Energy Modeling Laboratory Buildings With OpenStudio

Summary: OpenStudio® is a whole-building energy modeling software platform used to model complex interactions between the building envelope, plug loads, daylighting, lighting, and heating and cooling equipment. OpenStudio software is available to download for free and offers an intuitive graphical user interface with the EnergyPlus® engine that helps the user navigate through different inputs for the energy model. A unique feature of OpenStudio is that it provides the capability to quickly implement different energy efficiency and energy conservation strategies using a set of programmatic instructions called "measures."

Prototype building models have been developed in OpenStudio to represent the majority of the commercial building stock in the United States, including a laboratory building. The prototype building model can be customized to represent the 16 climate locations in the United States, as well as one international location (New Delhi, India). With robust documentation and well-supported inputs and assumptions, the prototype building models are useful as starting points for modeling new or existing buildings and can be easily modified by the user in OpenStudio.

This guide provides instructions for creating a laboratory building model using the OpenStudio Application and laboratory prototype building.

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Acknowledgements

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We thank the vast number of current and past NREL employees who have contributed to the development, testing, and analysis of OpenStudio and associated measures that form the basis of the laboratory prototype building model. We are grateful to all those who helped sponsored the development of this resource, especially the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Federal Energy Management Program.

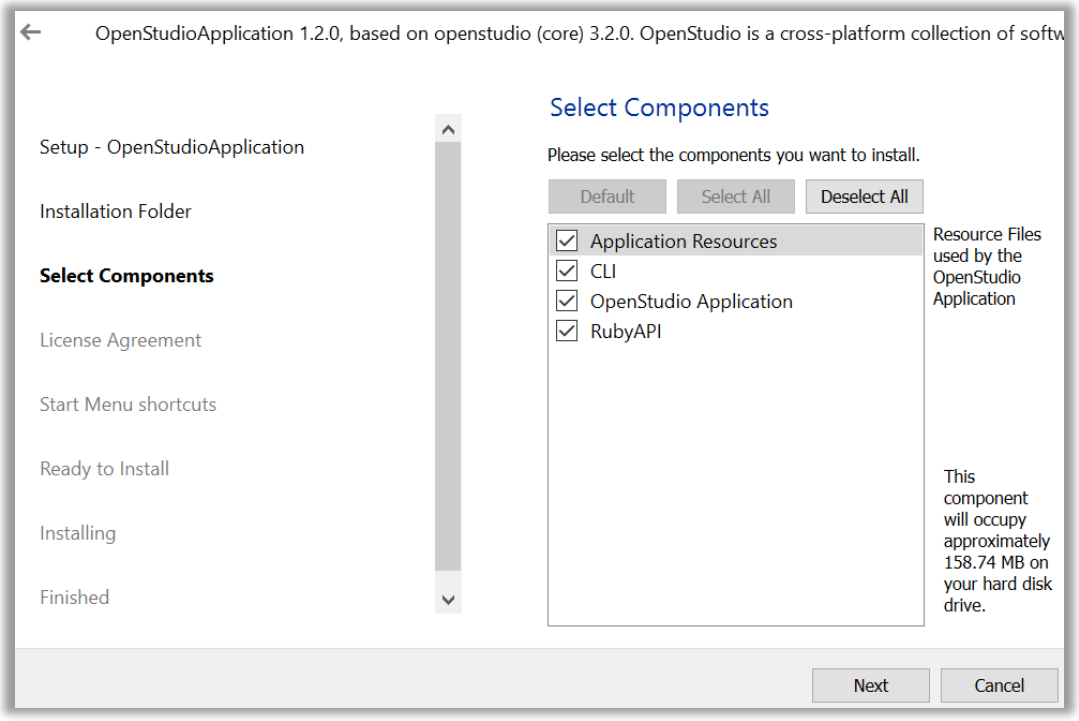
Installing the OpenStudio Application

1. Go to https://github.com/openstudiocoalition/OpenStudioApplication/releases.
2. Under "Assets" at the bottom of the page, you will see three options for "OpenStudioApplication-1.2.0."

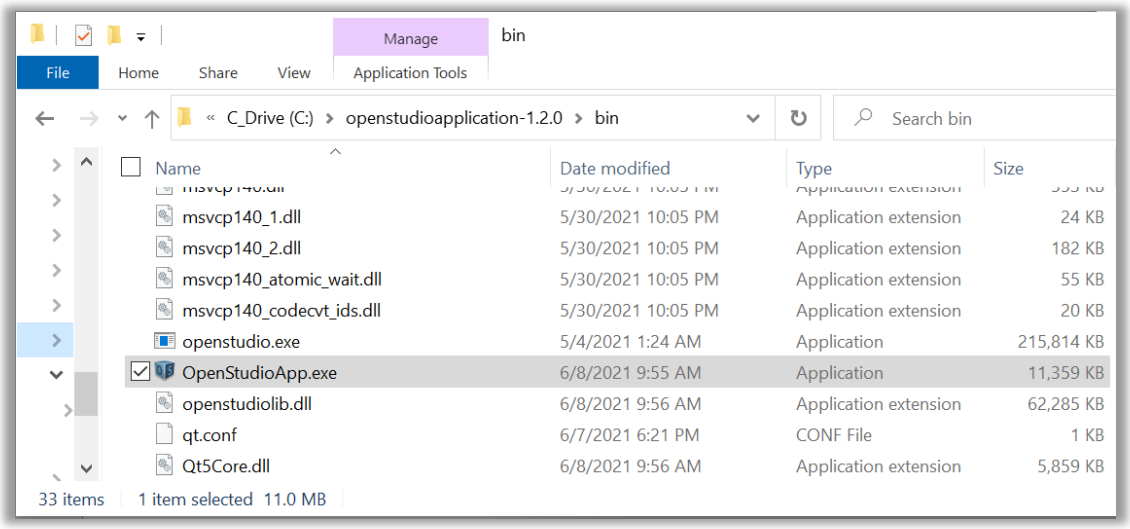
   Select the appropriate installer for your computer:

   a. Windows installer ends with "Windows.exe"

   b. Mac installer ends with "Darwin.zip."
3. Run the installer. Ensure all OpenStudio components are selected as shown below.



4. Once the installation wizard is complete, search for the folder titled “openstudioapplication-1.2.0” on your computer hard drive.
5. Navigate to the folder titled “bin” and search for “OpenStudioApp.exe.” Double-click to launch the OpenStudio application.

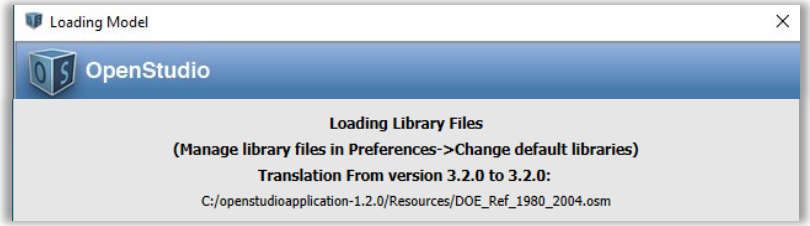


Creating a Model Using the DOE Laboratory Prototype Measure

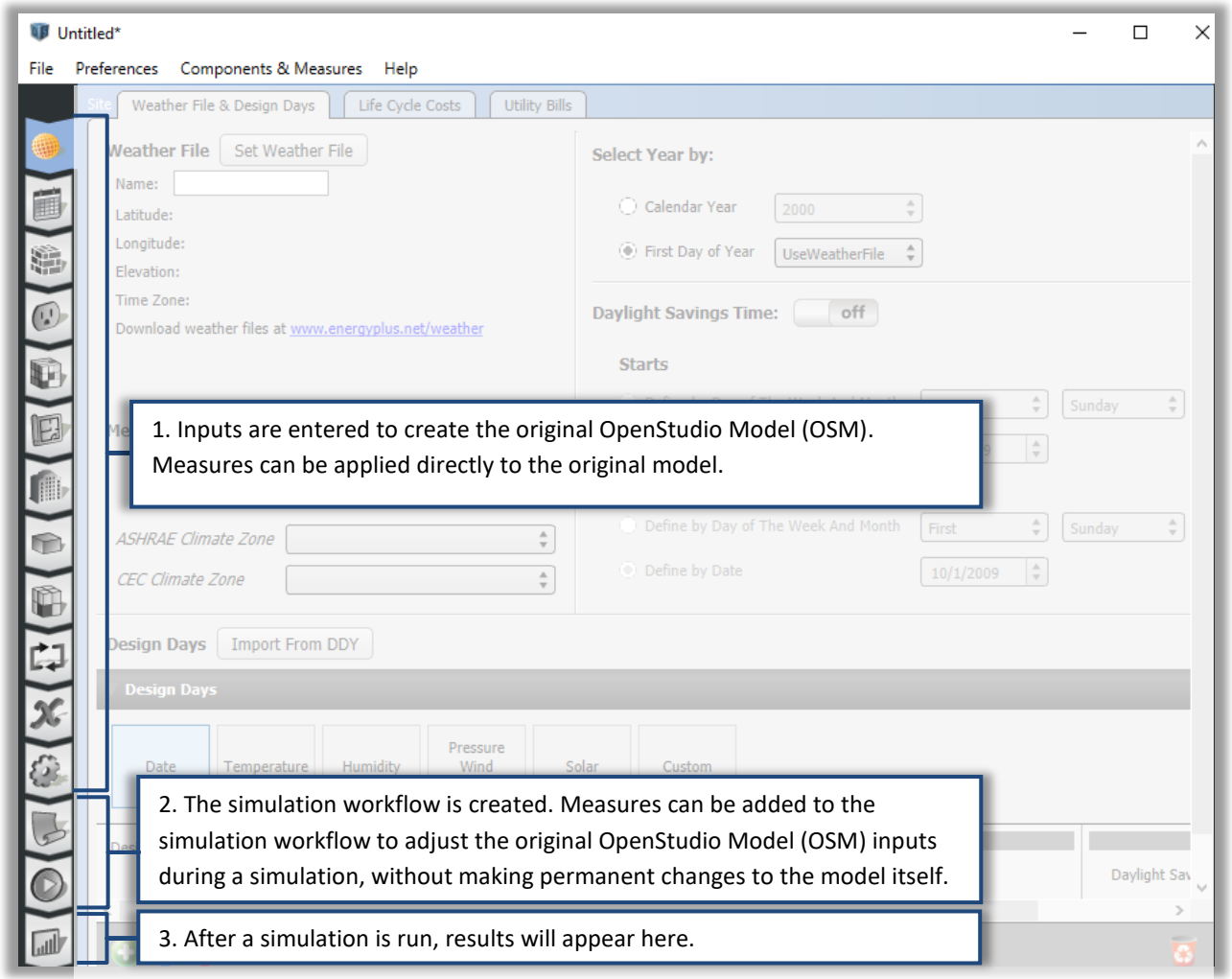
With the OpenStudio Application successfully installed, follow the instructions below to create a laboratory building model using the measure "Create DOE Prototype Building," with default inputs that can be adjusted to specific project parameters as needed.

1. Launch a new OpenStudio Model File

a. Launch the OpenStudioApplication-1.2.0 and check that the application loads the model with version 3.2.0 of OpenStudio.

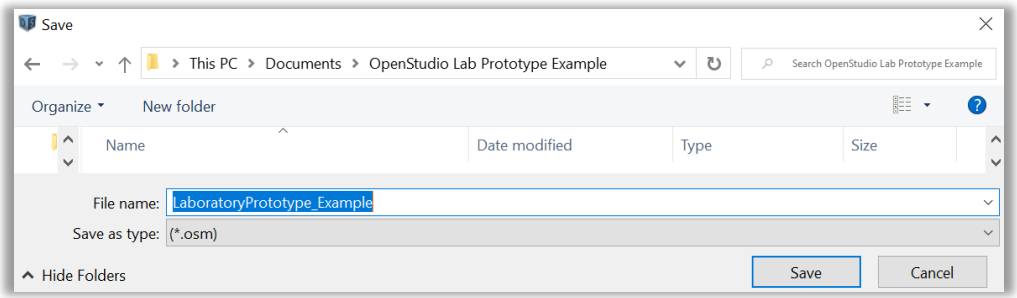


b. The OpenStudio Application runs simulations with the inputs entered by the user following a sequential workflow, as described in the image below.



c. Before making any changes, save the file in a designated folder on your machine.

Note: It is recommended that files are saved directly onto your machine. Using shared drives or cloud-based storage locations significantly slows down simulations and may cause the OpenStudio application to crash unexpectedly.



2. Apply the "Create DOE Prototype Building" Measure

There are two methods for applying measures in OpenStudio, with directions for each linked below:

a. Apply measure directly via "Apply Measure Now."

This method immediately populates the OpenStudio Model (OSM) with the inputs of the measure, directly altering the original OSM file.

Suggested for initial use as it allows the user to inspect the resulting model within the OpenStudio Application and understand the assumptions included for the DOE Laboratory Prototype.

b. Add the measure in the simulation workflow via the Measures tab.

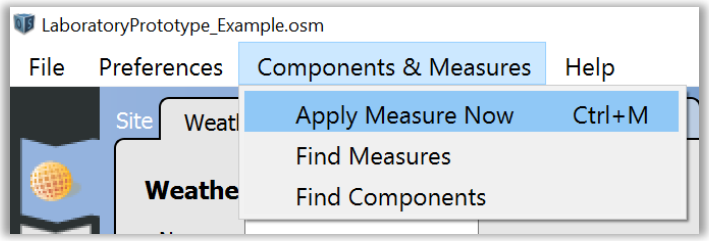
This method makes adjustments to the model inputs when the user runs a simulation. Measures are applied in the order they appear in the workflow and do not make any permanent adjustments to the model file itself.

Best used for preserving the original OSM file model inputs while investigating the impact of multiple improvement measures. Once the user is familiar with the assumptions for the DOE Laboratory Prototype building, this method is suggested to apply energy efficiency measures.

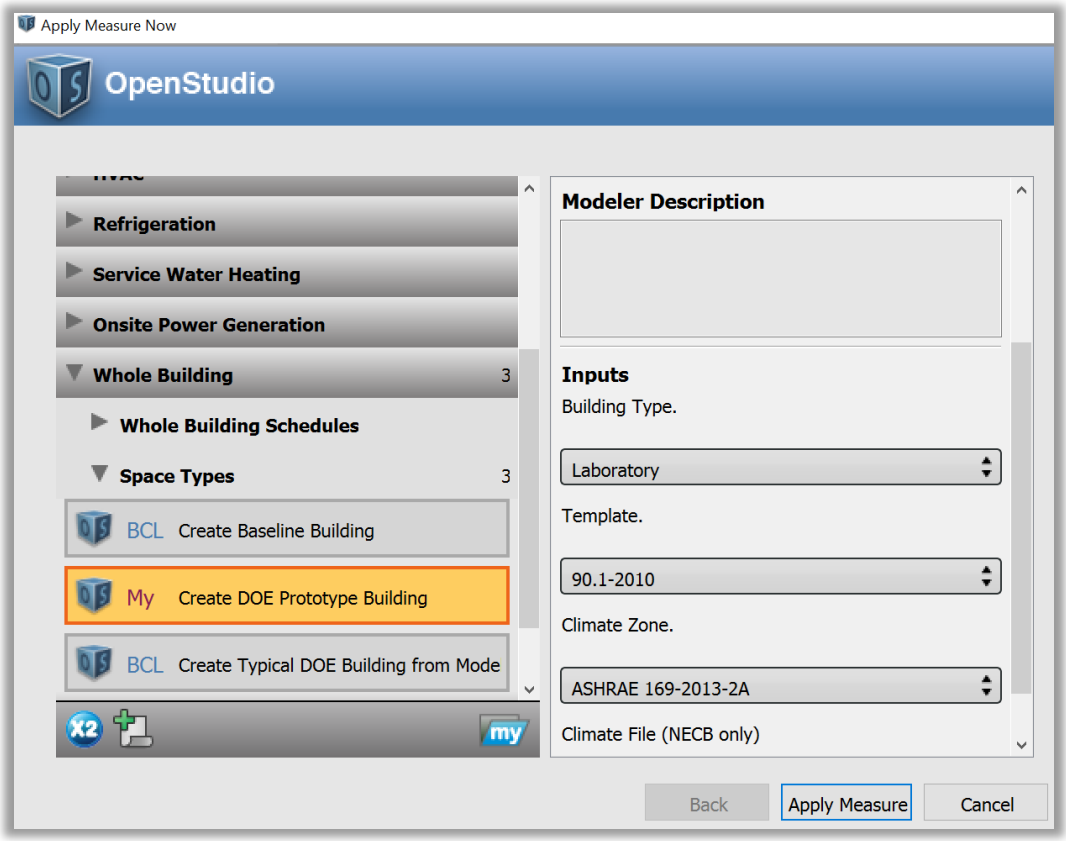
a. Apply Measure Directly via "Apply Measure Now"

To gain more insight into the constructions and other parameters included in the DOE Laboratory Prototype measure, the measure can be applied directly to the model using "Apply Measure Now."

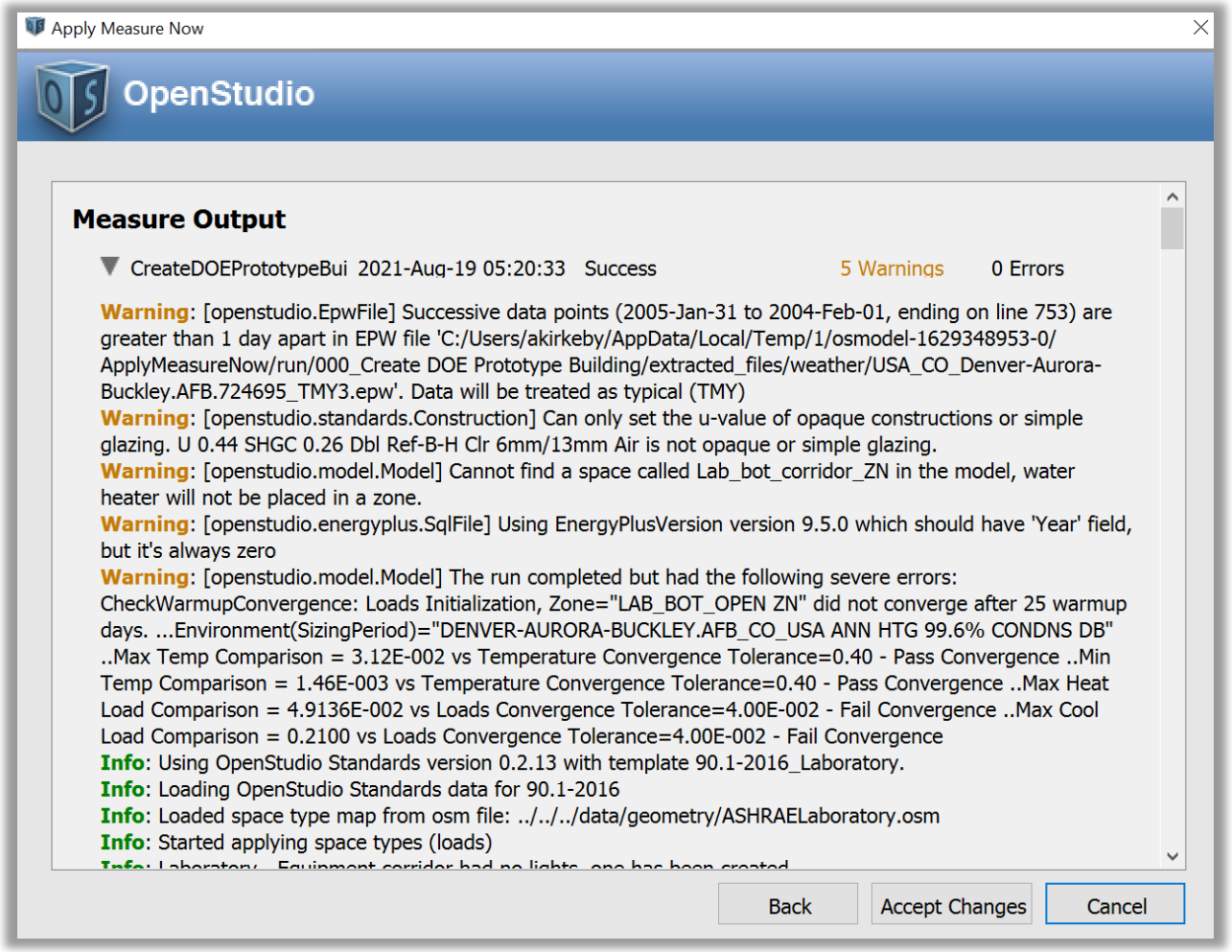
1. In the OpenStudio Application, navigate to the "Components & Measures" tab and choose "Apply Measure Now."



2. Select "My Create DOE Prototype Building" Measure and enter the appropriate inputs for your facility. Refer to Climate Zone Reference Table for guidance on Climate Zone selection.



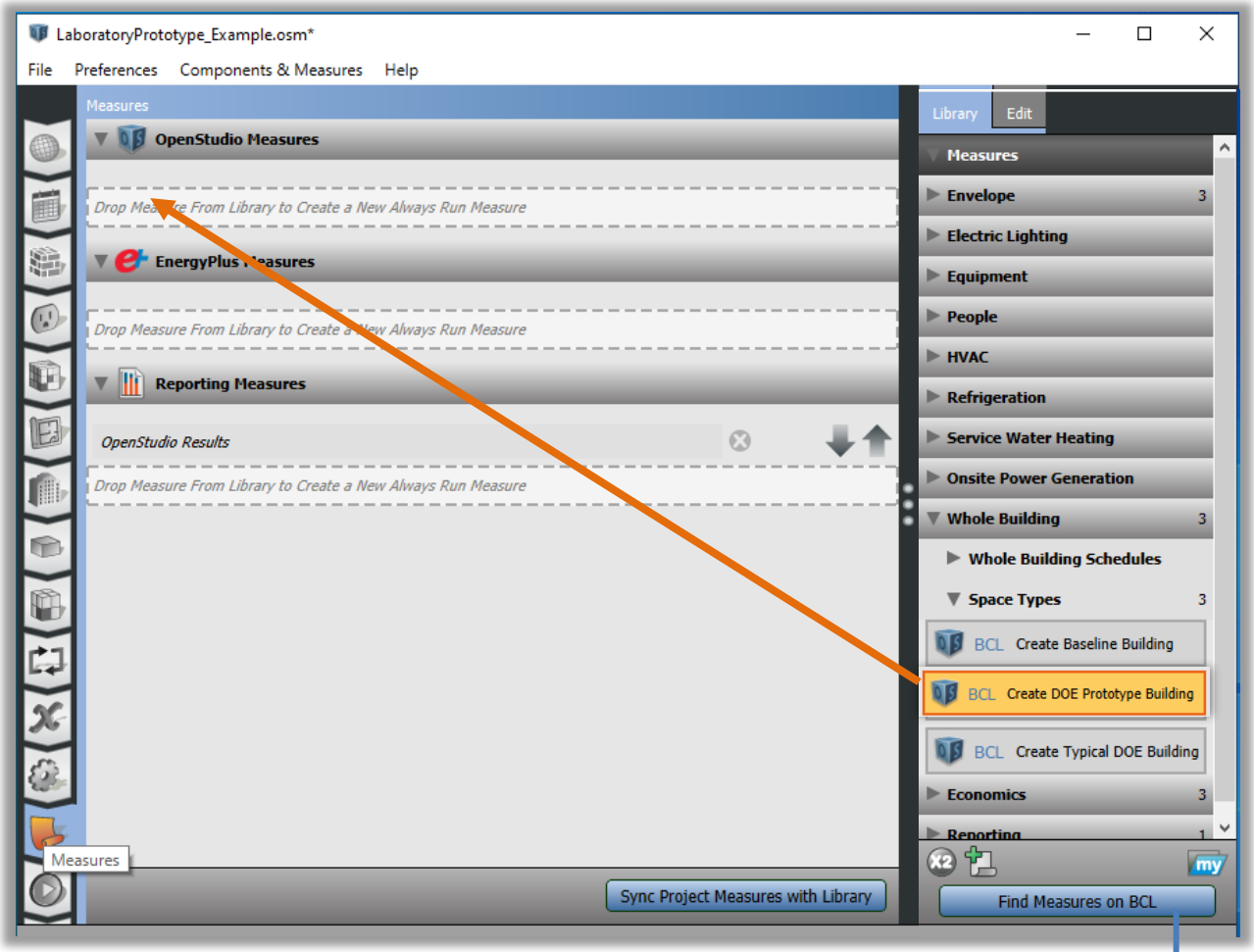
3. Click "Apply Measure." This will automatically populate the model with parameters included in the DOE Laboratory Prototype measure. This may take a few moments to process. When finished, a window will appear with Model Outputs; there will be a few warnings that will not affect the simulations. Click "Accept Changes. "



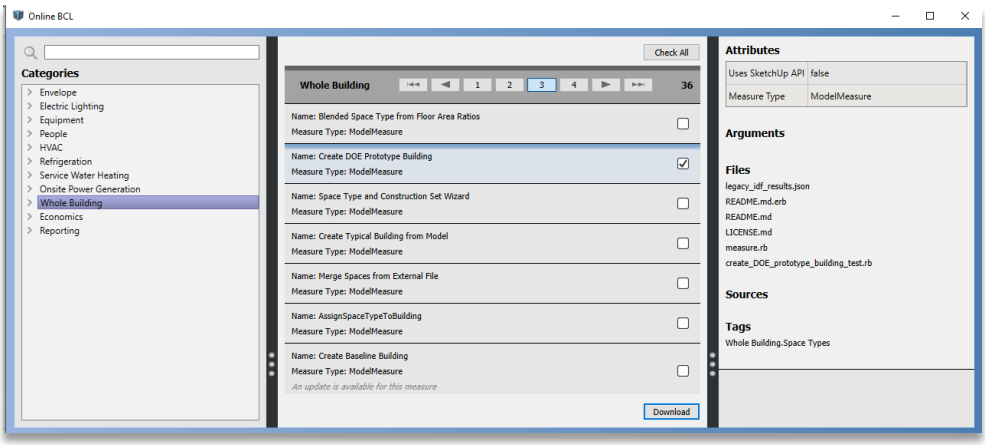
4. The model is now populated with prototype schedules, construction sets, and geometries for a standard laboratory building. To view model inputs, click through the tabs in the OpenStudio Application and adjust inputs to better reflect your laboratory facility.

b. Add the Measure in the Simulation Workflow via the Measures Tab.

1. In the OpenStudio Application, navigate to the Measures tab. At the right-hand side of the window, there is a library of measures that allow the user to adjust model parameters.
2. Navigate to “Whole Building” and select Space Types.
3. Click on the measure titled "Create DOE Prototype Building" and drag to OpenStudio Measures.

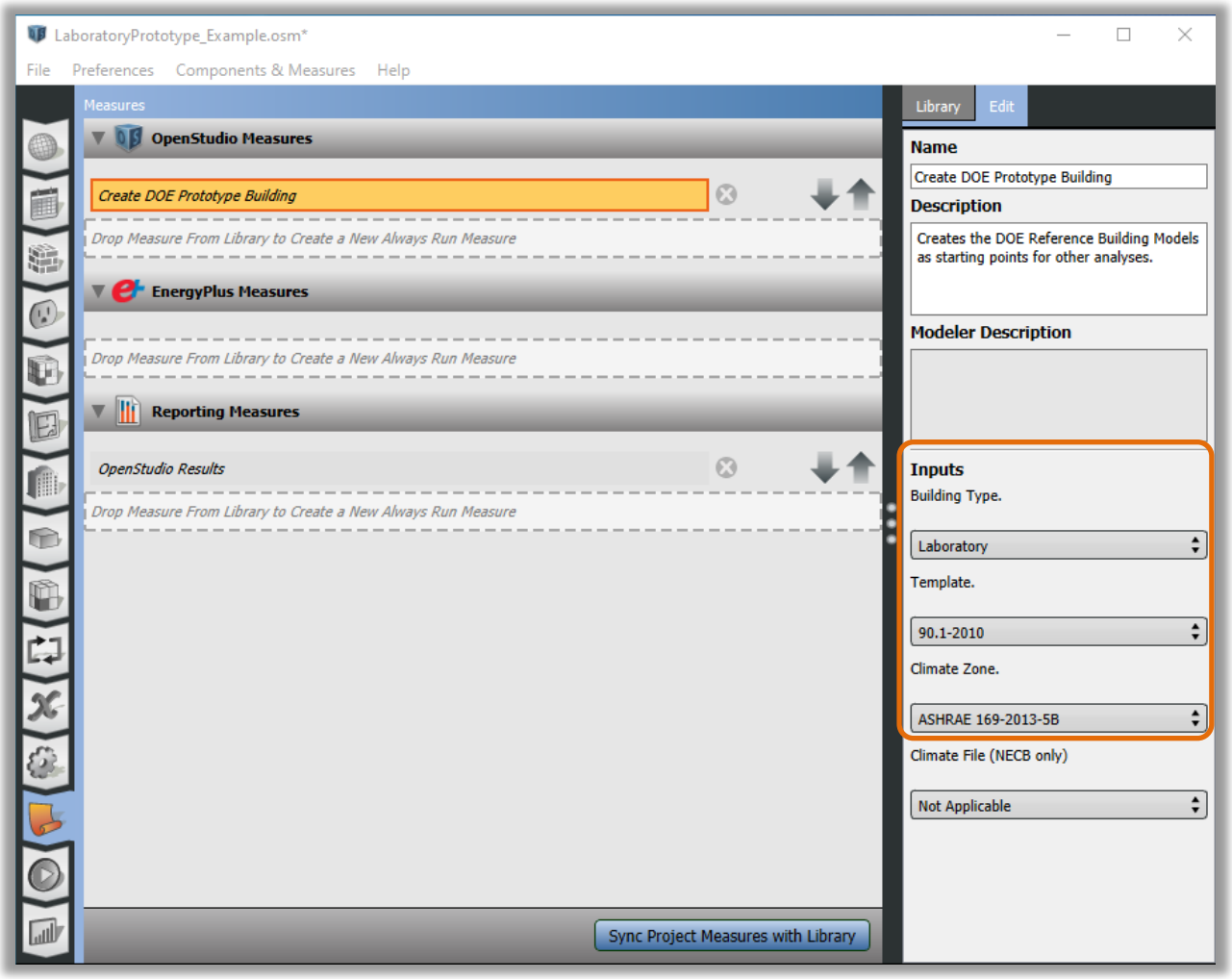


Note: If no measures are available, click on “Find Measures on BCL” at the bottom of the window. Search for “Create DOE Prototype Building” under Whole Building measures and download. Additional measures can be downloaded in the future from this Building Component Library (BCL).



4. Click on the new line just created, labeled “Create DOE Prototype Building.” Under Inputs, select “Laboratory” for Building Type and other appropriate inputs for your lab facility.
    - For Template, select version of ASHRAE 90.1 or DOE Reference building that is most relevant to the building being modeled.
    - For Climate File, select “Not Applicable” for Climate File.
    - For Climate Zone, refer to the Climate Zone Reference Table for guidance.

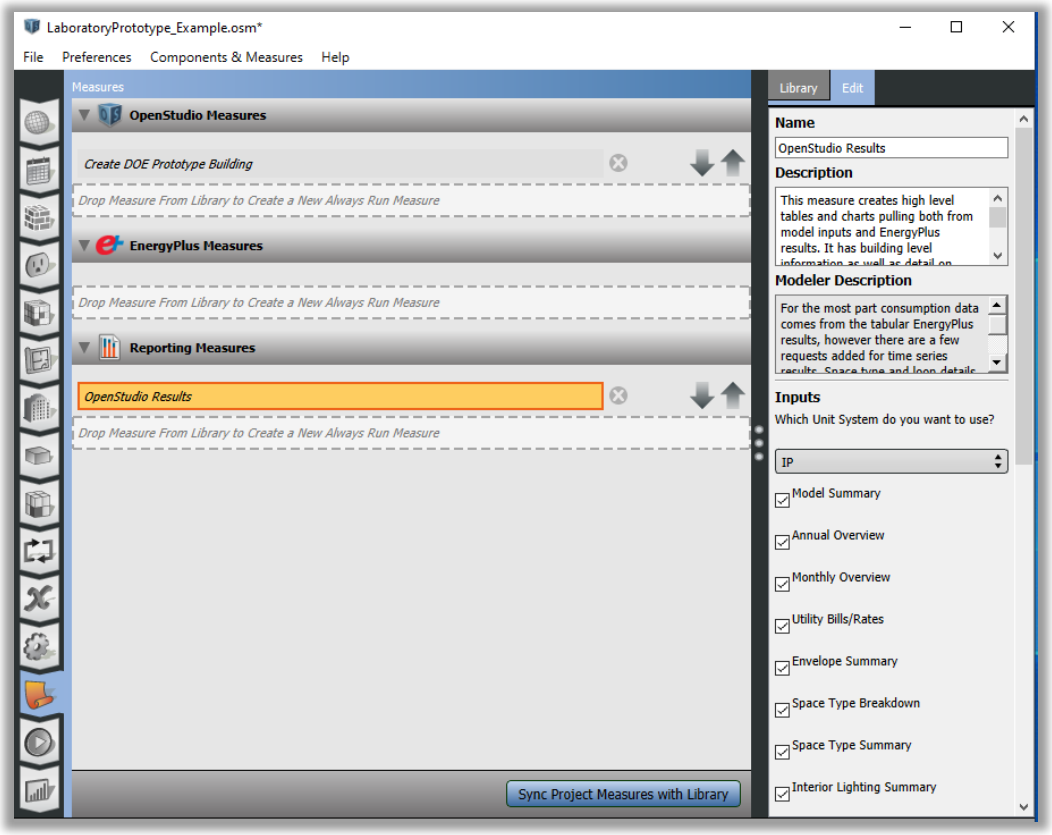
Note: If there is no option for laboratory available, please see SectionDownloading Measures Directly From the Online Building Component Library for detailed instructions.



3. Run a Simulation and View Results

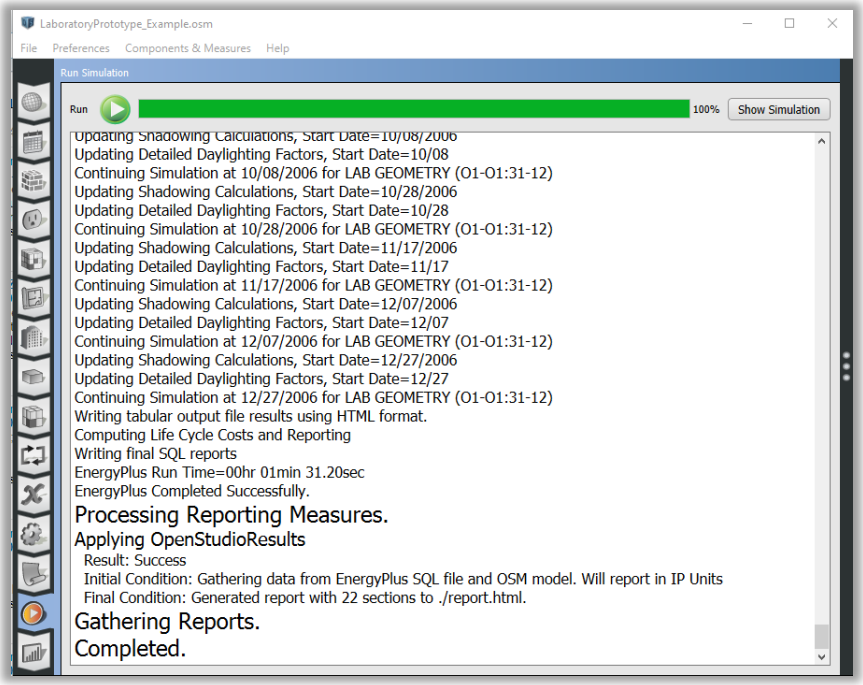
After the “Create DOE Prototype Building” measure has been applied using either method described above, the model is now ready to run simulations.

1. Navigate to the Measures tab. In the Measures Library under Reporting, select “OpenStudio Results” and drag to Reporting Measures. This will generate a readable report of results.

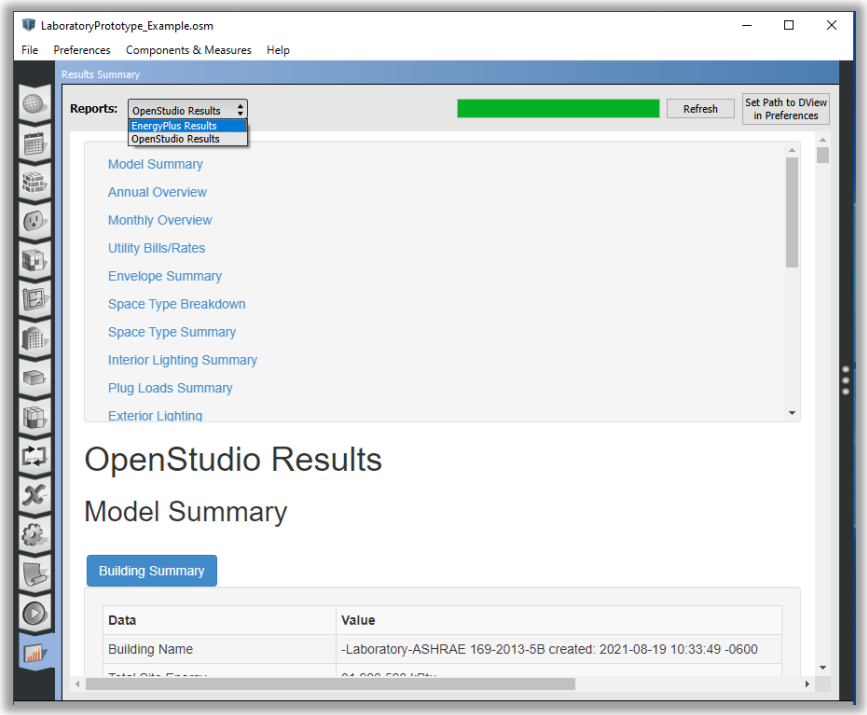


2. Navigate to the Run tab and click “Run.” This will run simulations based on the inputs included in the “Create DOE Prototype Building” Measure.

   The report will read “Completed” when the simulations have finished successfully.



3. To view results of the simulation, navigate to the Results Tab.



Refer to the Next Steps and Helpful Resources section for additional guidance.

Climate Zone Reference Table

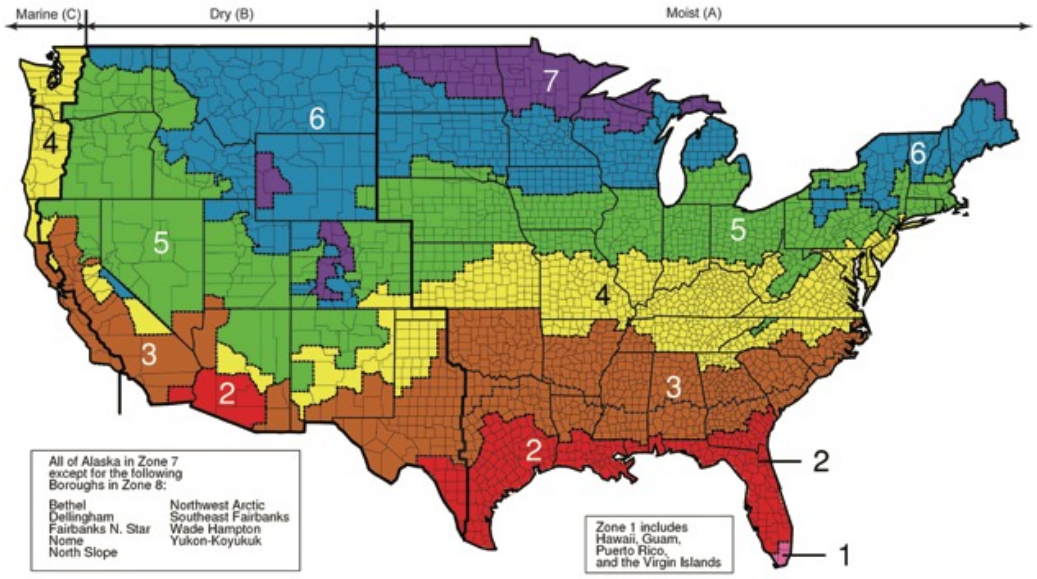


Table 1. Each building location in OpenStudio corresponds to a climate zone and associated weather file.

Climate Zone	Building Location	EnergyPlus Weather File
0A*	Hanoi	VNM_Hanoi.488200_IWEC.epw
0B*	Abu Dhabi	ARE_Abu.Dhabi.412170_IWEC.epw
1A	Honolulu	USA_HI_Honolulu.Intl.AP.911820_TMY3.epw
1B*	New Delhi	IND_New.Delhi.421820_ISHRAE.epw
2A	Tampa	USA_FL_MacDill.AFB.747880_TMY3.epw
2B	Tucson	USA_AZ_Davis-Monthan.AFB.722745_TMY3.epw
3A	Atlanta	USA_GA_Atlanta-Hartsfield-Jackson.Intl.AP.722190_TMY3.epw
3B	El Paso	USA_TX_El.Paso.Intl.AP.722700_TMY3.epw
3C	San Diego	USA_CA_Chula.Vista-Brown.Field.Muni.AP.722904_TMY3.epw
4A	New York	USA_NY_New.York-J.F.Kennedy.Intl.AP.744860_TMY3.epw
4B	Albuquerque	USA_NM_Albuquerque.Intl.AP.723650_TMY3.epw
4C	Seattle	USA_WA_Seattle-Tacoma.Intl.AP.727930_TMY3.epw
5A	Buffalo	USA_NY_Buffalo-Greater.Buffalo.Intl.AP.725280_TMY3.epw
5B	Aurora	USA_CO_Aurora-Buckley.Field.ANGB.724695_TMY3.epw
5C	Port Angeles	USA_WA_Port.Angeles-William.R.Fairchild.Intl.AP.727885_TMY3.epw
6A	Rochester	USA_MN_Rochester.Intl.AP.726440_TMY3.epw
6B	Great Falls	USA_MT_Great.Falls.Intl.AP.727750_TMY3.epw
7	International Falls	USA_MN_International.Falls.Intl.AP.727470_TMY3.epw
8	Fairbanks	USA_AK_Fairbanks.Intl.AP.702610_TMY3.epw

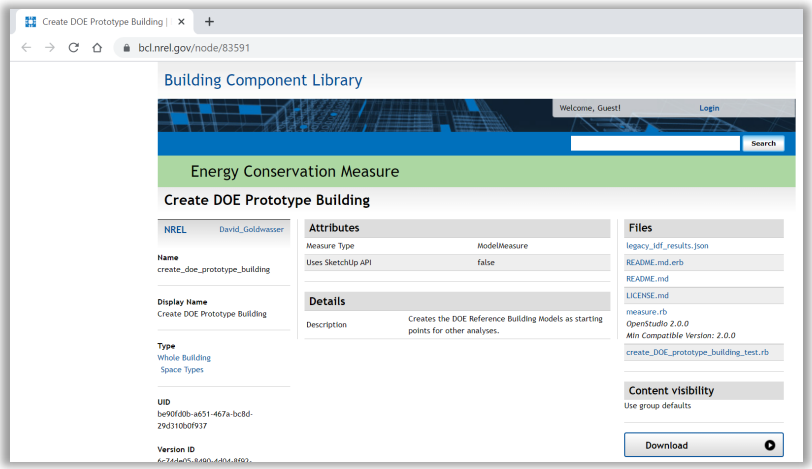
** Climate Zone 1A will be assigned for weather files in Climate Zones 0A, 0B, and 1B. This is to support AEDG measures that do not have recommendations for those climate zones.*

Downloading Measures Directly From the Online Building Component Library

Many measures can be downloaded from the Building Component Library within OpenStudio.

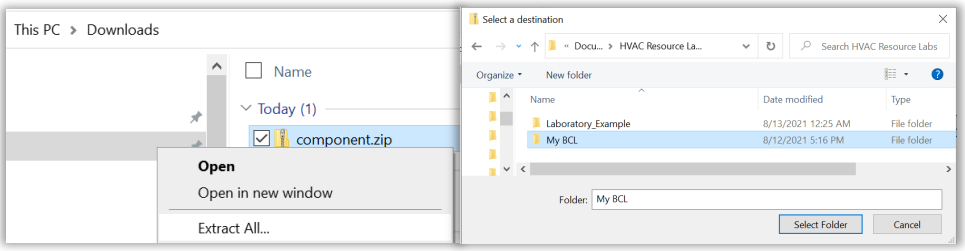
In some cases, recent measure updates are not translated in the initial download of the OpenStudio Application. For the "Create DOE Prototype Building" measure, if the option for laboratory is not available under the dropdown menu for Building Type:

a. Navigate to the online Building Component Library and download the updated measure by following this link: Create DOE Prototype Building.



b. Navigate to Downloads and right-click on the file labeled "components.zip."

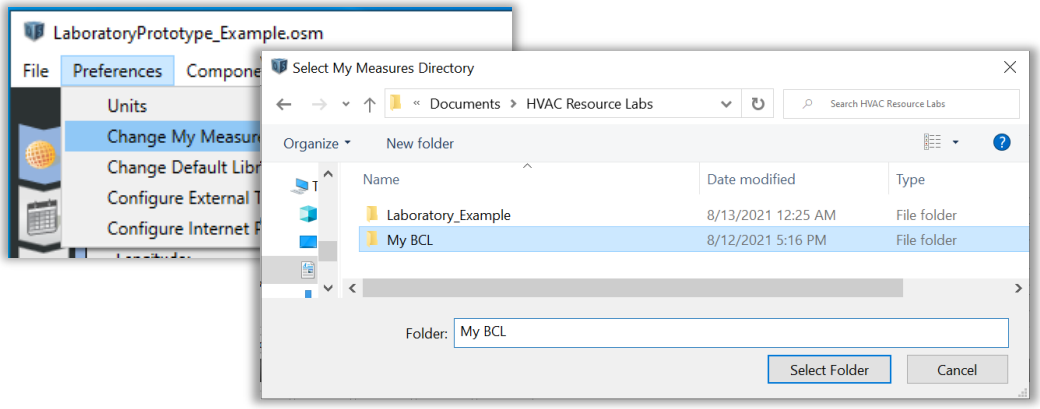
Select "Extract all" and save in a unique directory on your machine title "My BCL."



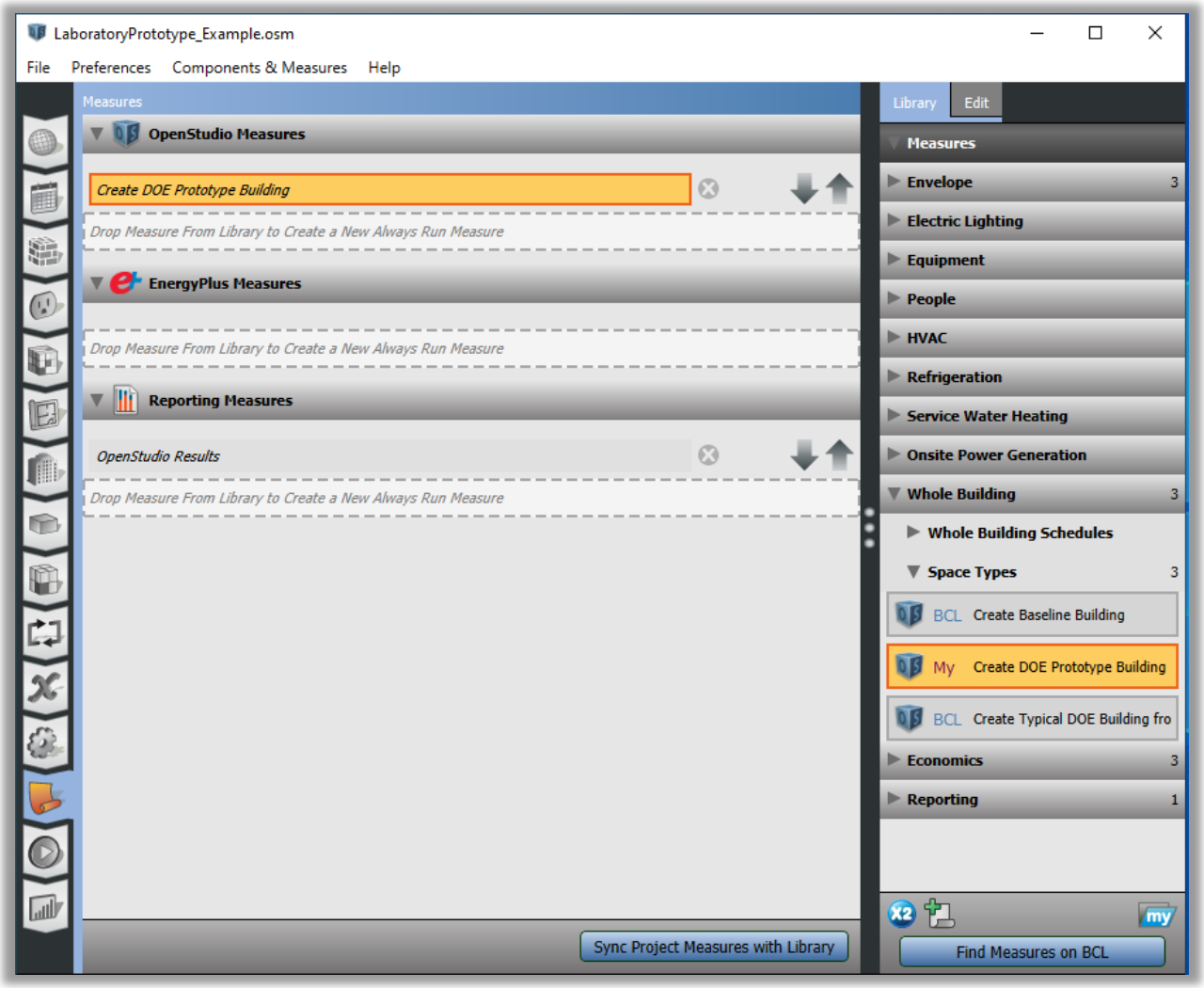
c. Return to the OpenStudio Application.

d. Under "Preferences," choose "Change My Measure Directory."

e. Select the folder directory in which you saved the "Create DOE Prototype Building" measure.



f. Navigate to the Measures tab. Under Space Types, choose the option “My Create DOE Prototype Building” and drag to the OpenStudio Measures. The laboratory option should now appear under Building Type.



Next Steps and Helpful Resources

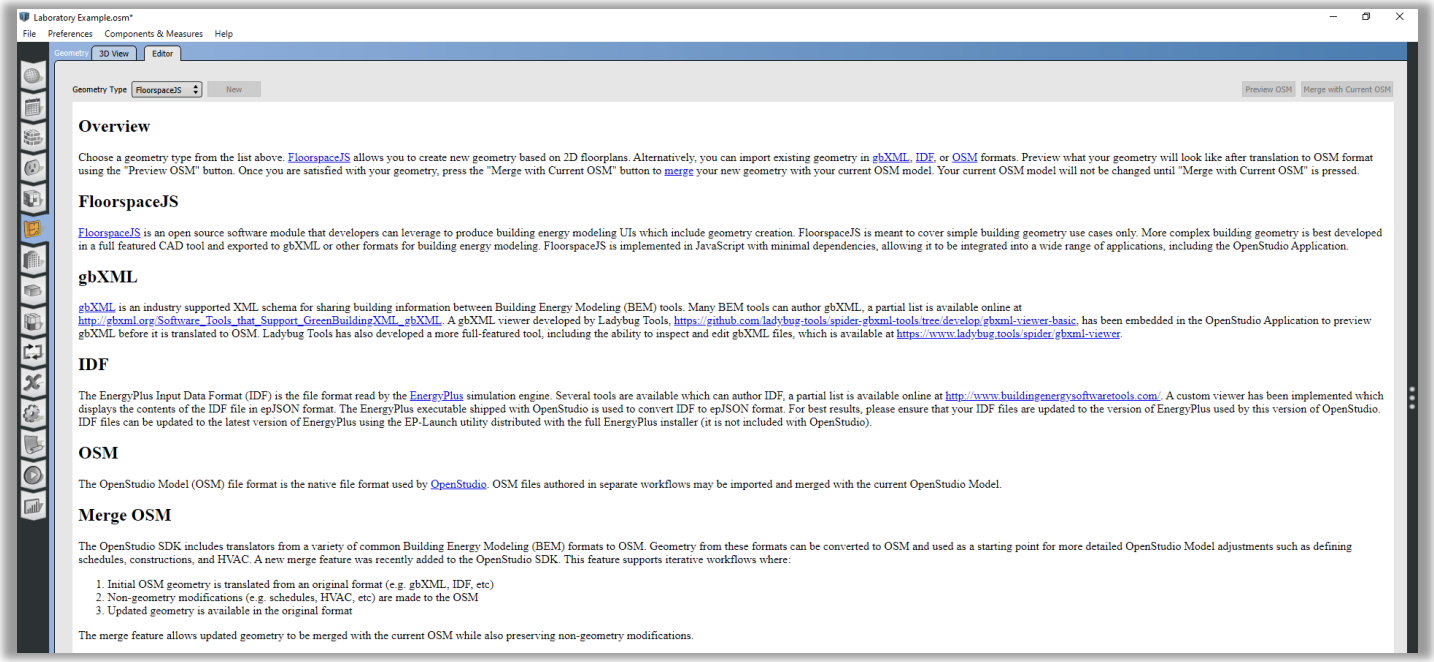
Apply Additional Measures

Now that a baseline model has been created, energy conservation measures can be applied to the model to see their impact on total energy consumption.

Search through the Building Components Library for measures to apply, such as simulating different system types or window-to-wall ratios by facade, and follow the process outlined in Section 2b for adding the measure in the simulation workflow via the Measures tab.

Change the Prototype Geometry

Geometry of the laboratory building being modeled can be adjusted within the OpenStudio Application using the FloorspaceJS Plug-in or uploading an existing geometry. Navigate to the Geometries tab for more instructions.



Use the Parametric Analysis Tool to Simulate Multiple Design Alternatives

The Parametric Analysis Tool is useful when comparing multiple design alternatives.

Refer to Parametric Analysis Tool Documentation for more information.

Additional Resources

- The OpenStudio Coalition
- ASHRAE Zero Energy Design Guides
- UnmetHours: An online forum for troubleshooting energy modeling issues.