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Level(s) indicator 2.3: Design for adaptability and renovation

User manual: introductory briefing, instructions and guidance

(Publication version 1.1)

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Title

Level(s) indicator 2.3: Design for adaptability and renovation 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

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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

Terms	Definition
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.
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	Construction product manufactured as a distinct unit to serve a specific function or functions.
Estimated service life	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.
Reference service life	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.
Renovation	Modification and improvement to an existing building in order to bring it up to an acceptable condition.
Scenario	Collection of assumptions and information concerning an expected sequence of possible future events
Service life (working life)	Period of time after installation during which a building or an assembled system meets or exceeds the technical performance and functional requirements

Introductory briefing

Why measure performance with this indicator?

The projected service life of a building has significant implications for how much functional use can be obtained from the investment of materials and resources to initially construct a building. The most significant environmental impacts of constructing a building relate to its structure and facade. If the useful life of the building, and therefore also its structure, can be extended, there can be significant environmental benefits.

A buildings service life may end earlier than its potential design life. This may be due in part to market factors that make it obsolescent, such as changing user requirements and needs. This highlights the importance of considering at design stage how future flexibility and adaptability to changing needs can be addressed. The International Energy Agency (IEA) has identified 3 main ways in which building designs can be made more adaptable [1]:

- **More efficient use of space**: More effective usage as occupiers needs change, for example as a business or family expands, which in turn may bring higher space utilisation.
- **Increased longevity**: Extension of the total lifetime of a building, ensuring that this lifetime reflects the design life of components such as the structure. This will reduce the need to incur significant environmental impacts related to the construction phase.
- **Improved operational performance**: Easier change over to new, more efficient technology as it becomes available. This could include technological innovations in lighting, heating, cooling, ventilation and energy generation. The average efficiency of many energy technologies in buildings has improved by between 20-100% in the last decade.

Addressing these design aspects does, however, carry a high degree of uncertainty and can therefore be challenging to consider alongside the immediate functional requirements of the client and/or prospective buyers and occupiers. By providing an indicator for adaptability, project actors will be presented with clear options to take a longer view on the design aspects and decisions that may influence the building's service life. This may, as a consequence of their decisions, enable the service life of the building as a whole to be extended, either by facilitating continuation of the intended use or through possible future changes in use. This in turn will allow for greater value to obtained from the initial investment.

What does it measure?

The indicator provides a semi-quantitative assessment of the extent to which the design of a building could facilitate future adaptation to changing occupier needs and market conditions. It therefore provides a proxy for the capacity of a building to continue fulfilling its function and to extend the useful service life into the future.

The indicator measures the design and servicing aspects of particular relevance, identified based on market research and experience. The aspects assessed differ depending on whether it is an office or residential building.

- **For offices**, the design and servicing aspects focus on flexibility within the office market, as well as flexibility to change use within the property market.
- **For residential properties**, the checklist focuses on the potential to adapt to changing family and personal circumstances over time, as well as the flexibility to support a change of use within the property market.

At what stage of a project?

Level	Activities related to the use of indicator 2.3
1. Conceptual design (following design principles)	✓ Key design aspects for the architect and structural engineer to take into consideration ✓ Value appraisal of the design aspects by the building promoter and cost surveyors

[1] International Energy Agency, *Assessing buildings for adaptability*, Annex 31 Energy-related environmental impacts of buildings, November 2001

Level	Activities related to the use of indicator 2.3
2. Detailed design and construction (based on drawings and dimensions)	✓ Spatial dimensions of the building and structural design, including bay widths, spans, ceiling heights, room sizes and accesses. ✓ Servicing design of the building, including plant rooms, access ducts and distribution networks
3. As-built and in-use (based on final design features and inspection)	✓ Awareness and information relating to adaptable design features and their potential future value

The unit of measurement

The common unit of measurement is a **dimensionless scoring of the adaptability** of a building. The score represents the sum of the weighted scores for each of the adaptability aspects that have been incorporated into the building design.

System boundary

The assessment boundary is the building and the relevant spatial and structural design features that it incorporates.

Scope

The aspects that may contribute to the design for adaptability score mainly comprise a building's structural engineering, internal layouts and technical services.

Calculation method and reference standards

The calculation method is provided as a bespoke part of Level(s). A transitional calculation method is provided for use, which is partly based on the building flexibility calculator provided by BREEAM Netherlands and the Dutch Real Estate Norm (REN). The German Green Building Council's (DGNB) flexibility and adaptability criterion ECO2.1 may also be used to allocate a score.

The method additionally makes reference to the principles and design aspects that are included in EN 15643-3, EN 16309 and ISO 20887.

Instructions on how to use the indicator at each level

Instructions for Level 1

L1.1. The purpose of this level

This level is for those users who would like to:

- Understand how the design of a building could facilitate future adaptation to changing occupier needs and market conditions.
- How these design aspects could extend the service life of the building as a whole, either by facilitating continuation of the intended use or through possible future changes in use.

L1.2. Step-by-step instructions

These instructions should be read in conjunction with the accompanying technical guidance and supporting information from page 16 onwards.

1. Make sure to have completed the Level(s) building description, as some of the information may be needed to check the relevance of design concepts.
2. Consult the checklist of adaptability design concepts under L1.4 and read the further information in the Level 1 guidance provides later in this user manual.
3. *(optional)* Seek advice from property market expert with relevant knowledge of the building type and local, regional and/or national market needs (as relevant to the nature of the investment being made).
4. Within the design team, review and identify how the adaptability design concepts could be introduced into the design process.
5. Once the design concept is finalised with the client, record the adaptability design concepts that were taken into account using the L1 reporting format (in L1.5).

L1.3. Who should be involved and when?

Actors involved at the conceptual design stage, led by the concept architect. The adaptability design concepts can be further explored once professionals such as the structural engineers and service engineers have become more involved in the project.

L1.4. Checklist of relevant design concepts

The following adaptability design concepts have been identified from property market assessments and building certification tools. They provide proxies for a building design that is more adaptable and may provide improved long-term environmental performance. The design concepts are divided into concepts applicable to office buildings (see Table 1) and residential buildings (see Table 2).

Table 1. Office building checklist of adaptability design concepts

Adaptability design concept	Specific design aspect to address	How the design aspect can contribute to adaptability
1. Changes to the internal space distribution	1.1 Column grid spans	Wider column spans will allow for more flexible floor layouts.
	1.2 Façade pattern	Narrower bays will allow for more internal space configurations
	1.3 Internal wall system	Non-loading bearing internal walls will allow for changes to be more easily made to floor layouts.
	1.4 Unit size and access	By ensuring that access/egress is possible from sub-divisions of the spaces this will provide more sub-letting options.
2. Changes to the buildings servicing	2.1 Ease of access to service ducts	Access will be improved if services are not embedded in the building structure.
	2.2 Ease of access to plant rooms	Future changes of technical equipment will be facilitated if there is ease of access to plant rooms and equipment.
	2.3 Longitudinal ducts for	The inclusion of longitudinal ducts will provide flexibility in the

Adaptability design concept	Specific design aspect to address	How the design aspect can contribute to adaptability
	service routes	location of service points.
	2.4 Higher ceilings for service routes	The use of greater ceiling heights will provide more flexibility in the routing of services.
	2.5 Services to sub-divisions	By ensuring that individual servicing for sanitary facilities is possible for sub-divisions of the spaces, this will provide more sub-letting options.
3. Changes to the building façade and structure	2.5 Non-load bearing facades	Non-load bearing facades will allow for changes to be made more easily to both internal layouts and external elements.
	2.6 Future-proofing of load bearing capacity	The incorporation of redundant load bearing capacity will support potential future changes in the building's façade and uses.
	2.7 Structural design to support future expansion	Structural designs that have the vertical strength to support additional storeys will allow for future expansion of the floor area.

Table 2. Residential building checklist of adaptability design concepts

Adaptability design concept	Specific design aspect to address	How the design aspect can contribute to adaptability
1. Changes to the internal space distribution	*1.1 Wall systems that support layout changes*	*Internal wall designs that allow for ease of changes to floor layouts.*
	1.2 Greater ceiling heights for surface routes	The use of greater ceiling heights will give more flexibility in the routing of services.
2. Changes to the buildings servicing	2.1 Ease of access to the building services	Location of services within the house or apartment building to ensure they are flexible to change.
	2.2 Ease of adaptation of the distribution networks and connectors	The internal layout of rooms, the distribution networks and connections can be adapted in the case of any layout modifications.
3. Change to the use of units or floors	3.1 The potential for a segregated home working spaces	The potential to segregate a space with adequate dimensions, light and services within the home will support teleworking.
	3.2 The potential for ground floor conversion to a contained unit	The potential for the ground floor to become a contained unit with bed space, kitchen, toilet and shower will support future changes in circumstances.
4. Changes in access requirements	4.1 Ease of access to each residential unit	Ease of access to residential units in cases of the need for pram or wheelchair mobility.
	4.2 Access to and manoeuvrability within rooms	Ease of access to and space to manoeuvre within living spaces, kitchens and bathrooms will support pram or wheelchair mobility.

L1.5. Reporting format

To complete the reporting format for Level 1 you should answer yes or no for each of the design concepts that you have addressed and provide brief descriptions of the measures or decisions taken for each one.

Office building reporting format

Adaptability design concept	**Addressed?** (yes/no)	**How has it been incorporated into the building design concept?** (provide a brief description)
1. Changes to the internal space distribution		
2. Changes to the buildings servicing		
3. Changes to the buildings' façade and structure		

Residential building reporting format

Adaptability design concept	**Addressed?** (yes/no)	**How has it been incorporated into the building design concept?** (provide a brief description)
1. Changes to the internal space distribution		
2. Changes to the buildings servicing		
3. Change to the use of units or floors		
4. Changes in access requirements		

Instructions for Level 2

L2.1. The purpose of this level

This level is for those users who wish to set design targets or who are at the stage of making design decisions and wish to compare design options for their relative adaptability.

L2.2. Step-by-step instructions

These instructions should be read in conjunction with the accompanying Level 2 technical guidance and supporting information from (see page 19).

1. Bring together the architect as well as the structural and service engineers in order to review the design aspects that have/are planned to be addressed.
2. *Optional step:* Seek advice from property market expert with relevant knowledge of the building type and local, regional and/or national market needs (as relevant to the nature of the investment being made).
3. *For renovation projects:* those adaptability design aspects that are within the influence of the scope of the proposed works shall be identified.
4. Develop the design options for appraisal, taking into account different combinations of adaptability design aspects.
5. For residential developments with several house or apartment typologies, make a representative selection of the designs.
6. Identify and gather the relevant architectural and structural design drawings, service plans as well as supporting calculations required to make the scoring.
7. *Optional step:* In order to explore the potential for trade-offs in the life cycle environmental performance of different adaptability design concepts, a life cycle GWP assessment or full LCA assessment may be carried out.
8. Use the matrix of design aspects provided in tables 6 and 7 of the technical guidance for Level 2 to allocate a score for each aspect addressed.
9. To obtain the adaptability score for the design, multiply the score obtained for each design aspect by the weighting factor and then sum up the weighted scores, to obtain a score out of 100.

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

The main items needed are as follows:

- ✓ A building design, including structure and servicing plans, that is sufficiently advanced to provide the detailed information on which to make a scoring for the adaptability design aspects.
- ✓ *For renovation projects,* an agreed scope of works that will allow for those adaptability design aspects that can be influenced to be identified.

L2.4. Who should be involved and when?

Those actors involved at the detailed design stage, led by the architect and with the involvement of the structural and services engineers. Supporting life cycle GWP or LCA assessments may be carried out by the energy/sustainability consultants or those within the design team with in-house competencies.

L2.5. Ensuring the comparability of results

A single method is provided for making the assessment which shall be used by Level(s) users. Any scores from other methods can be read across to the Level 2 scoring system but must relate to the same specific design aspects. The score can then be determined using the points classes provided in tables 6 and 7.

L2.6. Going a step further

Two options can be pursued in order to optimise designs for the adaptability of a building:

1. Life cycle performance: Indicator 1.2 Life cycle GWP or a full LCA may be used to assess the performance of different building design options or to optimise the life cycle performance of a design.

To do this, designs shall be developed and tested and the rules laid down for adaptability scenario modelling in the user manual for indicator 1.2 guidance shall be followed.

2. Property market scenarios: Complementary to either option 1 or to an assessment of Life Cycle Costs using indicator 6.1, software tools may be used for the probabilistic analysis of market-based, life cycle scenarios for the future occupation of a building (see the user manual for indicator 6.1).

Note that for option 1, if the life cycle GWP or LCA results are to be publicly reported, it is recommended that input is sought from a property market specialist and that their opinion is appended to the reporting.

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

Adaptability score for an office building design

Adaptability design concept	Specific design aspect to address	Weighted score
1. Changes to the internal space distribution	1.1 Column grid spans	
	1.2 Façade pattern	
	1.3 Internal wall system	
	1.4 Unit size and access	
2. Changes to the buildings servicing	2.1 Ease of access to service ducts	
	2.2 Ease of access to plant rooms	
	2.3 Longitudinal ducts for service routes	
	2.4 Higher ceilings for service routes	
	2.5 Services to sub-divisions	
3. Changes to the buildings' façade and structure	3.1 Non-load bearing facades	
	3.2 Future-proofing of load bearing capacity	
	3.3 Structural design to support future expansion	
	Total weighted score	

Adaptability score for a residential building design

Adaptability design concept	Specific design aspect to address	Weighted score
1. Changes to the internal space distribution	1.1 Wall systems that support layout changes	
	1.2 Greater ceiling heights for surface routes	
2. Changes to the buildings servicing	2.1 Ease of access to the building services	
	2.2 Ease of adaptation of the distribution networks and connectors	
3. Change to the use of units or floors	3.1 The potential for a segregated home working space	
	3.2 The potential for ground floor conversion to a contained unit	
4. Changes in access requirements	4.1 Ease of access to each residential unit	
	4.2 Access to and manoeuvrability within rooms	
	Total weighted score	

Instructions for Level 3

L3.1. The purpose of this level

This level is for those users who wish to compare the final as-built design with the earlier detailed designs. It can also form the starting point for a long-term monitoring of the building and how it performs in the local property market.

L3.2. Step-by-step instructions

These instructions should be read in conjunction with the accompanying Level 3 technical guidance and supporting information from page 17 onwards.

1. Bring together the architect and contractor as well as the structural and service engineers in order to identify the design aspects that have been addressed.
2. Identify and gather the relevant as-built architectural and structural design drawings and service plans as well as supporting calculations required to check the as-built scoring.
3. Ensure that the same representative selection of house or apartment types as was used as for the scoring at Level 2.
4. To obtain the adaptability score for a completed design, multiply the score obtained for each design aspect by the weighting factor and then sum up the resulting weighted scores, to obtain a score out of 100.
5. *Optional step:* In order to assess the potential for trade-offs in the life cycle environmental performance of different adaptability design concepts, a life cycle GWP assessment or full cradle to grace LCA assessment may be carried out.

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

The main items needed are as follows:

- ✓ The as-built building design, including structure and servicing plans, to provide the detailed information on which to make a scoring for the adaptability design aspects.
- ✓ *For renovation projects,* an agreed scope of works that will allow for those adaptability design aspects that can be influenced to be identified.

L3.4. Who should be involved and when?

Those actors involved in the completion of the building, led by the architect and with the involvement of the contractor and structural and services engineers. Supporting life cycle GWP or LCA assessments may be carried out by the energy/sustainability consultants or those within the design team with in-house competencies.

L3.5. Ensuring the comparability of results

A single method is provided for making the assessment which shall be used by Level(s) users. Any scores from other methods can be read across to the Level 2 scoring system but must relate to the same specific design aspects. The score can then be determined using the points classes provided in tables 6 and 7.

L3.6. Format for reporting the results of an assessment

Adaptability score for a completed office building

Adaptability design concept	Specific design aspect to address	Weighted score
1. Changes to the internal space distribution	1.1. Column grid spans	
	1.2. Façade pattern	
	1.3. Internal wall system	
	1.4. Unit size and access	
2. Changes to the	2.1. Ease of access to service ducts	

buildings servicing	2.2. Ease of access to plant rooms	
	2.3. Longitudinal ducts for service routes	
	2.4. Higher ceilings for service routes	
	2.5. Services to sub-divisions	
3. Changes to the buildings’ façade and structure	3.1. Non-load bearing facades	
	3.2. Future-proofing of load bearing capacity	
	3.3. Structural design to support future expansion	
	Total weighted score	

Adaptability score for a completed residential building

Adaptability design concept	Specific design aspect to address	Weighted score
1. Changes to the internal space distribution	1.1 Wall systems that support layout changes	
	1.2 Greater ceiling heights for surface routes	
2. Changes to the buildings servicing	2.1 Ease of access to the building services	
	2.2 Ease of adaptation of the distribution networks and connectors	
3. Change to the use of units or floors	3.1 The potential for a segregated home working spaces	
	3.2 The potential for ground floor conversion to a contained unit	
4. Changes in access requirements	4.1 Ease of access to each residential unit	
	4.2 Access to and manoeuvrability within rooms	
	Total weighted score	

Guidance and further information for using the indicator

For using level 1

In this section of the guidance, additional background explanations and information are provided for three key concepts that form the basis for the L1.4 adaptability design concept checklist, namely adaptation to:

- L1.4a. Checklist in general: Existing and future occupier needs.
- L1.4b. Checklist in general: Changing future demand in the property market.
- L1.4c. Checklist in general: Life changes in the case of residential property.

In this way, users can obtain a better understanding of why adaptability is important to address and how it can influence the useful service life of a building in the medium to long term.

L1.4a. Checklist in general: Adaptation to existing and future occupier needs

Adaptation to reflect changes in occupier needs is a natural focus for clients for investment properties, as they will need to consider how to minimise voids and, where buildings and floors are sub-divided and let to different occupiers, meet their target yield or rate of return. A good example is the Dutch Real Estate Norm, which identifies location, site and building related factors and seeks to relate them to vacancy risk factors [2].

This commercial outlook on adaptability has also been the focus of attention for the so-called 'Open Building' movement in the Netherlands, as well as adaptability criteria set by the building certification schemes DGNB (Germany) and BREEAM Netherlands. The latter two schemes, as well as research by the IEA, have been used to inform the transitional scoring method to be used to report on this indicator.

In designing an office building, four distinct 'layers' can be identified, each of which have typical average lifetimes:

1. **Shell**: Superstructure, including façade if loadbearing (>50 year lifespan)
2. **Services**: Pipes, ducts, cables, machinery, lifts, escalators (15 year lifespan)
3. **Scenery**: Partitioning, ceiling, finishes (6 years)
4. **Set**: Furnishings, furniture, IT equipment (years to months)

By relating the data collected for indicator 2.1 to the potential need for adaptation and replacement over time, a better understanding can be gained of where the focus of attention should be in order to facilitate future flexibility.

Research and experience has shown that for office buildings, factors such as floor to ceiling heights and problems to adapt service distribution such as electricity and air conditioning, which is generally located in the ceilings, can be major barriers to their conversion. Other important factors to consider include:

- The placement of columns and bay widths;
- The ease with which interior walls can be moved;
- The extent to which the building is divided into one or more parts or wings;
- The load bearing capacity of the floors;
- Plan depth and daylight penetration.

Factors such as these, sometimes also referred to as 'functional adaptability' aspects, should be considered at both the concept and detailed design stage. The designs aspects taken into account in Level(s) are summarised in Table 3.

[2] Real Estate Norm, Netherlands Foundation (1992)

Table 3. Functional adaptability design aspects

Specific design aspect to address	How the design aspect can contribute to adaptability
1.1 Column grid spans	Wider column spans will allow for more flexible floor layouts.
1.2 Façade pattern	Narrower bays will allow for more internal space configurations
1.3 Internal wall system	Non-loading bearing internal walls will allow for changes to be made more easily to floor layouts.
1.4 Unit size and access	By ensuring that access/egress is possible for sub-divisions of the spaces this will provide more sub-letting options.

L1.4b. Checklist in general: Adaptation to changing demand in the property market

Adaption to changing demand in the property market is more challenging, as it supposes the potential for changes in the overall demand for a use or even a change in the use class of a building. The resulting market response could include conversions of offices to residential buildings, or vice versa. Constraints that may be difficult to work within and that may originate from the initial residential building design could indicatively include lower ceiling heights, narrow structural bays and smaller floor plate sub-divisions.

The potential to respond to changes in the internal loads on structures – for example, in the case of offices that may still require archives - and in exceptional cases the height and massing of a building, are more technically challenging. Increases in the height of a building by adding additional super-structure, and the assessment of the capacity of the existing superstructure and substructure to support the additional load, require careful technical assessment.

A related consideration is the potential to change the façade. This is because design aesthetics, as well as performance considerations, may change over time. A decision to change or modify a façade would entail a substantial financial investment.

The designs aspects taken into account in Level(s) that relate to structures and facades are summarised in Table 4. This aspect of adaptability is addressed further in the Level 2 guidance of this user manual.

Table 4. Structural capacity related adaptability design aspects

Aspect	How the design aspect can contribute to adaptability
3.1 Non-load bearing facades	Non-load bearing facades will allow for changes to be made more easily to both internal layouts and external elements.
3.2 Future-proofing of load bearing capacity	The incorporation of redundant load bearing capacity will support potential future changes in the building's façade and uses.
3.3 Structural design to support future expansion	Structural designs that have the vertical strength to support additional storeys will allow for future expansion of the floor area.

An additional factor for consideration is the design of Heating, Ventilation and Air Conditioning (HVAC) systems so that they can be adapted to future changes along the life cycle of the building. This could relate to changes in fuels or input energy sources, but also occupancy patterns, which may in turn be reflected in the use intensity of a building and internal layouts.

The ease of replacement of the HVAC plant is also a major consideration, given the potential future need to change the servicing strategy and to make planned improvements in a buildings performance over time.

The design aspects taken into account in Level(s) that relate to services are summarised in Table 5.

Table 5. Servicing related adaptability design aspects

Aspect	How the design aspect can contribute to adaptability
2.1 Ease of access to service ducts	Access will be improved if services are not embedded in the building structure.
2.2 Ease of access to plant rooms	Future changes of technical equipment will be facilitated if there is ease of access to plant rooms and equipment.
2.3 Longitudinal ducts for service routes	The inclusion of longitudinal ducts will provide flexibility in the location of service points.
2.4 Higher ceilings for service routes	The use of greater ceiling heights will provide more flexibility in the routing of services.
2.5 Services to sub-divisions	By ensuring that individual servicing for sanitary facilities is possible for sub-divisions of the spaces, this will provide more sub-letting options.

L1.4c. Checklist in general: Adaptation of residential properties to life changes

Whilst there is some overlap between the adaptability design aspects relevant to office buildings – for example, in the case of a change of use from residential to office – for residential properties there are also distinctive aspects that relate to life changes. Some examples may include starting a family or a change in circumstances that leads to reduced mobility. The mass confinements resulting from the Covid-19 pandemic of 2020 have also highlighted the importance of flexibility to provide suitable home working environments.

Probably the most important reference point for residential property is the Lifetime Homes criteria set [3]. Developed in the 1990s, Lifetime Homes is a set of design criteria intended to reflect the changing needs of individuals and families at different stages of life. They are sometimes also referred to as criteria for 'inclusive design'. The Level(s) adaptability score incorporates a number of the aspects addressed in the 15 criteria.

Table 6. Residential adaptability design aspects related to life changes

Specific design aspect to address	How the design aspect can contribute to adaptability
3.1 The potential for a segregated home working spaces	The potential to segregate a space within the home that has adequate dimensions, light and services and which will support teleworking.
3.2 The potential for ground floor conversion to a contained unit	The potential for the ground floor to become a contained unit with bed space, kitchen, toilet and shower will support future changes in circumstances.
4.1 Ease of access to each residential unit	Ease of access to residential units in cases of the need for pram or wheelchair mobility.
4.2 Access to and manoeuvrability within rooms	Ease of access to and space to manoeuvre within living spaces, kitchens and bathrooms will support pram or wheelchair mobility.

[3] The Lifetime Homes criteria can be obtained here: http://www.lifetimehomes.org.uk/pages/revised-design-criteria.html

For using level 2

In this part of the guidance, additional background guidance and explanations are provided to support the assessment of adaptability at Level 2. The specific topics covered are as follows:

- L2.2. Step 2: Scenarios for future property market conditions.
- L2.2. Step 3: European Technical Rules for the Assessment and Retrofitting of Existing Structures.
- L2.2. Step 7: Assessment of the life cycle environmental performance of building designs.

Table 7, which provides the scoring and weighting for a level 2 or 3 adaptability assessment, can be found at the end of this section.

L2.2. Step 2: Scenarios for future property market conditions

Given the inherent uncertainty related to decisions and investment linked to adaptability measures, it is recommended to seek additional advice from commercial property market experts. In this way, insight can be obtained into the prospective needs of buyers and tenants, both in the short and medium term. In the public sector, the brief for the building project should aim to identify the medium to long-term strategy for use of the asset.

As well as expert market knowledge, software tools may be used to further support the probabilistic analysis of life cycle scenarios for the future occupation of a building. For example, the EU-funded CILECCTA project[4] 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.

By using the CILECCTA software tool, users 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 potentials for either an increase in the height of a building or to change 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 3: European Technical Rules for the Assessment and Retrofitting of Existing Structures

The Joint Research Centre has published new European Technical Rules for the Assessment and Retrofitting of Existing Structures [5]. These have been developed by the CEN/TC250 Working Group (WG) 2 on assessment and retrofitting of existing structures.

An assessment of existing structures may be necessary in cases where they are renovated or re-used. This may include where there may be a change in use or the addition of new floors or structures. Such an assessment of an existing structure may be required in the following cases:

- Adequacy checking in order to establish whether the existing structure can resist loads associated with any anticipated change in use of the facility, operational changes or extension of its design working life;
- Repair of an existing structure, which has deteriorated due to time dependent environmental effects or which has suffered damage from accidental actions, for example due to impact, explosion, fire or earthquake;
- Doubts concerning the actual reliability of the structure;

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

[5] Joint Research Centre, *New European Technical Rules for the Assessment and Retrofitting of Existing Structures*, Institute for the Protection and Security of the Citizen, European Union, 2015

- Rehabilitation of an existing building structure in conjunction with the retrofitting of the building services;
- Requirements from authorities, insurance companies, owners or from a maintenance plan.

The deterioration of an existing structure shall be taken into consideration. When deterioration of an existing structure is observed, the reliability assessment of the structure becomes a time-dependent deterioration problem as described in ISO 2394, and an appropriate analysis method shall be used.

L2.2. Step 7: Assessment of the life cycle environmental performance of building designs

Some of the adaptability design aspects may involve trade-offs between greater adaptability and environmental performance. Some examples are as follows:

- The use of post-tensioned concrete in place of in-situ concrete to achieve wider spans can result in higher GWP emissions [6].
- The potential for independent arrangements by office building tenants of HVAC services. This could have the effect of working against the design of a whole-building natural ventilation and passive cooling options. In the case of residential units, the same could apply to communal renewable energy systems.
- Flexible space layouts could encourage more frequent refitting of offices. Figure 2 illustrates how recurring fit outs can contribute to overall life cycle embodied CO_2 equivalent emissions.

These trade-offs cannot be captured by the adaptability score and can only be quantified by making a life cycle GWP assessment or a full LCA for the building. This will allow for the performance of designs to be calculated and compared. To do this, possible future scenarios for the use of the building should be developed and tested, drawing upon expert input. Specific rules shall be followed that are provided in the user manual for indicator 1.2.

[6] Kaethner,S.C and Burridge,J.A. Embodied CO_2 of structural frames, *The Structural Engineer*, May 2012

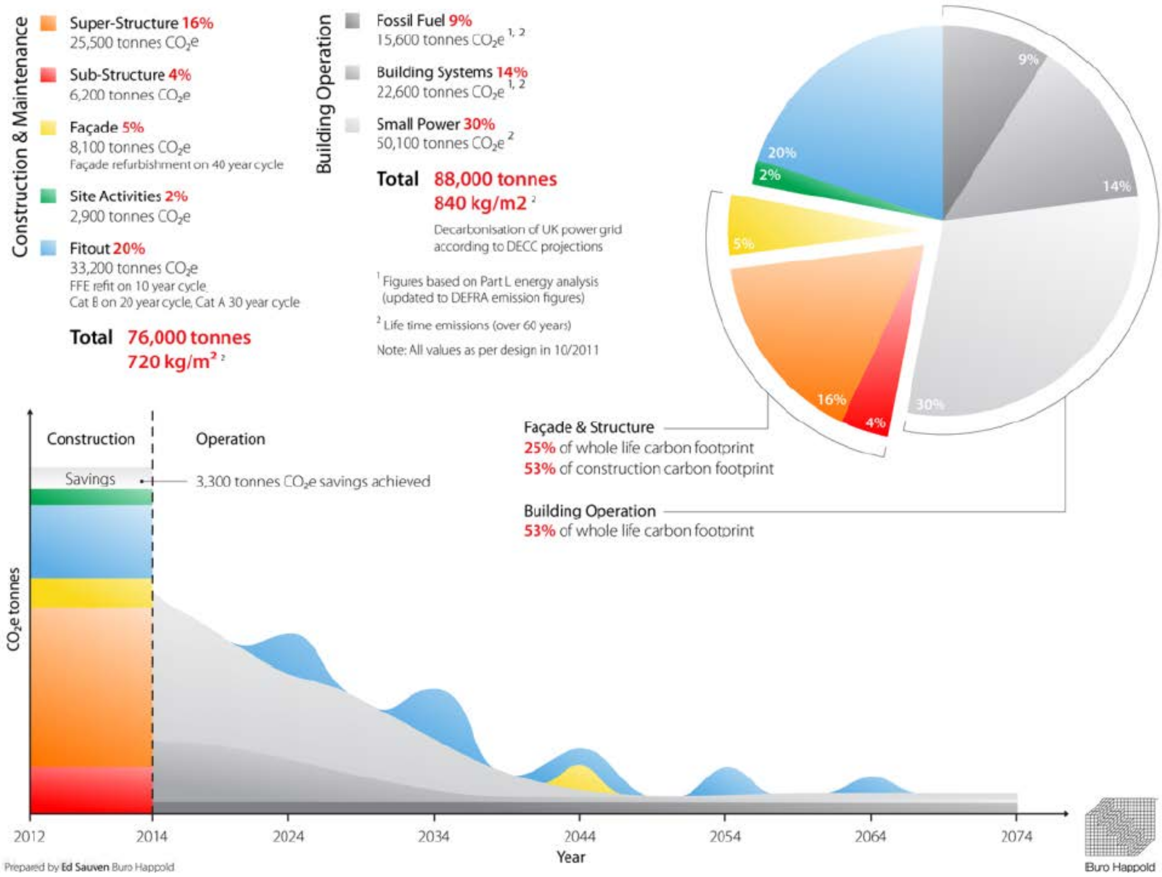

Figure 2. Indicative whole life CO_2 footprint for an office building in Northern Europe

Source: Buro Happold (2014)

Table 7. Office building scoring and weighting system for adaptability design aspects

Adaptability design concept	Specific design aspect to address	How the design aspect can contribute to adaptability	Scoring system	Weighting factor
1. **Changes to the internal space distribution**	**1.1 Column grid spans**	Wider column spans will allow for more flexible floor layouts.	Column spacing: - < 5400 mm 0 points - 5400 mm < 8100 mm 1 point - > 8100 mm 2 points - free span 3 points	1.5
	1.2 Façade pattern	Narrower bays will allow for more internal space configurations	Spacing between bays: - 1350 to >1800 mm 0 points - 1350 - 1800 mm 1 point - 1350 - 1800 mm, some bays 900 - 1350 mm 2 points - 900 - 1350 mm, some bays < 900 mm 3 points	1.5
	1.3 Internal wall system	Non-loading bearing internal walls will allow for changes to be made more easily to floor layouts.	- Immovable interior walls, multiple functions 0 points - Immovable interior walls, temporary structures 1 point - Movable interior walls, requires disassembly 2 points - Easily movable interior walls, partition system 3 points	4.5
	1.4 Unit size and access	By ensuring that access/egress is possible for sub-divisions of the spaces, this will provide more sub-letting options.	Weighted average unit/floor plate size: - > 600 m^2 0 points - 400 - 600 m^2 1 point - 200 - 400 m^2 2 points - < 200 m^2 3 points	3.0
2. **Changes to the buildings servicing**	**2.1 Ease of access to service ducts**	Access will be improved if services are not embedded in the building structure.	Location of key service ducts: - Embedded in the floor 0 points - Between 2 building layers 1 point - Above one building layer (floor) 2 points - Below one building layer (ceiling) 3 points	1.5
	2.2 Ease of access to plant rooms	Future changes of technical equipment will be facilitated if there is ease of access to plant rooms and equipment.	- Embedded in a sub-basement of the building 0 points - Located in a plant room on the roof or within an accessible patio 1 point - Located in a ground floor plant room with easy external access 2 points - Located external to the building with complete access 3 points	1.5
	2.3 Longitudinal ducts for service	The inclusion of longitudinal ducts will provide flexibility in the location of service points.	- Connection grid in 1 direction 0 points - Cable duct in 1 direction 1 point	1.5

Adaptability design concept	Specific design aspect to address	How the design aspect can contribute to adaptability	Scoring system	Weighting factor
	routes		- Connection grid in 2 directions 2 points - Cable duct in 2 directions 3 points	
	2.4 Higher ceilings for service routes	The use of greater ceiling heights will provide more flexibility in the routing of services.	Internal height (floor surface to ceiling surface): - < 3000 mm 0 points - 3000-3500 mm 1 point - 3500-4000 mm 2 points - > 4000 mm 3 points	4.5
	2.5 Services to sub-divisions	By ensuring that individual servicing for sanitary facilities is possible for sub-divisions of the spaces, this will provide more sub-letting options.	Weighted average unit/floor plate sub-division size that can be serviced: - > 600 m² 0 points - 400 - 600 m² 1 point - 200 - 400 m² 2 points - < 200 m² 3 points	3.0
3. Changes to the buildings' façade and structure	**3.1 Non-load bearing facades**	Non-load bearing facades will allow for changes to be made more easily to both internal layouts and external elements.	- Bearing facade with bearing obstacles 0 points - Bearing facade, no bearing obstacles 1 point - Non-bearing facade, bearing obstacles 2 points - Non-bearing facade, no bearing obstacles 3 points *Note: Examples of obstacles include bearing interior walls, columns, elevator shafts or installation ducts.*	4.5
	3.2 Future-proofing of load bearing capacity	The incorporation of redundant load bearing capacity will support potential future changes in the building's façade and uses.	Variable capacity: - 1,75 kN/m² 0 points - 2,50 kN/m² 1 point - 4,00 kN/m² 2 points - 5,00 kN/m² 3 points	4.5
	3.3 Structural design to support future expansion	Structural designs that have the vertical strength to support additional storeys will allow for future expansion of the floor area.	Capacity to add storeys: - 1 storey 0 points - 2 storey 1 point - 3 storeys 2 points - 4 or more storeys 3 points	1.5