BIM for Integrated Design: A Process for Design Analysis

When working together as an integrated design team, there are new and unprecedented opportunities to design high performance buildings using today's design analysis methods. Traditionally, energy modelers in the United States have had a consistent and fairly straightforward process. They would begin by using the architect's and MEP engineer's building designs to run an annual energy simulation. Then they would model the same building according to the ASHRAE baseline standards and compare the two results. The proposed design should score higher than the baseline and the percentage improvement translates almost directly into LEED® points.

While this energy modeling process is excellent for providing an objective evaluation of how your building may perform it often occurs too late in the project to have much influence over design decisions. For your analysis to be able to inform your designs you need an integrated design team utilizing analysis software like Autodesk® Ecotect® Analysis software with Autodesk® Green Building Studio® web-service* for faster feedback at the very earliest stages of design.

DESIGN ANALYSIS PROCESS

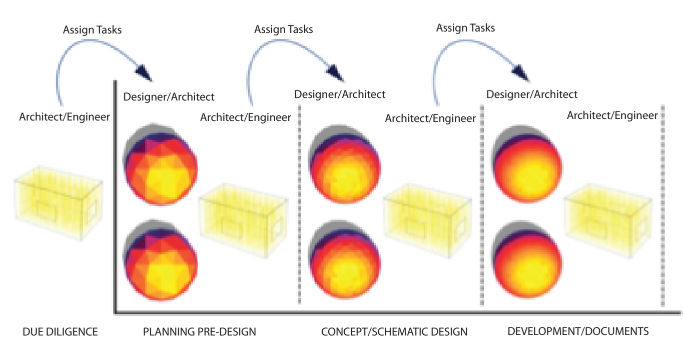
Unlike the ASHRAE process for energy modeling, most design analysis processes are not well defined and have unpredictable outcomes. With so many options, designers and engineers are often lost before they start, simply because they don't know the right questions to ask. Knowing the right questions really means knowing the right strategies to optimize a design. Strategies such as daylighting, natural ventilation, or passive solar—all of which influence the entire design, from the building form to the details.

Before you begin to evaluate strategies, a distinction should be made between the design analysis process for buildings that are skin-load dominated (such as a single family house) versus internal-load dominated (such as an office building or convention center). Think of this distinction as the building's metabolic rate. If your building is very active it will generally need cooling and lots of fresh air; if it is not very active it will be sensitive to temperature, particularly in cold climates. Buildings with low metabolic rates generally rely on passive strategies, such as thermal mass, solar design, and tempered air. On the other hand, buildings with higher metabolic rates tend to rely on active systems such as daylight dimming, double facades, and innovative HVAC systems.

Although the design analysis process will vary between building types, it should begin with a building information modeling (BIM)-based energy model. This energy model can be created using Autodesk® Revit® MEP or Autodesk® Revit® Architecture software in conjunction with Ecotect Analysis, Green Building Studio, or any other compatible energy modeling software you are familiar with.

You should first create a very simple energy model that takes into account building type, size, and location. As a quick check, you should compare the simulated energy consumption against similar types of buildings in the region. You can easily do this by using the Energy Star® functionality built into Green Building Studio web service. From your Revit MEP or Revit Architecture model you can export via the open schema gbXML to Green Building Studio where you can then estimate how much energy is spent on heating, cooling, and lighting—three energy uses that are easily influenced by thoughtful design.

Once you begin evaluating the basic energy model you may find that the heating bill is three times your cooling bill. This doesn't automatically mean that passive solar will be the best approach—you should still do some research, or consult with a local expert on building energy use for your climate zone. In addition, you can use the weather tool in Ecotect Analysis. Ecotect Analysis

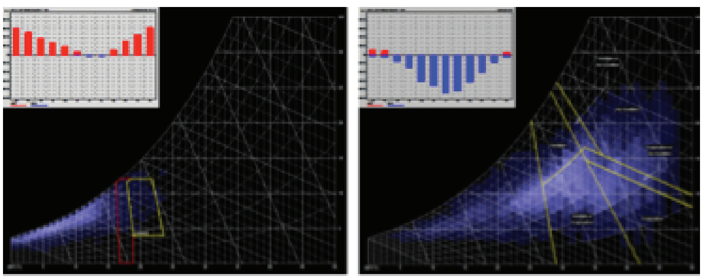


Architects and engineers working together in integrated design teams have new opportunities to design high performance buildings.

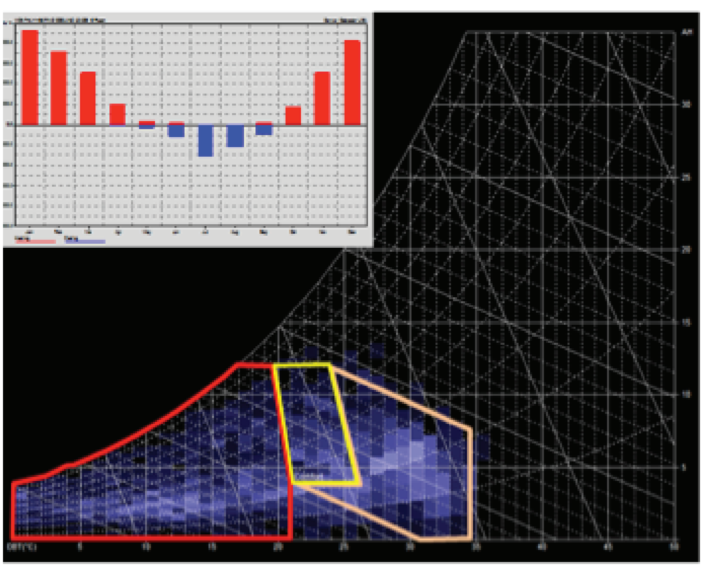
software's passive strategies analysis helps you quickly determine what strategies will be most effective for reducing heating and cooling loads for your climate. When you overlay this level of information with your base energy model, you can instantly spot the low hanging fruit for improvements. Bear in mind that the passive strategies analysis is most relevant with skin-load dominated buildings. For internal-load dominated buildings, there are other considerations (described later in this article).

SKIN-LOAD DOMINATED BUILDINGS

An ideal first step for skin-load dominated buildings is to compare the passive strategies analysis from Ecotect's weather tool with your Revit MEP or Revit Architecture baseline energy model. Once you have determined the best passive strategy/strategies for reducing your heating and cooling loads, Ecotect Analysis can then be used to help evaluate these strategies at the level of detail necessary to define the architectural forms and design details.



Weather Tool Passive Strategies Analysis overlaid with Ecotect Thermal Analysis. On the left is a passive solar strategy overlay for Newcastle, UK. The yellow box shows the range of temperature and humidity where people are comfortable while the red region shows the effectiveness of any given strategies (in this case it is showing that passive solar is ineffective). On the right are active cooling strategies for Riyadh, Saudi Arabia. The yellow lines here break up the temperature and humidity ranges into associated active strategies that will be effective for cooling.



Weather Tool Passive Strategies Analysis overlaid with Ecotect Thermal Analysis. This image shows the heating and cooling required for Denver Colorado. The most effective passive strategies shown are passive solar heating (red overlay) and evaporative cooling (pink overlay). Passive solar is a successful strategy due the large amount of solar radiation, while evaporative cooling works well in the summer because the air is shown as being very dry.

Here is a typical design analysis process for a skin-load dominated building:

Start with an early design model, whose building form has been influenced by programmatic and site constraints, or simply by the client's interests.

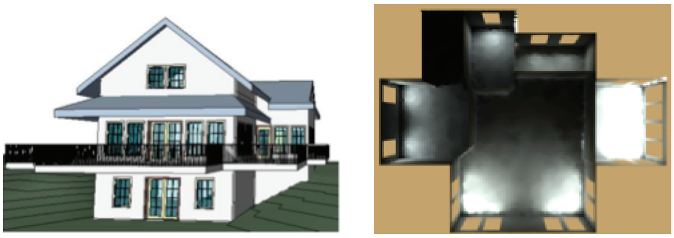
Heating/Cooling

- Determine envelope and internal heating and sensible cooling periods from a thermal analysis.
  - √ Reduce solar gains during the cooling period with passive solar shading.
  - √ Improve solar gains during the heating period with south glazing.
  - √ Devise a strategy to store excess solar gain using thermal mass inside the envelope.
  - √ Devise a strategy to migrate your thermal barrier after sunset with the use of features such as sunspaces or window curtains (residential).
- Study summer prevailing winds and modify the interior layout to allow cross-ventilation.

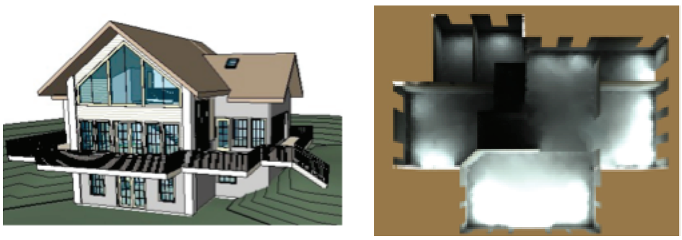
Daylight and Views

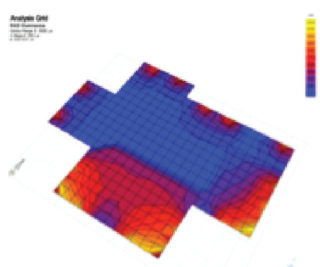
- Determine worst case daylight levels
  - √ Increase the overall daylight area through the careful placement of windows, light shelves, and interior partitions.
  - √ Reduce the amount of glass on non-south facades.
  - √ Protect against glare by studying luminance on interior surfaces (non-residential).

Skin-load dominated residential building. Design and Images Courtesy of Amanda Hansen, University of Wyoming

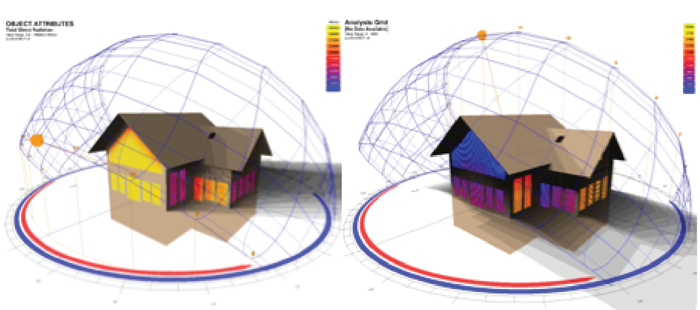


Original design and the daylighting analysis of the main floor of a skin-load dominated building.





A modified building design featuring a larger second-story window and the resulting daylighting analysis and grid. Note the increased amount of light in the interior spaces of the building.

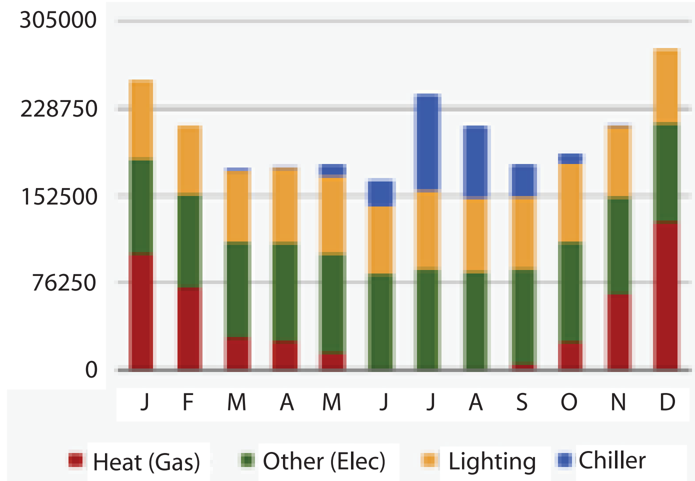


A winter and summer solar analysis of the modified building design.

INTERNAL-LOAD DOMINATED BUILDINGS

For internal-load dominated buildings, you will need to compare the associated heating and cooling energy with lighting and other electricity use. In this situation, you should simulate multiple scenarios to determine areas for energy savings.

When designing internal-load dominated buildings, you need to consider that the lighting and equipment loads will work with the heating loads and against the cooling loads. Remember that when you turn on a light you're actually turning on a mini space heater. Conversely, a daylight-driven building design typically works with the cooling loads and against the heating loads due to increased envelope heat loss, better solar control, and better access to ventilation. In order to capture this benefit, it is critical that the lights are controlled in some manner to ensure that the "mini space heaters" are turned off when sufficient daylight is available. Therefore,



The energy-use breakdown, including lighting, for an internal-load dominated building.

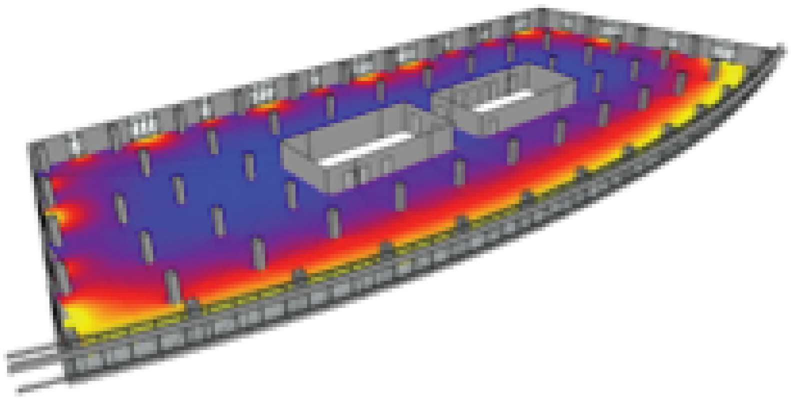
determining the best strategy or strategies for an internal-load dominated building requires a more iterative investigation with an integrated design team. This, in turn, requires an early commitment from the client and project stakeholders.

Your results may clearly indicate a specific building performance strategy. For example, you may find that a daylight-driven design is more effective than a design intended to minimize surface heat loss (e.g. a bar vs. a cylinder). Or perhaps you'll discover that a ventilation-driven design (oriented for cross ventilation or with an atrium for stack ventilation) is optimal.

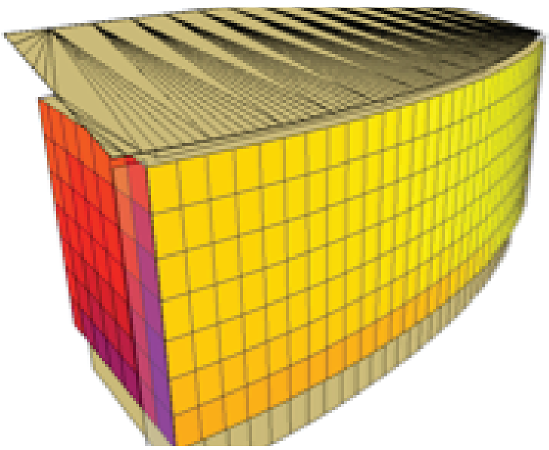
But if early energy modeling does not clearly point towards one strategy (or one combination of strategies), there are still building performance rules of thumb to guide your decision-making process. For example:

- Daylight won't save you any energy if your lighting control systems are not designed for sensor dimming.
- Glare in workspaces makes daylighting ineffective because it causes the occupants to close their blinds.

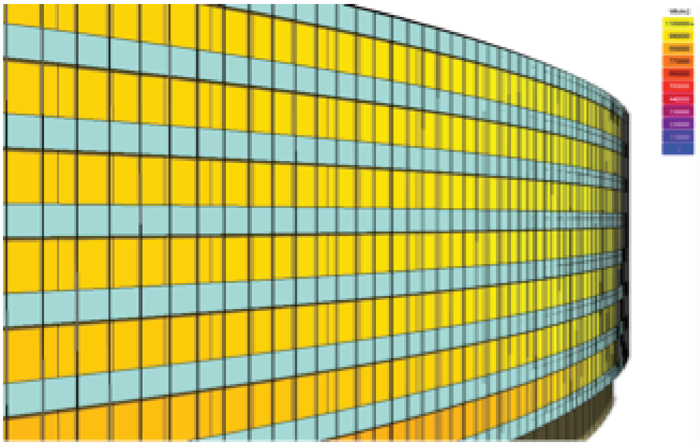
Internal-load dominated office building



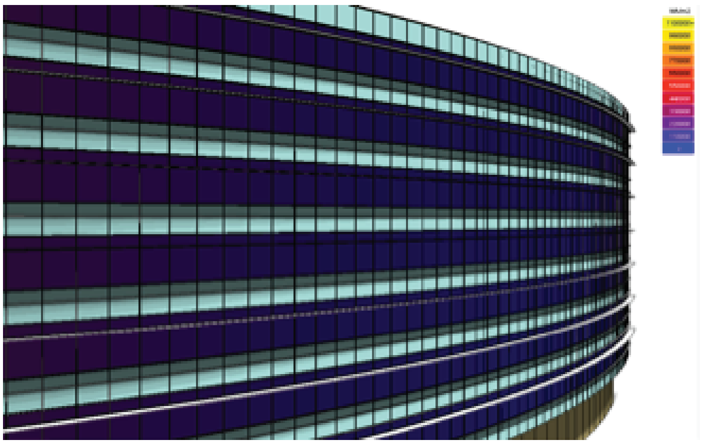
Analysis images showing a well daylit space that is free of glare on a sunny day



Solar analysis of building massing during cooling period



Solar analysis of a untreated façade during cooling season



Solar analysis of a treated façade during cooling season.

- Solar gain through windows is not beneficial after your building heats up, unless you are in an extremely cold climate.
- Daylight dimming during the cooling season is a double bonus on energy savings because it reduces the unwanted heat gains in your space.
- Solar heating requires a great deal of winter sunlight and proper orientation. Many cold climates don't have enough sunlight to offset the heat-loss through south glazing.
- Horizontal shading strategies are effective on all orientations for daylighting since they bounce daylight to interior spaces while blocking the hot summer sun.
- Carrying out a "whole building energy analysis" of this sort done by Green Building Studio will automatically account for the interactions between lighting, heating, cooling and other systems.

To study these "rule of thumb" design considerations you need a detailed model with more accurate geometry. Ecotect Analysis excels at evaluating these green design strategies in detail and, if you are using Ecotect Analysis in conjunction with Revit Architecture, you can more easily analyze building performance at the required level of detail.

CONCLUSION

Using an integrated team and an iterative design analysis process, you can often make the right building design decisions early on with confidence and clarity. If your building types are very complex and it is unclear which strategies will have the best payoff, you can still use analysis to avoid potential problems while providing the best level of performance given your programmatic, climatic, and site constraints. Using Autodesk Revit Architecture and Revit MEP with Autodesk Ecotect Analysis helps give the design team a greater advantage in understanding building performance during the design process.

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Jon Allen Gardzelewski is the owner of Free-form Energy, a design and consulting company which specializes in high performance buildings. He has practiced architecture in San Francisco, Portland, Washington DC, Paris, and London, becoming an expert in both Building Information Modeling (BIM) and Building Performance Analysis. Jon also teaches at the University of Wyoming where he collaborates with building systems engineers for architectural design studios that focus on integrated design.

Philip (Chico) Membreno is a LEEP AP certified professional with over 15 years of experience in the AEC Industry. Currently, Chico is Autodesk's Technical Marketing Manager for Architecture and Sustainable Design where his primary focus is building information modeling (BIM). Prior to joining Autodesk, Chico practiced as an architect for 10 years in the Boston area.