VSB TECHNICAL UNIVERSITY OF OSTRAVA | FACULTY OF CIVIL ENGINEERING | DEPARTMENT OF BUILDING CONSTRUCTIONS

BIM and LCA

image source online, 20230328, taken from https://economictimes.indiatimes.com/opinion/et-commentary/view-sustainable-industries-both-green-and-greening-go/articleshow/89810238.cms

BIM

At the present time, the utilisation of the Building Information Modelling (BIM) in the Czech Republic is in a phase of slow development in the Czech building environment. However, in terms of their utilisation in the building practice, the BIM topics in the Czech Republic are highly relevant because of continuously increasing pressures on the building sustainability.

What is the BIM? The Building Information Modelling (BIM) is a process of generating and management of data concerning the building during its life cycle. A typical BIM process utilises three-dimensional, dynamic real-time software supporting productivity growth in the design and execution stages.

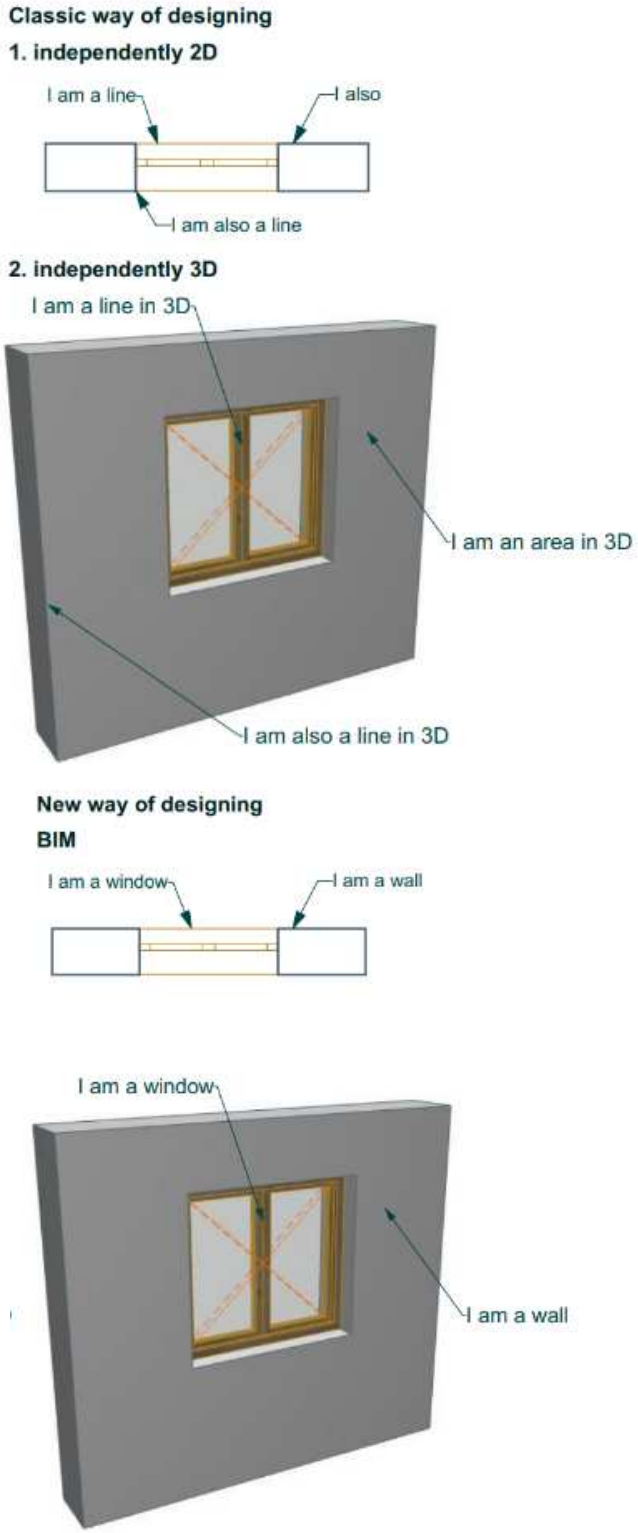
BIM

Among the principal benefits of the Building Information Modelling, belong the following items:

1. Centralisation of data – the BIM accumulates all data into the (shared) central data repository. The design data can be thus used even in the next (after-design) stages of the building life cycle.
2. Documentation is created more efficiently - according to the degree of documentation, the improvement in work effectiveness is estimated from 10 to 30%.
3. Coordination of individual collaborators – the BIM process can save up to 20% of costs otherwise incurred because of insufficient cooperation.
4. Preparations of supporting documents for pricing of the building – the bill of quantities connected with the 3D model is the supporting document for budgeting of construction and installation works. The largest volume of work of a quantity surveyor in building budget estimations represents the composition of the bill of quantities. In case of documentation updates, the bill of quantities is updated automatically.
5. Coordination on the construction site – interconnections of the 3D model (quantities of individual materials) with construction works.

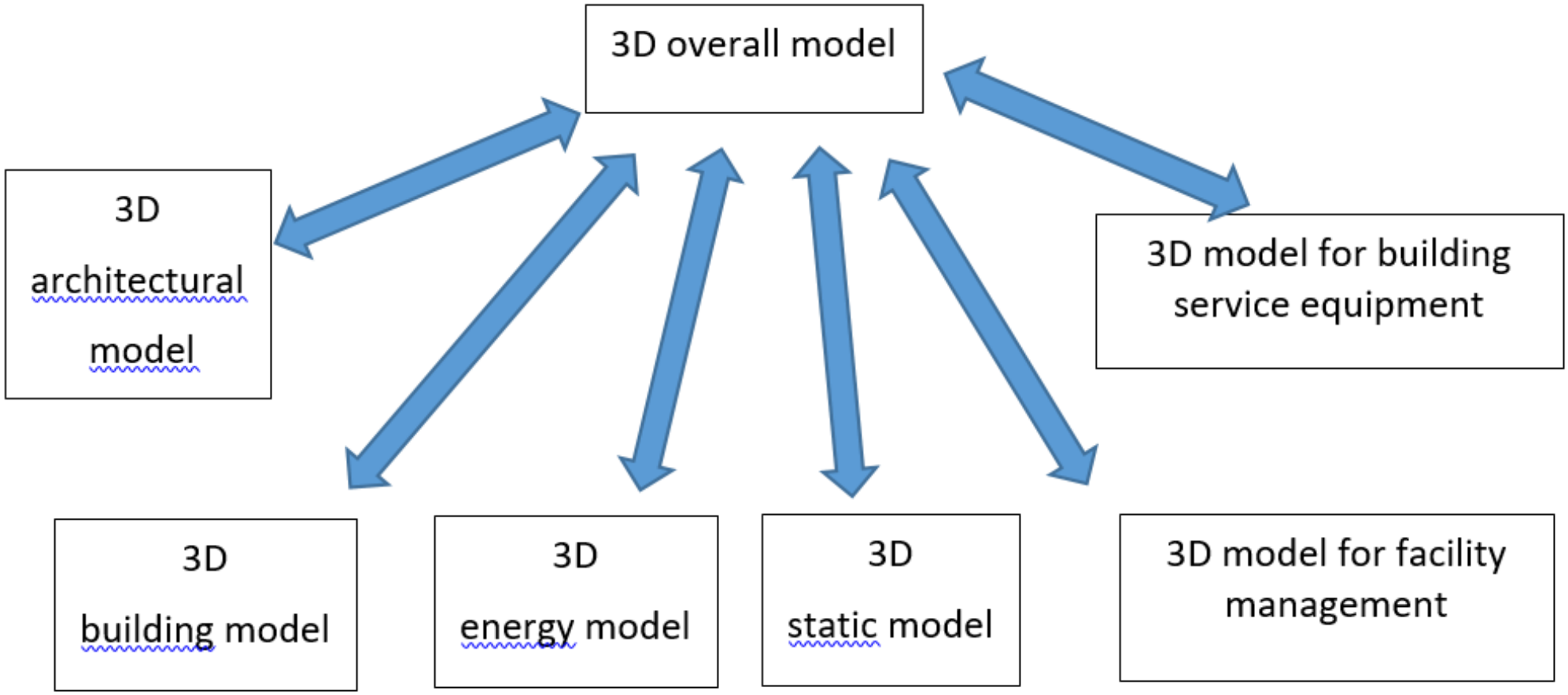
BIM

At present, traditional designing methods in the form of 2D drawings, or individual 3D models representing the CAD designing (Computer Aided Design), are still widely in use. The individual 3D models are currently used mostly for the design visualisation and its presentation to a developer. In a BIM type software is used, various models and drawings are generated at the same time. In the course of building model creation, the 2D drawings are generated automatically in addition. If a model update is prepared, the changes will take effect automatically in the 2D drawings as well, and the same applies to mutually interconnected documents.



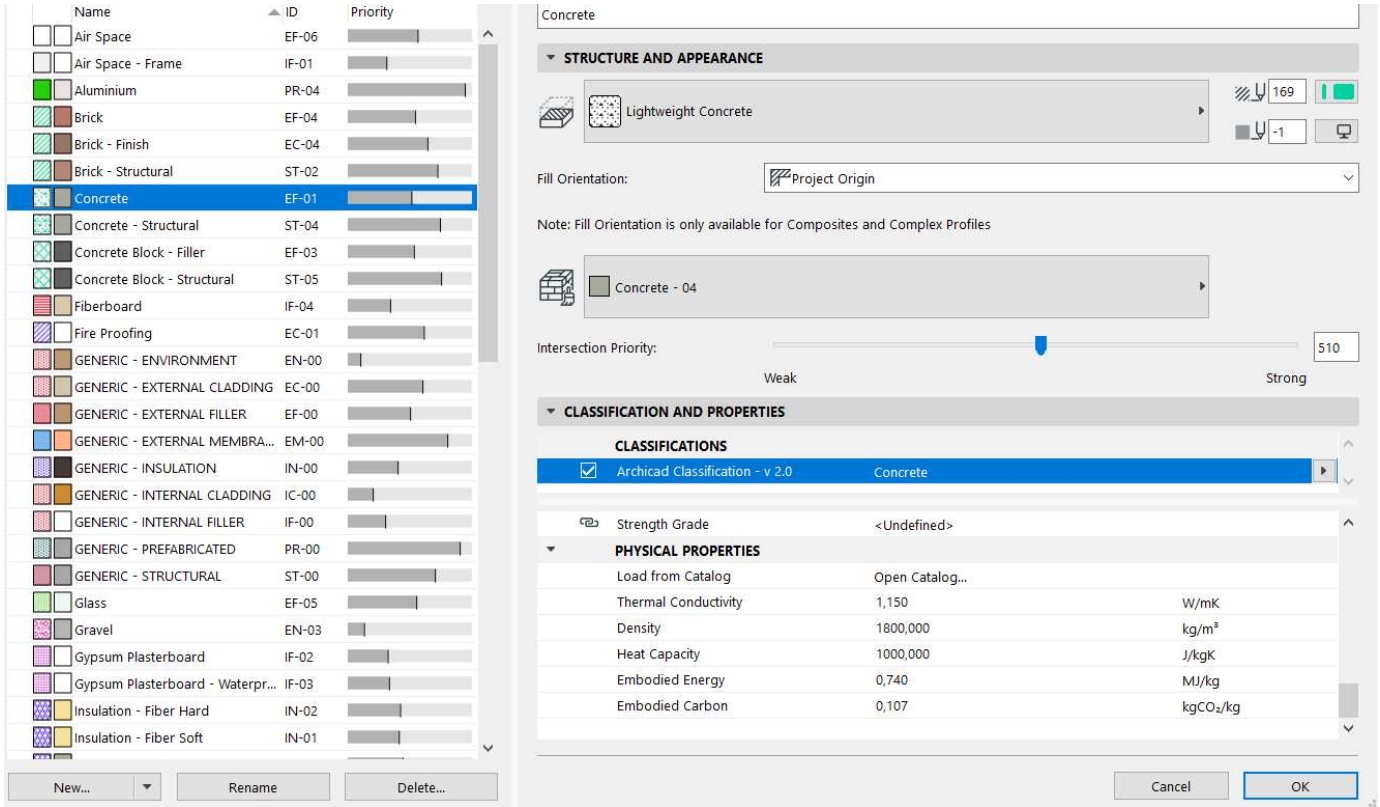
BIM

Through the standardised IFC data format, necessary BIM data can be exchanged and shared in the course of cooperation in the project.



BIM

The BIM model contains geometric and non-geometric information plus additional data (parameters, attributes, properties) that are assigned to individual construction elements and structures (entities). This information can be consequently used for searching of construction elements in the BIM model and obtaining of various specifications.



BIM

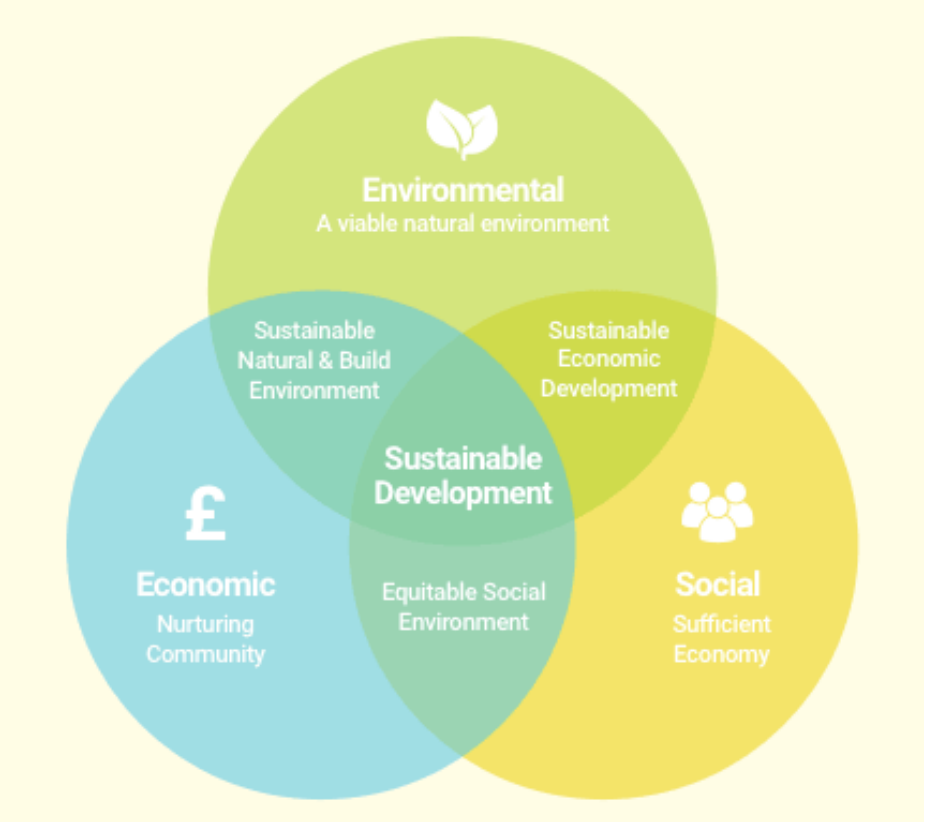
The procedure of creating a BIM model at the project designing stage / building construction documentation is as follows:

1. A new building construction (static model): concrete, masonry, steel structures, foundations, stairs, ramps, ceilings/floors, etc.
2. Layout design and building accessories, elements, and sets: partition walls, bricking-ups, windows, doors, floors, suspended ceilings, roofs, facades, curtain walls, furniture, fixtures & fittings.
3. Building service equipment (BSE) – installations:
   a) Main horizontal and vertical routes (risers and backbone pipes).
   b) Coordination of BSE main routes.
   c) Positioning of end-elements (heating bodies, HVAC diffusers, lighting fittings, switches, instrument panels, terminals, etc.); the end-element positioning may be modelled by an architect /a designer of the construction part.
   d) Final connections of the end-elements to the main routes.
   e) Coordination of final connections and other coordination measures (detailed coordination).
4. 3D coordination model for specialised trades vs. static model and construction model: openings, joints, grooves, necessary cladding, builder's work in connection, etc.
5. Model detailed finishing: wall tiling, products, sheet-metal lining, railings, parameter filling, etc.
6. Bill of quantities, other reports: product tables, areas, reports
7. Graphic finalisation of the documentations: dimension figures, legends, notes, layouts, drawings, conventional signs, etc.

Sustainable Development

Sustainability is the ability to maintain a way of life indefinitely (within the limits of life on earth). The depletion of resources must be avoided to make sustainability possible. Sustainability is defined as the ability to meet the basic needs of today without compromising the ability of future generations to meet their basic needs.

Sustainable development is based on three aspects, namely (social, economic and environmental) aspects (or pillars).



Aspects of sustainable development
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LCA

Life Cycle Assesement or **life – cycle analysis**, **ecobalance** or **cradle – to – grave analysis.**

LCA is an analysis aimed at assessment of product lifecycle with regard to its environmental impact. The analysis is applicable to any product, including building materials. LCA assesses inputs and outputs with effect on the environment throughout the assessed product lifecycle.

Environmental impact of building materials is assessed in connection with: **raw material extraction, product manufacture, building in structures, operation and disposal.**

LCA

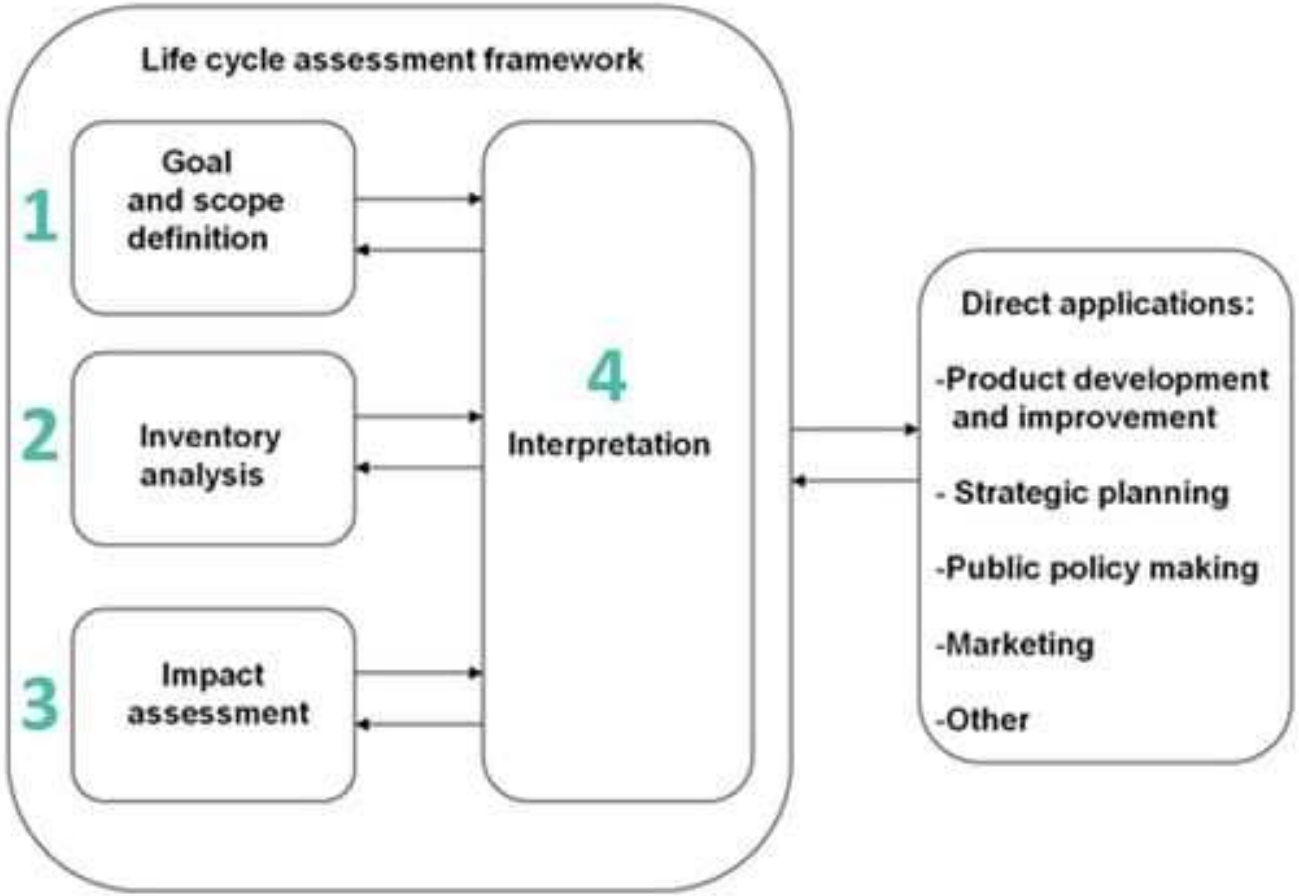
LCA **focuses on environmental properties** of product. **All products affect the environment** throughout their lifecycle. **Environmental impact** of product in individual stages of its lifecycle are **different**.

LCA method is based on **specification of material and energy flows**. Attention is paid to their quantity, nature and seriousness in relation to the environment. **The result of LCA analysis** is **data** that can be divided into two groups. One is **quantitative data** expressing environmental impact and the other is **qualitative data** expressing accuracy of quantitative data, and further description of non-measurable aspects.

The results of LCA analysis are used by contracting authorities (companies) who can use them as the basis of changes for example in product manufacture or by state administrative authorities.

LCA - Study Stages

LCA analysis is divided into 4 stages. They are: definition of goals and scope, inventory analysis, impact assessment and result interpretation.



Graphic representation of LCA analysis stages, image source online, 20230328, taken from: https://circularecology.com/lca.html

Archicad

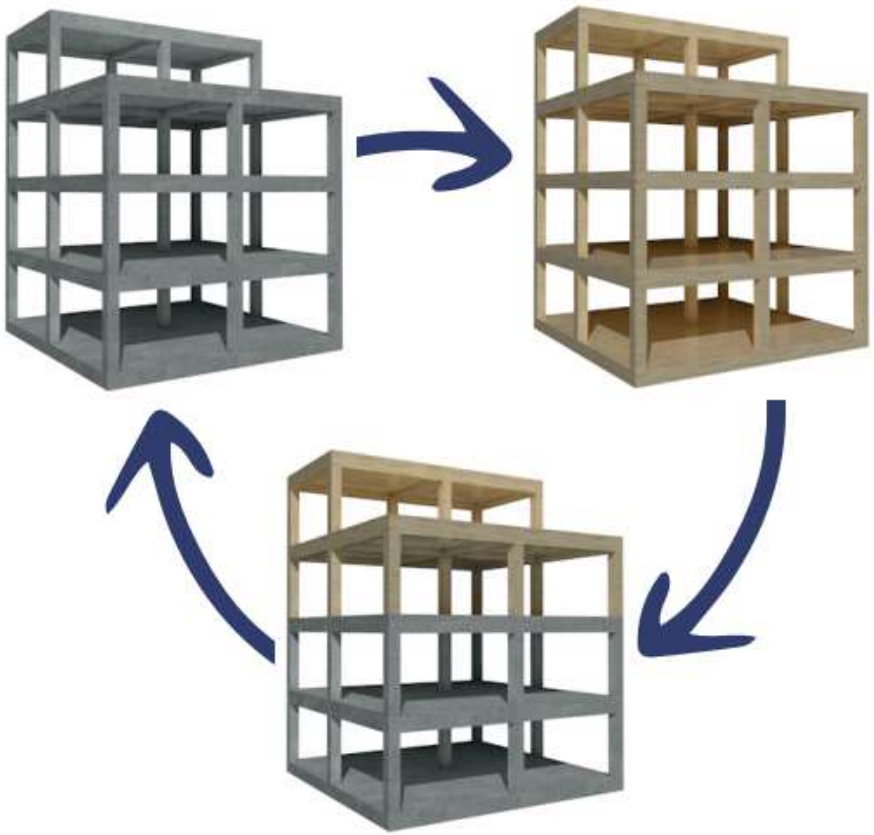
Software especially for 3D / BIM modeling. For team collaboration using BIM Cloud Server technology. Software enabling interprofessional communication based on the IFC (Industry Foundation Classes) data format.

DesignLCA

is a free plugin for Archicad that easily allows you to calculate LCA on your BIM project from early sketching. The best thing is that you don’t even have to be a LCA expert.

LCA in the early design phase

Sustainability in the building sector has become a major topic worldwide and multiple European countries are working on implementing regulations. This means that we must investigate new ways to assess a building's climate impact already from the early stages. LCA is a detailed method for assessing a building's footprint and is still undergoing rapid development in line with increasing demand. However, it is a method that requires a large amount of data on included processes.



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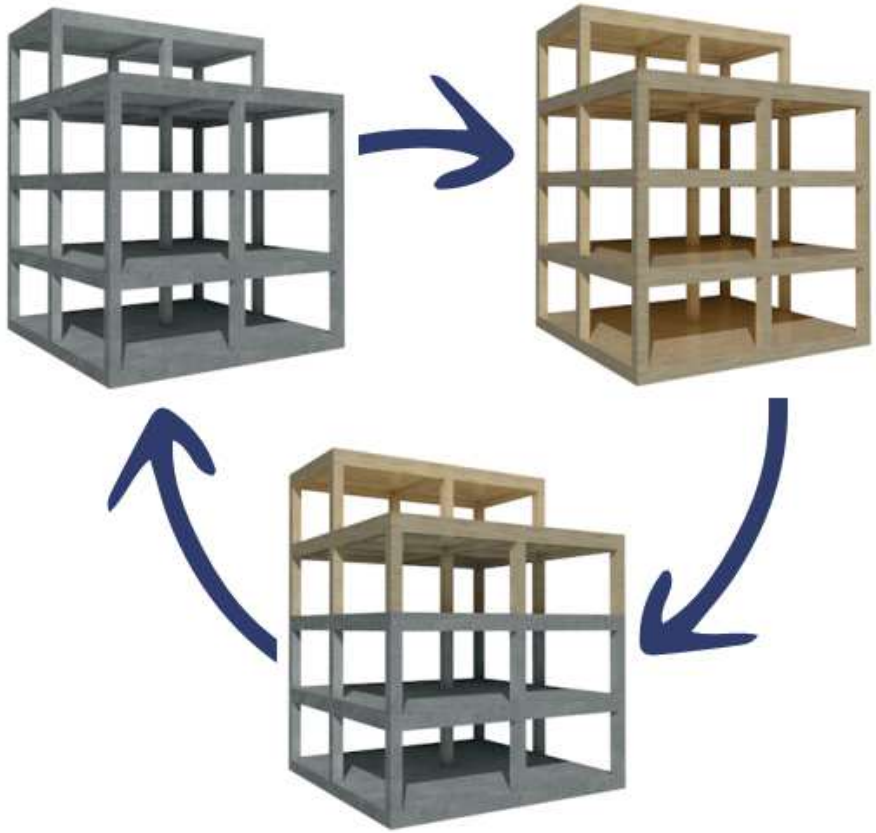
LCA in the early design phase

It is crucial to be able to consider the environmental impact in the initial phases of a project, so that you can continuously see how the geometry and choice of materials can affect the final result. For example, testing different materiál compositions on e.g. the load-bearing structure, facades, roof, etc. This saves both architects and engineers time, as it provides a better prerequisite for achieving the desired results in the final design LCA.

That is why Graphisoft Center Danmark has developed an Add-on, DesignLCA, for Archicad to estimate impacts from any construction along with the modelling. The Add-on enables you to compare different solutions as well as getting an estimate of the whole perfomance of your building throughout its life cycle.



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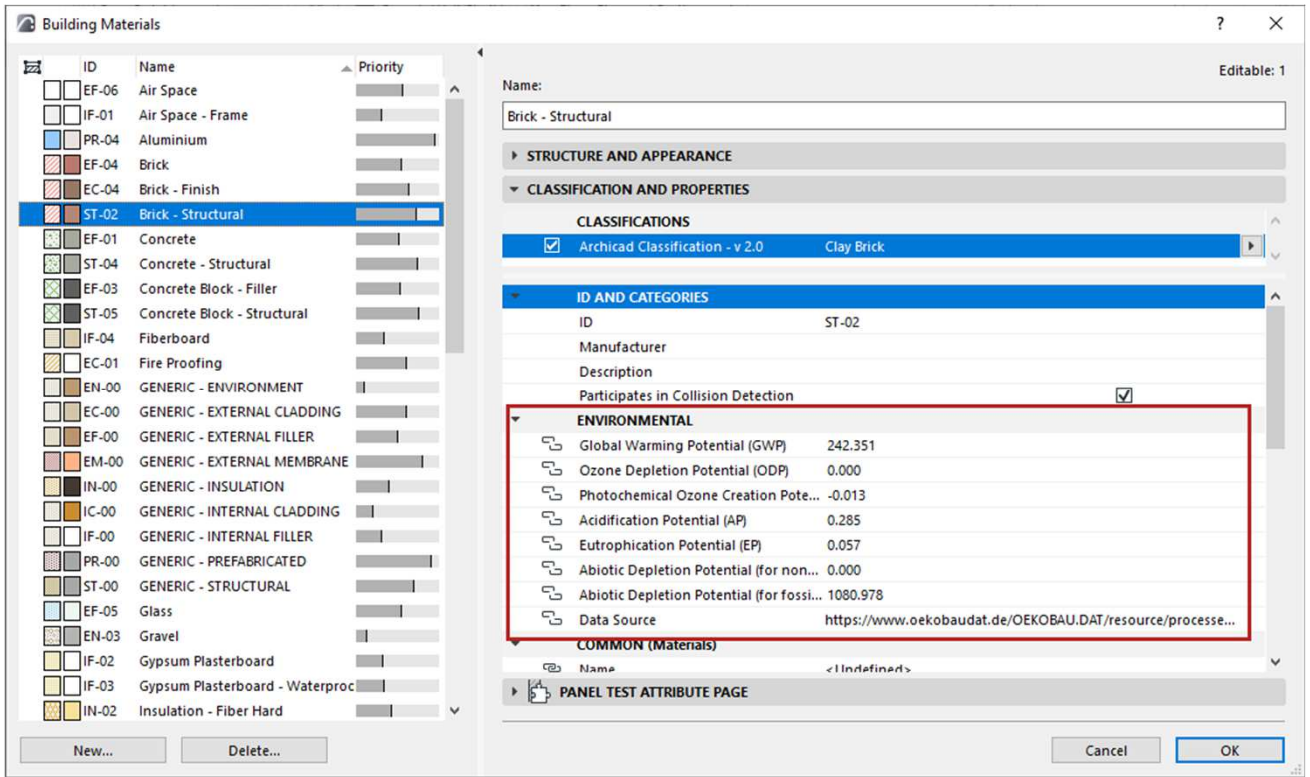
DesignLCA

https://www.oekobaudat.de/en.html

Archicad 27 includes a new set of Building Material properties, corresponding to standard environmental indicators.

Property values are based on data of the German ÖKOBAUDAT database. Use these validated properties to document embedded energy and CO_2 footprint data for building lifecycle analysis and sustainability reports.



ÖKOBAUDAT

Process Data set: Cushioned Polyvinyl chloride floor coverings according to EN ISO 26986 (en) *en*

Tags	Dieser Datensatz ist Bestandteil der ÖKOBAUDAT.

Process information

Key Data Set Information	
Location	RER
Reference year	2019
Name	Cushioned Polyvinyl chloride floor coverings according to EN ISO 26986
Use advice for data set	Scope: In this EPD cushioned polyvinyl chloride floor coverings are declared. The application of this EPD is restricted to cushioned polyvinyl chloride floor coverings produced by the members of the European Resilient Flooring Manufacturers' Institute (ERFMI). Data are based upon production during 2017 in Europe. Data have been provided by 5 companies of ERFMI which represent 100% of ERFMI members. System boundary: Type of EPD: cradle to grave Modules A1-A3 include processes that provide materials and energy input for the system, manufacturing and transport processes up to the factory gate, as well as waste processing. Module A4 includes transport of the floor covering to the place of installation. Module A5 includes the production of offcuts and adhesive for the installation of the floor covering, and incineration of offcuts and packaging material. consumption for the cleaning of the floor covering incl. waste water treatment. The LCA results in this EPD are declared for a one-year usage. Module C1 considers electricity supply for the deconstruction of the flooring. Module C2 includes transportation of the postconsumer waste to waste processing. End of life scenarios are declared for: 100% incineration in a waste incineration plant (WIP) (Scenario 1, C3/1) 100% landfilling (Scenario 2, C4/2) 100% recycling according to information from AgPR, (Arbeitsgemeinschaft PVC-Bodenbelag Recycling) (Scenario 3 - for the recycling scenario the end of waste state is reached after removal from the building) Module D includes potential benefits from all net flows given in module A5 and C3 that leave the product boundary system after having passed the end-of-waste state in the form of recovery and/or recycling potentials.

ÖKOBAUDAT

Environmental Impact Indicators

Indicator	Unit	Production A1-A3	Transport A4	Installation A5	Maintenance B2	De-construction C1	Transport C2	Waste processing C3	Disposal C4	Recycling Potential D S1	Recycling Potential D S2	Recycling Potential D S3
Global warming potential (GWP)	kg CO_(2)-Äq.	3.936	0.1635	0.5163	0.284	0.0124	0.0159	3.36	0.121	-1.034	-0.0728	-0.0728
Depletion potential of the stratospheric ozone layer (ODP)	kg CFC11-Äq.	6.631E-10	4.453E-15	4.24E-11	1.03E-12	5.53E-14	4.34E-16	1.19E-12	3.26E-14	-1.953E-12	-1.41E-13	-1.41E-13
Formation potential of tropospheric ozone photochemical oxidants (POCP)	kg Ethen-Äq.	0.001457	-0.0001164	0.0000899	0.0000593	0.0000022	-0.0000114	0.0000686	0.0000361	-0.0001302	-0.0000092	-0.0000092

Global Warming Potential (GWP)

the insulating effect of greenhouse gases (GHG) - **CO_2** and **methane** - in the atmosphere preventing the earth losing heat gained from the sun. As global temperature rises, it is expected to cause climatic disturbance, desertification, rising sea levels and spread of disease.

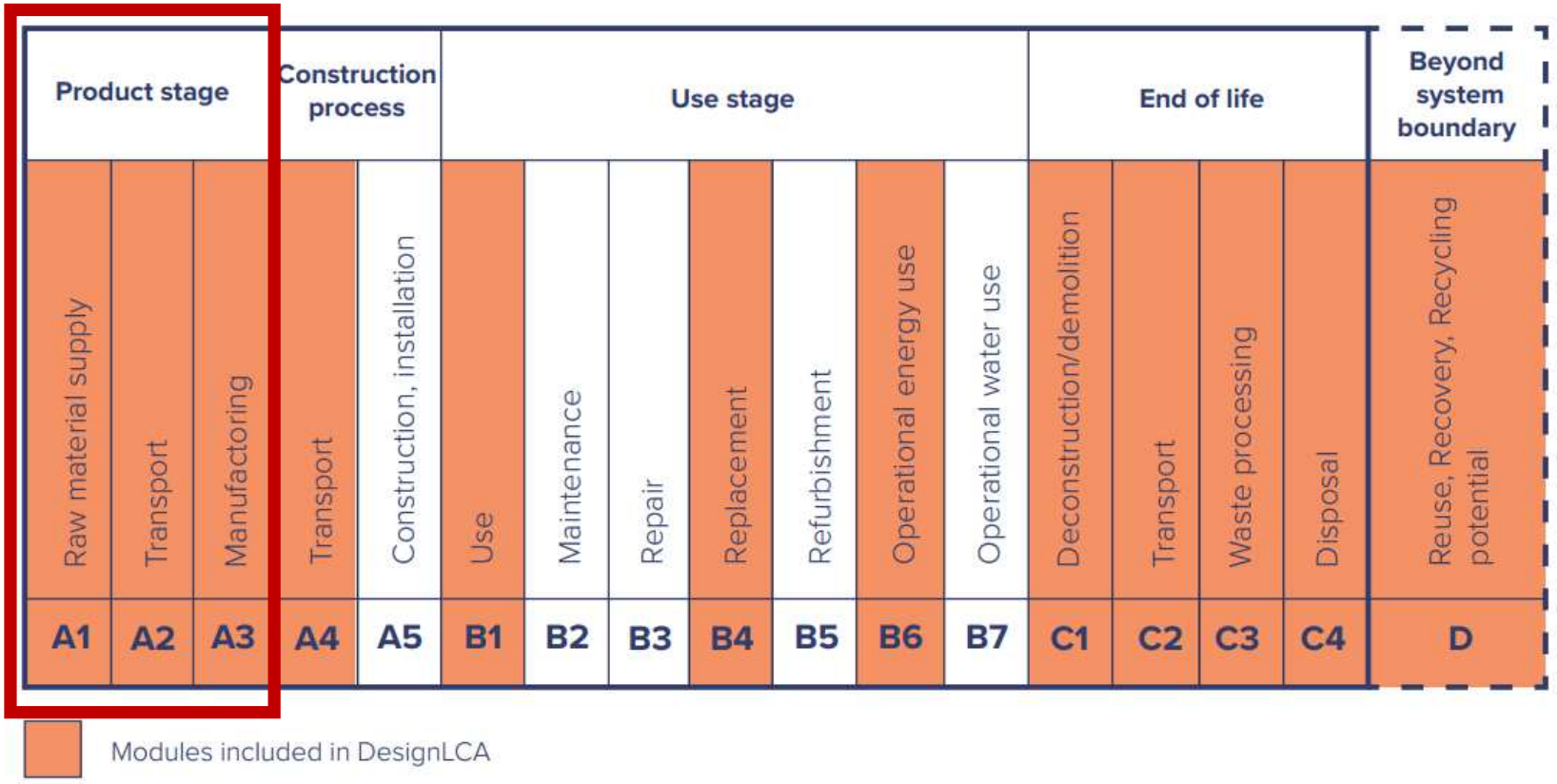
Unit: **kg CO_2 eq.**

The life cycle of any product has four main stages - **raw material sourcing**, **product production, product use and product disposal**. The LCA method makes it possible to determine at which stage of the life cycle a product or service has an impact on which environmental area. On this basis, the optimum extraction of the natural resources needed and the amount of waste generated during production and at the end of its 'life' that nature can cope with under certain circumstances can then be found for a given case, for a specific type of product.

source online, 20230414, taken from https://www.designlca.com/

DesignLCA

The Add-on enables you to compare different solutions as well as getting an estimate of the whole perfomance of your building throughout its life cycle.



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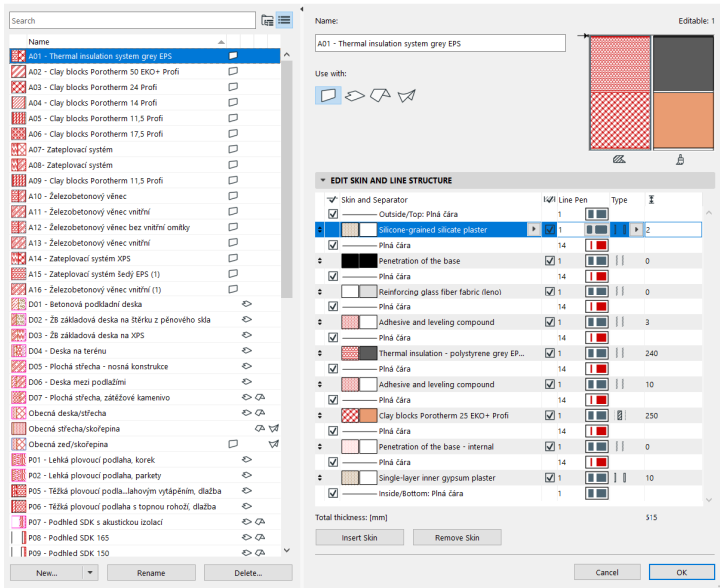
Modeling the building components

As mentioned, all building components must be assigned a material composite. Make sure to only use composites with materials containing both thermal properties and **GWP-data in DesignLCA**. The more detailed you model, the more precisely Archicad will produce a quantity extraction and thus a more precise estimate of the building's **CO_2 emissions**. This means that in addition to modeling walls, decks and roofs, you should model columns and beams with an assigned material.



3D building model

source online, 20230414, taken from https://www.designlca.com/

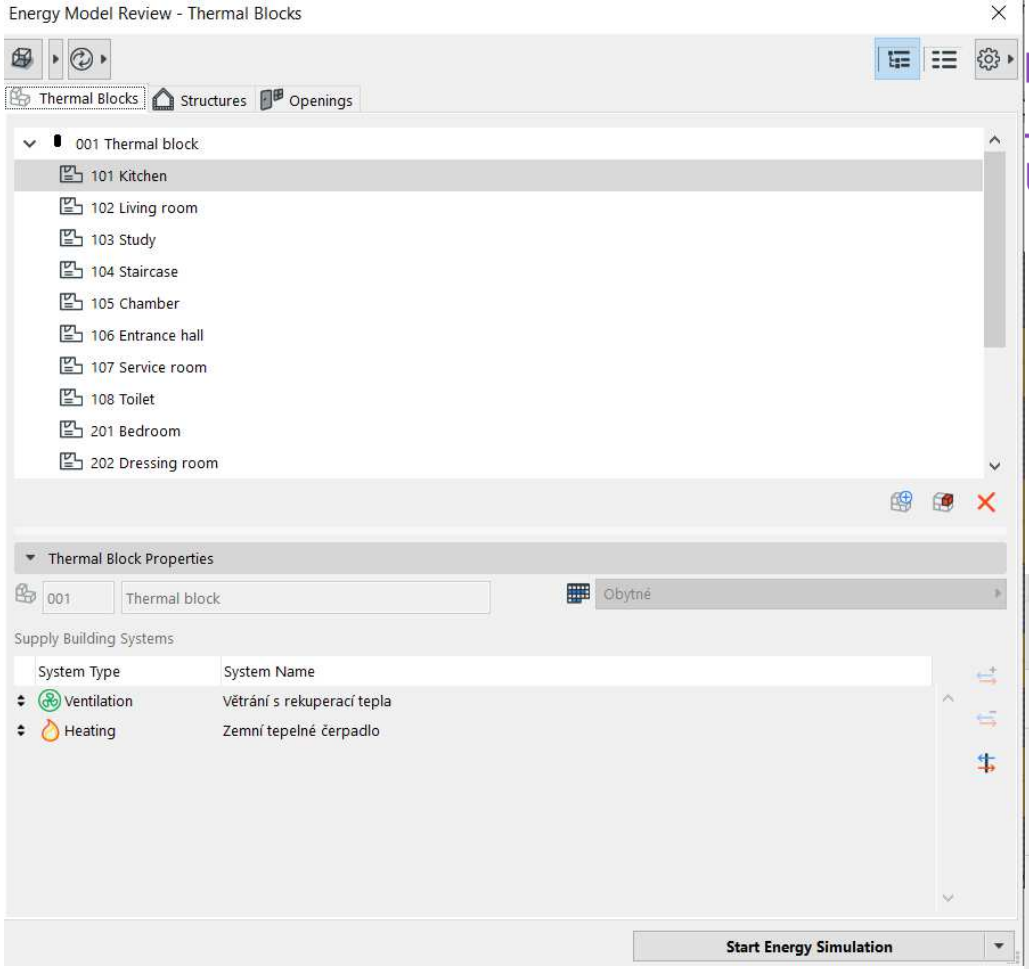
Building energy model (BEM)

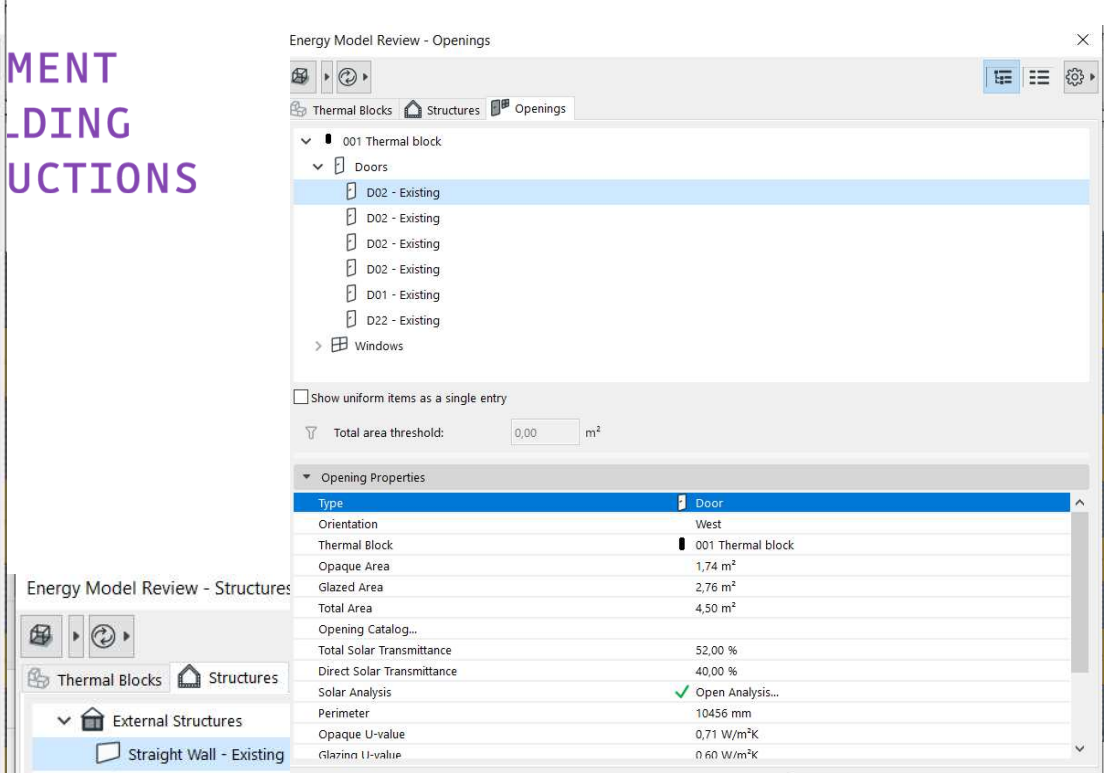
Thermal Blocks

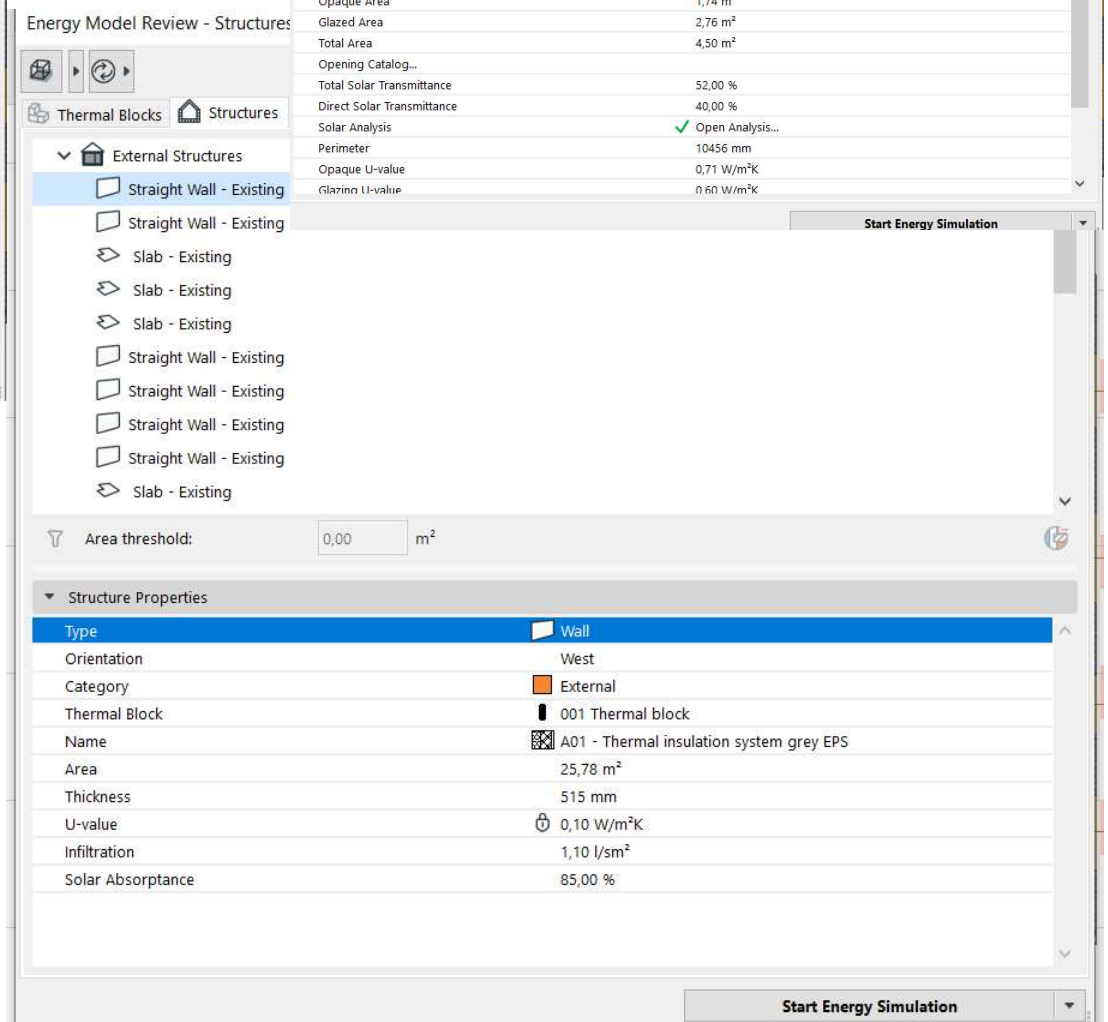
In order to calculate the model's energy consumption and associated CO_2 emissions, you must group the building's zones into 'Thermal blocks' in **Energy Evaluation**.

Thermal blocks represent a collection of one or more spaces with similar heating or cooling requirements – also called thermostat control equiments and similar operational function. Once you have created a Thermal block in the **EcoDesigner Star tool**, you can assign it to the zones. When these are in place, different parameters can be set in relation to heat consumption, ventilation etc. depending on the type of building. Here, it is important to be aware that all building components must be modeled as an overall composite of materials in order for the tool to calculate correctly. An 'Operation profile' must be set for each Thermal Block. If it e.g. is a classroom, you must assign it the profile 'Classroom, which is set to be in use during the day on all weekdays. You can customize the profiles and create your own as needed.

Under the 'Structures' tab you can access all building structures for each zone in each thermal block. Here you can view e.g. orientation, category and u-value for the selected building part. The u-value is calculated in Archicad based on the material composition, but can be overridden manually if you need to work with a specific u-value.





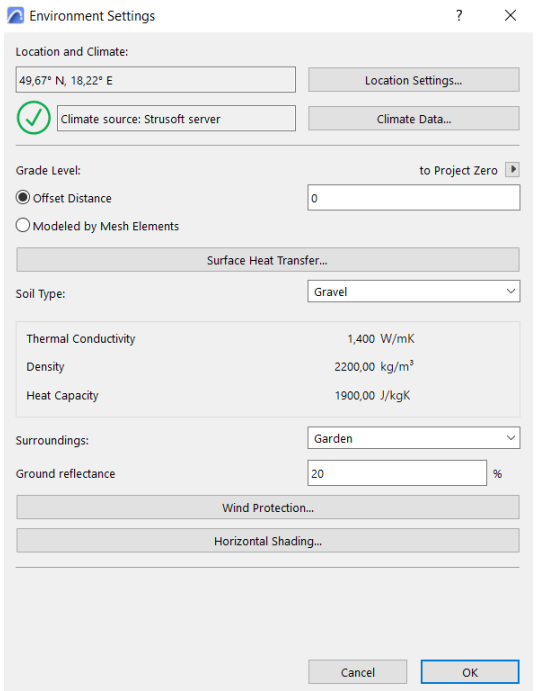


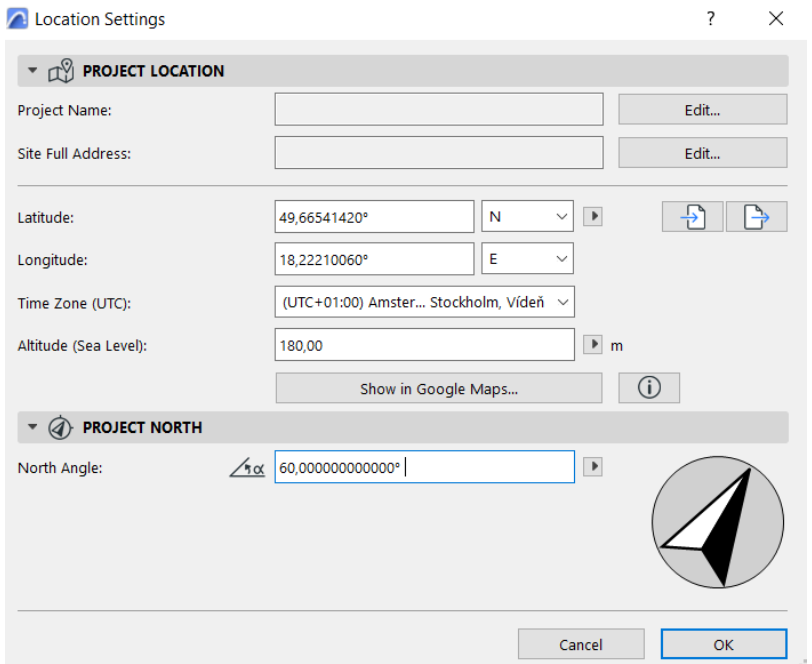
Thermal block

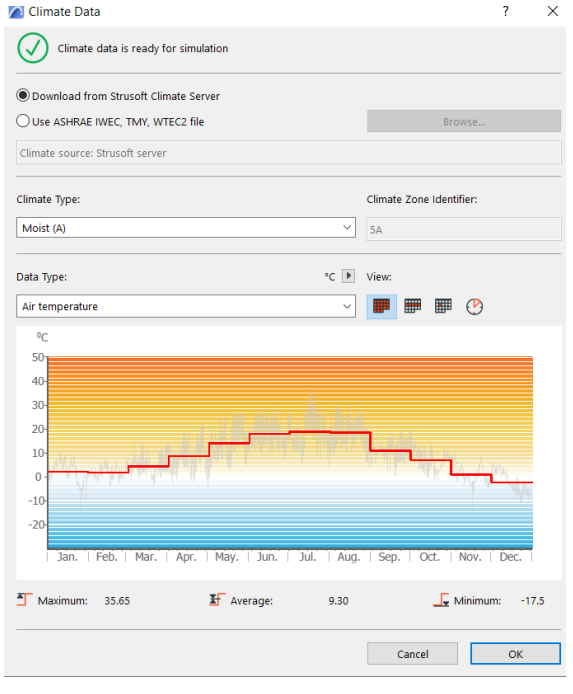
source online, 20230414, taken from https://www.designlca.com/

Location and Climate

The location and surroundings have an impact on the energy demand and thus the amount of CO2 emitted from the energy consumption. You can therefore set the location to the specific address for your construction and then the location of the plot in relation to True North. When the location is set, Archicad adapts the weather data for the given area. In Environment Settings, you can set up the environment to avoid modeling the context of the building. Here you can set zone conditions and shade and shelter from surrounding buildings.







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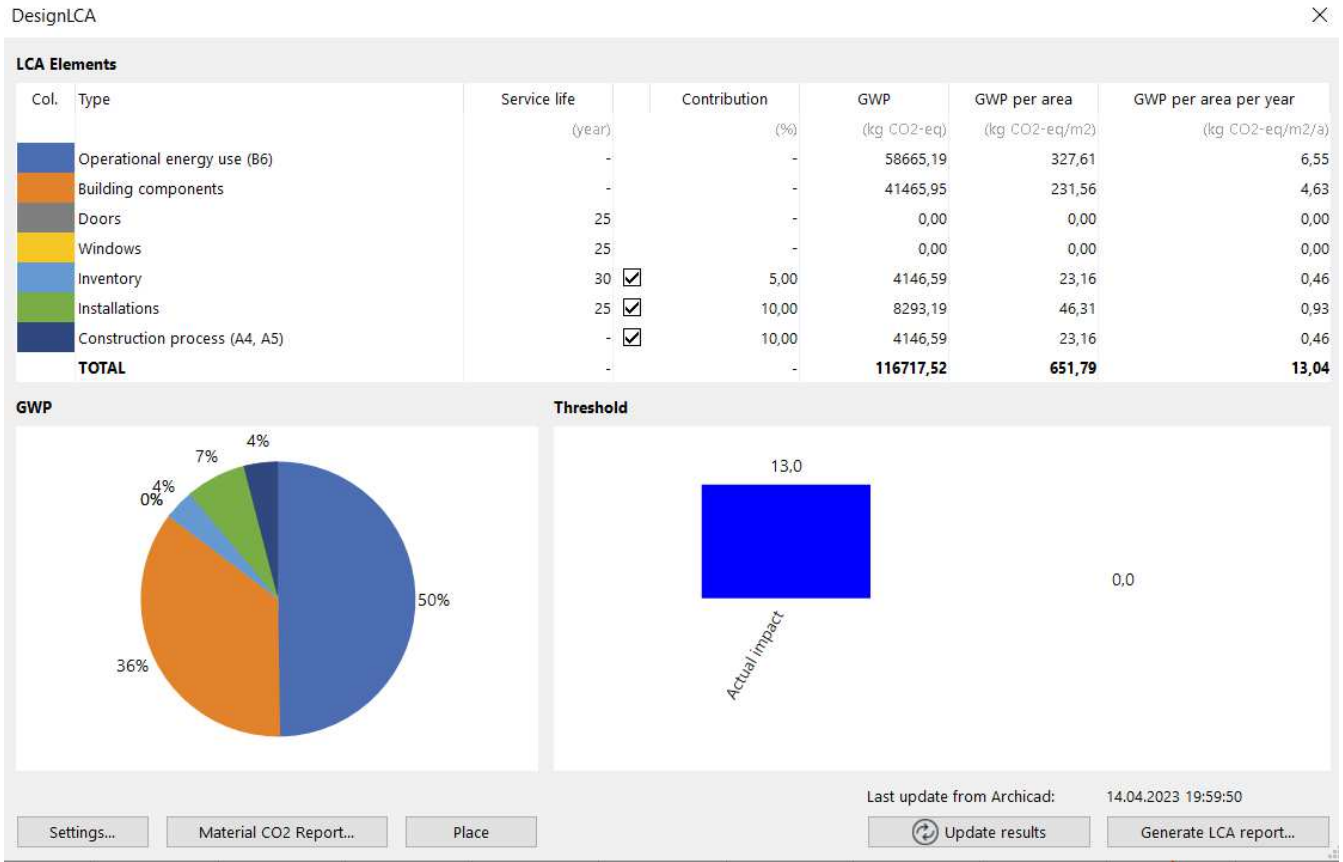
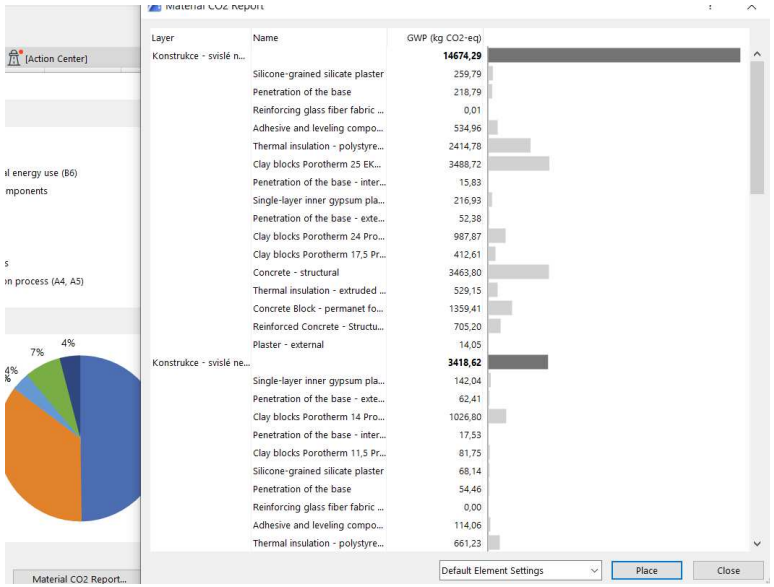
Using the DesignLCA palette

When the results from Energy Evaluation have been retrieved, the DesignLCA palette can display a result. The palette can be docked like other Archicad palettes, which makes it easy to work in the model and see quick results in DesignLCA at the same time.





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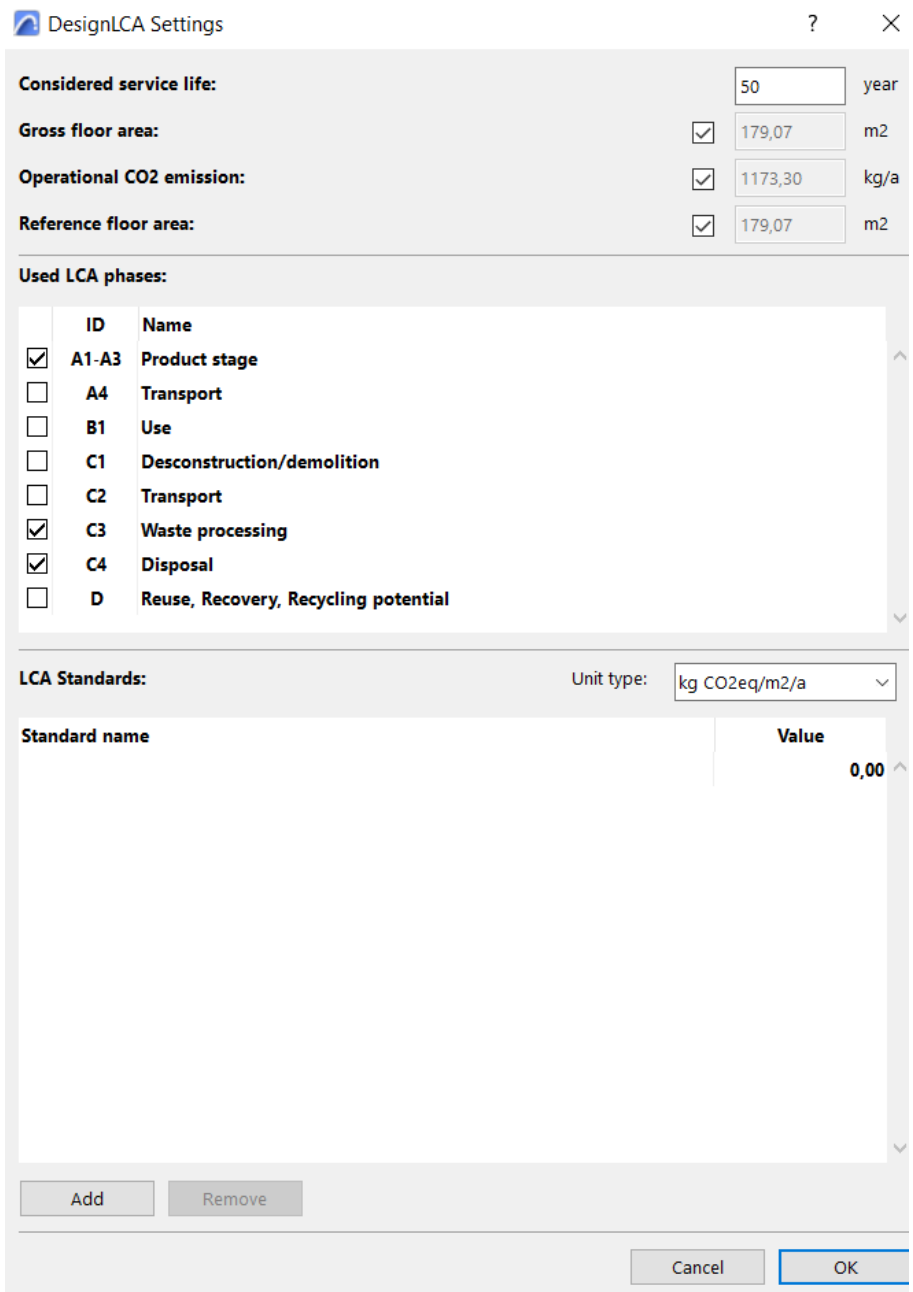
Using the DesignLCA palette



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Result

The result can reviewed both in the palette and in the Excel report. In the schedule, the total climate impact can be read in kg CO_2e, CO_2/m^2 and kg CO_2/m^2/year.

Furthermore, 2 diagrams are generated for the time being, which respectively shows the distribution of the climate impact in the project and the project's kg CO_2/m^2/year compared to reference values set in the DesignLCA Settings.

A	B	C	D	E	F	G
	Type	Embodied Carbon [kg CO2e]	Percentage stage [%]	Service Life [year]	Replacement	GWP [kg CO2eq]
Use stage (B6)	**Operational energy use**	1173				5
Product stage and EOL (A1-A3, C3, C4)	**Building components**	41466		50	1	4
	Doors			25	2	
	Windows			25	2	
	Inventory	2073	5	30	2	
	Installations	4147	10	25	2	
Construction process (A4, A5)	**Construction process**	4147	10			
	TOTAL					**11**
	Considered period [years]	50				
	Gross floor area [m2]	179				

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Thank you for your attention

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