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Level(s) indicator 2.1: Bill of Quantities, materials and lifespans

User manual: introductory briefing, instructions and guidance
(Publication version 1.1)

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Title
Level(s) indicator 2.1: Bill of Quantities, materials and lifespans user manual: introductory briefing, instructions and guidance (Publication version 1.1)

Abstract

Developed as a common EU framework of core indicators for assessing the sustainability of office and residential buildings, Level(s) can be applied from the very earliest stages of conceptual design through to the projected end of life of the building. As well as environmental performance, which is the main focus, it also enables other important related performance aspects to be assessed using indicators and tools for health and comfort, life cycle cost and potential future risks to performance.

Level(s) aims to provide a common language of sustainability for buildings. This common language should enable actions to be taken at building level that can make a clear contribution to broader European environmental policy objectives. It is structured as follows:

1. Macro-objectives: An overarching set of 6 macro-objectives for the Level(s) framework that contribute to EU and Member State policy objectives in areas such as energy, material use, waste management, water and indoor air quality.
2. Core Indicators: A set of 16 common indicators, together with a simplified Life Cycle Assessment (LCA) methodology, that can be used to measure the performance of buildings and their contribution to each macro-objective.

In addition, the Level(s) framework aims to promote life cycle thinking. It guides users from an initial focus on individual aspects of building performance towards a more holistic perspective, with the aim of wider European use of Life Cycle Assessment (LCA) and Life Cycle Cost Assessment (LCCA) methods.

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Figure 1. The Level(s) document structure

How this indicator user manual works

Level(s) is a framework of core indicators of sustainability that can be applied to building projects in order to report on and improve their performance. The supporting documentation has been designed to be accessible to all the actors that may be involved in this process.

If you are new to the assessment of building sustainability, we recommend reading the **first part of the Level(s) user manual**. This will provide you with an introduction to the basic concepts behind Level(s) and how you can apply it to a building project.

If you haven't yet set up your building project to use Level(s), including completing the project plan and the building description, then we recommend reading the **second part of the Level(s) user manual**.

This indicator user manual forms part of the third part of the Level(s) user manual where you will find instructions on how to use the indicators themselves. It is designed to help you apply your chosen indicator to a building project. It will help you to do this in the following way:

- **Introductory briefing:** This section provides an overview of the indicator, including:
  - ✓ why you may wish to measure performance with it,
  - ✓ what it measures,
  - ✓ at which stages in a project it can be used,
  - ✓ the unit of measurement, and
  - ✓ the relevant calculation method and reference standards.
- **Instructions on how to use the indicators at each level**: This section provides:
  - ✓ step by step instructions for each level,
  - ✓ what is needed to make an assessment,
  - ✓ a design concept checklist (at Level 1), and
  - ✓ the reporting formats.

  The instructions often refer to the guidance and further information section, which can be found after the instructions.
- **Guidance and further information for using the indicator**: This section provides more background information and guidance to support you in following specific steps in the instructions, including the design concepts introduced at Level 1 and the practical steps to calculate or measure performance at Levels 2 and 3. They are all cross-referenced to specific instruction steps at either level 1, 2 or 3.

This indicator user manual is structured so that once you are familiar with using the indicator and you know how to work with it, you may no longer need to refer to the guidance and background information, but only work directly with the instructions at the level of your choice.

Technical terms and definitions used

Term	Definition
Accessibility	The ability to allow for easy access to building components for disassembly, refurbishment, replacement, or upgrade.
Adaptability	The ability of the object of assessment or parts thereof to be changed or modified during its useful life to make it suitable to accommodate a new or adapted use.
Assembly	An arrangement of more than one material or component to serve specific overall purposes.
Building fabric	All construction works that are fixed to the building in a permanent manner, so that the dismantling or replacement of the product constitute construction operations.
Building component	A construction product manufactured as a distinct unit to serve a specific function or functions.
Disassembly	According to ISO/FDIS 20887:2020, it means the non-destructive taking-apart of a construction works or constructed asset into constituent materials or components (*note: the term disassembly should be considered as synonymous with "deconstruction", which is defined as the "removal of building elements from a demolition site in order to maximise their recovery and reuse" in the 2018 Guidelines for waste audits before demolition and renovation works of buildings.*).
Estimated service life	The service life that a building or an assembled system would be expected to have in a set of specific in-use conditions, determined from reference service life data after taking into account any differences from the reference in-use conditions.
In-use condition	Any circumstance that can impact the performance of a building or assembled system under normal use.
Material separation	An operation to separate materials, including mechanical, chemical or thermal processes (e.g. shredding, smelting, sorting etc.) other than dismantling or disassembly.
Preparing for re-use	According to the Waste Framework Directive, it means checking, cleaning or repairing recovery operations, by which products or components of products that have become waste are prepared so that they can be re-used without any other pre-processing.
Recovery	According to the Waste Framework Directive, it means any operation the principal result of which is waste serving a useful purpose by replacing other materials which would otherwise have been used to fulfil a particular function, or waste being prepared to fulfil that function, in the plant or in the wider economy. Annex II (to the same Directive) sets out a non-exhaustive list of recovery operations.
Recyclability	The ability of a waste product to be recycled, based on actual practices.
Recycling	According to the Waste Framework Directive, it means any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations;
Reference service life	The service life of construction product which is known to be expected under a particular reference set of in-use conditions and which may form the basis for estimating the service life under other in-use conditions.
Refurbishment	The modification and improvement of an existing building in order to bring it up to an acceptable condition.

Term	Definition
Re-use	According to the Waste Framework Directive, it means any operation by which products or components that are not waste are used again for the same purpose for which they were conceived.

Introductory briefing

Why measure performance with this indicator?

The construction and use of buildings in the EU account for about half of all our extracted materials[1]. As the energy efficiency of buildings improves, the embodied impacts of materials (e.g. CO2) and the cost of materials become more significant across the full building life cycle.

The information gathered for indicator 2.1 underpins the assessment of a number of other Level(s) indicators (especially 1.2, 2.2 and any Life Cycle Assessment (LCA) or Life Cycle Cost (LCC) analysis). This indicator, together with indicator 1.1, is crucial for the promotion of better building design that weighs resource use against the needs and functionality of the building[2].

Indicator 2.1 offers the possibility to:

- convert a bill of quantities (BoQ) into a bill of materials (BoM) that is compatible with reporting requirements on construction and demolition waste (link to indicator 2.2);
- factor in cost elements for each material/product purchased (link to LCC in indicator 6.1), and
- allocate specific lifetimes to each building element/material purchased relative to the planned lifetime of the building (link to indicator 1.2 and 6.1).

If a carbon footprint or LCA of the building is to be conducted, the data entered for the BoQ can be linked to EPD data or to appropriate datasets from lifecycle inventories (link to indicator 1.2 or LCA).

What does it measure?

Levels 2 and 3 of this indicator estimate and measure the mass of construction products and materials necessary to complete defined parts of the building (all of which are grouped under shell, core or external aspects of the building). For each entry, the mass is disaggregated into different material fractions (concrete/brick/tile, wood, glass, plastic, bituminous mixtures, metals, insulation materials, gypsum, mixed and EEE[3]). If optional cost data is entered, the costs of each entry will be measured. If optional lifespans are entered for each entry, the masses and costs of materials over the building lifetime can be measured, assuming a like-for-like replacement.

At what stage of a project?

Level	Activities related to the use of indicator 2.1
1. Conceptual design (choice of building form and main construction materials, elements and methods)	✓ For the conceptual design, information is provided to prompt discussion and decision making for the project about aspects that will directly or indirectly influence the choice of building structure and the main materials to use in the shell and core.
2. Detailed design and construction (based on drawings and estimations)	✓ During the detailed design and construction stages, estimates of BoQ can be compiled in an inventory following the Level(s) excel template.
3. As-built and in-use (based on invoices and site records)	✓ The material footprint of the as-built building can be calculated by compiling the real Bill of Quantities. Any replacement of building components (as they reach the end of their service lives, or for other reasons) can be recorded as part of monitoring in-use performance.

Unit of measurement

Data is reported in tonnes and % of total mass, with further splits by:

- material type (i.e. concrete, wood, metals etc.), and
- building aspect (i.e. shell, core or external).

Where optional cost data is entered, this is reported in units of thousand Euros (‘000 €) and is broadly split into shell, core and external aspects of the building. To allow for better comparability, the cost data are also

[1] COM(2011) 571 final. Roadmap to a Resource Efficient Europe
[2] COM(2014) 445 final. On resource efficiency opportunities in the building sector
[3] Electrical and electronic equipment.

normalised to €/t and €/m^2. The same units apply whether the BoQ is for construction only or for the duration of the projected building lifetime (i.e. including scheduled repair and replacement).

System boundary

In the context of the Module A-D life cycle stages set out in EN 15978, the indicator is generally focused on the A5 stage (construction & installation) of the building life cycle. However, the choice and quantities of materials have a strong influence on A1-A3 (product) and A4 (transport) stages for impacts associated with their manufacture and transport to site. If lifespans for different building elements and materials are factored into a "*lifetime BoQ*", module B (use stage) impacts also become relevant for any replacement materials bought in and module C (end-of-life) impacts for the materials that are disposed of.

Scope

The scope includes data for all construction products and materials that are purchased to construct or renovate the building. The relationship between the inputs to indicator 2.1 and other indicators is illustrated below.

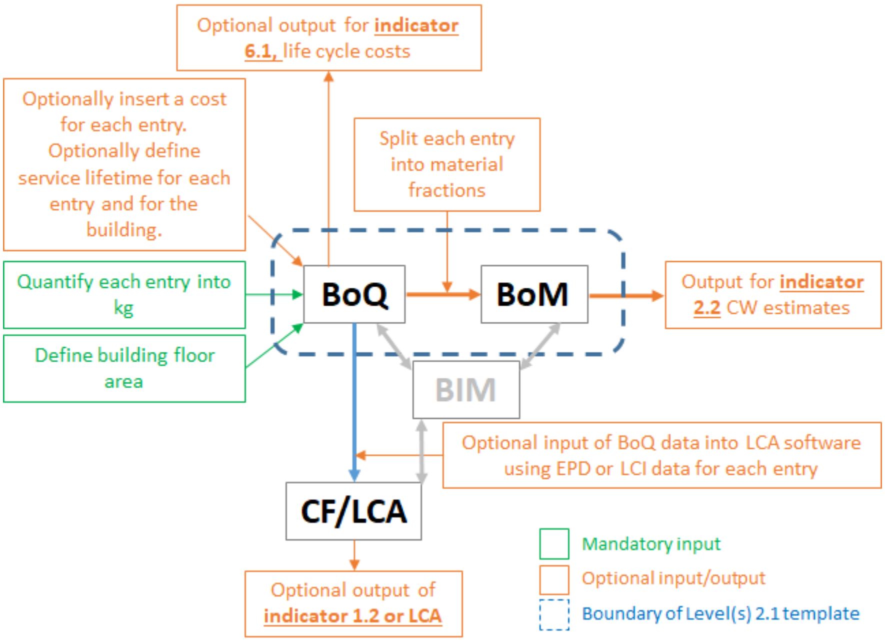

Figure 2. Illustration of inputs and outputs of indicator 2.1 and potential relationship with BIM

When correctly filled out, the data from indicator 2.1 will be suitable to use as a basis for making estimates of construction waste (CW) from the building project (relevant to indicator 2.2), provide material costs for indicator 6.1 (life cycle costs) and provide a basis for conducting a life cycle assessment (LCA) or carbon footprint (CF) in line with indicator 1.2.

It is worth noting that BIM (Building Information Modelling) is also capable of creating the same links as the Level(s) template for indicator 2.1 (and more). In cases where users are already using BIM, it may be more appropriate for them to continue using BIM software for data compilation and manipulation regarding the BoQ, BoM and associated costs and service life estimates.

Calculation method and reference standards

The calculation used for Levels 2 and 3 is based on the excel-based Level(s) reporting template for BoQ. Data in green cells must be entered and data in yellow cells is optional. In cases where the user intends to estimate CW, the user must define the split by % mass into one of 10 material fractions that are compatible with indicator 2.2 (Construction and Demolition Waste, CDW).

The excel template simply adds/multiplies numbers and allows them to be automatically reported (in red cells) and normalised (red cells) in ways that are aligned with the Level(s) reporting format.

When considering the optional service life data for each entry in the BoQ, the user is recommended to follow the rules in section 9.3.3 of EN 15978, ISO 15686-8, tools such as BCIS, DGNB or ETool, specific standards for specific elements (e.g. EN 15459 for heating systems) know-how gained from experience with such elements in similar buildings and circumstances.

Instructions on how to use the indicator at each level

Instructions for Level 1

L1.1. The purpose of this level

The focus of Level 1 is to make the reader aware of 6 highly relevant aspects for optimising the consumption of construction materials and products, regardless of whether they intend to compile BoQs at Level 2 or 3 or not. Users of Level(s) should then briefly describe how these aspects were considered (or not) during discussions and decision-making at the concept design stage in a summary table.

L1.2. Step-by-step instructions

These instructions should be read in conjunction with the accompanying Level 1 technical guidance and supporting information (see page 18).

1. Consult the checklist under L1.4 of material efficient design concepts and read the background descriptions in the Level 1 technical guidance.
2. Within the design team, review and identify how material efficient design concepts can be introduced into the design process.
3. Once the design concept is finalised with the client, record any material efficient design concepts that were taken into account using the L1 reporting format (see L1.5).

L1.3. Who should be involved and when?

At the concept design stage, the main actors would be the concept architect, the building owner and the relevant building authority that grants the permit for the construction or renovation activity.

Later in the project, a quantity surveyor (ideally independent of the contractor), the contractor and suppliers of construction elements and materials would need to be consulted to better understand the quantities that will need to be purchased and the potential service lives of each element/material.

L1.4. Checklist of relevant design concepts

Level 1 design concept	Brief description
1. Consideration of building form on inherent material efficiency of the structure.	Always within client specifications and within project constraints, a relevant example for housing developments would be the choice between blocks of flats, terraced houses and detached houses. Flats have inherent material savings due to a common roof and common structural elements, but structural columns will be larger and take-up a larger share of the floor space. Terraced houses have inherent material savings compared to semi-detached or detached houses due to common walls. With office buildings, taller structures generally have the inherent impacts as with taller blocks of flats but as very tall structures are reached (e.g. >30 storeys in steel structures, the extra material for lateral resistance becomes more dominant on the total structural mass.
2. For a given structural design – consider the scope for optimising material efficiency.	Within the constraints set by relevant Eurocode safety factors and the site (e.g. wind loads, seismic activity etc.), consider the potential to optimise the design loadbearing capacity of beams, columns and floor plates to match client needs.
3. Consider potential trade-offs and benefits of material efficient design options.	Aspects such as thermal mass, noise, solar gain, daylighting, speed of construction, cost and overall CO_2 footprint can all be influenced, positively or negatively, by efforts to reduce the material footprint for a given building design brief.
4. Durable and reparable building components and systems.	The service lives of all building components and systems should be considered in the context of the estimated building lifetime. More durable options should be considered where relevant. Design features that maximise the ease with which building components can be accessed, repaired, disassembled or

Level 1 design concept	Brief description
	removed (e.g. with minimum destruction of fit-out materials) should also be considered.
5. Optimum use of fit-out materials.	Where possible, obtain occupant specifications for fit-out materials before finalising the construction stage to avoid the use of speculative fit-out materials that will later be discarded. Consider the ease with which fit-out materials can be disassembled for potential re-use in other buildings.
6. Incorporation of recycled materials.	The specification of prefabricated construction products and materials with recycled content or the incorporation of recycled aggregates into ready mix concrete pours onsite.

L1.5. Reporting format

Material efficient design concept	Addressed? *(yes/no)*	How has it been incorporated into the building project? *(provide a brief description)*
1. Consideration of building form on inherent material efficiency of the structure.	Yes	The residential development has permission for up to 200 housing units no higher than 40m above ground level. A mixture of high-premium detached houses, semi-detached houses and more economical terraced houses and flats is foreseen. A high percentage share of terraced houses is planned, which delivers material savings via common sidewalls. The flats will be built 5 storeys high and with underground parking, which will increase the m3 of structural concrete per m2 living space. The floor to ceiling height has been reduced from the initial 3m to 2.7m, thus reducing required wall materials.
2. For a given structural design – consider the scope for optimising material efficiency.	Yes	A more material efficient solution for concrete floor slabs was chosen by the use of prestressed, voided slabs which comply with loadbearing requirements but are lighter. This uses less concrete in the slab itself and allowed smaller columns and foundations to be used.
3. Consider potential trade-offs and benefits of material efficient design options.	Yes	Although the prestressed, voided slabs deliver 25% material savings in terms of tonnes of concrete, the total amount of cement used in the slab was actually 5% higher overall for the lighter slab. Any cutting through the slab in future renovations will be more complicated. The reduction of floor-to-ceiling height by 10% will reduce space heating requirements but may lead to an increased risk of overheating and a poorer perception of indoor air quality.
4. Durable and reparable building components and systems.	Yes	Access to services (electrical wiring, phone line, drinking water, greywater, wastewater and radiator piping) shall be via removable floor and wall panels.
5. Optimum use of fit-out materials.	Yes	A range of standard fit-out materials will be offered for customers to choose from, forming part of the cost. Alternatively, they can decide on no fit-out materials and save 3 000 EUR from the purchase price.
6. Incorporation of recycled materials.	Yes	Structural concrete will incorporate a recycled aggregate content of 20%. Reinforcement steel will be at least 98% recycled and wood-based laminate flooring will have a recycled content of at least 30%.

Instructions for Level 2

L2.1. The purpose of this level

The purpose of Level 2 is to allow users to make an estimate of BoQ during the design stage. Approximate estimates will be required in the early design stages in order to ensure that budgetary limits are respected.

The Level(s) inventory template for BoQ provides a means to insert and manage the BoQ data. Furthermore, by entering optional cost data and lifespans, BoQ template can generate outputs that are useful for other Level(s) indicators.

L2.2. Step-by-step instructions

These instructions should be read in conjunction with the accompanying Level 2 technical guidance and supporting information (see page 23).

When estimating the BoQ for a project, steps 1-4 below should be followed:

1. Define the technical specifications and layout for the building. For example, structural design, floor plans, load-bearing capacities required and so on.
2. Download the Level(s) template for BoQ.
3. Consult with a structural engineer and quantity surveyor to draft up an outline BoQ for the building shell – following the instructions embedded within the Level(s) BoQ template. If sufficient information is available, estimates for core and external elements should also be entered.
4. As more specific information becomes available, refine the entries to the BoQ template.
5. *Optional step:* if also reporting estimated Construction Waste (CW) under indicator 2.2, use the excel-based Level(s) BoQ template to convert BoQ into BoM and make a simplified estimate of CW in the "*BoM (for construction)*" worksheet. Alternatively, parts of the BoQ data can be directly imported into the indicator 2.2 template for a more detailed estimate.
6. *Optional step:* if also reporting under indicator 6.1, enter estimated lifespans for each BoQ entry and use the BoM output (for lifetime) as a basis for estimating the cost of construction products and materials.
7. *Optional step:* if also reporting under indicator 1.2 or conducting an LCA, enter estimated lifespans for each BoQ entry and use the "*BoM output (for lifetime)*" worksheet as a basis for estimating the carbon and/or other life cycle impacts embodied in the construction products and materials across the building lifetime.

L2.3. What do you need to make an assessment?

The main items needed are as follows:

- ✓ A completed Level(s) building description.
- ✓ The excel-based Level(s) BoQ template (or BIM software) for compiling the BoQ.
- ✓ Relevant building documentation and design calculations relating to materials and dimensions.
- ✓ (optional) assumptions about the split of construction products and materials into different material fractions, the unit cost and estimated service life.

L2.4. Who should be involved and when?

The architect, building owner, planning authority and structural engineer should be involved in step 1. The structural engineer and quantity surveyor should be heavily involved in step 2. In steps 3 and 4, the structural engineer, quantity surveyor will need to consult with suppliers of construction products and materials. In the optional step 5, liaison with the relevant person or team responsible for waste management (the waste manager) will be necessary. Finally, in optional steps 6 and 7, further input from the architect and suppliers is strongly recommended.

L2.5. Ensuring the comparability of results

Normalising the results by m^2 helps to ensure comparability between different designs and even between different buildings. Cost data should not include labour as this can vary significantly from one country to another and is much more complicated to estimate compared to materials.

The comparison of projects simply by shell materials, which must be accurately known for all buildings in the as-built design, offers a deeper comparison between buildings which may have completely different core and external elements. For a better understanding of what is meant by shell, core and external elements, please see Table 2 in the guidance section.

L2.6. Going a step further

Optional steps 5, 6 and 7 all provide examples of how to go further with the BoQ data from indicator 2.1. They use the BoQ data as a basis for estimating Construction Waste, Life Cycle Costs and Carbon/other LCA impacts respectively. Some details about how to do this are provided in the guidance sections later (see page 24 onwards).

L2.7. Format for reporting the results of an assessment

The core outputs for BoQ are:

- Total quantity of materials used (tonnes and % split for ten predefined material fractions).
- Quantities of material used split by building aspect (tonnes and % split for shell, core & external elements)
- Cost of materials used split by building aspect (€ and % for shell, core & external elements)
- Normalised total material (in kg/m^2) and,
- Normalised total cost (in €/m^2).

The output that is automatically generated in the Level(s) excel template is shown in the screenshot below.

Bill of Quantities/ Materials (for building life time)							
Breakdown by material type			Breakdown by building aspect				Building floor area (m2)
			Shell	Core	External	Total	2500
	Material total (t)	Material total (%)	Split by mass (t)				Totals check (should = 0)
Concrete, brick, tile, natural stone, ceramic	3472	88.7%	3839.6	75	0	**3914.6**	0
Wood	71.25	1.8%	Split by mass (%)				
Glass	128.04	3.3%	98.1%	1.9%	0.0%	**100.0%**	
Plastic	3.75	0.1%	Split by cost '000 €				
Bituminous mixtures	0	0.0%	669.825	120	0	**789.825**	
Metals	239.56	6.1%	Split by cost (%)				
Insulation materials	0	0.0%	84.8%	15.2%	0.0%	**100.0%**	
Gypsum	0	0.0%	Total cost €/m2		Total cost €/t		
Mixed	0	0.0%	315.9		201.8		
Electrical and Electronic Equipmnt	0	0.0%					
Combined total	**3914.6**	**100.0%**					

Figure 3. Reporting format for 2.1 Bill of quantities, materials and lifespans

The only data that needs to be inserted is the total useful floor area in the green cell in the top right. This should be the same number used for the building description. All the numbers in red cells are automatically generated from the data entered into green and yellow cells in the data input worksheet.

The screenshot above is for outputs of materials used over the building lifetime (i.e. accounting for replacement of materials during the use phase). The exact same reporting format is also produced in a separate worksheet that only accounts for materials used during construction. Which worksheet to use will depend on the aims of the user.

Instructions for Level 3

L3.1. The purpose of this level

While Level 2 focusses on the purely estimated BoQ, Level 3 is based on actual quotations and purchases, where BoQ data is registered and logged as materials and products are procured and delivered to the site. A centralised record of purchases will be helpful to track spending in line with project budgets and schedules. The Level(s) inventory template for BoQ provides a means to insert and manage the BoQ data, not only for actual purchases, but also for other quotations received, for ease of comparison. As long as the same scope is defined (i.e. shell/core/external elements), Level 3 reporting allows a direct comparison to Level 2 estimates.

L3.2. Step-by-step instructions

These instructions should be read in conjunction with the accompanying Level 3 technical guidance and supporting information (see page 32).

When gathering actual BoQ data for a project, steps 1-4 below should be followed:

1. Download the Level(s) template for BoQ (the same worksheets apply for both Level 2 and 3).
2. Using the Level 2 estimates or other sources as a basis, gather quotations for the BoQ provided. Where practical, quotations from 3 different suppliers should be sought.
3. *(optional)* Fill out the "*Quotations*" worksheet in the BoQ Level(s) template for BoQ.
4. Directly insert or copy over the purchased material details into the "*BoQ input*" worksheet.
5. *(optional)* if also reporting under indicator 6.1, enter estimated lifespans for each BoQ entry and use the "*BoM output (for lifetime)*" worksheet as a basis for calculating the cost of construction products and materials.
6. *(optional)* if also reporting under indicator 1.2 or conducting an LCA, enter estimated lifespans for each BoQ entry and use the "*BoM output (for lifetime)*" worksheet as a basis for calculating the carbon and/or other life cycle impacts embodied in the construction products and materials across the building lifetime.

L3.3. What do you need to make an assessment?

The main items needed are as follows:

- ✓ Records of quotations sent by suppliers, together with technical details of the construction product or material in question.
- ✓ Purchase records and invoices for construction products and materials actually delivered to site.
- ✓ The Level(s) BoQ template (or BIM software).
- ✓ Optionally and only if going further, access to carbon footprinting or LCA software.

L3.4. Who should be involved and when?

The quantity surveyor and project manager are responsible for agreeing on the information to provide for step 1 and should be involved in steps 2, 3 and 4, together with the contractor. Manufacturers, suppliers or other relevant experts should be directly involved or consulted if the optional approaches in steps 5 and 6 are followed.

L3.5. Ensuring the comparability of results

Due to the identical reporting format, a direct comparison of Level 2 estimates and Level 3 actual data is possible. For any Level 2 and Level 3 comparison, it is important that the scope of BoQ is also comparable and that the scope of costs for any given BoQ entry is equal (i.e. material costs only? Or also including delivery to site? Or also including installation? etc.).

L3.6. Going a step further

Optional steps 3, 5 and 6 all provide examples of how to go further with the BoQ data from indicator 2.1. Step 3 shows that quotations could be logged and kept as part of valuable, commercially sensitive information that would help the company to make more accurate cost estimates in the future and keep track of the different suppliers with whom they have been in contact.

Steps 5 and 6 use the BoQ data as a basis for estimating Life Cycle Costs and Carbon/other LCA impacts respectively. Some details about how to do this are provided in the guidance sections later (see page 27).

L3.7. Format for reporting the results of an assessment

The core outputs for BoQ are:

- Total quantity of materials used (tonnes and the % split for ten predefined material fractions).
- Quantities of material used split by building aspect (tonnes and % split for shell, core & external elements).
- Normalised total material (in kg/m^2) and,
- Optionally the cost of materials used split by building aspect (€ and % for shell, core & external elements).
- Optionally the normalised total cost (in €/m^2).

These outputs, and the reporting format itself, is identical to that already described for Level 2. For this reason, to see a screenshot of the reporting format, consult the Level 2 instructions section L2.7.

Guidance and further information for using the indicator

For using level 1

Additional background guidance and explanations are provided for 3 key concepts introduced in the Level 1 design concept checklist, namely:

- L1.4 Checklist design concept 1: Consideration of building form on inherent material efficiency of the structure.
- L1.4 Checklist design concept 2: Optimising material efficiency for a given building form.
- L1.4 Checklist design concept 3: Potential trade-offs and benefits of material efficient design options**.**

L1.4. Checklist design concept 1: Consideration of building form on inherent material efficiency of the structure.

Building forms are not generally designed with the aim of optimising the BoQ. Nonetheless, because the building structure and other shell elements are generally the dominant influence on total material mass used, the building form does have an inherent impact on BoQ.

For residential buildings, Nemry et al. (2008)[4] and Cuéllar-Franca and Azapagic (2012)[5] identified that multi-family (semi-detached and terraced) and high-rise residential buildings tend to be more energy and material efficient than single-family dwellings. Moreover, this finding is also supported by Norman et al (2006)[6], who analysed building construction, use and associated transport using an economic input-output life cycle assessment model, and Steemers (2003) [7], who identified the potential to optimise the energy efficiency of the built form by increasing residential densities up to 200 dwellings per hectare (0.01 km^2).

The comparison below covers at least 80% of the material mass and clearly illustrates the positive relationship between compact form, fabric heat loss and material mass.

Table 1. Comparison of the material intensity of three residential forms (Cuéllar-Franca and Azapagic)

Key Variables	Detached home	Semi-detached home	Terraced home
LCA assumptions			
Household size (persons)	2.3	2.3	2.3
Bedrooms	4	3	2
Useable floor area (m^2)	130	90	60
Fabric heat loss (W/K)	220	170	120
Building materials (kg)			
Brick			
- Inner leaf	22,302	19,199	9,809
- Outer leaf	43,828	31,747	20,193
- Other	16,144	13,362	10,956
Cement mortar	11,662	8,447	5,373
Concrete			
- Block (aerated)	14,577	10,559	6,716
- Slab	19,615	16,157	13,094
- Other	15,600	10,824	7,200
Material total (kg)	**143,728**	**110,295**	**73,341**

4 Nemry et al (2008) *Environmental improvement potentials of residential buildings (IMPRO-Buildings),* Joint Research Centre IPTS, European Commission.

5 Cuéllar-Franca.R.M and A.Azapagic, *Environmental impacts of the UK residential sector: Life cycle assessment of houses*, Building and Environment 54 (2012) p.86-99

6 Norman.J, MacLean.H, and C.Kennedy, Comparing High and Low Residential Density: Life-Cycle Analysis of Energy Use and Greenhouse Gas Emissions, *Journal of Urban Planning and Development*, March 2006, Vol. 132, No. 1 : pp. 10-21

7 Steemers.K, Energy and the city, density, buildings and transport, *Energy and Buildings* 35 (2003) 3–14

The same examples were also cross-checked by the authors for trade-offs in the embodied GWP (Global Warming Potential) of the building lifecycle (of 50 years). The GWP totals were lower for materials, for energy and for transport in the more material efficient forms.

When comparing structural material footprints for 41 residential buildings and 29 office buildings, De Wolf et al., (2015)[8] found that specific structural material quantities varied much more in residential buildings (middle 50% ranging from around 350 to 1350 kg/m^2) than in office buildings (middle 50% ranging from around 400 to 700 kg/m^2). From this, it could be argued that the scope for optimising structural material efficiency in building structures is greater in residential buildings than in office buildings.

The effect of factors such as building size and height on structural material mass per m^2 floor area were also analysed by De Wolf et al., (2015). As buildings become taller, more steel is needed in the structure, as illustrated in the Figure below.

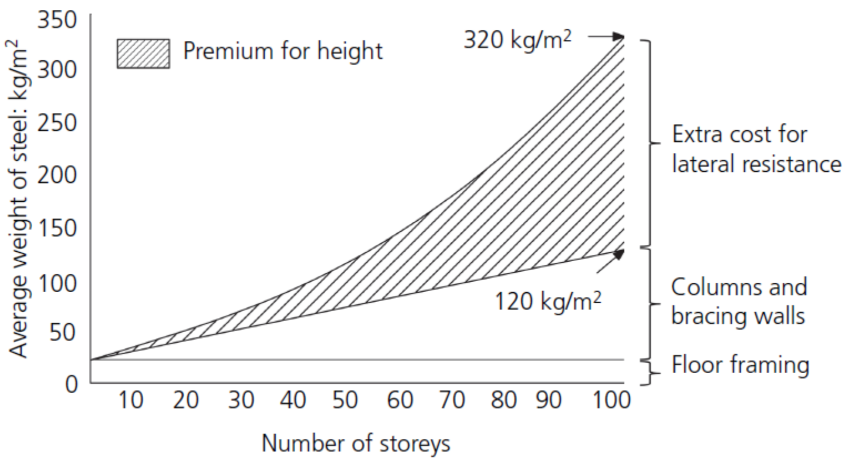

Figure 4. General relationship between specific quantity of structural steel and building height (no. of storeys)

From the Figure above, it is clear that the steel for floor framing remains constant on a kg/m^2, but that the relative amount of steel in columns and bracing walls (kg) increases more than the increasing floor area (m^2) as the building gets higher. From around 30 storeys and higher, the quantity of structural steel to resist lateral wind loads increases greatly.

A further analysis of data compiled by De Wolf shows the relationship between structural material quantities, embodied carbon and building height.

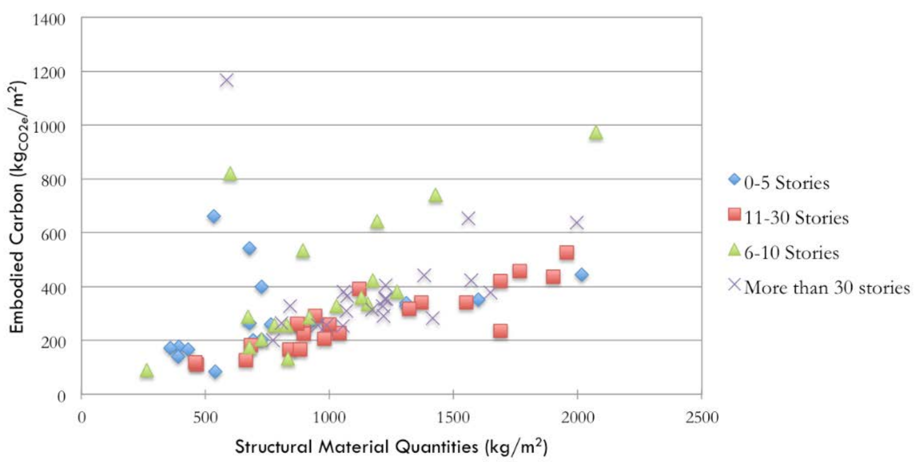

Figure 5. Relationships between building height, embodied CO_2 equivalents and Structural Material Quantities

[8] De Wolf C., Yang F., Cox D., Charlson A., Hattan AS., Ochsendorf J., 2015. Material quantities and embodied carbon dioxide in structures, *ICE Proceedings*, August.

There does seem to be some degree of correlation between structural material quantities (SMQ) and embodied carbon, both for the full group of data and for individual building height categories. However, the data does not show any clear relationship between higher buildings having higher SMQs, at least when the buildings are >5 storeys high.

One main finding from the literature was that it is better to improve material efficiency on a case-by-case basis, rather than selecting one specific building form or structural design over another. This is in part because improvements can be made for all building sizes and forms. This finding is supported by analysis by Arup (Kaethner and Burridge 2012)[9].

De Wolf (2015) furthermore suggests that material and embodied CO_2 equivalent metrics could be used as tools to encourage improved building design when benchmarked in comparison to other buildings of similar floor area, size and/or height.

L1.4. Checklist design concept 2 – Optimising material efficiency for a given building form

In general, the application of the Eurocode methodologies for structural design and the clients brief will dictate the structural design tolerances of a multi-storey building.

However, there is the possibility that structural engineers often over-specify structures and material structure grades when, with more detailed design calculations, significant structural material savings could be made without compromising the design and functional requirements.

For concrete structures, it is interesting to refer to the Concrete Usage Index (CUI)[10] as a metric and benchmark for similar building types (it is expressed as m^3 concrete/m^2 floor area). There are several possibilities for reducing the specific quantity of structural concrete. Some examples mentioned by the Concrete Centre (2018)[11] include:

- The use of flat slabs with equal spans (i.e. square) as much as possible.
- Use standard beam and slab forms (and formwork) for lower likely wastage rates.
- The use of post-tensioned slabs for longer spans (i.e. fewer columns) and thinner floors for a given loadbearing capacity compared to normal floor slabs.
- The use of voided floor slabs, which are lighter and can be supported by smaller foundations.
- The use of exposed concrete forms (floor, wall or ceiling) to reduce the later need for fit-out materials (this benefit does not actually impact on the value of structural materials).

Possible trade-offs need to be considered as well. For example, thinner slabs will present a lesser barrier to noise, and may require a false ceiling for maintaining acoustic performance of the building. Thinner slabs will require higher % contents of cement, which may completely offset the environmental impact of needing fewer m^3 of concrete in the slab.

For steel structures, the potential for savings in structural steel for 23 different building structures was reviewed by Moynihan and Allwood (2014)[12]. Steel columns and beams are supplied in standardised sizes and, when looking at a given structure, the design load placed on each element can be compared to the load that the steel section is designed to support. The utilisation efficiency of each beam within a given structure was analysed in order to determine the potential to reduce steel mass without compromising design performance requirements and safety factors.

[9] Kaethner SC. and Burridge JA., 2012. Embodied CO_2 of structural frames, *The Structural Engineer*, May.

[10] Building and Construction Authority (2012) *A guide on Concrete Useage Index*, BCA Sustainable Construction Series - 6, Singapore

[11] Material Efficiency, 2018. See: https://www.concretecentre.com/Publications-Software/Publications/Material-Efficiency.aspx

[12] Moynihan.M.C and Allwood,J.M, *Utilisation of structural steel in buildings*, Proceedings of the Royal Society, 470 (2014)

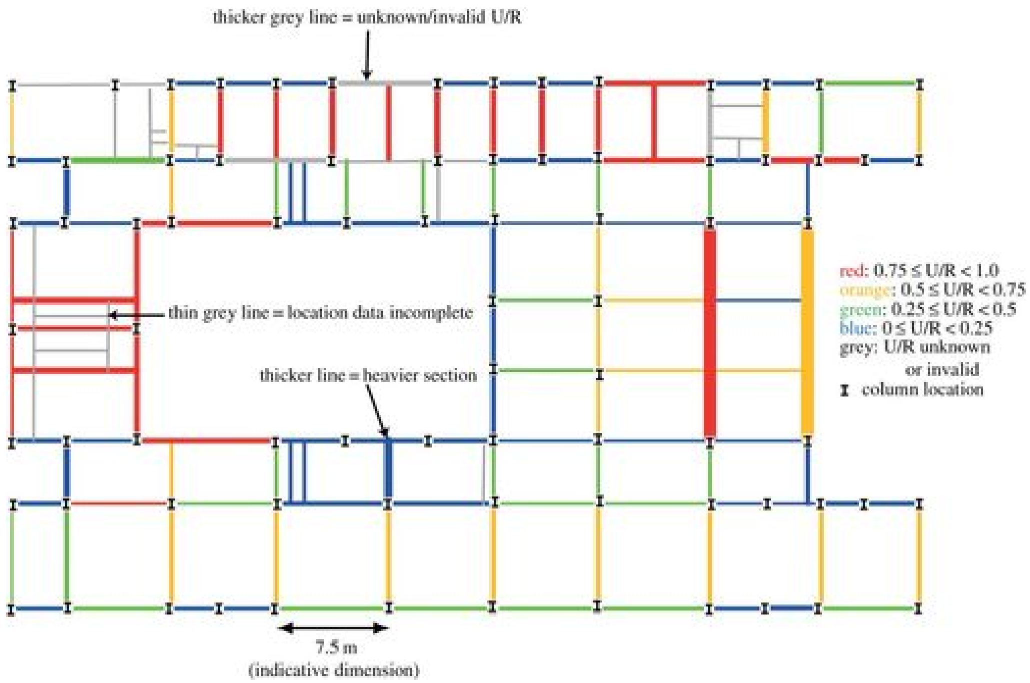

Figure 6. Example plot of floor showing U/R and section weight (Source: Moynihan and Allwood, 2014).

The study found that, on average, the utilisation rate of the beams analysed was less than 50% of their capacity. That is to say that their full load bearing capacity is not being utilised. A significant potential reason was identified as 'rationalisation' – the selection of beams based on availability, time and cost. Moreover, they suggest that aspects of structures are '*not explicitly designed*'.

Reference to a catalogue of standard beams during the analysis suggested that, on average, 36% of the beams' mass could be saved. To achieve this scale of saving they recommend the greater use of existing design and optimisation software. They also recommend that building assessment schemes incentivise improved utilisation rates, and that an initial step could be to '*mandate reporting of average UR* (Utilisation Rates).

L1.4. Checklist design concept 3: Potential trade-offs and benefits of material efficient design options

Prioritising structural material mass can deliver other environmental benefits but it is important to consider whether or not these benefits translate into, for example, reduced embodied carbon.

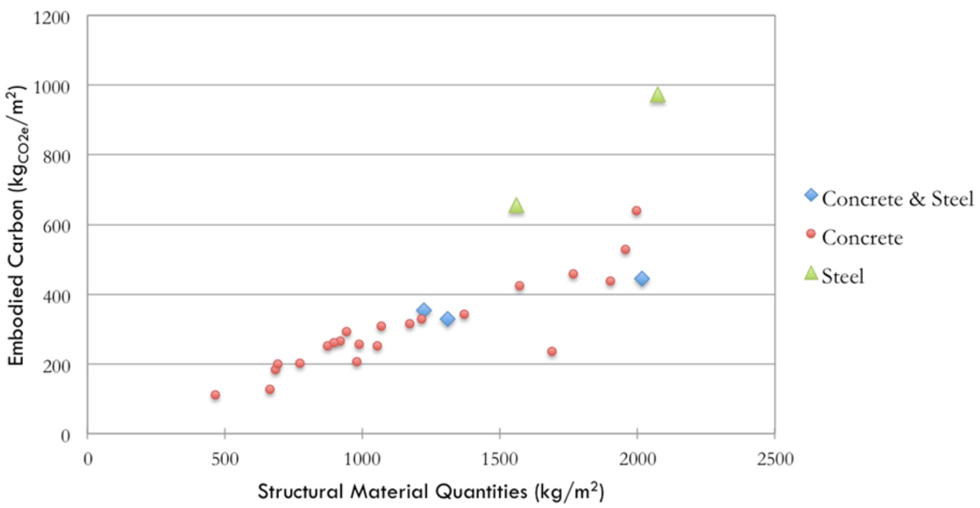

Figure 7. Relationship between structural material quantities and embodied carbon for residential buildings (Source, De Wolf, personal communication).

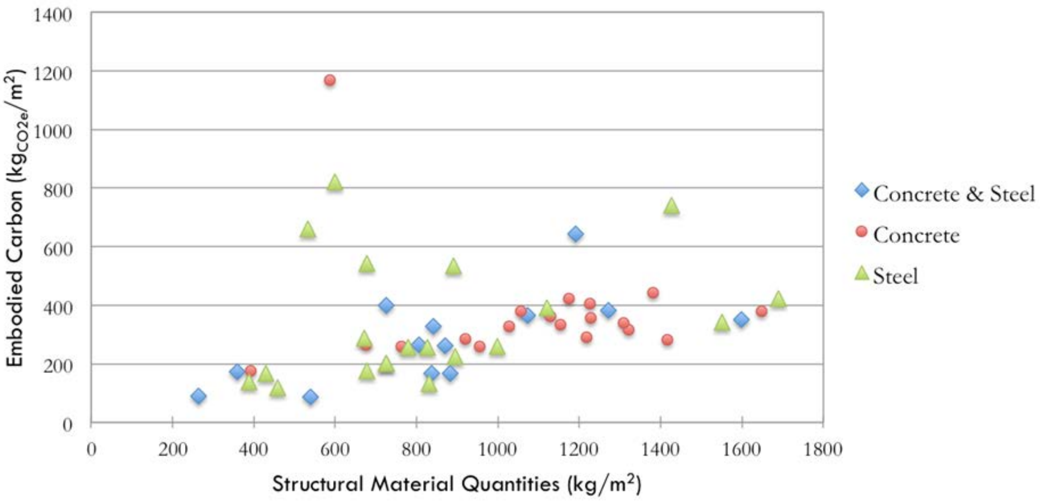

Figure 8. Relationship between structural material quantities and embodied carbon for office buildings (Source, De Wolf, personal communication).

Looking at the data above, it is clear that there is a strong correlation for residential buildings but only a slight correlation for office buildings.

The lower material footprints of residential buildings result from more compact building spaces which deliver embodied carbon reductions but more compact spaces can lead to adverse trade-offs with insufficient passive solar gain and daylighting, especially in northern climates (Strømen-Andersen and Sattrup (2011)[13] and Trigaux et al (2014)[14]).

[13] Strømen-Andersen.J and P.A.Sattrup, *The urban canyon and building energy use: urban density versus daylight and passive solar gains*, Energy and buildings, 43(2011) p.2011-2020

[14] Trigaux.D, Allacker.K and F.de Troyer, *A simplified Approach to integrate Energy Calculations in the Life Cycle Assessment of Neighbourhoods,* Submission to the 30th International PLEA Conference, 16-18 December 2014, CEPT University, Ahmedabad

For using level 2

Additional background guidance and explanations are provided for 6 steps introduced in the Level 2 instructions, namely:

- L2.2. Step 2: Quick overview of the Level(s) BoQ template
- L2.2. Step 3: BoQ data for "shell", "core" and "external" elements
- L2.2. Steps 3 and 4: How to fill out the Level(s) BoQ template
- L2.2. Step 5: (optional) going further, estimating BoM and link to indicator 2.2 (construction waste estimate)
- L2.2. Step 6: (optional) going further, estimating BoQ and costs over the projected building lifetime
- L2.2. Step 7: (optional) going further, linking BoQ to EPDs or Life Cycle Inventories to calculate carbon footprints and any other life cycle environmental impacts

L2.2. Step 2: Quick overview of the Level(s) BoQ template

The key worksheet for the user is the BoQ input. The Level(s) reporting format in the BoM worksheets are simply outputs of the BoQ input. A brief description of the worksheets is shown below.

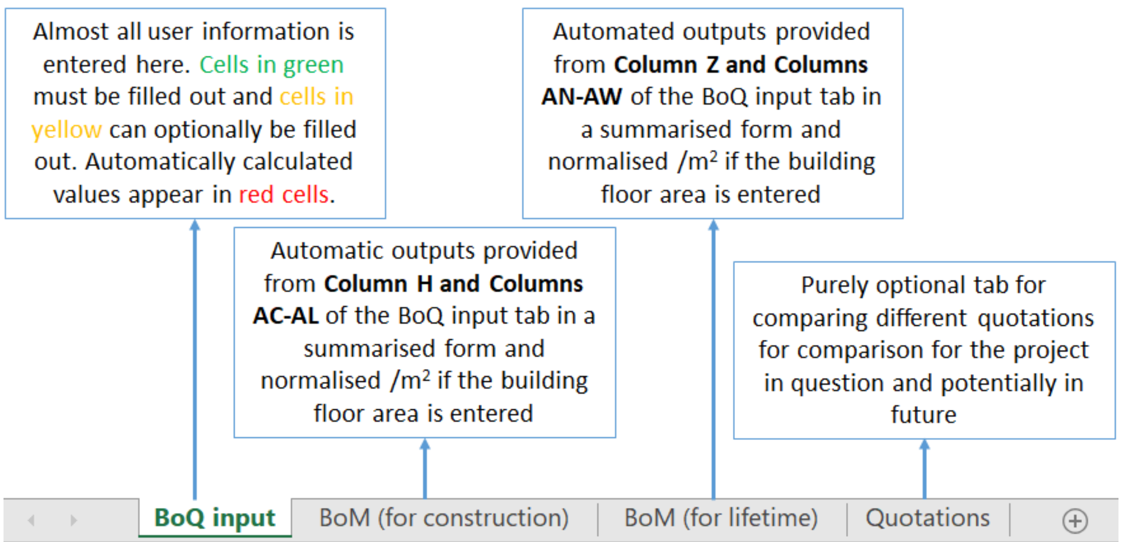

Figure 9. Description of the four main worksheets in the Level(s) excel template for indicator 2.1.

There are separate worksheets depending on whether the BoQ simply corresponds to the materials used for construction (look at outputs in the BoM for construction worksheet) or if the future replacement of materials during the projected building lifetime are accounted for (look at outputs in the BoM for lifetime worksheet).

L2.2. Step 3: BoQ data for "shell", "core" and "external" elements

To improve the consistency of reporting under Level(s) and the potential to compare "*apples with apples*" in different building projects, the following hierarchy for defining the scope of use of construction products and materials is recommended.

In all projects, for any BoQ inputs the top tier must be defined as "*shell*", "*core*" and "*external elements*". This is hard-wired into the excel-based Level(s) BoQ template. Users have the possibility to redefine or add new descriptions to the lower levels of the hierarchy, although this should be limited to the 3rd tier only, as far as possible.

Table 2. Explanation of different building elements and components that fall under the "shell", "core" and "external element" categories for reporting on BoQ.

Tier 1	Tier 2	Tier 3
Shell	Foundations (substructure)	(i) Piles; (ii) Basements; (iii) Retaining walls
	Loadbearing structural frame	(i) Frame (beams, columns and slabs); (ii) Upper floors; (iii) External walls; (iv) Balconies
	Non-load bearing elements	(i) Ground floor slab; (ii) Internal walls; (iii) partitions and doors; (iv) Stairs and ramps
	Facades	(i) External wall systems; (ii) cladding and shading devices; (iii) Façade openings (including windows and external doors); (iv) External paints, coatings and renders
	Roof	(i) Structure; (ii) Weatherproofing
	Parking facilities	(i) Above ground and underground (within the curtilage of the building and servicing the building occupiers)
Core	Fittings and furnishings	(i) Sanitary fittings; (ii) Cupboards, wardrobes and worktops (where provided in residential property); (iii) Ceilings; (iv) Wall and ceiling finishes; (v) Floor coverings and finishes
	In-built lighting system	(i) Light fittings; (ii) Control systems and sensors
	Energy system	(i) Heating plant and distribution; (ii) Cooling plant and distribution; (iii) Electricity generation and distribution
	Ventilation system	(i) Air handling units; (ii) Ductwork and distribution
	Sanitary systems	(i) Cold water distribution; (ii) Hot water distribution; (iii) Water treatment systems; (iv) Drainage system
	Other systems	(i) Lifts and escalators; (ii) Firefighting installations; (iii) Communication and security installations; (iv) Telecoms and data installations
External works	Utilities	(i) Connections and diversions; (ii) Substations and equipment
	Landscaping	(i) Paving and other hard surfacing; (ii) Fencing, railings and walls; (iii) Drainage system

Adapted from CEN (2011), BCIS (2012), DGNB (2014), BRE (2016)

The scope includes data for all construction products and materials that are ordered for the construction or renovation of the building. As a common minimum scope, it is recommended that all users should report on "*shell*" elements.

Construction products, materials and furnishings which are procured and installed by occupants who are not involved with Level(s) assessment should generally be considered as beyond the scope of reporting.

L2.2. Steps 3 and 4: How to fill out the Level(s) BoQ template

A screenshot of the first part of the BoQ input is shown below, together with the comments that are embedded into certain cells.

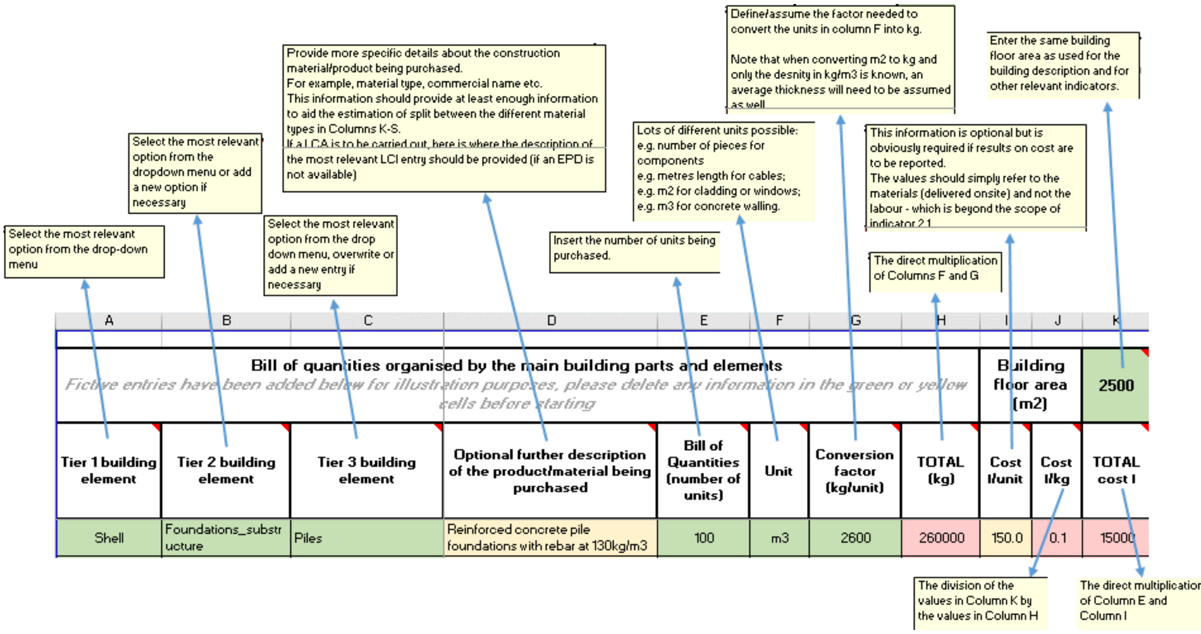

Figure 10. Screenshot of the first 8 columns that the user should fill in (in green and yellow).

Entries to the first three columns are from dropdown menus, an option needs to be first chosen from Column A, then Column B, then Column C. This is because the dropdown options in Column C are dependent on what has been selected in Column B, and the options for Column B are dependent on what is chosen in Column A. While the options in Column A are fixed (i.e. “shell”, “core” or “external element”), the dropdown options in Columns B and C can be overwritten. This will prompt a warning message, to which the user should simply click “OK”.

Column D is an optional free text entry. In reality, the user will always need to enter some additional information here. Such information could simply be commercial names of the products, a technical description of the product or material (especially if it is complex), minimum performance specifications and so on. If the user intends to use the BoQ as a basis for estimating embodied carbon or other life cycle impacts, then EPD data or a reference to the most relevant LCI description could be entered here.

The rest of the columns in the figure above refer to numerical inputs and simple mathematical operations.

L2.2. Step 5: (optional) Going further, estimating BoM and link to indicator 2.2

If the user wishes to convert the BoQ data into a useful format for estimates of Construction Waste (CW) for indicator 2.2, they need to estimate the % split of each construction product/material being purchased among the different material fractions in Columns M-V. For example, if 100 windows are ordered, how many kg of glass, metal and plastic is that? A screenshot of the relevant cells in the BoQ input worksheet, together with relevant embodied comments, is shown below.

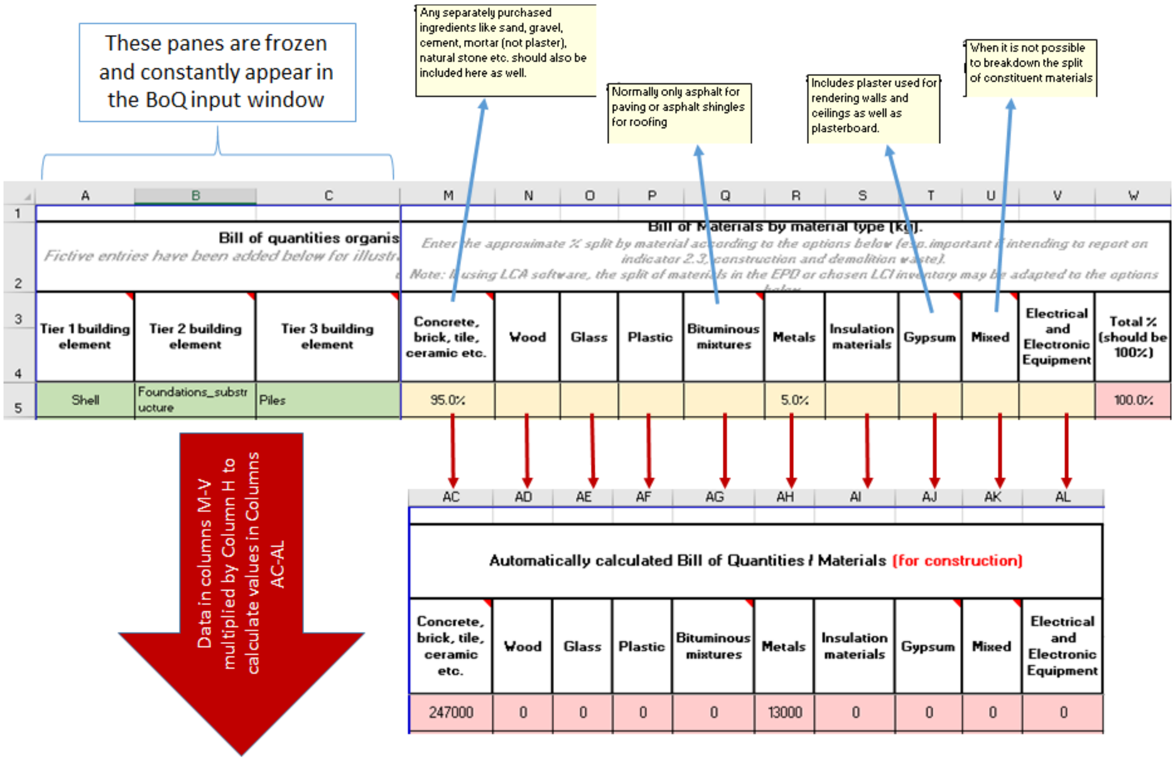

Figure 11. Screenshot of the next (up to 10) columns that the user may fill in (in yellow).

In cases where materials are purchased to mix concrete onsite (e.g. sand, gravel and cement), they should be reported as separate entries and each total summed under the concrete column. The example shown above is for reinforced concrete, where the weight is approximately 95% concrete and 5% steel reinforcement bar. As a quick check against any errors in the manual allocation of % splits, the values in Column W should sum to 100% for each row.

The percentage values in Columns M-V are then multiplied by the relevant total quantity (in kg) in column H, and translated into kg for each material fraction in Columns AC-AL in the same "*BoQ input*" worksheet.

The output data then appears in the reporting format (in both the "*BoM (for construction)*" and the "*BoM (for lifetime)*" worksheets), expressed in both mass and % splits among the 10 material fractions. A simplified Construction Waste (CW) estimate can be made in the "*BoM (for construction)*" worksheet if an average % of the BoQ for each material action that ends up as waste or over-ordered material is entered into the yellow cells in column O, see example screenshot below.

N	O	P	Q	R
Simplified estimate for Construction Waste				
	Assumed wastage/ over-ordering rate	Assumed waste type	Assumed LoW code	Total CW (t)
Concrete, brick, tile, natural stone, ceramic	15.0%	Inert	17 01 01	452.43
Wood	20.0%	Non-haz	17 02 01	3.56
Glass	15.0%	Inert	17 02 02	9.60
Plastic	10.0%	Non-haz	17 02 03	0.09
Bituminous mixtures	5.0%	Non-haz	17 03 02	0.00
Metals	8.0%	Non-haz	17 04 07	16.38
Insulation materials	20.0%	Hazardous	17 06 05	0.00
Gypsum	22.5%	Non-haz	17 08 02	0.00
Mixed	10.0%	Non-haz	17 09 04	0.00
Electrical and Electronic Equipment	10.0%	Hazardous	16 02 XX or 20 01 XX	0.00
	Inert	Non-haz	Hazardous	Total
Tonnes	462.03	20.04	0.00	482.07
% split	95.8%	4.2%	0.0%	100.0%

BoQ input | **BoM (for construction)** | BoM (for lifetime) | Quotations

Figure 12. Screenshot of the built-in simplified estimate of Construction Waste in the indicator 2.1 excel template

The above approach is simplified because it assumes a single wastage rate, a single waste type and a single waste code for each of the 10 waste fractions. In reality, these factors may vary for different materials/products that fall within the same waste fraction. Nonetheless, the simplified approach gives an idea of the probable split between inert, non-hazardous and hazardous waste generated.

If users wish to examine in more detail the potential for reuse, recycling and recovery of different waste fractions, it is necessary to transfer the BoQ data into the reporting template for indicator 2.2 (which reports in more detail on Construction and Demolition Waste). In this case, users should copy over relevant input BoQ data to the indicator 2.2 worksheet titled "*L2 CW estimate*".

2.3. LEVEL 2 (estimate): construction waste (CW) estimates based on Bill of Quantities (BoQ): DATA INPUT

Insert more rows if needed (*a non-exhaustive fictive example is provided below, which should be deleted before filling out*):

A	B	C	D	E	F	G	H	I	J	K	L	M	N
Building aspect	Construction project stage	Material / element identification	BoQ (number of units)	BoQ conversion factor (and optionally material cost)	BoQ (kg)	Estimated wastage & over ordering rate (%)	Estimated CW & over-ordered (OO) material (kg)	Optional: unit price (€ /kg)	Optional: "cost" of CW+OO	Nature of waste	List of waste code	Best outcome for CW (not excess materials)	Probable outcome for CW (not excess materials)
Shell	Foundations (substructure)	Poured concrete	500m3	1200kg/m3 (& 100€/m3)	600000	20.0%	120000	0.08	9600	Inert	17 01 01	Onsite recycling of pure stream(s)	Onsite recovery as backfill/ landscaping

L1 LoW info | L2 DW inventory-estimate | **L2 CW estimate** | L3 CDW measure

Figure 13. Screenshot of the data inputs needed (in green) for doing a ***full estimate*** *of CW in the indicator 2.2 spreadsheet.*

If the user wishes to use BoQ data as the basis for estimates of CW, the relationship between the inputs for the indicator 2.1 template and the indicator 2.2 template is as follows:

- Column A in 2.1 → Column A in 2.2
- Column B in 2.1 → Column B in 2.2
- Column D in 2.1 → Column C in 2.2
- *One of Column AC-AL in 2.1 → Column F in 2.2
- Column J in 2.1 → Column I in 2.2

** in cases where BoQ entries contain more than one material fraction (e.g. reinforced concrete having both concrete and metal fractions) simply entering the combined total value (Column H in 2.1) would not provide sufficient detail for the 2.2 CW estimate.*

In the case of reinforced concrete, the combined entry in 2.1 needs to be split into two entries in 2.2 (one for concrete, using the value from Column AC, and one for metal, using the value from Column AH). The same logic applies for any other multi-material BoQ entries.

L2.2. Step 6: (optional) Going further, estimating BoQ and costs over the projected building lifetime

A lifecycle cost (LCC) perspective is of particular interest for the building owner if they intend to rent or occupy the building for a long time. Level(s) allows users to report on LCC in indicator 6.1. One important contribution to the LCCs of buildings is the materials used, both during construction and in any maintenance interventions.

The Level(s) excel template for BoQ input under indicator 2.1 allows for a simplified estimation of additional costs of construction materials and products by optionally assigning an estimated lifetime to each entry and comparing this to the projected building lifetime. The template assumes a simple like-for-like comparison and no difference in costs in the future.

Costs should only cover the purchase price and delivery to site, but not any labour costs. A screenshot of the most relevant cells and their embedded comments is provided below.

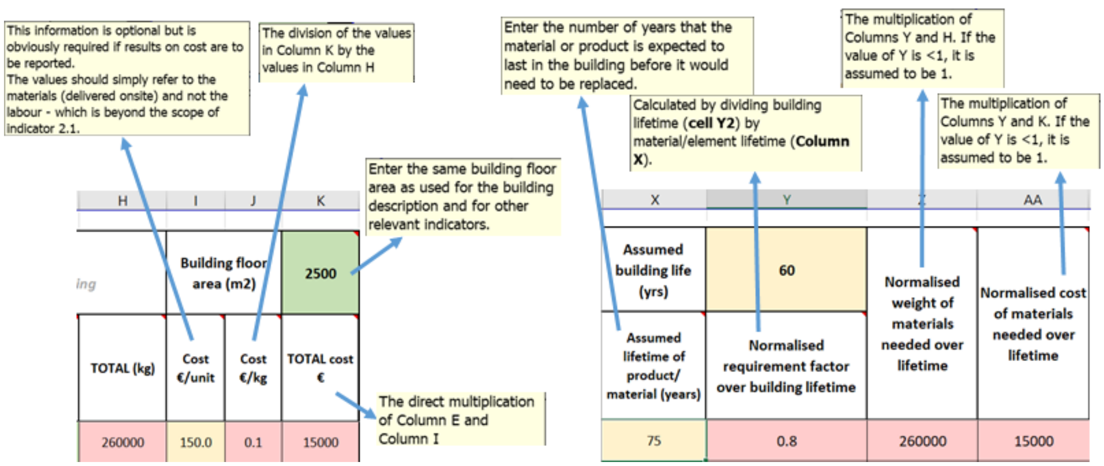

Figure 14. Screenshot of the relevant cells in the BoQ input worksheet for cost factors

In the screenshot above, the cells relevant to the cost of materials for construction only are shown on the left-hand side. All the numbers are based on a cost/unit price that is optionally entered in Column I. This is then multiplied by the total units purchased (in Column E, not shown above) to generate the value in Column K. Dividing the value in Column K by the value in Column H will generate the cost/kg, shown in Column J.

In order to account for the replacement of construction products and materials during the building lifetime, it is first necessary to define a projected building lifetime (cell Y2). A default value of 50 years is suggested. Then in Column X, it is necessary to assign an estimated useful life for each entry in the BoQ input. This will generate values in Column Y.

It is important to note that if the lifetime of the element is longer than the projected building life, a number < 1 will be generated in Column Y (e.g. the example in the screenshot above shows a value of 0.8). However, this does not mean that the calculation only accounts for 80% of that BoQ entry because in reality, the result over bill of materials over the building lifetime can never be less than the bill for construction only (e.g. compare numbers in Column H and Column Z in the screenshot above). To ensure that this does not happen, the calculation in Column Z automatically rounds up any value for Column Y that is < 1 to =1. In cases where Column Y values are > 1, the normalised lifetime factor is directly multiplied by the as constructed value (i.e. Column H x Column Y).

If a lifecycle BoQ is to be carried out by the user, the following sources of information should be consulted when estimating service lifespans for each entry into the BoQ input worksheet:

- Consult reported averages in tools such as BCIS, ETool or the DGNB building assessment scheme.

- The factor methodology prescribed in ISO 15686-8.
- Specific standards for specific materials/products/systems (e.g. EN 15459 for heating systems).
- Estimates from manufacturers based on durability tests and feedback from customers.
- Field experience from building professionals, building managers and portfolio managers.
- Generic lifespans from carbon footprinting or LCA tools.

In the absence of estimations from the above sources, the typical service lifespans in the table below may be used.

Table 3. Typical service lives for the minimum scope of building parts and elements

Tier 1 building aspect	Tier 2 building aspect	Tier 3 building aspect	Expected lifespan
Shell	Loadbearing structural frame	- Frame (beams, columns and slabs) - Upper floors - External walls - Balconies	60 years
	Non-load bearing elements	- Ground floor slab - Internal walls, partitions and doors - Stairs and ramps	30 years
	Facades	- External wall systems, cladding and shading devices - Façade openings (including windows and external doors) - External paints, coatings and renders	30 years (35 years glazed) 30 years 10 years (paint), 30 years (render)
	Roof	- Structure - Weatherproofing	30 years
	Parking facilities	- Above ground and underground (within the curtilage of the building and servicing the building occupiers) [15]	60 years
Core	Fittings and furnishings	- Sanitary fittings - Cupboards, wardrobes and worktops - Floor finishes, coverings and coatings - Skirting and trimming - Sockets and switches - Wall and ceiling finishes and coatings	20 years 10 years 30 years (finishes) 10 years (coatings) 30 years 30 years 20 years (finishes) 10 years (coatings)
	In-built lighting system	- Light fittings - Control systems and sensors	15 years
	Energy system	- Heating plant and distribution - Radiators - Cooling plant and distribution - Electricity generation - Electricity distribution	20 years 30 years 15 years 15 years 30 years
	Ventilation system	- Air handling units - Ductwork and distribution	20 years 30 years
	Sanitary systems	- Cold water distribution - Hot water distribution	25 years

[15] If the share of underground car parking (usable area plus traffic area) accounts for more than 25% of the total useful floor area, the traffic area of the underground parking must be subtracted from the total useful floor area.

Tier 1 building aspect	Tier 2 building aspect	Tier 3 building aspect	Expected lifespan
		- Water treatment systems - Drainage system	
	Other systems	- Lifts and escalators - Firefighting installations - Communication and security installations - Telecoms and data installations	20 years 30 years 15 years 15 years
External works	Utilities	- Connections and diversions - Substations and equipment	30 years
	Landscaping	- Paving and other hard surfacing - Fencing, railings and walls - Drainage systems	25 years 20 years 30 years

Source: Adapted from RICS (2017) and ETool (2017)

Whatever source is used for estimating the service lifespan, it should be specified.

The outputs for the BoQ and BoM over the building lifetime appear on a separate worksheet titled "***BoM (for lifetime)***". As with the "*BoM (for construction)*" worksheet, if a split is desired for the different material fractions, it is necessary to estimate the % splits of each BoQ entry into the 10 different material fractions defined in Columns M-V of the BoQ input worksheet.

Users that wish to take a more sophisticated approach to assess lifetime BoQs and associated costs should use bespoke software or calculators. One particular relevant example is the EU-funded CILECCTA project[16], which has developed a software tool that allows users to analyse future scenarios for different building configurations and the influence that these scenarios would have on cost and environmental impacts.

The user may define, ideally based on professional knowledge and experience, the local market conditions, their probability of occurring during a defined study period, and building specifications that can allow for adaptation to potential future changes in market conditions. Examples include the potential for increasing the height of a building or changing the primary uses of a building.

Present and future costs for adaptations can be defined, to then be triggered by runs of the model over a defined period of time using a Monte Carlo simulation. In this way, the net present cost of different adaptability measures can be evaluated based on reasoned assumptions about the future market conditions.

The CILECCTA software tool is available in a trial Beta form via an online platform. Access for non-commercial use can be requested from the software's designers.

L2.2. Step 7: (optional) Going further, linking BoQ to Environmental Product Declarations (EPDs) or Life Cycle Inventories (LCIs) to calculate carbon footprints and any other life cycle environmental impacts

For the sake of accurately estimating the embodied CO2 and any other relevant life cycle impacts, it is necessary to associate each BoQ entry with a more detailed breakdown of BoM than the 10 material fractions provided in the Level(s) BoQ template.

Greater detail that links to or results in environmental impacts being estimated can be obtained by consulting any associated EPD that is provided with the construction product or material that is purchased.

In the absence of an EPD, the identification of a suitable product or material from an inventory associated with a LCA database. Such inventories will support a more comprehensive assessment of the life cycle inventory flows and

[16] CORDIS (2014) *CILECCTA Report Summary* http://cordis.europa.eu/result/rcn/141443_en.html

associated environmental impacts. An example of the options that could appear in an LCA software package for window frames is shown below.

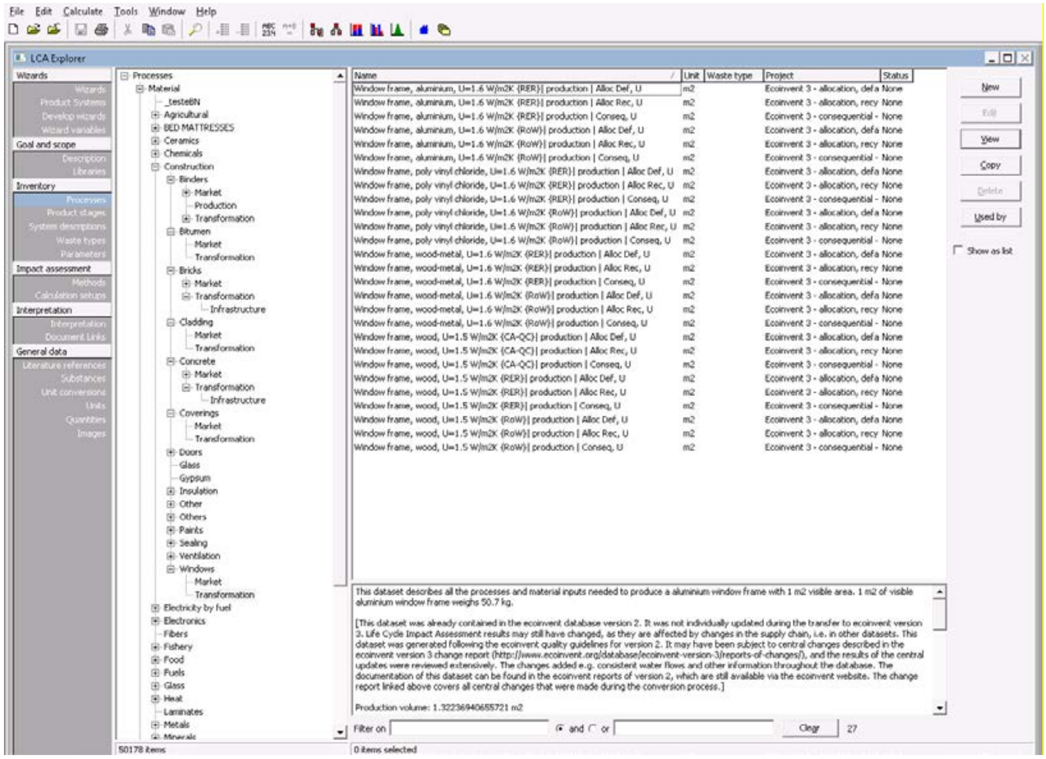

Figure 15. Screenshot of window frame options in an LCA software package

The screenshot shows that in this particular software package, selecting the menu heading "processes", then "materials" and then "construction", reveals a broad range of construction materials and products to choose from.

When selecting "windows", more than 20 options are available, with frames made of aluminium, PVC, wood-metal or just wood. For each window frame material, there are different choices to be made depending on whether the LCA study is to be allocational or consequential. A certain level of expertise in LCA will be needed to make consistent and compatible choices of life cycle inventories for relevant construction products and materials. A second example is shown below for concrete.

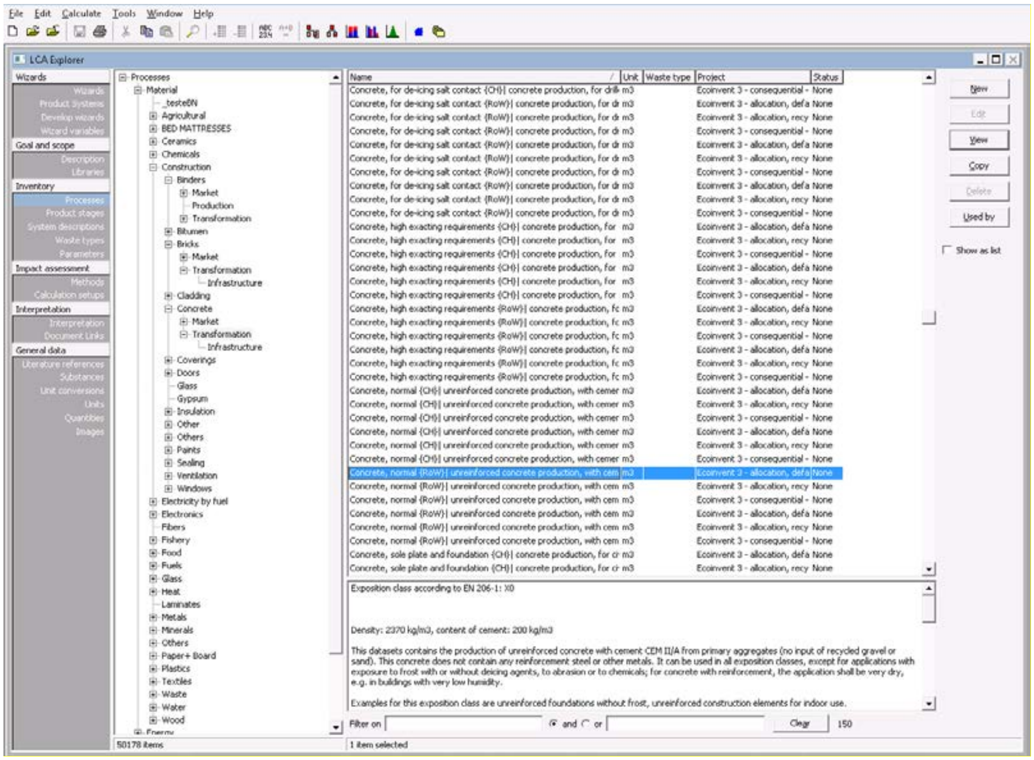

Figure 16. Screenshot of concrete options in an LCA software package

Once a representative dataset has been identified from within the LCA database, the material inputs listed on screen need to be matched up to inventory flows of inputs and outputs associated with the production of each material using the LCA software. This will generate what is called a 'reference flow' for the target building element. Where complex building elements with many component parts are being modelled, it might be necessary to continue the analysis at the level of the components and sub-components.

Table 4. Concrete material inputs for life cycle inventory selected

Products	**Amount**	**Unit**
Normal concrete produced with cement CEM II/A (Average World's conditions)*	1	m^3
Material resources	**Amount**	**Unit**
Lubricating oil	0.02	Kg
Sand	720	Kg
Concrete mixing factory	4.17E-07	P
Gravel, round	1280	Kg
Synthetic rubber	0.12	Kg
Tap water (CA-QC)	0.1912	Kg
Tap water (Europe without Switzerland)	67.95	Kg
Tap water (Rest of the World)	101.9	Kg
Cement, alternative constituents 6-20%	20.82	Kg
Cement, alternative constituents 6-20%	179.2	Kg

(*) Notes: Exposition class according to EN 206-1:X0, density: 2370 kg/m^3, cement content: 200 kg/m^3

Each material resource will have its own production processes and associated material resource footprint. Due to the large range of possible material inputs and the underlying assumptions associated with each of them, any inputs from EPDs or lifecycle inventories should be managed separately via a compatible LCA software package and not in the Level(s) BoQ inventory template.

The outputs for such analysis will be different life cycle impacts, for example Global Warming Potential (directly relevant to indicator 1.2) and other life cycle impacts such as acidification potential, ozone depletion potential etc. (directly relevant when a building-level LCA is carried out).

As mentioned at the end of the L2.2 step 6 guidance (see page 29), the use of the CILECCTA software tool could also be a relevant way to assess environmental impacts of the building for different building use scenarios.

For using level 3

Additional background guidance and explanations are provided to support the measurement of the bill of quantities and materials at Level 3. Since much of this guidance is identical to that provided for Level 2, in such cases, readers are simply referred to the relevant section of the Level 2 guidance.

- L3.2. Step 2: Quick overview of the Level(s) BoQ template (see L2.2. guidance for step 2).
- L3.2. Step 3a: BoQ data for "shell", "core" and "external" elements (see L2.2. guidance for step 3).
- L3.2. Step 3b: Quick overview of the Level(s) "Quotations" worksheet.
- L3.2. Steps 3 and 4: How to fill out the Level(s) BoQ template (see L2.2. guidance for steps 3 and 4).
- L3.2. Step 5: (optional) going further, estimating BoQ and costs over the projected building lifetime (see L2.2. guidance on optional step 6).
- L3.2. Step 6: (optional) going further, linking BoQ to EPDs or Life Cycle Inventories to calculate carbon footprints and any other life cycle environmental impacts (see L2.2. guidance for optional step 7).

L3.2. Step 3: Quick overview of the "Quotations" worksheet

Since the Level(s) excel template for BoQ is the same for Levels 2 and 3, the reader is referred to the guidance section for Level 2 in order to familiarise themselves with the template.

However, some specific guidance is provided below about the "*Quotations*" worksheet in the Level(s) excel template for BoQ. A screenshot of the worksheet is shown below.

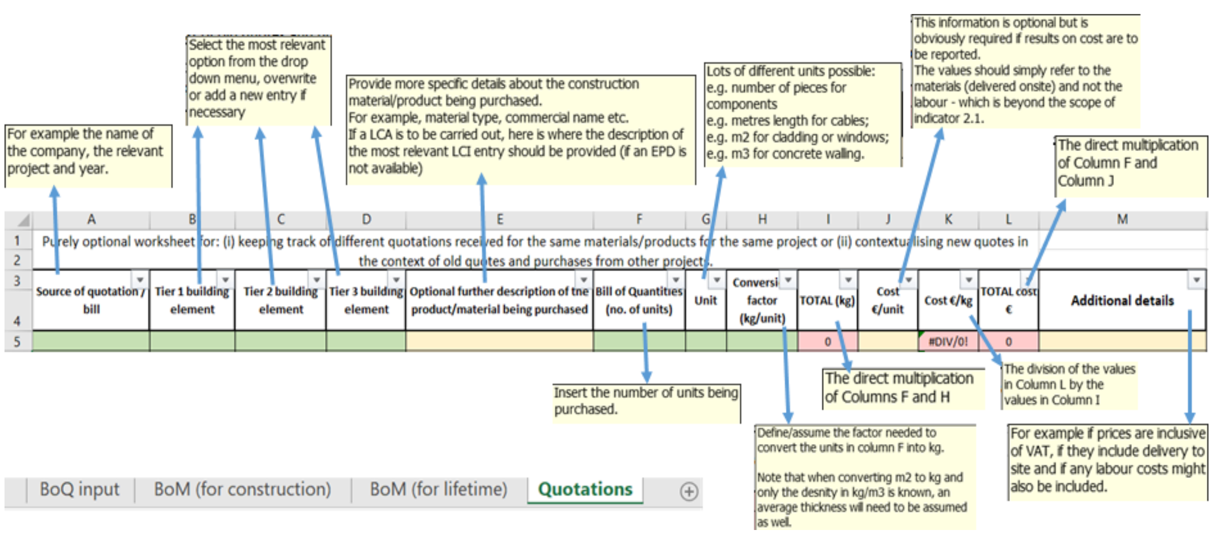

Figure 17. Screenshot of "Quotations" worksheet from the Level(s) excel template

The quotations worksheet allows multiple quotations for the same BoQ requirement to be placed next to each other. In reality, quotations will not arrive simultaneously. Nonetheless, if the entries in Column E are consistent when deciding to obtain quotations for a given BoQ requirement, the Column E entries can be sorted from A-Z or even be filtered so that all relevant quotations for that BoQ requirement are listed next to each other.

The entries in Column A are specific to the quotations worksheet. The entry should be what is sufficient for the user to follow up the quotation (e.g. name of company, contact details and so on). Further details could be entered in the additional details section in Column M.

Columns B-L of the "*Quotations*" worksheet are identical to Columns A-K of the "*BoQ input*" worksheet and can be copied directly over.