USING BUILDING INFORMATION MODELING FOR GREEN INTERIOR SIMULATION AND ANALYSES

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Abstract

There is a growing trend of green building design that relies on technologies and computer simulations based on building information modeling (BIM) during the design process. Green building project teams are increasingly adopting BIM due to its capabilities of analyzing and simulating various design scenarios to make informed decisions to achieve green objectives. However, there is currently a gap in the technological approach to achieving green design in interior design. In order for interior designers to make informed decisions for effective green interior designs, interior designers need to understand the critical functions of BIM-based simulations and analyses in achieving green interior environments. We intend to analyze how BIM can be used for green simulations during the design process In addition, we will mention the nowadays experiences as well as the challenges and benefits of incorporating green simulations to interior design projects

Keywords: BIM, green project, sustainable design, CAD, Autodesk Revit, Green Studio Design.

1. Introduction

There is a growing trend of the green design movement that relies on technologies and computer science to make better design decisions during the design process. The most popular technology used in the architecture and design industry is building information modeling (BIM). Green building project teams are increasingly adopting BIM to achieve green objectives because of its capabilities of analyzing and simulating design options during the design process. Optimizing building performance for sustainability practices through BIM-based simulations and analyses is becoming an integral part of the mainstream practice in the architecture and design industry because BIM technology allows the direct input of building geometry to the analysis programs unlike the traditional practice where a separate modeling for building performance is done by other experts [14].

Methods for high-performance buildings require use of passive design strategies, use of advanced building technologies and renewable energy systems. Passive design strategies include shading, response to building orientation and site, utilization of thermal storage and natural ventilation, and use of daylight. Active design strategies include use of energy-efficient building systems and advanced building technologies where appropriate, such as mixed-mode ventilation, radiant heating and cooling systems, dynamic windows (for example, using electrochromic glass), and combined heat and power systems. Passive strategies should be utilized to the fullest extent since their cost is minimal and their effect on energy efficiency is significant. Advanced building technologies should be used to increase energy efficiency measures when and where applicable. Lastly, renewable energy should be used to supplement energy demand with renewable sources, such as wind power, photovoltaic systems and geothermal energy. Building performance simulations are an integral part of the design process, since they help in investigating different options and simulation of design decisions [2]. It is important to note that improvements in building efficiency reduce the energy consumption, thus reducing the needs for renewable energy sources. Therefore, understanding effects of design decisions on building performance is crucial in achieving low and zero energy buildings.

2. Literature Review

2.1 The definition and implementation of the BIM

In order to identify the clear definition if the BIM and understand it's impact on the creation of the green and sustainable design, we will analyze the definitions below:

According to The National Institute of Building Standards (NIBS)puts forward a definition of aBuilding Information Model as follows:

"BIM is a digital representation of physical and functional characteristics of a facility.As such it serves as ashared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle from inception onward."[11].

Also U.S. General Services Administration (GSA) in its published report (GSA BIMGuide) defines Building Information Modeling as follows [12]:

"Building InformationModeling isthe developmentand useof a multi-faceted computer softwaredatamodeltonotonlydocumentabuildingdesign,buttosimulatetheconstruction and operation of a new capital facility or a recapitalized (modernized) facility. The resulting Building Information Model is a data-rich, object-based, intelligent and parametric digital representation of the facility, from which views appropriate tovarious users' needs can be extracted and analyzed to generate feedback and improvement of the facility design."

These definitions establish a clear separation between regular 3D geometric models thatcontain very little intelligence. BIM models contain a high level of intelligence, a 3Dmodel includes a three-dimensional geometric representation of the building, whereas aBIM is organized as a prototype of the building, in terms of building floors, spaces, walls,doors, windows and a wide array of information associated with each of these elements.The main characteristics of BIM can be summarized in the following points:

BIM operates on digital databases. The term "Information model" has its roots in the arena of information technology andmanagement of digital databases. An Information Model provides the framework for organizing content, once you have created it for your content repository, you will be ableto label information in ways that will enhance search and retrieval. The information can be reorganized in many ways, depending upon who is doing the search [13].

Every element ina BIM model comes with editable attributes that are stored as data in a table. The links between the datain differentelementsof aBIMassembly areconsistentlymanaged and interconnected (fig. 1).Such applications start with capturing information about the building, then present them back and make it availablefor use and reuse at every phaseinthe project. [12].

Storing and managing building components in theform of a database gives a BIM processthe following advantages [6]:

- Better change management. Maintaining an internally consistent representation of the building as a database improves drawing coordination and reduces errors in the documents.
- Better coordination. Ambiguities in the design documents are resolved between the design and construction teams before construction.
- Information reuse. Reuse of building information leads to connections from BIM authoring solutions to other applications for energy analysis, structural analysis, cost reporting, facility management, and many others.

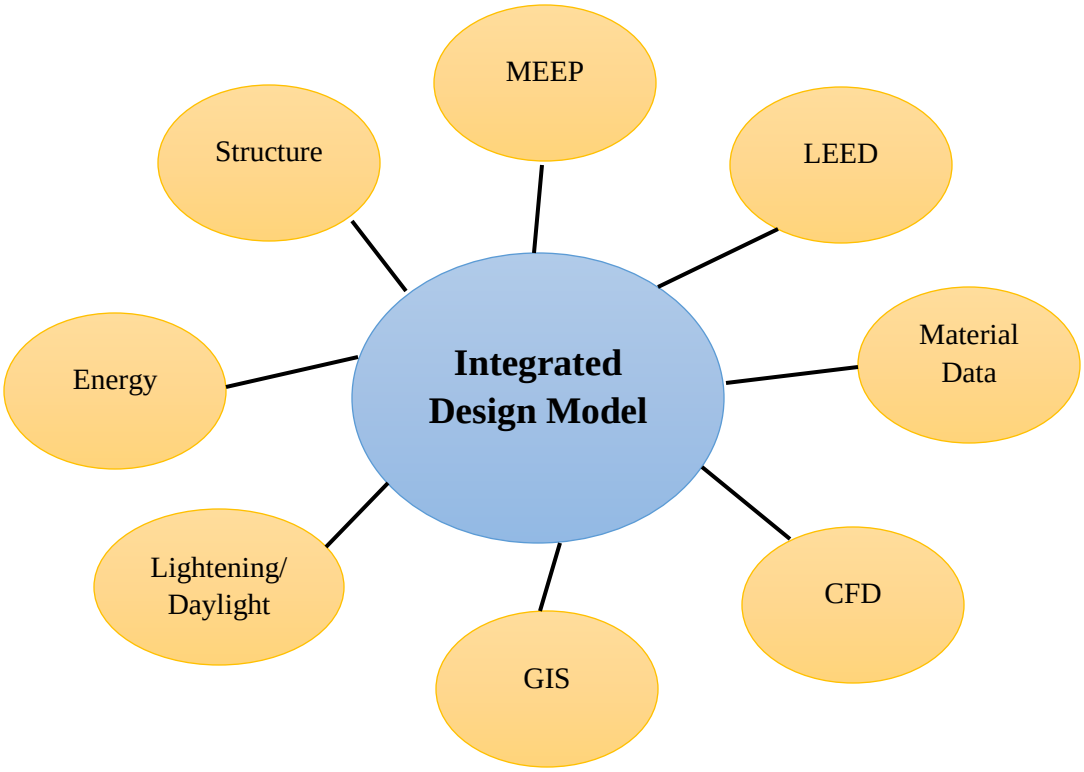


Figure 1: The integrated design model as a central database. Source: [12].

BIM is object based. Traditional CAD models are recognized as the digital representations of well-understooddrawings of building objects. Thus the models represent the shapes and dimensions byassembling lines into solid models. As an example,Figure 2gives the elevation view of a building in CAD. The objects canbe clearly classifiedby differentlayers in the design - Layer for exterior walls, another one for windows, etc. Every aspect of element'sgeometry must be edited manually, and it will take substantial amount of time to conductthese changes, while some errorsand omissions may occur in this process.

BIM models include a 3D geometric representation of the building, it is organized as a prototype of the building, in terms of building floors, spaces, walls, doors, windows and awide array of information associated with each of these elements. Embedded informationcan describe the geometry, as well as, materials, specifications, price, manufacturer, andany other related data associated with how the object is actually used. A window as asmart object understands its relationship to a wall and reacts accordingly (fig. 3).

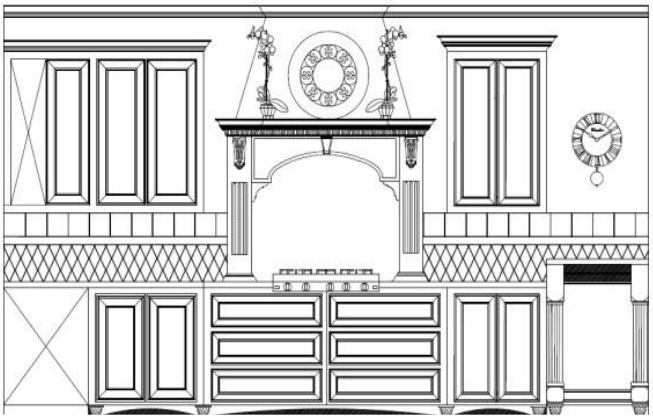


Figure 2: CAD elevation showing drawing entities created on separate layers. Source: [26].

Figure 3: In aBIM model, building elements areclassified according to their real nature. Source: [25].

BIM provides more enhanced parametric modeling. There are differences between the parametric modeling tools used in BIM and those usedin other industries. Each building system has typical building rules that are more predictable than for general manufactured objects.

BIM toolshave theirownpredefinedset of object types; each having possibly different behaviors programmed with them, likewalls, windows etc. BIM builds upon the concept of parametric geometric modeling,offering a more comprehensive approach to building design as follows;[9]

Object-based parametric modeling addresses geometry, but objects also need to carry a varietyof properties if they are to be interpreted, analyzed, and priced.

For example, design properties address space and are a names, properties for spaces such as occupancy, activities, and equipment performance needed for energy analysis. Figure 4 shows a wall cladding scheme created in Autodesk Revit. Wall cladding properties include geometric definition as well as material and phase of construction.

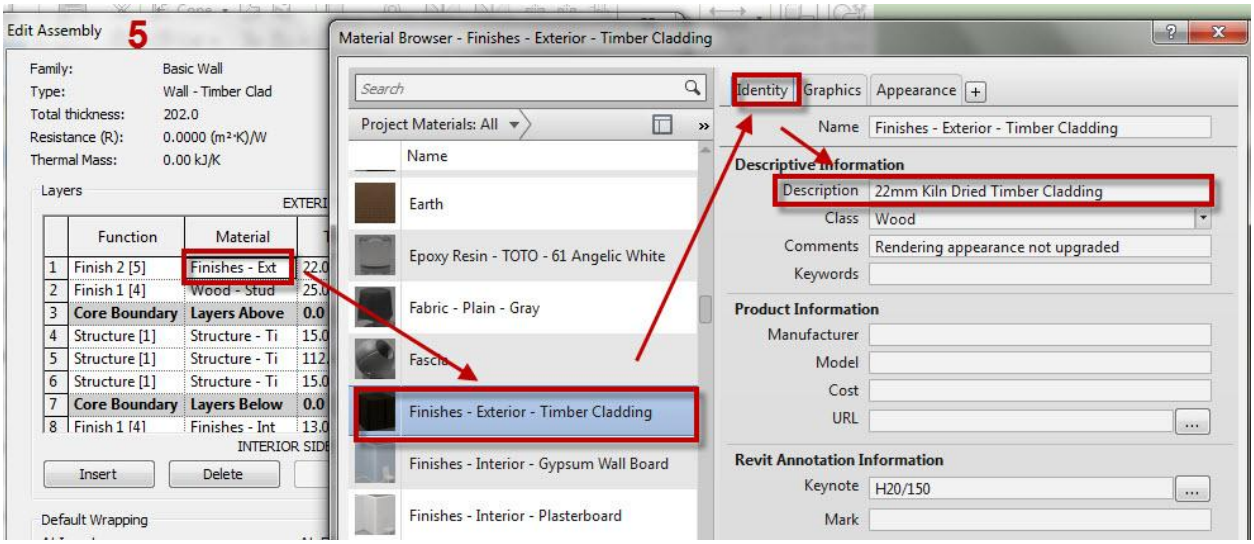


Figure 4: Snapshot of the properties of a wall cladding, created in Autodesk Revit. Source: [24].

2.2 Building performance analysis and design process

In order to evaluate and optimize the building performance, different analysis cycles supported by simulations should be part of an integrated design process. This is the basis for performance-based design method. However, this is challenging paradigm when compared to a traditional design method [2]:

1) Traditional Method has deficiencies because:

- it may include simplified assumptions based on rules-of-thumb which can be inaccurate;
- it may force an aesthetic feature without considering performance impacts;
- it may not provide performance measurement/evaluation of a certain design solution.

2) Building Performance-Based Design. Method has an ability to estimate the impact of a design solution since:

- performance measures are investigated with actual quantifiable data and not rules-of thumb;
- it uses detailed building models to simulate, analyze and predict behavior of the system;
- can produce an evaluation of multiple design alternatives.

Despite the increase in number of available tools in the last decade, some architects and designers are finding it difficult to use these tools, since they are not compatible with their working methods and needs, or the tools are judged as complex and cumbersome [10, 15]. To

remain competitive, design professionals must weigh the value of information gained through simulation tools against the invested time, resources and against the value of comparable information that might be gained through the use of other or no tools [4]. Quantifiable predictions through simulations and modeling can help in identifying strategies and methods to improve building energy efficiency and building performance, and help in the decision-making process for sustainable design. They must be integrated with the design process from the earliest stages of the design.

Starting point for the schematic design is site analysis, where environmental factors must be systematically examined. Typical information about environmental conditions of the site includes topography, context, solar orientation, climatic characteristics, surrounding structures, and infrastructure [3]. Building orientation plays a significant role in providing access to daylight, as well as solar exposure. Solar radiation introduces passive solar heat gain, which can be advantageous in heatingdominated climates and unfavorable in cooling-dominated [18]. While passive solar gain can be harnessed to decrease heating demand in winter, gains during summer months create the need for cooling. Building Information Models (BIM) can be used for energy and performance simulations, where the analysis process can be integrated with the design process. Figure 5 shows the basic types of performance analysis in relation to the project stages indicating what types of analysis should be performed when and how they relate to the BIM development process. The top part of the diagram shows the impact of decisions on actual building performance and relationships to project stages. As early as conceptual phase, the analysis should focus on the bigger design picture such as climate information, orientation, passive strategies and building massing. Then at the schematic stage, the analysis should explore the shading methods, solar access and building envelope options. For example, the iterative cycle of different design options of sun shades can be analyzed at this stage. During the design development stage, optimization of shading devices, daylight and glare studies, energy performance studies, thermal analysis and optimization should take place. However, BIM design authoring software programs and analysis applications are currently distinct and require exchange of data and building information. To successfully use BIM design models for environmental and performance analysis, it is important to consider the Level of Development (LOD) of BIM design models, what type of information is needed from them to develop BIM analysis models, and data exchange mechanisms and workflow between different software programs. LOD refers to the amount of information embedded in BIM design models, and widely accepted example is the American Institute of Architects (AIA) document E202 [1].

For example, LOD 100 should include overall building massing, area, height, volume; and can be used to analyze building orientation. LOD 200 includes model elements as generalized systems or assemblies, and may include non-geometric information, such as material properties. BIMs at this stage of development can be used for performance analysis of shading devices, daylight/glare analysis, basic energy analysis, as well as thermal studies. LOD 300 includes model elements that are accurate in terms of quantity, size, shape, location and orientation, and the amount of information embedded in the models is equivalent to construction documentation. BIMs at this stage of development can be used for detailed daylight/glare analysis, energy analysis, as well as optimization of systems. It is important to note that these

types of studies have the greatest impact on the building performance if they are conducted early in the design process (conceptual, schematic and design development).

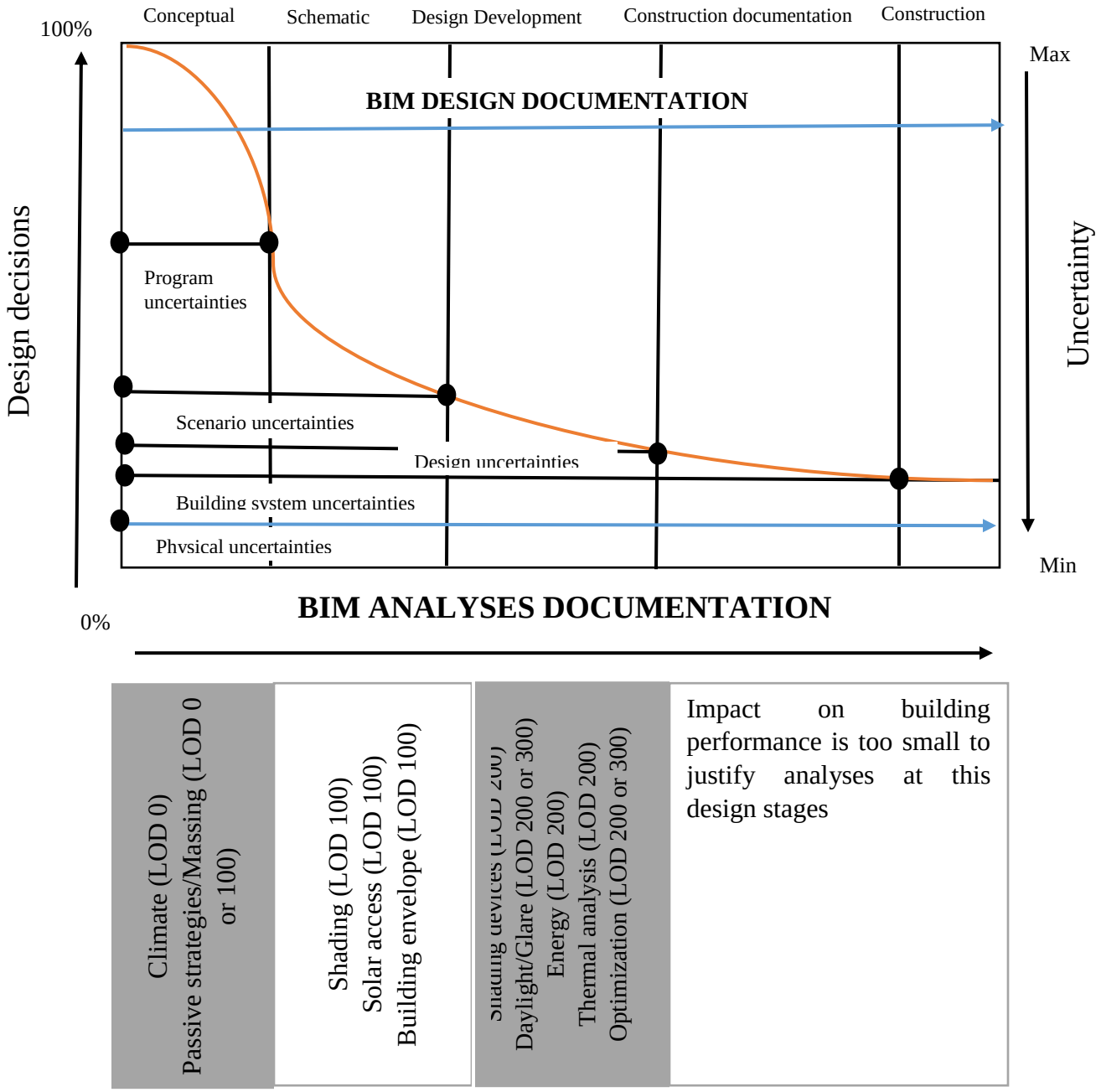


Figure 5: Design decisions and uncertainly for building performance. Relations between "BIM design" and "BIM analysis" process and documentation, indicating recommended level of development (LOD) to be embedded in the BIM models corresponding to each simulation type/analysis. Source: [1].

Building Information Modeling (BIM) is both the creation of a set of digital models of a planned or built environment, as well as the process of working collaboratively with these

models during the lifecycle of that facility. BIM typically contains a set of 3D models and information about relevant components and attributes. Currently, BIM is used mostly during the design phase of a building project although its use during the construction and operation phases is increasing.

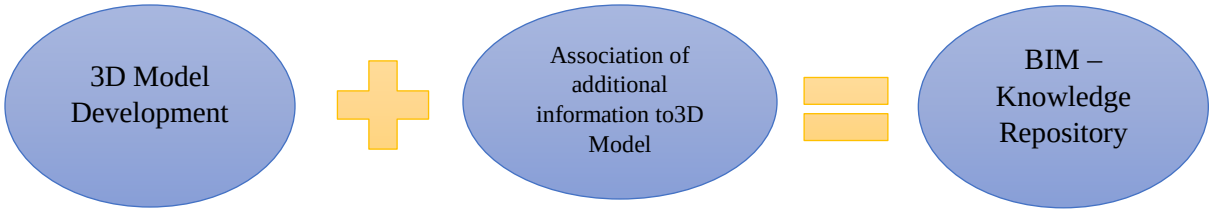


Figure 6: The scheme of the BIM Modeling. Source: [16].

Sustainability means meeting the needs of today without compromising the ability of future generations to meet their needs. Most of the advances promoted by the sustainability mega-trend are derived from something very intangible, software. Software is a sustainable product, especially when it comes to supporting other sustainable tools to do more with less. The sustainability of the construction business can be measured by defining how "green" the building is in terms of energy and material consumption during its construction, usage, maintenance, and demolition. There is no need to invent that much new; a lot can be learned from established practices used in, for example, electricity distribution and the maintenance processes of off-shore structures. Software can be used to optimize material selection, utilize the resources of the construction process more efficiently, and improve the maintenance of buildings by a diversity of applications [16].

In current practice, many digital models do not contain sufficient information for building performance analysis and evaluation- the building blocks of sustainable building design. As with traditional physical models and drawings, evaluating building performance based on graphic representation of conventional CAD or object CAD solutions requires a great deal of human intervention and interpretation, which renders the analysis too costly and/ or time consuming. The BIM-based building modeler represents the building as an integrated database of coordinated database. Beyond graphically depicting the design, much of the data needed for supporting sustainable design is captured naturally as design of the project proceeds. Linking the building model directly to the analysis software, allows for preliminary verification of the "broad stroke" or "big picture" sustainable design goals. With architectural computer software design tools and modeling programs, the design team can quickly generate multiple design options during the schematic phase that take into account site specific characteristics such as solar orientation and sky path [12].

Energy Analysis Quality sustainable design requires an understanding of how a building will perform after it's built, which in turn requires computer-based simulation software for rigorous building analysis. The advent of BIM (building information modeling) offers even greater opportunities for building analysis by pairing the analysis software and BIM for the seamless assessment of building performance. For decades, energy simulation software tools

have been available to assist in designing energy-efficient buildings. However, most building energy analysis is conducted late in design, when other building features cannot be changed. Using traditional CAD solutions, energy analysis can be a painful process. If it‘s a 2D solution, either special 3D analysis models are created or manual plan take-offs from the floor plans are done. If it‘s a 3D solution, building data is extracted from disparate CAD files and then merged into a single input file. In most cases, the data must be massaged for analysis import and then the output has to be ―translated‖ for the designer‘s consumption [8].

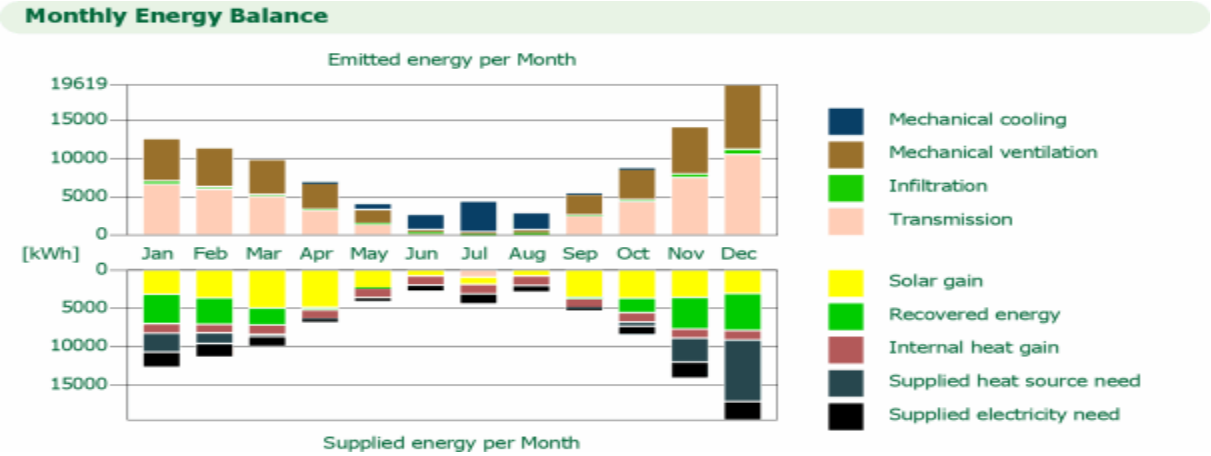


Figure 7: The building energy evaluation scheme. Source: [23].

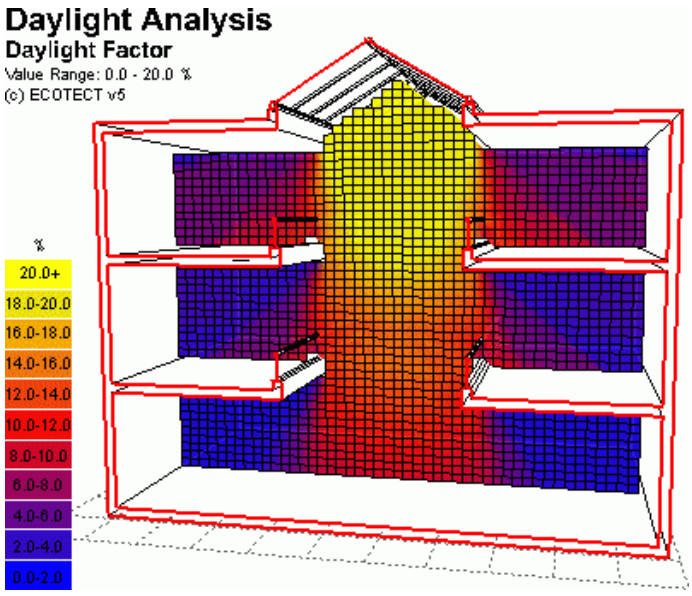


Figure 8: Daylight and shadow Analysis. Source: [22].

Daylight Analysis. Daylighting, the practice of using natural light to illuminate buildings, not only makes people more comfortable and productive, it can sharply reduce the electrical lighting load and subsequent heat and energy loads. A sustainable high performance design can derive much of its ultimate success from effective relationship to, and integration of sun's energy in to the design of the building envelope and fenestration. Using the building model for sustainability can be a great advantage. Before the older processes would include creating a separate digital model for analysis or creating a physical model and placing it on-site to measure the daylight levels. This could take a great deal of time to get an accurate analysis. Now the BIM model can be exported to a format that can be imported into Ecotect Analysis or 3Ds Max Design. This saves time and can be more accurate since the materials are assigned in the model, windows are placed in precise locations, and curtain walls and storefronts are modeled to exact dimensions. When bringing this information into 3Ds Max Design, the program will recognize most material assignments and all of the model geometry. Furthermore, in the 3Ds Max Design program it is possible to modify and adjust material characteristics, glazing characteristics, reflectance and refractive values and many other variables. This takes into account the entire interior environment of the building so that the designer can adjust these elements as necessary for the visual comfort of the future occupants. It is very important to get more accurate feedback from the daylight analysis, especially because each material has specific reflective and refractive values to consider [14].

One way of taking a BIM model (Revit Architecture) into daylight analysis software (3Ds Max) is First, model the building in Revit to the extent that it would be ready for analysis (preferably it has interior spaces defined and windows positioned). By using Day light system and accurate whether data file and most importantly by setting up the cameras, the first set of analysis can be run. Rapid energy modelling is a streamlined process that helps you analyze and estimate building energy consumption using Building Information Modeling (BIM) solutions. With a smaller budget, shorter timeframe, and less initial data, building professionals can evaluate expected building performance and identify areas for improvement.

This rapid energy modeling workflows using Autodesk solutions and documents results from real-world validation. The table below shows how the various software options are used in the three-step rapid energy modeling process [17].

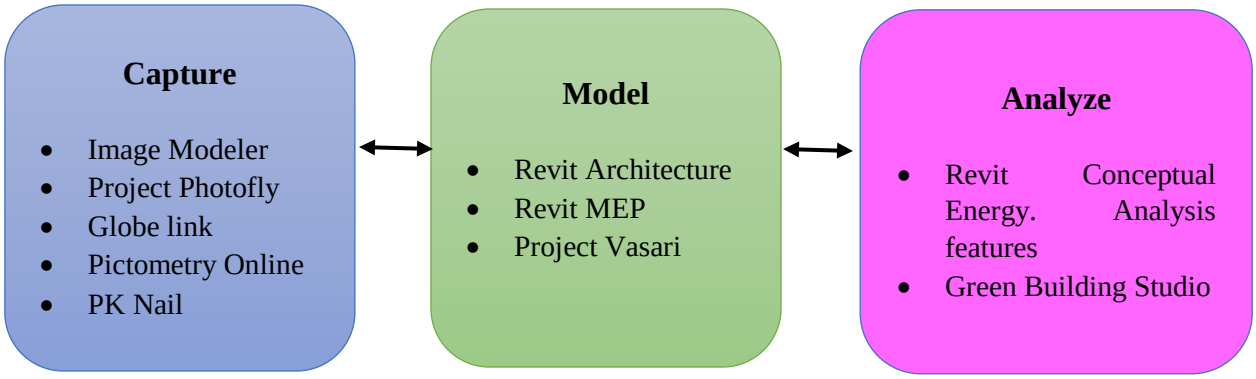


Figure 9: The combination of these various software options translate into a series of distinct rapid energy modeling workflows. Source: [16].

3. Analyze of a Building Design with the help of the "Autodesk"

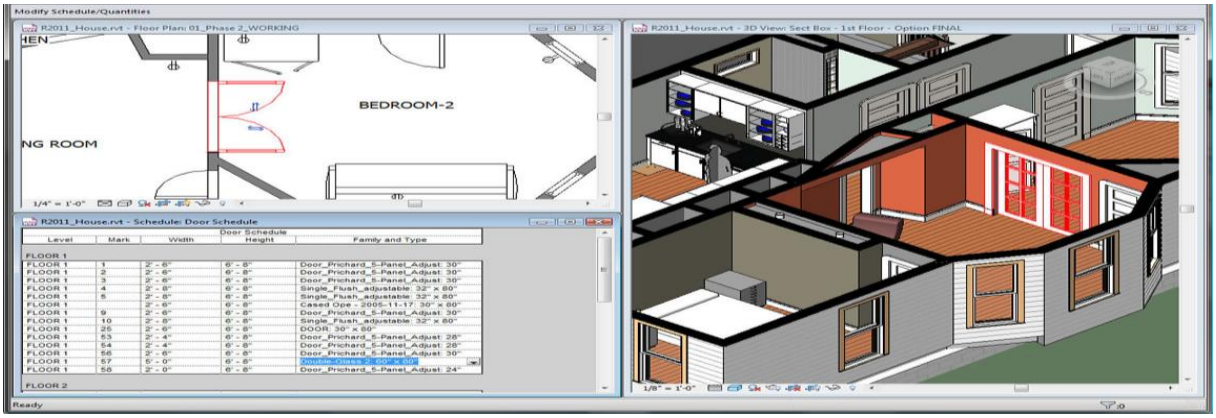
BIM enables architects and engineers to use digital design information to analyze and understand how their projects perform before they are built. Developing and evaluating multiple alternatives at the same time enables easy comparison and informs better sustainable design decisions.

A computable Revit design model is a great fit for the analyses needed for sustainable design — even during schematic design. As soon as the layout of a building's walls, windows, roofs, floors, and interior partitions (elements that define a building's thermal zones) are established, a Revit model is ready for whole building analyses.

Performing these analyses in a CAD workflow is a fairly difficult undertaking as the CAD model has to be exported and carefully massaged to work with analysis programs. In addition, most analysis software is complex and requires special training — making it unsuitable for casual users like architects or designers. Furthermore, the output of most analysis programs is complicated, making it hard for architects or designers to understand what to do to improve upon their designs [7].

Revit Architecture 2010 is used to develop the 3D model. Built for Building Information Modeling (BIM), Autodesk Revit Architecture software helps to capture and analyze most innovative design conceptsand maintain vision through documentation. The information-rich models that the software provides support decision-making for sustainable design, clash detection, construction planning and fabrication, while helping to work collaboratively with engineers, contractors and owners. Autodesk Revit Architecture generates every schedule, drawing sheet, 2D view, and 3D view from a single foundational database, automatically coordinating changes as the project develops and evolves.

Bidirectional Associativity: A change anywhere is a change everywhere. In Autodesk Revit Architecture, all model information is stored in a single, coordinated database. Revisions



and alterations to information are automatically updated throughout the model, minimizing errors and omissions

Schedules: Schedules provide another view of the comprehensive Autodesk Revit Architecture model. Changes to a schedule view are automatically reflected in all other views. Functionality includes associative splitschedule sections and selectable design elements via schedule views, formulas, and filtering.

Additional Flow	Area	Bottom Elevation	Friction	Height	Hydraulic Diameter	Flow	Loss Coeffi
0.0 L/s	7 m²	4100	0.72 Pa/m	200 mm	246 mm	236.0 L/s	0.5678
0.0 L/s	1 m²	4100	1.79 Pa/m	250 mm	308 mm	707.9 L/s	0.0455
0.0 L/s	0 m²	4100	0.41 Pa/m	250 mm	281 mm	236.0 L/s	0.0048
0.0 L/s	3 m²	4300	0.72 Pa/m	200 mm	246 mm	236.0 L/s	0.2237
0.0 L/s	0 m²	4132	0.72 Pa/m	200 mm	246 mm	236.0 L/s	0.0309
0.0 L/s	0 m²	4800	13.21 Pa/m	100 mm	133 mm	236.0 L/s	0.1216
0.0 L/s	0 m²	4800	2.20 Pa/m	200 mm	200 mm	236.0 L/s	0.0160
0.0 L/s	8 m²	4800	1.53 Pa/m	200 mm	267 mm	471.9 L/s	0.5135
0.0 L/s	0 m²	4800	0.00 Pa/m	200 mm	267 mm	0.0 L/s	0
0.0 L/s	3 m²	4800	0.43 Pa/m	200 mm	267 mm	236.0 L/s	0.1769

Figure 11: Schedule review “Autodesk”. Source: [20].

Parametric Components: Parametric components, also known as families, are the basis for all building components designed in Autodesk Revit Architecture. These components offer an open, graphical system for design thinking and form making, while providing the opportunity to adjust and express design intent at increasingly detailed levels. Parametric components can be used for elaborate assemblies, such as cabinetry and equipment, as well as for elementary building parts, such as walls and columns. Best of all, no programming language or coding is

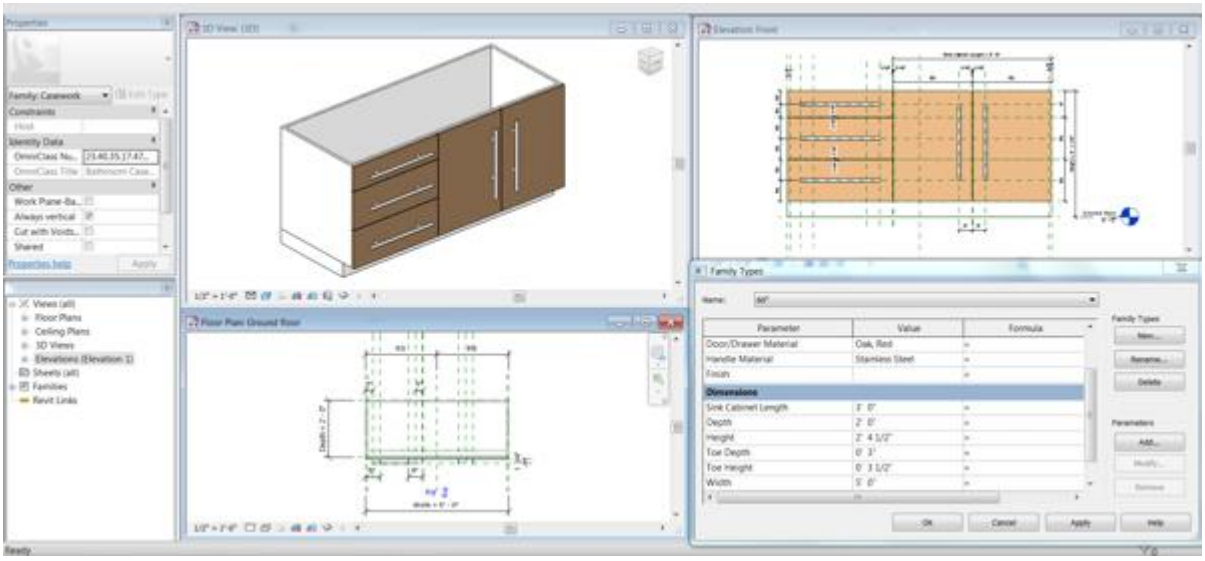


Figure 12: Autodesk Revit LT uses families as the basis for representing all building components, including furniture, casework, doors, windows, walls, and more. Source: [19].

required.

Material Takeoff : Calculate detailed material quantities with Material Takeoff. Ideal for better calculation of material quantities on sustainable design projects and cost estimates, Material Takeoff helps smooth the material quantity tracking process. As projects evolve, the Autodesk Revit Architecture parametric change engine updates material takeoffs.

Sustainable Design: Conceptual energy analysis tools help one to make every design more sustainable. Cloudbased analysis tools are used to quickly compare the energy consumption and lifecycle costs of design alternatives right from within Autodesk Revit Architecture software. Analysis results are presented in a highlyvisual, graphical format for easy interpretation [5].

Building Information Modeling (BIM) is poised to be a major innovation in architecture industry in the 21st century, and Revit supplies oxygen to this wonderful innovation. There are considerable numbers of reasons behind the increasing acceptance of Revit software in architecture industry. BluEnt, a globally leading construction documentation firm, has observed the following advantages of Revit Building Information Modeling software:

1. *Preview the Future Home in 3D BIM Modeling:* Revit Parametric modeling is a significant tool for conceptual design. With Revit software, architectural designers can quickly sketch a rough layout of the floor plan, or make changes to the standard set of building designs and instantly let their customers preview their future homes. 3D design views give designers to try out different design ideas and guide their design decisions at early stage.
2. *Quick Changes to Design, No Repetitive Tasks:* During the design phase, the building structure and floor plans needed to be modified frequently. With Revit BIM software, architecture designing and drafting becomes very fast and accurate. In Revit architecture model, all building components such as plans, sections, and elevations are intelligently connected to each another. Whenever a change is made to the model, the software automatically updates every related component, affecting the whole building model.
3. *Vast Library of Parametric Building Components:* BIM authoring tool Revit software comes with a full set of parametric building design components. It also allows quick changes to the existing components. It stores the newly created or customized parametric objects to be reused in other projects. While designing a new project, architectural designer can use the stored parametric building objects for quick references to the prospective clients.
4. *High Quality Construction Documents:* 3D modeling capacity of Revit architecture enables designers and drafters to easily identify the clashes and areas of congestion, and resolve them early in the process. It results in error-free and high quality construction documentations.
5. *Accurate Estimation of Quantities and Cost:* One of the most important advantages of building information modeling software is the automatic generation of bill of quantities (BOQ). BIM modeling software like Revit produces accurate material quantity takeouts

as a by-product, with less-efforts. This advantage helps the contractors and owners to determine if the project adheres to budgets.

6. *Improved Coordination:* BIM drafting software Revit unifies design, drafting, construction and facility management processes in single environment, allowing all stakeholders to remain updated and aware of their responsibilities, and thus improving overall coordination. A total understanding by everyone on the project of what's happening removes the design conflict and risks.
7. *High Level of Flexibility:* Unlike AutoCAD, Revit allows all project data to be stored in single project file. It allows multiple users to work on the same project file and merge their changes with every save. Besides, Revit exports and imports DWG, DXF, DGN, PDF, JPEG files [17].

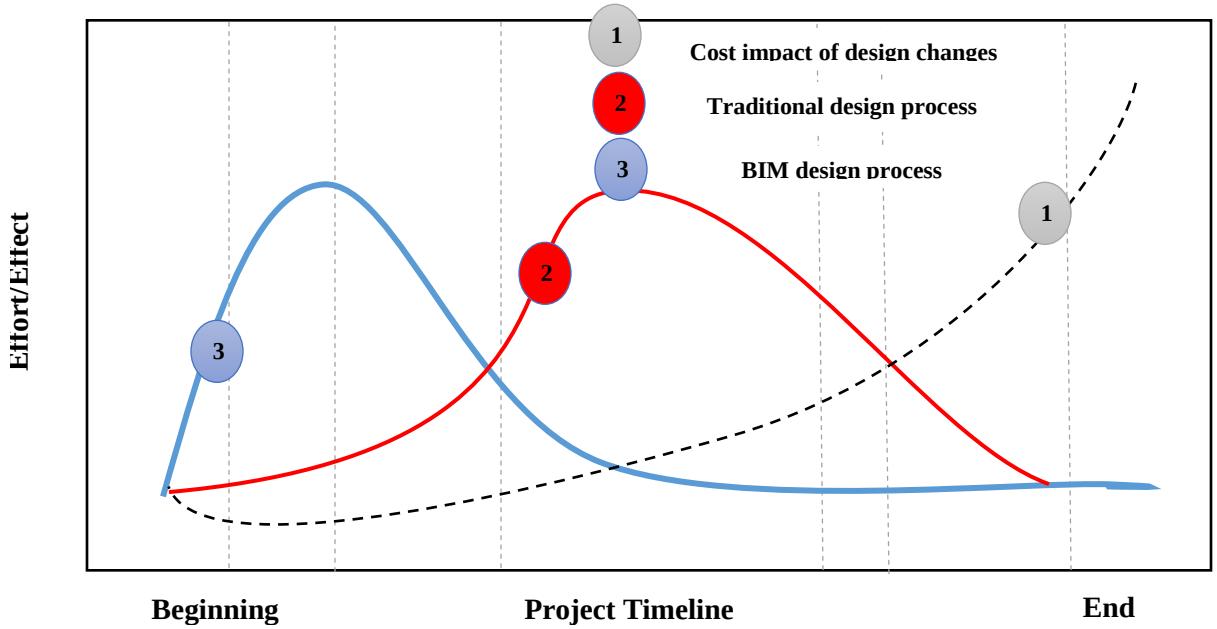


Figure13:BIM Process Shift the Design Curve. Source: [17].

The list of Revit advantages continues. It is proved that BIM approach is ―significantly more efficient‖ than the traditional drafting-based approach. Architectural design and drafting firms are realizing the benefits of BIM implementation software. For example BluEnt BIM, a leading BIM construction documents developer has started drafting in Revit BIM software for large and complex building practices, and delivering the clients significant benefits in terms of time and Cost.

Autodesk Green Building Studio is a web-based service that includes industry leading building energy and carbon analysis tools. Green Building Studio tools enable architects and designers to evaluate the energy profiles and carbon footprints of various building designs. Files are shared between engineering software programs and among engineers and architects early in the design cycle, making sustainable design more efficient and cost effective. It is offered free to members of the Education Community. This web service supports products in the architecture and building design family such as; Autodesk Ecotect Analysis, Autodesk Revit Architecture,

Autodesk Revit MEP, AutoCAD Architecture, AutoCAD MEP. Autodesk Green Building Studio supports the needs of those who challenge themselves with design of sustainable and environmentally responsible structures [7].

With the AutodeskGreen Building Studio web-based energy analysis service, architects and designers can perform whole building analysis, optimize energy efficiency, and work toward carbon neutrality earlier in the design process.

Energy and Carbon Results: The Green Building Studio energy engineering results pages provide extensive information on a building‘s energy performance and resource use to help compare the relative energy costs of building design scenarios at the conceptual design stage.

Whole Building Energy Analysis: With Green Building Studio, a virtual building‘s total energy use and carbon footprint are determined, and can be reduced. Annual energy use, including all electrical and fuel uses, is broken down into lighting, HVAC, and other equipment, with hourly analysis simulations using the DOE-2.2 simulation engine. Further breakdowns of energy use for major electric and gas end users—such as lighting, HVAC, and space heating—are provided in graphical format. Percentages associated with each category can be seen by clicking on the pie charts with the mouse.

Carbon Emission Reporting: Carbon dioxide (CO2) emissions are reported for nearly all aspects of the building, including on-site fuel use and emissions at power plants that supply electricity to the building. The power plants that generate electricity to the electric grid that serves the building are also summarized by their fuel type.

Water Usage and Costs Evaluation: A summary is given of the estimated water use, in, and outside the building, based on the number of people in the building, as well as the building type. To obtain Water Efficiency LEED credits, you can make adjustments to your fixtures, and get immediate results in water use calculations. The water usage analysis allows the user to apply a variety of water savings measures, including efficient fixtures, water catchments, and native vegetation. It also provides the potential LEED credits available for these measures.

Photovoltaic Potential: Every exterior surface on your building is analyzed to determine the amount of electricity that could be generated if photovoltaic panels were on the surface. A high-level summary of your building‘s photovoltaic electricity potential is provided.

Daylighting: Qualification for LEED daylighting credit is automatically provided for every analysis. Each room‘s glaze factor calculations are summarized to allow you to determine the action required to improve this factor, and increase eligibility for LEED daylight credits [16].

Table 1. Comparison between Green building Studio and Ecotect Analysis

	Autodesk Green Building Studio. *Measures how the building consumes resources*	**Autodesk Ecotect.** *Measures how the environment impacts building performance*
Life cycle costs	✓	
CO2 Emissions	✓	
Acoustic		✓
Water use	✓	
Energy use and cost	✓	

Airflow/Ventilation	✓	✓
Thermal Loads	✓	✓
Lighting(LEED & Energy Saving)	✓	✓
Climate	✓	✓
Shading		✓
Solar		✓
Energy code compliance		✓

4. Conclusion

This research indicates that BIM can facilitate the very complex processes of sustainabledesign and the related activities and analyses, as well as automate a multitude of activitieslike material takeoffs, while capturing and coordinating information into a singleintegrated model. Thus greatly saving time and effort associated with such complexdesign tasks, and more importantly, provide design model data and geometry that is up to date to all project participants.

The increase in the number of analysis tools is a testament to the increasing importance of sustainable design in architecture and the need to optimize building performance. The BIM-based design and documentation system is ideally suited for delivering the kind of information that can be used to improve design and building performance. Much of the data needed for supporting green design is captured naturally during the design process and is extracted from the building information model as needed. Revit Architecture facilitates the very complex process of sustainable design like daylighting and solar access, and automates the drudgery of activities like material takeoffs- all the while capturing and coordinating information in the documentation set. The analysis products it leverages such as Green Building Studio and Ecotect analysis expand its natural capabilities to provide specialized function bounce light calculations, energy analysis and specification management. Linking these products to Revit Architecture make this technology far more accessible than before, giving architects easy access to tools that provide quick feedback on green design alternatives.

References

1. AIA, (2008). AIA Document E202: The American Institute of Architects Building Information Protocol Exhibit. - 12
2. Aksamija, A., and Mallasi, Z., (2010). “Building Performance Predictions: How Simulations Can Improve Design Decisions”, Perkins+Will Research Journal, Vol. 2, No. 2, pp. 7-32.
3. Aksamija, A., (2010). “Analysis and Computation: Sustainable Design in Practice”, Design Principles and Practices: An International Journal, Vol. 4, No. 4, pp. 291-314. - 10

4. Attia S., Beltran L., de Herde A., and Hensen J., (2009). "Architect Friendly: A Comparison of Ten Different Building Performance Simulation Tools", Proceedings of IBPSA '09 Buildings Simulation Conference, Glasgow, 204-211 -9
5. Autodesk®Revit®Architecture, Design without compromise. (prepared by: Autodesk)
6. Building Information Modeling (Autodesk white paper, 2002).
7. BIM and Green Building Studio (1-2-3 Revit Tutorial) prepared by: Rick Rundell, AIA)
8. Doyle J. (2009). Building Information Modeling and sustainability.
9. Eastman Ch. and others, BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors (New Jersey: John Wiley & Sons, 2011), pp. 58 – 62
10. Gratia, E., and de Herde, A., (2002). "A Simple Design Tool for the Thermal Study of an Office Building", Energy and Buildings, Vol. 34, pp. 279-289. -7
11. GSA BIM Guide Overview (U.S. General Services Administration, 2007)
12. Ibrahim M., 'CAD Smart Objects: Potentials and Limitations', in 21th eCAADe Conference Proceedings, 2003.
13. JoAnn T. Hackos, Content Management for Dynamic Web Delivery, 1st edn (Wiley, 2002), p. 124
14. Lee Young S. (2010). Using Building Information Modeling for Green Interior Simulations and Analyses. Michigan State University
15. Punjabi, S., and Miranda, V., (2005). "Development of an Integrated Building Design Information Interface", Proceedings of IBPSA '05 Buildings Simulation Conference, Montreal, pp. 969-976. -8
16. Rundell R. BIM and Green Building Studio (1-2-3 Revit Tutorial) prepared by: Rick Rundell, AIA)
17. Streamlining Energy Analysis of Existing Buildings with Rapid Energy Modeling, (prepared by: Autodesk)
18. Zisko-Aksamija, A., (2008). "Information Modeling in Architectural Design: Collaborative Environment for Decision-Making Process", Design Principles and Practices: An International Journal, Vol. 2, No. 2, pp. 79-88. -11
19. www.cabs-cad.com
20. apps.exchange.autodesk.com
21. www.autodesk.com
22. archicad-talk.graphisoft.com
23. www.3dcadco.com
24. aectrainer.com
25. www.cadalyst.com
26. www.archblocks.com