ecobim

value driven life cycle based sustainable business models

WP4 Case studies

D4.1a Finnish case study

Revision: Final

Due date: 2014-06-30

Actual release date: 2015-03-30

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 WP4		Eco-Innovera	
No & name	**D4.1a Finnish case study**				
Status	<Draft / Working / Released>	**Due**	m18	**Date**	2014-06-30
Author(s)	Jukka Lommi (T&L), Aapo Huovila, Carmen Antuña (VTT)				
Editor	Jukka Lommi (T&L)				
Description	This document describes the Finnish case study: the project building, its two versions, the workflow through IFC export, assessment tools, indicators and the results. It also addresses new business models within the assessment process, upscaling issues of the tools and the need for an import solution for up-to-date values of performance properties.				
Comments					
Document workflow					
Released	T&L			**Date**	2015-03-24
Accepted	VTT			**Date**	2015-03-30

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

EXECUTIVE SUMMARY

The Finnish case study focuses on an apartment building project and the assessment of the project with two different tools that allow BIM supported life cycle based sustainability assessment. The project has two different versions which both are assessed. In this case study the tools are tested to assess embodied greenhouse gas emissions but several other indicators could already be assessed as well. These methods result in new services and also in new business models, especially for SMEs. The achieved impacts can be assessed through increased environmental, economic and social or cultural sustainability throughout the process.

This deliverable describes the workflow of the BIM supported life cycle based sustainability assessment in the case study describing the value driven process when using these two tools, IFC based assessment, concurrent stages within the BIM/IFC/Test process and ecobim indicators. New business models for life cycle based building process are addressed as these tools already represent new possibilities for assessment. They are linked with new business models within the stages of BIM/IFC/Test process and local adaptation and upscaling issues related to the tools and business models.

The report explains the use of indicators in the whole building process to set sustainability targets when using the two IFC based assessment tools. 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. This brings forth the most significant issue of developing the tools towards a more open structure, where accurate performance properties from databases could be imported in the tools for accurate locally specific assessment results.

1. THE ASSESSMENT PROCESS IN THE FINNISH CASE STUDY

1.1 Introduction

The Finnish case study led by Tiuri & Lommi Architects Ltd. focused on an apartment building project, which at the moment of IFC export had reached the commissioning stage. The building site is situated in Finland, in the city of Vantaa, close to the commercial center of Tikkurila with walking distance to the local train station.

The site consists of six buildings forming a semi-closed block. Three of the six buildings have been previously built and the case study focuses on the fourth building.

The chosen building includes a basement and five apartment floors. A parking is situated in a garage built under the courtyard of the site. There are entrances to the building from the street and from the courtyard which levels with the first floor of the building.

The chosen building went through a revision of design concerning the amount of apartment units, floor plans, windows and balconies.

The size and house types of the 1st version were as follows:

- A five storey apartment building with 45 units
- Floor area (gross): 3956 m2 + basement 303 m2
- Floor area (net): 2771 m2

The size and house types of the 2nd version were as follows:

- A five storey apartment building with 50 units
- Floor area (gross): 3956 m2 + basement 295 m2
- Floor area (net): 2775 m2

The construction period was from May 2013 to October 2014.

As a standard solution the following properties were already obtained in the building process:

- A good indoor climate is obtained in the flats with mechanical intake/exhaust ventilation with heat recovery.
- Indoor materials detrimental to health are not used.
- The building is provided with moisture control plan for construction, a maintenance plan and user instructions for materials and equipment.

New energy performance regulations were launched in Finland in 2013 and their implementation meant better energy performance for new buildings. Their implementation requires the use of an energy certificate for all new buildings and for sold or rented existing buildings. The energy performance is calculated with factors of primary energy using a new calculation methodology.

1.2 Workflow of a BIM based sustainable value driven process

The BIM supported life cycle based sustainability process is thoroughly explained in ecobim deliverable 2.2 “Description of the life cycle based design/procurement process”. In this section the general workflow of the process and its main points are described with emphasis on the workflow itself.

The ecobim life cycle process is a BIM supported IFC based sustainability assessment process which relies on the use of the different ICT solutions developed and used in the project.

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 and material information of the used parts, and can deliver information about amount, size, volume, direction and geographical location.

The basic workflow with overlapping stages is common to all BIM design. 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 design process. An assessment tool supporting BIM is used in the sustainability assessment process. For the tool's assessment purposes the required numerical indicator values describe environmental or technical performance properties that have to be available for all used parts.

The goals are sustainability related objectives set during the first stage in requirement setting (brief). Those are expressed with help of quantity values and performance properties. Quantity values define the amount and size of a construction product. The performance properties describe the targeted performance level of the end product and include both environmental and technical properties. The sustainable value driven process requires that the selected optional variables in the goal setting should be expressed with numerical values which are assessable with the proposed ecobim indicators.

In the requirement setting stage indicators are subject to selection. The selected ecobim indicators for a project reflect the sustainable values given in the goal agreement. The selected indicators are then assessed during the process. This sets the demand to correct the values which have to be presented for each selected indicator.

Several optional variables are numerical values regarding the size or amount of different parts of the building. 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 choosing it to be a concrete or a steel structure. The model and the IFC output include the wall structure and its size, but it is also possible to assess it with different tools 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.

As described above, the workflow of a design process starts with a certain goal setting which is agreed on in the brief. The goals can be related to economic, social and environmental aspects. The workflow within the overlapping stages can include assessment of different selected areas of the design. The assessment can be predefined but it can also be done whenever necessary.

As the design process continues the direction is chosen at every assessment point. The assessment is done with the help of tools in which the output within every assessment stage is through the use of an exported IFC model. The assessment tools use the numerical and directional values included in the IFC model. The tools themselves include indicators and the resulting values of the indicators can be assessed throughout the process. The direction can of course vary, but with the help of the tools developed in ecobim the chosen eco-values are also present at every assessment stage. It will also be quite simple and fast to evaluate a certain chosen building part at a chosen stage, for example by changing its material, technology, size, and amount or changing the part totally to a different one. These different options can be compared and a desired result can be optimised. The result is implemented into the BIM and the workflow continues with several steps which include stages of assessment and agreement, and which enable the development of the design towards a chosen direction.

The possibility to choose diminishes towards the end of the construction process. With the help of BIM supported life cycle based sustainability assessment tools it is possible to evaluate the whole process and to choose between several possibilities already at an early stage of the process. By doing so a desired result is easier to achieve.

1.3 Use of Ilmari and eveBIM-Elodie tools in BIM supported life cycle based assessment

The main emphasis in the case study is to test and evaluate how easily the BIM supported indicators and ICT solutions developed in ecobim function in IFC based environmental assessment of the case study building. More specifically, the case study evaluates how embodied carbon can be calculated for the case study building with the Finnish tool Ilmari and the French tool eveBIM/Elodie while the plot and the building size of the case study building are strictly regulated and the construction system remains the same.

When the selected case study building design was brought to the construction stage, the owner decided to alter the design (see Figures 1 and 2). The alteration of the design was completed in two weeks.

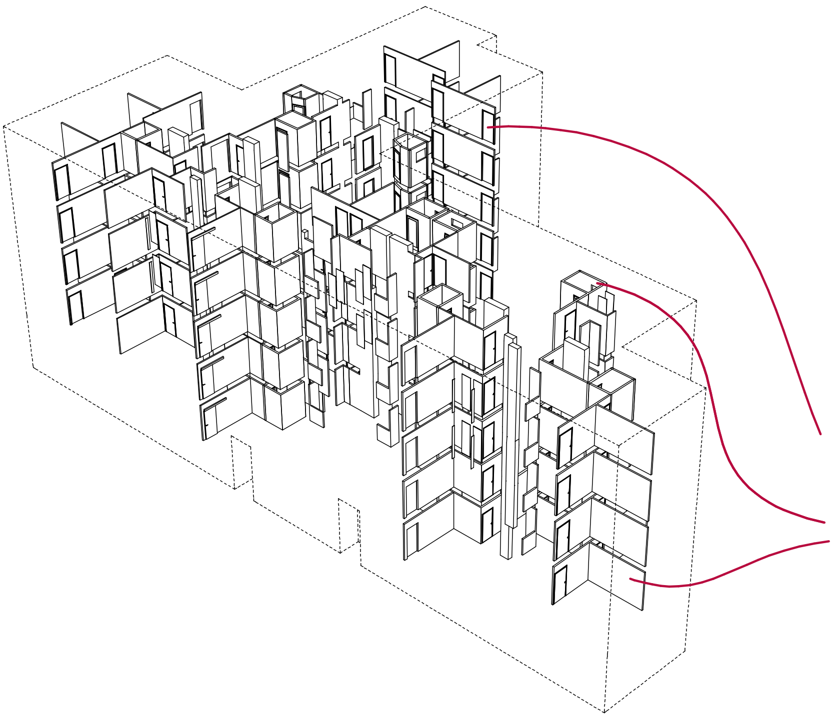

Figure 1: Interior changes' effects on assessment; a 3D view (As Oy Vantaan Puuvilla, ArchiCAD 3D model, Arkkitehtitoimisto Tiuri & Lommi Oy).

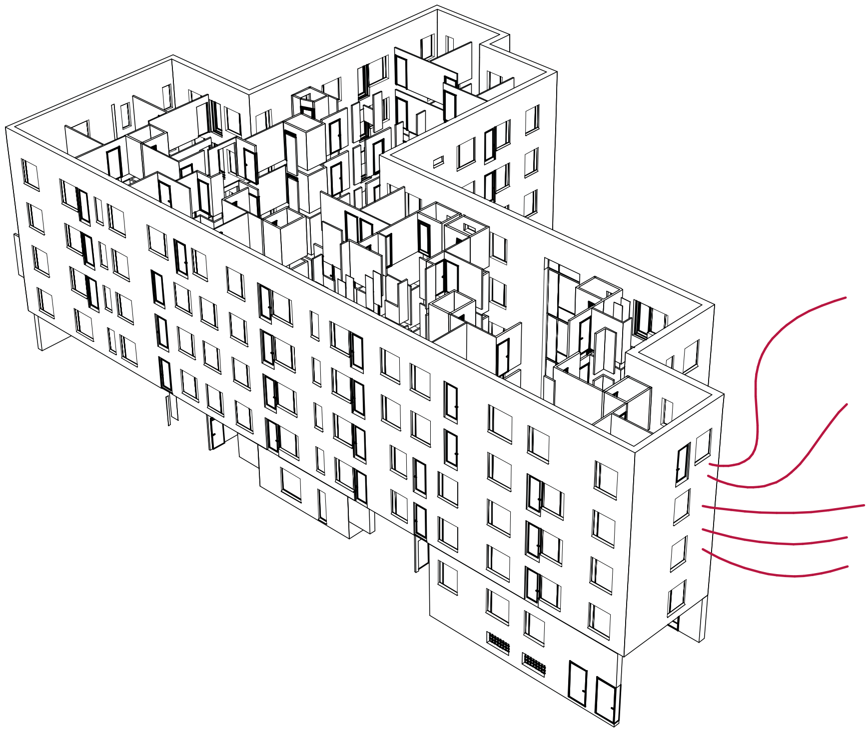

Figure 2: Exterior wall changes' effects on assessment, a 3D view (As Oy Vantaan Puuvilla, ArchiCAD 3D model, Arkkitehtitoimisto Tiuri & Lommi Oy).

As the workflow continued, we came to the situation where the second IFC is a commissioning model. It is of course more precise, but altogether a good version for comparison. It includes changes in floor plans, windows and balconies, but the building mass, its size, dimensions and materials remained the same. This now gives us the possibility to compare the two designs, their slight differences and what is the impact on the results.

For the ecobim evaluation two tools have been used. These tools use the above described method where the imported IFC model information is assessed with a set of selected ecobim indicators.

The first tool is Ilmari which was developed by VTT and Pöyry Ltd. in Finland. The tool has built in a value indicator assessment set for embodied impact on climate change, in kilograms of CO_2 equivalents. Ilmari tool is based on a design which can be easily further developed. As the IFC imports all the given numerical and material information of the used parts of the BIM, and can deliver information about amount, size, volume, direction and geographical location, an addition of a new indicator set is technically very simple. The main issue of the further development of Ilmari is to include more assessment areas to the program, and more performance property values with accurate information.

The second tool is Elodie, developed by CSTB in France. The tool already has several ecobim indicator sets built in and allows an import of French EPDs from the Inies database and has an interface to the BIM tool eveBIM also used in ecobim. Elodie can already assess several of the ecobim indicators when the values of the BIM are present in the exported IFC. Also here the accurate information of the performance properties has to be present. In the case study the comparison of the Finnish and French tools is made using national EPD databases. Thus, for the French evaluation of embodied kg CO_2 values Inies database is used as if the case study building was constructed in France.

The two different versions of the case study have been evaluated with Ilmari. Both IFC exports have been assessed. The performance properties have been given to the building parts: mainly walls, slabs, pillars and beams. This was done by adding performance properties, in this case embodied CO_2 values used in Finland in 2012, to all the building parts. The results are computed using Ilmari, which combines the volumes of the IFC model with accurate CO_2 values.

Elodie uses basically the same kind of process, but in addition to the embodied carbon the tool contains many other sustainable building indicators that can be assessed along with it. The environmental performance properties are provided by manufacturers and part of those are verified by a third party. Still, as in Ilmari, the different properties have to be given to different materials manually for the evaluation. This is mainly due to the fact that the case study construction includes combinations of materials different from the ones used in France. When assessing French structure types, the workflow requires less manual effort.

We now have comparisons using the two tools and two material performance properties sets.

1.4 Case study workflow and evaluation

The objects and building parts used in the BIM include quantity values and assessable values of performance properties that are used to calculate indicators. Quantity values define quantities, i.e. amount, size, area, volume, height, length etc. of a building part. The performance properties describe the environmental or technical properties of a building part.

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 be easily assessed as the values of the indicators can be numerically presented. This is essential as the life cycle process is BIM based. Those indicators have been selected in ecobim as core indicators and represent the main points for the life cycle sustainability assessment process. This selection does not hinder the possibility for adding other indicators in a project as long as the values can be numerically presented.

1. Environmental impact

- 1.1. Energy
  - 1.1.1 Embodied energy [kWh/m^2/a]
  - 1.1.2 Operational energy [kWh/m^2/a]
- 1.2 GWP
  - 1.2.1 Embodied GHG emissions [kg (CO_2 eq.)/m^2/a]
  - 1.2.2 Operational GHG emissions [kg (CO_2 eq.)/m^2/a]
- 1.3 Water
  - 1.3.1 Embodied water [m^3/m^2/a]
  - 1.3.2 Operational water [m^3/m^2/a]
- 1.4 Waste
  - 1.4.1 Embodied waste [kg/m^2/a]
  - 1.4.2 Operational waste [kg/m^2/a]

2. Indoor environmental quality

- 2.1. Thermal comfort
  - 2.1.1 Operative temperature [˚C]
  - 2.1.2 Air humidity [%]
  - 2.1.3 Air velocity [m/s]
- 2.2 Visual comfort
  - 2.2.1 Illuminance [lux]
  - 2.2.2 Daylight factor [%]
- 2.3 Acoustic comfort
  - 2.3.1 Noise levels [dB]
- 2.4 IAQ
  - 2.4.1 CO_2 concentration [ppm (CO_2)]

3. Economy

- 3.1. Life cycle costs
  - 3.1.1 Life cycle costs [EUR]

The selection of indicators studied in this case study has been diminished to one indicator. This is due to the fact that the scope of this case study is to compare Ilmari and Elodie tools and Ilmari is developed to assess only the embodied GHG indicator.

The Elodie tool is a more comprehensive life cycle assessment tool and it is already able to calculate all the ecobim indicators related to the material impacts: embodied energy, GHG emissions, waste and water. The only issue is the life cycle coverage: it is not always transparent which stages are included.

Even though Ilmari has been initially developed to calculate embodied GHG emissions only, it is considered here that it would be useful to further develop it to cover also other indicators. Indicator categories and indicators are presented on the next page including the evaluation of their compatibility with Ilmari. The availability of performance property values for all indicators is crucial for the functionality of the tools. It is also considered that Elodie could cover other fields of indicators than environmental only.

Embodied water and energy

These indicators can be easily added to Ilmari as this information is usually available in EPDs. The possibility to modularly separate the values related to the product, construction, use and end-of-life stages depends on whether the EPD databases follow the new standard EN 15804. Uniformity between countries, databases and EPDs hasn't been reached yet.

Embodied waste generation

These indicators can be easily added to Ilmari. To which extent different waste types are separated is a question that is not always clear. In addition to the total amount of waste, it is always very important to know the share of hazardous, non-hazardous, inert, nuclear, re-usable and biodegradable waste. There is currently no uniformity in the extent of details to which this separation between waste types is made and expressed.

Indoor environment quality indicators

These indicators can be technically added to both tools as those are numerical values that can be easily implemented. The question is from where to get or how to evaluate those values. In design phase separate simulation tools are needed and in operation the values can be obtained through measurements. Benchmark values and standardised methods for comparisons represent another key issue that needs to be solved independently of these tools.

Life cycle cost

This indicator can be easily added to both tools as technically only numerical values need to be implemented. The estimations and calculations need to follow agreed methods and need to be done by experts. Another question is how the targets and results should be expressed.

Currently the different indicators can be calculated by separate and well adapted tools. The addition of new categories would bring the possibility to compare the more holistic performance: what are the strong and weak points of a solution and what is the impact of change in one indicator on other indicators or categories. Therefore, in such case, attention needs to be put to the user interface used for the comparisons and analysis of the results (graphs, spiders, etc.). But if the indicators are fixed for one tool that cover many aspects, the drawback can be the lack of flexibility of the tool to adapt to calculate the indicators needed by a certain stakeholder in a specific project.

The result of the test in this case study uses the two tools and the selection of indicators for the use have proved that both tools are capable of computing results of the selected indicator from the exported IFC models. Essential for the further development of these tools is the need for correct values of the performance properties. The performance property values are strongly related to the location. Values will vary significantly globally as several indicators are dealt with from very different local perspectives. Also this shows the main issues of the desired development for the tools, as at this point both tools relied on manual value input. What is essential for further development of the tools is an up to date database import solution of the performance properties values which has to be present and integrated in the tools.

1.5 Calculation of embodied carbon footprint with Ilmari and eveBIM-Elodie tools

The comparison between the two tools and the two IFC models of the Puuvilla apartment building have resulted in better analyses and upgrading propositions.

The Ilmari tool is an online tool where construction materials for structure types are selected from preloaded variables (type, thickness etc.). The volumes are imported from the IFC file and the calculation is done with the tool online. The embodied GHG emissions used are from Finnish 2012 EPDs. The results are given per structure type, walls, slabs etc. grouped and total results. The comparison was easily done online from selected two versions of the building.

The tool itself is straightforward and simple to use but for further use and to be able to add the selected ecobim indicators for assessment, an upgrade of the user interface and of the EPD information import would be essential.

The results from the calculation of embodied carbon footprint with the Ilmari tool for the two designs of the case study building are presented in Table 1.

Table 1: Results from the calculation of embodied carbon footprint with Ilmari for the two versions of the case building

Version		Design 1	Design 2
Slabs	Total area	4 804 m^2	4 888 m^2
	Total GHG emissions	468 635 [Kg (CO_2 eq)]	477 159 [Kg (CO_2 eq)]
Exterior walls	Total area	2 121 m^2	2 296 m^2
	Total GHG emissions	190 731 [Kg (CO_2 eq)]	241 568 [Kg (CO_2 eq)]
Partition walls	Total area	4 366 m^2	3 767 m^2
	Total GHG emissions	652 173 [Kg (CO_2 eq)]	662 649 [Kg (CO_2 eq)]
Total emissions	Total GHG emissions	1 311 540 [Kg (CO_2 eq)]	1 381 376 [Kg (CO_2 eq)]
	Total GHG emissions per area	303 [Kg (CO_2 eq)/m^2]	303 [Kg (CO_2 eq)/m^2]
	Total GHG emissions per volume	95 [Kg (CO_2 eq)/m^3]	95 [Kg (CO_2 eq)/m^3]

The calculations gave us two slightly different results on embodied GHG emissions. This reflects the addition of number of flats and windows in the version 2 of the design.

The Elodie tool is more versatile and advanced in several ways. The tool functions are described more thoroughly in the ecobim deliverable 3.2 “User interface”. The user interface is coherent and the tool provides already several of the ecobim indicators for assessment. The restriction of the tool lies in its built-in system which at the moment only supports French EPDs (called FDES) from the Inies database. Those EPDs are given for existing French construction products. The problem that was encountered when trying to assess the Finnish case building with the French tool and French EPDs was that for some building parts the same material thicknesses didn’t exist in France. The only solution would have been to convert the EPD result based on the difference in the thickness. This option was, however, not allowed by the eveBIM-Elodie tool interface. Therefore in such cases the environmental impacts were calculated in eveBIM-Elodie with the closest French equivalent of the building part. The results of the calculation with eveBIM-Elodie tool are shown in Figure 3.

Component module - More results

Component module

Calculation period :
- (•) one year
- ( ) the building life cycle

Available building reference units :
- ( ) Without unit
- (•) Net floor area 'SHON' (m²)
- ( ) Length of building occupancy (number of months per year)

Name of the environmental impact	Value	Unit
Use of total primary energy	10.4 ± 2.09	KWh / m² Net floor area 'SHON' / year
Use of total renewable energy	9.31 ± 1.86	KWh / m² Net floor area 'SHON' / year
Global Warming Potential, GWP	2.86 ± 5.71e-001	kg equivalent CO2 / m² Net floor area 'SHON' / year
Use of net fresh water	38.6 ± 7.72	L / m² Net floor area 'SHON' / year
Hazardous waste to disposal	6.27e-003 ± 1.25e-003	kg / m² Net floor area 'SHON' / year
Non hazardous waste to disposal	11.4 ± 2.28	kg / m² Net floor area 'SHON' / year
Radioactive waste to disposal	2.50e-004 ± 4.99e-005	kg / m² Net floor area 'SHON' / year
Acidification Potential of land and water, AP	1.09e-002 ± 2.18e-003	kg equivalent SO2 / m² Net floor area 'SHON' / year
Formation potential of tropospheric ozone photochemicals oxidants, POCP	2.14e-003 ± 4.29e-004	kg equivalent ethylene / m² Net floor area 'SHON' / year

Figure 3: Elodie LCA results, see GWP value (Elodie calculations made by CSTB).

Since Elodie calculations were made for a life time of 100 years, the total result of embodied carbon is 286 kg CO_2, eq / m^2 while the result with Ilmari was 303 kg CO_2, eq / m^2. The difference is explained by the use of national Finnish and French EPDs, some wrong thicknesses in Elodie and possible differences in the data coverage of the EPDs.

At least a quick analysis of the French Inies EPD database indicates that it doesn't follow the principles of the latest standard EN 15804. The impacts of different life cycle stages are not yet modularly expressed and it is therefore difficult to know what is the data coverage used for the environmental indicators. Since the environmental impact is expressed only as "total life cycle", it is difficult to know for example if the use and end-of-life stages are considered and how.

For further use and to be able to add the selected ecobim indicators for assessment an upgrade for the EPD information import is essential. The Ilmari tool is more transparent and enables the calculation of a precise and reliable embodied carbon footprint. The calculation requires quite much manual work. The EPDs could be updated.

Elodie is a much more comprehensive LCA tool that currently enables the calculation of nine environmental indicators. The user interface enables the analysis of the results in many ways. The connections to Inies EPD database and eveBIM tool make BIM-supported life cycle analysis quite easy. Some built-in features as presented earlier are not transparent which is problematic when the user wants to have a precise result. This case study also shows that the tool is not yet applicable outside France.

1.6 Business models

Business model possibilities have been analyzed during the case study assessment process. The case study is an assessment of two versions of a building at a design stage showing the difference between the final version and the commissioning version. This can be of course assessed with all available indicators, which gives us the differences in all the assessed parts. For a business model this kind of example of comparison using selected indicators should be one that would, after the comparison, lead the design towards a desired direction.

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.

What this case study strongly brought up is the importance and need for correct values of the performance properties. The comparison, argumentation and decision making throughout the process lies in the open numerical information in terms of results but also in the values of the performance properties. A tool which provides easy and reliable assessment is a significant help when arguing and debating on alternative options and making and communicating decisions.

Regarding both of the tools used in the case study also a significant upgrade of the tools is needed for a direct import possibility for the performance properties database. This import mechanism will provide users an interface where the local databases can be easily selected and used for an assessment base.

The strength of the ecobim tools lies in their fast adaptability and response to different options and changes, thus easily giving answers. Even if the client is not directly expecting exact values, the assessments will direct the decision process towards the desired result.

2. Conclusions

This case study described the assessment process of the two versions of the project building "Puuvilla" with two different tools Ilmari and Elodie analysing their functionality, versatility and limitations. The Puuvilla building project was created with 3D CAD and exported IFC with correct properties. Both of the tools use correct assessable data for the selected indicator embodied carbon footprint and are capable of computing results for the selected indicator and the selected properties from the IFC.

There is a need for a tool like Ilmari in Finland. The tool is transparent and enables a precise and reliable calculation of embodied carbon footprint. The calculation requires, however, quite much manual work. As a next step it is recommended to update the tool's EPD database, data import system and the user interface, and further develop the tool to be able to calculate also other environmental indicators than embodied carbon footprint.

The Elodie tool is a more comprehensive life cycle assessment tool and is already able to calculate all the ecobim indicators related to the material impacts (i.e. embodied energy, GWP, waste and water). The user interface enables the analysis of the results in many ways. The connections to Inies EPD database and eveBIM tool make BIM-supported life cycle analysis easy. There are however issues of lack of transparency. For life cycle coverage of EPDs it is not always clear which stages are included. It was also found out that the tool is not yet adapted for use outside France. In this case study it was not always possible to use the correct material thicknesses because only those typically used in France were available and a conversion was not allowed.

The comparison, argumentation and decision making throughout the assessment process lie in the open and transparent numerical information in terms of results but also in the reliable and accurate values of performance properties. A tool which provides easy and reliable assessment is a significant help when arguing and debating on alternative options and making and communicating decisions. The drawback of the tools currently stands in the lack of a reliable and versatile import solution from different EPD databases. The most significant issue is to develop the tools towards a more open structure where accurate performance properties from databases could be imported in the tools for accurate locally specific assessment results. As a solution new business models are described including the upgrade of both tools for more open database import features.

Both of the tools are quite straightforward, coherent, accurate and easy to use and adjust. Their strength is the fast adaptability and response to different options and changes, thus easily giving answers. The use of this type of tools will significantly speed up and simplify the assessment process. Even if the client is not directly expecting exact values, the assessments will direct the decision process towards the desired result.

3. Acknowledgements

The LCA calculations of the Finnish case study building with its IFC exports were carried out by Elisa Rolland (CSTB) with the eveBIM-Elodie tool and by Jukka Lommi (TL) with the Ilmari tool. In addition to Elisa Rolland, Eric Lebègue from CSTB is acknowledged for general consultation with the French ICT solutions. Sirje Vares and Mikko Tuomisto from VTT are acknowledged for their support with the use of the Ilmari tool.