NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Audience: Engineer/Architect

For Energy Simulation Experience Range:

Beginner | Intermediate | Advanced

OpenStudio Workflow Training
Energy Modeling for Retrofit Projects

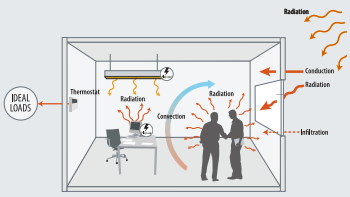
This interactive checklist is tied to online video tutorials and walks you through the steps necessary to create an energy model of your existing building. You can create a baseline simulation, model and run simulations for retrofit alternatives, and compare them against your baseline model. You can just watch the videos or follow along with your own files or files supplied with the videos. The video player offers choices at a number of points, such as choosing from different methods for creating building geometry. You can click the link below to launch the Web-based video player, or you can click links to specific videos and resources throughout the checklist. Once you are in the video player , you can use the player's table of contents to link to subtopic videos.

Use OpenStudio to Create Your Own Energy Model

4-6 hours

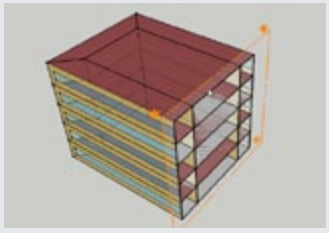
Download OpenStudio at ***http://openstudio.nrel.gov/downloads***.
Access videos and additional resources for tutorial at
http://openstudio.nrel.gov/energy-modeling-retrofit-projects.

1. Introduction to OpenStudio Energy Modeling and EnergyPlus Thermal Zones



☐ Role of a thermal zone in an energy simulation

A thermal zone is a core element of energy modeling and simulation using EnergyPlus and OpenStudio. This video is a primer to explain what thermal zones are and the role they play in EnergyPlus. It introduces you to heat transfer surfaces, internal and external loads, and ideal air loads system.



☐ Strategies for dividing building massing into thermal zones

Now that you know what a thermal zone is, learn some of the factors that influence how to divide the volume of your building into a series of thermal zones: building activity, schedule, thermostat set points, geometry, and analysis goals. Also remember that internal heat transfer surfaces do not always represent physical walls, but are just zone boundaries.

2. Onsite Building Documentation

☐ Field measurements

If you plan to model from photographs, you generally need only one field measurement to scale your model against. Ideally this is a large measurement such as the length or height of your building. It could also be something smaller such as a door; however, you may lose some accuracy with a small measurement. You may want the height from a window sill to the floor. This will provide you more accurate position on the internal floors; however, the exact height of the internal floor is not usually critical to your simulation results.

NREL/PIX 09019

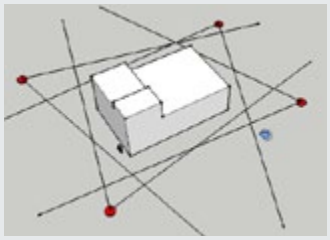
☐ Building vintage

You can use vintage to identify constructions and lighting and equipment technology. You do not need to know the specific year the building was built, just enough to assign it to the most appropriate template vintage. The template files include data for four vintages: pre-1980, post-1980, 2004, and 2009. It is important to know if the building envelope, equipment, or lights have been renovated since it was built. You can use these data to customize your model.

NREL/PIX 09218

☐ Building type and internal activity

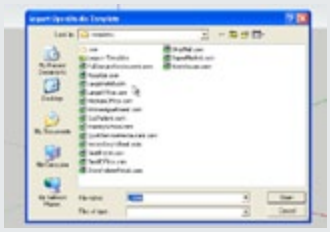
The building type and internal activity of a specific zone will affect the internal loads. The schedule, the number of people, and the extent of equipment and lighting in a space are all factors. You should identify what primary activates occur in different parts of the building. Our templates have vintage- and building type-specific smart defaults for loads and schedules. If you want to go beyond the defaults, the most likely areas for you to customize your data are thermostat set points and other schedules.



☐ **Exterior photography**

If you do not already have digital drawings or models of your building, often the quickest method to create geometry is to photograph its exterior and use SketchUp's Match Photo feature to create the 3-D model. Even if you plan to use a more traditional method, exterior photos are still useful reference data to confirm that drawings are correct.

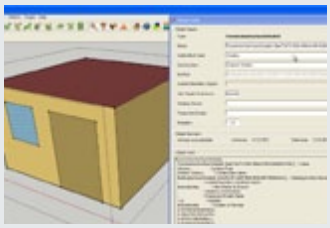
3. Setting Up a New File



☐ **Using OpenStudio building type templates**

OpenStudio has 16 building type-specific templates. You can set up a default building type template to use when SkechUp is first launched and click the "New OpenStudio Model" button to select a different building type. These templates are loaded with constructions, schedules, and internal loads specific to that building type. Each contains information for all U.S. climate zones and for the four vintages.

4. Creating Building Geometry



☐ **Introduction to SketchUp and OpenStudio**

If you are not very familiar with SketchUp or OpenStudio, this will introduce you to some of the basic SketchUp tools needed to make an OpenStudio model. It will also give you an overview of the tools and toolbar for the OpenStudio SketchUp plug-in.

☐ **Methods for creating geometry**

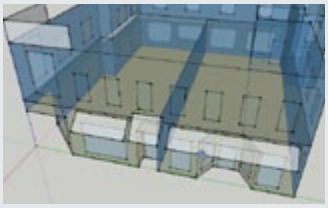
Building geometry serves as the primary data to shape your thermal zones. The following videos demonstrate methods of creating model geometry for an existing building. By default, the Match Photo video will play after this, but links are provided to tutorials on other methods of geometry creation.

CHOOSE ONE OF THESE FOUR METHODS FOR CREATING GEOMETRY

- ☐ Use SketchUp's Match Photo feature to create building geometry from your own photographs.
- ☐ Use Google's Web-based Building Maker to model geometry. This is similar to SketchUp's Match Photo, but you use oblique aerial photos supplied by Google. This is available for limited geographic areas.
- ☐ Work from architectural plans or field measurements.
- ☐ Use a 3-D model as a guide to create your thermal zones and heat transfer surfaces.

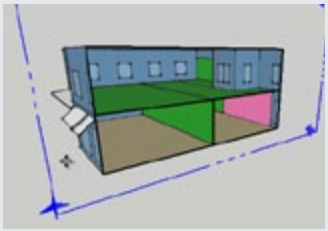
☐ Expanded geometry and thermal zoning

This video shows the model from the Match Photo tutorials with completed geometry. It demonstrates how to relink an SKP and an OSM file, and discusses the appropriate level of geometry detail for your energy model.



☐ Surface matching and setting boundary conditions

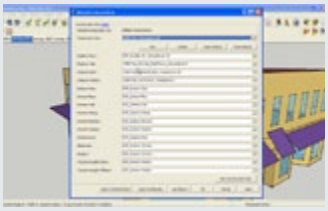
An important part of an energy model is defining the boundary conditions between adjacent interzone heat transfer surfaces. Learn how to use OpenStudio's surface matching tools to easily create additional geometry and set boundary conditions and constructions.



☐ Boundary conditions for adjacent buildings

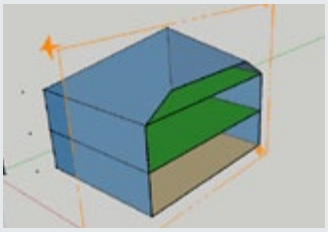
You need to assign special boundary conditions where your building is adjacent to another building. This could be a shared wall or a shared floor and ceiling. The easiest approach is to set an adiabatic boundary condition to eliminate any conductive heat transfer through the surface. This will run the simulation as if the adjacent building had the same schedule and thermostat set points as yours. If the adjacent building's use is vastly different than yours, you can set up an "other side boundary condition."

5. Defining Building Envelope Materials and Constructions



☐ Applying constructions from the template file data

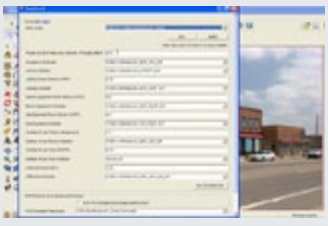
Your original template file is loaded with constructions and construction sets for your building type. Learn how to assign the correct construction set, and customize as necessary. For example, you can change your wall type from steel frame to mass wall.



☐ Setting constructions for an attic zone

Attic zones represent a unique condition where you have insulation on interzone surfaces. Learn how to use the sample attic zone construction sets that are included with the template files to properly model attic zone constructions and geometry.

6. Adding Internal Loads and Schedules to Your Model



☐ Apply loads and ideal loads air system

Use OpenStudio's zone loads dialog to assign area based zone loads and to create an optimal loads air system. Unique zone load sets are available for different vintages and space types. You can alter these or make new ones. After checking to activate the optimal air loads system, you need to choose a thermostat and set the heating point and cooling point schedules. These schedules contain the setback schedule as well as the thermostat set point values.

7. Adding Site Context

☐ Geolocating your model with SketchUp

Learn how to use SketchUp's geolocation to properly locate your building. You can also use imported satellite imagery to properly orient your building. This orientation is critical for proper sun exposure.

☐ Different methods for modeling nearby structures

You need to model nearby context as part of your energy model when that context affect sun exposure. Rather than modeling these buildings as thermal zones, you can model them as shading groups. Use shading groups to expedite modeling and simulation and ensure you are simulating your energy use only, and not your neighbor's. Learn different techniques for modeling surfaces in shading groups. Use SketchUp's "Nearby Components" feature to import nearby context from Google 3D Warehouse.

8. Running Your EnergyPlus Simulation

☐ Checking your model geometry for nonconvex surfaces

To accurately simulate surface shading in EnergyPlus, exterior surfaces that cast or receive shadows should not be nonconvex. These would include any surfaces that contain an interior angle greater than 180 degrees. This video demonstrates OpenStudio's surface search and how to divide a nonconvex surface into multiple convex surfaces.

☐ Choosing a weather file

A critical component of an energy simulation is the weather file. This feeds the simulation time series data on temperatures, wind, humidity, sky conditions, and addition weather data. Weather files for more than 2000 locations are available on the EnergyPlus website. Download one and link it into your model.

You can request many variables as part of an EnergyPlus simulation. The most common requests are included in the template file. This video shows you how to see all possible variables for your model and how to add the requests in for future simulation runs.

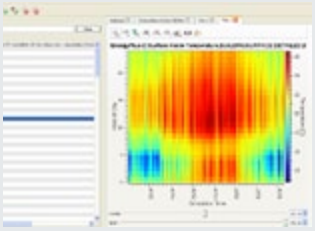
☐ Running Simulations

To run a simulation, set its time frame. An annual simulation is typical, but you can also run a partial year. The simulation engine is EnergyPlus, but you can trigger the simulation directly from the OpenStudio SketchUp plug-in or OpenStudio RunManager applications.

9. Viewing and Understanding Simulation Results

☐ **Viewing results in the SketchUp Plug-in**

You can map surface and zone variables onto your geometry in SketchUp. These variables represent time series data for the period of your simulation run. You can use SketchUp's shadow dialog box to control the time and date of the data.



☐ **Line and flood plots in ResultsViewer**

OpenStudio ResultsViewer can create plots from any of the variables or meters requested as part of your simulation. This enables you to view data for all or part of the simulation through line or flood plots. You can also map multiple variables from one or more simulations on top of each other.

ResultsViewer

☐ **Looking at tabular data in the Annual Building Summary Report**

This provides a summary of annual energy use, and details on specific elements such as end use breakdowns.

ResultsViewer

10. Creating Variations of Your Baseline Model to Evaluate Retrofit Options

☐ **Lowering internal loads: Upgrading kitchen equipment**

Change zone loads for electric and gas equipment in selected zones.

☐ **Compare baseline model to upgraded kitchen equipment**

Load annual end use data for the baseline and proposed design into a Google Documents spreadsheet. View side-by-side charts to compare the two simulations.

☐ **Upgrading envelope: Replacing restaurant windows**

Use the default constructions dialog to change constructions for selected surface types throughout the model.

☐ **Multiuse buildings: Importing zone loads and schedules from other OpenStudio files**

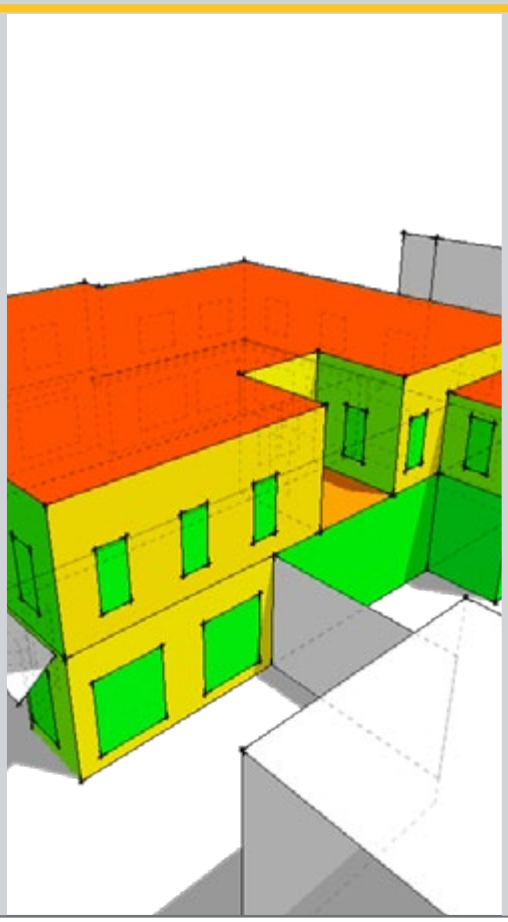
Import zone loads and schedules from other OpenStudio files or templates to assign zone loads for multiuse buildings with space types from more than one building type template.

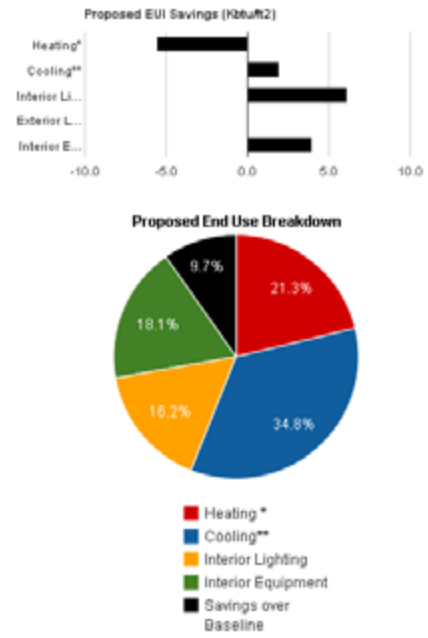
☐ **Retrofit example for an office building**

This video applies envelope and internal load changes to an office building instead of a full-service restaurant (shown earlier).

STEPS		APPLICATION	RESOURCES
	☐ **Moving a model to a different climate zone** This video shows you how to relocate your model to a different climate zone by loading a different weather file. This changes the weather file and the solar position for sun exposure. In this case the model is moved from Boulder, Colorado, to Tampa, Florida.		
OPTIONAL VIDEO	☐ Batch run multiple simulations from OpenStudio RunManager.	RunManager	
	☐ **Show results from multiple perturbations** This video expands the earlier Google Documents spreadsheet to show the Boulder and Tampa office building results. It also shows results of additional retrofit options that are outlined in the following sections.		
	☐ **Introduction to the additional retrofit options**		
CHOOSE ANY OR ALL OF THESE ADDITIONAL EXAMPLES	☐ Photovoltaic Analysis (Simple) Learn how to request exterior solar incident values as a variable on your heat transfer surfaces. This is a quick way to evaluate the potential of a surface to generate power with photovoltaic (PV) panels.		
	☐ Photovoltaic Analysis (Advanced) Learn how to implement a full PV system including panels, meter, inverter, and related equipment.		
	☐ External Shading Devices Run a simulation and study the effectiveness of external shading devices. Run a simulation and study the sunlit fraction of fenestration surfaces in SketchUp and ResultsViewer.	ResultsViewer	
	☐ Cool Roof Learn how to use OpenStudio ModelEditor to alter the material properties of your roof membrane to simulate a cool roof.	ModelEditor	
	☐ Thermostat and Schedule Another retrofit example using ModelEditor; in this case you change an operational component of the building versus physical properties of its envelope or systems.	ModelEditor	
	☐ Envelope Elimination Parametric This example shows you how to determine the maximum benefit you could gain from envelope improvements. This is a good method to figure out if your effort is better spent on envelope improvements, internal load reductions, or operational improvements.	ModelEditor	

MODEL SIMULATE ANALYZE





Unless otherwise noted, all images are screenshots taken by David Goldwasser of NREL from training videos he created. Photographs in the photo matching section were taken by David Goldwasser.

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