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BIM4Energy Project

Title: Use of BIM to analyse Building Energy Efficiency

1 – Aims

The objectives of this BIM and Building Energy Analys tutorial are as follows:

- To Know the role of BIM in enhancing energy efficiency in buildings .
- Learning about the role of BIM in Sustainable Design of buildings
- Understanding the benefits of the 6th BIM dimension.
- Knowing the state of the art of BIM applications for the building energy model (BEM)
- Learn about available computer tools that use BIM to analyse Building Energy Efficiency

2 - Learning methodology

The teacher will give an explanation about Use of BIM to analyse Building Energy Efficiency of about 30 minutes.

Students will read this tutorial and follow the steps shown in the tutorial, namely:

- The Role of BIM in Enhancing Energy Efficiency
- Sustainable Design and BIM.
- BIM applications
- The 6th Dimension of BIM - Sustainability and Lifecycle Analysis
- Application of BIM to Building Energy Modeling.
- Software that uses BIM to analyse Building Energy Efficiency: OpenStudio, DesingBuilder, ClimateStudio, CypeTherm EPlus.

In order to evaluate the success of the application, we suggest a questionnaire to be held for the students.

3 - Tutorial duration

The implementation described in this tutorial will be carried out through the BIM4ENERGY Project website by self-learning.

3 lesson hours are suitable for this training.

4 – Necessary teaching recourses

Computer room with PCs with internet access.

Required software: Microsoft Office.

5 – Contents & tutorial

5.1– Needy to save energy with the building design

5.1.1. The Role of BIM in Enhancing Energy Efficiency

The global community is currently facing one of its most pressing challenges: reducing greenhouse gas (GHG) emissions while maximizing energy efficiency [1]. The construction industry is a major contributor to GHG emissions and energy consumption, surpassing the industrial and transportation sectors in this regard [2]. Increased energy consumption has significant environmental implications, as a substantial portion of global energy production relies on the combustion of fossil fuels, which leads to ecosystem degradation [3]. According to the United Nations Environment Programme [3], the construction sector is responsible for approximately 30% of global annual GHG emissions and up to 40% of total energy consumption. Greenhouse gases, including carbon dioxide (CO_2), methane (CH_4), nitrogen oxide (N_2O), and fluorocarbons, contribute to climate change and global warming [4]. Among these, CO_2 emissions play a particularly significant role in increasing global temperatures [5]. Studies indicate that buildings account for approximately 40% of global CO_2 emissions [5, 6]. The consequences of global warming, such as the melting of polar ice caps and rising sea levels, threaten to reduce habitable land, exacerbating challenges associated with a growing global population [7]. Given the increasing concerns surrounding climate change and carbon emissions, the construction sector is continuously striving to mitigate its environmental impact [8], primarily by reducing energy consumption in buildings [3]. To meet global CO_2 reduction targets, both consumers and industry stakeholders must actively participate in the development of low-carbon buildings [9]. Failure to address this issue will likely result in continued growth in the sector's GHG emissions over the next two decades [8]. Consequently, architects and industry stakeholders face the significant challenge of designing and constructing buildings that align with emission reduction goals, ultimately contributing to a more sustainable and environmentally responsible built environment.

In response to growing environmental concerns and the rising costs of energy, building professionals have increasingly emphasized the importance of sustainability and energy efficiency in architectural design. The development of sustainable buildings often requires specialized expertise and can be associated with high costs [10]. Given the significant environmental impact of buildings, designers must seek to minimize this effect by optimizing energy efficiency from the earliest stages of the design process [10, 11]. Enhancing energy efficiency offers multiple benefits, including reduced operational costs and long-term economic advantages, which in turn foster innovation in construction methodologies [12].

Achieving low net energy consumption in buildings is imperative, and this objective can be realized through innovative design approaches. In recent years, various methodologies and technologies have emerged to improve building energy efficiency, among which Building Information Modeling (BIM) has gained widespread recognition and adoption [13]. The integration of BIM with energy performance analysis has become increasingly prevalent, as BIM has proven to be an effective tool for conducting energy assessments during the early design stages [14]. By leveraging BIM technology, designers can model various aspects of a building's energy use, including thermal flow, lighting patterns, and other sustainability-related parameters [9]. BIM-based energy analysis tools enable the evaluation of heating and cooling requirements, daylighting opportunities, and the selection of building components that contribute to energy efficiency. Moreover, by incorporating real-time weather data and electrical grid information, BIM facilitates more accurate estimations of a building's energy consumption and carbon footprint [15].

The effectiveness of a building's performance is largely influenced by the properties of its materials, thermal resistance, and overall physical characteristics. These attributes are digitally represented in BIM models, allowing for a comprehensive assessment of energy performance [15]. The application of BIM tools, such as Revit Architecture, plays a pivotal role in streamlining the energy modeling workflow. By enabling the rapid development of basic building models, BIM facilitates the simulation of energy performance and cost estimation processes. Traditionally, sustainable building design has relied on Computer-Aided Design (CAD) tools, with design data being manually entered into energy simulation software [9]. However, the direct integration of BIM with energy performance analysis at the design stage enhances efficiency, as design iterations can be easily adjusted and refined [16].

Several energy simulation tools, including EnergyPlus, Ecotect, and IES Virtual Environment, have been developed to analyze key building design features such as climate responsiveness, glazing, thermal insulation, solar gain, ventilation (both natural and mechanical), and HVAC system performance. The integration of BIM with these simulation tools has resulted in the development of sophisticated decision-making frameworks for designing energy-efficient buildings [17]. By leveraging BIM technology, designers can iteratively modify and test various design alternatives, ensuring optimal energy performance before construction begins.

The use of BIM with energy simulation tools offers significant advantages in achieving energy-efficient and sustainable building designs. Through automation, data integration, and advanced simulation capabilities, BIM enhances decision-making processes, enabling architects and engineers to create buildings that align with global sustainability goals [18].

5.1.2. Sustainable Design and BIM

The rapid advancement of technologies in the building industry has had a profound impact on the environment. The construction sector is a significant contributor to greenhouse gas (GHG) emissions and energy consumption, primarily due to the high reliance on fossil fuels for energy generation. This dependence on fossil fuel combustion results in substantial carbon dioxide (CO_2) emissions, which contribute to global warming and environmental degradation. To mitigate the adverse effects of GHG emissions and excessive energy consumption, it is essential to develop sustainable solutions that address these environmental challenges. One of the most effective strategies in this regard is enhancing energy conservation in buildings. The incorporation of natural material resources in construction can significantly reduce energy demands, as these materials typically offer better thermal performance compared to conventional alternatives.

The energy efficiency of a building is heavily influenced by the design of its **building envelope, thermal performance, ventilation systems, and HVAC systems**. If not properly designed, these components can lead to excessive energy consumption and create uncomfortable indoor conditions for occupants. The increasing global emphasis on environmental sustainability has prompted many countries to adopt sustainability-focused practices throughout the **entire building lifecycle**, including the **design, construction, in-use, and post-construction stages**. Incorporating energy conservation strategies during the **early design phase** can result in substantial energy savings over the building's operational lifetime.

To achieve sustainable design objectives, designers must evaluate multiple design alternatives and select the most energy-efficient option. This process necessitates the use of **advanced tools** that assist in decision-making during the design phase. Building Information Modeling (BIM) has emerged as a critical tool for supporting designers in selecting optimal building designs. BIM enables **parametric modeling**, which allows the Architecture, Engineering, and Construction (AEC) industry to implement sustainable design principles more effectively and improve overall building energy efficiency.
It is evident that **architectural design and material selection** play a crucial role in determining a building’s energy consumption and carbon footprint. Consequently, designers must conduct **comprehensive evaluations of material properties** to ensure that the selected materials not only support environmental conservation but also enhance occupant comfort. Parametric **performance-based design tools** integrated within BIM provide designers with data-driven insights, enabling them to make informed decisions regarding sustainable material selection and energy efficiency optimization [18].

5.2– BIM Applications

5.2.1. Definition of BIM

The definition of Building Information Modeling (BIM) varies depending on the specific content included within the model. An information model may encompass various aspects of a building, such as geometry, envelope components, materials, costs, HVAC systems, electrical systems, and thermal properties of materials.

According to the U.S. National BIM Standard (NBIMS-US), BIM is defined as "the act of creating an electronic model of a facility for the purpose of visualization, engineering analysis, conflict analysis, code criteria checking, cost engineering, as-built product, budgeting, and many other purposes" [19]. Similarly, Krygiel and Nies describe BIM as "information about the entire building and a complete set of design documents stored in an integrated database" [20]. Furthermore, Smith and Tardif characterize BIM as "a mechanism to transfer from data into information to gain the knowledge that allows us to act with wisdom" [21].

These definitions highlight the comprehensive and integrative nature of BIM, emphasizing its role in enhancing decision-making processes, improving design efficiency, and facilitating the management of building information throughout its lifecycle.

5.2.1. Application of BIM

The application of Building Information Modeling (BIM) is continuously expanding as researchers recognize its potential benefits across various domains. While BIM is frequently utilized for structural analysis (27%) and energy analysis (25%), its primary application remains the rapid development of 3D geometric models and 3D coordination, with a usage rate of 60% [22]. However, the use of BIM is not limited to architects and engineers; it also offers advantages for homeowners, facility managers, contractors, and fabricators [23].

Several key factors drive the adoption of BIM in projects, including automation of the modeling process, improved accuracy of construction documents, enhanced communication among stakeholders during the design and construction phases, automatic updates across all views when modifications are made, and a reduction in field coordination issues [23-26]. While BIM is predominantly applied in building design, certain areas—such as energy modeling—have not received equivalent attention. The integration of BIM with Building Performance Simulation (BPS), sometimes referred to as BIM-Based Building Performance (BBIP), remains an underexplored area.

A comprehensive review of BIM-related literature reveals that most studies focus on planning, design, construction, operation, and energy consumption, with archival publications emphasizing design and energy efficiency [27]. This trend has been observed globally, indicating that although construction companies widely use energy simulation tools, there is a lack of integration between BIM and Building Energy Modeling (BEM) within a single platform. The absence of such integration necessitates manual data reentry, even when relevant information already exists in other models developed for a project [28,29]. Addressing this gap by developing a unified BIM-BEM framework could significantly improve efficiency in energy modeling and building performance analysis.

5.3– The 6th Dimension of BIM - Sustainability and Lifecycle Analysis

Building Information Modeling (BIM) is a revolutionary methodology that enhances the planning, design, construction, and management of infrastructure projects through digital representation. Among the various dimensions of BIM, the 6th Dimension (6D) focuses on sustainability and lifecycle analysis, integrating environmental and energy efficiency considerations into the design and operational phases of a building. This paper delves into the significance, applications, and advantages of 6D BIM, illustrating its role in promoting sustainability within the Architecture, Engineering, and Construction (AEC) industry.

5.3.1. Introduction to 6D BIM

The 6D dimension of BIM extends beyond the traditional 3D design, 4D scheduling, and 5D cost estimation by embedding sustainability aspects within a building model. It allows stakeholders to analyse energy consumption, carbon footprint, material sustainability, and overall environmental impact throughout the lifecycle of a structure. With global emphasis on green building practices, 6D BIM emerges as a crucial tool in achieving sustainability targets, such as LEED (Leadership in Energy and Environmental Design) certification and compliance with international energy efficiency standards [30,31].

5.3.2. Key Components of 6D BIM

- Energy Performance Analysis: 6D BIM enables simulation of energy consumption patterns, allowing designers to optimize insulation, glazing, lighting, and HVAC systems to enhance efficiency.
- Sustainable Material Selection: By integrating material databases, BIM assists in choosing eco-friendly materials that reduce embodied carbon and improve recyclability.
- Lifecycle Assessment (LCA): It assesses the environmental impact of a building from construction to demolition, ensuring long-term sustainability.
- Carbon Footprint Estimation: 6D BIM helps in calculating CO2 emissions, aiding developers in implementing carbon reduction strategies.
- Renewable Energy Integration: The model supports the evaluation of solar panels, wind energy, and other renewable sources to enhance self-sufficiency.

5.3.3. Applications of 6D BIM in the AEC Industry

- Green Building Certifications: Facilitates compliance with environmental certification programs like BREEAM, LEED, and WELL Building Standard.
- Energy Optimization Strategies: Assists in designing buildings that minimize energy consumption through smart design choices.

- Sustainability Reporting: Generates reports and dashboards to track environmental impact throughout the project lifecycle.
- Facility Management Efficiency: Post-construction, 6D BIM aids in sustainable operation and maintenance, reducing energy waste and operational costs.

5.3.4. Advantages of Implementing 6D BIM

- Enhanced Decision-Making: Provides data-driven insights to architects, engineers, and facility managers.
- Cost Reduction: Helps in minimizing long-term operational and energy costs.
- Regulatory Compliance: Ensures adherence to environmental laws and standards.
- Improved Stakeholder Collaboration: Enhances transparency and communication between various project participants.
- Future-Proofing Infrastructure: Ensures that buildings are designed with resilience to climate change and evolving sustainability demands.

5.3.5. Challenges and Future Prospects

Despite its numerous benefits, 6D BIM adoption faces challenges such as high initial implementation costs, complexity in data integration, and the need for specialized training. However, advancements in artificial intelligence (AI), cloud computing, and IoT (Internet of Things) are expected to further enhance the capabilities of 6D BIM, making it a standard practice in sustainable construction.

The 6th dimension of BIM plays a pivotal role in achieving sustainability goals by enabling precise energy analysis, material efficiency, and lifecycle optimization. As the construction industry moves towards net-zero emissions and environmentally responsible building practices, 6D BIM emerges as a vital technological advancement. By leveraging its potential, stakeholders can create smarter, greener, and more sustainable infrastructures, contributing to a more resilient built environment for future generations.

5.4– Application of BIM to Building Energy Modeling (BEM)

5.4.1. BIM to BEM

These are applications of BIM to Building Energy Modeling [32]:

- **Automation of Energy Modeling:** BIM simplifies energy modeling by automating data handling, reducing errors, and saving time compared to conventional methods.

- **Integration with BEM Tools:** BIM can connect with energy simulation tools like OpenStudio to import building data (geometry, materials, thermal properties) from IFC files.
- **Improved Output Presentation:** BIM enhances visualization in energy management systems, particularly for tools without a GUI, enabling real-time monitoring of energy performance.
- **BIM-based Energy Management Support System (BIM -EMSS System):** A framework that integrates BIM models with smart meters and sensors to perform real-time energy simulations using tools like eQuest.
- **Data Storage & Organization:** BIM enables structured storage of real-time energy-related data, including temperature, occupancy, and energy consumption.
- **Real-Time Monitoring:** Systems like RTPM and RE-BIM Model utilize BIM to track energy use, facility upgrades, and occupancy changes.
- **Sensor Integration:** BIM supports linking sensor data to building models using SensorML, facilitating automated energy tracking.
- **Enhancing Material Libraries:** BIM contributes to expanding material property databases used in energy modeling, improving thermal property accuracy.
- **Life Cycle Assessment (LCA):** BIM acts as middleware between CAD and energy tools, adding extra attributes for LCA assessments.
- **Optimizing Building Envelope Design:** BIM enables pre-evaluation of materials and systems to enhance energy efficiency.
- **HVAC System Sizing:** BIM aids in designing and optimizing HVAC systems by assessing different alternatives.
- **Comprehensive Energy Management:** Overall, BIM improves energy simulations by automating workflows, enhancing visualization, integrating real-time data, and optimizing material and system selection.

5.4.2. Components of BIM-to-BEM interoperability process (BBIP)

Various components contribute to BBIP, and analyzing each component individually can enhance the understanding of challenges, issues, and potential solutions. As illustrated in Fig. 1, BBIP consists of three primary components. This study primarily focuses on the second and third components in the process, specifically BIM files and Building Energy Modeling (BEM) tools.

BEM tools generally consist of two main components: a Graphical User Interface (GUI) and a simulation engine. GUIs such as OpenStudio, BEopt, DesignBuilder, and eQuest facilitate the energy modeling process by providing an interactive interface for users. However, the energy simulation engine, which operates in the background, performs the actual calculations. Examples of widely used energy simulation engines include EnergyPlus and DOE2.

Figure 1: BBIP components.

One of the critical challenges in BBIP involves mapping building information into energy simulation tools and subsequently transferring simulation results back to the GUI. These processes, illustrated in Fig. 2, represent key areas where interoperability issues and data integration challenges arise in BBIP workflows.

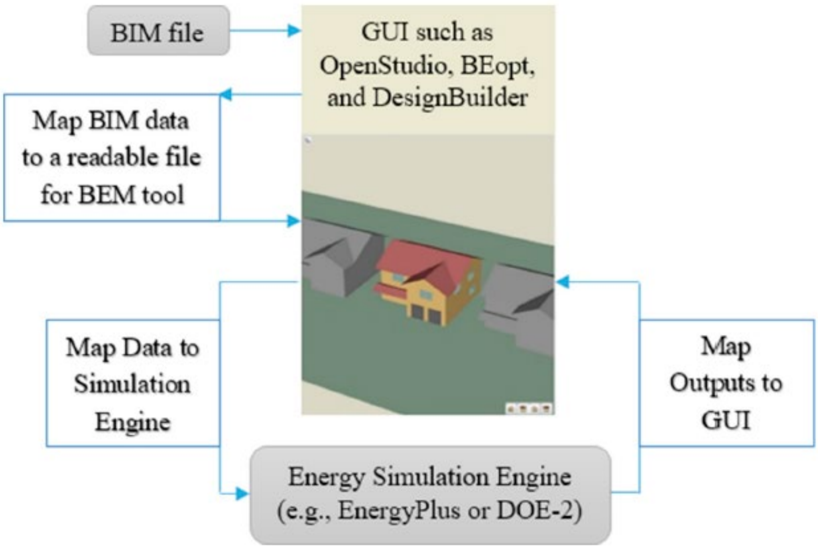


Figure 2: Information workflow in BBIP. Source [32].

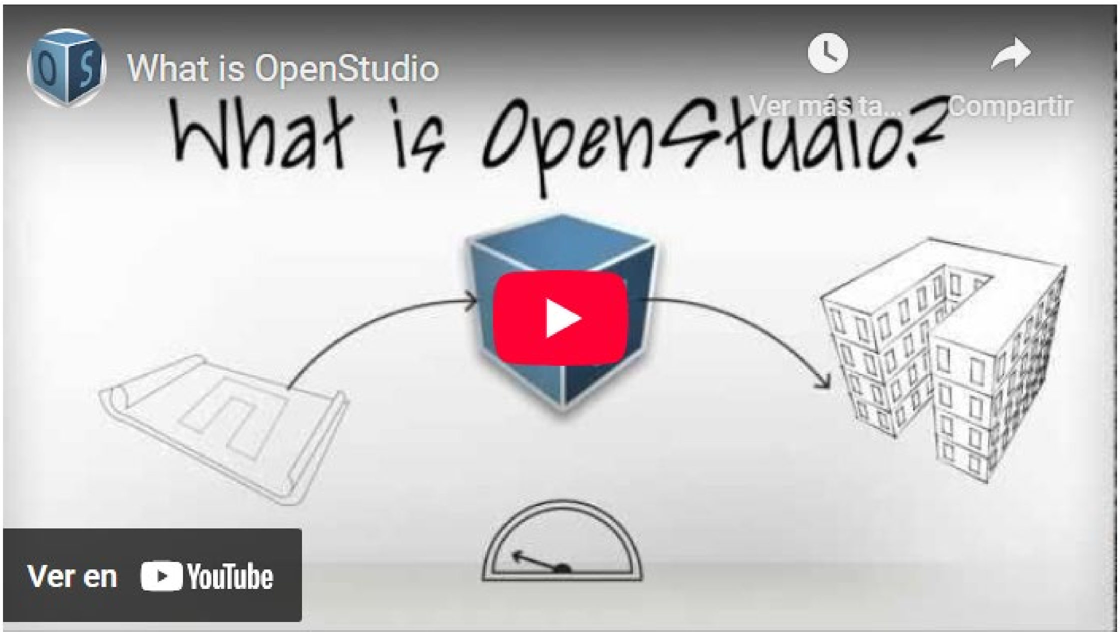
5.5 Software that uses BIM to analyse Building Energy Efficiency

5.5.1. Open Studio

[OpenStudio] is a cross-platform (Windows, Mac, and Linux) collection of software tools to support whole building energy modeling using EnergyPlus and advanced daylight analysis using Radiance. OpenStudio is an open source project to facilitate community development, extension, and private sector adoption.

OpenStudio SDK is both a Software Development Kit (SDK) and a Command Line Interface (CLI). Conceptually, OpenStudio SDK provides an Application Programming Interface (API) to access the EnergyPlus modeling engine. This interface provides many benefits such as a stable, version-controlled interface, space typology abstractions that make it easier for end-users to model buildings, and language bindings in Ruby, Python and C-Sharp to make it more accessible to users familiar with these languages. The CLI is a powerful, cross-platform tool that allows users to run OpenStudio based workflows on supported architectures such as Linux, Windows and Mac.

The graphical applications include the **OpenStudio SketchUp Plug-in, OpenStudio Application**, and **the Parametric Analysis Tool**. The SketchUp Plug-in and the Openstudio Application are maintained by the **OpenStudio Coalition**, which was founded to maintain and develop these graphical applications for the building energy modeling community. The SketchUp Plug-in is an extension to Trimble's popular SketchUp 3D modeling tool that allows users to quickly create geometry needed for EnergyPlus. Additionally, OpenStudio supports import of gbXML and IFC for geometry creation. The OpenStudio Application is a fully featured graphical interface to OpenStudio models including envelope, loads, schedules, and HVAC. ResultsViewer enables browsing, plotting, and comparing simulation output data, especially time series. The Parametric Analysis Tool enables studying the impact of applying multiple combinations of OpenStudio Measures to a base model as well as export of the analysis results for EDAPT submission.



https://youtu.be/ovLt4-q_UEg

5.5.2 DesingBuilder

DesignBuilder

https://designbuilder.co.uk/

A completely modular solution, DesignBuilder comprises a core 3-D modeller and 11 modules which work together to provide in-depth analysis for any building. Every module fully integrates with its counterparts, so you can pick individual modules or choose one of the packages.

Software packages contain the most common module combinations for each class of user as shown below. Modules can also be purchased separately and a site network license with any combination of modules is also available. Click on the module name or the job role for more information.

Modules:

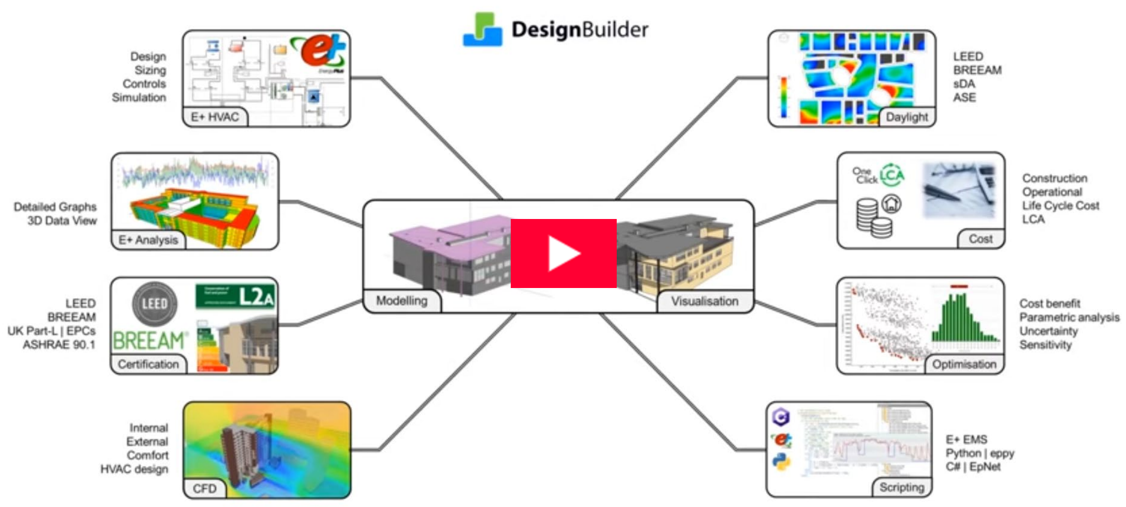
- 3-D Modeller - The core module, our efficient 3-D building modeller.
- Visualisation - Visualisation: Stunning rendered images and site shading analysis.
- Certification - EPCs and Part-L2 calculations in UK and Ireland.
- Simulation - EnergyPlus simulations for energy and comfort analyses.
- Daylighting - Reports daylight factors and illuminance using Radiance.
- HVAC - A powerful and flexible interface to EnergyPlus HVAC.
- Cost - Early stage building cost estimation.
- LEED - LEED EAp2 and ASHRAE 90.1 calculations.
- Optimisation - Multi-criteria optimisation to help meet design goals.
- Scripting - Customise EnergyPlus simulations using EMS or FMU.
- CFD - Computational Fluid Dynamics calculates distribution of air properties in and around buildings.

DesignBuilder enables you to

- Generate a wide range of outputs and reports to help you compare the performance of design alternatives.
- Optimise the building at any design stage based on the client's objectives.
- Model even complex buildings with the minimum of time and effort.
- Import existing BIM and CAD design data to give you a head start with data entry.

- Generate impressive rendered images and movies.
- Simplify EnergyPlus thermal simulation.

Video:



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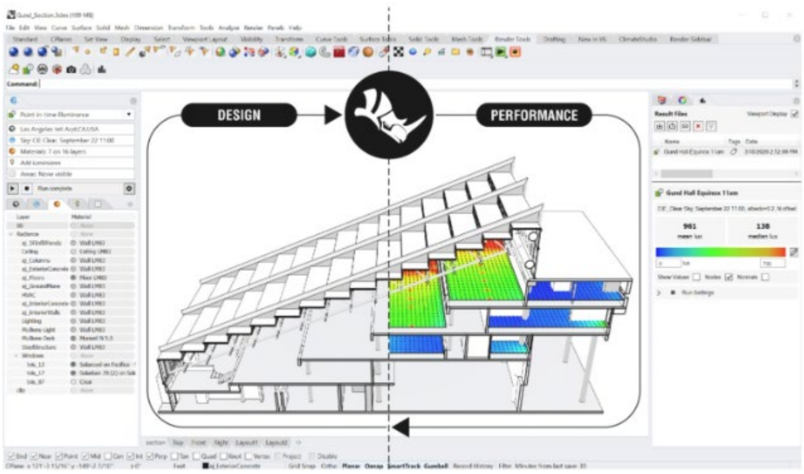
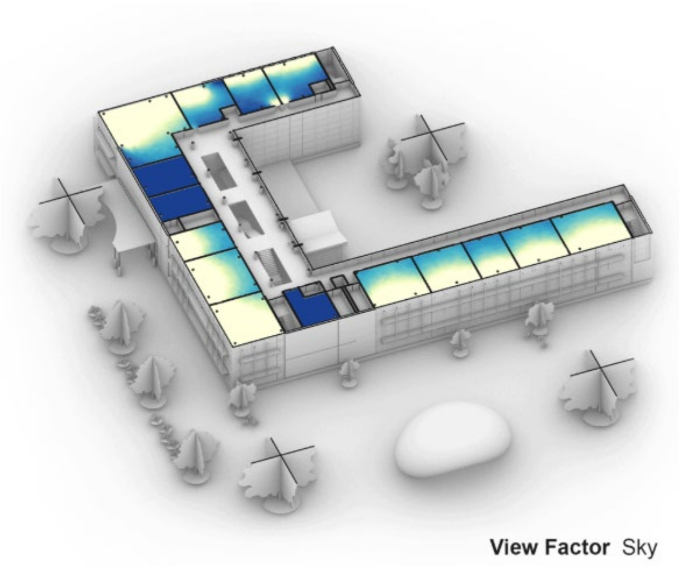
5.5.3 ClimateStudio

ClimateStudio

https://www.solemma.com/climatestudio



ClimateStudio is the fastest and most accurate environmental performance analysis software for the Architecture, Engineering and Construction (AEC) sector. Its simulation workflows help designers and consultants optimize buildings for energy efficiency, daylight access, electric lighting performance, visual and thermal comfort, and other measures of occupant health. ClimateStudio is a plugin for Rhinoceros 3D and requires the latest service release of version 6, 7, or 8.



Features of ClimeteStudio:

FAST AND ACCURATE

Built on EnergyPlus and a novel RADIANCE-based path tracing technology, ClimateStudio is the fastest and most accurate simulation software on the market. Yes, faster than cloud-based tools. And yes, more accurate than DIVA-for-Rhino. Finally, reliable results at 1000x the speed.

EASY TO USE

One-click wizards and intuitive results make ClimateStudio easy to use and understand. Custom settings, meanwhile, give experts full control.

BUILT FOR THE REAL WORLD

ClimateStudio comes with thousands of materials, constructions, and templates taken from real-world measurements and validated sources. Whether using DOE benchmarks, ASHRAE standards, or glazing products from the IGDB, ClimateStudio projects are always rooted in reality.

CLIMATE ANALYSIS

ClimateStudio includes a searchable library of over 30,000 weather files, and offers interactive visualizations of temperature, humidity, wind, radiation, and UTCI conditions on site.

SUN PATH AND SHADOW STUDIES

Visualize sun angles and shadows to highlight passive design opportunities and site impact.

LEED DAYLIGHTING COMPLIANCE

ClimateStudio calculates sDA the right way, using dynamic shading and the latest LM-83 standards. With groundbreaking speeds and automated reporting, you can go from zero to compliance with the click of a button.

ANNUAL GLARE

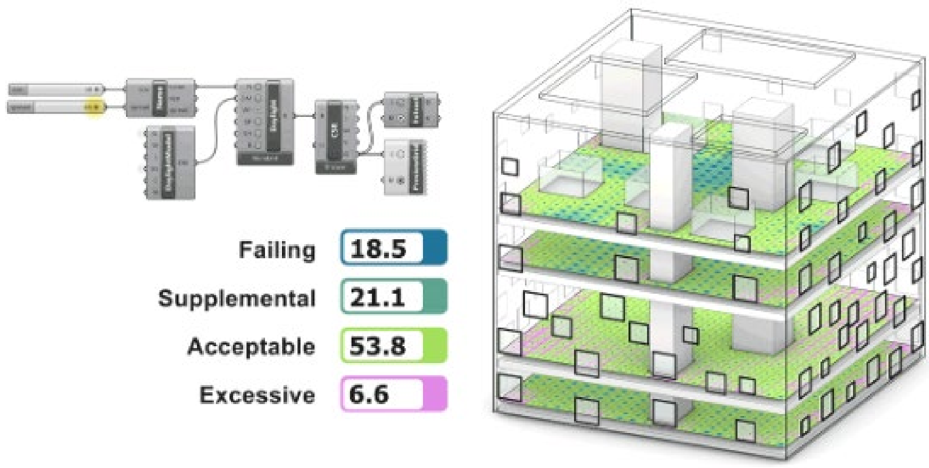
Assess glare from hundreds of viewing positions, for every hour of the year, all in a matter of seconds.

MULTIZONE ENERGY MODELING

With a fully-fledged UI, automatic adjacency detection, and interactive results, ClimateStudio makes multizone energy modeling a breeze.

PARAMETRIC TOOLS

ClimateStudio features fully parametric daylight and energy modeling via Grasshopper. Optimizations, sensitivity analysis, and automated model generation have never been easier.

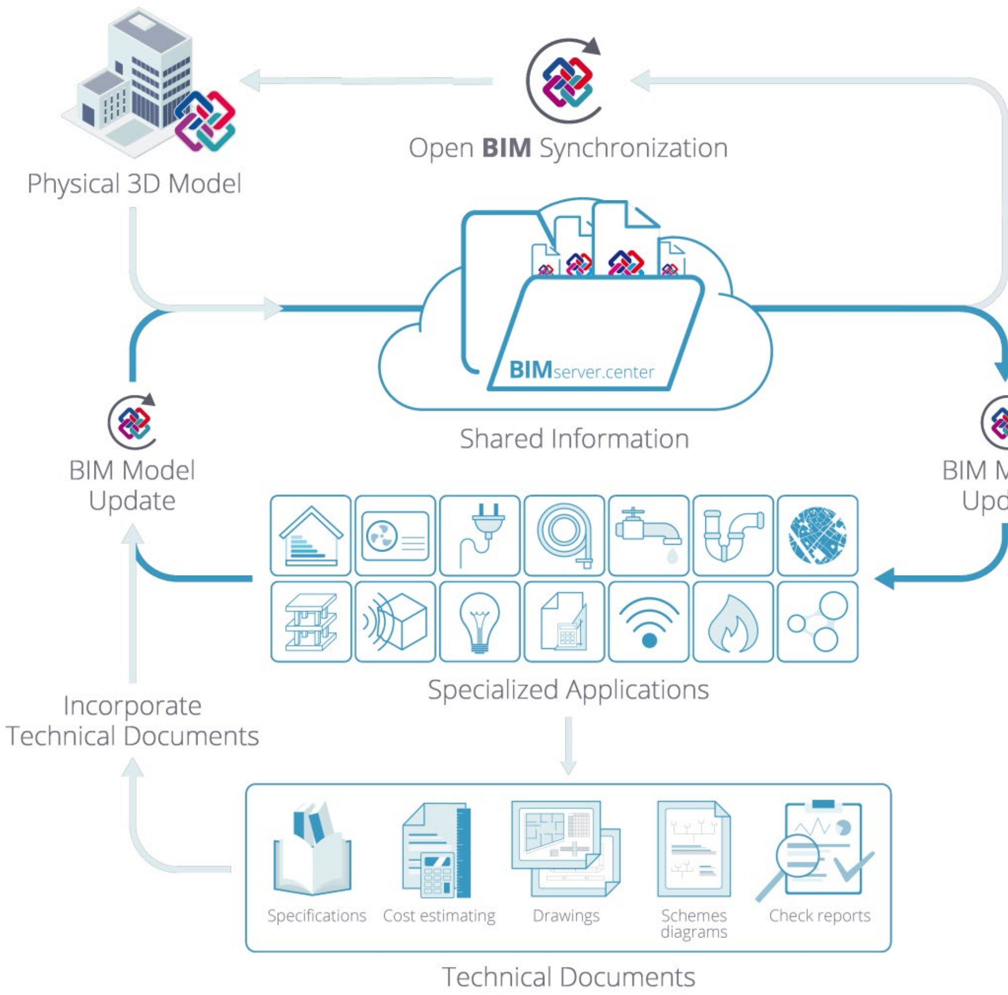


RENEWABLE ENERGY

Simulate the performance of photovoltaics to offset energy demands or demonstrate net-zero feasibility. Include battery storage and variable electricity pricing in your analysis.

5.5.4 Cype Package - CypeTherm E+

OpenBIM workflow with Cype



Using BIMserver.center, there is direct communication between all the users and applications that participate in a project that has been developed using the Open BIM workflow.

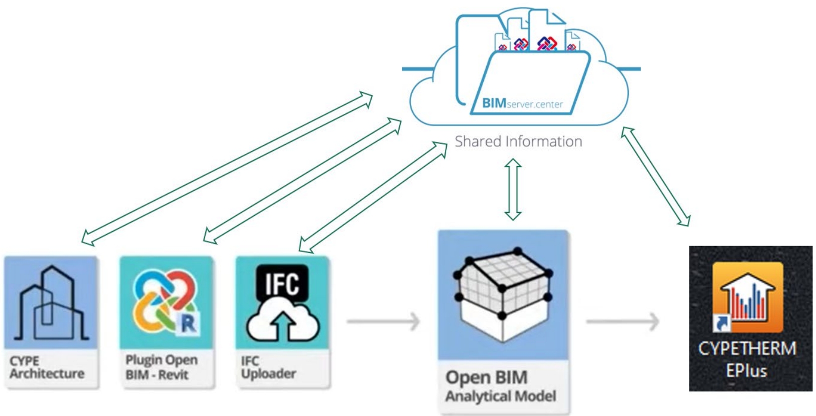
Using an updating serve in the cloud, with BIMserver.center, it is possible to manage and share all the files of a BIM project, providing the means for good organisation and communication amongst the users who are authorised to intervene in the project.

Furthermore, those who are responsible for the projects can manage the permits and accesses for each project, and for each authorised user, even allowing the possibility to provide contributions or proposals to any BIMserver user that is interested in participating in a project.

Energy performance analysis workflow with Cype

There are several possible workflows to perform analyses of the energy performance of buildings with Cype programs. In this tutorial we are going to show two of them.

Energy analysis workflow



Workflow 1

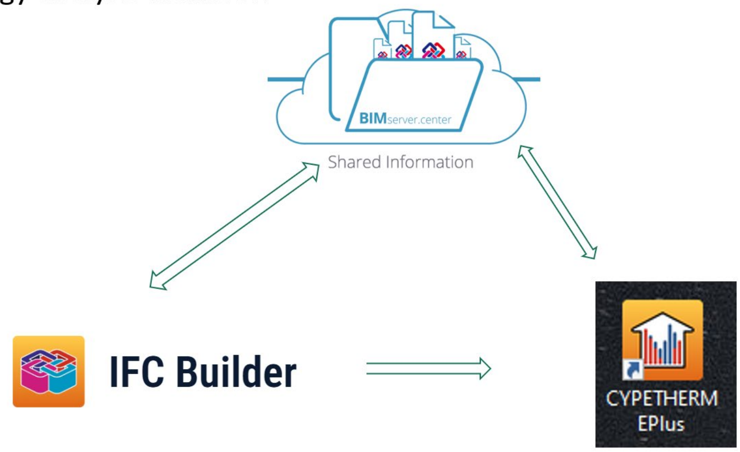
In workflow 1, a BIM modeler is used, which can be Cype Architecture, Revit or other software that builds a BIM model of the building in IFC4 format.

Once the BIM model has been built in IFC format, this model is sent to BIMServerCenter, and from there the OpenBIM Analytical Model software downloads it to make the analytical model of the building that has information about the spaces and volumes of the building. The OpenBIM Analytical Model then sends the analytical model to BIMServerCenter.

The next step is to use CypeTHERM Eplus which using the BIMServerCenter models created up to this point, finishes characterizing the energy model of the building (properties of the thermal envelope, HVCA systems, climate, solar radiation, thermal loads, comfort levels, etc.) and performs the energy analysis through the Energy+ engine.

If you opt for workflow 2, you only need to use two programs from the Cype package. IFC Builder to create the BIM model of the building and CypeTHERM Eplus to perform the energy analysis.

Energy analysis workflow



Workflow 2

CypeTherm HE Plus

CYPETHERM EPlus

[CYPETHERM EPlus - CYPE]

CYPETHERM EPlus is a program created to perform energy modelling and simulation of buildings with **EnergyPlus™**.

CYPETHERM EPlus is integrated into the Open BIM workflow via the IFC standard. It includes some of the following features:

• Importing the geometric model of the building from IFC files generated by CAD/BIM programs such as IFC Builder (free CYPE application), Allplan®, Archicad® or Revit®.

• Importing the building's air conditioning installation defined with manufacturers' systems from IFC files, generated by the Open BIM DAIKIN, Open BIM FUJITSU and Open BIM VAILLANT programs.

• Simulating the most widespread air conditioning systems in buildings, including manufacturers' predefined equipment.

• Integrating international codes and approved manuals for the definition of the thermal characteristics of the building.

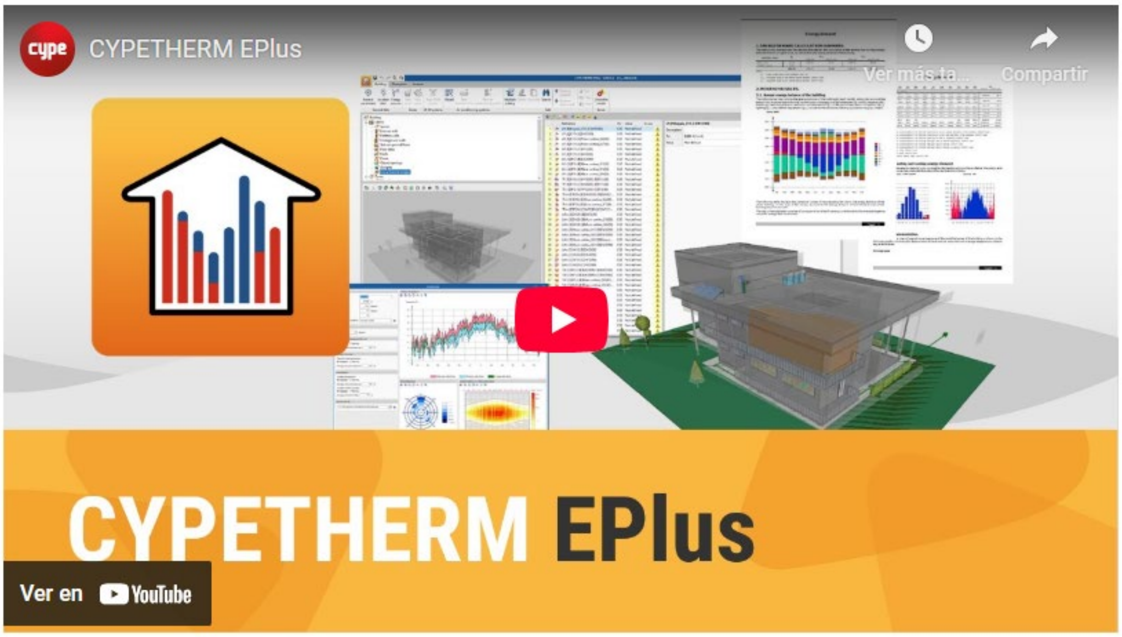
• Checking for surface and interstitial condensation.

• Automatically defining the building's thermal bridges from the edges of the BIM model.

• Reports on the results of the energy simulation of the building: energy demand, energy consumption, indoor comfort.

• Exporting analysis results to CYPETHERM Improvements Plus for the energy analyses and economic analyses of different building proposals.

Video



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6 - Deliverables

In order to evaluate the success of the application, we suggest a questionnaire to be held for the students.

7- What we have learned

The role of BIM in enhancing energy efficiency in buildings .

The role of BIM in Sustainable Design of buildings

The benefits of the 6^{th} BIM dimension.

The state of the art of BIM applications for the building energy model (BEM)

Examples of software that use BIM to analyse the Energy Efficiency of Buildings