Autodesk University 2012

Autodesk® 360 Energy Analysis for Autodesk® Revit®: An Introduction to Innovative New Workflows

Ian Molloy – Autodesk

AB2678 New subscription-based features in Autodesk Revit software provide significant enhancements to integrated whole-building energy simulation powered by the Autodesk® Green Building Studio® cloud service. This demonstration will highlight the automatic creation of accurate energy model geometry from detailed Revit software elements, such as walls, floors, roofs, windows, etc. This eliminates the time and effort required to rebuild a separate energy model, leaving more time for design iteration and optimization. This class will also show how other energy analysis data, such as thermal properties of building materials and building/space function, can be defined in Revit for use in the energy simulation and how the Autodesk Green Building Studio cloud service supports a more collaborative energy analysis process between architects and engineers, leading to greater accuracy and better design optimization from the earliest stages in the process. Finally, the extensive validation work conducted on this new feature will also be presented. While knowledge of Revit will be beneficial for attendees, it is not a requirement.

Learning Objectives

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

- Run whole building energy simulation directly from Revit and powered by the Green Building Studio cloud service
- Use certain Revit objects to capture varying levels of detail at different stages throughout the building lifecycle
- Create energy analysis model documentation using Revit views and schedules
- Collaborate with engineers / energy analysts to optimize the design and ensure validity

About the Speaker

Ian Molloy is Senior Product Manager for Autodesk 360 Energy Analysis for Autodesk Revit with over 16 years' experience in the development and application of Building Performance Analysis software.

ian.molloy@autodesk.com

Introduction

First of all thank your interest in my lecture!

Energy Analysis is a truly vast topic and while I've mostly aimed this lecture at those who are new to or have maybe had some experience of it I hope there will be a little something here for everyone.

My goal here more than anything else is to leave you with greater sense of understanding, trust and confidence in what Autodesk 360 Energy Analysis for Revit can actually do and the direction these tools are heading in. In order to do that I will get a little technical at times but my intent is not to baffle but to reveal the amazing power that's all too easily masked by so much complication. It's not the only Energy Analysis you'll ever need but both Revit and Autodesk 360 can play critical roles in reducing the complexity of Energy Analysis significantly and move us all towards delivering better performing buildings faster and easier with greater confidence.

In order to do this I've tackled the four learning objectives above in three main themes:

- **Navigation** – A step by step guide to the basic operation of Autodesk 360 Energy Analysis and Green Building Studio currently available.

- **Validation** – A description of what's behind it all, the intended purpose and how accurate is it (yes, *that* question!).

- **Vision** – A look towards further potential convergence of BIM and cloud based Energy Analysis (please read and note the safe harbor statement).

Disclaimer

We may make statements regarding planned or future development efforts for our existing or new products and services. These statements are not intended to be a promise or guarantee of future availability of products, services or features but merely reflect our current plans and based on factors currently known to us. These planned and future development efforts may change without notice. Purchasing decisions should not be made based upon reliance on these statements.

These statements are being made as of today the 12th of November 2012 and we assume no obligation to update these forward-looking statements to reflect events that occur or circumstances that exist or change after the date on which they were made. *If this presentation is reviewed after the 12th of November 2012 these statements may no longer contain current or accurate information.*

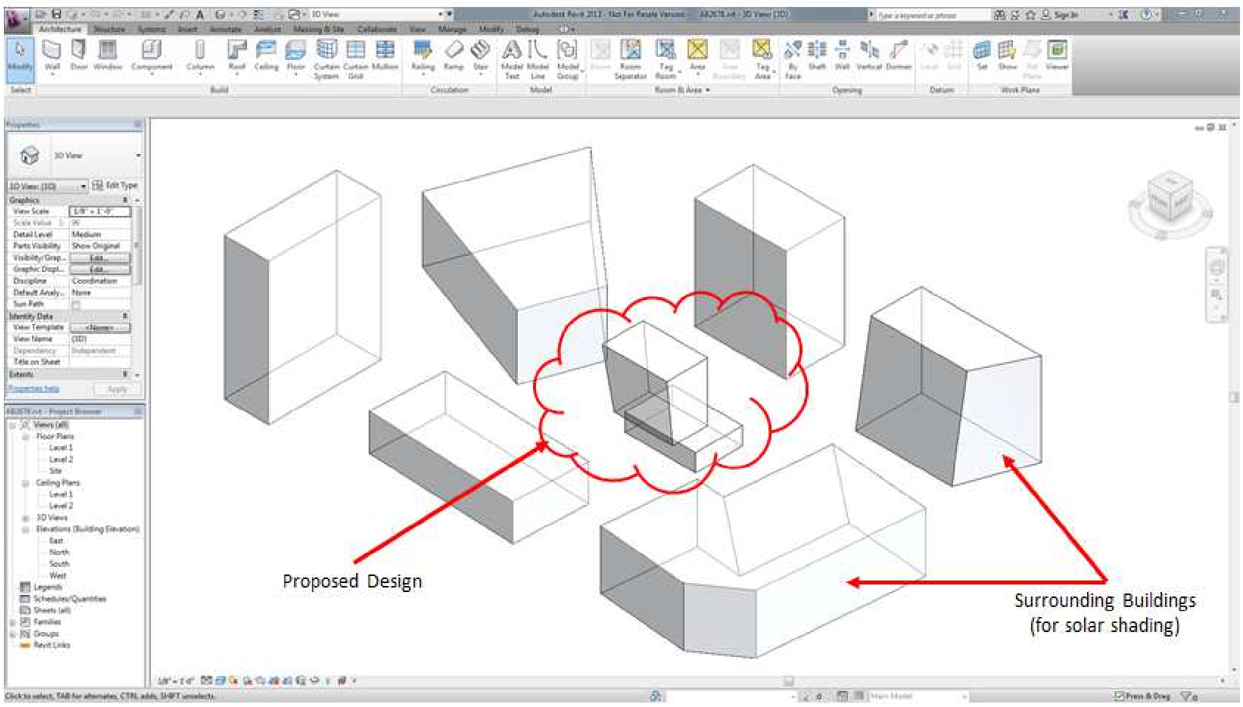
Learning Objective 1 – Run whole building energy simulation directly from Revit and powered by the Green Building Studio cloud service

This section details the essential steps to running an Energy Analysis directly from within Revit, an explanation of what that actually comprises, what it is intended for, how accurate it is and areas of opportunity in the future.

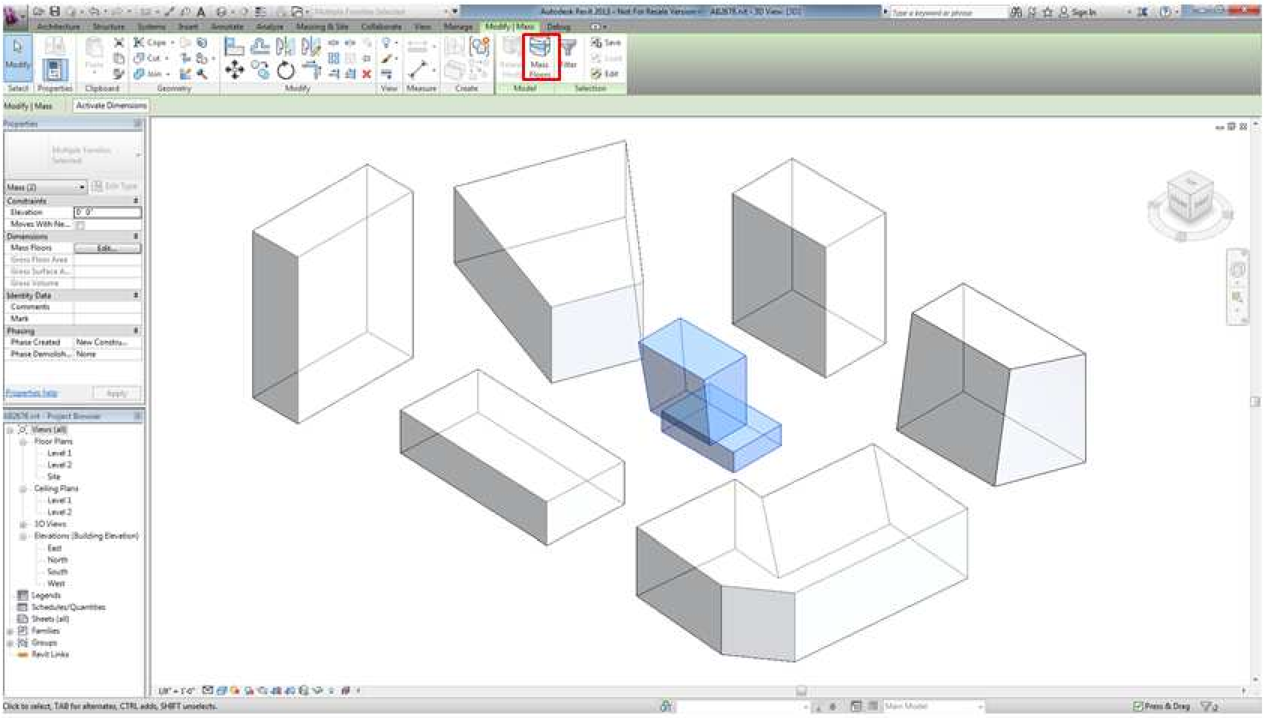
NAVIGATION

1. Start by signing in to Autodesk 360 from Revit…

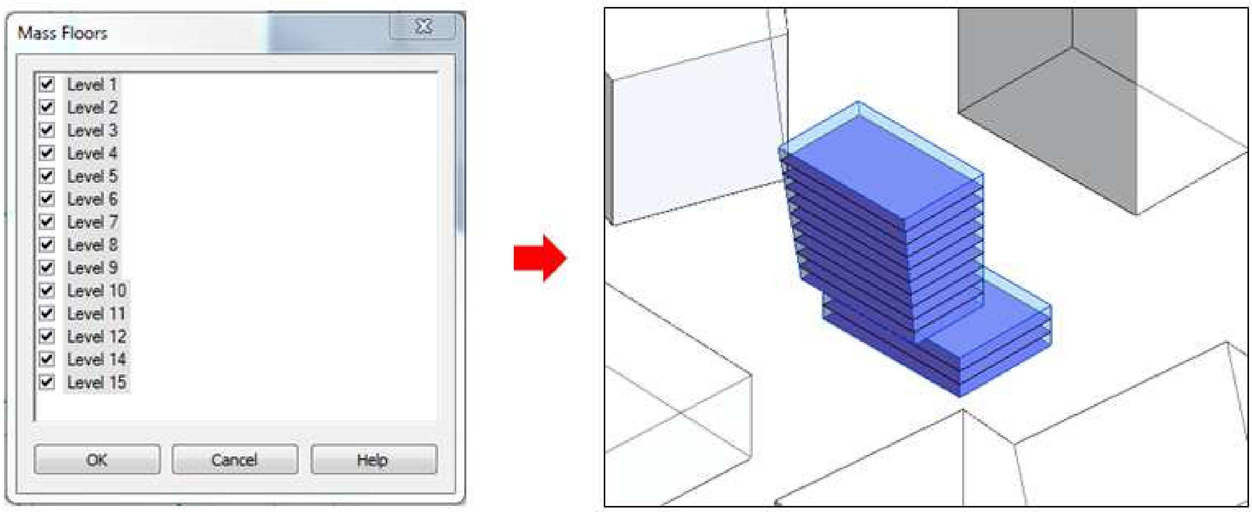
2. Create some Conceptual Massing elements e.g.…



3. Select all of the Conceptual Masses of the Proposed Design and select Mass Floors…

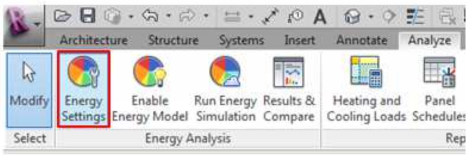


4. Then enable Mass Floors on Levels…

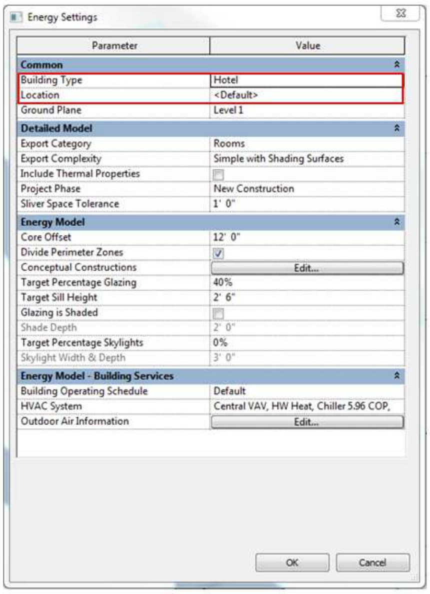


Note: Energy Analysis is only conducted on Masses with Mass Floors Enabled. All other Masses are considered as shading.

5. Go to the Analyze tab, find the Energy Analysis panel and select Energy Settings…

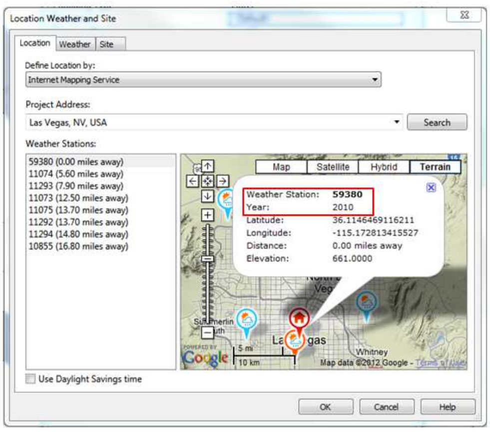


6. In Energy Settings, set Building Type and Location (at a minimum for now)…



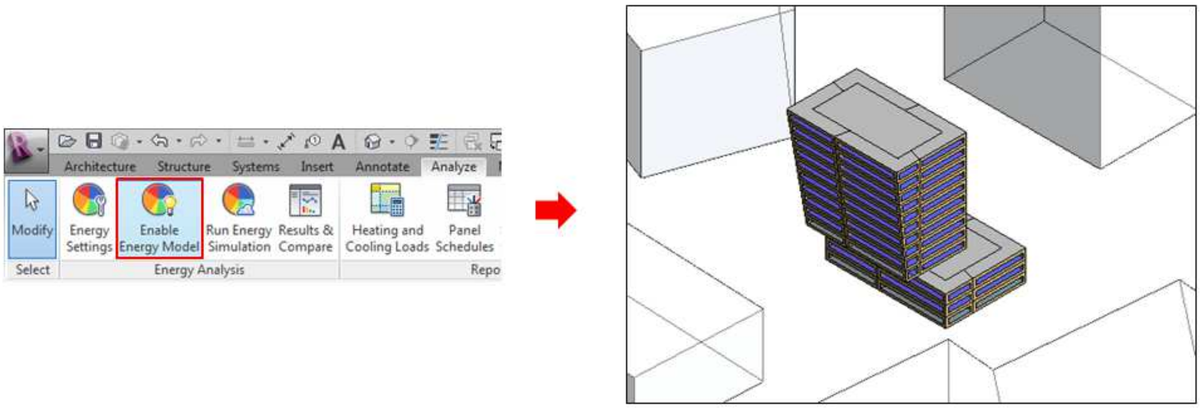
Note: Setting the Building Type sets ASHRAE 90.1 datasets for Occupancy, Lights etc.

7. Set location and climate data…



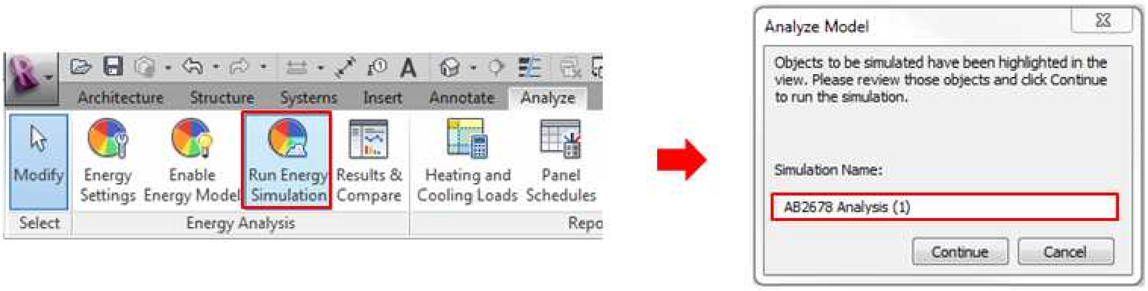
Note: Weather stations starting with ‘59’ indicate TMYs (Industry standard reference files).

8. Select Enable Energy Model…



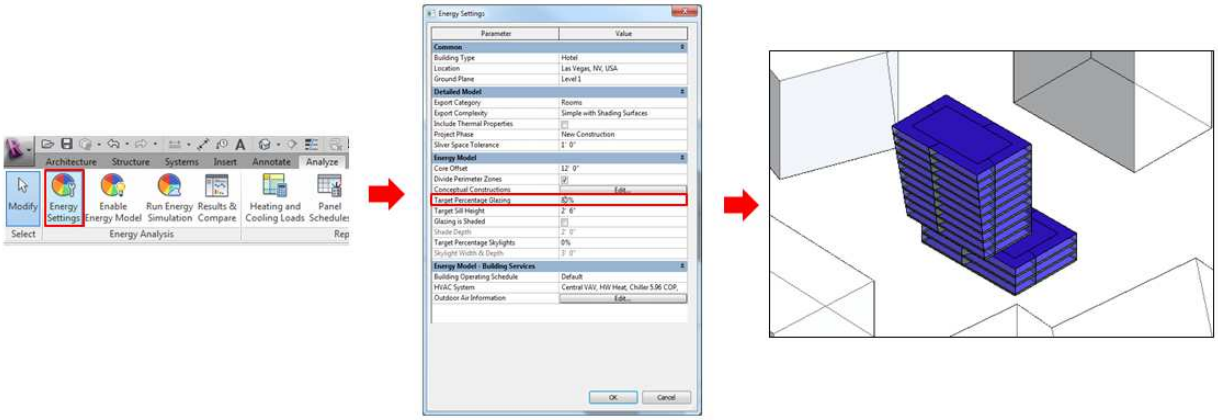
Note: Enabling the Energy Model applies thermal zoning, glazing % etc. settings to the Conceptual Mass elements.

9. Select Run Energy Simulation and (optionally) name the analysis run…

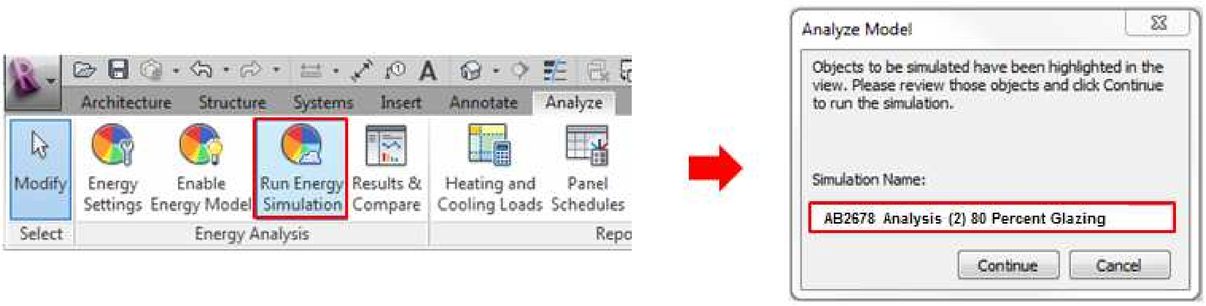


10. Note the progress bar showing the model being uploaded to Green Building Studio…

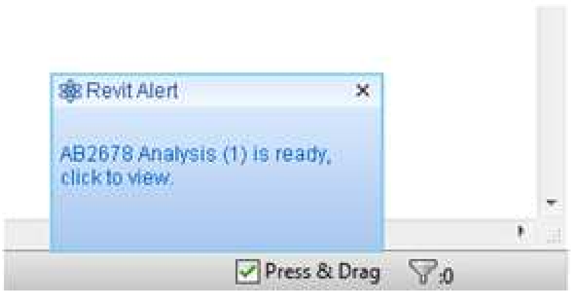
11. Once the upload is complete the simulation runs on the cloud in the background leaving you free to continue working in Revit. Energy Analysis is all about comparison and relative differences so while that runs let's make a simple change and send another run. Go to Energy Settings and set Target Percentage Glazing to 80%...



12. Then Select Run Energy Simulation again and name the run…

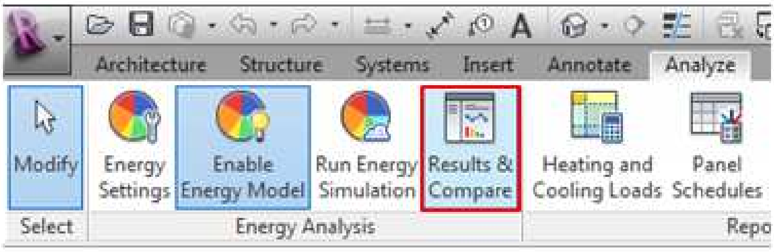


13. Revit will then alert you when simulations are complete.



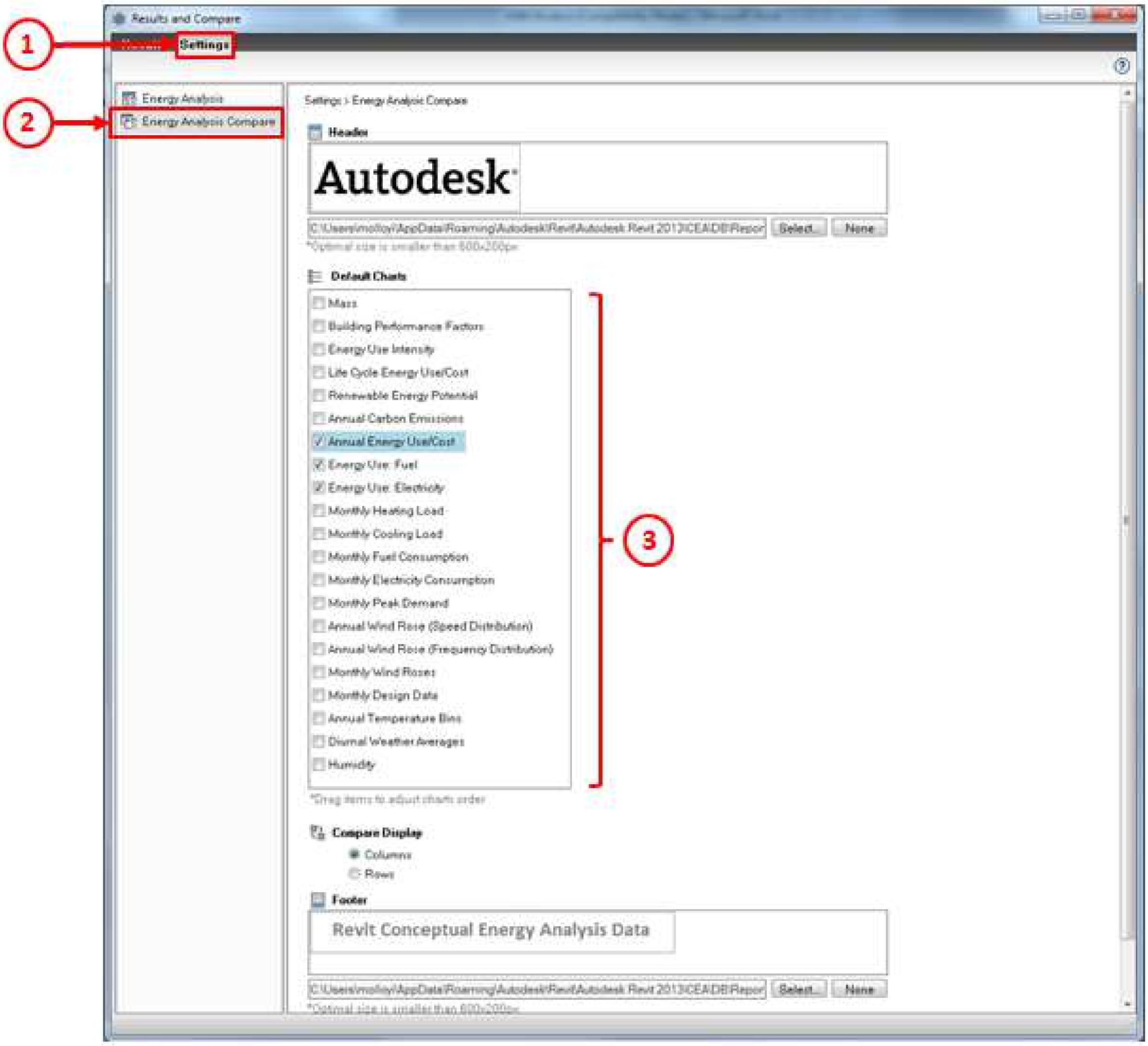
Note: Simulation time depends on model size and complexity. They typically take just a couple of minutes but large complex models can take up to an hour.

14. Once complete select 'Results & Compare…

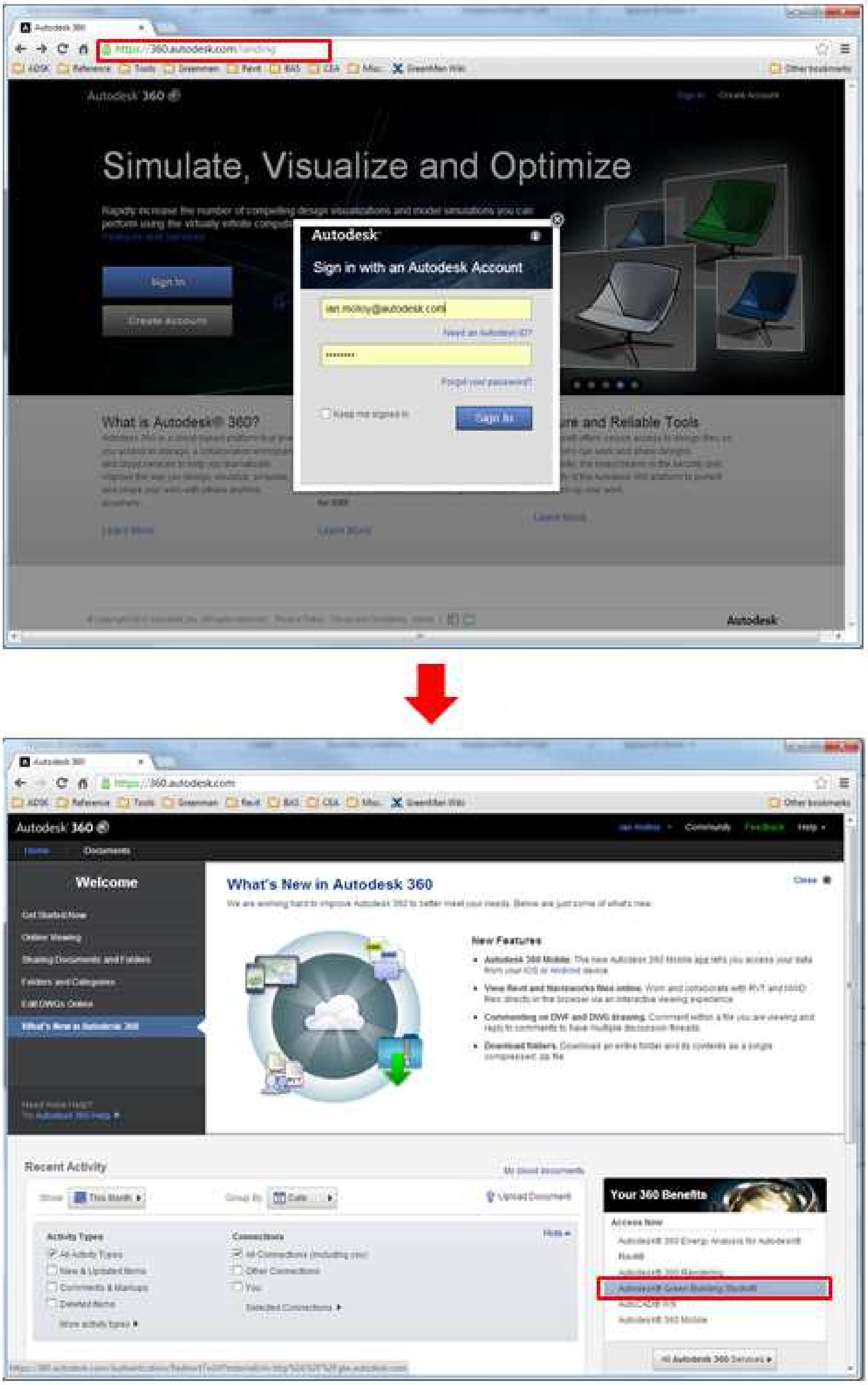


15. Then (1) select both results, (2) select compare and then (3) scroll to view / focus on specific results. Here I'm showing Annual energy Use/Cost and the difference between 40% and 80% glazing can be clearly seen (4)…

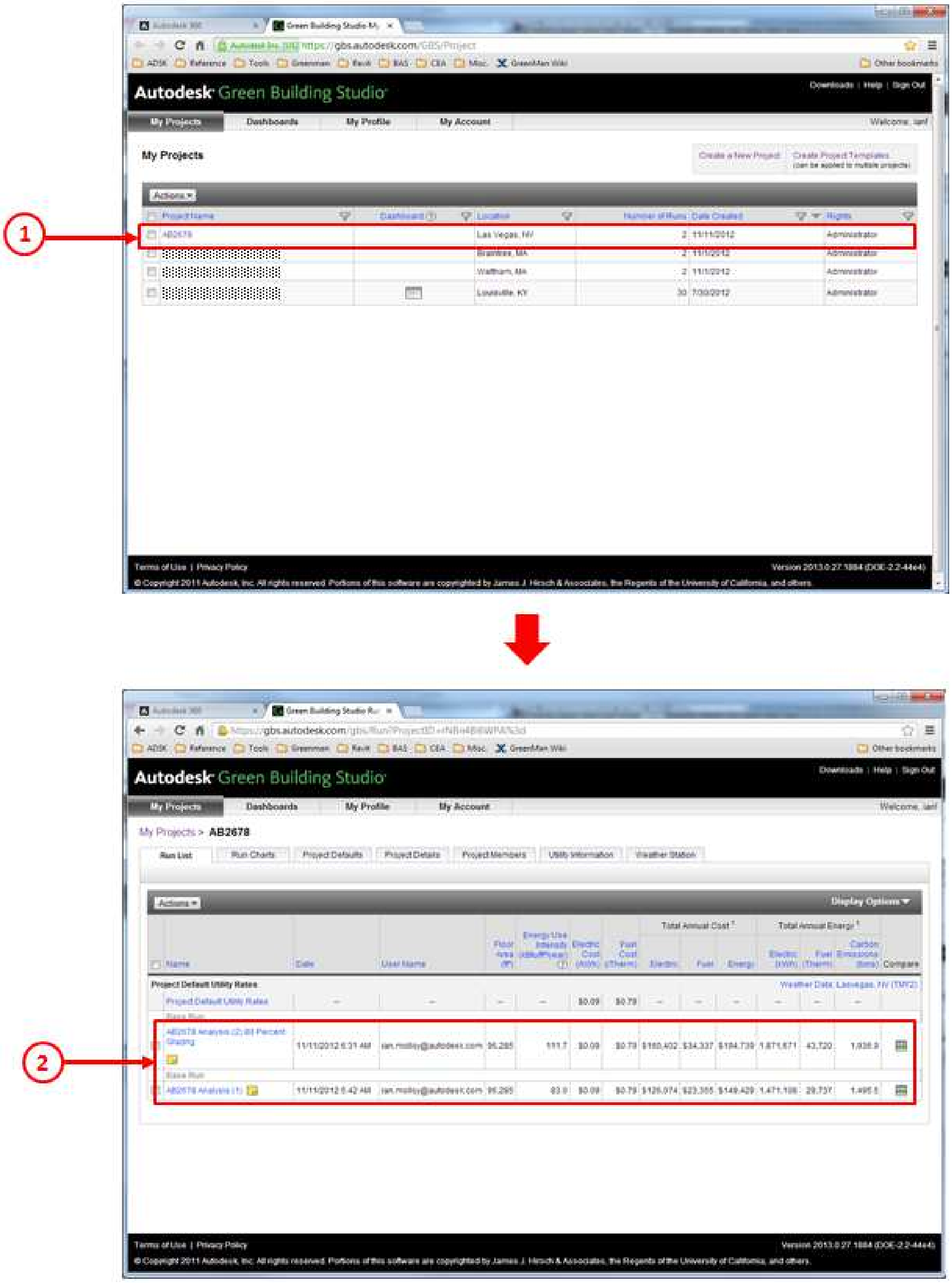
16. If you like you can customize the results and order shown by (1) selecting settings, (2) select ‘Energy Analysis Compare’ and (3) Enable, disable and order the results as you wish. I tend to focus on those shown enabled because they provide the best overall indicator of performance…



17. In order to see more the detailed results stored on Green Building Studio open a web browser and go to https://360.autodesk.com sign in and select Autodesk Green Building Studio from Your 360 Benefits…


Autodesk 360
Simulate, Visualize and Optimize
Autodesk
Sign in with an Autodesk Account
Sign In
What is Autodesk® 360?
Autodesk
Autodesk 360
Welcome
What's New in Autodesk 360
New Features
Recent Activity
Your 360 Benefits

18. Green Building Studio then shows all of your analysis projects (1) and analysis runs (2)…



VALIDATION

So what exactly is the ‘Energy Analysis’ provided by Autodesk 360 for Revit? How accurate is it and what can it tell me about my design?

Over the years I have heard many things called ‘Energy Analysis’. Unfortunately given such a large and complex domain combined with bad experiences of many who have dabbled the strength and value that really does exist is all too easily obscured or quickly cast in to doubt.

Now while I don’t own the term Energy Analysis my opinion there really is only one class of Energy Analysis that provides a level of strength and value far above anything else and that is ‘dynamic thermal whole building energy simulation’. Yes, that’s quite a mouthful but don’t be put off, I’ll try to explain it clearly here.

Firstly though, in order to illustrate my point above and help describe what Autodesk 360 Energy Analysis is the following is a quick rundown of some things that are often confused with or done in place of ‘real’ Energy Analysis. Note that my intent here is not to knock these types of analysis; they have their roles to play. Instead I simply want to use them to position the Energy Analysis we’re focused on here.

Climate Studies

Extensive climate data is readily available for almost anywhere in the world today and it’s very common, almost expected, to see tables, graphs etc. of climate data in a concept / scheme design stage report. While these can sometimes provide pointers to certain design opportunities and strategies more often than not they don’t really tell anyone anything and are really just there to give the impression that the building has been designed in response to the climate. The data itself however though is extremely important and a critical part of Energy Analysis.

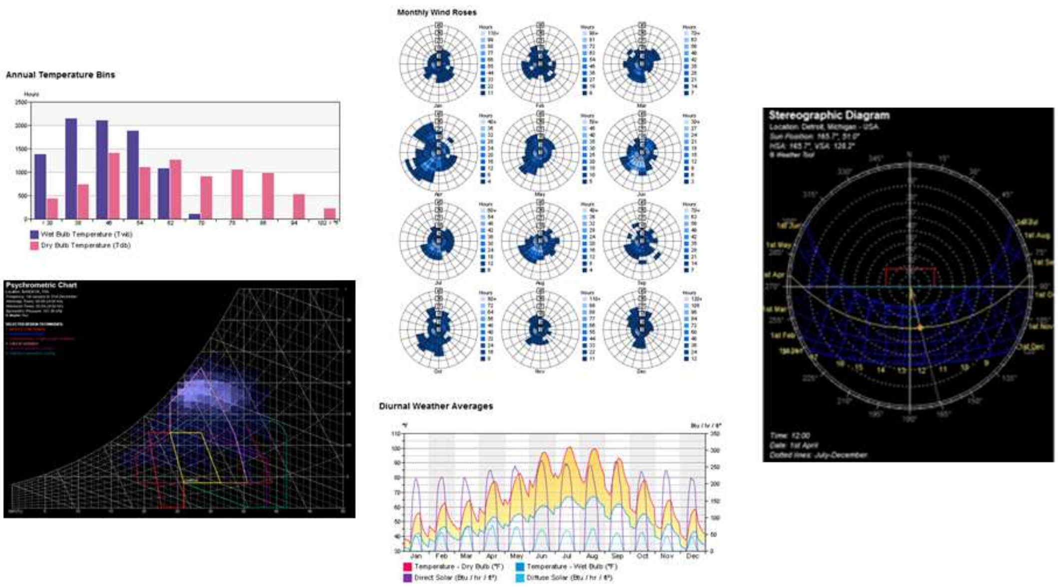


Figure 1: Climate Studies – Valuable data but doesn’t inform much on its own

Solar Shading Studies

There are many tools available today that can provide graphical and numerical simulations of building shading and insolation. After all, the data and mathematics involved are reasonably straightforward. Once again these do have very valuable uses like for siting and sizing solar panels but by focusing on a single climatic force when there are many others at play along with the buildings own dynamics this does not provide an holistic insight into performance and opportunity. As a result I am sorry to say these are unfortunately all too often largely another ubiquitous nod to sustainable design found in concept and scheme design stage reports.

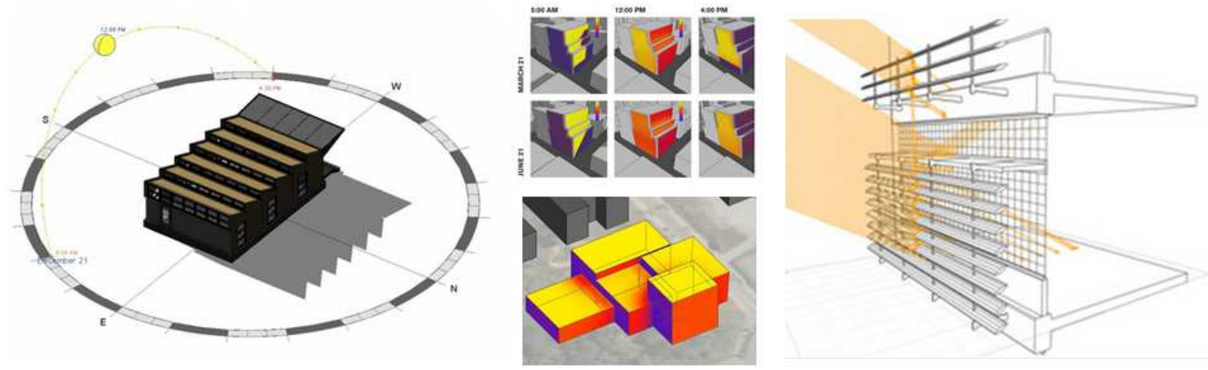


Figure 2: Solar Shading Studies – Easy to do and visually compelling but narrowly focused

Lighting Simulation

Artificial lighting is a major end user of energy in buildings and daylight is a key strategy for minimizing it. As such it's very important to consider and there are many tools available that can help with that. The focus of these tools is light itself, how it enters and reflects in the building. While these tools can provide valuable information to inform Energy Simulation on their own they do not determine lighting system energy use directly.

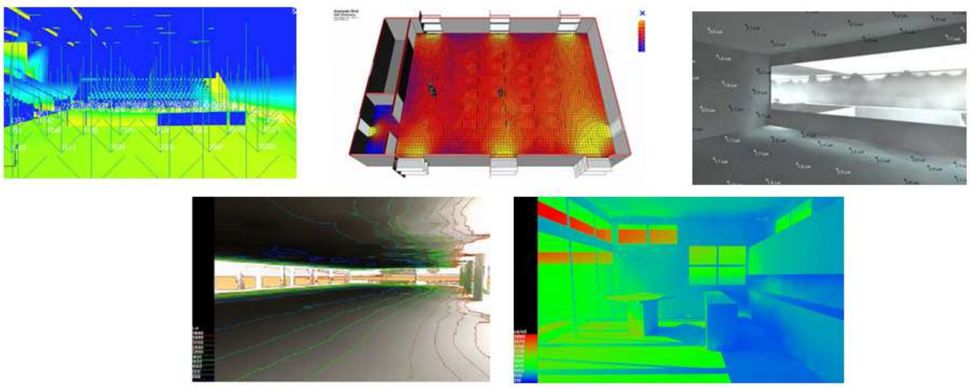


Figure 3: Lighting Simulation – Critical for optimizing daylight but doesn't compute energy directly

Computational Fluid Dynamics (CFD) Simulation

This is a huge domain in its own right with many valuable applications to buildings. Much like solar shading studies and lighting simulation the main strength and draw of CFD is how its output clearly reflects the nature of the subject matter i.e. the movement of air and heat. While this can give the impression of the ‘ultimate’ building performance simulation it’s important to remember these are snapshots over very small periods of time requiring many assumptions. CFD studies are typically done separately on the building exterior or interior. Exterior can provide an insight into the buildings pressure envelope, pedestrian comfort and contaminant dispersal. Interior provides an insight into the movement of air and heat at a microscopic level so good for detailed design decisions and fine tuning like air system supply/extract design. While CFD simulates air movement in detail and some of the wider thermal characteristics of the building structure and operation it does not determine energy use.

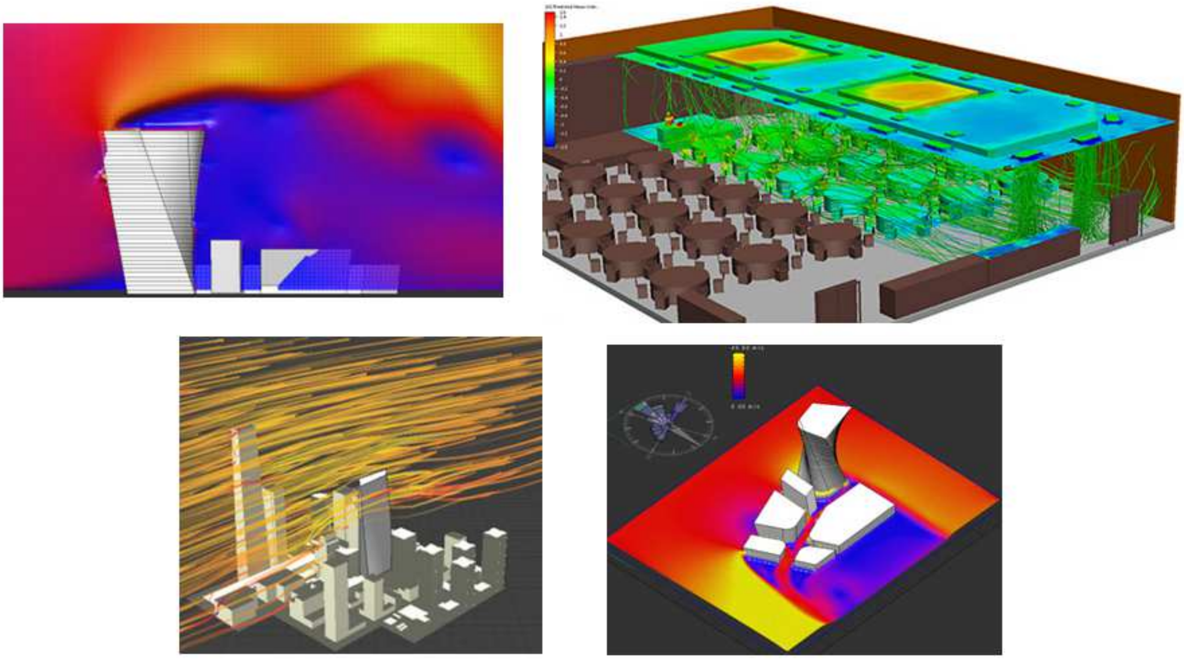


Figure 4: CFD Simulation – Great for exterior airflow and fine tuning HVAC at specific instants in time

‘Steady state’ Heating and Cooling Load Calculations

These are the typical minimum standard of care for a Mechanical Engineer selecting and sizing an HVAC system. While these often share much of the same information as an Energy Simulation the big difference is essentially in how the thermo-dynamics of buildings are represented. ‘Steady state’ basically means an ‘idealized snapshot’. The origins of these tools actually go back to calculation method that could be performed manually. As such many shortcuts needed to be taken and wherever that was done margin safety margin was built in. Add to that the safety margins built into most engineer’s assumptions (peak outside temperature, coinciding with peak occupancy, peak equipment and lighting etc) plus a final ‘safety factor’ for good measure and it’s no wonder these tools and processes are responsible for significant equipment over sizing, in the order of 100-200% across the industry. These tools cannot provide an accurate estimation of annual energy use.

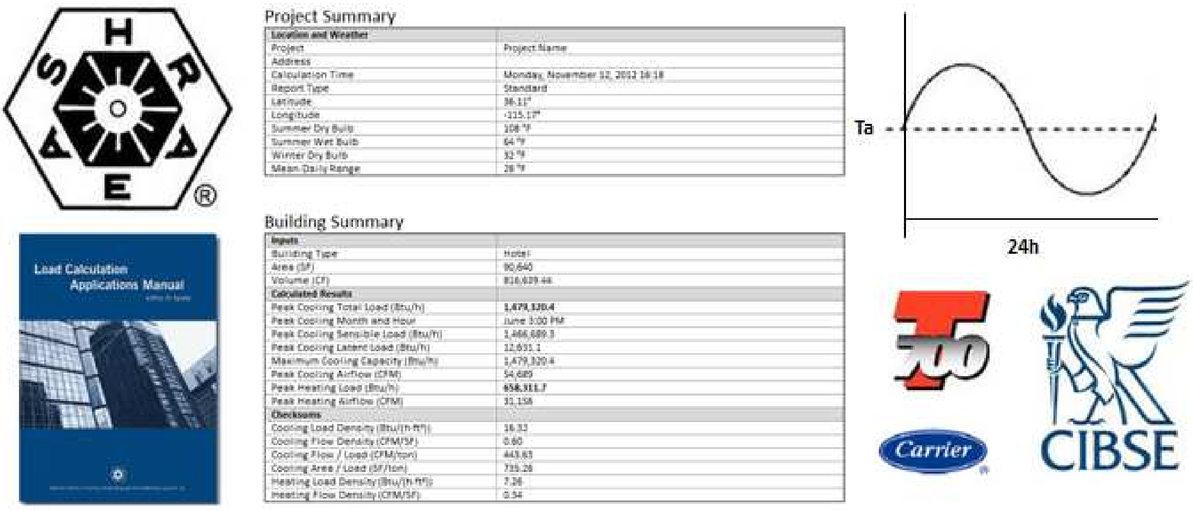


Figure 5: Heating and Cooling Load Calcs – Highly simplified snapshots with a bias to over estimation

Miscellaneous Other / Custom spreadsheets

You only have to go to the [DOEs Building Energy Software Tools Directory] to see the vast array of tools that have been developed over the years relating to 'Energy Analysis'. Add to that the countless efforts made by many individuals and firms, either through enthusiasm but more likely frustration with other tools, to create their own. The important thing to remember with many of these tools is that each were borne out of a specific need or goal, perhaps in a specific market. From there they either remained much the same or were gradually added to until they become almost full building energy simulations, but not quite. Each also has its own unique concepts, UI and data model and this makes for a long term learning and not much doing.

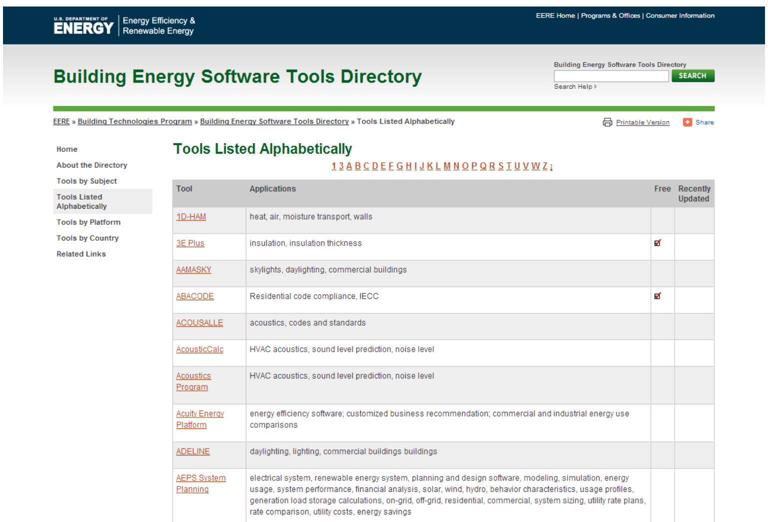


Figure 6: The DOE Building Energy Software Tools Directory - ?? tools listed (Nov-12)

Energy Code / Green Building Rating Systems Compliance

On top of the fundamental complexity of the building energy use and the range of tools available local Energy Code Compliance, Green Building Rating Systems and other industry initiatives all add a further layer of complexity to the mix. In fact the success of LEED itself has largely driven the definition of 'Energy modeling' itself. While many of these do utilize Energy Simulation the focus is more on carefully following a prescribed path and set of assumptions used to create a notional baseline to compare to. One of the big challenges with things like LEED energy modeling is that it's difficult to apply to the early stages of design when most opportunities exist.

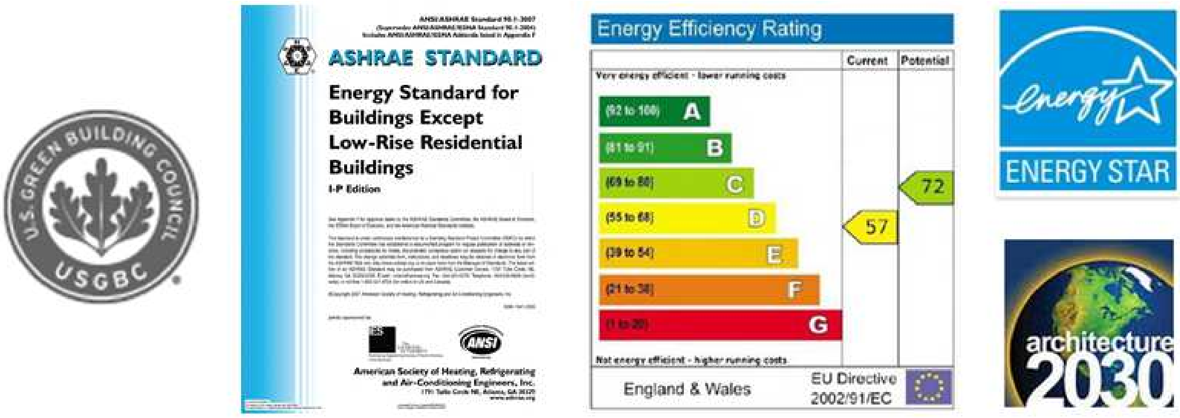


Figure 7: Energy Code / Green Building Rating Systems – Highly prescribed methodologies

Autodesk 360 Energy Analysis – Dynamic thermal whole building energy simulation

In reality there really are only a handful of complete dynamic whole building energy simulation engines available today with DOE2 and EnergyPlus being by far the two most widely used, capable and well validated. Green Building Studio, the cloud service behind Autodesk 360 Energy Analysis uses DOE 2.2. While DOE2 does have a number of limitations compared to EnergyPlus, DOE2's big advantage, especially for early stage design is that it is extremely fast with simulations usually taking minutes instead of hours. The key aspects that really define an Energy Simulation are:

- The whole building is represented as a set of discrete spaces or 'thermal zones' that exchange heat with one another and the external environment.
- Hourly climate data is used, specifically including air temperature, relative humidity, direct and diffuse solar radiation, wind direction and wind speed – all the key things that drive a buildings energy use.
- All sources of heat gain/loss, the paths of heat transfer via conduction, convection and radiation and how they vary over time (hence, dynamic) are captured in detail using finite element computational methods

Figure 8 below helps to illustrate all of the components and interactions captured by an energy simulation like DOE2. Don't worry if you can't follow it yet, I'll explain in my presentation better.

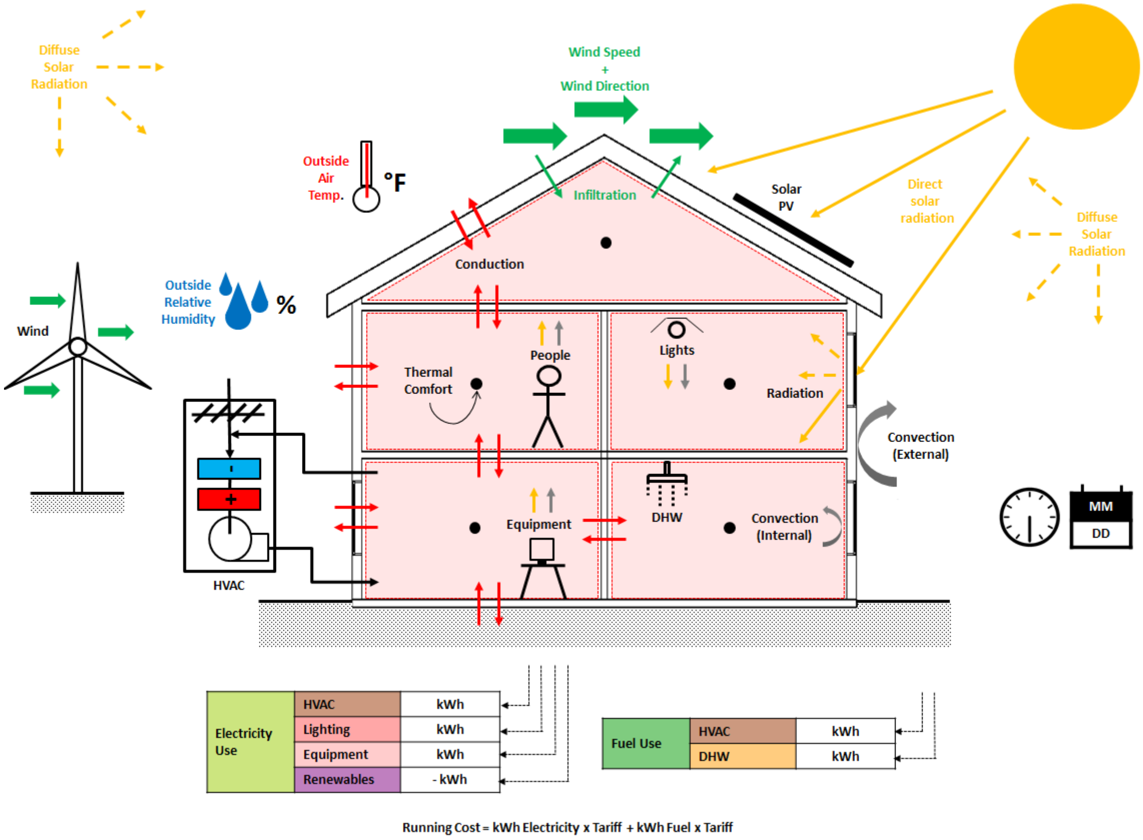


Figure 8: Dynamic thermal whole building energy simulation – Captures all this varying over time

Looking at this diagram you can see that virtually all of the ‘Energy Analysis like’ things I listed earlier are actually a fundamental component of energy simulation i.e. annual climate data, solar shading, lighting / daylighting, infiltration/convection, heating and cooling demand. Then of course don’t forget the component of time, which is usually a full year at hourly intervals. The real strength and value of energy simulation is therefore in having this complete, integrated picture of all the parts and processes in the building, how they interact and what the net result in end energy use terms are. For example why try to optimize a solar shade design for incident radiation when the actual energy use impacts can be determined? The only real short fall with energy simulation is its own complexity and given that energy is invisible the output is generally numerical and therefore not as meaningful as other analysis. It is however by far the most valuable.

How accurate is it?

I really love this question. Unfortunately though there are no easy answers, unless you’re just willing to accept me saying ‘trust me, it’s good’, in which case we can all go home, but somehow I doubt that’s going to happen!

In the limited time we have available here I can only go into this so much detail but given the better appreciation you should now have of all the energy flo paths and processes Energy Analysis actually comprises I hope we can build upon that to provide you with a good sense of what can be expected from A360 Energy Analysis for Revit and therefore give you more confidence in using it.

To start with, it's very important to differentiate between 'computational accuracy' and 'informational accuracy'. That might seem obvious but the issues are often conflated and lead to 'I just don't trust it and so won't use it' far too quickly.

Computational accuracy

This essentially relates to all the physics, math and programming involved in capturing everything contained in Figure 8. The reality is the vast majority of the algorithms and engines have been around for a very long time and are well understood and proven. DOE2 for example has been around for over 30 years and is extremely well tried and tested. That said there are many cases or conditions that create challenges for energy simulation, certainly at least not without significant skilled user intervention to create a workaround. These shouldn't necessarily undermine confidence in the analysis completely but are worth bearing mind. If in doubt, seek advice.

- Large and / or highly glazed open spaces – Spaces like atria and double skin facades are 'thermally complex' and difficult to capture effects like stratification.
- Advanced materials and HVAC systems (DOE2 especially) – things like phase change materials, green roofs and radiant heating/cooling systems cannot be modeled completely.
- Infiltration and Natural ventilation – These are treated very simply in most energy simulations and require fairly significant time and skill.

Ultimately no simulation is perfect but Measurement & Verification work has shown that where simulations are calibrated to account for the buildings built state and actual operating conditions accuracy is typically well within +/- 5%. Of course the key to achieving that level of accuracy is having the right information, which nicely brings us on to our next topic.

Informational accuracy

What should be clear by now is that information – the data and assumptions used in energy analysis is by far the weakest link relating to the question of accuracy. I find a good way to understand this better is to break down the main drivers of energy use in buildings, much like what's shown in Figure 8 but in simple logically grouped buckets and then map these to the design and operational components and datasets used. See Table 1 below for an illustration of this.

Main Energy Use / Cost Drivers	Relevance	Main Components	Available Datasets
Form	Design	• Volume, Floor area and Shape • Orientation • Massing • Percentage Glazing • Exterior shading	• Conceptual Massing elements with Auto-zoning
Materials	Design	• R-value and Thermal mass • Absorptance, Roughness • Material density, specific heat, conductivity • Glazing U-value, SHGC and VLT	• 'Conceptual Constructions' – Small selection across a broad range (fixed)
Systems	Design / Operation	• Primary heating and cooling • Secondary distribution • Lighting and Equipment power density • Controls	• ASHRAE baseline building / space type data (fixed) • ASHRAE baseline HVAC system types (generally / fixed)
Utilization	Operation	• Occupancy • Hours of operation • Heating and Cooling set-points	• ASHRAE baseline building / space type data (fixed)
Climate	Operation	• Air temperature • Relative humidity • Direct and diffuse solar radiation • Wind speed and direction	• Typical Meteorological Years (TMYs) • 1.5 million+ other (2004 & 2006) • Actual location and period (GBS)
Tariff	Operation	• $ / kWh Electricity • $ / kWh Fuel	• Average State flat rate (EIA)

Table 1: Main energy use / cost drivers and A360 Energy Analysis datasets

You can see from this that in reality a large portion of the main energy use drivers are operational in nature and therefore at concept or scheme design stage it is impossible to know or expect to know the 'end state'. That said it is possible to make very reasonable assumptions for Climate and Tariff for concept and scheme design development. Just acknowledge that the weather and what you'll pay for energy will most likely be different by the time the building gets to operation.

Systems present the single biggest bucket where little control and specificity exists over inputs. While frustrating for Engineers / Energy Analysts this is actually reasonably consistent with the level of information usually available on systems at concept and scheme design stages i.e. little to none. The simple system choices available are 'close to' ASHRAE baseline based on the fact that actual baselines require a lot of information and time. These system choices are intended to simply put that driver on a broad range so that other aspects like form and materials can be focused on. Although you won't be able to make decisions on form and materials based on exact ROIs you will at least see the relative contributions and know if something is 'directionally' better or worse.

Building use is another significant cause for discrepancy between predicted energy use and actual energy use. This is a challenge for all Energy Analysis but here the same industry standard ASHRAE building and space type data sets are available and used.

In conclusion what you should realize is that while energy simulation is a very exact science building design and construction is not and the real purpose and intent of A360 Energy Analysis is to assist with Form and Material design optimization at concept and scheme design stages which is precisely when important decisions are made. It is not pretending or even realistic (for anyone with any software!) to expect any analysis done at an early design stage to account for all the differences that will exist in the real building by the time it is built and operated. The whole point of A360 Energy Analysis is therefore simply to provide a very fast 'directionally accurate' indicator of performance, identify key drivers and at the very least facilitate some discussion around energy performance with someone who should be responsible at the earliest design stages possible.

VISION

To be provided at AU.

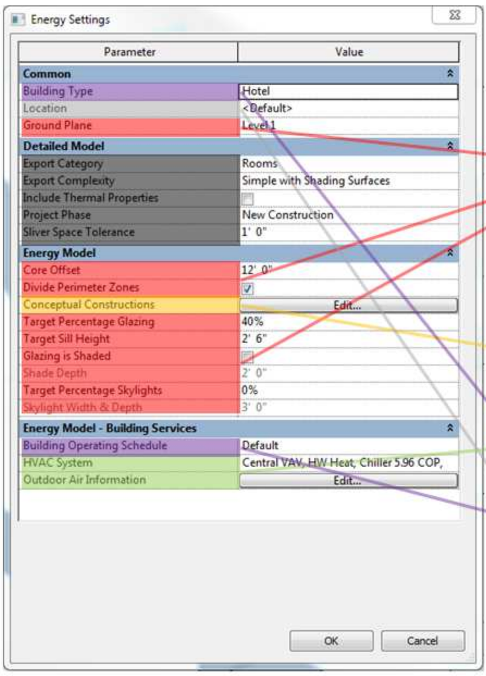
Learning Objective 2 – Use certain Revit objects to capture varying levels of detail at different stages throughout the building lifecycle

This section describes the main Revit elements and parameters that drive the Energy Analysis, the accuracy of the automatic energy model created with thermal zoning and how this can be leveraged for faster, better analysis at concept and scheme design stages.

NAVIGATION

Energy settings

The Energy Settings dialog essentially controls all of the data and assumptions used in the energy simulation at a building level. I will explain how to set individual space and surface properties shortly but for now it's worth having a basic understanding of what each of the parameters relate to. The dialog itself is a little complicated because it serves other purposes in Revit (like room/space gbXML export) but in Figure 9 below I have mapped each parameter to one of the main energy use drivers from earlier to show overall relevance and provided a short explanation of each.

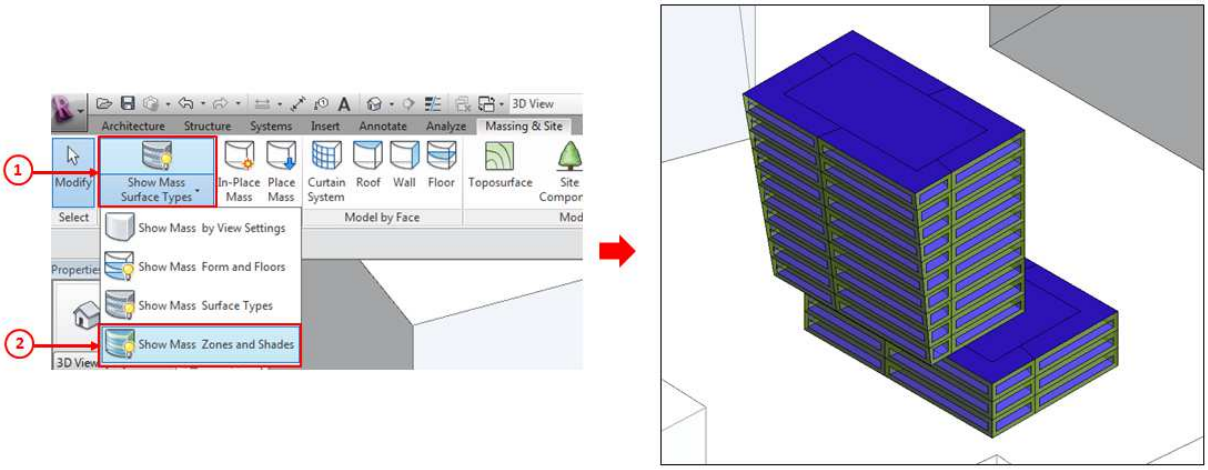


Main Energy Use Drivers	Item / Description
Form	**Ground plane** – This determines the Revit level used to differentiate surfaces above or below ground in the Energy Analysis. Sloping sites cannot be dealt with at this time. **Core offset** – Mass floors can be split into a perimeter and core 'thermal zones' which is usual practice for Energy Analysis. Setting this to zero will mean no core is created. **Divide Perimeter Zones** – This provides the option for perimeter thermal zones to be subdivided which is also usual practice for Energy Analysis. Note that perimeter zones are currently split using cardinal directions which can lead to some error (+/-5% on average but it can be higher). Note that Vasari currently provides more accurate thermal zoning. **Other** – These parameters all relate to glazing, skylights and shading applied to the Conceptual Masses
Materials	**Conceptual Constructions** - These offer a small but broad selection of thermal properties useful for wide range sensitivity testing. Typical selections are close to ASHRAE 90.1 baseline standards.
Systems	**HVAC System** – These are close to ASHRAE 90.1 baseline standards. Outdoor Air Information – Energy used to heat / cool fresh air required by occupants
Utilization	**Building Type** – This sets ASHRAE 90.1 datasets occupancy levels, lighting and power equipment densities and schedules based on Building Operating Schedule – Default means 'default for building type'.
Climate	**Location** – Sets latitude, longitude, height above sea level (al required for solar shading) and Climate file. TMYs are indicated by a '59...' reference.
Tariff	These are automatically determined by Green Building Studio based on location using latest data from EIA.

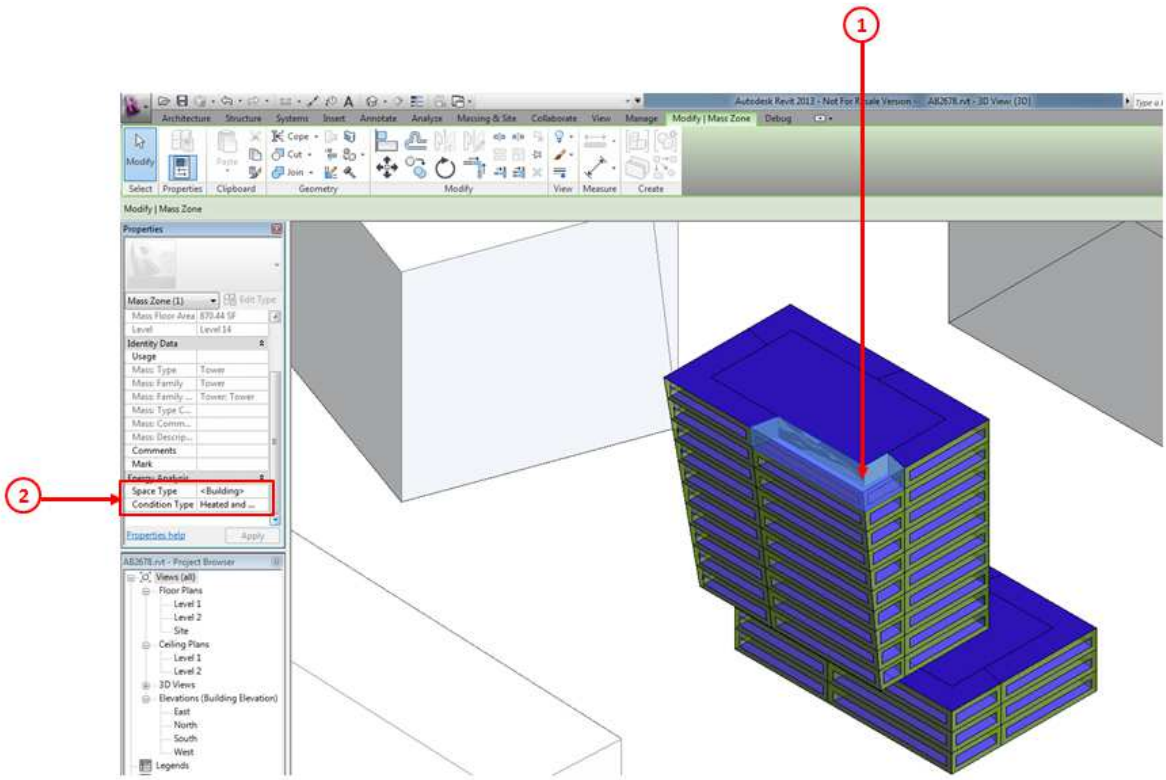
Figure 9: Summary of Energy Settings Parameters

Mass zones

In order to set the properties of individual 'Mass zones' aka 'thermal zones' go to the Massing & Site tab, (1) select Show Mass by View Settings and (2) select Show Mass Zones and Shades…

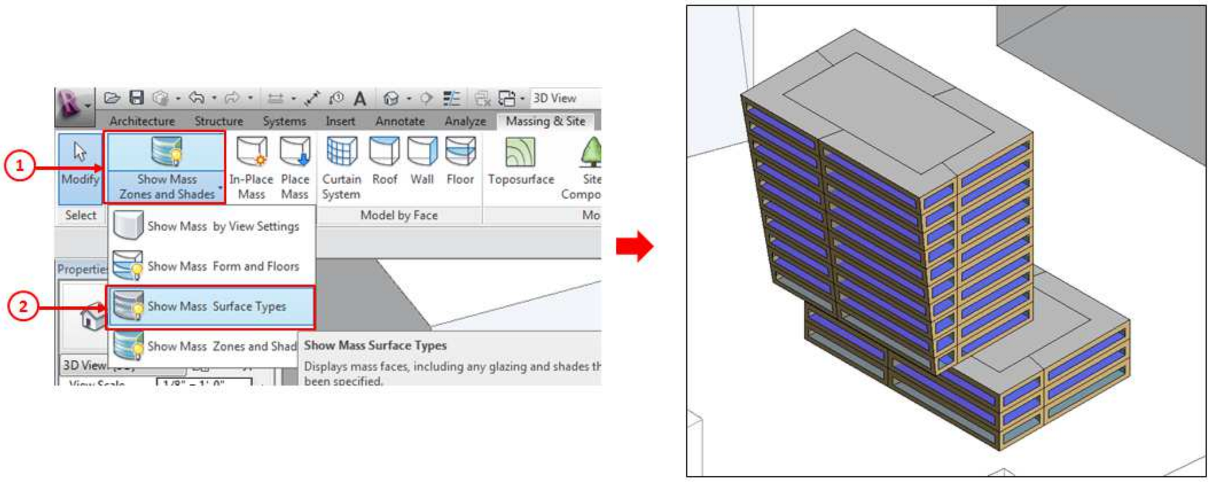


Then (1) select one or more mass zones, (2) go to the properties sheet and edit Space type and Condition type as required. See later for a list of space and condition types…

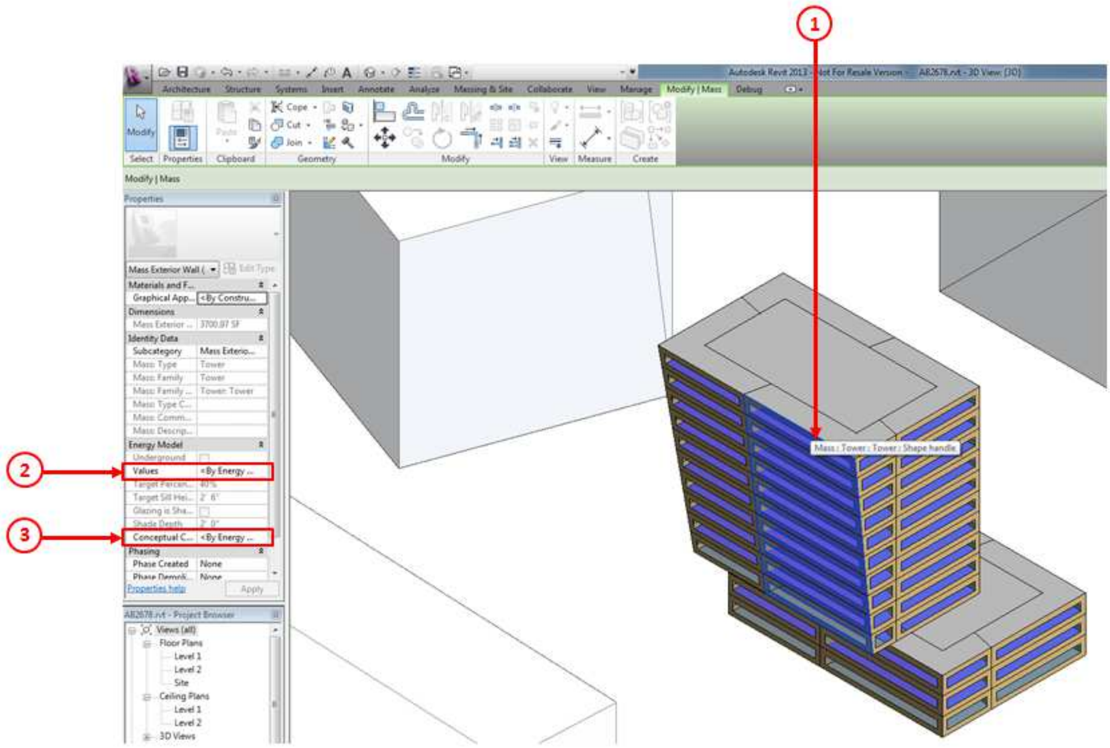


Mass surfaces

In order to set the properties of individual Mass Surfaces go to the Massing & Site tab, (1) select Show Mass by View Setting and select (2) Show Mass Surface Types...



Then (1) select a surface or surfaces (use tab to cycle through selections), (2) go to the properties sheet and change Values and / or Conceptual Constructions from <By Energy Setting> to <By Surface> and set as required.



VALIDATION

Energy Model Geometry (incl. thermal zoning) – Automatic Creation from Conceptual Masses

Energy model geometry is typically very time consuming to create and therefore cannot usually support the early design stages of a project when rapid change and iteration is taking place. One of the key strengths of A360 Energy Analysis for Revit is the automatic creation of energy model geometry from Conceptual Massing elements including thermal zoning.

As a single line closed form or 'egg shell' model Revit's Conceptual Masses are already pretty close to what is required for Energy simulation however 'thermal zoning' must be applied. The primary reason for this is to capture the variation in heat gain and loss throughout different parts of the building. As such it is common practice in Energy Analysis to create perimeter and core zones because perimeter zones are influenced more by the external environment while core zones are influenced by interior loads. In addition to that it is also common practice to sub-divide perimeter zones further to account for variation in solar gain from different elevations.

Figure 10: Examples of perimeter and core thermal zoning (c/o Vasari)

The auto-zoning in Revit 2013 is currently based on simple cardinal directions meaning the zones are cut into 4 equal parts N, S, E, W and across their centroid. While this makes the automatic energy model creation very fast and stable the one downside is that it does not always result in the precise zoning that an Energy Analyst would employ and can result inaccuracy. Depending on your project this may or may not be an issue and if required I would recommend using Vasari as its auto-zoning is more advanced than Revit's at this time and it follows, even improves upon, ASHRAE guidelines for thermal zoning. An example of the difference between Revit 2013 and Vasari auto-zoning is shown in Figure 11 below

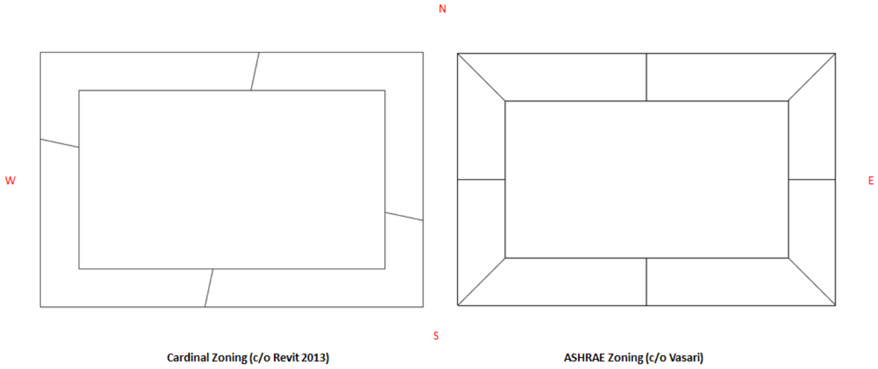


Figure 11: Examples showing difference in auto-zoning methods

Figure 12 shows an excerpt from a recent ASHRAE paper (‘Beyond the Shoe Box’ by Lilli Smith at Autodesk) which focused on the subject of thermal zoning and its impact on Energy Analysis accuracy. The study included a range of building forms, climate zone, building types and tested the impact of different zoning configurations against the advanced auto-zoning in Vasari that meets and exceeds ASHRAE requirements. It can be seen from this that Revit’s current auto-zoning can result in an average inaccuracy of +4.69% for total annual Fuel use and +3% for total annual Electricity but cases can exist where the inaccuracy is much higher, especially for Fuel. These are in effect computational inaccuracies.

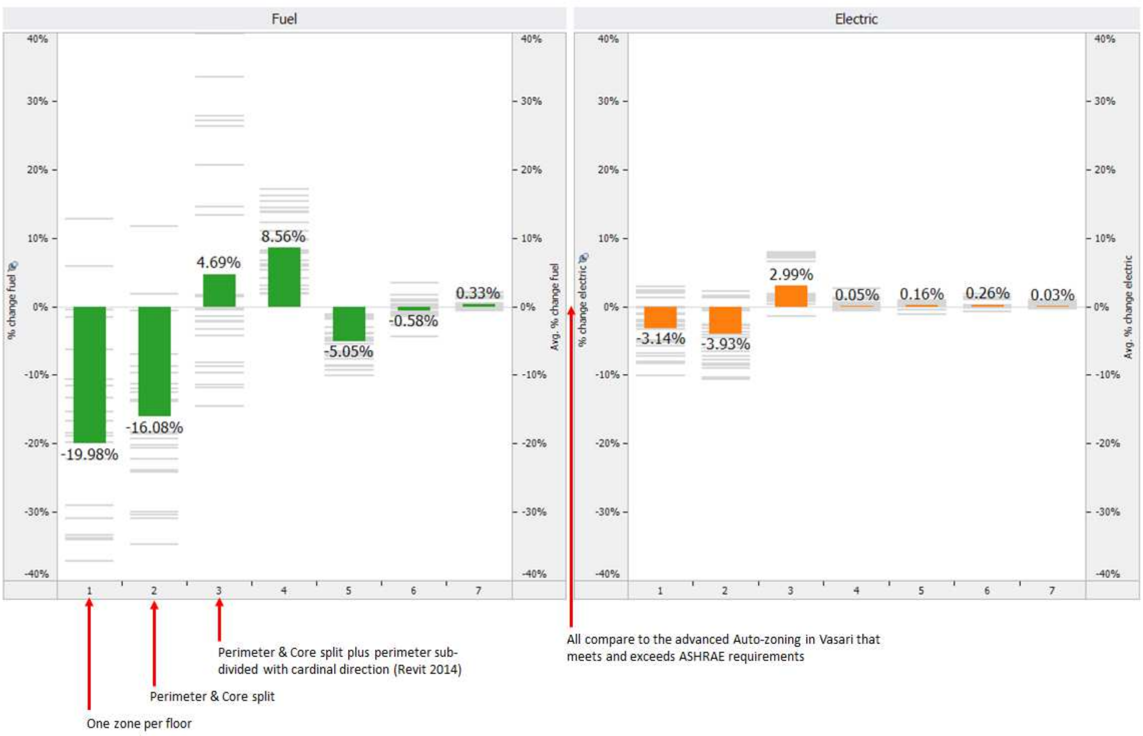


Figure 12: Sensitivity of different building form, climate and building type to thermal zoning

Despite the inaccuracies that can exist due to the thermal zoning (for which there is always Vasari) the ability to automatically create an energy model from a conceptual design model is extremely valuable because it provides directional feedback on performance without having to create a separate model. Even the example shown in Figure 10 it would take perhaps at least a day or more to create that geometry in a standalone and almost as long to make any changes. This means these tools simply can't keep pace with the rate of design change and that leads to lost opportunity.

Energy Model Geometry – Room / Space based gbXML export

Although not strictly part of A360 Energy Analysis, while on the subject of Energy Model geometry it is worth mentioning Revit's room/space based gbXML export. I'll spare you the details here because much experience of its pros and cons is being shared elsewhere, especially at AU. All I will say though is that you can of course upload this gbXML direct to Green Building Studio to run Energy Analysis there. Instead I'm going to focus on the main differences between this 'type' of Energy Model and that created by A360 Energy Analysis and what's important about that.

As you will have gathered by now A360 Energy Analysis for Revit automatically creates Energy Model geometry including thermal zoning from Conceptual Massing elements and provides integrated Energy Analysis aimed at the very earliest stages of the design process.

The room/space based gbXML export on the other hand works with Revit's Architectural Building elements (walls, roofs, floors etc.) and is essentially 'manual' in nature i.e. a user must place room / space objects, set / check heights, then export gbXML and go into a 3rd party analysis application, leaving Revit behind. As such it is more suited to much later stages in the design process when the required Architectural Building elements exist and the design is less subject to significant change. In all of these respects I believe it's reasonable to say that there isn't really all that much in the difference between gbXML export and creating and maintaining a separate energy model in any other 3rd party analysis application.

My main reason for saying that is essentially because both paths are largely manual in nature and subject to significant variation in 'accuracy' due to differences in the knowledge and practices of the individual Engineer / Energy Analyst. It's an old joke about energy modeling, but there's a serious reality to it, that if you gave 10 different energy analysts the exact same information and request for 'an Energy Analysis' they'd all create 10 different models and get 10 different results. The fact is that before they even get into Material, Systems, Use, Climate and Tariff data there can be many differences in the energy model geometry created.

In order to help illustrate this Figure 13 shows six fundamentally different energy model geometries illustrated. Figure 14 then illustrates a number of common configurations in buildings that create further differences. In reality much of the simplification that takes place with energy model geometry is down to the capabilities of the 3rd party tool and the skill and time of the user.

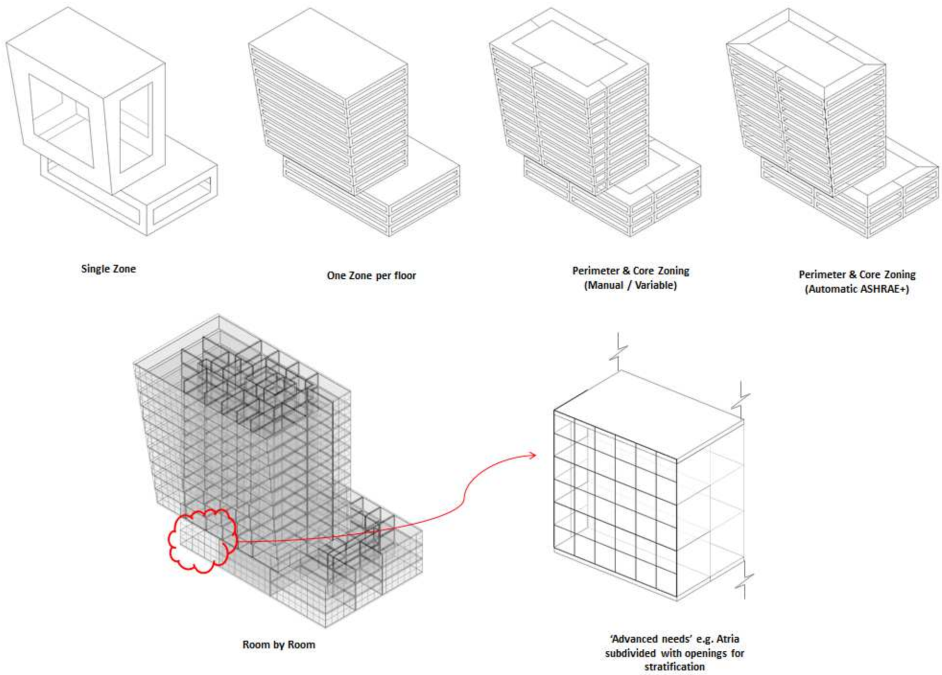


Figure 13: Illustration of broad differences found in manually created energy model geometry

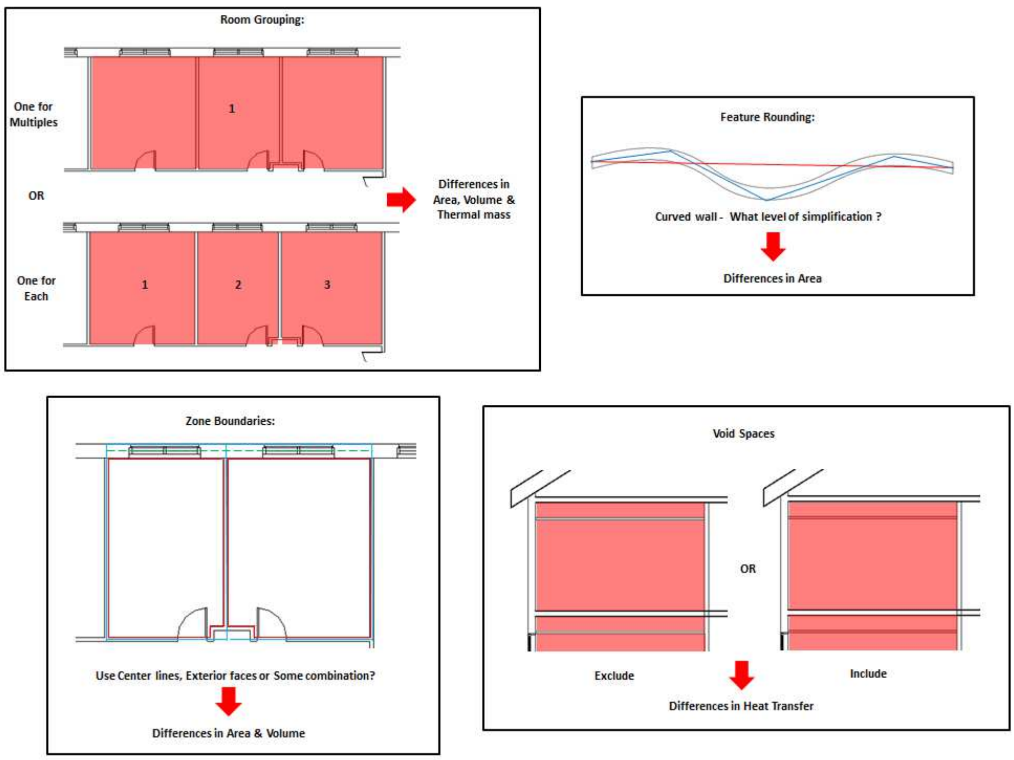


Figure 14: Common conditions that create differences in manually created energy model geometry

Considering all of that the real difference between Revit's gbXML room/space based gbXML export, a separate 3rd party Energy Analysis application geometry and A360 Energy Analysis for Revit is automation and while saving time is a good enough reason for that alone the ease of repeatability is also very important towards building trust in energy analysis.

Building / Space type data

This essentially defines key information for the Systems and Utilization drivers including occupancy levels, installed lighting and equipment levels and importantly how those items vary over time (schedules). ASHRAE 90.1 provides reference data sets for these items based on both a Building type and Space type basis. Generally speaking Building type data is 'broad brush' typical average across a whole building whereas Space type data is more specific to one type of function in a room. Figure 15 shows an example of Building and Space type data.

⊟ Office

Parameter	Value
Occupancy Schedule	Office
People/100 sq. M.	3.5
People Sensible Heat Gain (W/person)	73
People Latent Heat Gain (W/person)	59
Lighting Load Density (W/sq. M.)	10.9
Equipment Load Density (W/sq. M.)	14.4
Infiltration Flow (ACH)	0.1
Outside Air (ventilation air) Flow Per Person (liters per second)	8.5
Outside Air (ventilation air) Flow Per Area (cubic meters per hour per square meter)	3.7
Unoccupied Cooling Set Point (C)	29.4

Building type: Office

⊟ Office - Enclosed

Parameter	Default Value
Occupancy Schedule	Common Office 8 am - 5 pm
Power Schedule	Office Lighting 6 am - 11 pm
People/100 sq. M.	5.0
People Sensible Heat Gain (Btu/hr)	250
People Latent Heat Gain (Btu/hr)	200
Lighting Load Density (W/sq. ft.)	1
Power Load Density (W/sq. ft.)	1.5
Electrical Equipment Radiant Percentage	0.3
Infiltration Flow (CFM/sq. ft.)	0.038
Carpet (Y/N)	Y

Space type: Office - Enclosed

Figure 15: Examples of Building and Space type data sets

All of the Building type data provided in A360 Energy Analysis can be found on the Autodesk wiki help here.

All of the Space type data provided in A360 Energy Analysis can be found on the Autodesk wiki help here.

Building Operating Schedule

The building operating schedule is the primary driver for defining the varying levels of occupancy, lights and equipment. The default Energy Setting implies default for that Building type. Figure 16 shows an example set of schedules for a building that runs 12h/day, 5 days a week.

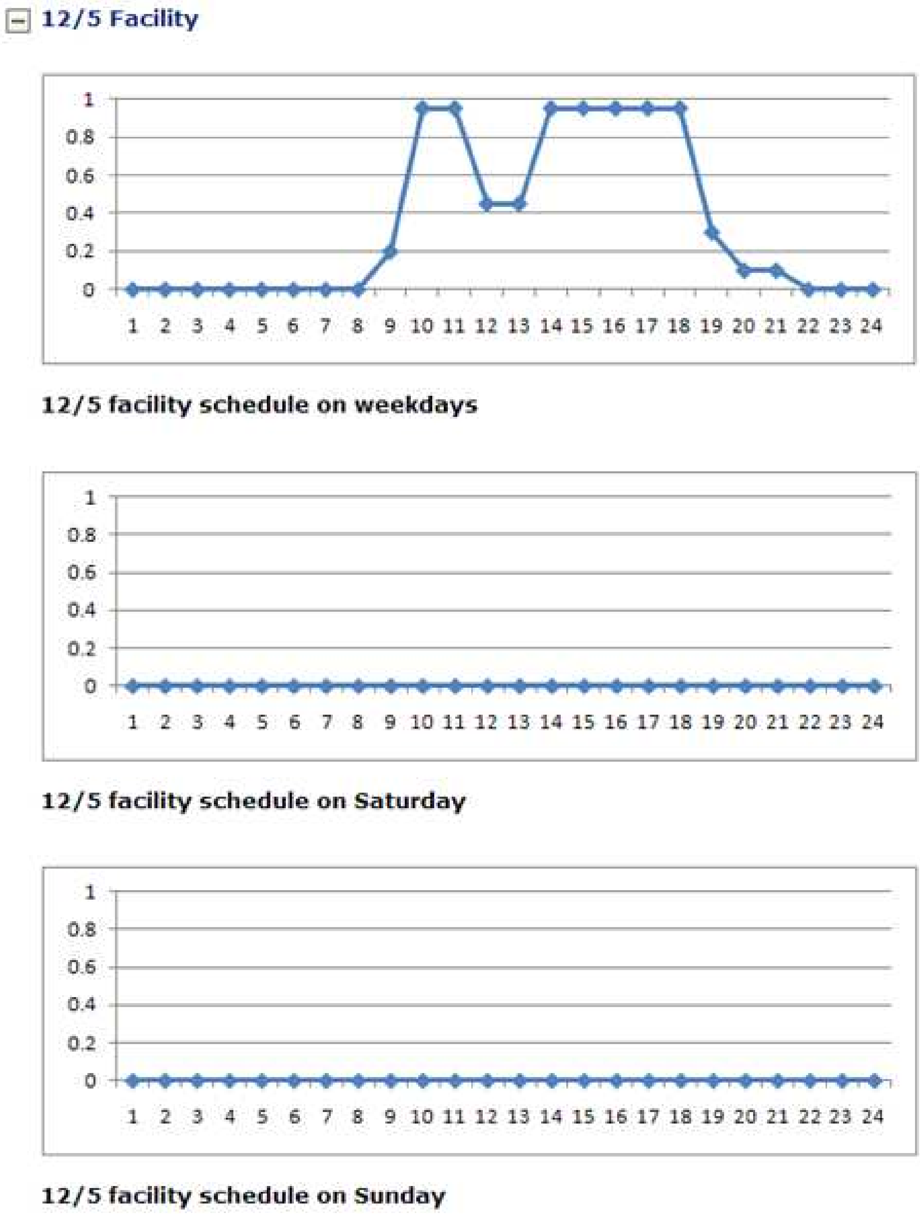


Figure 16: Example Building Operating Schedule

All of the Building operating Schedules used in A360 Energy Analysis can be found on the Autodesk wiki help [here](#).

Occupancy schedules

Each Building type references Occupancy schedules and these are essentially 24 hour profiles for weekdays, Saturdays and Sundays. An example of an Occupancy profile is shown in Figure 17 below.

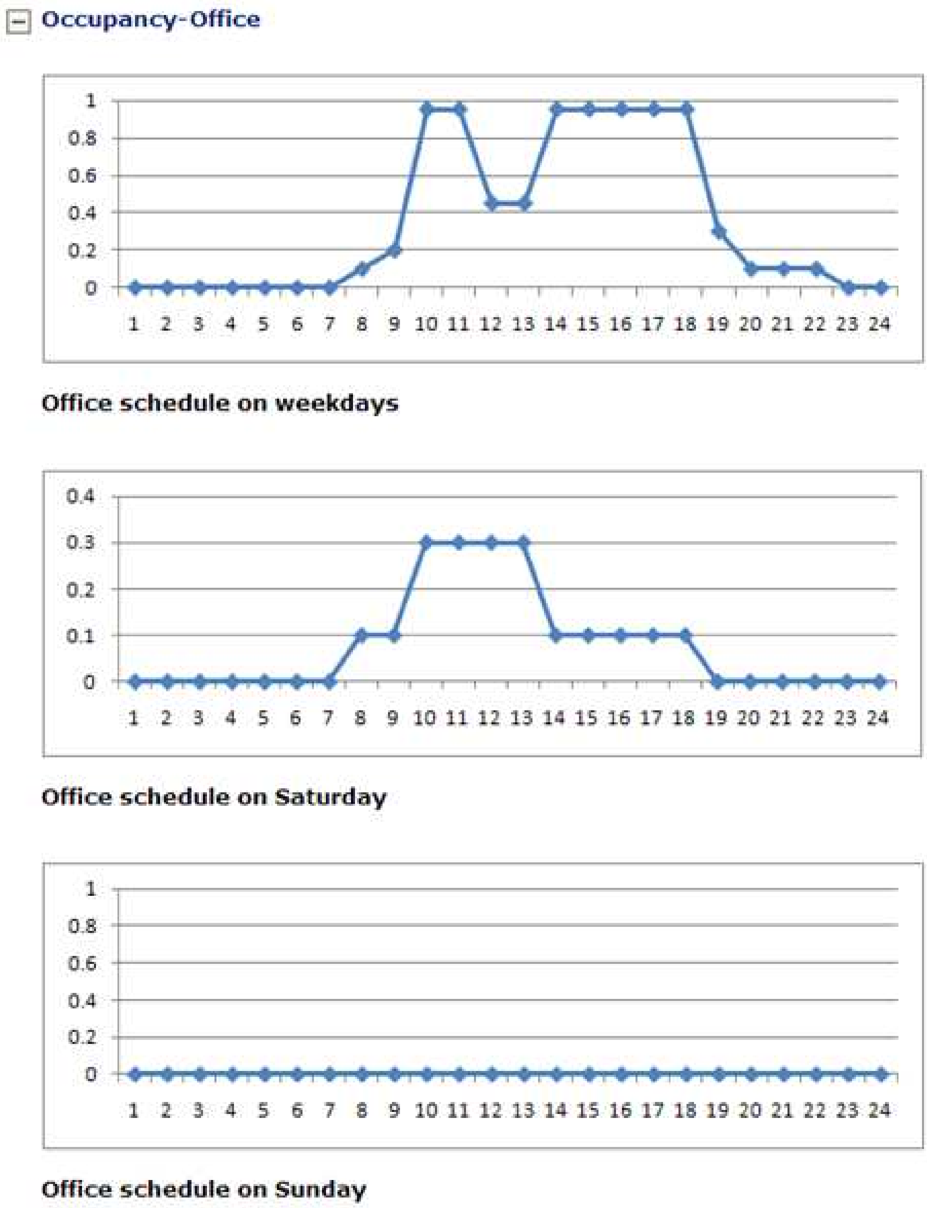


Figure 17: Example Occupancy profile

All Occupancy Schedule data used in A360 Energy Analysis can be found on the Autodesk wiki help here.

Condition types

By default the entire building (each zone) is assumed to be both heated and cooled. There may however be parts of your building that are not conditioned this way, like a car park. These can be a significant part of the massing but do not / should not influence your model.

Condition Type	Description
Heated	The space is heated only, no cooling is provided
Cooled	The space is cooled only, no heating is provided
Heated and Cooled	Default – maintains heating and cooling set-points.
Unconditioned	No heating or cooling is provided ad the space will 'free float'
Vented	Only mechanical ventilation is provided (uses some energy)
Naturally Vented Only	Ventilation is provided but uses no energy

Table 2: Table of Condition Types

HVAC systems

A small selection of HVAC system types are available to chose from that are 'generally close to' the ASHRAE 90.1 baseline systems. In reality a 'true' ASHRAE 90.1 baseline system contains many detailed building design specific settings which takes time (plus a suitable 3rd party analysis tool). These limited system selections should however be sufficient for the purposes of early design stage Form and Material design optimization. Figure 18 shows an example of HVAC system data. This is the default and a reasonable assumption for most new commercial buildings.

Central VAV, HW Heat, Chiller 5.96 COP, Boilers 84.5 eff (default)

- Water cooled centrifugal chiller (COP 5.96)
- Open, atmospheric pressure cooling tower with variable speed fan and 5-degree Fahrenheit (2.8-degree Celsius) approach
- Forward curved fan with Variable Speed Drive (VSD) and premium efficiency motor
- 3.5 inch of water gauge (871.8 pascals) static pressure Variable Air Volume (VAV) duct system
- Integrated differential dry-bulb temperature economizer
- Gas-fired hot water boiler with draft fan >2500 kBtuh, 84.5% combustion efficiency
- Variable volume hot water pump
- Hot water coil
- Hot water reheat boxes
- Variable volume chilled water pump
- Chilled water coil
- Variable volume condenser water pump
- Domestic hot water unit (0.575 Energy Factor)

Figure 18: Example of HVAC system data

All of the HVAC systems data used in A360 Energy Analysis can be found here.

gbXML export / DOE2 / EnergyPlus import

In order to validate the energy model geometry created it is possible to open the gbXML, DOE2 input file or EnergyPlus input file in any suitable 3rd party program. Figure 19 below shows the DOE2 output file created from the example above in eQUEST.

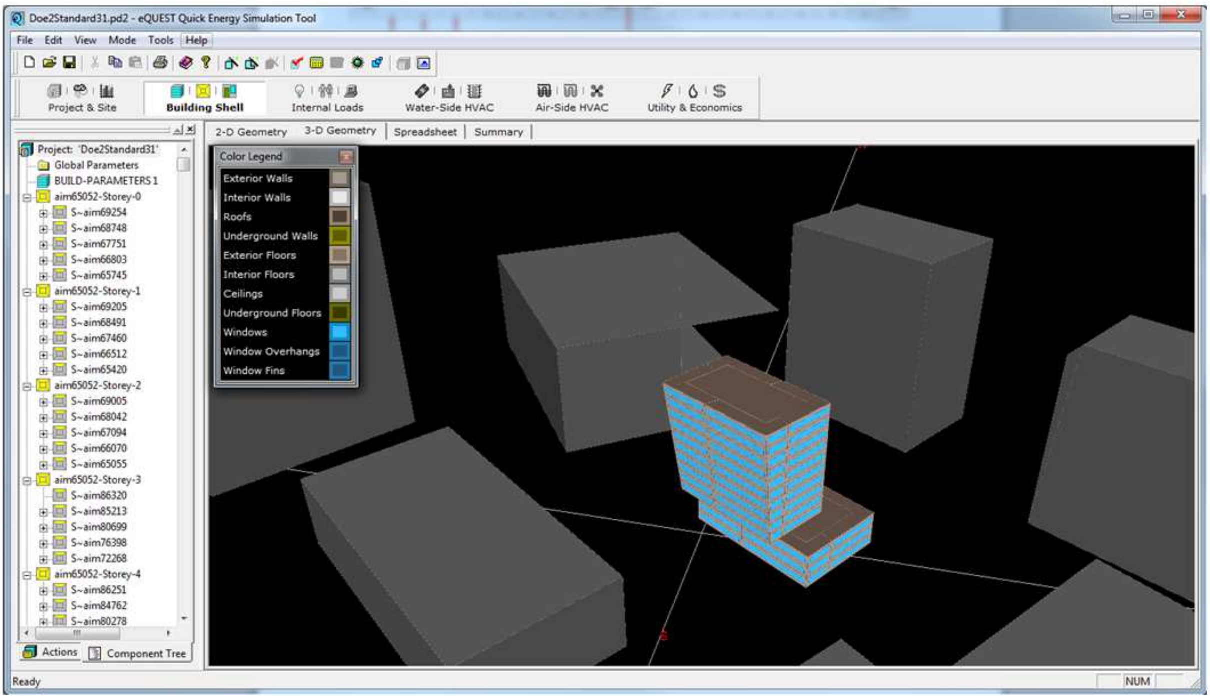


Figure 19: Model created by A360 Energy Analysis for Revit viewed in eQUEST

This is not only valuable for validation but is also useful for collaborating with engineers / energy analysts using any of these 3rd party analysis tools to do more detailed / specific energy analysis.

VISION

To be provided at AU.

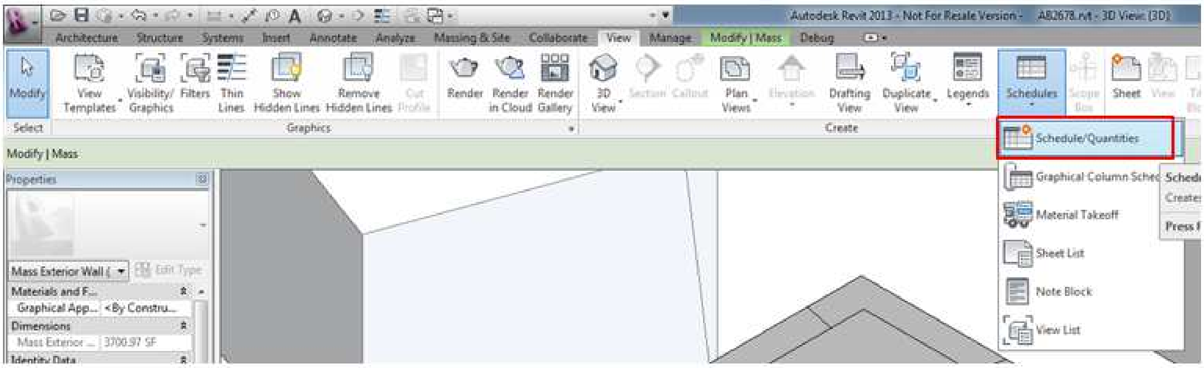
Learning Objective 3 – Create energy analysis documentation using Revit views and schedules

This section describes how Revit can be used to create further information to support energy analysis, what are the challenges it can address and where there is scope for further capability.

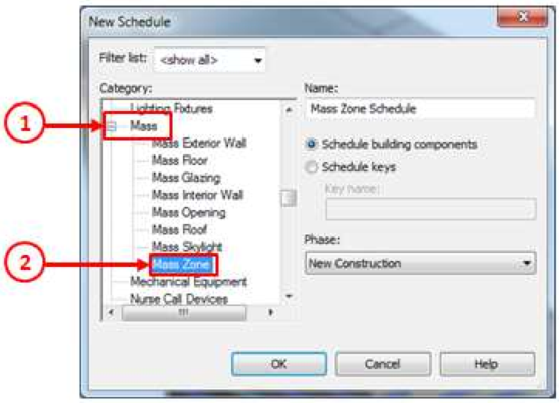
NAVIGATION

Revit Schedules

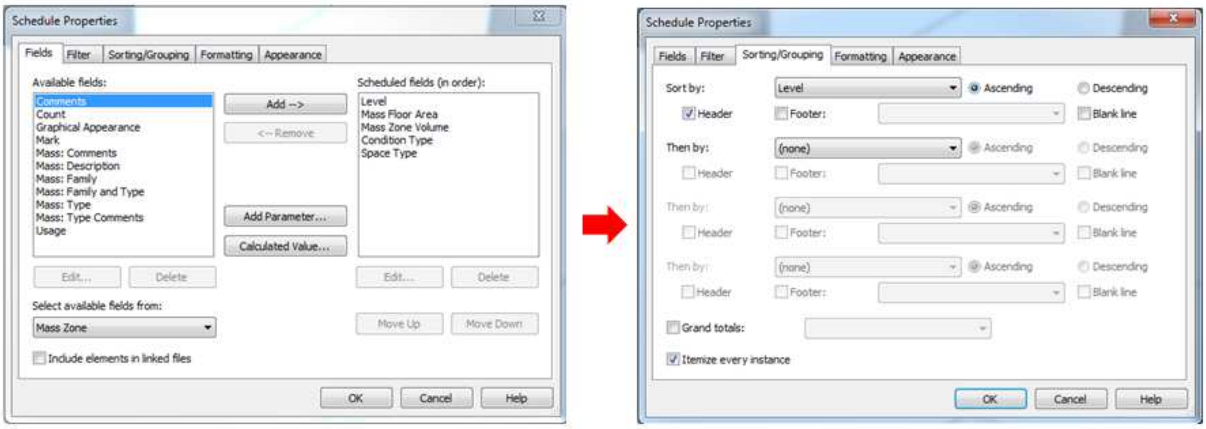
Schedules are a fundamental part of Revit's value and they can be used to help manage Energy Settings on a Mass Zone by Mass Zone basis. To setup a schedule of Mass Zones go to the View tab and select schedules…



Then in the New Schedule dialog scroll down to the Mass category and select Mass Zone…



Then in the Schedule Properties dialog add the fields for Level, Mass Floor Area, Mass Zone Volume, Condition type and Space type (as shown) and then from the Sorting/Grouping tab sort by Level…



Revit will then create and open a Schedule for all Mass Zones sorted by level. If you open this side by side with the 3D view it provides an excellent way to browse and set properties as shown in Figure 20 below. Here each zone can be identified and its space type and condition type set from a drop down which makes it very fast.

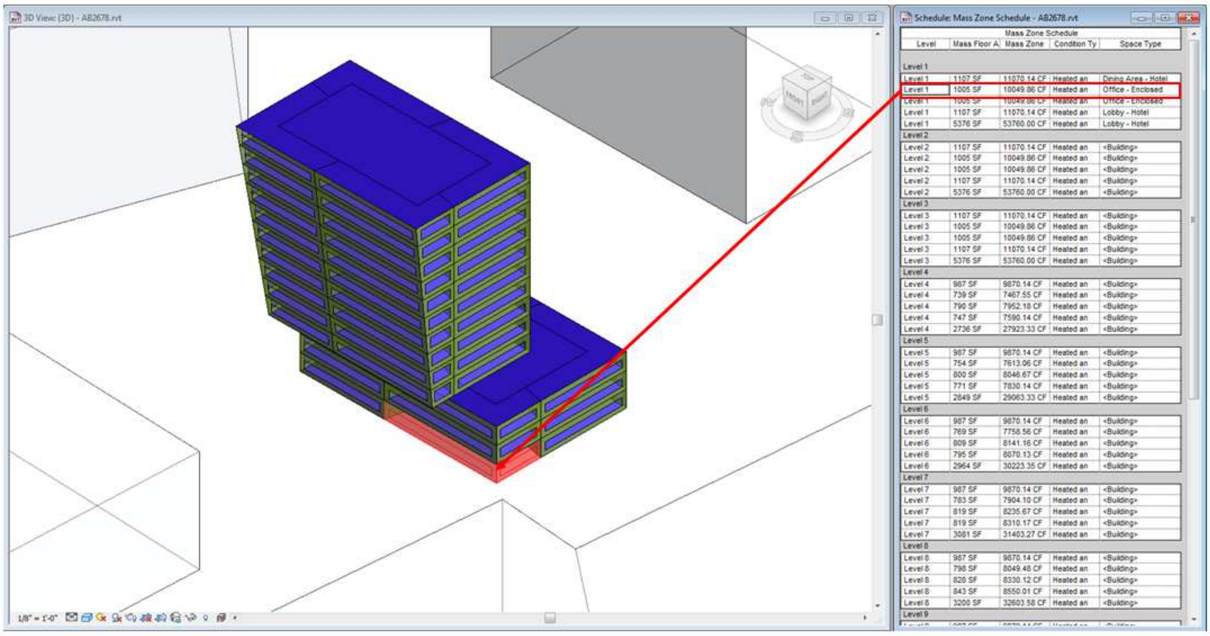


Figure 20: Revit schedule of Mass Zones and 3D view

Revit Views

Views contain many powerful features that can be used for further detailed energy analysis documentation. Figure 21 below shows a plan view of Level 1 with filters setup to match space type settings.

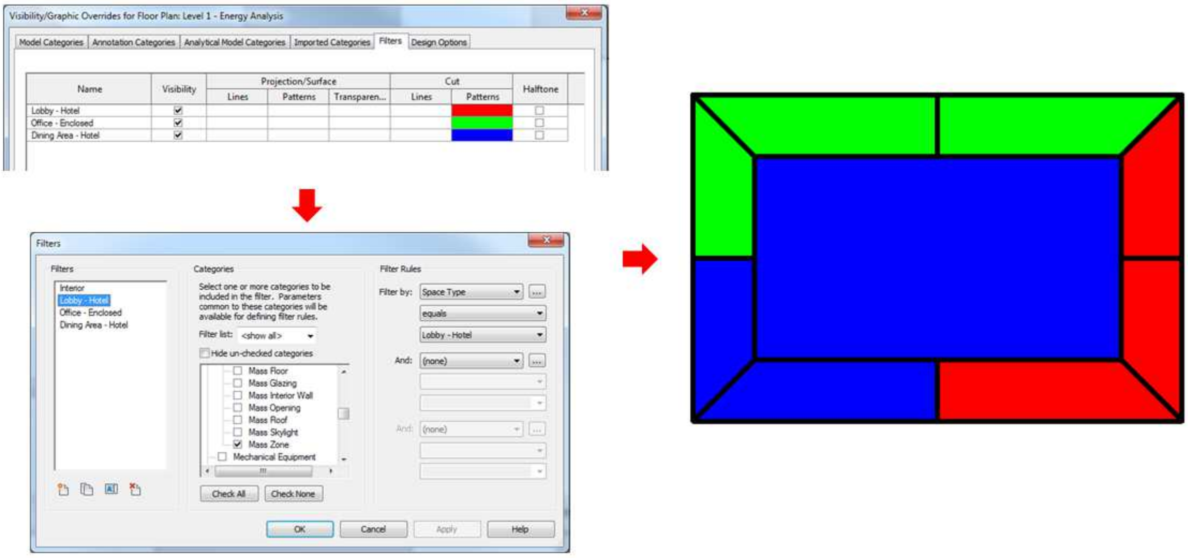


Figure 21: View filters used to show space type assignments by color on a plan view

Design options

Another very powerful feature of Revit is Design options. Rather than having to copy and maintain separate models design variations can be maintained (and analyzed) using design options.

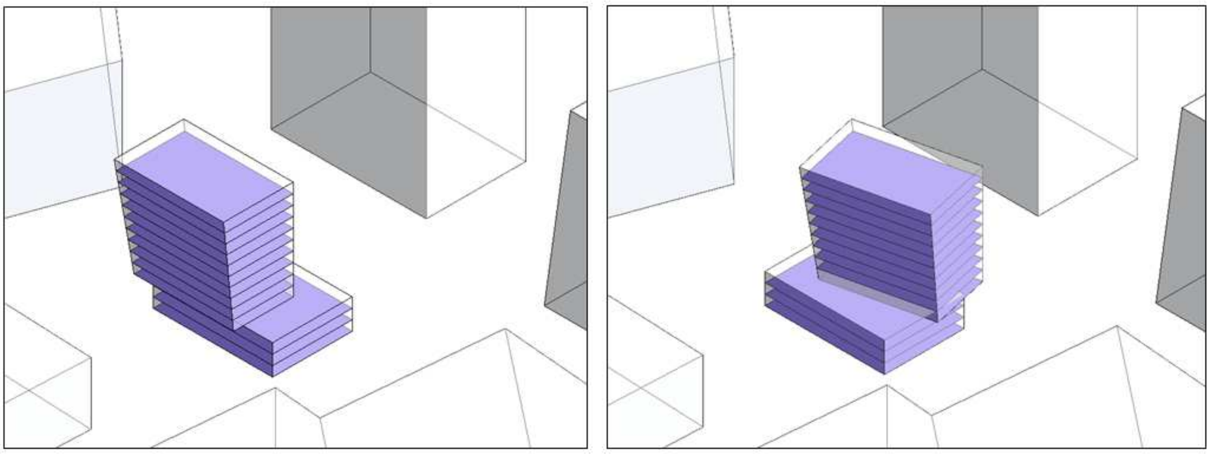


Figure 22: Use of design options to manage analysis of different mass forms

VALIDATION

There isn't really a whole lot I can say here about validation because it should be self-evident. That is to say; the ability to view and interact with the energy model in the ways illustrated should provide anyone interested with the insight needed to know that the buildings form has been captured effectively enough for early design stage Energy Analysis.

VISION

To be provided at AU.

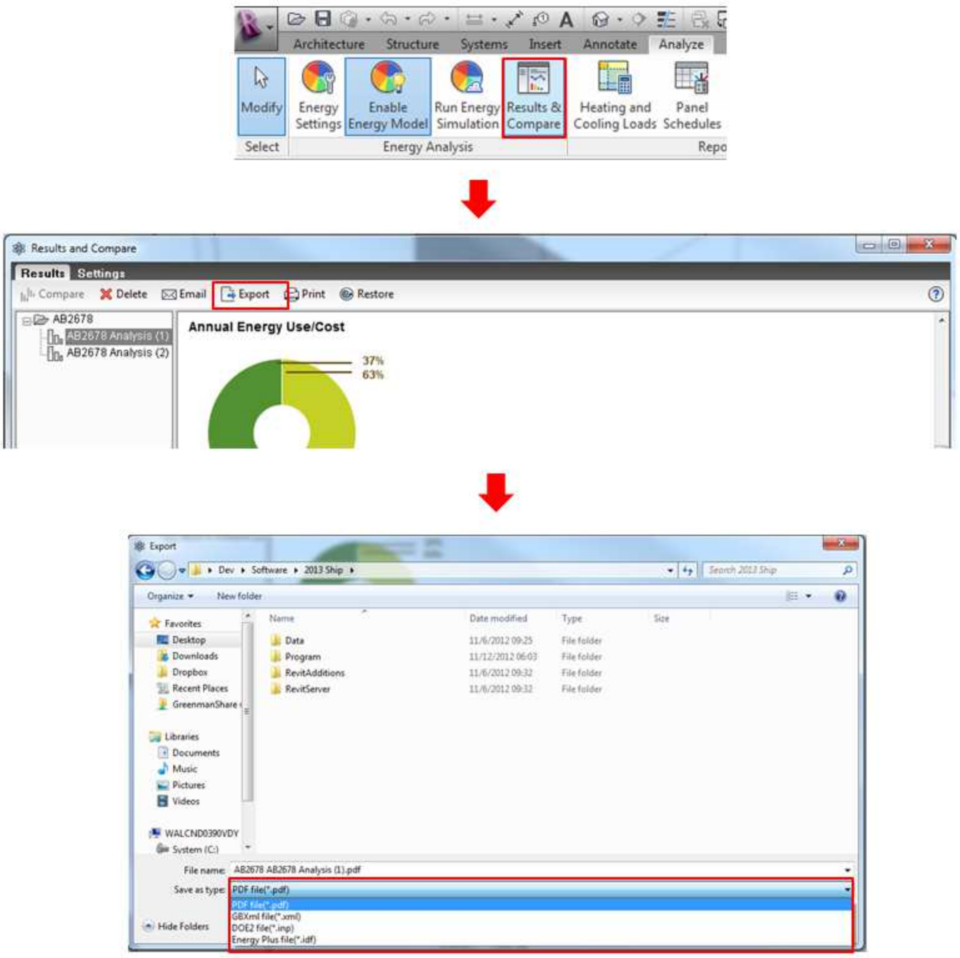
Learning Objective 4 – Collaborate with engineers / energy analysts to optimize the design and ensure validity

This section describes how Revit and cloud based energy analysis lends itself to better and more frequent collaboration with engineers and energy analysts, how they can be helped and can help, what to focus on and how this new platform is opening up new possibilities.

NAVIGATION

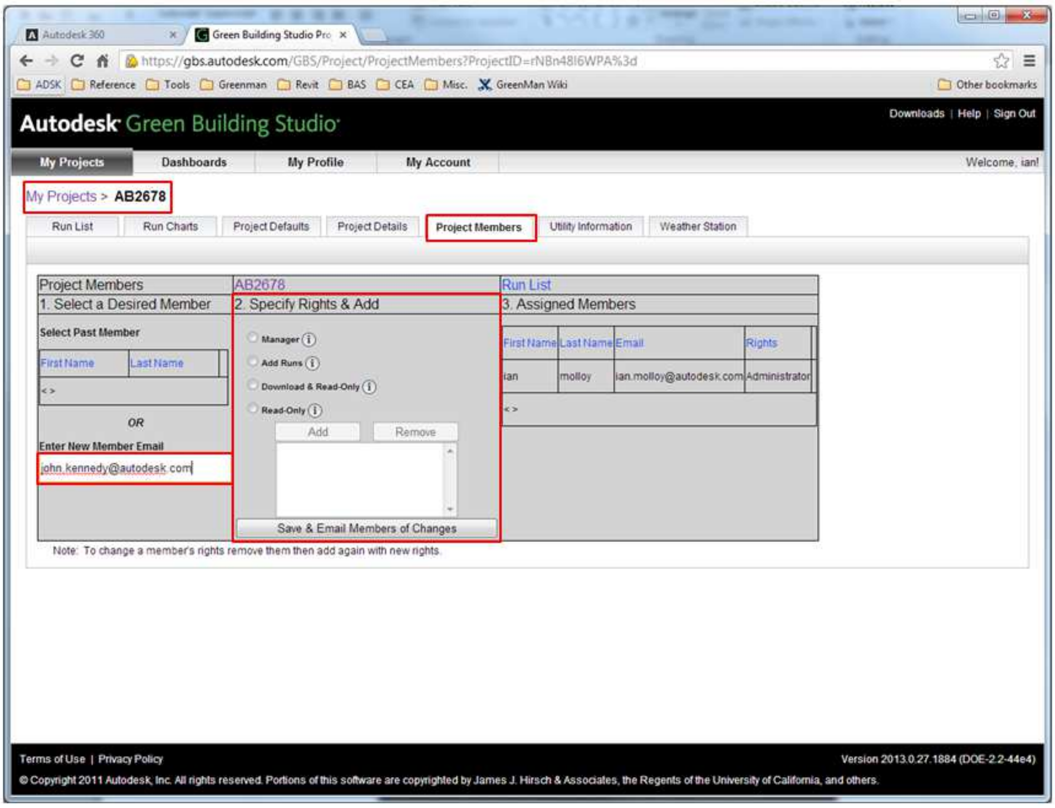
There are really two key aspects of A360 Energy Analysis for Revit that helps better collaboration between Architects and Engineers / Energy Analysts 1) Export multiple file formats for 3rd part analysis tools and 2) Storage, sharing and review of analysis projects and runs on Green Building Studio.

From the Analyze tab in Revit select Results & Compare, select export and chose from one of four output formats; .pdf, gbXML, DOE2 and EnergyPlus…

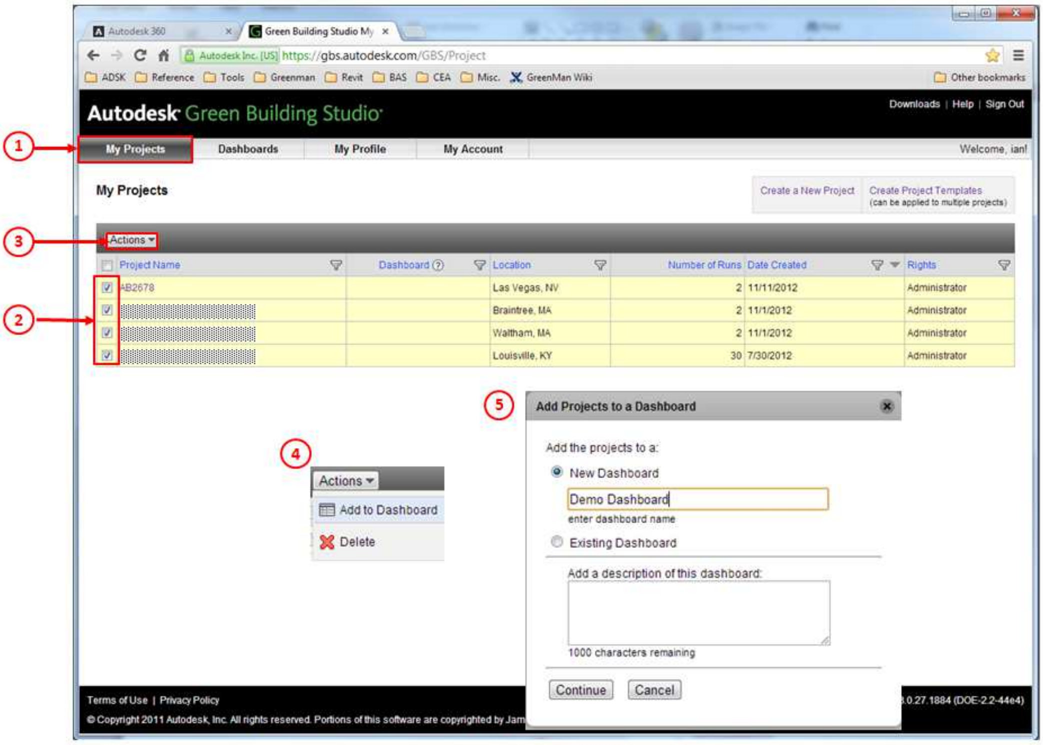


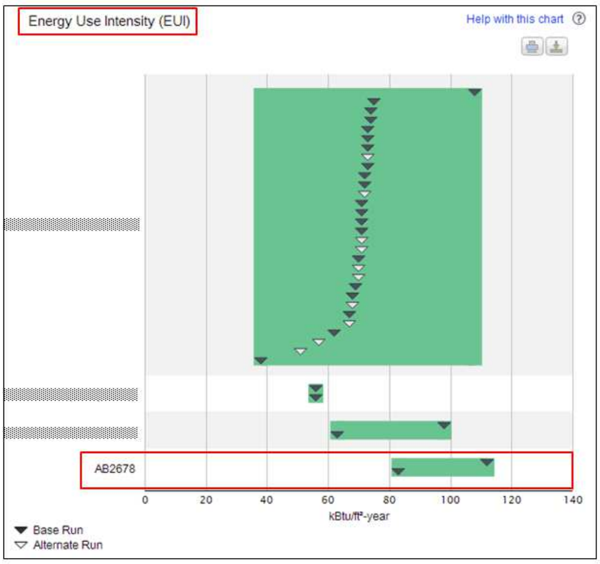
These files can be opened and used in the majority of standalone 3rd party analysis tools and contain more than just energy model geometry but include the thermal properties of constructions, occupancy, lighting, equipment and (some) systems information. This allows anyone familiar with any of these 3rd party tools to do further analysis and provide feedback on how both the building and model can be improved.

To provide a team member with view/run access to Projects in Green Building Studio from My Projects select the Project and from the Project Members tab add the email addresses and set access rights of people you would like to be able to review your work…



Then to create a dashboard view in Green Building Studio go to My Projects, select the project you wish to add to a dashboard, select actions, then add to dashboard and give the dashboard a name.





The dashboard will then show a series of charts showing each of the projects runs and how they compare to one another. This is very useful for monitoring of progress and making comparisons across multiple projects.

VALIDATION

As we discussed earlier energy model geometry is one of the single biggest challenges in Energy Analysis. It's not that it's necessarily the most complex part but can be very time consuming to create and difficult to keep up to date with design change. At the same time at the early design stages in a project there is little to no information on what the building is made of, what systems there may be and how it will all be operated. Therefore given existing tools and requirements which are largely driven today by energy code / green building rating system compliance (ASHRAE 90.1 Appendix G / LEED energy modeling) Energy Analysis is typically relegated to much later in the design process when things have 'settled down'. Unfortunately though this is often too late in the process to make any significant changes and opportunities can be lost.

The big advantage of Autodesk 360 Energy Analysis for Revit is the fact that it works more or less directly with the primary information being authored by the architect, assuming Revit (or Vasari) Conceptual Massing is being used to do that. This provides designers with energy simulation in line with their normal authoring workflows i.e. they do not have to go far out of their way to run analysis.

Given the support that exists for gbXML which is the most popular file exchange format amongst analysis applications and input files for DOE2 and EnergyPlus anyone can review the inputs/outputs and take the analysis further. Finally, the cloud provides more than mere simulation processing power. By storing all analysis projects and runs in a central place individuals, teams and organizations can all achieve better overall visibility of Energy Analysis work in progress.

VISION

To be provided at AU.

CONCLUSIONS

Congratulations if you have made it this far!

I hope by now you have a much better appreciation of what Autodesk 360 Energy Analysis for Revit actually is, what it's intended for and how you could start to use it for early design stage energy analysis. If you cheated and skipped straight to this conclusion here are the key things about Autodesk 360 Energy Analysis for Revit worth remembering:

- There's only a few simple steps involved in running a full dynamic thermal whole building energy simulation powered by Revit massing elements with automatic thermal zoning, the DOE 2.2 simulation engine which is well suited and proven for the job and using industry standard datasets throughout
- Manually created energy model geometry is the main bottle neck in Energy Analysis today and a source of many discrepancies. Automation is key to saving time and ensuring the repeatability of results.
- It is unrealistic to expect to be able to predict the actual end energy use of a building you are only at the concept stage of designing. There are simply too many things that will be different in the end that you have no control over.
- That shouldn't stop you though, reasonable assumptions can be made and you can just focus on the impacts or opportunities surrounding the things you are working on at the time (like form, orientation, glazing etc.) based on best possible information available.
- Its cloud based which means its fast and all your analysis projects and runs can be viewed and managed.
- Finally if you have any doubts it's easy to share your projects and runs with other team members.