ecobim
value driven life cycle based sustainable business models

WP2 Business models

D2.2 Description of the life cycle based design/procurement process

Revision: Released
Due date: 2013-09-30
Actual release date: 2014-03-31
Lead contractor: T&L

ECO-INNOVERA

Dissemination level		
PU	Public	X
RE	Restricted to a group specified by the consortium	
CO	Confidential, only for members of the consortium	

Deliverable Administration & Summary				ecobim WP2	Eco-Innovera
No & name	**D2.2 Description of the life cycle based design/procurement process**				
Status	<Draft / Working / Released>	**Due**	m09	**Date**	2013-09-30
Author(s)	Jukka Lommi T&L, Aapo Huovila, Carmen Antuña, Pekka Huovila VTT				
Editor	Jukka Lommi T&L				
Description	This document describes BIM supported life cycle based sustainability assessment describing the value driven process, IFC based assessment, concurrent stages within the BIM/IFC/Test process and ecobim indicators. Other aspects of life cycle based building process are linked with new business models within the stages of BIM/IFC/Test process and localisation and upscaling issues in ecobim life cycle process and business models.				
Comments					
Document workflow					
Released	T&L			**Date**	2014-03-31
Accepted	VTT			**Date**	2014-03-31

TABLE OF CONTENTS

Table of figures

EXECUTIVE SUMMARY

ecobim focuses on paradigm change towards eco-innovation supported by new ICTs and new processes. They result in new services and also in new business models, especially for SMEs. The achieved impacts can be assessed though increased environmental, economic and social or cultural sustainability.

Value driven, life cycle based process re-engineering leads into new processes that can be supported by e.g. Building Information Models, Product Life Management and Life Cycle Assessment based on a set of Core Indicators. New processes and new ICTs (or the combination of existing ones in a novel way as it is already happening during the development ecobim project) open opportunities for eco-innovative services. Sustainable business models can be developed based on these innovations and new earning logic.

This deliverable describes BIM supported life cycle based sustainability assessment describing the value driven process, IFC based assessment, concurrent stages within the BIM/IFC/Test process and ecobim indicators. Other aspects of life cycle based building process are linked with new business models within the stages of BIM/IFC/Test process and localisation and upscaling issues in ecobim life cycle process and business models.

The report explains how indicators are used through the whole building process to set sustainability targets, adjust those and monitor as well as validate the achieved performance. In the BIM based process, indicators are also important to communicate sustainability features between different stakeholders involved and to justify decisions in defined points during the life cycle process. In principle, the party responsible for the assessment should also be responsible for collecting the correct data and storing the results. Since the proposed indicators are a substantial part of the BIM based assessment process, their validity will be further tested and reported in D2.3.

1. BIM SUPPORTED LIFE CYCLE BASED SUSTAINABILITY ASSESSMENT

1.1. BIM supported life cycle based sustainability process

The ecobim life cycle process is a BIM supported IFC based sustainability assessment process which relies on the use of the ecobim tool which is described below.

The basic requirement for the ICT environment is a standard BIM capable 3D CAD modelling tool which is able to export a standard IFC model for assessment purposes. The modelling environment uses standard construction parts which include the numerical information of the used parts, materials, and can deliver information about amount, size, volume, direction and geographical location. The ecobim tool is used in the sustainability assessment process. For ecobim tool's assessment purposes the required numerical indicator values describe environmental or technical performance properties that have to be present for all used parts.

The common practice in building design using BIM varies in detail in different countries, but the basic workflow with overlapping stages is common to all BIM design. For example, the RIBA plan of work 2013 describes a standard designing procedure very well. One of the main results and outcome of the work in different stages is a standard IFC model. The IFC file will be used in common assessment throughout the designing process. The use of the ecobim tool brings a new level by presenting a sustainability assessment process. As an addition to common practice, the model has to include the necessary building parts and the accurate quantities for the parts that will be assessed with the ecobim tool.

The ecobim tool is a stand-alone BIM/ IFC model life cycle analysis tool which evaluates the given IFC model through a set of performance indicators. The ecobim tool provides possibilities for evaluating different approaches and solutions for different stages of the building process.

The different indicators and their assessable values can be freely chosen for the assessment and varied throughout the whole process, which makes the tool flexible and reliable.

The ecobim assessment reliability lies in the quantitative accuracy (i.e. reliable quantity take-of information) and quality of the BIM/IFC model and all of its parts and the presence of a reliable provider of indicator value information that describe environmental or technical performance properties.

The ecobim assessment improves the decision making according to sustainability values and demonstrates its benefits.

The result is a sustainable value driven building process.

1.1.1. Goals for a sustainable value driven process

The goals are sustainability related objectives set during the first stage in requirement setting (brief). Those are expressed with help of quantitative values and performance properties. Quantitative values define the amount and size of a construction product and are used for example for quantity take-offs. The performance properties describe the targeted performance level of the end product and include both environmental and technical properties.

These goals are a selection of values given to different aspects of sustainability that can be called “initial values of agreement”. Those are expressed as target values for the indicators that have been selected for the project. The values can be monitored and compared in the different stages of the building life cycle [**Figure 1**]. This is important since it helps to understand the effect of a certain selection on other building or system parts and their values. For example, by selecting better insulated windows, the need for cooling can increase thus raising energy consumption and technical system investment needs.

The assessment of the project often results in requirement changes which cause amendments in the “initial values of agreement”.

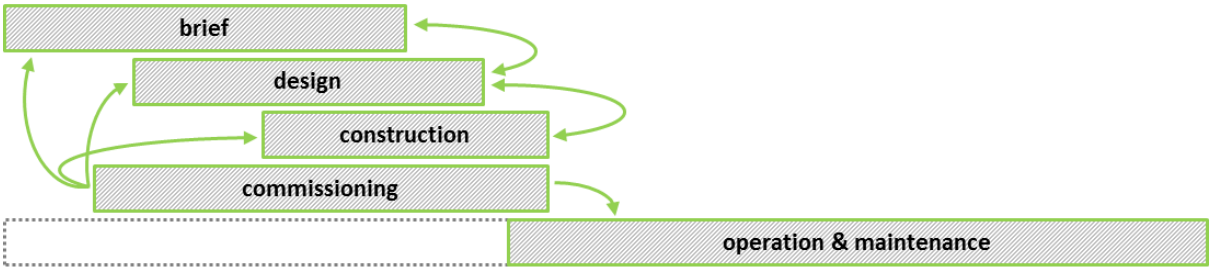

Figure 1: Building life cycle showing concurrent activities.

The goals of a project should include values and standards that are already set by the legislation and mandatory guidelines. These restrictions direct the goal setting by narrowing the possibilities of selection. Several optional variables are numerical values regarding the size or amount of different parts of the project. These options also include material, production, technological and environmental values which are used to calculate the performance indicators.

The optional variables here consist of choices which are selected as possible variants within the project. For example a wall structure can have optional variables by presenting it to be a concrete or a steel based structure. The model and the IFC output include the wall structure and its size, but it is also possible to assess it with the ecobim tool by giving it the properties as if the wall was a steel structure or in comparison a concrete structure, thus getting comparable results within a selected indicator set.

Several optional variables involve systems that are selected for the project. These systems are for example those related to heating, lighting, sanitation or ventilation. All systems include building parts but also sources of energy and environmental load, which all have their impact on the monitored variables. For example the heating system of the building can be presented as a possible variant. The model and the IFC output include the selected construction system, size and volume, but the heating system and its variants of energy source are assessed thus giving comparable results within a selected indicator set.

The sustainable value driven process requires that the selected optional variables in the goal setting should include numerical values which are assessable with the proposed ecobim indicators.

1.1.2. IFC based assessment

Several of the selections made during goal setting can be assessed through all the stages when accurate data is inserted in the BIM/IFC model.

The selected ecobim indicators for a project reflect the sustainable values given in the goal agreement. The values can be changed or modified during the different stages, and the ecobim tool gives us the possibility for continuous assessment, comparison and monitoring throughout the process.

The output within every assessment stage is achieved through the use of an IFC model. The ecobim assessment tool uses the numerical and directional values included in the IFC model.

In order to assess the values of the indicators, a reliable provider of indicator value information has to be present.

For example if a material selection is assessed with the ecobim indicator that measures the embodied impact on climate change, the amount of embodied CO_2(kg) has to be present for each material chosen for the comparison assessment. Some manufacturers of construction products offer databases (often publicly available) that contain Environmental Product Declarations (EPDs) with information on the environmental impacts of building materials.

If a desired result has to be reached, the most optimal result can be found by assessing and comparing different values with the ecobim tool. For example a wall has to have a certain insulation level and certain maximum embodied CO_2(kg). The result can be found by comparing different suitable wall structures with the ecobim tool indicators assessment.

One chosen value change can also be reflected in other assessment areas of the project. The ecobim tool is able to immediately assess the reflected result, which helps to reach a more accurate overall assessment result and a more accurate result for the whole sustainability assessment. For example, if an apartment building has a certain amount of windows, the minimum and maximum size may already be regulated by legislation and recommendations. By changing the value of the insulation level of the window element the cost of one window rises but on the other hand the energy efficiency of the whole building will be improved, thus lowering the CO_2 emissions, and life cycle energy cost of use.

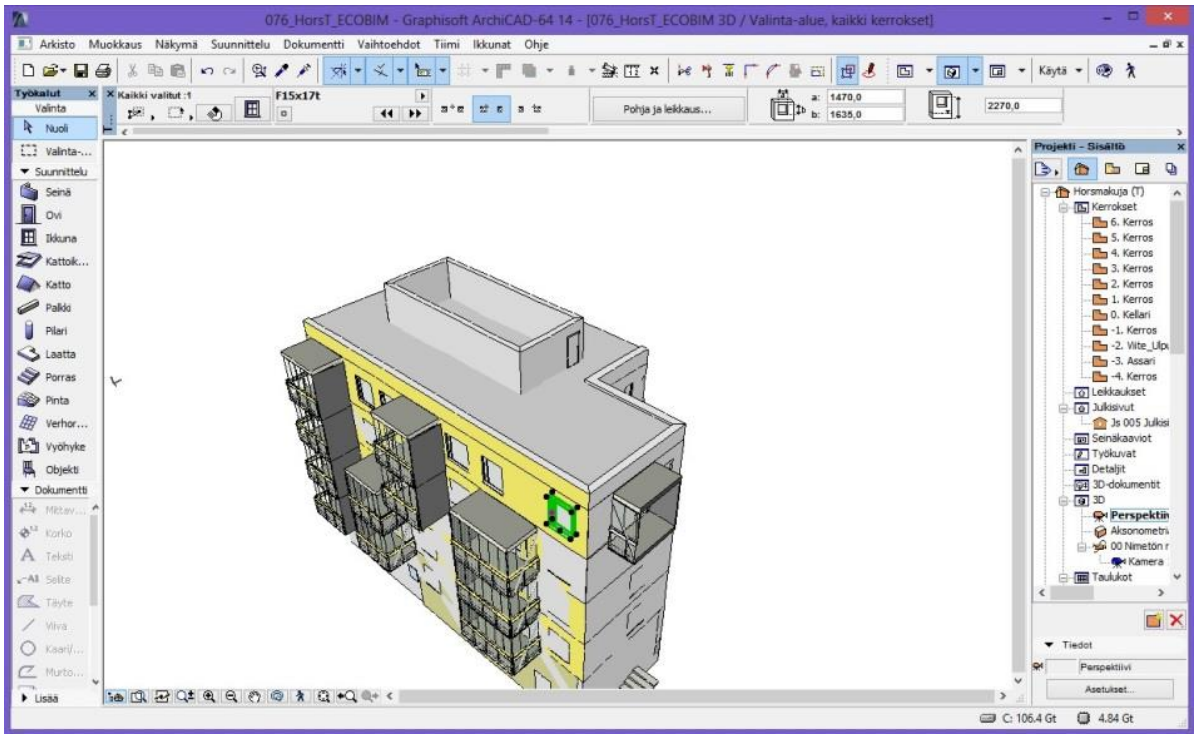

Figure 2: 3D view from a building showing the activation of a selected window.

This means that a window has parameters such as size, amount and direction. The assessment sheet includes performance indicators for CO_2 emissions from heating, life cycle energy cost of use and energy efficiency. These assessment possibilities help to reach desirable solutions quickly and easily.

The possibility to choose diminishes towards the end of the process. By using the ecobim tool it is possible to evaluate the whole process and to choose between several possibilities already at an early stage of the process.

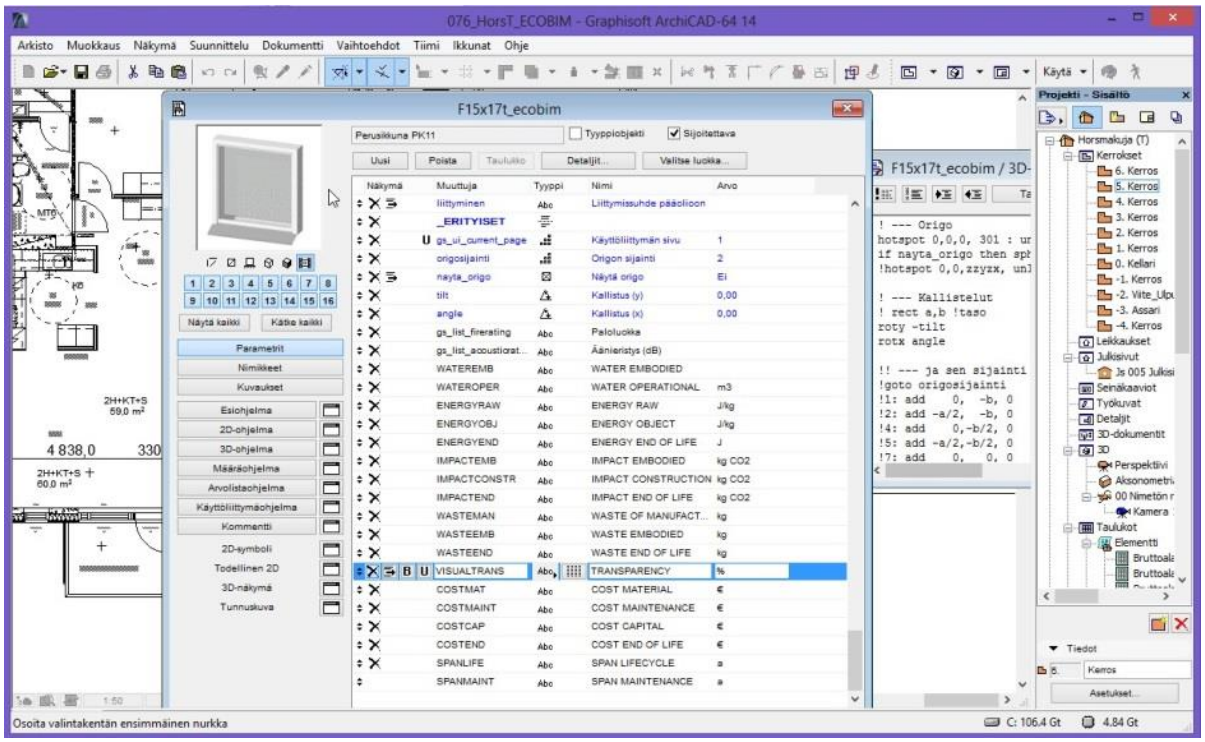

Figure 3: Properties listing view of the selected window.

1.1.3. The concurrent stages within the BIM/IFC/Test process

BRIEF

At this stage the goals of project are defined. They are translated into indicators and targeted indicator values. Different design options fulfilling the same requirements set for the indicators can then be compared e.g. with regard to environmental impacts or costs. Selected values and their indicators are included in the BIM test sheet for constant assessment.

DESIGN

During this stage the draft design of the project is started. The design is done by following the goals agreement as a guideline to reach the desirable results. The IFC model of the designed BIM is continuously assessed and in the goals agreement test sheet the results are compared to the results of the design. The outcome of the test sheet will result in changes in the design and possibly amendments to the goals agreement. When the design process reaches a point of completion it evolves to become an implemented BIM, a base for the construction process.

CONSTRUCTION

During this stage the construction of the project is started and completed and the implemented BIM will undergo changes. The design, done following the amended goals agreement, is implemented and the workflow of the construction process begins. During the construction process, amendments to the goals agreement can still be made and the design can be changed, but the possibility of change narrows throughout the process as the project approaches its completion. Also the correction of the design is one of the main reasons for the amendments and it is often a result of an external demand. The designed BIM is continuously corrected and the changes of this stage are implemented to become a commissioned BIM. The outcome of the test sheet will give results of the changes in the design and possibly amend the goals agreement.

COMMISSIONING

At this stage of the project the finalized BIM/IFC commissioned model is assessed. The results of the test sheet are compared, the goals agreement is validated and the closing areas of the agreement will be reported. The completed project will now be taken into use.

OPERATION & MAINTENANCE

After the project is taken into use, several of the test sheet results from the as-built IFC model are compared with the building performance. The comparison correction is implemented into the goals agreement. The changes made during the use of the building can be implemented in the BIM to be able to continue assessment. At the end of life stage the calculations can be compared with the goals agreement results.

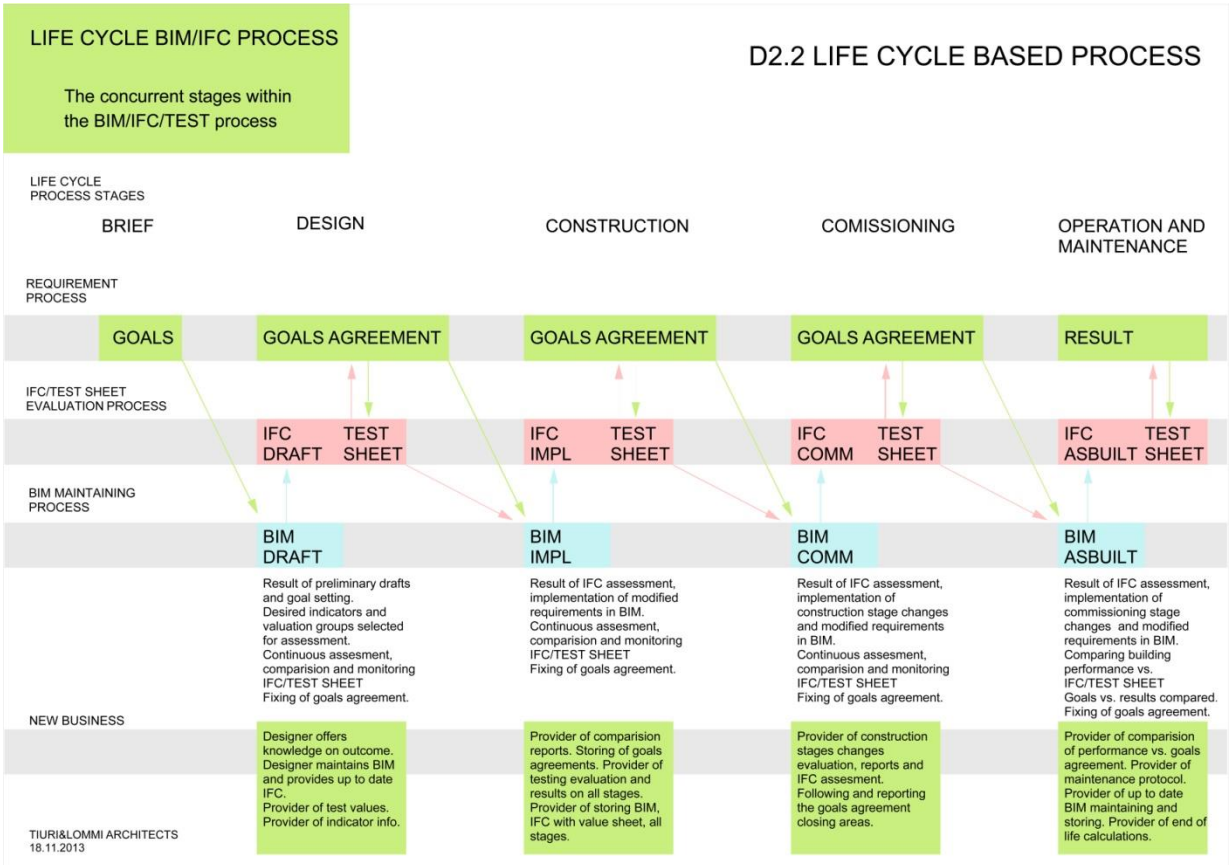

Figure 4: Life cycle based stages and processes.

1.2. The ecobim indicators

ecobim tool is an easy to use source of data and information for LCA.

To achieve reliability, properly scaled information from multiple data sources is needed for each assessment level throughout the life cycle process.

Secondly the available and commonly used benchmarks established by authorities and decision makers are needed to make comparisons.

The use of the ecobim tool simplifies the LCA process by using a BIM IFC model to export the numerical quantitative values and the assessable indicators of building parts. This export can be processed very fast in databases selecting the assessable areas and the variables and indicators for the assessment. Alternative results are simultaneously viewable for comparison.

The objects and building parts used in the BIM include quantitative values and assessable values of performance properties that are used to calculate indicators. Quantitative values define quantities, i.e. amount, size, area, volume, height, length etc. of a building part. The performance properties describe environmental or technical properties of the building part. As an example, the environmental impacts of a construction product are usually given by its producer in the form of EPDs.

The selection of indicators presented below includes indicators that have proven to be important in the evaluation of sustainability issues in such life cycle process as described in this document. They can also be easily assessed as the values of the indicators can be numerically presented. This is essential as the LC process is BIM based. This does not hinder the possibility for new additions as long as the values can be numerically presented.

In the requirement setting stage (brief) these indicators are subject to selection. The selected indicators are then assessed during all stages of the process. This sets the demand to correct the values which have to be presented for each selected indicator.

The main categories, indicators and their units are presented below:

1. Use of water.

This indicator reflects the use of a main resource, which in many cases is a necessity but which can be limited, finite and restricted.

-embodied use	m^3
-operational use	m^3

2. Energy consumption.

This indicator has an impact on energy and its consumption for production. Energy sources create a clear environmental impact regardless of the source.

-embodied energy in raw material	J/kg
-embodied energy in object, construction part	J/kg
-construction energy use	J
-operational energy use	J
-end of life energy use	J

3. Impact on climate change.

The amount of produced CO_2 emissions is one of the main sustainability issues.

-embodied impact	kg (CO_2)
-construction impact	kg (CO_2)
-operational impact	kg (CO_2)
-end of life impact	kg (CO_2)

4. Waste generation hazardous/non-hazardous.

Waste generation as a whole is a sustainability issue, it is also reflected in recyclable and non recyclable waste. This indicator promotes the use of recyclable and non hazardous construction materials.

-generated waste from manufacturing	kg
-embodied waste	kg
-operational waste generation	kg
-end of life waste	kg

5. Indoor thermal environment

The indoor thermal environment indicator shows the reached values, and reflects how well the design implements the goals and the necessities from a human user point of view.

-air temperature effect	K
-air humidity effect	%
-air velocity effect	m^3/h

6. Visual comfort

The visual comfort indicator shows the reached values, and reflects how well the design implements the goals and the necessities from a human user point of view.

-illumination	lux [lx]
-transparency	%
-daylight factor	%

8. Life cycle cost

This indicator shows how sustainability issues have an impact on different costs of the life cycle, for example when compared with standard construction methods.

-material cost	€
-operational cost	€
-maintenance cost	€
-capital cost	€
-end of life cost	€

7. Life span

This shows the expected time span and how the chosen indicator values affect on the time span, and vice versa how a selected time span is reflected in the other chosen values of the construction.

-life cycle time span	a
-service time span	a

2. OTHER ASPECTS OF LIFE CYCLE BASED BUILDING PROCESS

2.1. Identification of new business opportunities within the stages of BIM/IFC/Test process

The life cycle based and BIM/IFC assisted design process requires expertise and services that can offer business opportunities for different actors involved. The required tasks and expertise are identified for different stages of the process.

BRIEF

The stage of requirement setting offers business opportunities for designer, tool provider and provider of EPDs and databases:

- Designer offers knowledge of ecobim tool's assessment possibilities.
- Designer guides goals setting process and assists in the selection of assessment areas.
- Provider of ecobim tool.
- Provider of test values.

DESIGN

In design management, the following expertise is needed:

- Designer offers knowledge to outcome.
- Designer maintains BIM and provides up to date IFC.
- Provider of indicator information.
- Provider of test values.
- Assessment validator and analyst.

CONSTRUCTION

In construction management the following services can be needed:

- Provider of comparison reports.
- Storing of goals agreements.
- Provider on testing evaluation and results on all stages.
- Provider of storing BIM/IFC with value sheet on all stages.

COMMISSIONING

The following is needed in commissioning validation:

- Provider of construction stages evaluation, reporting and IFC assessment.
- Following and reporting the goals agreement closing areas.

OPERATION & MAINTENANCE

Use and maintenance offers the following types of business opportunities:

- Provider of comparison of performance vs. goals agreement.
- Provider of maintenance protocol.
- Provider of up to date BIM maintaining and storing.
- Provider of end of life calculations.

2.2. Localisation issues in ecobim LC process

Presently the possibilities for starting an ecobim based LC process as described previously have several localisation issues which will affect the way the process is driven, as well as the results and the evaluation of the results.

When evaluated through the described stages of ecobim LC process, the following aspects have to be taken into account:

1. Requirements of local legislation, rules and regulations affect the goals setting. In this manner they also guide the process and affect the evaluation but also on the cost of selections.
2. The climate zone: temperature, humidity, light and wind, all affect the issues of choosing construction and technical systems, materials, insulation, and building volume.
3. The available and commonly used construction systems affect the selection of materials, insulation, technical systems, size of building and cost.
4. The available and commonly used materials affect the selection of construction system, technical systems, size of building and cost.

When the above mentioned have been taken into account and the goals are set, the assessment process itself has to adjust to the local environment.

When assessing the project by using the ecobim indicators, also many of the values of the indicators are subject to local variation. As an example, depending on the location, in some cases it is more viable to manufacture some materials locally and in some cases to transport them from elsewhere. These choices vary locally and have an effect on environmental impacts and costs. In this way the ecobim LC process steers the project towards sustainability also on a local level.

2.3. Up-scaling issues in ecobim LC process and business models

The pre-design stages (area planning, zoning and site planning) can also be brought to the ecobim assessment process.

Already in the early stages of a project simple building masses can be assessed by comparing different locations and the building masses, their directions, volumes and forms within the different locations. This can be a helpful tool for area planning on different levels. Also issues of distances to available water, waste, electricity, energy and transportation systems will be assessed. The tool can provide numerical information for comparison and assessment purposes.

The current practices in area planning and zoning differ from each other in different countries. The environmental sustainability issues are continually increasing their importance also in larger scale preliminary planning. The importance of open numerical information which is easily assessable is evident, and can be of significant help when arguing and debating on alternative options and making and communicating decisions.

The strength of the ecobim tool lies in its fast adaptability and response to different options and changes, thus easily giving answers and directing towards the desired result.

3. CONCLUSIONS

This report described BIM supported life cycle based building process and sustainability assessment. The characteristics of different stages were highlighted, applicability in different contexts considered and new business opportunities identified.

The main goal of the process and sustainability assessment described in this document is to simplify the process itself. For that to happen, the following is needed: a project created with 3D CAD, exported IFC with correct properties, correct assessable data for the selected indicators, excel of the exported selected properties from the IFC, excel with macros which is capable of computing results of the selected indicators and the selected properties from the IFC.

As explained in this report, indicators are used through the whole building process to set sustainability targets, adjust those and monitor and validate the achieved performance. In the BIM based process, indicators are also important to communicate sustainability aspects between different stakeholders involved in the process and to justify decisions. Since the assessment of the indicators requires time and resources (e.g. use of reliable data sources) and for the communication of the results the data often needs to be stored and exported to different tools used by different actors, it has been identified as a need to define the decision points in the life cycle process during which the indicators should be assessed.

As a solution the description of different stages can include an assessment schedule which corresponds to the decision making throughout the process. The goal setting includes a sustainability assessment schedule in which the assessment points are predefined when the assessed indicators are selected for the project. This does not hinder the assessment of the selected indicators whenever wanted. As a consequence, deliverable D2.3 will define the required assessment points for the indicators.

In principle, the party responsible for the assessment procedure should also be responsible for collecting the correct data and carrying out the assessment. In addition, it should take care of storing the data and assessment results. To enable a better understanding of its benefits, the solution abovementioned will be applied to the Finnish case study.

It should be also stressed that the indicators selected and described in this deliverable are a substantial part of the BIM based assessment process described. However, even though these indicators have proven to be relevant along years of professional practice, as already discussed in section 2.2, it is considered necessary to test their validity further. Therefore, a focused workshop with SMEs will be held in Finland to collect their feedback on the set proposed.