



# No Pain All Gain: Autodesk Revit 2014 Automatic Energy Analytical Model Creation and Analysis

Ian Molloy – Autodesk

## AB2260

Energy analysis has typically been a complex and time-consuming endeavor. At its foundation lies an Energy Analytical Model (EAM) and while advances in BIM have made significant gains in collaboration and productivity, EAM creation is still largely a skilled manual effort and subject to wide variability in BIM and energy analysis practices. A new feature in Autodesk Revit 2014 Energy Analysis software that uses architectural building elements now greatly simplifies and standardizes EAM creation and subsequent analysis. This class provides background on what an EAM actually is, current industry practices and standards, and a comprehensive walkthrough of numerous worked examples directly in Revit 2014 to highlight how this new feature actually translates different architectural building elements and configurations into a high quality EAM, all without having to add, rebuild, or do any other bespoke model preparation, thereby helping you to deliver higher performing buildings more cost effectively and with greater confidence.

## Learning Objectives

At the end of this class, you will be able to:

- Learning objective 1: Explain what exactly an energy analytical model (EAM) is and the different ways and means they can be created
- Learning objective 2: Describe how the new Energy Analysis feature, which uses Building elements, works in Revit 2014
- Learning objective 3: Show how accurate the resulting EAMs can be and how they compare to typical industry tools and practices
- Learning objective 4: Describe how the EAM can be analyzed by Autodesk® Green Building Studio® in the cloud in a fraction of the usual time and effort

## About the Speaker

*Ian Molloy is a Senior Product Manager for Autodesk's Building Performance Analysis group. Ian has almost 20 years of experience in the development and application of Building Performance Analysis software to the design, construction and operation of higher performing, more sustainable buildings. He has a 1st class honors degree in Building Science and Mechanical Engineering as well as a degree in Mathematics. He is based in the Waltham office where he works closely with the Revit team on the expanding the Revit platforms ability to support BPA tools and workflows, especially Green Building Studio for whole building energy simulation.*

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## Introduction

The purpose of these exercises are to provide an understanding of the new Energy Analysis 'using building elements' feature in Revit 2014.

**Exercise 1.0** provides an outline of the basic steps for running an energy simulation using building elements and viewing the Energy Analytical Model (EAM) produced.

**Exercise 2.0** provides a recommended series of steps to follow when using the feature for the first time on a new Revit model in order to ensure the highest quality, most computationally efficient EAM possible.

**Exercises 1.1 & 1.2** provides an outline of some of the more advanced ways to set data in Revit to be used in the energy simulation.

## What you'll need

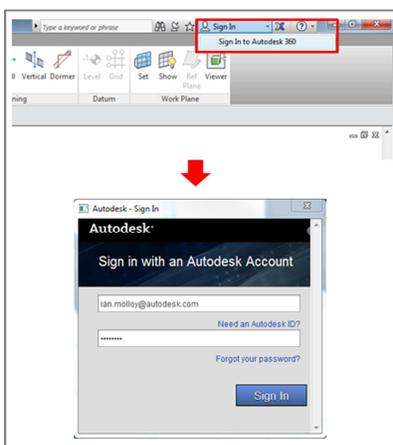
Revit 2014. Ideally with Update Release 2.

A subscription enabled Autodesk 360 account

Some Revit models – Samples have been provided to accompany these exercises.

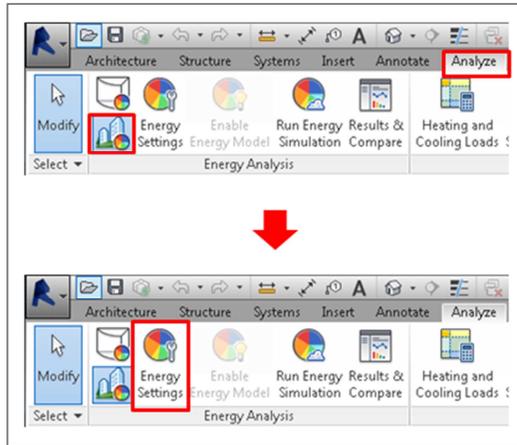
## To sign in to Autodesk 360

Select Sign In from Revit's title bar...

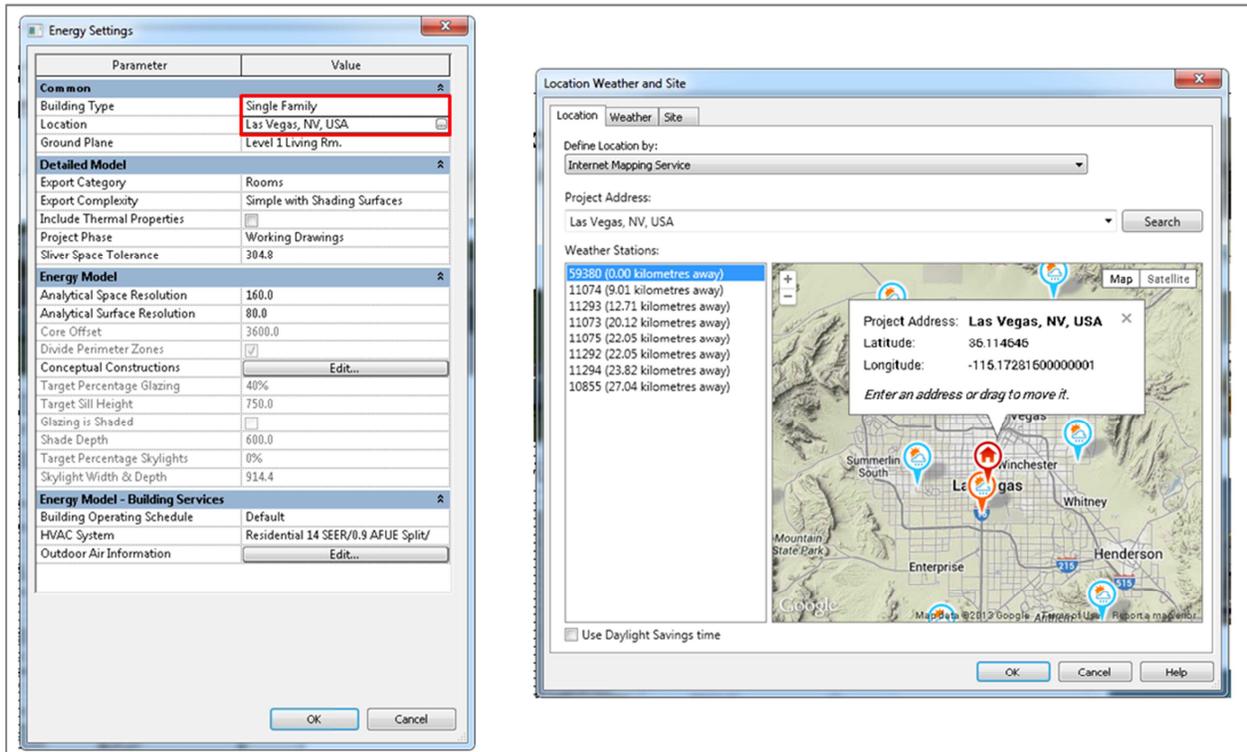


### Exercise 1.0 – The basics of running an energy simulation using building elements and checking the Energy Analytical Model (EAM)

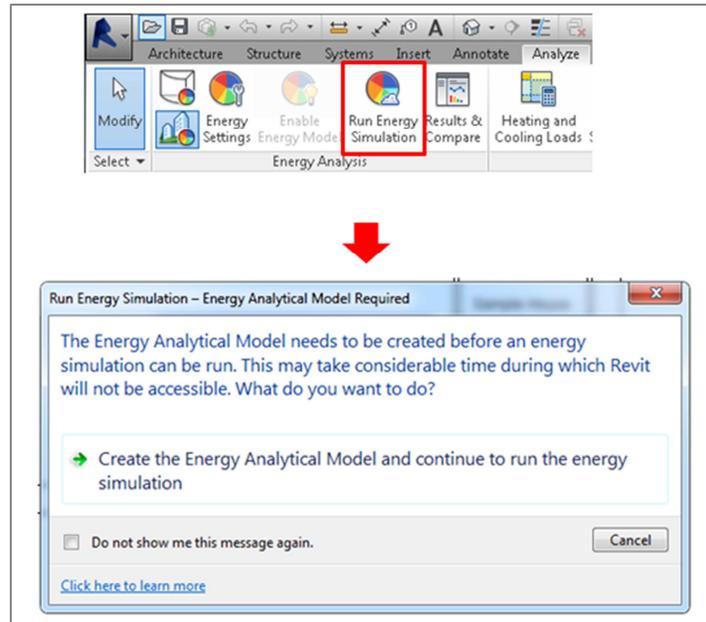
Open model 'AB2260 Ex\_1.0.rvt' in Revit, go to the Analyze tab and then find the Energy Analysis panel. Ensure the 'use building element mode' is selected and then select Energy Settings...



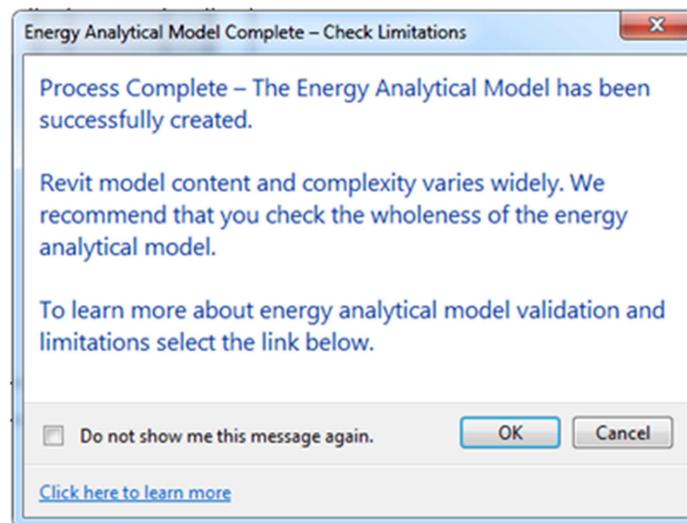
In order for Revit and Green Building Studio to set reasonable data for the simulation at a minimum you should always set the Building Type and Location. Note this model is already set to Single Family and Las Vegas, NV...



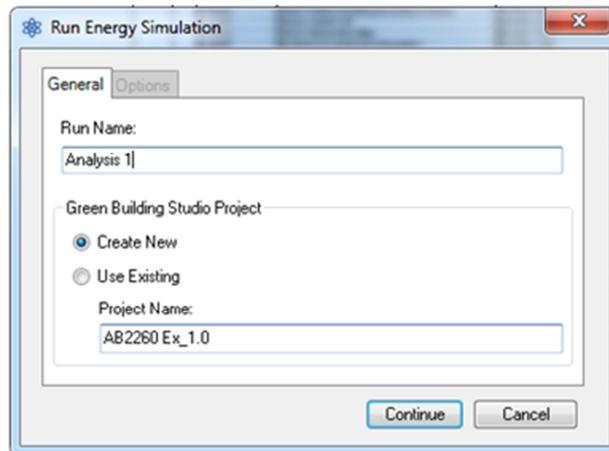
Next select the Run Energy Simulation button and select Create the Energy Analytical Model from the dialog that appears to confirm that (you can disable this message in the future if you wish)...



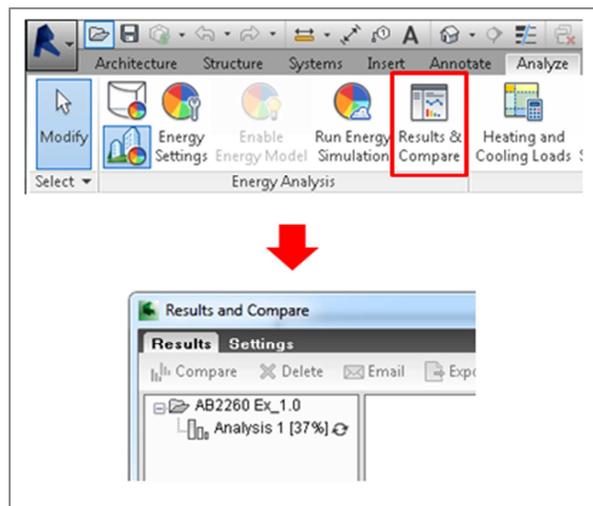
Depending on your computer a small bit of time will pass while the EAM is created during which Revit will be locked. Once that stage is complete you will then be provided with a message that reminds you to check the EAM created which you will learn how to later. (You can disable this message in future if you wish). Select OK...



The Run Energy Simulation dialog will then appear. Enter the run name 'Analysis 1', ensure the Create New Green Building Studio project is selected and set the Project Name to 'AB2260 Ex\_1.0'.

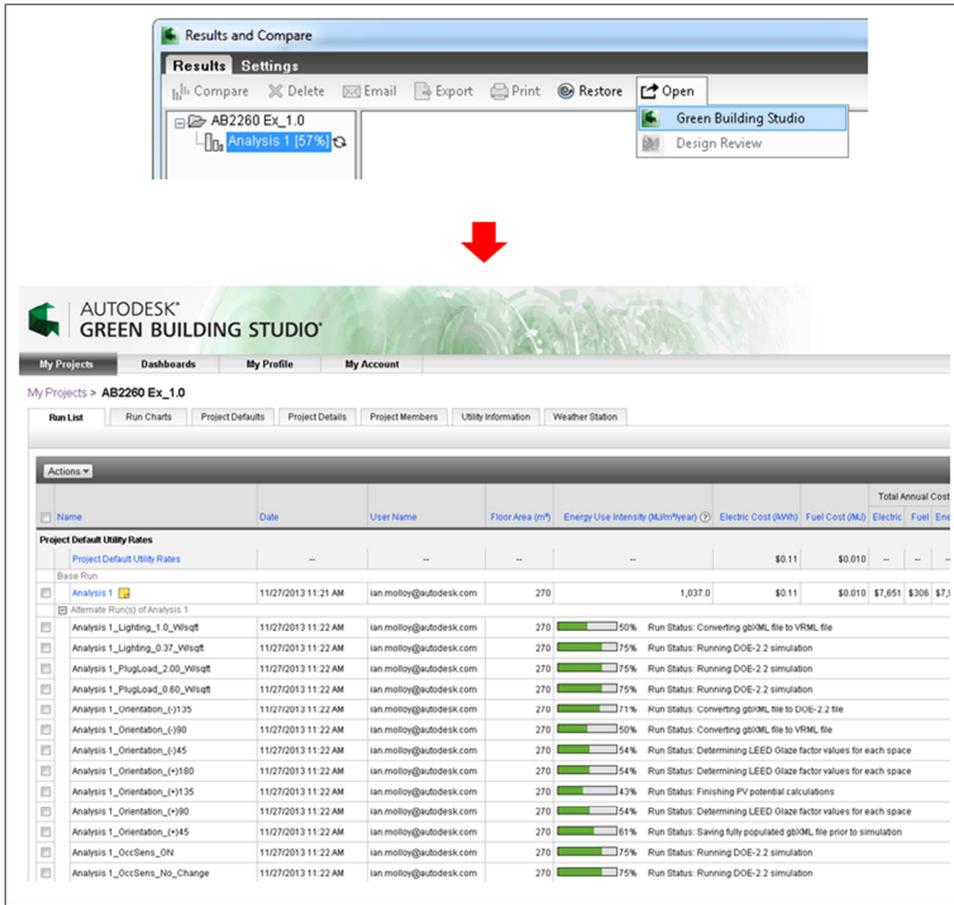


The simulation will then be sent to Green Building Studio for processing. While the simulation is running you can check progress opening Results & Compare...

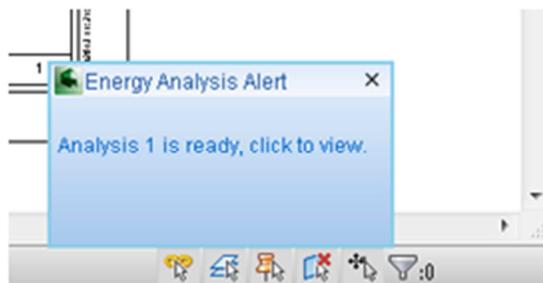


If you wish you can also watch the simulation progress directly on Green Building Studio by selecting it from the Open button within Results & Compare...

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You will be notified in Revit when the simulation is complete...



Results & Compare provides a collection of key Building Performance information from energy use and cost to heating and cooling loads and weather information...

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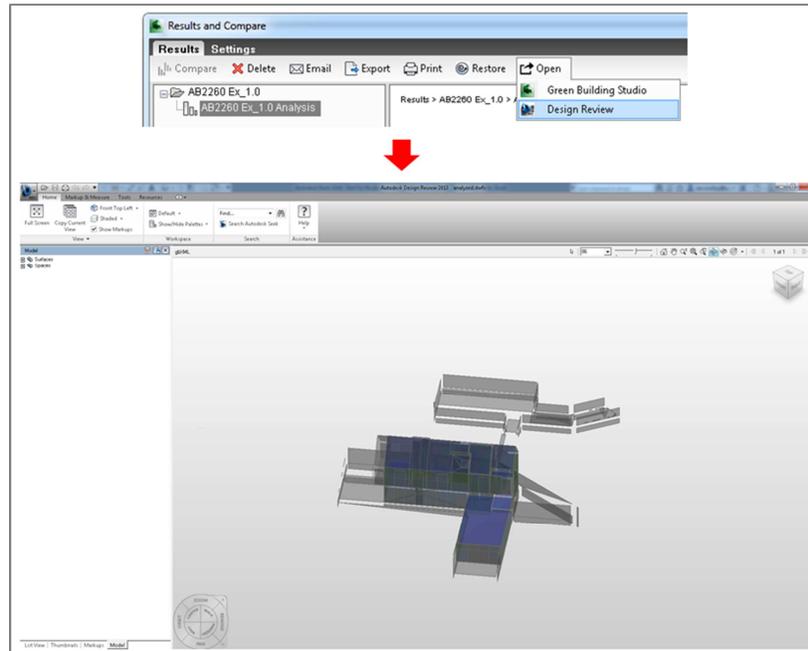


If you look under Building Performance Factors you will see Floor Area and Exterior Wall Area. These values are useful high level checks for EAM quality and completeness. For example in this case we happen to know this buildings floor area is ~270m<sup>2</sup> so this would indicate the EAM is accurate.

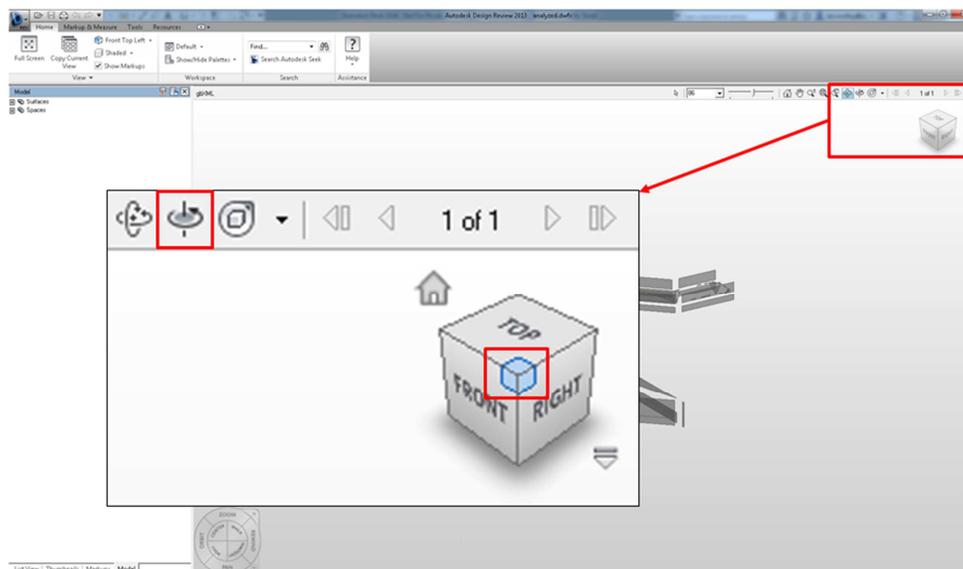
Building Performance Factors	
Location:	Las Vegas, NV, USA
Weather Station:	59380
Outdoor Temperature:	Max: 44°C/Min: -4°C
Floor Area:	271 m <sup>2</sup>
Exterior Wall Area:	223 m <sup>2</sup>
Average Lighting Power:	4.84 W / m <sup>2</sup>
People:	2 people
Exterior Window Ratio:	0.99
Electrical Cost:	\$0.11 / kWh
Fuel Cost:	\$1.04 / Therm

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From within Results & Compare select the simulation result, go to the Open button on the toolbar and select 'Design Review'. This will open a DWFx version of the EAM in Autodesk Design Review...

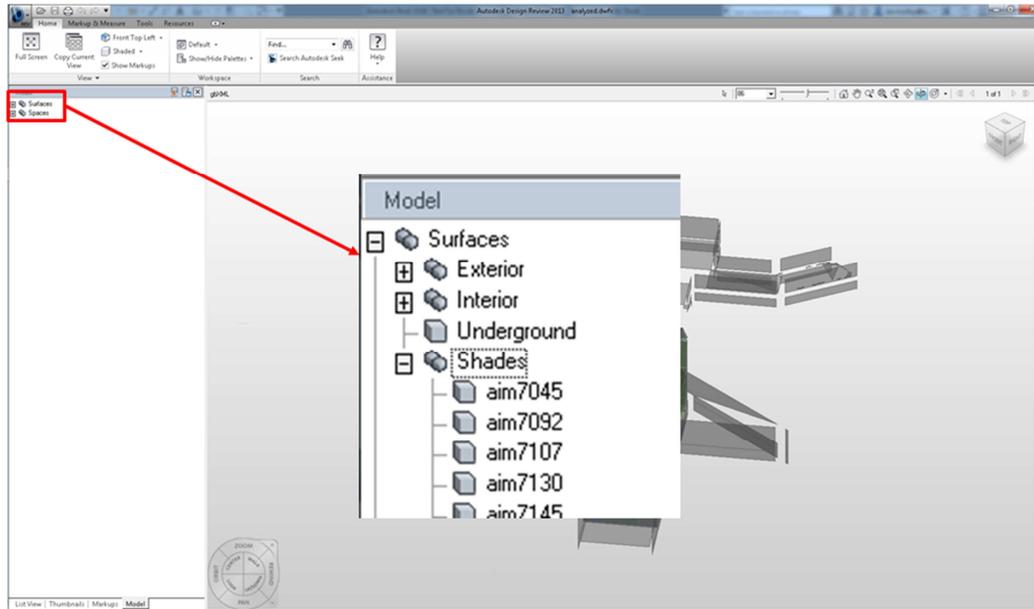


*Useful tip:* When Design Review first opens always select one of the corners of the view cube and then select the rotate view button as this puts the model at the center of the view for when you orbit it. Otherwise as you rotate the model you will have to work to keep the view centered on the model...

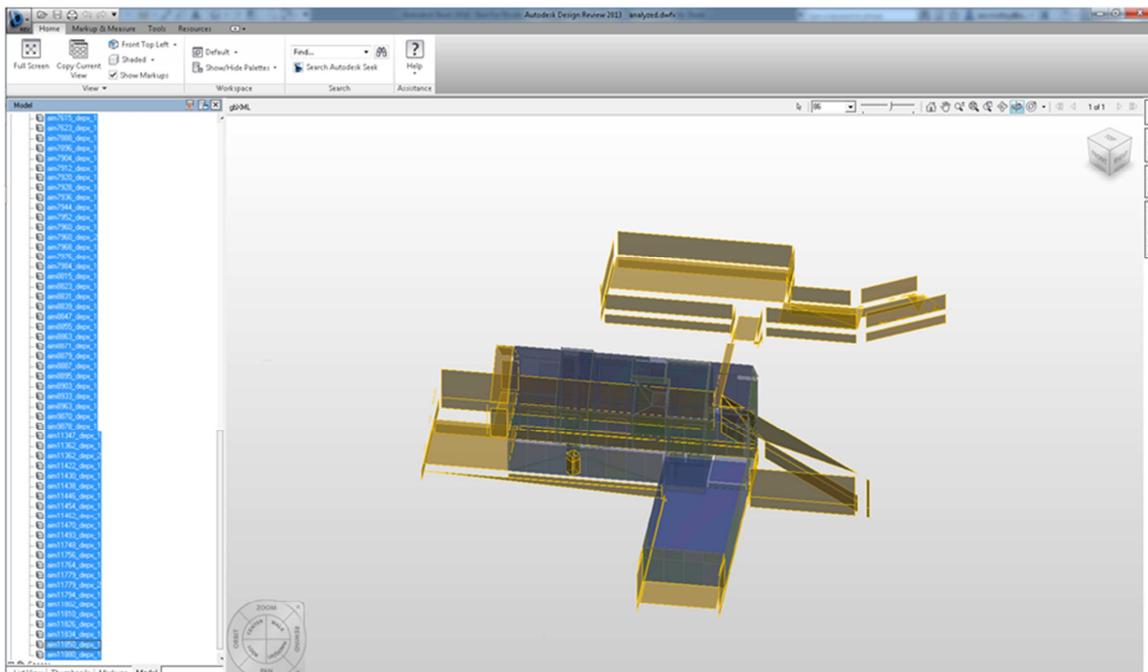


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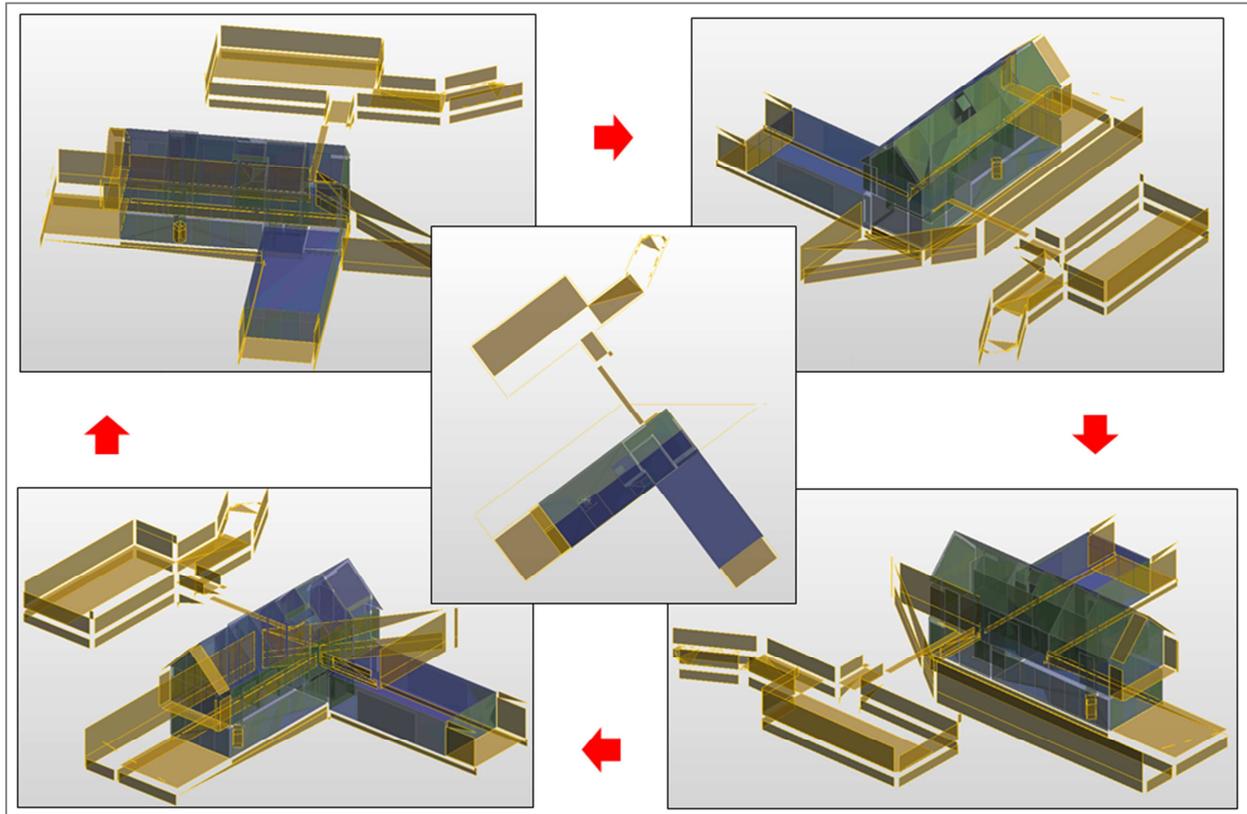
The first thing to check in the EAM is the presence of Shade surfaces. To do this go to Design Review's model browser, expand the Surfaces tree, then expand the Shades tree...



Select the first item in the list then scroll down to the bottom, press ctrl and select the last item. This will highlight all the analytical surfaces of type shade...



Then use the view cube or mouse to do a 360° orbit of the building, viewing it from above and below...



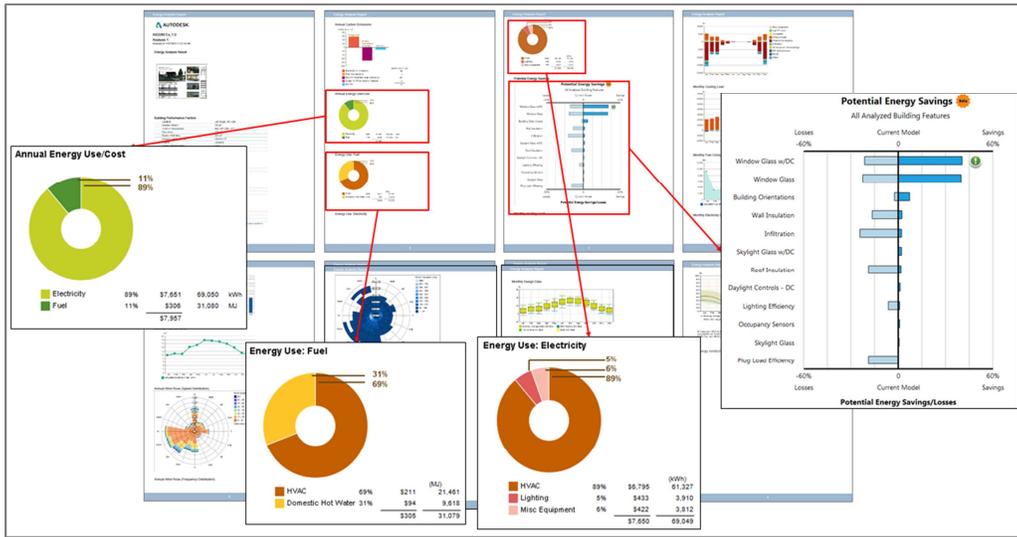
What you are basically looking for here is that Shade surfaces are only present where it makes sense i.e. where Revit elements used in the EAM creation like walls, floors, roofs etc. (see later for a complete list) are found to be 'external' to the analytical spaces identified.

The reason for this is if there were missing elements or gaps between elements in the Revit model then no analytical space are found in that area and the resulting analytical surfaces will be present as shades. Therefore shades are a useful indicator of where there are missing elements or gaps between elements in the Revit model.

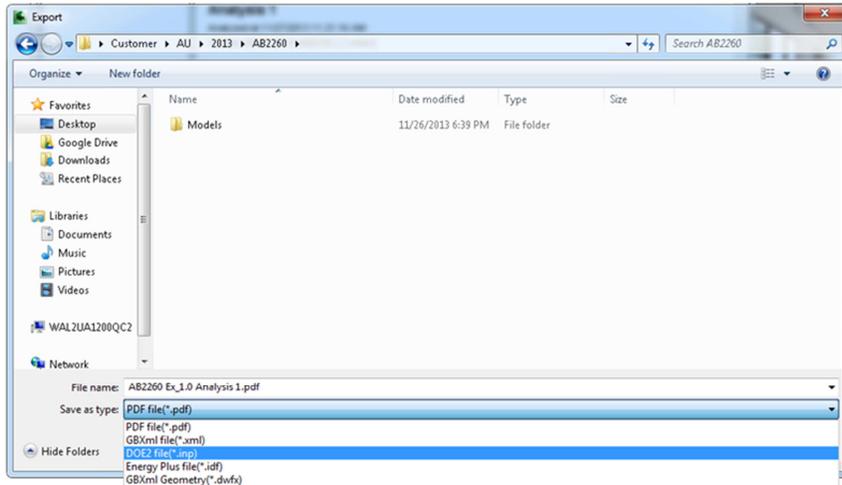
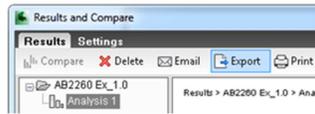
We can see in this particular model that all shades present are reasonable, even if some are a little unnecessary (see later for ways to speed your simulations up by disabling elements that are irrelevant to the Energy Analysis).

Essentially now that we have confidence the EAM represents the buildings form and layout sufficiently we can trust the simulation results. It's especially worth highlighting the annual energy cost graphs and the new 'Potential Energy Savings' chart which presents the results of ~40 alternative simulations run in addition to the base run that you submitted...

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If you wish you can export the results from Results & Compare and/or the EAM as gbXML, DOE2 or EnergyPlus input files by selecting Export from the Results & Compare toolbar...



So for example you can export a DOE2 .inp file and open it in eQUEST for viewing and subsequent analysis...



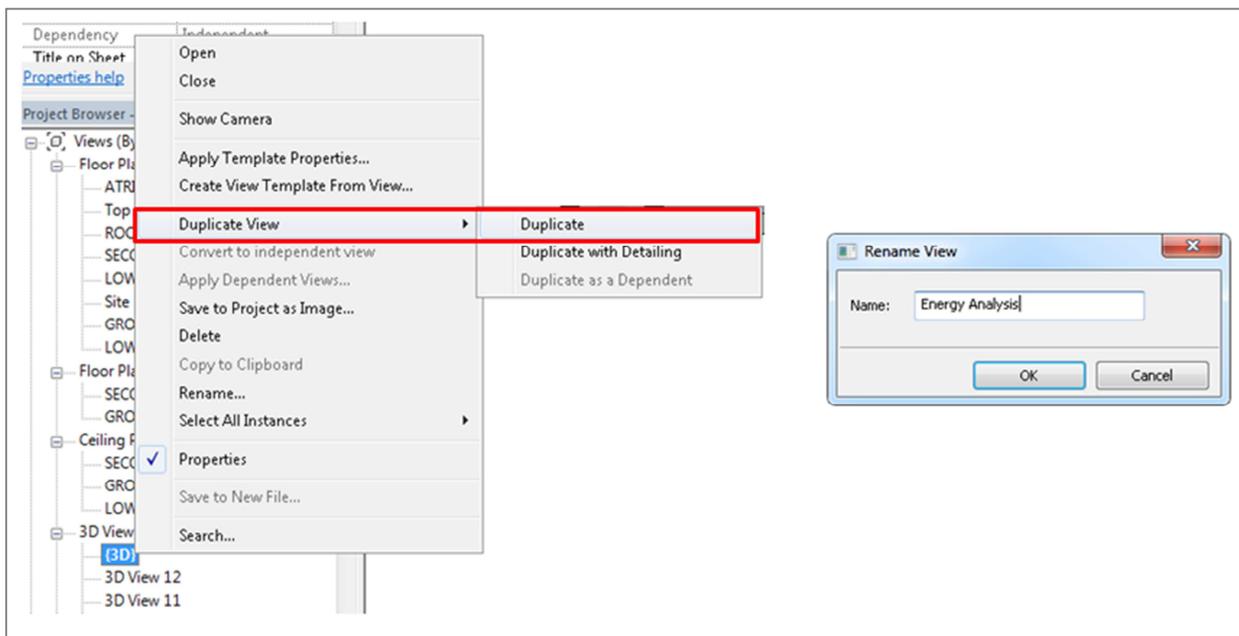
## Exercise 2.0 – Recommended series of steps to ensure the highest quality, most computationally efficient EAM possible.

Open 'AB2260 Ex\_2.0.rvt' to start. To skip any step and move to the next simply open the sample model referenced at the start of each step.

### Step 1 – Clearly identify the elements used in EAM creation

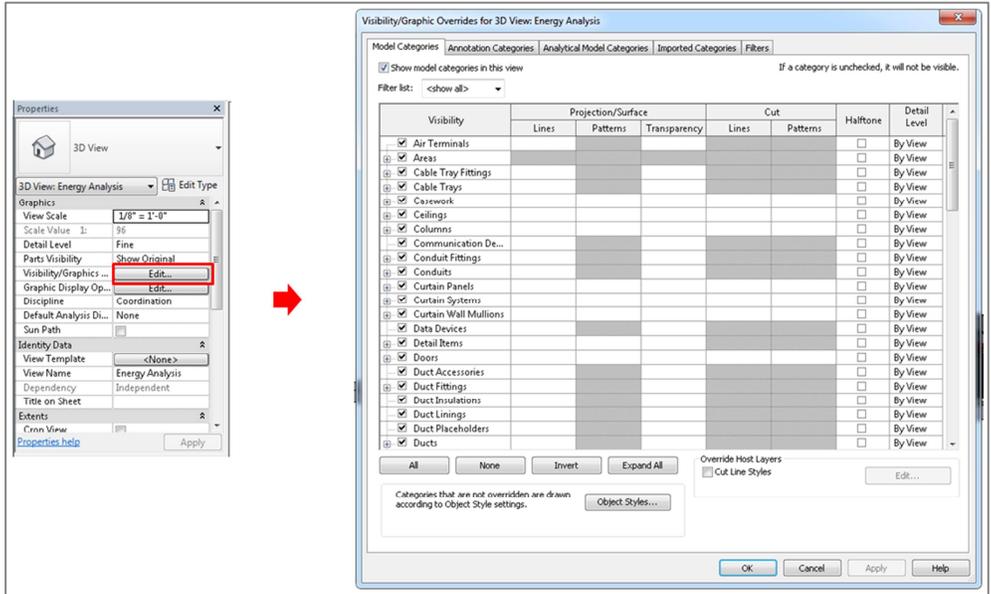
**Background:** The purpose of this step is to create a view in Revit to make it much easier to spot missing elements or gaps between elements that can lead to analytical spaces and surfaces being omitted from the EAM. Its worth noting that the EAM is not actually created from this or any other particular view settings but is created using all of the elements present in the model of the type listed below and having their room bounding property enabled.

To create a new view go to the project browser, find the default 3D view, right click to create a duplicate and then rename the new view 'Energy Analysis'...

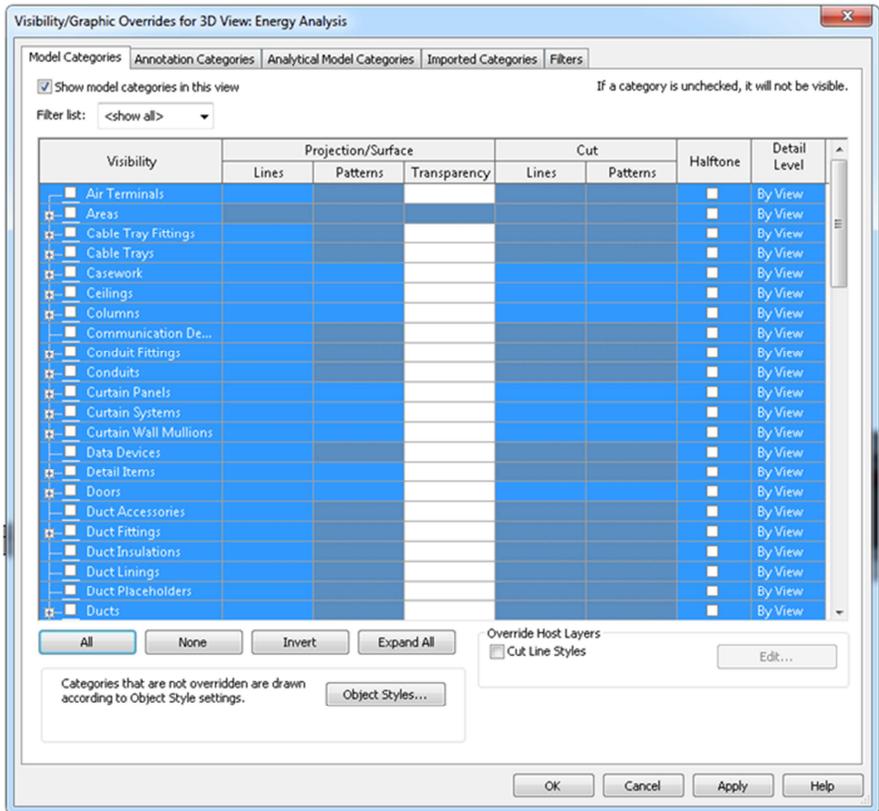


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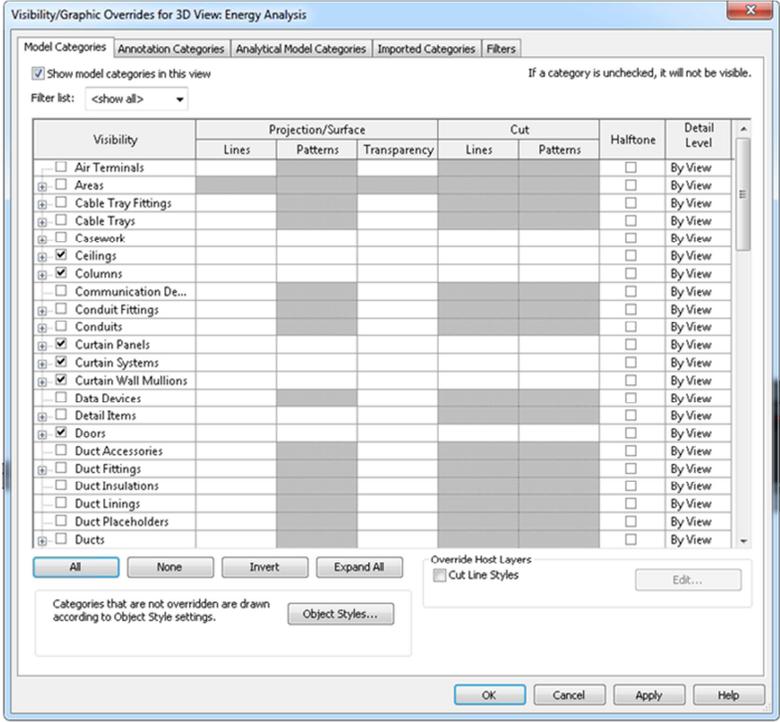
Next from the view properties open the Visibility / Graphics overrides dialog.



From the Visibility / Graphics overrides dialog select All and then uncheck one of the elements, thereby unchecking all of them...

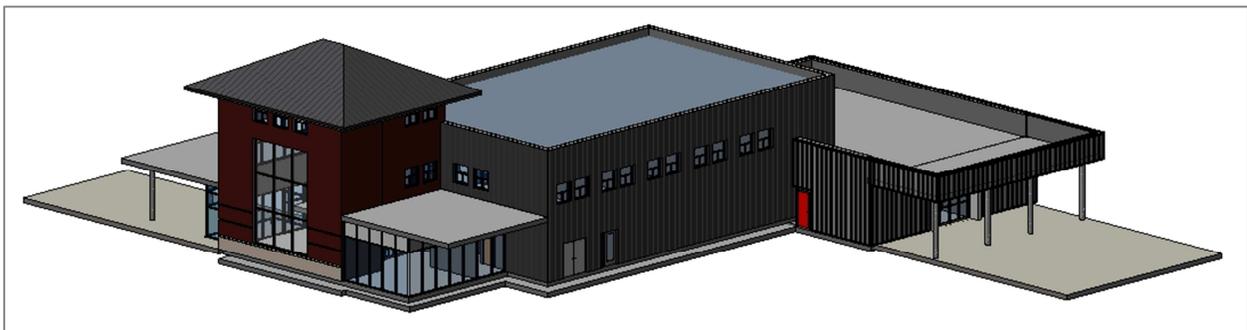


Then one by one re-enable the following elements that are used in EAM creation...



- ✓ Ceilings
- ✓ Columns
- ✓ Curtain Panels
- ✓ Curtain Systems
- ✓ Curtain Wall Mullions
- ✓ Doors
- ✓ Floors
- ✓ Roofs
- ✓ Common edges
- X Fascias
- X Gutters
- ✓ Hidden Lines
- ✓ Interior Edges
- ✓ Roof soffits
- ✓ Shaft Openings
- ✓ Site
  - X Hidden Lines
  - X Landscape
  - ✓ Pads
  - X Project Base Point
  - X Property Lines
  - X Stripe
  - X Survey Point
  - X Utilities
- ✓ Structural Columns
- ✓ Walls
  - ✓ Common Edges
  - ✓ Hidden Lines
  - X Walls Sweeps – Cornice
- ✓ Windows

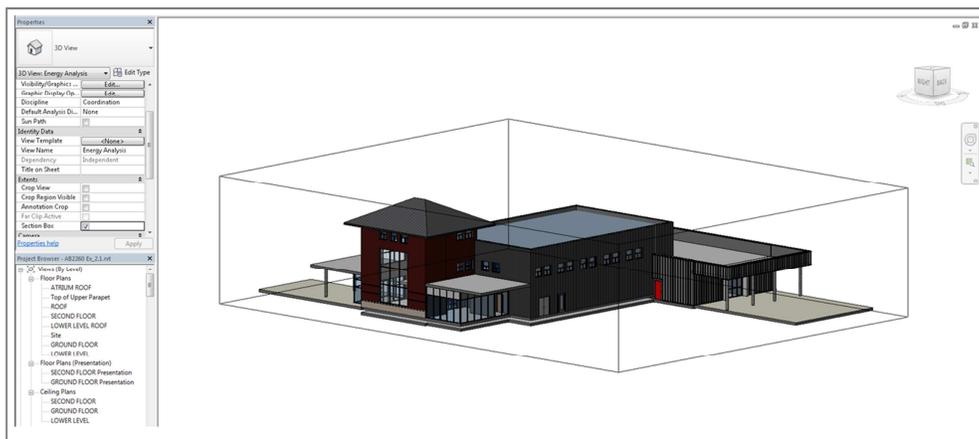
This now leaves you with a view only showing the elements used in EAM creation and this makes it easier to spot any obvious missing elements or gaps between elements.



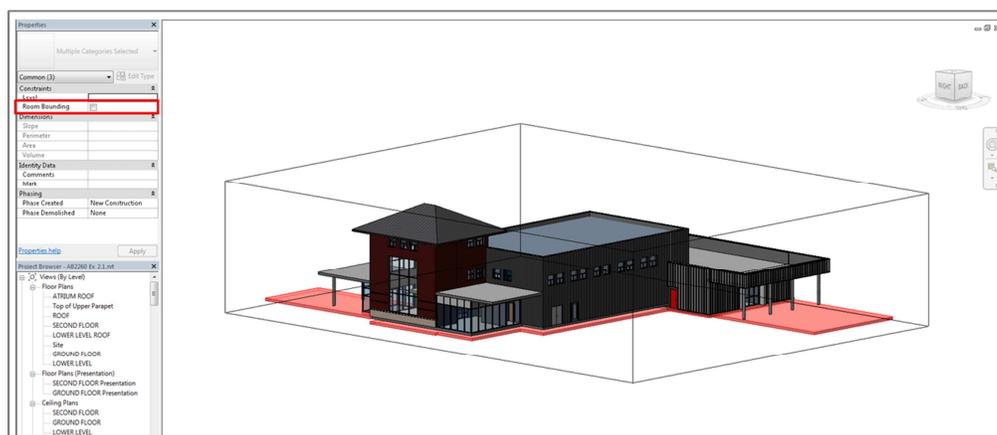
## Step 2 – Disable and hide any elements unnecessary to the analysis

**Background:** The purpose of this step is essentially to minimize the processing time and memory required for EAM creation. The EAM creation algorithm works on the basis of creating a form of ‘bounding box’ containing all of the elements present in the model and set to room bounding. As models often contain elements that are external to the building and do not play a significant role in solar shading yet will require a larger than necessary bounding box to contain them it can be very beneficial to exclude these elements as processing time essentially scales to the cube of the bounding box volume i.e. doubling the bounding box size means 8x the processing time therefore it can be very valuable to do this, especially on large Revit models.

Although the EAM creation algorithm’s ‘bounding box’ isn’t exactly the same as Revit’s 3D view section box that can provide a useful idea of bounding box size and ways it can be minimized. To enable this check the Section Box from the Energy Analysis view properties.

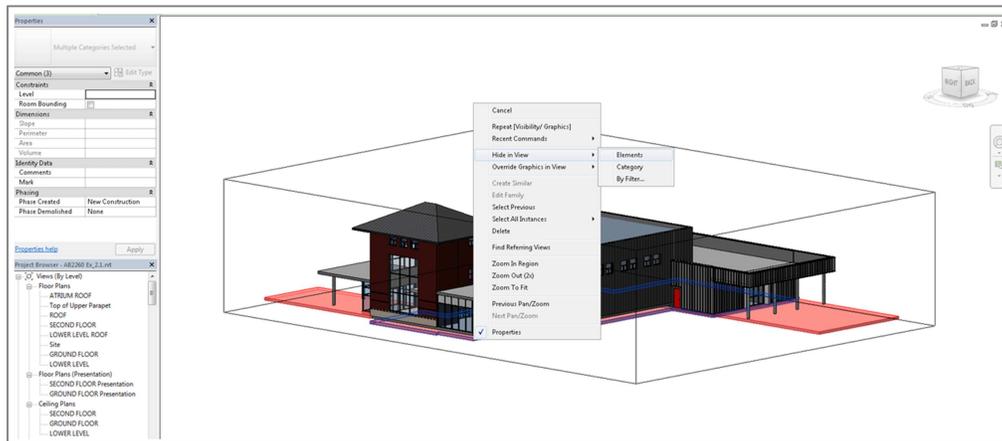


What we can see from this is that there are elements in the model, floors and a slab that are irrelevant to the Energy Analysis i.e. will not form analytical spaces or cause significant shading. Therefore to exclude these from the EAM creation and thereby speed the process up select these elements and uncheck their room bounding property...

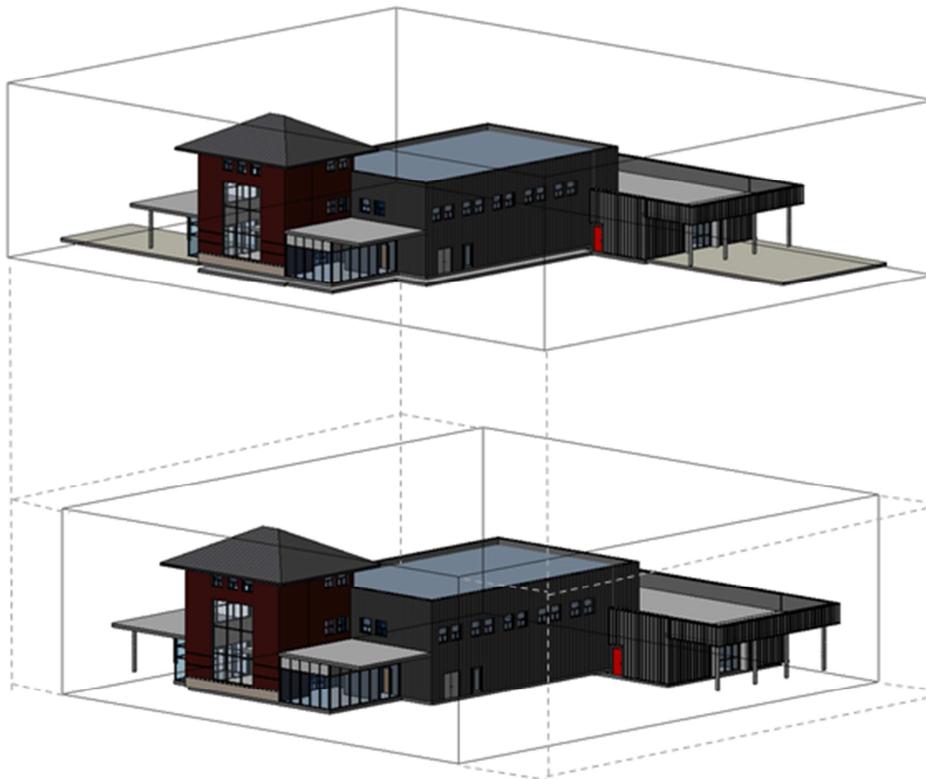


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In order to keep track of elements that have been disabled it is useful to hide them in the Energy Analysis view. You can do this by right clicking and selecting hide in view and then elements...



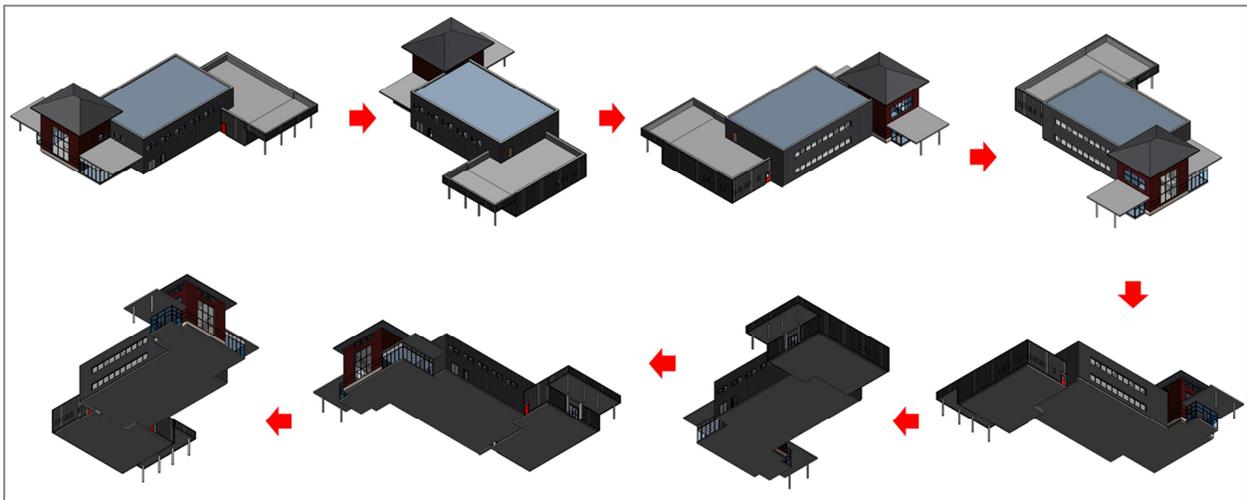
If you then disable and then re-enable the Section Box you will now see its shrunk from before. Although in this case the reduction is not significant it's likely reducing processing time by ~30% but this can be much more significant on other models.



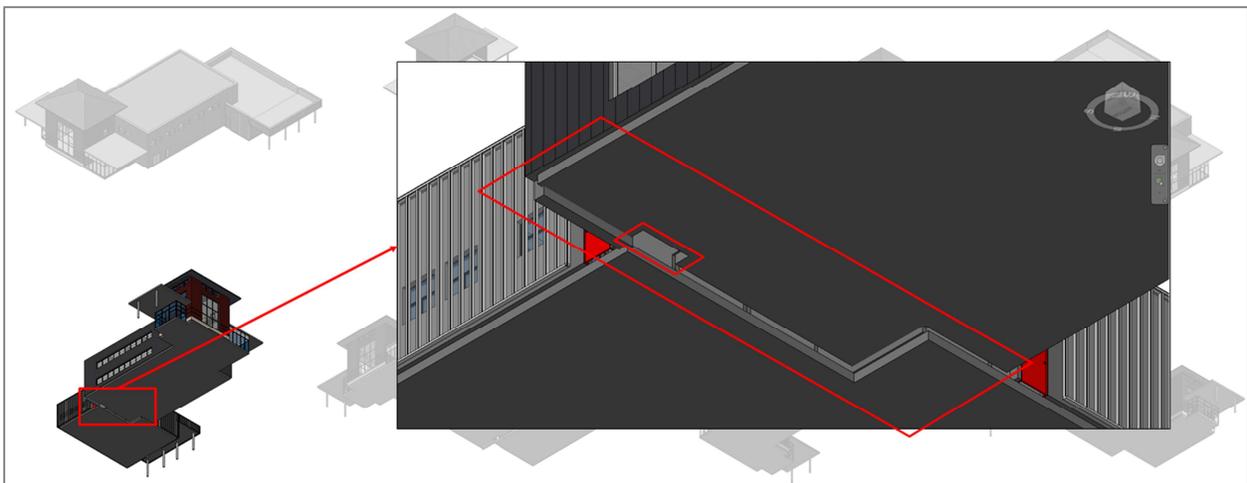
### Step 3 – Look for and address any obvious missing elements or gaps

**Background:** The purpose of this step is to identify and fix any obvious missing elements or gaps between elements that may exist in the model and would cause analytical spaces and surfaces to be omitted from the resulting EAM. As subsequent steps of this process will ultimately identify any missing elements or gaps that cannot easily be seen this step is simply to address any glaring issues.

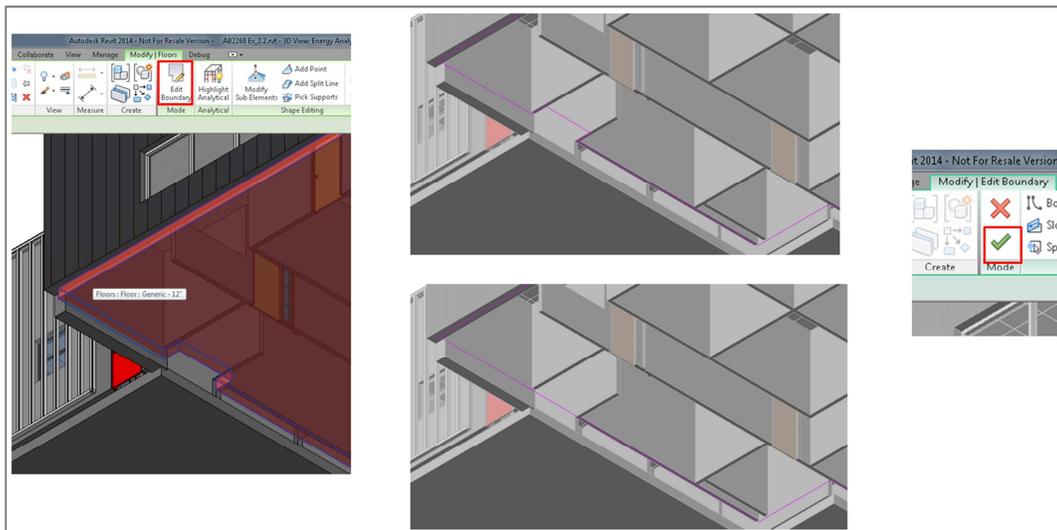
To start, using the view cube or by pressing and holding shift and the right mouse button do a 360° orbit of the building, viewing it from above and below and looking for any obvious gaps or missing elements...



Looking at this model in this way we can see that for the most part the model appears to be 'reasonably enclosed' by the building elements however when viewed from below we can see a narrow gap between the floors and one of those floors appears to contain a 'cutout' along its edge..



Its worth noting that when an elements profile is edited to contain a cutout like this the EAM creation will see this as a 'hole' in the building and therefore this will mean analytical spaces cannot be created for that part of the building. The narrow gap between floors should also probably be addressed from a model completeness perspective i.e. isn't there a wall missing here?, however as the elements do not need to be perfectly tight this is actually ok and we will leave it as is. Instead we will simply adjust the profile of the floor to remove the cutout. To do this select the floor, select edit profile, adjust the elements profile and then select ok when done....

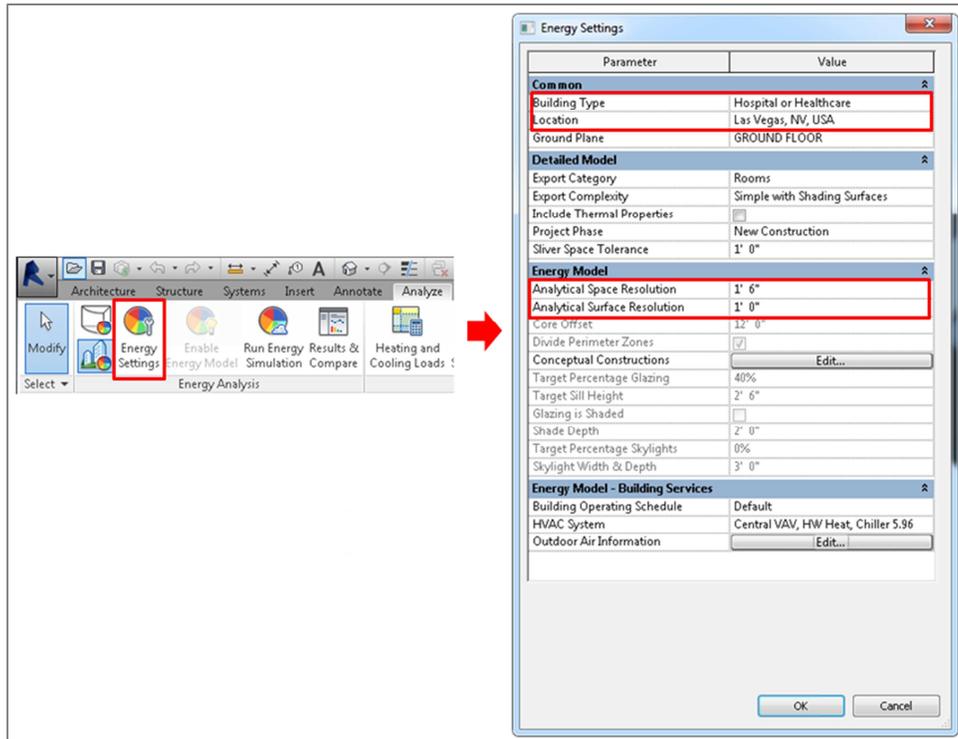


### Step 3 – Run a preliminary simulation to check the EAM

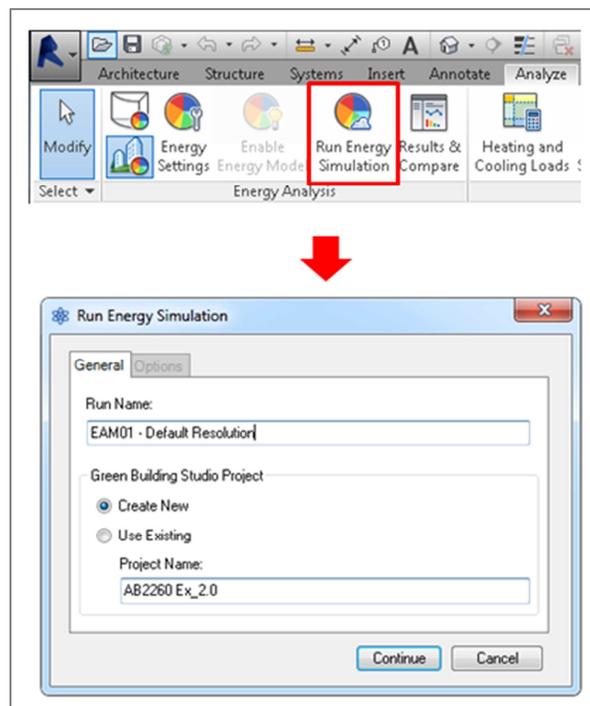
**Background:** Typically its not possible to spot all missing elements or gaps between elements up front therefore the purpose of this step is to run an initial simulation for the purposes of checking the EAM where any missing elements or gaps will become clear.

To run the preliminary energy simulation go to Energy Settings and (like always) set the building type (to Hospital or Healthcare) and location (to Las Vegas, NV). Also note the values for analytical spaces and surface resolution is set to 1'6" and 1' respectively. These are the defaults and provide a good starting point so no need to change these yet.

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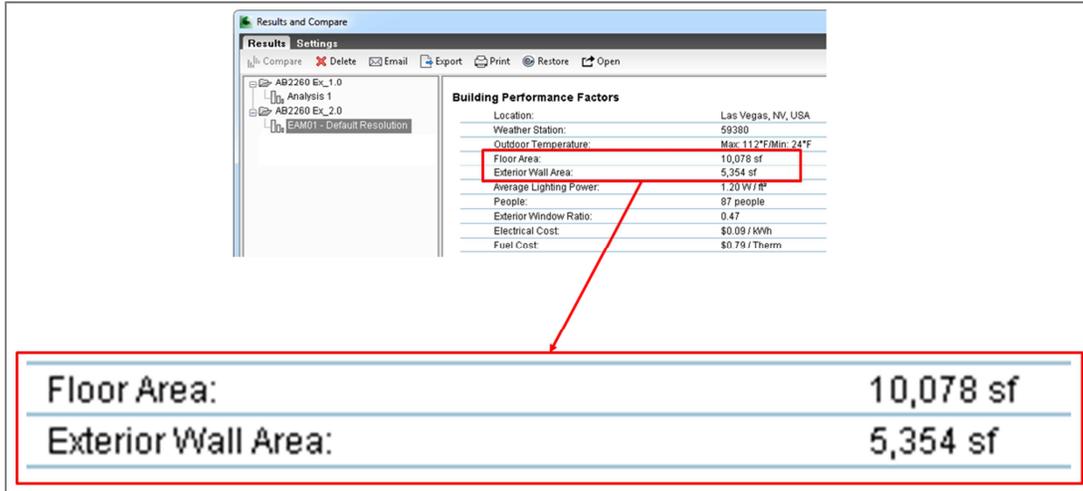


Next, select Run Energy Simulation, set the run name to 'EAM 01 – Default Resolution' and ensure the Create New Green Building Studio project is checked and name the project 'AB2260 Ex2.0'

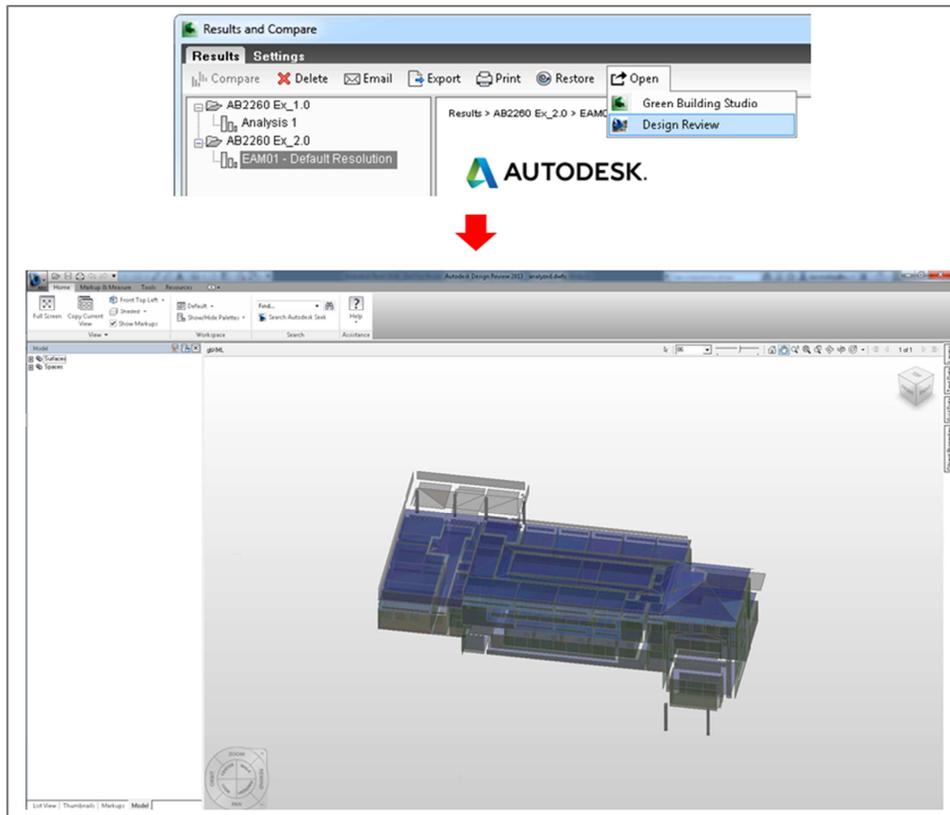


### Step 4 – Inspect the preliminary EAM for errors & omissions

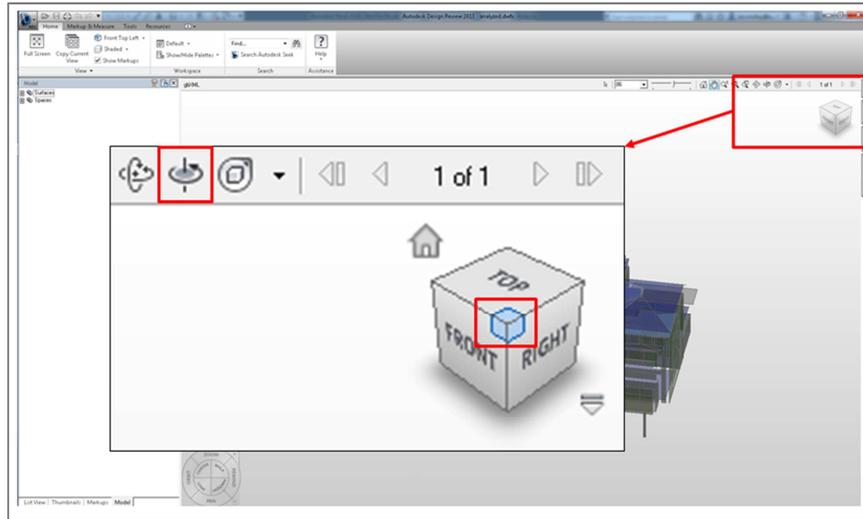
When the simulation is complete open Results & Compare and look at first the floor and wall area values reported under Building Performance Factors as these provide a good high level indication of the EAM that has been created...



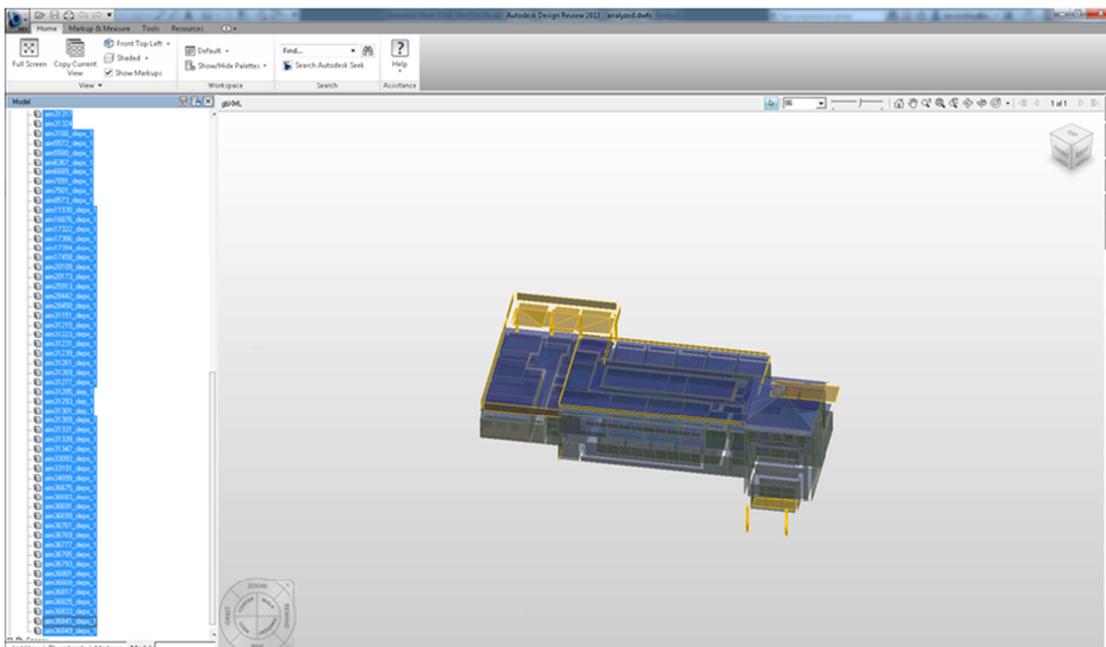
Next, select Design Review from the Results & Compare Open toolbar button...



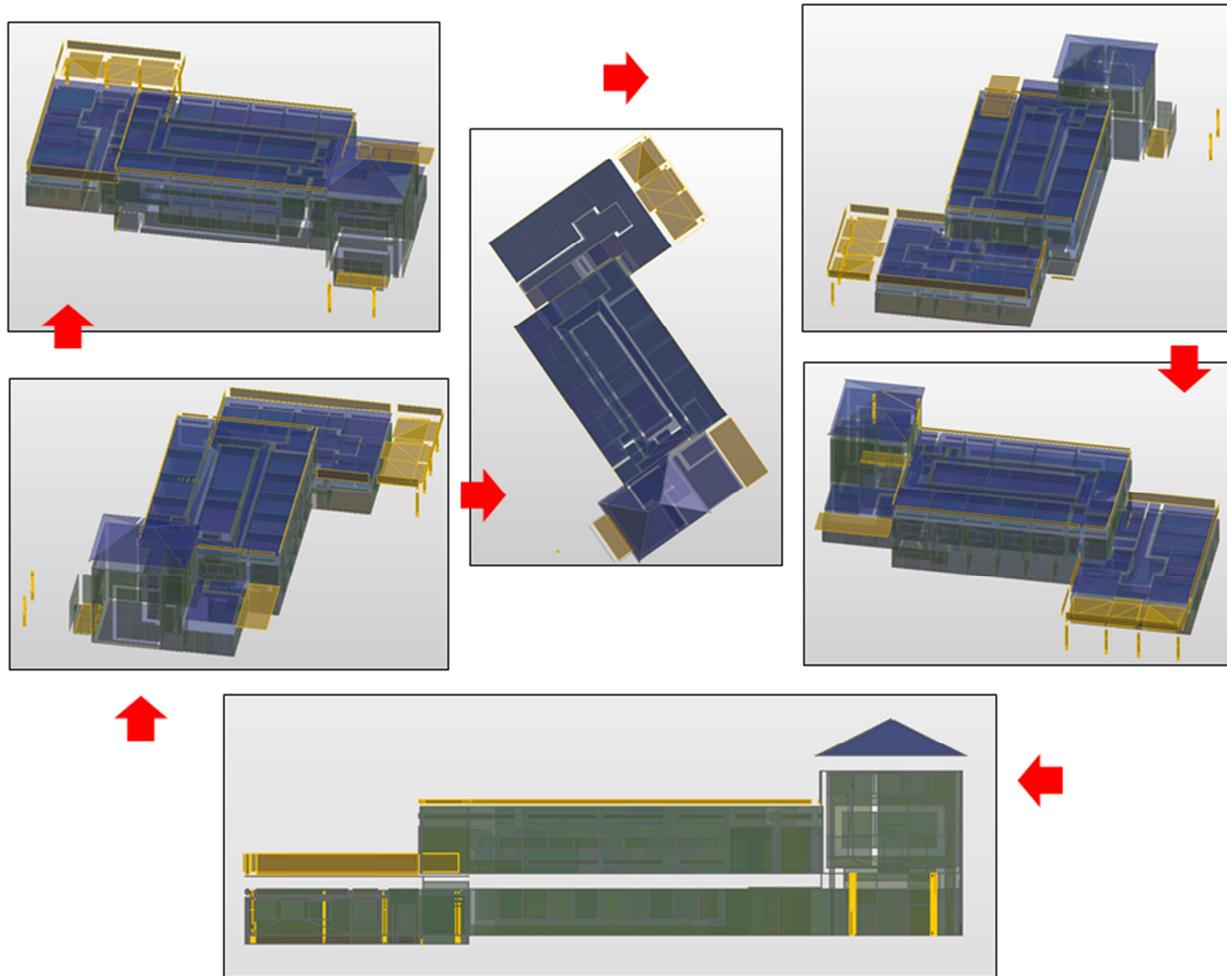
Again as in exercise 1 when Design Review first opens always select one of the corners of the view cube and then select the rotate view button as this puts the model at the center of the view for when you orbit it. Otherwise as you rotate the model you will have to work to keep the view centered on the model...



The first thing to check in the EAM is the presence of Shade surfaces. To do this go to Design Review's model browser, expand the Surfaces tree, then expand the Shades tree. Then select the first item in the list then scroll down to the bottom, press ctrl and select the last item. This will highlight all the analytical surfaces of type shade...

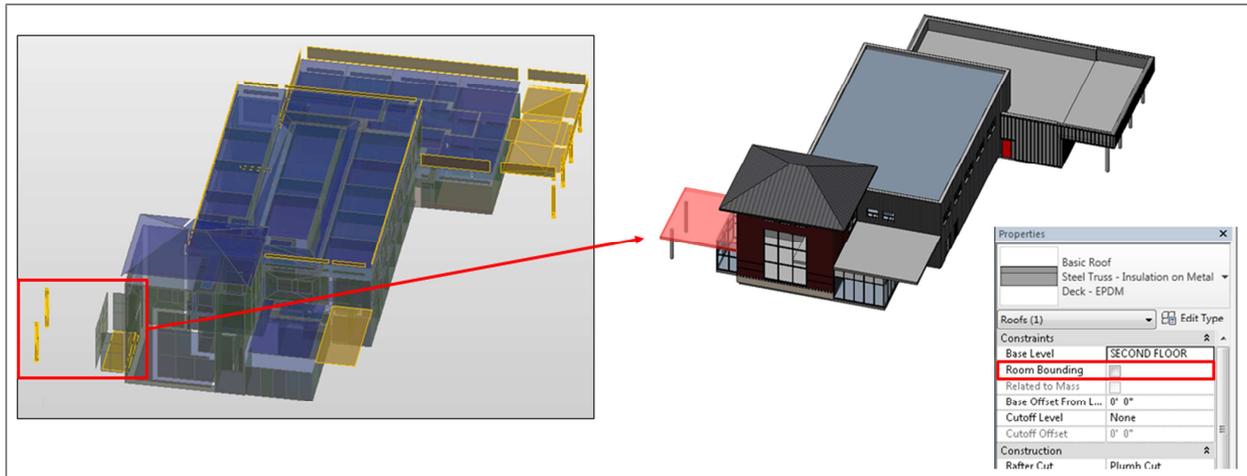


Then using the view cube or mouse to do a 360° orbit of the EAM, viewing it from above and below looking for any place where shades are present to determine if these are appropriate or the sign of some part of the building has been omitted from the EAM due to missing elements or gaps between elements...



### Step 5 – Address any issues in the Revit model

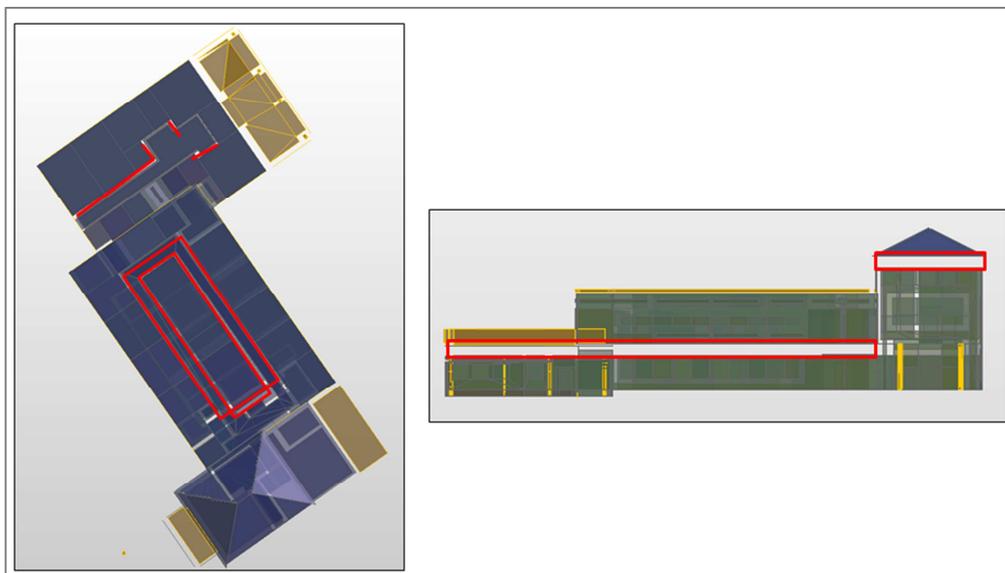
Looking at EAM 01 we can see that the roof over one of the vestibules seems to have been omitted and a shade surface exists in its place (on the floor). Therefore go back to the Revit model and inspect the elements in that part of the building. Selecting the Vestibule roof shows that its room bounding property is disabled and therefore needs to be re-enabled in order to be included in the EAM creation....



Other than this all other shade surfaces appear valid.

### Step 6 – Reduce the EAM resolution incrementally

Looking at EAM 01 it's possible to see some reasonably significant gaps between analytical surfaces. This is a function of the EAM's resolution values. For example there are some gaps between the roof surfaces and a large section missing in the elevation view (due to the presence of a ceiling void that was too small for the default resolution settings to find)...

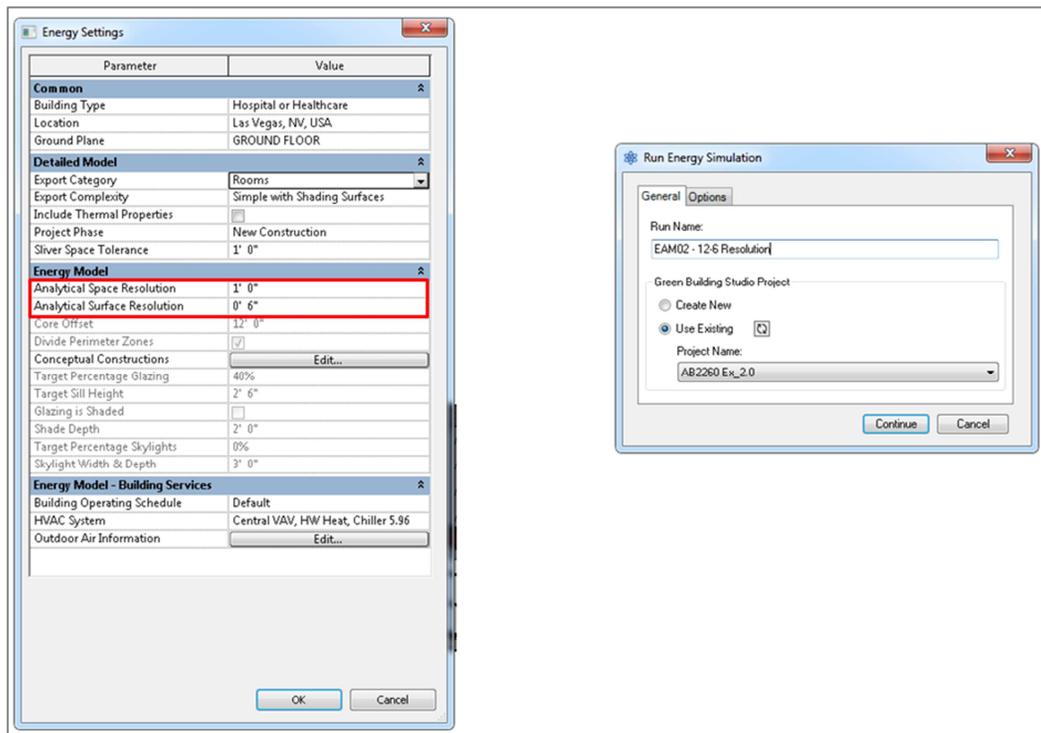


Therefore the next step is to incrementally reduce the analytical space and surface resolution values incrementally in order to arrive at an optimal setting.

**Useful tip:** While it may be tempting to immediately just lower the resolution values to their lowest possible settings (6" and 3" respectively) it is recommended you do this in incremental steps mainly because as you reduce these values processing time increases rapidly and spaces

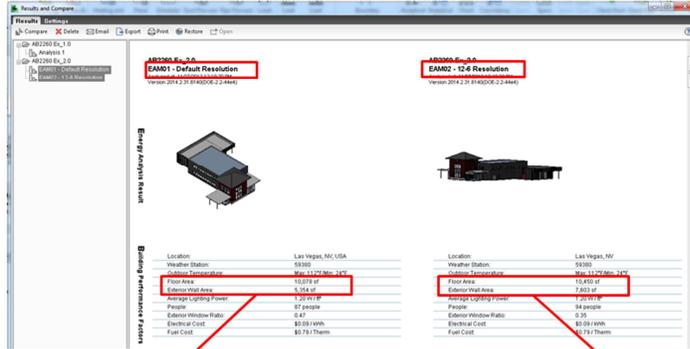
that were previously not omitted can become so due to smaller missing elements or gaps between elements that the default resolution did not find.

To set the analytical space and surface resolution values go to Energy Settings, change the values to 1' and 6" respectively then run another energy simulation named 'EAM02 – 12 & 6 Resolution'...



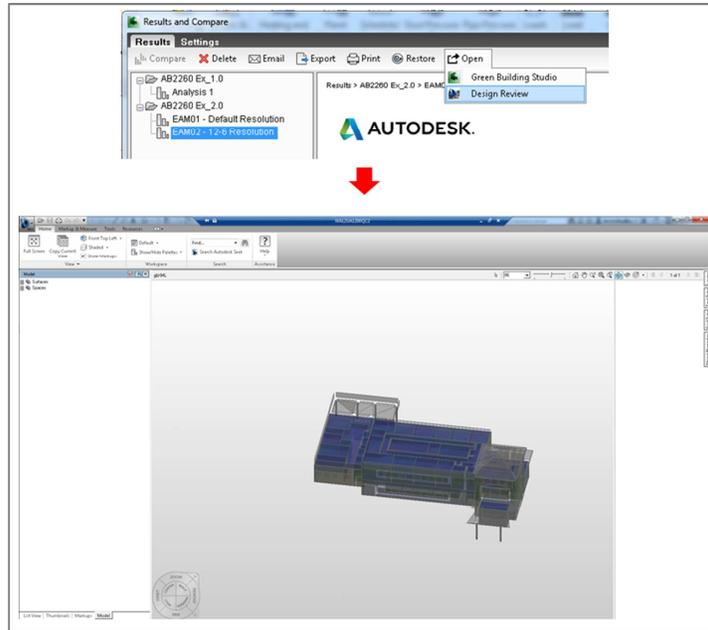
When the simulation is complete, again note the floor and wall areas values and compare to EAM01 as these values provide a high level overview of your EAM. Typically as resolution values are reduced values for floor and wall area should increase unless a missing element or gap that was previously not detected with the default resolution settings is encountered. Here we see floor area has gone up slightly which is a good sign...

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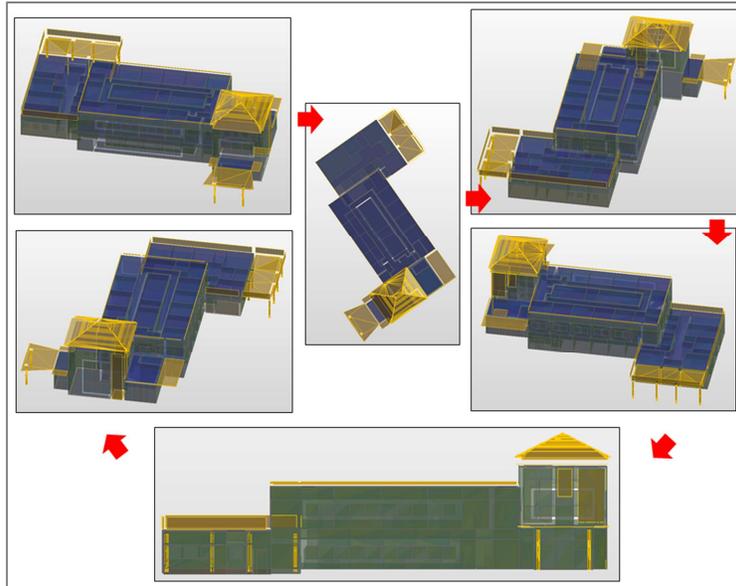


Floor Area:	10,078 sf	Floor Area:	10,450 sf
Exterior Wall Area:	5,354 sf	Exterior Wall Area:	7,603 sf

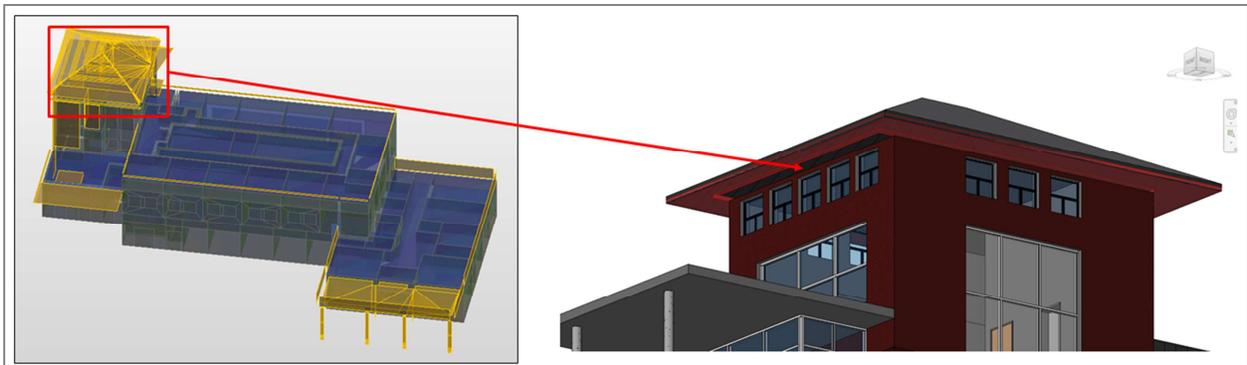
Next open EAM-02 in Design Review again...



Again select shade surfaces and using the view cube or mouse to do a 360° orbit of the EAM, viewing it from above and below looking for any place where shades are present to determine if these are appropriate or the sign of some part of the building has been omitted from the EAM due to missing elements or gaps between elements...



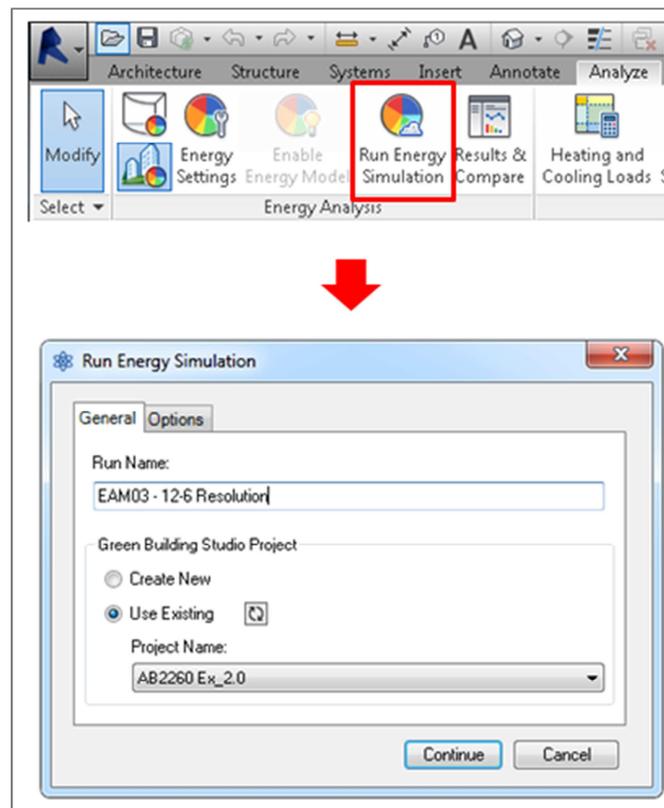
Note that now in EAM 02 the Atrium roof is appearing as shade surfaces therefore go back to that part of the Revit model and inspect it more closely and you will notice a large gap at the roof soffit...



Address this gap by editing the profile of the roof soffit to the walls and roof...

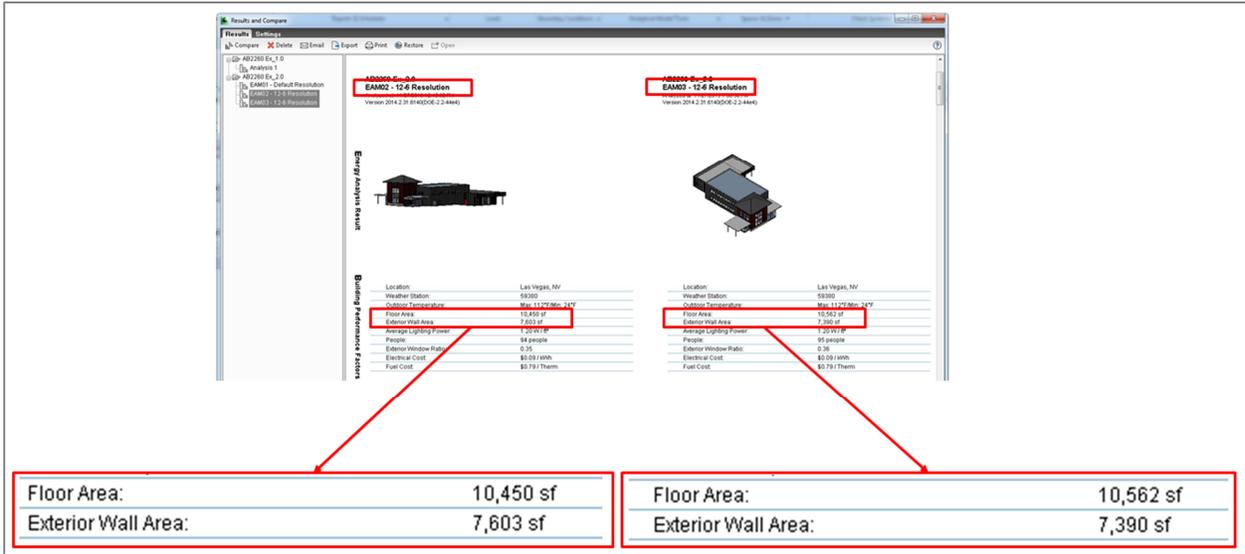


Then run another simulation, this time EAM03 – 12 & 6 Resolution (note we're keeping the resolution the same for now just to check the issues we just addressed are correct...

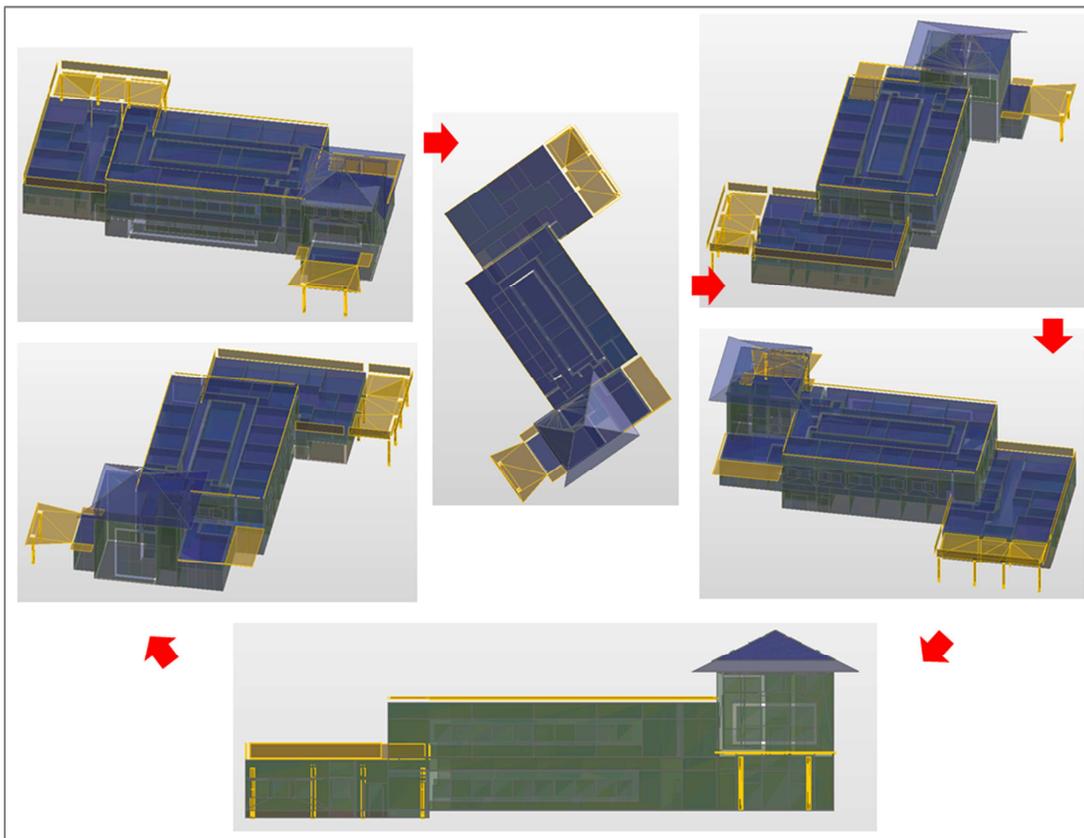


When the simulation is complete again check floor and wall areas against previous. As you progress through these steps the values will start to converge at which time you are at the optimal resolution setting...

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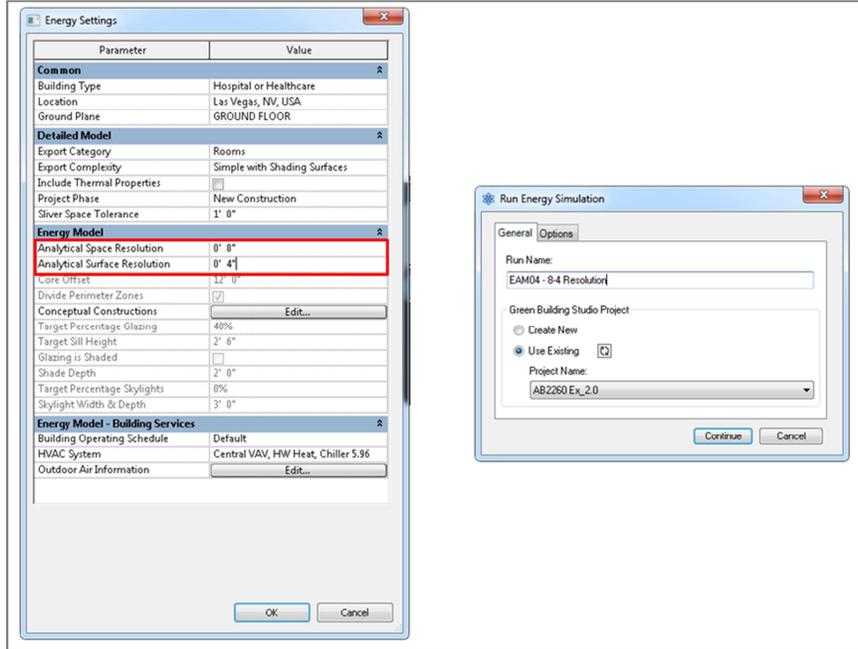
Again check EAM-02 shade surfaces by opening in Design Review and selecting shades...



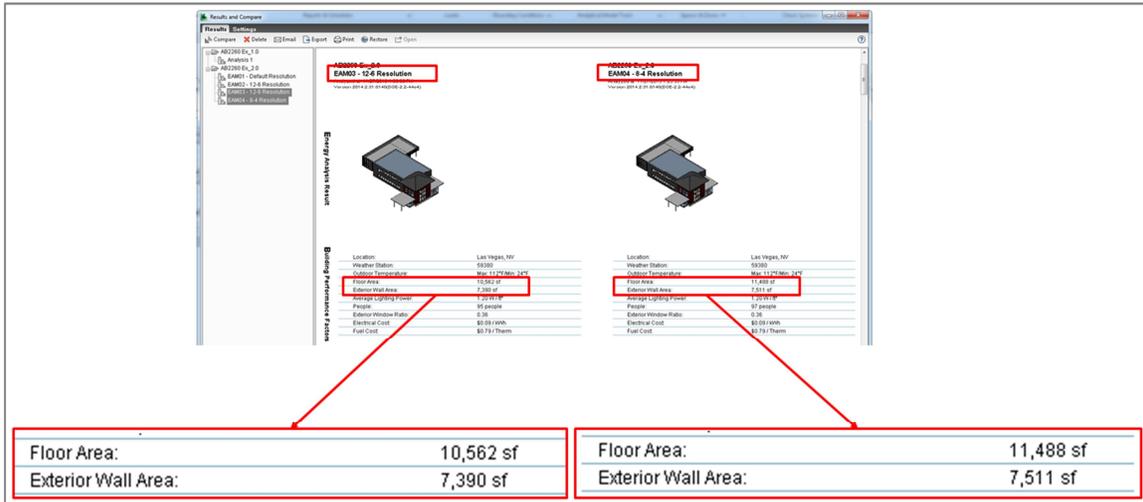
It can now be seen that all shades that are present are appropriate.

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Next reduce the resolution values to 8" and 4" respectively and run another simulation 'EAM0 – 8 & 4 Resolution'...

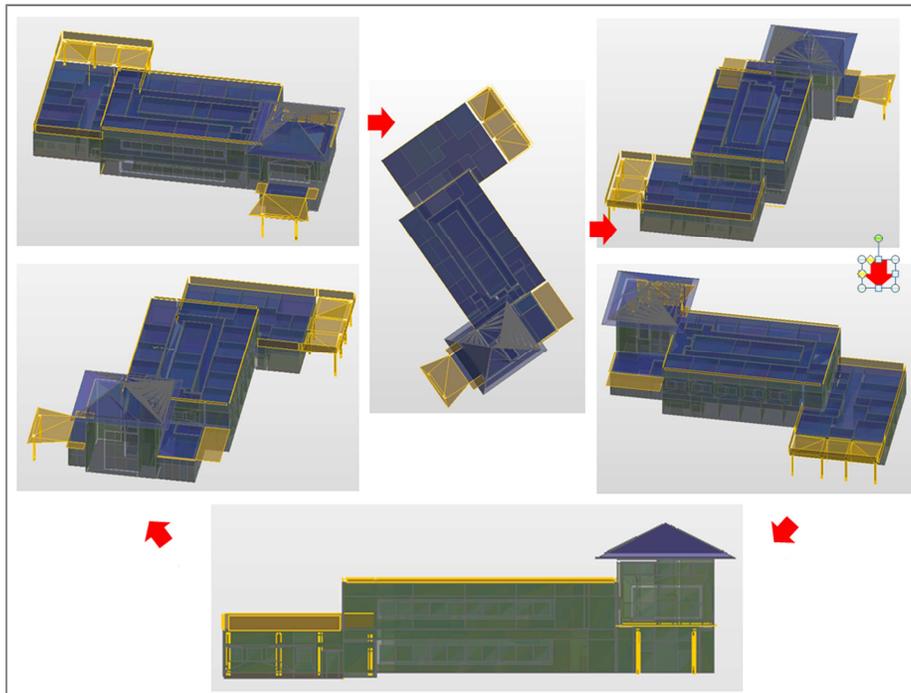
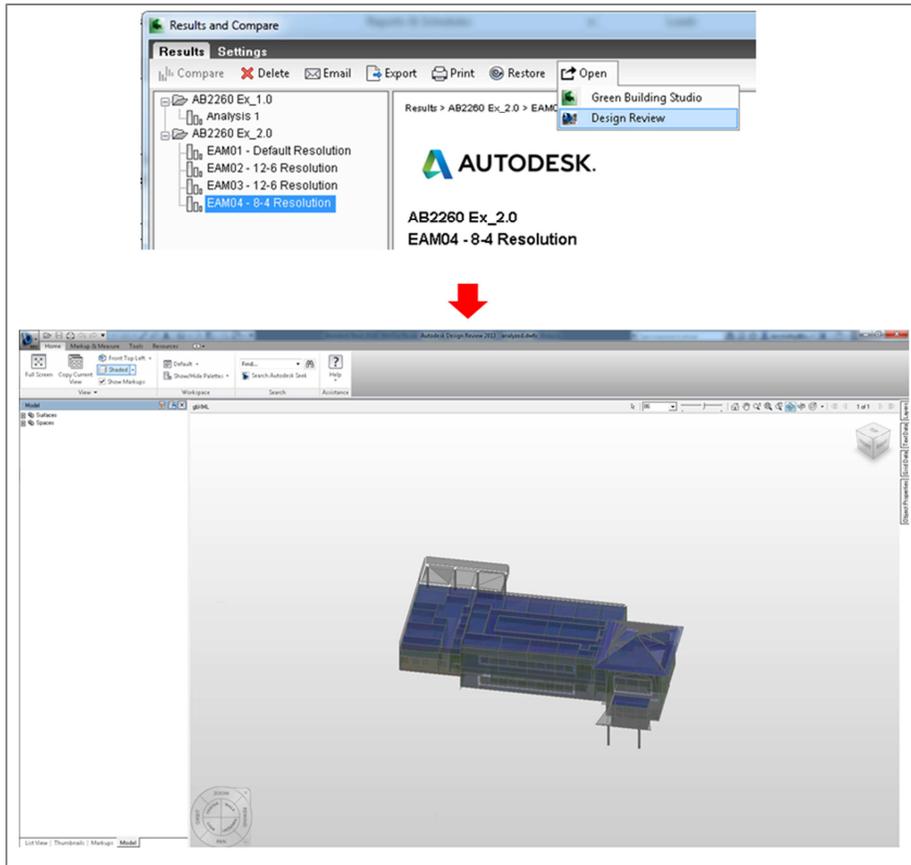


When the simulation is complete, again note the floor and wall areas values and compare to EAM02...



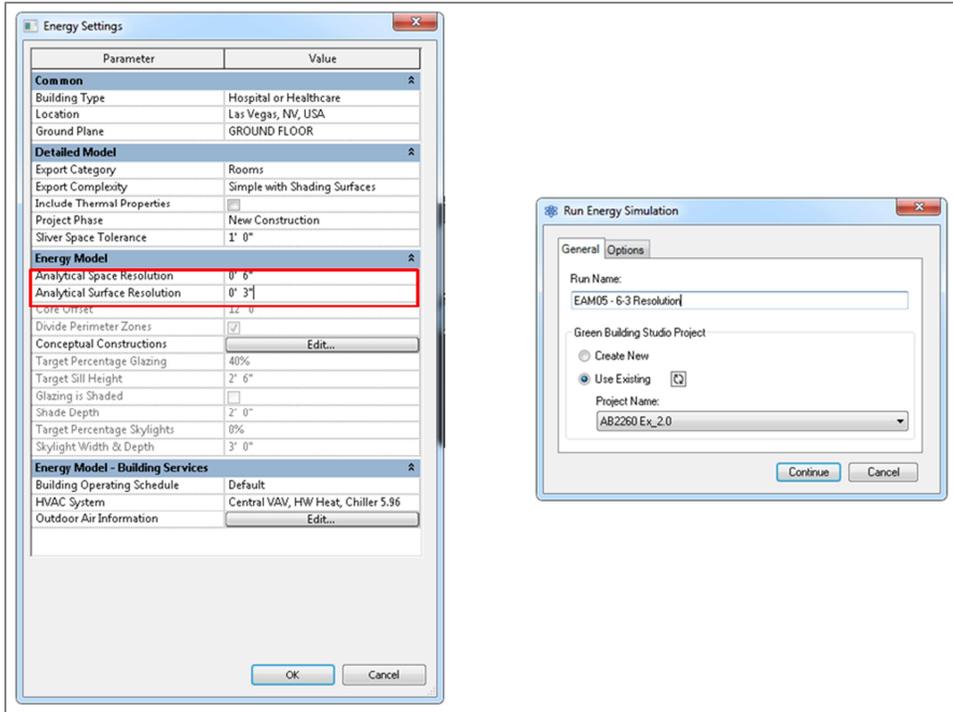
You can see the values continue to increase and opening the model in Design Review and looking for shade surfaces shows that everything is ok...

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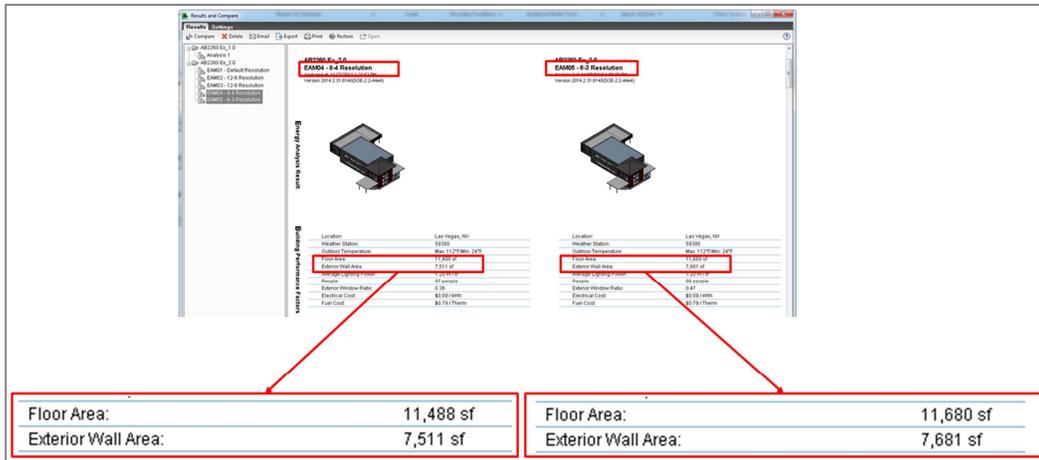


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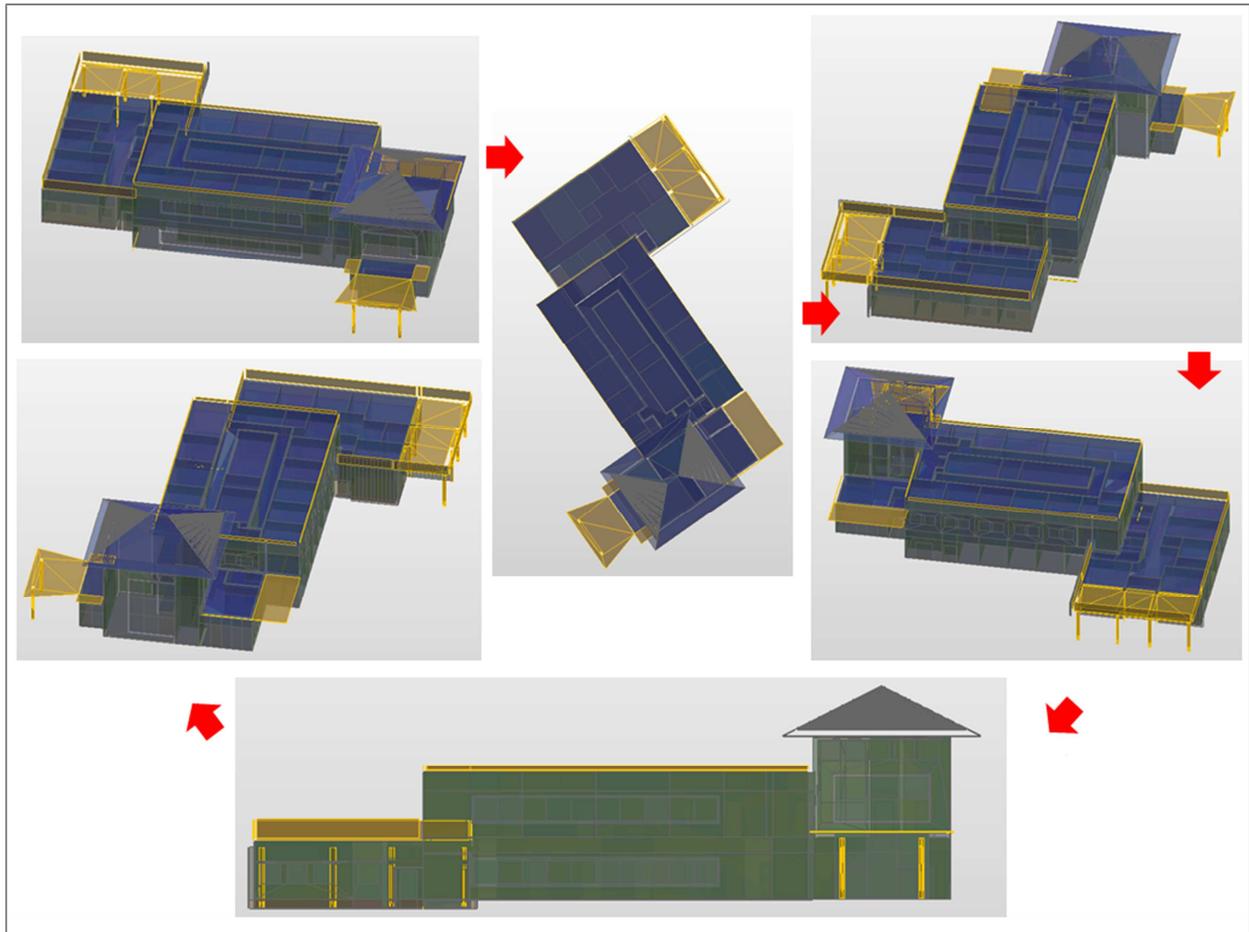
At this stage even though the EAM looks good processing time has been reasonable therefore its possible to try the lowest resolution settings i.e. 6” and 3” respectively and run a new energy simulation ‘EAM05 – 6 & 3 Resolution’...



When the simulation is complete again look at floor and wall area. Note this time the difference is very marginal...



Open the EAM in Design Review...

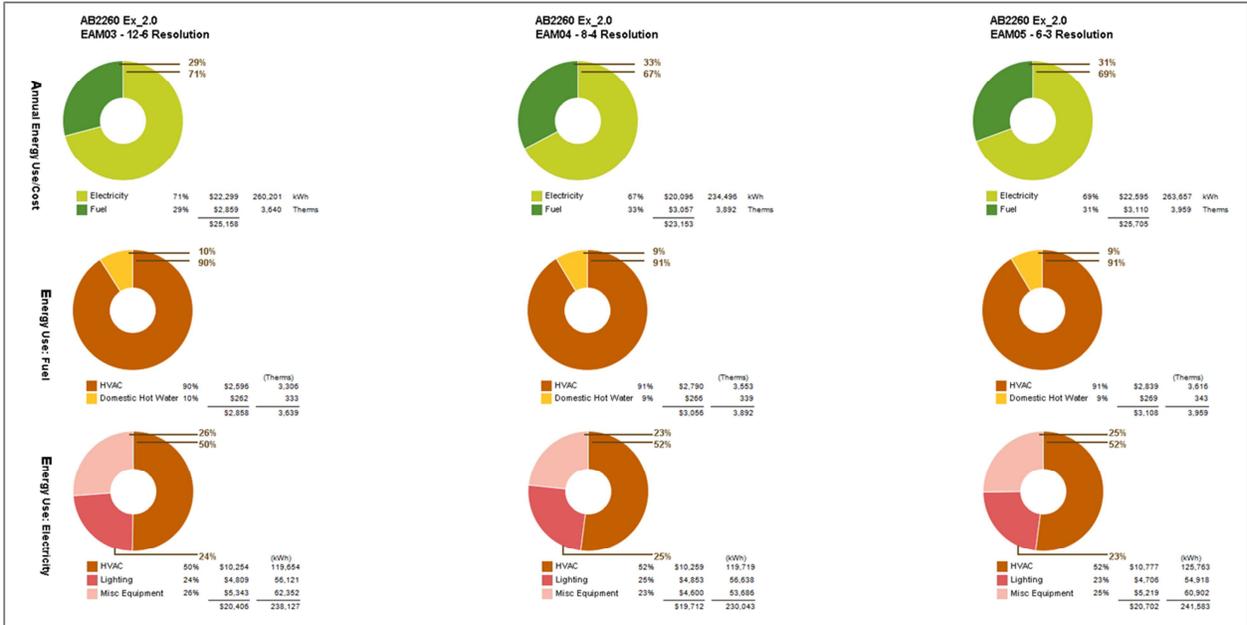


Once again everything looks correct. Also note how the gaps between analytical surfaces have been virtually eliminated.

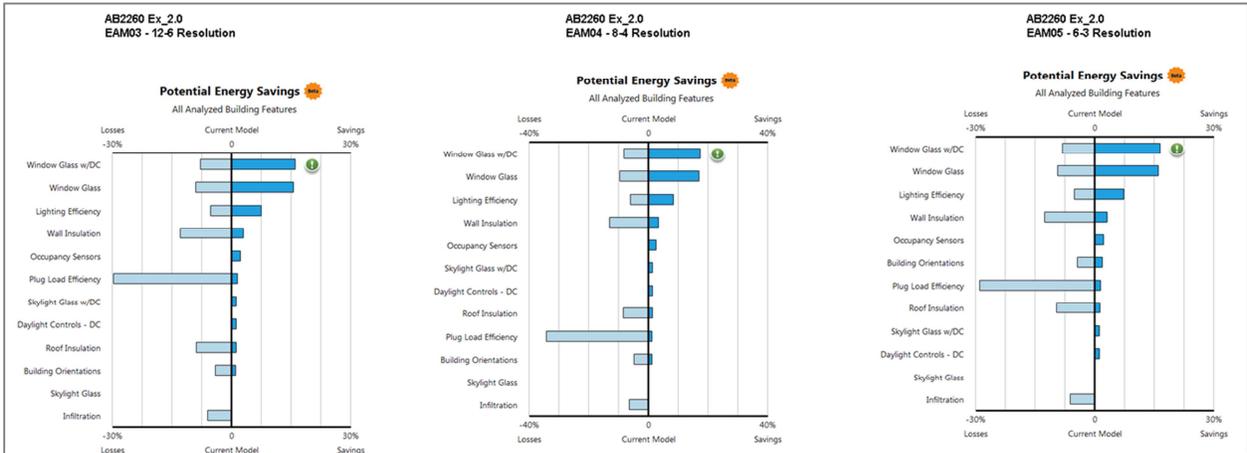
### Step 7 - Compare results (if required)

**Background:** Once you are at this stage if you are unsure what resolution to use it can be useful to compare the energy simulations results as this will show if the analysis is sensitive to the small gaps between analytical surfaces. Go to Results & Compare and look at energy end use / cost charts...

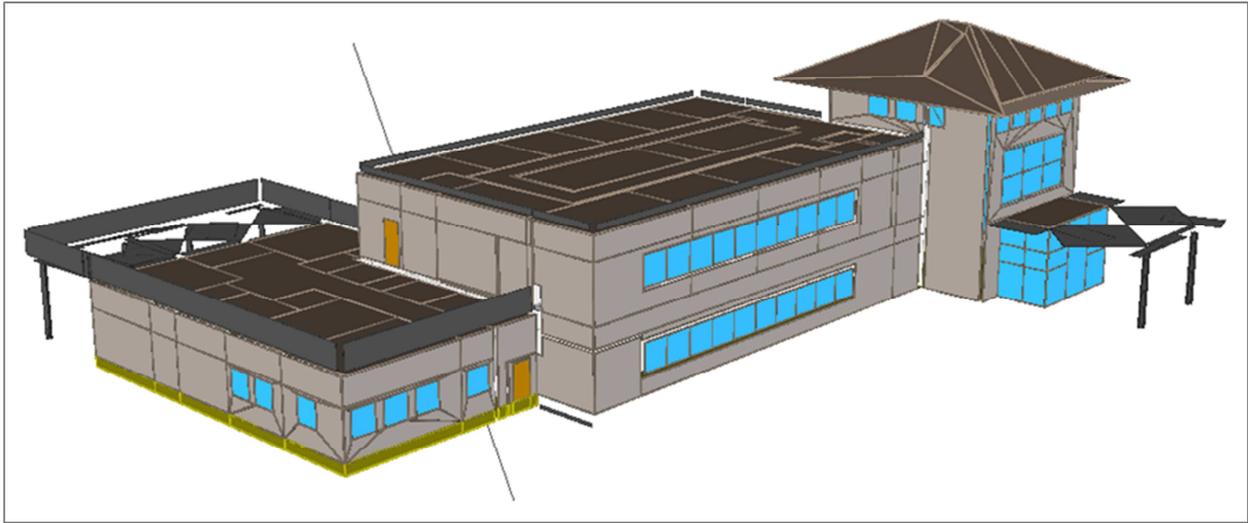
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Here if we consider total annual energy cost we can see that going from 12”/6” resolution all the way down to the minimum yields a difference of around 10%. This seems significant but of course the simulation is not trying to determine actual end energy use but represent the key factors that drive. Interestingly if you then look at the Potential Energy Savings chart you will see the top energy saving measures are the same for all resolutions meaning the analysis is not especially sensitive to resolution and it would be reasonable to use a higher value for faster run times...

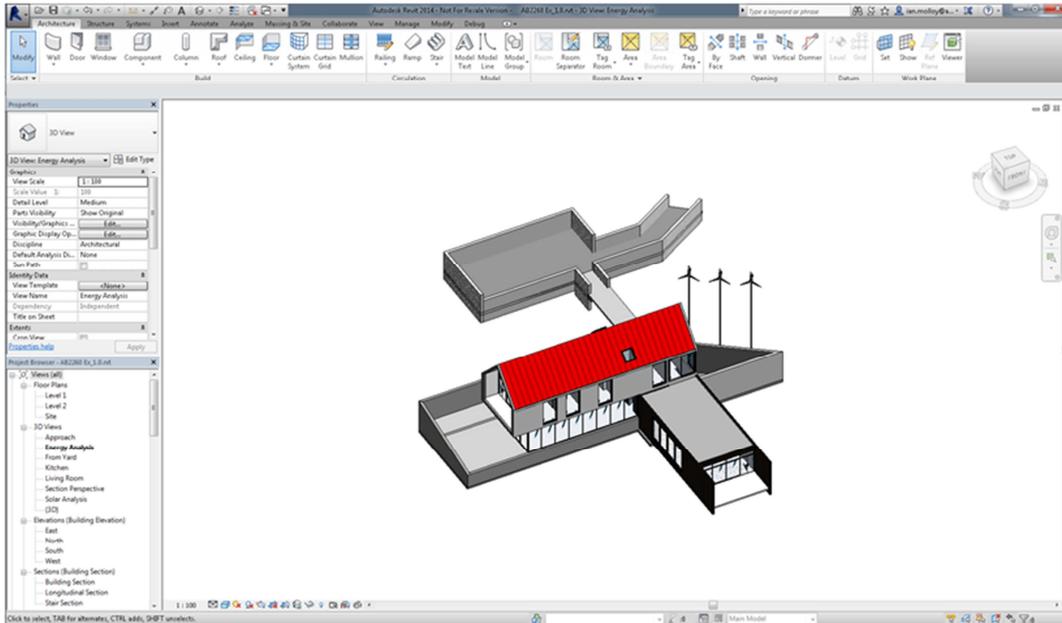


Finally, you can export gbXML, DOE2 or EnergyPlus output files to view the model in a 3<sup>rd</sup> party tool of your choice...

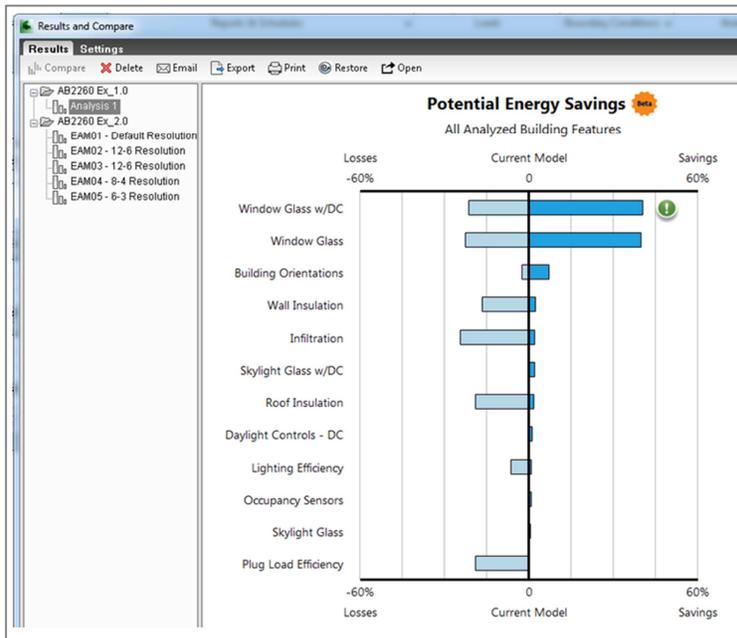


### Exercise 1.1 – Specifying material thermal properties in Revit elements

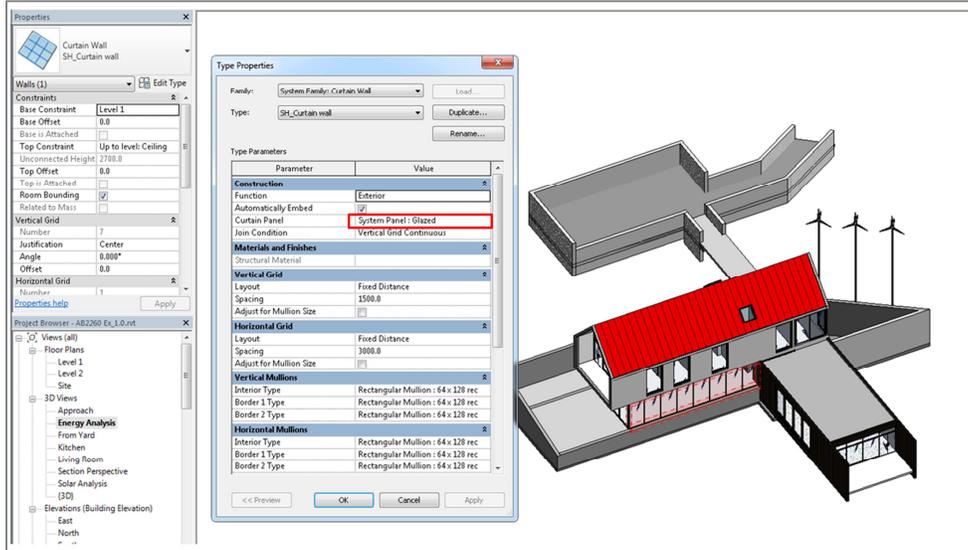
Open Revit model ‘AB2260 Ex1.0.rvt’ and go to the Energy Analysis view...



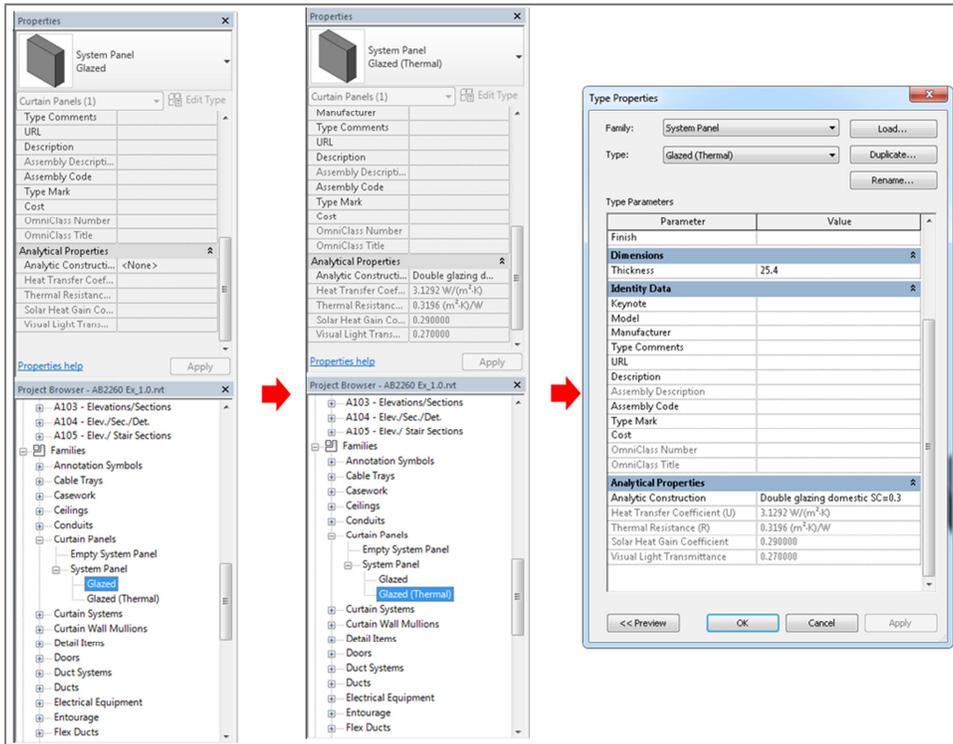
Open Results & Compare and look at the Potential Energy Savings chart for Analysis 1 (from Exercise 1.0). Note that it indicates glazing, wall and roof insulation as reasonable opportunities for energy savings...



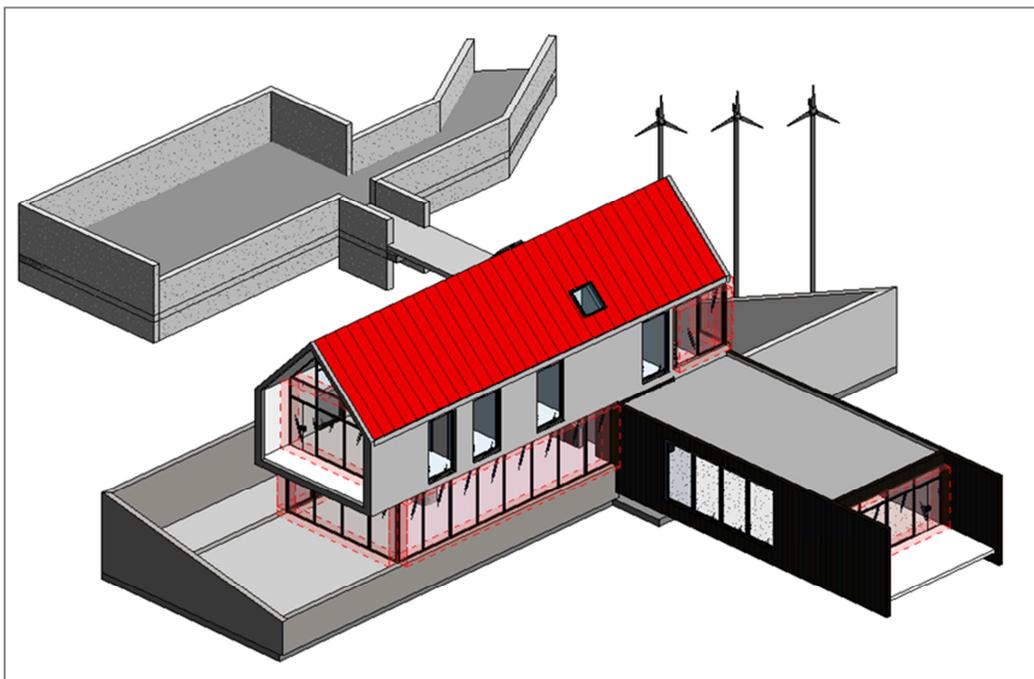
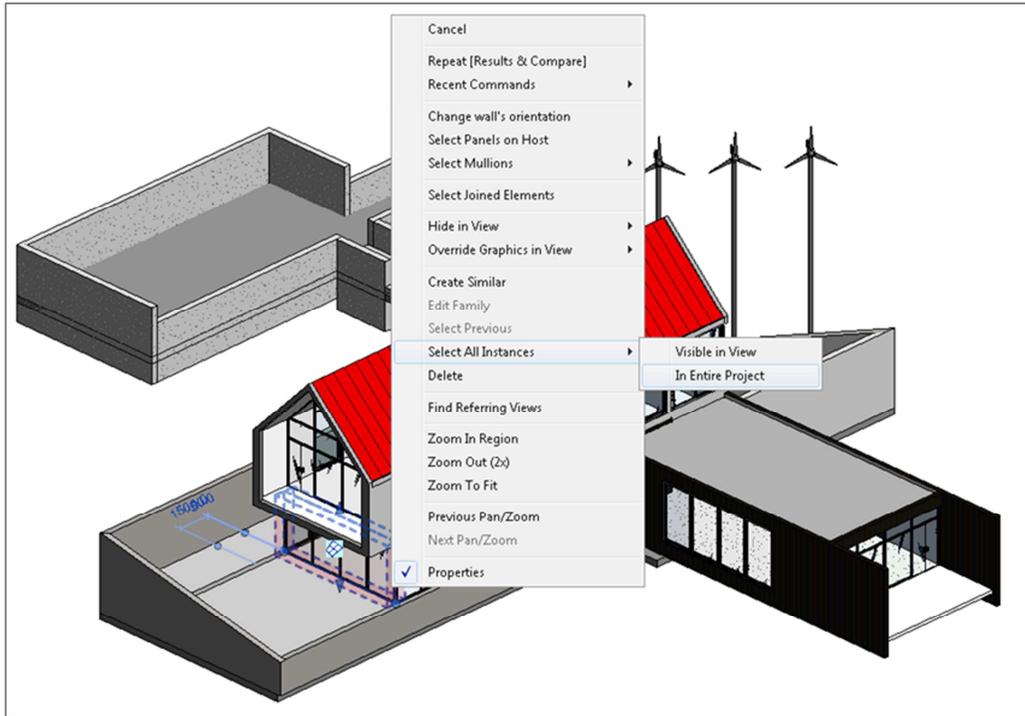
Select one of the curtain walls in the model, select edit type and go note the Curtain Panel setting...



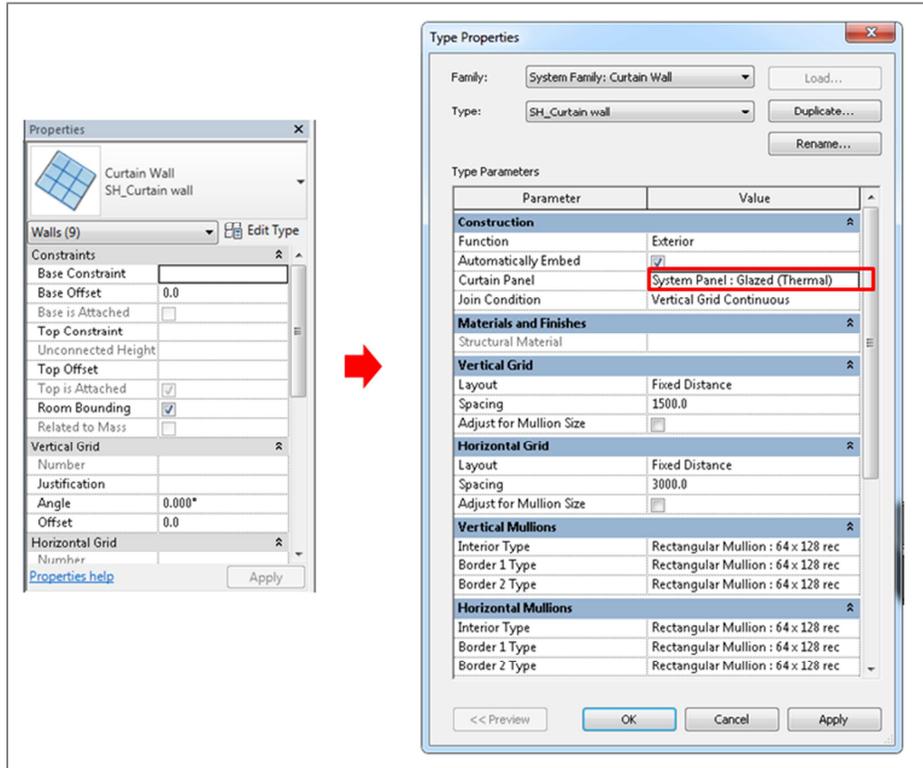
To view the properties of the curtain panel go to the family browser, find curtain panels, system panels. Note that the current panel has no thermal properties assigned to it whereas the alternative 'thermal' panel present does. Note that at this time the thermal properties for glazing can only be set from a predefined list that spans a reasonably broad range of performance.



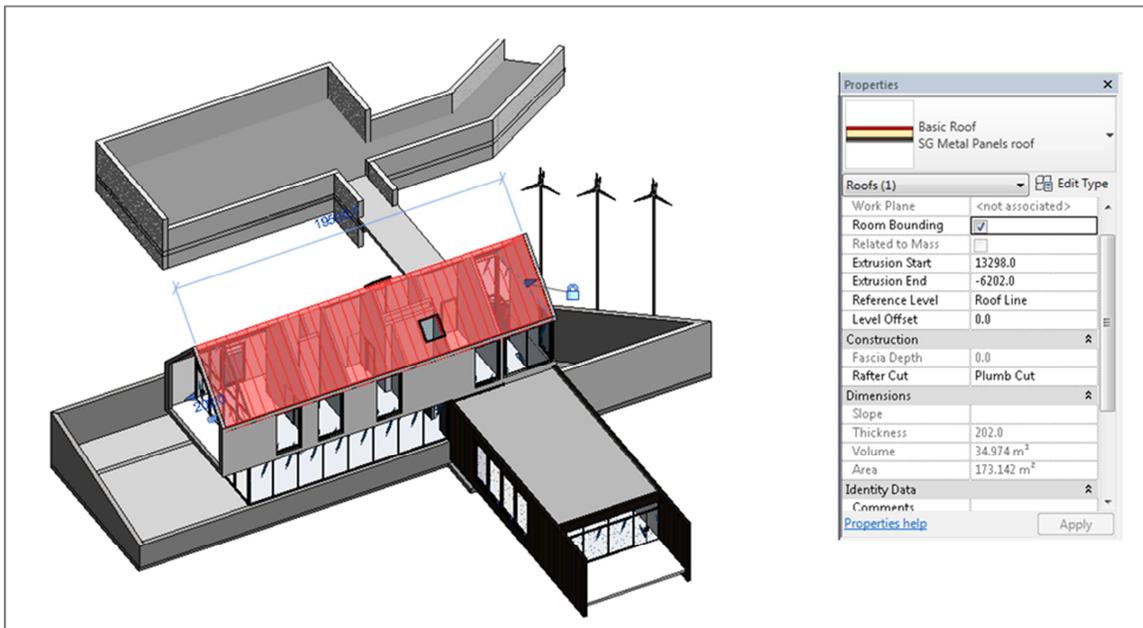
So then back in the Energy Analysis view with the curtain wall selected right click and select all instances in entire project...



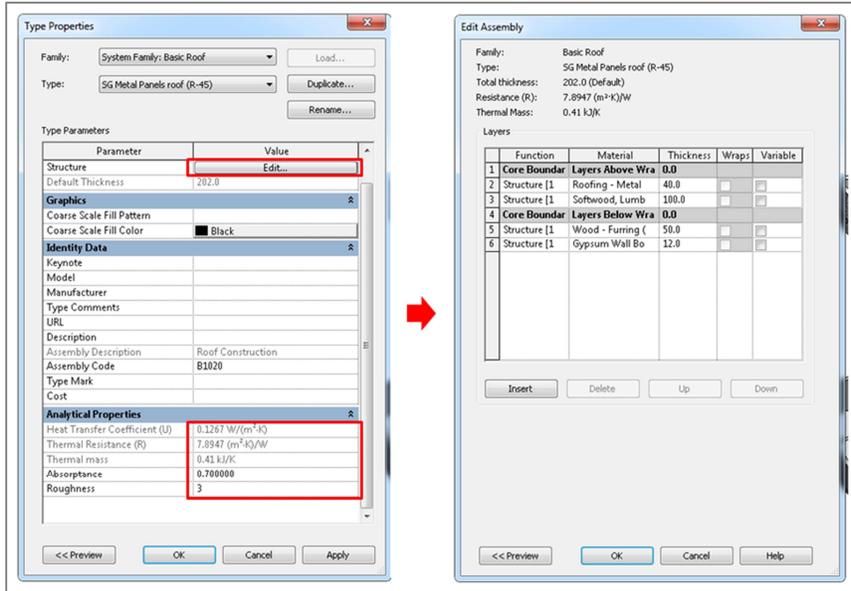
Then from the curtain wall properties change the curtain panel type from the original type to the alternative 'thermal' type that contains thermal properties...



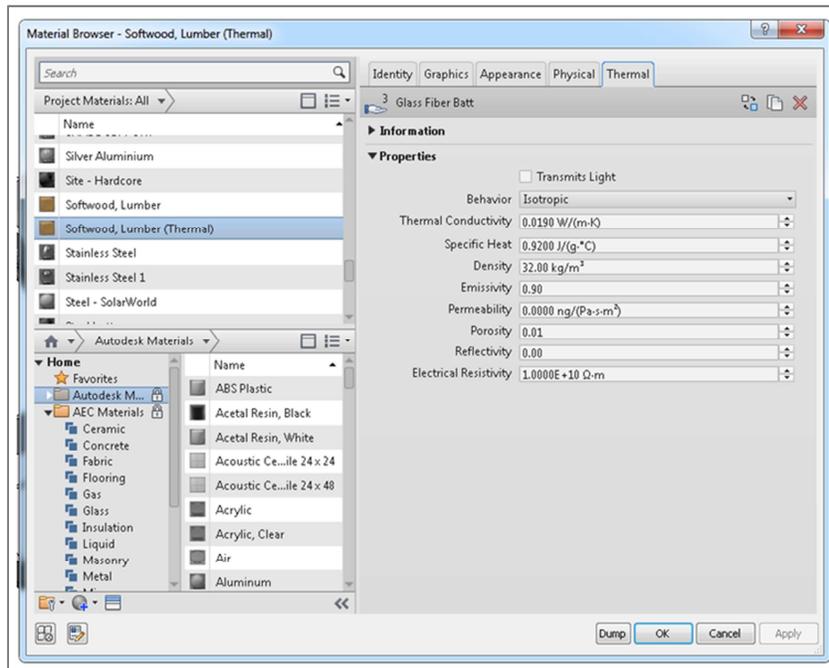
Next, select the buildings pitched roof and note its properties...



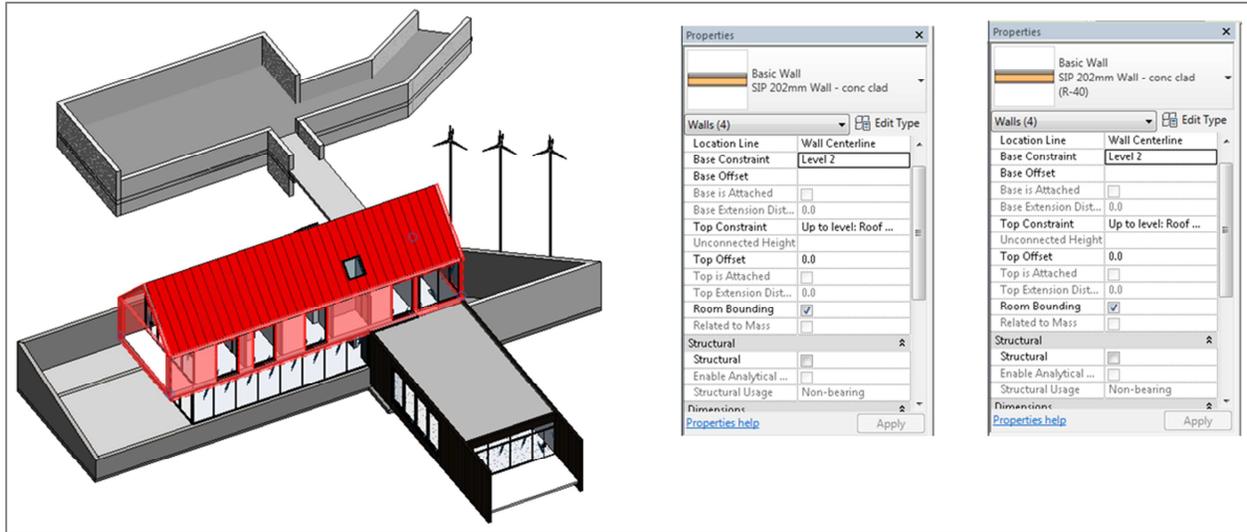
Select roof type drop down and select the same wall that contains thermal properties ('R-45'). Edit Type and you will note the thermal properties of this roof. Selecting edit.. then opens the roofs material layers where thermal properties can be set...



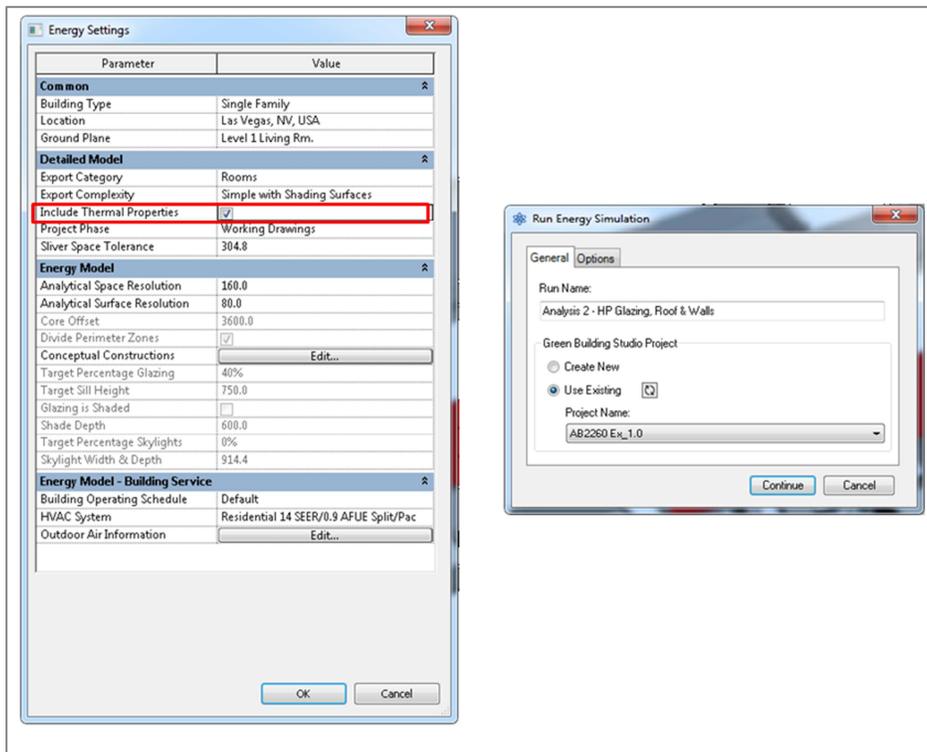
Select the layer 'Softwood lumber' to see its properties. Note that any 'thermal asset' can be associated with any material which facilitates definition of elements for both purposes of documentation and analysis...



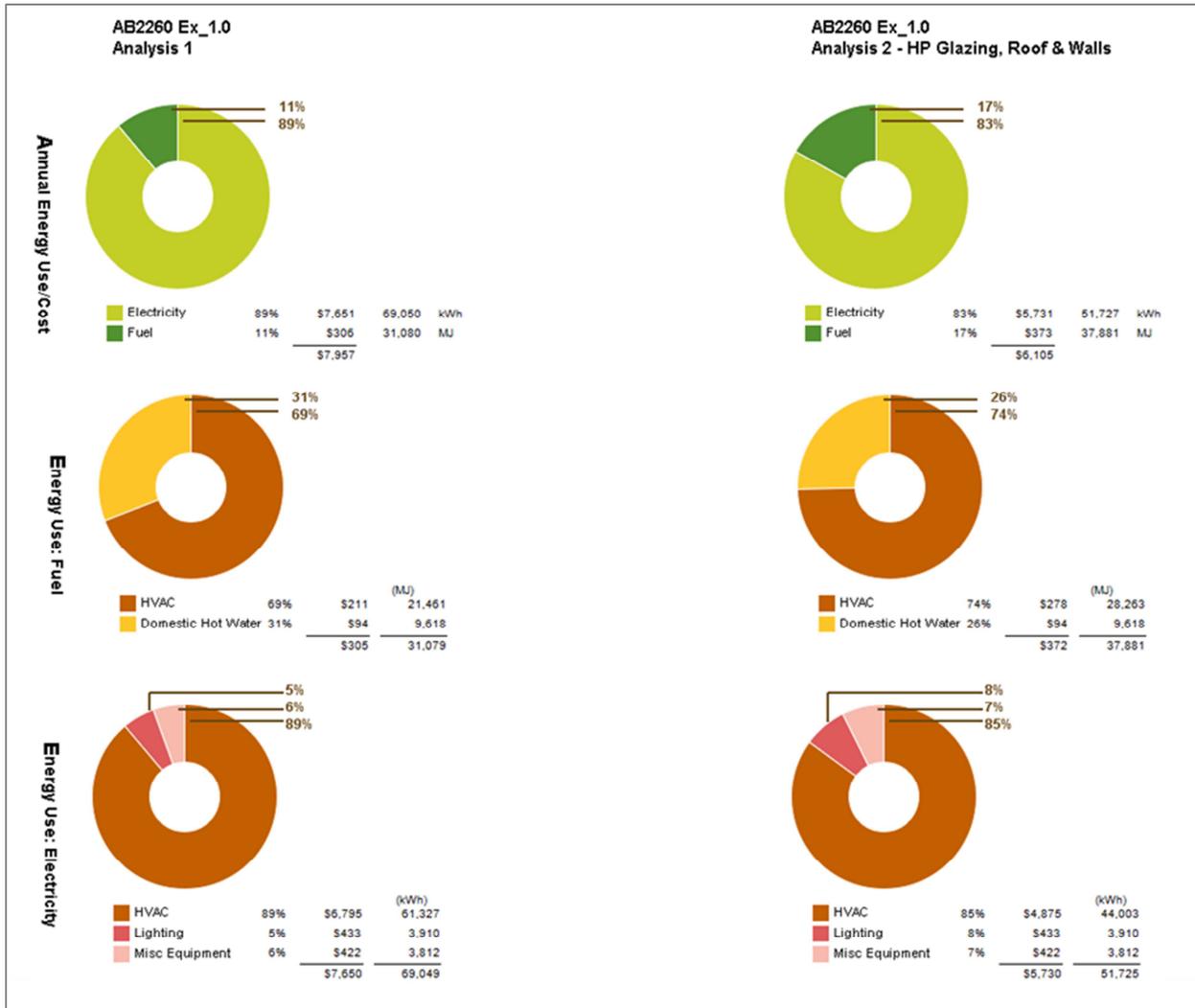
Finally, select one of the main walls in the model, right click to select all in project and then change from the current wall type to the same instance containing thermal properties i.e. 'R-45'...



Finally, before running a simulation open Energy Settings and check the option to include thermal properties and then run a simulation named 'Analysis 2 – HP Glazing, Roof & Walls'...

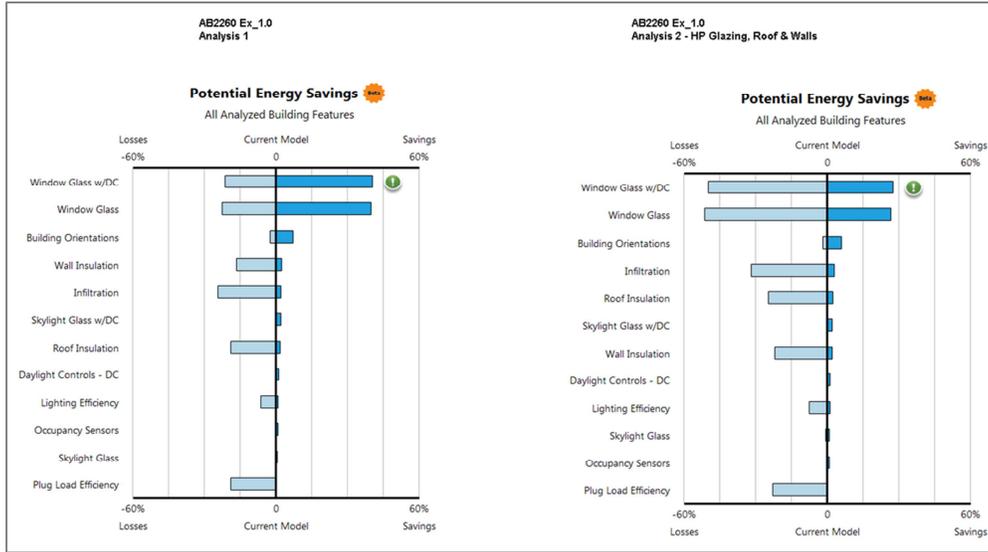


When the simulation is complete select Analysis 1 and Analysis 2 results and look at the total annual energy use / cost to see the difference due to the recently defined higher performing thermal properties of elements...



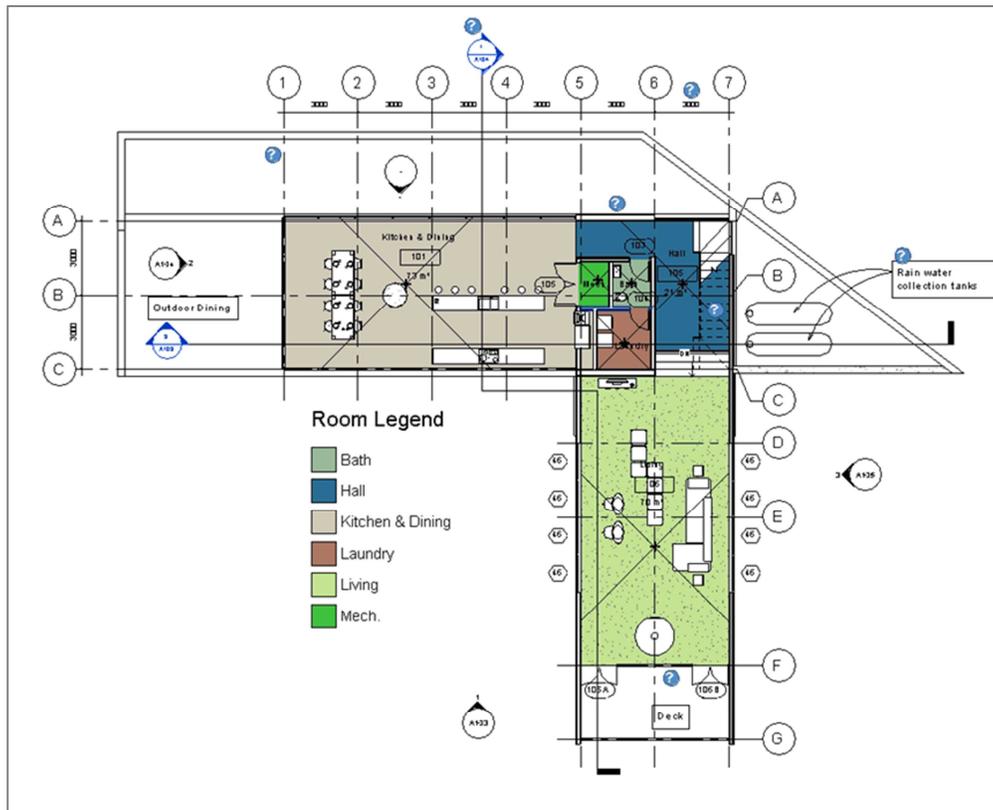
You can also view the Potential Energy Savings chart to see the impact that change has made to energy savings opportunities...

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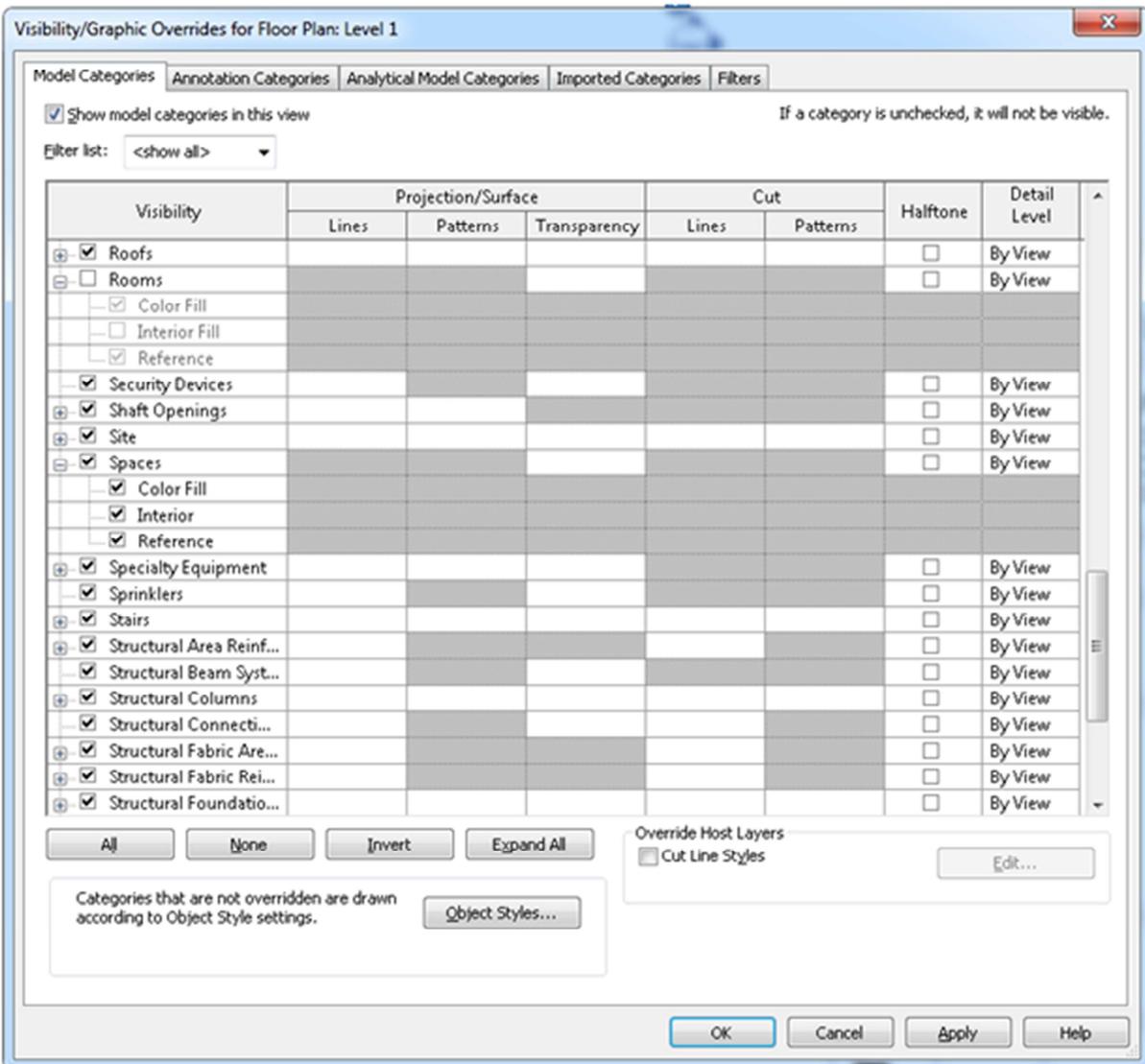


**Exercise 1.2 – Specifying space data**

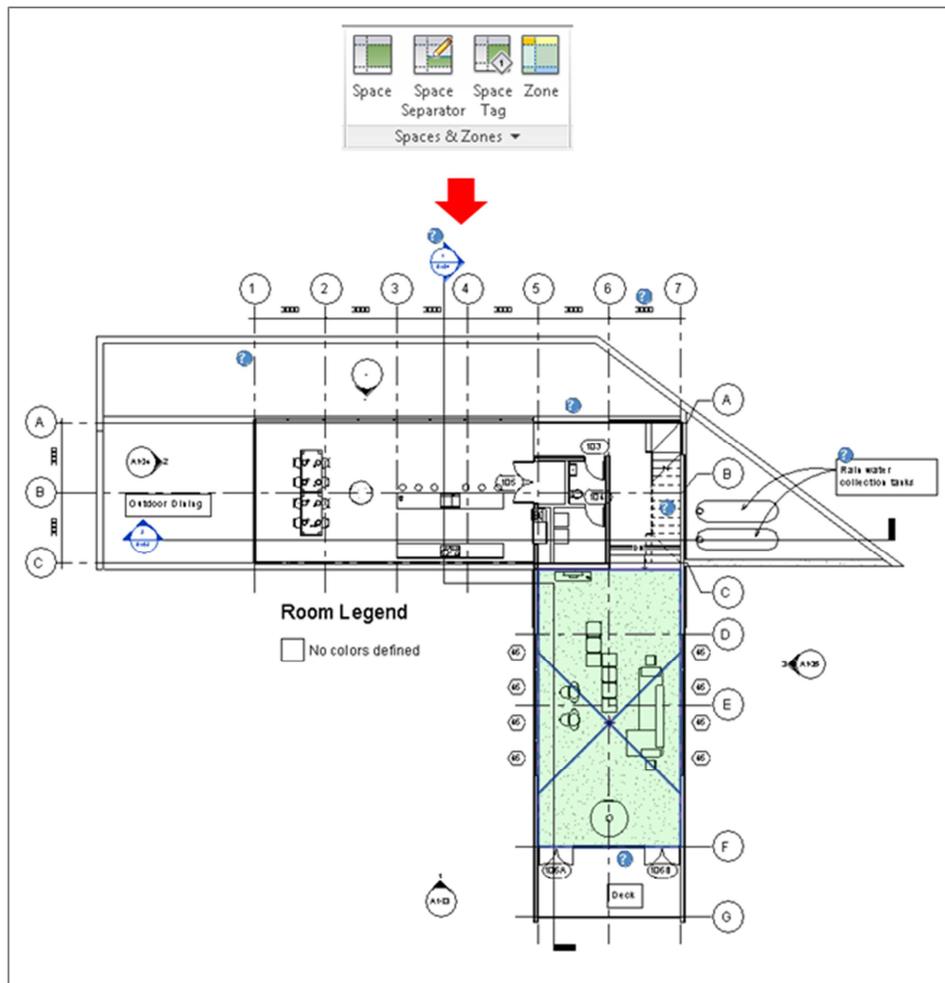
From the project browser the Level 1 floor plan...



Open the Visibility / Graphics dialog and disable Rooms but enable Spaces....

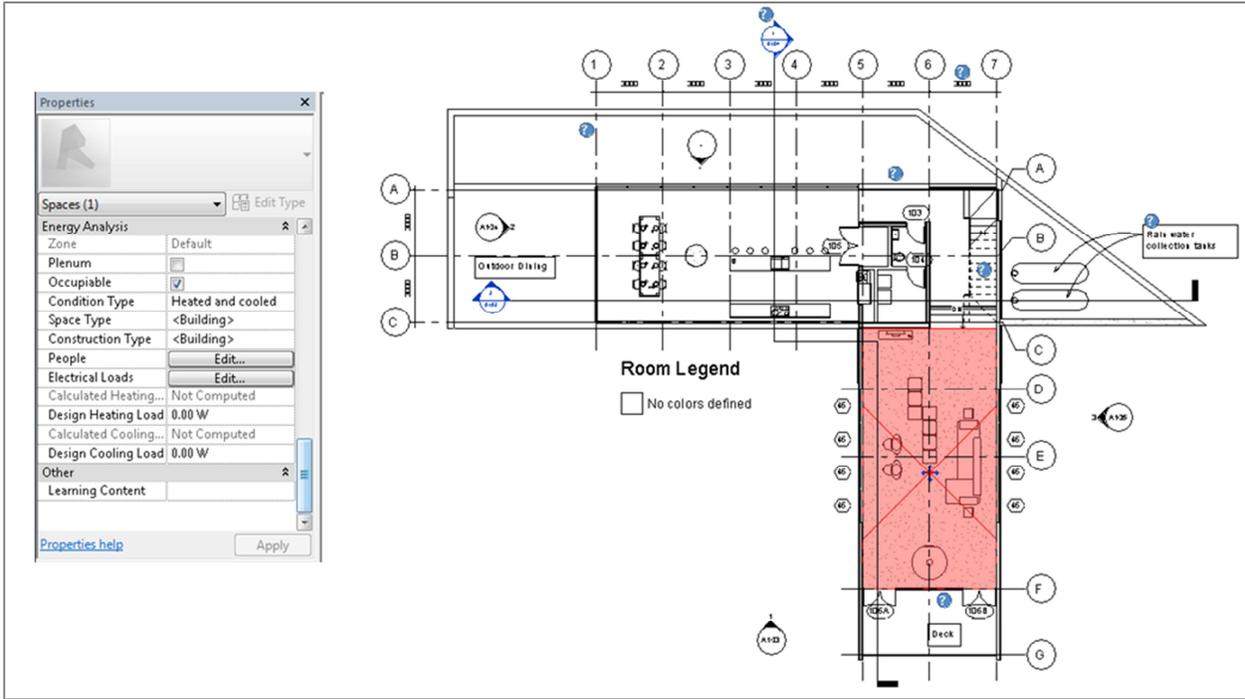


Then from the Analyze menu select Space and add one to the lower level living room...

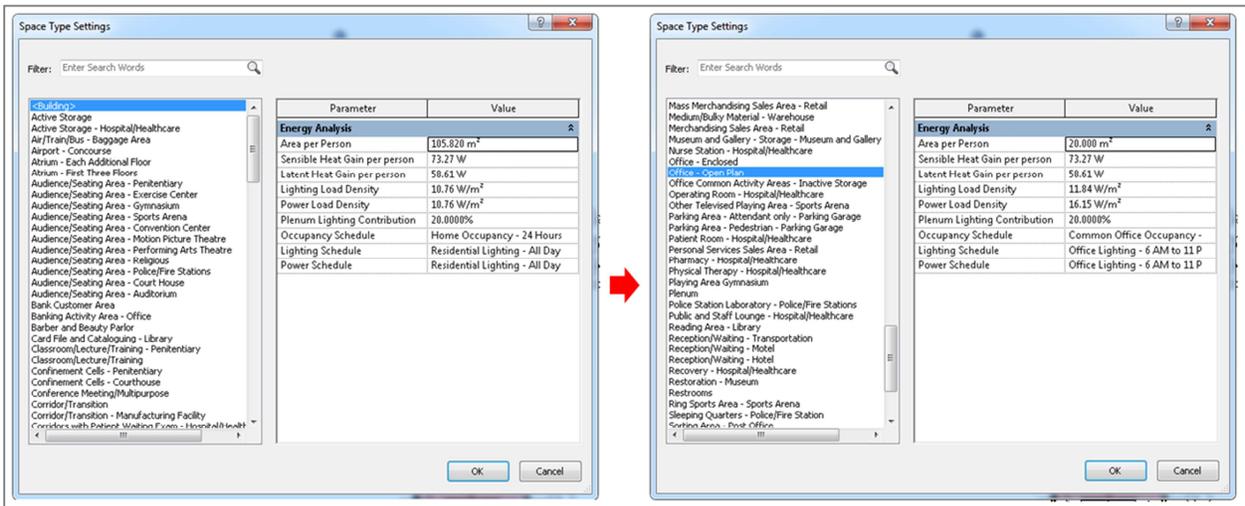


Next, select the space and view its properties....

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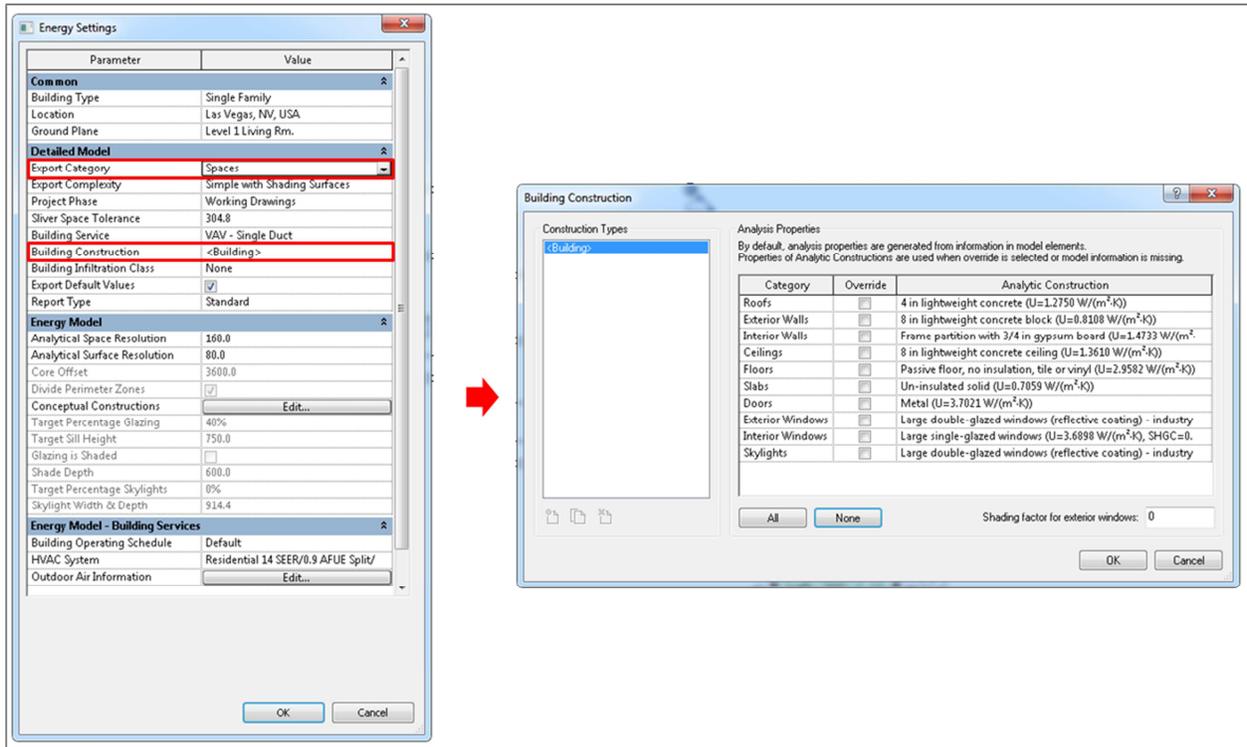


Select Space type and change from <Building> to Office. Note this is purely for the purposes of demonstration - we are making the assumption here that this room will be operated more like an office than a living room. Our goal is simply to show how space data can be used to inform the EAM.

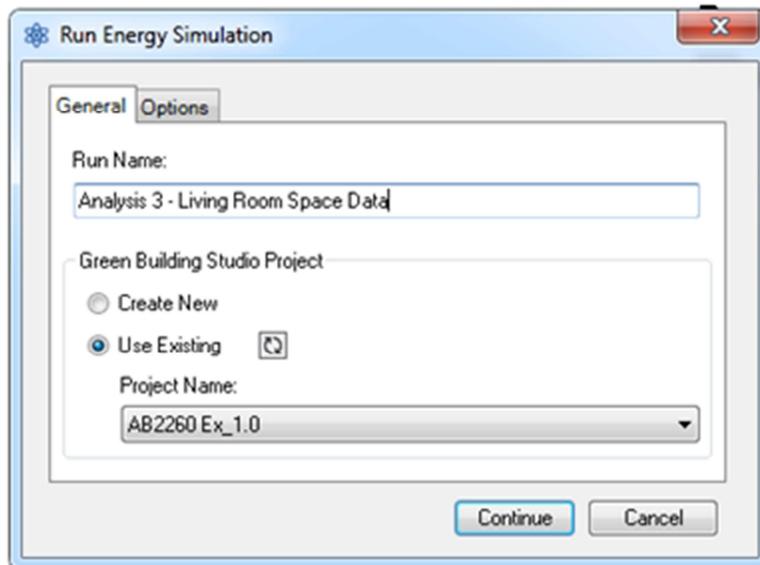


Then in Energy Settings set Spaces for the Export category then open the Building Construction dialog and select None.

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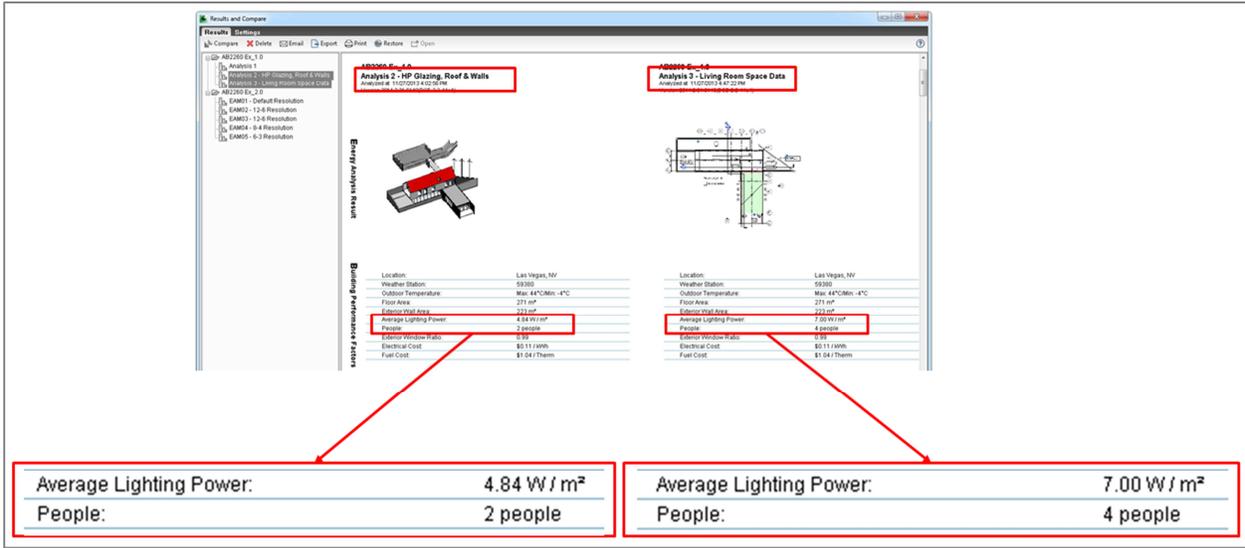


Run an energy simulation call 'Analysis 3 – Living Room Space Data'

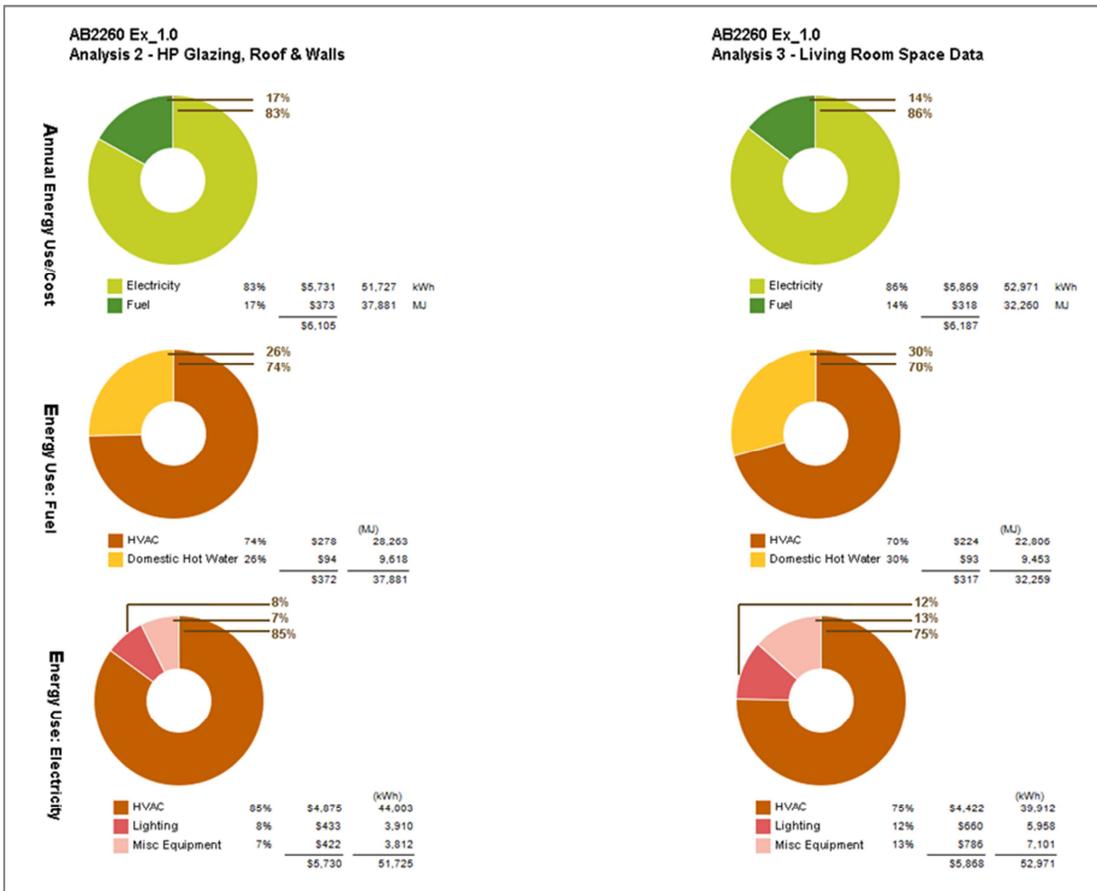


When the simulation is complete compare Analysis 2 and 3 and under Building Performance Factors note average lighting power and people are different (due to specifying the space properties of one of the rooms).

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The impact of this change can also be seen in the annual energy use / cost and cost charts...



Especially Lighting and Misc. Equipment electrical energy use and cost...

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