AUTODESK®
WHITE PAPER

Creating Models for Performance Analysis on Existing Buildings

Contents

Introduction

Every day, government buildings use substantial amounts of energy, water, and raw materials, creating a sizeable environmental footprint. The mandates are clear: government buildings must become more energy-efficient and environmentally friendly. Because you need to evaluate the performance of and proposed modifications for dozens—if not hundreds or thousands—of buildings, your review process must be practical, repeatable, and scalable. Building information modeling (BIM) provides the basis for such analysis.

Whether you are a member of a government energy, facility, design, or construction department, an engineering or design firm, or an energy service company (ESCO), using BIM to develop a basic 3D model for existing buildings allows you to quickly perform an initial energy analysis and compare the energy efficiency of buildings. And because a basic model can be built using a few key building dimensions, you can create the first model in just a few hours. This cost-effective approach makes BIM a perfect tool for developing and evaluating energy plans for even the most unwieldy portfolio of heterogeneous, geographically-dispersed buildings.

This paper provides an overview on how to create a basic building model suitable for performing energy analysis. We'll show you how to use it to visualize and simulate the performance, appearance, and cost of building retrofits—even before you begin implementing measures. Using BIM, you'll make better, more informed decisions that maximize the economic and financial return on your energy efficiency projects. The output from a BIM-based analysis can also increase the transparency and accountability of your decision making process.

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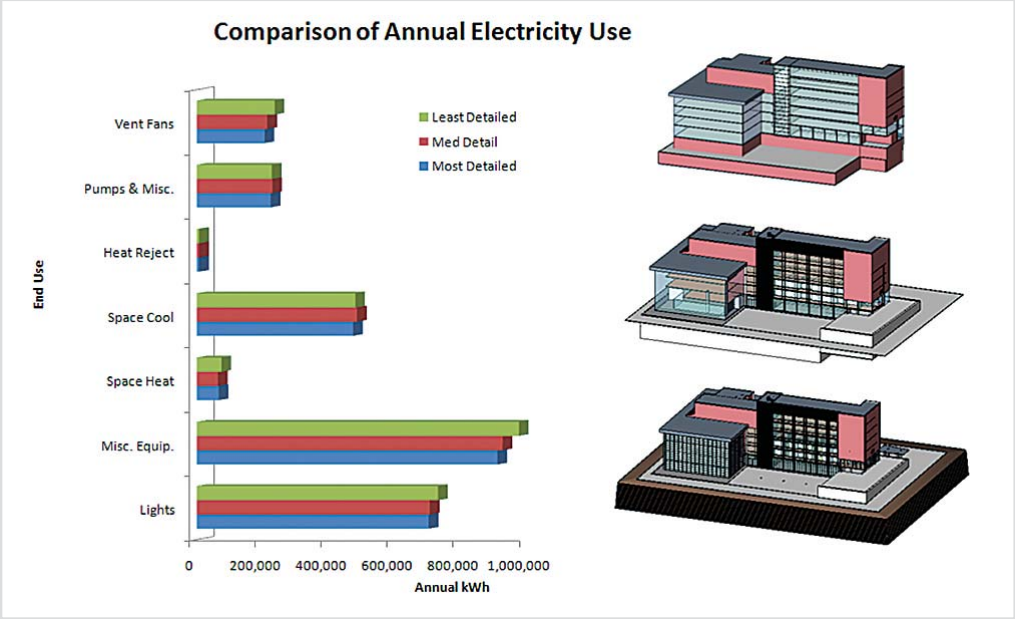
How Much Detail Is Needed

Creating a building information model is not an overwhelming or onerous task. Even with minimal upfront effort, you can generate a basic model that represents the form and geometry of the building and begin analyzing and prioritizing building improvements. In fact, a relatively simple building information model, created in about two hours, can produce a surprisingly high level of predictability for your building performance analysis. For example, Figure 1 shows that even using the least detailed building model, you can attain the results you need to make better decisions about which measures to pursue for the greatest impact on reducing your annual energy consumption.[1]

Figure 1: Comparison of results using different levels of model detail.



Further building details and model development are required to support the detailed analysis and implementation phases.

What is a basic building information model and how is it used?

A basic model captures building location, size, volume, occupancy, and function. If your objective is to conduct an initial energy audit or to establish a baseline to compare plans to improve the efficiency of a building, a basic model is sufficient. However, if there is a strong likelihood that you will pursue an energy-efficiency project, you would still start with a basic model. The next step is to add details to support further design and analysis during implementation—such as daylighting options—and eventually construction documentation.

How to Create and Use a Basic Model for Building Performance Analysis

Creating basic building information models—using simple roof, wall, floor, and opening dimensions—for each of your buildings allows you to perform an initial performance analysis. From this baseline analysis, you can compare alternative measures and develop a comprehensive plan to improve building performance throughout your portfolio.

The process is outlined in four key steps:

Step 1: Collect building data
A basic model requires generalized information on quantities, sizes, shapes, location, and orientation of the building. This includes data points such as windows, exterior doors, and openings; roof area and geometry; interior core arrangement and zoning; floor-to-floor slabs; and other major functional spaces, such as parking garages, auditoriums, and atriums. To get started, you need to collect all available building data.

Most government buildings will have either paper or CAD construction plans or design files, but some older buildings may have no documentation at all. Let's look at how you can create a basic model in each of these cases.

If you have paper plans
With your paper building plans in hand, the first step is to review the data and assess its quality and source. For example, if you have structural plans for a relatively new building, this could be a solid starting point for dimension takeoffs. However, older blueprints for a building that has undergone extensive renovations will require additional information on the renovation or substantial field verification.

[1] Autodesk 2008

Next, you'll want to scan your drawings to digitize them and model as much information as possible to create a reference drawing. Start with the basic building shape and floor-to-floor heights and input as many other key dimensions as is practical prior to a field inspection.

If you are unable to scan the paper drawings, the process will take a bit longer as you will need to manually capture information from the structural drawing and input it into a modeling system. The building structure serves as a framework upon which you add the 3D shell and basic interior dimension before field verification.

You then verify building dimensions in the field and fill in any data gaps to complete your building model.

If you have an existing CAD file
For a building with an existing CAD file, you'll need to verify the accuracy of the files to determine whether to use it or whether to simply start from scratch. Generally speaking, a CAD file authored by a maintenance crew is not as valuable, complete, or accurate as a CAD file from construction documentation. The older the CAD file, the more field verification will likely be required. Conversely, with newer buildings and current CAD drawings, you can capture all the data needed to create a model very quickly. Using a modeling application, your 2D CAD files become a foundation as you work to extrude the heights in the vertical direction (z-axis) to draw your 3D building model and then adjust dimensions during field verification.

If no plans exist
What if you need to create a model for a building with no plans? There are several methods you can use to collect the information required to complete a building model—such as a conventional survey, a laser scan, or digital pictures. See the accompanying sidebar for further explanation.

Step 2: Create a basic model
After you gather all available building data, the next step is to create basic models for each building in your portfolio. Using purpose-built software, such as Autodesk® Revit® Architecture software as your modeling tool, you can generate a basic model faster and more cost-effectively. With Revit Architecture, you can create more accurate floor plans, elevations, sections, and 3D views from the most basic building dimensions. For example, you can create a model from paper plans for a typical 100,000-square-foot, rectangular governmental office building in as little as a few hours. The key is to be smart about what you model—selecting essential elements such as floor, roof, walls, and windows—and precise in the component measurements. Upfront accuracy is important, as this model will form the basis for your initial energy analysis as well as detailed performance analysis further downstream in the review and implementation process.

Step 3: Perform building performance analysis
Using your model, you can facilitate smarter, more sustainable performance by analyzing the energy efficiency of basic building configurations and systems. Utilize the files created in Revit Architecture with Autodesk® Ecotect Analysis™ software to perform whole building assessments with the Autodesk® Green Building Studio® web service or more detailed exhaustive analysis with the desktop tools. Use these purpose-built building performance analysis tools to complete scenario—or "what-if"—modeling to better evaluate materials, quantities, sun position, and solar effects, and help identify ways to improve building performance and meet environmental and economic goals.

Autodesk Green Building Studio is designed to perform whole-building energy, water, and carbon-emission analyses. You can study discrete building forms and systems to better understand overall building performance before making key decisions on your energy project. You can also benchmark energy use to the integrated U.S. Environmental Protection Agency ENERGY STAR® score. Use local weather and electric grid data to help estimate building energy consumption and carbon emissions. EnergyPlus files can be downloaded for detailed comfort, natural ventilation, and unique HVAC analysis in Green Building Studio. Apply and compare manufacturers' products to the building design and understand their effects on energy consumption from the earliest stages of planning.

You can further evaluate selected projects using Autodesk Ecotect Analysis software. This comprehensive conceptual building performance analysis tool helps simulate and analyze a wide range of issues, such as solar effects including radiation, shading, and daylighting. Address environmental factors, such as thermal, lighting, and airflow, in the early phases of energy project planning—when your decisions can have a greater impact on achieving building performance goals. The modeling and visualization capabilities in Ecotect help you more precisely predict how a building will operate and perform post-implementation, as illustrated in Figure 2. You can even transfer your Revit model to Autodesk® 3ds Max® Design software to perform more detailed lighting and daylighting analysis to help identify the best location for building controls.

Gathering basic data in the field

Several methods work for gathering the data required for a basic building information model:

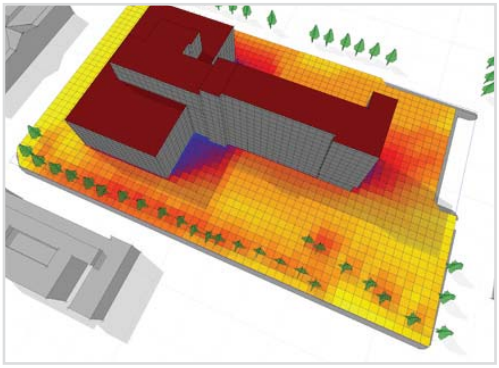
Field survey. A traditional survey gathers building dimensions during field verification. Once on-site, you can use several techniques to collect building data:

- Verify both exterior and interior dimensions with standard **tape measures, measuring wheels**, and **story poles**.
- Employ handheld **electronic distance meters (EDM lasers)** to quickly take building measurements.
- Use a **total station** or high-end optical instrument and a GPS receiver to establish precise GPS coordinates on the building location while you point and shoot the corners of the building from a survey tripod. This process requires engaging a surveyor to establish appropriate horizontal and vertical controls to use as references.

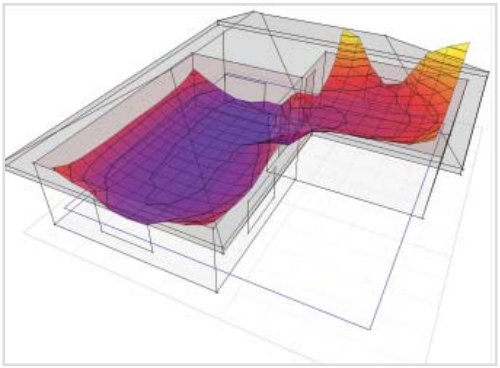
Digital photos. From 2D digital pictures, image-based modeling and photogrammetric tools—such as Autodesk® ImageModeler™ software—helps generate 3D models of existing buildings.

Laser scan. 3D laser scanning technology allows you to rapidly scan and capture the current state of a building. Laser scanning uses an exterior laser to precisely size and position roofs, exterior walls, windows, doors, and other openings into an accurate 3D point cloud model. This point cloud can then be imported into your design software, such as AutoCAD® software, and then converted into your modeling tool. With some additional interior volumetric verification, you can create a basic model.

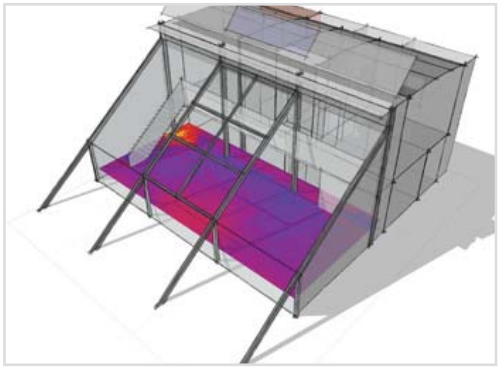
Figure 2: Use Autodesk Ecotect Analysis to help visualize and simulate building performance.



Solar radiation



Thermal



Daylighting

Step 4: Compare and then prioritize projects
After your performance analysis is complete, the next step is to compare and prioritize investment projects or alternatives based on your agency's objectives, such as water conservation, fossil fuel usage reduction, or financial return on the investment. You can rank projects based on government-mandated standards or set your own goals.

For example, you can evaluate the economic and environmental return on improvements to mechanical, electrical, and plumbing (MEP) systems across multiple buildings. This will help you to identify the buildings in your portfolio that would benefit the most from specific upgrades. BIM also lets you compare renovation options within a building. For example, what generates a better economic and energy-efficient return: window replacements, harnessing on-site wind or solar power, or adding a graywater reclamation system?

At the end of step 4, you will benefit from having a more credible and consistent data set with which to help you prioritize and select the best investments for performance upgrades.

Exchange data with ease

Use Green Building XML (gbXML) to transfer and exchange model data from your BIM process to leading energy analysis tools such as eQUEST®, EnergyPlus™, and IES.

Conclusion

The fortunate convergence of building performance mandates, available financing for energy savings contracts, and funds from the American Recovery and Reinvestment Act means that there's no time to waste in identifying your renovation projects—and justifying them with the proper level of analysis.

Evidence-based decisions support your ability to act quickly while helping to address risk management concerns. Leveraging important building information, BIM allows you to deliver projects faster, more economically, and with maximum environmental efficiencies.

Offering a comprehensive set of innovative products, Autodesk technology enables you to use BIM to create and benefit from a basic building model. Autodesk software provides a more cost-effective and practical way to prioritize energy-efficient building renovations.

To learn more about the benefits of applying BIM to government buildings, review "The Advantages of BIM for Government Building Performance Analysis," available at www.autodesk.com/government.

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