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Energy Modeling with Revit and Insight

Andrew Leavitt
Leo A Daly

Learning Objectives

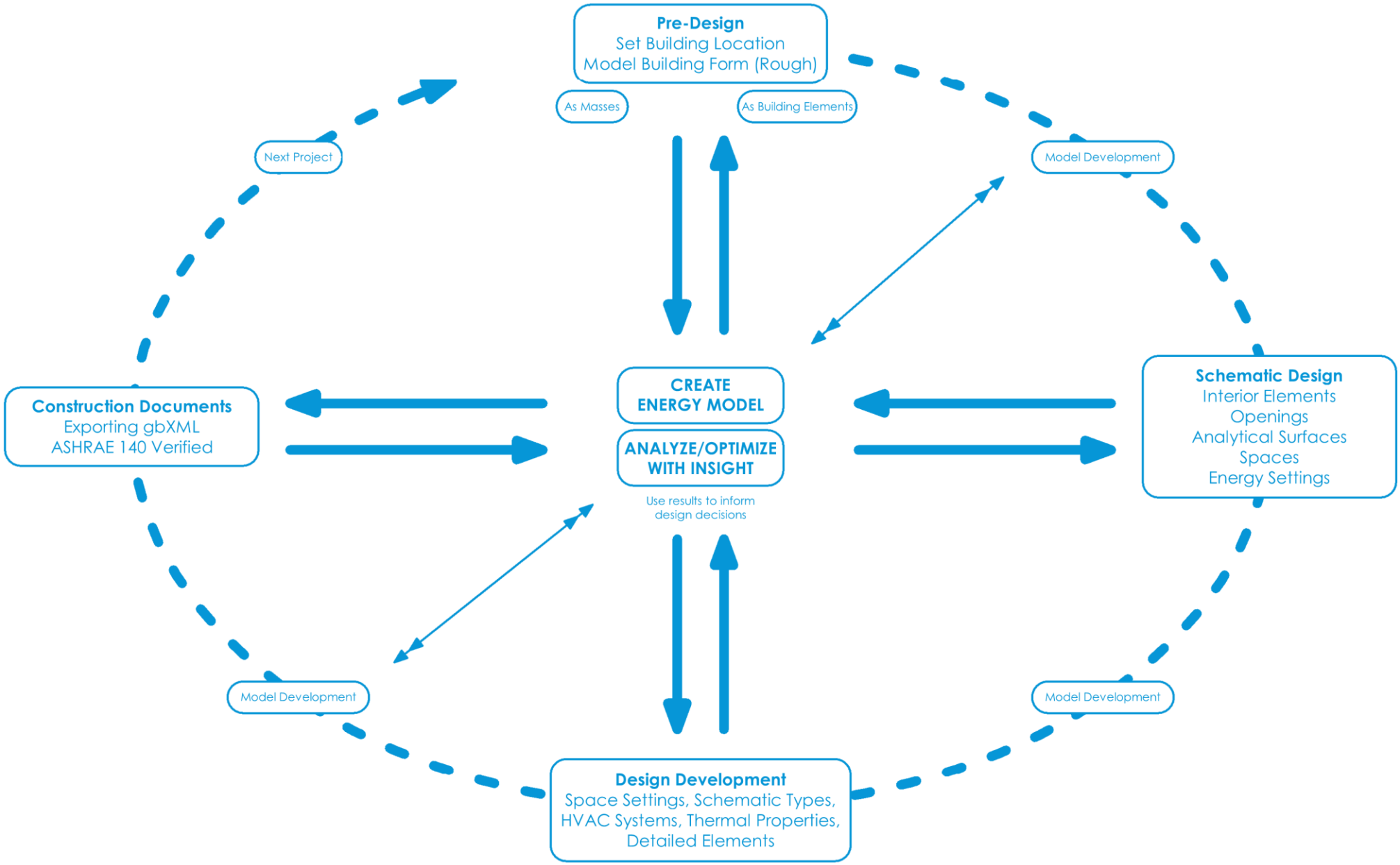
- Use Revit and Insight to design more-sustainable buildings, optimize energy use, and meet Architecture 2030 goals
- Analyze and compare the energy use and impact of a range of HVAC and electrical systems
- Model schematic constructions or detailed thermal constructions to guide decisions regarding materials and methods
- Analyze and reduce energy use from the early design stages through the entire course of a project

Description

Insight is a component of Revit software offering powerful energy-modeling capabilities through all stages of design. This course will cover the use of Insight to analyze Revit models, from the very earliest conceptual stages all the way through issuing construction documents. By using these methods, attendees can achieve their Architecture 2030, B3, and even net-zero goals. Attendees will learn how to use this powerful software to predict and optimize energy use, evaluating factors affecting both architects and engineers. With Insight, it is possible to analyze a wide range of potential design choices and chart a clear course toward reducing overall energy use, designing sustainable buildings with an easy-to-use and intuitive process.

Speaker(s)

Andrew Leavitt is a Digital Practice Specialist and Electrical Designer at Leo A Daly in Minneapolis, Minnesota. He graduated from Tufts University with a degree in Mechanical Engineering and Astrophysics and has had a passion for learning ever since. He has worked closely with engineers and architects for his entire career and his breadth of knowledge has allowed him to develop strategies for bridging the gap between disciplines. He has experience with 2D and 3D design, lighting design, rendering, energy modeling, virtual reality, and a litany of programs and add-ons. He considers himself strong with computers and takes an interest in learning new software and developing new workflows to teach his colleagues.


Pre-Design
Set Building Location
Model Building Form (Rough)
As Masses
As Building Elements
Model Development
Schematic Design
Interior Elements
Openings
Analytical Surfaces
Spaces
Energy Settings
Model Development
Design Development
Space Settings, Schematic Types,
HVAC Systems, Thermal Properties,
Detailed Elements
Model Development
Construction Documents
Exporting gbXML
ASHRAE 140 Verified
Next Project
CREATE
ENERGY MODEL
ANALYZE/OPTIMIZE
WITH INSIGHT
Use results to inform
design decisions

1. Energy Modeling with Revit and Insight

Energy modeling with Revit and Insight is a powerful way to analyze the efficiency and sustainability of a building design. Beginning with only a location and a rough building shape, it is possible to evaluate schematic concepts and preliminary designs in the early stages of a project. Ongoing refinement of the model with feedback from Insight can then drive design decisions that improve sustainability. By making these decisions early in the design process, all of the disciplines affected by the decisions can design their systems to interoperate optimally and meet sustainability and budget goals.

Insight harnesses the power of cloud computing to rapidly evaluate not just the energy model as designed, but also with changes to many critical energy criteria. Using this tool, it is possible to see potential areas in which to gain more efficiency and ultimately produce a better-performing building. From large decisions like building orientation to smaller, more granular decisions like the sill height and shading depth on a given wall, Insight reveals the potential benefits of making changes to the building design.

Regardless of the level of detail in a building model, Insight can provide guidance regarding sustainability and energy use. Because Insight calculates many different variations of an energy model, it is not necessary to begin with a detailed, accurate building model. However, a more detailed building model with building elements, spaces, zones, and HVAC systems will provide more accurate energy modeling results. Insight is a useful tool throughout all stages of the design process, pointing the way to more energy efficient design.

1.1. Sustainability

Sustainability is an increasingly important aspect of building design. Recent studies have determined that buildings account for 47% of energy consumption in the U.S., with 88% of that energy consumption coming from building operations. Improving the efficiency and sustainability of building design can have a significant impact on the overall cost of operations.

Designing with efficiency in mind is necessary to meet energy guidelines like Net Zero and the 2030 Challenge, which impose stringent restrictions on energy use, requiring systems to interoperate with maximum efficiency. While these challenges can seem formidable, they are achievable with proper planning and analysis. Using Revit and Insight to make and analyze decisions early and throughout the design process allows sustainability to inform design decisions, resulting in a more cohesive and effective design.

2. Building Concept

Before the modeling process can begin it is necessary to have an idea of what to model and where to model it. The best time to analyze critical factors like building form, orientation, and location is in the early stages of the energy modeling process, when it is still possible to make big changes. Building and location information can come from a source as vague as a rough concept or image from Google Earth or as detailed as a Programming Study or set of existing plans. It is possible to model the building using masses to gain a rough understanding of how

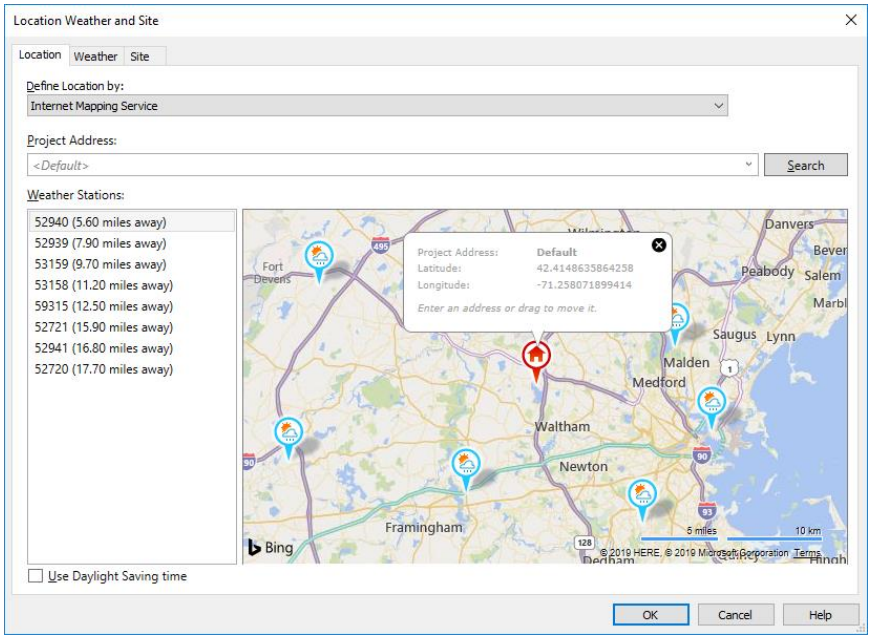
the building will perform under generalized conditions, using building elements to attain more control and precision for modeling and analysis, or using a combination of both.

2.1. Project Location and Orientation on Site

In order to accurately model climate conditions it is necessary to assign a location to the building. This is a project-wide setting that affects more than just energy modeling, so it is a good practice to enter this information correctly in all projects. The Location tool uses either the ASHRAE 2007 Default City List or an internet mapping service to locate a weather station with climactic data close to the project location.

2.1.1. Setting the Building Location

Click Manage ► Project Location ► Location to bring up the Location Weather and Site dialog box.



THE LOCATION WEATHER AND SITE DIALOG BOX

2.1.2. Using the ASHRAE 2007 Default City List

1. In the Location tab of the Location Weather and Site dialog box activate the Define Location by pulldown menu and select Default City List.
2. Select the city nearest to the project location from the City pulldown menu. Revit automatically assigns latitude and longitude based on this selection.

2.1.3. Using the Internet Mapping Service

1. In the Location tab of the Location Weather and Site dialog box activate the Define Location by pulldown menu and select Internet Mapping Service.
2. Enter the address of the building in the Project Address entry field. Be sure to include state, province, or country to ensure Revit is able to find the address.

3. Press enter or click the **Search** button and, if necessary, select the correct project location from the list of possible locations. Drag the red home location pin to manually adjust the project location.

After setting the project location, navigate to the Weather tab to review weather data. While it is generally unwise to make any changes in this tab, it is possible to assign custom weather data to the project by unchecking the Use closest weather station checkbox and manually entering values into the weather data fields.

2.1.4. Modifying the Building Orientation

The Revit energy modeling process reflects the orientation of the model with respect to True North. Navigate to a view with Orientation set to True North and orient the building model relative to this view. In order to change the orientation of the building, select all of the masses or building elements and rotate them. It is common to adjust the building orientation throughout the course of the design process based on energy analysis results. It is also possible to change the orientation of true north relative to plan north using the **Manage ► Project Location ► Position ► Rotate True North** command.

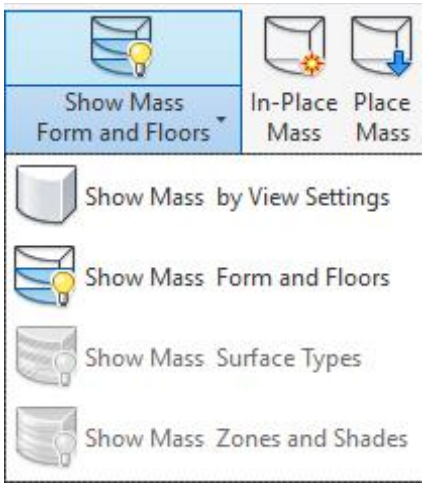
3. Conceptual Mass Energy Modeling

At a basic level, all that is required for an energy model is a building form and location. By modeling Conceptual Masses, it is possible to generate a form representing a building in a specific location and apply standard Energy Settings to the model. While more detail will result in a more accurate energy model, analyzing Conceptual Masses using Insight can provide direction from the earliest design stages.

3.1. Modeling Conceptual Masses

The simplest way to analyze the efficiency of a building design is to create a Revit model consisting of Conceptual Masses that correspond to the overall building form or to zones within the building. Location and orientation play a major role in building performance, so it is important to set a project location and orient the mass model properly with relation to a True North view (*see Section 2.1.4*).

By default, Revit does not display masses in floor plans. Turn on the display of masses in the Visibility/Graphics Override Menu or use the **Massing and Site ► Conceptual Mass ► Show Mass** pulldown menu to cycle through different mass display settings. This pulldown allows display of conceptual masses according to view settings or as the overall mass form and floor. Options to display masses as mass surfaces or divided into mass zones are only available when analyzing only Conceptual Masses. Use this pulldown menu to make it easier to select masses or the elements that make them up.



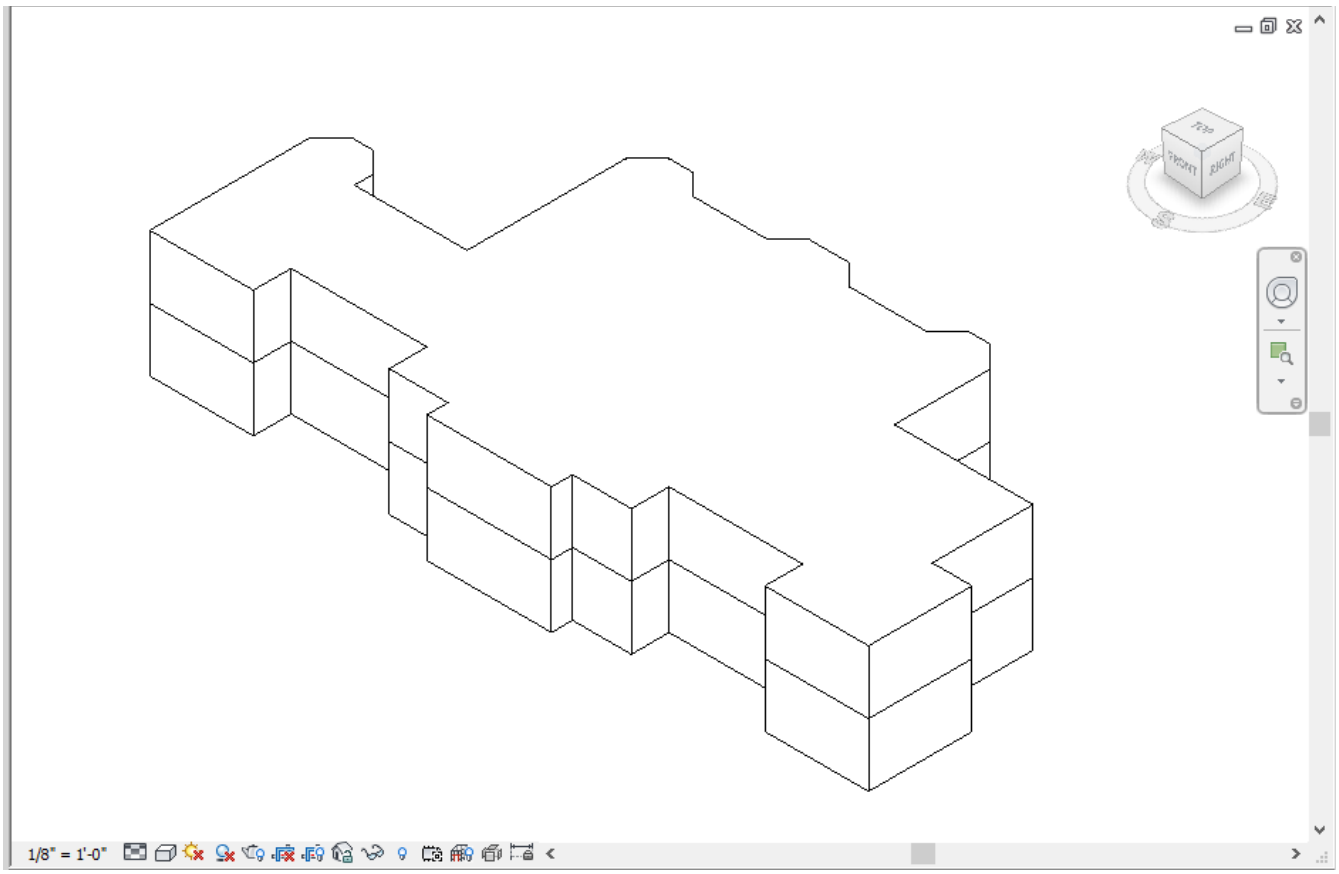
THE CONCEPTUAL MASS VIEW SETTINGS PULLDOWN

To create a custom design using Mass Families:

1. Load the desired Mass Families into the conceptual model.
2. Use the **Massing & Site ► Conceptual Mass ► Place Mass** tool to place an instance of a Mass Family. Switch between Mass Families in the Properties pane.
3. Adjust the dimensions of the mass block by dragging grips or modifying parameters.
4. Assign room name, number, department, and other parameters.
5. Assemble mass blocks into a conceptual building form. Use snaps or the Align tool to prevent sliver spaces between masses.

To create a custom mass using the In-Place Mass tool:

1. Activate the **Massing & Site ► Conceptual Mass ► In-Place Mass** tool.
2. Assign a name to the mass. It is possible to change the name of a mass through the Project Browser.
3. Use the **Create ► Draw** tool panel to draw Model Lines forming the perimeter of the mass. Lines must form closed loops and must not overlap.
4. Select the perimeter and click **Modify | Lines ► Form ► Create Form** to create a 3D object.
5. Use forms and voids to create complex shapes. Masses can consist of multiple forms.
6. Select surfaces or edges to use shape handles to modify forms.
7. Select a form and use the tools from the **Modify | Form** panel to create even more complex shapes. A more accurate form will produce a better final result, but additional geometric complexity results in increased calculation time.
8. Click the **Finish Mass** button to exit the In-Place Editor.
9. Use shape handles to adjust the boundaries of the conceptual mass outside the mass editor. It is possible to align mass surfaces to reference lines or planes, if desired.
10. Assemble mass blocks into a conceptual building form. Use snaps or the **Align** tool to prevent sliver spaces between masses.



A Conceptual Model Made Of In-Place Masses

3.2. Assigning Mass Floors

Mass floors horizontally divide masses into zones. Mass floors correspond to the levels in the model. It is necessary to create and assign at least one mass floor to a given mass in order for Revit to analyze that mass.

1. Create levels in the project.
2. Select a mass in the model. It is generally faster to select all masses from which to create a given mass floor.
3. Click **Modify | Mass ► Model ► Mass Floors** to open the **Mass Floors** dialog box.
4. Check each level in the list that requires a mass floor.
5. Click **OK** to create mass floors from the intersections between conceptual masses and the selected levels.

Assigning mass floors to a mass tells Revit to split the mass into analytical surfaces and zones for energy analysis. Masses without mass floors will act as shading elements in the energy model, allowing surrounding buildings, geography, or anything else that might cast a shadow on the building model to impact the energy analysis.

4. Building Element Energy Modeling

Modeling Building Elements allows for a much greater degree of control and precision than modeling masses alone. Instead of generating Analytical Elements by applying standard Energy Settings to Conceptual Masses, Revit generates Analytical Elements from Building Elements like walls, floors, and windows. While this allows analysis of much more complex and accurate models, model complexity and absolute accuracy are not required. It is possible to analyze energy use at any stage of the modeling process and gain direction from Insight in making a model more efficient and sustainable.

The most basic requirement for energy modeling using Revit is merely a model with an enclosed volume. A model as simple as four walls, a floor, and a roof or ceiling enclosing a space is valid for energy modeling. Revit recognizes the function of various surfaces in the model and converts those surfaces into Analytical Surfaces. Similarly, Revit generates Analytical Spaces, which it then subdivides according to Energy Settings, in enclosed volumes within the model. These automatically-generated Analytical Elements form the basis for energy analysis using Insight.

4.1. Modeling Building Elements

Use functions in the **Architecture ► Build** tab to model architectural elements such as walls, floors, ceilings, and roofs. The **Analyze ► Create Energy Model** function generates a variety of Analytical Elements from model elements, substituting typical surface and opening types for model elements (*see Section 5*). Revit recognizes and converts a wide variety of model elements, so it is not necessary to leave out certain elements or otherwise create a simplified model. By default, Revit applies standard Conceptual Types to all Analytical Surfaces, but it is possible to apply Schematic Types to a specific Space or to model Detailed Elements with Thermal Properties. Modeling Building Elements and fine-tuning individual elements and Spaces allows users to begin with a simple schematic model and increase the level of accuracy and detail as more information becomes available.

4.2. Creating Spaces

When creating an energy model, Revit generates Analytical Spaces within enclosed volumes in the model and automatically populates data from the Name and Number of any corresponding Room or Space. The **Advanced Energy Settings ► Room/Space Data ► Export Category** setting determines whether Revit uses Room or Space properties to generate Analytical Spaces. It is not possible to select an Analytical Space and manually alter the properties. Because Spaces contain Energy Analysis parameters that allow the user much greater flexibility in calculating energy usage, the recommended **Room/Space Data Export Category** is **Spaces**.

To create a Space in an enclosed area, click **Analyze ► Spaces & Zones ► Space**. To fully model and analyze the volume, set the Upper Limit to the level above the placement level with an Offset of 0’ 0”. Click within an enclosed area to place a Space. Select the Space to view the properties and assign a Number and Name.

By default, Analytical Spaces use the Energy Analysis settings from the assigned Building Type. To alter these properties for a given Analytical Space, select the corresponding Space and assign Energy Analysis parameters (*see Section 7.3*).

4.2.1. Scheduling Analytical Spaces and Surfaces

Revit automatically creates Schedules of Analytical Spaces and Analytical Surfaces in the energy model. Open these schedules to view the Area, Count, and other properties of these Analytical Elements. Select a type of Analytical Surface or an Analytical Space to highlight the selected Analytical Elements in the 3D Energy Model view.

4.3. Adding Thermal Properties to Materials and Assemblies

Although Conceptual Types and Schematic Types offer a valid approximation of the thermal properties of Analytical Surfaces, it is possible to model precise thermal properties of specific surfaces or assemblies. Autodesk provides a library of Material Assets with preassigned Thermal Properties. Assigning these Assets to Materials in the model and analyzing Detailed Elements results in a more precise energy model.

Analysis of Detailed Elements does not require that all elements or materials in the model contain Thermal Properties. Revit assigns Conceptual or Schematic Types to elements without detailed thermal information, allowing users to mix and match elements with known Thermal Properties and schematic elements.

4.3.1. The Material Browser

To open the Material Browser click **Manage ► Settings ► Material**. It is also possible to access the Material Browser through any element or assembly with a Material parameter by clicking the **…** button on the right of the Material parameter entry cell.

Select a Material from the list to display its properties. By default, most materials have tabs containing information on Identity, Graphics, and Appearance. If there is already a Thermal tab, click it to view Thermal Properties. If it is necessary to replace the Thermal Asset, click the **Replace Asset** button to open the Asset Browser. If there is no Thermal tab, click the **+** button in the tab bar and select Thermal to open the Asset Browser.

The Asset Browser contains a library of Physical Assets. Browse through this library to find an appropriate Physical Asset for a given material. Opening this library by clicking the Thermal tab filters the list to display only assets with Thermal Properties. Assigning an Asset to a Material populates the Thermal properties of the Material. Manually altering Thermal Properties in this tab will not affect the Thermal Properties of other Materials, even those that share the same Physical Asset. Although it can be time consuming, it is possible to assign Thermal Properties to all Materials in the model.

4.3.2. The Assembly Editor

Walls, floors, ceilings, and roofs can consist of multiple layers of different Materials. To see what Materials exist in a given compound element type, select an element and click **Edit Type**. In the Type Properties dialog, locate the Structure parameter under the Construction heading and click the **Edit…** button to open the **Assembly Editor**. Within this editor, select a Material and click the **…** button in the Material entry cell to open the Material Browser and assign Thermal Properties. After exiting the Assembly Editor,

verify that Revit has populated the Analytical Properties of the compound assembly. While it is not necessary to assign Thermal Properties to all Materials in an Assembly for Revit to calculate Analytical Properties, including more information results in a more accurate energy model.

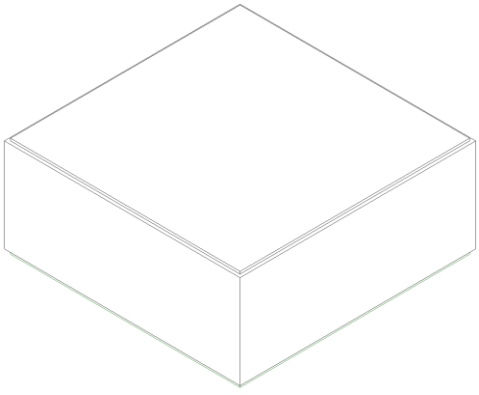
4.4. Detailed Elements Mode

To include elements with Thermal Properties in energy analysis, activate the **Advanced Energy Settings ► Material Thermal Properties ► Detailed Elements** checkbox. Create an Energy Model (*see Section 5*) to generate Analytical Elements from these elements. In the case of elements that do not have Thermal Properties, Revit generates Analytical Elements using the Conceptual Types in the model or the Schematic Types assigned to that particular Space.

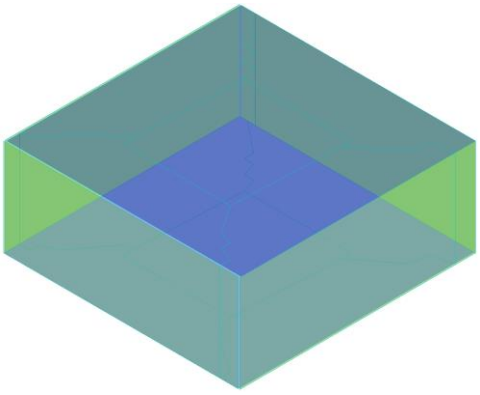
5. Creating an Energy Model

With masses and mass floors or building elements properly placed and oriented in the model, the next step is to create an energy model within the project. First, in order to make sure Revit will analyze the model in the correct analysis mode, activate the **Analyze ► Energy Optimization ► Energy Settings** tool to bring up the **Energy Settings** menu (*see Section 6.1*). For the time being, the important setting to select is **Mode** under the **Energy Analytical Model** heading. Make sure that this is set to **Use Conceptual Masses and Building Elements**. Click **OK** to save this setting and exit the **Energy Settings** menu. Analyzing both Conceptual Masses and Building Elements is the recommended mode in all but a few rare cases. This mode allows the greatest modeling flexibility and control.

Click the **Analyze ► Energy Optimization ► Create Energy Model** button. This will create an analytical energy model within the project. Depending on the complexity of the project this automatic process can be time consuming, but even in complex, multilevel buildings this process should only take a few minutes. The energy analytical model does not automatically update to reflect changes in the mass and building element model. Therefore, upon making a change to model geometry it is necessary to delete and recreate the energy model.



BEFORE CREATING AN ENERGY MODEL

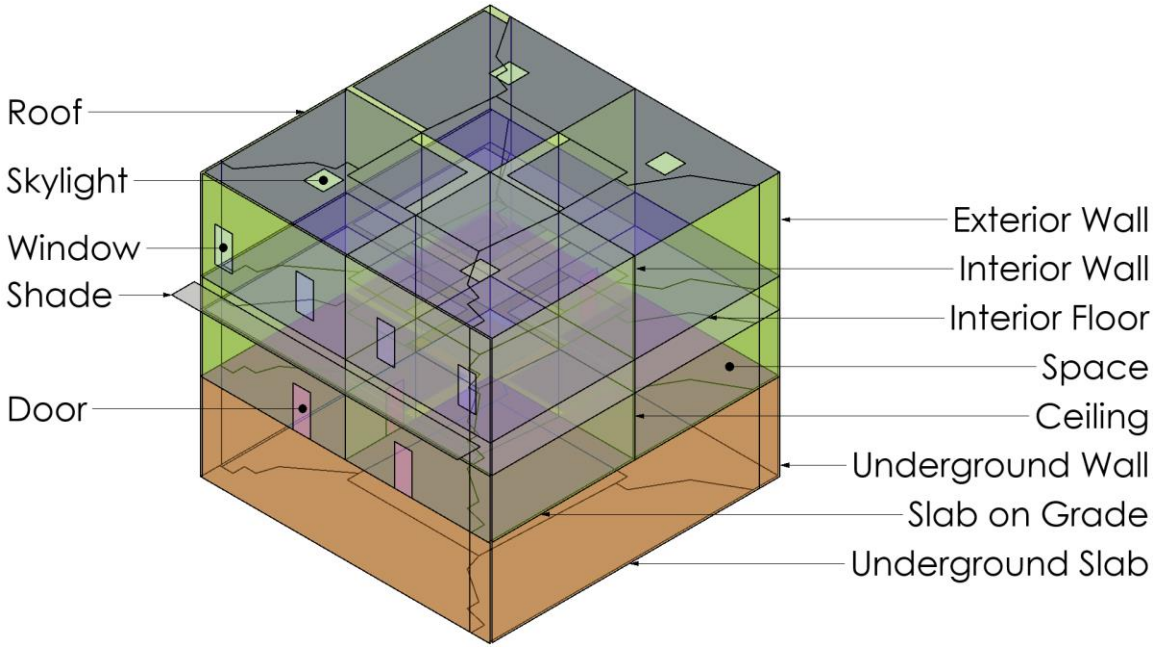


AFTER CREATING AN ENERGY MODEL

When creating the energy model, Revit automatically converts model geometry into an analytical model consisting of Analytical Spaces and Analytical Surfaces, dividing the spaces

into core and perimeter zones, further subdividing perimeter zones, and applying Conceptual Types to exterior and interior Analytical Surfaces. For masses in the model Revit applies glazing and shading to the exterior wall and roof Analytical Surfaces according to settings from the Energy Settings menu. Revit generates a 3D Energy Model view showing these Analytical Elements and any Masses or Building Elements in the model. It is possible to use Visibility/Graphics Overrides or Temporary Hide Isolate to filter out Building Elements and Masses and display only Analytical Elements for clarity and ease of use.

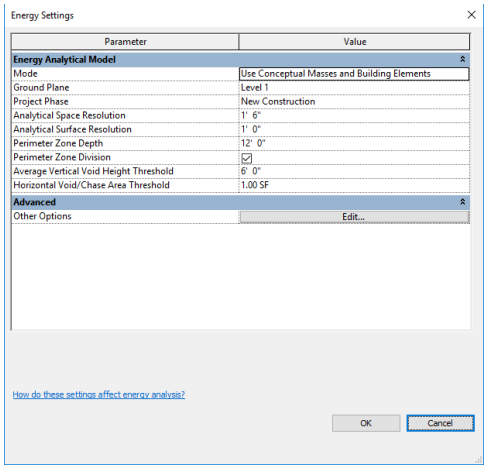
In addition to the 3D Energy Model view, Revit also generates schedules of all Analytical Spaces and Analytical Surfaces in the model. These schedules list essential information regarding these analytical objects and are therefore very useful in determining what is going on behind the scenes of the energy modeling process.



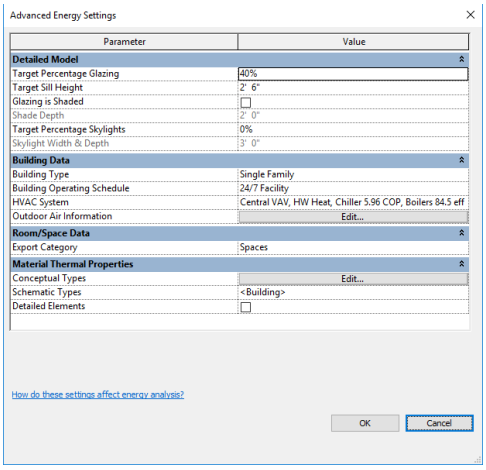
ANALYTICAL SURFACES AND SPACES IN AN ENERGY MODEL

6. Energy Settings

Creating an energy model applies user-selected energy settings to masses or building elements to generate analytical elements. Use the **Analyze ► Energy Optimization ► Energy Settings** command to bring up the **Energy Settings** menu. Using this menu, it is possible to change the assumptions underlying the modeling approximations. More information is available on the Energy Settings page in the Autodesk Knowledge Network.



THE ENERGY SETTINGS MENU



THE ADVANCED ENERGY SETTINGS MENU

6.1. Basic Energy Settings

This heading contains parameters related to fundamental aspects of the energy model.

6.1.1. Energy Analytical Model

Mode determines whether Revit uses Conceptual Masses, Building Elements, or a combination of the two in energy analysis. The recommended mode is **Use Conceptual Masses and Building Elements**. When analyzing Conceptual Masses alone, Revit uses a different, less-accurate algorithm. Using Building Elements alone excludes any conceptual masses in the model, making it useful if placeholder masses exist that should not be included in energy analysis. However, in most cases it is better to model both Conceptual Masses and Building Elements, even if elements of one type do not exist in the model.

Ground Plane determines the level in the model that defines the ground.

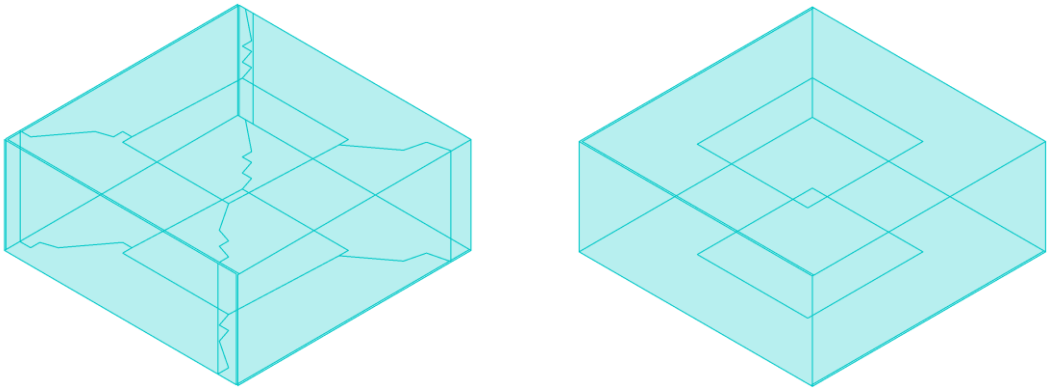
Project Phase specifies the phase of the model to analyze. Revit will not include elements on a different phase in energy analysis.

Analytical Space Resolution defines the size of the largest break between Revit elements that will bound analytical spaces as though there were no break. Revit will ignore gaps up to two times the Analytical Space Resolution setting. Adjusting this setting allows Revit to account for modeling errors or imperfections.

Analytical Surface Resolution defines the size of the smallest Analytical Surface that Revit will include in energy analysis. Revit will ignore Analytical Surfaces with any dimension smaller than the Analytical Surface Resolution. Reducing Analytical Space Resolution and Analytical Surface Resolution will result in a more accurate but more complex energy model that takes longer to generate and analyze.
When creating an energy model, Revit generates Analytical Spaces and subdivides those spaces into zones based on the Perimeter Zone Depth and Perimeter Zone Division settings.

Perimeter Zone Depth specifies the depth of perimeter zones measured from exterior Analytical Surfaces

Perimeter Zone Division determines whether Revit further subdivides perimeter Analytical Spaces into zones after applying the Perimeter Zone Depth option.



ANALYTICAL SPACES WITH AND WITHOUT PERIMETER ZONE DIVISION

Average Vertical Void Height Threshold defines the average height below which analytical spaces are considered Unconditioned. Spaces with average heights below this threshold, determined by dividing volume by area, will not be assigned heating or cooling loads or included in systems analysis.

Horizontal Void/Chase Area Threshold defines the area below which analytical spaces are considered Unconditioned. Spaces with areas below this threshold will not be assigned heating or cooling loads or included in systems analysis.

6.2. Advanced Energy Settings

This heading contains parameters that allow finer control of energy analysis assumptions.

6.2.1. Detailed Model

These settings mainly affect conceptual masses, as they approximate the more precise inputs from a building element model.

Target Percentage Glazing specifies the percentage of conceptual mass exterior surfaces that Revit will display and calculate as glazed. When generating Analytical

Surfaces from building elements, Revit ignores this setting, requiring manual placement of windows.

Target Sill Height indicates the height of automatically-generated glazed surfaces above the mass floor.

Glazing is Shaded controls whether Revit generates light shelves that shade the glazed portion of conceptual mass surfaces.

Shade Depth determines the depth of light shelves measured from the exterior wall.

Target Percentage Skylights specifies the percentage of the roof Analytical Surfaces generated from conceptual masses that Revit will display and calculate as glazed.

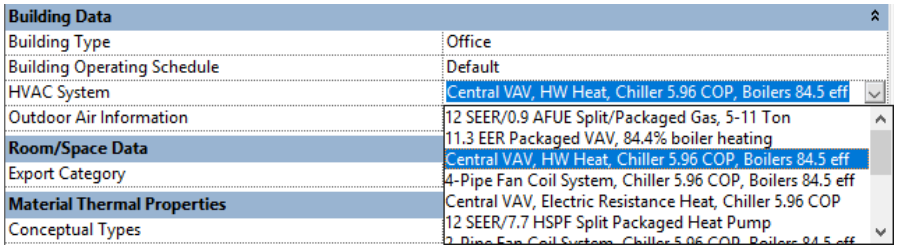
Skylight Width & Depth defines the size of the square skylight elements. Increasing this number results in fewer, larger skylights to match the Total Percentage Skylights setting.

6.2.2. Building Data

Building Type uses settings from the **Building/Space Type Settings** menu (*see Section 7.1*) to assign energy analysis parameters to the entire building.

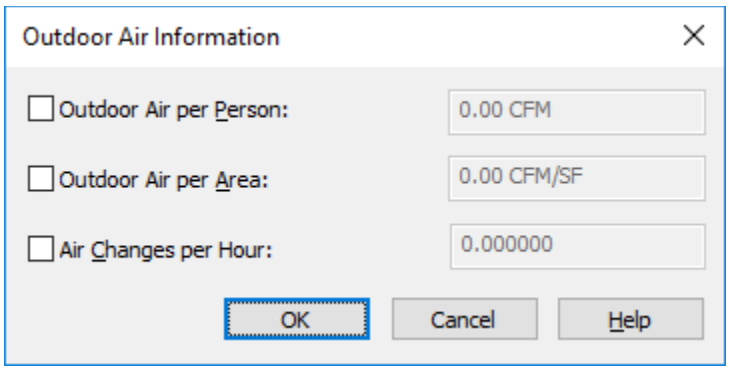
Building Operating Schedule controls the operating schedule of the building. This setting overrides the default setting from **Building Type**.

HVAC System specifies the type of HVAC system used in calculations. These systems derive from a standard list, details of which are available through the Autodesk Knowledge Network.



HVAC Systems In The Advanced Energy Settings Menu

Outdoor Air Information allows analysis of the effects of outdoor air, calculated as Outdoor Air per Person, Outdoor Air per Area, Air Changes per Hour, or any combination of the three.



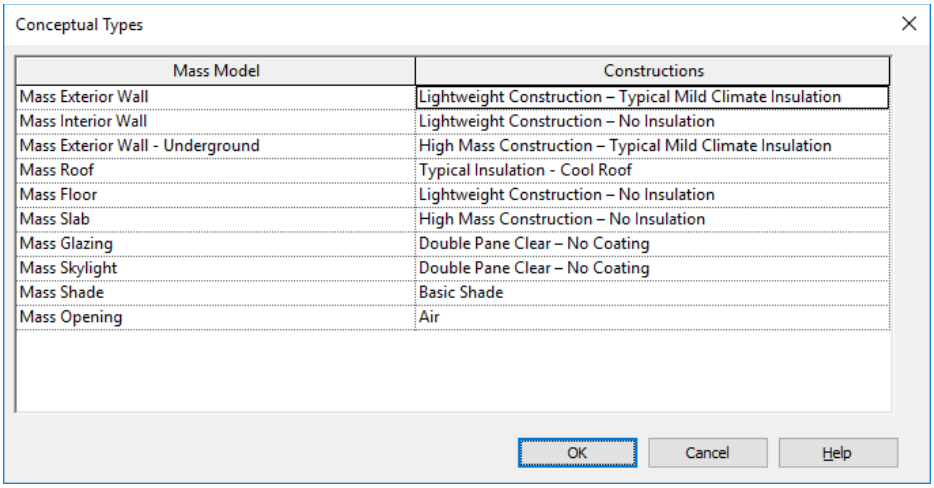
THE OUTDOOR AIR INFORMATION MENU

6.2.3. Room/Space Data

Export Category determines whether Revit analyzes data from Rooms or Spaces in the model. The default setting is Rooms, but changing it to Spaces allows a much greater degree of control over the energy analysis parameters of Analytical Spaces in the energy model.

6.2.4. Material Thermal Properties

Conceptual Types assigns thermal properties to Analytical Surfaces based on a standard list of conceptual construction types available through the Autodesk Knowledge Network. Click the **Edit** button to open the **Conceptual Types** window and assign conceptual types to Analytical Surface categories.



THE CONCEPTUAL TYPES MENU

The **Schematic Types** dialog overrides **Conceptual Types** and allows selection of analytic construction types from a much more comprehensive list. This option allows finer control over insulation and infiltration of Analytical Surfaces. Detailed information on the thermal properties of specific Schematic Types is available through the Autodesk Knowledge Network.

The **Detailed Elements** checkbox overrides both **Conceptual Types** and **Schematic Types** for any building elements in the model that have Thermal Properties (*see Section 4.3*). Because Revit continues to use Conceptual Types or Schematic Types for building elements without Thermal Properties, it is not necessary to assign Thermal Properties to all materials and assemblies in the model to analyze Detailed Elements. Beginning with a rough model and adding data regarding materials and assemblies as it becomes available, it is possible to increase the accuracy of energy analysis over the course of the design process.

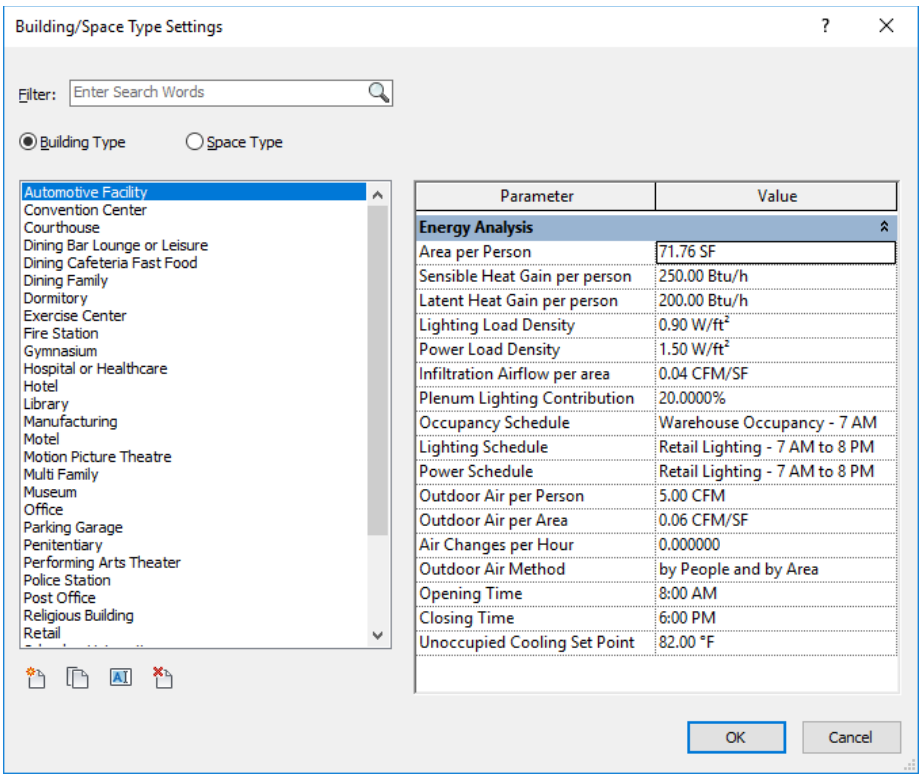
7. Adjusting the Energy Analytical Model

The Revit energy modeling process initially relies on default types, values, and assumptions. It is possible to adjust these underlying assumptions in order to better approximate the real-world conditions and functioning of the building. Revit draws on a library of conceptual types, systems, building types, and space types to apply reasonable parameters for energy analysis. With mass geometry, Revit applies the default space type to each zone and adds glazing and shading to exterior surfaces according to the Energy Settings (*see Section 6*). With building element geometry, Revit applies the default space type to each zone and the appropriate Analytical Surface type to each surface. However, it is possible to manually apply custom settings to individual zones and surfaces and even to modify and add building and space types in order to achieve more accurate results.

7.1. Building and Space Types

The **Building/Space Type Settings** menu controls project parameters affecting overall operation, such as operating schedule and load densities. These parameters mainly affect the calculation of heating and cooling loads, and can therefore have a significant impact on the efficiency and energy consumption of a building.

In order to access the **Building/Space Type Settings** menu, click **Manage ► Settings ► MEP Settings ► Building/Space Type Settings** or click the small arrow in the lower-right corner of the **Analyze ► Reports and Schedules** panel. Through this menu it is possible to view and edit the default settings for the Building and Space Types already in the project and add custom Building and Space Types.



THE BUILDING/SPACE TYPE SETTINGS MENU

7.1.1. Building Type

Building Type defines parameters affecting overall building operation. By default, these parameters control the function of all of the Analytical Spaces and zones in the project. Change these parameters to change the assumptions for default building types in the project, or add to the list using the **Duplicate** or **Add** buttons to create new building types.

In order to change the **Building Type** of the project, access the **Advanced Energy Settings** menu by clicking **Analyze ► Energy Optimization ► Energy Settings** and then by clicking **Advanced ► Other Options ► Edit…**.

7.1.2. Space Type

Space Type defines parameters affecting individual Analytical Spaces. Apply a Space Type to a Space and Create an Energy Model (*see Section 5*) to generate a corresponding Analytical Space with the same energy analysis parameters. Space Type settings largely affect the same parameters as **Building Type** settings, and therefore override those settings when applied.

7.2. Adjusting Individual Masses and Mass Floors

Use the **Massing & Site ► Conceptual Mass ► Show Mass Form and Floors** command to show the overall masses in the project.

7.2.1. Mass Properties

Select one or more masses to access **Mass Properties**.

- Click **Mass Floors ► Edit** to apply or remove mass floors for the selected mass or masses.
- Uncheck **Use Energy Data** to allow custom rules for automatic creation of zones from the selected mass or masses.
- This menu also displays the area, surface area, and volume of a selected mass.

7.2.2. Mass Floor Properties

Select one or more mass floors to access **Mass Floor Properties**.

- Use the **Materials and Finishes ► Graphical Appearance** field to assign a texture from the material library to the selected mass floor. This appearance is cosmetic only and does not apply any thermal properties to the mass floor.
- Click the pulldown arrow in the **Energy Analytical Model ► Conceptual Types ► <By Energy Settings>** field to apply a custom **Conceptual Type** that will override the selection in the **Advanced Energy Settings** menu.
- Use the **Identity Data ► Usage** field to assign a usage to the selected mass floor or floors. This is a text parameter that can appear in tags and schedules.
- This menu also displays the perimeter, area, exterior surface area, and volume of a selected mass floor.

7.3. Adjusting Analytical Spaces

When analyzing Conceptual Masses and Building Elements, Revit assigns data to Analytical Spaces based on Rooms or Spaces in the model and the corresponding **Export Category**. When using the recommended **Spaces** Export Category, it is necessary to place a Space and assign properties to it in order to adjust Analytical Space properties.
Place a Space within the model and select it to assign a Number and Name in the Properties palette. Create an Energy Model to generate Analytical Spaces (*see Section 5*). Select an Analytical Space that corresponds to the Space or open the Analytical Spaces Schedule to verify that the Analytical Space reflects the Space Name and Number.

7.3.1. Energy Analysis Parameters

Select a Space and scroll to the Energy Analysis heading of the Properties palette to fine-tune parameters pertaining to energy usage. It is only necessary to adjust these settings if the selected Space differs from the default building function.

Zone reflects the HVAC Zone to which the selected Space belongs. If the Space is not yet part of a Zone, this will read Default. It is not possible to change this setting through the Properties palette.

The **Plenum** checkbox determines whether Revit will model the Space as an occupiable room or as an unconditioned plenum space. Note that selecting this option unchecks the Occupiable option, sets Condition Type to Unconditioned, and makes both of those options inactive.

The **Occupiable** checkbox determines whether the selected Space is considered occupiable. Uncheck this box for unoccupied Spaces such as plenums, chases, or storage closets.

Condition Type controls how Revit calculates a space based on the heating and cooling loads and ventilation. Use this setting to indicate whether a space is Heated, Cooled, Heated and cooled, Unconditioned, Vented, or Naturally Vented Only.

Space Type assigns load, occupancy, and energy values based on the Space Type Settings. By default, Spaces in the model reflect the overall <Building> setting, but it is possible to assign different Space Types to individual Spaces in the model (*see Section 7.3*).

Construction Type allows users to create and assign Construction Types that determine the Schematic Types assigned to Analytical Surfaces generated from the selected Space. The default <Building> Construction Type does not contain any overrides, but assigning a new Construction Type and checking the Override checkbox for a given category results in Revit calculating all elements of the specified category and Construction Type with the selected Schematic Type.

The **People** dialog box controls whether Revit calculates the Occupancy and Heat Gain (per Person) according to the Space Type or the Specified values.

Similarly, the **Electrical Loads** dialog box controls whether Revit calculates the Lighting and Power loads according to the Space Type or the Specified values. However, it is also possible to analyze these loads based on Actual elements in the model.

Outdoor Air Information reflects whether Revit obtains outdoor air values for the Space from the Space Type or from the Zone. By default, this option is set to Space Type, but it is possible to assign a Space to a Zone and use Outdoor Air Information specific to the Zone instead. This option sets values for **Outdoor Air per Person**, **Outdoor Air per Area**, and **Air Changes per Hour**. This option is not user editable in this dialog box. Select a Zone and click the **Edit…** button next to the Outdoor Air Information parameter to alter these settings.

Outdoor Air Method displays the method for calculating outdoor air in the selected Space. The Building and Space Type Settings control this option.

Calculated Heating Load and **Calculated Cooling Load** reflect calculated or imported values for the total heating and cooling loads for the selected Space. It is possible to calculate these values using the integrated heating and cooling loads analysis tool or to import the values from a gbXML file.

Design Heating Load and **Design Cooling Load** are user-editable fields reflecting the specified heating and cooling loads for the selected Space. Similar to the Calculated Heating and Cooling Loads, it is also possible to calculate or import these values.

7.4. Adjusting Analytical Surfaces

When creating the energy model, Revit automatically creates Analytical Surfaces that are divided and categorized according to location and function. The Conceptual Types menu governs the materials assigned to these Analytical Surfaces unless the Construction Type overrides those selections with Schematic Types.

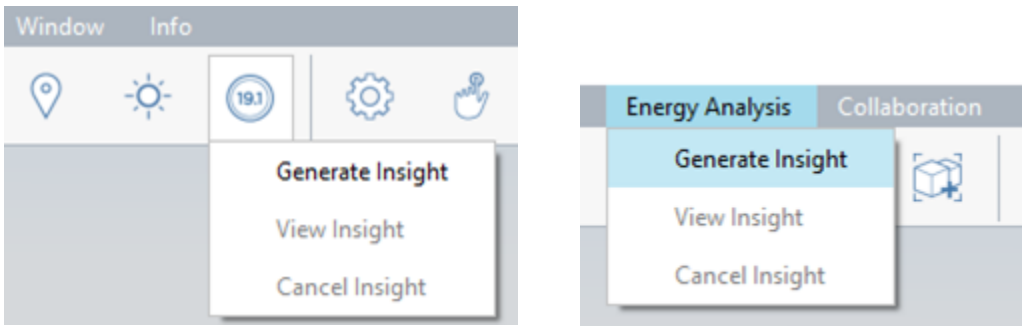
Although it is not possible to select a specific Analytical Surface and manually apply a material or Schematic Type, modeling a building element with Thermal Properties assigned to it and calculating using the Detailed Elements setting overrides any Conceptual Types or Schematic Types applied to that surface. Beginning with a simple model consisting of default Analytical Surfaces, it is possible to add specific critical elements with known thermal properties and improve the detail level of the energy analysis over time (*see Section 4.3*).

8. FormIt

Autodesk FormIt is architectural modeling software that features integration with Revit and Insight. Designers can use this software to intuitively translate design intent to a 3D model with easy and flexible tools. This content translates directly to Revit masses, levels, and building elements. With FormIt Pro, it is possible to assign materials from the Autodesk standard material library, access intelligent design functionality through Dynamo, and perform energy analysis using Insight. FormIt features built-in tools to translate content to and from Revit, enabling the use of more advanced energy analysis features and add-ins.

CONCEPTUAL 3D MODELING WITH FORMIT

Many menus and settings in FormIt Pro are similar to those in Revit. Therefore, much of the above guide applies to FormIt Pro as well as Revit. The basic workflow of modeling conceptual masses or building elements, applying energy settings, and establishing the location of the model is the same regardless of modeling platform.



INSIGHT ENERGY ANALYSIS IN FORMIT PRO

FormIt is available as a web application and as an application for iOS and Android. Using a Revit add-in, it is possible to import and export between FormIt and Revit. FormIt Pro features a standalone Windows application, energy and solar analysis tools, Autodesk materials, Dynamo integration, and more. Visit https://formit.autodesk.com/ for more information.

9. Analyzing the Energy Model and Interpreting Results

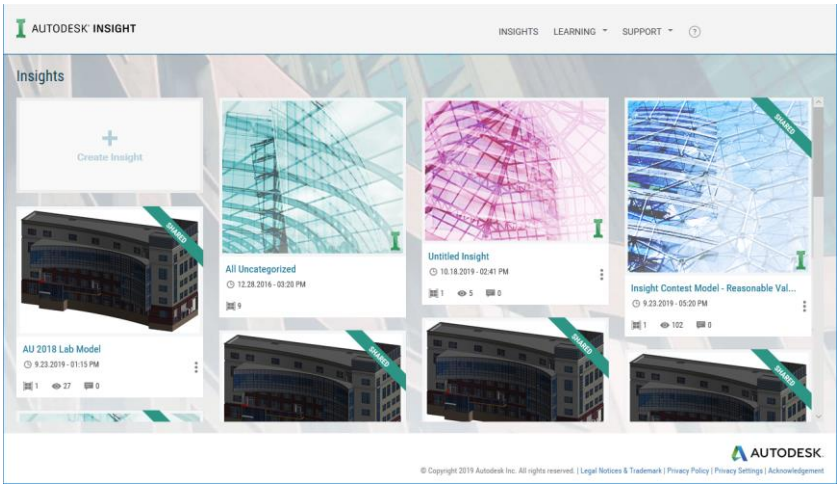
After creating and editing the energy model the next step is performing energy analysis and generating design options using Insight. Revit automatically creates a gbXML file from the energy model and sends it to Insight and Autodesk Green Building Studio for analysis. While it is possible to view the raw results of this analysis through the Green Building Studio website, Insight displays results in a more intuitive format and includes suggestions to assist with design decisions. With Insight, it is possible to determine a desired outcome in advance and see potential areas for improvement in performance and energy efficiency that will help to reach that outcome. With stringent requirements like the 2030 Challenge and Net Zero on the horizon, Insight is an indispensable tool in setting and achieving sustainability goals.

9.1. Insight

Insight makes use of Autodesk 360 cloud services to analyze not just the model as designed, but also the potential results of different design choices. This powerful tool provides guidance when making design decisions to improve building performance and efficiency. By narrowing design criteria or applying specific scenarios, it is possible to refine the building design to optimize the use of resources.

Click **Analyze ► Energy Optimization ► Generate** to package the energy model and send it for analysis. Insight is an Autodesk Cloud service and therefore requires a login, so Revit may display a prompt for a username and password at this time. Autodesk Insight Support sends an email to the address associated with the Autodesk A360 account upon receiving the model and sends another email upon completion of analysis. During this time, calculations take place in the cloud and do not require local processing.

After calculations are complete, click **Analyze ► Energy Optimization ► Optimize** to bring up the Insight window. This is a web browser window that is separate from Revit and shows the Autodesk Insight website. It is possible to view this website through any web browser by visiting https://insight.autodesk.com/ and logging into the Autodesk A360 account associated with the calculations.

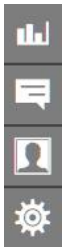


THE INSIGHT LAUNCH SCREEN

Click **Create Insight** to create an untitled Insight for this project. This creates a category for sorting analysis and calculations associated with this project. Click the **⋮ menu** button to rename the Insight, add a custom picture to the menu page, add multiple models, or delete the Insight. Click the image or title to open the Insight and view a display of models and results.

Within the Insight view, each model has a **⋮ menu** button that allows renaming, moving, exporting, and deleting individual models. This menu also contains a **Retrofit Analysis** function that can generate analysis based on electricity and gas cost figures from a selected historical date range.

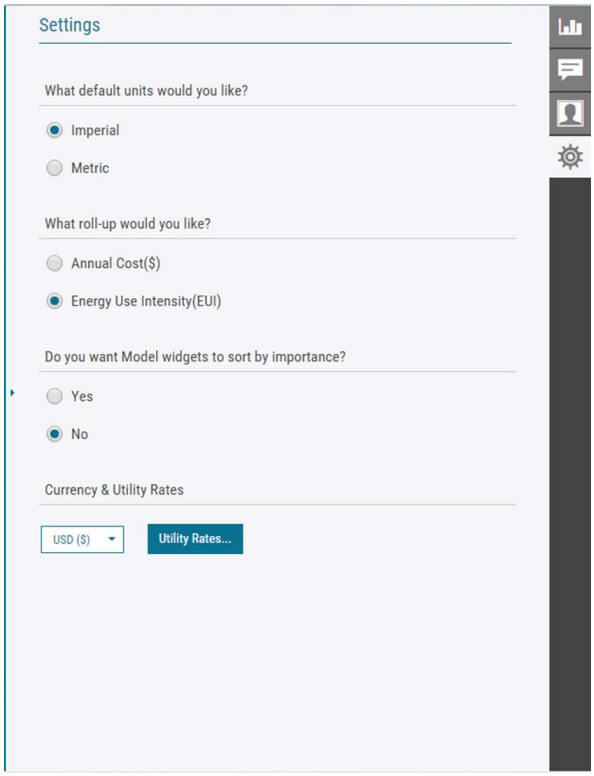
The **Sidebar** menu on the right side of the Insight page brings up a pane with options for displaying and sharing the model.



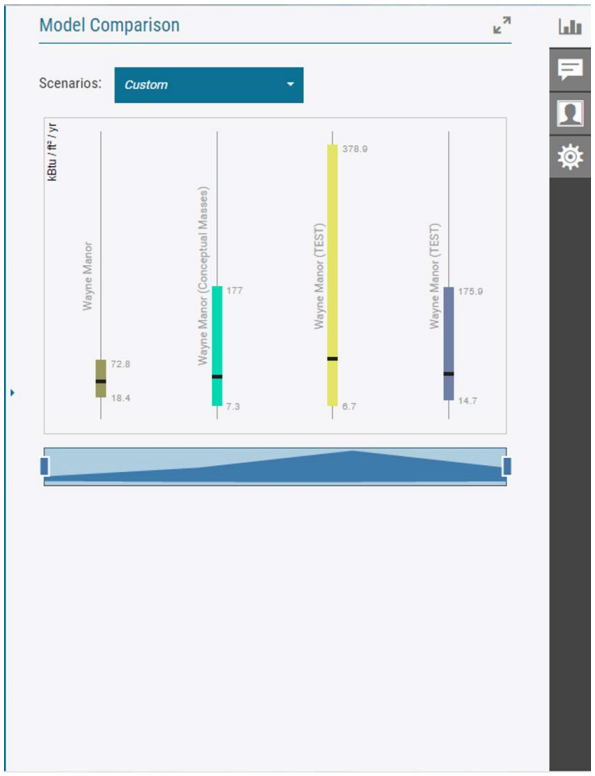
THE SIDEBAR MENU

- Click the **Model Comparison** button to display a graph comparing models in the Insight. In this view, it is possible to apply a Scenario to all models in the Insight.
- Click the **Comment** button to add comments to the model and view a chronological list of previous comments.
- Click the **Members** button to invite other users to access the Insight. With this feature, multiple people can view analysis results and apply constraints and Scenarios to models and Insights.

- Click the **Settings** button to access options governing display and unit settings. Because these settings affect the way in which Insight displays results but do not affect the underlying results it is possible to see the results of any changes instantaneously:
    - Display imperial or metric units.
    - Display annual cost or EUI in the Model Comparison view.
    - Display model widgets in order of importance or grouped by category.
    - Select currency type.
    - Manually set utility rates or use the automated rates service.



THE SETTINGS MENU



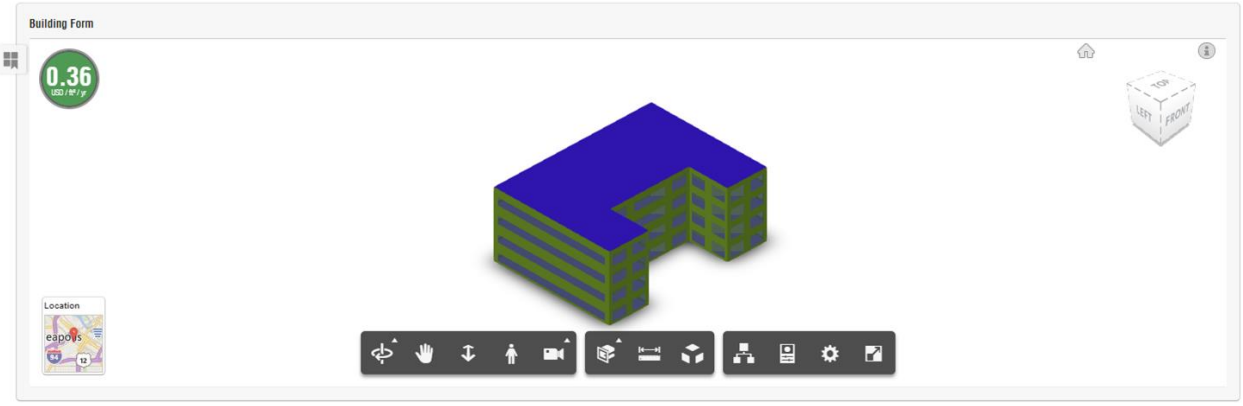
VIEWING AN INSIGHT – MODEL COMPARISON

9.2. Insight Model Analysis

Click a model to view detailed calculation results, benchmarks, and potential improvements.

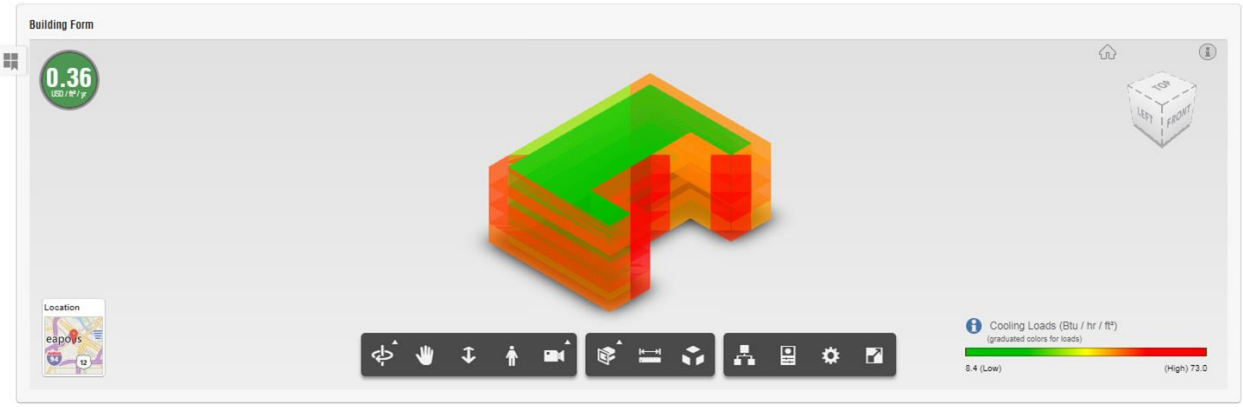
9.2.1. Building Form

Within the analysis results view, the topmost window shows the building form in 3D and an overall benchmark for the project, by default cost per area per year.



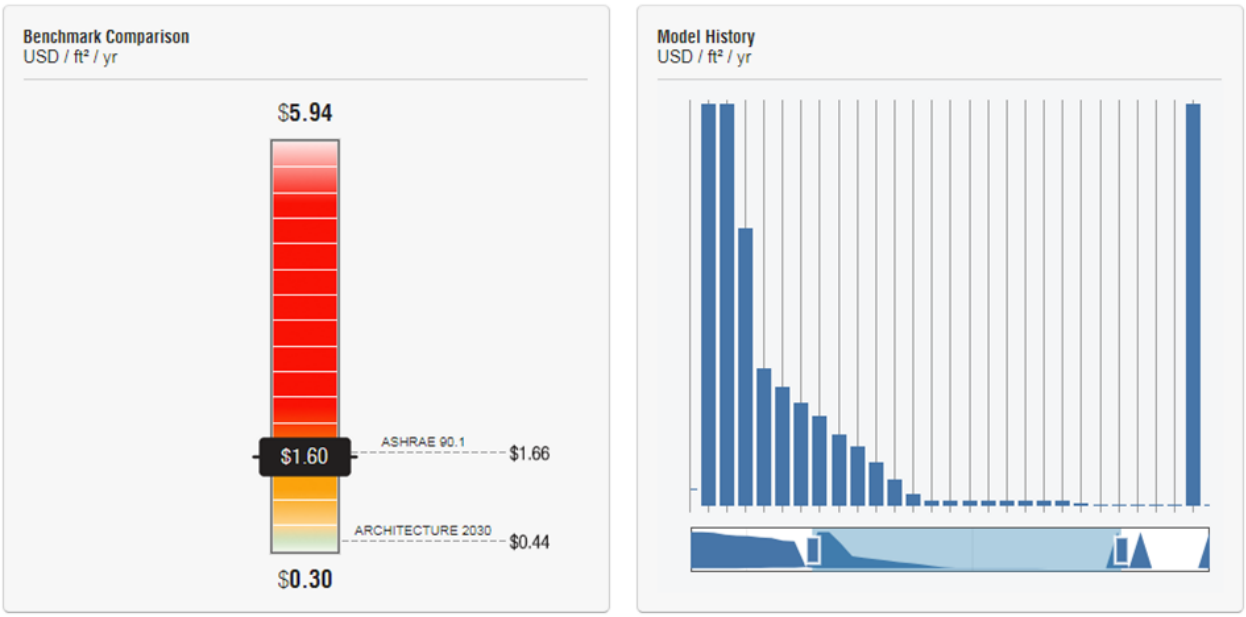
THE BUILDING FORM PANE

- Use the left set of controls in the Building Form window to orbit, pan, and navigate the view.
- Use the middle set of controls to cut sections, measure, and explode the model.
- Use the right set of controls to browse individual model elements, view properties, change display settings, and view the model in a full screen window.
- Click the **benchmark** circle to toggle the display between a cost benchmark (USD/ft²/yr) and an energy use benchmark (kBtu/ft²/yr).
- Click the **Location** button to display the project location on a map. When viewing the map, click the Building Form button to return to the Building Form display.
- Use the **Navigation Cube** to orbit the view.
- The pulldown arrow next to the Navigation Cube brings up a menu with options to return to the Home view, change between orthographic and perspective display, or set the current view orientation as Home, Front, or Top.
- Use the **Home** button to return to the Home view.
- Use the **Properties** button to display model properties.
- Use the **Visualize** button to display the model colored by surface type or by photovoltaic analysis, heating loads, or cooling loads.



THE BUILDING FORM PANE SHOWING COOLING LOADS

9.2.2. Benchmark Comparison and Model History



THE BENCHMARK COMPARISON AND MODEL HISTORY WIDGETS

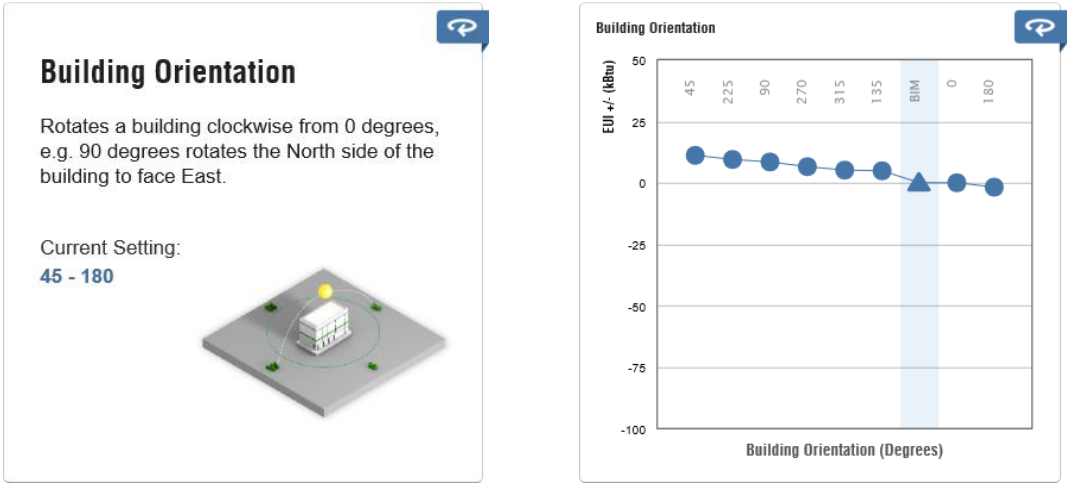
Insight displays results broken up by category in interactive panels called widgets. The first two widgets after the **Building Form** pane display the **Benchmark Comparison** and **Model History**. These widgets reflect analysis results but do not provide any recommendations for improving design efficiency. The **Benchmark Comparison** widget shows the results of the energy analysis measured against the ASHRAE 90.1 and Architecture 2030 efficiency standards. This gives a rough idea of how close the building is to meeting efficiency goals and whether the current design will meet current and future performance standards.
The **Model History** widget displays historical benchmark comparison results from each model iteration. Every change to the overall model, energy options, or model widgets generates a new entry in the model history, allowing for a comprehensive view of the resulting change in performance in comparison to all previous benchmarks. It is possible to select a specific range in order to compare specific benchmarks more accurately. Mouse over the bars in the graph to see further details about the selected analysis.

9.2.3. Model Widgets

The next widgets show analysis results for specific model categories. Depending on the current settings, these widgets may be in a logical order grouping connected categories – such as window to wall ratio, window shade size, and window glass type – or in order of importance, meaning decreasing order of the magnitude of possible change in overall efficiency.

By default, these widgets display as a descriptive panel. Press the elliptical arrow button to flip the widget and see analysis results compared with the potential results of different design decisions. In this graph, the point for the model as designed and calculated is a

triangle and all other points are circles. Mouse over any of these points to display further details and the calculation result associated with it. The blue highlight indicates the acceptable range of design inputs or analysis results.



THE BUILDING ORIENTATION WIDGET

Click a widget to bring up an expanded view of specific analysis results. This view also includes a display of the overall Benchmark Comparison of the project in order to instantly show the results of changes to design criteria. Within this view, it is possible to limit the acceptable range of design inputs or analysis results by dragging the sides of the blue highlight or the blue grips on the X-axis. It is also possible to move the entire design range by clicking and dragging the middle of the blue bar.

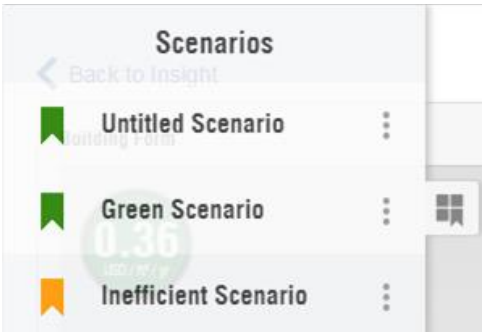
Much like modifying the building design, modifying analysis criteria results in a new entry in the Model History for comparison. It is possible to save specific settings and design criteria as a Scenario with which to evaluate further iterations of the model.

9.2.4. Scenarios

Create a new Scenario to save design options and apply them to future iterations of a model. In order to save a Scenario for a model, click the **Add Scenario** button in the header of the Insight window showing the model.

THE ADD SCENARIO BUTTON

The new Scenario will appear in a sidebar listing all saved Scenarios. Use the **⋮ Menu** button to rename or delete the associated Scenario. The button on the right of the sidebar shows or hides the sidebar.

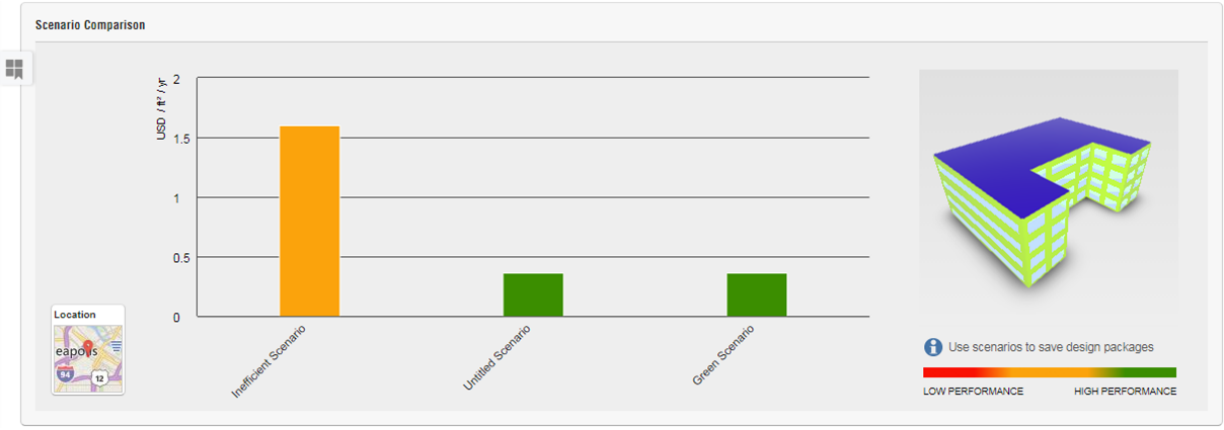


THE SCENARIOS SIDEBAR

After saving multiple Scenarios, it is possible to compare them using the **Scenario Compare** button in the header of the Insight window.

THE SCENARIO COMPARE BUTTON

Click the **Scenario Compare** button to display the **Scenario Comparison** graph in the top pane of the Insight window. This graph compares the benchmark results of all Scenarios for the energy model in the same units as the **Building Form** pane. Mouse over an entry in the graph to see the precise value of the benchmark.



THE SCENARIO COMPARISON PANE

After creating a Scenario for a specific building, it is possible to apply that Scenario to other buildings in the Insight. Click the **Back to Insight** link in the header of the Insight window to return to the Insight containing the active building. In the Insight view, use the **Model Comparison** button to expand the sidebar. Click the **Scenarios** pulldown and select a Scenario to view the results of applying the criteria of that Scenario to multiple models in the Insight. Click the star next to the name of a Scenario to add it to the list of Favorites. Favorite Scenarios are available across all Insights.

THE SCENARIO PULLDOWN IN THE MODEL COMPARISON SIDEBAR

Insight includes premade Scenarios that apply constraints to a sample building model based on Net Zero and Architecture 2030 standards. Because these Scenarios are Favorites by default, it is possible to apply the corresponding constraints to all Insights, which can be an informative exercise. Do not remove these Scenarios from the list of Favorites.

By using Insight to assess efficiency and potential for improvement, it is possible to create a model to meet even the most stringent energy standard. The results of Insight provide guidelines to follow throughout the design process. Assessing the efficiency of a proposed design and applying the resulting recommendations to the model is iterative and ultimately drives the direction of the design process for an efficient and sustainable building.

9.3. Insight Energy Analysis Validation

Energy analysis using Insight is fast and accurate, making use of validated, industry-standard simulation software.

- Insight uses the **DOE 2.2** simulation engine for energy analysis. This engine performs hourly analysis of building components and weather data to produce energy use and cost estimates. More information is available at http://doe2.com/.
- Insight utilizes the **EnergyPlus** engine when calculating heating and cooling loads, as well as evaluating annual energy impacts. Visual results of this calculation are visible in the Building Form pane of Insight (*see Section 9.2.1*).
- Insight is **ASHRAE 140** verified. This standard compares building energy analysis software, focusing on building thermal envelope and fabric loads and HVAC equipment performance.

9.4. Exporting gbXML

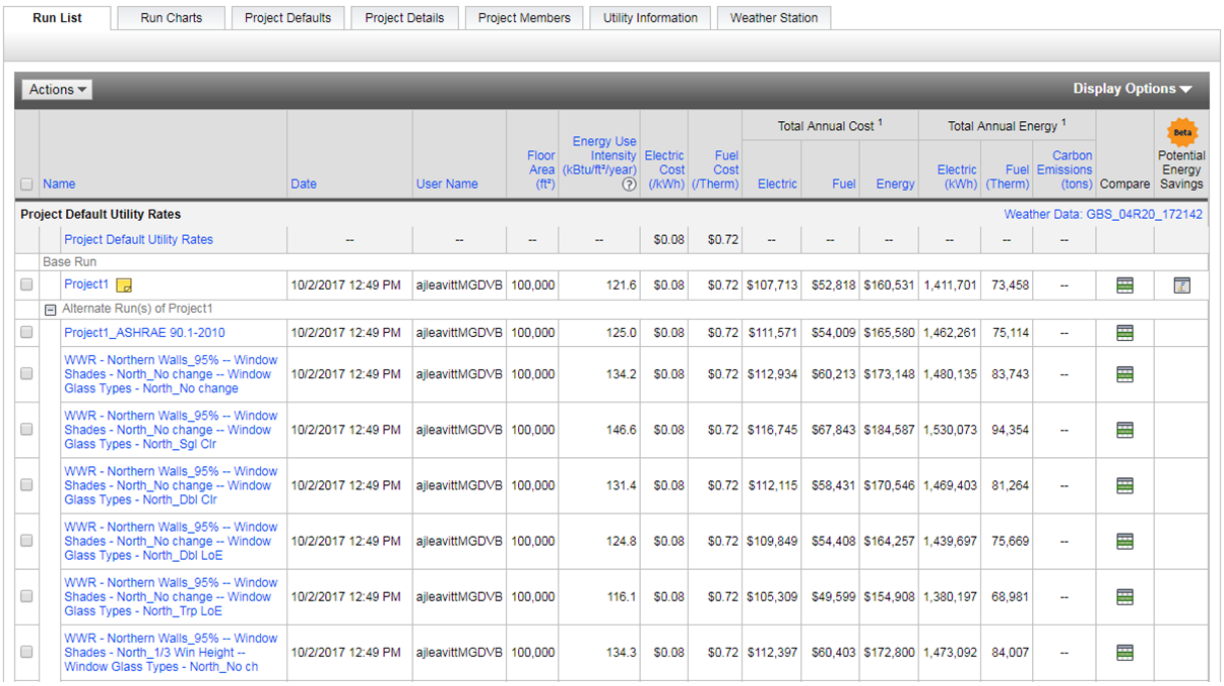
Exporting a gbXML file of the energy model allows analysis using other software. It is possible to export a gbXML file both from Revit and from Insight.

To export a gbXML file from Revit, click **File ► Export ► gbXML**. In the Export gbXML dialog box, select **Use Energy Settings** to export data from the energy analytical model. This will ensure that exported data matches Analytical Elements in the energy model. Data generated from exporting Room/Space Volumes may not be as accurate. Click **OK** and select a location for the exported gbXML file.

To export a gbXML file from Insight, highlight an Insight and click the **⋮ menu** button. Click Export in this menu and select gbXML. Click the **Export** button and select a location to download the exported gbXML file. Note that it is possible to export Insight energy analysis results in a number of other useful formats, including Energy Plus and DOE-2.

9.5. Green Building Studio

It is possible to view detailed energy analysis results through the Autodesk Green Building Studio website (https://gbs.autodesk.com/). Data on this page reflects the energy analysis from Revit and does not reflect any of the additional constraints or changes made using Insight.



VIEWING ANALYSIS RESULTS THROUGH THE AUTODESK GREEN BUILDING STUDIO WEBSITE

While the data on this website is valid, Insight has replaced the functionality and Green Building Studio is no longer part of the suggested energy analysis process.

10. Energy Analysis as Part of the Design Workflow

Energy analysis using Revit and Insight is meant to be a straightforward means of assessing decisions throughout the design workflow. Because Insight is an Autodesk cloud service, analysis is fast and has low computing demands. The preselected list of conceptual constructions combined with the building and space types and energy settings provide a

reasonable starting point for predicting building performance, and adding spaces and individual building elements can further refine the model for even more accurate results.

10.1. Early and Ongoing Analysis

Creating an energy model and analyzing that model throughout the design process is an effective and powerful way to assess and track the potential effects of design decisions. Early in the design process, when making the largest decisions about building form and orientation, energy analysis can have the most dramatic results. Later in the design process, this analysis can guide and reveal the potential outcomes of more granular design decisions. Continuing this analysis throughout the course of the project can help to keep the design on track and achieve sustainability goals. This way, efficiency and sustainability can be deciding factors in the design process rather than afterthoughts.

10.2. Calculate, Tweak, and Repeat

Once a model is in place representing the overall design of a building, there are still a large number of considerations that may affect efficiency and sustainability. Insight shows a range of possible outcomes for energy analysis based on potential design decisions. Taking the recommendations from Insight and applying them to the Revit model results in a more efficient building that potentially has new sustainability considerations to take into account. This ongoing process of making a building model more efficient, analyzing the energy model, and applying the results and recommendations from the energy analysis to the building model ultimately results in a sustainable building in which the various components interact to maximize efficiency.

10.3. Integrative Design

Energy analysis using Revit and Insight is an essential part of an integrative design process unifying architecture with mechanical, electrical, and structural engineering. The energy modeling process takes into account the effects of design decisions on the energy use intensity of the project, including building layout, location, and orientation; mechanical systems; heat gains and losses; electrical loads; glazing and shading; insulation; wall and roof types; and even operating schedule. Because it is so easy and the results are so informative, energy modeling with Insight should be a part of any integrative design process using Revit.

11. Links

Below is a list of the links mentioned in this handout and other relevant links:

Insight:
https://insight.autodesk.com

Autodesk Knowledge Network:
https://knowledge.autodesk.com

Autodesk Knowledge Network: Energy Optimization for Revit:
https://knowledge.autodesk.com/support/revit-products/learn-explore/caas/CloudHelp/cloudhelp/2017/ENU/Revit-Analyze/files/GUID-2043E09F-40E5-4155-AE28-134F62E54F54-htm.html

Autodesk Knowledge Network: Energy Settings:
https://knowledge.autodesk.com/support/revit-products/learn-explore/caas/CloudHelp/cloudhelp/2020/ENU/Revit-Analyze/files/GUID-36B2F66A-E423-4D9C-B266-3ABA57573F4A-htm.html

Autodesk Knowledge Network: HVAC Systems:
https://knowledge.autodesk.com/support/revit-products/learn-explore/caas/CloudHelp/cloudhelp/2017/ENU/Revit-Analyze/files/GUID-38A9EB5B-8631-43B4-9AD6-6F532BC860D8-htm.html

Autodesk Knowledge Network: Material Thermal Properties - Conceptual Types:
https://knowledge.autodesk.com/support/revit-products/learn-explore/caas/CloudHelp/cloudhelp/2017/ENU/Revit-Analyze/files/GUID-004A470D-675B-4CB0-96AE-D4A6852BDDA3-htm.html

Autodesk Knowledge Network: MEP Constructions for Buildings and Spaces:
http://download.autodesk.com/us/revit_mep_2016/constructions-revised.pdf

FormIt:
https://formit.autodesk.com

Green Building Studio:
https://gbs.autodesk.com

DOE-2:
http://doe2.com/