

SUSTAINABLE REFURBISHMENT

DECISION SUPPORT TOOL AND
INDICATOR REQUIREMENT



Nordic
Innovation

Sustainable refurbishment

Decision support tool and indicator requirements

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Contents

Foreword	3
Introduction.....	4
1 Scope	5
2 Normative references.....	5
3 Terms, definitions and abbreviations	5
4 Sustainable refurbishment, general principles.....	7
5 Methodology	9
5.1 General	9
5.2 Restrictions	9
6. Evaluation of building condition and performance	11
6.1 General	11
6.2 Planning the condition survey	12
6.3 Condition registration.....	14
6.4 Analysis.....	15
6.5 Reporting.....	16
7 Process of sustainable refurbishment	17
7.1 Strategic decision approach — step 1	17
7.2 Energy.....	18
7.2 Evaluating the building — step 2	19
7.3 Sustainable demolition — Step 3.....	23
7.4 Sustainable rebuild — Step 4	24
7.5 Sustainable commissioning – step 5.....	26
7.6 Sustainable refurbishment: In use stage – step 6	27
Annex A Example of classification of indicators in performance and condition classes, from 1 – 4.	28
Annex B Guides on chemicals in chemical building product, building products and building materials.....	29
Annex C The SURE list of indicators; explanation and discussion on use.....	31
Annex D The SURE list of indicators; with weighting (score) concluding for Denmark, Finland and Norway.	33
Bibliography	37

Foreword

In November 2011 the Nordic Prime Ministers issued a report “The Nordic Region – Leading in Green Growth” with eight initiatives to strengthen Nordic strongholds within green solutions. One of these initiatives was to co-operate within green technical norms and standards in the building sector.

Nordic Innovation under the auspices of Nordic Council of Ministers was given the task of further developing this initiative. A mapping process of green regulation and standards in the building sector and the current development of the European regulation was followed up at a workshop in June 2012 with Nordic participants from industry, standardization bodies, research and the public authorities and as result, the following areas were selected:

- 1) Sustainable refurbishment of existing buildings.
- 2) Indoor Climate and voluntary classification standards.
- 3) Future EU regulation on product and building declarations.

This document is the result of work area 1) Sustainable refurbishment of existing buildings. The main objective of this document is to deliver specific Nordic results for sustainable refurbishment of existing buildings to a European level.

Deliverables:

- Develop simple tools for qualifying the considerations to be made in relation to categorizing the existing building: which buildings to give first priority for a sustainable refurbishment. Sustainable includes the three aspects environmental, economic and social. This also includes energy efficiency.
- Define common Nordic requirements for a sustainable refurbishment of existing buildings taking into accounts existing regulation. The requirements should be based on Nordic experiences from establishing environmental requirements to new constructions

Former projects supported by Nordic Innovation on related topics:

- Sustainable Refurbishment – life cycle procurement and management by public clients (SURE), [1], and
- Sustainable Rehabilitation of Civil and Building Structures [2].

Introduction

This document was developed to collect and structure systems and experiences from the Nordic countries for sustainable refurbishment. The Nordic countries like all other European countries face big challenges transforming the existing building stock to environmentally and socially feasible buildings for the future with a low carbon societies and a higher focus on resource efficiency. The transformation should be done in a cost effective manner and hence the refurbishment should be sustainable. This document gives a simple method for qualifying the considerations to be made in relation to categorizing the existing building: which buildings to give first priority for a sustainable refurbishment also taking into consideration that not all buildings should be refurbished.

Building refurbishment modifies the human living environment. Hence, it is critical that the financial and technical visions by engineers, architects [3] and technical experts do not impose restrictions on the living environment of the people. The past century has witnessed an ongoing debate regarding the feasibility of demolition as compared to the refurbishment of older housing and buildings [4, 5, 6, 7]. Power [8] argues that there are significant economic, social and environmental benefits of refurbishment in comparison to demolition. These benefits include reduced landfill disposal, transportation costs, greater reuse of materials, retention of community infrastructure and additional benefits of local economic development and neighbourhood renewal and management. Contrary to the mentioned advantages of refurbishment, building demolition requires higher capital costs, the need for more aggregates and subsequent new build than refurbishment and further includes embodied carbon inputs, noise and disruption. Moreover, a greater transportation need for materials and waste is observed for building demolition which also involves a polluting impact of particulates.

Refurbishment can be seen as an opportunity not only to modernize a building's appearance but also to enhance its overall technical performance [9]. The need for refurbishment emerges due to the increasing demands for better-quality housing and the quest for energy efficiency of commercial and industrial buildings. The individuals responsible for design, construction, and initial financing of a building are often times different from those operating the building and meeting its operational expenses. Nevertheless, the decisions made at the early stages of building design and construction can considerably influence the costs and efficiencies of subsequent phases. Depending on the object in need of refurbishment, a positive attitude towards sustainability can further be completed by the preservation of architectural, historical and cultural values of a building.

The benefits of sustainable refurbishment can contribute to preservation of the existing built environment and its protection for future generations. In addition, application of the concept sustainable building contributes to reduced environmental footprint and better adaptation to climate change, for instance by limiting the solar gain in summer and improved water efficiency contributing to lower operating costs [10] and reduces flood damage from flash showers. Moreover, sustainable buildings will be a mark of quality when accredited independently designating a healthy living environment. For building owners, the decision of refurbishment versus redevelopment is dependent on the commercially available options in conjunction with maximizing the building's economic performance for the building occupant as well as the owner.

This document describes the process from when the stakeholder considers taking measures to renovate. This method can also be used when mapping a large number of buildings. This document divides the process into six steps and gives recommendation for indicators and methodology to use in each step. The indicators from the categories and sub categories in this document shall be used. Which indicators to use from each subcategory depend on the stakeholder's requirement and national regulation. Indicators in this document are meant for guidance.

Sustainable refurbishment – Decision support tool and indicator requirements

1 Scope

This document gives a method for how to decide if and how a sustainable refurbishment should take place. It defines the necessary steps and the considerations and indicators to use. It also recommends a scoring system with grade classes for evaluation for sustainable indicators.

This document enables the user to sufficient but simple analysis for sustainable development of one building as well as a portfolio of buildings.

This approach is generic for all types of buildings.

This document does not give benchmarks for the evaluation. For benchmarking the user are referred to local regulation.

NOTE The subsequent project, Swan labelling of building refurbishment, carried out by Nordic Ecolabelling can be referred to for benchmarking.

2 Normative references

This document has no normative references

3 Terms, definitions and abbreviations

3.1

sustainable development

meeting the needs of the present without compromising the ability of future generations to meet their own needs [SOURCE: ISO 14050:2002]

3.2

sustainable building

a building that fulfils all necessary economic, environmental and social as well as technical and functional requirements, based on its intended use

3.3

renovation

upgrade of components, elements and systems including energy efficiency upgrading

Note 1 to entry: This also applies when upgrading is required by e.g. changed regulations.

Note 2 to entry: Major renovation, according to 2010/31/EU, Directive on the energy performance of buildings, means the renovation of a building where: a) the total cost of the renovation relating to the building envelope or the technical building systems is higher than 25 % of the value of the building, excluding the value of the land upon which the building is situated; or b) more than 25 % of the surface of the building envelope undergoes renovation. Member States may choose to apply option (a) or (b). (Note that this EU Directive definition does not take in to account the term refurbishment.)

3.4

refurbishment

modification and improvements to an existing building, or civil engineering works in order to bring it up to an acceptable condition

[SOURCE: EN 15643-1:2010, 7.1.50, modified: the word "plant" is taken out]

Note 1 to entry: Refurbishment will normally include fulfilling new requirements on performance from core business.

3.5

sustainability assessment of buildings

combination of the assessments of environmental performance, social performance and economic performance taking into account the technical and functional requirements

[SOURCE: EN 15643-1:2010 3.68, modified]

3.6

reference level

set level that is used as a basis for description and determination of condition class

Note 1 to entry: Can be specified through reference to authority requirements (legal/regulatory requirements), client requirements, user requirements, functional requirements or other requirements.

3.7

new building

performance and state of a building as it was when first handed over to the owner/user

Note 1 to entry: It is implied that the building is compliant with current regulation at this time.

3.8

maintenance

combination of all technical, administrative, and managerial actions during the life cycle of an item intended to retain it in or restore it to a state in which it can perform the required function

[SOURCE: ISO 16484-2:2004, 3.114]

3.9

adaptability

a function of flexibility, generality and elasticity

3.10

flexibility

possibility to change space distribution

3.11

generality

possibility to change the function of the building

3.12

elasticity

possibility to change the volume of the building outside the building unit

3.13

usability

possibility to change volume within the building unit

4 Sustainable refurbishment, general principles

Refurbishment is in this document considered broader than renovation, and can include change of space plan. By also adding the sustainability aspect to refurbishment the result is a more nuanced project with the view to meet future requirements and minimum environmental impact. See

Figure 1.

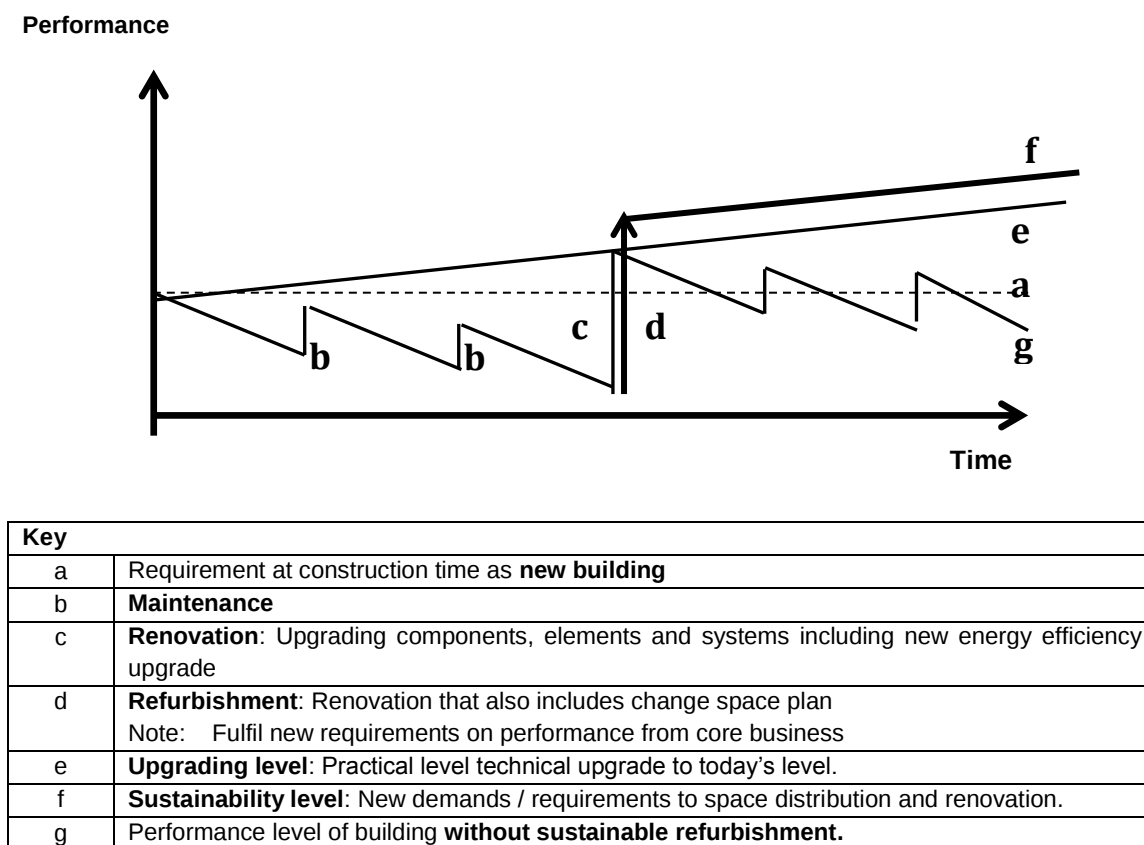


Figure 1 — Relation between renovation and refurbishment

Today's condition and performance of buildings should be evaluated according to expected requirements and needs in the future. To do this the existing condition and performance needs to be assessed. The difference between the two levels gives information on the refurbishment needed. See Figure 2.

This work shall take into account effects that may affect sustainability of the building; an important part being energy and indoor air quality as this may seriously affect the total cost as determined by the standard of the building (see also EN 15251, Introduction [11]).

NOTE The Nordic Innovation project "Indoor Environment — Classification of the indoor environment in buildings — Office buildings, schools, kindergartens and residential buildings", secretariat by Danish standards.

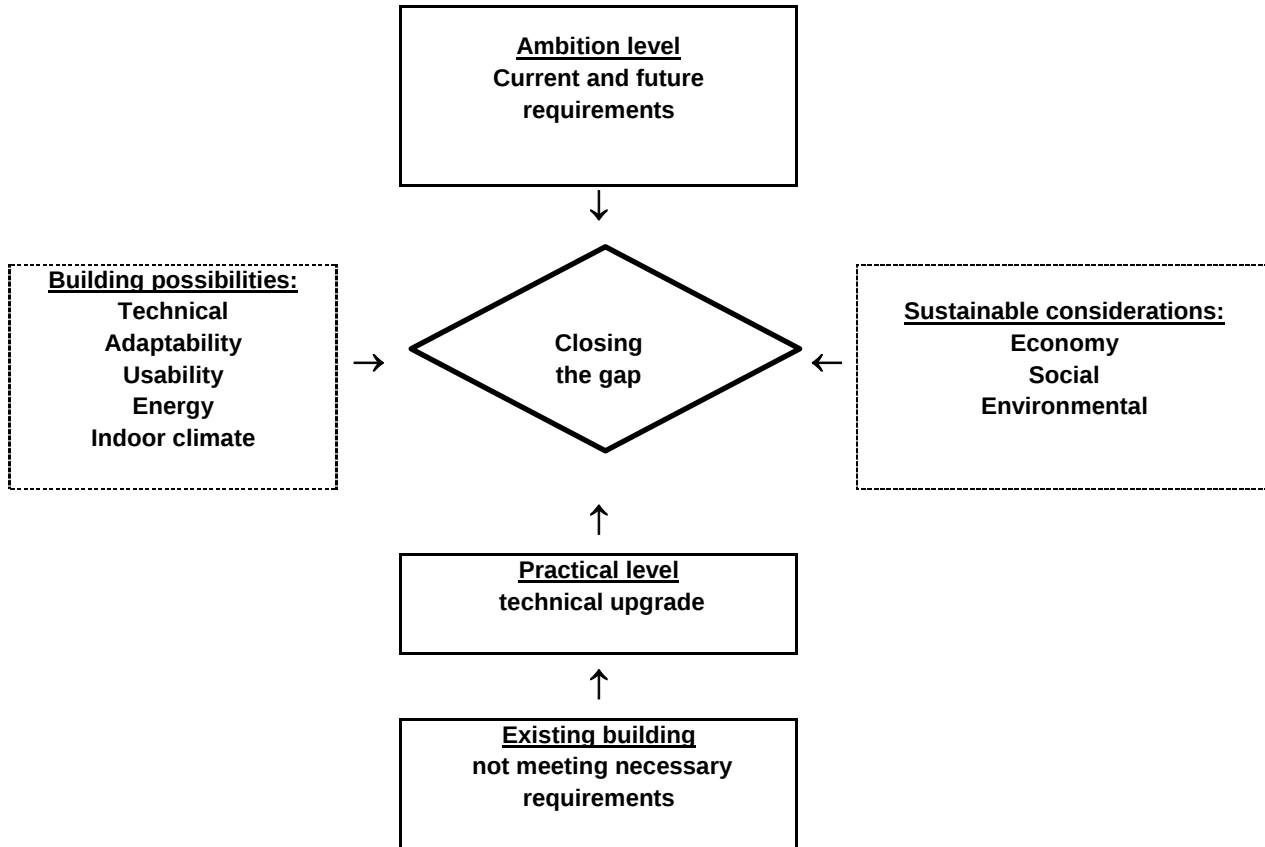


Figure 2 — The aim of sustainable refurbishment is to close the gap between old buildings condition and new building requirements with a sustainable approach.

The main aspects of key performance indicators as defined in this document are intended to be complete regarding general needs from the sustainable point of view (and as a classification tool for buildings in general).

The indicators covers the aspects;

- economical;
- environmental;
- social;
- technical;
- process.

5 Methodology

5.1 General

Process starts when the property owner evaluate the status of the building (or buildings), and consider to either energy efficiency upgrade or refurbishment (

Figure 3, step 1), new use, keep as is or demolish (

Figure 3, step 2). Step 3 describes how to take care of the sustainable aspects of demolishing and step 4 describes sustainable rebuild. Step 5 necessary steps during the commissioning face. Step 6 describes how to keep the building sustainable when it is in use. See Fleet diagram in Figure 4.

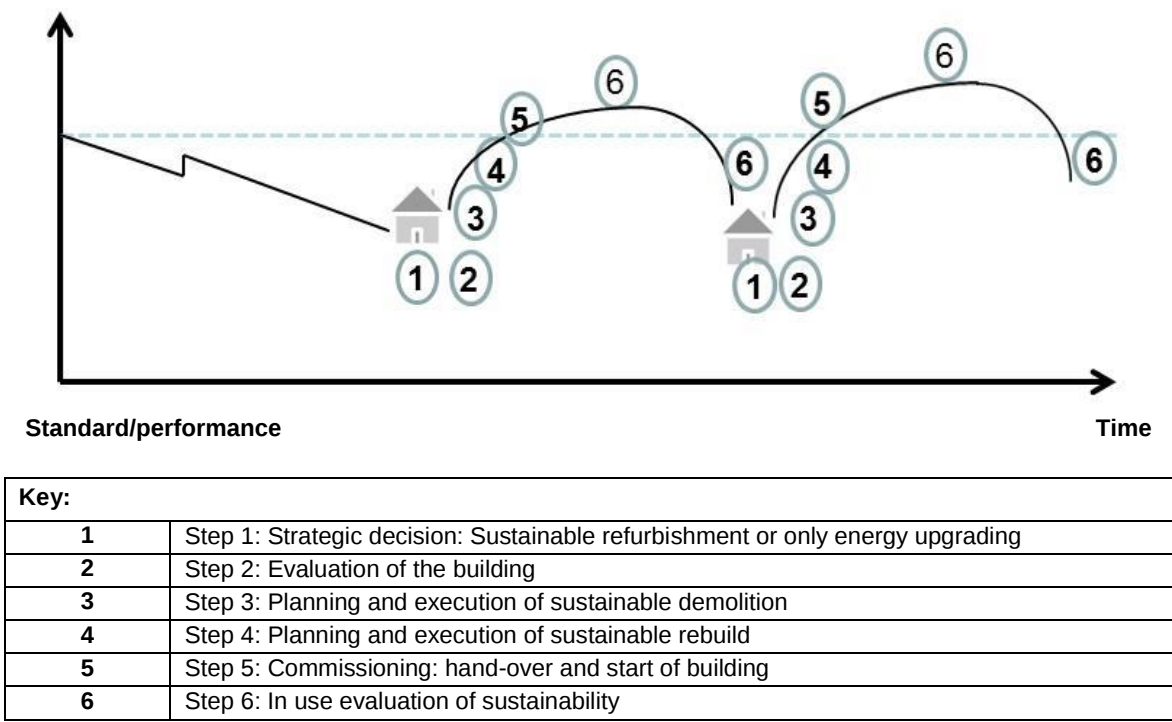


Figure 3 — Life Cycle Spiral with 6 steps in each cycle.

Clause 7 specifies the requirements for the various stages and tasks in the process.

5.2 Restrictions

Listed buildings and buildings of heritage value will need extra considerations. Refer to standard EN 16096 Conservation of cultural property - Condition survey and report of built cultural heritage [12].

Step		Indicator categories	Comment/ Reference to clause
Strategic level	Step 1 Sustainable approach? No → Yes ↓	Strategic decision just to energy renovate: Upgrade energy standard as close as possible to today's regulation	Not part of scope of this document (it is not a sustainable approach) Clause 7.1
Sustainable refurbishment	Step 2 Keep the building ↓	Technical Usability Adoptability Health	Clause 7.2
	Step 3 Environmental demolishing ↓	Waste handling Reuse Neighbouring Energy	Clause 7.3
	Step 4 Sustainable construction process ↓	Extended indicator list Example: SURE, annex C.	Clause 7.4
	Step 5 Commissioning ↓	Documentation Technical systems Operational Competence Acceptance building as is	Clause 7.5
	Step 6 Sustainable in use	Social Environment Economy	Clause 7.6

Figure 4 — Fleet diagram Steps 1 to 6.

6. Evaluation of building condition and performance

6.1 General

The condition survey is used for classification of the performance and condition of the present building. The model for condition survey is simple by comparing performance and requirements. This is the bases for evaluation to determine what measures should be taken.

Condition survey is used in step 2 in to determine whether to sustainable refurbish or to demolish or other ways of changing use. The condition survey is also the tool for planning the demolition process either for the whole building as a result of step 2 or as the first part of refurbishment in step 3. Step 4 is conditional survey used as a simple tool to select building products and services for a sustainable rebuild while step 5 and 6 for checking status during commissioning and in use of the building.

General procedure for conditional survey is given in Figure 5, and the procedures are given in subsequent clauses.

NOTE This methodology is adapted from NS 3424.E:2012 (English) [13].

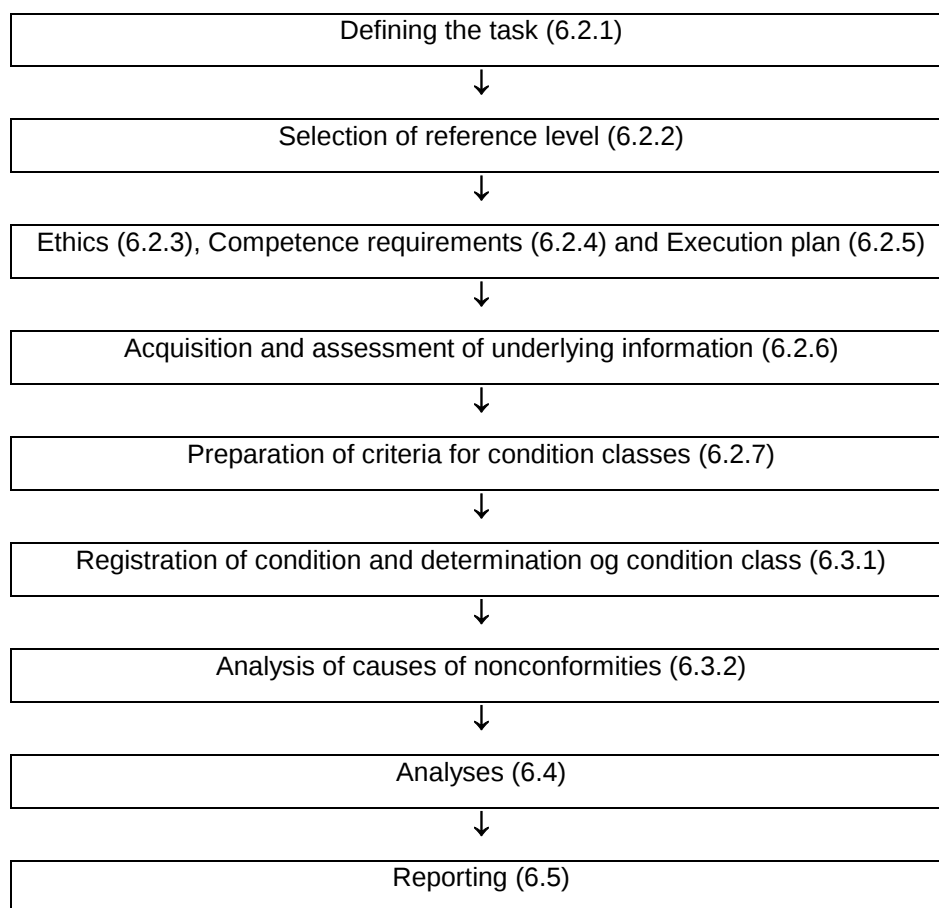


Figure 5 — Recommended procedure for the condition survey [13].

6.2 Planning the condition survey

6.2.1 Defining the task

The purpose and scope of the condition survey shall be described with the owner. Condition survey for a building with its technical systems may be used as basis for maintenance planning, repair, valuation, upgrading or refurbishment. The purpose level of registration should be defined and use of resources shall be established and described. To get an overview of the situation it is enough with comparison of fewer indicators for some purposes, for example maintenance plan. For steps 2 - 6, there are given indicators for consideration. For indicators see appropriate sub clause under clause 7. All indicators shall be considered. Relevant indicators should be carefully selected and further detail to satisfy the interest and finances of the stakeholder. When appropriate further sub indicators can be defined and used.

The building shall be described according to the condition survey's scope and survey level. A brief description shall be given of the method of construction, the structural design and material usage.

NOTE The description may include history, physical limitations, function and a description of the surroundings.

6.2.2 Selection of reference level

The reference level that is used as a basis for the description and determination of condition class 1 shall be specified through reference to authority requirements (legal/regulatory requirements), client requirements, user requirements, functional requirements or other requirements.

6.2.3 Ethics

The condition survey shall be carried out on the basis of best professional judgement and without any consideration to the interests of the parties involved.

The party who carries out the survey shall state his or her relationship to all parties which could have an interest in the results of the survey.

6.2.4 Competence requirements

The person(s) who participate in the condition survey shall collectively have:

- knowledge and experience of carrying out condition surveys and methods;
- knowledge of the type of building that is to be analysed and possible hazards and problem areas;
- knowledge of the interaction between the building and other factors, both internal and external;
- necessary knowledge of all relevant disciplines.

The party who is responsible for performance of the condition survey shall be familiar with the requirements in this document and possess the competence that is required under applicable laws, regulations, standards or norms for the object that is to be assessed. The condition survey shall be carried out by qualified persons who possess the necessary competence within the discipline or disciplines that are to be assessed. All areas that are relevant given the purpose and scope of the condition survey shall be covered. The competence of the person(s) who carried out the condition survey shall be documented;

NOTE A competence description covers education and relevant practical experience, including experience of carrying out condition surveys in accordance with this document or NS 3424.E:2012.

6.2.5 Execution plan

A plan for the condition survey which covers all activities in accordance with **Figure 5** shall be prepared.

The condition registration is carried out through an inspection of all relevant parts of the building that are covered by the survey or through random sampling. In the case of random sample investigations, selection of the building or parts thereof to be covered shall be based on professional judgement, i.e. where the occurrence of nonconformities would be most likely or most critical.

6.2.6 Acquisition and assessment of underlying information

Relevant information concerning the building shall be obtained and collated according to the task. Available underlying information shall be reviewed and assessed.

The way in which missing underlying information is handled shall be reported.

In the case of lack of documentation of the building, there will be many opportunities for hidden nonconformities. In such cases, it can be appropriate to state that the documentation is generally inadequate and does not meet current requirements, and to carry out a general assessment of the extent to which the possible hidden nonconformities are real, instead of listing all possible hidden nonconformities.

6.2.7 Preparation of criteria for condition classes

The condition class is an expression of the condition of building or a part/component in relation to the chosen reference level. Prior to the registration of condition, a set of criteria shall be prepared which represents the framework for the determination of the condition class for the various parts of the building. Examples are given in Annex A. These criteria shall be determined on the basis of the purpose of the analysis and a consequence assessment. Four condition classes shall be used, as defined in **Table 1**. Reference for weighing between indicators is given in Annex D: The SURE list of indicators; with weighting (score) concluding for Denmark, Finland and Norway.

NOTE 1 Criteria can be set out in separate building-specific standards or other documents with standardised descriptions.

NOTE 2 The significance and determination of condition classes can be based on symptom descriptions. The use of symptom descriptions will contribute to greater objectivity in the specification of condition. Such symptom descriptions could for example be formulated as image directories.

For grading a scale from 1 to 4 as described in Table 1 shall be used.

Table 1 — Condition classes

Grade classes	Condition in relation to the reference level	Importance/description
1	No nonconformity	- the condition corresponds to the chosen reference level
2	Minor or moderate nonconformity	- the building or part thereof exhibits normal wear and has been maintained; or - the nonconformity or lack of documentation is not important in relation to the reference level
3	Essential nonconformity	- the building or part thereof is severely worn or has suffered major damage or has a significantly reduced performance in relation to the reference level. Local severe wear and a need for local measures; or - lack of important documentation; or - the remaining useful life is short; or - it has been inadequately or incorrectly designed; or - it has been inadequately or incorrectly maintained.
4	Major or serious nonconformity	- the building or part thereof has suffered or will imminently suffer total functional failure; or - need for immediate measures. Danger to life and health.
NI	Not investigated	- the part is not accessible for inspection and no documentation is available to verify correct design and a possible nonconformity can involve major consequences and risk. More comprehensive investigations are needed in order to identify any nonconformity

Choose the condition grade class as objective as possible. Example of how to build up grading classes is shown in Annex A.

6.3 Condition registration

6.3.1 Registration of condition and determination of condition class

Condition registration consists of an examination and registration of condition. In some cases, condition is registered directly, while in others symptoms are registered. In connection with condition registration, an assessment shall be made of whether the survey level and the scope which is determined in advance is sufficient to achieve the purpose of the condition survey and changes shall be made if necessary.

Where a condition survey includes measurements, the equipment used shall be calibrated for safe results in accordance with the product manual for the instrument concerned.

The condition shall be specified through condition classes, as described in clause 6.2.7. In the case of nonconformity being identified, a statement shall be given of the requirement to which nonconformity relates, and it shall be documented, if appropriate with descriptions, drawings, reports, sketches and photographs.

NOTE 1 See also clause 6.5 concerning what shall be included in the report.

NOTE 2 The scope of nonconformity can be specified in writing as a percentage of the total quantity, as absolute dimensions or by normative references.

For parts of building that are inaccessible, a condition class shall be determined insofar as is possible on the basis of symptoms of nonconformities relating to adjacent parts/ building or according to other indications of nonconformities. If this cannot be assessed, there is a possible nonconformity present, and the part of building shall be assigned a condition class of NI ("Not investigated"). The use of NI shall be limited insofar as is practicable. In order to reduce the use of NI in reports, an assessment shall be made as to whether certain parts of building shall be subject to a more comprehensive and detailed survey.

The person who carries out the condition survey shall notify the building owner/client immediately of any circumstances with major and serious consequences.

6.3.2 Assessment of expected remaining useful life

For all parts of the building for which a condition class of NI has been registered, the expected remaining useful life shall be assessed and specified.

NOTE The expected remaining useful life may also be assessed for other cases if the purpose of the analysis indicates that such an assessment is appropriate.

6.4 Analysis

The registered condition shall be assessed as part of building level and at an overarching, general level.

NOTE 1 More than one consequence can arise from a single observed condition.

Grade classes Consequences shall be described through the specification of consequence levels and four levels shall be used as described in Table 2.

Table 2 – Priority of actions

Grade class	Description of action	Priority	Priority of action	Action type Step 2 ¹⁾
1	No action necessary	4	No action necessary	
2	Minor and medium action necessary	3	Action can be made depending on maintenance strategy, budget, and cost benefit	a) minor repair, maintenance b) replace c) upgrade
3	Essential action necessary can come in near future	2	Keep close attention, prepare for action in neare future:	a) repair b) replace c) upgrade
4	Major and serious action necessary	1	Action shall be made as fast as possible:	a) repair b) replace c) upgrade
¹⁾ Action type is here indicated with relevant example for Step 2. Other actions are selected relevant to the application of the conditional survey.				
NOTE 2 Examples of aspects for which the indicators are being assessed: — safety (for example, safety with regard to personal injuries, loss of value, fire damage, intrusion); — health (for example, possible damage to health as a result of a poor indoor climate, radon, electronic radiation, mould/fungi); — external environment (for example, environmental impacts in the form of emissions of greenhouse gases, other harmful substances, noise); — aesthetics (for example, surfaces); — energy consumption;				

- loss of cultural heritage;
- consequences for the organization (e.g. reputation, consequences of operational problems and interruption);
- finance (reduction in value, direct costs (maintenance, replacement) and indirect costs for the organization);
- violations of laws and regulations.

Recommended action type gives an indication on further action. The basis for the recommendation shall be specified. Final decision on action shall be made on a building level or at an overarching, general level.

6.5 Reporting

The report shall be adapted to the intended use of the report. The report should contain the following:

- 1) Introduction giving the following information:
 - the purpose of the condition survey; see 6.2.1;
 - the owner of the building;
 - identification of the building or parts thereof, e.g. address, land registry number, property registration number;
 - principal construction, year of construction/age;
 - significant changes since the year of construction;
 - client (and his representatives);
 - time of survey;
 - executive and responsible person for the condition survey and their competence (including any certificate number); see 6.2.4;
 - other parties involved (and their representatives);
 - scope and use of resources; see 6.2.1, 6.2.4 and 6.2.5;
 - survey level; see 6.2.1;
 - what, if anything, is not covered by the survey; see 6.2.1.
- 2) The conclusions shall contain the following information:
 - principal conclusion/summary;
 - overview of parts of building with grade class 3 and 4 (6.4);
 - overview of relevant actions (6.4).
- 3) The main report shall contain the following points:
 - the reference level and criteria that have been used as a basis for assessing condition and nonconformity; see 6.2.2 and 6.2.7;
 - condition registration, determination of condition class and nonconformities; see 6.3.1;
 - assessment of grade class, priority and action used as a basis; see 6.4;
 - assessment, recommendation and prioritisation of measures;
 - assessment and specification of expected remaining useful life for parts of building with NI; see 6.3.3.
- 4) Attachments to the report
 - The condition registration shall be verifiable. Records, observations, measurements, photographs, calculations and analyses used as a basis for determining the condition class shall be attached to the report.
 - The basis for further assessing shall be attached to the report.
 - Any background material which describes the building as built or modified which does not form part of the condition survey, and supplementary material from the condition survey which need not be included in the main report, shall be attached to the report.

Under all the listings under 3) an assessment shall be made of how much documentation shall be included in the main report and what, if anything, could be included as an attachment.

7 Process of sustainable refurbishment

7.1 Strategic decision approach — step 1

At the start of the sustainable refurbishment process it is important to clarify the strategy the owner has for the building or building portfolio. The owner should consider the following:

- investment costs or life cycle costs (investment -, management -, operation – and maintenance costs;
- today's needs or future needs;
- carbon footprint;
- only energy efficiency upgrade or total refurbishment includes considerations of (see also 7.2):
 - energy source;
 - energy demand;
 - electricity usage;
 - energy management;
 - renewable energy percentage.
- other.

It is important to determine if the actions only have focus on energy upgrading or a more complete sustainable refurbishment (Figure 6). Sustainable refurbishment contain environment, social and economy aspects, and just energy upgrading in itself is therefore only a part of sustainable improvement.

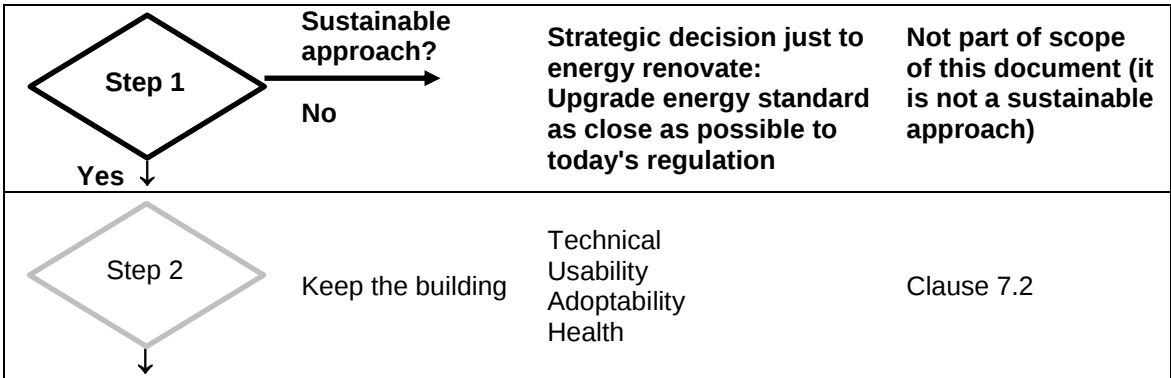


Figure 6 — Step 1

NOTE Energy renovation or upgrade can be motivated by incentives given by the government or as a demand from those renting space in the building.

Energy efficiency upgrade is not further described in this document.

7.2 Energy

When considering energy usage in a building all aspects of energy flow have to be taken into account. The energy flow through the system is illustrated in Figure 7.

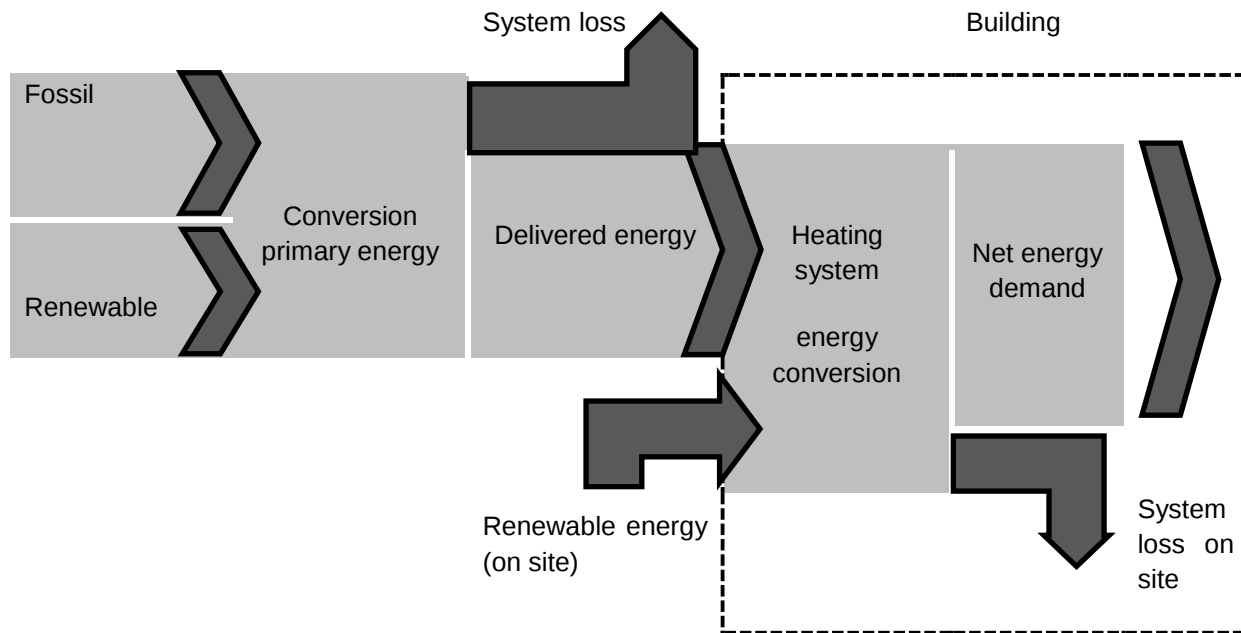


Figure 7 — Energy flow in thru the building [14]

Figure 8 show how the energy flow from the primary energy source (left) to net energy demand (right) on site. The net energy will, together with the internal heat and passive solar heat, serve the need for energy in the building – i.e. heat loss, cooling, lighting, water heating and technical equipment.

7.2 Evaluating the building — step 2

7.2.1 General

Considerations necessary to evaluate if the building has potential for sustainable refurbishment are to be made, see Figure 8.

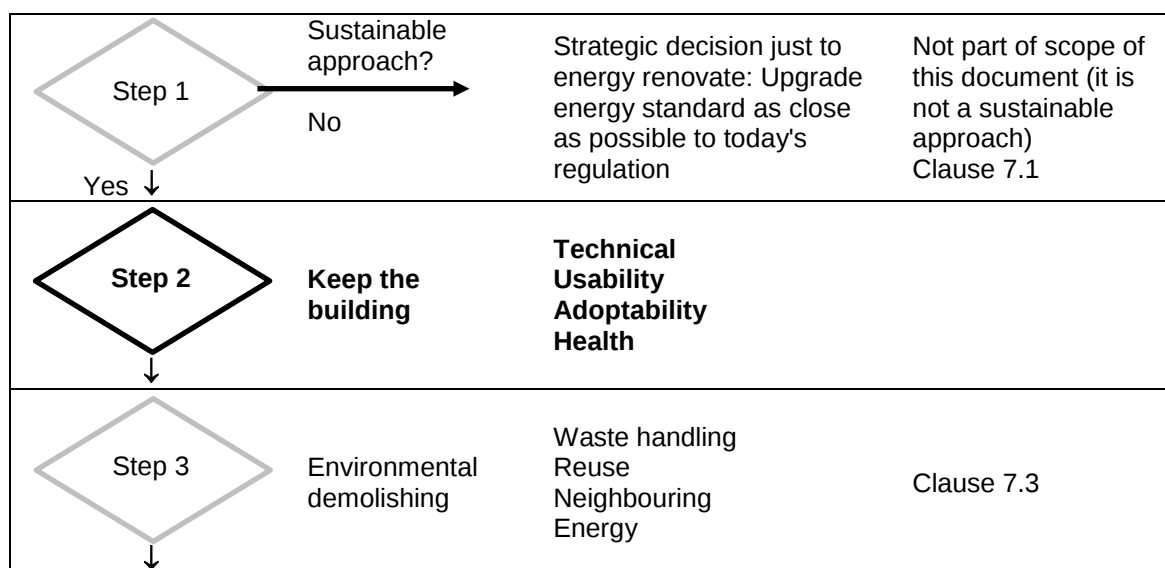


Figure 8 — Step 2

Decision should be taken without going into details but based on four main categories of indicators. These four categories are described in Table 3.

Table 3 — Main aspects for early decision making

Main category	Numbers of indicators	Exemplified description
Technical condition	18	Costs for upgrading, backlog of maintenance and building failures can be very costly and maybe not justifiable.
Usability situation	7	Unacceptable usability will lower efficiency in core business.
Adaptability	12	Adaptability tells us about flexibility (possibility to change space distribution), generality (possibility to change function in core business) and elasticity (possibility to change volume). Change in space distribution can be of high cost if all walls are load bearing, low load bearing capacity in slabs don't allow other functions and so on.
Indoor climate (Health)	11	Health and comfort based on factors within indoor climate. Bad condition of these factors have a big influence on "well-being" for the users and there of influence on core business economy.

The result of conditional survey should be used in two steps: Firstly to decide whether or not to sustainable renovate, and secondly to determine what areas needs addressing in the plan for the demolition process (step 3) and the rebuild (step 4). Economic considerations and technical solutions will then regulate how much is done.

7.2.2 Indicators for step 2

Each category has indicators as shown in Table 4.

Table 4 — Indicators for deciding whether to sustainable refurbish or not, and prioritising of efforts.

Categories	Indicators for step 2 (listed, not after priority)
Technical	1) foundation-load bearing system 2) windows-doors in facades 3) facade-balconies 4) roof 5) indoor surfaces (ceilings, floors, walls) 6) inventory (fixed) 7) sanitation 8) HVAC (heating, ventilation, aircondition) 9) fire protection 10) el-distribution 11) lightening 12) ITC 13) lifts 14) waste handling 15) outdoor technical systems 16) ground-drainage
Adaptability	Flexibility and generality: 1) Net floor to ceiling height 2) load bearing capacity (floors) 3) vertical space for installations 4) possibility for holes in slabs 5) amount of space on each floor 6) possibility to open space 7) width of communication areas 8) inner walls 9) width of building 10) lift Elasticity: 11) site situation 12) vertical or foundations load bearing capacity
Usability	1) capacity within a unit 2) size and design of rooms 3) space design within unit or floor 4) communication path within unit or floor 5) core business related installations (not building requirements) 6) esthetic and social 7) logistic local and external
Indoor climate	1) Ventilation rate 2) CO₂ content in indoor air 3) Thermal conditions 4) Radon 5) Formaldehyde 6) Hazardous chemicals 7) Particles and fibers 8) Microbes 9) Dampness and mold 10) Daylight and artificial lighting 11) Acoustics and noise

These indicators are used in conditional survey in clause 6. Based on the costumers scope (see 6.2.1 Defining the task) the person responsible for the conditional survey select relevant indicators from the four main categories. Based on the costumers requirements and the selected reference level (see 6.2.2) the levels in each grade class are defined for each indicator (and sub indicators). (See Annex A)

7.2.4 Modeling of results and communication

Communication of results is important for understanding the message given. The result of the conditional survey of many buildings can be presented visually in a map or photo. Colour codes can indicate the four grade classes. After analyses of the result and the owners priorities a second map with colour codes for priorities can be developed. Figure 10 shows how the buildings can be categorized. Buildings in I) is very suitable and should be maintained when needed. Buildings in II) can be adapted and then will go in to category I) when refurbished. Buildings in III) are recommended maintained with minimum of costs until they no longer have good usability and end up as category IV). Buildings in IV) are hard to adapt and are also not useable for its purpose any longer and should be recommended new use or demolished. Buildings with heritage value (often ends up as IV) need extra considerations.

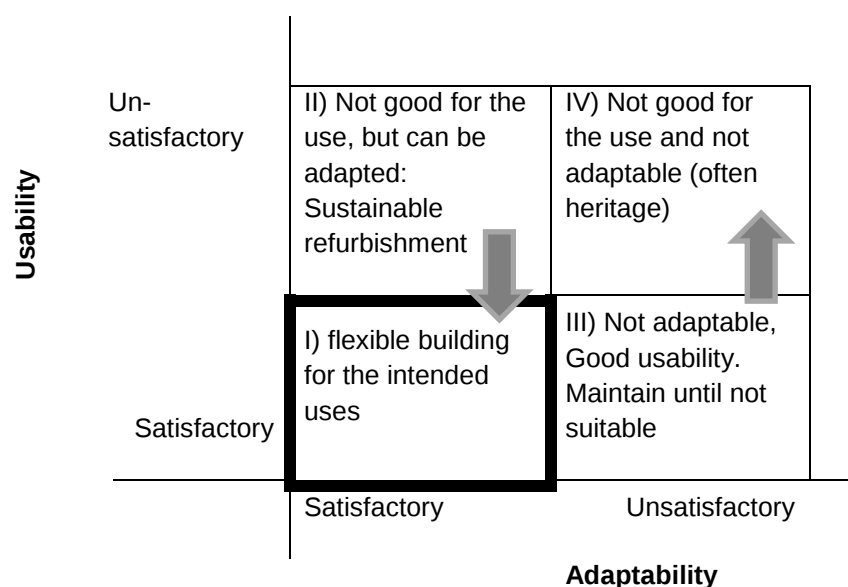


Figure 9 — Correlation between usability and adaptability. The arrows indicates the likely development path for the building.

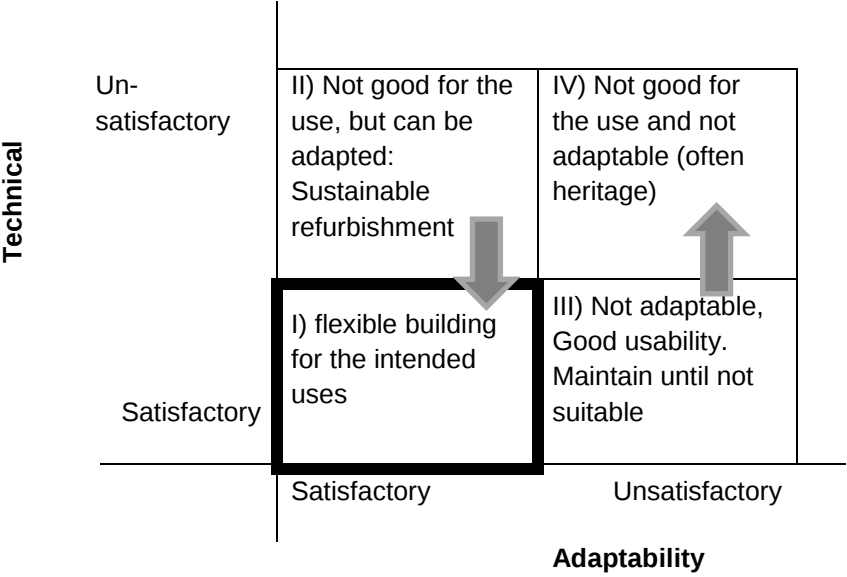


Figure 10 — Correlation between technical and adaptability. The arrows indicates the likely development path for the building.

7.3 Sustainable demolition — Step 3

7.3.1 General

Step 3, Sustainable demolition, is valid for both taking the whole building away or as initial work as a start on refurbishment process.

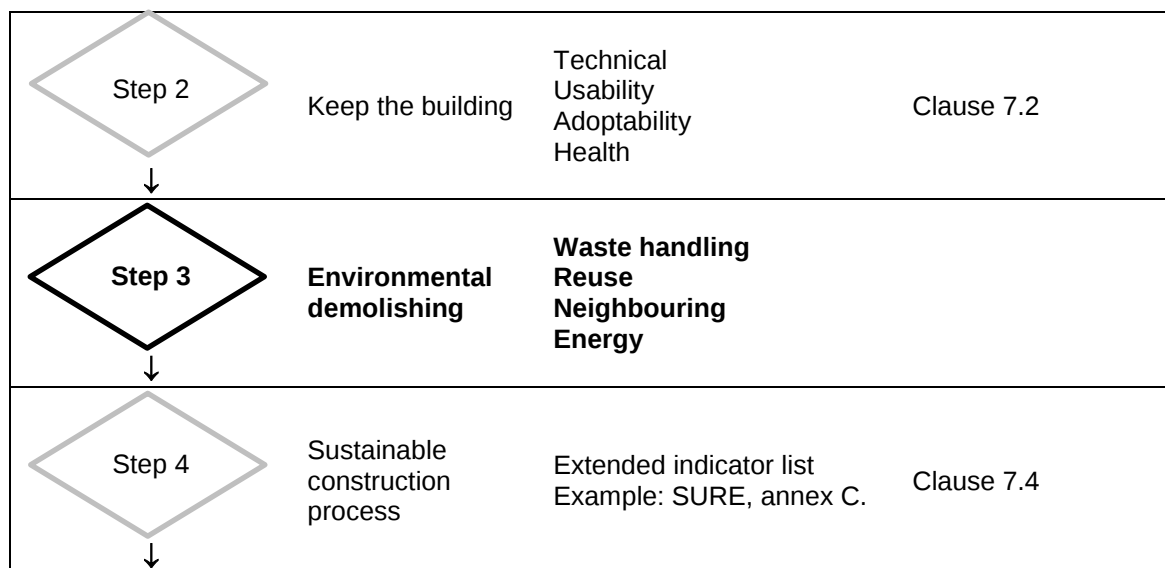


Figure 11 — Step 3

To utilise building products potential and reduce impact on the environment an assessment including the indicators in Table 5 should be used. The assessment tool should follow the principles in conditional survey, See Clause 6.

7.3.2 Indicators for Step 3

The indicators for assessment of the demolition are divided in to four categories: reuse, waste handling, social and process.

NOTE Information given in EPD for a building product (according to EN 15804 [15]) can give information on potential benefits in the end of life stage (Module C and D according to EN 15804).

Table 5 — Indicators for sustainable demolition

Categories	Indicators for step 3
Reuse	1) Components for re-use on site or offsite 2) Materials for recycling 3) Materials for recovery
Waste handling	1) Hazardous waste disposed (safe destruction or deponi/landfill) 2) Non-hazardous waste disposed (safe destruction)
Social (Neighbors and workers)	1) Dust/particles 2) Noise 3) Traffic 4) Vibrations 5) Light pollution
Process	1) Energy for demolition 2) transport

7.4 Sustainable rebuild — Step 4

7.4.1. General

The rebuild process can still be quite different from a regular new building: some steps of a regular new construction is not necessary, but other steps (not present in a new build) will be necessary in a rebuild.

For a sustainable rebuild conditional survey can be used as a tool to select construction products and services to achieve a sustainable building.

NOTE For an even more thorough evaluation of Step 4 EN 15643[16], EN15978[17], EN16309[18] and EN16627[19] can be used.

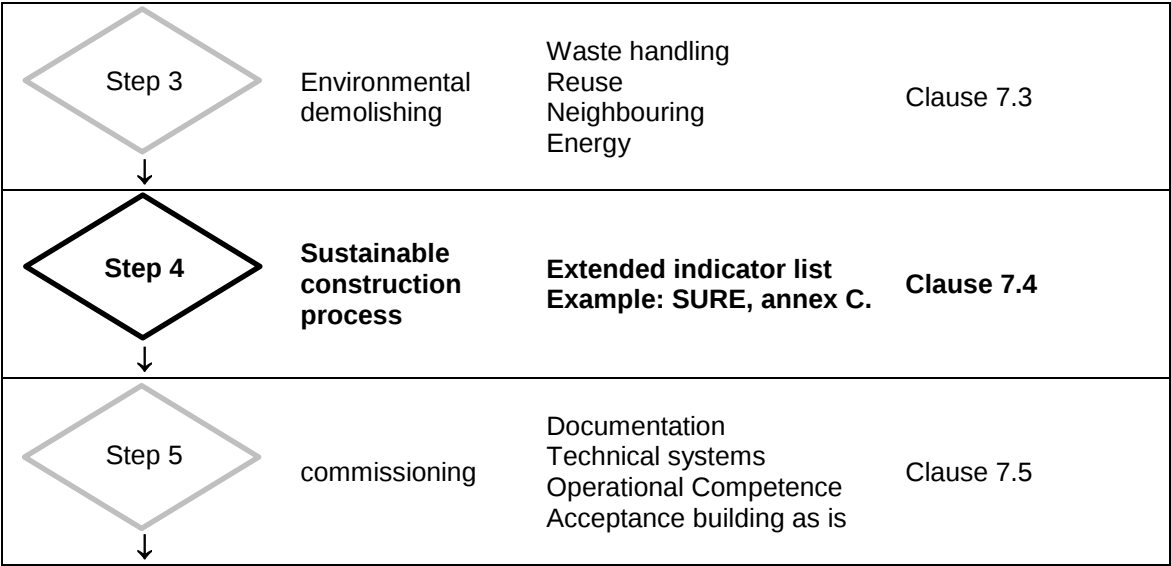


Figure 12 — Step 4

7.4.2. Indicators for Step 4

This document gives indicators derived from SURE [1], DGNB [20] and EN15978, EN16309 and EN16627 in Table 6, for use in the planning of the rebuild.

NOTE The Nordic project SURE [1] has an extended indicator list given in Annex C)

NOTE EN 15643, EN15978, EN16309 and EN16627 are generally applicable (horizontal) and describe a harmonized methodology for assessment of environmental performance of buildings and life cycle cost performance of buildings as well as the quantifiable performance aspects of health and comfort of buildings throughout the life cycle. Indicators from these standards are found in: EN15978 (environmental), EN16309 (social) and EN16627 (economic).

Table 6 — Indicators for sustainable rebuild

Categories	Indicators for step 4 (Design for sustainability)
Social	1) Accessibility; 2) Public transport and facilities for bicycle; 3) Impacts on neighborhood (light and noise to the surroundings); 4) Flexibility for other use/ adaptability; 5) Thermal comfort winter/summer; 6) Indoor air quality; 7) Acoustic comfort; 8) Visual comfort; 9) Space efficiency; 10) Safety and security; 11) User participation; 12) Quality of outdoor areas; 13) Design and city planning; 14) Building integrated artwork;
Environmental	1) Global warming potential; 2) Depletion potential of the stratospheric ozone layer; 3) Formation potential of tropospheric ozone 5; 4) Acidification; 5) Nutrient load; 6) Risk for local environment; 7) Sustainable resource use; 8) Fossil (non-renewable) primary energy use; 9) Energy use and quantity of renewable energy; 10) Water consumption and waste water; 11) Space requirements 12) Chemicals in chemical building product, building products and building materials, see Annex B; 13) Soils and fill materials; 14) Use of secondary material; 15) Waste categories (hazardous, non-hazardous and radioactive) disposed; 16) Output flows leaving the systems (re-use, recycling, energy recovery, exported energy); 17) Abiotic resource depletion potential elements and fossil fuels (ADP- _);
Economy	1) Life cycle costs (LCC), 2) New present value (NPV) of cash flow, 3) value development

7.5 Sustainable commissioning – step 5

7.5.1 General

Time given to commissioning should be in accordance to the complexity of the building. Aim is a functional building when it is taken into use. Also all technical staff should at this time be trained in all operating processes. Remember documentation, training and acceptance should be in place prior to using the building. prNS 6450 *Operational testing of technical building installations* [21] gives guidance for the commissioning of building.

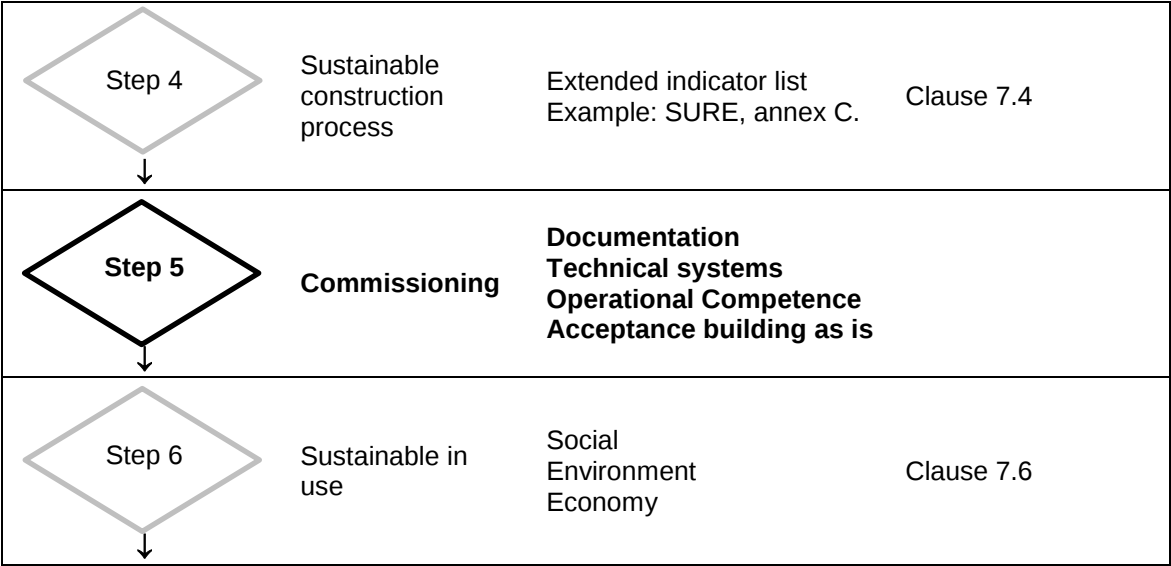


Figure 13 — Step 5

7.5.2 Indicators for Step 5

The commissioning survey should include the main indicator categories in Table 7. Sub indicators and other indicators are chosen appropriately for the location, currant- and future use.

Table 7 — Indicators for commissioning-stage

Categories	Indicators for step 5 Commissioning
Documentation	1) As Built documents 2) Guidelines for operation and maintenance 3) Documentation on adaptability 4) Manuals for IKT-systems 5) Simple user's manual
Technical Systems	1) Functionality of integrated systems 2) Airflow demands proved 3) Security and safety systems functions 4) Outdoor systems functions
Operational Competence	1) Training program fulfilled 2) Organisation of MOM (Management, Operation, Maintenance) defined
Acceptance Building as is	1) Inspection of completion totally finished 2) Surfaces are as described 3) Indoor climate as described

7.6 Sustainable refurbishment: In use stage – step 6

7.6.1 General

Step 6 gives guidance on how to make sure that the building stays sustainable also in the user phase. The facility manager can apply the conditional survey principle in clause 6 to check the sustainable building(s). The facility management should on basis of the conditional survey develop a periodic reporting of the building during use. Recommended frequency is 5 years. Changes in use or regulation can trigger more frequent or more detailed reports. The report shall enable the owner to prioritise and take necessary measures to keep the building sustainable.

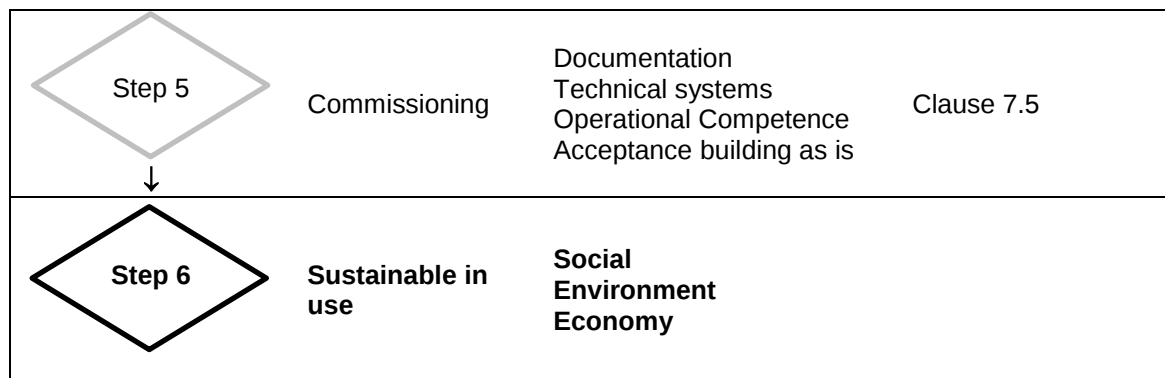


Figure 14 — Step 6 keeping buildings sustainable in the use stage.

7.6.2 Indicators for Step 6

The conditional survey should include the main indicator categories in Table 8. Sub indicators and other indicators are chosen appropriately for the location, current- and future use.

Table 8 — Indicators for in use-stage

Categories	Indicators for step 6
Social	1) Indoor climate 2) Aesthetic environment 3) Acoustic environment (for users of the building and neighbors) 4) Actinic (light conditions) environment (for users of the building and neighbors) 5) Universal design 6) Usability 7) Safety
Environmental	1) Material and chemical usage 2) Waste treatment 3) Energy source 4) Energy demand 5) Electricity usage 6) Energy management 7) Water consumption
Economy	1) Adaptability 2) Location 3) Branding 4) Value 5) Life cycle costs

NOTE Further guides on facility management are given in the EN 15221 – series [22].

Annex A Example of classification of indicators in performance and condition classes, from 1 – 4.

Example of how to build up criteria for performance and condition classes as describes in clause 6.2.7.

Table A.1 Example of criteria for performance and condition classes

	Class 1	Class 2	Class 3	Class 4
Technical (Step 2)				
Cooling (indicator 9)	The quality of pipeline network, armatures, outfits are of new built-condition. Service life left as new built. Sufficient capacity. Zoning.	About 10 years of age. Zoning. No signs of leakages or other problems. Sufficient capacity.	About 20 years/older than 20 years, but well maintained and parts with short service life are replaced. No zoning. Signs of low capacity Keep close attention	Older than 20 years and parts with shorter service life are not replaced. No zoning unsatisfactory capacity. Need for renovation or replacement.
Adaptability (Step 2)				
Net floor to ceiling height (indicator 1)	More than 4,0 meters. (or that the over or underlying floor is a technical mezzanine)	3,5-4,0 meters	3,0-3,5 meters	Less than 3 meters
Social (step 4)				
Acoustic comfort (indicator 7)	The building is better than the current regulation requirements. The building has no installations that disturb the building users or neighbors with noise. The noise reduction between rooms and floors is good. Very few complaints from building users.	The building meets the current regulation requirements. The building has some installations that disturb the building users or neighbors with noise. But noise reduction between rooms and floors is good. Few complaints from building users.	The building has poor acoustic environment. The building has some installations that disturb the building users or neighbors with noise. The noise reduction between rooms and floors is partially satisfactory. There are some complaints from building users. Some improvements are to be done.	The building does not meet the current regulation requirements and has very poor acoustic environment. The building has installations that disturb the building users or neighbors with noise. The noise reduction between rooms and floors is not satisfactory. There are many complaints from building users. Needs for improvements

Annex B Guides on chemicals in chemical building product, building products and building materials

Guides to Table 6, Environmental indicator 12) Chemicals in chemical building product, building products and building materials.

Table B.1 Chemicals in chemical building product, building products and building materials

Category Environment. Indicators for	High ambitions	Medium ambitions	Low ambitions	Legal requirements
Building products/ materials including chemical building products (like paint, varnishes, adhesives, sealants, fillers etc.)	The rebuilding has used products that fulfil strict requirements regarding chemicals and other environmental parameters throughout the lifecycle. E.g. 3. party controlled, lifecycle based, ecolabelled products like - Nordic Ecolabel (Swan)¹ - EU-Ecolabel.	The rebuilding has as minimum used products pre-assessed for not being environmental and health hazardous or added such chemical ingredients.^{a)} E.g. as system with minimum verification on chemical ingredients based on information from manufacturer/ supplier like - Basta³ - ECOproduct (as green or white)⁴ - Byggvarubedomningen⁵ - Sunda hus⁶ - Or equivalent.	The rebuilding has as minimum used a) chemical products without SVHC (Substances of Very High Concern) > 0.1 % (w/w) and without hazard classification (Acute Toxicity, CMR, Acute and chronic aquatic toxicity) b) products without obliged notification of chemical substances on the Candidate list over SVHC > 0.1 % (w/w) Assessment - MSDS for chemical products - EPD with information on SVHC⁷ - SINTEF Technical Approval with information on SVHC⁸ - Product Xchange (based on EPD)⁹ - Or equivalent.	Products that meet national legislation and are CE marked where applicable. MSDS must be available for chemical products. National legislation includes requirements for substitution of hazardous chemicals with less dangerous alternatives.

^{a)} The criteria includes limits for chemicals and ingredients with different hazard classification (CMR, toxicity etc.), PBT, vPvB etc.

¹ <http://www.nordic-ecolabel.org/>

² http://ec.europa.eu/environment/ecolabel/index_en.htm

³ http://www.bastaonline.se/download/18.21d4e98614280ba6d9e315d/1389864295993/Basta+properties+criteria_2014_Opt+1.pdf

⁴ <http://www.bygggtjeneste.no/WPpages/Produkter/Byggeportalen/ECOproduct.aspx>

⁵ <http://www.byggvarubedomningen.se/sa/node.asp?node=455>

⁶ <http://www.sundahus.se/home.aspx>

⁷ <http://epd-norge.no/> (information on SVHC substances from 2014), <http://www.environdedec.com/> (information on SVHC substances???)

⁸ <http://www.sintefcertification.no/en-us/Default.aspx> (information on SVHC substances from 2014)

⁹ <http://www.productxchange.com/en/International/Solutions/PXC/>

Annex C The SURE list of indicators; explanation and discussion on use.

In the SURE [1] project a complete list was defined, but based on response from the industry the list was then limited to fewer items. A very long list is considered to be impractical and not likely to be of use for practitioners.

In the SURE project the indicator list is to be used in two stages; the building is evaluated, the aim for future standard of the building is defined and the difference between these two cases is the required refurbishment needs; economic considerations and technical solutions will then regulate how much is done. For the indicator list to be of use the relevant local regulation to specify how the indicator is to be evaluated- and the project describes the process based on such evaluations.

Table C.1 – Indicators for sustainable rebuild (Step 4)

Category	Subcategory	Indicator
Economical	LCC	Paybacktime Annual costs
	Value	Plot opportunities Meeting owner's/user's strategy Branding/certification
Technical standard		Ground, foundations and grid systems Windows, exterior doors Exterior cladding and surface Roof, gutters, drains Interior trim, surfaces (floor, wall, ceiling) fixtures Water and sanitation heating cooling Fire fighting Air treatment / ventilation Electricity: general construction / distribution Electrical: lighting, electric heating, operational technology Telecom and auto: general construction, electrical and electronics systems elevators waste Outdoor technical facilities Drainage, terrain management
Environmental	Energy	Delivered energy Primary energy Electrical Heating
	Material	Life time Product documentation Waste management

Social	Indoor climate	Room temperature Design air flow Air velocity Noise level Formaldehyd concentration Air quality Acoustics Lightening intensity Thermal comfort Radon CO2-concentration Emission Cleanness of air-handling components
	Adaptability	Flexibility Generality Elasticity Climate change
	Safety & accessibility	Structual safety Fire safety Accessibility (HC/UU) Safety in use (slippery floors etc.) Feeling of safety
	Comfort	View to outside Architectural design Support spaces Visual stimulation
	Usability	Functions (core activity) Support functions Capacity Logistics
	Cultural values	Protection level Cultural heritage Community acceptance
Process		Cost Time Users Maintenance Life Cycle Commision Monitoring Measurements
		Construction waste
		Accidents/deaths

Annex D The SURE list of indicators; with weighting (score) concluding for Denmark, Finland and Norway.

NOTE Weighting should be discussed from project to project.

Table D.1 – Indicators for sustainable rebuild (step 4) with weighting (score)

Category	Sub-category	Indicator	Norway	Danmark	Finland	Average indicator	Average sub-category	Average indicator/ Sub-category
Economical	LCC	Paybacktime	4,0 %	6,8 %	4,5 %	5,1 %	0,128	0,396
		Annual costs	6,0 %	6,8 %	10,5 %	7,8 %	0,128	0,604
	Value	Plot opportunities	6,0 %	3,6 %	7,5 %	5,7 %	0,130	0,438
		Meeting owner's/user's strategy	6,0 %	3,6 %	3,0 %	4,2 %	0,130	0,323
		Branding/certification	3,0 %	1,8 %	4,5 %	3,1 %	0,130	0,238
Technical standard		Ground, foundations and grid systems	3,0 %	2,3 %	0,2 %	1,8 %	0,155	0,118
		Windows, exterior doors	2,0 %	2,3 %	0,2 %	1,5 %	0,155	0,096
		Exterior cladding and surface	2,0 %	2,3 %	0,2 %	1,5 %	0,155	0,096
		Roof, gutters, drains	3,0 %	2,3 %	0,2 %	1,8 %	0,155	0,118
		Interior trim, surfaces (floor, wall, ceiling)	2,4 %	2,3 %	0,2 %	1,6 %	0,155	0,105
		fixtures	1,6 %	2,3 %	0,2 %	1,4 %	0,155	0,088
		Water and sanitation	0,7 %	0,9 %	0,2 %	0,6 %	0,155	0,040
		heating	0,5 %	1,4 %	0,2 %	0,7 %	0,155	0,045
		cooling	0,5 %	1,4 %	0,2 %	0,7 %	0,155	0,045
		Fire fighting	0,5 %	0,5 %	0,2 %	0,4 %	0,155	0,026
		Air treatment / ventilation	0,5 %	0,9 %	0,2 %	0,6 %	0,155	0,036
		Electricity: general construction / distribution	0,5 %	0,9 %	0,2 %	0,6 %	0,155	0,036
		Electrical: lighting, electric heating, operational technology	0,4 %	0,9 %	0,2 %	0,5 %	0,155	0,033
		Telecom and auto: general construction, electrical and electronics systems	0,4 %	0,5 %	0,2 %	0,4 %	0,155	0,023
		elevators	0,5 %	0,5 %	0,2 %	0,4 %	0,155	0,026
		waste	0,2 %	0,5 %	0,2 %	0,3 %	0,155	0,020
		Outdoor technical facilities	0,4 %	0,5 %	0,2 %	0,4 %	0,155	0,023

Environmental	Energy	Drainage, terrain management	0,5 %	0,5 %	0,2 %	0,4 %	0,155	0,026
		Delivered energy	5,3 %	1,1 %	9,6 %	5,3 %	0,168	0,318
		Primary energy	5,3 %	1,1 %	9,6 %	5,3 %	0,168	0,318
		Electrical	2,3 %	4,5 %	0,0 %	2,3 %	0,168	0,134
		Heating	2,3 %	4,5 %	4,8 %	3,9 %	0,168	0,230
	Material	Life time	5,0 %	4,5 %	3,0 %	4,2 %	0,091	0,457
		Product documentation	2,0 %	4,5 %	3,0 %	3,2 %	0,091	0,347
		Waste management	3,0 %	2,3 %	0,1 %	1,8 %	0,091	0,196
	Indoor climate	Room temperature	0,4 %	0,7 %	2,7 %	1,3 %	0,081	0,156
		Design air flow	0,3 %	0,3 %	2,0 %	0,9 %	0,081	0,109
		Air velocity	0,2 %	0,3 %	0,0 %	0,2 %	0,081	0,024
		Noise level	0,4 %	0,7 %	0,0 %	0,4 %	0,081	0,044
		Formaldehyd concentration	0,2 %	0,3 %	0,0 %	0,2 %	0,081	0,024
		Air quality	0,4 %	0,7 %	0,0 %	0,4 %	0,081	0,044
		Acoustics	0,4 %	0,7 %	2,0 %	1,0 %	0,081	0,128
		Lightening intensity	0,2 %	0,7 %	2,0 %	1,0 %	0,081	0,121
		Thermal comfort	0,2 %	0,7 %	0,0 %	0,3 %	0,081	0,038
		Radon	0,2 %	0,3 %	0,0 %	0,2 %	0,081	0,024
		CO2-concentration	0,4 %	0,7 %	1,4 %	0,8 %	0,081	0,100
		Emission	0,2 %	0,3 %	2,0 %	0,9 %	0,081	0,107
		Cleanness of air-handling components	0,3 %	0,3 %	1,4 %	0,7 %	0,081	0,081
	Adaptability	Flexibility	0,9 %	0,6 %	1,8 %	1,1 %	0,028	0,395
		Generality	0,6 %	0,6 %	0,0 %	0,4 %	0,028	0,141
		Elasticity	0,6 %	0,6 %	0,0 %	0,4 %	0,028	0,141
		Climate change	0,9 %	0,6 %	1,2 %	0,9 %	0,028	0,323

Process	Safety & accessibility	Structural safety	1,0 %	0,8 %	0,0 %	0,6 %	0,032	0,184
		Fire safety	1,0 %	0,8 %	0,0 %	0,6 %	0,032	0,184
		Accessibility (HC/UU)	0,2 %	0,2 %	2,3 %	0,9 %	0,032	0,275
		Safety in use (slippery floors etc.)	0,8 %	0,1 %	1,1 %	0,7 %	0,032	0,210
		Feeling of safety	0,2 %	0,1 %	1,1 %	0,5 %	0,032	0,148
	Comfort	View to outside	0,9 %	0,7 %	0,0 %	0,5 %	0,038	0,140
		Architectural design	0,9 %	0,9 %	2,4 %	1,4 %	0,038	0,373
		Support spaces	0,8 %	0,2 %	3,6 %	1,5 %	0,038	0,407
		Visual stimulation	0,5 %	0,5 %	0,0 %	0,3 %	0,038	0,080
	Usability	Functions (core activity)	1,6 %	1,8 %	0,4 %	1,3 %	0,033	0,378
		Support functions	0,4 %	0,9 %	0,4 %	0,6 %	0,033	0,168
		Capacity	0,8 %	0,9 %	0,4 %	0,7 %	0,033	0,208
		Logistics	1,2 %	0,9 %	0,4 %	0,8 %	0,033	0,248
	Cultural values	Protection level	1,0 %	0,9 %	0,0 %	0,6 %	0,027	0,238
		Cultural heritage	0,5 %	1,4 %	0,5 %	0,8 %	0,027	0,288
		Community acceptance	0,5 %	2,3 %	1,1 %	1,3 %	0,027	0,475
		Cost	2,4 %	1,3 %	0,6 %	1,4 %	0,102	0,139
		Time	2,4 %	1,3 %	0,6 %	1,4 %	0,102	0,139
		Users	1,2 %	2,5 %	0,6 %	1,4 %	0,102	0,141
		Maintenance	1,0 %	1,3 %	0,8 %	1,0 %	0,102	0,100
		Life Cycle Commission	1,4 %	1,3 %	1,2 %	1,3 %	0,102	0,126
		Monitoring	0,8 %	1,3 %	0,8 %	1,0 %	0,102	0,093
		Measurements	0,8 %	1,3 %	1,2 %	1,1 %	0,102	0,106
		Construction waste				1,20 %	0,102	0,118
		(Number of accidents/deaths)	0,8 %	0,2 %	0,1 %	0,4 %	0,102	0,037

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EN 15643 – 2, Sustainability of construction works - Assessment of buildings - Part 2: Framework for the assessment of environmental performance
-

EN 15643 – 3, Sustainability of construction works - Assessment of buildings - Part 3: Framework for the assessment of social performance

EN 15643 – 4, Sustainability of construction works - Assessment of buildings - Part 4: Framework for the assessment of economic performance

- [17] *EN15978, Sustainability of construction works - Assessment of environmental performance of buildings - Calculation method*
- [18] *EN16309, Sustainability of construction works - Assessment of social performance of buildings - Calculation methodology*
- [19] *EN16627, Sustainability of construction works - Assessment of economic performance of buildings - Calculation method*
- [20] Source DGNB (Danish version by Green Building council Denmark)
- [21] prNS 6450 *Operational testing of technical building installations*
- [22] *EN 15221 – 1 - 7, Facility Management - Part 1 to 7*

Note CEN/TC 346 is undertaking work on a new standard: work item id: 00346033 Conservation of Cultural Heritage - Guidelines for improving energy performance of historically, architecturally or culturally valuable buildings. The standard is planned published in beginning of 2018.