Autodesk® Ecotect™ Analysis 2010
Revit® Architecture and Revit® MEP

Sustainable Design Analysis and Building Information Modeling

The white paper explores how Autodesk® Ecotect™ Analysis software helps architects and other users analyze the performance of their conceptual building designs.

The world is changing, the economy is changing, and the architectural practice is changing. Designing energy- and resource-efficient buildings, in many locations, is no longer optional, but mandatory. While owners have always sought designs that are cost-effective to operate and that will command premium lease values, research shows that green buildings (for example, LEED®-certified) are more likely to deliver on these criteria. A 2008 report from McGraw Hill Construction finds a 13.6 percent decrease in operating costs from green building and a 10.9 percent increase in building values as reported by architects, engineering firms, contractors, and owners over the past three years. (McGraw Hill Construction September 19, 2008) More pressing is the growing number of local and national regulations that mandate targets for energy and resource efficiency as well as carbon emission reductions in new and renovated buildings. These government initiatives—such as the 2007 U.S. Energy Independence and Security Act or the European Union's Energy Performance Buildings Directive—are certainly put in place to help reduce greenhouse gas emissions and slow our impact on climate change, but they are also instituted to reduce dependence on unpredictable markets for oil as an energy source and, most recently, to help stimulate the global economy.

According to the U.S. Department of Energy (DOE), buildings contribute roughly one-third of greenhouse gas emissions worldwide, primarily from electricity consumption; in the United States, 76 percent of all power generated is consumed by buildings. As voluntary goals—such as the AIA 2030 Challenge to achieve carbon neutral buildings by 2030—become the basis for regulation, improving building energy performance presents an enormous opportunity for innovative architecture, engineering, and construction practices.

Building professionals can help dramatically reduce the negative environmental impact of new and renovated buildings by employing sustainable design principles.

Sustainable Design in Practice

Design decisions made early in the process can deliver significant results when it comes to the efficient use of the vital resources. Employing sustainable analysis tools helps architects and engineers to make better informed decisions earlier in the design process and enables them to have a greater impact on the efficiency and performance of a building design. Historically, analysis software could be complex and require special training—making it unsuitable for infrequent users such as architects or designers. Sustainable analysis tools, such as Autodesk Ecotect Analysis helps users to become proficient faster by providing access to immense stores of data and the ability to more quickly iterate for optimal sustainable designs.

Designing and delivering more sustainable projects can be complex. It requires close coordination across different project stages, from design through construction and operation. Many firms are looking for the best way to integrate building information modeling (BIM) technology with sustainable design and analysis tools. BIM is core to Autodesk's sustainable design approach for building performance analysis and simulation.

Analyzing a Building Design

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 Autodesk® Revit® Architecture design model is devised for sustainability analyses—even during early conceptual 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, the information employed to create a Revit® model can be used to perform 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. Using the Autodesk Ecotect Analysis to analyze early building designs emerging from a Revit-based BIM process can simplify the analysis process.

Whole Building Energy, Water and Carbon Analysis

Subscribers to Autodesk Ecotect Analysis can get access to the Autodesk® Green Building Studio® web-based service for the duration of their subscription. The web-service enables faster, more accurate whole-building energy, water, and carbon emission analyses and helps architects—the majority of which are not specially trained in any of these analyses—to evaluate the carbon footprint of a Revit-based building design with greater ease.

The Green Building Studio web service was first introduced in 2004. Today, its analysis results meet ASHRAE Standard 140 and are qualified by the U.S. Department of Energy. The service received the Microsoft Ingenuity Point Award in 2008.

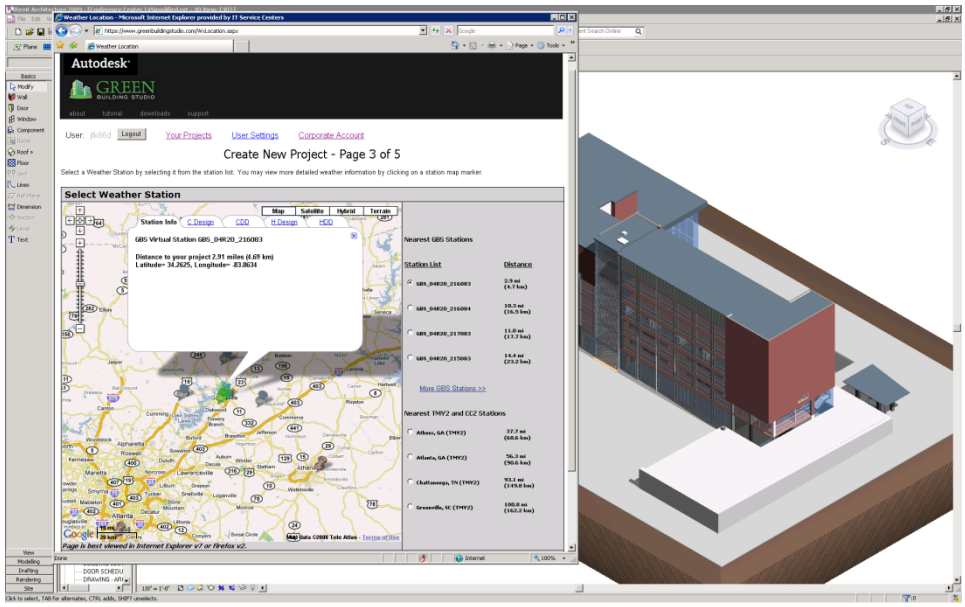


Figure 1:

The Autodesk Green Building Studio web-based service enables faster, whole-building energy, water, and carbon emission analyses of a Revit-based building design. The building location (being defined here) drives the resulting electricity and water usage costs.

Built specifically for architects and using green building extensible markup language (gbXML) for easy data exchange across the Internet, the web-based service was one of the first engineering analysis tools to deliver easy-to-use interoperability between building designs and sophisticated energy analysis software programs such as DOE-2.

The link between the Revit platform and the Green Building Studio web service is facilitated through a plug-in that enables registered users to access the service directly from their Revit Architecture design environment.

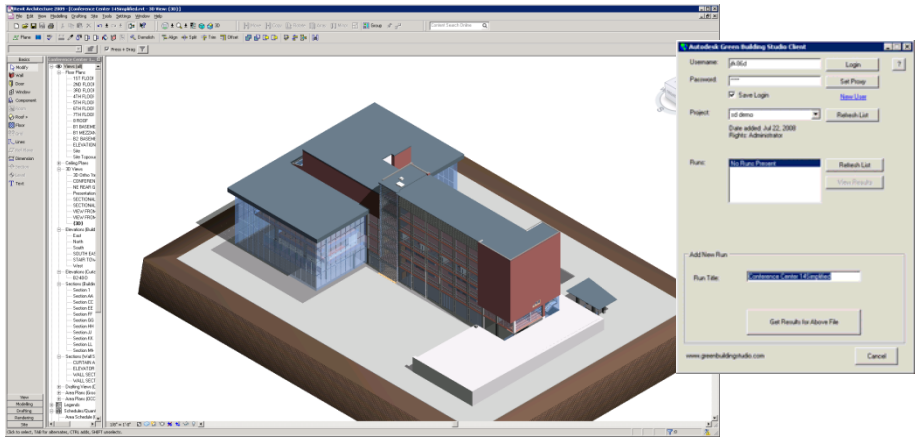


Figure 2:

The link between the Revit platform and the Autodesk Green Building Studio web-based service is facilitated through a plug-in that enables registered users to access the service directly from their Autodesk Revit Architecture design environment.

Inline Energy Analysis

The Autodesk Green Building Studio web-based service enables architects and other users to perform faster analyses of a Revit-based building design, from within their own design environment, directly over the Internet. This helps streamline the entire analysis

process and enables architects to get faster feedback on their design alternatives—making green design more efficient and cost-effective.

Based on the building's size, type, and location (which drives electricity and water usage costs), the web-based service determines the appropriate material, construction, system, and equipment defaults by using regional building standards and codes to make intelligent assumptions. Using simple drop-down menus, architects can quickly change any of these settings to define specific aspects of their design; a different building orientation, a lower U-value window glazing, or a 4-pipe fan coil HVAC system.

The service uses precise hourly weather data, as well as historical rain data, that are accurate to within 9 miles of the given building site. It also uses emission data for electric power plants across the United States and includes the broad range of variables needed to assess carbon neutrality.

Analysis Results

Usually, within minutes the service calculates a building's carbon emissions and the user is able to view the output in a web browser, including the estimated energy and cost summaries as well as the building's carbon neutral potential. Users can then explore design alternatives by updating the settings used by the service and rerunning the analysis, or by revising the building model itself in the Revit-based application and then rerunning the analysis.

The output also summarizes the water usage and costs, and electricity and fuel costs; calculates an ENERGY STAR score; estimates photovoltaic and wind energy potential; calculates points toward LEED daylighting credit; and estimates natural ventilation potential. Unlike most analysis output, the Autodesk Green Building Studio report is easier to understand—giving architects and other users actionable information they need to help make greener design decisions.

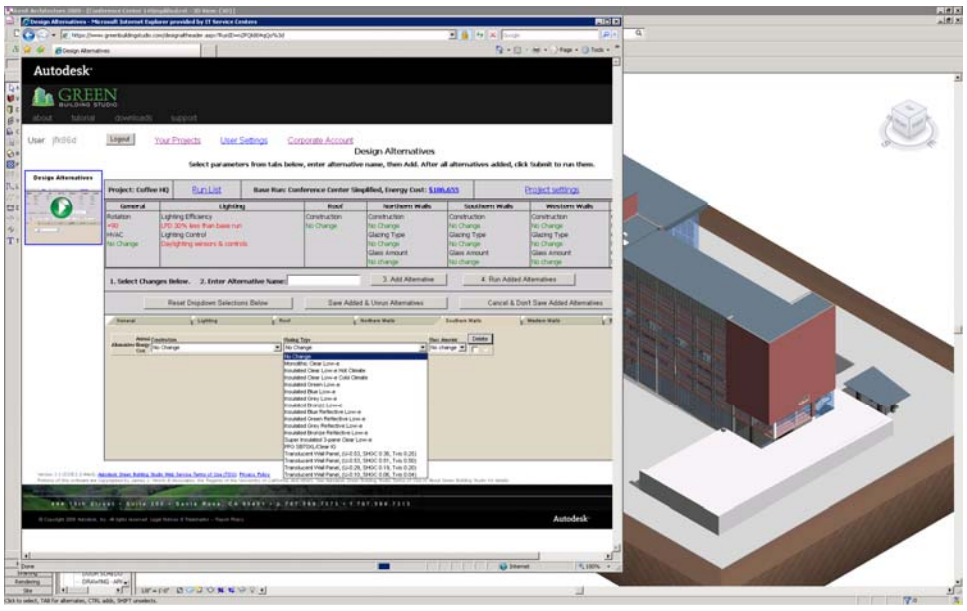
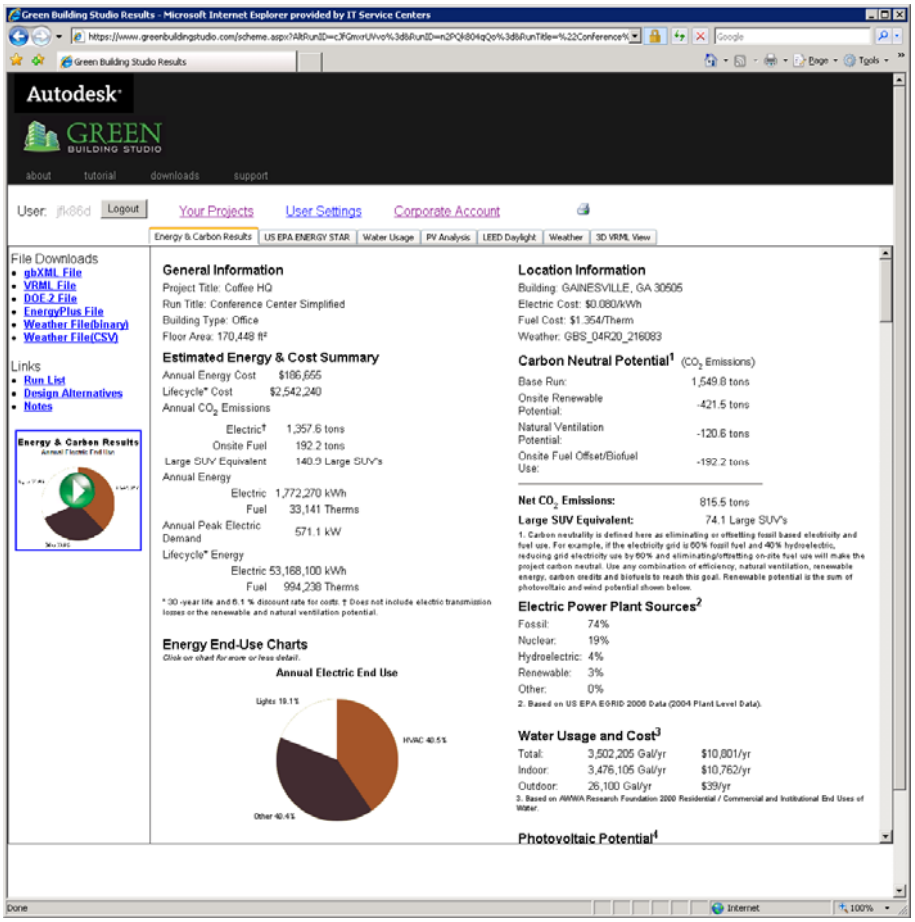


Figure 3:

Architects and other users can explore design alternatives by updating the settings used by the Autodesk Green Building Studio web-based service and rerunning the analysis, or revising the building model itself in the Revit-based application and then rerunning the analysis.



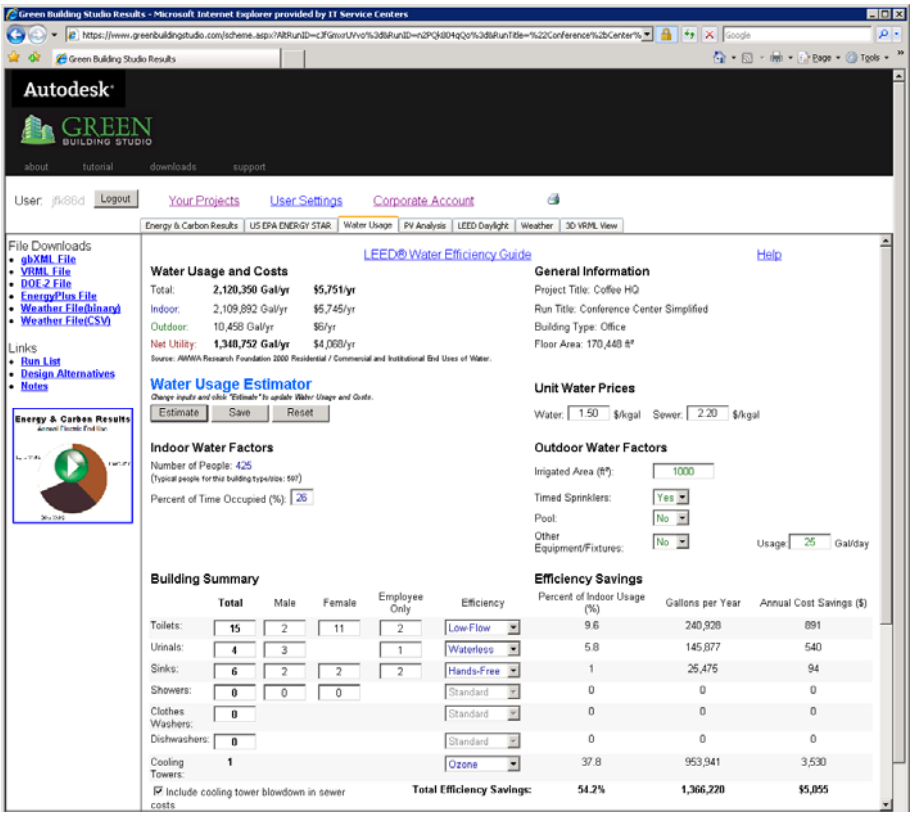


Figure 4:

The Autodesk Revit-based software application user views the output of the analyses in a web browser, including the estimated energy and carbon emission summaries (shown left) and a detailed LEED water efficiency guide (shown below).

Detailed Environmental Performance

The desktop tools in Autodesk Ecotect Analysis provide a wide range of functions and simulations, helping architects and other users to understand how environmental factors will impact building operation and performance in the early design phase.

Working *with* the Environment

To mitigate a building's impact on the environment, it is important to first understand how the environment will impact the building. Built specifically by architects and focused on the building design process, Autodesk Ecotect Analysis is an environmental analysis tool that enables designers to simulate the performance of their building projects right from the earliest stages of conceptual design.

Autodesk Ecotect Analysis combines a wide array of analysis functions—including shadows, shading, solar, lighting, thermal, ventilation, and acoustics—with a highly visual and interactive display that presents analytical results directly within the context of the building model. This visual feedback enables the software to communicate complex concepts and extensive datasets more effectively and helps designers quickly engage with multifaceted performance issues—at a time when the design is sufficiently "plastic" and can be easily changed.

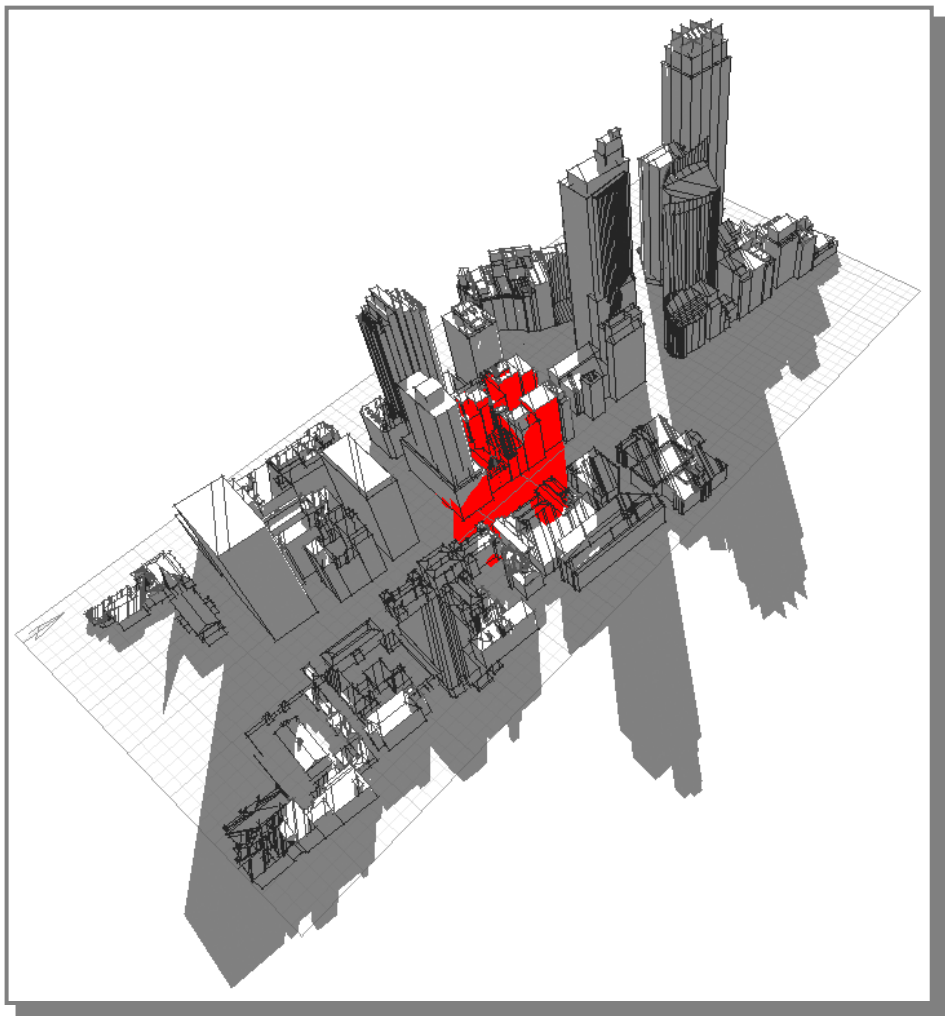


Figure 5:

Early stage Autodesk Revit Architecture models can be analyzed with Autodesk Ecotect Analysis to help determine the optimal location, shape, and orientation of a building design—based on basic environmental factors such as the overshadowing of a particular building (highlighted in red) shown here.

Analyzing a Design in the Context of BIM

Revit-based design models can be exported to gbXML format and imported directly into Autodesk Ecotect Analysis for simulation and analysis throughout the design process. At the onset of the design process, very early stage Autodesk Revit Architecture massing models can be used in combination with site analysis functionality in Autodesk Ecotect Analysis to help determine the optimal location, shape, and orientation of a building design—based on fundamental environmental factors such as daylight, overshadowing, solar access, and visual impact.

As the conceptual design evolves, whole-building energy, water and carbon analysis can be conducted using the integrated access to Autodesk Green Building Studio in order to benchmark its energy use and recommend areas of potential savings. Once these fundamental design parameters have been established, Autodesk Ecotect Analysis can be used again to rearrange rooms and zones, to size and shape individual apertures, to design custom shading devices, or to choose specific materials—based on environmental factors such as daylight availability, glare protection, outside views, and acoustic comfort.

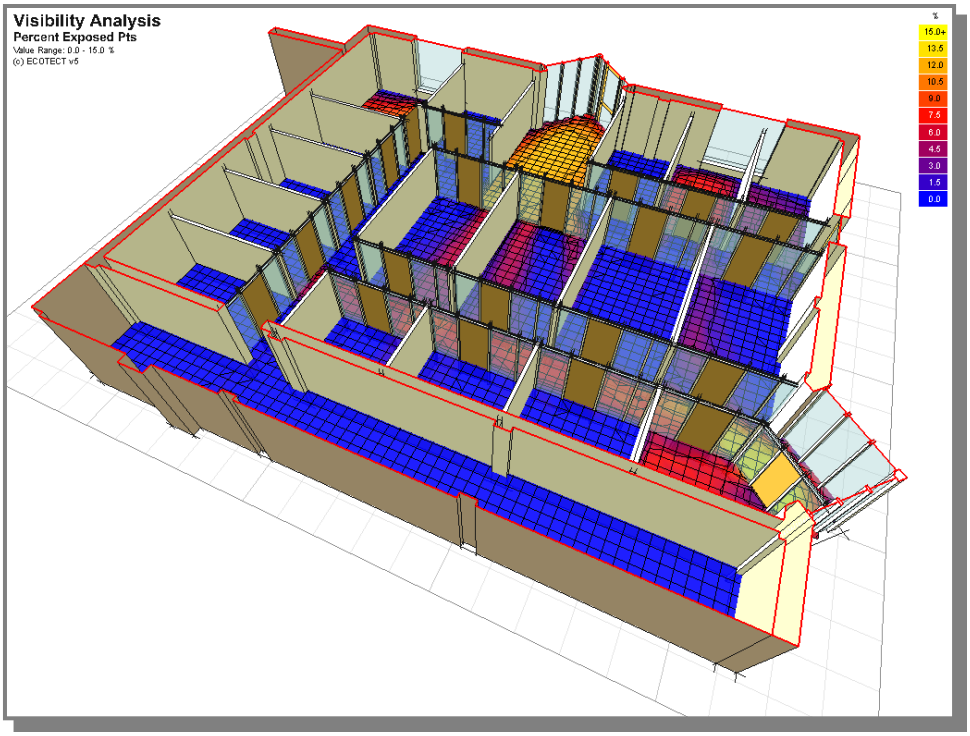


Figure 6:

Autodesk Ecotect Analysis can also be used for detailed design analysis. For example, the visibility analysis displayed here shows the amount and quality of views to the outside mapped over the floor area of an office.

Visual Feedback

Perhaps the most unique aspect of the software is its visual and interactive display of the analysis results. The inability of the designer to easily interpret the results of analyses is often the biggest failing of building performance analysis software. Autodesk Ecotect Analysis provides actionable feedback to the designer in the form of text-based reports as well as visual displays. These visual displays are more than just charts and graphs. The analysis results are presented directly within the context of the model display: shadow animations resulting from shadow casting analysis; surface-mapped information such as incident solar radiation; and spatial volumetric renderings such as daylight or thermal comfort distribution in a room.

This type of visual feedback lets designers more easily understand and interact with analysis data, often in real time. For instance, a designer can rotate a view of surface-mapped solar radiation looking for variations over each facade, or watch an animated sequence of solar rays to see how sunlight interacts with a specially designed light shelf at different times of the year.

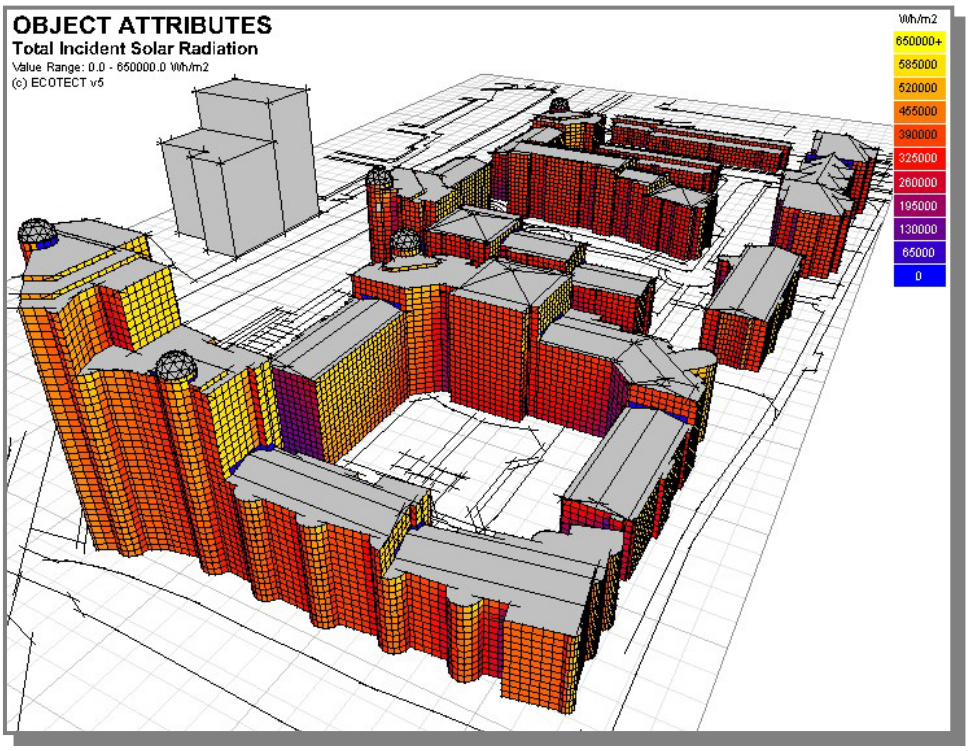


Figure 7:

Using Autodesk Ecotect Analysis, architects can see the results of their analysis displayed in the context of a building model, such as the surface-mapped results of this solar radiation analysis.

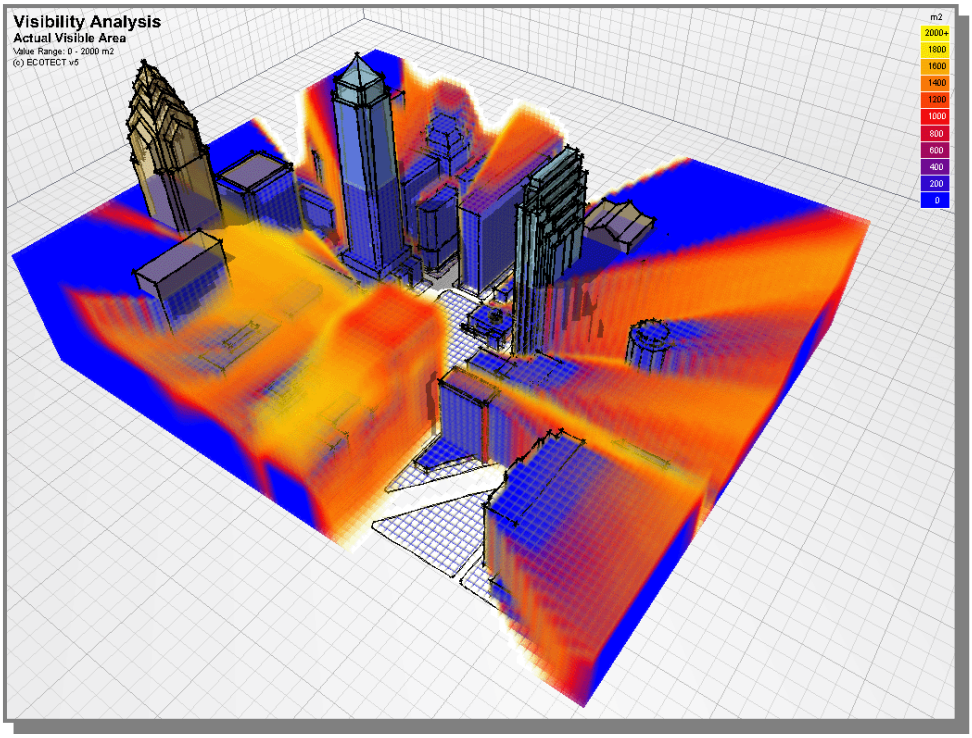


Figure 8:

Autodesk Ecotect Analysis software also displays analysis results using spatial volumetric renderings, such as this analysis of the visual impact of a building within an urban site.

Ongoing Building Performance Analysis

During conceptual design, Autodesk Ecotect Analysis and the Autodesk Revit Architecture model can be used for a variety of early analysis. For example, the designer can perform overshadowing, solar access, and wind-flow analyses to iterate on a form, and orientation that maximizes building performance without impinging on the rights-to-light of neighboring structures.

As the design progresses and the elements that define a building's thermal zones are established (the layout of the walls, windows, roofs, floors, and interior partitions), the Revit model can be used for room-based calculations such as average daylight factors, reverberation times, and portions of the floor area with direct views outside.

Eventually the Revit model can be used for more detailed analysis—such as shading, lighting, and acoustic analysis. For example, the designer can use Autodesk Ecotect Analysis in conjunction with a shading louver design modeled in Autodesk Revit Architecture to simulate how the design will work under different conditions throughout the year. Or the architect can use Autodesk Ecotect Analysis to help assess the acoustic comfort of a Revit-based design, and then adjust the location of a sound source or adjust the internal wall layout or the geometry of sound reflectors for optimal comfort.

Summary

The consistent, computable data that comes from Autodesk Revit Architecture combined with the breadth of performance analysis and meaningful feedback of Autodesk Ecotect Analysis work in combination to help reduce the cost and time to perform energy modeling and analysis. The feedback from these analyses helps architects and other users to optimize the energy efficiency of their designs and work toward carbon neutrality earlier in the design process—a key ingredient not only for incorporating energy efficiency into standard building design practices but also for mitigating the carbon footprint of our built environment.

About Revit

The Revit platform is Autodesk's purpose-built solution for building information modeling. Applications such as Autodesk® Revit® Structure software, and Autodesk® Revit® MEP software built on the Revit platform are comprehensive, discipline-specific building design and documentation systems supporting all phases of design and construction documentation. From conceptual studies through the most detailed construction drawings and schedules, applications built on Revit help provide competitive advantage, better coordination and quality, and can contribute to higher profitability for architects and the rest of the building team.

At the heart of the Revit platform is the Revit parametric change engine, which automatically coordinates changes made anywhere—in model views or drawing sheets, schedules, sections, plans… you name it.

For more information about building information modeling please visit us at **http://www.autodesk.com/bim.** For more information about Autodesk Revit and the discipline-specific applications built on Revit, please visit us at **http://www.autodesk.com/revit.**

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