Sustainability assessment of a Flemish office building with Level(s): a Level 1 assessment

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Abstract. Recently, Level(s) has been developed by the European Commission as a common EU framework to assess sustainability of buildings with the intention to provide a consistent and comparable framework across national boundaries. It aims at providing a general language for sustainability for buildings and to promote life cycle thinking. This paper describes the application and results of a Level 1 assessment for the design stage of a Flemish office building. Level 1 is a common performance assessment which aims to be used amongst others by building professionals. Common standards and simplified methods are used for the indicators. The paper focusses on the experiences of testing the method by evaluating the user-friendliness of the assessment method for architects considering the information and calculations needed. The added value of applying the methodology in the design stage is furthermore discussed. Based on the test phase, further improvement is recommended by aligning current national tools for data gathering and by providing default values. A Level 1 assessment allows to gain insights in various performances of a building but does not aim to evaluate the "sustainability" level. A level 2 assessment is probably more useful for practitioners to make well-founded choices between different design options.

1. Introduction
The building industry, being one of the biggest waste creators and energy consumers, started to pay significantly more attention to sustainable buildings during the past decades. Since the first mentioning of sustainable development in 1987 in ‘Our Common Future’, the assessment of sustainable development in the building sector has gone through an evolution [1]. Different stakeholders have to make informed decisions in order to meet sustainability goals [2]. Hence, sustainable building had to become ‘measurable’. John Elkington defined the three fundaments of the Brundtland report as ‘triple P’ (People, Planet and Profit) in 1994 [3], but without defining the importance of each the three pillars. Based on personal interests and views on society, different attitudes towards sustainable development have appeared, reflected in a proliferation of sustainability assessment methods for buildings [4].

Worldwide, more than 600 sustainability tools are available for products and buildings [2]. The United Kingdom developed the first one for buildings, called BREEAM, in 1990. After that, western Europe (e.g. HQE) and North America (e.g. LEED) followed in the 1990's, Asia (e.g. CASBEE) in the 2000's and finally South America (e.g. Processo AQUA) in 2008 [2]. At first, single indicator metrics were developed in order to assess for example CO2 emissions or construction waste [4]. Gradually, the evaluation methods and related tools became more complex and evolved to more holistic and comprehensive approaches. Eventually, the idea of life cycle analysis was introduced to prevent burden
shifting between different domains and life cycle phases [4]. The nature of the different tools can be categorized into two groups: quantitative and qualitative tools. However, due to a lack of international regulations, different national assessment frameworks have been developed with each their own focus, amongst others Active House (Denmark 2017), DGNB (Germany 2007), Milojöbyggnad (Sweden 2005) and GRO (Belgium 2017) [2,5].

To respond to the concern of the proliferation of assessment methods in Europe, the Level(s) framework for environmental impact assessments was developed by the Joint Research Centre (JRC) in close co-operation with industry stakeholders [6]. The EC aimed for a consistent and comparable framework across national boundaries as well as for promoting life cycle thinking. Level(s) features three different assessment levels: the common performance assessment (Level 1), the comparative performance assessment (Level 2), and the optimized performance assessment (Level 3). Level(s) can be used during different phases in the design process as well as for the post-occupancy phase. The framework is launched in 2018 and is currently going through a two-year test phase to get insights in cost, application and time implications.

This paper discusses the application of a Level 1 assessment for the design stage of a Flemish office building and describes the experiences of testing the method by evaluating its user-friendliness for building practitioners. The added value of applying the methodology in the design stage is furthermore discussed by showing how the results might influence decision taking. The scope of the paper is limited to the indicators which are closely related to life cycle assessment and life cycle costing. Further, only the most relevant results are shown due to the limited pages available.

2. Methodology

2.1. Level(s) framework

The Level(s) framework comprises assessment criteria related to six macro-objectives (see Table 1) of the EC in the field of sustainable building: (1) reduction of greenhouse gas emissions along the building life cycle, (2) increased resource efficiency and circular material life cycles, (3) increased efficient use of water resources, (4) provide healthy and comfortable spaces, (5) adaptation and resilience to climate change, and (6) optimized life cycle cost and value. The six macro-objectives can be linked to the three previously mentioned pillars of sustainability as indicated in Table 1. Indicator 2.4 ‘Cradle to cradle life cycle assessment (LCA)’ is an overarching assessment method which covers the first three macro-objectives [7].

Table 1. Overview of the Level(s) macro-objectives and indicators to be assessed.

| Pillar       | Macro-objective                                    | Indicator                                                                 |
|--------------|----------------------------------------------------|--------------------------------------------------------------------------|
| PLANET       | 1 Greenhouse gas emission along a building life cycle | 1.1 Use stage energy performance                                         |
|              | 2 Resource efficient and circular material life cycles | 1.2 Life cycle global warming potential                                    |
|              |                                                    | 2.1 Building bill of materials                                            |
|              |                                                    | 2.2 Scenarios (3) for lifespan, adaptability and deconstruction          |
|              |                                                    | 2.3 Construction & demolition waste and materials                        |
| PEOPLE       | 4 Health and comfortable spaces                    | 3.1 Use stage water consumption                                           |
| PROFIT       | 5 Adaptation and resilience to climate change      | 4.1 Indoor air quality                                                   |
|              |                                                    | 4.2 Time out of thermal comfort range                                     |
|              |                                                    | 4.3 Lighting and visual comfort                                           |
|              |                                                    | 4.4 Acoustics and protection against noise                               |
|              | 6 Optimized life cycle cost and value              | 5.1 Scenarios for projected future climatic conditions                   |
|              |                                                    | Potential future aspects:                                                |
|              |                                                    | 5.2 Increased risk of extreme weather events                             |
|              |                                                    | 5.3 Increased risk of flood events                                      |
|              |                                                    | 6.1 Life cycle cost                                                      |
|              |                                                    | 6.2 Value creation and risk factors                                      |
Most of the indicators are further divided in sub-indicators, which are described more detailed in section 3. As this paper focusses on the indicators which are closely related to life cycle assessment and life cycle costing, the indicators belonging to macro-objective 4 and 5 are not further discussed. A reporting excel file is available and used (version Beta v1.1) for this Level 1 assessment.

In addition to the sustainability indicators, also a data quality indicator is included in Level(s), entitled “reliability rating of the performance assessment” [8]. This indicator must be evaluated for each of the sustainability indicators assessed, but is not further elaborated in this paper.

2.2. Case study building - BelOrta

The BelOrta office building is located in Sint-Katelijne-Waver in Flanders (Belgium) and has a net floor surface of approximately 3000m². The office is designed by the architectural office ar-te and is finished in 2014. The building is an extension to the existing auction hall of the BelOrta company. The two-floor building has a compact layout with an inner courtyard and consists of landscape and cellular offices, and meeting rooms. It is seen as a representative Flemish office building regarding building typology, energy performance and technologies. For the Level(s) assessment, the scope was limited to the building itself excluding external works. This case study was selected because of previous analysis. Hence, all of the building data was already inventoried based on a BIM-model, bill of materials, performance documents and technical information sheets. It moreover allows to compare the results of the Level(s) testing with results obtained using other assessment methods such as the Belgian method GRO and the EC PEF (Product Environmental Footprint) method. A detailed description of the case is not included in the paper but can be found in [9] and [10]. Although the building is already in use, the design stage documents are used for the assessment as an assessment during the design stage is focussed on.

2.3. MMG+_KULeuven tool

As shown in table 1, the Level(s) framework requires to perform a cradle to cradle environmental life cycle assessment (criterion 2.4) and financial life cycle costing (criterion 6.1) of the building. National tools in line with EN 15978 [11] and EN 15804 [12] can be used for this assessment. For the cradle to cradle life cycle assessment and life cycle costing the excel-based MMG_+KULeuven tool has been used. The latter uses the Belgian LCA method for buildings, called the MMG method (“Environmental profile of building elements”) [13] and allows to calculate financial life cycle costs too. The MMG method is in line with the European standards EN 15804 and EN 15978, but considers ten additional impact categories (in line with the recommendations of the International reference Life Cycle Data (ILCD) Handbook). For the life cycle inventory, the Ecoinvent database (version 2.2) is used. The life cycle stage of module D (as referred to in the EN15978 standard) is currently not considered in the MMG method [13]. The life cycle cost calculation in the MMG_+KULeuven tool includes material and labour costs based on data from the ASPEN database [14] and the British Spon’s Price Books External Works and Landscape Price Book [15], with 2015 as reference year. The financial cost is calculated as the sum of the present values of all costs occurring during the life cycle of the building.

3. Application

This section describes the application of the different indicators for the Level 1 assessment. An overview is given of the requirements to perform this assessment and the repercussions for architectural firms.

3.1. Indicator 1.1: Use stage energy performance

The use stage energy performance requires information about the primary and delivered energy demands for spatial heating, cooling, ventilation, production of hot water and lighting. In case the energy calculation method used is able to calculate unregulated energy uses (e.g. electricity use for appliances, elevators …), a section with ‘small power’ and ‘other uses’ is provided.
For the Belgian case, the energy performance is calculated based on the NBN EN 15603 with the EPB software Flanders version 1.8.5. Such calculation is required in Belgium during the design stage and was hence provided by the architectural firm. For the primary energy demands, the EPB calculations suffice to fill in the required data for Level(s) (see Table 2) but some small additional calculations are needed (e.g. breakdown of auxiliary energy use). Further, the delivered energy demand differentiated between the different energy sources used is asked for (e.g. renewable and non-renewable electricity use, fuels used).

Table 2. Primary energy data of the BelOrta building (design stage) as required by Level(s)

|                  | Total (kWh/m²/yr) | Energy uses (kWh/m²/yr) | Heating | Cooling | Ventilation | Hot water | Lighting |
|------------------|------------------|-------------------------|---------|---------|-------------|-----------|----------|
| 1.1.1 Use stage primary energy demand | 116.8            |                         | 57.9    | 21.1    | 11.4        | 0.0       | 26.4     |
| Total primary energy demand          | 116.8            |                         | 57.9    | 21.1    | 11.4        | 0.0       | 26.4     |
| Non-renewable primary energy demand  | 0.0              |                         | 0.0     | 0.0     | 0.0         | 0.0       | 0.0      |
| Renewable primary energy demand      | 0.0              |                         | 0.0     | 0.0     | 0.0         | 0.0       | 0.0      |
| Exported energy generated             | 0.0              |                         | 0.0     | 0.0     | 0.0         | 0.0       | 0.0      |
| 1.1.2 Use stage delivered energy demand |                |                         |         |         |             |           |          |
| Fuels                               | 57.2             |                         | 57.2    | 0.0     | 0.0         | 0.0       | 0.0      |
| Natural Gas                         |                  |                         |         |         |             |           |          |
| Electricity                         | 15.9             |                         | 0.0     | 8.4     | 4.5         | 0.0       | 2.9      |
| Non renewable                       |                  |                         |         |         |             |           |          |

3.2. Indicator 1.2: Life Cycle global warming potential (GWP)

For the evaluation of the GWP of the building, Level(s) differentiates fossil carbon, biogenic carbon and biogenic carbon related to land occupation and land transformation. A simplified assessment is possible for Level 1 including the product stage (A1-3) and use stage (B4-5, B6) called an “incomplete life cycle”. A building service life of 60 years is assumed, which is in line with the Belgian MMG method.

The MMG+_KULeuven tool was used to calculate the GWP of the building. As this tool does not include module D, the simplified reporting option was chosen. The Belgian MMG method furthermore does not include biogenic carbon, hence only GWP due to fossil carbon has been assessed (see Table 4 in section 3.6). Further, only the building elements of the shell are assessed defined as minimum building scope for a Level 1 assessment.

A material inventory of the building is needed to calculate the GWP. In general, architects do not have such a detailed list readily available and hence this is a time-consuming activity. If an inventory exists, it often has a different focus (e.g. cost sheet) and is mostly not as detailed as required for an LCA. It is hence recommended to provide a list of predefined elements per country with pre-calculated GWP values. As mentioned in Röck et al. [16] harmonization between the existing LCA and BIM standardization could help to facilitate LCA studies and improve the accuracy of the life cycle inventory.

3.3. Indicator 2.1: Building bill of materials

With this indicator an overview of the total mass of the building materials is provided, categorised into four material types defined by Eurostat (i.e. metal, non-metallic mineral, biomass and fossil energy) [7]. 99% of the total building mass should be covered and at least encompass the shell, core and external work elements [7]. For this assessment, the external works were not included in the scope and left out.

The data inventory for this indicator was taken from a BIM model provided by the architects, complemented with extra information found in technical information sheets, building construction plans, tender document. Such inventory is time consuming, but was already available (in a different format than the one required by Level(s)) from a previous LCA study of the same building. Although the format was different, the bill of materials was already structured per building element. Such detailed bill of materials is however not standard practice in architectural offices and hence will require additional efforts from architects assessing their building design with Level(s) [16]. It is furthermore important to note that the table format as required by Level(s) does not provide sufficient information for a hotspot analysis and hence will be of limited value for architects to improve their design in a time-efficient way.
3.4. Indicator 2.2 Scenarios for lifespan, adaptability and deconstruction

3.4.1. S1: Scenarios for life span. For every building element defined in indicator 2.1 the expected life span and corresponding data source should be provided. Four possible data sources can be used: 1) typical life spans based on reported averages, 2) life span estimate calculated by building professional, 3) life span estimate provided by building element manufacturer; or 4) life span estimate obtained from field experience. In this assessment, the default life spans of the materials and building components according to the Belgian MMG method were used.

3.4.2. S2: Scenarios for adaptability. Firstly, an overview of the addressed design aspects related to adaptability and refurbishment is required (e.g. column grid span, flexible cabling patterns, …). For office buildings three focus areas are brought forward: 1) changes in user space requirements; 2) changes to building servicing; and 3) changes to building structure. A description of the design solutions should be added for each of these (see Table 3). Secondly, it is asked whether a property market check is carried out or not, which was not the case in this project. To retrieve the needed information, additional interviews with the architects were required in addition to the available building documentation.

| Aspects addressed | Design aspect | Description of design solution(s) |
|-------------------|---------------|----------------------------------|
| Office            | Change in user space requirements | Internal wall system | System walls that can be (re)moved. |
| Office            | Change in user space requirements | Column grid spans | Possibility to convert the landscape office to office rooms on both sides of a corridor. |
| Office            | Changes to building servicing | Flexible cabling patterns | There horizontal and vertical cable trays everywhere. Lowered ceiling |
| Office            | Change to building structure | Future-proofing of load bearing capacity | Structure allows adding an extra storey later. |

3.4.3. S3: Scenarios for deconstruction. Firstly, the availability of building inventories and a deconstruction plan is quested. The specific deconstruction, reuse and recycling characteristics of the building have to be described. For each topic a series of design aspects are presented, such as “mechanical and reversible connections” or “constituent materials can be easily separated” Similar to the previous, an additional interview with the architects was required.

3.5. Indicator 2.3: Construction and demolition waste

The waste indicator aims at gathering information about the total amount of waste and the types of waste (hazardous or non-hazardous) during construction and at the end of life. Pre-estimates or actual data can be used as source. Further, possibilities for reuse and recycling and for recovery during specific life cycle stages (i.e. A3, A5, C1/3 and module D) are asked for.

As for the BelOrta building, no special attention was given by the architects to end of life recycling or reuse, the default end-of-life scenarios of the Belgian MMG method for each of the materials were assumed. The MMG method does not include information about waste being hazardous or not. This hence had to be inventoried which is time intensive if a detailed material list is not available.

3.6. Indicator 2.4: Cradle to cradle life cycle assessment

The Level(s) framework has selected a set of nine environmental indicators to be evaluated with a corresponding measurement unit in line with EN 15978 and EN15804. With exception of use of renewable primary energy sources used as raw material and use of non-metallic mineral resources all indicators are listed in Table 4. The indicators have to be assessed separately for the five different modules (life cycle stages) defined in EN 15978.
Similar as for indicator 1.2 (life cycle GWP), the MMG+_KULeuven tool was used to assess the various environmental impact categories required (this would not have been the case if a carbon foot printing calculation tool was used). The same simplified reporting option and building scope are used for this indicator as discussed above. Similar challenges were faced as for indicator 1.2. Results can be found in Table 4.

Table 4. Environmental impacts per life cycle stage and environmental indicator

| Indicator | Unit | Product (A1-3) | Construction process (A4-5) | Use stage (B1-7) | End of life (C1-4) |
|-----------|------|----------------|-----------------------------|-----------------|-------------------|
| Global Warming Potential (GWP) | kg CO₂ eq | 982958 | 117775 | 5429271 | 115390 |
| Depletion potential of the stratospheric ozone layer (ODP) | kg CFC11 eq | 0.3 | 0.0 | 0.7 | 0.0 |
| Acidification Potential of land and water (AP) | kg SO₂ eq | 2926 | 516 | 11024 | 391 |
| Eutrophication Potential (EP) | kg (PO₄)₃ eq | 419 | 102 | 2632 | 88 |
| Formation potential of tropospheric ozone photochemical oxidants (POCP) | kg C₂H₄ eq | 230 | 23 | 682 | 11 |
| ADP elements | kg Se eq | 1.8 | 0.3 | 7.7 | 0.1 |
| ADP fossil fuels | MJ (LHV) | 11799810 | 1612427 | 92414796 | 878909 |

3.7. Indicator 3.1: Use stage water consumption

Indicator 3.1 deals with the operational water use of the building, expressed in litres per occupant per year. An extra calculation file is provided to calculate the water use based on various inputs. First, the country and river basin of the case study are asked for to generate the water exploitation index\(^1\) and ranking. Second, based on the entered occupancy conditions (i.e. gender distribution, building use factor and occupants behaviour) the volume of water per occupant per day is calculated (see Table 5). If the building is located in an area with water stress, which is not the case for the case study, extra reporting on the division of water consumption into potable and non-potable water is required. As no detailed information was available (except the absence of showers), the provided default values file were used.

In general, this default values simplified the needed calculations for this indicator and the availability of these default values could also be of interest for other indicators.

Table 5. Water consumption (litre) per occupant per day

| Male occupants | 0.5 | Female occupants | 0.5 | Sum of occupants | 1.0 |
|----------------|------|------------------|------|-----------------|-----|
| Building use factor | 250 days/annum | | | | |
| Sanitary fittings | | | | | |
| Toilet (full flush) | 7.5 L/full flush | 1 flushes/o/day | 7.5 L/o/d |
| Toilet (small flush) | 4 L/small-flush | 2 flushes/o/day | 4 L/o/d |
| Urinal | 3 L/flush | 2 flushes/o/day | 3 L/o/d |
| Bathroom tap | 4 L/minute | 45 seconds/o/day | 3 L/o/d |
| Shower | 0 L/minute | 30 seconds/o/day | 0 L/o/d |
| Kitchenette tap | 12 L/minute | 30 seconds/o/day | 6 L/o/d |
| Total | | | | 23.50 L/o/d |

3.8. Indicator 6.1: Life cycle cost

This indicator evaluates the different costs occurring during the building service life. Various types of costs are distinguished according to their recurrence: the one-off costs, annual costs and periodical non-annual costs. Both the annual as periodic non-annual costs are based on the sum of the present values of

\(^1\) “The mean annual total abstraction of fresh water divided by the long-term average freshwater resources. It describes how the total water abstraction puts pressure on water resources.” [7, p. 106]
those future costs [7,17]. The costs are subdivided according to the same life cycle stages as for the life cycle assessment (see Table 6).

A combination of data sources was used for the assessment of this indicator. The building tender gave information about the construction and production costs while the MMG+ KULeuven tool gave an estimate for the costs of the use stage and EoL stage. As there was not a concrete maintenance plan nor a plan for element replacements, default scenarios from the MMG method were used.

| Table 6. Life Cycle costs of BelOrta building |
|---------------------------------------------|
| **Type of costs** | **Cost by life cycle stage (€/m²/yr)** |
|                 | **Product and Construction stages** | **Use stage** | **End of life stage** |
| One off costs   | 74.54 | 0.00 | 4.41 |
| Annual recurrent costs | - | 17.44 (Energy) | - |
|                   | - | 1.68 (Water use) | - |
| Projected non-annual costs | - | 37.78 (Cleaning) | - |
| Total costs      | 74.54 | 89.30 | 4.41 |

4. Discussion
Firstly, some of the main results of the assessment are discussed followed by the main lessons learned in terms of time effort, actors needed, required information, relevance of the different indicators and added value for the practitioners.

4.1. Results
Based on the assessment results, it is clear that the use phase has an important contribution to the buildings environmental impact (see Table 4) and financial costs (see Table 6). Likely the importance for the environmental impact is mainly caused by the energy use for heating (see Table 1), while for the financial cost, cleaning and maintenance are important. Further, the construction phase as well has a big influence on the costs and impacts. Lastly, it has to be recognised that multiple aspects considering future adaptability of the building to changing user needs are implemented in the building design as discussed section 3.4.2. However, based on these results, it is not possible to highlight the importance of the different building elements and to get insights about opportunities to improve the sustainability of the building. This would be an added value for practitioners as now a Level 1 assessment is limited to reporting only.

4.2. Time effort
The testing of the Level(s) to BelOrta revealed that for many of the indicators detailed life cycle inventory data is needed which cannot be directly retrieved from the architectural plans or documents. A complete assessment of all the indicators on a Level 1 requires a lot of time. The reporting itself is not time consuming due to the excel files provided. To reduce the time efforts, it is recommended to establish or improve the links with national tools (e.g. current link with EPB-software for indicator 1.1). Default values are seen as a second way to reduce time efforts (especially in the design stage) as was experienced for the water consumption indicator. Default values could for example be provided for cleaning costs for typical elements, for EoL scenarios of construction products and for life spans of building products. In addition to the above, it is important to mention that the documentation provided by the JRC revealed to be sufficiently complete and comprehensive, but sometimes confusing.

4.3. Actors needed
As a team of actors are typically involved in the design of buildings, it became clear that the data and knowledge required for Level(s) is spread over these different actors. For example, the EPB-document
for indicator 1.1 was drafted by the collaborating engineer firm, the design strategies for indicators 2.2.S2-3 require interaction with a designer of the building, while the LCA and cost analysis were now performed by an academic institution. In order to work efficiently, it might be recommended that various actors are responsible for parts of the Level(s) reporting. Although this is probably more time efficient, a good overall coordination will then be required to ensure that the same assumptions are taken for the multiple calculations required. Linking as much as possible with available tools and interfaces (e.g. BIM-model) could enhance uniformity across different assessments and actors.

4.4. Required information

The testing revealed that most of the indicators are linked to assessment methods that require data structuring that is different than in architectural practice to date. This is for example the case for the LCA study: even if a BIM model is available, this model may provide information about the general composition of building elements and their amounts but information on sub-element composition is lacking, such as for example the kg of brick per m² wall or the kg of cement mortar per m² wall. Default element compositions and related amount of materials could help practitioners. Further alignment between different tools could moreover improve this information flow.

4.5. Relevance indicators

The scope of the Level(s) framework is office buildings and residential buildings [8]. However it was found that some parts of indicators are more relevant for office buildings than for residential and conversely. Water consumption is for example more relevant for residential buildings though not unimportant for office buildings neither. While the relevance of the cleaning cost could be questioned in case of residential buildings.

4.6. Added value for practitioners

The objective of the Level 1 assessment is “to provide a common reference point for the performance assessment of buildings across Europe” [8]. The testing phase is interesting for architects to become familiar with the assessment methodology, requirements and challenges. The assessment moreover provides general insights in the various environmental impacts, waste streams and costs their design is causing. However, it does not allow to evaluate the ‘sustainability’ level of their project as reference values are not available to compare with and detailed hotspot analysis is not possible. In order to increase the added value of the assessment for practitioners it is recommended to integrate such reference values (benchmarks) or more detailed reporting in future. To use Level(s) to date during a design phase, the authors would rather recommend to use a level 2 assessment to be able to compare various design options.

5. Conclusion

This paper discusses a Level(s) Level 1 application on an office building in Belgium. The assessment of the indicators related to the macro-objectives (1) Greenhouse gas emissions along a building life cycle; (2) Resource efficient and circular material life cycles; (3) Efficient use of water resources; and (6) Optimised life cycle cost and value have been presented. The study showed the implications of performing a Level 1 assessment for building practitioners in terms of information, time and experience needed. It was found that the assessment requires information and experience from practitioners which is not commonly available in current practice. Further improvement is recommended by aligning current national tools for data gathering and by providing default values. The testing furthermore revealed that Level 1 assessment allows to gain general insights in various performances of a building (e.g. waste streams, impacts across different indicators …) but does not allow to evaluate the “sustainability” level of the design as reference values are lacking as basis of comparison. As long as such reference values are not available, a level 2 assessment is probably more useful to make well-founded choices between different design options.
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