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Content

Executive Summary

Goal,
The Smart-ECO project aims at stimulating and supporting the concept of eco-buildings. It brings together experienced organizations that span a range of stakeholder views to focus on the global issues of sustainable building and add value to current and future RTD activities and identify future focus areas for the European Union.

Work package 4 evaluates the contribution of innovative technologies (work package 3) to the vision on sustainable building (work package 2). For this, the innovation potential and the efficiency of innovative technologies are considered in work package 4.

The work further considers that innovative technologies are not applied as "stand-alone" technologies, but that they are integrated in a building that is performing as a well balanced system.

Regional preconditions (T4.1)
A good starting point for obtaining this balance is addressing the regional preconditions as for instance climate, legislation, availability of materials, local recourses, economical setting and cultural aspects.

For colder **climates**, Eco Building designs must address cold winters by decreasing thermal losses and utilizing solar and internal gains in winter. On the other hand, eco building designs for warm European climates must address summers with high outdoor temperatures and substantial solar gains.
The basis of very low energy buildings are substantial insulation, avoiding thermal bridges, air-tightness, exploitation of solar and internal gains and controlled ventilation with some form of heat recovery for all but the hot European Southern climates.
By addressing these basic principles adequately, energy requirements for heating and cooling can be reduced considerably as shown by current passive solar houses.
As a consequence, the required heating and cooling system capacity can be reduced substantially or even be avoided (cooling). This must be considered thoroughly within the total design balance.

Local (or central) **legislation** can frustrate the development and implementation of smart Eco Building related measures. For instance the use of thermal storage in the ground can be prohibited. Fixed demands on minimum ventilation levels can frustrate demand driven ventilation for instance based on CO_2 levels. Additionally, benefits of various measures are not granted within existing local or central legislation or Energy Performance Building Directive (EPBD).
There is on the other hand, no measure as effective moving towards energy efficient buildings as legislation.
Surely public and privately financed innovations and demonstration projects form the necessary technical basis of energy transition, but will only gain real impact with increasingly strict legislation.

The **availability of relevant local building materials** must be weighted thoroughly. The availability of **local recourses** as for instance local hydro power, thermal earth energy, energy generated from thermal "waste" e.g. from nearby plants, factories etc. can be very relevant. These aspects must be considered thoroughly.

Economical settings impacts the investing possibilities in Smart Eco related measures. The opportunities and conditions related to obtaining mortgages or loans differ substantially between European regions and must be taken into account.

Evaluation of innovation potential and efficiency (T 4.2)
Innovative technologies should by no means be considered and applied as “stand-alone” technologies. Because of the complex interrelations with the building and other systems, innovative technologies should be carefully combined and observed as a component within a well balanced system.
This contradicts with an evaluation of the different innovative technologies as such.
It is, on the other hand, impossible to evaluate the different technologies or measures within all relevant applications and combinations.

To evaluate the various possible measures, a set of key questions was defined by the WP4 group.
The questions are in short: What does it do?, how effective is it?, does it have a potential large impact?, is it sustainable?, what are the cost?, is it implementable?, what are key success factors?
The questions were answered by various interviewed experts and by the stakeholder groep and presented in a 1 page summary per measure (Annex 1).

Operation of innovative buildings (T4.3)
Substantial reduction of heat losses in smart eco buildings without adequate control of solar gains will in many cases lead to overheating surely not only in the warmer European climate zones.
Overheating will be further expanding if ventilation losses are further decreased by heat exchangers without adequate bypass control.

To harvest the potential energy saving benefits of smart eco buildings without spoiling the indoor climatic environment, a well balanced interaction between the indoor and outdoor climate must be realized, aiming at sufficient levels of thermal comfort, indoor air quality and (day)light quality.

Many smart building eco designs will include a relative complicated mix of systems not suitable for standard control systems. Adequate control systems should be applied as for instance adaptive model based control systems able to calculate the optimal set points for complex multi output multi input control systems.
In addition adequate fault detection should be integrated to avoid discomfort and energy losses due to system failures.

Mapping issues related to sustainability (T4.4)
Legislation can have a mayor driving force on the implementation rate of smart eco buildings or related measures. Task 4.4 surveyed the main recent relevant legislative EU documents in order to identify to what extend they help matching the vision, as elaborated in work package 2, and moreover whether they constitute a driving force for complying with the resulting requirements.
According to the vision (WP2), Smart Eco Buildings should:

1. Apply the general principles of sustainability
2. Be designed or refurbished from a Life Cycle perspective
3. Be designed or refurbished to be adaptable throughout its service life, with an end-of-life strategy
4. Have its environmental impact minimized over the estimated or remaining service life
5. Be healthy, comfortable and safe for its occupants
6. Deliver economic value over time
7. Have social and cultural value
8. Result from the involvement of all interested parties and be designed to meet its occupants’ needs individually and collectively

9 Be completely integrated into a local planning strategy and accessible for all
10 Be designed or refurbished to be user-friendly, simple and cost effective to operate, with measurable technical and environmental performances over time

Twenty most relevant legislative documents were analyzed, with each a short description including goal and content.
A matrix is provided, where the 20 analyzed papers are crossed with the vision items in 4 domains (environmental, economical, social health and comfort requirements).
The results show that not all the vision items are adequately addressed in the analyzed European papers.
On the economical requirements for instance, the EU legislation shows rather poor. The only relevant reference is neither a Regulation nor a Directive but a report on Life Cycle Costing (LCC) approach. The consideration of adaptability is not addressed, neither the support of activity.
The environmental requirements are rather well supported except for the land resource consideration.
Several documents strongly support the social requirements. The life quality requirements are however mainly communications with relative weak incentive power. Satisfaction of the residents is not considered, lacking supporting text on the quality in the building use phase.
Several quite specific texts exist in support of almost all the requirements for health and comfort, with the following weaknesses: Several documents address only workers, without addressing inhabitants; Magnetic fields are not addressed; Visual and indoor air quality are not considered, or only indirectly.

The analysis concludes with the following recommendations:
1. a better organization of the construction process by involvement of interested parties, efforts for user-friendly buildings, performance measurement.
2. an integrated approach of the town planning and adaptability of the build environment by integration of new works into existing schemes, land resource management, future of the built objects.
3. a better consideration of the increased satisfaction of the inhabitants.

Life performance (T4.5)
This chapter addresses the evaluation of long-term technical performance of innovative technologies, combining the concepts of performance based building, service life planning, environmental and economic life cycle assessment (LCA and LCC) and life management systems.

Sustainability has become a key concern in the discussion of the overall performance of buildings based on international standards, mainly the “General principles of sustainability in building construction”, as defined in ISO 15392, provide important input to the Smart-ECO project.
This input is manifested in the establishment of the vision and the evaluation of innovation. According to ISO 15392, economic, environmental and social aspects of sustainability should be addressed equally. According to the European Construction Products Directive as well as to the ISO standard, the performance requirements are to be met throughout the service life of the building. ISO 15392 sets out that a holistic consideration of all relevant sustainability aspects throughout the life cycle of the building be conducted.
The building must meet the requirements for technical and functional performance.

The following concepts support these demands:
1. Performance based building
2. Service life planning

3. Environmental and Economic Life Cycle Assessment
4. Life Management Systems

The state of the Art is that ***Performance Based Building*** has gained significant attention and is already applied in larger projects. The concept of performance based building is regarded as being an enabler of sustainable construction.
As soon as requirements with regards to sustainability aspects can be expressed by the client and can be handled by the project planners and builders, PBB will provide the framework to integrate sustainability requirements and targets together with other project targets. PBB delivers the platform for balancing various requirements and to identify solutions that deliver required performance over time.

Service Life Planning concerns the functionality and performance over time of building products, components and buildings. Service Life Planning is subject of international standardisation (ISO 15686) establishing a framework defining the methodology as well as concepts that shall enable practitioners to include a long-term performance-based concern into their building-related decision making.
Service Life Planning produced spin-off activities as routines and databases with service life information for construction products. Service life information as useful life spans of products, and factors influencing these life spans, provide elementary information for life cycle cost calculations and the assessment of environmental impacts over a building's life cycle.
Market application of service life planning is lacking behind its potential. The increasing demand of service life information for instance for life cycle assessment is clearly visible.
With the first databases enabling scenario-adapted service life information on the one hand and the first integrated building assessment and certification schemes allowing the inclusion of such information on the other hand, the market for service life planning and service life information appears to be emerging.

Environmental and Economic Life Cycle Assessment had originally a strong focus on energy aspects and gained increasing concern of sustainability aspects over the years.
International Standards on environmental life cycle assessment (ISO 14040) and life cycle costing (ISO 15686-5) define the concepts and methodologies.
Both concepts are broadly applied inside and outside the building sector. The link to environmental management (ISO 14001), sustainability reporting and environmental product declarations (EPD – ISO 14025) made all relevant parties aware of both concepts.
Economic and environmental life cycle assessment of buildings is still not commonly carried out on a mandatory basis.
It is however starting to be triggered by client interests and through the application of building assessment and labelling schemes. Both concepts include the full life cycle of products and buildings and individual client priorities. The identification and quantification of building related information forms the basis for the assessment. Such assessments may be carried out against absolute benchmarks, or against relative references. The user of the information can then iterate and optimize his decisions with respect to the balanced overall economic and environmental performance.
Integrated life cycle assessments are often the core of sustainability assessments, enabling to provision and discussion of information, as well as helping to identify and optimize the sources of adverse environmental and economic impacts.

Perspectives on Life Management Systems benefit from combining predictive facility management systems as the described Life cycle Management System, LMS, with Building Information Modeling, BIM, to realise modeling and visualization of time dependent changes of construction works, enabled by recent ICT developments.
A solution to the general problem of information communication and exchange in the different stages of design, construction, and operation is now facilitated by the open

standard Industry Foundation Classes (IFC) for common data structure and information capturing, which is developed on the initiative of the International Alliance of Interoperability (IAI). IFC facilitated the exchange of building information between different IFC compatible BIM applications.
=Numerous available models describe performance changes over time of materials, products, and systems. The operation and management of this knowledge base, developed since the 1980: is in international cooperation, in practical engineering and service life planning of construction works is standardized by ISO (ISO 15686; ISO TC59/SC14).
Combining BIM, with product life cycle models tapping into LMS platforms opens up the possibility of long-term and dynamic maintenance and operation strategies in facility management, representing a substantial step forward.

1. Background

Project summary

The Smart-ECO project aims to develop and support the concept of eco-buildings. It brings together experienced organizations that span a range of stakeholder views to focus on the global issues of sustainable building and add value to current and future RTD activities and identify future focus areas for the European Union.

Work Package Objectives

Work package 4 evaluates the contribution of innovative technologies to the vision on sustainable building. For this, the innovation potential and the efficiency of innovative technologies will be considered. The work further considers that innovative technologies are not applied as "stand-alone" technologies, but that they are integrated in a building that is performing as a system. Life performance aspects as well as regional preconditions for the operation of innovative technologies may have a significant influence on the long-term efficiency of these technologies as incorporated into buildings. Aspects related to the operation and user-friendliness are considered.
It illustrates how innovative technologies that have the potential to contribute to the vision need to be promoted in order to become successful elements. Indicate where and how existing elements can support the vision, how far the building sector can develop towards the vision based on these elements, and consequently indicate the demand for further innovation in order to meet the vision. Finally, to communicate this to relevant stakeholders and multipliers..

Description of work

<u>T4.1 Regional preconditions:</u> This task focuses on regional preconditions for the application of innovative technologies. A primary focus is directed to the influence of regional preconditions on the efficiency and appropriateness of applying an innovative technology. The work reflects the innovations identified in WP3 as well as the "Current position of EU-Eco-Buildings" as described in M3.
(Partners involved: TNO, Milano, Servitec, T-UT)

<u>T4.2 Evaluation of innovation potential and efficiency</u>: The task addresses the potential and the efficiency of innovative technologies with reference to the performance of buildings applying the technologies. The task addresses the technical performance of the technologies, analyses the system performance (i.e. the building applying the technologies) and indicates the market potential of the innovation. The efficiency and potential is measured through performance indicators supporting the vision (M2), meeting requirements (M5) and that are aligned with core interests of the stakeholder group (task 5.2)
(Partners involved: TNO, MACE)

<u>T4.3 Operation of innovative buildings</u>: The task elaborates on the novelties that operators of smart sustainable eco-buildings need to handle. Usability and prevention of mal-operation ("smartness") are key aspects ensuring the intended efficiency of innovative eco-buildings to be achieved in practice. Operation includes consideration of maintainability and preconditions for long-term efficiency.
(Partners involved: FH-Soest, Endo, TNO, MACE)

T4.4 Mapping issues related to sustainability: This task gives an overview of the issues of sustainable smart eco-buildings in the EU. The issues related to sustainable eco-buildings and innovative technologies on the one hand and topics in policies and directives on the other hand are mapped. The task results in an identification of the focus area as well as the gaps that need to be addressed in order to sustain development towards the vision. The integral approach will be used to manage and interrelate this complex information.
(Partners involved: TNO, CSTB, BMG)

T4.5 Life performance: the task addresses the evaluation of long-term technical performance ("life performance") of innovative technologies, combining the concepts of performance based building, service life planning, environmental and economic life cycle assessment (LCA and LCC) and life management systems.
(Partners involved: BMG, CSTB)

2. Regional preconditions (Task 4.1)

This task focuses on regional preconditions for the application of innovative technologies. A primary focus is directed to the influence of regional preconditions on the efficiency and appropriateness of applying an innovative technology. The work reflects the innovations identified in WP3 as well as the “Current position of EU-Eco-Buildings” as described in M3. (Partners involved: TNO, Milano, Servitec, T-UT)

The performance requirements included in the vision have shown that a Smart Eco building should:

According to the vision (WP2), Smart Eco Buildings should:

1. Apply the general principles of sustainability
2. Be designed or refurbished from a Life Cycle perspective
3. Be designed or refurbished to be adaptable throughout its service life, with an end-of-life strategy
4. Have its environmental impact minimized over the estimated or remaining service life
5. Be healthy, comfortable and safe for its occupants
6. Deliver economic value over time
7. Have social and cultural value
8. Result from the involvement of all interested parties and be designed to meet its occupants’ needs individually and collectively
9. Be completely integrated into a local planning strategy and accessible for all
10. Be designed or refurbished to be user-friendly, simple and cost effective to operate, with measurable technical and environmental performances over time

These requirements are the practical and concrete expression of the vision and make reference to the current and future challenges for the construction sector.

This implies the following goals:

- Reduce use of resources (land, water, materials and energy)
- Reduce pollution (soil, water, air, flora and fauna, waste)
- Reduce contribution to climate change
- Be adaptable (to change in use and environmental changes)
- Meet occupants’ needs and provide comfort (indoor air quality, acoustic, thermal, visual, olfactory, water quality)
- Deliver economic value over time
- Be integrated with the natural and built environment

Innovations will play an integral part in meeting these requirements. Technological innovation plays a critical role but just as important are changes in the wider political, institutional, and cultural environment that enable technologies to be exploited and provide incentives for their deployment.

Areas of innovation considered in this report include technologies, materials, design or evaluation tools, processes, policies and financial tools. Innovation is considered at different scales: micro (product, service and process), meso (sector, supply chain, region and system) and macro (economy-wide).

The task identifies innovative technologies, especially concerning the utilisation of renewable energies and energy saving technologies in buildings. Case studies are considered where appropriate to illustrate the feasibility of applying innovations in the built environment.

This implies a thorough design process were various combinations of options are projected on the specific circumstances and boundary conditions including regional preconditions.

Most relevant preconditions are climate, legislation, availability of materials, local recourses, economical setting and culture.

2.1 Climate

2.1.1 Thermal climate

As already extensively elaborated in D4 H2.1, Eco building designs for colder European climates must address cold winters by decreasing thermal losses and utilizing solar and internal gains in winter. On the other hand, eco building designs for warm European climates must address summers with high outdoor temperatures and substantial solar gains.

Figure 2.1a, b: Different European climate zones (Spain and Finland)

This implies that generally for Northern European designs, reducing thermal losses by increased thermal insulation, avoiding thermal bridges, reduced ventilation losses e.g. by demand driven ventilation and heat recuperation e.g. by heat exchangers and utilizing internal and passive solar energy are the more important issues and on the other hand, that for Southern European designs, avoiding overheating and reducing energy for cooling by reducing thermal and solar gains in summer by adequate solar shading and control of the solar shading including optimized daylighting control, are the key issues.
For moderate European climates, both issues are of importance.

The basis of very low energy buildings are substantial insulation, avoiding thermal bridges, air-tightness, exploitation of solar and internal gains and controlled ventilation with heat recovery for all but the hot European Southern climates.
By addressing these basic principles adequately, energy requirements for heating and cooling can be reduced considerably as shown by current passive solar houses.
As a consequence, the required systems for heating and cooling can be reduced substantially or even be avoided. This is surely realistic for cooling systems in many buildings. This is very relevant within the perspective of the current trend towards increased implementation and utilization of air-conditioning systems in buildings in the warmer European climates but also in the more moderate European climates.
Smart Eco buildings must address this adequately.

As mentioned in D4 H2.1, Solutions that allow reaching a low- or zero-energy building in a cold climate (or, for temperate climates, in winter) are quite consolidated and already demonstrated their economic and technical viability: among these, the Passivhaus buildings in Germany and the Minergie-P buildings in Switzerland.

Substantial insulation, avoiding thermal bridges and air tightness are the first step required.
Controlled ventilation, utilizing internal gains and optimizing passive solar energy are the second.

The first step insulates the indoor climate from the outdoor climate potentially resulting in lower energy use but also increased overheating.
With the second step, the interaction between the indoor and outdoor climate is optimized. The thermal energy flow between indoor and outdoor clime must be balanced taking into account the day-lighting quality.
This is not arbitrary and when not adequately done, leading to more energy than designed and or thermal discomfort and glare.

Chapter 4 will further elaborate on operation of Smart Eco buildings.

2.1.2. Wind

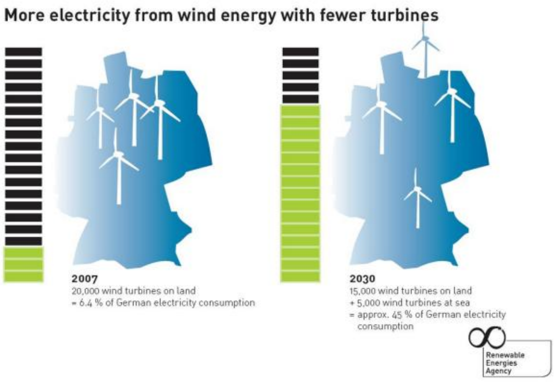

Figure 2.2a, b: Wind turbines

Looking at Smart Eco Buildings, wind does not only determines the potential energy production by wind energy (the density of wind turbines is often dense close to shores) but also determines if and when or what sort of external solar shading is feasible together with the amount of potential infiltration and ventilation in buildings and consequently the indoor temperatures, the amount of overheating and energy use for heating, cooling and ventilation.

Figure 2.3a, b: Wind resistant and non wind resistant solar shading

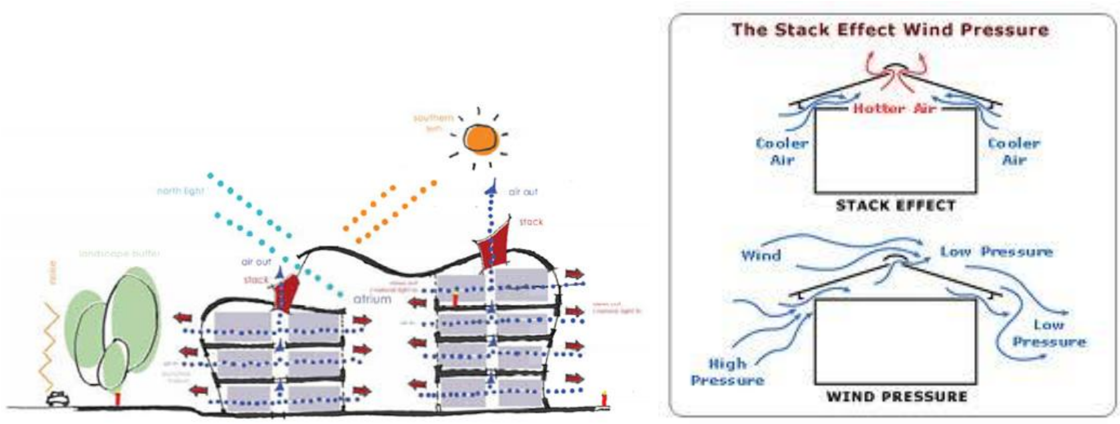

Figure 2.4a, b: Ventilation design

Although It is too complex and therefore useless to specify and quantify these aspects per wind condition, region, type of building and use, type of wind turbine shading system etc, it is very clear that in windy (and windless) environments, wind energy, solar shading, air tightness and ventilation in general must be considered more closely on the whole design process balance.

2.1.3. Legislation

Local or European legislation can restrict the development and implementation of smart Eco Building related measures.
Examples are restrictions related to the use of thermal storage in the ground, fixed minimum ventilation demands frustrating demand controlled ventilation.

Additionally, benefits of various Smart Eco Building related measures are not granted within existing local or European legislation as for instance for energy saving related measures within the EPBD, delaying the implementation and sometimes development of these measures.

This “not being granted” within existing local or European legislation is mostly due to the complexity of determining the benefits of these measures. In many cases and countries it is possible to proof the benefits of the measure often by detailed simulations and have the benefits granted. This often is a relative time consuming, complex and costly exercise.

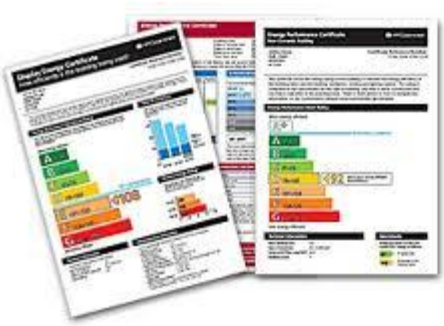

Figure 2.5: EPBD sheets

There is, on the other hand, no measure as effective, moving towards energy efficient buildings as legislation. Surely public and privately financed innovations and demonstration projects are the technical basis of this transition, but will only gain real impact with increasingly strict legislation.

Within the scope of implementation of Smart Eco Buildings related measures, the process of further developing the EPBD for energy related issues and additional uniform normalisation for other than energy related Smart Eco Building issues is very important for gaining impact and reaching the present ambitious goals set.

Different approaches for stimulation Smart Eco measures and buildings by Legislation will be further elaborated in chapter 5.

2.1.4 Availability of materials

Projecting regional preconditions projected on the availability of materials:
Local materials used for Smart Eco Buildings must be considered thoroughly especially if they are easily available.

Walls from local stones

Biological insulation materials applied

Processing biological insulation material

Swedish wooden house

Figure 2.6a, b, c, d: Examples of local material usage

This will potentially decrease material and energy use. Often local materials and the processing, application and treatment of local materials are well known locally.

Material use is further elaborated within chapter 5.

2.1.5 Recourses

Similar to local material usage the use local recourses will decrease transport const. Examples of resources are local power generation as hydro power, thermal energy from the earth, energy generated from thermal “waste” from, thermal energy from a nearby plants, factories, heated greenhouse etc. possibly through a district heating grid.
These options as described in detail in D4 must be considered thoroughly within the total design balance.

2.1.6 Economical setting

Economical setting impacts the possibilities for investing in Smart Eco related measures and buildings substantially. The conditions and possibilities to obtain a mortgages or loans differ substantially between different European regions and countries.

Important factors are the scale of the local economy but also the possibility for financing constructions as lease constructions or the availability of private, public cooperation’s aimed at structural implementation of Smart Eco Buildings related measures or Smart Eco buildings.

Figure 2.7a, b: Different economical settings

Figure 2.8a, b: Getting a bank lone individually or private public stimulating programs

The implementation rate of smart eco related measures or buildings can be increased substantially by improving the economical settings. An example for this are private public stimulating programs in close cooperation with banks or other financial institutes.

3 Evaluation of innovation potential and efficiency

3.1 Background

The task addresses the potential and the efficiency of innovative technologies with reference to the performance of buildings applying the technologies. The task addresses the technical performance of the technologies, analyses the system performance (i.e. the building applying the technologies) and indicates the market potential of the innovation. The efficiency and potential is measured through performance indicators supporting the vision (M2), meeting requirements (M5) and that are aligned with core interests of the stakeholder group

Referred is to D4 H2.2 which provides a wealth of examples and explanations of various energy saving measures, on durable energy and more. The description, explanation and examples of various technologies will not be repeated in this report. Please read the reference first.

3.2 Process and approach

Detailed projection of parameters on measures is not feasible

During an early WP4 workshop in Brussels, it was acknowledged by the WP4 group and Smart Eco project team that detailed validation of all relevant measures as defined within WP3 by performance parameters defined within WP2 is practically impossible and will not produce useful results.

This is due to large amount of possible measures in combination with the amount of validation parameters.

Furthermore, first exercises to construct this detailed matrix showed that the validation parameters are strongly context dependent in terms of building type, location, local preconditions, culture, accompanying measures etc. making a detailed validation this way not feasible.

To resolve this several approaches were generated and discussed over time within WP4 workshops and teleconferences.

Finally It was decided to cluster both the measures and the validation parameters into clear questions aiming at results providing both practical insight and overview to a braod audience with decision makers in mind.

Additionally a questionnaire was developed within WP4. This WP4 questionnaire was based on the feedback of former WP2 and WP3 questionnaires,

aimed at the validation of by the stakeholder group these earlier questionnaire pre-selected technologies. For the questionnaire and the results it is referred to WP5 Stakeholders and the deliverable 6 “Market Perspectives on Eco-Buildings & Stakeholders”

3.3. Validation questions

To validate the various possible measures a set of key questions was defined by the WP4 group. The questions were answered by various interviewed experts.

The questions are in short:

1. what does it do?
2. how effective is it?
3. does it have a potential large impact?
4. is it sustainable?
5. what are the cost?
6. is it implementable?
7. what are key success factors?

The definition of these questions are:

1. What does it do?
This is a very short description of the validated measure, technology and the most relevant issues if any. This item was not rated.

2. How effective is it?
Short description of possibly different effects and/or goals and how effective these goals are met after implementing together with the most relevant issues if any.
This item was rated by the experts between 1 and 5 where 1 is not effective., 3 moderately effective and 5 highly effective.

3. Does it have a large Impact?
Short description of impact of measure from a broader relevant perspective if relevant related to comparable or alternative measures if relevant and available on EU scale.
This item was rated by the experts between 1 and 5 where 1 indicates no or very little potential impact, 3 average impact and 5 very high potential impact. Because impact can be rated on various scales for the various rated measures, the rating is an indication.

4. Is it sustainable?
Short description of the effect of the measure on energy use, CO_2 production, material use, social aspects, toxic waste.
Here is 1 not sustainable and 5 very sustainable and 3 average sustainable.

5. What are the cost?
Short description of relevant cost and benefits
If relevant and known: Investment and running costs, benefits in terms of energy material use and usability and if available pay back time
Here 1 means low costs and 5 very high costs. (Please be cautious here since some experts interpreted the rating differently before explanation during the interviews).

6. Is it implementable?
Short description of relevant issues related to implementation as required conditions
If relevant and known: problems to overcome, relevant market and technological developments.
Here 1 indicates not or very difficult implementable and 5 relative easy implementable.

7. What are key success factors?
Short description of most relevant success factors as the context, accompanying measures, users, social attractiveness etc.

These questions were worked out for various measures by interviewing various domain experts as experts on the field of (1) photovoltaic's and implementation of photovoltaic's, (2) Solar thermal energy, (3) wind energy, (4) thermal insulation materials, (5) EPBD and European and national building energy related normalization, (6) heat pumps, (7) thermal comfort (8) light quality, use of daylight and electrical lighting (9) façades, (10) thermal and optical glazing materials and properties etc.

3.4 Energy saving and renewable energy related measures

The output the interviews was condensed in a one page summary per measure (Annex 1). The ratings as provided by the experts and stakeholders per item, per measure are provided in the tables beneath.

Table 3.1: Rating by experts for renewable energy related measures

Topic	Renewable Energy													
measure	Roof mounted wind turbines	Solar Thermal Energy	Photovoltaic cells (PV)	Solar Cooling	Biomass	smart grids	fuel cells	Micro combined heat and power	Smart Building manage-ment	Personal Climate	Ground water (aquifers) with heat pump	Ground coupled heat pump with heat exchanger	Air coupled heat pump	surface water coupled heat pump sea, river , lake
effective	2	3	3	5	3	5	2	4	4	5	5 cool 4 heat 3 tap	5 cool 4 heat 3 tap	5 cool 4 heat 3 tap	5 cool 4 heat 3 tap
potential Impact	1	3	4	3	3	4	2	3	5	4	?	?	3	3
sustainable	2	4	4	4	4	4	2	4	4	3	3	?	4	4
cost	1	2	2	3	4	2	2	4	3	4	3	3	4	4
implementability	1	4	3	3	4	3	3	3	4	3	3	3	3	?

Table 3.2: Rating by experts for energy saving measures I

Topic	Energy saving											
measure	Insulatating materials	Inulating panels with IR shield	Aerogel insulation	Vacuum insulation panels VIP	multi foil reflective insulation	TiO2 meterials and coatings	green roofs	cool roofs	Vacuum glazing	Translucent insulation	Glass including PCM	Variable Solar transmittance
effective	5	5	5	5	2	3	4	2	5	3	1	2
potential Impact	5	5	4	2	2	1	3	2	4	1	1	2
sustainable	4	4	3	3	3	2	4	3	4	2	3	2
cost	5	5	3	2	3	4	3	3	2	2	1	2
implementability	5	5	3	2	4	3	2	4	4	2	2	3

Table 3.3: Rating by experts for energy saving measures II

Topic											
measure	Light shelves	Special shaped louvres and venetian blinds / prismatic glass	Glazing with integrated shading	Light tubes and heliostats	Improved lighting systems	LED P-OLED, OLED WOLED	Phase change materials (PCM)	Solar chimneys	Use of atria for climate tempering	Hybrid ventilation	Low energy Ventilation (RESHYVENT)
effective	3	3	3	2	5	4	5	2	2	3	5
potential Impact	3	3	2	2	3	3	3	1	2	3	5
sustainable	3	0	2	2	3	4	4	4	2	3	4
cost	3	0	2	2	3	2	3	3	1	3	4
implementability	2	3	2	2	3	3	3	2	2	2	4

Table 3.4: Rating by experts for Building and operation measures

Topic	Building construction and operation				
measure	Smart Building manageme nt	assembled layered constructio n = factory based and minimise use of materials	sensors that will provide information of air quality such as pollution,	assembly and logistics (transport, handling, delivery and storage of	reuse and recycling: use of recycled materials / component s, waste manageme
effective	4	4	4	4	5
potential Impact	5	4	4	5	4
sustainable	4	4	4	4	3
cost	3	4	4	3	4
implementability	4	5	3	4	3

Table 3.5: Rating by experts for holistic design measures

Topic	Holistic design				
measure	Integrated design process	Tools for knowledge exchange	Operatibe tools	LCA tools	Water saving technology and strategies
effective	5	0	3	5	3
potential Impact	5	0	4	3	3
sustainable	5	0	4	4	4
cost	5	0	4	4	4
implementability	5	0	3	3	4

Table 3.6: Rating by experts for policies measures

Topic	Policies					
measure	Legislation	Energy labeling	knowledge transfer suppliers	Information transfer consumers	Financial incentives	Private and public initiatives
effective	5	4	3	2	4	?
potential Impact	5	4	3	2	4	?
sustainable	4	4	3	3	4	4
cost	5	4	3	3	3	4
implementability	4	3	4	4	4	4

3.5 Politic related measures

Table 3.7: Rating by expert for politic related measures

1. Legislation is increasingly complex with increasing complexity of building configurations and number of combinations and issues to include, leaving out many smart eco building related issues at present.
On the other hand legislation is a very effective way to stimulate implementation of Smart Eco Building related measures.

2. Labelling provides clear information on items, systems or whole buildings and can be effective especially in combination with legislation. At present labels provide mostly only information on energy use but can in future be expanded towards other relevant Smart Eco Building issues.

3. Knowledge transfer suppliers (demonstration projects, brochures courses) are moderately effective measuring the follow up due to the information transfer on its own. Information transfer should be part of a larger plan to be really effective.

4. Information transfer to consumers
Similar to 3 but less effective on its own. Also more effective as part of a integral plan.

5. Financial incentives (subsidies, revolving funds, etc.) are usually quite effective. Stimulation measures by decreasing pay back times which are usually broadcasted in some form, show to be quite effective.

6. Papers of intention usually signed by governmental bodies and relevant market parties stating their intention to realize usually specific goals are usually less effective.

Expressed intentions are usually not enough to stimulate implementation.

7. Private and public initiatives are a good idea but show in practice not always very effective depending on the quality of the organisation.

3.7 Conclusions

For measures related to politics, the most effective measures are measures providing validation tools and making implementation obligatory (labelling and legislation) on one hand and financial stimulation on the other hand.
Knowledge transfer and other measures are less effective as such and should be combined with labelling, legislation and financial stimulation.

A one page summary per measure is provided in annex 1.

4 Operation of innovative buildings

Substantial insulation, no thermal bridges and air tightness are the first steps required within the Smart Eco Building concept.
Reducing heat losses without adequate control of solar gains will lead in many cases to overheating surely not only in the warmer European climate zones.
Overheating will be increased even further if ventilation losses are decreased by ventilation air recuperation, retrieving the energy from the exhaust air with heat exchangers or other means.

4.1 Control of heating, (free)cooling, ventilation, shading and lighting

It is very important that the interaction between the indoor and outdoor climate is adequately controlled. The thermal energy flow between indoors and outdoors must be balanced also taking into account dynamic thermal effects and dayligting quality.
This is not arbitrary and when not adequately done, easily leading to discomfort and loss of productivity and decreased health.

Practice shows that adequate operation is a key success factor for Smart Eco buildings and low energy buildings in general.
By addressing this complex balance adequately, energy requirements for heating, (free) cooling, ventilation and lighting can be reduced considerably with optimal comfort.
In addition, the need for cooling systems can be reduced substantially or avoided.

Smart Eco buildings aim at summer comfort with no or low energy use.
To avoiding overheating starts with sufficient and adequately controlled solar shading, and additional night time ventilation in warm periods to cool the buildings (thermal) mass.

4.2 Manual versus automatic control

Experience show that shading devices and night time ventilation are best automatically controlled.
Manual control often showed to be contra productive. Users mostly only apply shading and / or ventilation after discomfort in the form of overheating or glare is experienced. This is too late since by them the building mass is already warmed up.

With well balanced automatic control systems with some form of overheating prediction can apply additional night time ventilation to cool the building structure and close the shading early in the morning to minimize or even avoid overheating. During warm sunny periods it can be preferable to "cool" the building using additional night time ventilation below comfort temperatures in the morning to avoid excessive overheating in the afternoon.

Another possibility to further minimize overheating is to utilize an heat exchanger for ventilation air over the day when outdoor temperatures exceed indoor temperatures and use a bypass in case the indoor temperature exceeds the outdoor temperature.

NB: Practice shows that heat exchangers nowadays are often controlled only based on one outdoor temperature sensor. The bypass is used if the outdoor temperature is over a specific value thus only applying heat exchanger with cold outdoor conditions. Looking at avoiding overheating this is exactly the opposite of what is desired. During the night (cooler temperatures) the heat recovery is utilized avoiding night time ventilation to cool the building. And during the (warm) day the by-pass is utilized warming the building up.

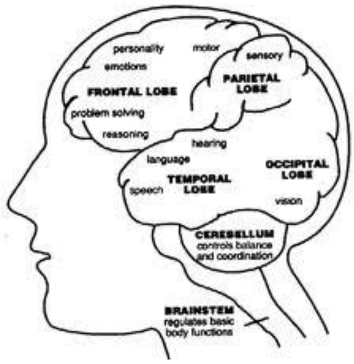

Figure 4.1: Mental model thermal behavior of buildings

Automatic control based on indoor temperature / overheating prediction can be based on measured averaged indoor and outdoor temperatures but can also be more sophisticated and self learning / auto adaptive using model based predictive control with some form of weather prediction. Weather prediction can be obtained for instance from the many available weather sites from the internet. This is less complex as it may seem. A simple general purpose microcontroller of a view Euros coupled to a router can as scrape (as it is called) internet pages with a view lines of high level code.

Although there have been and are various national and European research projects dedicated on this issue resulting in various worked out examples, there is no clear procedure and consensus on how to design and implement this type of automatic control in daily life.
Smart Eco Buildings must however designed in such a way that minimal energy is required and minimal overheating occurs using adequate control of passive solar energy and ventilation.

Occupant behaviour often is contra productive also in the sense that windows and doors are opened in warm periods. The higher air velocities give the occupant the impression that fresh air comes in while in reality the temperature of the incoming air is warmer and the indoor comfort can decrease after some period due to overheating.
On the other hand doors and windows can be opened in cooler sunny periods.
Due to the higher solar radiation, the experienced temperatures exceeds air temperatures. Opening windows and doors in this situation can lead to further energy losses.
This issues should be addressed adequately for instance by sufficient information transfer to the occupants on how to operate the doors and windows.

4.3 Maintenance

Smart Eco Buildings are often more complex compared to present building stock and many used systems and materials are less common and less known by parties responsible for installation and maintenance.

This requires additional attention to installation and maintenance.

Smart Eco Buildings must be controlled thoroughly after installation and a clear maintenance plan tailored to the specific Smart Eco Building configuration should be developed and maintained.

Operation of innovative buildings must be observed within the scope of performance based building, service life planning, environmental and economic life cycle assessment and life management systems as further described in chapter 6.

5 Mapping issues related to sustainability (task 4.4)

Foreword

The aim of this task is to survey the main legislative documents recently produced by the EU regarding the sustainability issues, in order to identify whether or not they help in matching the vision items elaborated in the work package 2, and moreover whether or not they constitute a driving force for complying with the resulting requirements.
We first provide a list of the selected legislative documents, with a short description of their goal and content.
Then a matrix is given, where the 20 texts are crossed with the vision items, and with the requirement in the 4 domains (environmental requirements, economical requirements, social requirements, and finally health and comfort requirements. Each box of the matrix is reviewed, and ticked if the given document is considered as having an impact on the given item or requirement.
The resulting tables are finally commented, in terms of gaps and missing incentives.

List of EU documents and short description of each document content

The following list of EU Regulations, Directives and Communications is not intended to be exhaustive. But we are quite sure that it includes the essential documents.

1- **Directive 89/106/EEC:** The Construction Products Directive (CPD)
2- **Com(2005) 670 :** Thematic strategy on the sustainable use of natural resources
3- **Regulation (EC) N° 1907/2006 :** Registration, Evaluation, Authorization and Restriction of Chemicals (REACH)
4- **Com(2003) 302 :** Integrated Product Policy – Building on Environmental Life Cycle Thinking
5- **Regulation (EEC) N° 761/2001 :** Voluntary participation by organizations in a Community Eco-management and Audit Schemes (EMAS)
6- **Directive 2008/28/EC :** Framework for the Setting of Eco-design requirements for Energy-using Products
7- **Regulation (EC) N° 66/2010 :** EU Ecolabel
8- **Directive 2002/91/EC :** Energy Performance of Buildings
9- **Decision N° 406/2009/EC :** Effort of the Member States to reduce their greenhouse gas emissions to meet the Community's commitments up to 2020
10- **Directive 96/62/EC :** Ambient Air Quality Assessment and Management
11- **Directive 2006/118/EC :** Protection of ground water against pollution and deterioration
12- **Directive 2008/98/EC :** Waste
13- **Com(2006) 216 :** Halting the loss of biodiversity by 2010 – and beyond – Sustaining ecosystem services for human well-being
14- **EC Contract Report May 2007 :** Life-cycle costing (LCC) as a contribution to sustainable construction: towards a common methodology
15- **Com(2007) 62 :** Improving quality and productivity at work: Community strategy 2007-2012 on health and safety at work
16- **Directive 2003/10/EC :** minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise)
17- **Com(96) 406 :** A new European Community Disability Strategy
18- **Com(2001) 723 :** The future of health care and care for the elderly: guaranteeing accessibility, quality and financial viability
19- **Com(2008) 800 :** A European Economic Recovery Plan

20- **Com(2005) 658 :** Review of the Sustainable Development Strategy – A platform for action

For each document of the list, a short summary is given. The main source of information is the following website:

http://europa.eu/legislation_summaries/index_en.htm

Directive 89/106/EEC: The Construction Products Directive (CPD)

The CPD applies to construction products, i.e. any products produced with a view to their incorporation in a permanent manner in construction works. The purpose of the Construction Products Directive (CPD) is to ensure the free movement of all construction products within the European Union by harmonizing national laws with respect to the essential requirements applicable to these products.

Construction products may only be placed on the market if they are fit for their intended use. In this regard, they must be such that works in which they are incorporated satisfy, for an economically reasonable working life, the essential requirements with regard to mechanical strength and stability, safety in the event of fire, hygiene, health and the environment, safety in use, protection against noise and energy economy and heat retention, as set out in Annex 1 to the Directive.

The essential requirements are defined in the first instance in interpretative documents drawn up by technical committees and are then elaborated further in the form of technical specifications. The latter may consist of:

- Harmonized European standards adopted by the European standardization bodies (CEN and/or CENELEC) acting on a mandate from the Commission and following consultations with the Standing Committee on Construction;
- A system of European technical approvals to assess the suitability of a product for its intended use in cases where there is no harmonised standard, no recognised national standard and no mandate for a European standard and where the Commission feels, after consulting the Member States within the Standing Committee on Construction, that a standard cannot or cannot yet be prepared. In order to facilitate this task, the European Organisation of Technical Approvals (EOTA), which groups together the national approvals bodies, would be in a position to draw up technical approvals guidelines in respect of a construction product or family of construction products, acting on a mandate from the Commission and after consulting the Standing Committee on Construction.

Where neither a European standard nor guidelines for European technical approval yet exist, construction products may continue to be assessed and marketed in accordance with existing national provisions conforming to the essential requirements.

This directive is under a revision process, and will soon become a Regulation (the Construction Products Regulation – CPR). The main additive changes lay in the essential requirements: the scope of the ER3 (regarding environment) will include all the life cycle stages, and a seventh ER in introduces, regarding the sustainable use of the natural resources.

Com(2005) 670 : Thematic strategy on the sustainable use of natural resources

This strategy sets out the guidelines for European Union (EU) action for the next 25 years aimed at more effective and sustainable use of natural resources throughout their life cycle.

The aim of the strategy is to reduce the negative environmental impact of the use of natural resources (depletion of resources and pollution) while meeting the economic growth and employment objectives of the Lisbon European Council. All resource-consuming sectors are taken into account with a view to improving resource yield, reducing the environmental impact of resource use and replacing excessively polluting resources with alternatives.

No target figures have been set at this stage, but the strategy provides for the possibility of setting such targets in the coming years, when knowledge of the use of resources and their development indicators has become sufficiently developed and exploitable.

Integrating the resource life cycle based approach into existing policies

The strategy aims to reduce the pressures on the environment at each stage of the life cycle of resources, which embraces their extraction or harvesting, use and ultimate disposal. It therefore seeks to integrate this concept of life cycle and impact of resources into the associated policies.

This approach will in future be applied systematically to all environmental policies. It already forms an integral part of certain measures, such as the thematic strategy for waste. Specific actions, such as the integrated product policy or the action plan for environmental technologies, are complementary to such an approach.

The approach also has to be built into non-environmental policies that consume resources. Some measures have already been adopted in this direction, particularly in the areas of transport and energy. The use of impact studies will also be a determining factor in certain industrial or infrastructure fields.

New measures created by the strategy

To enhance knowledge relating to the use and environmental impact of resources, the strategy proposes the creation of a natural resources data centre, to be run by the Commission. This data centre will collect information coming from the various analysis and research bodies (both within the Commission and elsewhere). It will make it easier to exchange information and make it available to policymakers.

By 2008 the Commission intends to develop indicators for monitoring and periodically evaluating progress towards achieving the strategy's goals. These indicators will relate to the more efficient use of resources, the delinking of resource use from its negative environmental impact, and the decoupling of negative environmental impact from economic growth.

The Member States, for their part, are asked to prepare measures and programs at national level (e.g. on education, training or economic incentives). They will be helped by the setting up of an information exchange forum made up of representatives of the Member States and the Commission, as well as other players as appropriate.

Regulation (EC) N° 1907/2006: Registration, Evaluation, Authorization and Restriction of Chemicals (REACH)

The European Union (EU) has established REACH, an integrated system for the registration, evaluation, authorization and restriction of chemicals, together with a European Chemicals Agency. REACH requires firms which manufacture and import chemicals to evaluate the risks resulting from the use of those chemicals and to take the necessary steps to manage any identified risk. Industry has the burden of proving that chemicals produced and placed on the market are safe.

The purpose of the regulation is to ensure a high level of protection of human health and the environment, and to strengthen the competitiveness of the chemicals sector and promote innovation.

The scope of the Regulation covers all substances, whether manufactured, imported, placed on the market, or used on their own or in mixtures.

The following are excluded from the scope of the Regulation:

Radioactive substances (covered by Directive 96/29/Euratom);
Substances under customs supervision which are in temporary storage, in free zones or free warehouses with a view to re-exportation or still in transit;
Non-isolated intermediates
The transport of dangerous substances; and
waste.
The rules on registration, downstream users, evaluation and authorization do not apply to substances used in medicinal products for human or veterinary use or in food or feeding stuffs (including additives) provided they fall within the scope of Community legislation on medicinal products or food.

Com(2003) 302 : Integrated Product Policy – Building on Environmental Life Cycle Thinking

This communication presents the Community strategy for making products more environment-friendly. It focuses on two approaches:

- Establishing general conditions which will improve the environment-friendliness of products throughout their life cycle;
- Concentrating on products which have the greatest potential for improvement from an environmental standpoint.

To implement the strategy the communication recommends:

The creation of an appropriate economic and legal framework: this includes measures concerning taxes and subsidies, standardization, voluntary agreements and public procurement;

The promotion of life-cycle thinking: this includes making life-cycle data available, integrating a product dimension in environmental management systems and promoting IPP within companies and in relation to specific products;

The transmission of product information to consumers: this includes taking greater account of environmental criteria in public procurement and corporate purchasing, and measures concerning eco-labelling.

Regulation (EEC) N° 761/2001: Voluntary participation by organizations in a Community Eco-management and Audit Schemes (EMAS)

The Community eco-management and audit scheme (EMAS) aims to promote a continuous improvement of the environmental performance of European organizations, together with providing the public and interested parties with information. The introduction and implementation by organisations of environmental management systems as set out in Annex I to this Regulation;

- Objective and periodical assessment of those systems;
- Training and active involvement of the staff of such organisations;
- Provision of information to the public and the other interested parties.
- Any organization wishing to take part in the scheme must:
- Adopt an environment policy setting out the objectives and principles of its environmental measures;

- Conduct an environmental review of its activities, products and services (in accordance with Annexes VII and VI), except for organisations which already have a certified, recognised environmental management system;
- Introduce an environmental management system (in accordance with Annex I);
- Carry out regular environmental audits (in accordance with the requirements set out in Annex II) and make an environmental statement. That statement must be validated by an environmental verifier whose name and number must appear in the statement;
- Register the validated statement with the relevant Member State body;
- Make the statement available to the public.

Each Member State must establish a system for accrediting independent environmental verifiers and for supervising their activities. The competent bodies may suspend or delete an organisation or refuse its registration where the latter fails to meet the requirements of this Regulation. A register of environmental verifiers and of organisations registered with EMAS will be kept by the Commission and made available to the public.

Member States must examine the scope for taking account of the participation of organisations in the EMAS when checking compliance with environmental legislation in order to avoid any duplication of effort.

The Regulation commits the Member States to encourage the participation of small and medium-sized undertakings in the eco-management and audit scheme.

Directive 2008/28/EC: Framework for the Setting of Eco-design requirements for Energy-using Products

Eco design is a new concept aimed at reducing energy consumption by products such as household electrical appliances. Information concerning the product's environmental performance and energy efficiency must be visible if possible on the product itself, thus allowing consumers to compare before purchasing.

The framework directive defines the principles, conditions and criteria for setting environmental requirements for energy-using appliances.

It therefore makes no direct provision for mandatory requirements for specific products; this will be done at a later stage for given products via implementing measures which will apply following consultations with interested parties and an impact assessment.

In principle, the framework directive applies to all energy-using products that are placed on the market. It also covers parts that are intended to be incorporated into products that are placed on the market as individual parts for end-users, the environmental performance of which can be assessed independently.

This new issue of the Directive includes a wider range of products as not only energy using products, put also “energy related” products are now concerned. This means that many construction products like insulation materials are now concerned by that Directive.

All energy sources are covered, in particular electricity and solid, liquid and gaseous fuels.

It applies to all products placed on the EU market and to imported products.

Regulation (EC) N° 66/2010: EU Ecolabel

The European Union Ecolabel is a voluntary environmental labelling system. It enables consumers to recognise high quality eco-friendly products.

The EU Ecolabel may be awarded to products and services which have a lower environmental impact than other products in the same group. The label criteria were devised using scientific data on the whole of a product's life cycle, from product development to disposal.

The label may be awarded to all goods or services distributed, consumed or used on the Community market whether in return for payment or free of charge. It does not apply to medicinal products for human or veterinary use, or to medical devices.

The system was introduced by Regulation (EEC) No 880/92 and amended by Regulation (EC) No 1980/2000. This Regulation (EEC) No 66/2010 aims to improve the rules on the award, use and operation of the label.

Award criteria

The label shall be awarded in consideration of European environmental and ethical objectives. In particular:

- The impact of goods and services on climate change, nature and biodiversity, energy and resource consumption, generation of waste, pollution, emissions and the release of hazardous substances into the environment;
- The substitution of hazardous substances by safer substances;
- Durability and reusability of products;
- Ultimate impact on the environment, including on consumer health and safety;
- Compliance with social and ethical standards, such as international labour standards;
- Taking into account criteria established by other labels at national and regional levels;
- Reducing animal testing.

Some construction products are under an eco-labeling procedure, such as paints and floor tiles, nevertheless the economic impact of the Eco label is still quite low in the construction sector.

Directive 2002/91/EC: Energy Performance of Buildings

The four key points of the Directive are:

- A common methodology for calculating the integrated energy performance of buildings;
- Minimum standards on the energy performance of new buildings and existing buildings that are subject to major renovation;
- Systems for the energy certification of new and existing buildings and, for public buildings, prominent display of this certification and other relevant information. Certificates must be less than five years old;
- Regular inspection of boilers and central air-conditioning systems in buildings and in addition an assessment of heating installations in which the boilers are more than 15 years old.

The common calculation methodology should include all the aspects which determine energy efficiency and not just the quality of the building's insulation. This integrated approach should take account of aspects such as heating and cooling installations, lighting installations, the position and orientation of the building, heat recovery, etc.

The minimum standards for buildings are calculated on the basis of the above methodology. The Member States are responsible for setting the minimum standards.

The Member States must apply minimum requirements as regards the energy performance of new and existing buildings, ensure the certification of their energy performance and require the regular inspection of boilers and air conditioning systems in buildings.

Decision N° 406/2009/EC: Effort of the Member States to reduce their greenhouse gas emissions to meet the Community's commitments up to 2020

This Decision puts into practice the commitment made by the European Union to reduce its greenhouse gas emissions by 2020. It sets emission levels for each of the Member States and defines the use of credits from project activities. This is the first step towards a higher target which aims at a reduction of 50 % in these emissions by 2050.This Decision sets out minimum contributions for Member States in terms of greenhouse gas emissions, following commitments made by the Community for the period from 2013 to 2020.

Emission levels for the period from 2013 to 2020 and flexibility

Each Member State shall, by 2020, limit its greenhouse gas emissions by the percentage set for each Member State in Annex II to the Decision. From 2013, Member States undertake to reduce their emissions in a linear manner. During the period from 2013 to 2019, a Member State may carry forward from the following year a quantity of up to 5 % of its annual emission allocation. It is also possible to transfer up to 5 % of this allocation to other Member States.

Energy efficiency

In 2012, the European Commission will assess the progress achieved by the Community and Member States with regard to the implementation of the Action Plan for Energy Efficiency which lays down the first objectives for emission reductions by 2020. Following this assessment, the Commission will propose strengthened or new measures.

Use of credits from project activities

In order to fulfill their obligations, Member States may use two types of greenhouse gas emission reduction credits: Certified Emission Reductions (CERs) and Emission Reduction Units (ERUs)

Reporting, evaluation of progress, amendments and review

Pursuant to Decision 280/2004/EC, Member States must declare the following in their reports:

- Their annual greenhouse gas emissions;
- Use, geographical distribution and types of credit used;
- Forecasted progress and national projections;
- Information on policies and national measures.

Every two years, the Community will evaluate progress achieved and compliance with commitments.

Directive 96/62/EC: Ambient Air Quality Assessment and Management

In relation to the fifth environment programme, this framework Directive establishes the basic principles of a common strategy to define and set objectives for ambient air quality in order to avoid, prevent or reduce harmful effects on human health and the environment, assess ambient air quality in the Member States, inform the public, notably by means of alert thresholds, and improve air quality where it is unsatisfactory.

To maintain and improve air quality within the Community, this Directive lays down the basic principles of a strategy for:

- Establishing quality objectives for ambient air;
- Drawing up common methods and criteria for assessing air quality;
- Obtaining and disseminate information on air quality.

The Member States are responsible for implementing the Directive.

The European Parliament and the Council must lay down limit values and alert thresholds (see "Related Acts") for the following pollutant: sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead, benzene and carbon monoxide, ozone, polycyclic aromatic hydrocarbons (PAH), cadmium, arsenic, nickel and mercury.

Ambient air quality must be monitored throughout the territory of the Member States. Different methods may be used for this: measuring, mathematical modeling, a combination of the two, or estimates. Assessment of this type is mandatory in built-up areas with more than 250 000 inhabitants, or in areas where concentrations are close to the limit values.

Member States are required to draw up a list of the areas and conurbations where pollution levels exceed the limit values. Where the alert thresholds are crossed, Member States must inform the inhabitants and send the Commission any relevant information (recorded pollution level, duration of the alert, etc.).

Where certain geographical areas and conurbations have pollution levels below the limit values the Member States must maintain those levels below the said values.

Directive 2006/118/EC: Protection of ground water against pollution and deterioration

The EU establishes a framework for measures to prevent and control groundwater pollution and, in particular, measures for assessing the chemical status of groundwater and measures to reduce the presence of pollutants.

The European Union (EU) has established a Community framework for water protection and management. The Framework Directive provides, among other things, for the identification and analysis of European waters, on the basis of individual river basin districts, and the adoption of management plans and programmes of measures appropriate for each body of water.

By means of this Framework Directive, the EU provides for the management of inland surface waters *, groundwater *, transitional waters * and coastal waters * in order to prevent and reduce pollution, promote sustainable water use, protect the aquatic environment, improve the status of aquatic ecosystems and mitigate the effects of floods and droughts.

Directive 2008/98/EC: Waste

With a view to breaking the link between growth and waste generation, the European Union has provided itself with a legal framework aimed at the whole waste cycle from generation to disposal, placing the emphasis on recovery and recycling. This Directive establishes a legal framework for the treatment of waste within the Community. It aims at protecting the environment and human health through the prevention of the harmful effects of waste generation and waste management.

It applies to waste other than gaseous effluents; radioactive elements; decommissioned explosives; faecal matter; waste waters; animal by-products; carcasses of animals that have died other than by being slaughtered; elements resulting from mineral resources.

Waste hierarchy: In order to better protect the environment, the Member States should take measures for the treatment of their waste in line with the following hierarchy which is listed in order of priority: Prevention; preparing for reuse; recycling; other recovery; notably energy recovery; disposal.

Member States can implement legislative measures with a view to reinforcing this waste treatment hierarchy. However, they should ensure that waste management does not endanger human health and is not harmful to the environment.

Waste management: Any producer or holder of waste must carry out their treatment themselves or else must have treatment carried out by a broker, establishment or undertaking. Member States may cooperate, if necessary, to establish a network of waste disposal facilities. This network must allow for the independence of the European Union with regard to the treatment of waste.

Dangerous waste must be stored and treated in conditions that ensure the protection of health and the environment. They must not, in any case be mixed with other dangerous waste and must be packaged or labeled in line with international or Community regulations.

Permits and registrations: Any establishment or undertaking intending to carry out waste treatment must obtain a permit from the competent authorities who determine notably the quantity and type of treated waste, the method used as well as monitoring and control operations. Any incineration or co-incineration method aimed at energy recovery must only be carried out if this recovery takes place with a high level of energy efficiency.

Plans and programmes: The competent authorities must establish one or more management plans to cover the whole territory of the Member State concerned. These plans contain, notably, the type, quantity and source of waste, existing collection systems and location criteria. Prevention programmes must also be drawn up, with a view to breaking the link between economic growth and the environmental impacts associated with the generation of waste. These programmes are to be communicated by Member States to the European Commission.

Context: The generation of waste is increasing within the European Union. It has therefore become of prime importance to specify basic notions such as recovery and disposal, so as to better organise waste management activities. It is also essential to reinforce measures to be taken with regard to prevention as well as the reduction of the impacts of waste generation and waste management on the environment. Finally, the recovery of waste should be encouraged so as to preserve natural resources.

This Directive repeals directives 75/439/EEC, 91/689/EEC and 2006/12/EC.

It is not clear whether this framework directive repeals also sectorial ones, and especially in the case of the construction sector, the Directive 2000/60/EC related to Construction and Demolition Waste

Com(2006) 216: Halting the loss of biodiversity by 2010 – and beyond – Sustaining ecosystem services for human well-being

The Commission is introducing an Action Plan which includes objectives to halt the decline of biodiversity and measures enabling these objectives to be achieved by 2010. The Action Plan is based on an assessment of biodiversity loss in the EU and globally and the measures taken by the European Union to deal with the problem to date.
The Commission has produced an Action Plan aimed at conserving biodiversity and preventing biodiversity * loss within the European Union (EU) and internationally.

Halting damage to ecosystems * is a matter of urgency if we are to protect the future of the natural world, on account of both its intrinsic value (recreational and cultural value) and the services it provides (ecosystem services *). These services are essential for competitiveness, growth and employment and for improving livelihoods worldwide.

The Action Plan stipulates priority objectives, which are divided into four policy areas (biodiversity in the EU, the EU and global biodiversity, biodiversity and climate change, and the knowledge base). It further specifies four main supporting measures (financing, decision-making, building partnerships, and public education, awareness and participation), as well as monitoring, evaluation and review measures. The Action Plan is aimed at both the EU and the Member States. The relevant measures will have to be taken by 2010 and will be continued beyond.

EC Contract Report May 2009: Life-cycle costing (LCC) as a contribution to sustainable construction: towards a common methodology

This report follows the conclusions of a working group previously established under the responsibility of the DG Enterprise. It has been carried out by David Langdon Consulting, and suggests a common LCC methodology, with essential components as follows:

- A process model
- An issues and decisions matrix
- User scenarios
- Data requirements and Cost classification
- Economic and Financial Analytic tools
- Other Analytic and evaluation tools

The LCC approach is also developed within ISO, Technical Committee 59 (Building and civil engineering works), Design Life). The related document is ISO 15686-5

Com(2007) 62: Improving quality and productivity at work: Community strategy 2007-2012 on health and safety at work

Workplace accidents and work-related illnesses are very costly in not only human but also economic terms. The Commission's strategy aims for a 25% reduction in the total incidence rate of accidents at work by 2012.

Good health at work helps improve public health in general and also the productivity and competitiveness of businesses. Furthermore, workplace problems of health and safety exact a high cost for social protection systems and therefore workers need to be provided with suitable working conditions if their general wellbeing is to be enhanced.

The Community's current strategy on workplace health and safety is a continuation of its strategy for 2002-2006. The previous strategy has already borne fruit: workplace accidents have been markedly fewer in number. The new 2007-2012 strategy, which is even more ambitious, is focusing on achieving a 25% reduction in the total incidence rate of accidents at work and, in order to achieve its goal, the Commission has established six intermediate objectives, which are summarised below.

Directive 2003/10/EC: minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise)

Exposure limit values and exposure action values

The physical parameters used to measure noise are as follows: peak sound pressure (maximum value of instantaneous noise pressure), daily noise exposure level and weekly noise exposure level.
The exposure limit value is fixed at 87 decibels (taking into account the attenuation

provided by the individual hearing protectors worn by the workers) and the exposure action values are fixed at 80 decibels (lower value) and 85 decibels (upper value).

Obligations of employers

Determination and assessment of risks, Provisions aimed at avoiding or reducing exposure, Personal protection, Limitation of exposure, Worker information and training, Consultation and participation of workers

Com(96) 406: A new European Community Disability Strategy

The aim of this text together with a related Resolution taken the same year is to promote equal opportunities for people with disabilities by incorporating disability issues into Community policies and to consolidate cooperation between Member States in preventing all forms of discrimination on grounds of disability. One out of ten citizens in the European Community has a disability, which may be of a physical, sensory, mental or psychic nature. There are still a number of obstacles to the integration of people with disabilities into society:

- in education, many children with disabilities are excluded from mainstream schools and are confined to institutions which give them no opportunity for normal social interaction;
- in the field of employment, a great number of people with disabilities within the working age are excluded from the labour market; they are also two to three times more likely to be unemployed and to be so for longer periods than the rest of the working population;
- many transport systems and public buildings continue to be inaccessible or accessible only with difficulty to people with disabilities;
- as regards housing, suitably adapted or adaptable accommodation is in short supply and prohibitively expensive;
- welfare systems tend to provide a minimum level of support, falling some way short of achieving the goal of integration.

Historically, the response to disability has been mainly one of social compensation through charity and the development of specialist caring services outside the mainstream of society. However necessary and well intentioned they might be, such responses have compounded the problem of exclusion and under-participation. The traditional approaches are slowly giving way to a stronger emphasis on identifying and removing the various barriers to equal opportunities and full participation in all aspects of life.

Responsibility for eliminating exclusion and discrimination based on disability lies primarily with the Member States. The new approach is already being implemented in all the Member States, in different ways and at different speeds.

The Commission considers that Community-level involvement can bring significant added value to the efforts of the Member States. The strategy will be organised along the following lines:

- Consolidation of the cooperation with and between the Member States: establishment of a high-level group of Member State representatives on disability,
- Development of social dialogue focusing on disability-related issues;
- Continued support for non-governmental organisations working in the field of disability to encourage European cooperation;
- Incorporation of disability issues into the formulation of Community policy proposals: an interdepartmental group focussed on issues relating to disability has been set up by the Commission.

- Strengthening of measures to prevent long-term unemployment and to integrate disabled people into working life in line with the European employment strategy;
- Assessment of the extent and impact of Structural Fund action targeting people with disabilities, with particular reference to combating social exclusion.

Com(2001) 723: The future of health care and care for the elderly: guaranteeing accessibility, quality and financial viability

All national health care systems are today faced with three major challenges, as the population of Europe is ageing, health care is increasingly effective but also becoming more expensive, and patients, having become true consumers, are also more demanding. Faced with these three challenges, the Commission has proposed three long-term objectives: access to health care for all, a high level of quality in health care and ensuring the financial viability of health care systems.

The EU's overall health situation and health care systems are among the best in the world, thanks to the widespread extension of cover against sickness and invalidity, the rise in the standard of living, improved living conditions and better health education. Total health care spending rose from around 5% of GDP in 1970 to over 8% in 1998. Public health care spending followed the same trend of growing faster than GDP in most countries.

The Communication identifies three long-term objectives for national systems, which should be pursued in parallel.

Accessibility: Access to health care is a right enshrined in the Charter of Fundamental Rights of the European Union. However, it is often affected by an individual's social status. It is therefore particularly important to ensure that access to health care for disadvantaged groups and for the poorest members of society is guaranteed. The joint report to evaluate the national action plans for social inclusion proposes three categories of measures:

- Measures to develop disease prevention and promote health education (mother and child care, medical care at school and medical care at work);
- Providing less expensive and even free care for those in low-income brackets;
- Measures aimed at disadvantaged groups, e.g. the mentally ill, migrants, the homeless, alcoholics and drug addicts.

Quality: In order to provide quality health care, national governments are required to achieve an optimum balance between the health benefits and the cost of medication and treatment. Ascertaining quality in this way is made complex by:

- The diversity of the structures and levels of health care, which often influence demand for health care and consequently the level of expenditure;
- The different approaches to medical treatment.

Comparative analysis of health care systems and medical treatment should make it possible to identify "best practice" and thus to help improve the quality of health care systems.

Financial viability: A certain level of financing is required to ensure the availability of high-quality health care that is accessible to the population. There is upward pressure on these health care costs, irrespective of the way in which Member States' health care systems are organised. Member States have been undertaking reforms since the early 1990s, based mainly on two methods:

- Regulation of demand, by increasing contributions or by ensuring that the final consumer bears an increasingly large share of the costs;

- regulation of supply, by determining budgets or resource envelopes for health care providers, creating a contractual relationship between "buyers" and "providers" of health care.

It is often difficult, however, to distinguish the short-term effects from the more structural effects of these reforms, which allow spending to develop at a sustainable pace. This Communication recommends more exchanges of experience, which would help to keep track of the policies introduced, and would be a useful way of comparing health care systems and encouraging progress.

In order to achieve these objectives it is essential that all parties concerned (local authorities, health care professionals, social protection bodies, supplementary insurance companies, consumers) work together to build strong partnerships.

Com(2008) 800: A European Economic Recovery Plan

In the face of the economic crisis of October 2008, the European Union is equipping itself with an Economic Recovery Plan aimed at proposing both European and global solutions. On the one hand, the plan proposes short-term action at the level of businesses, individuals and banks. On the other hand, it aims, in the longer term, to develop a clean economy with low CO2 emissions which is capable of encouraging future growth.

The European Economic Recovery Plan is a response to the global economic crisis which affected the real economy in 2008. It sets out the broad lines of a coordinated European approach which involves:

- swiftly stimulating demand;
- helping the most vulnerable people affected by the economic downturn;
- preparing Europe to be competitive with a view to future growth;
- taking advantage of this period of upheaval in order to accelerate the establishment of a cleaner economy with more concern for the environment.

The European Commission proposes that Member States and the European Union agree on an immediate budgetary impetus amounting to EUR 200 billion.

Com(2005) 658: Review of the Sustainable Development Strategy – A platform for action

This strategy provides an EU-wide policy framework to deliver sustainable development, i.e. to meet the needs of the present without compromising the ability of future generations to meet their own needs.

It rests on four separate pillars – economic, social, environmental and global governance – which need to reinforce one another. The economic, social and environmental consequences of all policies thus need to be examined in a coordinated manner and taken into account when those policies are being drawn up and adopted. The EU also needs to assume its international responsibilities with regard to sustainable development, whose various aspects – including democracy, peace, security and liberty – need to be promoted beyond EU borders.

This strategy, which complements the Lisbon Strategy, shall be a catalyst for policy makers and public opinion, to change society’s behaviour. It is built around measures covering the main challenges identified, as well as cross-cutting measures, adequate funding, the involvement of all stakeholders and effective policy implementation and follow-up.

The strategy is based on the following guiding principles: promotion and protection of fundamental rights, solidarity within and between generations, the guarantee of an open and democratic society, involvement of citizens, involvement of businesses and social partners, policy coherence and governance, policy integration, use of best available knowledge, the precautionary principle and the polluter-pays principle.

Measures for responding to the key challenges :

The strategy identifies seven unsustainable trends on which action needs to be taken:

- Limit climate change and its effects by meeting commitments under the Kyoto Protocol and under the framework of the European Strategy on Climate Change. Energy efficiency, renewable energy and transport will be the subject of particular efforts.
- Limiting the adverse effects of transport and reducing regional disparities
- To promote more sustainable modes of production and consumption.
- Sustainable management of natural resources is also an objective.
- Limiting major threats to public health is another of the strategy's objectives. Food safety and quality must be ensured throughout the food chain.
- Combat social exclusion and poverty.
- Strengthening the fight against global poverty

Cross table with the 10 vision items, and with the four categories of requirements (environmental, economic, social, health and safety)

Boxes are filled if the given EU Document brings an impact on the given Vision Item or Requirement. The filling is:

- Green if the impact is a direct one.
- Grey if the impact is an indirect one.

All boxes empty on the line of one Vision Item or one Requirement is then identified as a gap on the way to the SSE Building. This means that the corresponding vision item or requirement will be more difficult to sustain or fulfill. Suggestions can be made for developing an incentive EU text for supporting that particular vision item or requirement.

Table 5.1: Vision: items

Boxes ticking: - empty: *this text has no impact on that item/requirement* - **grey filling:** *this text may have an indirect impact on that item/requirement* - **green filling:** *this text has a direct positive impact on that item/requirement*	EU LEGISLATION: REGULATIONS, DIRECTIVES COMMUNICATIONS and others																			
	Dir 86/106/EEC	Com(2005) 670	Reg EC 1907/2006	Com(2003) 302	Reg EEC 761/2001	Dir 2008/28/EC	Reg (EC) 66/2010	Dir 2002/91/EC	Decision 406/2009/EC	DIR 96/62/EC	DIR 2006/118/EC	Dir 2008/98/EC	Com(2006) 216	Report May 2007	Com(2007) 62	Dir 2003/10/EC	Com(96) 406	Com(2001) 723	Com(2008) 800	Com(2005) 658
	Construction Products Directive (EPD) (> CPR)	Sustainabie use of natural resources	REACH	Integrated Product Policy (IPP)	EMAS	Eco Design of EUP (>ERP)	EU Ecolabel	Energy Performance of Buildings (EPBD)	Reducing greenhouse gas emissions	Ambient Air Quality	Ground water protection	Waste	Biodiversity	*LCC Common tool*	Health and safety at work	Exposure of workers to noise	Disability strategy	Health care and care of the elderly	European Economic Recovery Plan	Sustainable Development Strategy
VISION ITEMS																				
Apply the general principles																				
Involve interested parties				grey	grey										grey					grey
Integrate the existing planning schemes and infratructures																				
Life Cycle perspective				green		green														green
Minimize environmental impacts over the service life	green	green	grey	green	green	green	green	green	green		grey	green	green							
Economic value over time														green					green	
Social and cultural value over time for all															green	green				
Healthy, comfortable, safe ans accessible for all										green					green	green	green	green		
User-friendly, simple and cost effective in operation, with measurable performance over time														grey					grey	
Adaptable througout the service life, and end of life strategy																				

Table 5.2: Requirements: environmental

Boxes ticking: - empty: *this text has no impact on that item/requirement* - **grey filling:** *this text may have an indirect impact on that item/requirement* - **green filling:** *this text has a direct positive impact on that item/requirement*	EU LEGISLATION: REGULATIONS, DIRECTIVES COMMUNICATIONS and others																			
	Dir 86/106/EEC	Com(2005) 670	Reg EC 1907/2006	Com(2003) 302	Reg EEC 761/2001	Dir 2008/28/EC	Reg (EC) 66/2010	Dir 2002/91/EC	Decision 406/2009/EC	DIR 96/62/EC	DIR 2006/118/EC	Dir 2008/98/EC	Com(2006) 216	Report May 2007	Com(2007) 62	Dir 2003/10/EC	Com(96) 406	Com(2001) 723	Com(2008) 800	Com(2005) 658
	Construction Products Directive (EPD) (> CPR)	Sustainabie use of natural resources	REACH	Integrated Product Policy (IPP)	EMAS	Eco Design of EUP (>ERP)	EU Ecolabel	Energy Performance of Buildings (EPBD)	Reducing greenhouse gas emissions	Ambient Air Quality	Ground water protection	Waste	Biodiversity	*LCC Common tool*	Health and safety at work	Exposure of workers to noise	Disability strategy	Health care and care of the elderly	European Economic Recovery Plan	Sustainable Development Strategy
REQUIREMENTS: ENVIRONMENT																				
Resources: energy	green			grey	grey	grey	grey	green	grey											
Resources: raw materials	green	green		grey	grey	grey	grey													
Resources: land																				
Resources: water				grey	grey	grey	grey				green									
Resources: biodiversity				grey	grey	grey	grey						green							
Air quality	green			grey	grey	grey	grey		green	green										
Climatic change				grey	grey	grey	grey	grey	green											
Water and Soil pollution			grey	grey	grey	grey	grey				green									
Waste				grey	grey	grey	grey					green								

Table 5.3: Requirements: economics

Boxes ticking:
- empty: *this text has no impact on that item/requirement*
- **grey filling:** *this text may have an indirect impact on that item/requirement*
- **green filling:** *this text has a direct positive impact on that item/requirement*

REQUIREMENTS: ECONOMICS	EU LEGISLATION: REGULATIONS, DIRECTIVES COMMUNICATIONS and others →	Dir 86/106/EEC Construction Products Directive (EPD) (> CPR)	Com(2005) 670 Sustainable use of natural resources	Reg EC 1907/2006 REACH	Com(2003) 302 Integrated Product Policy (IPP)	Reg EEC 761/2001 EMAS	Dir 2008/28/EC Eco Design of EUP (>ERP)	Reg (EC) 66/2010 EU Ecolabel	Dir 2002/91/EC Energy Performance of Buildings (EPBD)	Decision 406/2009/EC Reducing greenhouse gas emissions	DIR 96/62/EC Ambient Air Quality	DIR 2006/118/EC Ground water protection	Dir 2008/98/EC Waste	Com(2006) 216 Biodiversity	Report May 2007 *LCC Common tool*	Com(2007) 62 Health and safety at work	Dir 2003/10/EC Exposure of workers to noise	Com(96) 406 Disability strategy	Com(2001) 723 Health care and care of the elderly	Com(2008) 800 European Economic Recovery Plan	Com(2005) 658 Sustainable Development Strategy
	Life cycle cost performance														green					grey	grey
	Adaptability																		grey		
	efficient support for activity																				

Table 5.4: Requirements: social

Boxes ticking:
- empty: *this text has no impact on that item/requirement*
- **grey filling:** *this text may have an indirect impact on that item/requirement*
- **green filling:** *this text has a direct positive impact on that item/requirement*

REQUIREMENTS: SOCIAL	EU LEGISLATION: REGULATIONS, DIRECTIVES COMMUNICATIONS and others →	Dir 86/106/EEC Construction Products Directive (EPD) (> CPR)	Com(2005) 670 Sustainable use of natural resources	Reg EC 1907/2006 REACH	Com(2003) 302 Integrated Product Policy (IPP)	Reg EEC 761/2001 EMAS	Dir 2008/28/EC Eco Design of EUP (>ERP)	Reg (EC) 66/2010 EU Ecolabel	Dir 2002/91/EC Energy Performance of Buildings (EPBD)	Decision 406/2009/EC Reducing greenhouse gas emissions	DIR 96/62/EC Ambient Air Quality	DIR 2006/118/EC Ground water protection	Dir 2008/98/EC Waste	Com(2006) 216 Biodiversity	Report May 2007 *LCC Common tool*	Com(2007) 62 Health and safety at work	Dir 2003/10/EC Exposure of workers to noise	Com(96) 406 Disability strategy	Com(2001) 723 Health care and care of the elderly	Com(2008) 800 European Economic Recovery Plan	Com(2005) 658 Sustainable Development Strategy
	Full access																	green	green		
	Life quality										green	green		green			green				
	Safety, security, privacy																green		green		
	Satisfaction of the users			grey	grey		grey		grey		grey					green	green	green	green		
	Satisfaction of the local residents								grey												
	Social accessibility (affordability)								grey									green	green	grey	grey

Table 5.5: Requirements: health and comfort

Boxes ticking:
- empty: *this text has no impact on that item/requirement*
- **grey filling:** *this text may have an indirect impact on that item/requirement*
- **green filling:** *this text has a direct positive impact on that item/requirement*

REQUIREMENTS: HEALTH and COMFORT	Dir 86/106/EEC Construction Products Directive (EPD) (> CPR)	Com(2005) 670 Sustainable use of natural resources	Reg EC 1907/2006 REACH	Com(2003) 302 Integrated Product Policy (IPP)	Reg EEC 761/2001 EMAS	Dir 2008/28/EC Eco Design of EUP (>ERP)	Reg (EC) 66/2010 EU Ecolabel	Dir 2002/91/EC Energy Performance of Buildings (EPBD)	Decision 406/2009/EC Reducing greenhouse gas emissions	DIR 96/62/EC Ambient Air Quality	DIR 2006/118/EC Ground water protection	Dir 2008/98/EC Waste	Com(2006) 216 Biodiversity	Report May 2007 *LCC Common tool*	Com(2007) 62 Health and safety at work	Dir 2003/10/EC Exposure of workers to noise	Com(96) 406 Disability strategy	Com(2001) 723 Health care and care of the elderly	Com(2008) 800 European Economic Recovery Plan	Com(2005) 658 Sustainable Development Strategy
Indoor air quality										green										
Acoustic comfort																green				
Thermal comfort				grey				green												
Olfactif comfort			grey																	
Visual comfort - users													grey							
Visual comfort - neighbourhood													grey							
Internal comfort - dust										green										
Internal comfort - magnetic fields																				
Water quality											green									

Comments

When considering the result of the box filling exercise, one can see that some lines are empty. A detailed analysis brings the following comments:

Vision Items

The first vision item was not expected to be supported by any EU text as it reflects the 9 general principles of the ISO 15392.
But some others items are in the same situation: the adaptability over the life cycle is not considered in any document, neither the integration into the existing planning schemes and infra structures, while “involving all the interested parties” and “user-friendly, simple and cost effective in operation, with measurable performance over time” and only indirectly addressed. The gap identified here is rather about the construction process, and the town planning approach. The resulting suggestion here is not clear: the construction process is rather different all over Europe, and it would be a great stake to go for any EU document in this field. Nevertheless, it doesn’t seem impossible to envisage recommendations on both items.

Requirements: environmental

The environmental requirements are rather well supported by EU texts, with at least a green filling for each of them, except for the land resource consideration. This gap is close to the gap identified above, regarding the vision item on planning schemes.

Requirements: economics

On that aspect, the EU legislation is rather poor. The only relevant reference is neither a Regulation nor a Directive: it is a report on Life Cycle Costing (LCC) approach. And again the consideration of adaptability is not addressed, neither the support of activity. On both topics, an appropriate suggestion is not clear.

Requirements: social

Some documents are supporting the social requirements, but they are strong ones. Except for life quality, these are mainly Communications, the incentive power of which is rather weak. The satisfaction of the residents is not considered. This remark raises the lack of supporting text on the quality of the use phase of the buildings, already mentioned for the vision item “user-friendly, simple and cost effective in operation, with measurable performance over time”. A suggestion can be made in this field.

Requirements: health and comfort

Several quite specific texts do exist in support of almost all the requirements for health and comfort, with some weaknesses:

- some documents address only for workers, and not inhabitants
- visual and olfactif comfort are not considered, or only indirectly
- magnetic fields are not treated at all

A suggestion could be made for a better consideration on the visual comfort.

Suggestions

The way to sustainable smart-eco buildings could be facilitated with EU recommendations to be developed on the following topics:

- a better organization of the construction process (involvement of interested parties, efforts for user-friendly buildings, performance measurement)
- an integrated approach of the town planning and adaptability of the build environment (integration of new works into existing schemes, land resource management, future of the built objects)
- a better consideration of the satisfaction of the inhabitants, including specifically the visual and comfort.

6 Life performance (task 4.5)

This chapter addresses the evaluation of long-term technical performance ("life performance") of innovative technologies, combining the concepts of performance based building, service life planning, environmental and economic life cycle assessment (LCA and LCC) and life management systems.

After a short introduction to these concepts, we provide a discussion of the state of the art of these and an outlook on how these concepts best can contribute to addressing sustainability aspects of buildings.

Introduction - the relevance of Life Performance to the Smart-ECO project

In recent years, internationally and throughout Europe, Sustainability has become a key concern in the discussion of the overall performance of buildings. The common grounds for such discussions and for evaluations and assessments are defined in international standards where mainly the "General principles of sustainability in building construction", as defined in ISO 15392, provide important input to the Smart-ECO project. This input is manifested in the establishment of the vision and the evaluation of innovation.

According to the general principles as defined in ISO 15392, economic, environmental and social aspects of sustainability need to be addressed without assigning particular preference to either one of them.

The primary aspects of sustainability need to be addressed, while at the same time considering that the building meets the requirements for technical and functional performance.

Further and according to the European Construction Products Directive as well as to the ISO standard, the performance requirements are to be met throughout the service life of the building. ISO 15392 sets out that a holistic consideration of all relevant sustainability aspects throughout the life cycle of the building be conducted.

Smart-ECO expressly needs to be in line with the concepts and requirements established in the ISO standards and in the CPD. Primarily, this means that:

- The vision is addressing and elaborating on the general principles as identified in ISO 15392
- The evaluation is following a multi-criteria approach relating to multiple aspects of sustainability
- The evaluation and discussion is considering and reflecting the full life cycle of the discussed innovations.

This chapter gives a short introduction to the key concepts that enable the consideration of a full life cycle, giving reference to performance requirements. Applying these concepts in an evaluation enables to

- Identify performance requirements and to relate them to buildings and their elements
- Identify scenarios that enable the building and its elements to provide that performance over time
- Identify and quantify processes that need to be applied to maintain buildings and their elements

In the following sections, this report elaborates briefly on the concepts of

- Performance-based building
- Service Life Planning

- Environmental and Economic Life Cycle Assessment (LCA and LCC)
- Life Management Systems

Presentation of Concepts

Performance Based Building

Performance-based Building concerns a way of conceiving, describing, producing and operating a building in performance terms rather than in descriptive terms. To enable performance-based building, all contractual parties need to be able to specify the desired, agreed, delivered or maintained level of functionality and performance.

Ultimately, performance-based building aims to replace descriptive agreements on product solutions with an open platform for service-oriented solutions. With that, it suggests to be open to innovation, both in terms of products as well as in terms of ways to obtain the desired function and performance.

As soon as the demand is not concerned with initial performance alone, the term "life performance" is to describe the development of performance over time. Especially when applied in the context of sustainable building, the temporal scope of concern is prolonged, and the performance consideration needs to follow this addressed time (period of analysis).

Service Life Planning

Service Life Planning embraces the performance concept at its outset, by defining "service life" as the *period of time during which the product meets or exceed the specified performance requirements*. The thematic field has one of its origins in the EUs Construction Products Directive, requiring the fulfillment of *essential requirements throughout an economically reasonable working life of products and buildings*. Thus the working life needs to become quantifiable, the ways to maintain performance manageable, and the associated costs specifiable.

Service Life Planning is subject of international standardization, the ISO 15686 series identifies concepts stretching from the establishment of Reference Service Life on building products, through a description of the reference conditions under which such values are applicable, to routines for the adaptation of such information to the real current planning or operation situation in a given building. The standards also address how generate information (e.g. on environmental exposure) and how to apply service life information (e.g. factor method; life management systems). They also indicate the link between service life and environmental as well as economic life cycle assessment.

Environmental and Economic Life Cycle Assessment

The life cycle of a building comprises all stages from "inception" to eventual recycling or deposit. This includes all sub-stages from the planning process, the claiming of resources, production of materials and products, construction of the building, operation including maintenance and possible refurbishments and alterations, redevelopment, dismantling, recycling and disposal. Often, these life cycle stages are grouped into the pre-use-stages

(1) "planning", "materials production" and "building construction"
(2) building operation
(3) end of life

Based on a complete description of the life cycle, the processes and products interacting with the life cycle can be identified and ideally quantified and ascribed to the system that is "delivering" the building life cycle. The model of the life cycle will necessarily include assumptions and simplifications.

Once the processes and products have been quantified, environmental or cost information can be ascribed to these. Such information forms the basis for environmental or economic life cycle assessment.

International standards define the procedures for the quantification and assessment. Both are not “holistic” in the meaning of covering all relevant aspects. The environmental LCA is currently restricted to global potential environmental impacts. Economic LCA is commonly agreed to for quantifying costs related to buildings, but faces difficulties in addressing other economic aspects, as these often relate to economic parameters that are in large not defined by the studied building, but rather by the economy in general, the development of the regional market, etc.

Life Management Systems

A large number of IT-based Facility Management Systems (FMS) established to support technical and economical operation, management, refurbishment and maintenance planning are available on the market. The vast majority of these FMS lack a necessary asset to make the systems efficient in support of the construction market need for changing today’s reactive approach to facility management to a more proactive, and that is Predictivity, i.e. the ability to predict and hence plan for forthcoming technical needs, economical, and environmental consequences. Such tools have, however, been developed in three consecutive EU-projects, Wood Asses, MMWood and Lifecon (Haagenrud et al 1999, Haagenrud et al 2001, Sarja 2004). The projects, promoted by an increased European awareness and focus on research and development on sustainable construction, have in several steps developed methods, systems and tools for predictive maintenance management aimed to meet the demand on sustainability during the whole service life of the construction works. A result of the projects is a predictive and generic Life cycle Management System (LMS), which aims at supporting all types of decision making and planning of optimal and long-term design, maintenance, repair and refurbishment (MR&R) activities of any construction works (Hallberg 2005, Sarja 2006). Due to its predictive assets it is possible to adopt short-term as well as long-term planning in which decisions may be based on economical, environmental, safety, cultural and social values etc. The prerequisites, options, adaptability to different technical business areas, and opportunities are in depth analysed in Hallberg, 2009:1. Further developments involving mergers of the LMS conceptual thinking with the rapid development of IFC standards, BIM (Building Information Modelling) and Building Smart concept offers great potential.

State of the Art

Performance-based Building

Especially in larger construction projects and in infrastructure projects, performance-based building has gained significant attention and is frequently applied in the industry. The paradigm shift from short term concern stretching to the handover, or through the warranty period at maximum, to a longer-term concern including the buildings performance in operation was boosted by “public-private-partnerships” and “build-and-operate” tenders. Such contractual agreements require that both parties agree on not only on a price as built, but also on performance in operation, or even on a value at a future day at which the building is agreed to change ownership. With that, performance as well as value over time needs to be handled and needs to be included already in design decisions. Performance-based building has enabled the market for build-operate-transfer concepts.

As the concept requires a highly competent professional client who is able to handle performance based contracting, the concept is frequently applied to public and to larger private construction projects.

The concept has been elaborated by a variety of research organisations, in direct cooperation with industrial and client organisations. CIB is playing a significant role in the development and promotion of performance-based building.

While performance-based building itself is currently not an item of international standardisation, it has dominant links to the standards of service life planning, as these relate to “performance over time” of products, components and entire buildings.

Performance-based building as a concept is regarded as being an enabler of sustainable construction. As soon as requirements with regards to sustainability aspects can be expressed by the client and can be handled by the project planners and builders, PBB would provide the framework to integrate sustainability requirements and targets with other project targets. PBB delivers the platform for balancing various requirements and to identify solutions that deliver required performance over time. Meanwhile, PBB would not prescribe solutions, but would be a non-biased tool to identify solutions that provide the desired functionality and performance.

Service Life Planning

Service Life Planning is subject of international standardisation, see ISO 15686. The standards establish a framework defining the methodology as well as concepts that shall enable practitioners to include a long-term performance-based concern into their building-related decision making. Key elements of service life planning are the consideration of the functionality and performance over time of building products, functional components and entire buildings. Information about service life of products is highly dependent on the product’s qualities and abilities in a real application scenario, involving the built-in situation, the use, application and maintenance and the related development of its performance over time.

Service Life Planning has started to be producing spin-off activities, for example routines and databases allowing the generation of service life information for construction products. Service life information, as a combination of useful life spans of products, in combination with the presentation of factors having an influence on these life spans, can provide elementary information for life cycle cost calculations and for the assessment of environmental impacts over a building’s life cycle.

The link of exposure, use and maintenance through performance requirements to estimated service life values allows practitioners to balance and optimize in the planning stage, but also in already existing buildings.

Market application of service life planning is still lacking behind its potential. However, the increasing demand of service life information (for example as integrated element in economic and environmental life cycle assessment) is clearly visible. With the first databases enabling scenario-adapted service life information on the one hand and the first integrated building assessment and certification schemes allowing the inclusion of such information on the other hand, the market for service life planning and service life information appears to be emerging.

Environmental and Economic Life Cycle Assessment
Life Cycle Assessment has been developed along with the first oil crisis having a strong focus on energy aspects. Over the years, with the shifting concern from energy demand through environmental aspects to the consideration of sustainability aspects, the life cycle assessment concepts have been elaborated and refined to be applicable to the shifting fields of application. International Standards on environmental life cycle assessment (ISO 14040) and life cycle costing (ISO 15686-5) define the concepts and methodologies to be applied.

Both concepts are broadly applied in the industry, not only in building and construction, but in general. The link to environmental management (ISO 14001), sustainability reporting and environmental product declarations (EPD – ISO 14025) leads to a situation where basically all enterprises are aware of the concepts and need to relate at least to elements thereof.

Meanwhile however, economic and environmental life cycle assessment of buildings is still not commonly carried out on a mandatory basis. It is however starting to be triggered either by specific client interests, or through the more and more widespread application of building assessment and labelling schemes. Both concepts hold the potential to address the full life cycle of products and buildings, as much as they allow the client to identify his individual priorities. The identification and quantification of building related information forms the basis for the assessment. Such assessments may be carried out against absolute benchmarks, or against relative references. The user of the information can then iterate and optimize his decisions with respect to the balanced overall economic and environmental performance.

Integrated life cycle assessments are often the core of sustainability assessments, enabling to provision and discussion of information, as well as helping to identify and optimize the sources of adverse environmental and economic impacts.

Perspectives on Sustainability Assessment Systems
Recent years have shown a significant market development embracing sustainability aspects in project planning, facility management and portfolio decisions. Open and equal-base communication of sustainability aspects relies on the availability of a consensus on the aspects to be included in communication as well as on measurement and comparison rules. Ultimately, harmonized models of the building life cycle, agreed aspects to be included, established calculation rules and agreed benchmarks for comparison enable the integration of sustainability information in decision making as well as in market communication. Successful communication in the market, paired with an appraisal of the communicated qualities creates a market and promotes sustainable construction.

International standards harmonize the basis – mainly they consider the modeling and calculation rules, while “softer” elements, such as benchmark comparisons and evaluation and interpretation, are regarded as not being suitable for international standardization. The latter, often entitled as “subjective elements”, are however necessary in order to enable the application of sustainability assessment systems. Especially in these elements, assessment systems can address regional and local conditions and preconditions as well as user-related performance requirements.

A current trend in building related sustainability assessment systems is to include a full life cycle perspective, meaning that a balance between construction-related and use-related aspects can be included in an assessment. This also means, that assessments systems are conceptually open to include performance-over time and service life in the assessments.

As a result, the complexity of the assessment systems will increase, and the inter-linkage to other concepts will most likely only become managerial in IT-based solutions. The EU-project Stand-Inn focused on the potential of BIM-based solutions enabling the integration of performance based building, service life planning, life management and sustainability assessment.

Sustainability assertions of construction products and entire buildings must consider aspects from the entire life cycle of the assessed object. Therefore, service life and performance throughout the service life are key aspects of concern. As assessments of a building design are supposed to reflect the current design rather than a fictitious combination of default-situation assessments of components, the manufacturers alone cannot provide the information needed for these assessments. However, information from the manufacturers constitutes the point of departure for the generation of case specific assessments.

Perspectives on Life Management Systems

There are pronounced possibilities to derive advantage from combining predictive facility management systems like the earlier described Life cycle Management System, LMS, with Building Information Modeling, BIM, to realise modeling and visualization of time dependent changes of construction works. This is enabled by the rapid development in the ICT area, both as regards the development of hardware and software, but also in terms of concepts. The ICT area has opened up for a manifold of innovative solutions, specifically relevant to the area of sustainable construction.

The LMS is one example of an ICT-dependent innovative solution that includes methods, systems, and tools for life cycle design and predictive maintenance management and operation in order to meet requirements on sustainability of construction works. Another innovative concept is Building Information Models/Modeling/Management (BIM). The development of BIM software applications offers new possibilities of efficient computerized information management in the Architectural, Engineering, Construction and Facility Management (AEC/FM) sector. It has been reported up to 50% time savings in the design documentation phase due to the use of BIM (Kam et al, 2003). A BIM may include all types of building project information in design, construction and operation phases, and is traditionally most often presented in 3D. A significant advantage of BIM is that it is parametric and object oriented. Thus the BIM becomes a virtual model of the real building, with all its design and construction aspect and allows also for describing and visualizing performance requirements.

A solution to the general problem of information communication and exchange in the different stages of design, construction, and operation is facilitated by the open standard

Industry Foundation Classes (IFC) for common data structure and information capturing, which is developed on the initiative of the International Alliance of Interoperability (IAI). IFC makes it possible to share and exchange building information between different IFC compatible BIM applications.

There are numerous models (Damage models, Performance over Time models, Dose/Response models) available that describe performance changes over time of materials, products, and systems. The operation and management of this knowledge base, developed since the 1980: ies in international cooperation, in practical engineering and service life planning of construction works is standardized by ISO (ISO 15686; ISO TC59/SC14). These standards should form a basis of any life management system, and specifically does so as regards the LMS. The core module of the LMS is the Service Life Analysis & Prediction module, which may make the most relevant damage or performance over time model available for the specific operation and planning procedure in question.

Combining BIM, and with the aid of IFC, with product life cycle models as mentioned above and tapping this into an LMS platform opens for adopting long-term and dynamic maintenance and operation strategies in facility management. Studies has been carried out (Hallberg, 2009) analysing the use of commercial BIM design tools as an information repository for the use of an LMS. This also included the visualization of a 4D model (3D + time) that simulated the degradation of the parts of a Swedish hospital building. These studies show that visualization and simulation of performance over time in 4D will significantly improve the understandability and hence the effectiveness of the life cycle performance and the maintenance and operation of buildings than ever possible to reach via tables and graphs.

In accordance with – or as a consequence of – the European Construction Products Directive CPD), which in revised form is proposed to become the Construction Products Regulation (CPR), buildings/construction works should be service life planned. A service life planning process consists of combining service life declared products and systems parts to reach a planned design life of the building/construction works while meeting agreed performance requirements. A predictive life management system should ideally be used already in this design and planning process. When the building/construction works is delivered to the operation and management phase the life management system follows the building and then supports a predictive facility management. As has been shown in recent studies (Hallberg, 2009), that this approach is possible to adapt to any system aspect of a building/construction work, i.e. it is as applicable to energy systems, as to building components or structural parts.

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ANNEX 1: Validation summary per measure

Renewable Energy

Roof mounted wind turbines (Renewable Energy)

What does it do?

Relative small wind turbines implemented in the build environment e.g. on roofs of possibly larger buildings generating electricity out of wind energy

How effective is it?

+ smaller wind turbines can provide off grid power
+ latest mid sized wind turbines seems more robust and efficient
- Noise production
- Possibility of broken detached rotor or other parts with high speed
- Efficiency [kWh/Euro] decreases with size making off site power generation with larger wind turbines more efficient
- more defects compared to larger systems
- limited maximum power output, not benefitting form higher wind speeds

Rating: 2

Does it have a potential large Impact?

- potential impact is limited due to limited applicability and relative high costs and robustness of present systems

Rating: 1

Is it sustainable?

+ energy saving / CO_2 reduction
- Various smaller systems showed to cost more energy than gained during their life time

Rating: 2

Cost?

- the efficiency [kWh/Euro] increases with size considerably making off site wind turbines more attractive

Rating: 1

Implement ability?

- noise production
- often not appreciated / allowed in the build environment

Rating: 1

What are success factors?

* Careful picking suitable not too small wind turbine
* Reasonable prize for energy delivered to the grid for on grid sites
* For off grid sites, adequate demand and supply matching.

Solar Thermal Energy (Renewable Energy)

What does it do?

Water is heated using a collector and an insulated storage vessel. In a domestic situation water can be used to (pre-)heat water for showering, dishwashing etc. Some larger systems are designed for a combination of hot water production and low temperature room heating.
Collectors usually are applied with a spectral selective coating maximizing absorbing solar radiation and minimizing thermal transmission by thermal radiation with surroundings.

How effective is it?

+ present systems for domestic warm water production can usually provide 50% of the required thermal energy.
+ application in hospitals elderly homes etc surely is feasible
- additional systems for domestic water heating are required
- systems for room heating must be large because solar radiation is limited in winter.

3

Does it have a potential large Impact?

+ solar hot water heating can be applied in many housing buildings to (pre) heat domestic hot water providing 50% of the required thermal energy for water heating for primarily showering

3

Is it sustainable?

+ energy saving CO2 reduction

4

Cost?

- mature technology suitable for broad implementation potentially cost effective

2

Implement ability?

+ Large capacity for heating domestic water due to high amount of for solar irradiated roofs and facades and ground based

4

Photovoltaic cells (PV Renewable Energy)

What does it do?

PV cells produce electricity by absorbing solar radiation.

How effective is it?

- \+ Typical 15% system efficiency solar irradiation to electrical output. Use and demand match for grid connected systems (majority)

3

Does it have a potential large Impact ?

- \+ when applied on all suitable roofs 60% of EU electricity use is covered

4

Is it sustainable?

- \+ CO_2 pay back time is 2 years max
- \- modest amounts of Cd utilized in CdTe modules and various chemicals in production processes.

4

Cost?

- +- Costs are typical 4 - 5 Euro per WattPeak installed;
- \+ Low maintenance costs
- \+ typical Mid EU 0,9 kWh/Wp
- \+ Costs have decreased over the years substantially and are expected to decreasing further.
- \+ PV can be used as a building material decreasing costs and improving integration

2

Implement ability?

- \+ Large capacity due to high amount of for solar irradiated roofs and facades and ground based
- \- costs are still relative high

3

What are success factors?

Being able to deliver electricity to the grid for a reasonable prize is usually important because of unmatched demand and supply.

Solar Cooling (Renewable Energy)

What does it do?

Different techniques are used for solar cooling. Refrigerators can be operated by the principle of the heat pump or by thermoelectric systems. Buildings and rooms are cooled by allowing warm air to dehumidify while being absorbed into a suitable material (evaporative cooling). In order that the material can once again absorb moisture, it is dried by heat delivered by a solar collector. So the same collector can be used for cooling in the summer and for heating during winter.

How effective is it?

+ depending on the specific situation and conditions it can be very effective
+ heatpumps are / can be used for both heating and cooling

5

Does it have a potential large Impact ?

+ cooling in European buildings increases
- not very widely implementable

3

Is it sustainable?

+ CO_2 and energy reductions (compared to conventional cooling)
+ improved indoor comfort compared to no cooling

4

Cost?

+ reduction of energy costs (compared to conventional cooling)
- installation cost can be higher compared to conventional systems

3

Implement ability?

+ Large capacity due to high amount of for solar irradiated roofs and facades and ground based
- costs can be relatively high

3

Biomass (Renewable Energy)

What does it do?

Biomass is organic material processed to be used as fuel mainly used in transport, electricity producution and heating.

Prizes increase from unprocessed waste up to highly processed specially grown bio mass.

For electricity production and heating mainly waste is used.

Solid biomass fuels
Biogas
Bio-oil
Bio-diesel
Bio-Ethanol

How effective is it?

+ Burning Biomass can be efficient
+ Producing from waste is often very efficient
- Specially grown production (at present mostly used for transport) occupies land possibly suitable for food production
+- Production efficiency varies with feed, technology combination

` 3

Does it have a potential large Impact ?

+ biomass has a Substantial potential

3

Is it sustainable?

+ closed CO2 chain
- polluting if not fully burned (sufficiently hot with suficient oxigen)

4

Cost?

+ Bio mass waste is in principle very cost effective
- specially grown bio mass cost more
-- include eu study figures--- (something to be included?)

4

Implement ability?

+ very implementable for heating
- biomass directly from waste is often not suitable for more delicate systems without pre-processing.

4

What are success factors?

At present for the building sector fairly unprocessed waste is used.

The burning process should completely burn all Bio mass without leaving toxic residues.

Develop smart grids and metering (Renewable Energy)

What does it do?

The output of a renewable energy system at a specific time usually depends on external factors (e.g. solar energy, wind).
When at that time supply exceeds demand, energy is lost if not stored or shared through a grid.
At present, this sharing is often impossible or financially unattractive.
The concept of smart grids aims at optimal integration of local and central (renewable) energy production in grids.
With dynamic prizing and smart meters, supply and demand can be balanced and local and central net stability increased.

How effective is it?

+ increased efficiency of local and more central renewable energy systems by matching local and central energy demand and supply.
+ enable selecting the most suitable locations and systems to generate renewable energy (e.g. larger wind turbines on a windy location in stead of many smaller wind turbines on buildings).

5

Does it have a potential large Impact ?

+ Increased efficiency of renewable systems
+ decreased use of fossil fuels and CO_2 production;
+ stimulates investments (decreased pay back times)
+ supports efficient billing and prizing

4

Is it sustainable?

+ Energy saving / CO_2 reduction
-- control and communication systems and networks required
-- energy use for control system

4

Cost?

NB: Smart meters providing remote information on energy use and production are or getting obligatory in several EU countries.

+ Using this already available information from already present smart meters intelligently to control larger energy systems should not be too costly (4).
-- A system where the smart meter also controls for instance local microCHP systems or the optimal timing of washing machines based on energy prizes is more complex and costly

2

Implement ability?

+ A smart grid, based on existing smart meters to control larger energy systems is implementable.
-- Privacy of energy usage must be solved adequately.
-+ A system based on smart meters optimizing the total energy and heat balance in buildings is more complex and still in R&D phase but implementable in future.

3

Smart Building management (Renewable Energy)

What does it do?

Many projects have shown that prognosed energy savings are not met in practice due to (control) design errors, installation errors, undetected broken sensors valves etc. and insufficient maintenance.
Other studies showed that in many office buildings, incoming air is centrally heated and locally cooled or vice versa.
Present building energy management systems are far less advanced compared to their general perception.

Smart building management can include many things as 1) detecting if sensors and actuators are not operating correctly, 2) detecting if control loops are not functioning as predicted 3) remote building management (internet)
4) advanced control as presence sensor controlled heating cooling and ventilation, operating solar shading to save energy, free cooling by night time ventilation etc.

How effective is it?

- \+ it is expected that in most BEMS controlled buildings 5 to 10% savings can be achieved with basic measures and solving basic problems.
- \+ decreased discomfort
- \+ longer life systems due to correct operation
- \- there is little relevant standardization

4

Does it have a potential large Impact ?

- \+ it is expected that in most BEMS controlled buildings 5 to 10% savings can be achieved with basic measures and solving basic problems.
- \+ decreased discomfort can have an effect on health and productivity. This can have huge economical impact but is very difficult to quantify.
- \+ buildings with renewable energy systems can benefit from smart building management

5

Is it sustainable?

- \+ energy savings and CO_2 reductions
- \- additional control and communication hardware required.

4

Cost?

- \+ energy savings
- \+ better efficiency of durable energy and energy savings due to better operation
- \- costs for complex systems can be substantial

3

Implement ability?

- \+ it is not a mature technology but there are parties who offer smart building management

4

Personal Climate (Renewable Energy)

What does it do?

People differ in preferred indoor climate.

In many buildings there are limited possibilities to adjust indoor climate parameters to personal preferences often leading to discomfort and possible decreased health and productivity.

Systems allowing for personal climate not only increase indoor comfort but also potentially decrease energy use and CO_2 production because boundary conditions for the building are less strict.

How effective is it?

+ increased comfort
+ potentially better productivity
+ potentially less health problems

5

Does it have a potential large Impact ?

+ Expected energy savings and CO_2 reduction for heating and cooling are in the order of 10%
+ Because staff costs are usually dominant, improved productivity has an substantial financial impact (but very hard to quantify)

4

Is it sustainable?

+ Potential energy saving and CO_2 reductions
+ improved indoor comfort
+ For many buildings personal climate can be realized by only changing the software
- extra hardware

3

Cost?

+ Improved productivity has a large potential financial impact (Energy costs are generally 10% of the building running costs and 1% of the staff costs).
- improved productivity including health issues as sick leave are very hard to predict and measure.

4

Implement ability?

+ In some buildings as for instance office buildings with advanced climate systems, implementing personal climate is mostly a question of software since all hardware is already available.
- in many buildings personal climate will be expensive to realize.

3

What are success factors?

In many buildings personal climate can be realized with little hardware adjustments.

In many other buildings personal climate can be realized with local hardware as for instance heated tableaus on desks.

Fuel cells (Renewable Energy)

What does it do?

A fuel cell is an electrochemical cell that converts a source fuel into an electric current. It generates electricity inside a cell through reactions between a fuel and an oxidant, triggered in the presence of an electrolyte. The reactants flow into the cell, and the reaction products flow out of it, while the electrolyte remains within it.

Fuel cells are different from conventional electrochemical cell batteries in that they consume reactant from an external source. By contrast, batteries store electrical energy chemically and hence represent a thermodynamically closed system.

Many combinations of fuels and oxidants are possible. A hydrogen fuel cell uses hydrogen as its fuel and oxygen (usually from air) as its oxidant.

Fuel cells are especially interesting for off grid applications as for transport and remote areas

How effective is it?

- efficiency generation electricity is typically in the order of 20%

+ if the heat used efficiency is higher (combined heat and power generation)

2

Does it have a potential large Impact ?

- efficiency for electrical energy generation not impressive

2

Is it sustainable?

- efficiency for electrical energy generation not impressive

2

Cost?

+- Interresting for off grid siuations

2

Implementability?

- only Interresting If thermal Energy is usable

3

What are success factors?

- only Interesting If thermal Energy is usable

Micro combined heat and power (Renewable Energy)

What does it do?

the use of a heat engine or a power station to simultaneously generate both electricity and useful heat

Home-generated power exceeding the instantaneous in-home needs is often sold back to the electrical utility.

This system is efficient because the energy used is distributed and used instantaneously over the electrical grid. The main losses are in the transmission from the source to the consumer which will typically be less than losses incurred by storing energy locally or generating power at less than the peak efficiency of the micro-CHP system. So, from a purely technical standpoint dynamic demand management and net-metering can be efficient.

How effective is it?

+ if generated heat is usefull (heating water or buildings) efficiency can be high

4

Does it have a potential large Impact ?

+ can be used in many buildings

+ if generated heat is usefull (heating water or buildings) efficiency can be high

3

Is it sustainable?

+ Energy saving / CO_2 reduction

4

Cost?

+ factory costs $450/kW

4

Implementability?

+ can be used in many buildings

+ if generated heat is usefull (heating water or buildings) efficiency can be high

3

What are success factors?

posibility to sell electricity to utility

usability heat

Energy Storage (Renewable Energy)

Ground water (aquifers) with heat pump

What does it do?

Low temperature room heating, cooling and water heating using a heat pump with open water as source
How effective is it?
+ Effective generating thermal energy for room heating, cooling and warm water preparation from electricity (typical COP values cooling >= 10, heating 5.5 for low temperature (45oC) and for water heating 2,5.
5 cool
4 heat
3 tap

Does it have a potential large Impact ?

+ suitable for utility buildings, apartment buildings and larger dwelling projects
0

Is it sustainable?

+ Energy efficient saving energy and CO2 reduction
(depends on electricity source)
3

Cost?

+ good alternative for conventional heating and cooling systems in offices
+ comparable prized increased Energy efficiency
- in dwelling more expensive
+ but cooling as bonus
3

Implement ability?

+ suitable for various building types
- Only for central Europe (energy neutral storage)
- ground must be suitale to be combined with low temperature systems
requires sufficient insulation and solar shading
3

What are success factors?

For low temperature heating
relative high temperature cooling
Combine with floor and/or wall heating cooling

Ground coupled heat pump (with heat exchanger) Energy Storage Renewable Energy

What does it do?

Low temperature room heating, cooling and water heating using a heatpump with ground as source using an heat exchanger (not geothermal)

How effective is it?

- + Effective generating thermal energy for room heating, cooling and warm water preparation from electricity (typical COP values cooling >= 10, heating 5 for low temperature (45oC) and for water heating 2,5

5 cool
4 heat
3 tap

Does it have a potential large Impact ?

- + suitable for utility buildings, apartment buildings and larger dwelling projects

0

Is it sustainable?

- + Energy efficient saving energy and CO2 reduction (depends on electricity source)
- \- Medium should not leak (synthetic media CO equiv. 1500)

0

Cost?

- + good alternative for conventional heating and cooling systems in offices
- + comparable prized increased Energy efficiency
- \- in dwelling more expensive
- + but cooling as bonus
- \- additional costs for heat exchanger (typical 4000 Euro)

3

Implement ability?

- + suitable for various building types
- \- suitable for mid Europe (Paris, Londen, Amsterdam, Berlin)
- \- ground must be suitable
- \- in principle not for badly insulated buildings or large solar or internal gains

3

Air coupled heat pump (Energy Storage Renewable Energy)

What does it do?

Low temperature room heating, cooling and water heating using a heatpump with outdoor air as source

How effective is it?

+ Effective generating thermal energy for room heating, cooling and warm water preparation from electricity (typical COP values cooling: 4-6, heating: 4 for low temperature (45oC) and for water heating 2,5

5 cool
4 heat
3 tap

Does it have a potential large Impact ?

+ suitable for utility buildings, apartment buildings and larger dwelling projects

3

Is it sustainable?

+ Energy efficient saving energy and CO_2 reduction
depends on electricity source)

4

Cost?

+ No costs for ground system
+- prize heatpump comparable to central heating system for dwelling

4

Implement ability?

+ widely applicable

3

Surface water coupled heat pump (sea, river, lake) (Energy Storage Renewable Energy)

What does it do?

Low temperature roomheating, cooling and waterheating using a heatpump with surface water as source

How effective is it?

+ ffective generating thermal energy for room heating, cooling and warm water preparation from electricity (typical COP values cooling: 4-6, heating: 5 for low temperature (45oC) and for water heating 2,5

5 cool
4 heat
3 tap

Does it have a potential large Impact ?

+ suitable for utility buildings, apartment buildings and larger dwelling projects

Is it sustainable?

+ nergy efficient saving energy and CO_2 reduction
(depends on electricity source)

4

Cost?

No costs for ground system
prize heatpmp comparable to central heating system for dwelling
4

Implementability?

- water source must be available (sea and deeper lakes rivers etc.)

0

Insulatating materials (Thermal insulation Energy saving)

What does it do?

Insulating materials decrease conduction losses, potentially decreasing the demand for heating and cooling and related energy and possibly required systems. On the other hand increased insulation can cause overheating in warmer periods.

How effective is it?

+ Thermal conduction through insulation materials as mineral wool is 20 times lower compared to building materials as concrete or stone and aproximately 10 times higher compared to wood.
+ energy saving potential is substantial 20-50%

5

Does it have a potential large Impact ?

+ The impact is substantial for uninsulated buildings
+ The potential compared to present insulation levels iare still substantial for low energy buildings but obviousely more modest in general.

5

Is it sustainable?

+ Energy saving and CO2 reductions
- toxic insulation materials??

4

Cost?

+ very cost effective
- decreases relative effective net floor surface

5

Implementability?

+ Implementable in many many ways in almost all buildings

5

I**nulating panels with IR shield** (Thermal insulation Energy saving)

What does it do?

Insulating panels are often very practical being able to withstand forces without additional materials.

IR shields decrease thermal radiative heat exchange (next to conductive and possibly convective heat exchange)

How effective is it?

+ Thermal conduction through insulation panels materials as mineral wool is 20 times lower compared to building materials as concrete or stone and approximately 10 times higher compared to wood.
+ energy saving potential is substantial 20-50%

5

Does it have a potential large Impact ?

+ The impact is substantial for un-insulated buildings
+ The potential compared to present insulation levels are still substantial for low energy buildings but obviously more modest in general.

5

Is it sustainable?

+ Energy saving and CO_2 reductions
- toxic materials

4

Cost?

+ very cost effective
- decreases effective net floor surface

5

Implement ability?

+ Implementable in many many ways in almost all buildings

5

Aerogel insulation Thermal insulation Energy saving

What does it do?

Silica aerogel excists for 99,8% of air with a very low density and low thermal conductivity (approx 0,03 - 0,004 W/m.K)
It absorbs thermal radiation.
It is avaulable as granular material and as solid material which is relatively fragile.

How effective is it?

+ Conductive losses in buildings can be decreased without loosing a limmited amount of net floor area.
+ Aerogel can be used in windows (translucent, scattering)
5

Does it have a potential large Impact ?

+ substantial reduction of thermal conductive lossed without lossing too much floor area.
4

Is it sustainable?

+ Energy saving and CO_2 reduction
- materials??
3

Cost?

+ Substantial reduction of conductive losses possible with limited wall thicknesses (floor area losses)
- the costs are still relatively high and often NOT suitable for on site application
- no load carrying properties

3

Implement ability?

+ can be implemented in facades and windows
+ grannual aerogel suitable for space fillings
- panels are relatively fragile and less suitable for on site building.

3

Vacuum insulation panels VIP Thermal insulation Energy saving

What does it do?

A VIP consists of a gas-tight enclosure and a rigid core from which the air has been evacuated.

By removing air from fiber, powder, or foam core materials, VIPs achieve high thermal performance with modest thickness. VIP products are often made-to-fit architectural details, with specified service lives for floor, wall, and roof constructions.

How effective is it?

+ offer a very high thermal resistance by thickness
+ enables high thermal resistance in small spaces
- age as it usually impossible to completely keep air from leaking.
5

Does it have a potential large Impact ?

+ when higher thermal insulation is required (legislation) the benefit of space becomes increasingly important
- due to higher prize and aging effects now less suitable for the bulk market
2

Is it sustainable?

+ saving energy and CO_2 reductions
- various alternatives
3

Cost?

+ save space
- are relative expensive (high cost thermal resistance ratio)
- Age (air leakage in time)
2

Implementability?

+ suitable for prefabricated constructions
- VIP products are often made-to-fit architectural details, with specified service lives for floor, wall, and roof constructions.
2

What are success factors?

When higher thermal insulation is required (legislation) the benefit of space becomes increasingly important.

Air tightness

multi foil reflective insulation Thermal insulation Energy saving

What does it do?

multi foil reflective insulation or multi-layer insulation, or MLI, is thermal insulation composed of multiple layers of thin sheets often used on spacecraft. It is mainly intended to reduce heat loss by thermal radiation. In its basic form, it does not appreciably insulate against other thermal losses such as heat conduction or convection. It is therefore commonly used on satellites and other applications in vacuum where conduction and convection are much less significant and radiation dominates.

How effective is it?

+- thermal resistance is usually not better than conventional insulation materials

2

Does it have a potential large Impact?

- in space it has

2

Is it sustainable?

+- depends on used materials

3

Cost?

- NOT so good cost resistance ratio
- higher cost for applying materials

2

Implement ability?

+ can be implemented relatively easy
- compared to conventional insulation materials relative difficult to apply

4

TiO2 materials and coatings Gladding materials Energy saving

What does it do?

As pigment (titanium white) it is very white and has a wide range of applications, from paint to sunscreen to food colouring. Titanium dioxide is found in almost every sunscreen with a physical blocker because of its high refractive index (n = 2.7), its strong UV light absorbing capabilities and its resistance to discolouration under ultraviolet light.
TiCo2 paint can also be applied on roofs and facades to reflect solar radiation to reduce solar gain / overheating

How effective is it?

+ high reflective properties for solar radiation
3

Does it have a potential large Impact ?

- it is already used in many solar shading systems (not new)
1

Is it sustainable?

+ avoid overheating
2

Cost?

+ Competitive costs (already widely in use)
4

Implementability?

+ can and is implemented in many situations
3

What are success factors?

it is already a success

green roofs Gladding materials Energy saving

What does it do?

Building roof that is partially or completely covered with vegetation and a growing medium, planted over a waterproofing membrane. It may also include additional layers such as a root barrier and drainage and irrigation systems. Green roofs absorb rainwater, provide insulation, create a habitat for wildlife. The additional thermall mass toether with the increased insulation can decrease the energy use for heating and cooling.

How effective is it?

+ reduce heating by adding mass and thermal resistance
+ reduce cooling (evaporative cooling)
+ reduce stormwater run off
+ water buffer
+ natural Habitat Creation
+ sound insulation
+ agricultural space
+ reducing heat island effect
- higher initial costs
4

Does it have a potential large Impact ?

+ many benifits
+ decreased energy use for heating and cooling
+ avoiding the nessesety of cooling installation
- additional initial costs
- not applicable on all roofs
3

Is it sustainable?

+ Energy reduction
+ better indoor control
+ possible avoid the need for cooling installation
+ biological material
4

Cost?

+ increase roof life span
+ ads value to the building
- additional innitial costs
3

Implementability?

- not applicable on all roofs
2

What are success factors?

making the roof suitable
initial care (after some time maintenance in minimal)

Cool roofs Gladding materials Energy saving

What does it do?

Roofing system that can deliver high solar reflectance (the ability to reflect the visible, infrared and ultraviolet wavelengths of the sun, reducing heat transfer to the building) and high thermal emittance (the ability to radiate absorbed, or non-reflected solar energy) is a cool roof. Most cool roofs are white or other light colors. http://www.coolroofs-eu.eu

How effective is it?

+ energy reduction for cooling
+ reducing heat island effect
- possibly additional heating energy
2

Does it have a potential large Impact ?

+ decreased energy use for cooling
+ avoiding the nessesety of cooling installation
- possible additional energy for heating
- not applicable on all roofs
2

Is it sustainable?

+ Energy reduction for cooling
- possible additional energy for heating
3

Cost?

+- not nessesarely more expensive compared to alernatives
+ cooling energy reduction
3

Implementability?

'+ reduce overheating and or cooling energy use in warm climates
- in climates where there are more heating days than cooling days, white reflective roofs are not typically a worthwhile investment in terms of Energy efficiency or savings.
4

What are success factors?

Only suitable with limited heat demand

Vacuum glazing Glazing Energy saving

What does it do?

Vacuum glazing consists of a pair of glass sheets with an evacuated spacing gap containing a lot of small support pillars, the insulating property depends on heat flow through the pillars, radiation from the inside glass surface and convection of quite small amount of air in the spacing gap. For higher thermal insulation, low temperature manufacturing process was developed to enable the use of tempered glass necessary for wider pillar separation.

How effective is it?

+ very high thermal resistances can be achieved in small thicknesses (e.g. 0,5 w/m2k)
5

Does it have a potential large Impact ?

+ very high thermal resistance for glazing - will production costs decrease suficiently
- will the vacuum maintain long enough
4

Is it sustainable?

+ saving energy and CO_2
+ material use comparable to high performance glazing
4

Cost?

+ material costs comparable to high performace glazing and performance outperforms tripple glazing
- production costs for vacuum and support pillars
2

Implementability?

+ widely implementable
+ implementable for instance historical buidings with limmits on glazing thickness.
- window framing must be on par
4

What are success factors?

Framing must be of good thermal quality not to spoil the very high thermal performance of the glazing also due to the due to the small thickness

Translucent insulation Glazing Energy saving

What does it do?

Translucent insulation material is insulation material that transmits solar radiation and absorbs radiative radiation.
It is used in front of walls to buffer the by the usually painted wall absorbed solar radiation transmitting the heat to indoors with a time shift increasing efficiency and dcreasing overheating. It is also used captured by to sheets of glas.
Translucent transmits light but is not transparant..

How effective is it?

+ the thermal resistance is higher than of conventinal double glazing but usually requiring substantial increased thicknesses
- thermal performance is now in the same order as nowadays high performance glazing

3

Does it have a potential large Impact ?

- due to its relative large thickness and performance cost ratio not likely

1

Is it sustainable?

+ saving energy and CO_2 reduction

2

Cost?

+ relative large costs including costs for the building process

2

Implementability?

+ can be implemented in many buildings
- in many cases unobstructed view to outdoors is required
- because gap thicknesses are relative high, a sealed gap will put a lot of pressure on the glazing if temperatures increase. This can be solved with a mild vacuum but will potentially cause problems when the system becomes leaky.

2

What are success factors?

Because gap thicknesses are relative high, a sealed gap will put a lot of pressure on the glazing if temperatures increase. this can be solved with a mild vacuum but will potentially cause problems when the system becomes leaky.

Glass including PCM, Glazing, Energy saving

What does it do?

PCM between two sheets of glass absorbs and stores sunlight for periods with lower temperatures.
The effect is that solar gain is stored in PCMs.

How effective is it?

+ stores energy
- obstructs view and light
- over 50% of the stored heat will be lost to outdoors

1

Does it have a potential large Impact ?

- limited application expected thus limmited impact

1

Is it sustainable?

- some PCM's are toxic

3

Cost?

- unattractive costs saving ratio

1

Implementability?

- view to outdoors is usually important

2

Variable Solar transmittance Glazing Energy saving

What does it do?

There are different types of glazing with solar transmittance changed with electricity (electrochrome), temperature (thermochrome) and solar radiation (photochrome).

How effective is it?

- \+ can decreases overheating and need for cooling to some extend
- \- Solar transmittance of thermochrome and photochrome change with temperature and solar radiation respectively and can not be controlled directly (decreasing potential benifits)
- \- the dynamic range between transparent and reflective or absorbing states of electrochrome glazing is limited resulting in limited affectivity.
- \- glazing requires shading to avoid glare
- \- outdoor shading usually has a larger dynamic range and better controllability

2

Does it have a potential large Impact ?

- \- limited potential because of the relative high costs and drawbacks
- \- mostly not very attractive compared to solar shading

2

Is it sustainable?

+ can save some energy
- various toxic materials are used
2

Cost?

- relative high costs
2

Implementability?

+ can be implemented in many windows
- electrochrome glazing requires installation of wires electricity
- often additional (indoor) shading required to avoid glare
3

What are success factors?

Thermochrome and photochrome glazing can not be controlled / optimized. Energy savings are therefore limited.

Light shelves Natural lighting Energy saving

What does it do?

Architectural element that allows daylight to penetrate deep into the room.
This horizontal light-reflecting overhang is placed above eye-level and has a high-reflectance upper surface. This surface is then used to reflect daylight onto the ceiling and deeper into the room.
In addition they shade near the windows, due to the shelf overhang, and help reduce window glare. A combination of exterior and interior shelves will work best in providing an even illumination gradient.

How effective is it?

\+ reduce glare
\+ reduce contrast between back and window sides
\- light does bounce into the back of the room
\- are less effective without direct sun

3

Does it have a potential large Impact ?

\+ results in more balanced lighting situation
\+ save energy for lighting
\- limited controllability and thus energy saving

3

Is it sustainable?

\+ energy savings and CO_2 reductions
\- additional material

3

Cost?

\- costs can be substantial for retrofit\situatons

3

Implement ability?

\- less effective with diffuse light (without direct solar radiation)

2

Special shaped louvers and venetian blinds / prismatic glass
Natural lighting , Energy saving

What does it do?

Glazing elements allowing daylight to penetrate deeper into the room. Sometimes accompanied by reflective elements on the ceiling.

How effective is it?

+ reflects light deepen into the room
+ potential better light distribution
- potential glare caused reflected sunlight by light form the facade
- not very effective without direct light
- can obstruct view to outdoors
- decreases visual contact with outdoors
3

Does it have a potential large Impact ?

+ results in more balanced lighting situation in the room
- limited controlability
- can cause glare from the window
3

Is it sustainable?

+ energy savings and CO_2 reductions
- additional materials
0

Cost?

- relative high costs
- in many cases additional indoor shading required
0

Implementability?

+ implementable in many windows
3

Glazing with integrated shading Natural lighting , Energy saving

What does it do?

Outdoor shading is an effective way to decrease solar gain thus decreasing overheating and cooling energy.

Outdoor shading is often not practical as for large heights (large wind forces). shading is less effective in decreasing solar gains.

An alternative is shading applied in the gap of windows (between two sheets of glass).

In special glazing systems as for instance double skin facades, the by the shading system absorbed heat can be ventilated to outdoors decreasing the solar transmittance (and solar gains)

How effective is it?

+ Effective alternative for situations were outdoor shading is not an option.

- it is usually not effective

3

Does it have a potential large Impact ?

- in most buildings there is a good alternative (outdoor shading) .

2

Is it sustainable?

+ depends on reference

2

Cost?

+ lower maintenance costs

- expensive to replace

2

Implementability?

+ suitable for most new build buildings

- usually not possible without replacing existing glazing in excistong buildings

2

What are success factors?

Light tubes and heliostats Natural lighting Energy saving

What does it do?

Light tubes or light pipes transport (day)light into the building.
A heliostat tracks the sun and typically utilizes a mirror to redirect sunlight into the building.

How effective is it?

+ brings daylight deep into the building
- amount of light is limmited by the amount of light entering the system which is often modest.

2

Does it have a potential large Impact ?

- the impact is limmited due to the limmited effects due to limmited light entering the system

2

Is it sustainable?

+ saving on energy for lighting
+ more daylighting in darker areas or in areas without daylighting

2

Cost?

+ savings on energy for lighting
- installation costs
- use of space
- maintenace costs for heliostat

2

Implementability?

+ light tubes can be implemented in many roofs
- heliostats require space and need to be powered and control from a distance

2

Improved lighting systems electrical lighting Energy saving

What does it do?

Average typical energy use for different lighting systems for offices:
1970: 40 W/m2 fluerecent tubes
1980:20 W/m2 improved fixures and efficiency
1990: high frequency 10W/m2
2000: daylight controlled T5 8W/m2 - 500 Lux
daylight control + TL5 20-30% 5 W/m2
LEDS colour quality (CRI) is not yet very good efficiency 50-60 lumen/Watt (best flurecent tubes 110 lumen /W)

How effective is it?

+ the efficiency of lighting in offices can be improved up to 800% depending on the reference
+ compact fluerecent and LED lamps are 400 to 600% more efficient compared to Incandescent light bulbs
5

Does it have a potential large Impact ?

+ Energy for lighting in offices is substantial
- energy for lighting in dwellings is less substantial
3

Is it sustainable?

+ saving on energy for lighting
+ daylight controlled lighting provides relative more delighting
- various lighting systems contain toxic elements and must be recycled
3

Cost?

+ energy savings
- high costs LED
3

Implementability?

+ lighting systems can be implemented
- sometimes fixures need to be replaced
3

LED P-OLED, OLED WOLED Electrical lighting (Energy saving)

What does it do?

A light-emitting diode (LED) is a semiconductor light source. LEDs are used as indicator lamps in many devices, and are increasingly used for lighting. Introduced as a practical electronic component in 1962, early LEDs emitted low-intensity red light, but modern versions are available across the visible, ultraviolet and infrared wavelengths, with very high brightness.

There are differnt types of LEDs as
organic light emitting diode (OLED), Polymer OLED (P-OLED) and White OLEDs.

How effective is it?

+ better efficiency than incand. bulbs.
+ efficiency not affected by shape
+ can emit light of intended color
+ can be very small
+ light up very quickly
+ easily dimmable
+ low IR radiation
+ slow failure (dimming over time)
+ relatively long useful life
+ shock resistant
+ can be designed to focus light
+ Low toxicity (no mercury)
- less efficient than fluorescent lighting
- high initial price:
- temperature sensitive life span
- light quality (no black body radiator)

4

Does it have a potential large Impact ?

+ better efficiency than inacdent bulbs
- efficiency fluorescent tubes in general higher

3

Is it sustainable?

+ saving on energy for lighting
+ daylight controlled lighting provides relative more daylighting
+ no mercury

4

Cost?

- high costs LED
+ lower maintenance costs (langer life span)

2

Implementability?

+ can be implemented widely
- replacement of fixures
- not suitable when colour should resemble blackbody radiation

3

What are success factors?

costs reductions over time
possibility to replace excisting light

Solar chimneys Natural Ventilation Energy saving

What does it do?

A solar chimney is a way of improving the natural ventilation of buildings by using convection of airheated by passive solar energy. A vertical shaft utilizing solar energy to enhance the natural stack ventilation through a building.

How effective is it?

'+ it can help reduce energy use for ventilation
- it works only on sunny days (where additional ventilation may cause overheating or increased cooling needs)

2

Does it have a potential large Impact ?

- limiitted

1

Is it sustainable?

'+ potential energy saving and CO_2 production reduction (if not too much ventilation is realized in warmer (sunny) periods)

4

Cost?

- additional costs for chimney

3

Implementability?

- should fit in Architecture

2

Passive wind cowls Natural Ventilation Energy saving

What does it do?

A cowl is a usually hood-shaped covering used to increase the draft of a chimney.

How effective is it?

- relative small benifit (5%) especially with low energy mechanical ventilation beacause of the low velocities (pressure < 1 Pa)

2

Does it have a potential large Impact ?

- savings on energy for ventilation are liimmited

2

Is it sustainable?

'+ (limmited) energy saving potential

+ siimple system

4

Cost?

+ cost can be limmited

- benifits usually limmited

3

Implementability?

+ can be omplemented on many ventilation systems

- will not work in combination with hibride ventilation

3

What are success factors?

seems a technology that could be interesting if costs can be kept very low.

Use of atria for climate tempering Natural Ventilation Energy saving

What does it do?

Non heated and non cooled Atria can function as a buffer zone between indoor and outdoor conditions potentially increasing the use of passive solar energy and reducing energy losses by transmission and ventilation.
In many cases the atriums are used more extensively as anticipated and often (indirect) heated and cooled by opening doors between indoors and the Atrium.
In those cases energy losses can be substantial

How effective is it?

+ Atria ce save substantial fractions of energy foor heating and cooling.
- in many cases Atria are (indirectly) heated and cooled opposed to their design resulting in negative energy savings.
- the energy saving efects decrease in combination with heat recovery systems.
2

Does it have a potential large Impact ?

- limited because atria require space and are relative expensive
2

Is it sustainable?

+ potential energy savings and CO2 reductions
2

Cost?

- relative large costs (saved joule/Euro)
1

Implementability?

- require space which shoyild be available
2

What are success factors?

Hybrid ventilation Natural Ventilation Energy saving

What does it do?

tilation system where machanical ventilation complements natural ventilation.

How effective is it?

+ effective in the sense of reducing energy required for ventilation
- energy for ventilation usually not substantial compared too energy for heating and cooling
- good alternatives available (low energy ventilators)

3

Does it have a potential large Impact ?

+ Energy savings

3

Is it sustainable?

+ Energy saving and CO_2 reductions
- larger more complex system required

3

Cost?

+ energy savings
- larger ducts etc. required for natural ventilation

3

Implementability?

+ suitable for most buildings
- more space required for larger dusts etc. required
- larger dusts are usually not suitable for integration in floors

2

What are success factors?

Costs for ducts installation
availability of space for ducts etc.
control

Low energy Ventilation (RESHYVENT) Natural Ventilation Energy saving

What does it do?

Use relative large ducts and efficient fans to decrease energy by fans (e.g. < 1W for dwelling)

How effective is it?

+ very effectively reducing energy required for ventilation
5

Does it have a potential large Impact ?

+ From 10-30 W per dwelling to 1 W for meachnical exhoust
+ Heat recovery units HRE from 100 -300 W per dwelling to 2 W
5

Is it sustainable?

+ Energy saving CO2
- larger Ducts and Heat exchanger
- space
4

Cost?

+ decreased costs for ventilation energy
+ smaller fans
- larger ducts and heat recovery systems etc. required
4

Implementability?

+ implmentable in many buildings
- more space required
4

Phase change materials (PCM) Materials and technologies that store thermal energy
Energy saving

What does it do?

Changing phase between liquid and solid states PCMs store thermal energy.
Various PCMs are applied in buildings to decrease indoor temperature variation around comfort levels, decreasing heating and cooling requirements and / or thermal comfort.

How effective is it?

+ ability to store energy per Kg or m3 compared to liquid and solid materials.
-- air connected PCMs must be well connected determined by surface area to volume ratio and airflow.
+ The effectiveness as a system to decrease the temperature variation, keeping the temperature within the comfort levels can be substantial
-- sufficient insulation and solar protection required to be effective
5

Does it have a potential large Impact ?

+ can be applied widely with impact
3

Is it sustainable?

+ Energy saving for cooling and heating
+ Possible avoid requirement of a cooling system
+ Potentially better indoor comfort
- some PCM are toxic
4

Cost?

+ Costs for application in new buildings in the building mass are in the order of …
-Using PCM in the air costs
3

Implementability?

+It can be implemented in floors, walls, ceilings or false ceiling (air connected) PCM materials can be applied in most new buildings.
+Lightweight building designs can benefit from PCM's
- Application in excising buildings installation costs are substantially higher
3

TABS Thermal storage in building mass (Energy saving)

What does it do?

Thermally activated building slabs (TABS) exploit thermal capacity of construction materials to create a heat sink in the floor slab (typically in the ceiling).
In summer, the exposed mass of the floor slab can absorb excess heat from the rooms, thus levelling out peak cooling loads. This heat can be removed by night time ventilation or circulate chilled water in embedded pipes.
In winter, the exposed slab can soak up free heat from the sun and release it at a later time. The slab can be kept warm with water circulating in the pipes.

How effective is it?

+ decreases heating and cooling energy
5

Does it have a potential large Impact ?

+ decreases heating and cooling energy
3

Is it sustainable?

+ energy saving potential
3

Cost?

+ Active system can be relative expensive cost can be limmited
3

Implementability?

+ can be implemented in many new buildings
- can not be easely implemented in excisting buildings
2

Operations

Innovative building management systems - better control - comfort - remote supervision and control of equipment and security systems Advanced sensors that will provide information of air quality such as pollution, microbes, etc. and smart ventilation to ensure health

What does it do?

Forced ventilation follows a fixed time schedule. Free ventilation is determined by openings, wind direction and speed leading to potentially too much or too little ventilation resulting in bad indoor air quality, draft, thermal discomfort and additional energy for heating, cooling and ventilation.

Ventilation in educational buildings is often insufficient leading to high CO_2 levels possibly effecting the learning abilities. Human produced CO_2 indicates human pollution (odors etc.). Recent CO_2 sensor prize drops make CO_2 controlled ventilation feasible. Other (material related) pollutions are in practice difficult and expensive to measure.

How effective is it?

+ CO_2 controlled ventilation can save substantial amounts of energy and improve the indoor air quality.

+ Indirect effects as increased health and productivity can be very substantial but are difficult to quantify

- Using additional sensors for material related pollutions as VOC's is complex and expensive. Different types of pollutants must be measured with different sensors. Not yet feasible.

4

Does it have a potential large Impact?

+ The positive impact of CO_2 controlled ventilation can be substantial in terms of health, productivity and energy efficiency.

+ Avoiding unnecessary ventilation and providing sufficient ventilation when required. Many buildings can benefit.

+- Realizing the required ventilation can mean increased ventilation and with that improved indoor conditions but also increased energy requirements

4

Is it sustainable?

+ better energy efficiency

- more energy use if ventilation is increased

+ better indoor air quality

+ better health and productivity

4

Cost?

+ costs of CO_2 sensors decreases rapidly the last years (from 1000 Euro to minimal 70 Euro).

+- Energy savings due to increased efficient ventilation can be substantial (needing less energy for ventilation, heating and cooling). On the other hand if in the reference situation ventilation levels were too low, the energy for ventilation can be increased.

+ The benefits in terms of better comfort, productivity and health can be substantial but difficult to quantify

4

Implementability?

+ Implementation of CO_2 sensors in new building management systems is very feasible.

+ In existing systems this requires software adaption which often is complex also because of lacking building and installation information.

+ Simple CO_2 controlled ventilation system are feasible (e.g. schools)

3

Innovative technologies and industrialized processes Construction

What does it do?

Innovative technologies and industrialized processes that reduce waste during the sourcing, fabrication, transportation construction and demolition of a physical asset.
Factory dry assembled layered construction means minimized use of materials.

How effective is it?

+ less material usage
+ less waste
+ better and more consistent quality
+ less heavy work on building site
+ faster building process
+ more possibilities and better conditions for integrated solar and other systems
- more planning required
4

Does it have a potential large Impact ?

+ The impact in terms of efficiency
4

Is it sustainable?

+ less material usage
+ less waste
+ more possibilities and better conditions for efficient integrated solar and other systems
4

Cost?

+ more efficient building process
+ less material use and waste
+ decreased failure costs
+ faster building process
- more planning required
- higher transport costs
4

Implementability?

+ implementable in most new build projects
+ also suitable for retrofit projects
- not very suitable for separately designed small projects
5

What are success factors?

+ prize and flexibility

Integrated design process LCA tools Holistic design

What does it do?

Smart Eco buildings must be well balanced and therefore carefully designed to be able to meet the goals set.
In this design process all relevant aspects must be integrated and balanced.
Adequate tools as LCA tools and building simulation tools must be used to reach a high level of design required for the design and operate of smart eco buildings.

How effective is it?

+substantial increases overall quality
5

Does it have a potential large Impact?

+potential impact very large with increased complexity
+energy saving
+increased indoor comfort and health
+lower CO_2 production
+better use of materials
-higher initial costs
5

Is it sustainable?

+save Energy
+save materials
+improved indoor comfort
+better in line with the local situation
+more comfort
+better value over time
+less maintenance costs
5

Cost?

+save Energy
+save materials
+better in line with the local situation
+more comfort
+better value over time
+less maintenance costs
2

Implementability?

+always implementable
+more so for larger projects
5

What are success factors?

Availability of adequate tools

Legislation Policies

What does it do?

Develop and implement legislation toward decreased energy use, energy efficiency and energy production and also material use, land use etc.

How effective is it?

+ very effective for new buildings (all buildings must apply)
+ performance based legislation will promote the most cost effective measures
- difficult to apply to existing buildings
5

Does it have a potential large Impact ?

+ very large potential impact
- difficult (legally) to implement legislation for existing buildings
5

Is it sustainable?

+ energy savings and CO_2 reductions
+ decreased polution
4

Cost?

+ measures become more cost effective when widely applied
+ performance based legislation will promote the most cost effective measures
5

Implementability?

+ measures become more common practice when widely applied
4

What are success factors?

Especially for performance based legislation a simplified model is required that rewards measures sufficently and suits practice

Energy labeling Policies

What does it do?

Energy labeling provides consumers and others with a clear indication of energy efficiency of a building.
This will be an incentive to buy and build more energy efficient buildings
In addition legislation on European, national and local level can demand minimum levels

How effective is it?

+ provides consumers and others with a clear indication of energy efficiency of a building.
+ incentive to buy and build more energy efficient buildings
+ can be utilized by legislation on European, national and local level by demanding minimum levels
4

Does it have a potential large Impact ?

+ can stimulate and facilitate
4

Is it sustainable?

+ energy savings and CO_2 reductions
+ decreased polution
4

Cost?

+ measures become more cost effective when more widely applied
+ performance based labeling will promote the most cost effective measures
4

Implementability?

+ labeling systems can be translated to computer programs
- an accurate and widely usable method for labeling buildings related to energy use showed to be complex
3

What are success factors?

Especially for performance based labeling systems a simplified model is required that rewards measures sufficiently and suits practice

knowledge transfer suppliers Policies

What does it do?

Knowledge transfer to suppliers in the form of brochures, papers, presentations can stimulate suppliers and provide relevant information on smart eco buildings related topics

How effective is it?

+ stimulates suppliers and thus implementation
+ informs suppliers on possibilities and correct application, combinations etc.
- indirect stimulation
3

Does it have a potential large Impact ?

+ stimulates suppliers and thus implementation
+ informs suppliers on possibilities and correct application, combinations etc.
- indirect stimulation
3

Is it sustainable?

+ energy savings and CO_2 reductions
+ decreased polution
3

Cost?

+ measures become more cost effective when adequately applied applied
+ Cost for brochures web sites etc. can be modest
3

Implementability?

+ brochures, web sites etc. can be implmented easely
4

Information transfer consumers Policies

What does it do?

Knowledge transfer to consumers in the form of brochures, papers, presentations demonstration buildings can stimulate consumers and provide relevant information on smart eco buildings related topics

How effective is it?

+ stimulates consumers and thus implementation
+ informs suppliers on possibilities and correct application, combinations etc.
- effectivity is limmited

2

Does it have a potential large Impact ?

+ stimulates costomers and thus implementation
+ informs costumors on possibilities and correct application, combinations etc.
- effectivity is limmited

2

Is it sustainable?

+ energy savings and CO_2 reductions
+ decreased polution

3

Cost?

+ measures become more cost effective when adequately applied applied
+ Cost for brochures web sites etc. can be modest

3

Implementability?

+ brochures, web sites etc. can be implmented easely

4

Financial incentives Policies

What does it do?

Financial incentives in the form of subsidies, revolving funds, etc. can make measures cost effective of avoid large initial investments and thus stimulate implementation

How effective is it?

+ decrease initial investments for consumers
+ can make measures cost effective
+ can stimulate joint innitiatives where larger scale can reduce costs and stimulate consumers
4

Does it have a potential large Impact ?

+ Effective measure implementable on a large scale
4

Is it sustainable?

+ energy savings and CO_2 reductions
+ decreased polution
4

Cost?

3

Implementability?

+ can be implmented on large scales
4

Private and public initiatives Policies

What does it do?

1) Investing in eco buildings for private persons and organization is often complex and sometimes financial difficult or impossible.
2) Measures which involve many stakeholders are often very difficult to organize and realize.

Public - private partnerships for building and infrastructures can help to overcome both issues freeing the way also for larger and more complex smart eco related projects, leading eventually to energy savings and CO_2 reductions, better material use etc. etc.

How effective is it?

Effects:
- better awareness and knowledge sharing
- better financial possibilities (sharing budgets, costs, better loan conditions)
- enabling executing large and complex projects with many stakeholders

0

Does it have a potential large Impact ?

Impact can be substantial. It can substantial stimulate implementation of smart eco related measures in general. The joined approach will result in increased application of smart eco related measures and systems, resulting in energy savings, CO_2 reductions etc.

0

Is it sustainable?

Joined projects will result in increased implementation of and better designed eco buildings or related measures

4

Cost?

The project cost are project specific. The cost effect of the joined approach as such can be substantial.
Available public budgets can be directly matched with concrete projects. Private investments can be more efficient because of larger scale projects often mean lower investment and fail costs. Larger public private project often provide better conditions for loans.

4

Implementability?

Public private partnerships can be implemented in many situations.

4

What are success factors?

Attractive offer for potential parties