Life Cycle Sustainable Assessment and BIM

Bruno Fiès
Research Engineer
Centre Scientifique et Technique du Bâtiment
France
bruno.fies@cstb.fr

Thomas Lützkendorf
Professor
Karlsruhe Institute of Technology, Chair of Sustainable Management of Housing and Real Estate
Germany
thomas.luetzkendorf@kit.edu

M.Sc. Maria Balouktsi, Karlsruhe Institute of Technology, Chair of Sustainable Management of Housing and Real Estate, Germany, maria.balouktsi@kit.edu

Short Summary

The task of assessing the contribution of individual buildings to sustainable development becomes more and more complex. Currently, there is a transition in the sustainability assessment from a previously predominantly qualitative to a predominantly quantitative evaluation. In addition, in the assessment the entire life cycle of a building is included, increasing the need to exchange and adapt data related not only to the technical and functional requirements of the building but also to the sustainability oriented requirements throughout the life cycle. As a result sustainability consultants among others have been added to the traditional building stakeholder groups, like designers and owners. Therefore, as communication, organization and management of information flow becomes of much greater importance, the integration of sustainable building assessment and benchmarking systems with the different stages of BIM is suggested. The BIM (Building Information Model) creates a single information node that simplifies updates and synchronisation mechanisms among the various actors involved in the same construction project. We will present in the paper how the current version of the IFC (the open language supporting the exchange with the BIM) suits the needs to compute and store the various indicators selected or developed in the frame of the SuperBuildings projects.

Keywords: Sustainable Assessment, Sustainable indicators, BIM, IFC, IFC4, Property Sets

1. Introduction to Sustainable Building Assessment

The assessment of the contribution of individual buildings to sustainable development is a complex task. This has to do both with the specifics of the object of assessment and the complexity of the assessment task.
The object of assessment is the building including its plot. In the assessment the entire life cycle of a building is included from the manufacture of building products to the construction of the building on its plot as well as from the stage of operation, management and maintenance to deconstruction and disposal.

To ensure the comparability of the assessment results, the building must be described through its functional equivalent. This task is usually carried out with reference to the functional and technical requirements of the owner of the building, which can be supplemented in accordance with EN 15643-1 [1] with additional demands on the economic, environmental and social performance of the building.
According to the ISO 21929-1:2011 [2] and EN 15643-1 the described requirements for a sustainability assessment of buildings are from an environmental, economic and social viewpoint.

Thus, the impact of manufacturing, construction, use, removal and disposal of the building on the environment, economy (including managerial interests of those involved) and society (including the interests of the community, the participants at the manufacturing and construction, the neighbourhood and the immediate users) is evaluated. Additionally, it needs to be checked and displayed whether and how the building meets all the technical and most importantly the functional requirements in an effective way.
Currently, in the sustainability assessment a shift is taking place. There is a transition from a previously predominantly qualitative (e.g., presence of green roofs) to a predominantly quantitative evaluation (e.g., calculation and evaluation of the GWP). For example, the Life Cycle Analysis is applied, which combines the Life Cycle Assessment (LCA) with the Life Cycle Costing (LCC), while this is often supplemented by a user satisfaction analysis, or a complaint management.
The results of a sustainability assessment can be used to improve the building performance only when they are successfully integrated into the process of planning, construction and management so that they are available at the time of a decision. This requires that the sustainability assessment can be adapted to the achieved state during the planning process and the lifecycle of the building. This state is a consequence of present at that time information about the building, its components and its former or foreseeable future life span as well as of the type of decisions reached at that time.
The impact of a building on the environment, economy and society during its life cycle must not only be described and evaluated, but also manipulated in a targeted way. This is done not only during the formulation of the brief, but as well as during the design, construction, management, deconstruction and disposal. The information on a building over its life cycle must not only be managed but also updated, supplemented and expanded.

2. The need for input data

It is clear that a prerequisite for the sustainability assessment and management in the life cycle of buildings is the identification, update and supplementation of information and data as well as their interpretation and assessment. Thus, the management of data both on the life cycle of buildings (perspective of object of assessment) and in the life cycle of buildings (perspective of a process of the life cycle of the building) becomes essential. For managing the information appropriately issues arise in relation to the identification and updating of data, including the representation of data source, data quality and data history. This includes information on:

- the location, including the forecast of future developments (e.g., climate and climate change, existing infrastructure and infrastructure development)
- the site (e.g. the ground, exposition to sun light)
- the user requirements (including requirements for the technical and functional quality, possibly supplemented by requirements for the economic, environmental and/or social performance of the building)
- the functional equivalent on the basis of user requirements including scenarios of for the nature, scale and intensity of use
- the geometry of the building and its components
- the physical composition of the building at the time of its construction – among others as a prerequisite for the application of the LCA (from cradle to handover) - including verifying the completeness of its description (possibly including the costs incurred during the construction of divergence and breakage losses of construction products in consequence of the construction activities)
- the cost of manufacture and construction of the building - possibly expressed as the construction price at the time of delivery, if calculated using the element method
- the actual or the forecast of the consumption of services (energy, water) and the occurrence of wastewater and waste, if necessary separately for the user related and the building related activities
- the actual or the forecast of the material consumption due to cleaning, repair and replacement investments on the basis of scenarios, including where necessary the possibility of checking of the coverage completeness of the data collection

The demand of data with a direct as well as indirect relationship with sustainability assessment needs to be specified. This is the subset of data that arise during the life cycle of buildings and has to be managed.
The determination of data for a sustainability assessment can be based on a documentation of requirements, a prediction (e.g., planning, calculation or evaluation), the representation of current conditions or facts and the acquisition of consumption data or survey results. On the one hand, the assessment has to be guided by the available data in relation to the various stages of planning and thereby the first generic or average data to be replaced gradually by manufacturer- and product-specific information. On the other hand, in the course of the construction process and the life cycle planned data have to be replaced by actual data. Possibly the actual values have also to be compared with the planned ones. In this case, the respective perspectives (geometrical, physical, functional, technical, environmental, economic, and social) are considered and managed. In particular, the ecological assessment requires further calculations. Both data from the area of physical composition of the building, including the scenarios for maintenance and replacement cycles as well as in the field of supply and disposal must be linked to data that allow the creation of an LCA. Usually, these are available on the basis of environmental product declarations (EPD's).

3. The need for harmonised indicators

In the frame of the SuperBuildings project, a number of European and international harmonisation and standardisation activities, i.e. CEN TC 350, ISO TC59 SC17, Sustainable Building Alliance (SBA), UNEP SBCI, LEnSE and Perfection, has been reviewed for the current availability and state of harmonisation of sustainability indicators and their assessment methods for buildings. Based on these analysis [3] and review [4], it can be conclude that both issues and indicators that are not (commonly) covered by the different tools and issues and indicators that are most occurring within the tools have been identified.
For all issues that are covered by more than one tool, the variation in assessment criteria and methods has been looked into in order to draw conclusions on their needs for further development and/or harmonisation.
Furthermore, both missing indicators and indicators that need (further) development and core indicators have been identified and compared to the indicators that are considered by the different tools.

4. Selected indicators

More than 20 key indicators have been either selected, or improved or developed, and documented through a structured format [5]. 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, cultural heritage, aesthetic quality, long term stability of economic value.
These indicators are listed in three tables below. Each table is presenting the indicators sorted by “subject of concerns” under the three “dimensions” of sustainability which are the environmental; societal and economic aspects.
Each of the selected indicators is documented on a textual basis according to the same structured methodology.
The next step is now to identify if and how the integration of these sustainable indicators with the BIM is feasible.

5. Relevance of a BIM based approach

5.1 Definition of BIM

There are several definitions for the notion of BIM. The Acronym BIM is sometimes turned into “Building Information Model” or “Building Information Modelling”, one representing more the concept and the other the approach.

On Wikipedia, the following definition is given to BIM:
"*Building information modelling covers geometry, spatial relationships, light analysis, geographic information, quantities and properties of building components (for example manufacturers' details). BIM can be used to demonstrate the entire building life cycle, including the processes of construction and facility operation. Quantities and shared properties of materials can be extracted easily. Scopes of work can be isolated and defined. Systems, assemblies and sequences can be shown in a relative scale with the entire facility or group of facilities. Dynamic information of the building, such as sensor measurements and control signals from the building systems, can also be incorporated within BIM to support analysis of building operation and maintenance.*"
This definition presents several facets of the notion of BIM, among others, the most important ones are:

- It covers the whole life cycle of a building project;
- It creates a single information node that simplifies updates and synchronisation mechanism among actors of the same construction project.
- It is a structured collection of building and construction objects including physical components, spaces, processes, actors involved, and relationships between these objects. All of these objects may be enriched by shared or specific properties. As a con-sequence, quantities or values stored in these proper-ties can be extracted and reused as the source of in-formation to perform calculations, analysis or simulations.
- It is a mean to enable heterogeneous actors to work together in an efficient way and for better results;

SD pillar	Subject of concern	Issue	Indicator
Environmental	Resources	Depletion of non-renewable energy resources	Consumption of non-renewable primary energy
		Non-renewable and scarce material resources	-
		Sustainable management of renewable resources	-
		Rational use of water	Embodied water use Operational water use Wastewater production
		Land use / Change of land use	Soil sealing Change of land use
	Biodiversity	Loss of biodiversity Respect of the local original species (planting) Preservation / improvement / restoration of local biodiversity	-
	Ecosystems	Protection of atmosphere (GHG)	Global warming potential
		Protection of atmosphere (other pollutants)	-
		Protection of water and soil quality (pollution and waste)	-
			Construction and demolition waste generation - Non-hazardous waste to disposal - Hazardous waste to disposal - Nuclear waste to disposal Solid waste separation
	Climatic systems	Climatic systems (risk of extreme climatic events) Adaptation to climate change	-

SD pillar	Subject of concern	Issue	Indicator
Societal	Health	Indoor air quality	Concentration of various pollutants
	Comfort	Thermal comfort	PMV (Predicted Mean Vote) PPD (Predicted Percentage Dissatisfied) Operative temperature Air temperature Relative Humidity Air velocity
		Visual comfort	Illuminance Daylight factor
		Acoustic comfort	-
	Safety / security		-
	Human interactions / relationships		-
	Culture and architecture	Architectural quality	Aesthetic quality
		Cultural heritage	Monument or monumental value / Historical value

SD pillar	Subject of concern	Issue	Indicator
Economic	Economic value	Economic value of 'goods' on the long term versus obsolescence	Life cycle costs - Capital cost - Costs in the operational phase *(Whole life costs)* *(External costs)*
	Economic risks	Prosperity versus risks	Long term stability of value *(Cost/value ratio at point of hand-over)*

Fig. 1: SuperBuildings key indicators

5.2 Advantages from a Sustainable Building Assessment point of view

From the user side, relying on a BIM centred approach presents several benefits from a sustainable assessment point of view. Among others, the following ones can be mentioned:

- BIM contains already most of the data listed above to perform a Sustainability assessment (building location, geometry, detailed composition) of a building that can be analysed from different environmental analysis point of views with different analysis tools (even if the data only was general geometries, quantities and qualities).

- BIM can include also data about the environmental properties of the building parts and building products (there are links with EPD's).
- BIM is the place where the results of the analyses could be stored back to ease comparison between different options or approaches.

The concept of BIM is easy to understand but hard to turn into a tangible reality in a current working environment as there is a strong need for an interoperable exchange format, rich enough to allow ALL users / stakeholders working simultaneously around the same digital model to enrich and retrieve data from the same single model.
BuildingSMART International (neutral, international and non for profit organisation coordinating technical and standardisation work around the BIM) is supporting the notion of OPEN BIM and thus promoting the use of a unique exchange language to dialogue with the BIM. This language is the IFC.

5.3 IFC4, the open language for an Open BIM

The building sector's Industry Foundation Classes IFC represent an open specification for Building Information Modeling BIM data that is exchanged and shared among the various participants in a building construction or facility management project. IFC's are the international openBIM standard.
The IFCs were originally developed to describe building components in an objectified way [6]. Based on STEP principles, the IFC data model is an object oriented model that separates the object identification and the associated properties, including potential different geometric representations and materials association. Since the beginning a lot of improvement has been made but the integration of sustainable/environmental notions is quite new as it has been done in the last release.
Now the IFC counts approximately 800 entities.

5.3.1 The "Property Sets" mechanisms

In the IFC4 documentation, a Property set is presented as "any specialization of object can be related to multiple property set occurrences. A property set contains multiple property occurrences. The data type of property occurrence are single value, enumerated value, bounded value, table value, reference value, list value, and combination of property occurrences. "
In the construction domain, for instance, IFC-based implementation of product libraries has a good prospect for meeting the industry requirements. Indeed, while IFC classes represent generic categories of elements (e.g. wall, beam, space) with very few attributes associated with a class to transfer information relevant to a manufacturer, IFCs incorporate a mechanism called Property Sets (PSets) which allow information publishers to dynamically allocate new properties to an object they wish to describe. Since there are numerous alphanumeric attribute definitions depending on discipline, life-cycle stage, building regulation and region, there will never be a complete set of internationally standardized attributes. Therefore, IFC defined property sets intent to standardize a basic set of properties, whereas other property sets can be regionally defined, or agreed upon in projects. The current drawback, however, is that there is no specification of the semantics of PSet information outside that published in the IFC distribution (PSD - Property Set Definition - Schema for the definition of property sets and properties).
It is important to stress the assets of such mechanism. IFC objects can have properties attached to them. The IFC model differentiates between attributes that are directly attached to the object as attribute of the entity, and properties, group in a property set and assigned to the object by a relationship. The latter is the more flexible way to extent applicable properties.
Furthermore these properties may be specific to particular regions, projects or process. The IFC schema supports storing and transmitting these properties in named sets (so called "IfcPropertySet"). Therefore, a property set is a collection of properties that can be declared outside of the IFC schema but that can be assigned to all objects defined within the IFC schema.

In the case of a BIM way of working and a process lead approach, it is worth defining well-suited property sets commonly agreed by parties as the right structure to convey the domain specific information between BIM and this specific activity.
In the current version IFC4, there are more than 400 property sets already defined.

5.3.2 Environmental Property sets and their connections with Building elements

In the scope of this paper it is worth mentioning two property sets that have just been introduced in this IFC4 version.
The first one is the property set “Pset_EnvironmentalImpactIndicators” which official definition is “Environmental impact indicators are related to a given “functional unit” (ISO 14040 concept). An Example of functional unit is a "Double glazing window with PVC frame" and the unit to consider is "one square meter of opening elements filled by this product”. Indicators values are valid for the whole life cycle or only a specific phase (see LifeCyclePhase property). Values of all the indicators are expressed per year according to the expected service life. The first five properties capture the characteristics of the functional unit. The following properties are related to environmental indicators. There is an international consensus agreement for the five one. Last ones are not yet fully and formally agreed at the international level”.
The second one is the property set “Pset_EnvironmentalImpactValues” which official definition is “the following properties capture environmental impact values of an element. They correspond to the indicators defined into Pset_EnvironmentalImpactIndicators. Environmental impact values are obtained multiplying indicator value per unit by the relevant quantity of the element”.
These two property sets are strongly interrelated as the first one is dedicated to the definition of the considered indicator(s) along with its unit(s) and validity domain(s).
They are commonly attached to the notion of IfcElement which is an abstract concept in the IFC ontology that can be further described as a generalization of all components that make up an Architecture, Engineering and Construction product. Those elements can be logically contained by a spatial structure element that constitutes a certain level within a project structure hierarchy (site, building, storey or space).

5.4 IFC elements addressed in a Sustainable Building Assessment

Actually, 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 to perform Sustainable Building Assessment. A report for the Sustainable Building Alliance [7] shows a list of different devices and appliances that are concerned by different indicators and it makes the link from these devices to the corresponding IFC objects, expressing thus the ability of the IFC language to support the representation of various objects that are concerned by sustainable assessments. Of course, the inputs listed in the chapter “Need for Input Data” are present in the IFC model (building location, building structure and composition).
Sustainable analysis tools require the input of geometry to define the simulation model. This is mostly done by either importing the geometry or manually rebuilding it. Importing and exporting of building geometry is error-prone and tedious, especially as geometry models established in CAD-software are often not suitable as simulation models. The main asset of the BIM is to facilitate the reuse of existing data without retyping them. Even the environmental data produced by manufacturers (EPD’s on construction products) are now available via the BIM [8].

5.5 Sustainability indicators and corresponding IFC objects

In the frame of the SuperBuildings project a survey has been conducted in order to identify if the IFC model already contains the concepts able to support the 20 indicators listed previously.
This survey shows clearly that in its recent update (IFC4), the IFC have made a significant step forward in the integration of sustainable indicators into the BIM.
In the tables below, for each of these indicators, the corresponding IFC property set and element is indicated when existing.

Table 1 : List of SuperBuildings environmental indicators and corresponding IFC structures

Issue	Pset & Related property	Comment / definition attached to the property	IFC related element
Consumption of non-renewable primary energy	Pset_EnvironmentalImpactIndicators/NonRenewableEnergyConsumptionPerUnit	Quantity of non-renewable energy used as defined in ISO21930:2007	IfcEnergyMeasure
• **Embodied Water use** • **Operational water use** • **Wastewater production**	Pset_EnvironmentalImpactIndicators/ WaterConsumptionPerUnit	Quantity of water used	IfcVolumeMeasure
Soil sealing **Change of land use**	Pset_SiteCommon/SiteCoverageRatio	The ratio of the utilization, Total Area/Buildable Area, expressed as a maximal value	IfcAreaMeasure
Global warming potential	Pset_EnvironmentalImpactIndicators/ ClimateChangePerUnit	Quantity of greenhouse gases emitted calculated in equivalent CO2	IfcMassMeasure
Protection of atmosphere (other pollutants)	Pset_EnvironmentalImpactIndicators/ • PhotochemicalOzoneFormationPerUnit • StratosphericOzoneLayerDestructionPerUnit • AtmosphericAcidificationPerUnit	• 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 SO2	IfcMassMeasure
Construction and demolition waste generation • **Non-hazardous waste to disposal** • **Hazardous waste to diposal** • **Nuclear waste to disposal** • **Solid waste separation**	Pset_EnvironmentalImpactIndicators/ • NonHazardousWastePerUnit • HazardousWastePerUnit • RadioactiveWastePerUnit	• Quantity of non hazardous waste generated • Quantity of hazardous waste generated • Quantity of radioactive waste generated	IfcMassMeasure

Table 2 : List of SuperBuildings Societal indicators and corresponding IFC structures

Issue	Pset & Related property	Comment / definition attached to the property	IFC related element
Concentration of various pollutant			
Thermal comfort • **PMV** • **PPD** • **Operative temperature** • **Air Temperature** • **Relative humidity** • **Air velocity**	Pset_SpaceThermalRequirements • NaturalVentilation • NaturalVentilationRate • SpaceTemperature • MechanicalVentilationRate • SpaceHumidity	Properties related to the comfort requirements for thermal and other thermal related performance properties of spaces. This includes the required design temperature, humidity, ventilation, and air conditioning.	IfcThermodynamicTemperatureMeasure IfcRatioMeasure IfcCountMeasure
Illuminance **Daylight factor**	Pset_SpaceLightingRequirements Illuminance	Properties related to the lighting requirements that apply to the occurrences of IfcSpace or IfcZone. This includes the required artificial lighting, illuminance, etc.	IfcIlluminanceMeasure

Table 3 : List of SuperBuildings Economic indicators and corresponding IFC structures

Issue	Pset & Related property	Comment / definition attached to the property	IFC related element
Life cycle cost • **Capital cost** • **Cost in the operational phase**			IfcCostItem
LongTerm stability of value			

The property set mechanism demonstrates its ability to provide a semantic layer above the IFC elements. For instance, in the Table 1 above, the same IFC element "IfcMassMeasure" is used four times to store four different notions (Quantity of greenhouse gases emitted calculated in equivalent CO2, 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 enabling the fact that the semantic attached to the four occurrences of this "IfcMassMeasure" element differs.

5.6 Gaps between the Indicators and their support in IFC

There is room for enhancement. Among others, one of the main assets of the BIM is to provide a unique repository of data along the whole life cycle of a construction project. In order to facilitate the understanding among the various actors, the exchange model and corresponding language (IFC) is structured and documented to ensure a semantic continuity about the information exchanged and stored at the various phases.
Three levels of trust for this semantic continuity can be defined:

- Level 0: There is not support from the IFC language and thus there is not guarantee at all that other actors or software platforms will be able to reuse it
- Level 1: There is a support from the IFC language. But there is no dedicated specific object or property to explicitly qualify the value of the indicator. The best example for that are the different notions of costs. There are few IFC entities dedicated to the cost and the notion of “cost per phase” can be determined and its value stored thanks to the “IfcCostItem” element but this specific meaning cannot be explicitly defined in current version. It relies for the moment on a possible agreement among concerned actors.
- Level2: There is a direct and explicit support from the IFC. In that case a common understanding in ensured.

The tables below recap for all indicators the semantic quality of its support in the IFC model.

Table 4 : List of SuperBuildings Environmental indicators and corresponding IFC structures

Issue	IFC related element	Quality of the IFC support	Comment
Consumption of non-renewable primary energy	IfcEnergyMeasure	**Level 2**	There is a direct support with the dedicated Property Set
Embodied Water use	IfcVolumeMeasure	**Level 1**	There is a support of the Water use via the WaterConsumptionPerUnit property. The notion of Embodied Water is not explicit.
Operational water use	IfcVolumeMeasure	**Level 2**	Direct support with the dedicated Property Set
Wastewater production	IfcVolumeMeasure	**Level 2**	There is a direct support with the dedicated Property Set
Soil sealing	IfcAreaMeasure	**Level 2**	Direct support with the dedicated Property Set
Change of land use		**Level 0**	No support
Global warming potential	IfcMassMeasure	**Level 2**	Direct support with the dedicated Property Set
Protection of atmosphere (other pollutants)	IfcMassMeasure	**Level 2**	Direct support with the dedicated Property Set Pset_EnvironmentalImpactIndicators/ • PhotochemicalOzoneFormationPerUnit • StratosphericOzoneLayerDestructionPerUnit AtmosphericAcidificationPerUnit
Construction and demolition waste generation • Non-hazardous waste to disposal • Hazardous waste to diposal • Nuclear waste to disposal Solid waste separation	IfcMassMeasure	**Level 2**	Direct support with the dedicated Property Set Pset_EnvironmentalImpactIndicators/ • NonHazardousWastePerUnit • HazardousWastePerUnit RadioactiveWastePerUnit

Table 5 : List of SuperBuildings Societal indicators and corresponding IFC structures

Issue	IFC related element	Quality of the IFC support	Comment
Concentration of various pollutant		Level 0	
Thermal comfort • PMV • PPD • Operative temperature • Air Temperature • Relative humidity Air velocity	IfcThermodynamicTemperatureMeasure IfcRatioMeasure IfcCountMeasure	Level 2	Direct support with the dedicated Property Set Pset_SpaceThermalRequirements • NaturalVentilation • NaturalVentilationRate • SpaceTemperature • MechanicalVentilationRate • SpaceHumidity
Illuminance	IfcIlluminanceMeasure	Level 2	Direct support with the dedicated Property Set Pset_SpaceLightingRequirements/ Illuminance
Daylight factor		Level 0	

Table 6 : List of SuperBuildings Economic indicators and corresponding IFC structures

Issue	IFC related element	Quality of the IFC support	Comment
Life cycle cost • Capital cost • Cost in the operational phase	IfcCostItem	Level 1	There is a support of the notion of Cost, via the IfcCost item and there possibilities to qualify this cost item via the “IfcCostValue” which is an enumeration of cost categories. But only the “whole life” category sounds related to the needs expressed here. The rest is not mentioned
LongTerm stability of value		Level 0	

It appears that:

- For the Environmental indicators 10 (among the12 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.

6. Conclusion

This paper presented part of the work performed in the frame of the SuperBuildings project.

Among the noticeable outcomes, the indicators developed represent the corner stone of a sustainable assessment process that becomes now more quantitative than qualitative. As environmental issues and sustainability increasingly have become hot topics in the building industry, there is a real need to perform sophisticated simulations and analysis based on detailed initial data and the analyses should be introduced as early as possible to allow for early collaboration between the design and assessment teams.

To perform such assessments it necessary to have an easy and quick access to input information such as the construction characteristics (dimensions of the building elements, composition and material used, physical and environmental characteristics, etc...). This is typically where the open BIM approach makes sense. The IFC model has proven its ability to convey necessary information to perform these assessments.

This paper has demonstrated also the ability of this language, especially in its latest version to support sustainable assessment results. Even if there are still some gaps most of the indicators developed or selected in the frame of the SuperBuildings project are already supported by the IFC4.

7. Acknowledgement

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