LCAByg thus complies with level 1 assessments. However, LCAByg environmental data might be supplied with other data or for complying with higher-level studies.

As LCAByg does not show the type of data used, the user has to follow a link to the German Ökobaumat web source. Data sources do neither occur in the tool's results, making a critical review as difficult as the assessment. Valuable support may be a transparent indication of environmental data type from Ökobaumat and user-specified sources in order to manage data requirements. A larger supply of representative EPDs or a national database may be future scenarios.

### **3.7. Life cycle scenarios**

Level(s) provide tools for service life, adaptability and disassembly in the sense that the user is guided through the process of making scenarios, which may influence environmental impacts deduced by service life, service life extending processes and end of life processes. Here, a major LCA optimisation potential is being made accessible for building design professionals. By specifying design and decision criteria to the professional, Level(s) exceeds the minimum amount of definitions by standardisation, towards supporting the integration of LCA performance into early stage design and decision parameters instead of retrospective environmental reporting after the design has been finalised. Level(s) both provide user guidance to work with existing definitions including service life definition and fills definition gaps for scenarios not yet covered by standardisation, namely for adaptability and disassembly.

LCAByg complies with Level(s) scenario tools, however with no direct support of adaptability and deconstruction. Service life planning is supported primarily with two functions. One is a service life menu with most relevant life spans for the components that are being edited. The second functions include a diagram view indicating replacements and accumulated environmental impact in the

building's lifetime. The user can choose between a graph or list view on how the environmental impact of different types of building components or operational processes evolve.

Even though life cycle scenarios may still be set up externally for qualifying the data used in the tool calculating environmental impact, a deeper integration of checkpoints assisting scenario making directly in the tool might strengthening processes that utilise the environmental and economic potential of advanced scenarios for service life, adaptability and deconstruction.

### 3.8. Interpretation: Critical review and reliability ratings

Level(s) criteria for the quality management of data, processes and conclusions are placed in chapter 6.2 and 7.4.2. The chapter 6.2 quality rating applies to all indicators in the scheme. However, chapter 7.4.2 includes adjusted, specific rating procedures for LCA-based indicators, which are relevant here. Three ratings with different focus shall be conducted. The first includes data quality in terms of representativeness, accuracy and uncertainty. A sensitivity analysis for reporting on the level of uncertainty is mentioned in EN 15978 as an example method. However, it is a requirement in Level(s) and accompanied with criteria and guidance. The rating of independent verification resembles the voluntary status, EN 15978 gives to verification, but categorises the answer to the question, of and how verification has been taken place. A rating of the professional capabilities is an original Level(s) requirement for transparency of the results. LCAByg complies with these requirements, but does not include structured quality management functions. Nonetheless, the tool allows for commenting on datasets, which can be used during the assessment or review. Further support might be achieved with an integrated function and reporting format for sensitivity analyses, where iterations of in data and the uncertainty of result may be tested more convenient than manually.

**Table 3.** Comparing Level(s) LCA definitions with standardisation and LCAByg functions

Topic	Levels(s) definition	EN 15978 and related standards	LCAByg compliance with Level(s) and support options
1. Minimum building scope (product system)	Level 1,2: The building and its constituent parts without external works Level 3: The building and its constituent parts with external works (chapter 1.1.2)	The building and its constituent parts or an assembled system (EN 15978)	Compliance: Yes, user definition Enhanced Level(s) support: Checklist of building parts (procedure guidance)
2. Life cycle stages (system boundary)	Level 1,2: Simplified reporting including at least stages A1-3 Level 3: Full stage LCA	Full stage LCA is the regular approach for new buildings (EN 15978)	Level 1 and 2 compliances: Yes, incomplete life cycles are supported (A1-3, B4, B6, C3-4) Level 3 compliance: No Enhanced Level(s) support: System border indicator (reporting)
3. Cut-off rules (product system, system boundary)	Items comprising less than 1% of total building mass / impact can be excluded Sum of excluded items must be max. 5% of total building mass / impact Input flows to unit processes comprising less than 1% of primary energy usage and 1 % of the total mass input of that unit process can be excluded Sum of excluded flows must be max 5% of the total primary energy usage and mass input, or the total environmental impacts depending on the complexity of the calculation tools, of that life cycle module.	Identical with Level(s) (EN 15804)	Compliance: Yes, no rules defined Enhanced Level(s) support: Integrating calculation function (procedure guidance)

Topic	Levels(s) definition	EN 15978 and related standards	LCAb compliance with Level(s) and support options
4. Type of building use (functional unit)	Housing and offices (chapter 1.1.1)	Open for all building types (EN 15978)	Compliance: Yes
5. Impact categories	<p>11 categories included in 3 indicators:</p> <p>1.2 Indicator of life cycle Global Warming Potential (1 impact category)</p> <p>2.3 Indicator on construction and demolition waste (3 waste categories)</p> <p>2.4 Cradle to cradle LCA, 7 impacts categories:</p> <p>GWP, ODP, AP, EP, POCP, ADPe, ADPf</p> <p>2 resource categories: use of renewable biotic resources, use of non-metallic minerals.</p> <p>Recommendation using relevant categories, which can be different than the mentioned ones</p> <p>3 Waste categories</p> <p>3 output flows (2 categories in other material recovery operations)</p>	Identical with Level(s) (EN 15978)	<p>Compliance: No.</p> <p>7 impact categories: Yes (GWP, ODP, POCP, AP, EP, ADPe, ADPf)</p> <p>2 resource categories: No. Instead, PETot, Sek are available.</p> <p>3 Waste categories: 0</p> <p>3 Output flows: 0</p> <p>Enhanced Level(s) support: Including missing available impact categories from Ökobaudat (data)</p>
6. Environmental data types	<p>Level 1: Generic data</p> <p>Level 2,3: Specific data for foreground processes, territorially representative data for background processes, validated and third party verified</p>	No definite data type specified, mostly informative guidance (EN 15978)	<p>Level 1 compliance: Yes, no rule given for foreground data</p> <p>Level 2 and 3 compliances: No. Background processes: Built-in Ökobaudat includes different data types, not all of which are third party verified</p> <p>Enhanced Level(s) support: Convenient manual integration of specific EPD. Tool indicates Ökobaudat data type (data)</p>
7. Life cycle scenarios	Scenarios for service life, adaptability and disassembly	<p>No defined criteria for adaptability and disassembly.</p> <p>Defined service life planning (ISO 15686-8)</p>	<p>Compliance: Yes, not defined.</p> <p>Enhanced Level(s) support: Service life: Rules for more specific service life planning Adaptability, disassembly: Guidance and tool integration (procedure guidance)</p>
8. Interpretation: Reliability ratings and critical review	<p>Three ratings:</p> <p>1. Basis for the performance assessment Checking representativeness and uncertainty regarding hot-spots, trade-offs between stages, data quality, assumptions, conclusions, sensitivity analysis, methods, transparency, consistency among other aspects</p> <p>2. Professional capabilities</p> <p>3. Independent verification</p> <p>Moreover a critical review according to ISO 14071, 14040, 14044, 14067.</p>	Interpretation and critical review are standardised in EN15978 and relevant ISO standards	<p>Compliance: Yes, partly supported (Hot-spot analysis, trade-offs between stages)</p> <p>Enhanced Level(s) support: Integrating possibility for declaring data quality and review procedures (procedure, reporting)</p>

#### 4. Conclusions

Even though Level(s) does not have the status of a technical standard, it is a step towards greater European harmonisation, especially when national policies and certification schemes are going to align to its common definitions.

Level(s) material LCA definitions are a combination of communicating main portions of content from existing standards and referring to other portions. Definitions or guidance missing in standards – Levels original definitions, tools and guidance – are taken from other initiatives and schemes worldwide. Structurally, Level(s) is a multi-source amalgam, which resembles certification schemes regarding their completeness, but does not define benchmarks.

The choice and structure of information on LCA given by Level(s) shall be more related to the assessment process and thus more accessible to the practitioner compared with standardisation. The tripartition of requirements is one of the features, which would provide more non-experts in LCA access to the approach. However, three levels result in a greater content volume packed into a single publication. Similarly, the classification of content into indicators, tools and scenarios has the potential of easing access, but is not communicated in a consistent way.

LCAbyg complies with Level(s)' material LCA requirements on level 1 and partly 2 and 3, except the lack of impact and resource categories. Compared to the volume of definitions and guidance Level(s) is providing, LCAbyg is a calculation tool, which is neutral regarding the purpose of assessment and the programmes or policies to be met. In order to support the use of the tool for making Level(s) assessments, more transparent data functions and programme-specific guidance may have to be considered.

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