

## **Executive summary:**

The main objectives of SUPERBUILDINGS were as follows:

- 1) to develop the potential of sustainability assessment and benchmarking methods in progress towards sustainable built environment,
- 2) to develop indicators for assessing the environmental, social and economic performance of buildings,
- 3) to develop criteria for the benchmarking of sustainable buildings (SBs),
- 4) to develop recommendations for the use of indicators in different stages of building process and in steering,
- 5) to disseminate the results for standardisation bodies, policy makers and construction professionals and encourage the development of SB services.

The focus was to develop understanding about assessment methods and performance levels paying special attention on the validity of indicators and the comparability of assessment results. Validity determines whether the indicator truly measures what it was intended to measure or how truthful the results are. The outcomes of the research work suggest that a top-down approach should be followed in the selection of indicators in order to ensure the validity of sustainability assessments. Two main criteria for individual indicators are: Sustainability indicators of buildings must indicate an issue of concern of sustainable development; buildings must have a significant impact on that issue of concern.

The goal of the project was not to develop a uniform assessment system with a defined list of indicators but the aim was to support the further development of existing systems. The discussion focused on indicators for which there are still lack of information about different factors (e.g. carbon footprint) or methodological issues (e.g. land use) and on indicators that are missing at the moment (e.g. in the field of economics). SUPERBUILDINGS selected the following indicators: 1) Rational use of water, 2) Consumption of non-renewable primary energy, 3) Land use, 4) Global warming potential, 5) Construction and demolition waste generation, 6) Water pollution due to material leaching, 7) Hygro-thermal comfort, 8) Visual comfort, 9) Indoor air quality, 10) Cultural heritage, 11) Aesthetic quality, 12) Life cycle costs, 13) Long term stability of value.

The project showed that there is a lot of - especially local - understanding about the typical and best performance values of different building regarding certain sustainability indicators. However, much work is still needed to improve understanding of benchmarks and also to develop good processes for the determination of benchmarks. The possible sources for benchmark values depend on the type of the benchmark and can be outlined as follows: a) Target values: political targets, technical optimums, economic optimum; b) Best practice value: best practice, upper quartile; c) Reference value: median value; d) Limit value: legal minimum, prescriptive minimum.

SUPERBUILDINGS studied the effective use of sustainability indicators in different stages of building processes. The description of the process and the recommendations were given for the following stages: 1) customer briefing for SB, 2) programming for SB, 3) bidding for SB, 4) design for SB, 5) implementation for SB, 6) use and maintenance for SB.

The project studied the ability of BIM to provide the needed input information in order to calculate the indicator values. The BIM is a concept that represents a way of working based on integrated exchange via ICT solutions. To allow such exchanges, a specific open standardized language has been developed (IFC). The work results show that many of the indicators are already supported by the IFC4 but there are still some gaps. The combined use of IFC4 and Information Delivery Manual (IDM) provides the right tools to ensure the technical and semantic integration of SUPERBUILDINGS indicators to the BIM.

SUPERBUILDINGS defined that an effective steering mechanism a) has an impact on its focus area, b) has support from the citizens and building owners, c) is feasible because tools needed in assessment and verification are available and accessible for all who need those and because guidelines and instructions needed are clear. The project dealt with the following types of instruments: 1) normative control and regulatory instruments, 2) informative control and regulatory instruments, 3) economic and market-based instruments, 4) fiscal instruments and incentives, 5) support and information, 6) municipal steering. SB indicators are mature enough and should be actively be brought to guide all life cycle phases of buildings. The following recommendations were formulated: Comprehensive understanding about the goal, Guidelines for planning and design, A wider scope for regulatory instruments, Development of municipal support and building supervising processes, Development of substantiation processes in performance based procurement, Further economic support for the refurbishment of existing buildings.

**Project Context and Objectives:**

The main objectives of the SUPERBUILDINGS project were as follows:

- To develop a common understanding about the potential of sustainability assessment and benchmarking methods in progress towards sustainable built environment
- To develop indicators for assessing the environmental, social and economic performance of buildings
- To develop criteria for the benchmarking and labelling of sustainable buildings (SBs)
- To develop recommendations and solutions for the use of the system in different stages of building process and in steering and building regulation
- To disseminate the results for standardisation bodies, policy makers and construction professionals and encourage the development of new sustainable building services

The premise of the project was that it is possible to

- develop a logical structure for the sustainability assessment of buildings considering the environmental, economic and social performance of buildings;
- define core indicators for SBs;
- effectively use indicators in building processes;
- use sustainability indicators as an instrument of SB building steering and thus promote design and construction for sustainable built environment.

The project is divided into the following 8 work packages:

- 1) WP 1 Management of consortium
- 2) WP 2 Establishment of the common starting point for the project
- 3) WP 3 Potential of SB benchmarking systems
- 4) WP 4 Assessment of sustainability performance of buildings
- 5) WP 5 Performance levels and benchmarking criteria
- 6) WP 6 Recommendations for effective exploitation
- 7) WP 7 Piloting
- 8) WP 8 Dissemination

SUPERBUILDINGS project developed and selected sustainability indicators for buildings; improved the understanding about performance levels considering new and existing buildings, different building types and different national and local requirements; developed methods for the assessment and benchmarking of SBs; and made recommendations for the effective use of benchmarking systems as instruments of steering and in different stages of building projects. The framework for the assessment of environmental, social and economic performance is being developed within CEN and ISO. SUPERBUILDINGS considered the output of the standardisation processes and focused on the development of the validity of SB indicators, comparability of assessment results, benchmarking criteria and the usability of project also provided recommendations for the improvement of standards.

**State-of-the-art**

The project collected information about the availability of sustainability indicators and assessment methods in order to make conclusions about the needs for the further development and harmonisation. CEN and ISO standards are based on a life-cycle analysis based approach supplemented by additional environmental and technical information. The current standards focus on environmental performance assessment, though methods for the assessment of social performance are

under development. The SBA and UNEP initiatives focus on a much narrower set of metrics than included in the standards. LEnSE project identified 31 environmental, social and economic issues. The current Perfection project focuses on setting up a framework and a set of indicators for the overall quality of the indoor environment of buildings. Eleven national building evaluation tools were reviewed and analysed with regard to the availability of sustainability indicators and assessment methods and their degree of common understanding.

Overview of issues and indicators within the building evaluation tools considered by the partners as missing or to be (further) developed.

Environmental indicators   Economic indicators   Social indicators

- LCA indicators:
- photochemical ozone creation potential
- abiotic depletion
- biotic depletion
- human toxicity
- eco-toxicity
- materials
- use of wood
- Ecological value of the site:
- landscape degradation
- evaluation of site ecology
- ecological footprint
- Waste and radioactive waste
- Needs for irrigation • Lifecycle costs
- Flexibility/adaptability • User related indicators:
- consideration of user's needs
- individual lifestyles and preferences
- usability
- Protection from domestic accidents
- Space efficiency
- Building aesthetics and context

Overview of most covered issues and indicators within the building evaluation tools.

Environmental indicators   Economic indicators   Social indicators

- Primary energy consumption
- Minimise water consumption
- Materials
- Waste production during the use phase
- Global warming potential
- Ecological value of the site • Building adaptability
- Ease of maintenance • Indoor air quality
- Provision of safe and adequate bicycle lanes and facilities
- Visual comfort
- Thermal comfort
- Acoustic comfort
- Access to public services and amenities
- Access for users with physical impairments
- Access to public transport

All analyzed tools have performance rating scale at indicator and building levels. However, considering the lack of some indicators, the further development of both performance levels and benchmarking criteria is also required. Most of these tools have a single global score as the result of a total aggregation process with weighting factors. Most of them are based on a four-level aggregation scheme. The consistency of the

final set of criteria and the establishment of rules that clearly define weighting factors based on rational arguments and intermediate levels of aggregation should be further developed.

### **Barriers and drivers**

SUPERBUILDINGS studied barriers and drivers for sustainable building and stakeholder needs with regard to assessment methods. The study of literature summarised the research results concerning the barriers and potentials of sustainable building. The biggest challenges concern the following sections: Steering and regulations, Demand and the role of owners, Tendering and procurement processes, Availability of integrated methods, Cooperation and networking. The target groups of the interviews were the members of the project groups (research group, stakeholders' group, network group) and participants of two sustainable building conferences. The results indicated that in general sustainability assessments are at present very important for architects and designers, building authorities and planning authorities. On the other hand, it seems to be currently of low importance for insurers, banking sector and community representatives.

### **Development of indicators**

The goal of the project was not to develop a uniform assessment system with a defined list of indicators but the aim was to support the further development of existing systems. The discussion focused on indicators for which there are still lack of information about different factors (e.g. carbon footprint) or methodological issues (e.g. land use) and on indicators that are missing at the moment (e.g. in the field of economics). SUPERBUILDINGS selected the following indicators: 1) Rational use of water, 2) Consumption of non-renewable primary energy, 3) Land use, 4) Global warming potential, 5) Construction and demolition waste generation, 6) Water pollution due to material leaching, 7) Hygro-thermal comfort, 8) Visual comfort, 9) Indoor air quality, 10) Cultural heritage, 11) Aesthetic quality, 12) Life cycle costs, 13) Long term stability of value.

### **Performance levels and benchmarking**

One of the objectives of SUPERBUILDINGS was to develop knowledge on typical performance levels. Seven key indicators were selected for that purpose, and these were the objects of an inventory of accurate and actual data, based on statistical studies, regulation standards, voluntary schemes, or even case studies, across seven European countries: Land Use, Energy Consumption, Greenhouse gas emissions, Water Consumption, Waste production, Hygro-thermal comfort, and Indoor Air Quality.

SUPERBUILDINGS project showed that there is a lot of - especially local - understanding about the typical and best performance values of different building regarding certain sustainability indicators. However, much work is still needed to improve understanding of benchmarks and also to develop good processes for the determination of benchmarks. The typology of benchmarks can be combined with values from appropriate sources. The possible sources for benchmark values depend on the type of the benchmark and can be outlined as follows: a) Target values: political targets, technical optimums, economic optimum; b) Best practice value: best practice, upper quartile; c) Reference value: median value; d) Limit value: legal minimum, prescriptive minimum.

### **Sustainable building processes**

The effective use of SB assessment and benchmarking systems in different phases of building processes requires the availability of needed information, communication and information flows between different actors of the process, and possibility also new services, new roles and new actors. The recommendations for the use of sustainability indicators in building processes were developed through a series of workshops with experts. The description of the process and the recommendations were given for the following stages: 1) customer briefing for SB, 2) programming for SB, 3) bidding for SB, 4) design for SB, 5) implementation for SB, 6) use and maintenance for SB.

## **BIM**

The sustainability indicators that were developed by the consortium were checked against their potential integration to BIM. This means to answer three questions: 1) does the BIM be able to provide the needed input information in order to calculate the value of the indicators? 2) does the BIM be rich enough to have already concepts well suited to support the indicators (definitions and corresponding values)? 3) is-it enough to ensure consistency of information?

The BIM is an approach, which represents a way of working based on integrated exchange via ICT solutions. To allow such exchanges, a specific open standardized language has been developed - Industry Foundation Classes (IFC). All the construction elements that are needed to determine the value of the indicators are already present in the IFC. In its recent update (IFC4) this language has been greatly enriched especially with regards to sustainable assessment. The work results show that many of the indicators are already supported by the IFC4. There are still some gaps as some indicators are not supported and some others are weakly supported. However, it is not enough to ensure the consistency of the information among the various exchanges and over the phases of a construction project. There is also a need for a formalised description of the assessment processes. In order to perform such task and in order to keep the link with the BIM and the IFC, a dedicated methodology has been developed by the BuildingSmart association. This method based on the production of interchange manuals is called IDM (Information Delivery Manual). The combined use of IFC4 and IDM provides the right tools to ensure the technical and semantic integration of SUPERBUILDINGS indicators to the BIM.

## **Steering**

SUPERBUILDINGS defined that an effective steering mechanism a) has an impact on its focus area, b) has support from the citizens and building owners, c) is feasible because tools needed in assessment and verification are available and accessible for all who need those and because guidelines and instructions needed are clear. The project dealt with the following types of instruments of steering: 1) Normative control and regulatory instruments, 2) Informative control and regulatory instruments, 3) Economic and market-based instruments, 4) Fiscal instruments and incentives, 5) Support and information, 6) Municipal steering, Steering actions in city planning and land use.

The researchers of steering instruments seldom recommend a single method but often a combination of methods is recommended. Many researchers emphasize the importance of regulatory methods. However, they also suggest the use of these in the combination of awareness raising campaigns and economic incentives. The true impact of the voluntary methods on the impacts of buildings on sustainable development has

remained quite low. The reasons for this may be that the methods are often used in limited market segments and the required performance levels may not be ambitious. There is a need to understand and explain the linkage between property value and issues of sustainable development in order to promote the wide use of methods. There is also a need to get more knowledge about the real and desired performance levels of buildings in order to show real benchmarks for those who aim at the development of sustainability of buildings. When considering new policies and policy instruments it is important to assess the position of different stakeholders with regard to such policies and instruments. A good support from relevant stakeholders contributes to the effectiveness of policy instruments. Indicators of sustainable design and construction SB assessment systems are mature enough and should be actively be brought to guide all life cycle phases of buildings.

### **Future prospects**

It is estimated that the demand for results of a sustainability assessment of buildings will grow even more in the coming years. Both voluntary processes as well as policy steering and municipal steering instruments need sustainability assessment methods and indicators. The project summarised that possible reasons for an increased need for assessment results and assessment tools are seen in:

- the concern about greenhouse gases and the knowledge about construction sector's potential in the reduction of GHGs may lead to the further development of regulatory and fiscal instruments;
- the intention of the public sector to become a role model, leading to an integration of sustainability aspects into the procurement process;
- the intention of cities to search for significant savings in energy consumption and GHGs, which may lead the increased consideration of sustainability aspects in building supervising processes;
- an integration of sustainability aspects into the analysis and management of large building stocks (portfolio analysis and portfolio management concerning both private and public owners and developers), leading to a demand for different system variants for the use phase (sustainability assessment - in use);
- an integration of sustainability aspects into the risk analysis and valuation, leading to a demand for disaggregated assessment results;
- the integration of sustainability aspects into the establishment of conditions for the financing and insurance of buildings leads to a demand from banks and insurance companies;
- companies want to integrate information on the sustainability of their corporate offices and building stocks into the sustainability report and need information;
- sustainable property funds give emphasis on a positive sustainability assessment as a condition for the purchase of objects;
- an integration of sustainability aspects into planning and architectural competitions, leading to the question of suitability of rating systems for early stages of planning;
- an integration into the planning process, which must lead to a development of new approaches;
- sustainable buildings increase the user satisfaction and productivity.

## **Project Results:**

SUPERBUILDINGS project developed and selected sustainability indicators for buildings; improved the understanding about performance levels considering new and existing buildings, different building types and different national and local requirements; developed methods for the assessment and benchmarking of SBs; and made recommendations for the effective use of benchmarking systems as instruments of steering and in different stages of building projects. The framework for the assessment of environmental, social and economic performance is being developed within CEN and ISO. SUPERBUILDINGS considered the output of the standardisation processes and focused on the development of the validity of SB indicators, comparability of assessment results, benchmarking criteria and the usability of project also provided recommendations for the improvement of standards.

## **Existing sustainability assessment systems**

SUPERBUILDINGS collected information about the content and characteristics of the current assessment systems. The work consisted of a review of pertinent European and international initiatives and standardization activities, as well as existing national building evaluation tools.

The review of European and International initiatives and standardisation activities revealed that CEN and ISO standards start from a common life-cycle analysis based approach, supplemented with additional environmental and technical information. However, the standards only fully address environmental performance assessment, while currently work is continuing to address more fully the social performance of buildings. The SBA and UNEP initiatives focus on a much narrower set of metrics than included in the standards. Within the LEnSE project, 31 environmental, social and economic issues are identified and an assessment method is developed, starting from a review of existing evaluation tools and standardisation and harmonisation activities. Finally, the Perfection project focuses on setting up a framework and a set of indicators concerning the overall quality of the indoor environment of buildings. The review of national sustainable building evaluation tools was mainly based on the information provided by the SUPERBUILDINGS' partners with the help of the questionnaire.

In order to be able to draw the above conclusions based on the information received (list of indicators and description of corresponding evaluation methods from 11 tools) a broad table of issues that could potentially be covered by existing tools was made. For each national tool, the indicators were then classified in that table (each indicator under the issue(s) it covers). This enabled to identify issues that are not, little or well covered by existing tools and, for issues that are covered by more than one tool, a comparison of evaluation methods could be made.

The list of issues that served as framework for the analysis was mainly based on the issues covered by LEnSE, ISO 21929-1 and to make it as exhaustive as possible it was also completed with additional issues encountered in the reviewed tools but which did not fit into the originally established framework.



The fact that an issue is covered by most tools, indicates that it is generally considered as important and relevant. Those issues are thus potential core indicators. Finally, regarding the issues covered by many tools, the assessment methods used in the different tools were compared. This showed that there is a need for harmonization. The most important differences between the tools relate to:

- the use of qualitative versus quantitative indicators
- performance based indicators versus indicators based on an evaluation with the help of a checklist of measures (assessment of building features, which are never the same for all tools)
- system boundaries considered (e.g. CO2 only for the use phase or also for materials)
- level of detail and number of sub-indicators.

For environmental issues the core indicators identified by the partners are already covered by most of the analysed tools. However, this is not the case with regard to economic indicators.

Additional issues that were identified as issues to be further developed (proposed by at least one partner) are:

- local depletion caused by exploitation of primary surface resources (e.g. gravel),
- LCA impact from using different types of wood (from sustainably managed forests or not),
- protection from domestic accidents,
- space efficiency,
- building aesthetics and context.

Finally, regarding the issues covered by many tools, the assessment methods used in the different tools were compared. This showed that there is a need for harmonization. The most important differences between the tools relate to:

- the use of qualitative versus quantitative indicators
- performance based indicators versus indicators based on an evaluation with a checklist of measures (assessment of building features, which are never the same for all tools)
- system boundaries considered (e.g. CO2 only for the use phase or also for materials)
- level of detail and number of sub-indicators.

## **Barriers and drivers for sustainable building**

SUPERBUILDINGS carried out a study about barriers and drivers for sustainable building (SB). The study was a review of literature mainly found in academic journals. The results were published in Häkkinen and Belloni (2011 Building research and information). The results are summarised here as a background. On the basis of the study, the following outline was developed for the barriers of SB:

- Steering mechanisms
- Economics
- Client understanding
- Process
- Procurement and tendering
- Timing
- Cooperation and networking
- Underpinning knowledge
- Knowledge and common language

- Availability of methods and tools
- Innovation

The result emphasises the importance of demand both among the professional clients and home buyers, the adoption of methods for SB requirement management, the mobilisation of powerful SB tools, the development of designers' team working, competence and the role of chief designer and finally the development of new concepts and services for SB.

The target groups of the interviews were the members of the project groups (research group, stakeholders' group, network group) and participants of two sustainable building conferences. The results indicated that in general sustainability assessments are at present very important for architects and designers, building authorities and planning authorities. On the other hand, it seems to be currently of low importance for insurers, banking sector and community representatives.

The study was published in Building research and information in 2011: Barriers and drivers for sustainable building. Authors Tarja Häkkinen and Kaisa Belloni. BUILDING RESEARCH & INFORMATION (2011) 39(3), 239-255. Abstract: What are the actual barriers and drivers for sustainable building? A literature review, interviews and case studies are presented to address this question. Sustainable building is not hindered by a lack of technologies and assessment methods, but is instead beset with organizational and procedural difficulties entailed by the adoption of new methods. New technologies are resisted because they require process changes entailing risks and unforeseen costs. These hindrances can be reduced by learning what kind of decision-making phases, new tasks, actors, roles and ways of networking are needed. The barriers are outlined as steering mechanisms, economics, a lack of client understanding, process (procurement and tendering, timing, cooperation and networking), and underpinning knowledge (knowledge and common language, the availability of methods and tools, innovation). The most important actions to promote sustainable building are the development of the awareness of clients about the benefits of sustainable building, the development and adoption of methods for sustainable building requirement management, the mobilization of sustainable building tools, the development of designers' competence and team working, and the development of new concepts and services. The interviews and case studies were carried out in Finland, but the results may be applicable or interesting to other countries as well.

### **Top-down approach**

Part of the aim of the SUPERBUILDINGS project is the development and establishment of principles for the design of new systems or further development of existing systems for describing, measuring and reporting the sustainability of buildings and facilities. These principles may be applicable both during the planning stage of new buildings or at the time of delivery for demonstrating the quality of a property to third parties as well as in the evaluation and upgrading of existing buildings. In any case, it should be ensured that all aspects of sustainability and sustainable development are taken into account. For this reason, a systematic approach is needed that results among others in an appropriate structure of assessment systems.

The reason for dealing with this issue is the fact that although numerous sustainability rating systems already exist in EU, many countries face

the question of whether and how to develop and apply a customized assessment system that suit the regional characteristics.

From the beginning, the working team of SUPERBUILDINGS agreed not to add another sustainability system to the numerous existing ones. Instead, the principles for the design and development of assessment systems should be worked out, discussed and made publicly available. However, it is assumed that a number of rating systems are confronted with the tasks of revision and further development. This should be supported by SUPERBUILDINGS project. As a result of SUPERBUILDINGS, a contribution to the content-related approach of existing systems is achieved, while at the same time their independence and identity is preserved.

As the sustainability of buildings should always be assessed with the help of indicators, one of the key objectives of SUPERBUILDINGS is to ensure "validity" for sustainability indicator systems. This determines the true possibility of an indicator system to give information about the sustainability of buildings. So, validity is given to the proposed system by following a top-down approach starting from the subjects of concern and from there leading in a logical way to indicators, while considering also the relevance/significance of each indicator for the building sector. Of course, the fact that indicators must reflect a practical assessment of building characteristics and should be able to influence the different actors is not neglected.

The concept of the "areas of protection" comes from the environmental discussion and needs here to be expanded. Values worthy of protection are - in the interest of humanity - environmental, economic and social aspects. On the one hand it is about the preservation of the environmental, economic as well as social resources and on the other hand about the preservation of the environmental, economic and social balance - here also in terms of the preservation of the capacity to act of todays and future generations. From these "areas of protection" that can be assigned to the environmental, economic and social dimensions of sustainability in each case, are derived goals to help protect these values. Accordingly the goals of the conservation of natural resources and the preservation of the ecosystem, the preservation of social and cultural values as well as the health, comfort and security, the optimization of the life cycle costs as well as the preservation of the economic value exist during the planning, construction, use and management of buildings.

From this a general structure for sustainability assessment systems of buildings can be developed according to the top down approaches. The consideration of environmental, economic and social aspects is suggested, which must be supplemented by the proof that the technical and functional requirements are also fulfilled. This also agrees with the current state of the European standardization. Since functional and social aspects are usually very difficult to be distinguished, these also can be treated together in the same group.

The achievement of these goals must be for each actively engaged and/or responsible actor verifiable and in this sense also recordable and measureable. Therefore, assessment criteria and benchmarks are needed. In this respect, the assessment criteria are referred to the subjects of concern that are again arranged according to the sustainability dimensions. The assessment criteria have to be mainly quantitative and follow a performance oriented approach. It is important that some

features and characteristics of the buildings can have an impact on more than one criterion (i.e. the energy quality of the building envelope on the durability (technical), on the energy consumption and CO2 emissions (environmental), on the life cycle costs and value (economic) as well as on the thermal comfort (social)). The assessment criteria can have in turn an impact on more than one dimension of sustainability - where applicable in form of consequences. For example the climate change has an influence not only on the environment but also as a result on the society and economy. This is not a double counting but an acknowledgement and assessment of multi-effects. Further investigations related to the consequences of this subject are required.

Assessment criteria can be grouped into criteria groups. Possible weighting inside the criteria group should be a result of scientific considerations, while a weighting of the criteria groups among themselves is usually a convention.

Depending on the object of assessment, planning phase or point in time of the evaluation specific indicators (e.g. the calculated energy demand in the planning phase and/or the measured energy consumption in the utilization phase) can be assigned to the criteria. To the indicators apart from concrete calculation and evaluation rules also benchmarks must be assigned.

As the name suggests, the SUPERBUILDINGS project as a whole concentrates on the building as object of assessment. This contains all parts of a building including foundations as well as the site on which the building stands and all landscaping on the site. Site and building are therefore seen as one unit.

This can be supplemented by assessing a separate module designed for the location to reflect the different levels of influence on the surrounding area. Reference study period is - if not defined differently, the assumed design life.

Finally, the evaluation results must be documented and presented in such a way that they correspond to the respective needs for information of the stakeholders. The following aggregation levels are suggested:

- Raw building data (not weighted) behind the assessment per indicator
- Aggregated into an assessment result at indicator level (the score achieved for this indicator)
- Aggregated at indicator group level, with information of the weighting factors used (the score or the percentage fulfilled across a group of indicators)
- Aggregated at main group level (the score for each of the main categories: environmental, social, economic, technical and location)
- Aggregated into one main result

The second generation sustainability assessment systems will have to follow this top down approach, in order to fulfil all requirements. Therefore, the description of this approach is a central partial result of SUPERBUILDINGS project and the basis for the handling of the following sub-topics.

**The summary of the results was published in 2012:**

New trends in sustainability assessment systems - based on top-down approach and stakeholders needs. Authors: Thomas Lützkendorf, Petr Hajek, Antonin Lupisek, Andrea Immendörfer, Sylviane Nibel and Tarja Häkkinen.

2012. International Journal of Sustainable Building Technology and Urban Development. Abstract: Worldwide interest in future-proof buildings is growing, leading to increased demand for suitable methods and systems for assessing and communicating the sustainability of buildings. The number of stakeholders interested in sustainability assessment results as a basis for decision-making is growing. Ultimately, in order to bring about greater sustainability, stakeholders need to understand their potential impacts, but can only do so if this potential is clearly communicated to them through the system structure and through a language and in a format that suits their needs. Numerous systems exist, though these do not always meet the above requirements, do not always address all aspects of sustainability, may have certain methodological issues and may cause confusion through their sheer number. Therefore, there is a clear need for assessment systems to be developed further. This paper proposes that the issues raised can be tackled by a two-pronged approach: Firstly, by adhering to a top-down approach the structure of assessment systems is improved. Secondly, greater attention to stakeholder requirements is to be given. This paper is based on findings from survey results and on work in progress on the current EU-funded research project SUPERBUILDINGS. It aims to stimulate further development of existing assessment systems in a way that maintains the autonomy of such systems, while bringing them closer together in terms of their content.

### **Development of indicators**

The focus was directed not only on quantitative indicators but also on qualitative indicators. The topics Land use, Architectural quality, and Cultural heritage were paid attention to. The focus of the work was on the following issues: validity, reliability, comparability, assessment method in design and operation, quantitative and qualitative methods, applicability. The general subjects of concern identified in SUPERBUILDINGS are as follows:

This work used the following ideal framework for the assessment systems:

- Areas of protection (issues of concern) define those issues that a) are important for sustainable development and b) are relevant for building sector because buildings have an essential impact on these areas of protection.
- Sustainability aspects of performance of buildings define those aspects of buildings that have impacts on these areas of protection.
- Sustainability indicators together with measurement methods enable the quantitative and/or qualitative assessment and comparison of these aspects of performance.
- Benchmarks provide information about the typical levels of results of measurement for buildings with regard to different indicators (see WP5 work).

Once the key issues are identified, it is necessary to determine adequate indicators. Considering existing assessment methods for sustainable buildings, other EU projects (recent or on-going), and also standardization or harmonization works, indicators may be selected or improved or developed. More explicitly, 3 situations have been identified, leading to 3 types of indicators :

- the indicator already exists in one or several methods, is well documented, has got consensus, meets all the other requirements: selection (= type I);

- the indicator is not totally mature, not well documented, or needs some clarification, harmonization, extension to the entire life cycle of the building, or a certain level of improvement: improvement (= type II);
- the indicator does not exist, is not mature, or is not satisfactory: needs a development (= type III).

The work focused on the development of the validity of indicators and the data reliability for each key indicator. The objective was to develop and select appropriate measurement methods for each key indicator in order to enable the reliable assessment of performance levels. In order to achieve good data validity and reliability, the measurement methods have been developed and described in detail. This required that the project developed a deep understanding about the effect of different factors on the final assessment results. The project adopted the indicators and measurement methods for which there is a good common understanding and developed solutions for those indicators and measurement methods for which there was lack of knowledge and common understanding. It contains the following sections:

- Indicator definition
- Validity (with explanation and justification)
- Object of assessment
- Characterization
- Assessment in design and operation
- Comparability
- Sources of information.

The following indicators were selected:

- Rational use of water
- Consumption of non-renewable primary energy
- Land use
- Global warming potential
- Construction and demolition waste generation
- Water pollution due to material leaching
- Indoor thermal environment - Hygro-thermal comfort
- Visual comfort
- Indoor air quality
- Cultural heritage
- Aesthetic quality
- Life cycle costs
- Long term stability of value

These indicators were either selected, or improved or developed, and documented through a structured format. They cover the 3 pillars of sustainable development, but not all the related issues. Some are of particular interest and include added-value because they have been newly developed, as land use, eco-mobility potential, cultural heritage, aesthetic quality, long term stability of economic value, integrated design.

Five topics were selected for more close studies. Manuscripts for journal articles were prepared on the basis of these studies. The following Abstracts summarise the research outcomes:

#### **AESTHETIC QUALITY AS AN ASPECT OF SUSTAINABLE BUILDINGS**

Author: Carmen Antuña

Architectural quality - aesthetic quality has been developed by SUPERBUILDINGS as a quality indicator through four sub-indicators:

- Architectural quality in the design stage (design competition, considering alternative design options)
- Architectural quality in the tender stage (as obligation on the contractor)
- "Educated" decision making (as part of a design competition, considering alternative design options)
- Public art in/on/around buildings (mandatory inclusion of art work)

As it appears, this way of defining aesthetic quality concentrates mainly on the process (particularly in the case of the first three sub-indicators mentioned above) but as good as it may be, following a certain process does not guarantee in itself high aesthetic quality.

The inclusion of art works in buildings has become increasingly popular but can be misleading as a "measure" of the high aesthetic quality of a building. In short, there seemed to be a need to:

- Discuss the attributes that can be possibly related to aesthetic quality and their measurability. This is not a simple task and it became evident during the preparation of this research study that some previous clarification is needed in order to understand what is meant by aesthetic quality in relation to architecture instead of simply assuming that there is a general consensus on its meaning.
- Analyze more in depth aesthetic quality as an aspect of sustainable building. In this sense, a possible way to justify the validity of the indicator (according to SUPERBUILDINGS framework) might be to describe its impact on the main "subjects of concern" defined in relation to sustainable development upon which the building sector has a strong influence.

Therefore, the aim of the research study whose results are presented here was to provide some answers to the identified needs described above in order to determine whether aesthetic quality should be considered as an aspect of sustainable buildings and what possible related indicators might be developed.

The manuscript has been submitted to Architectural Engineering and Design Management.

## **LAND USE AS AN ASPECT OF SUSTAINABLE BUILDING**

Authors: Tarja Häkkinen, Tuomas Helin, Carmen Antuña, Susanne Supper, Nicoleta Schiopu, Sylviane Nibel.

This study discusses the validity and usability of land use as an aspect of sustainable building. Buildings have an effect on land use both because of the extraction and processing of raw materials and disposal of wastes and because buildings occupy land during their entire service life. In addition, location of buildings has an effect on the need of networks – such as traffic networks – and their land use. Land use related indicators are typically included in the European voluntary assessment systems of sustainable buildings. ISO 21929-1 defines two land use indicators for buildings: soil sealing and land use change. However, there is neither consensus nor harmonised method to assess this issue. As an example, land use was not included in CEN/TC350 EN 15978:2011 due to lack of agreement on a calculation method. This study outlines the environmental aspects of buildings' land use, assesses the significance of land use that happens because of the land occupation of buildings compared to the land use because of the extraction of raw materials

needed for the construction of buildings. The article also discusses the overall land use aspects of buildings, discusses the feasibility of land use indicators and makes conclusions about the compatibility of building level land use indicators with the urban level indicators.

The manuscript has been submitted to Sustainable land use and urban planning.

#### **BUILDING PERFORMANCE RELATED INDICATORS AS SOCIAL INDICATORS OF BUILDINGS**

Author: Tarja Häkkinen

Social indicators try to indicate people's wellbeing on societal level. Social issues are also dealt with on product level; social life cycle assesses social and socio-economic impacts of products along the value chain with the help of organization and process attributes.

Sustainable building indicators are often divided into economic, environmental and social indicators supposed to indicate financial, environmental and social performance respectively. Often aspects of building performance such as indoor environment (acoustical, lighting and thermal conditions and indoor air quality) are related to social performance because those affect the health and comfort - and thus wellbeing - of the users of buildings.

By defining social indicators as building-performance related indicators, the building standards and assessment systems differ from what is generally understood with social indicators. Up till now there has not been thorough discussion about the justification of this decision. This paper tries to respond for this shortage. The second objective of the paper is to study the validity of building performance aspects as indicators of sustainable building. The paper also discusses the nature of building-performance related indicators compared to environmental indicators. Especially the paper discusses the relation of functional equivalence with social performance and the use of efficiency approach.

The manuscript has been submitted to Building research and information.

#### **COMFORT ASSESSMENT IN THE CONTEXT OF SUSTAINABLE BUILDINGS: COMPARISON OF SIMPLIFIED AND DETAILED HUMAN THERMAL SENSATION METHODS**

Authors: Riikka Holopainen, Pekka Tuomaala, Patxi Hernandez, Tarja Häkkinen Kalevi Piira, Jouko Piippo.

This paper, based on research conducted under the EU FP7 "SUPERBUILDINGS" project, presents current practice and approaches to comfort assessment and specification. The paper compares and discusses the results of different methods used for the calculation of thermal comfort: Fanger's PMV method, a Human Thermal Model integrated in a building simulation environment and the adaptive comfort method are described and applied to a test case. Results show how more detailed methods such as HTM or adaptive comfort for summer assessment allow for more flexibility of the indoor conditions. These flexible conditions would mean that unnecessary heating and cooling could be avoided in situations where there is still an acceptable degree of satisfaction with the indoor environment. These approaches would therefore help for an assessment in the context of sustainable building assessment, where satisfactory indoor conditions are sought, while ensuring low energy use and running costs and therefore improving environmental and economic performance of the building.



To be submitted to Building and environment

## **THE SIGNIFICANCE OF DIFFERENT FACTORS ON GHG EMISSIONS OF BUILDINGS**

Authors: Antti Ruuska, Tarja Häkkinen

The objective of the research was to create improved understanding about the significance of different factors on the overall GHG emissions of buildings. Especially the research studied the significance of building materials. The significance was studied by assessing the share of building materials related GHG emissions from the total GHG emissions and by assessing the range of variation. The research was done with the help of a study of literature and with the help of a parametric case study. The parametric study assessed the possible range of variation.

The role of building materials is increasing due to several factors:

- Energy efficient buildings use less operational energy and cause less GHG emissions over their lifetimes; the relative importance of GHG emissions of materials increase
- Buildings are becoming more energy efficient; the GHG emissions from material production may increase in absolute terms (more materials)
- Use of renewable energy is expected to lead to less GHG emissions from energy production; the relative importance of GHG emissions of materials increase

The study showed that the share of embodied CO<sub>2</sub> may be significant compared to the total CF of a building. A gradual approach should be developed for the design process to consider the embodied carbon. The proposed stages are as follows:

- Ground works
- Frame
- Supplementary structures
- HVAC

Significant issues regarding the significance of building materials include the following:

- Quality of building site (stabilization)
- Weight of the frame
- Surfaces, windows, doors, furniture, fittings (renovation)
- Material related processes
- HVAC (cooling, solar energy).

To be submitted to International Journal of Sustainable Built Environment  
Performance levels and benchmarking criteria

SUPERBUILDINGS developed information about the performance levels and benchmarking criteria for sustainable buildings. Seven key indicators were selected for that purpose, and these were the objects of an inventory of accurate and actual data, based on statistical studies, regulation standards, voluntary schemes, or even case studies, across seven European countries: Land Use, Energy Consumption, Greenhouse gas emissions, Water Consumption, Waste production, Hygro-thermal comfort, and Indoor Air Quality.

SUPERBUILDINGS project showed that there is a lot of - especially local - understanding about the typical and best performance values of different building regarding certain sustainability indicators. However, much work is still needed to improve understanding of benchmarks and also to develop good processes for the determination of benchmarks.

Among other things, important lessons that can be drawn from this work are the followings:

- SUPERBUILDINGS project has drawn a map of Key Performance Indicator around European countries. The work showed that there is a lack of comparability due to differences within national calculation methods (different boundaries, definitions of reference units like the floor area; consideration of local requirements about buildings and local concerns),
- There is a lack of accurate data concerning typical performance values for life cycle Indicators of buildings currently considered in terms of sustainability. This issue can be explained by the current paradigm shift: assessment systems evolve from one indicator - especially energy - to a multi-criteria vision and from the use stage to a lifecycle approach.

Currently, the levels of performance for key performance indicators considered in sustainable management schemes are related to the use phase of buildings, and do not consider the provision and the end of life of building products and component. Tools and methods for LCA of buildings are currently under development in many countries of Europe. The use stage is the best understood stage regarding the quality and the consistency of data. However in the short or medium term, good quality data will also be available for the product stage because of environmental product declarations or other LCA information and databases that are currently under development.

The term benchmarking is frequently used; some common definitions of the terms are:

- a level of quality which can be used as a standard when comparing other things
- a mark cut into a stone by land surveyors to secure a "bench" (from 19th century land surveying jargon, meaning a type of bracket), to mount measuring equipment. Figurative sense attested circa 1884
- a benchmark is a point of reference by which something can be measured.
- a set of performance criteria which a product is expected to meet.
- a standard measurement that forms the basis for comparison.

There is a range of groups and stakeholders that have an interest in common benchmarks for buildings across the EU:

- European Commission: To monitor and judge the progress of the different requirements of individual MS (e.g., energy performance, or other environmental requirements); To check in which MS do the minimum requirements have a large potential to be tightened and which MS already have very strict requirements; To check how realistic is to expect from a MS a steep improvement on performance indicators.
- Member States : To know where they stand in comparison to their neighbours (for example, see studies on energy performance comparison in Germany, the Belgium and Scotland.
- Industrial parties: To compare performance with other companies; In case of international property portfolios, compare and assess potential for new technologies in different countries.

There are only a few attempts in literature to define a systematic framework to set benchmarking levels as limit or target values.

SUPERBUILDINGS discussed the development of benchmarks and assessed the use of the following sources of information:

- Laws, prescriptions, standards
- Experience based and statistical values

- The existing economic or technical optimum
- Political target values
- Labels and self-commitment by branches
- Benchmarks based on reference buildings

Concerning the evaluation method of Life Cycle Impact Assessment and Life Cycle Costing at the beginning there are not statistically significant reference values available. The benchmarks are developed in parallel with the development of the evaluation methods. As a result the values are directly depending on the specific database with the rules, assumptions and conventions, normally associated in a calculation tool. In certain countries (e.g. in Germany LEGEP) the existence of a calculation tool becomes the basis for the elaboration of the benchmarks. The typology of benchmarks can be combined with values from appropriate sources.

The project discussed the concept of benchmarking, the types and sources for the assessment, and the key issues of benchmark development. Key issues include the definition of the object of benchmarking exercise, which can be called as the functional equivalent, or issues related to the weighting and aggregation of results for communication. Each indicator, which has specific calculation and expression characteristics, needs to be further considered in the context of specific reference units, and in relation to normalization and aggregation rules, depending on how we want to show the indicators and assessment results. Different benchmarking approaches might be needed to different stakeholders, depending on the use and application of the benchmarks.

### **Recommendations for the use of sustainable building assessment and benchmarking systems in different phases of building process**

SUPERBUILDINGS developed recommendations for the use of the sustainable building assessment and benchmarking systems and sustainability indicators in different stages of the building processes. The work focused on the possibilities to make effectively use of the systems in sustainable building target setting, design for sustainable buildings, procurement and investment.

The effective use of sustainable building assessment and benchmarking systems in different phases of building processes requires the availability of needed information, communication and information flows between different actors of the process, and possibility also new services, new roles and new actors.

The results of the work describes the sustainable building process which effectively makes use of sustainable building assessment and benchmarking systems and addresses the needed sources of information and tools and addresses the relevant actors in different phases of building processes.

The work resulted in the explanation and description of the recommended way of voluntary usage of sustainable building assessment and benchmarking methods and systems in target setting, design, construction and procurement, and investment.

The recommendations for the use of sustainability indicators in building processes presented were developed through a series of workshops with experts. The process maps originally proposed by Häkkinen & Nykänen to describe the building process are used here as the main basis to develop

the recommendations for the use of sustainability indicators in building processes. The process is divided into the following six phases.

1 Customer briefing for sustainable building Sustainable customer briefing aims at the definition of the owners' and users' need for spaces considering sustainability targets  
Define sustainability targets

2A Programming for sustainable building The documents of customer briefing create a starting point for sustainable programming and acquisition planning.  
Definition of targets, and assessment and selection of basic alternatives (e.g. new building versus renovation) are the main tasks associated to this phase (comparing different design options is not dealt with at this stage).

### **Interpret sustainability objectives to the programme**

2B Bidding for sustainable building Setting sustainability requirements for the different bidding processes (direct selection, reference based selection, negotiated selection, competitive selection, etc.).  
Enable suppliers' sustainability competence to improve the plan

3 Design for sustainable building The main issues presented in the building programme and specifications include goals for sustainable construction and summary objectives. The most important design decisions for sustainable building are made in this phase.  
Assess the sustainability and make design decisions

4 Implementation for sustainable building Implementation is carried out in accordance to the building programme and specifications, and system design which states the target levels and assessment results of sustainable building.

Monitor and manage changes

5 Use, monitoring and maintenance for sustainable building Sustainable use, monitoring and maintenance are managed by plans and instructions from the previous phase which include performance targets.  
Monitoring and act respectively, communicate

The abovementioned recommendations were defined for each of the sub-phases considered within these main six phases. The overall process was described with the help of process maps. An example is given in the following:

The main stages were described (see an example in the following) and the information and recommendations were given for each sub-phase with the help of the following outline: Actors involved, sustainability principles, core indicators, assessment tools, assessment methods, background information needed.

Competition programme The competition programme (coming from 2A) should state what the client wants. This results in a document from which the rest of the process continues.

Designing the proposal At this stage the higher level sustainability targets (CFP, GHG, etc.) of the building begin to turn into more detailed design selections by the design team.

Design Build team selection criteria Design Build team selection criteria are defined on the basis of programme goals. Criteria are requirements of sustainable building knowledge and references described with the help of metrics regarding sustainability issues (considering both design values as well as operational values). The starting point is performance thinking, where the owner presents performance goals including environmental and economic viewpoints without limiting design solutions.

Note: Selection of the appropriate delivery system depends on the competence of the client and the project nature. When the client has the competence (e.g. earlier experience on similar projects), the sustainable solution could be designed by the client (Design Bid Build or Construction Management).

SUPERBUILDINGS has tried to increase the usability and mobilization of sustainable building benchmarking systems considering that the primary reason for promoting the use of these systems is the desire to promote sustainable building stock and sustainable built environment. The premise was that the principles of sustainable performance of buildings and the knowledge about the desired performance levels should be known in all stages of building projects. In order to achieve significant impacts, building maintenance and refurbishment are extremely important stages to be considered. Effective tools should support sustainable building and consideration of different aspects of sustainable performance.

#### **Recommendations for the integration of sustainable building assessment and benchmarking methods with BIMs**

SUPERBUILDINGS developed recommendations concerning the integration of sustainable building assessment and benchmarking systems with the different stages of Building Information Models. The project introduced the notion of BIM and the underlying concepts (integration, interoperability) and presented the characteristics of the IFC language, its object oriented structure and its mechanisms to attach properties and objects via the use of relationships. Finally 20 indicators (resulting from work carried out in previous work packages) were examined against the Industry Foundation Classes which is the open language used to exchange and retrieve data from the BIM. The correspondences between these indicators and the IFC concepts were identified when existing.

The work results show clearly that - in its recent update (IFC4) - the IFC have made a significant step forward in the integration of sustainable indicators into the BIM. The consequences are important. It shows the ability of the IFC to evolve and take into account new domains. The BIM centred approach coupled with this integrating capabilities of the IFC as a common open language multiply the interest for the integration of the nD digital mock-ups in the use of sustainable building assessment systems in different stages of building process, and in Multi-Discipline and Multi-Stakeholder environments.

The property set mechanism demonstrates its ability to provide a semantic layer above the IFC elements. The same IFC element "IfcMassMeasure" is used four times to store four different notions (Quantity of greenhouse gases emitted calculated in equivalent CO<sub>2</sub>, Quantity of gases creating

the photochemical ozone calculated in equivalent ethylene, Quantity of gases destroying the stratospheric ozone layer calculated in equivalent CFC-R11, Quantity of gases responsible for the atmospheric acidification calculated in equivalent CO2). It is only because the property set has a well-defined and documented structure that the knowledge attached to the four occurrence of this "IfcMassMeasure" element differs. The property set mechanism seems therefore the most appropriate way to translate the proposed ontology into an IFC compliant structure.

Most of BIM/CAD tools propose export function to IFC. The resulting IFC exported files then contain IFC objects with their properties that can be used for SBA.

On the bases of the assessment results it appears that:

- For the Environmental indicators 10 (among the 12 studied) have a direct equivalent in IFC, one has an indirect support and one is not supported;
- For the Societal indicators 7 (among the 9 studied) have a direct equivalent in IFC and 2 are not supported;
- For the Economic indicators none (among 2) have a direct equivalent in IFC, one has an indirect support and one is not supported.

The Ifc model is a taxonomy of objects starting from a single main object called IfcRoot. Under this root concept, IFC objects are sorted into a tree by level of specialisations. At each level there are possible relationship to attach information (other Ifc concepts or properties) in order to define the composition, the size, the weight, etc... of each considered object. Each need of exchange make use of a subset of the whole model for its specific purpose. This subset is called a Model View Definition. For the specific need of Sustainable Assessment, several IFC objects, properties, quantities have been addressed.

### **Simplified representation of the subset structure addressed by Sustainable Assessment.**

How the integration to BIM should happen:

To use Building Information Modelling effectively and for benefit to be unlocked, the level of understanding among partners involved in the same construction process and project needs significant improvement. For this to happen, there must be a common understanding of the building processes and of the information that is needed for and results from their execution.

In order to do that these practices have to be turned into shared/agreed processes. The first step is to define the different processes that are relevant in the sustainable building assessment across life cycle building. The aim is to have a set of processes described in a uniform way, to be used for sustainable assessment. Actors, sequence of actions, type of data and checks on data should become visible to support the sustainable building assessment practices.

There are several tools and approaches providing method for formalising exchange and processes among partners. IDM (Information Delivery Manual) is one of these solutions that allow the formal and accurate description of processes among actors and tools interacting around a BIM.

The IDM will target both BIM users and solution providers. For BIM users, it will provide a simple to understand, plain language description of building construction processes, the requirements for information to be

provided to enable the process to be carried out successfully, additional information that may need to be provided by the user and the expected end results of the process. For BIM solution providers, it will identify and describe the detailed functional breakdown of the process and the IFC capabilities needing to be supported for each functional part in terms of the entities, attributes, property sets and properties required. IDM captures (and progressively integrates) business process whilst at the same time providing detailed specifications of the information that a user fulfilling a particular role would need to provide at a particular point within a project. To further support the user information exchange requirements specification, IDM also proposes a set of modular model functions that can be reused in the development of support for further user requirements. IDM is a guideline, a method for formalising exchange and processes among partners. Therefore, there should be one Interchange Manual per process, which can be seen and considered as the expression of formal requirements for the described process.

From a pragmatic point of view, IDM starts with a high level graphical description of the process. This part is called the "Process Map". The formalism used to translate the process into a drawing (the so called "Process Map") is based on a standard, the BPMN. OMG is maintaining the BPM Notation (Business Process Modelling Notation). The BPMN is the recommended notation for the first part of the IDM methodology (ISO/DIS 29481-1). The goal of BPMN is to provide a standard notation that is readily understandable by all business stakeholders. BPMN is intended to serve as common language to bridge the communication gap that frequently occurs between business process design and implementation by providing a notation that is intuitive to business users yet able to represent complex process semantics.

The second part focus on the description of the exchange (data flow) among the different identified sub-processes. This part has some recommendation in terms of formalism but no specific standard support it. It is recommended that the description of the exchange should be done using natural language in order to be elaborated in conjunction with non-technical users.

Third and last part of the IDM is the functional part. This is the most technical one. After the high level analysis of the process (PM) and the description "in natural language" of different exchanges, it is then time to indicate what will be the basic technical elements that will support the data flow, keeping the semantics of the exchange. This part will also identify the common basic blocks that are used at different places all along the process. It is also very important to stress the fact that BuildingSMART it not promoting "yet another standard". The approach chosen, is to rely on validated and trustable standards tailored for the needs of the Construction Sector.

SUPERBUILDINGS case studies showed interesting results that are addressing BIM issue and collaborative work especially those carried out by Fraunhofer IAO and Werner Söbek (WS), which addressed the topics of integrated design and information management systems. There is a mandatory need to ensure the quality all along the whole process and among the list of key issues for the successful implementation of integrated design; one is of particular interest with respect to the BIM and the formalisation of process via the IDM. The need for a better communication is identified as a crucial point especially the need for a

"clear and well-defined communication structure". The BIM is seen as essential as a supporting tool for integrated design.

The sustainable indicators that have been developed by the consortium in the WP4 have been checked against their potential integration to BIM.

This means to answer three questions:

- Does the BIM be able to provide the needed input information in order to calculate the value of the indicators?
- Does the BIM be rich enough to have already concepts well suited to support the indicators (definitions and corresponding values)?
- Is-it enough to ensure consistency of information?

The answers to these questions have been given through the work presented in this document. As a conclusion it worth to recap the main outcomes this study has carried out. The BIM is an approach, a concept. It represents more a way of working based on integrated exchange via ICT solutions. In order to allow such exchanges, a specific open standardized language has been developed. It is the Industry Foundation Classes. This language supports the description of building projects and count approximately 800 entities. All the construction elements that are needed to determine the value of the indicators are already present in the IFC. But it is not enough to ensure the consistency of the information among the various exchanges and over the phases of a construction project. There is also a need for a formalised description of the assessment processes. In order to perform such task and in order to keep the link with the BIM and the IFC, a dedicated methodology has been developed by the BuildingSmart association. This method based on the production of interchange manuals is called IDM (Information Delivery Manual).

The combined use of IFC4 and IDM provides the right tools to ensure the technical and semantic integration of SUPERBUILDINGS indicators to the BIM.

Recommendations for the use of sustainable building assessment and benchmarking methods and systems in steering of sustainable building

The starting point of the work was that the principal reason for the common efforts to promote the use of these methods is the desire to promote sustainable building in Europe. It is believed that by making use of sustainable building assessment and benchmarking methods both on voluntary basis and as instruments of normative and economic steering, it will be possible to promote sustainable building and accelerate the adoption of sustainable building practices.

Sustainability assessment systems of buildings are defined as systems which outline issues of concern (atmosphere, land, health etc.), address the performance aspects that impact on these issues of concern, and finally give quantitative and qualitative indicators together with assessment methods which are able to measure the performance aspects. Indicators can be systemized with regard to the character of the assessment process. In principle we can speak of quantitative, descriptive and qualitative indicators on the bases of their assessment process.

In order to be able to use these kinds of indicators and calculation results in regulation and in decision making we also need information and understanding about the normal levels of assessment results for different kinds of buildings in different regions. This knowledge enables to define



benchmarks for performance and to define required levels of performance. In addition, different kinds of methods are needed for the assessment of different performance aspects of buildings. The basic requirement is that such unambiguous measurement methods are available which define the measurement processes, functional units and data quality requirements with adequate accuracy so that comparable and reliable results can be achieved.

SUPERBUILDINGS defined that an effective steering mechanism a) has an impact on its focus area, b) has support from the citizens and building owners, c) is feasible because tools needed in assessment and verification are available and accessible for all who need those and because guidelines and instructions needed are clear.

The project dealt with the following types of instruments of steering:

- 1) Control and regulatory instruments, Normative,
- 2) Control and regulatory instruments, Informative
- 3) Economic and market-based instruments,
- 4) Fiscal instruments and incentives,
- 5) Support and information,
- 6) Municipal steering, Steering actions in city planning and land use.

The following list shortly summarises the assessed impact of the use of SB assessment systems in the connection of different steering instruments:

- Normative regulatory instruments: Based on its normative character, the instrument affects directly on its focus area; is relatively easy to implement for new building but significantly more difficult to implement for existing building stock; the true impact depends on the selection of the required levels of performance.
- Mandatory information: The intended impact is to raise demand through information that enables comparisons; the impact depends on the extent of the focus area (all buildings/limited groups of buildings); it is easier to direct both to new and existing buildings than normative regulations; the impact may be significant if the focus area is wide.
- Voluntary certification schemes: The use of the instrument may become extensive if the marketing of the scheme is successful and if the relevant actors believe on the branding; the true impact of focus areas (like energy saving, savings in GHGs, improved accessibility and access and thus improved equity of different user groups) depends on several issues: the selection of right performance levels and weighting criteria needs good understanding of local conditions. If this is missing and the chosen criteria are too easy, the impact remains insignificant or even negative, a wide system with a number of different indicators may enable "playing" - users are not interested in ambitious development but on easy credits. Well-recognized and valued voluntary system which includes locally relevant and adequately demanding criteria may be effective in its focus area. The impact improves as the systems support target setting and design in addition to labelling. Also, more potential could be achieved if the certification results were integrated to the decision making processes of investors and insurance companies.
- Incentives and taxation: A right timing is important: the market must be ready for the intended activities (like renovations that save energy) for example in terms of the availability of needed skills and capacity. The level of tax reduction/incentive etc. has to be right in order to be attractive but on the other hand it shall not be too high in order not to cause injustice for those who cannot make use of the instrument (for example because the instrument is directed only for small houses/

multilevel buildings/owners ...). Correctly timed and directed instrument may have an important effect and stimulation on the targeted limited focus area.

- Municipal policy: The impact is different in different market segments. Municipal policy can contribute effectively to sustainability in the market segment of new residential buildings; the impact in the segment of existing residential buildings is not very high. However, when voluntary agreements are made for existing residential buildings, social housing agencies for instance can take sustainable building into account in renovation projects. Private persons might be stimulated to improve their dwellings by financial support of municipalities.

When considering new policies and policy instruments it is important to assess the position of different stakeholders with regard to such policies and instruments. A good support from relevant stakeholders contributes to the effectiveness of policy instruments.

Indicators of sustainable design and construction SB assessment systems are mature enough and should be actively be brought to guide all life cycle phases of buildings. The following recommendations were formulated:

- Comprehensive understanding about the goal
- New standards for planning and design
- Wider scope for regulatory instruments
- Development of municipal support and building supervising processes
- Development of substantiation processes in performance based procurement
- Further economic support for the refurbishment of existing buildings.

## **Case studies**

One of the attention points in the development of Sustainable Building Assessment (SBA) and benchmarking systems is the usability by different construction professionals, in different stages of the building process and for different types of buildings. Therefore, in order to confront the SUPERBUILDINGS research work with these different perspectives, pilot test cases were carried out within the project by industrial members and SME's of the consortium. The general objective of those test cases was to test the results from and make recommendations to WP4 (indicators and measuring methods for Sustainable building assessment) and WP5 (benchmarking). But apart from those general objectives, each of the pilots also approached their selected test case(s) with specific objectives related to their respective domain of expertise:

- IAO: Institute for Industrial Engineering (Germany): data base services and information management tools for SBA
- YIT Kiinteistötekniikka Oy (Finland): Energy management
- VINCI Construction France : Target setting and monitoring in construction projects
- Werner Sobek (WS) Stuttgart GmbH?Co (Germany): integrated design
- W/E consultants (Netherlands): Consultation for local governments (policy implementation)

The general conclusions and recommendations derived from the case studies are then summarized by topic in the following sections:

- Sustainable building indicators
- The process of sustainable building assessment
- Comparability and benchmarking of sustainable building assessment results

Pilot test cases were carried out, within the project consortium, by different members of the stakeholder group (industry members and SMEs of the consortium), who each approach the test case from their own views and perspectives.

**Institution Main field of expertise Specific objectives Selected case studies**

Fraunhofer IAO Institute for Industrial engineering, Germany Data base services and information management tools - Study role and needs of information management tools as enablers of common use of SBA ZVE-Center for Virtual Engineering

- Research and Office Building
- 3600m<sup>2</sup>
- (planned) completion: end of 2011
- Supported by latest standards of information management tools and methods
- DGNB certified

Architect: Asplan (Kaiserlautern) in cooperation with UN Studio (Amsterdam)

Werner Sobek (WS) Stuttgart GmbH, Germany) Integrated design - Give recommendations on the planning of integrated design in certification schemes

- Study the applicability of the SBA criteria in the different stages of the building process D10
- Residential building
- 150m<sup>2</sup>
- Completed in 2010
- Triple Zero® concept
- Successful example of integral planning

**Architect: Werner Sobek, Stuttgart/Germany**

YIT Kiinteistötekniikka Oy (Finland)

Building services (HVAC) - energy management - Study the possibilities of using information received by means of Building Automation Systems (BAS) for the assessment of environmental indicators

- In the long run use this information for the comparison and benchmarking of YIT buildings around Europe as well as target setting for new buildings

2 sets of in-use students housing buildings:

Set A (5 buildings):

- 15423m<sup>2</sup>
- Completed in 2010

Set B (11 buildings)

- 17638m<sup>2</sup>
- Completed in 1977-1978

VINCI Construction France General contractor - Test the use of a comprehensive set of sustainability indicators in real building projects

- pilot the use of sustainability indicators from the viewpoint of target setting and monitoring

Ensta Campus

- new students housing
- 2275m<sup>2</sup>
- Planned date of completion : end of 2011
- the building is also a pilot site for OXYGEN assessment versus HQE certification

**Architect: Hubert GODET**

W/E consultants (the Netherlands) SBA in the framework of municipal building policy contribute to a better understanding of:

- CO2 footprints (embodied vs operational)
- Methodological issues related to land use indicators
- Use of CO2 footprint and land use indicators in the context of municipal policy

Sport en jeugdcluster Engelen

- Municipality of 's Hertogenbosch sport and youth center
- 2200m<sup>2</sup>
- Completed in 2011
- SBA with GPR building

**Architect: Kuin en Kuin**

Methodological issues related to renovation and depreciation of building parts Appollo house

- Renovation of an office building in Amsterdam
- 14.000 m<sup>2</sup>
- Planned date of completion: end of 2011

**Architect: Fokkema -Partners**

As each member approached the test case from his own views and perspectives and with specific objectives, the methods and procedures for testing and evaluating the indicators developed within SUPERBUILDINGS project were very different for the six case studies. The following sections give a short overview on the general approach of each case study as well as some general recommendations concerning usability, availability of data of SBA indicators and how those can influence the performance of the building.

IAO's test case focused on the investigation of the potential of information management tools and other innovative solutions within SBA. Such tools like 3D modelling and VR (virtual reality) systems are considered to be very useful communication instruments between the different construction parties (e.g. architects, technical planners etc.) and the building users during the planning phase. In addition, the visual impression of the object and its surroundings can help to detect and eliminate planning mistakes before the construction of the building starts, leading to savings in costs and resources and higher user satisfaction.

In general the software solutions used in the case study already provide most of the data needed for indicator evaluation. Nevertheless improvements can be done, especially with regard to the collection of data. Indeed, the study recommends the establishment of a comprehensive database on building materials, components and technical equipment, containing information on embodied energy, embodied water use, embodied greenhouse gases and contained pollutants that is accessible for all relevant construction partners. Such a database would enable a faster and more precise building lifecycle assessment.

The main objective of YIT's test case was studying the possibilities of using information received by means of Building Automation Systems (BAS) for the assessment of environmental indicators, it therefore focused on indicators related to the operational phase of the building: energy use, water use, thermal comfort.

This case study underlines the following. "When discussing about sustainability indicators, two main aspects have to be taken into

account: What kind of knowledge do they provide and how can this knowledge be used for maximum benefit?" Also, in order to achieve sustainability targets the engagement of users is very important. Now, energy management systems that provide easy-to-understand and easy-to-use data and information on a building's energy (or water) consumption can support the engagement of users and can even influence user behaviour by making performance and consumption values easily available and apparent. Moreover, also basic knowledge on sustainable buildings in general can be communicated by means of such tools in order to educate users.

The purpose of the case study of VINCI Construction France was to test the use of a comprehensive set of sustainability indicators in a real building project. In order to allow comparisons of different types of buildings as well as different local conditions, the author introduces the building signature concept. Based on a radar profile, the building signature summarizes the quantitative assessment of 12 indicators, divided into six environmental impact and six anthropogenic indicators. Generally, the indicators identified in the case study correspond to the indicators assessed in WP4, but some additional indicators were proposed as well, with a multi-criteria approach of sustainability, considering environmental, financial and use performance indicators. Carrying the intrinsic building properties, the signature concept is meant to be seized by any organization and any third party can use it to develop its own label.

In the case study of Werner Söbek (WS), the evaluation of sustainability indicators has been carried out with regard to integrated design, giving recommendations and applied examples for implementing integrated design in certification schemes. For this reason, the evaluation of indicators was qualitative and not quantitative. In order to enable a clear understanding of the processes related to the optimisation and assessment of a certain indicators, each indicator has been described as a pure process, whereas a process is defined as the transformation of input elements into output elements. The output of the indicator sums up all information that has to be submitted in order to prove the fulfilment of a certain requirement. The input is the information required in order to produce the output. Tools allow the transformation of inputs into outputs. In order to allow for a correct interpretation of the indicator results, the boundary conditions have to be clear.

With regard to the indicators further developed in SUPERBUILDINGS, their usability was generally considered as good by WS. Nevertheless, the case study underlines that when evaluating the usability and applicability of sustainability indicators, the function and the size of the building, which has to be assessed, have to be taken into account, because these parameters influence time and effort that can be spent on assessment (e.g. in the case study D10 some calculations have not been carried out because of economical resources). Moreover, the importance of including a monitoring phase for the indicators related to the operational phase is highlighted, as well as the necessity to include a user survey for comfort indicators (indeed user perception cannot be measured as such, although it provides useful information for the optimisation of technical equipments).

Finally, in order to simplify the SBA process as well as to improve the performance of the building, WS suggests specifying in the indicator descriptions, which professions should be involved in the process and when the processing of the indicator should start.

The case studies carried out by W/E Consultants uses a different approach for the evaluation of the LCA based indicators (e.g. CO2 emission). The author suggests the aggregation of nine environmental impact categories into one single indicator: the shadow price, which is depreciated over the expected life time according to the type of the building. The shadow price is a way to evaluate and weight emissions and environmental impacts. In addition, the resulting CO2 emissions both from embodied and operational energy consumption are provided. As CO2 emissions are very high on the political agenda, shadow price and CO2 emissions (compared to a more extensive number of LCA indicators) are considered as a good set of output parameters for practical purposes (user friendly tools for building professionals). Land use is also seen as a relevant indicator, seen the fact that the Netherlands are so densely populated; however, it has not received much attention yet in the process of designing individual buildings.

Finally those test cases show that SBA can be useful not only to determine the environmental performance of a building after construction or renovation, but also within the decision making process.

### **Conclusion:**

The case studies show the usability of the indicators developed within SUPERBUILDINGS, but also provide valuable feedback on how to enhance SBA process, benchmarking and comparability of results.

The case study on information management systems concludes that the needed information management systems for SBA are already available; however, the linkage and connection of those tools could be enhanced. Indeed, as shown also by the case study on integrated design, industry wide standards for workflows, communication, information and data exchange, as well as data formatting would improve the SB assessment and construction process.

Amongst others, the evaluation of life cycle based environmental indicators (embodied water, energy and CO2) would be greatly facilitated by the availability of one comprehensive database with EPD's of materials, components and technical equipment, especially if such database is included in existing simulation software and BIM.

Several case studies also underline the importance of the planning phase. Indeed, the earlier sustainability targets are set and the sustainability assessor joins the building team, the more efficient the SBA process and the easier targets can be met without additional costs. Moreover, case studies point out the importance of the iterative process during the design phase and how SBA can support the decision making process not only in construction but also in renovation projects.

Another important aspect indicated by the case studies is the implementation of a monitoring phase (to be planned during the design phase) and a post-occupancy evaluation during the operation of the building. Indeed, this provides target-performance comparison, shows potential optimisations and adjustment of technical systems and therefore makes it possible to improve user comfort.

Moreover, as indicated by one of the case studies the results from monitoring systems can be used to calculate environmental indicators and therefore for the benchmarking of buildings across Europe. Also, the use

of easy-to-understand monitoring systems can positively influence the behaviour of residents and therefore reduce energy and water use. Indeed as pointed out by different case studies, user behaviour is a determining factor for the real performance of buildings.

Finally, regarding benchmarking and comparability of results, solutions mentioned by some case studies in order to improve the comparison of different types of buildings as well as different local conditions are:

- The use of relative values (expression of results as a % deviation from a target value),
- a Building Performance Pass which gives additional information on contributing factors affecting the performance of the building,
- or the use of a so-called building signature which represents the outcome of 6 user and 6 impact related indicators in a radar profile, together with a regional reference level.

### **Future prospects**

The project also analysed the general future prospects regarding the use of sustainability indicators. It is estimated that the demand for results of a sustainability assessment of buildings will grow even more in the coming years. Both voluntary processes as well as policy steering and municipal steering instruments need sustainability assessment methods and indicators.

Regarding future prospectives, the project made the following conclusions about research needs:

#### **- Further development of assessment systems**

There is a further development of assessment methods and principles in two directions. On the one hand there is finally the transition from systems that focus mainly on the issues of environment and health protection to systems that take into account the issues of sustainability in their full breadth and depth. At the same time, a transition from predominantly qualitative assessment systems to predominantly quantitative assessment systems takes place. Concurrently, the state of the international and particularly European standardization has been evolved. There is a great action over the introduction and testing of indicators related to the social and economic dimension of sustainability; there is a great need for action in the field of integration of quantitative assessment procedures (including life cycle assessment and life cycle costing). At the same time, there is a need for LCA results as databases with LCA data for building products.

#### **- Development of early design phases**

The most important decisions regarding SB building are done in planning districts and in early stages of design (new building / renovation, location, main functions and volume). Important architectural choices (size, shape and orientation, and the main construction materials) - are done in the preliminary design phase. In the past, the sustainability assessment was mostly used for marketing purposes. Now the situation has changed. More tools are needed for the design phase. Also tools that use simplified input are needed for early stages of design. To ensure the quality of the tools and comparability of the results, new standards may be needed at the same time. Early stages of design might also benefit from guidelines that characterize the process, list issues to be considered and outlines tasks of design for sustainable buildings.

#### **- Development of benchmarks**

The willingness to consider the sustainability aspects from the beginning of building and renovation projects emphasizes the need for knowledge

about benchmarks. Targets should be set for all relevant aspects with building level indicators. Although the current standards support the assessment and comparison of buildings, the standards, however, provide no information on benchmarks. There is a great need for the further setting-up and development (tightening) of benchmarks. As SUPERBUILDINGS project has shown there is a lot of - especially local - understanding about the typical and best performance values of different building regarding certain sustainability indicators. However, much work is still needed to improve understanding of benchmarks and also to develop good processes for the determination of benchmarks.



**Potential Impact:**

The goal of the SUPERBUILDINGS project was not to develop a uniform assessment system with a defined list of indicators. The aim was to support the further development of existing systems. The discussion focused on indicators for which there are still lack of information of different factors (e.g. CF) or methodological issues (e.g. land use) or indicators that are missing at the moment (e.g. in the field of economics). Therefore, the indicators that are analysed in the final report are not considered as a core list of indicators, but as a list of discussed and processed indicators.

SUPERBUILDINGS project has developed new understanding about core sustainability indicators with having the focus on the validity of indicators and assessment methods of indicators to provide comparable results. SUPERBUILDINGS project has developed recommendations for the further development of existing sustainability assessment methods and tools. These enable the existing tools, while maintaining their independence, to improve their content. For this purpose the top down approach was developed, where the assessment criteria are derived from the areas of protection and the protection goals.

The project has also described and given recommendations for the use of indicators in different stages of building processes, together with building information models and in the connection of different steering instruments. The project brings this knowledge and recommendations for policy makers, local building authorities, sustainable building practitioners and tool developers for the further development of practical methods and tools that will be powerful when used in target setting, design, portfolio management, and municipal and other steering processes.

The Lead Market Initiative is the European policy for 6 important sectors that are supported by actions to lower barriers to bring new products or services onto the market. The policy instruments deal with regulation, public procurement, standardisation and supporting activities. Sustainable construction is one of these lead markets in the EU. To reinforce the integration and implementation of the principles of sustainable development in the construction and real estate industry, manageable principles, methods and tools for the sustainability assessment and benchmarks are needed. It is estimated that the demand for results of a sustainability assessment of buildings will grow even more in the coming years. Both voluntary processes as well as policy steering and municipal steering instruments need sustainability assessment methods and indicators. Possible reasons for an increased need for assessment results and assessment tools are seen in:

- the concern about greenhouse gases and the knowledge about construction sector's potential in the reduction of GHGs may lead to the further development of regulatory and fiscal instruments;
- the intention of the public sector to become a role model, leading to an integration of sustainability aspects into the procurement process;
- the intention of cities to search for significant savings in energy consumption and GHGs, which may lead the increased consideration of sustainability aspects in building supervising processes;
- an integration of sustainability aspects into the analysis and management of large building stocks (portfolio analysis and portfolio management concerning both private and public owners and developers),

leading to a demand for different system variants for the use phase (sustainability assessment - in use);

- an integration of sustainability aspects into the risk analysis and valuation, leading to a demand for disaggregated assessment results;
- the integration of sustainability aspects into the establishment of conditions for the financing and insurance of buildings leads to a demand from banks and insurance companies;
- companies want to integrate information on the sustainability of their corporate offices and building stocks into the sustainability report and need information;
- sustainable property funds give emphasis on a positive sustainability assessment as a condition for the purchase of objects;
- an integration of sustainability aspects into planning and architectural competitions, leading to the question of suitability of rating systems for early stages of planning;
- an integration into the planning process, which must lead to a development of new approaches;
- sustainable buildings increase the user satisfaction and productivity.

The potential impact of SUPERBUILDINGS is that the project responds for the increased need for sustainability assessment and for better availability of indicators, assessment results and assessment tools.

The role of a sustainable construction sector has been assessed to be crucial for reaching the EU's long term 80-95% greenhouse gas emission reduction objective. According to the Roadmap for moving to a competitive low carbon economy in 2050 (COM (2011) 112) the cost-efficient contribution of the buildings sector would be around 40 to 50% reduction in 2030 and around 90% in 2050. As the potential of the construction is seen big and there is a strong willingness to make it realize effective steering instruments will be needed. These will probably be used on all levels of steering. Especially regarding control and regulatory instruments as well as fiscal instruments and incentives, precise indicators and assessments methods are required. The more the focus is on GHGs the more clearly the methods have to measure it directly and comprehensively.

**The foreseen impact of the project is that it helps to widen the focus on GHGs.**

To significantly speed the renovation rate of existing building stock, both mandatory and voluntary steering processes will be needed. As the owners of big portfolios face the need to accelerate renovation processes that improve the energy performance and reduce the GHGs of the stock, they will need comprehensive methods with the help of which essential aspects - including environmental, economic and social aspects - can be simultaneously considered.

**The project outcomes help to select appropriate indicators and make comprehensive assessments.**

From the view point of effective steering mechanisms it is of utmost importance that the guidelines are clear and the tools needed in assessment and verification of results are available and accessible for all who need those in different stages of building processes. The adoption of further sustainability aspects to be part of control, regulatory and fiscal instruments and subsidies emphasizes the need of quantitative assessment methods and indicators and their accurate

description on the basis of commonly agreed principles. The outcomes of SUPERBUILDINGS support the adoption of further sustainability aspects to be part of control, regulatory and fiscal instruments and subsidies.

When considering new policies and policy instruments it is important to assess the position of different stakeholders with regard to such policies and instruments. A good support from relevant stakeholders contributes to the effectiveness of policy instruments. Sustainability indicators are mature enough and should be actively brought to guide all life cycle phases of buildings. SUPERBUILDINGS formulated the following recommendations. The potential impact of the project outcomes includes that those support the implementation of the recommended measures.

### **Comprehensive understanding about the goal**

The definition of sustainable building covers the essential performance aspects considering environmental, economic and environmental aspects. If the European countries gradually agree that these aspects actually represent the essential performance aspects of buildings, we may gradually also come to the point where the same structuring could be used in the highest level of steering. In a situation like this, the building acts would give basic principles, building regulations and codes would give minimum requirements and guidelines and sustainability assessment systems would give indicators and methods for assessment and benchmarking by using the same outline for the aspects of building performance. At the same time it would also mean that those aspects recognised as essential aspects of building having an impact to the issues of concern of sustainable development, would also be recognised as aspects that we need to consider in all buildings. The achievement of this situation would still require a lot of discussions in order to achieve a common understanding of the performance aspects and basic principles. On the other hand the achievement of this situation would enable and possibly promote the use of sustainable building aspects in all levels of decision making.

### **Recommendation**

On the highest level of steering (meaning building laws and regulations) a comprehensive understanding about sustainable building could be adopted as a general outline and basic requirement for the overall quality of buildings.

Specific guideline, tools and standards for planning and early design  
It has been shown that often the most important decisions regarding sustainable building are done in planning and in early stages of design. Such fundamental decisions as whether to build a new building or renovate, location, and functions and volume have very significant impact on the final solutions environmental, economic and social impacts. The decisions and selection concerning the energy concept and energy supply solutions are essential. The utilization of distributed solutions and renewable energy remarkable affect the sustainability impacts. In addition, important architectural choices – such as size, shape and orientation, and the main construction materials of the building – are done in the preliminary design phase.

The current standards support the assessment and comparison of buildings but those give less support for the early stages of sustainable building. Quantitative indicators following a life cycle approach are the primary indicators for the assessment of the environmental impact of buildings and products. However, those are not easy to use in preliminary stages of

planning and design, where limited information is available. Although the assessment is possible by modelling and creating alternative solutions, the problem is that needed resources for time consuming tasks are not available. More tools are needed for the design phase. Tools that use simplified input and/or gradual approach are needed for early stages of design. To ensure the quality of the tools and comparability of the results, guidelines and standards are needed at the same time.

Recommendation

It is recommended that a new standardization process would be started in order to develop guidelines and standards that support the design for sustainable building. These standards should especially support the early design. The needed guidelines and standards are of two main types. On the other hand such guidelines, standards and/or tools would be useful that support the quality management of tools which work on with the help of simplified inputs. The standards should support the characterization of these tools especially in terms of data quality and coverage of assessment. Guidelines are also needed for client's brief. To enable requirement setting, guidelines are needed for benchmark development.

### **Wider scope for energy regulatory instruments**

The domain of control and regulatory steering instruments of sustainable building has much focused on the regulation of energy performance of buildings. The Directive on energy performance of buildings (2002/91/EC and its recast 2010/31/EU2010) is the main legislative instrument at EU level to achieve energy performance in buildings. Under this Directive, 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. The recast energy performance directive sets a target for all new buildings to be 'nearly zero-energy buildings' by 2020. The provisions of the Directive cover energy used for space and hot water heating, cooling, ventilation, and lighting for new and existing residential and non-residential buildings. The primary energy consumption is taken into account with the help of chosen primary energy factors which vary from country to country.

The complexity of the effect of energy supply technologies and solutions would require the further development of assessment methods. In order to consider the overall impacts of distributed energy supply methods and the impacts of electricity, district heat, district cooling, combined heat and power and tri-generation in terms primary energy and other environmental impacts, calculation methods and rules should be developed. The current building-level assessment methods provide both dynamic and simplified solutions for the simulation of building's energy performance, but methodological development should be done to enable planning and design for sustainable urban districts. In addition, methodological development should be done to consider life-cycle perspective. This includes also methodological rules for the consideration of the future scenarios for energy supply.

SUPERBUILDINGS' analyses show that materials have a significant effect on building's overall energy consumption and greenhouse gas emissions. To enable the consideration of embodied energy and embodied CO<sub>2</sub>e, product related information should be made available. EN gives guidance and rules for the calculation of embodied energy and GHGs on life-cycle basis. However, comprehensive availability of environmental product declarations

- as the standard sets a basis for a voluntary method - may take very much time.

#### **Recommendation**

The scope of the energy regulatory steering should be widened to cover life cycle based GHGs in addition to primary energy. In addition, building materials should be taken into account when GHGs are assessed. An improved assessment method which considers the complexity of energy supply technologies should be developed to support the measurement and the comparability of assessment results. The first step towards the comprehensive consideration of aspects that significantly affect the total energy use and total greenhouse gases could be the establishment of national methodologies for the assessment and the requirement about mandatory information. In addition, there is a need for better coordination of regulations given on different levels.

#### **Development of municipal support and building supervising processes**

Informative steering and support is needed in order to accelerate the refurbishment and retrofitting of existing building stock towards sustainable buildings. The ability of planning authorities and building permit authorities to provide more supportive guidance and consultation for designers and builders in building projects would probably facilitate the finding and utilization of better refurbishment and retrofitting solutions. More support is needed in order to accelerate the use of advanced solutions beneficial from the view point of energy performance and overall sustainability. This is especially important in the current situation where a huge number of existing buildings should be renovated all over Europe and much new information about sustainable refurbishment concepts is needed. On the other hand, the building authorities - considering their role in the process - want to avoid a situation where they give guidelines or recommendations about the use of specific solutions. Thus the availability of recognized standards and design guidelines is emphasized at the same time.

The most effective steering model from the view point of customers is consultation steering). It is not used too much because it is quite resource consuming. To overcome this problem, new service models could be developed for building supervising agencies. Service models could create added value especially to district and neighbourhood level urban infill project.

#### **Recommendation**

Such process indicators and guidelines should be developed which help local building authorities and building supervisors to give support and instructions for sustainable building planning and design. Guidelines are needed for consultation / cooperative steering; guidelines are needed for processes that help local building authorities to address different kinds of effective methods and tools for the design process and to follow performance based approach. These methods and tools should then support designers to consider sustainability aspects along the whole design process. Good examples of successive processes are available in some countries. The development of new kind of service models for building authorities that would help to add the use of consultation steering is recommended. This model could include different forms such as council sub-committees, task forces, steering groups, expert panels etc., that give input to policy process. In addition, contracted experts and consultants that bring their expertise to assessment process could be a part of new service models.

### **Development of procurement and verification processes**

The use of performance based procurement model is a natural choice in sustainable building where the target performance is assessed with the help of a verification process. The definition of required verification is as important as specifying the design / construction criteria. A new type of contract for public private partnership is needed. In sustainable building processes requirements are set for the final result on the bases of sustainability requirements. Clear rules are needed for the process. The process description should explain how SB indicators are used in the setting and verification of requirements. These kinds of processes should especially be developed for public procurement.

### **Recommendation**

The development of guidelines / standards for SB indicator based verification process is recommended. This would ease the operative implementation of the use of SB indicators in project level steering. SB-indicator based procurement and verification process should be adapted especially to performance based procurement models.

### **Main dissemination activities**

The main dissemination activities of SUPERBUILDINGS are as follows:

- the establishment of the SUPERBUILDINGS network group and the delivery of information of the project outcomes to the network group
- surveys and interviews carried out in the beginning of the project. Needs of different stakeholder groups were asked. At the same time information about the project objectives and preliminary results were presented.
- participation to several relevant seminars and workshops, presentation of SUPERBUILDINGS outcomes and face-to-face discussions together with participants
- organisation of and participation in special forums of SB11 and SB13
- organisation of the network group meeting in Porto in 2012
- organisation of the final conference in Brussels in 2012
- the communication of the project outcomes and events with the help of the social media
- all partners communicated the activities and outcomes of the project nationally for their partners and clients in the connection different kinds of meetings and seminars. Internationally and European wide discussion was especially going on together with ENCORD, ACE and other organisations.

### **Special forum in SB 11**

SUPERBUILDINGS organised a special forum "Core indicators" in the context of Sustainable Building world conference in 2011 in Helsinki.

The target of the special forum was

- To summarise the state-of-the-art of core indicators' development (projects, initiatives, regulations and standards)
- To explain the benefits from the use of measurable core indicators of sustainable buildings, to assess problems and possibilities to solve
- To assess the future potential of core indicators' as instruments of steering and voluntary processes for sustainable building
- To sketch the potential of core indicators in the harmonization of local rating systems

The target audience was developers and users of sustainable building indicators and rating systems.

The contents of the special forum were as follows:

- Summary of the current developments, Natalie Essig, Marcel Loomans and Sylviane Nibel
  - Potential of measurable core indicators as instruments of steering and voluntary processes, Tarja Häkkinen
  - Current role of core indicators in standards and regulation, Eva Schminke
  - Possibilities of core indicator developments to harmonise sustainable building rating systems, problems of classification, Thomas Lützkendorf
  - Facilitator: Tarja Häkkinen
- OpenHouse project participated to the Special Forum.

### **Special Forum in SB13**

SUPERBUILDINGS will also participate to the Special Forum - OPEN HOUSE - Towards a common European view on Sustainability of Buildings:

- Organiser: Fraunhofer IBP. Date: 24.04.2013 from 16:00 - 17:30
- Session Chair: Vincent Peyramale (Fraunhofer IBP)
- Speakers

Life Cycle Costing- Proposal for organisation of information based on the feedback of the European project OPEN HOUSE, Bruno Ziegler, EDF, France

Development of a European LCA rating methodology for OPEN HOUSE , Johannes Gantner, Fraunhofer IBP, Germany

Investigation on the differences between LEED, BREEAM and OPEN HOUSE assessment systems by means of two Hungarian case studies, Zsafia Belafi, ABUD Ltd., Hungary

Testing OPEN HOUSE methodology in former YU countries, Marjana Zavrl, Building and Civil engineering institute ZRMK, Slovenia

SUPERBUILDINGS, Tarja Häkkinen, VTT, Finland

### **Network group meeting**

The open workshop of the Network Group was held within the Building Sustainability Assessment 2012 conference in 25th May 2012 Porto, Portugal. The workshop entitled Recommendations for next generation of assessment systems has been widely announced by the SUPERBUILDINGS newsletter, on the conference website, at LinkedIn and also by direct e-mailing. The interest of the participants was really high and the room was full to the last seat.

The program was organized in two blocks of 1.5 hours each:

- SUPERBUILDINGS overview and starting points for discussion, Tarja Häkkinen
- Integration of SB issues into public procurement, Andrea Traspaderne (VISESA)
- Top-down approach, Thomas Lützkendorf
- Survey results and target groups Petr Hájek
- Indicators - Comparability and validity Sylviane Nibel
- Benchmarking and Aggregation Patxi Hernandez
- Facility management input Petr Hájek
- Property appraisal Thomas Lützkendorf
- Use of indicators in building processes Tarja Häkkinen, Sylviane Nibel and Carmen Antuña

In the first part of the program was included presentation given by invited speaker Andrea Traspaderne from VISESA, which is a public company within the Department of Housing, Public Works and Transportation of the Basque Government. The workshop as a whole was positively received. The new insights brought by the project were mentioned during the closing

ceremony of the BSA2012 conference in the concluding speech by Raymond J. Cole from University of British Columbia.

The representative of OpenHouse project participated the workshop. Important change of information was made.

### **Final conference**

The Final workshop of the SUPERBUILDINGS project took place in Brussels 18th December 2012. The 59 registered attendees were representatives of various stakeholders in sustainable building: architects and designers, academic and research bodies, representatives of professional organizations, producers of building components, construction companies and officers from DGs ENTER and ENV. The consortium of SUPERBUILDINGS got whole day to present to the audience the most important results of the project. The feedback from various representatives ranging from professional organisation of architects to the representatives of the European Commission shared words of appreciation of the project's outcomes.

The main purpose of the final workshop organized by the SUPERBUILDINGS project was to share the outcomes of the project and offer them to various stakeholders in sustainable building. Therefore Brussels was chosen as the workshop venue.

The invitation strategy came out from the fact that we wanted to approach as many stakeholders as possible. The list of various partners to invite included:

- European Commission (Project Officer, representatives of DG ENV and DG ENTER)
- SUPERBUILDINGS Network Group
- OpenHouse project group, network group and contacts
- SBAlliance members
- Professional associations
  - ACE - Architects' Council of Europe
  - European Council of Civil Engineers
  - ECTP
  - IFMA - International Facility Management Association
  - World Business Council for Sustainable Development
  - UNEP-SBCI
  - ENCORD, Sustainability Charter
  - CIB
  - CEPMC
  - iiSBE - International Initiative for a Sustainable Built Environment
  - FIDIC
  - European local Green Building Councils
  - UNSFA
- Social housing associations
- Public building owners
- Representatives of normalization activities
  - CEN TC 350
- Representatives of various research projects and research organisations
  - ECBCS Annex 57, Annex 56
  - South European projects
  - HQE Association
  - SINTEF
- Enterprises
  - SKANSKA
  - ARUP



YIT  
Vinci  
Werner Sobek  
PE-INTERNATIONAL  
IBU  
Environdec  
ICADE  
Royal BAM Group  
FCC Construcción  
Acciona  
Jones Lang LaSalle  
Ecofys

The contact list for invitations included over 700 individual professionals and more than 50 contacts of organizations. The invitation was made with help of a professional conference registration system provided by VTT. Many of those invited professional who were not able to participate in the final workshop made a special request to receive the material. After the workshop, the link to the project's web site was sent to all invited with instructions how to find the presentations, project's final report and all deliverables.

The workshop consisted of the three main parts. The first one has been focused on presentation of sustainability indicators for buildings and their validity, functional equivalency and maturity for comparability of assessment results across Europe. The second part of the workshop aimed at presentation of the experience coming out from the case studies carried out within the SUPERBUILDINGS project and also within the partner FP7 project OpenHouse. The final part has been dedicated to recommendations and conclusions. The first presentation of the session on research needs in development of benchmarks has been given by prof. Thomas Lützkendorf from (KIT, Germany). Guidelines for the use of BIMs as sources of information for the assessment of buildings were discussed by Bruno Fies (CSTB, France). Tarja Mäkeläinen (VTT, Finland) presented recommendations for the use of sustainable building assessment and benchmarking methods in steering.

After the event we approached certain experts attending the final SUPERBUILDINGS workshop and asked them for their opinion on the presented results.

Hereby is view of Manfred Fuchs from European Commission, DG Enterprise & Industry:

"By summarizing the main indicators of the different schemes used right now in the EU, SUPERBUILDINGS is not only providing a good overview for decision makers at EU and national level on what is actually assessed but - even more important - what can be actually measured. Keeping in mind that assessment schemes are not a goal on their own but also tools to provide information for policy makers who are focusing on global targets (e.g. energy efficiency, resource efficiency), the robustness of indicators (availability and quality of data) is essential. The SUPERBUILDINGS report will help to facilitate the dialogue between policy makers and scheme providers to improve both political targets and assessment schemes."

And Eleni Goni from the Architects' Council of Europe noted:

"As a member of the Consortium of the OPEN HOUSE-FP7 project, I found the results of SUPERBUILDINGS project to be very useful especially under the

prism of OPEN HOUSE. In fact, the recommendations presented are a valuable guide for the refinement of the sustainability indicators developed in the context of the OPEN HOUSE building assessment methodology. In overall, the work that has been done both in the analysis of the current situation and the definition of indicators is of very high quality. Through this research, a common framework for assessing sustainable buildings is finally possible: Important steps have already been made in order to facilitate market movement towards a better level of sustainability and to have a common view on building sustainability."

Several representatives of OpenHouse project participated in one of the SUPERBUILDINGS project meetings. Important change of information was made.

#### **Awareness raising package - final report**

The project's main results and findings were compiled to the final report which has been made available as the awareness raising package of the project:

Sustainability and performance assessment and benchmarking of building. Final report. Espoo 2012. 409 p. + App. 64 p. VTT Technology [No.72]. ISBN 978-9-1-38-7908-2

1. Introduction
  2. Current assessment systems and conclusions about needs of development
  3. Barriers and drivers for sustainable building
  4. Top-down approach
  5. Description and explanation of the selected indicators and related measurement and assessment methods with special focus on reliability, comparability and compatibility
  6. Performance levels of buildings
  7. Developing benchmarking criteria for sustainable buildings
  8. Recommendations about the use of sustainability indicators in building processes
  9. Recommendations about the use of indicators in Building Information Modelling
  10. Integration sustainable building benchmarking methods with steering mechanisms
  11. SUPERBUILDINGS summary and future prospects
- The final report also includes the summary of OpenHouse project.

#### **Overall communication**

The overall communication of project took place with the help of face-to-face meetings together with stakeholders, communication through social networks, participation in relevant meetings, workshops and seminars and presentation of SUPERBUILDINGS results in those occasions, carrying out interviews and surveys among stakeholders, establishment of the network group, establishment and maintenance of the external web site, presenting projects key findings in newsletters and making those available for the network group, arrangement of network group meeting, and arrangement of the final seminar. During the organization of the final seminar extensive communication with stakeholders took place during the invitation process. An important communication route among the scientific community is writing and publishing articles. 6 manuscripts of scientific articles were prepared and sent as manuscripts to refereed journals. One of the articles was published before the end of 2012.

The communication of the project outcomes and events used help of the social media. The invitations to key SUPERBUILDINGS events were announced

at LinkedIn and also at the Construction 21 and BUILDUP web portals, information portal of the ECTP, on the IRH-Med website, in the electronic magazine of the IBO (Österreichisches Institut für Bauen und Ökologie), EURIMA (European Insulation Manufacturers Association), CIB (International Council for Research and Innovation in Building and Construction), Baufachinformation.de and others.

All partners communicated the activities and outcomes of the project nationally for their partners and clients in the connection different kinds of meetings and seminars. Internationally and European wide discussion was especially going on together with

- ACE - Architects' Council of Europe
- ENCORD (European network of construction companies for research and development), Sustainability Charter
- CEN TC 350 (especially WG 5 which develops social indicators)
- IEA Annex 57
- UNEP-SBCI
- SB Alliance
- iisBE - International Initiative for a Sustainable Built Environment.

### **Individual meetings**

The individual meetings have been held usually as a focused part of the project meetings. There were present invited representatives of the professional organizations sharing their notes on the actual research tasks of the project and related topics. One of these meetings has been held within Karlsruhe meeting in November 2010 (Nils Larsson, CEO of the International Initiative for a Sustainable Built Environment and Natalie Essig, coordinator of the OpenHouse project), another one has been co-organized by the Austrian Chamber of Commerce together with a project meeting in Vienna in November 2011 (representatives of the Austrian organizations involved in sustainability assessment and certification of buildings). SUPERBUILDINGS representatives also participated the ENCORD's ENCORD 'Environmental Sustainability' Workshop in 12th February 2013.

### **Participation in relevant seminars and workshops**

SUPERBUILDINGS project has also presented the preliminary results in relevant conferences and workshops:

- Presentation in ENCORD's Environmental Sustainability Meeting in 12-2-2013
- Presentation in the 9th European conference on product and process modelling conference in Reykjavik, Iceland, July 2012
- Presentation in the 1st International Conference on Building Sustainability Assessment BSA May 2012, Porto, Portugal
- Presentations in Sustainable Building SB11 conference in Helsinki in October 2011
- Presentation in Sustainable Building 10 conference in Espoo, Finland
- Presentation in IALCCE 2012 conference
- Presentation in CESB10 Central Europe towards Sustainable Building. Prague: Czech Technical University, 2010
- Presentation in COST 25 workshop: Sustainability of Constructions Towards a better built environment. Malta: University of Malta, 2011
- Presentation in GREEN WEEK 2011: Open House and SUPERBUILDINGS projects made a joint presentation. EU research activities towards a common view on building sustainability.
- Presentation in Towards Sustainable Housing Conference in Barcelona in 2011 May 19th

- Presentation in European Construction Technology Platform, 4th conference, Brussels, November 24 - 25, 2009: Sustainability and Performance assessment and Benchmarking of Buildings  
The project outcomes will also be presented in SB13 Munich and SB13 Prague.

#### **Communication to the scientific community**

The following journal articles have been published:

- Barriers and drivers for sustainable building. Authors: Häkkinen, Tarja; Belloni, Kaisa. Building Information and Research Volume 39, Number 3, May 2011 , pp. 239-255(17)
- New trends in sustainability assessment systems - based on top-down approach and stakeholders needs. Lützkendorf, Thomas; Hájek, Petr; Lupíšek, Antonín; Immendorfer, Andrea; Nibel, Sylviane; Häkkinen, Tarja. International Journal of Sustainable Building Technology and Urban Development, Special Issue: Sustainability Assessment of Buildings. Vol. 3 (2012) No: 4, 256-269

The following three manuscripts have been submitted:

- Land use as an aspect of sustainable building. Tarja Häkkinen, Tuomas Helin, Carmen Antuña, Susanne Supper, Nicoleta Schiopu, Sylviane Nibel. Submitted to Sustainable land use and urban planning
- Building performance related indicators as social indicators of buildings. Tarja Häkkinen. Submitted to Building information and research
- Aesthetic quality as an aspect of sustainable buildings. Carmen Antuña. Submitted to Architectural Engineering and Design Management

The following two manuscripts will be submitted within coming weeks:

- Comfort assessment in the context of sustainable buildings: Comparison of simplified and detailed human thermal sensation methods. Riikka Holopainen, Pekka Tuomaala, Patxi Hernandez, Tarja Häkkinen Kalevi Piira, Jouko Piippo. To be submitted to Building and environment
- The significance of different factors on GHG emissions of buildings. Antti Ruuska, Tarja Häkkinen. To be submitted to International journal of sustainable built environment

#### **Newsletters**

**The following gives an overview of the newsletters:**

- The 1st newsletter in June 2010. Introduction of the project
- The 2nd newsletter in June 2011. Survey on stakeholders' needs for sustainable building assessment and benchmarking methods, Potential of sustainability indicators as instruments of steering, Logical structure for sustainability assessment systems, Selected indicators for assessment of buildings
- The 3rd (updated) newsletter in October 2011 (delivered at SB11 in Helsinki). Invitation to SB11 special forum
- The 4th newsletter in April 2012. Top down Approach to Develop a Structure for Sustainability Assessment Systems, Local/Regional characteristics in Sustainable Building Assessment, Preferences of Target Groups of Sustainable Building Assessment, Criteria Aggregation and Weighting, Benchmarking, Sustainable building process: definition and recommendations
- The 5th newsletter in February 2013. SUPERBUILDINGS final workshop. Insight on the project outcomes presented at the final SUPERBUILDINGS workshop, Abstract of the final report of the SUPERBUILDINGS project, List of contents of the final report, Project summary and future prospects, Deliverables, reports and articles

#### **List of Websites:**

<http://cic.vtt.fi/SUPERBUILDINGS/>