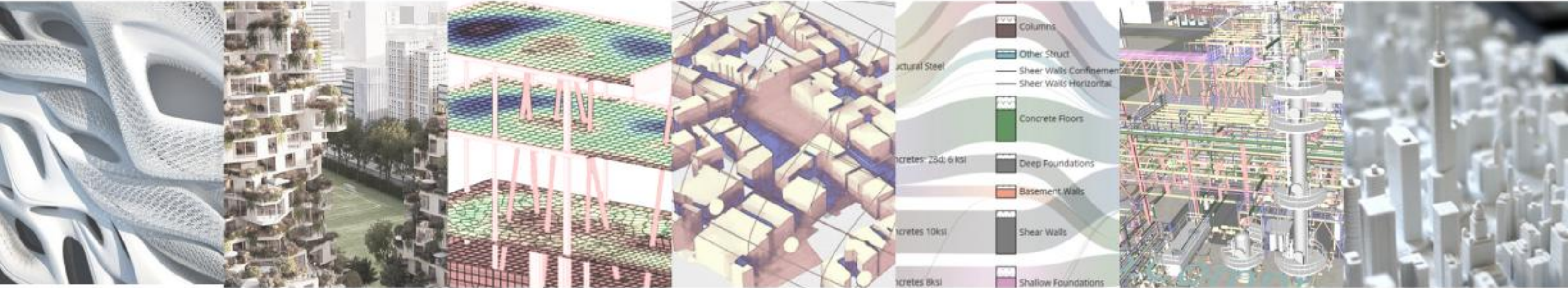


Department of Civil, Architectural and Environmental Engineering
Architectural Engineering Program

Design Technologies Handbook



Spring 2022

Introduction - Handbook of Design Technologies

April 2022

For the building-professions of architecture, engineering and construction, there have been many rapid advances in technology since the year 2000. Most significant to this industry is the advance of computer technologies.

Since 2000, the evolution from hand to computer methods has completely changed the workplace and workflows of the building industry. Entire paradigms have shifted in how we imagine, communicate and build.

The fastest pace of change can be seen in the software written to utilize the ever-increasing speed and power of computers. It seems that as soon as a new software is adopted by the industry, there are at least 3 new tools snapping at its heels, competing for the marketplace.

For universities, one of the greatest challenges is to keep up with this pace of change and decide on how to teach and what to teach.

This handbook is the result of research by our undergraduate third-year architectural-engineering students into the latest tools and products, organized into groups within the building industry.

For each technology we have tried to summarize the various tools that are commonly used and provide some quick access to those who would like to explore and learn more.

We hope that you find this handbook useful. It is our intention to update this information every 2 years.

Gregory Brooks
Professor of Practice
Architectural Engineering Program
The University of Texas at Austin
utgb.info

Table of Contents

- Parametric Design	3
- Physical Modeling	15
- Digital Rendering	24
- Structural Analysis	38
- Environmental Analysis	47
- Sustainability	71
- Construction Modeling	87
- Acknowledgements	95

Parametric Design

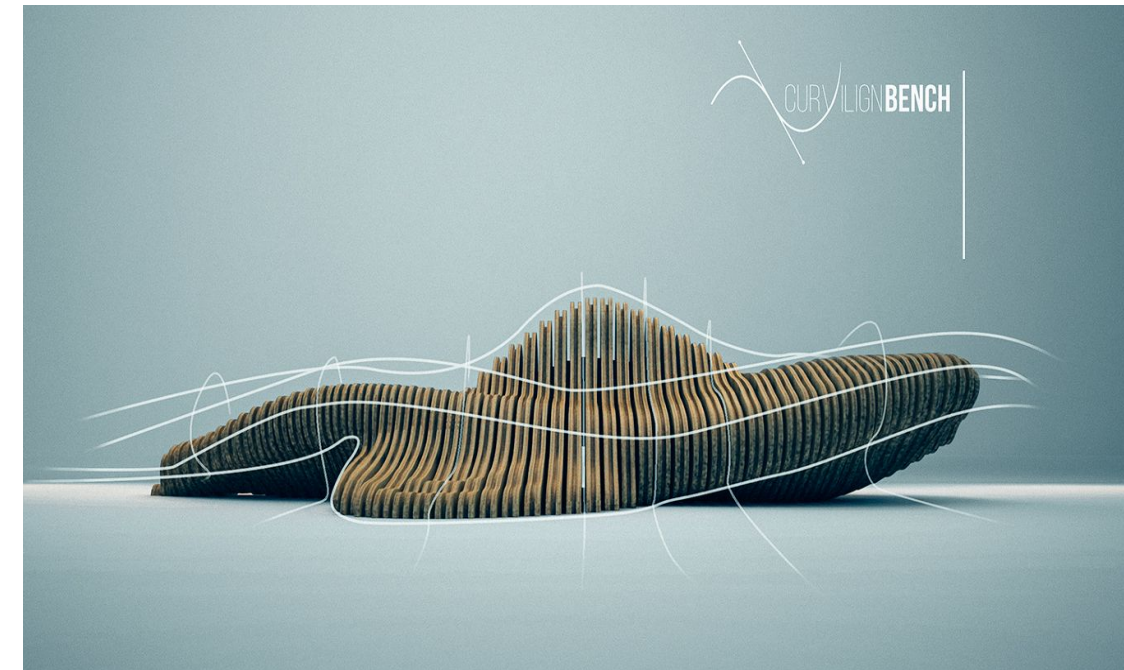
Parametric design is a design method where models are shaped according to algorithmic processes, in contrast to being designed directly through drawing.

In this method, parameters and rules determine the relationship between design intent and design response.

Parametric design is made possible by the computing power of technology today as well as improved manufacturing techniques such as 3D printing.

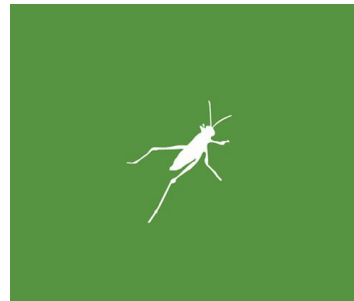


Intro Video: What is Parametric Design



Parametric Design Softwares

Rhino: Grasshopper



Revit: Dynamo



CATIA

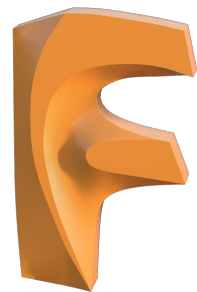


AEC Collection for Revit



4

Fusion 360



FreeCAD

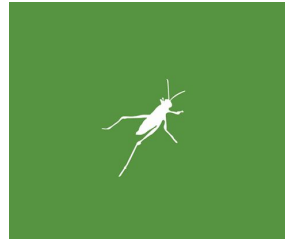


Solidworks



Inventor



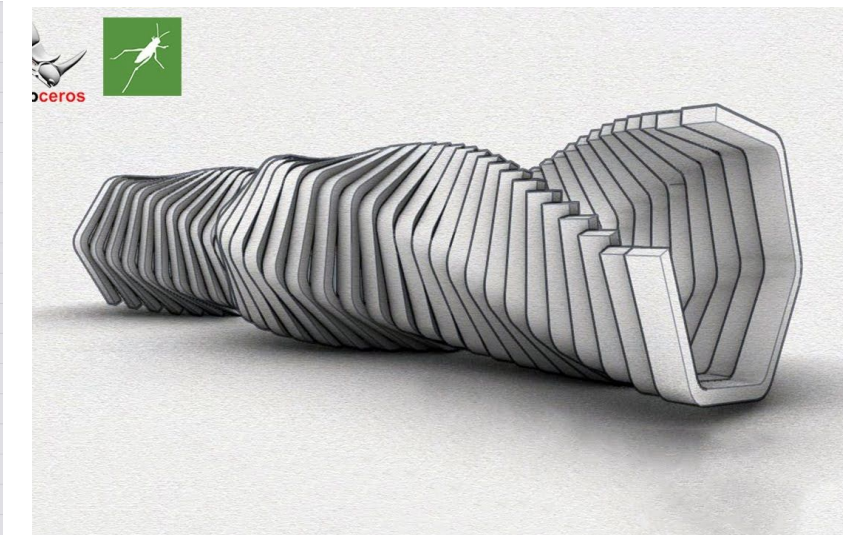
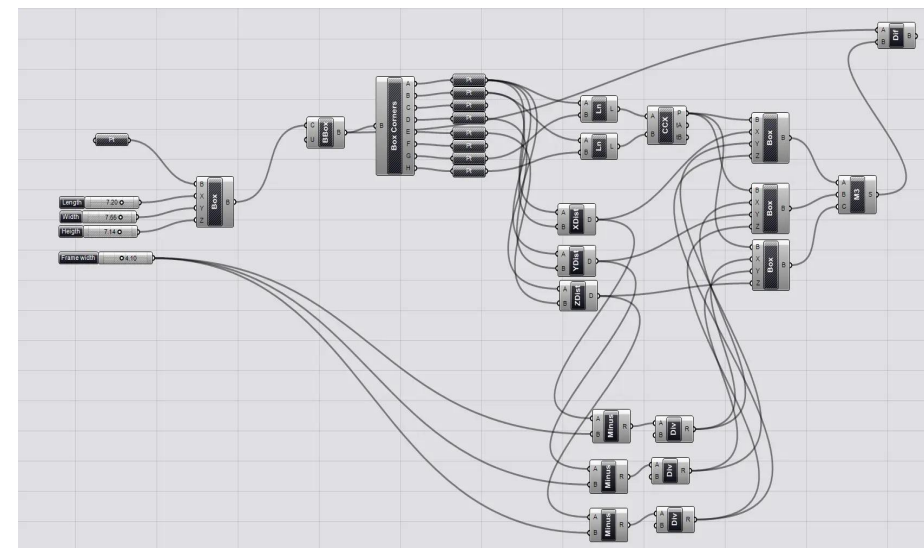


Grasshopper

Grasshopper is a parametric modelling tool that is included within Rhino v7 and allows for several different plug-ins. Grasshopper is one of the most widely used basic parametric design tools, which allows for a variety of different plug-in applications that make the program incredibly applicable to several different modelling needs.

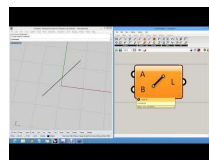
Designers can change core designs without having to learn programming. The software includes a visual programming interface that allows the user to drag and place the components, called Palettes, onto the canvas.

Grasshopper can be used for fabrication, performance analysis, structural engineering, and manipulation of modelled structures

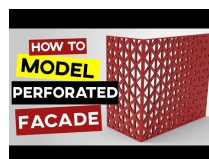


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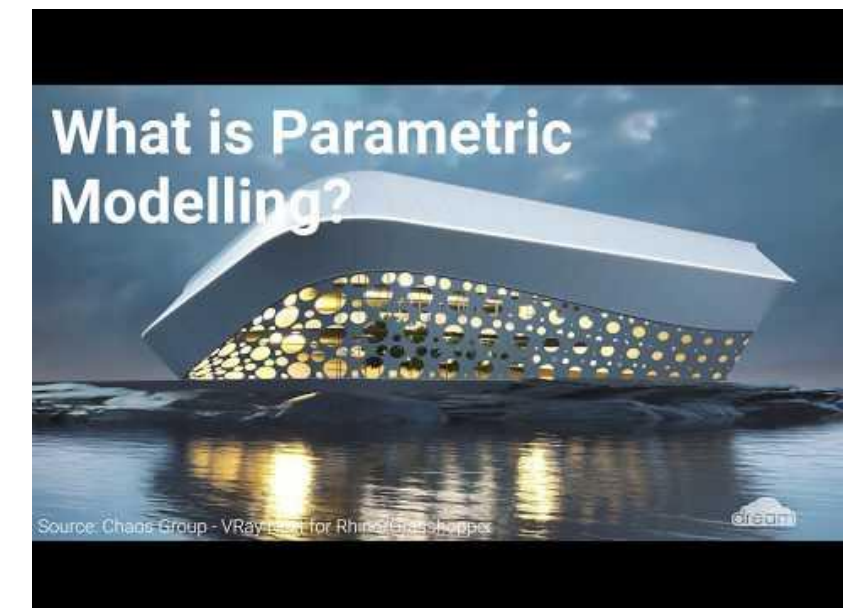
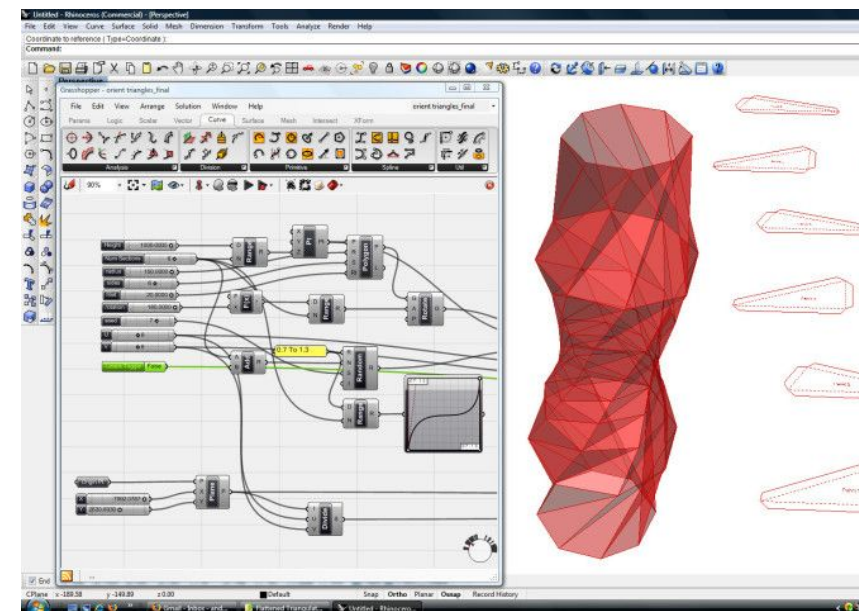
Tutorials



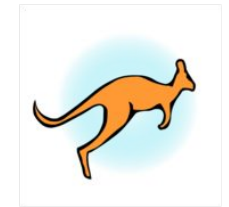
Tutorial 1: Grasshopper (Beginner)



Tutorial 2: Grasshopper (Parametric)



(Click image to see Promotional Video)

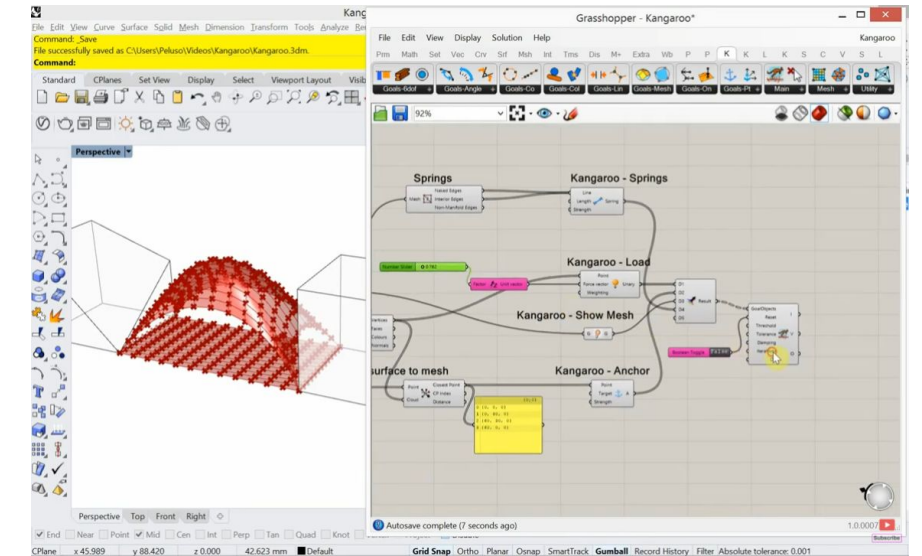
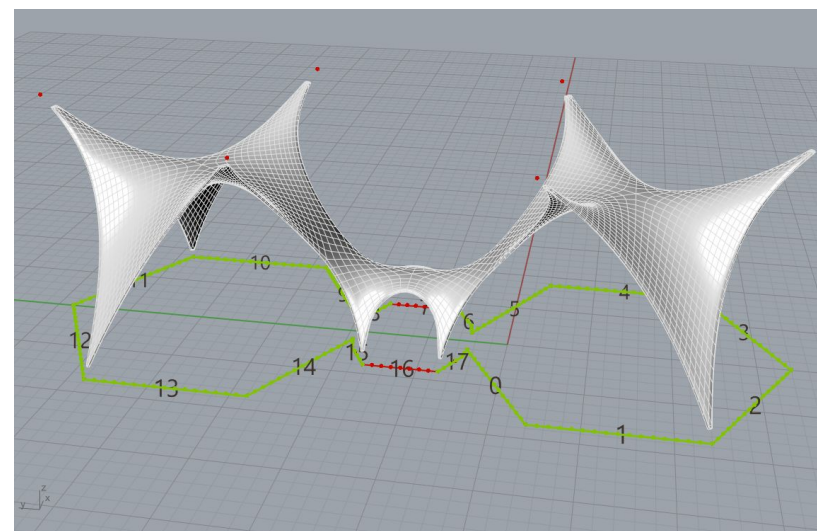
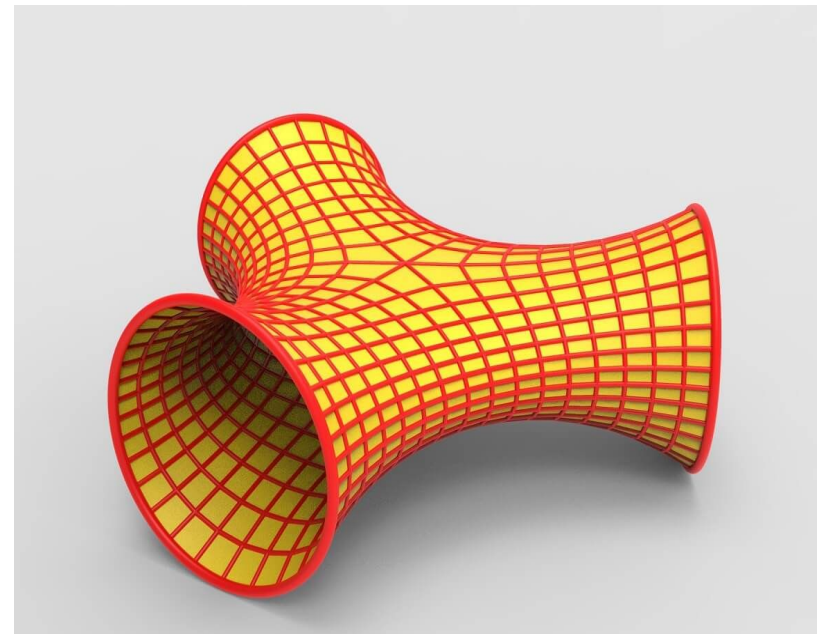


Plugins - Kangaroo Physics

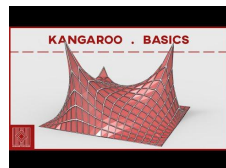
Plugins are essentially add-ons to Grasshopper that allow you to get more specific in your parametric design, and expand the scope and ability of operations in Grasshopper.

Plugins are typically made by individuals outside of Grasshopper, and are available to the public for free. (Kangaroo now included in Grasshopper!)

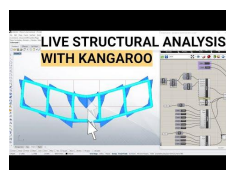
Kangaroo Physics - a live physics engine for interactive simulation, form-finding, optimization and constraint solving. Can be a useful tool for performing structural analysis or modeling a tensile canopy roof.



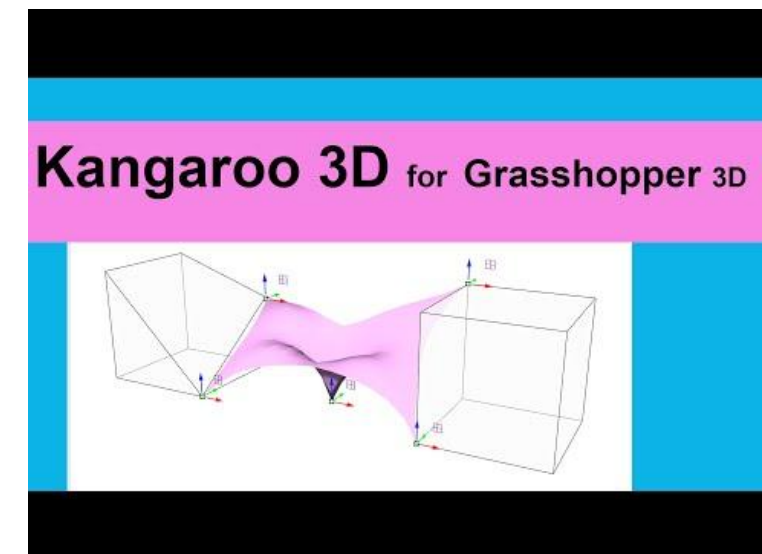
Tutorials



Tutorial 1: Kangaroo (Beginner)



Tutorial 2: Kangaroo (Structural Analysis)



(Click image to see Promotional Video)

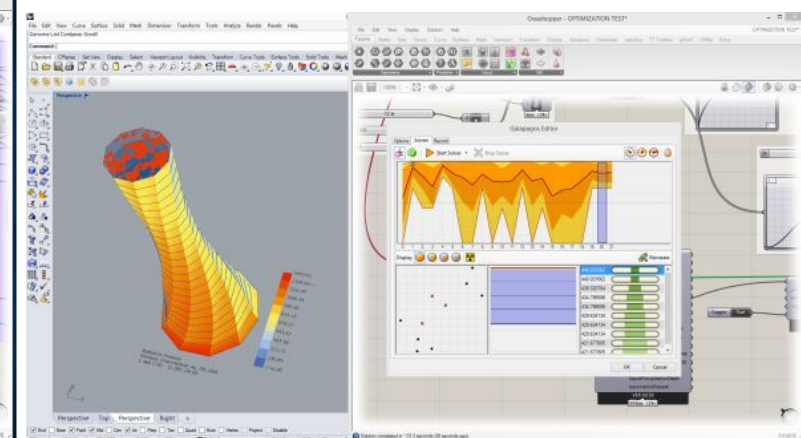
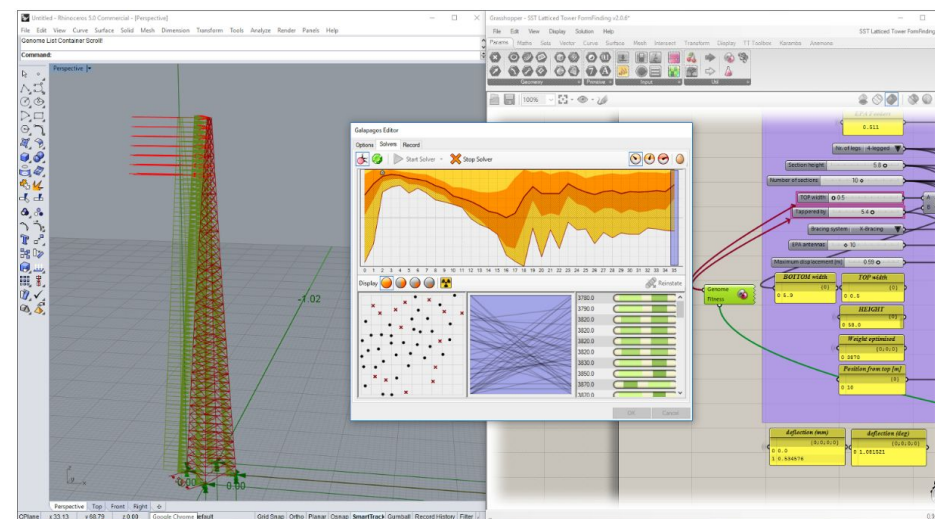


Plugins - Galapagos

Galapagos (Plugin already included in Grasshopper!)

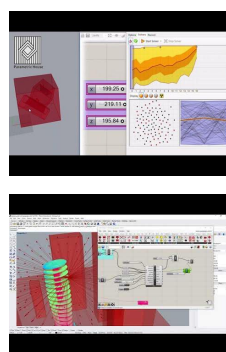
Optimize shape to achieve user-defined goals

A helpful tool to optimize complex design questions with several variables. Some examples of when to use Galapagos would be; optimizing a building mass to maximize its views, optimizing a facade system according to solar radiation, or to optimize member sizes in a structural space frame to reduce weight and cost.



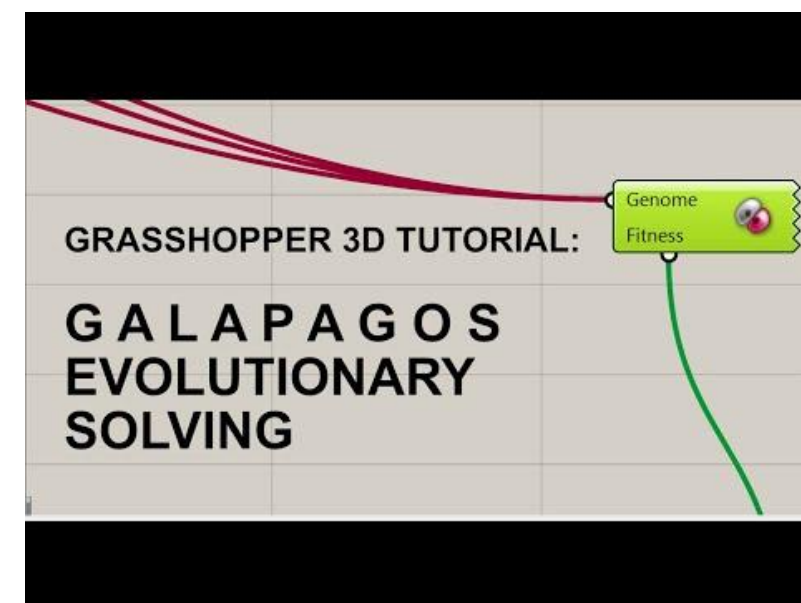
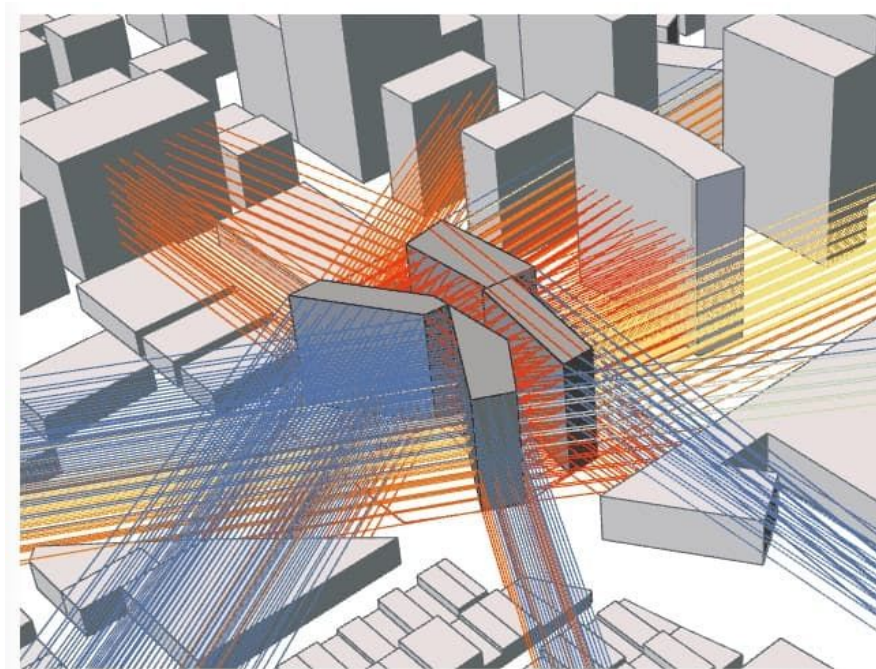
7

Tutorials



Tutorial 1: Galapagos (Beginner)

Tutorial 2: Galapagos (View Analysis)



(Click image to see Promotional Video)

Dynamo

Dynamo is an extension for Autodesk Revit that allows for the use of visual logic to design workflows and automate tasks. While Revit contains the visual models, Dynamo files provide sets of instructions for Revit to automate tasks and routines. Dynamo is typically used for repetitive engineering design and modelling needs. The software has been discontinued officially by Autodesk as of June 7, 2021, but is open source so it can still be supported by third-parties.

Program workflows and automated tasks.

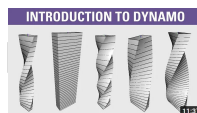
Dynamo provides a visual programming and scripting language for architecture and engineering firms that connects the bridge between Revit building information modelling (BIM) and traditional coding language.

Although Dynamo is officially discontinued as a stand alone software, Dynamo capabilities are now built into Revit tools since Revit 2020 and other Autodesk programs like Civil 3D and Robot Structural Analysis.

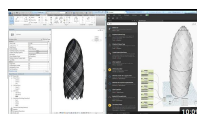
See page 'Revit' for compatible files.

See page 'Revit' for cost.

Tutorials

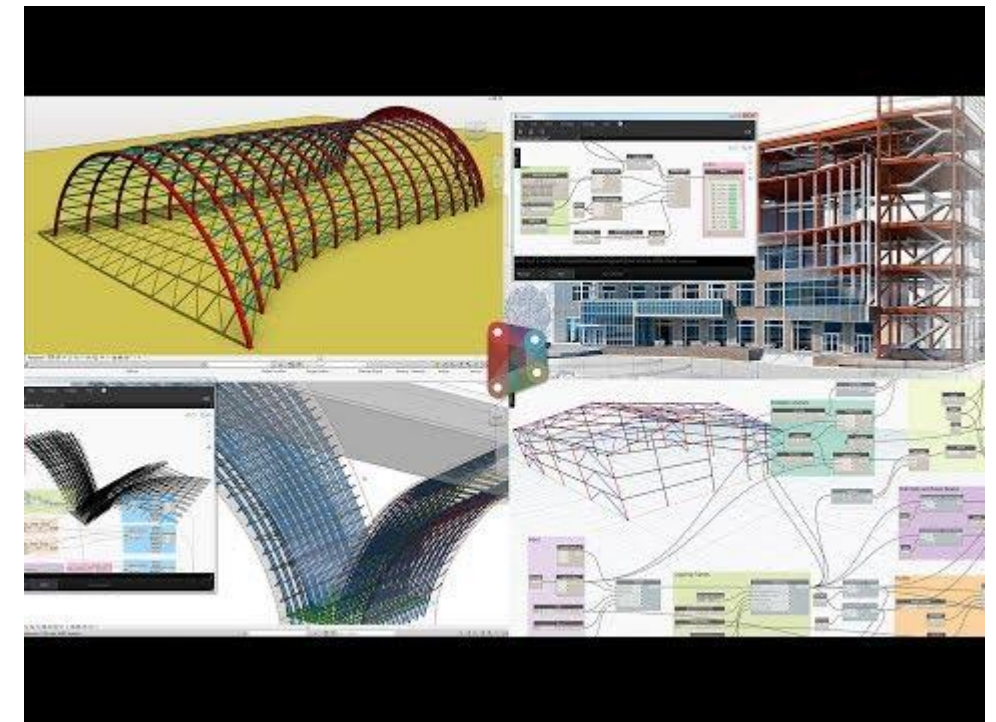
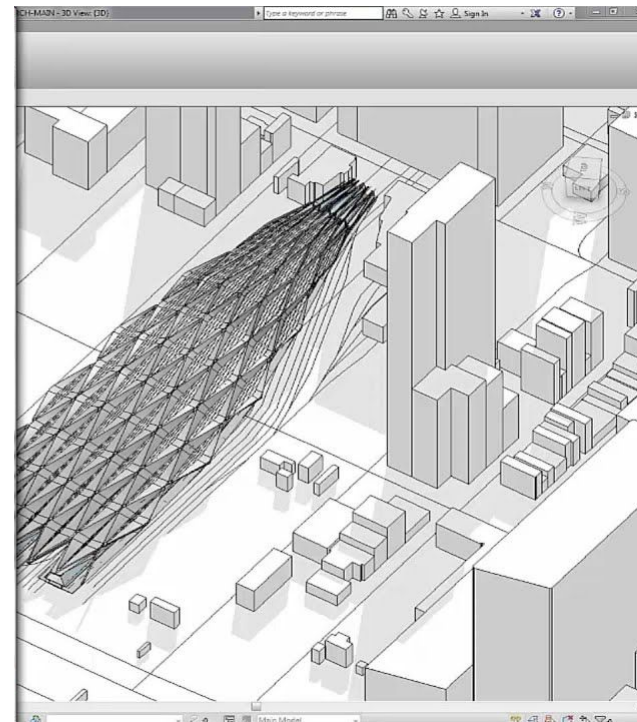
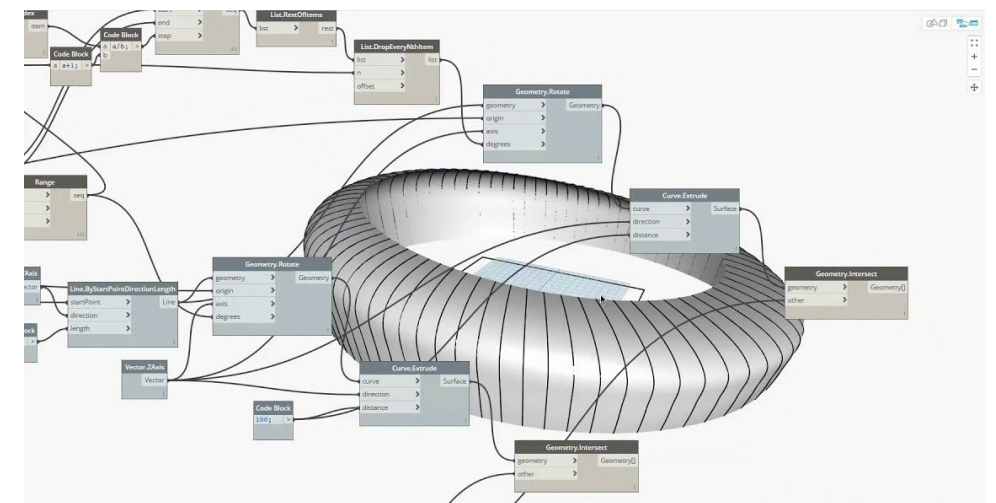
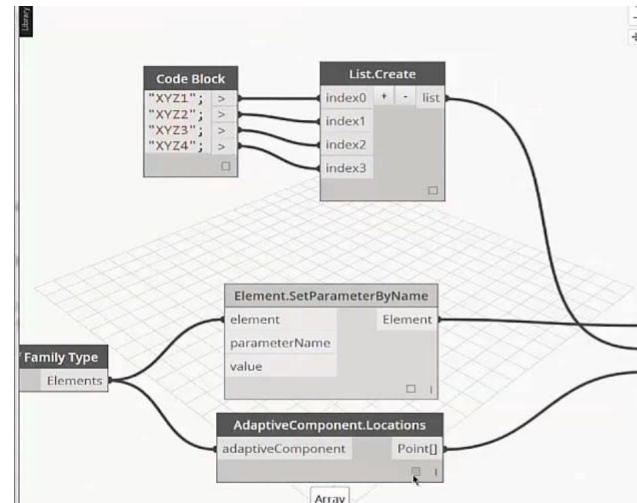


Tutorial 1: Introduction to Dynamo BIM - twisting tower tutorial



Tutorial 1: Dynamo / Revit Tutorial

(Click image to see tutorial)

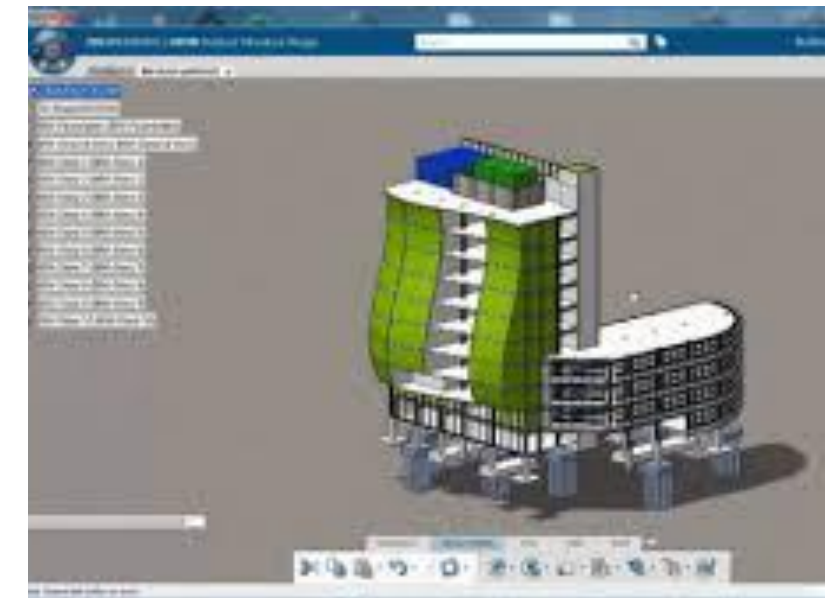
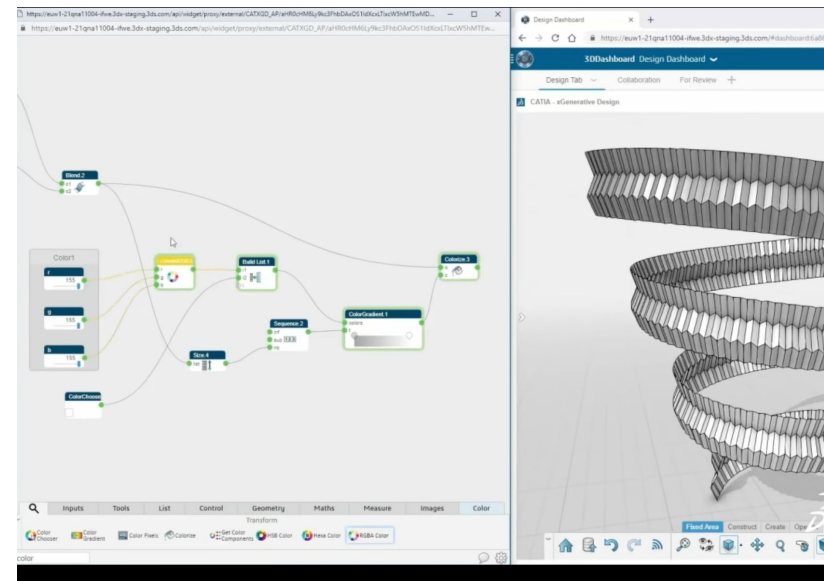


(Click image to see Promotional Video)

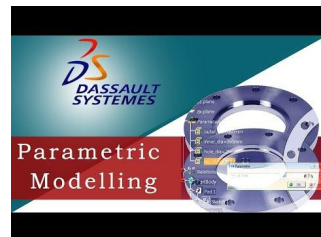


CATIA - “Computer Aided Three-Dimensional Interactive Application”

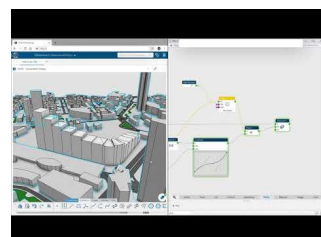
- CATIA delivers the unique ability not only to model any product, but to do so in the context of its real-life behavior: design in the age of experience. Systems architects, engineers, designers, construction professionals and all contributors can define, imagine and shape the connected world.
- Recognizes and predicts designer intent
- The Generative Surface Design workbench enables users to create wireframe construction elements and enrich existing mechanical part design with wireframe and surface features.
- 3D Virtual Reality experience that allows for designers to draw and design in the virtual reality
- Walt Disney Concert Hall designed using this software



Tutorials



Tutorial 1: Catia (Beginner)



Tutorial 2: Catia (More Hands-on)





Scripting

Scripting has been used since the 1990's by cutting-edge firms such as Foster + Partners to produce complex geometry models and fabrication strategies. Their use of programming languages have led to the development of teams like the Specialist Modeling Group. Once scripts have become too complex or difficult to operate, they are re-written and packaged into new softwares.

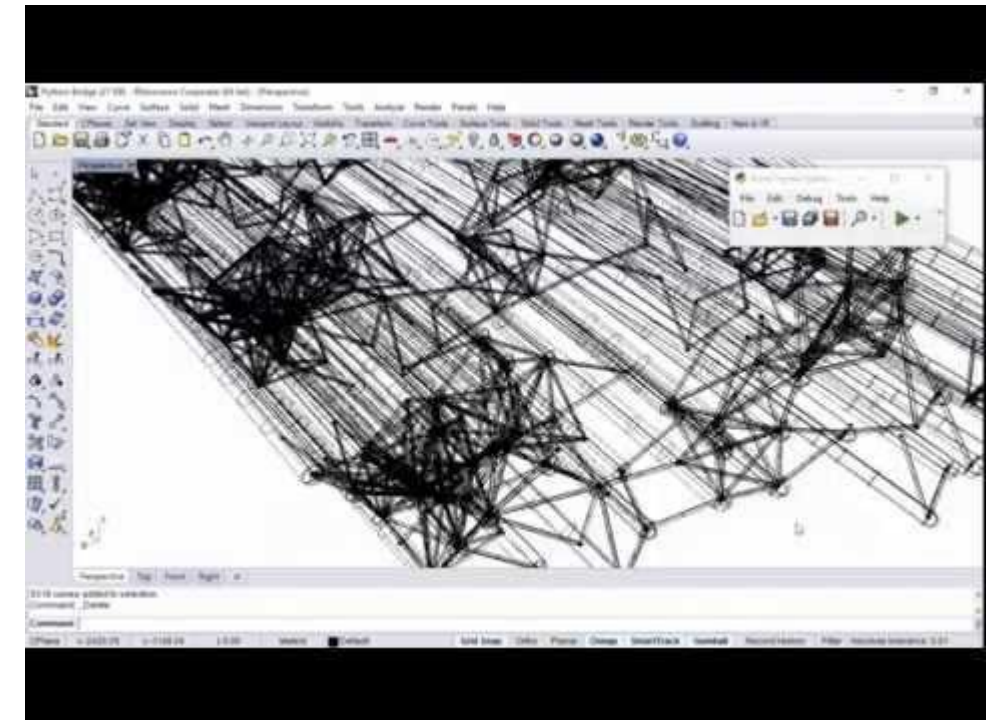
Re-written and packaged into new softwares.

Programming languages such as Python, Java, and C-Sharp are used to script parametric modeling of structures by architecture and engineering firms. These scripts can be adapted as plug-ins or softwares for in-house or commercial use.

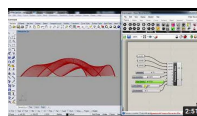
Each scripting software is a standalone program, but they can be used in collaboration with modeling software such as Rhino.

Since these programming softwares are independent of each other, compatible file types are specific to each program.

The cost for Python, one of the most popular programming languages, is free for both students and professionals.



Tutorial



Tutorial 1: Parametric waving* Algorithmic Design using Python Scripts

(Click image to see tutorial)

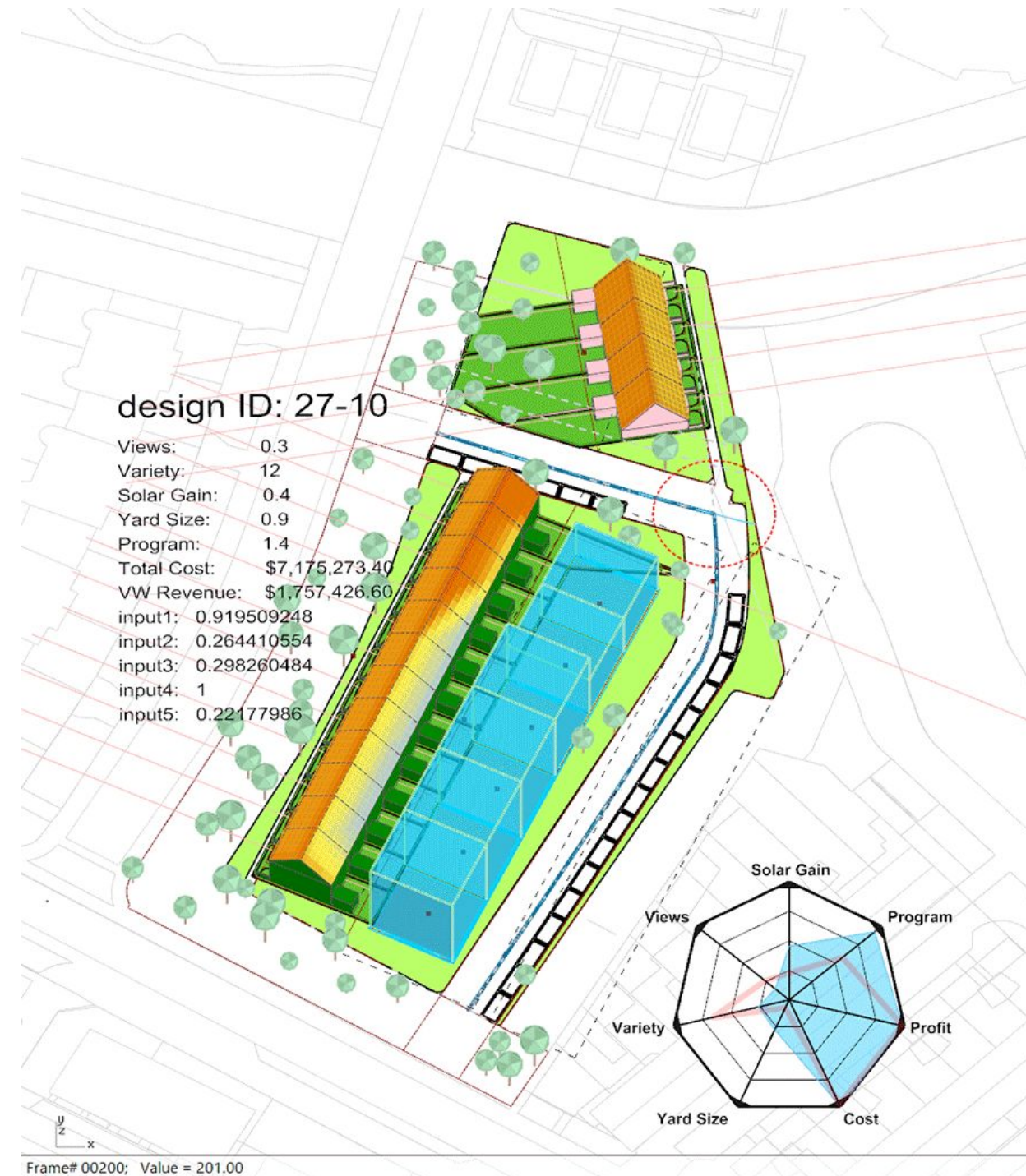
(Click image to see Promotional Video)

Generative Design

Generative design is one of the many practical application of parametric design. Softwares such as the Architecture, Engineering, and Construction Collection for Revit take a series on inputs to generate a list of radically different outputs.

The user then can rank the outputs given by the software. The generative design software will then intelligently reproduce and evolve the designs to meet the expectations of the designer, whilst keeping the design intention.

For example, a suburban neighborhood project focused on sustainability may want to input variables such as green space, water space, solar gain and residential square footage. The resulting outputs from the software will provide countless radically different orientations of the desired design intent.



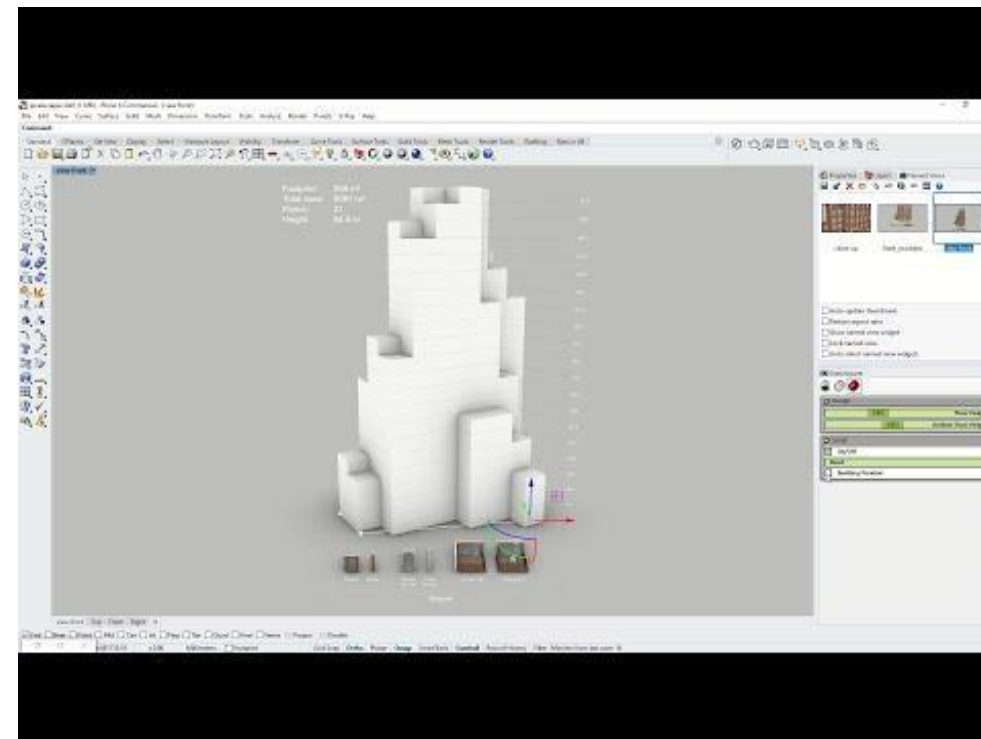
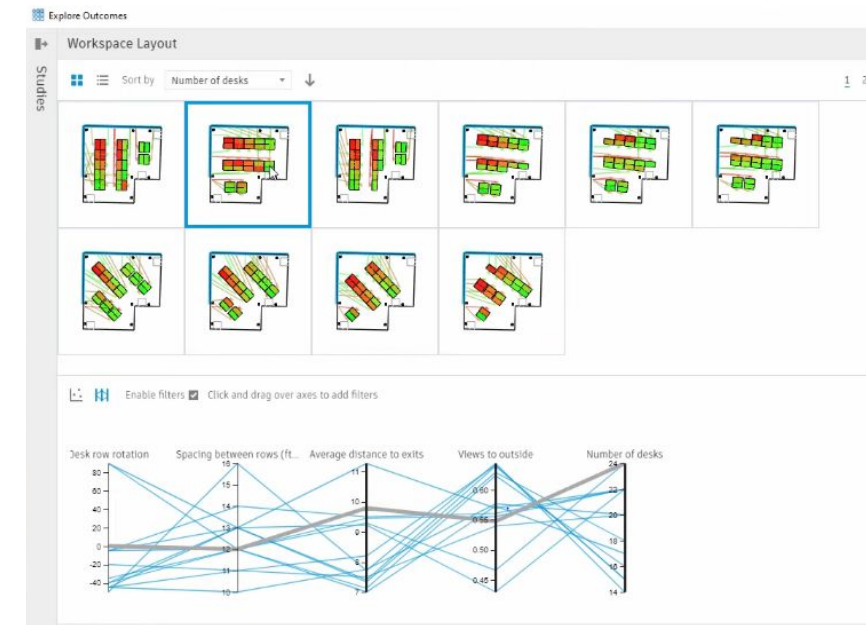
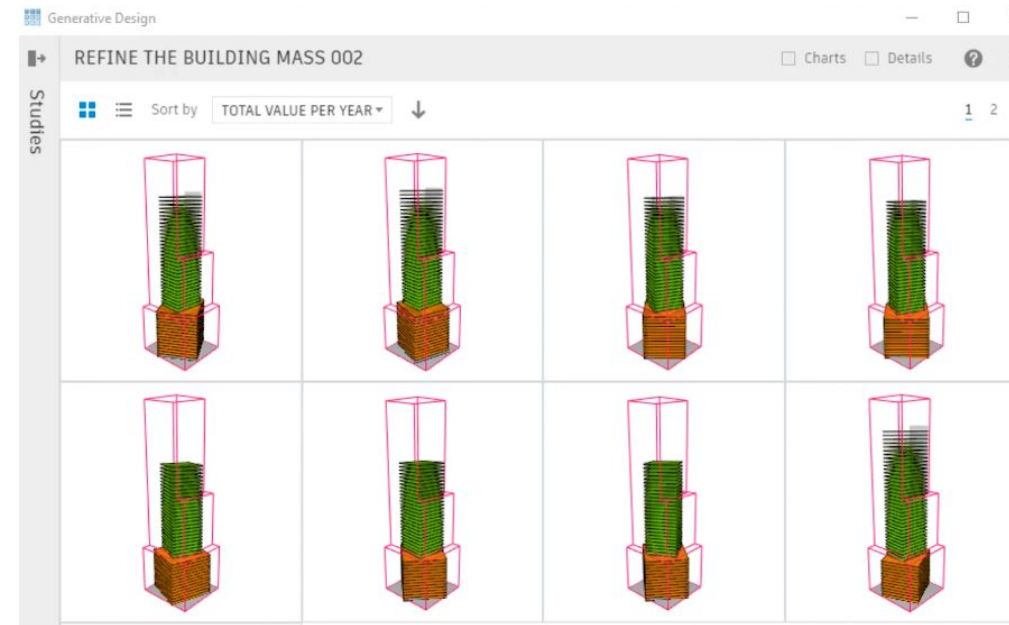
Generative Design Examples

Here some examples of generative design are shown.

The first image shows Revit maximizing commercial vs residential spaces in massing and floor plan. The second is Revit maximizing the number of desks in a while maintaining proximity to view outdoors (windows). These are examples of basic generative designs that Revit can produce given specific inputs and desired outcomes with defined variables.

Revit has preset generative option like the ones above but Dynamo can be used to create custom codes to design for specified inputs and constraints

Lastly, a video shows possible massing schemes in Rhino generated with a Grasshopper code.



Applications of parametric design

Parametric design can be used to optimize the facade or structure of a building, but it can also be used to optimize other building parameters. Additional applications of parametric design include but are not limited to:

- Acoustic installation
- Architectural facades
- Improved analysis for stakeholders
- Massing
- Noise
- Optimize sun exposure
- Optimize PV orientation
- Roof structure
- Structural design
- Views



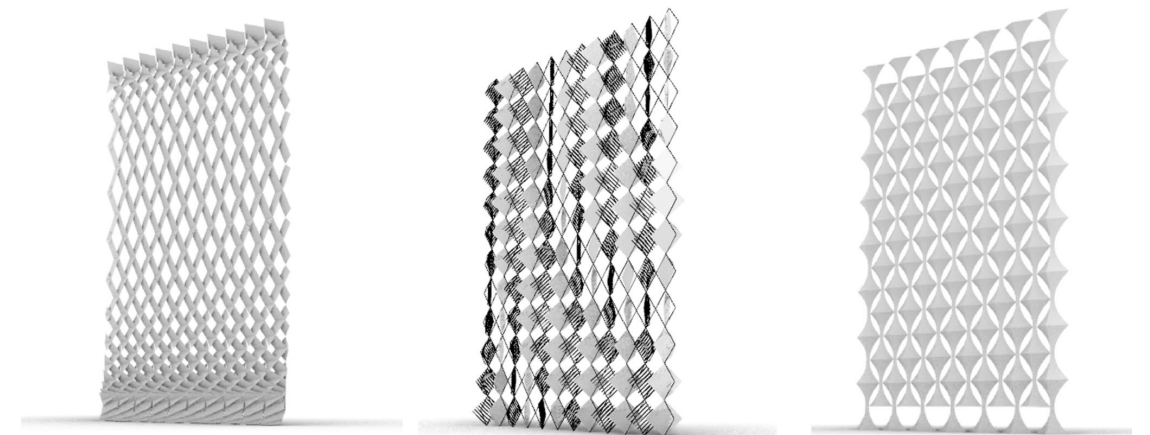
Acoustic Panels



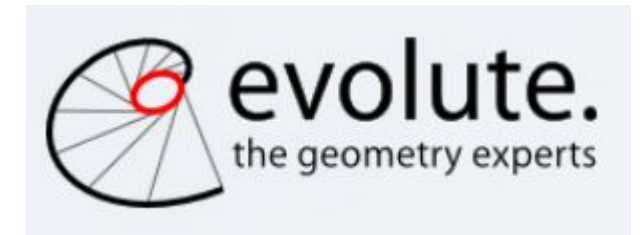
Smakkelaarspark (Spark), Utrecht



China Zun, Beijing



Facade Iterations



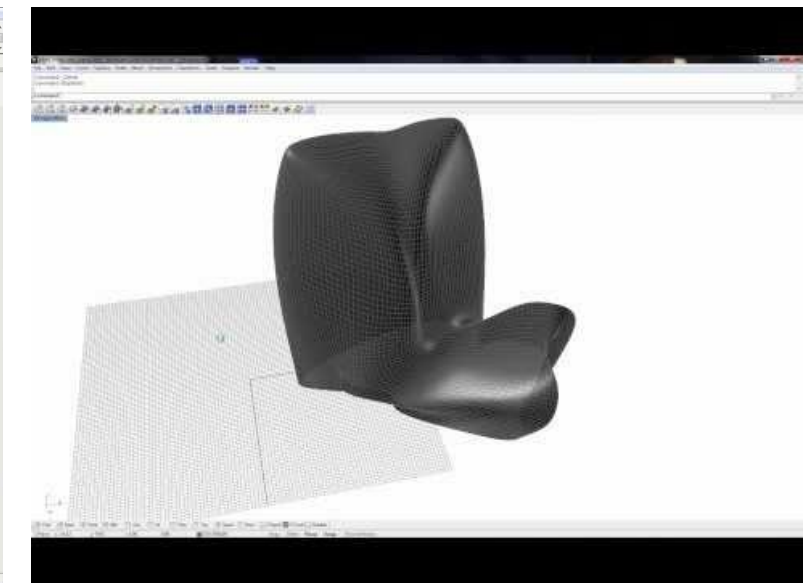
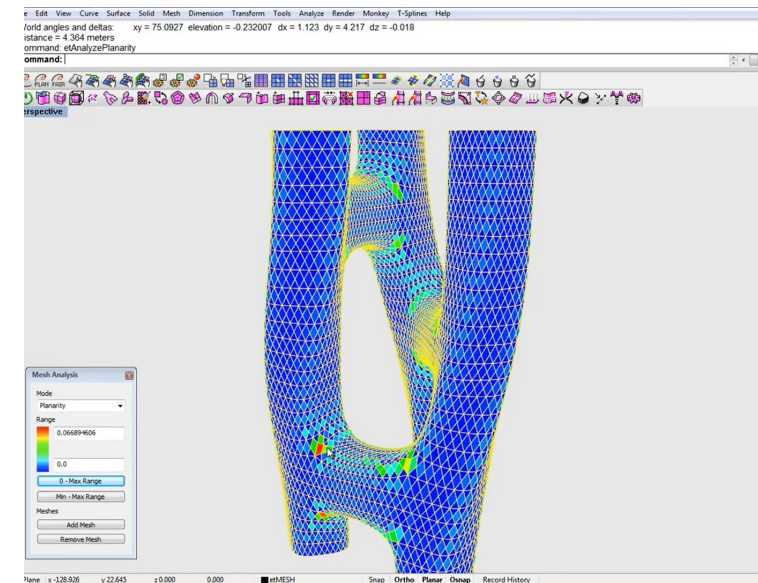
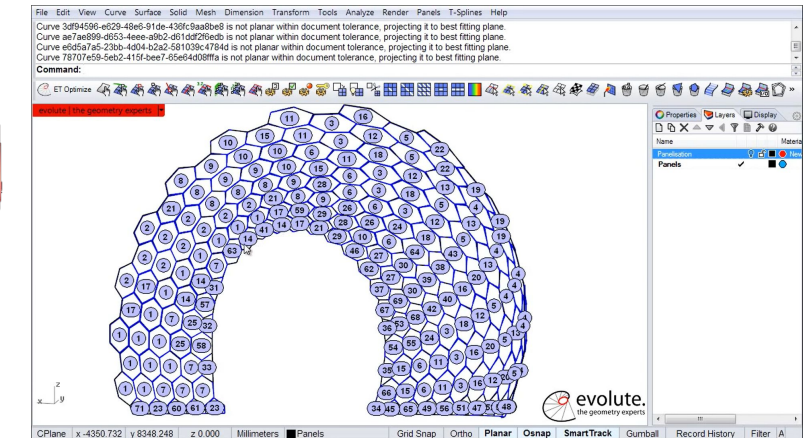
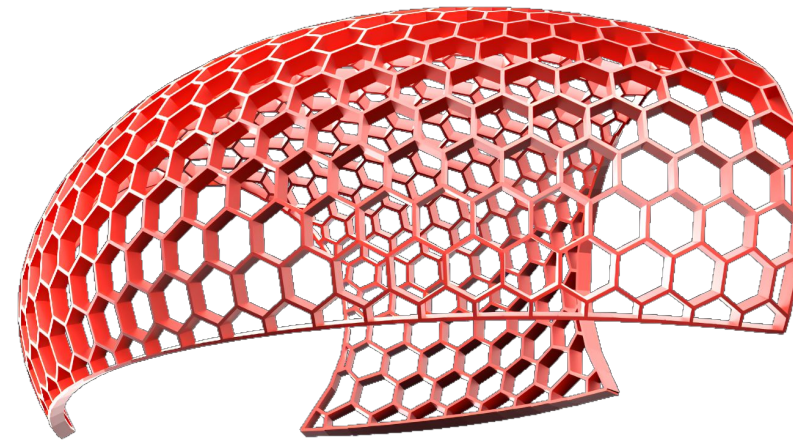
EvoluteTools

EvoluteTools LITE is a free Rhino plugin allowing intuitive design of panelizations using multi-resolution mesh modeling and mesh optimization. Evolute has been around since 2013 in compatibility with Rhinos 4 and 5 as a plug-in and is most recently available for Rhino 6.

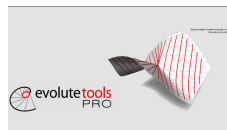
Designing and optimizing panel layouts.

Food4Rhino has tutorial videos as well as a primer that serves as a great starting point for newcomers as well as a reference point for the more experienced.

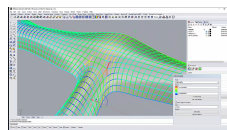
The program is downloadable with the LITE version for free, though there is a Pro version that goes for varying prices though the standard is \$220. The educational rate of EvoluteToolsPro for 30 lab seats is \$1088.



Tutorials



Tutorial 1: EvoluteTools PRO - Tutorial 01: Planarity Optimization



Tutorial 2: EvoluteTools PRO - Tutorial 02: Length Optimization

Physical Modeling

Physical Modeling is the process of bringing an idea to life in the simplest form, ranging from shapes to exact precise structures using a variety of methods.

A Design can be thought of and generated then modeled, or vice versa and either way more ideas and solutions will result because of it.

Physical models change the way anyone views anything, looking at it in all dimensions it will exist in, being able to touch it and get a feel of the form is different than looking at a sketch.



Intro Video: Why Make Architecture Models?

(Click on the image to see video)



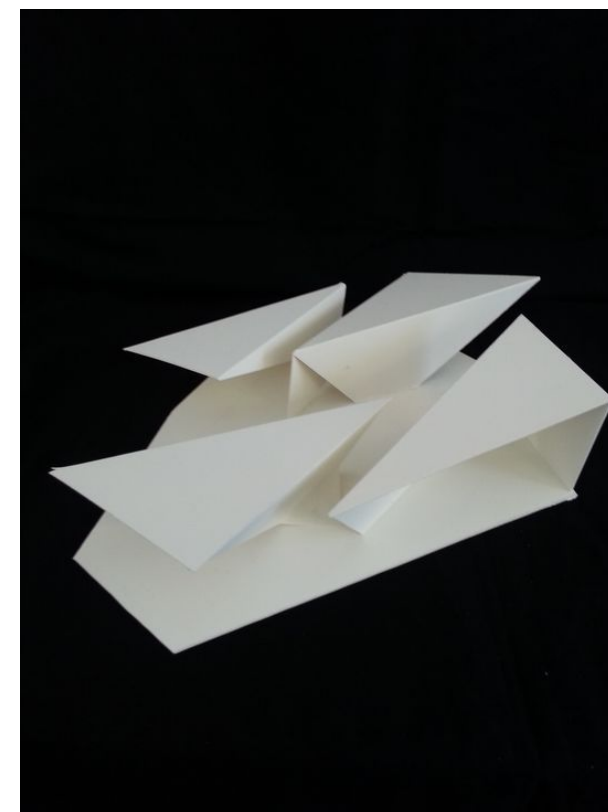
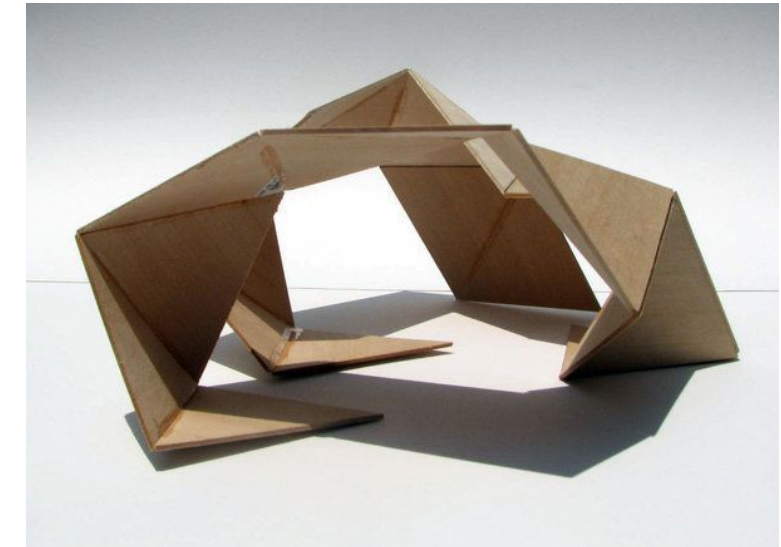
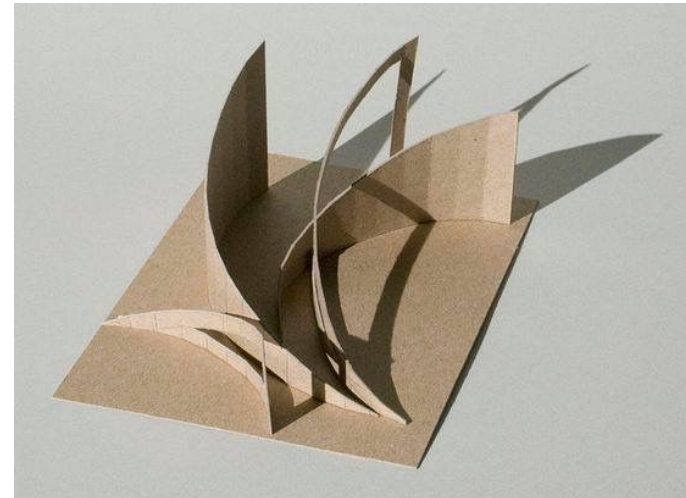
Conceptual Models

Conceptual Models have been used for as long as Architecture has existed. They are the first step after, sometimes even before, the design process as they are the most basic models generated after an idea is formed or sometimes they are done to generate ideas which leads to the development of the form.

Basic Models to Develop Form

Many architects will get an idea, generate a sketch to keep the idea and remember it, then using the simplest of materials such as paper, cardboard, blue styrofoam combined with the simplest equipments such as a hot glue gun, liquid glue, heat cutters they cut pieces and put together a simple model of the idea they thought of.

Sometimes, these models do not reflect the original idea and that is what they are looking for, development and more inspiration therefore they may veer off course and start putting pieces in different places or orientations than they originally intended.



Tutorials



Tutorial 1: Conceptual Model Making



Tutorial 1: Architecture Model Making

(Click image to see tutorial)

(Click image to see Promotional Video)

Handmade Modeling

Handmade modeling is an excellent way to represent an architecture project at any point in the design process. There are many types of handmade modeling such as conceptual models. Conceptual models are what a project looks like at the initial stage of development. The design starts to take shape and form at this stage. A working model is the next stage in the modeling process and is used to develop a design. This type of model is used to create solutions and communicates form, scale, and materials. The last type of model is the presentation model and is used to present the ideas to the public.

Architectural Models Sell a Project

Models are a visualization tool for clients and are able to provide information to the public. By having a tangible item that the client can feel and see in front of them is important in selling the idea.

Handmade models are made out of multiple different types of materials. Many architectural models are made out of wood and foam. It is vital to use the right tools for different materials. For cutting, a person should have sharp blades and a utility knife. Hot glue is an important tool because it is the fastest and provides the strongest hold but can be dangerous. A person can use wood glue, glue stick, or tacky glue instead.



(Click image to see Promotional Video)

Tutorials



Tutorial 1: Architectural Model Making Tutorial



Tutorial 2: Architectural Model Techniques Tutorial

(Click image to see tutorial)

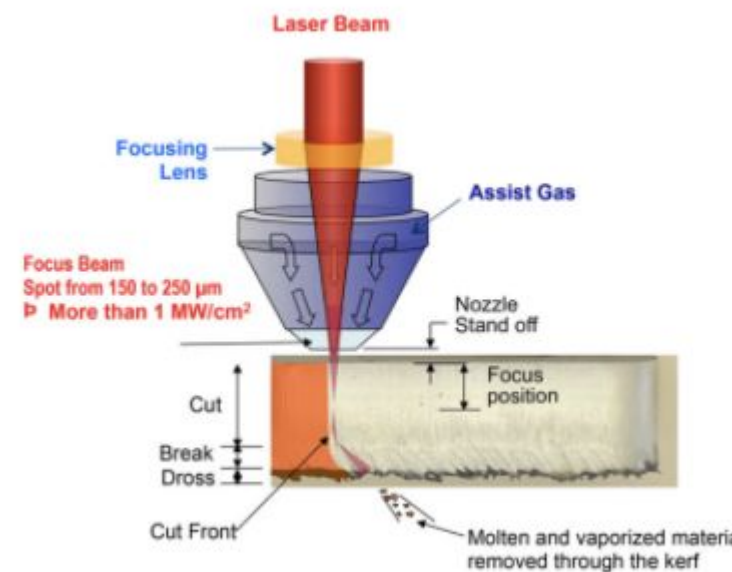
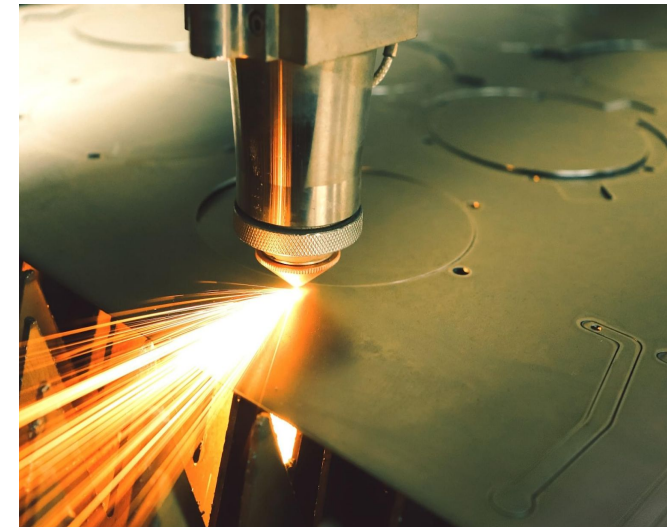
Laser Cutting

Laser cutting is a fabrication process that uses a thin, focused, laser beam to cut and etch materials into custom designs, patterns, and shapes as specified by a designer. This non-contact, thermal-based fabrication process is ideal for several materials, including wood, glass, paper, metal, plastic, and gemstone. It's also capable of producing intricate parts without needing a custom-designed tool.

Cutting edge technology resulting in a cut edge.

High speed laser cutting technology is an energy-efficient production solution that cuts down carbon footprint and reduces metal waste. It also keeps costs down and productivity up and is good for producing either a high volume of parts or more intricate and detailed parts.

The cost of a laser cutter varies depending on the size and quality, but they are all fairly expensive. Prices of laser cutters range anywhere from \$2000 to \$20000. Laser cutters can be used for cutting several types of materials, but basswood is a common material used in architectural modeling. The average price of basswood ranges from \$4.60 to \$7.30 for ten board-feet of wood.



(Click image to see Promotional Video)

Tutorials



Tutorial 1: Laser Cutting a Model From Revit



Tutorial 2: Laser Cutting Architectural Models

(Click image to see tutorial)

CNC

CNC, computer numerical control, is a machine programmed automatically to shape pieces of materials, commonly including wood and metal.

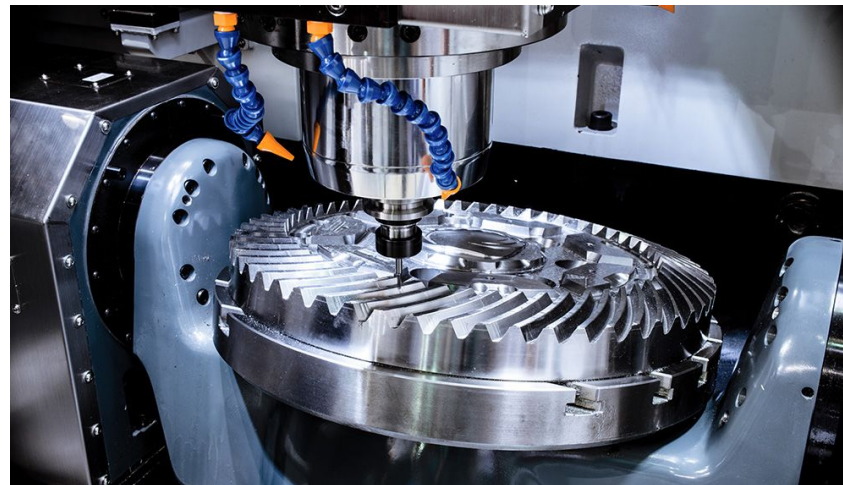
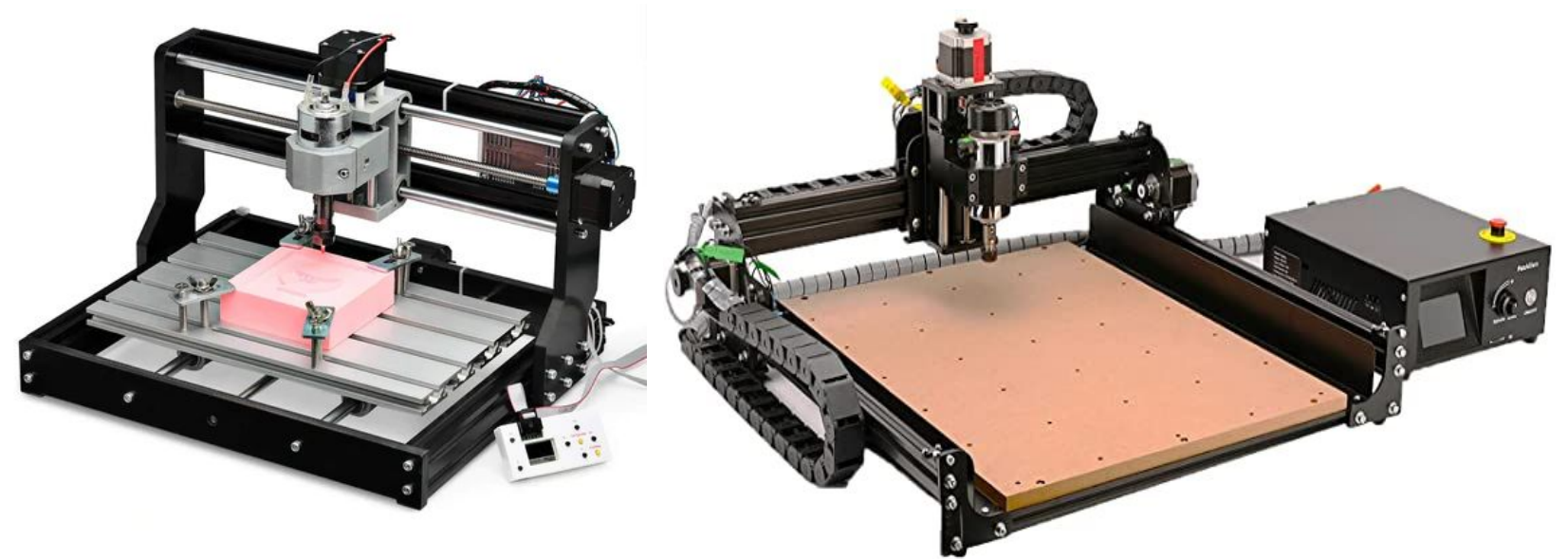
CNC machines render 2D vectoral drawings and 3D models, providing them detailed instructions for the machine to execute. Instructions are taken from digital archives, through files generated on Rhinoceros 3D, AutoCAD, and other 3D modeling softwares. CNC routers can rapidly and precisely cut material, which are quickly assembled later.

Precise cutting for Ready To Use Pieces

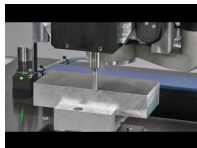
Time efficiency is maximized, and material use and labor costs are minimized.

Nail, Cross, and Glue laminated timber are common pieces CNC machines design for wood structural uses.

Digital Fabrication is a common application of CNC machines. CNC precision allows us to make advanced pieces of construction such as complex facade components, that are later put together for a complete design.



Tutorials



Tutorial 1: High Speed Milling



Tutorial 2: Rhino and CNC

(Click image to see tutorial)

(Click image to see Promotional Video)

3D Printing Models

Craftbot XL

Print Volume: 12x8x17 inches

Nozzles: .25, .4, .6, .8mm

Smallest Printing size: 50 microns per layer

LCD Display Use: Temperature, Speed, Start, Stop

Removable Heat Plates

Connection Type: USB 3.0 Plug-In

Price: \$3,999

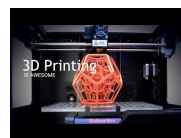
Note: Craftbot+ Is smaller version of Craftbot XL

Texas Inventionworks also has SLA (liquid-based, high resolution), SLS (powder-based, tough material) and Metal 3D printers.

Code Input File Type: Gcode

Link to 3d Print Tutorial: [Here](#)

Tutorials:

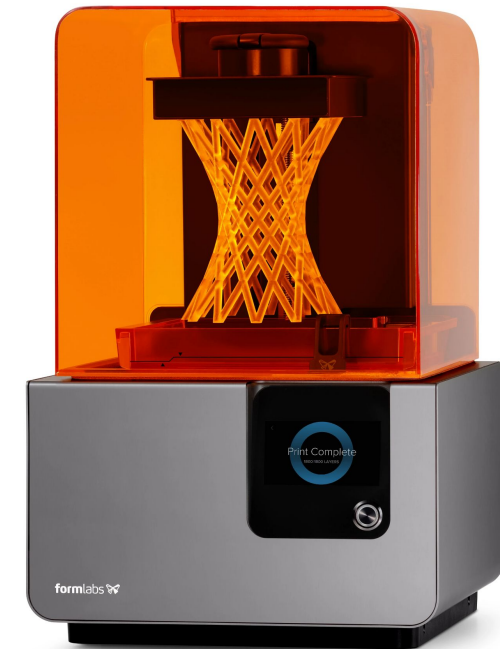


Tutorial 1: Beginner's Guide to 3D Printing

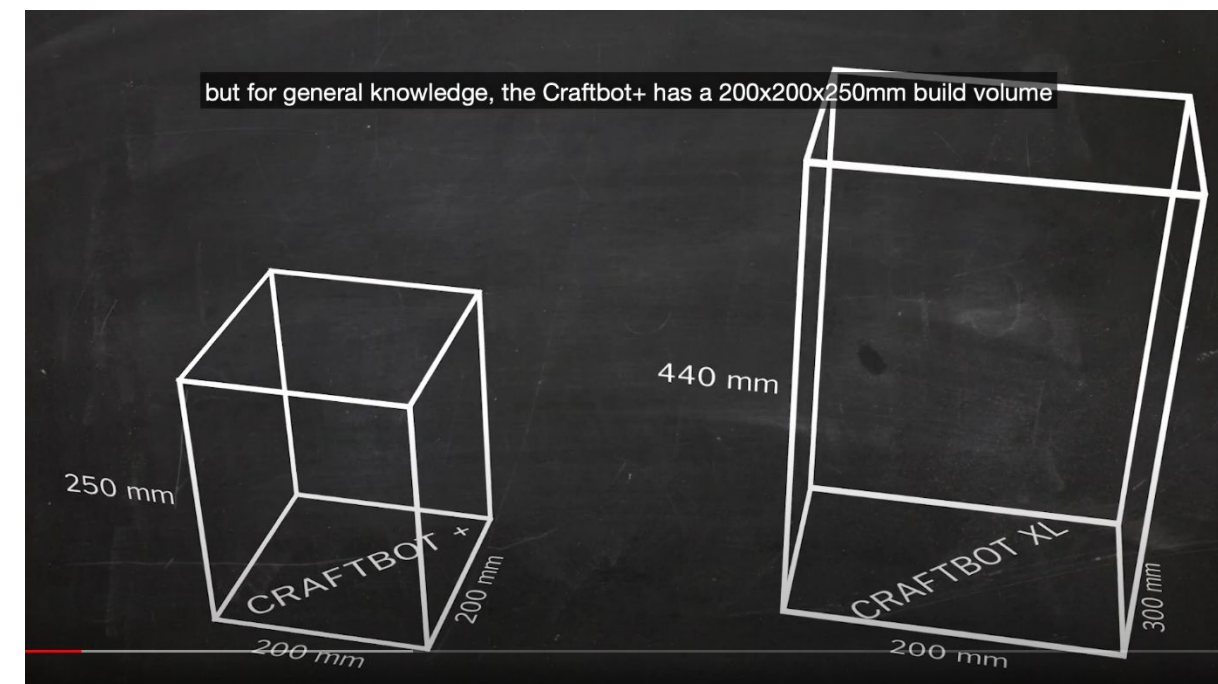


Tutorial 2: Learning how to 3D Print

(Click image to see tutorial)



20



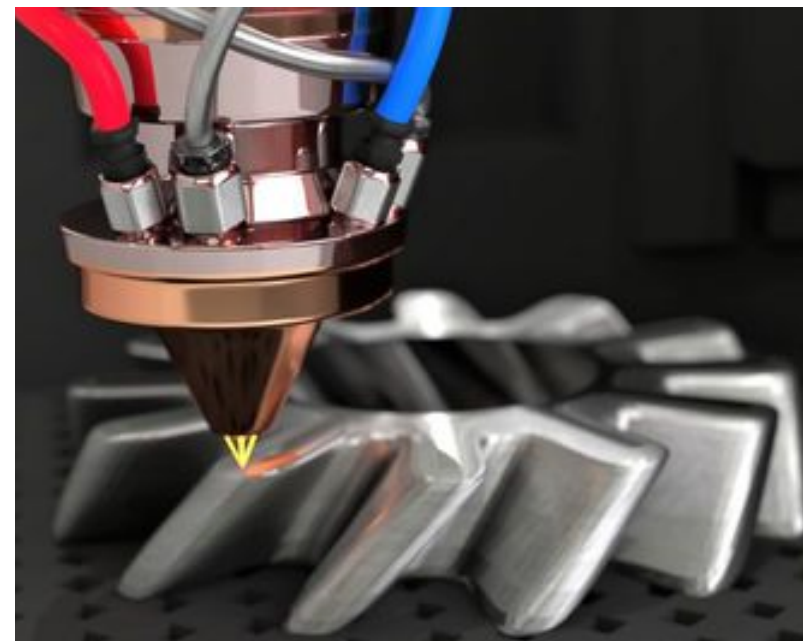
Metal Modeling

3D Metal printing is a technology that was invented in 1994 and ever since then has been used in multiple industries and that number is only growing. The various applications of 3d printing using metal has been a proven advantage as it gives users the ability to create parts that could not be cast or otherwise machined therefore providing a solution for a problem that will be encountered when dealing with unusual shapes.

Parts Within Parts

Metal 3D printing can create parts within parts therefore allows engineers to design a complex assembly in one piece thereby saving time and costs, but also produces a better quality product..

3D printing metal parts and pieces eliminates the need for melting and joining different or strands of metal to achieve the desired shape therefore allows for a better quality product than the other methods used to create different parts, The only drawback to 3D printing metal structures is the limitations that come with it as the size of the structure or part can only be so big. Almost every industry that uses metal has incorporated 3D printing into their work.

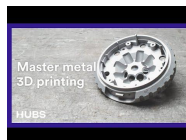


(Click image to see Promotional Video)

Tutorials



Tutorial 1: 3D Printing using metal composite filament



Tutorial 1: How to print strong and functional parts

(Click image to see tutorial)

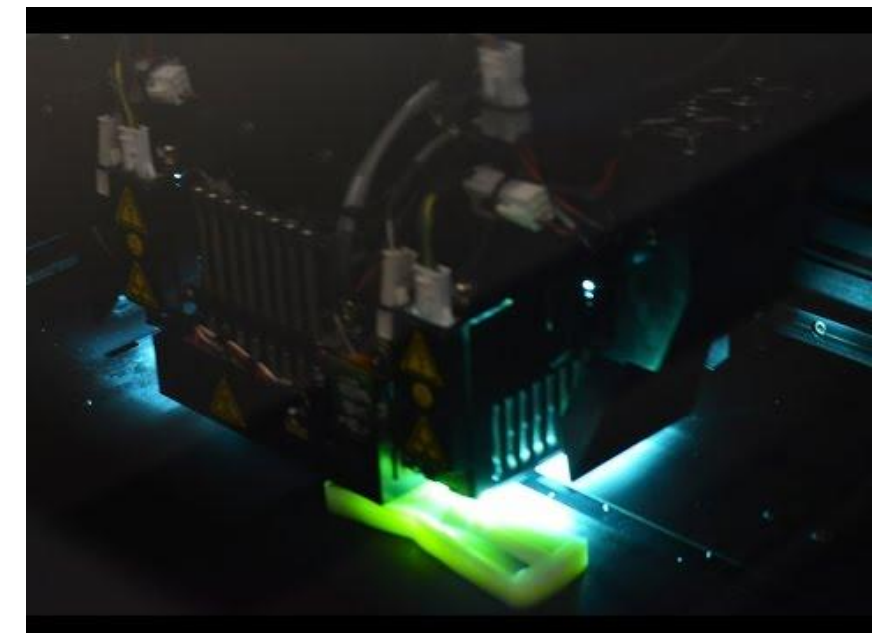
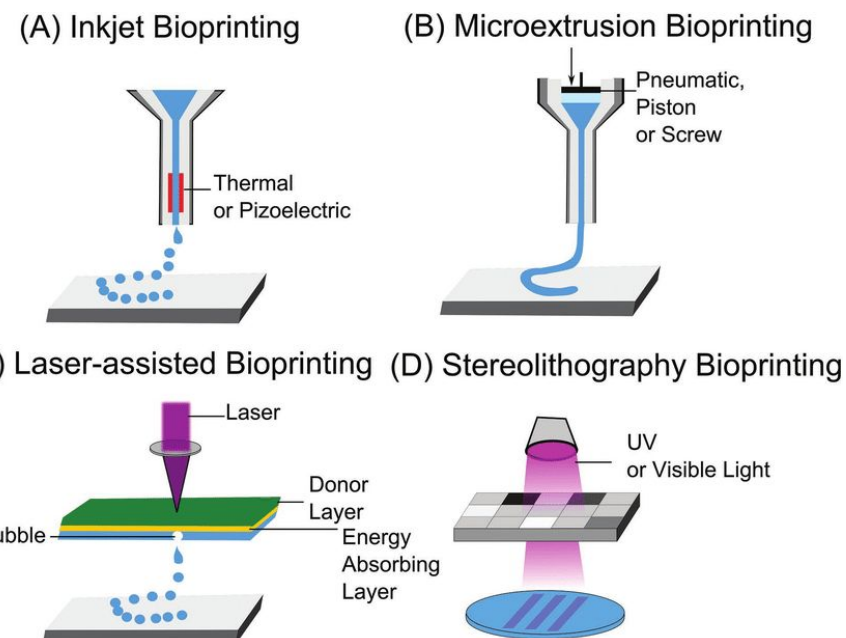
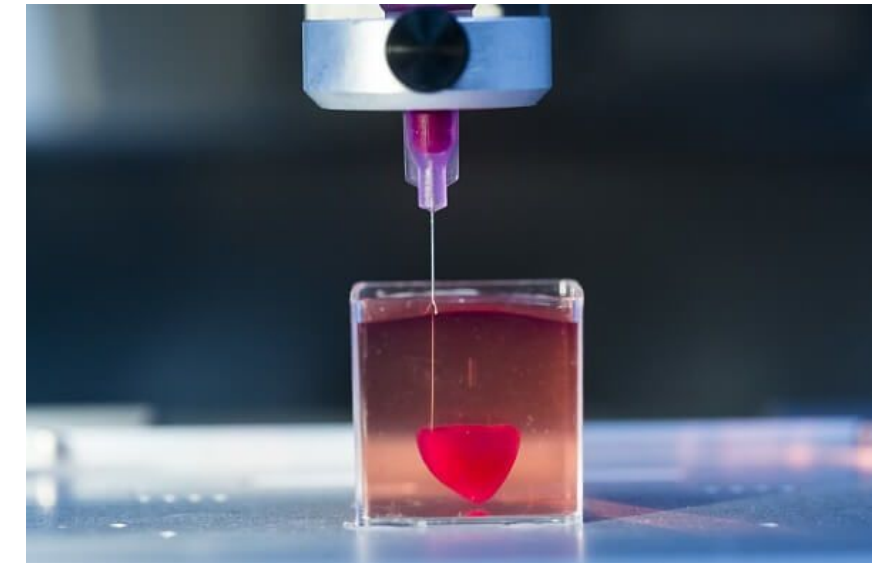
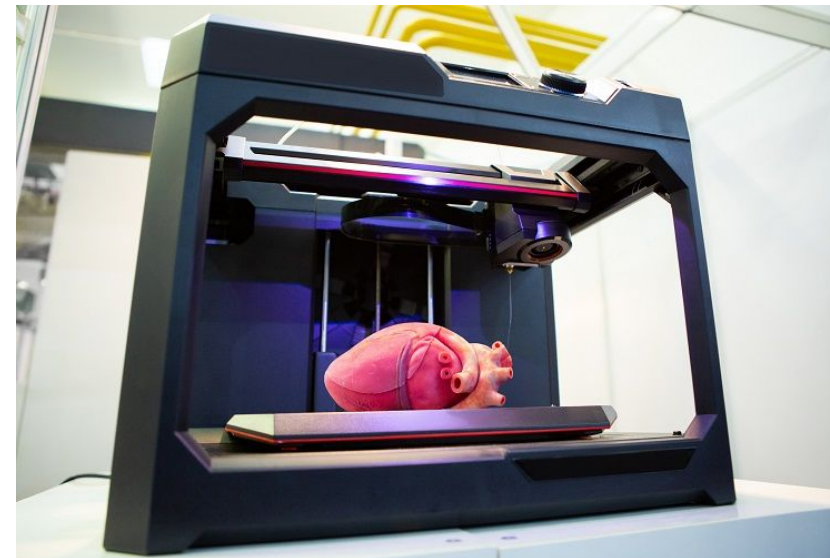
Bioprinting

Bioprinting is the artificial creation of human skin and tissue using 3D printers. Instead of using materials like plastic, these 3D printers deposit biomaterials.

These biomaterials are called bioinks. They mimic the composition of human tissues. Bioprinting can be applied to a variety of areas like regenerative medicine, drug discovery and development, and 3D cell culture.

Bioprinting Strategies

One method of printing uses bioink that can be deposited on a “bio paper,” culture dish, polymer construct, etc. This is a non-contact printing technique, where the printing takes place in a digitally controlled pattern. Next is extrusion based bioprinting. This can be done by direct ink writing (DIW). This is a material extrusion process in which material is continuously extruded out of a nozzle, building prints layer-by-layer. The stereolithographic method depends on the height of the build rather than its complexity. This method builds up the design layer-by-layer by projecting light on a photo-sensitive heat-curable bio-ink.

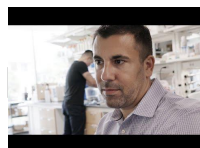


(Click image to see Promotional Video)

Tutorials



Tutorial 1: How to 3D Print Human Tissue



Tutorial 2: 3D Printing the Human Heart

(Click image to see tutorial)

3D Printing Buildings

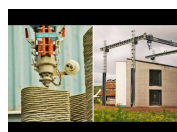
3D printing continues to get more advanced and is used for larger-scale projects. Now, there are buildings and homes being 3D printed around the world. 3D printed buildings will open up a world of choice in the shape and style of buildings and homes. It also requires a much smaller construction team and mitigates a lot of the safety risks with most construction projects.

3D-Printed homes push the boundaries of sustainable design

ICONBuild is leading the development and use of large scale printing here in the United States. They have already began printing individual houses in the Austin area with their proprietary Vulcan system which can print up to 10” of concrete per second. There are also future plans alongside the Bjarke Ingels Group to develop a 100-house community comprised solely of digitally printed homes.

The cost of 3D printing varies depending on the scale of the project. It can be cheaper to build a house by 3D printing it because it is much faster and requires less people, but there are many aspects that can cause price to vary. Materials and size play a large role in the price of a 3D home or building.

Videos

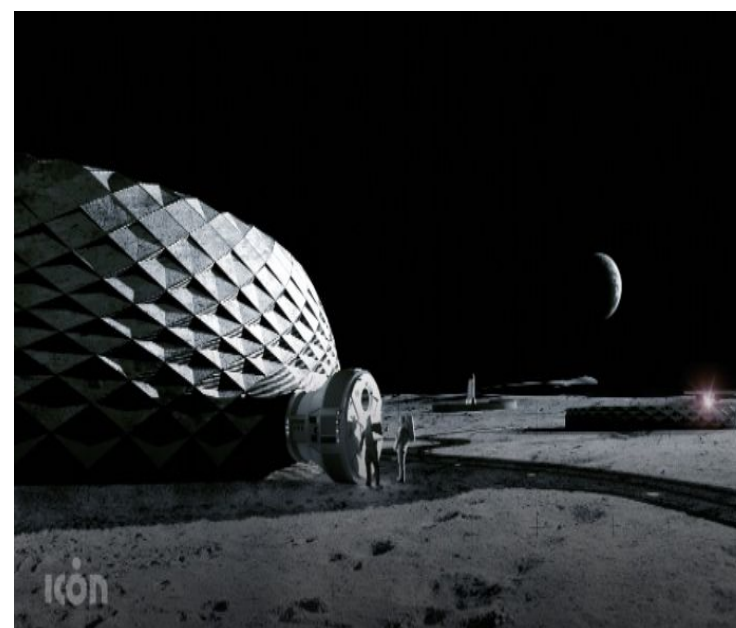


Video 1: Giant 3D Printer Builds a Two-Story House in One Piece



Video 2: Future Moon City - 3D Printed Habitats by ICON and BIG

(Click image to see video)



(Click image to see Promotional Video)

Digital Rendering

Rendering is an image synthesis process to develop photorealistic images from predefined 2D or 3D models. The data is loaded into a scene and contains information about textures, lighting, shading, and perspective to make something as close to reality as possible.

Rendering as a tool is useful on many levels. In this case, it is incredibly useful as a means of portraying an idea to a client, or another branch of a project, such that they can see a what the potential finished version of design might be and what they could change to suit their vision.

Video displaying the professional product of rendering programs:





Revit

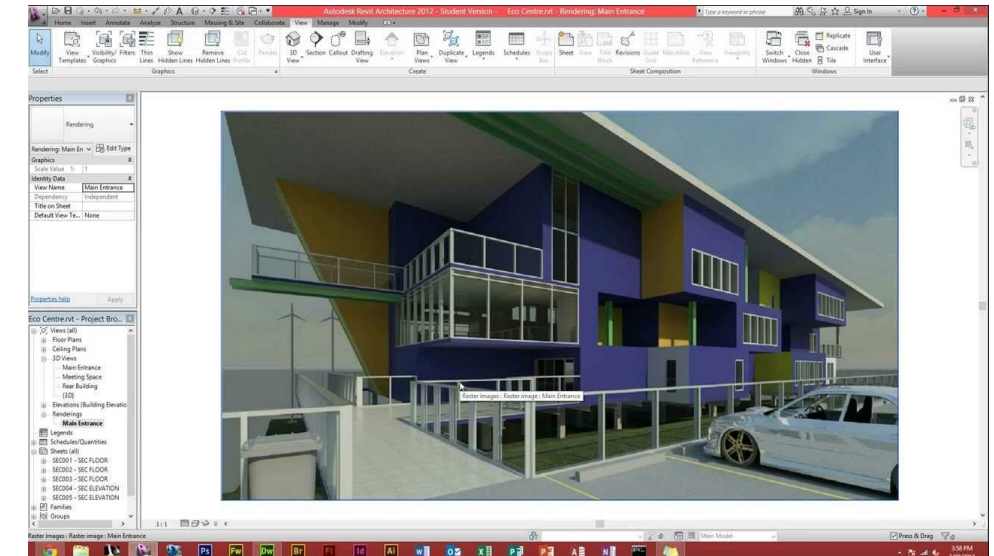
Revit is a BIM software utilized by a variety of disciplines such as architecture, structural engineering, and MEP engineering. Released by Autodesk in the year 2000, the software allows users to create, edit, and review 3D models in exceptional detail.

Images with richness of details and realism

In order for users to create a rendered image of a building model, Revit offers a plethora of predetermined materials they can apply to walls and floors. By adjusting textures and transparency of the materials, the rendering engine in Revit can produce a realistic, high-quality image of a building to the user's liking.

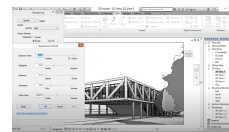
Revit also offers cloud-based rendering, where users with an Autodesk account may send their models to the Autodesk server for a rendered image to be returned to them. While the process requires a fee for a high quality image, this option is optimal for users with less powerful computers.

See page ['Revit'](#) for cost.



25

Tutorials



Tutorial 1: How to Setup a Rendering in



Tutorial 2: How to Render in Cloud in Revit

(Click image to see Promotional Video)

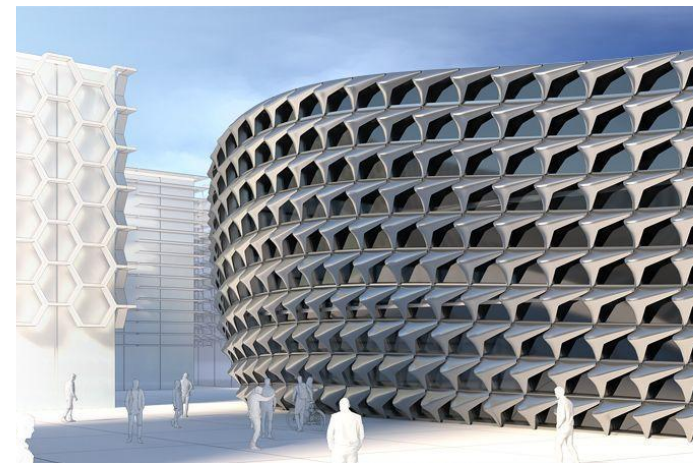


Rhinoceros 3D

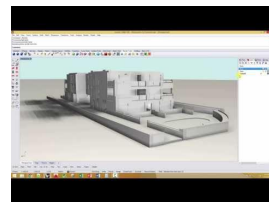
Rhinoceros 3D, more commonly known as Rhino, is a commercial 3D computer graphics and CAD design modeling software. The software is compatible with most design, drafting, prototyping, and rendering illustration programs.

As a rendering tool, Rhino can provide full-color renderings with lights, shadows, textures, and additional materials or entourage per the user's preferences. The rendering process follows four basic steps: add lighting, assign materials, adjust surrounding environment, and render. Any specific rendering attributes can also be further enhanced by utilizing a rendering plugin.

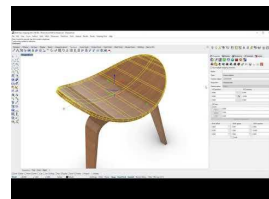
- Pricing (one time purchase - licenses do not expire)
 - Commercial: \$995 (\$595 to upgrade to newest version)
 - Students: \$195 (\$95 to upgrade to newest version)
 - Free Trial: 90 days
 - See page ['Rhino'](#) for detailed cost breakdown.
- Function
 - Utilizes NURBS mathematical model for complex geometries.
- Features
 - Industries: architecture, industrial design, product design, graphic design.
 - Files can be exported for 3D printing, laser cutting, and other fabrication machines.
- File Type
 - .3dm



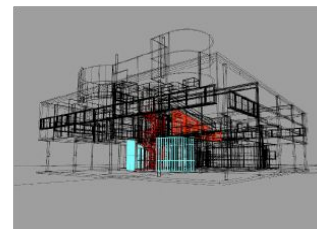
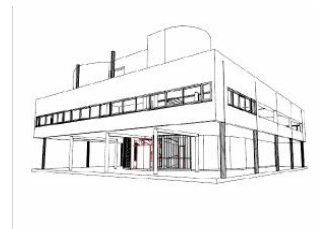
Tutorials (click image to watch tutorial video)



Rendering Basics in Rhino



Materials and Texture Mapping





Maya

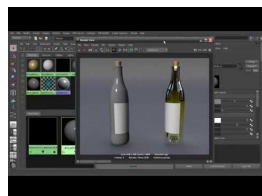
Autodesk Maya, commonly shortened to Maya, is a 3D computer graphics application used to generate 3D assets for animated films, television, video games, and special effects.

As a rendering tool, Maya can be used to create full motion effects in 3D, resulting in almost life-like animations in a CAD environment.

- Pricing
 - Professional: \$225 / monthly
 - Student: Free Access (up to 3 years)
 - Free Trial: 30 days
- Function
 - Compatible with Microsoft Windows and macOS operating systems.
 - Visualizes complex geometries and produces realistic animations.
- Features
 - Creates 3D models, character rigging, animation, dynamics, and rendering.
- File Type
 - .ma or .mb



Tutorials *(click image to watch tutorial video)*



Architectural Materials in Maya



Introduction to Lighting and Rendering

AutoCAD 3D

AutoCAD 3D is a computer-aided design and drafting software developed by Autodesk corporation in 1982. The software is used in the industry by architects, project managers, engineers, graphic designers, city planners, and other professionals.

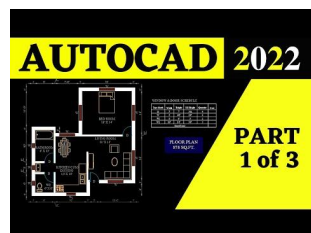
In regards to rendering, AutoCAD has its own in-house system and is also compatible with plugins such as Lumion and Enscape.

- Pricing
 - Professional: \$5315 / 3 years
 - Students: 1 year free license
- Functionality
 - Available and optimized for both Windows OS and MAC OS
- Features
 - Industry Specific Tool Sets Include: Architecture, Mechanical, Electrical, Map 3D, MEP, Plant 3D, Raster Design
 - Ability to share between work spaces and platforms
- File Type
 - .dwg and .dxf

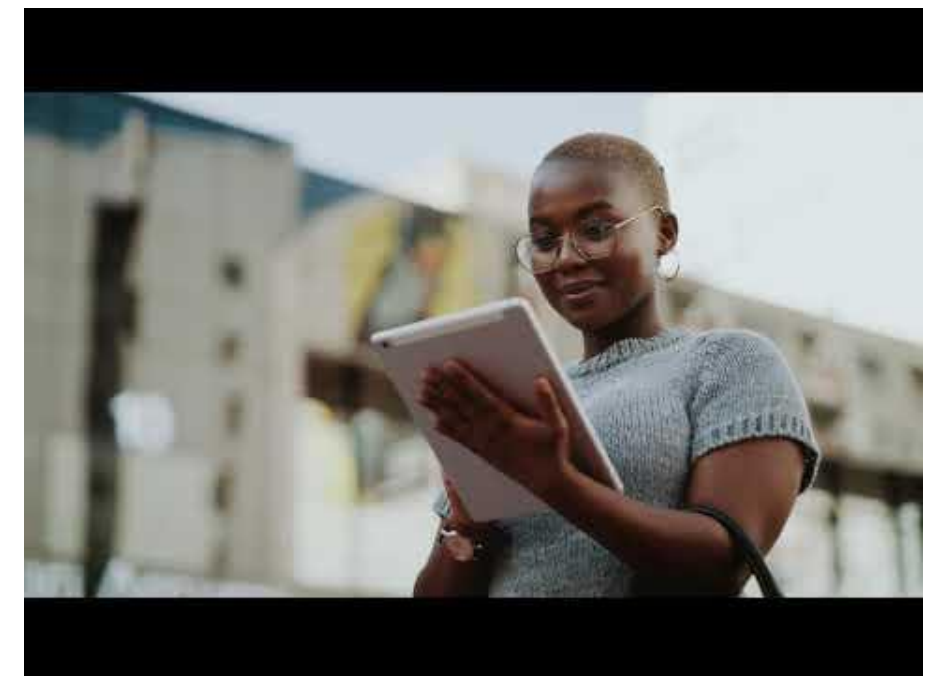
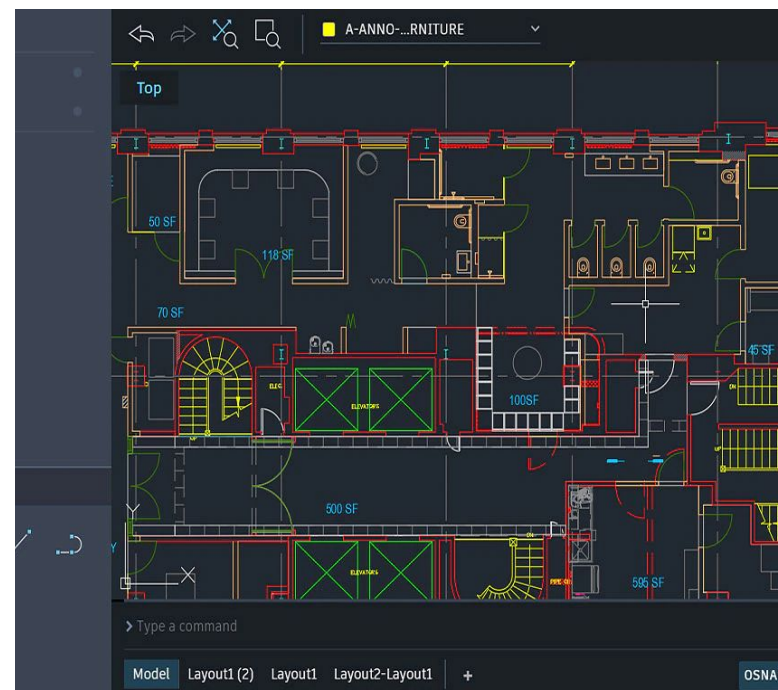
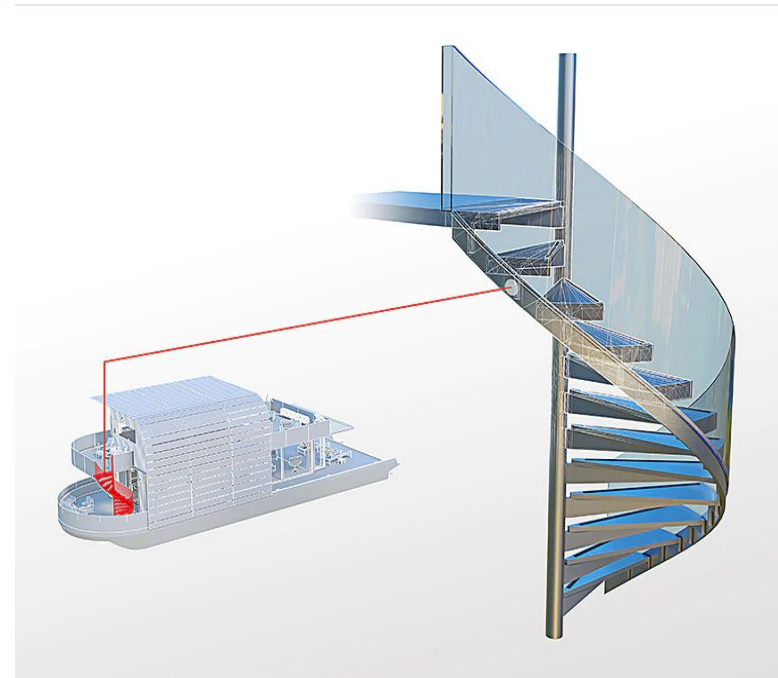
Tutorials



AutoCAD in 13 minutes



Making a floor plan in AutoCAD





3DS Max

3DS Max is a professional modeling, rendering and animation software enables you to create premium designs. Originally, the program started as THUD in 1988 just for rendering and modeling, and then transitioned to 3DS Max. The program was published by Autodesk on Halloween of 1990. 3DS Max has been used for award winning animations, games, and buildings.

Realistic 3D designs with powerful modeling tools

3DS Max is a popular platform used for modeling, rendering and composition solutions. 3DS Max is used by architect and engineers alike to render drawings in a photorealistic visualization from the AutoCAD or any other CAD software.

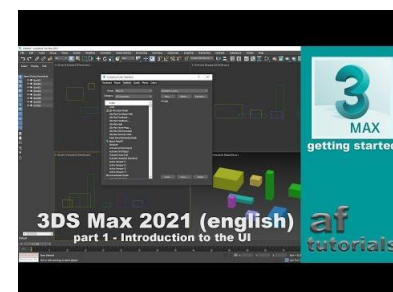
While CAD and BIM software tools do offer rendering options, 3DS Max have more control features for rendering settings. Autodesk offers a free trial for 3DS Max for anyone who is interested in learning 3D rendering.

See page ['3DS Max'](#) for pricing

Tutorials

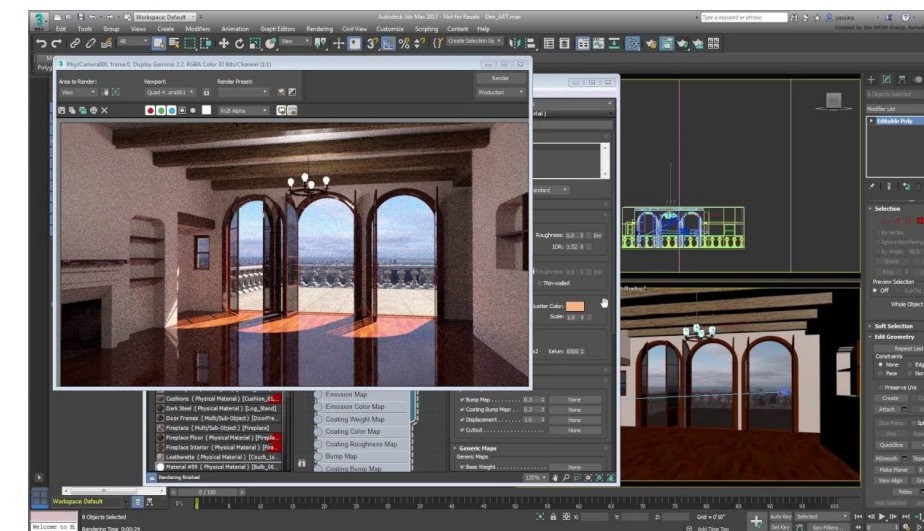
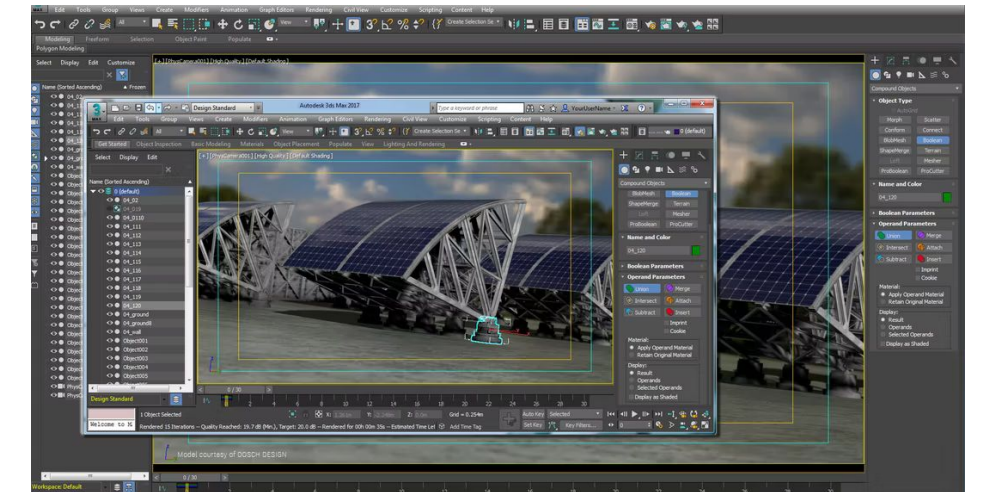


Getting Started in 3DS Max 2021 (Configuration after installation)



Getting Started in 3DS Max 2021 (Introduction to the UI)

(Click Image to see tutorial)



(Click image to see promotional video)

Archicad

Archicad is a software tool for designing buildings from the conceptual phase all through the construction phase. Archicad is a BIM software that enabled engineers to work in a BIM environment. Archicad is compatible with Windows and macOS.

As a rendering tool, Archicad is used by engineers to create planimetry of the building and it lets engineers communicate how the structure will look to the architects. The Nemetschek Group uses Archicad to render and model the structural elements that they will use to better communicate how the building will look to the architect.

You can read the article [here](#).

- Pricing:
 - \$280 per month
 - Free one year license for students (may renew when license ends)
 - Free 14 day trial
- Function
 - 2D and 3D models
 - Architectural renderings
 - Technical drawings
- Features
 - Facade design
 - Parametric custom profiles
 - Productivity and workflow enhancements

Tutorials



Introduction, Interface - Archicad Training Series



The BIM Concept - Archicad
Find the full Training Series [here](#).





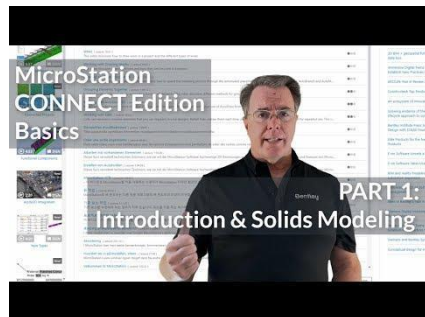
Microstation

Microstation is a stand alone program that was released in the 1980's by Bentley Systems that is used in the architectural and engineering industries. It is a CAD software program for two- and three-dimensional design and drafting. It generates 2D/3D vector graphics objects and elements and information modeling features. It is used to design, model, visualize, document, map, and sustain infrastructure projects because it delivers an integrated and proven suite of intuitive, interactive, and highly interoperable design capabilities.

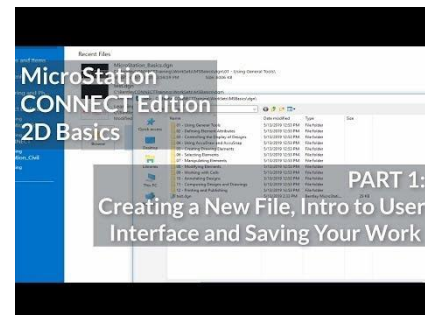
- Pricing
 - MicroStation VIRTUOSO Subscription
 - \$1,955 Annual Practitioner
 - MicroStation on SELECT
 - \$6,865 Perpetual (One Time)
 - \$1,299 SELECT (Annual)



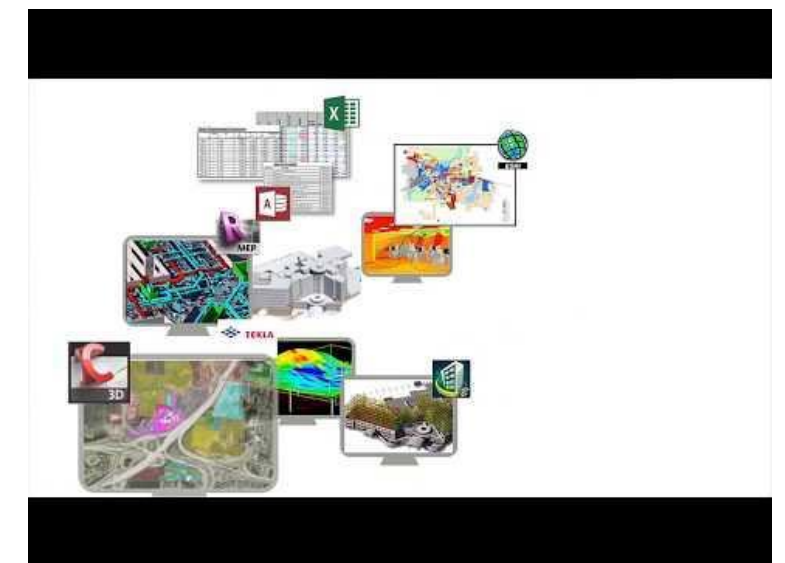
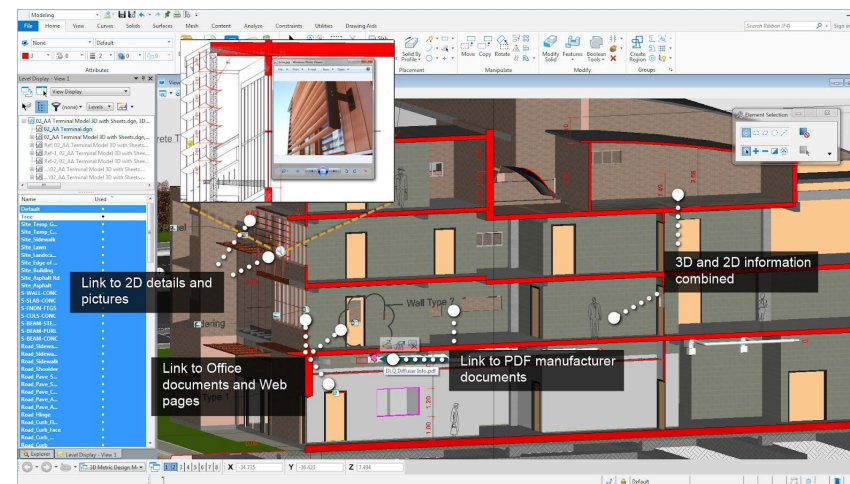
Tutorials



MicroStation CONNECT Edition 3D Basics



MicroStation CONNECT Edition 2D Basics



V-Ray



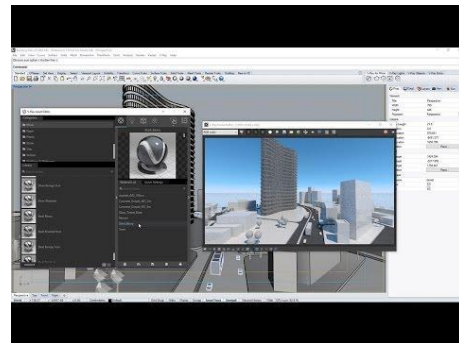
V-Ray is a rendering plugin used widely in architectural visualization, advertising, and visual effects for film and television. Real-time adaptive ray tracing technology produces high-quality visualizations. V-Ray is a powerful rendering tool, built to handle the toughest scenes and biggest projects.

Built to handle the toughest scenes.

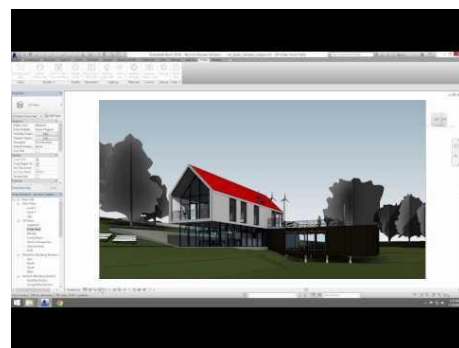
V-Ray is compatible with SketchUp, 3ds Max, Maya, Cinema 4D, Rhino, and Revit. The software has been honored with a Sci-tech Academy Award and an Engineering Emmy award. V-Ray provides a free 30-day trial and costs \$699 per year or \$59 per month for the V-Ray Collection, which includes 3ds Max, Maya, SketchUp, Rhino, Revit, Cinema 4D, Unreal, Houdini, Nuke and Blender. One can also just get V-Ray for one product and prices vary.



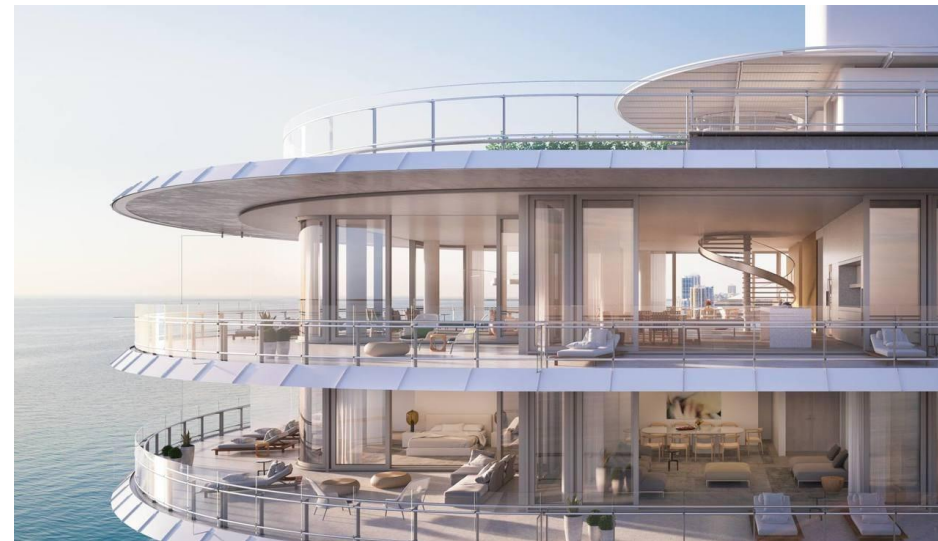
Tutorials



V-Ray for Rhino - Quick Start: Intro for Architects



V-Ray for Revit - Getting started





Enscape

- Stand alone program
 - Compatible with Revit, Rhino, SketchUp, Vectorworks, ArchiCAD
- United visualization and BIM
 - Materials, custom assets, collaborative annotation, animation, virtual reality all available
- Real time rendering for fast solutions
- Pricing
 - 14 day free trial
 - Floating License \$815/year
 - Fixed License \$479/year
 - [Free Student & Educational Licenses](#)



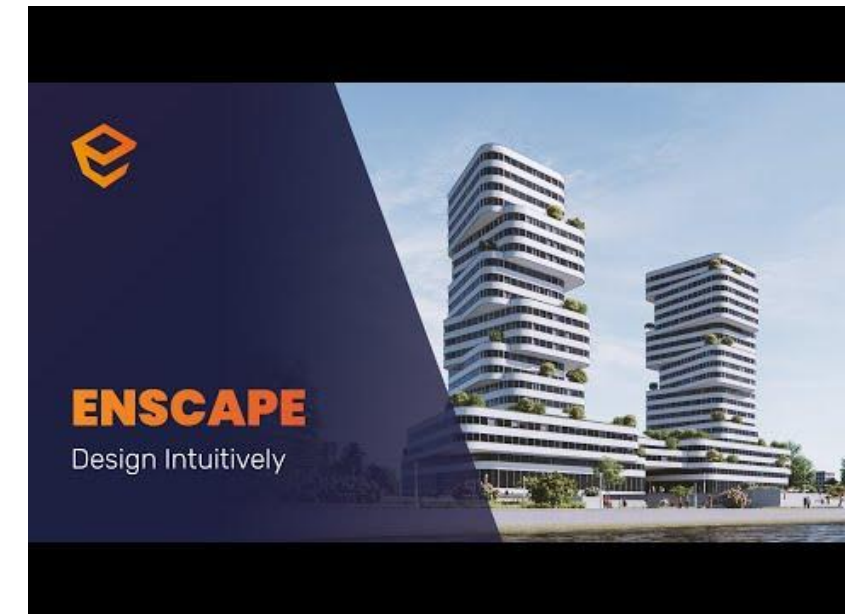
Tutorials



Using Enscape with Revit



Enscape 101



SketchUp



- Model and design in 3D
 - V-Ray for rendering
- Pricing
 - Professional: \$299/year
 - Students: \$55/year
 - Free on SketchUp Web
- V-Ray for SketchUp (plug-in)
 - \$350/year
 - See designs in SketchUp rendered real time and photoreal
 - Lighting, materials, asset models

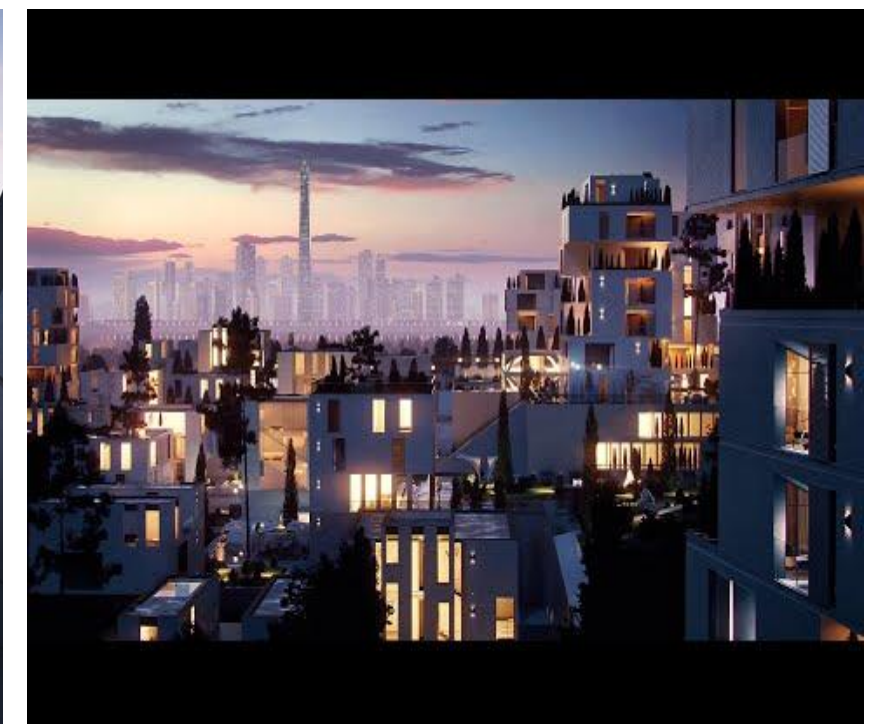
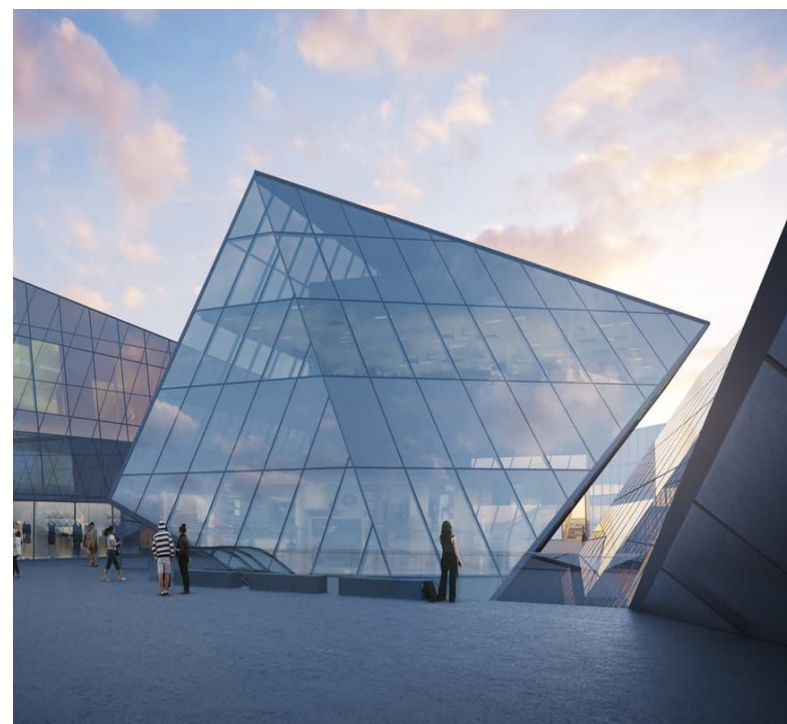
Tutorials



SketchUp in 10 min



V-Ray for SketchUp



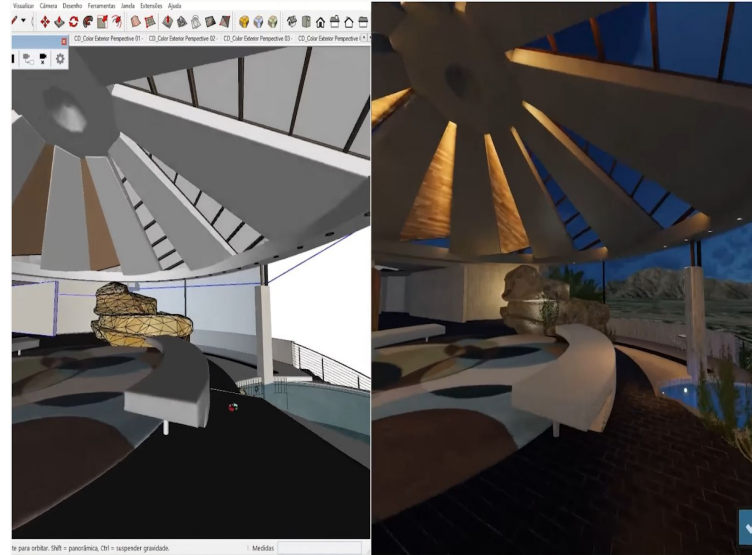
Lumion



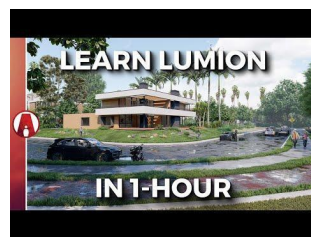
Lumion is a rendering software that allows you to easily convey how a project will translate into real-life experiences with photo-realistic images, panoramic pictures, and animations. The software has improved much over the past 10 years and has over time become more and more popular with its easy-to-use interface and fast rendering.

Easy-to-use interface and fast rendering.

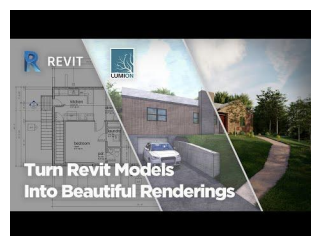
Lumion is compatible with Revit, Rhino, SketchUp, AutoCAD, and ArchiCAD. Lumion is free to students, costs \$1650 for the standard edition (1/3 library), and costs \$3300 for the Pro Edition.



Tutorials



Tutorial 1: Learn Lumion in 1 Hour



Tutorial 2: Revit Model to Lumion Rendering





D5 RENDER

D5 Render

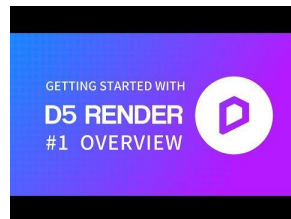
D5 Render is a real-time renderer based on ray tracing technology, producing renders with real-time interactivity and photo-realistic images.

Real-time, photo-realistic interactivity.

D5 Render supports files from SketchUp, Revit, Rhino, and Blender and contains a built in asset library. It is a relatively new program, released in January 2020, and is freely available with an option to purchase the pro version.



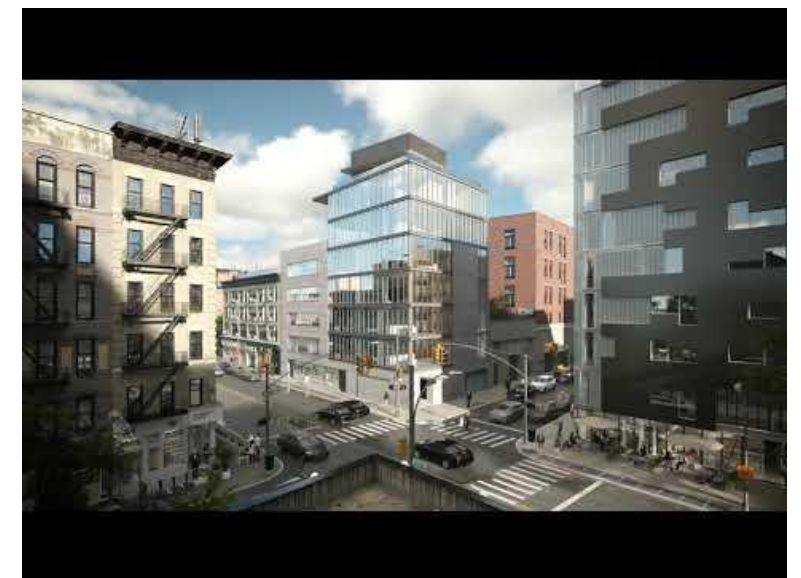
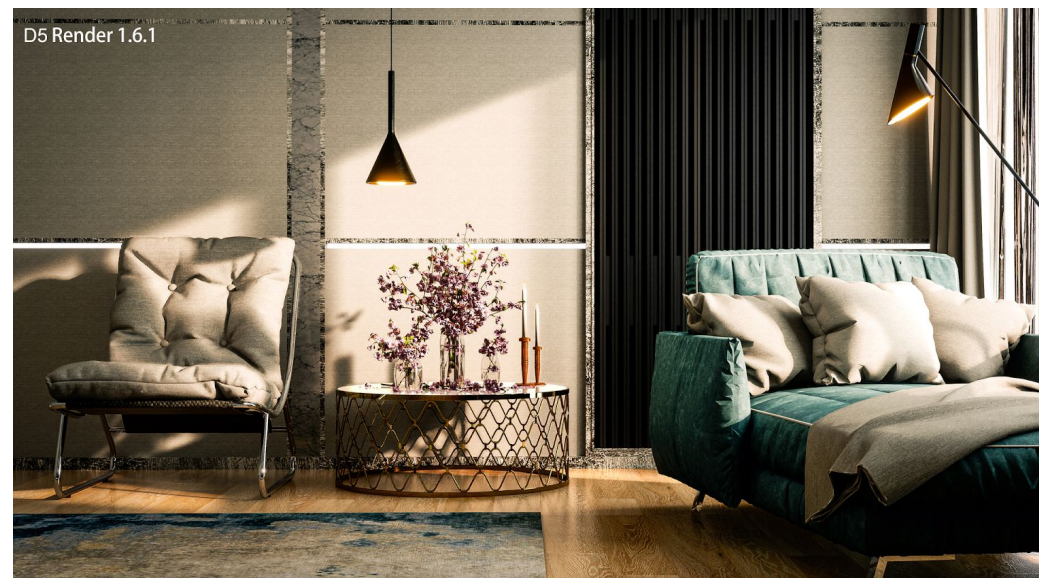
Tutorials



Tutorial 1: Getting Started - Overview



Tutorial 2: Syncing with Rhino



VR Modeling

Virtual Reality could be the future of modeling and rendering in the architecture and engineering industries. It has evolved from a gaming experience into a serious design tool that helps envision human scale, as well as quality control and tactile modeling.

Industries are starting to develop softwares that allow the user to wear a headset and walk around a virtual building, and even to push and pull object to essentially model and design in a 3D space. This technology is not the most accessible at this time since VR is not as affordable or practical as current modeling softwares.

AR - Augmented Reality - is similar to VR, but does not require a headset and other advanced technologies. Most iPhones are able to utilize AR by pointing a camera at a surface and creating a virtual 3D object in that space. This technique is useful, but limited, since the use would be very similar to a 3D printed or physical model.



“The #1 VR Platform for the Building Industry”
Integrates into Rhino and Revit
Requires VR Hardware
Mostly used for viewing models within VR



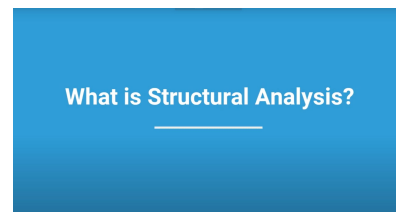
Better for more advanced VR users
Design-oriented, can edit the control points of all
your sketch lines



Structural Analysis

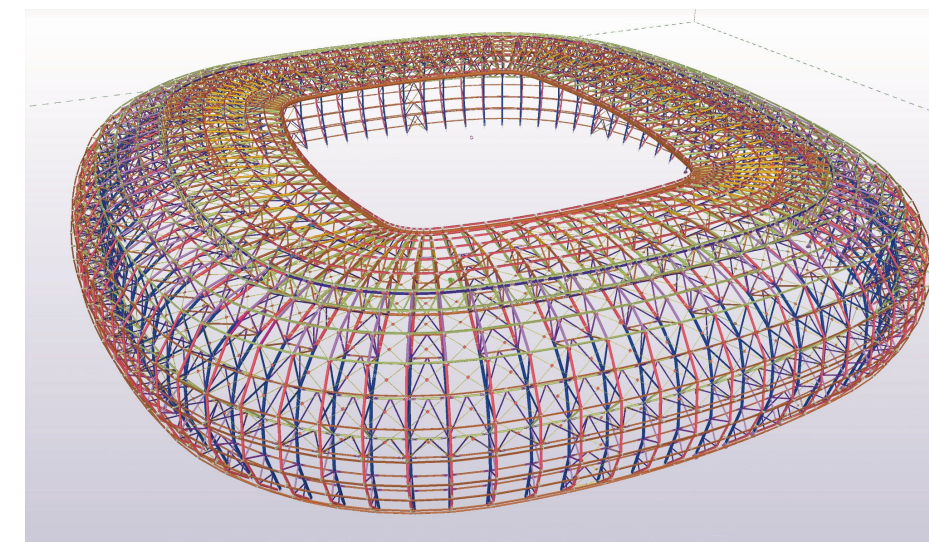
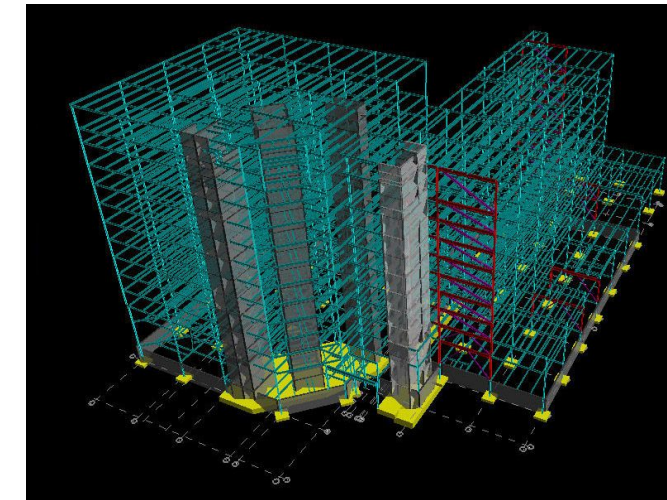
Structural Analysis is the process of calculating and determining the effects of loads and internal forces on a structure. It allows engineers or designers to ensure a piece of equipment or structure is safe for use under the estimated loads it is expected to withstand.

Structural Analysis Software performs finite element analysis and matrix structural analysis calculations without a manual set up of the complex process, saving days or weeks of work and allowing for more possibilities.



Intro Video: What is Structural Analysis?

(Click on the image to see video)



SAP2000

SAP2000 is a stand alone program used for structural analysis of beams and frames. This program is also capable of nonlinear and earthquake/wave analysis. Like most structural softwares, SAP2000 requires the input of many knowns, such as dead and live loads of the building type, location of the structure, and many more.

Inputs codes to express unknowns.

SAP2000 has a integrated design and analysis interface, allowing the user to do both simultaneously. Using the inputs from known loads, moving loads, and earthquake loads to give unknown values, such as beam types, deflections, and unknown reaction forces.

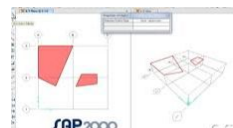
SAP2000 is available on the professional and educational level in various versions and prices. The most basic version starting at \$2000 per year with an annual maintenance of \$350. Student versions are available if a professor emails sales@csiamerica.com with their contact information. Evaluation versions are also available for the public, but both these versions are limited in their capabilities.

Compatible files: .SDB

Tutorials

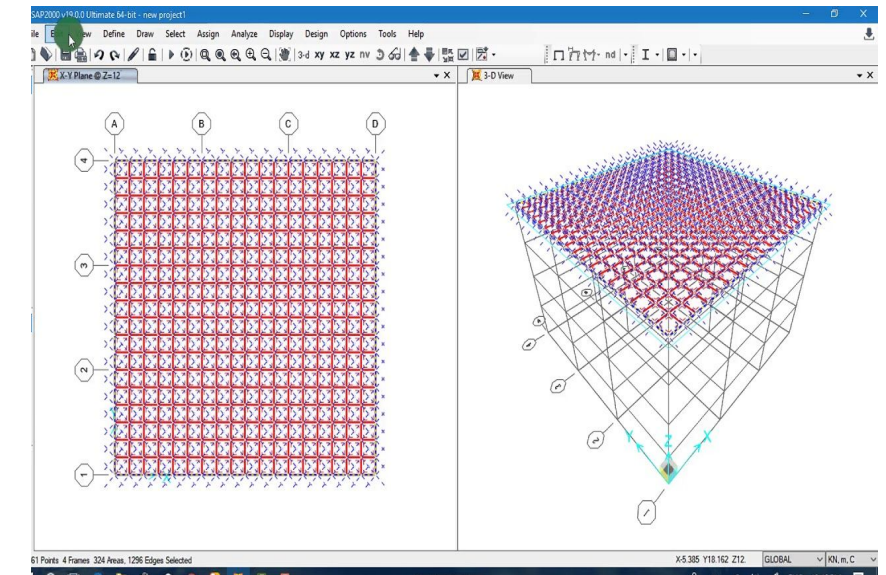


Tutorial 1: Introduction to SAP2000



Tutorial 2: Draw Commands

(Click image to see tutorial)



(Click image to see Promotional Video)

STAAD.Pro

Created in 1997 by Research Engineers International and bought by Bentley in 2005, STAAD.Pro is a software that is used for analyzing and designing any type of structure, simple or complex. It applies more than 90 international steel, concrete, timber, and aluminum design codes while running different analyses, such as traditional status analysis, p-delta analysis, pushover analysis, and buckling analysis.

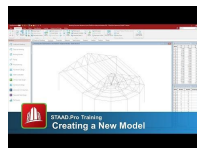
Saves time with a simplified workflow.

STAAD.Pro is very useful for interoperability between structural modeling, structural analysis, mechanical modeling, and mechanical analysis products, including (but not limited to) RAM, Revit, Tekla, OpenBuildings Designer, and AutoPIPE. It can import .dxf, .asa, and .stp files and export 2D and 3D .dxf, .asa and .stp.

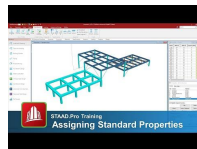
There is also an advanced version available with more analysis, as well as a Structural Worksuite bundle including STAAD.Pro and RAM. Anyone can schedule a demo online, and students have full access to all Bentley products for free.

Cost: around \$2,000 - \$4,000 /yr for professionals

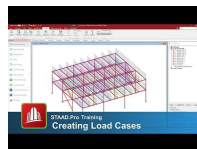
Tutorials



Tutorial Playlist 1: Creating a Model



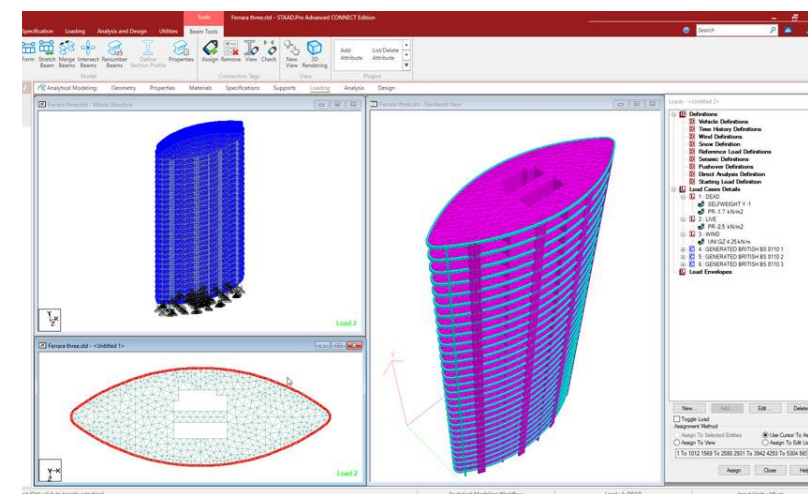
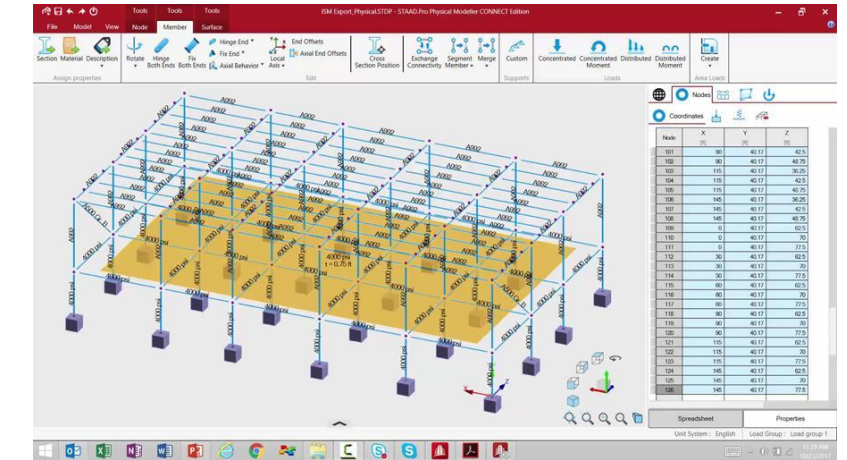
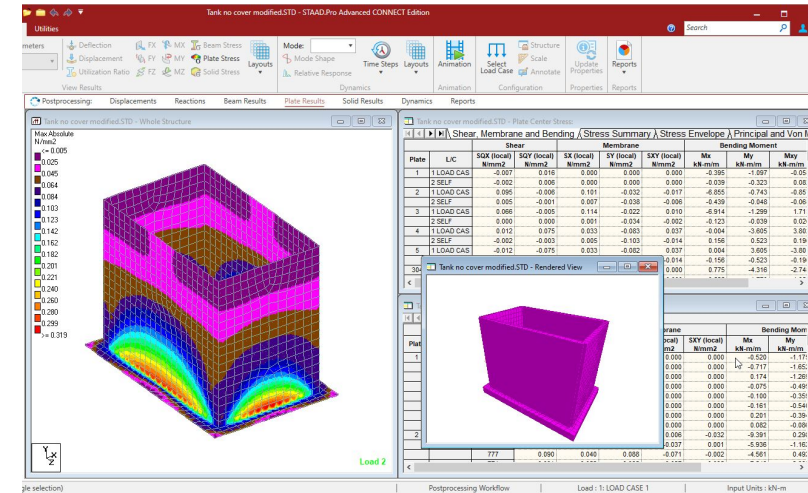
Tutorial Playlist 2: Assigning Properties



Tutorial Playlist 3: Modeling Loads

(Click image to see tutorial playlist)

Student Author: Ian Conery



(Click image to see Promotional Video)



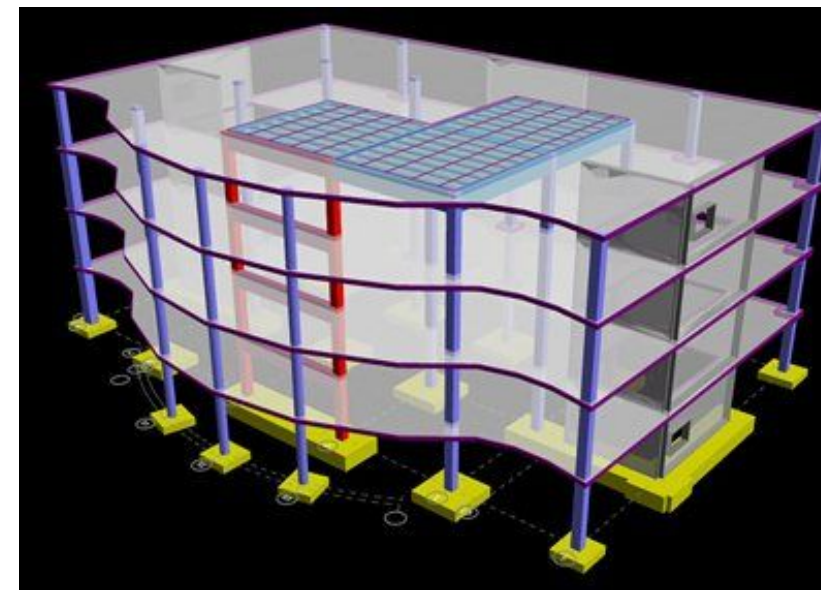
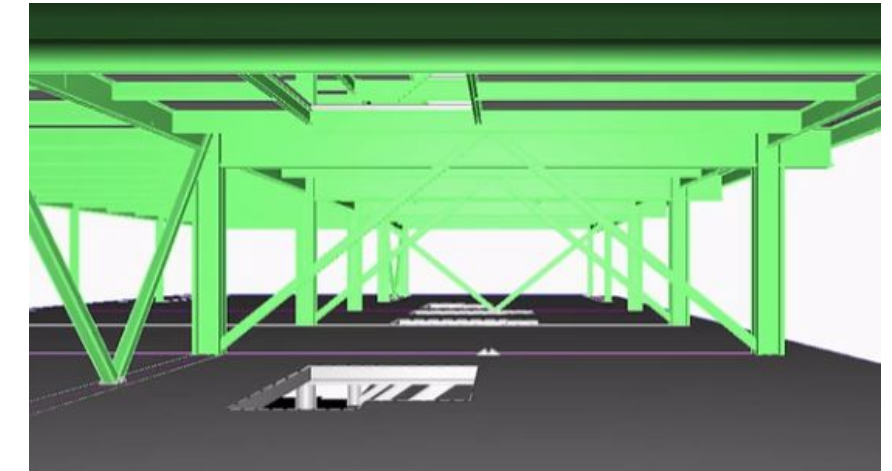
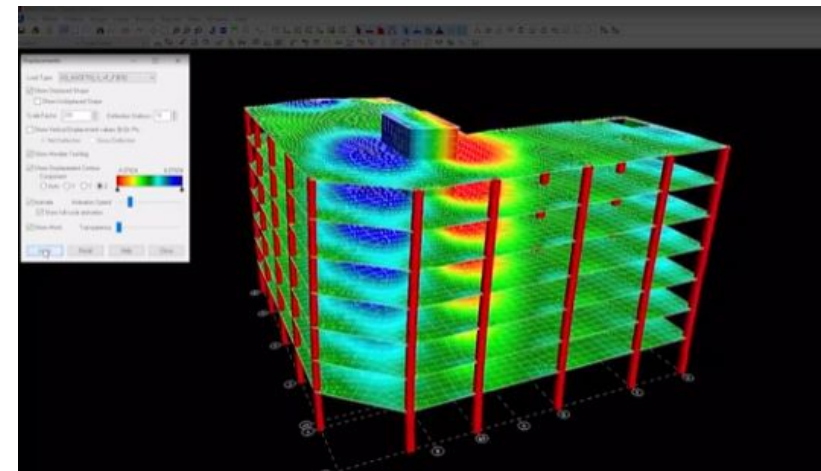
RAM

RAM is currently the most widely used structural analysis software. From Tilt-Up Wall and Frame design to complex gravity and lateral load analysis, this program allows the user greater ease of flow through the different phases of structure design.

Develop and integrate analysis with design.

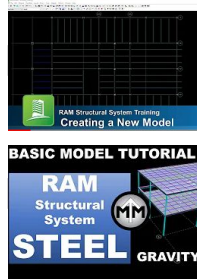
With such a wide range of capabilities, users can save large amounts of time by being able to develop, integrate, and create schedules for the entire process, all within one program. RAM especially excels in simple geometry, steel-reinforced concrete design, and developing lateral systems.

A 12-month professional subscription license costs \$3,392, but all Bentley software is available for free for students. RAM does offer cheaper alternatives of this software, which are simply elements of the actual program. These include RAM Sbeam, Elements, Connection, and Concept, costing \$250, \$1,200, \$1,066, and \$1,519-\$3,384, respectively. These are prices for 12-month subscription licenses, as well.

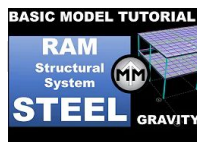


(Click image to see Promotional Video)

Tutorials



Tutorial 1: Creating a New Model



Tutorial 2: RAM Structural Steel

(Click image to see tutorial)

Tekla Tedds and Structural Designer

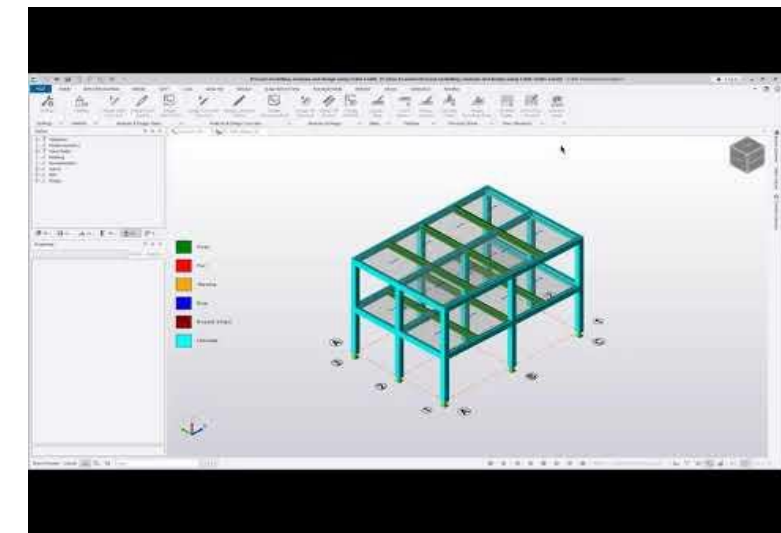
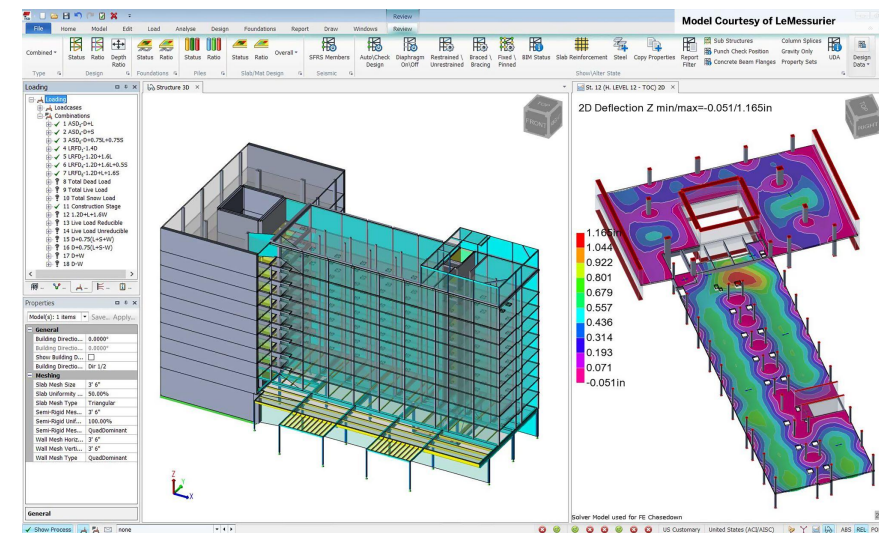
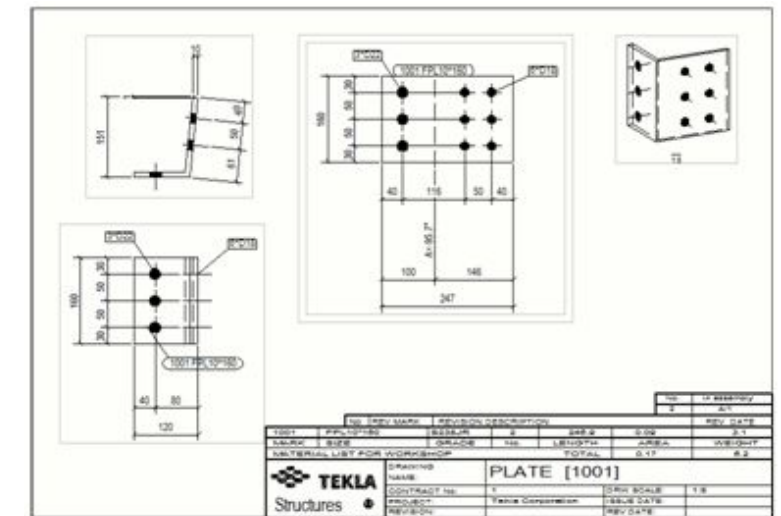
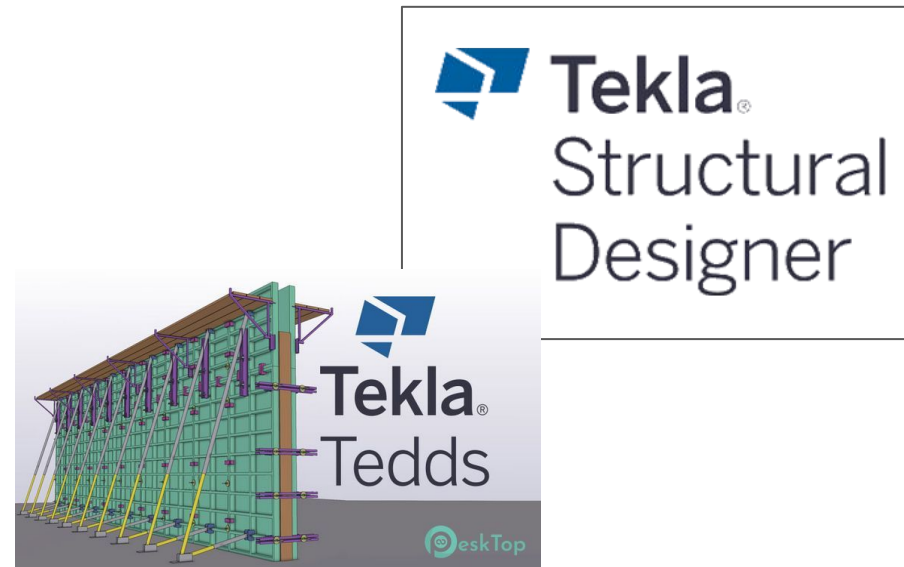


In general Tekla has a bigger platform in construction. Tekla Tedds is a modern structural design and analysis program used specifically for structural details and shop drawings. Specific beam, column, slab, footing, and connection design is the specialty of this tool. For the users, all calculations are very clear and present, and all design and information can be conveyed through very clear, professional documentation.

Develop shop drawings on a detailed level.

Tekla Structural Designer allows for an efficient merging of design and analysis, regardless of the materials used. With this product, there is an easy management of change, a quick comparison of design schemes, and sustainable design resulting from the accuracy of the analysis.

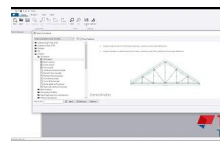
A 45-day free trial is offered by Tekla, with professional costs being determined only by contacting and negotiating with Tekla. This leads to the presumption that there is no student rate for this software system.



Tutorials



Tutorial 1: Tekla Tedds - Wood Member Design



Tutorial 2: Tekla Tedds - Tutorial for beginners



Tutorial 3: Tekla Structural Designer - Simple frame

(Click image to see tutorial)



ETABS

Extended Tridimensional Analyses of Building Structures

ETABS was developed by CSI (Computers and Structures, Inc.) about 30 years ago. It caters to multi-story building analysis and design, including a wide array of templates for quick model generation (define grid spacing, # of stories, default structural system sections, uniform loads, etc.).

Streamlines analytical-model generation.

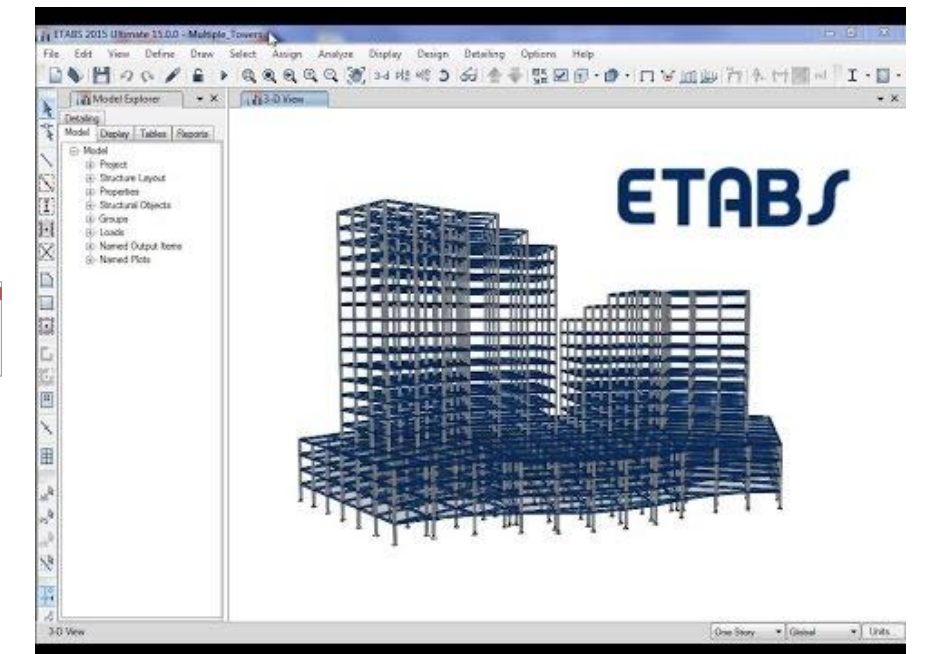
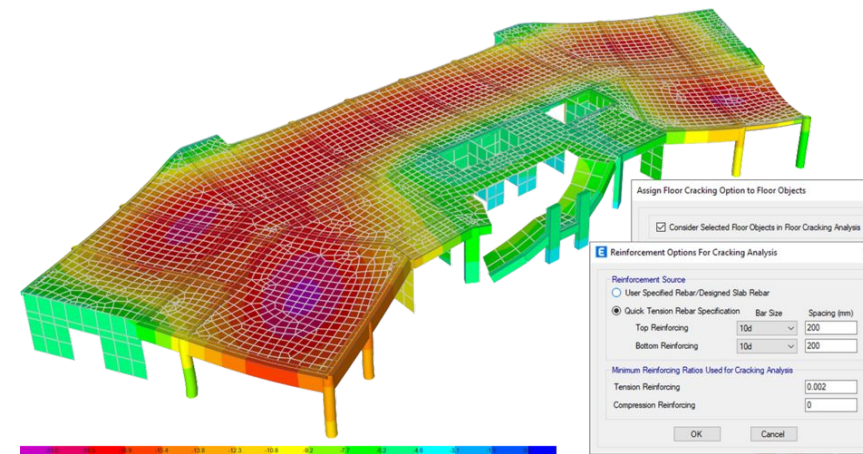
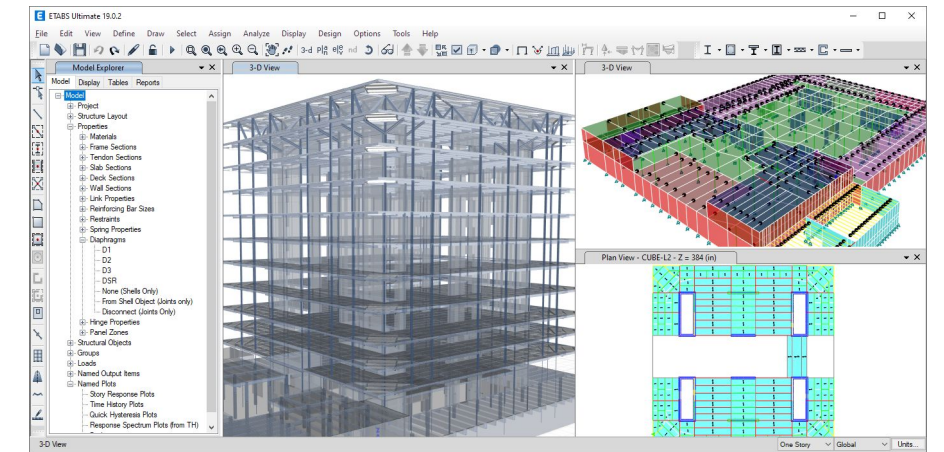
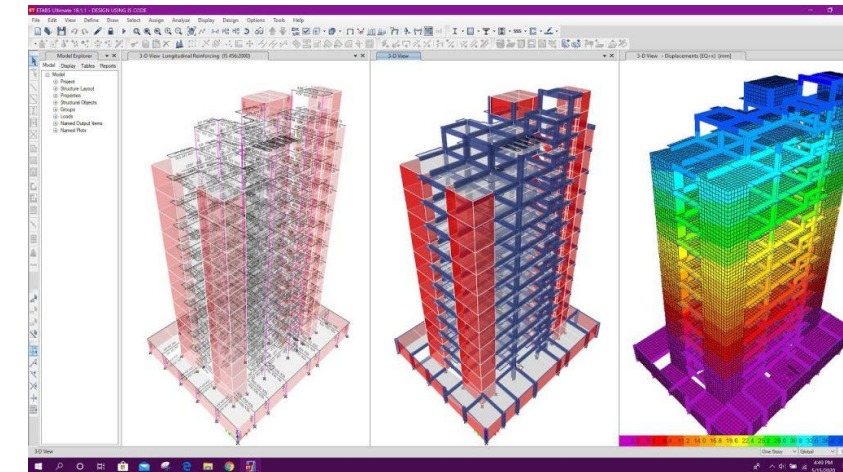
ETABS offers a wide range of US and international code-based design features. Also, given enveloping specification, design features will automatically size elements and systems, design reinforcing schemes, and otherwise optimize the structure according to desired performance measures.

It is more effective in concrete design over steel and does well with developing lateral systems. However, if only one structural analysis software is to be chosen for a firm, ETABS is the perfect choice because it does everything.

Interoperability: Revit, AutoCAD, STAAD, SAFE, etc. Revit, AutoCAD, STAAD, SAFE, etc.

Cost: \$5,000/yr + \$875/yr for maintenance

Student Pricing: Evaluation version available for free (with limitations)



(Click image to see 21 min. Overview Video)

Tutorials



Tutorials on CSI website, including introductions, user interface, modeling, loading, analysis, design, output and display, etc.

(Click image to see tutorials)

Student Author: Lily Cmerck

SkyCiv

SkyCiv is used as a structural analysis software for any types of models, beams, and wind load generations. This software is mainly used by Civil, Structural, and Mechanical Engineers, but is also suitable for Architects. SkyCiv is a fairly new stand alone software that is was created by Paul Comino and Sam Carigliano in 2013.

Many methods to solve for many solutions.

There are many functions within SkyCiv to focus on different structural analysis processes.

- Specified programs:
 - [Structural 3D](#)
 - [Beam](#)
 - [Section Builder](#)
 - [Wind and Snow Load Generator](#)
- Importing file types: DXF (.dxf), DWG (.dwg), Revit (.rvt)
- Exporting file types: DXF (.dxf), Revit (.rvt), STL file
- Prices:
 - *Students*: \$14/month with limited program access included
 - *Professional*: \$1,250/year with all program access included.

Tutorials

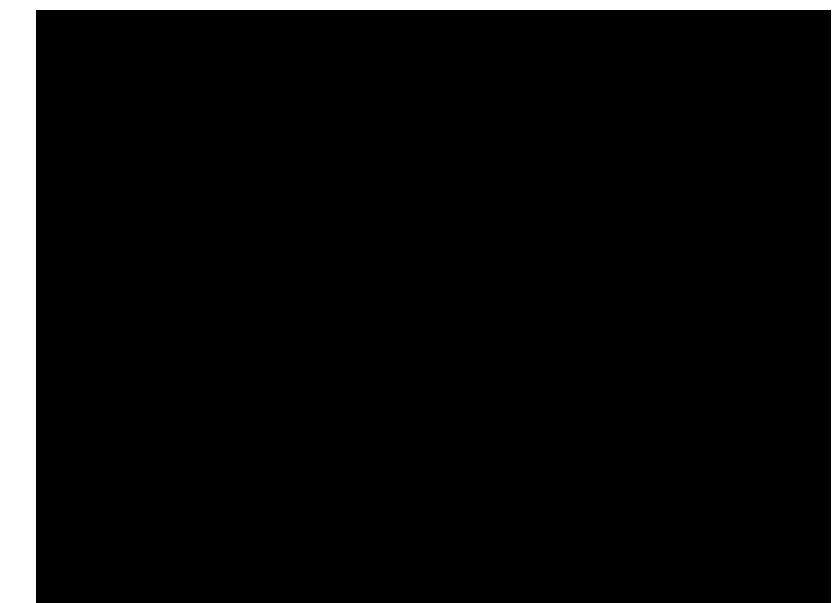
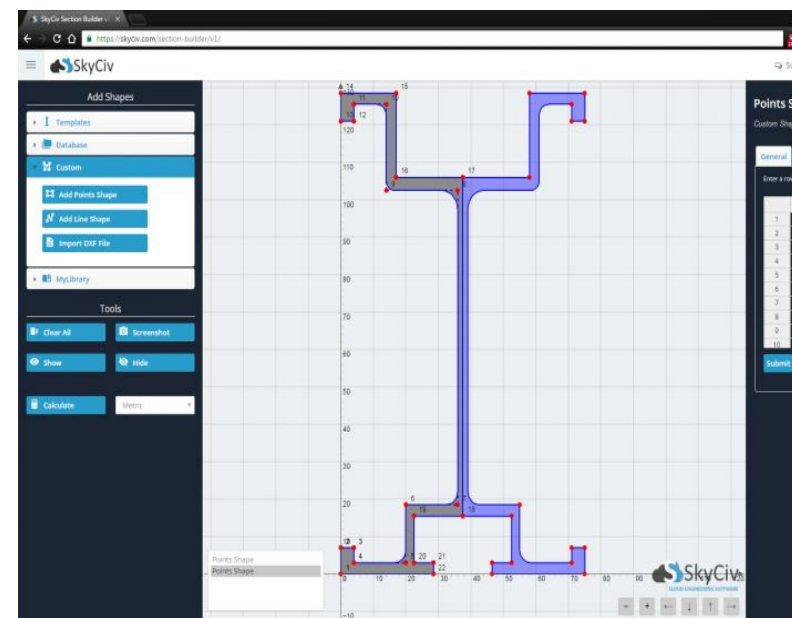
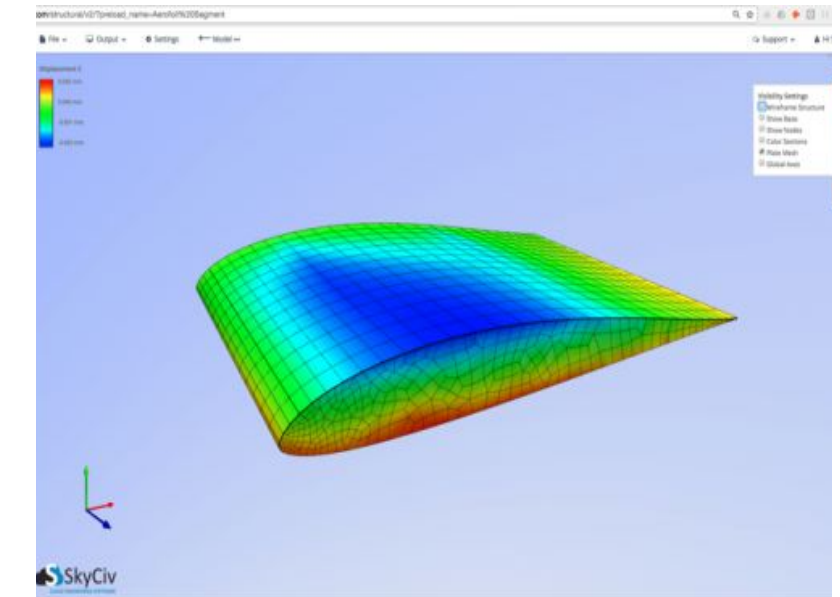


Tutorial 1: Structural 3D



Tutorial 2: Section Builder

(Click image to see tutorial)



(Click image to see Promotional Video)



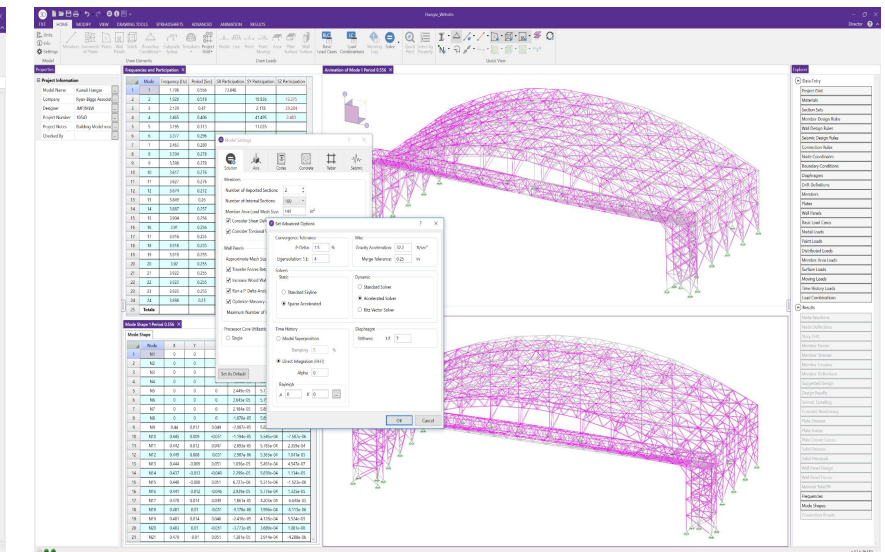
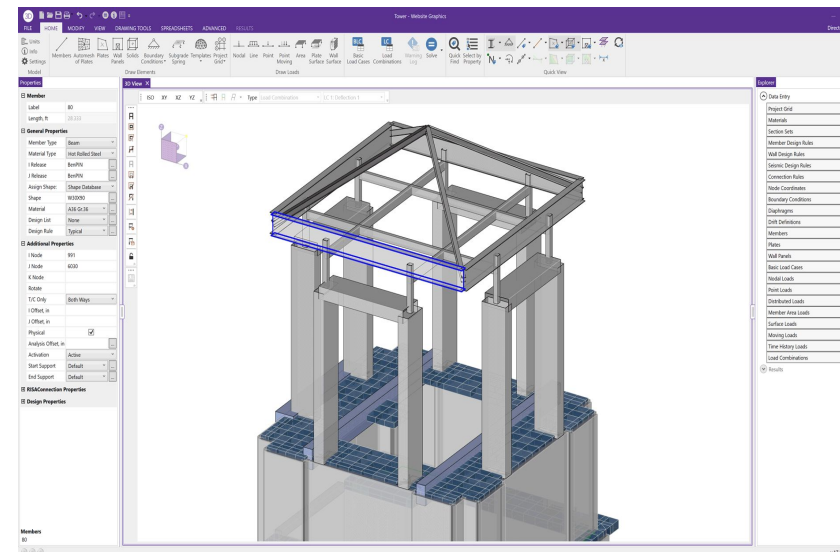
RISA

Rapid Interactive Structural Analysis

RISA offers multiple products, including RISA-3D, RISA-2D, RISAFloor, RISAConnection, ADAPT-Builder, RISAFoundation, and others. The most common software is RISA-3D, which offers a versatile solution for any structure.

Robust analysis and design.

With multi-core processing, RISA-3D is able to efficiently execute static, dynamic, and time history analysis. It is also able to analyze and design concrete, hot rolled & cold formed steel, masonry, wood and aluminum members and wall panels according to the latest design codes. It has an intuitive interface and modeling environment, as well as a comprehensive presentation of results, including expandable limit states that show all governing equations.



Interoperability: Revit, Tekla, Archicad, all RISA products

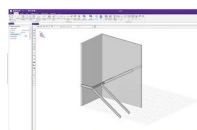
Cost: \$1.825/yr

Student Pricing: Free demo available, but can't save or print; free student version for RISA-2D only

Tutorials

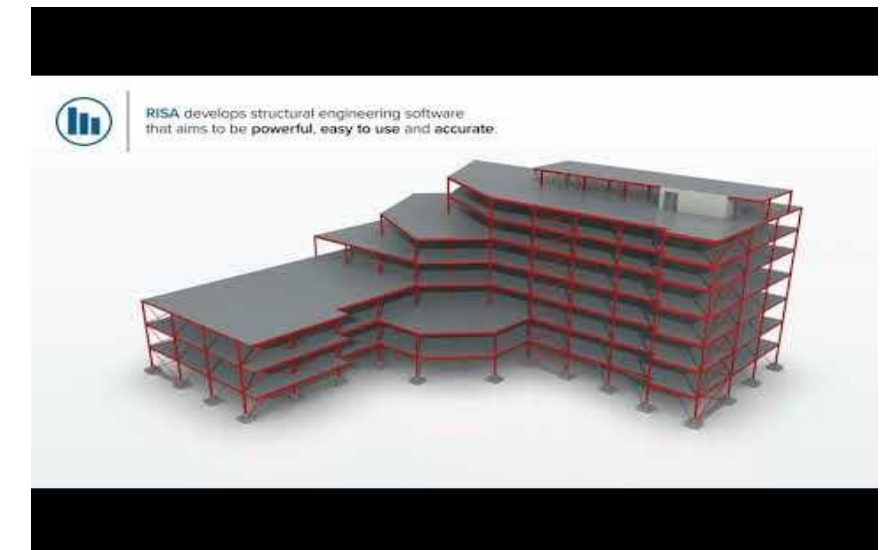
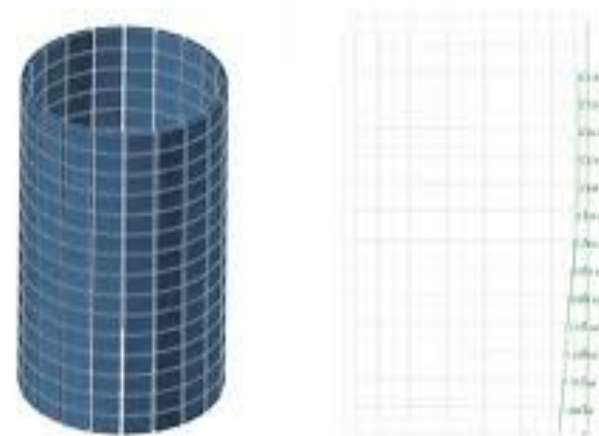


Tutorial 1: Modeling and applying loads



Tutorial 2: Basics of Model creation in RISA 3D

(Click image to see tutorial)



(Click image to see Promotional Video)

Karamba3D - Grasshopper Plugin

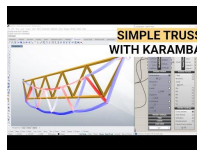
Karamba3D can be added into Grasshopper, a plug-in for Rhino. It is a parametric structural engineering tool which provides accurate analysis of spatial trusses, frames, and shells. This makes it easy to combine parameterized geometric models, finite element calculations, and optimization algorithms.

Perform structural and finite element analysis.

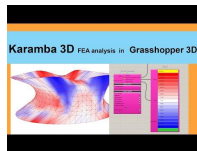
Cost: \$650/yr for professional license

Student Pricing: Download a free trial (with limitations) or purchase the educational version for 2 years for about \$33.

Tutorials

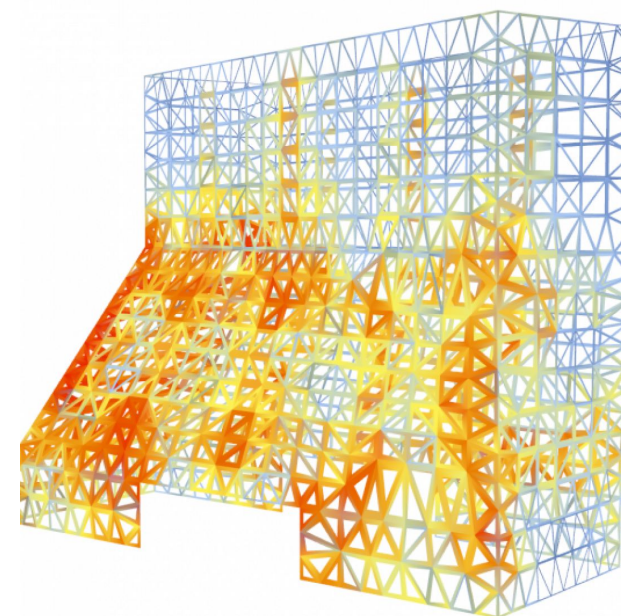
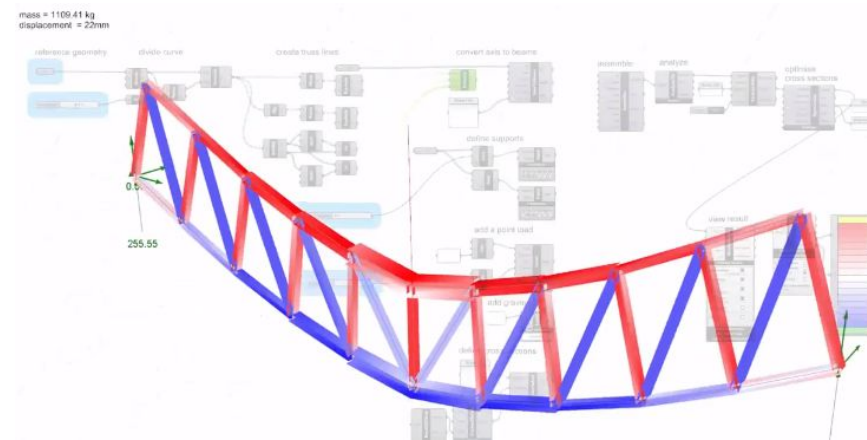


Tutorial 1: Simple Truss



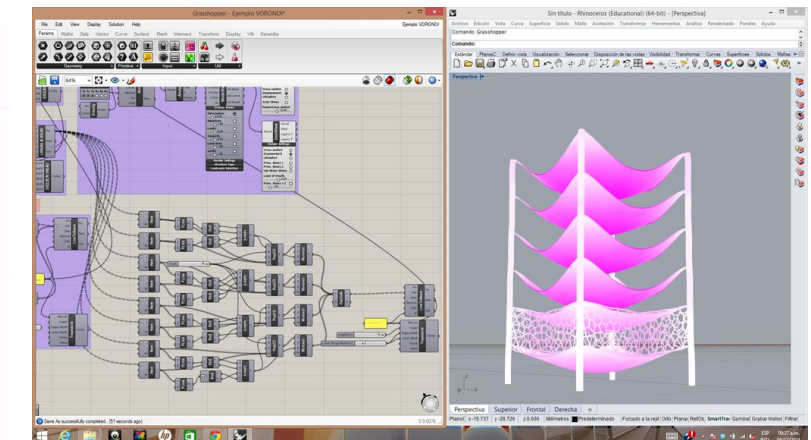
Tutorial 2: FEA Form Finding

(Click image to see tutorial)



Karamba 3D

parametric engineering



(Click image to see Promotional Video)

Environmental Analysis

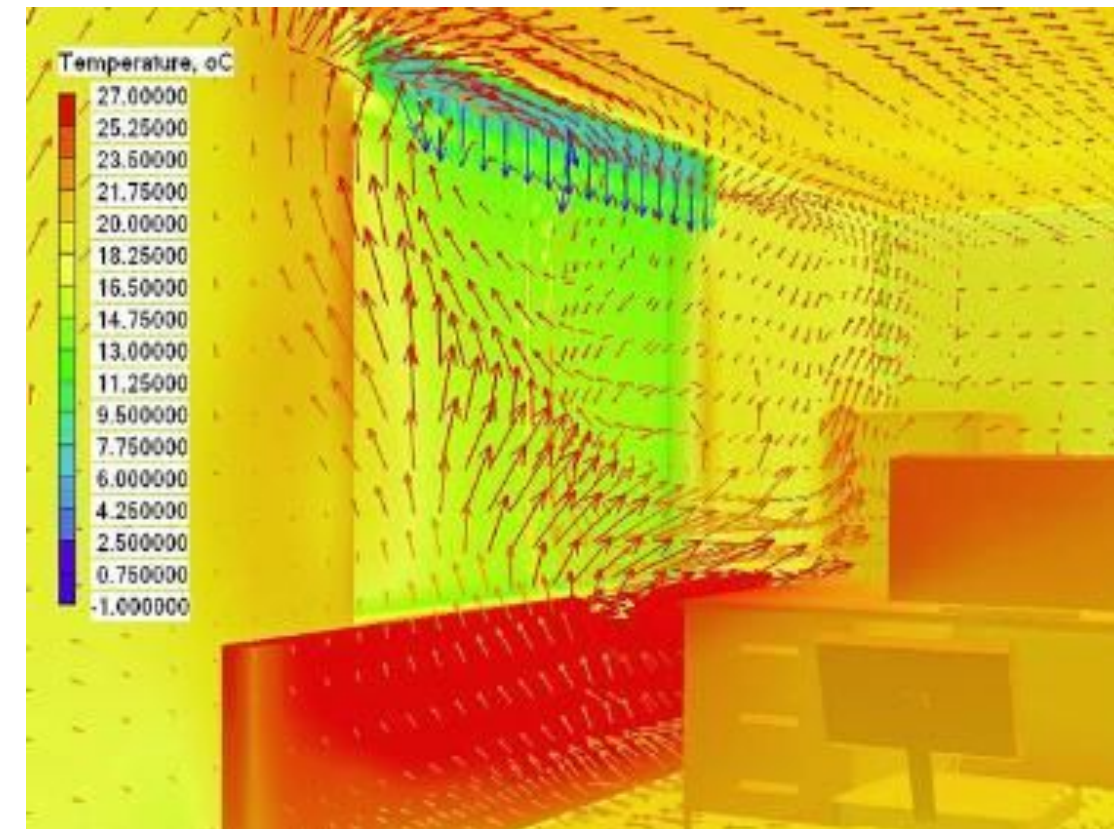
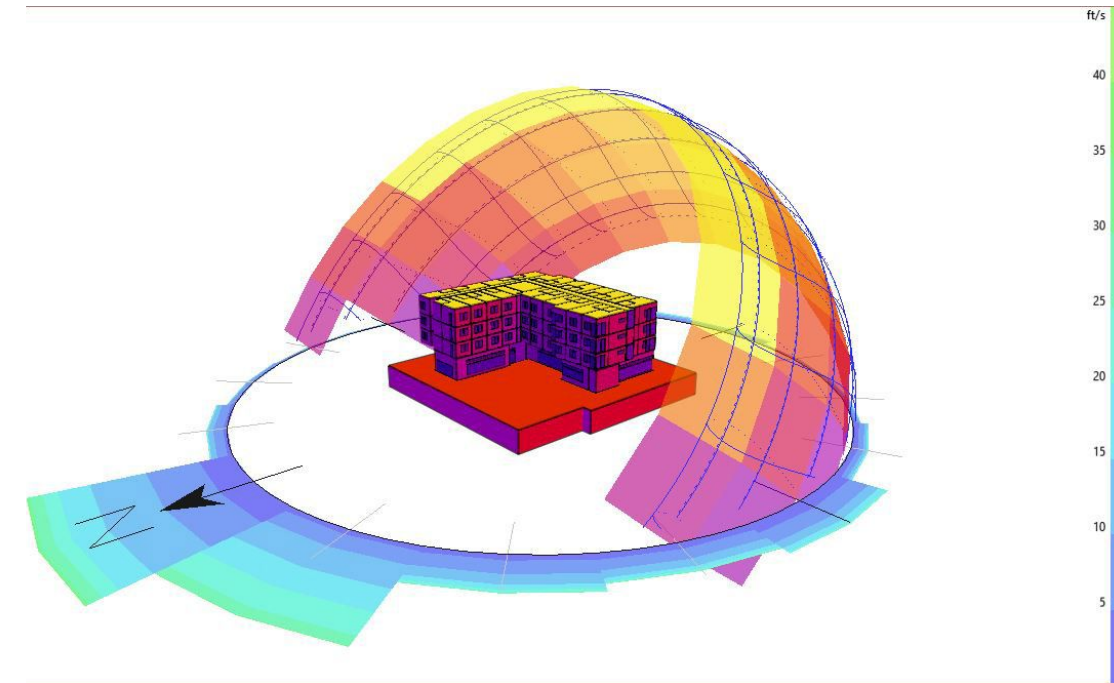
Environmental digital analysis is the use of digital software to understand and solve the many complex issues associated with buildings' relationship with the environment.

This spans from energy modeling and life cycle analysis to lighting and acoustic properties of space. The field covers a wide range of disciplines all relating to how a space performs based on input parameters and helps architects and engineers create the high performance structure.



Intro Video: What is Environmental Digital Analysis

(Click on the image to see video)



eQUEST



A software built with wizards and graphics along with the DOE 2 energy simulation and cost calculation engine. Architectural model geometries can be imported or constructed within the program and then simulated with three input wizards: Schematic Design Wizard (simple inputs), Design Development Wizard (detailed input), and Energy Efficiency Wizard. Each wizard has inputs are based on the California Title 24 building energy code. Weather data for 1000+ locations in North America are available to download from within eQUEST.

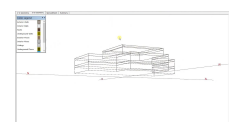
A sophisticated yet easy-to-use building energy analysis tool

- Standalone software
- File types
 - Import: .dxf
 - Export: .dat, .csv (reports)
- Price: FREE

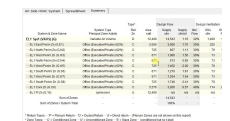
Getting Started Tutorials



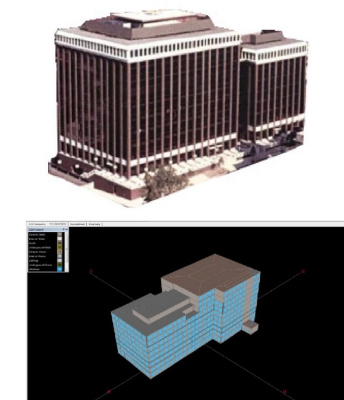
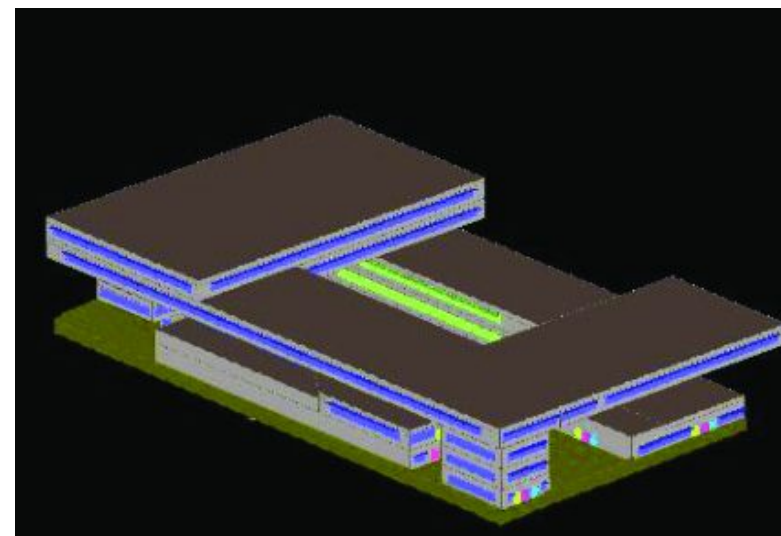
[Schematic Design Wizard](#)



[Design Development Wizard](#)



[Detailed Edit Input](#)



Comparison between GBS and E-Quest

	GBS baserun	eQUEST baserun	Relative Difference (%)
Electric (kWh)	4,189,312	4,189,200	Less than 0.0001
Fuel (MJ)	10343281	10350799	0.0007
Total Energy (MJ)	25424804.2	25431919	0.0002

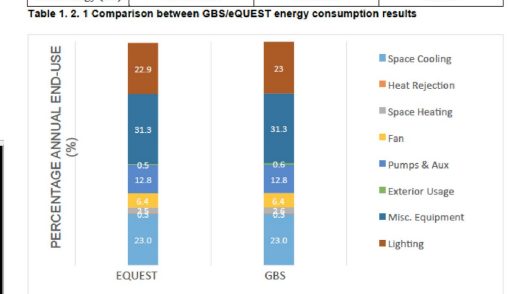
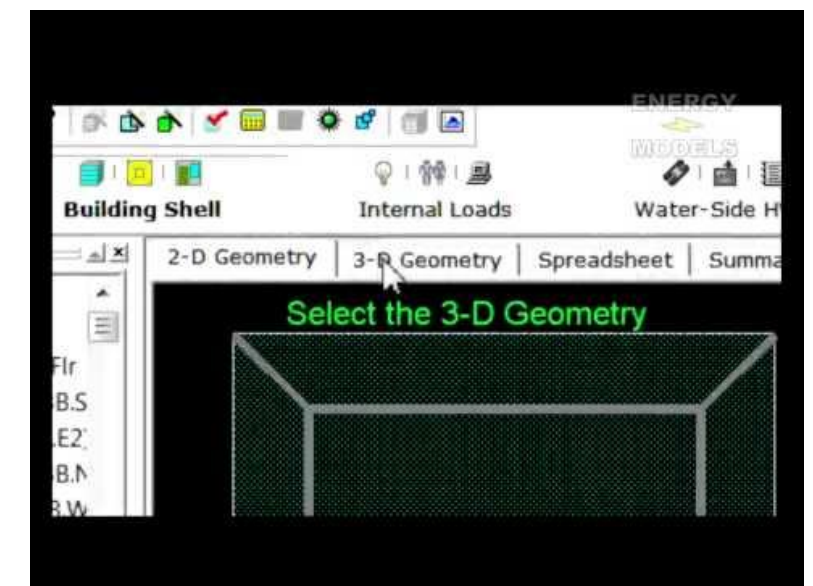
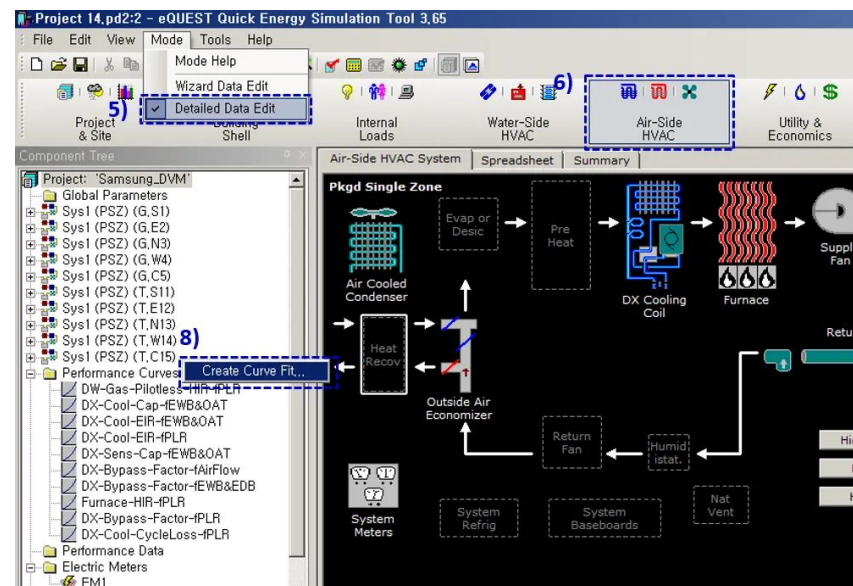


Figure 1. 2. 1. Comparison between GBS/eQUEST end-use energy consumption results





EnergyPlus

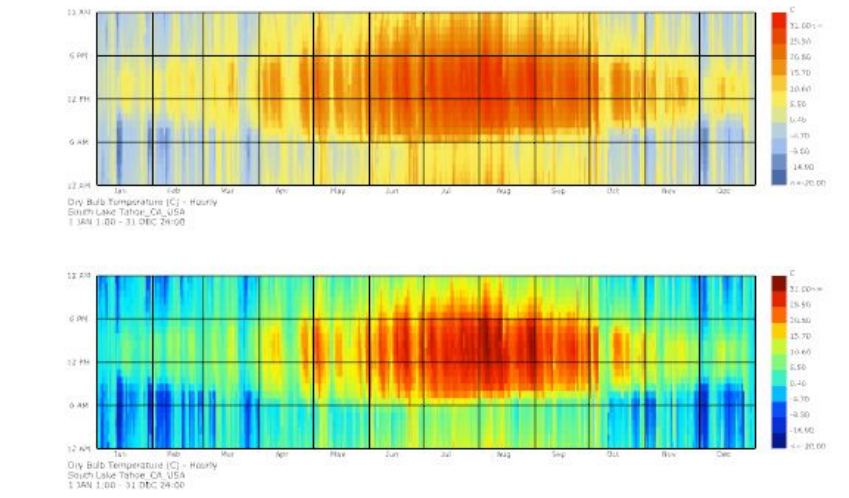
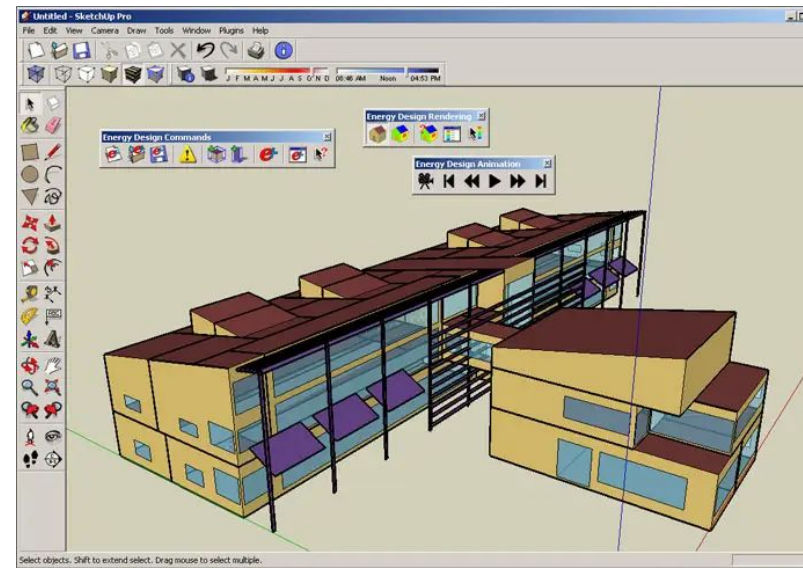
EnergyPlus is a free, open-source, and cross platform BEM (building energy modeling) program that is used to simulate energy consumption- eating, cooling, ventilation, lighting loads, and water use- in buildings. It is funded by the U.S. Department of Energy’s (DOE) Building Technology Office (BTO).

Engine that models energy consumption

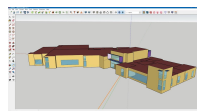
EnergyPlus can be run as a standalone software on Windows, Mac OS X, and Linux operating systems. However along with OpenStudio, it is part of BTO’s building energy modeling program portfolio; EnergyPlus data is also integrated in Ladybug.

Upgraded to C++ from FORTRAN, EnergyPlus operates as a command-line program that takes input files, runs simulations, and produces output files based on a building’s geometry, materials, usage, and systems.

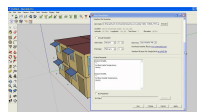
See [here](#) for a list of EnergyPlus compatible file types. EnergyPlus is open-source and free to install.



Tutorials

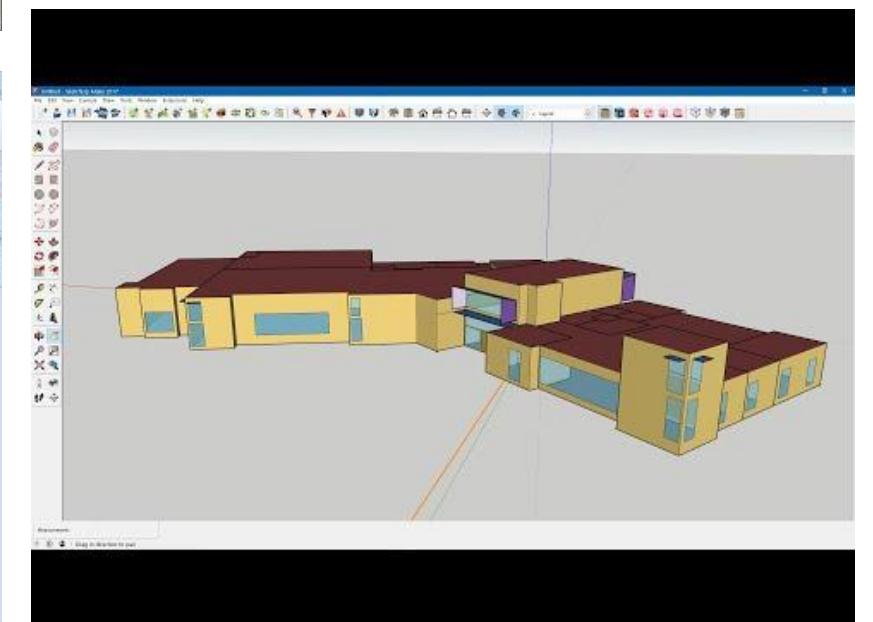
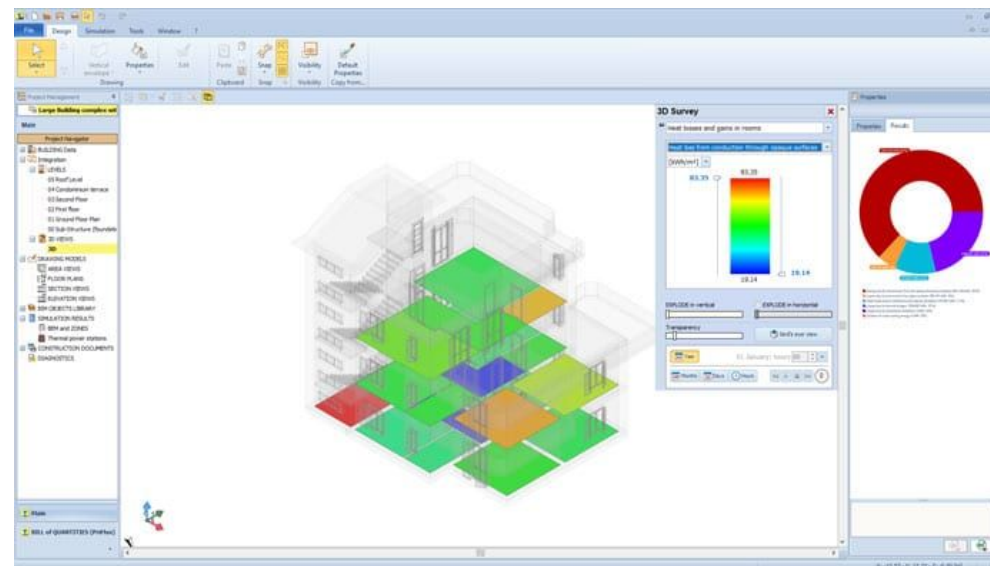


Tutorial 1: Introduction to Open Studio + EnergyPlus (5:22)



Tutorial 2: EnergyPlus Basics Youtube Playlist

(Click image to see tutorial)



(Click image to see Promotional Video)

[Official Site](#)

[Official Getting Started pdf](#)



OpenStudio

OpenStudio is a software development toolkit (SDK) for modeling whole building energy using data from EnergyPlus and Radiance. This graphical user interface generates results from a workflow of design, simulation, and analysis.

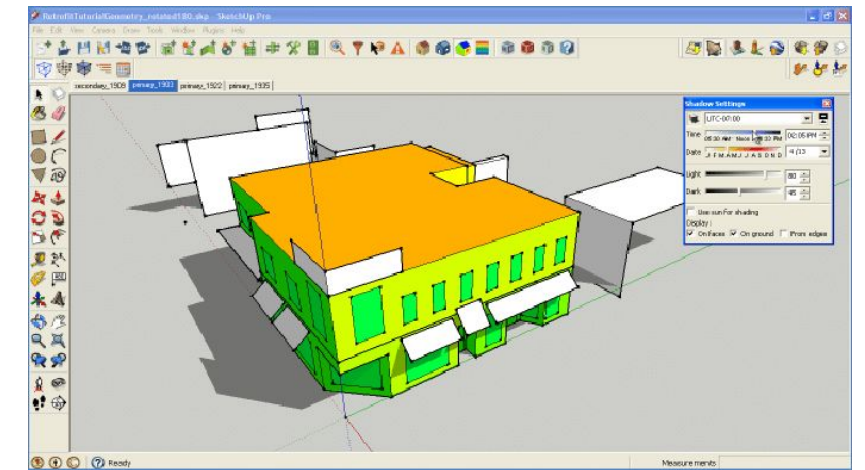
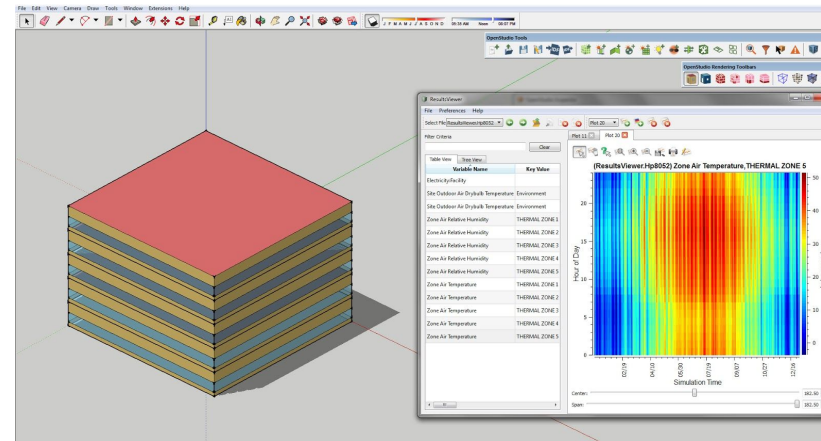
Whole building energy modeling

This software was developed by the US Department of Energy and the National Renewable Energy Laboratory (NREL) to help users create buildings that are more energy efficient.

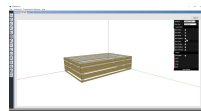
Software developers can code in C++, C#, or Ruby. The application can run on Microsoft Windows, Macintosh, and Linux platforms.

Also, an OpenStudio plugin exists for SketchUp. Sketchup Make is the freeware version, whereas a paid version with additional functionality- Sketchup Pro- costs \$299 annually.

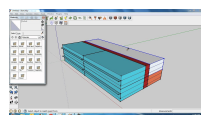
On its own It is a free, open-source product.



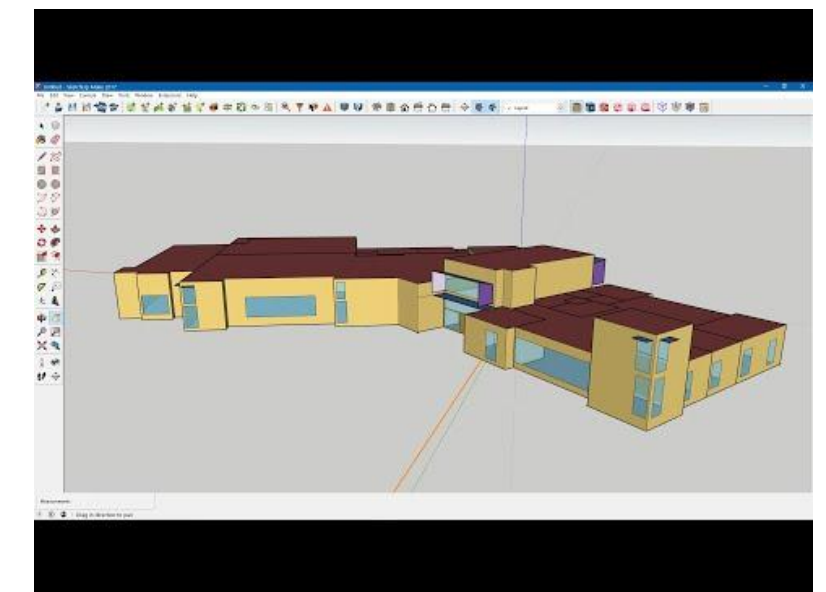
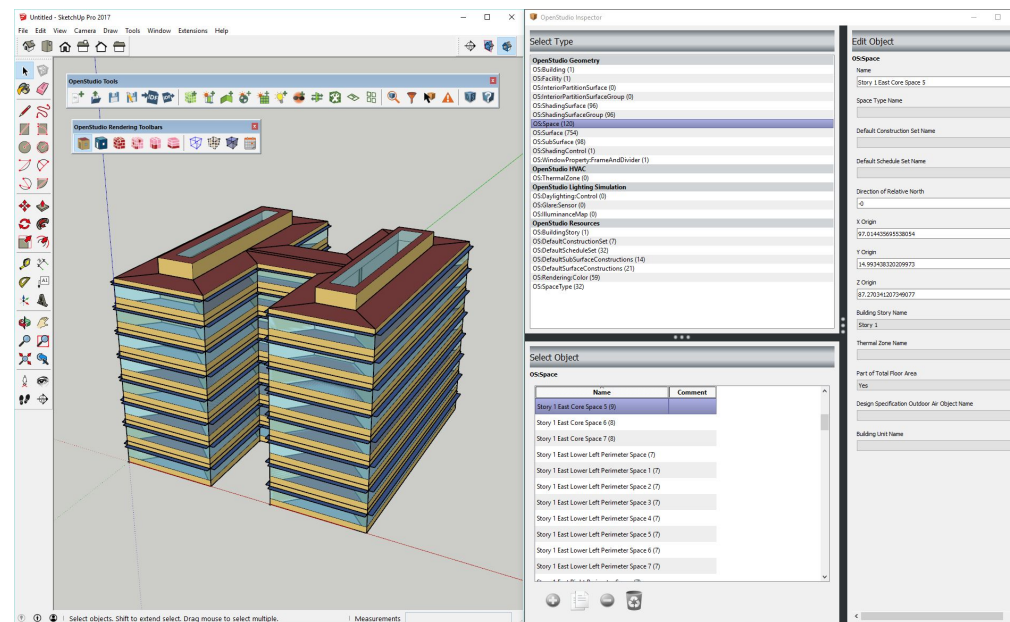
Tutorials



Tutorial 1: Energy Modeling 101 OpenStudio Application (10:43)



Tutorial 2: OpenStudio SketchUp Plugin - Space Types and Thermal Zones (7:18)



(Click image to see Promotional Video)

(Click image to see tutorial)

[Getting Started/Installation](#)

Student Author: Reiko Corteza

Cove.tool



Cove.tool’s new drawing tool allows users to import geometry from Revit, Rhino, or SketchUp, correct errors, make modifications, and group spaces into HVAC zones for export to EnergyPlus energy analysis via OpenStudio. By adding detailed energy modeling capabilities to their platform, the cove.tool team has created a cohesive designer-friendly platform with modeling approaches that are tailored to the specific needs of different stages of design—rapid feedback and multi-objective optimization in early design stages with additional detail in later ones.

<https://www.cove.tools/>

End-to-end automated performance analysis for every team.

- Standalone software
- File types
 - Import: Any drawing tool (dwg, .rvt, etc.)
 - Export: .idf, .osm
- Price
 - Free trial for students and professors

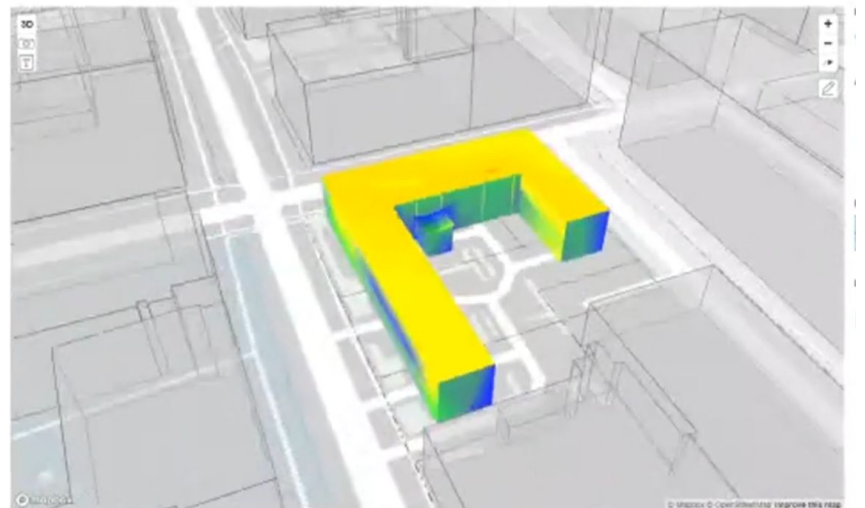
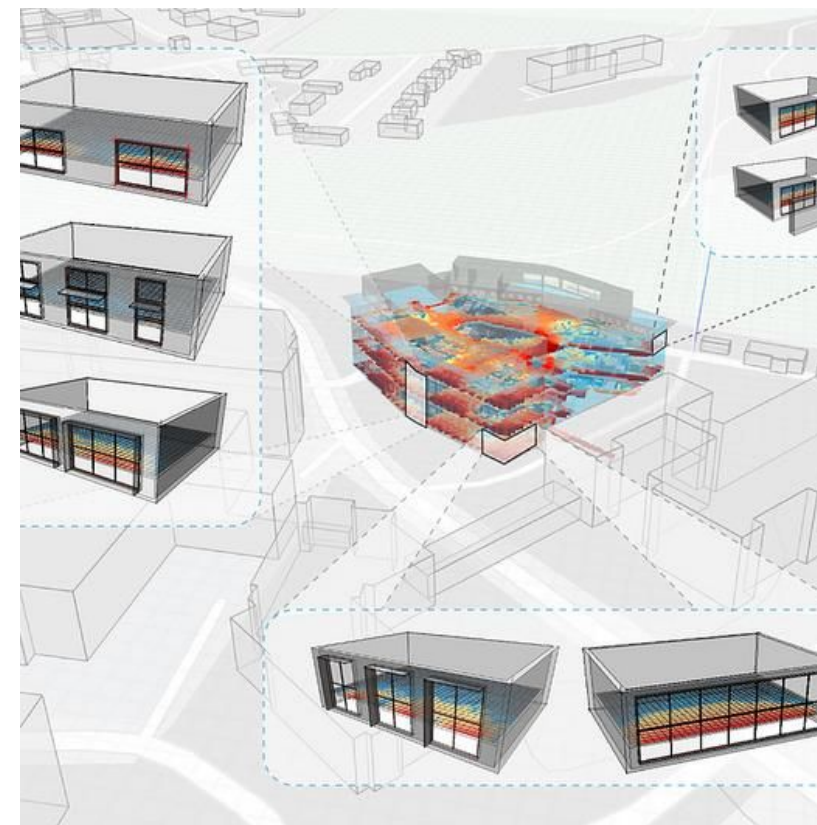
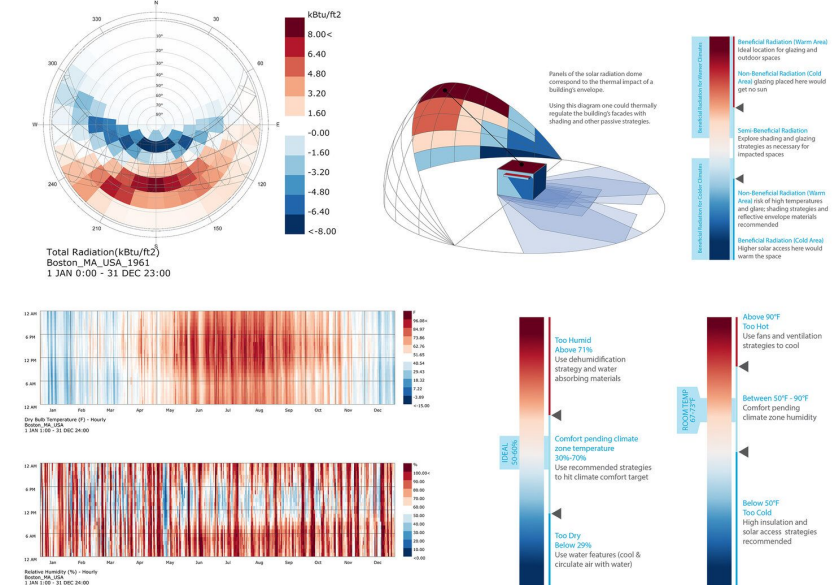
Tutorials



Step by Step Tutorial



Drawing Tutorial





Radiance

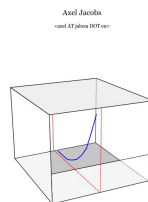
Input files specify the scene geometry, materials, luminaires, time, date and sky conditions (for daylight calculations). Calculated values include spectral radiance (ie. luminance + color), irradiance (illuminance + color) and glare indices. Simulation results may be displayed as color images, numerical values and contour plots. Radiance is used by architects and engineers to predict illumination, visual quality and appearance of innovative design spaces, and by researchers to evaluate new lighting and daylighting technologies. <https://www.radiance-online.org/>

Analysis and visualization of lighting in design

- Plug-in software
- File types
 - Import: BSDF
 - Export: BSDF
- Price
 - Free

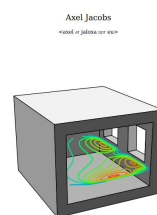
Tutorials

Radiance Tutorial

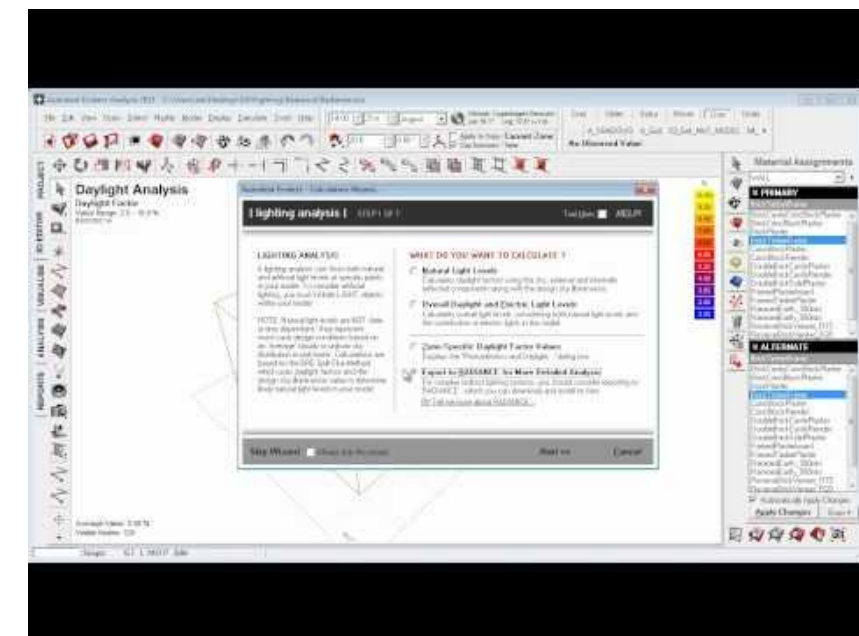
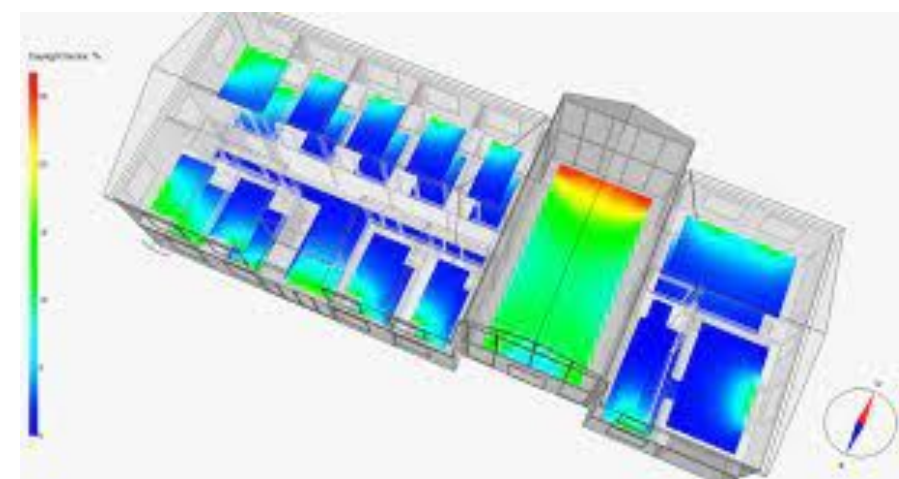
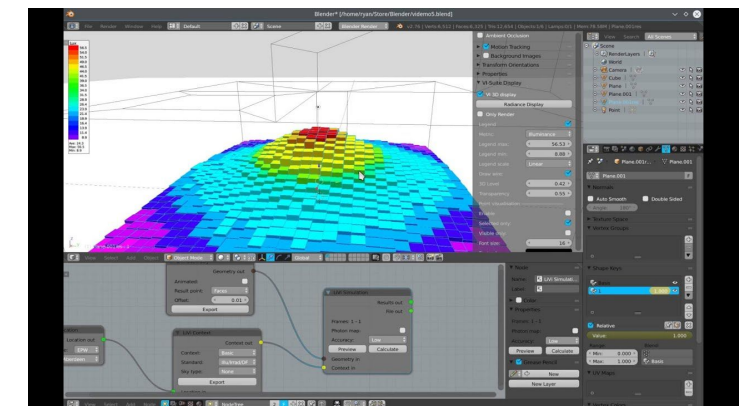
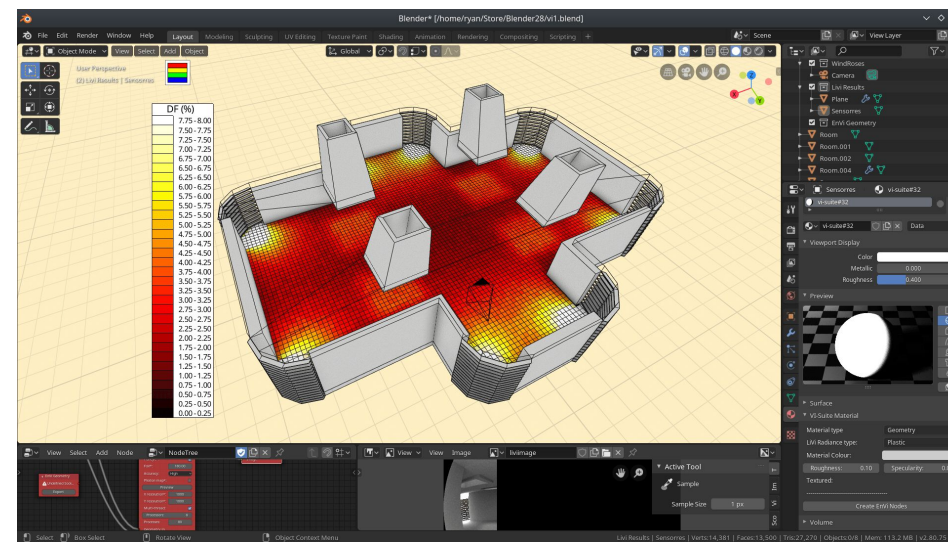


Radiance Tutorial

RADIANCE Cookbook



Radiance Cookbook





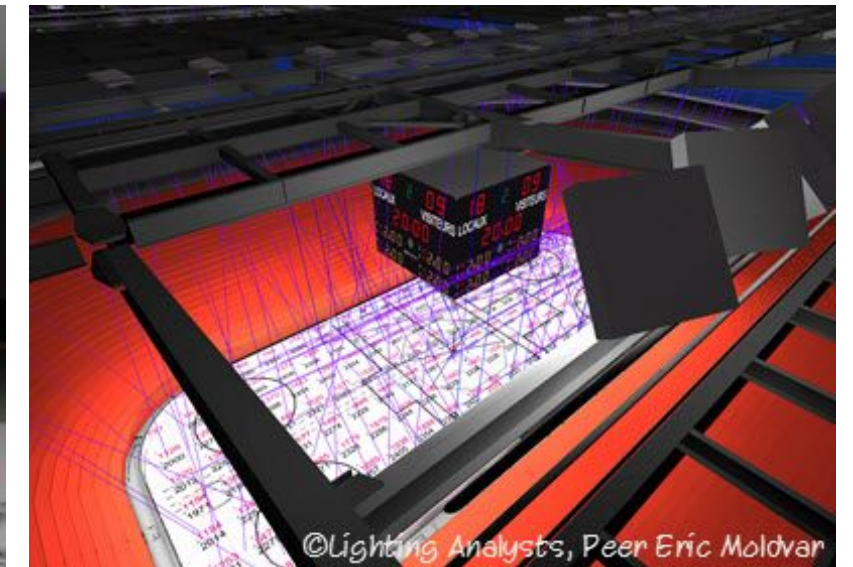
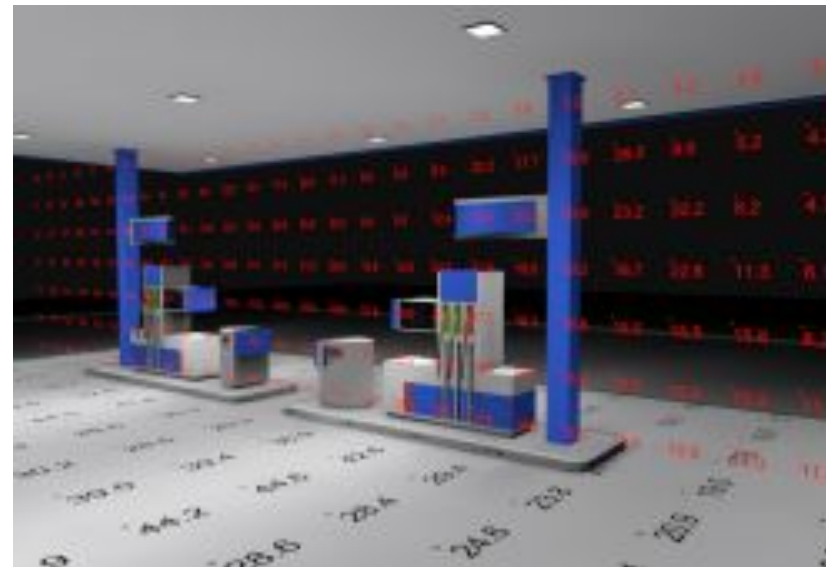
AGi32

AGi32 is a simulation tool used for designing lighting projects and calculating the amount of light that will be delivered based on user-set parameters. AGi32 can calculate the amount of light that will be delivered in any kind of design, interior or exterior, and incorporate surrounding objects, obstructions, and varying shapes like vaulted ceilings or rooms in non-linear shapes. It aids lighting designers, engineers, and electrical contractors in the evaluation of lighting designs for projects before they are built.

<https://lightinganalysts.com/>

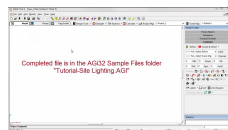
The Lighting Industry's Premier Calculation Tool

- Standalone software
- File types
 - Import: Laidex
 - Export: Laidex
- Price
 - Single Use: \$895 USD yearly (or \$94 USD monthly)
 - Multi User: \$1349 USD yearly (or \$141 USD monthly)
 - Free Trial: 14 days

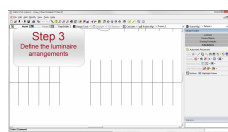


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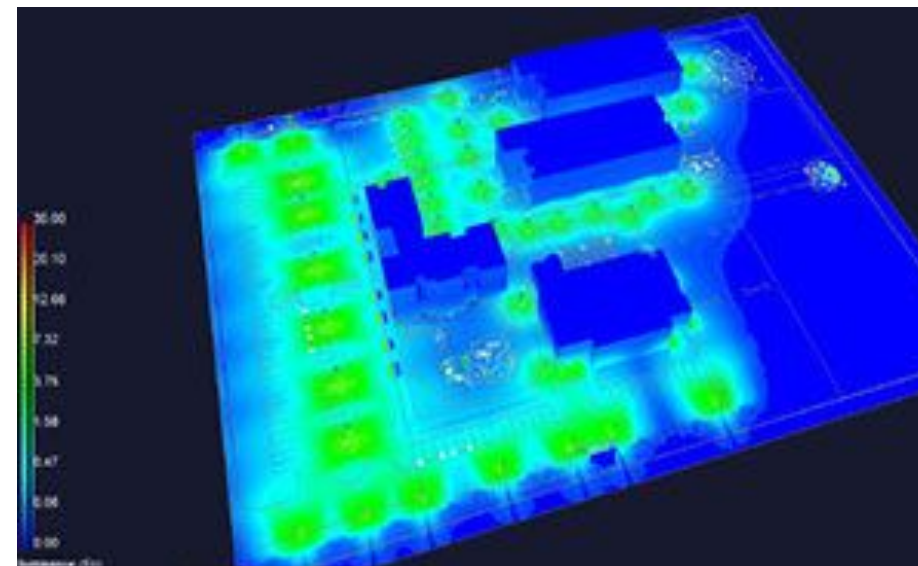
Tutorials



Tutorial: Site Lighting Video 1



Tutorial: Site Lighting Video 2





Ladybug

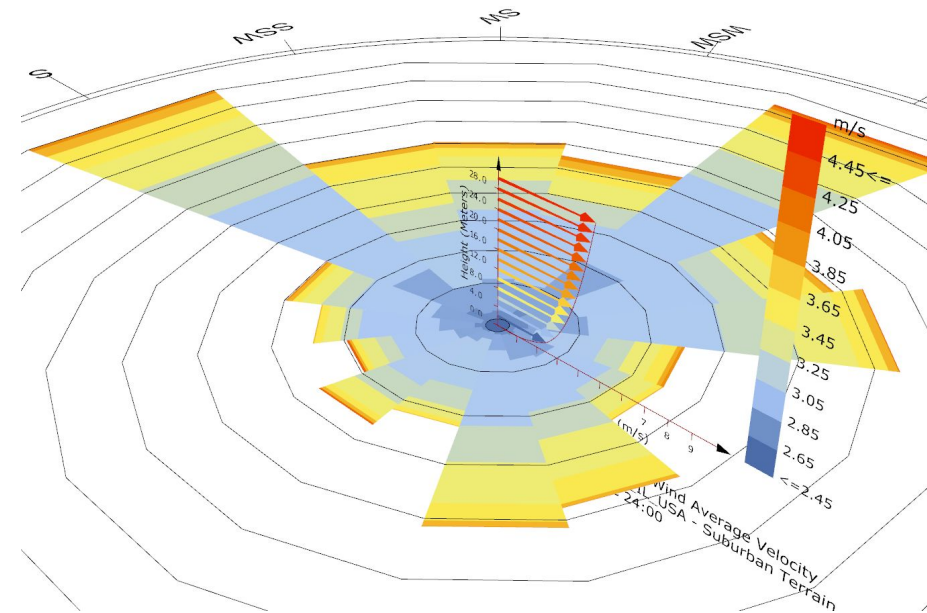
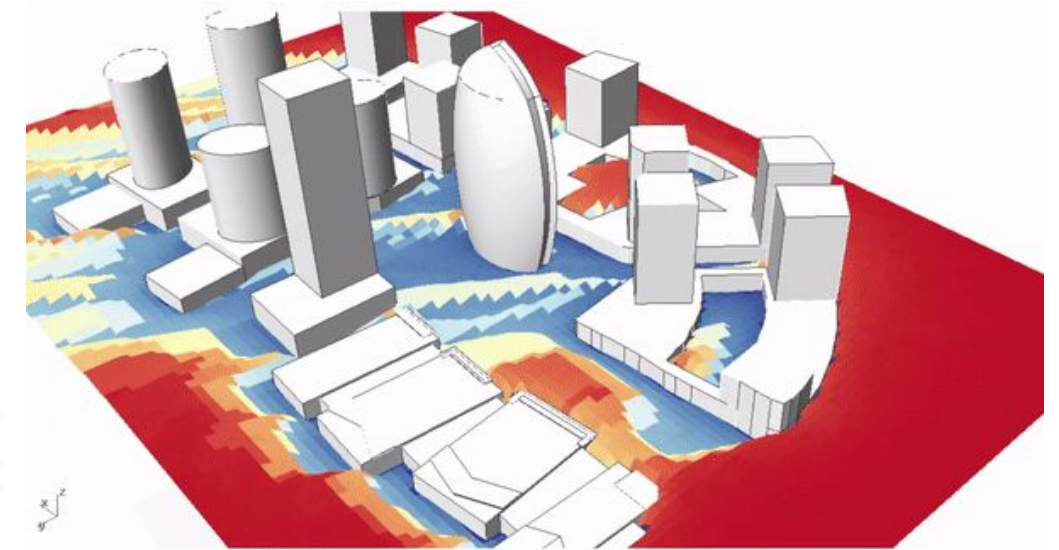
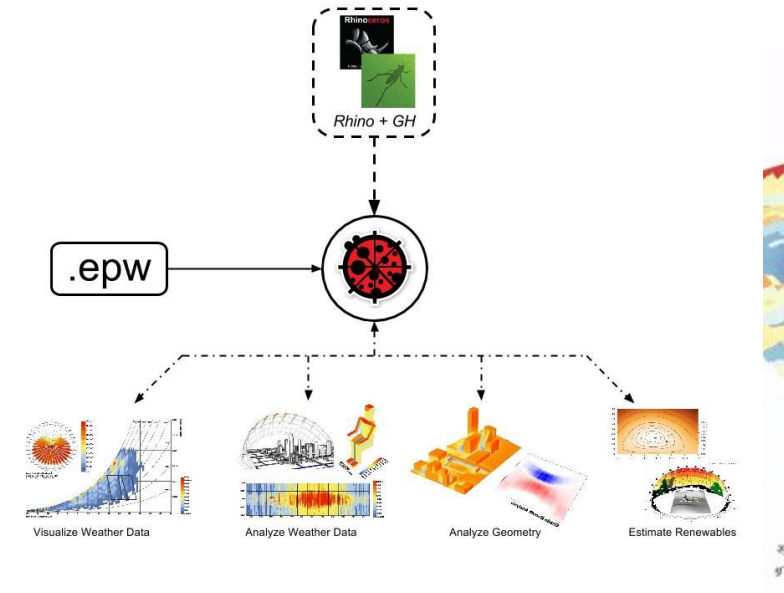
Ladybug is an open-source plugin for Grasshopper in Rhino and Dynamo in Revit that performs detailed analysis of climate data to produce customized, interactive visualizations for environmentally-informed design. Ladybug is typically used for early design phases when deciding on form and orientation.

Site specific climate analysis and visualization

Ladybug combines Rhino geometry, Grasshopper parameters, and EnergyPlus weather data to run simulations of how a design would perform in real world conditions.

This plugin can visualize solar sunpaths, shadows, radiation, solar envelopes, thermal studies, and wind profiles. Additionally, it can perform raytracing, shade design, adaptive comfort, estimate renewables, and create psychrometric charts.

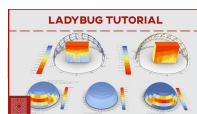
Imports .epw, .stat, .ddy file types and can output Excel tables, charts, and visual representations of the BEM data. The Ladybug Tools are open-source and free to install for Rhino and Grasshopper. See page 'Rhinceros 3D' for cost.



Tutorials



Tutorial 1: Installing Ladybug for Grasshopper (5:07)



Tutorial 2: Ladybug Basics (35:01)



Tutorial 3: 5 Ladybug Features (14:29)

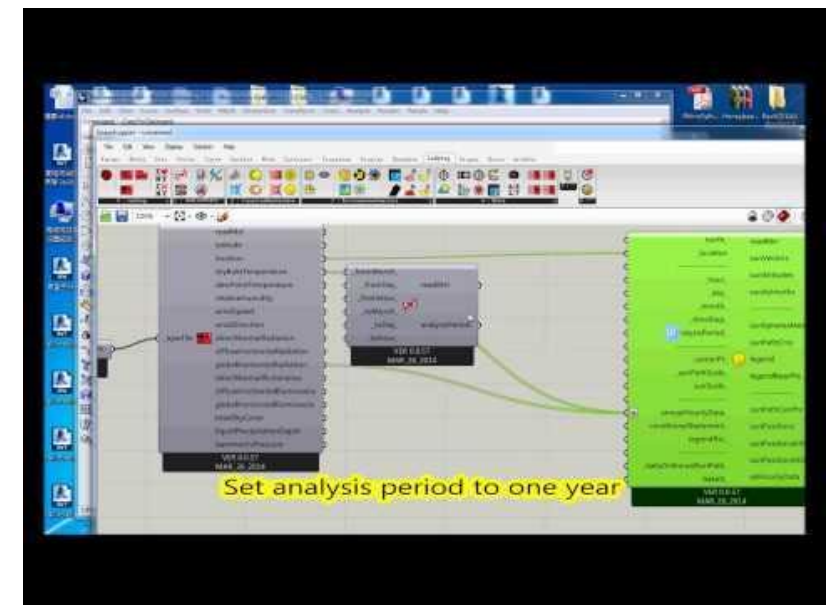
(Click image to see tutorial)

[Official Site](#)

[Download](#)

[Example Files](#)

student author: Reiko Corteza



(Click image to see Promotional Video)



Honeybee

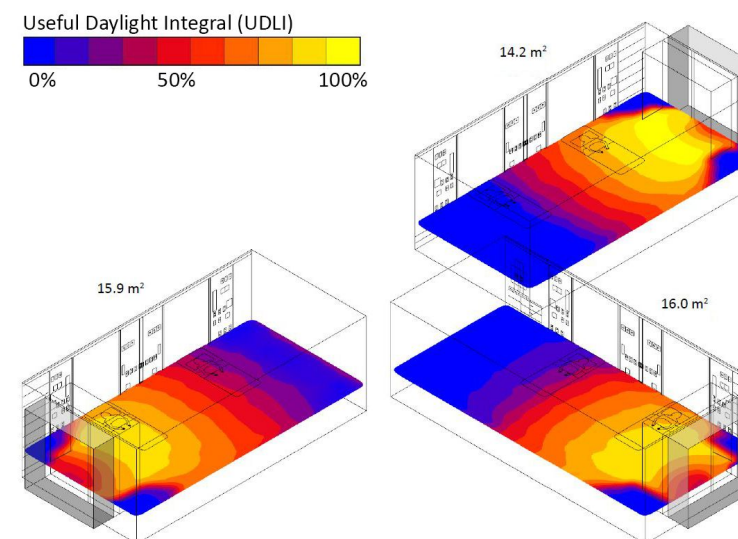
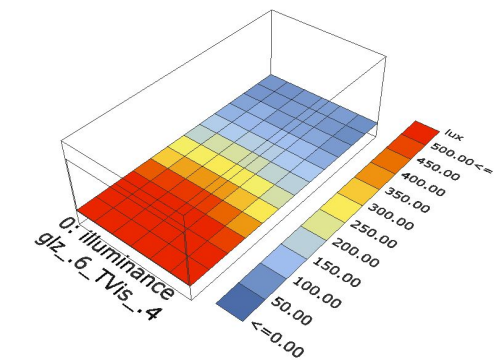
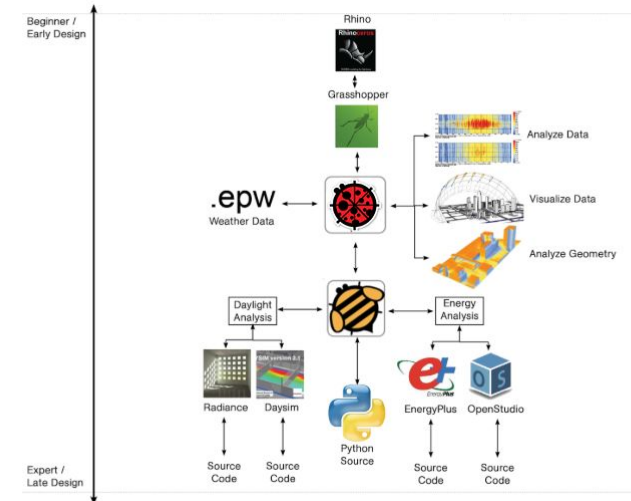
Honeybee is an open-source plugin for Grasshopper that performs full building energy simulations for Rhino models. It is primarily intended for later parts of the design process once the general form of the building is nearing finalization.

Building Performance Simulation

Honeybee incorporates multiple energy simulation softwares, including Radiance (daylight and radiance simulation), OpenStudio/EnergyPlus (energy models), and THERM (heat flow through materials) for energy analysis.

Honeybee can perform many different tasks, including illuminance studies, daylighting simulations, glare analysis, solar radiation studies, energy mapping, heating and cooling usage, HVAC sizing, color zoning, indoor thermal comfort, and passive/HVAC strategy modeling.

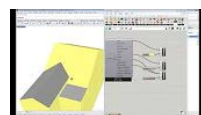
Honeybee is a plugin for Rhino and Revit. Honeybee is free to download, but you will need Rhino (\$195 for students, \$995 for professionals) or Revit (Free for students, \$2545 per year for professionals) to utilize.



Tutorials



1 - Honeybee Energy Modeling - Installation



2 - Honeybee Energy Modeling - HB Zones From Masses Part 1



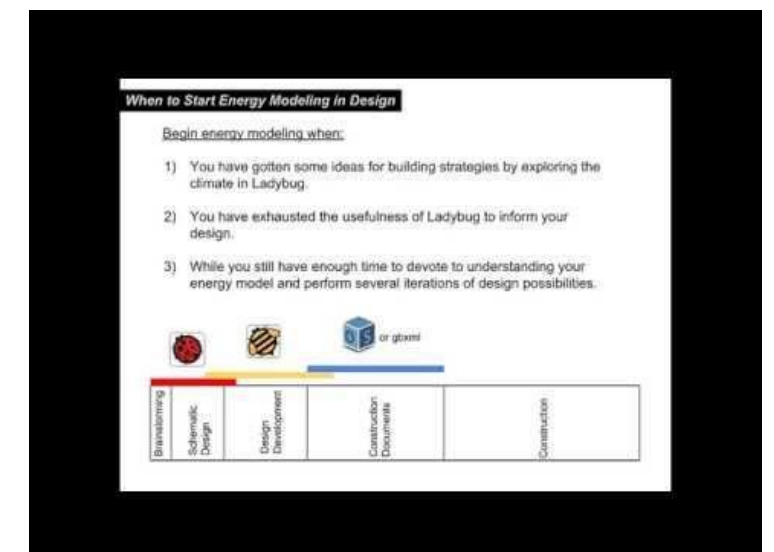
3 - Honeybee Energy Modeling - HB Zones From Masses Part 2

(Click image to see tutorial)

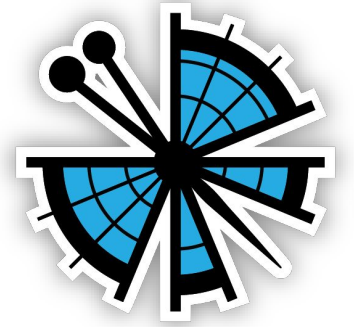
[Official Website](#)

[Honeybee Primer](#)

Student Author: Cameron Gibson



(Click image to see Promotional Video)



Butterfly

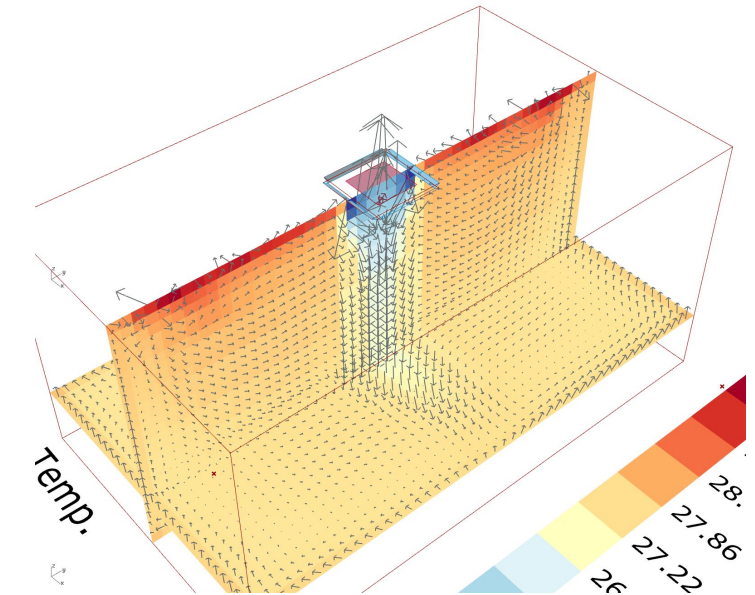
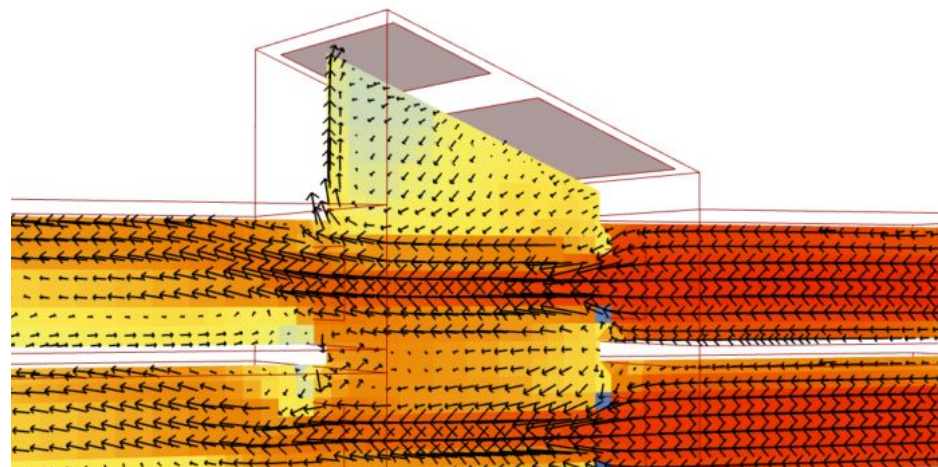
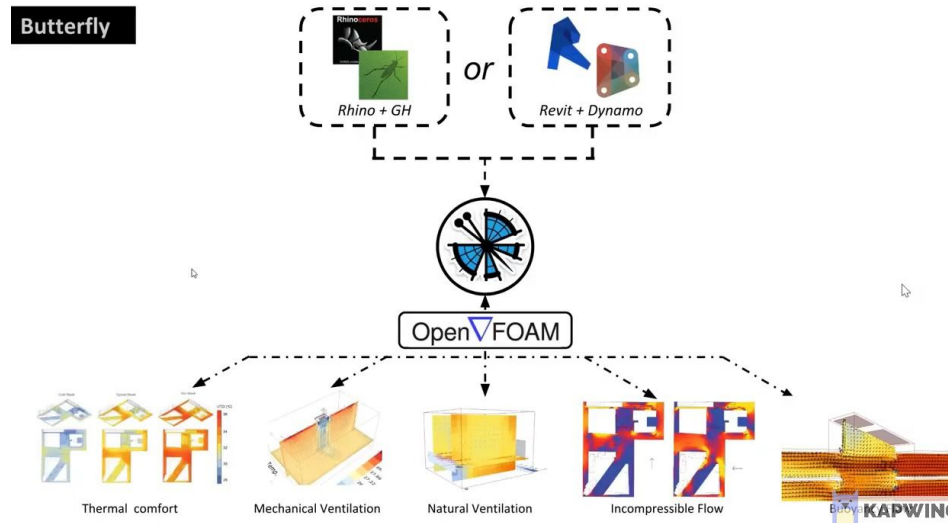
Butterfly is an open-source plugin for Grasshopper and Dynamo that specializes in performing complex air flow analysis for Rhino Models.

Air Flow Simulation

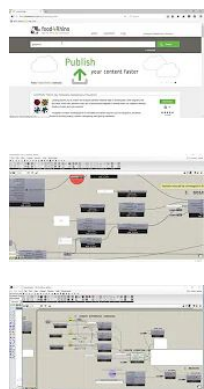
Butterfly runs simulations utilizing OpenFOAM, an open-source fluid dynamics simulation. Butterfly exports the Rhino model to OpenFoam, runs multiple types of simulations, then re-imports the data into Rhino.

Butterfly can perform indoor and outdoor air flow and comfort simulations, as well as analyze HVAC draft and air buoyancy.

Butterfly is a plugin for Rhino and Revit. Butterfly is free to download, but you will need Rhino (\$195 for students, \$995 for professionals) or Revit (Free for students, \$2545 per year for professionals) to utilize.



Tutorials



1 - How to Install Butterfly for Grasshopper

2 - Outdoor Airflow Modeling

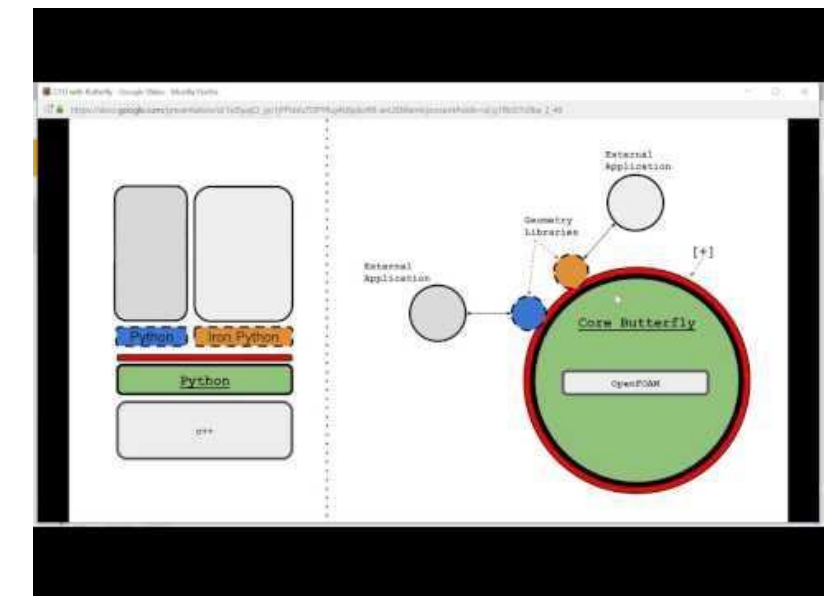
3 - Indoor Airflow Modeling

(Click image to see tutorial)

[Official Website](#)

[Butterfly Primer](#)

Student Author: Cameron Gibson



(Click image to see Promotional Video)



Dragonfly

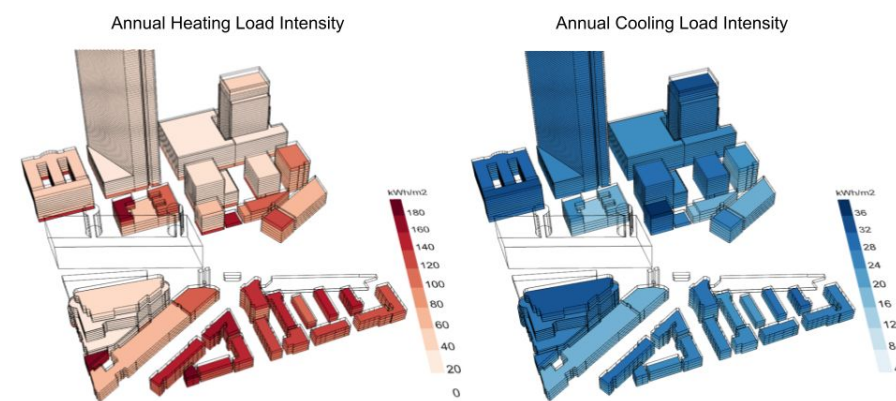
Dragonfly is an open-source plugin for Grasshopper that specializes in creating large-scale energy models in Rhino. Dragonfly is targeted towards large scale construction projects that include multiple buildings, such as district planning.

Large-Scale Energy Modeling

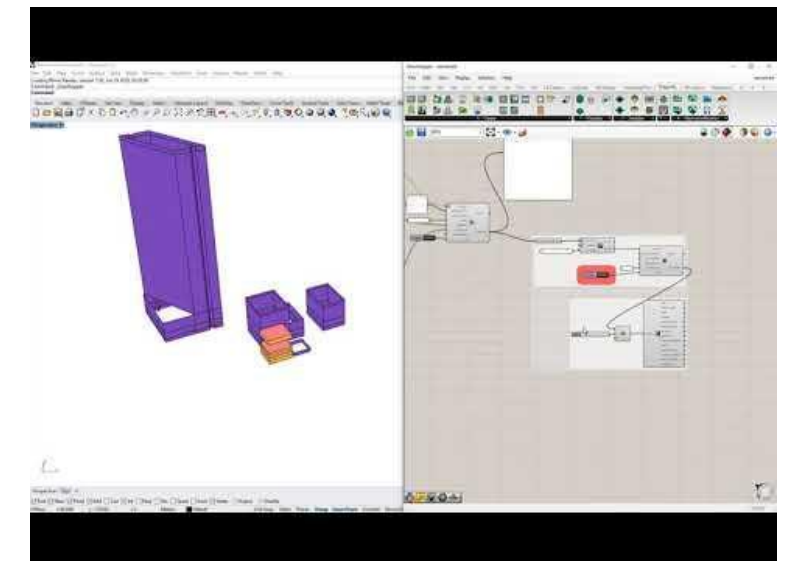
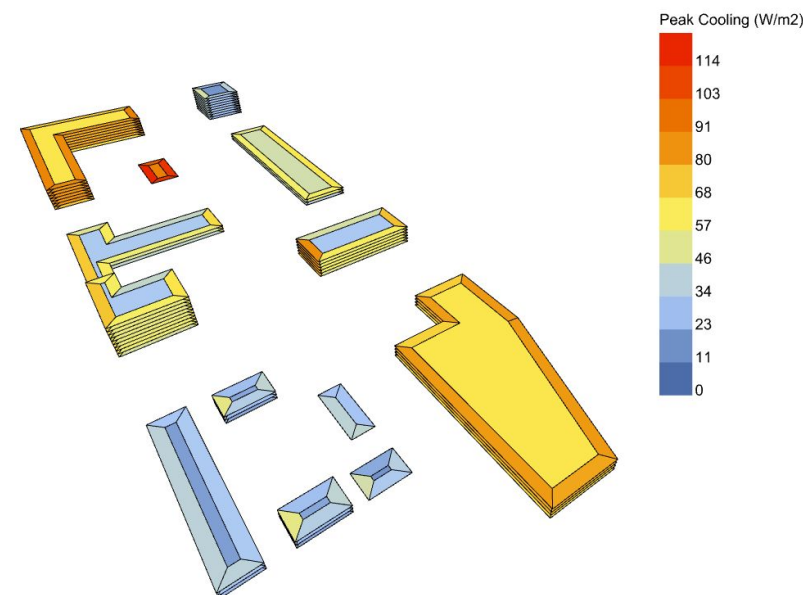
Dragonfly utilizes URBANopt for energy simulation, OpenDSS for electrical grid simulation, REopt for renewable energy optimization, and Urban Weather Generator for urban heat island modeling.

Dragonfly is able to simulate energy models for each room in a building/each building in a model, create .epw files from weather data, create district models from multiple sources, and simulate energy demand and usage,

Dragonfly is a plugin for Grasshopper, which in itself is a plugin for Rhino. Honeybee is free to download, but you will need Rhino to utilize Honeybee (\$195 for students, \$995 for professionals.)

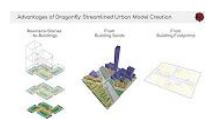


57



(Click image to see Promotional Video)

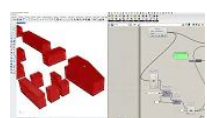
Tutorials



1 - Dragonfly: From Honeybee to Dragonfly



2 - Dragonfly - Running an URBANOpt Simulation



3 - Dragonfly - Creating Buildings from Footprints

(Click image to see tutorial)

[Official Website](#)

[Dragonfly Primer](#)

Student Author: Cameron Gibson

Environmental Digital Analysis - Honeybee



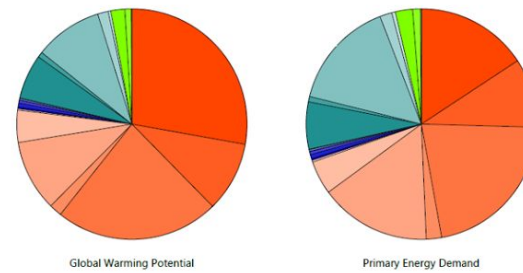
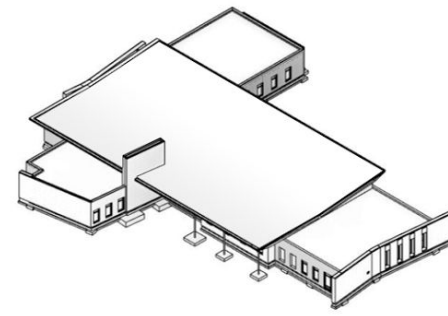
Tally

Tally quantifies a building's embodied environmental impacts to land, air, and water systems and provides a Life-Cycle Analysis (LCA) based on the building's materials and architectural products. This analysis provides more detailed material take offs than a typical BIM analysis, which allows for a more accurate report of material impacts to the LCA.

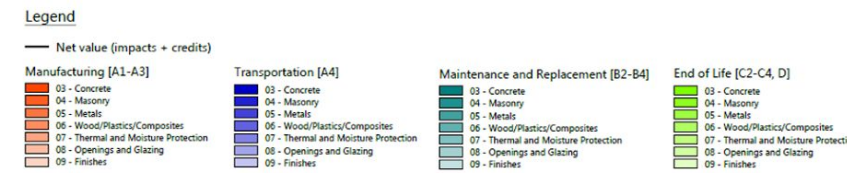
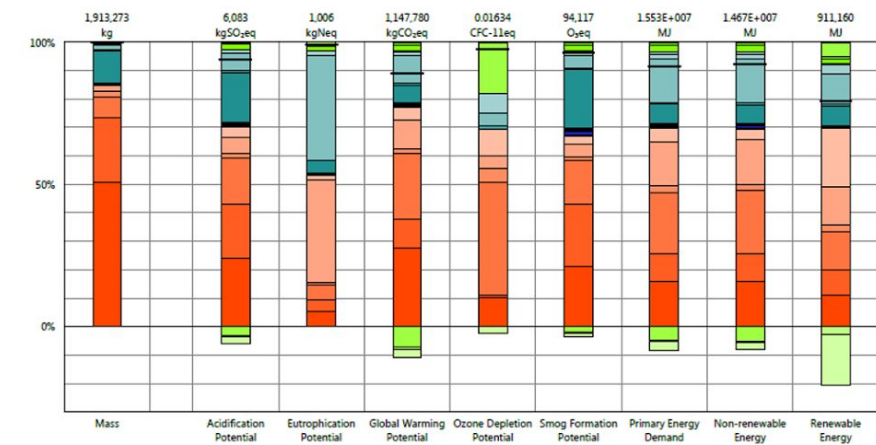
Life Cycle Analysis of environmental impacts.

Tally is utilized as a plugin for Revit and runs within typical Revit files. The reports generated by Tally are then exported as pdf files.

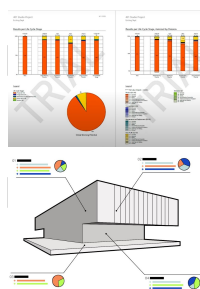
For an annual license, it costs \$695 for a floating basic license and \$995 for a floating premium license. Students can apply for an educational license on their website. There is a free 10 day trial once you download the software.



Results per Life Cycle Stage, itemized by Division



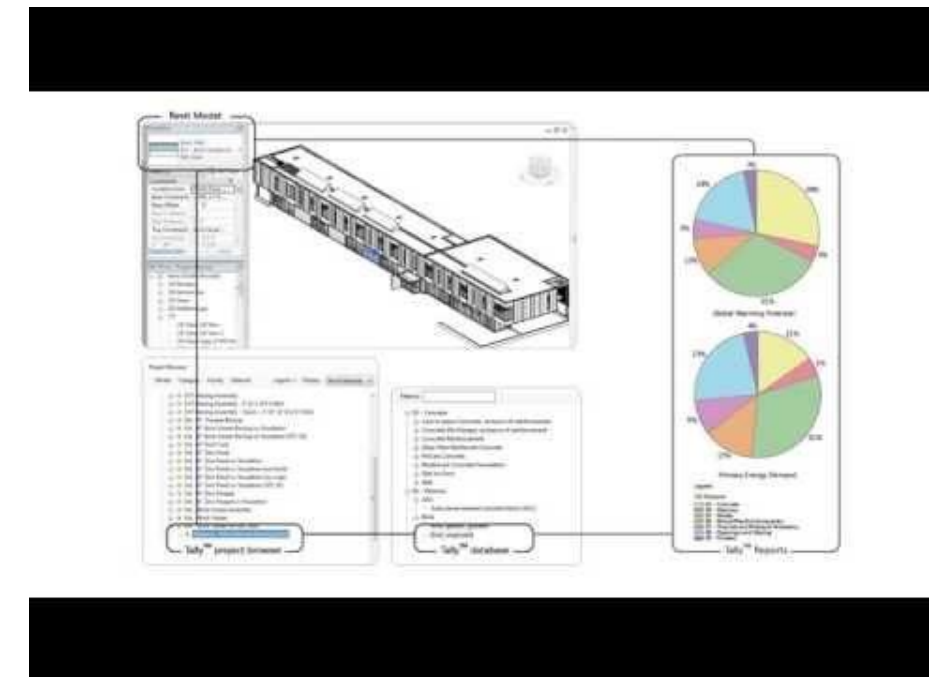
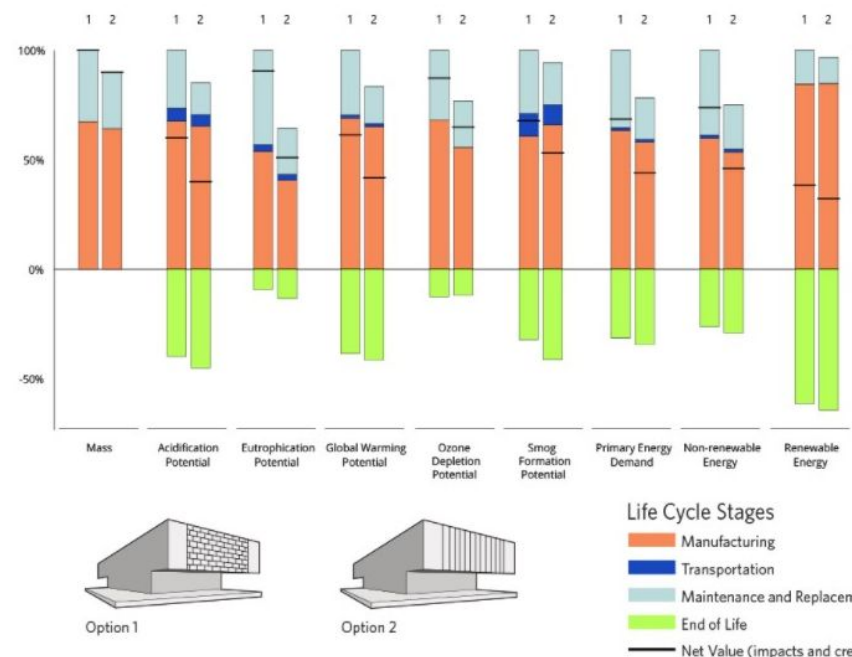
Tutorials



Tutorial 1: Tally Tutorial (Basic Introduction)

Tutorial 2: Webinars from Tally site

(Click image to see tutorial)



(Click image to see Promotional Video)



EC3

EC3 analyzes the embodied carbon of materials within a Revit model and compares the carbon intensity of these materials with embodied carbon data from Environmental Product Declarations. This tool only evaluates the product stage of a life-cycle analysis purely based on existing material data from a Revit file.

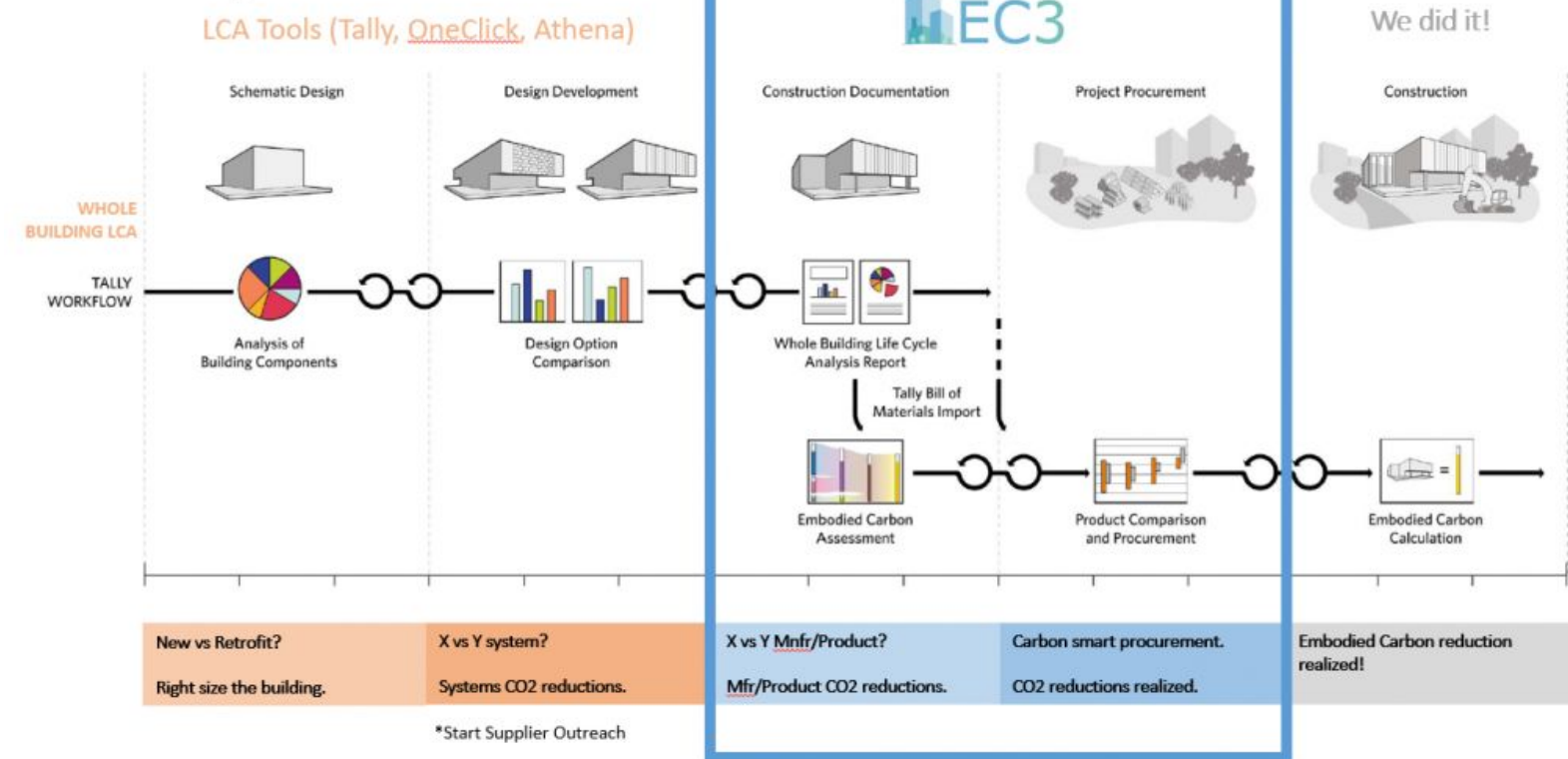
Cradle-to-gate material evaluation.

EC3 accepts imports from Revit, BIM 360, and Tally for material quantities. EC3 and Tally are currently being integrated to create the Tally Climate Action Tool to evaluate both lifecycle and product stage embodied carbon estimates.

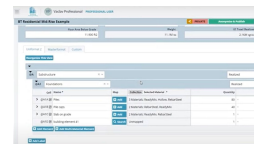
EC3 is free and open source for access by students and professionals in Revit.

See Revit page for costs.

What to do, when.



Tutorials

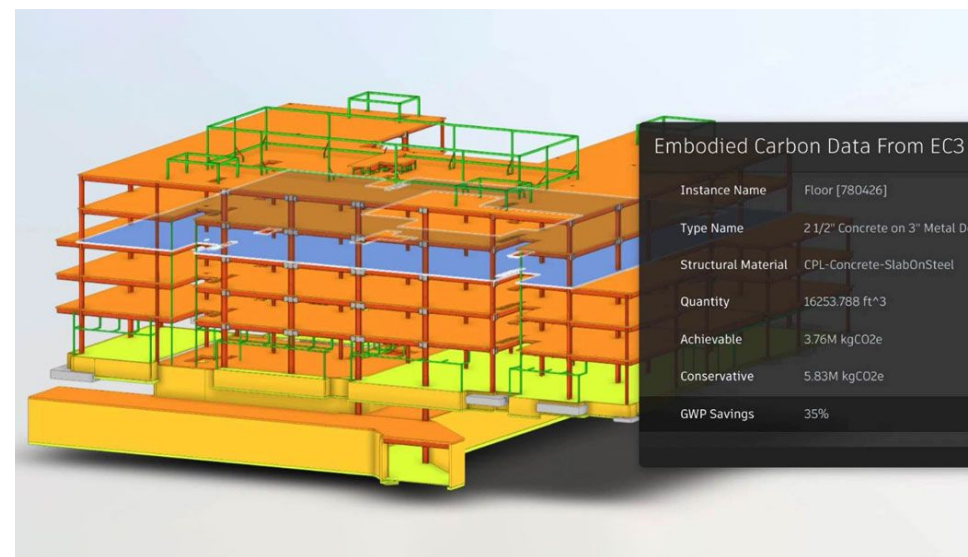


Tutorial 1: EC3 Building Planner Tutorial



Tutorial 2: Reducing Embodied Carbon with EC3 and Tally Trim

(Click image to see tutorial)



(Click image to see Promotional Video)



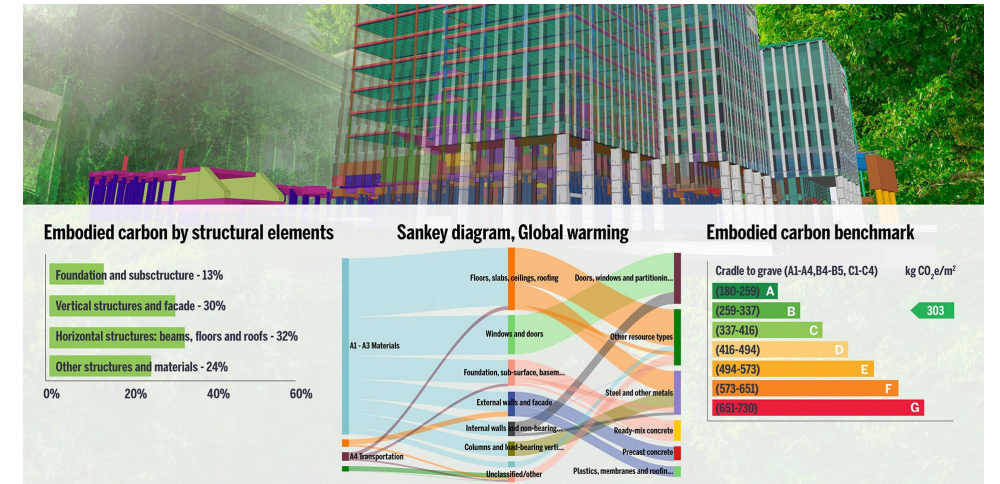
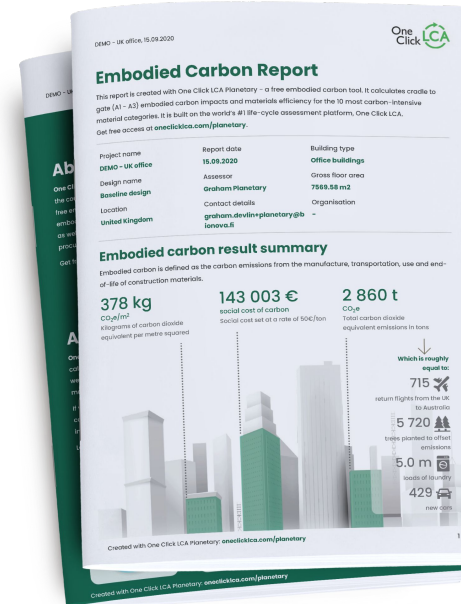
One Click LCA

One Click LCA is a carbon embodiment and life cycle analysis software compatible with most BIM software. This includes Revit, Rhino, Tekla, IES and many others.

The company formerly known as Bionova rebranded with the launch of this software in summer 2021 and has quickly become a prominent software in the industry.

One Click LCA analyzes the entirety of a building's life cycle from construction and supply chain management to eventual demolition or reuse.

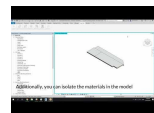
Price: Free for students



Tutorials

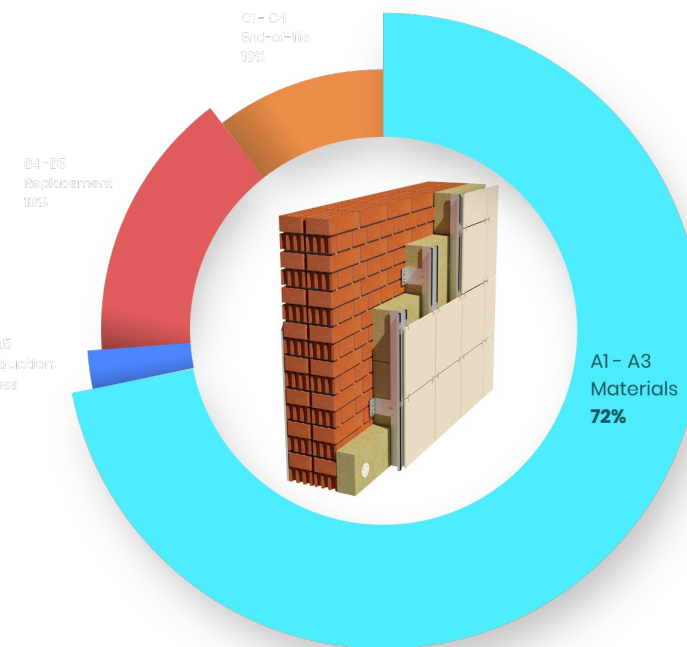


[1] Tutorial 1: How to get started with calculations One Click LCA



[2] Tutorial 2: One Click LCA Revit plugin

(Click image to see tutorial)



(Click image to see Promotional Video)

IES - Integrated Environmental Solutions



IES is designed to reduce the carbon footprint and energy consumption of building and cities through a suite of applications. Intelligent community life cycles are used to ensure everyone from the design, construction, and operations of a building have access to building environment. Digital twins respond like their real world counterpart and allow for precise analysis of the environmental impact of design decisions.

Digital twin technology

Suite includes:

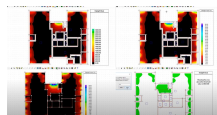
- ICL: Full Digital Twin Suite
- VE: New Design & Retrofit
- iCD: Sustainable Master Planning
- iSCAN: Optimal Building Operation
- Collaboration Cloud: Command Centre
- iVN: Community Energy & Renewables

Standalone Software (Import Revit, Sketchup, etc.)

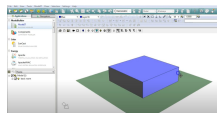
Professional: \$2290/year

Student: \$70/year for select applications

Tutorials

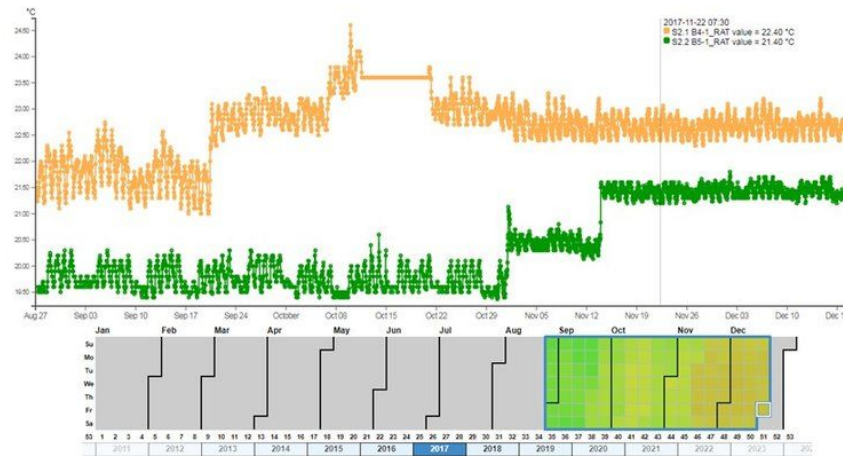
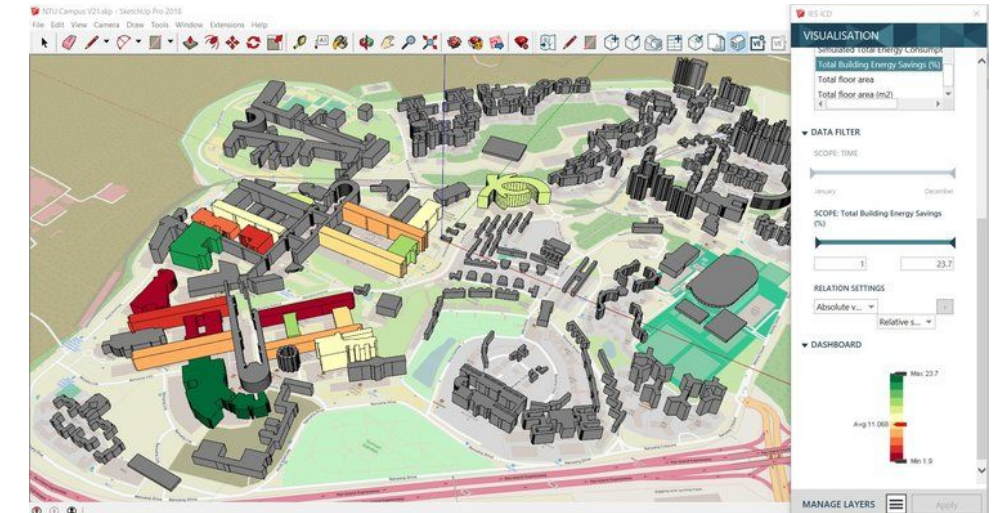


Tutorial 1: Introduction to VE



Tutorial 2: Geometry basics in IESVE

(Click image to see tutorial)



(Click image to see Promotional Video)



MassMotion

MassMotion is an advanced pedestrian simulation modeling software that predicts the behavior and flow of pedestrians. This tool allows the user to analyze their model to find the most efficient routes and edit geometries. It is used in airport design, fire safety, office, rail, and stadiums development.

Simulating pedestrian movement & crowd behavior

MassMotion is capable of simulating hundreds of thousands of people allowing for rapid design exploration. While providing 3D camera fly overs and digital graphics to communicate with clients.

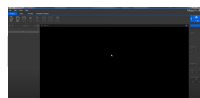
Standalone Software

Import: 3D objects or 2D drawings, images, 3ds, dgn, dwg, obj, mmxlm

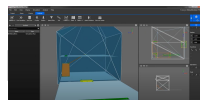
Export: Data to a csv file, obj, mmxlm

Professional: \$30,000/seat for MassMotion
\$7,500/seat for MassMotion Flow

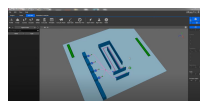
Tutorials



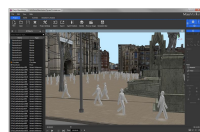
Tutorial 1: MassMotion User Interface



Tutorial 2: MassMotion Geometry Editing Tools

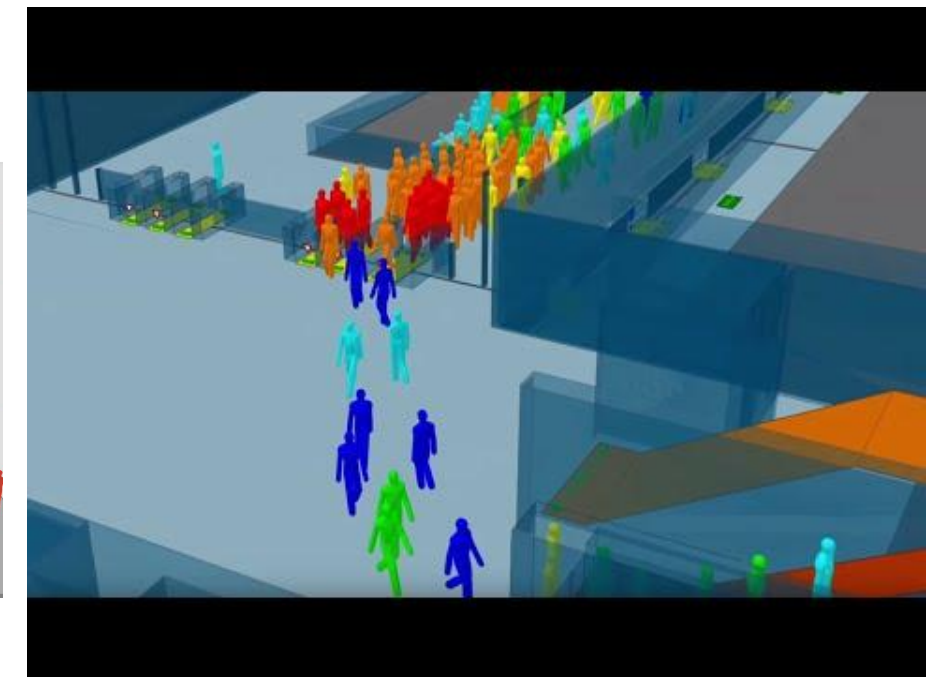
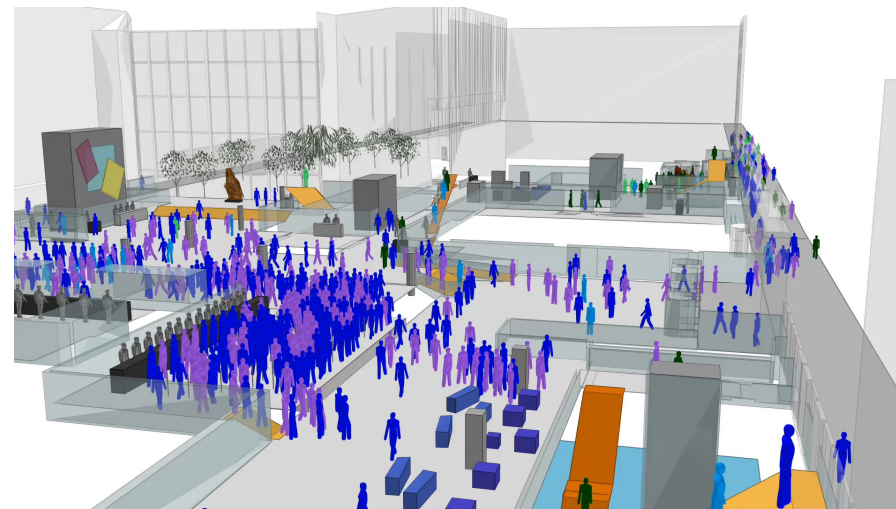
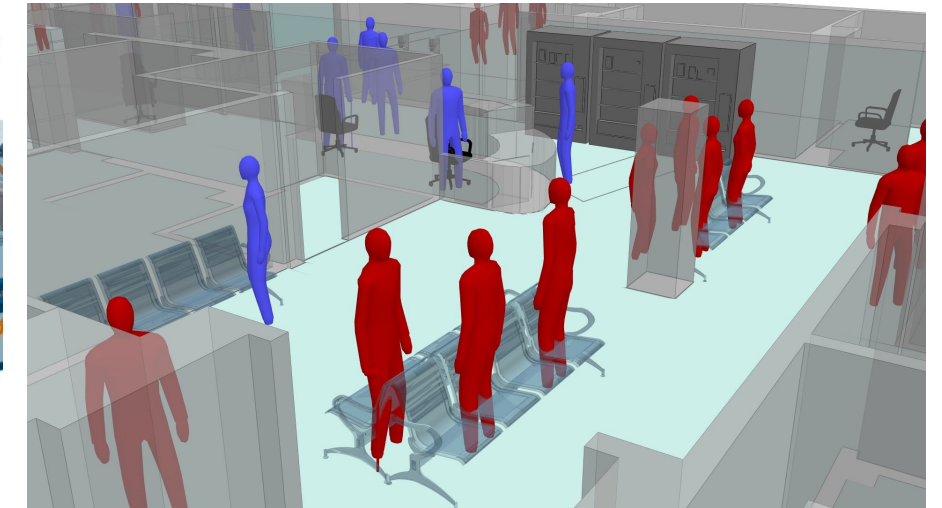
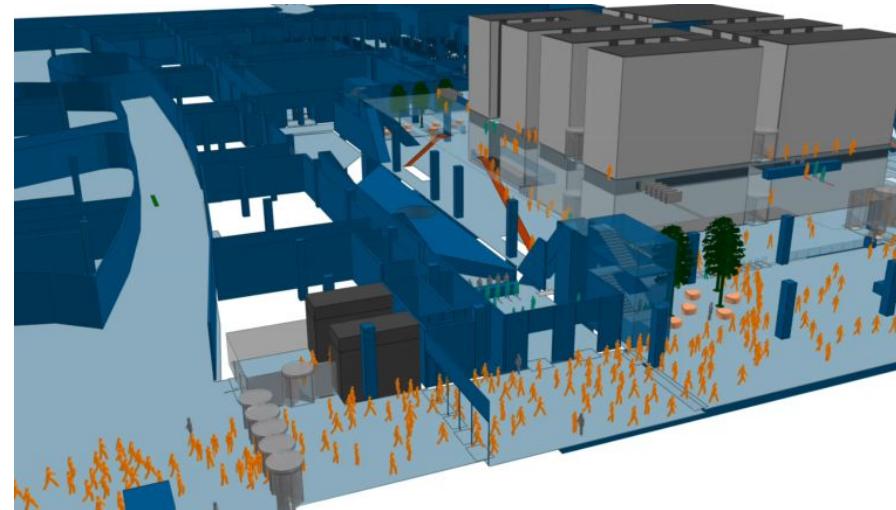


Tutorial 3: MassMotion Agent Actions



User Manual

(Click image to see tutorial)



(Click image to see Promotional Video)



Revit Insight

Revit Insight is a cloud based analysis tool that integrates energy, lighting, and solar analysis all in one place to improve your building's energy and environmental performance throughout the building's lifecycle

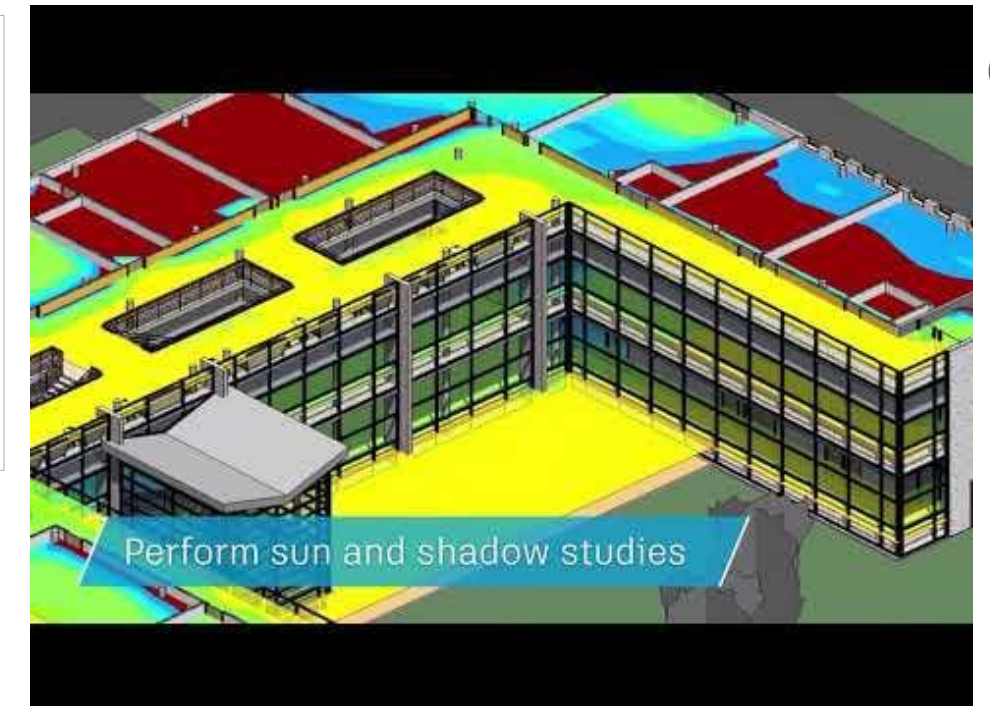
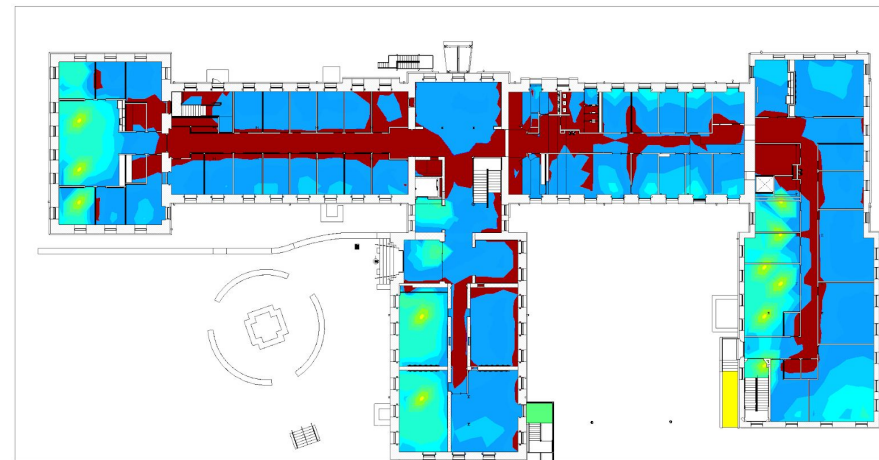
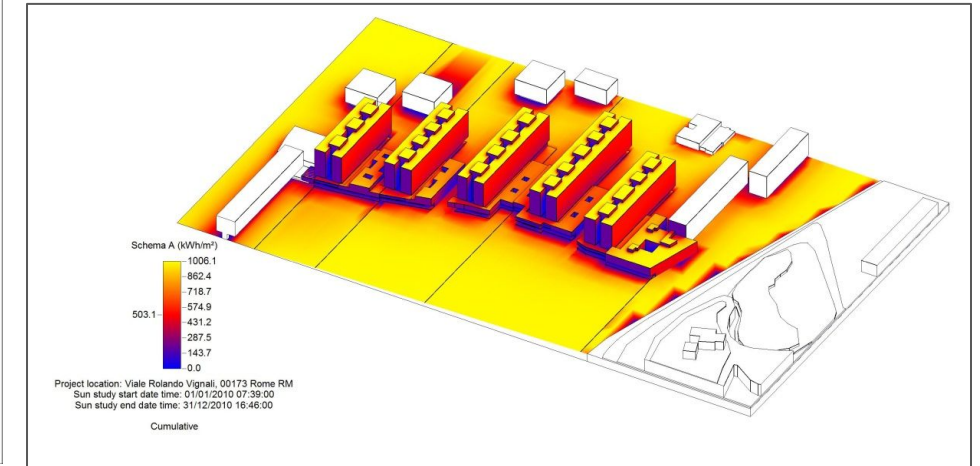
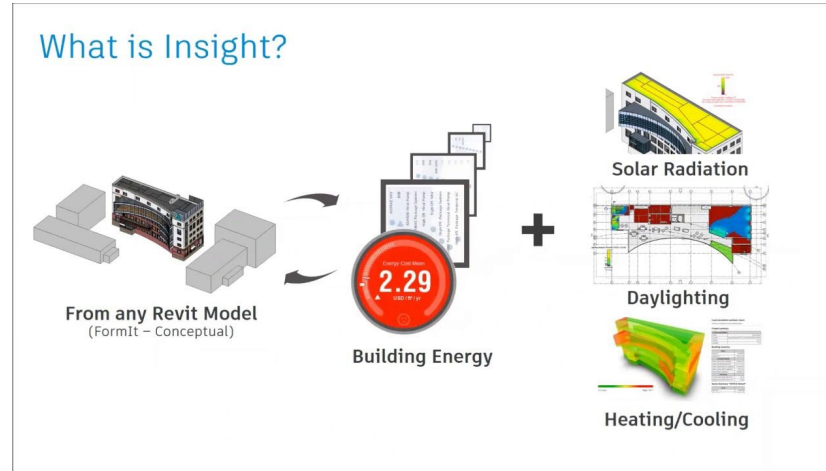
PV, Lighting, and HVAC Analysis

Insight used to be a plugin, but it is now a feature that exists directly in Revit. Simply generate an energy analysis model using a command, then open it in your preferred browser. Revit does all computations and modelling in the cloud: this can take up to a couple of hours for larger projects.

Take your Revit model (either in the massing phase or with construction materials), and create appealing infographics and models representing heating and cooling massings, PV potential analysis, and energy consumption estimates.

See page 'Revit' for compatible files.

See page 'Revit' for cost.

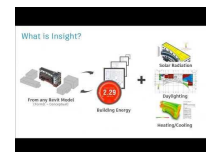


63

Tutorials



Tutorial 1: Energy Analysis in Revit Tutorial



Tutorial 2: Autodesk Insight webinar part 1: Learn everything about Insight

(Click image to see tutorial)

(Click image to see Promotional Video)



Environment

Environment is a Revit BIM plugin that brings site design to existing Revit models. Place your building into the real, existing site conditions using google maps, then design gardens, topography, amphitheatres, and more!

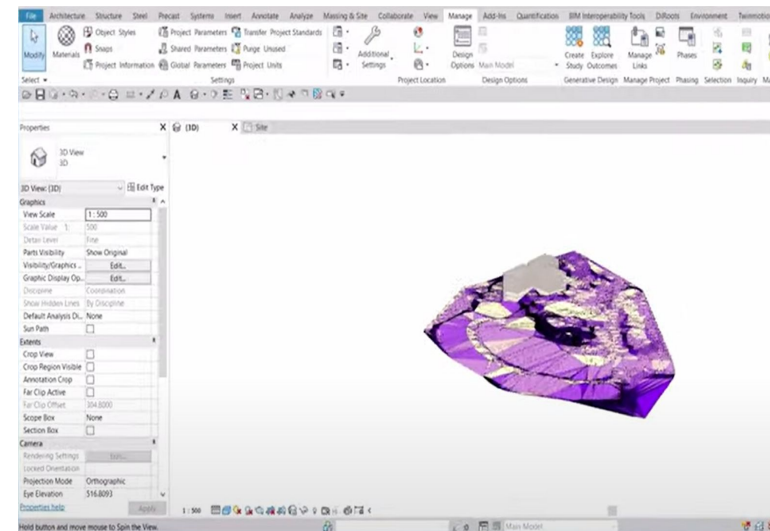
Landscape design and rendering tool

Environment is a Revit plugin designed by Arch-Intelligence. Once it is downloaded, you can use all of its features directly in the Revit design environment.

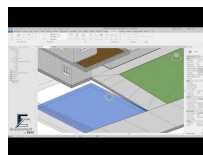
To make your life easier by creating contours, generating walls and fences, and creating contractor drawings for these features all without ever leaving Revit.

See page 'Revit' for compatible files.

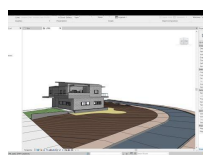
Cost: Free to students. \$500/yr individual subscription, \$475/seat/yr for corporate subscription (min. 10 seats).



Tutorials



Tutorial 1: How to Use the Match Slope Command in Revit Plugin | Environment for Revit® TUTORIAL



Tutorial 2: TUTORIAL - How to Create Toposurface from Edges in Revit | Environment for Revit®

(Click image to see tutorial)



(Click image to see Promotional Video)



Trane Trace 3D Plus

Trane Trace 3D Plus is an HVAC modeling and energy simulation software using the Energy Plus engine with an expanded interface. Trace 3D plus is an expansion on the now discontinued Trace 700 and continues to be one of the prominent design tools for HVAC modeling.

HVAC Sizing and Energy Modeling

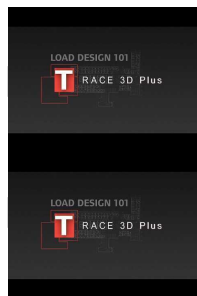
Trane Trace 3D Plus allows firms to experiment with energy simulation models and modify extensive design parameters to create a desirable energy system in the building.

Trane Trace 3D Plus serves as a standalone software but is an expansion on the Energy Plus interface and offers design as well as analysis tools.

File type: GBXML

Cost: 2,345/year

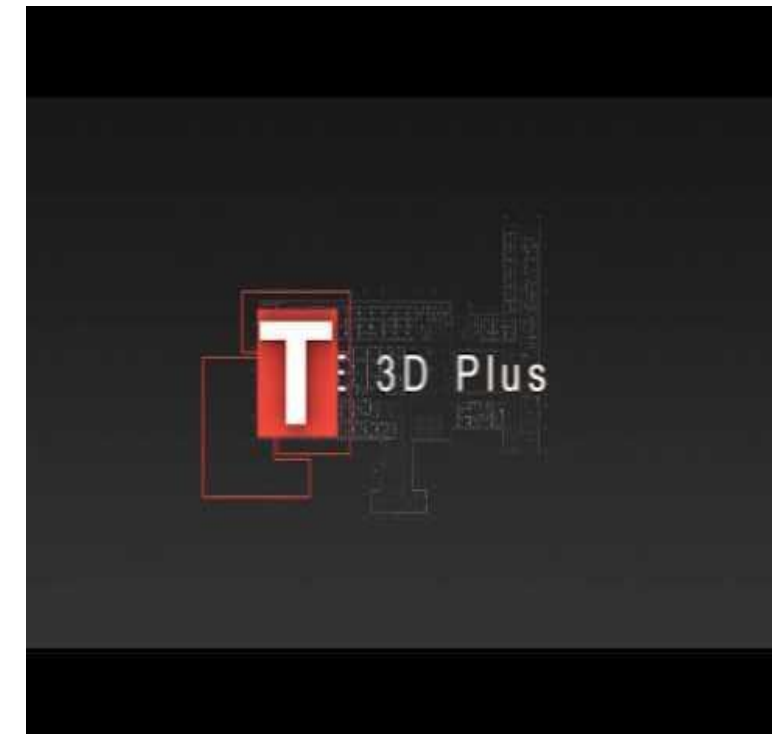
Tutorials



Tutorial 1: Introduction to Trace HVAC design

Tutorial 2: Introduction to Trace HVAC (part 2)

(Click image to see tutorial)



(Click image to see Promotional Video)



Carrier HAP

Dynamo is a standalone software that also has a Revit configuration Portal that allows you to preconfigure the family files based on the specifications of the job.

Designing HVAC Systems and Energy Analysis

Dynamo provides energy performance and energy costs models. For this software some hand calculations are necessary. Integrated system design & energy modeling to simulate peak cooling and heating loads, energy modeling and green building design. Compares energy consumption and operating costs of design alternatives.

HAP uses e3a files to import and export

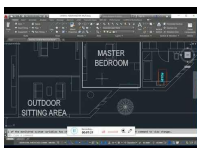
Costs: \$,495/year for professionals and a 90 day trial available. No student discounts available

Tutorials



Tutorial 1: Revit to Hap Fast and Easy cooling

Tutorial 2: [Official Carrier Videos](#) (multiple videos)



Tutorial 3: Heat load Calculation using HAP



Tutorial 4: Carrier HAP Installation

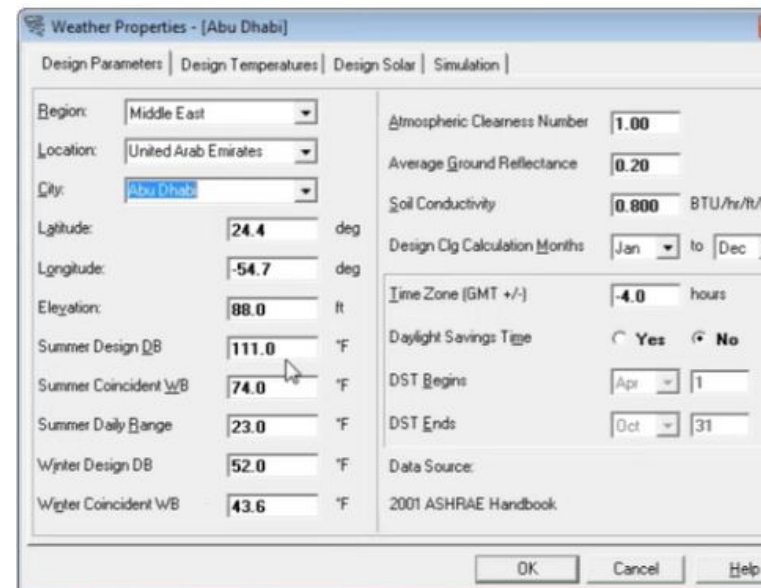
1. Annual Costs

Component	Annual Cost (\$)	(\$/ft ²)	Percent of Total (%)
Air System Fans	1,012	0.106	10.6
Cooling	1,153	0.121	12.1
Heating	4,479	0.469	47.1
Pumps	0	0.000	0.0
Heat Rejection Fans	0	0.000	0.0
HVAC Sub-Total	6,644	0.695	69.9
Lights	2,865	0.300	30.1
Electric Equipment	0	0.000	0.0
Misc. Electric	0	0.000	0.0
Misc. Fuel Use	0	0.000	0.0
Non-HVAC Sub-Total	2,865	0.300	30.1
Grand Total	9,508	0.995	100.0

Note: Cost per unit floor area is based on the gross building floor area.

Gross Floor Area 9559.0 ft²
 Conditioned Floor Area 9559.0 ft²

	DESIGN COOLING			DESIGN HEATING		
	Details	Sensible (BTU/hr)	Latent (BTU/hr)	Details	Sensible (BTU/hr)	Latent (BTU/hr)
ZONE LOADS						
Window & Skylight Solar Loads	403 ft ²	13491	-	403 ft ²	-	-
Wall Transmission	1623 ft ²	1728	-	1623 ft ²	12887	-
Roof Transmission	1489 ft ²	1418	-	1489 ft ²	7328	-
Window Transmission	403 ft ²	1394	-	403 ft ²	12906	-
Skylight Transmission	0 ft ²	0	-	0 ft ²	0	-
Door Loads	67 ft ²	322	-	67 ft ²	2321	-
Floor Transmission	1489 ft ²	0	-	1489 ft ²	2470	-
Partitions	1008 ft ²	4538	-	1008 ft ²	7276	-
Ceiling	1489 ft ²	1029	-	1489 ft ²	1650	-
Overhead Lighting	1489 W	2828	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	288 W	897	-	0	0	-
People	15	3605	7094	0	0	-
Infiltration	-	11	8	-	72	-
Miscellaneous	-	0	0	-	0	-
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads		31258	7102		46907	
Zone Conditioning	-	29996	7102	-	46768	-
Plenum Wall Load	30%	926	-	0	0	-
Plenum Roof Load	70%	3304	-	0	0	-
Plenum Lighting Load	30%	1504	-	0	0	-
Return Fan Load	1727 CFM	0	-	1727 CFM	0	-
Ventilation Load	360 CFM	2784	3378	360 CFM	28847	-
Supply Fan Load	1727 CFM	1280	-	1727 CFM	-1280	-



(Click image to see Promotional Video)



Sefaira

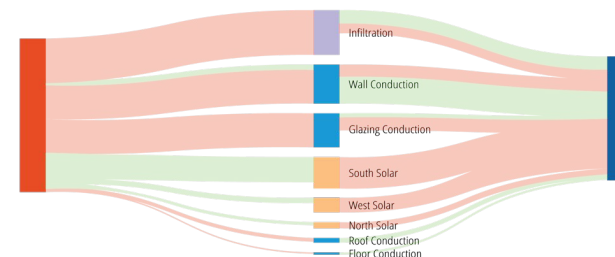
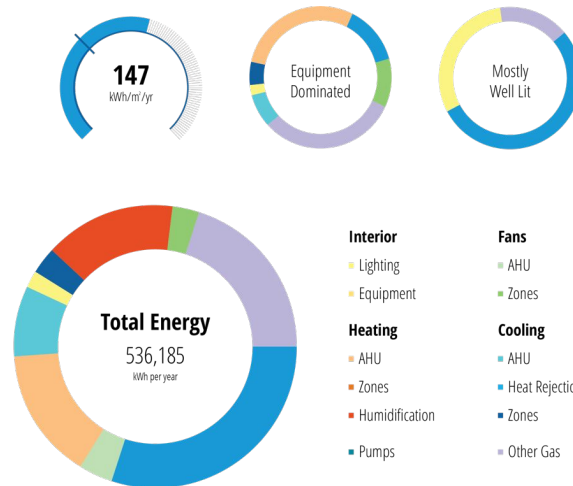
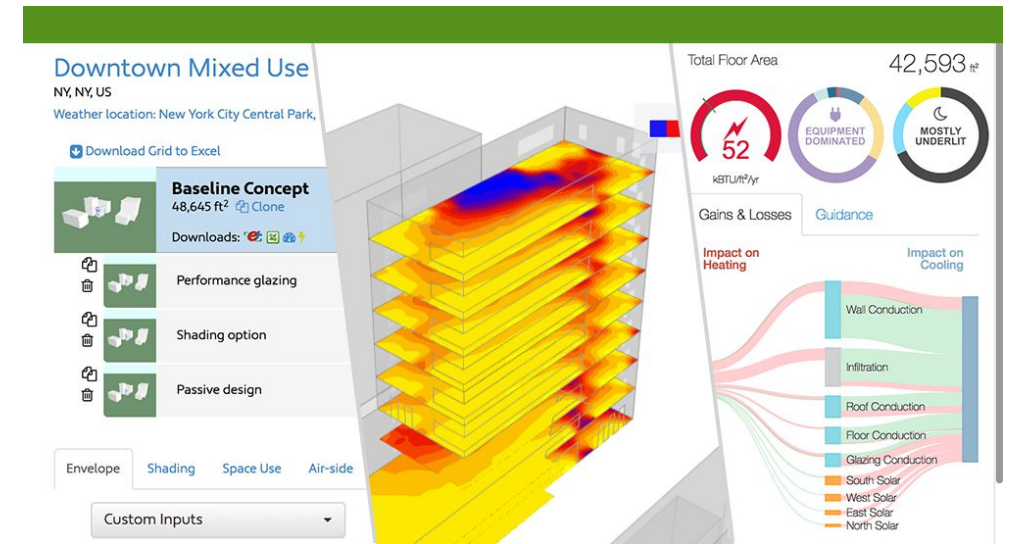
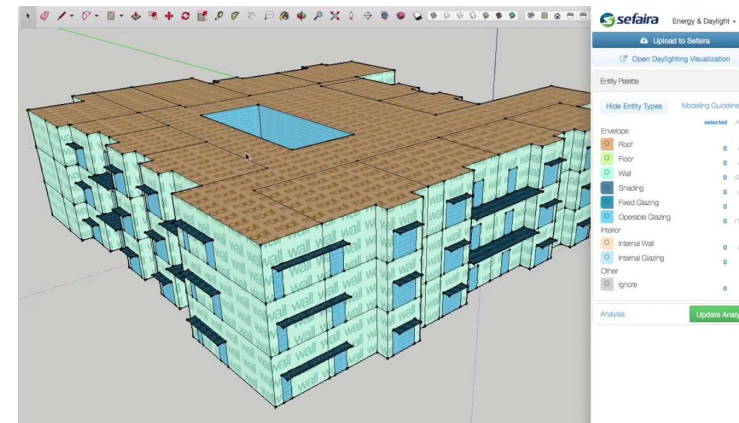
Sefaira is an extension for Autodesk Revit and SketchUp that allows for the use of visual methods to plot energy consumption. Compare massings, layout, and envelope options to shortlist the right concepts

Energy Analysis and Modeling

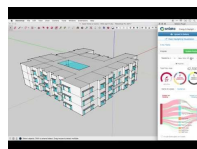
Understand how glazing, shading, and natural and mechanical ventilation impact the comfort of your spaces tracking Air Temperatures, PMV and Operative Temp. Mostly used in the early design stages of a project.

File Types: dwg, dxf, skp and 3ds

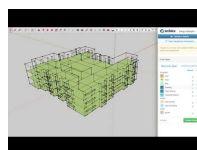
The price for the Architecture and Systems software is \$1,199 for both and \$899 fro each on their own.



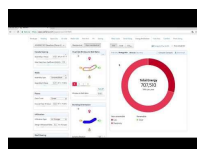
Tutorials



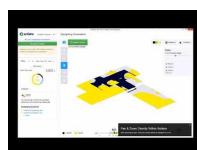
Tutorial 1: How to Setup my Sefaira plugin



Tutorial 2: Modeling for Analysis



Tutorial 3: Understanding Energy Charts



Tutorial 4: Daylight Analysis on Revit

Student Author: Joshua Arenas



(Click image to see Promotional Video)

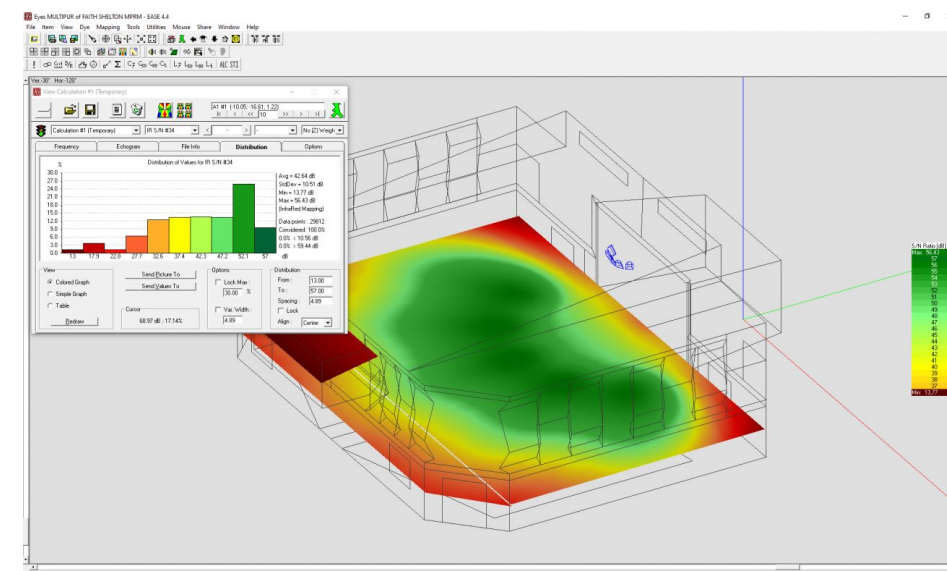
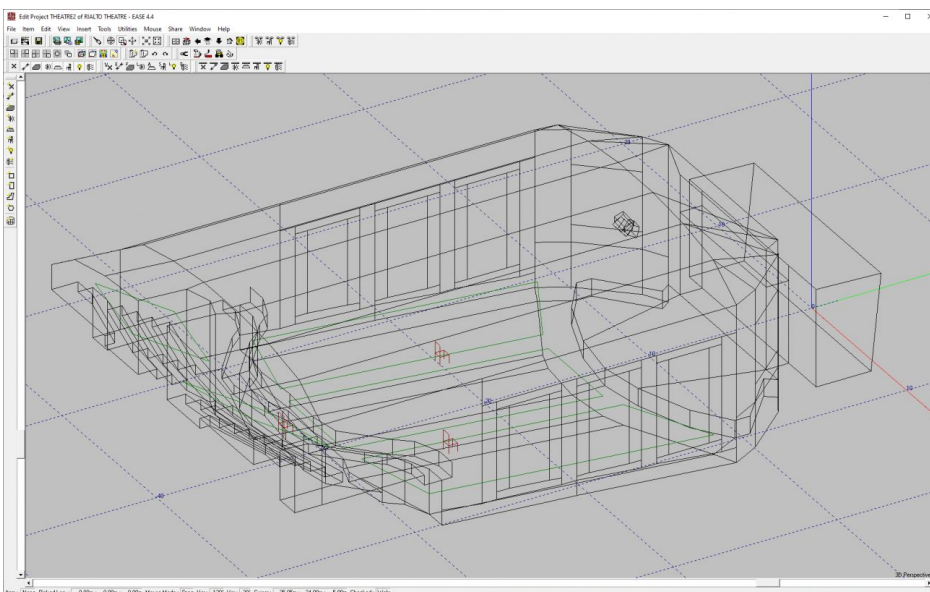


EASE

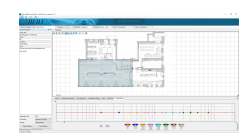
Acoustic analysis software that provides details including realistic modeling and simulation of venue acoustics and sound system performance, informative and engaging client presentations, and professional data assessment and verification. Rooms can be defined using a CAD module, absorption coefficients can be assigned to surfaces, and sound sources and listener positions can also be added to the model.

Industry standard for 3D electro-acoustic and room-acoustic modeling

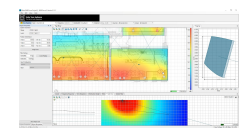
- Standalone software
- File types
 - Import: .dxf, .dwg, .skp
 - Export: .dxf, .skp
- Price
 - EASE Standard: \$2400 USD
 - EASE JR: \$1035 USD
 - Free Trial: 30 days



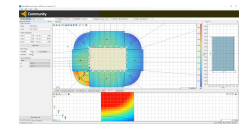
Getting Started Tutorials



[EASE Sound System Modeling Part I](#)



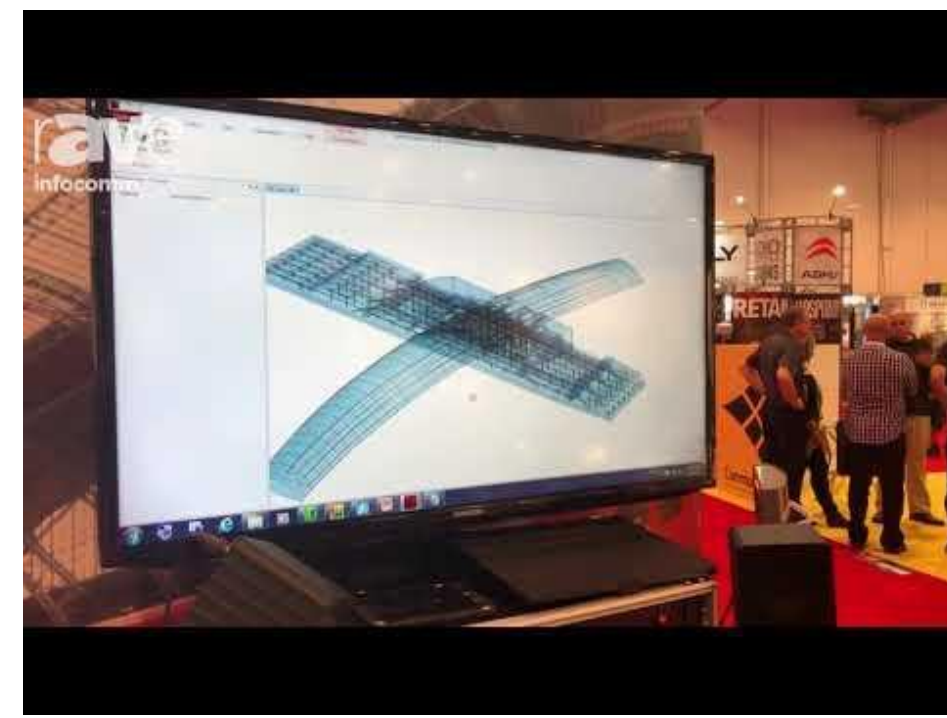
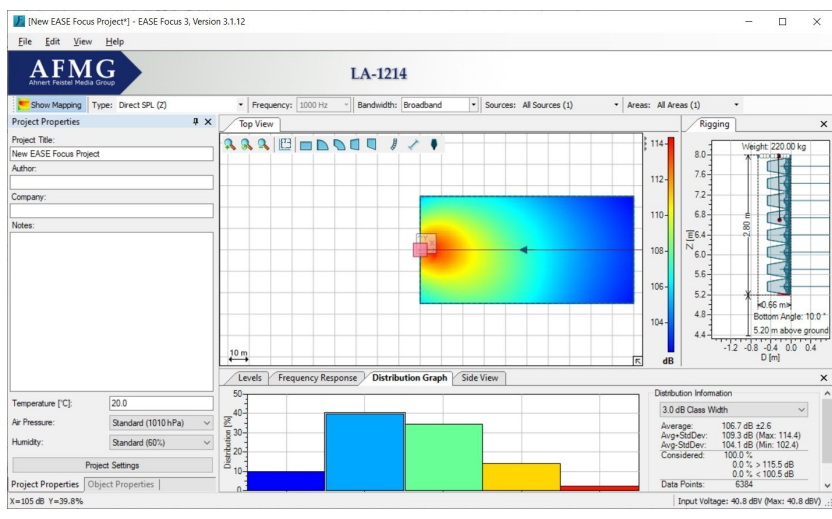
[EASE Sound System Modeling Part II](#)



[EASE Stadium Calculations](#)



[EASE User Manual](#)



ODEON

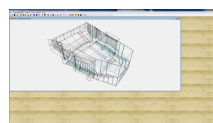


A comprehensive room acoustics software that simulates and measures the interior acoustics of buildings given a 3D model and material properties. ODEON uses the image-source method with a modified ray tracing algorithm to predict, illustrate, and listen to acoustics.

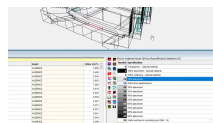
The most comprehensive software for room acoustics

- Standalone software
- File types
 - Import: .dxf, .3ds, .stl, .ifc, .skp
 - Export: .dxf, .cad, .geo
- Price
 - Commercial Price: \$5070 USD
 - Educational Price: \$2530 USD
 - Free demo version available

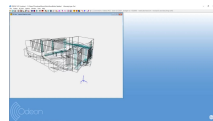
Getting Started Tutorials



[Working with Rooms](#)



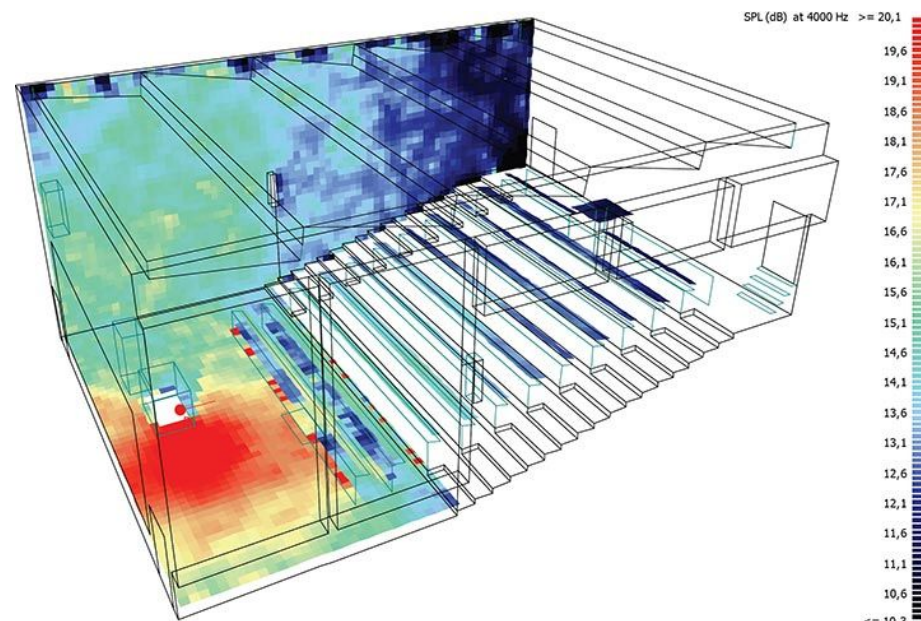
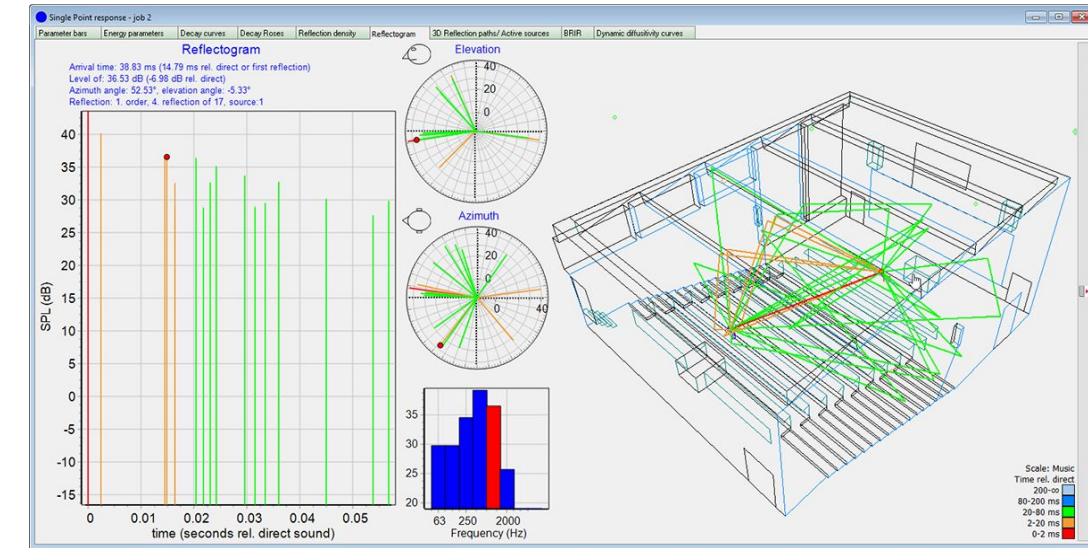
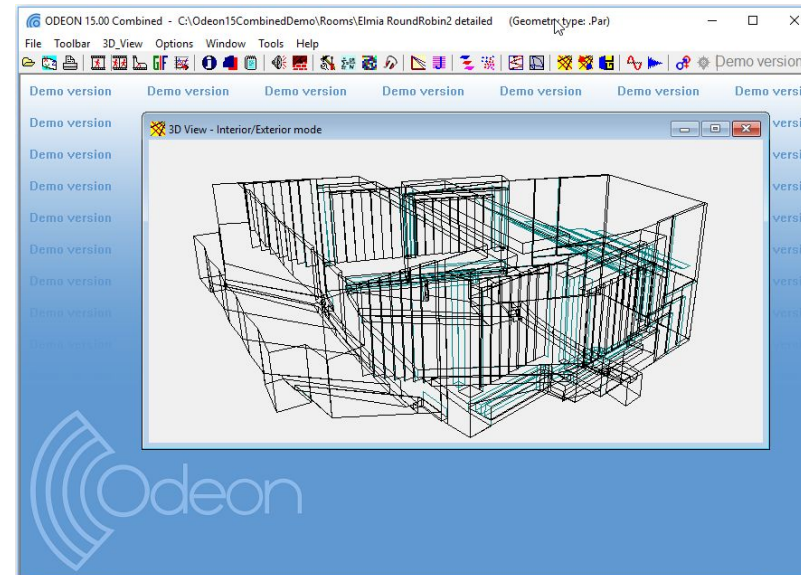
[Setting Acoustic Properties](#)



[Using 3D View](#)

ODEON
BASICS INDUSTRIAL AUDITORIUM COMBINED
User's Manual

[ODEON User Manual](#)



WELCOME TO

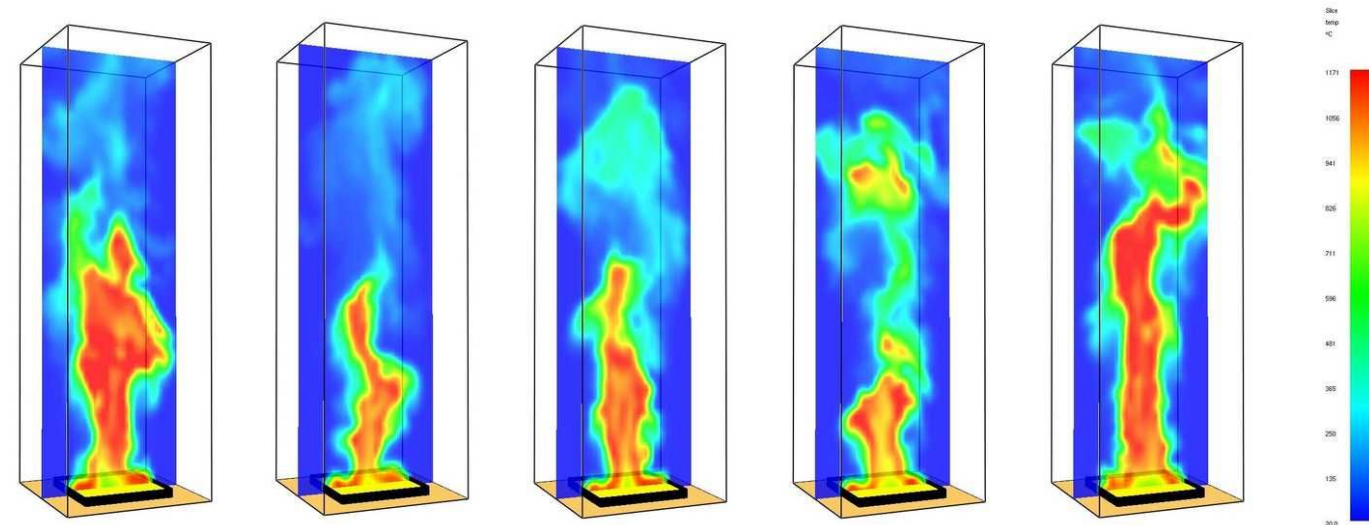
English & Spanish subtitles

CFAST

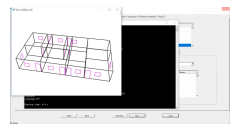
A two-zone fire model that can predict the environment in a multi-compartment structure subjected to a fire. CFAST calculates the time-evolving distribution of smoke and gaseous combustion products as well as the temperature throughout a building during a user-prescribed fire.

Fire Growth and Smoke Transport Modeling

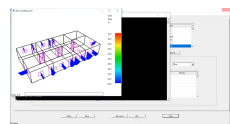
- Standalone software
- File types
 - Import: Parameters defined in CFAST
 - Export: .csv, .txt, .sf
- Price
 - Free (Open-Source)



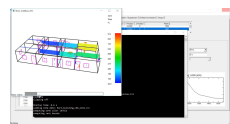
Getting Started Tutorials



[Building Geometry](#)



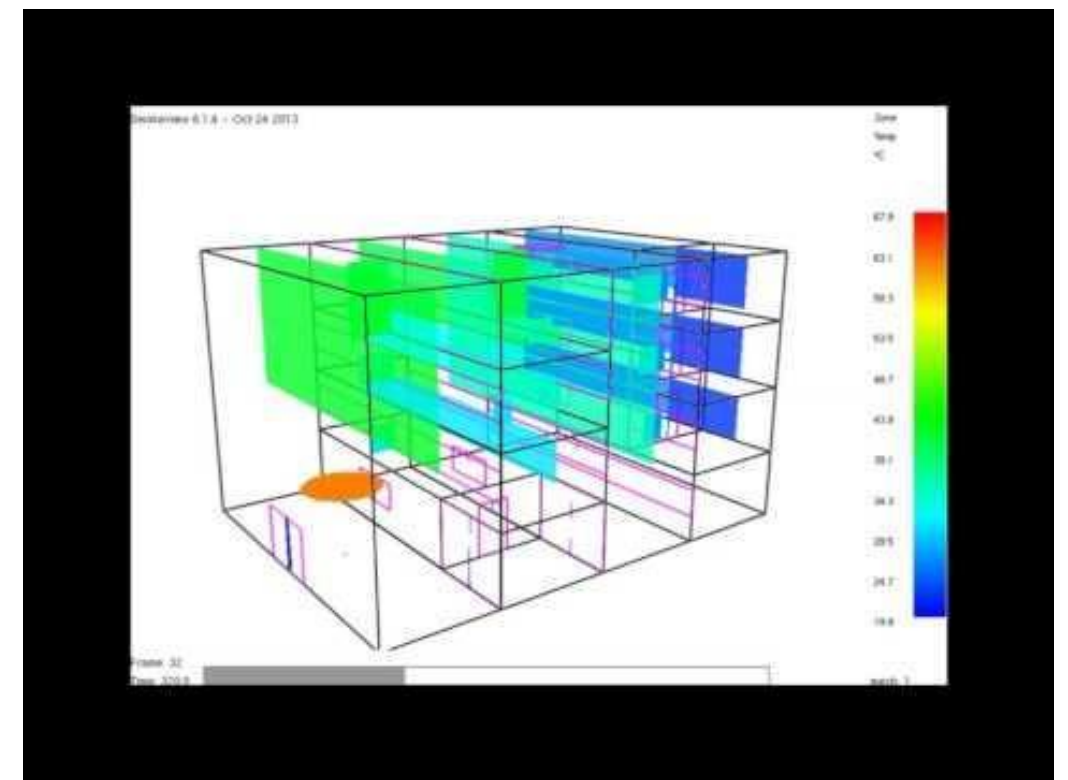
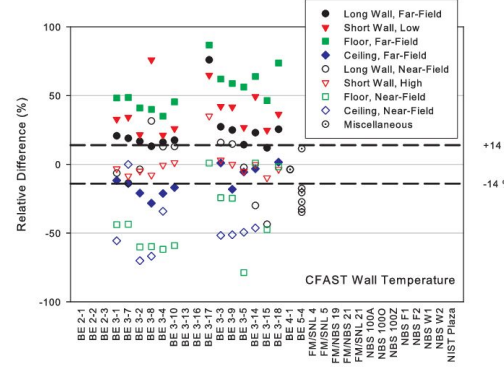
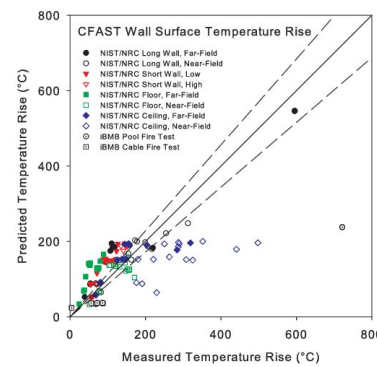
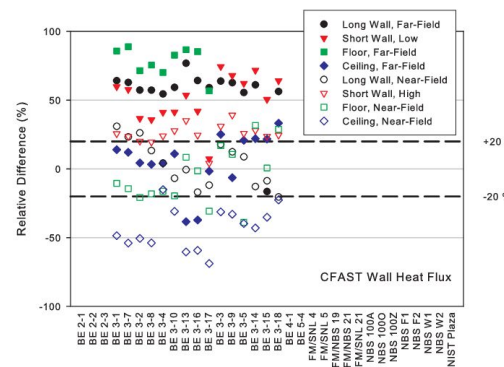
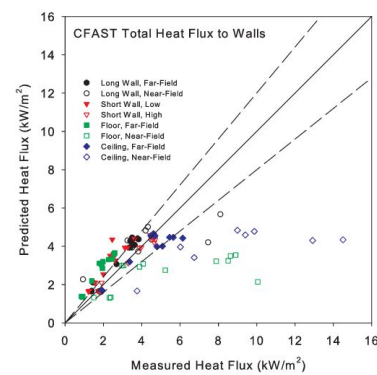
[Vent Modeling](#)



[Inputting Fires](#)

NIST Technical Note 1889v2
CFAST – Consolidated Model of Fire Growth and Smoke Transport (Version 7)
Volume 2: User's Guide

[CFAST User Guide](#)

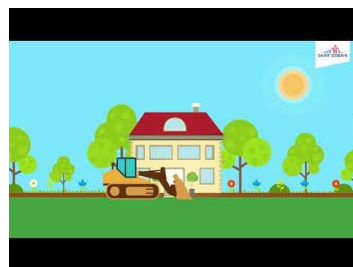


(Click image to see Promotional Video)

Sustainability

Sustainability is the balance between the environment, equity, and the economy. In practice, sustainability supports human, ecological, and economic health and vitality. And quoting the US Green Building Council, “Our vision is that buildings and communities will regenerate and sustain the health and vitality of all life within a generation.”

This section will discuss the various platforms and challenges of how to build green and meet expectation sets by various councils of what building green for the future is. Building green helps with energy efficiency, lower overall costs, and creating healthier places for people and the environment.



Intro Video: Green sustainable and healthy buildings explained

(Click on the image to see video)



Sustainability Rating Systems



BREEAM®



LIVING
BUILDING
CHALLENGE™





Leadership in Energy and Environmental Design (LEED)

LEED is a ranking system developed by the U.S. Green Building Council (USGBC) as a way to determine how sustainable a construction project is. It's goal is to promote healthy, efficient, low carbon, and cost-saving green buildings.

It's the world's most popular rating system, and constantly undergoes revisions— version 1.0 was launched in 2000 and is now on v4.1. Currently, LEED is the one of the most well known and leading certifications for green building.

LEED pushes integrative design processes and communication to ensure the quality and efficient projects. It also offers incentive strategies, such as tax breaks and permission to build an extra floor, to encourage clients to build green.

While new buildings are the most common type of LEED project, major renovations, shell and core projects, neighborhoods, and campuses can all apply for certifications.

Possible certification rankings are Certified (40-49pts), Silver (50-59pts), Gold (60-79pts), and Platinum (80+pts). These are awarded based on credits earned from the following categories:

Location and Transportation - Sustainable Sites - Water Efficiency - Energy and Atmosphere - Materials and Resources - Indoor Environment Quality - Innovation in Design

To get a high score, it's important to know which categories are weighed heavily. As of v4.1, 35% of the potential credits are related to climate change, 20% to human health, 15% to water resources, 10% to biodiversity, 10% to the green economy, 5% to community impact, and 5% to sustainable use of natural resources.



LEED Scorecard		Gold 0/110
INTEGRATIVE PROCESS	0 / 1	
LOCATION AND TRANSPORTATION	0 / 16	
SUSTAINABLE SITES	0 / 10	
WATER EFFICIENCY	0 / 11	
ENERGY & ATMOSPHERE	0 / 33	
MATERIALS & RESOURCES	0 / 13	
INDOOR ENVIRONMENTAL QUALITY	0 / 16	
INNOVATION	0 / 6	
REGIONAL PRIORITY CREDITS	0 / 4	



(Click image to see Promotional Video)

How to get LEED accredited (Green Associate)



How to get your building LEED certified



(Click image to see information)

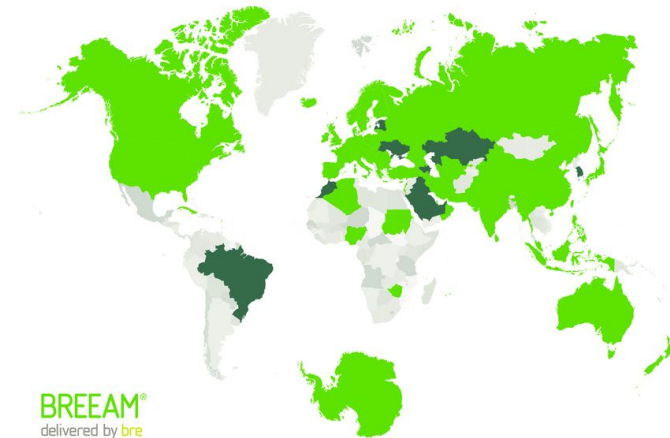
Building Research Establishment Environmental Assessment Method (BREEAM)

Breem is the world's oldest environmental assessment method for buildings. Mainly used in the UK, the method uses a rating systems based on percentages scored from BREEAM consultants. The rating system is organized from pass, good, very good, excellent, and outstanding. The rating system is based on several environmental factors below.

Rating System

Rating is based on the environmental and social factors listed below:

- Energy
- Water
- Health
- Materials
- Waste
- Transport
- Pollution
- Land Use & Ecology
- Management



Assessment score (%)	Assessment rating	Star rating
< 10	Unclassified	-
≥ 10 to < 25	Acceptable	★
≥ 25 to < 40	Pass	★★
≥ 40 to < 55	Good	★★★
≥ 55 to < 70	Very Good	★★★★
≥ 70 to < 85	Excellent	★★★★★
≥ 85	Outstanding	★★★★★★

Environmental section	Weighting
Management	12%
Health & Wellbeing	15%
Energy	19%
Transport	8%
Water	6%
Materials	12.5%
Waste	7.5%
Land Use & Ecology	10%
Pollution	10%
Total	100%
Innovation (additional)	10%

How to Get BREEAM Certification



Information on how to get certification for a building



Information on how to get BREEAM certified yourself

(Click image to see information)



One Angel Square Building - Outstanding

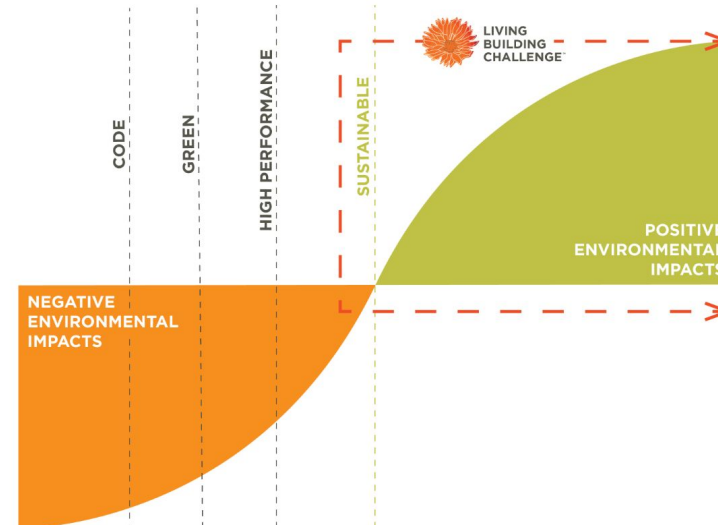


Living Building Challenge

Living Building Challenge (LBC) is an international sustainability certification that can be applied to buildings, infrastructure, landscapes and communities. Highly regarded as the most rigorous standard for green buildings, LBC requires each project to undergo a 12 month documentation process in order to be certified and determine its' sustainability grade.

Relationship between Impact & Effort

There are two main guiding principles of this challenge. One that the building is based on actual performance and needs to be fully operational for 12 months before an audit. The next is all projects must be holistic and address all seven petals of the LBC.



The Living Building Challenge is composed of 20 Imperatives grouped into seven petals. Some Imperatives are not required for all Typologies.

PETAL	IMPERATIVE	TYPOLOGY			
		New Building	Existing Building	Interior	Landscape + Infrastructure
PLACE	01 Ecology of Place	Core	Core	Core	Core
	02 Urban Agriculture	Core	Core	Core	Core
	03 Habitat Exchange	Core	Core	Core	Core
	04 Human Scaled Living	Core	Core	Core	Core
WATER	05 Responsible Water Use	Core	Core	Core	Core
	06 Net Positive Water	Core	Core	Core	Core
ENERGY	07 Energy + Carbon Reduction	Core	Core	Core	Core
	08 Net Positive Energy	Core	Core	Core	Core
HEALTH + HAPPINESS	09 Healthy Interior Environment	Core	Core	Core	Core
	10 Healthy Interior Performance	Core	Core	Core	Core
	11 Access to Nature	Core	Core	Core	Core
MATERIALS	12 Responsible Materials	Core	Core	Core	Core
	13 Red List	Core	Core	Core	Core
	14 Responsible Sourcing	Core	Core	Core	Core
	15 Living Economy Sourcing	Core	Core	Core	Core
	16 Net Positive Waste	Core	Core	Core	Core
EQUITY	17 Universal Access	Core	Core	Core	Core
	18 Inclusion	Core	Core	Core	Core
BEAUTY	19 Beauty + Biophilia	Core	Core	Core	Core
	20 Education + Inspiration	Core	Core	Core	Core

CORE IMPERATIVE
 SCALE JUMPING ALLOWED
 HANDPRINTING IMPERATIVE
 IMPERATIVE REQUIRED FOR TYPOLOGY
 REQUIREMENT DEPENDENT ON SCOPE
 NOT REQUIRED FOR TYPOLOGY

7

- Place
- Water
- Energy
- Health + Happiness
- Materials
- Equity
- Beauty

Petals



[LIVING COMMUNITY CHALLENGE HANDBOOK](#)

[LBC Document Requirements](#)

LBC Certified Buildings

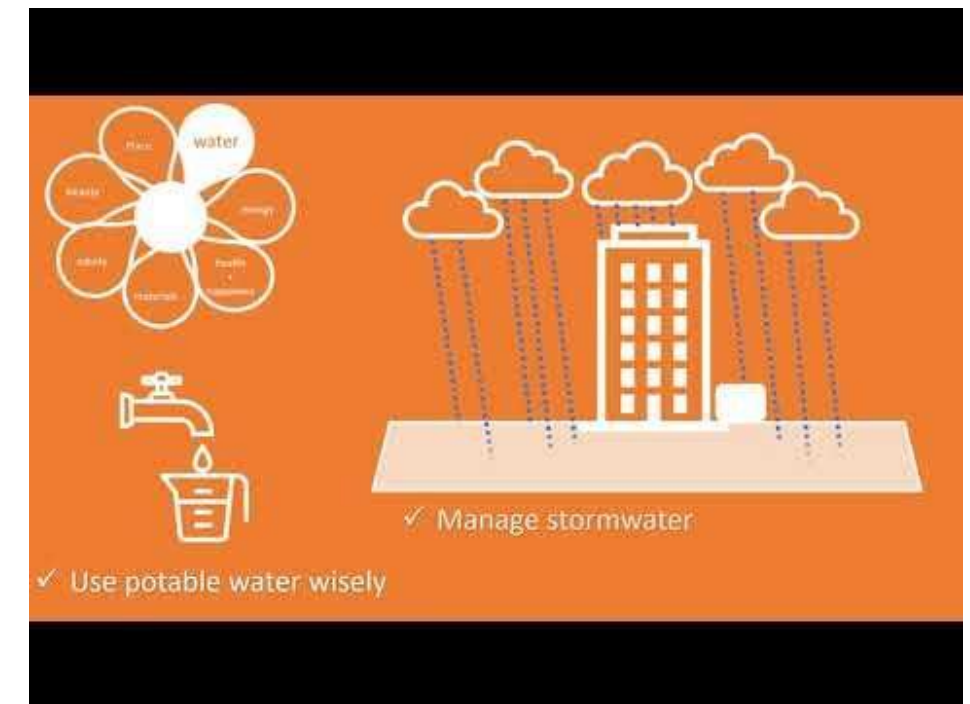


The Kendeda Building for Innovative Sustainable Design



R.W. Kern Center

(Click image to see detailed overview of building)



(Click image to see Promotional Video)

Green Globes



Green Globes is an alternative green building initiative to LEED that focuses on the sustainability, health and wellness, and resilience of new and old construction. Along with LEED, Green Globes is a nationally accredited program that uses a point system to grade a building based on existing criteria.

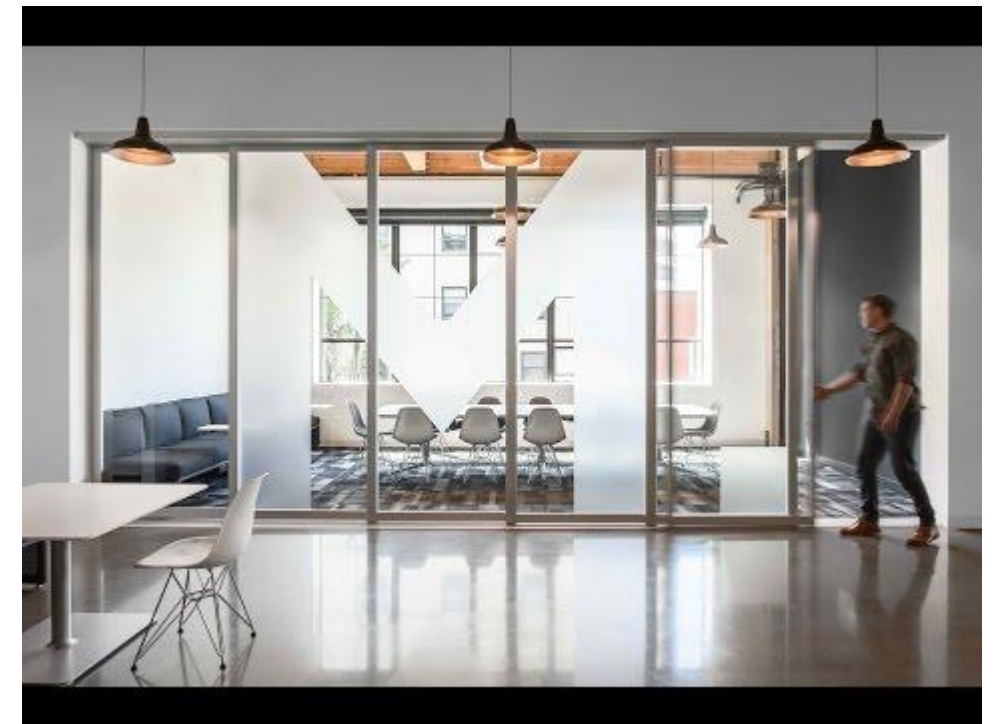
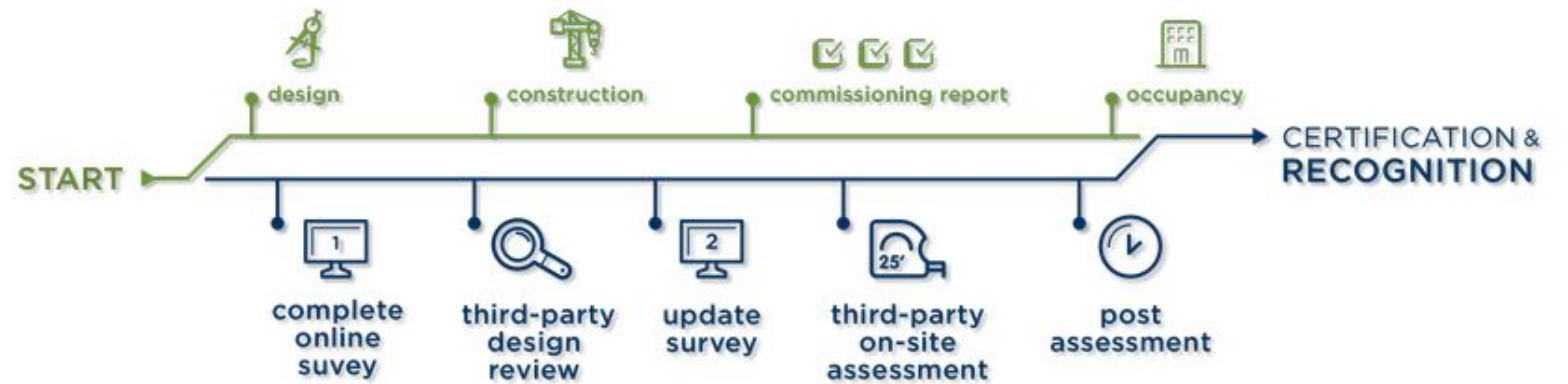
Unlike other green building programs, Green Globes has no prerequisites a building must meet in order to gain more points. Instead they use a 1,000 point scale where each building starts at zero and for any goals they have meet in design or maintenance, the building will gain points.

There are four levels of Green Globe certification from one to four globes. To reach one green globe there is a minimum of 350 points and to reach all four green globes a building must earn at least 850 points in its evaluation.

Prices for the Green Globes certification vary based on building size and what parts of a building are being assessed. Generally, prices range from \$0.001 to \$1 per square foot once for the design analysis and again for a final certification. Overall, this seems less expensive than some alternatives.

RATING AND CERTIFICATION PROCESS

GREEN GLOBES FOR NEW CONSTRUCTION



(Click image to see Case Study Video)



[Click image to learn more about certification](#)



Austin Energy Green Building Program (AEGB)

The AEGB Austin Energy Green Building Program is the first ever US rating system for measuring building sustainability (both new construction and renovation). The 5-star rating system stimulates innovation, and improves Austin and surrounding cities with environmental, economic, and human well-being benefits. As the first rating system, many other sustainability rating systems such as LEED have been inspired by AEGB. Furthermore, many local programs have been based off of AEGB, pushing many US cities to a more sustainable built environment.

19,000 buildings in Austin rated by AEGB

AEGB rates buildings in the public and private sectors, to have an all-encompassing influence, and help Austin achieve its sustainability goals (such as outlined in Vision Zero and Imagine Austin). Their team will even work with engineers, architects, homeowners, business owners, and developers from the early onset of a project, to ensure the building is on a sustainable trajectory. Unlike other rating systems, they're local and assist throughout the project—it saves the client time and money, when AEGB gives them advise and access to the best professionals for their project. AEGB has an extended area for single-family residential projects, so that residents in Greater Austin can also see the benefits of building sustainably. Categories that AEGB rates:

- Energy efficiency
- Water consumption
- HVAC systems
- Soil protection/ecology
- Affordability/equity/education
- Human health/air quality
- Architecture/integrated design
- Carbon footprint/materials/resources

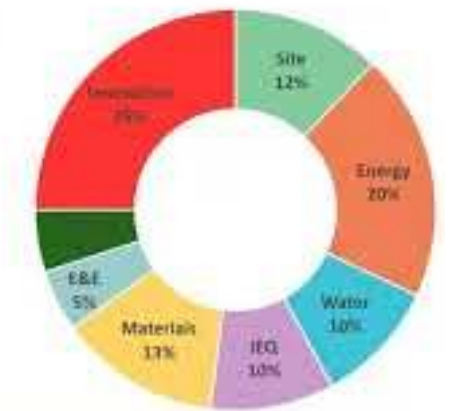
[AEGB Guidebook](#)

AEGB further impacts their community by providing further education, activism for sustainability-related projects, and rebates. As AEGB is part of Austin Energy, they prioritize energy efficiency, and are constantly trying to increase the amount of renewable energy to all Austin buildings—whether AEGB-rated or not



2022 Commercial Rating

Categories	Points
Site	12
Energy	20
Water	10
Indoor Environmental Quality (IEQ)	10
Materials	13
Education & Equity (E&E)	5
Priority	5
Innovation	25
Total	100



(Click image to see Promotional Video)



Customer Driven. Community Focused.
A City of Austin Service

Sustainability Resources & Awards





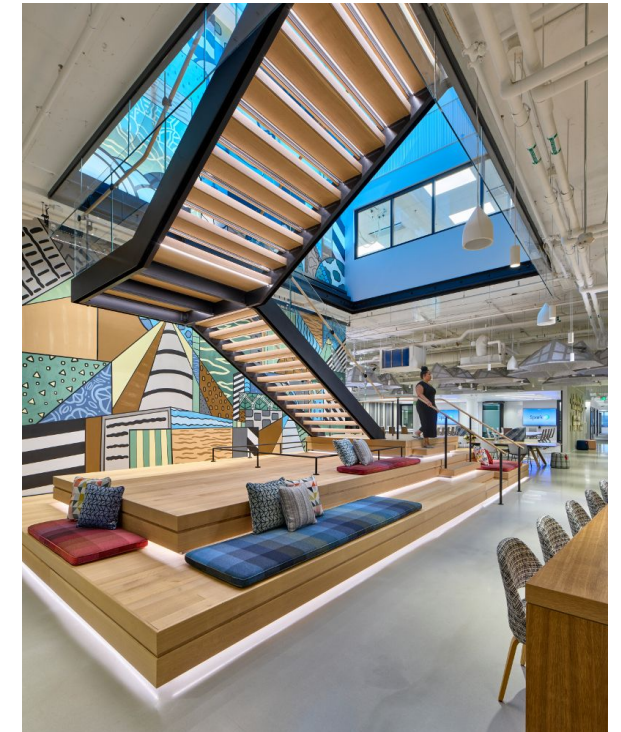
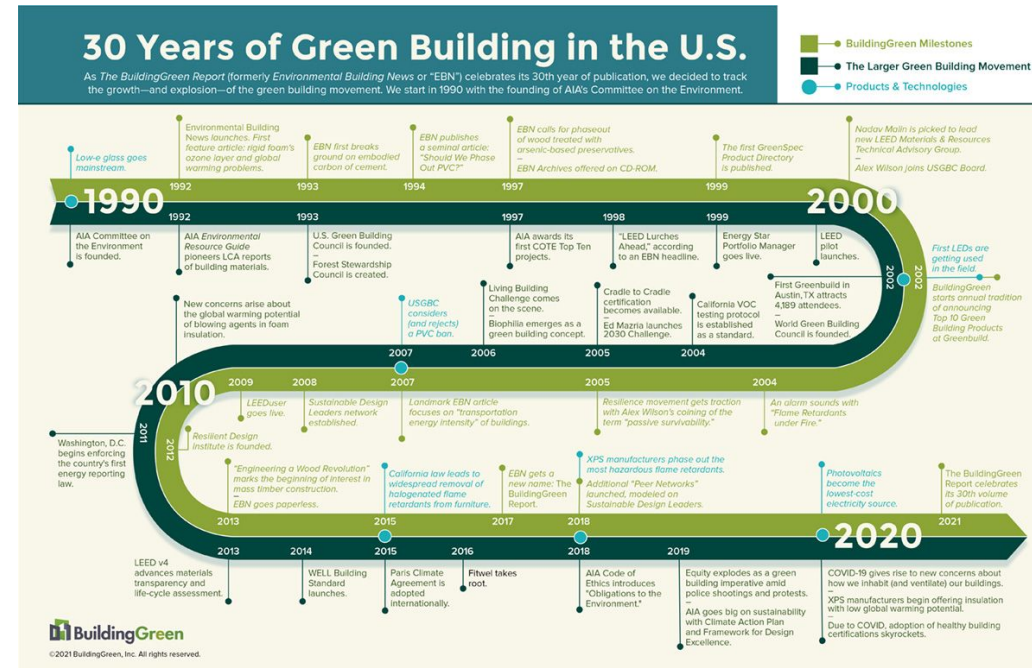
BuildingGreen

BuildingGreen is knowledge base that was started in 1985 with the purpose of making technical information regarding energy efficiency and sustainability more accessible to both building professionals and the public. Even though it is not its own challenge or certification, BuildingGreen makes it easy for people to learn about green building and connect with experts.

BuildingGreen provides information regarding sustainable materials, design strategies, building sciences, building and project types, design processes, and codes and certifications.

Resources offered include webinars, peer networks, project guidance, and exam prep for popular credentials like LEED and WELL. Additionally, BuildingGreen has its own consulting service that covers facilitation, public speaking, product and material screening, training and education, and technical writing.

A BuildingGreen premium membership can be purchased for an individual or a team at varying cost, and is offered free for students through their university.



(Click image to see Promotional Video)

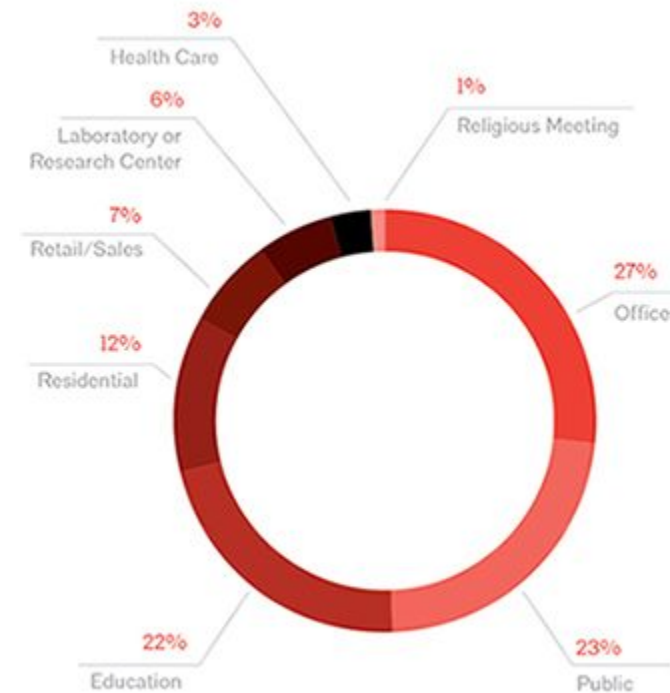


American Institute of Architects Committee on the Environment (AIA COTE)

Mission: As designers of the built environment, our work has tremendous influence on the human experience and the planet. AIA C.O.T.E. works to advance the positive impact of buildings on people and the environment. Members seek to engage in collaborative dialogue between designers, manufacturers, building owners, contractors, government officials, researchers, and educators.

Better Outcomes through Design

Core objectives include: improving health and human experience through design, promoting design practices integrating built and natural systems to enhance both design quality and performance of the built environment, and advocating policies and design practices to improve energy conservation, reduce carbon emissions and facilitate healthy, prosperous local communities.



AIA Framework for Design Excellence



(Click image to see Promotional Video)

AIA's framework for better design revolves around the following:

- Resilience
- Equity
- Health
- Zero Carbon

AIA Resilience and Adaptation Certificate Series

[Certificate Series](#)

Architect's Guide to Building Performance

[AIA Guidebook](#)

SE 2050 Challenge



The SE 2050 Challenge is a commitment to transform the practice of structural engineering that is holistic, firm-wide, projects based, and data-driven. The goal of the challenge is to reduce embodied carbon of structural materials by educating firms to use less or different materials. The challenge aims to have net zero embodied carbon for structural systems by 2050. For firms to register for the challenge is described below.

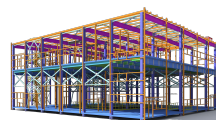
Joining the SE 2050 Challenge

Joining the SE 2050 challenge feature 3 requirements:

1. Upon Joining: Commitment letter from leadership firm
2. Within six months and annually: Embodied Carbon Action Plan (ECAP)
3. Within one year and annually: Submit data to SE 2050 project database.

The 2050 challenge is essentially a non-zero game between the firm and the challenge. The firm gets consulted by the challenge on how to built smart structure systems to reduce used structural materials while the challenge receives data on embodied carbon for different structural systems and materials.

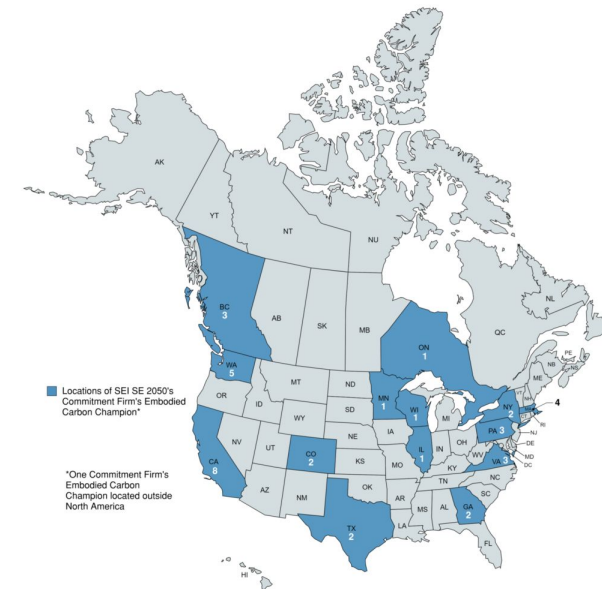
SE 2050 Challenge Firm Sign Up



How to sign up your firm for the SE 2050 Challenge



(Click image to see information)



ARUP

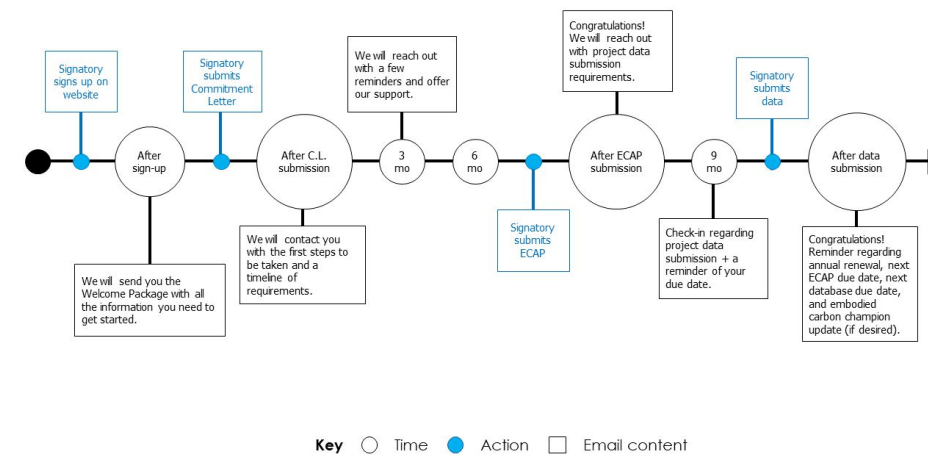


LeMessurier

SIMPSON
GUMPERTZ
& HEGER

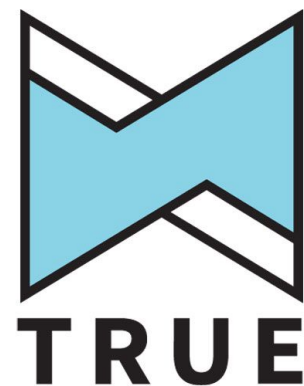


Program Mechanics Timeline: Signatory Tasks and SE2050 Communication



(Click image to see Promotional Video)

Sustainability Wellness





International WELL Building Institute (WELL)

The WELL Building Standard is a way for designers and organizations to create more thoughtful and intentional spaces that enhance the well-being of the inhabitants. WELL focuses on evidence based standards that can be verified and implemented into building design and function.

Concepts and Principles

The original version of WELL focused on 10 concepts that all hold preconditions that must be met before optimizations can be counted in scoring. The concept of WELL are: air, water, nourishment, light movement, thermal comfort, sound, materials, mind, and community.

In WELL v2, the main concepts of a WELL building stayed standing but the program further focuses on a set of principles. These principles include being equitable, global, evidence-based, technically robust, customer focused, and resilient.

The enrollment fee for WELL is \$4,200. However, there are multiple ways to lower that cost such as being a small business, registering multiple locations, or becoming a member of the WELL community.

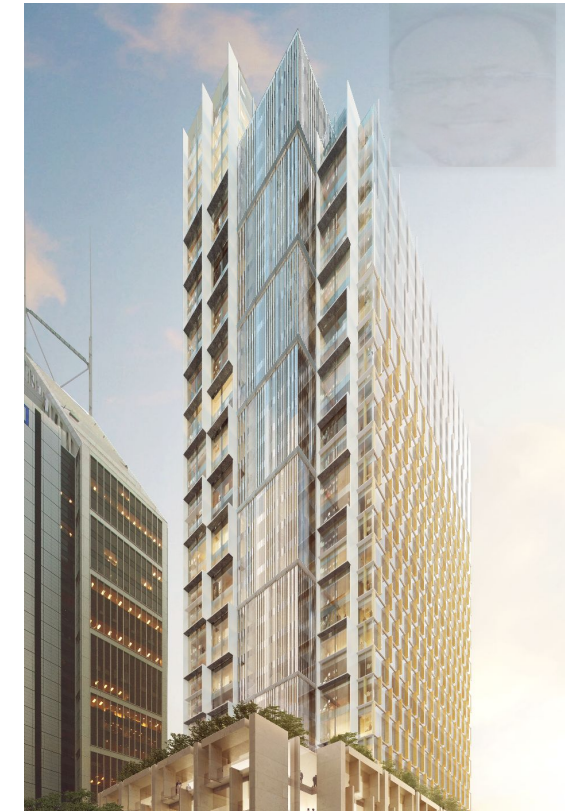
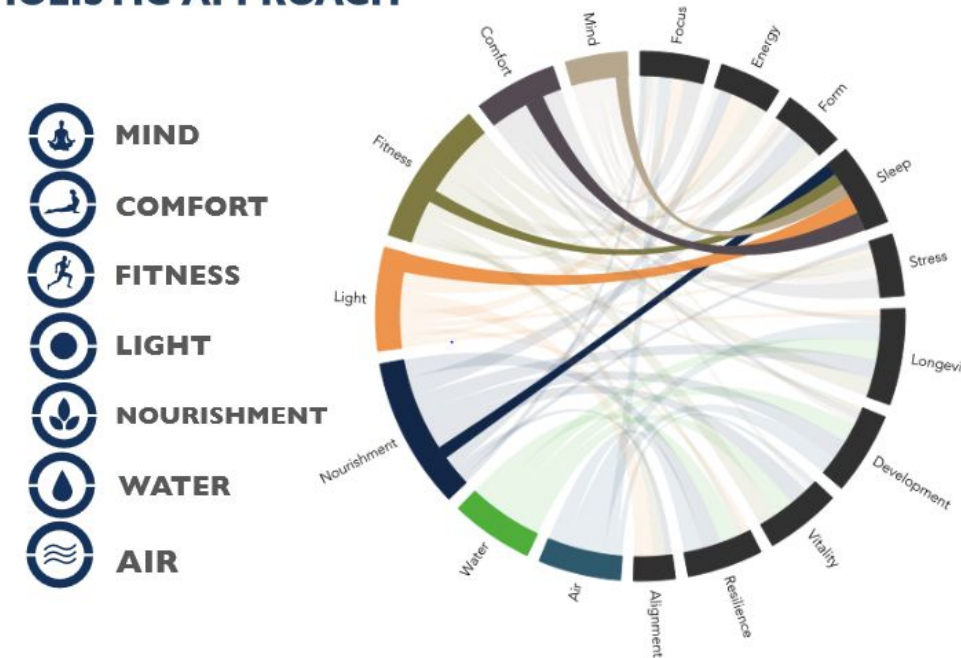


How to get WELL Accredited (WELL AP)

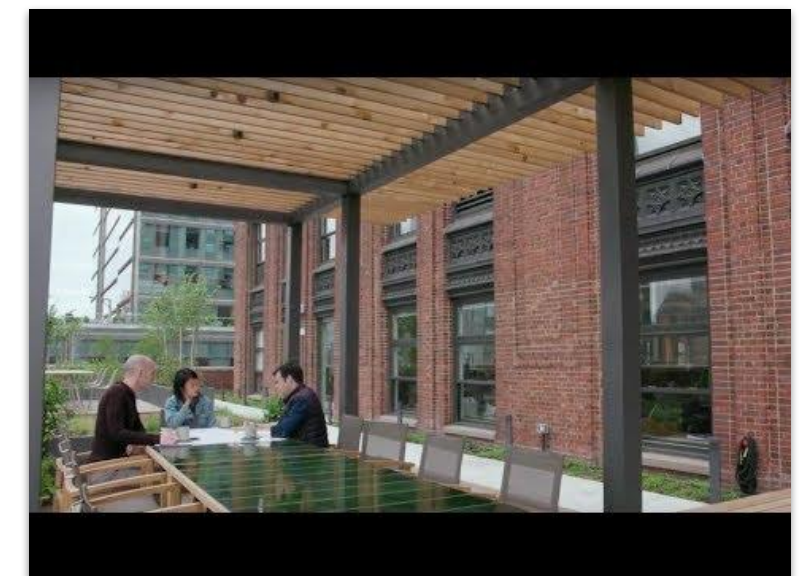


How to get your building WELL certified

HOLISTIC APPROACH



(Click image to see Promotional Video)



(Click image to see information)

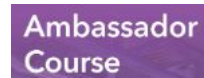
Fitwel

Fitwel is a ranking system dedicated to designing buildings that encourage the health of its occupants through measures backed by academic research studies and evaluations, and emphasizes health being an interconnected system. It was created by the U.S. Centers for Disease Control and Prevention (CDC) with the U.S. General Services Administration.

Fitwel uses a scorecard system to award rankings of one, two, and three star certifications. There are seven health categories a building can score points in:

- Impacts surrounding community health
- Reduces morbidity and absenteeism
- Supports social equity for vulnerable populations
- Instills feelings of well-being
- Enhances access to healthy foods
- Promotes occupant safety
- Increases physical activity

Both new and existing buildings can apply for a Fitwel certification. The process to get Fitwel certified takes about 16 weeks, and requires a flat price of \$500 with a fee dependent on the property's square footage starting at \$5500. Reduced costs and review times are available to Fitwel "Champions," or members.

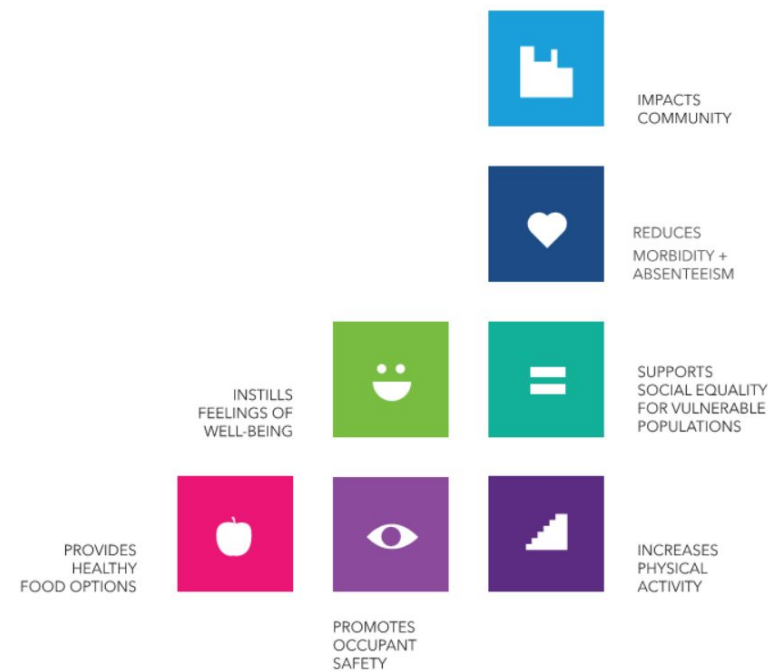


How to become a Fitwel Ambassador



How to get your building Fitwel certified

(Click image to see information)



(Click image to see Promotional Video)

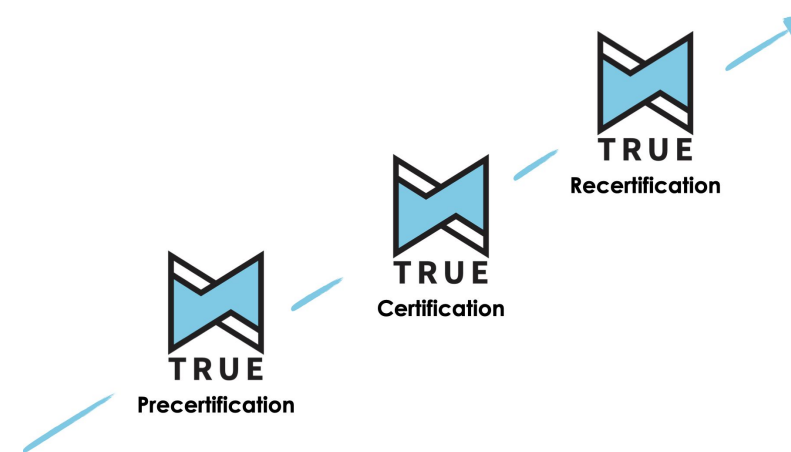


TRUE Certification

TRUE is a certification-based program under the USGBC. Their primary goal is to divert solid waste away from the environment and landfills, in order to become more environmentally responsible and resource efficient. Working to accomplish this goal will also aid in cutting greenhouse gases, reducing pollution, and reinvesting resources locally.

Becoming TRUE Certified


The process to achieving a TRUE certification involves first becoming precertified, then certified, and finally recertified. Each process comes with its own set of requirements, but a few of the primary ones are listed below.




- Company/project has zero waste policy implemented
- Project has achieved 90% waste diversion
- Project doesn't exceed 10% contamination level for lost materials
- Company submits case study of zero waste initiatives

Certification rating is then determined by a point system, shown to the right.

Certification Steps

 Detailed guide to certification

 Analysis of rating system

(Click image to see information)

Certification Levels

Certified: 31-37 points Silver: 38-45 points Gold: 46-63 points Platinum: 64-81 points

Overview of Categories & Points

Redesign	4	Leadership	6
Reduce	7	Training	8
Reuse	7	Zero Waste Analysis	5
Compost (Re-earth)	7	Upstream Management	4
Recycle	3	Hazardous Waste Prevention	5
Zero Waste Reporting	4	Closed Loop System	4
Diversion (Min 90%)	5	Innovation	3
Zero Waste Purchasing	9	Total Points	81



EcoDistricts

EcoDistricts was founded in 2009 in response to the rapidly growing population and movement into cities. Cities are currently undergoing the largest growth seen in the past 100 years, and are consequently contributing to a rapid increase in global greenhouse gas emissions and energy consumption. EcoDistricts has developed a certification based method to help create more sustainable neighborhoods and cities.

Creating an EcoDistrict

EcoDistricts has set up a process that encompasses their goals and planned methods of implementation, stated below.



3 Goals:

- Equity
- Resilience
- Climate Protection

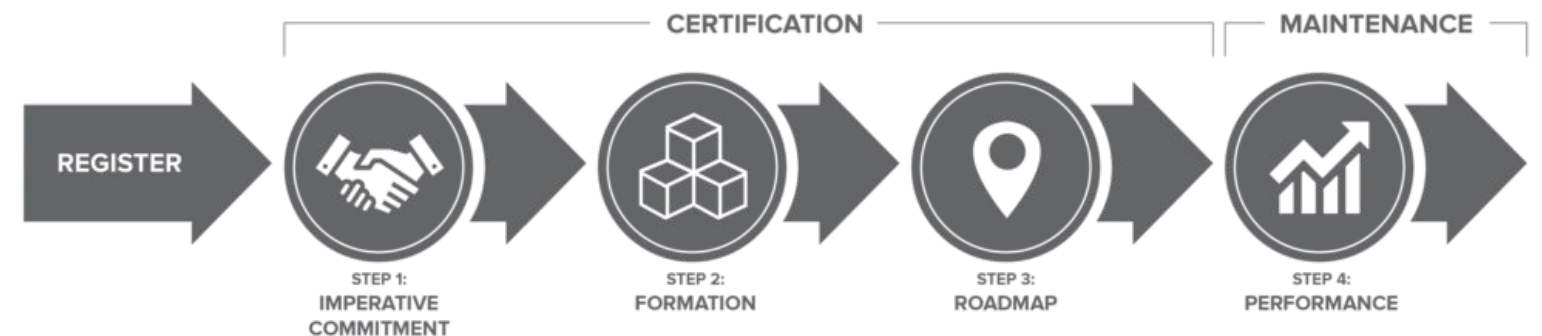
6 Priorities:

- Place
- Prosperity
- Health and Wellbeing
- Connectivity
- Living Infrastructure
- Resource Restoration

3 Implementation Methods:

- Formation
- Roadmap
- Performance

All of the information related to creating and maintaining these sustainable districts is compiled in the EcoDistrict Protocol, which has over 3000 downloads in over 700 cities.



How to become EcoDistrict certified

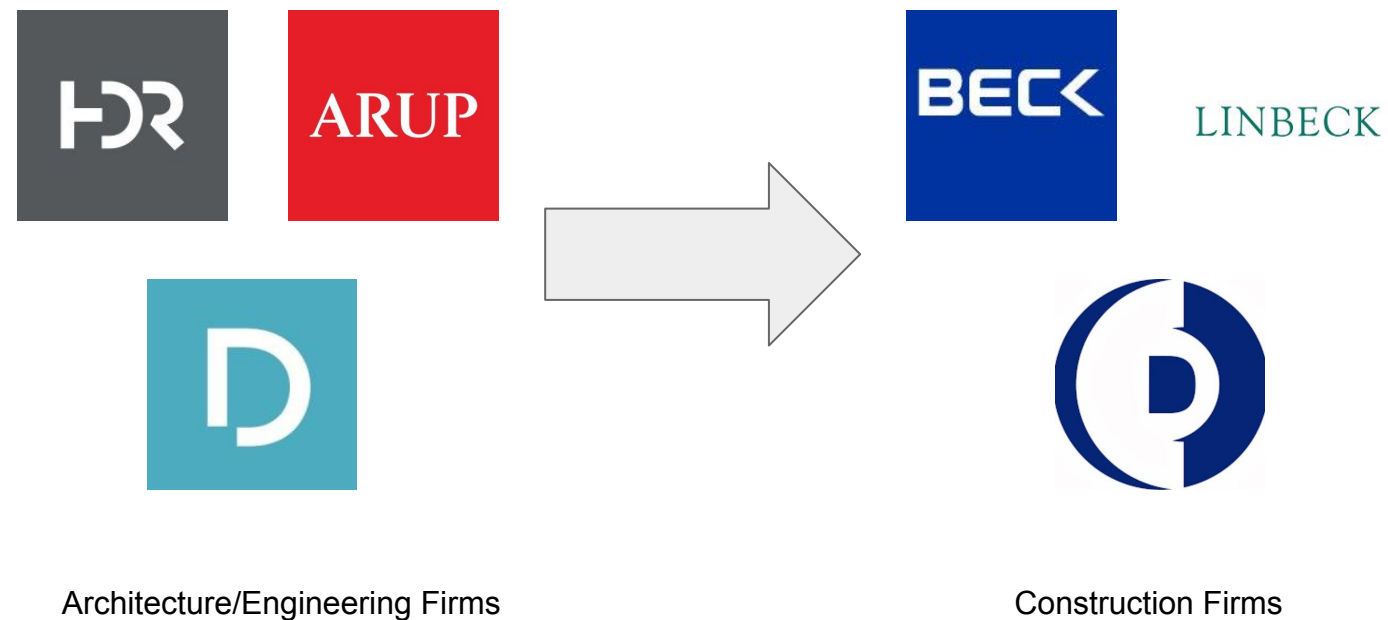


[Link to download certification handbook](#)

(Click image to see information)



Construction Modeling



“BIM means building twice; first on the computer and then in the field.”

- Turner Construction

Workflow

An architecture/engineering firm creates the initial BIM models and resulting 2D construction drawings.

From these drawings, construction firms build their own BIM model to price labor and materials, check for any system clashes, and study various construction schedules.

Recent advances in digital fabrication allow for components to be CNC-cut directly from a 3D model, and small buildings can be 3D printed.

Estimating

Construction modeling allows companies to estimate the final cost of a construction project.

Some costs in construction estimating include:

- Equipment
- Labor
- Materials
- Permit/Inspection Fees
- Professional Fees

Planning

Planning models are visualize a set of procedures that lay out what specific activities needed to be completed in order to complete the project.

There are softwares that allow project managers envision the end product and add comments or revisions and from then on, create work packages.

Clash Detection

Clash detection consists of creating a comprehensive model that includes design models made independently by various engineering and design disciplines such as MEP engineers, architects, and structural engineers.

The primary purpose of clash detection in BIM is to identify clashes, which are specific places where the models may overlap and create compatibility problems. Clash detection software enables these problems to be solved at the design stage rather than in the construction phase.

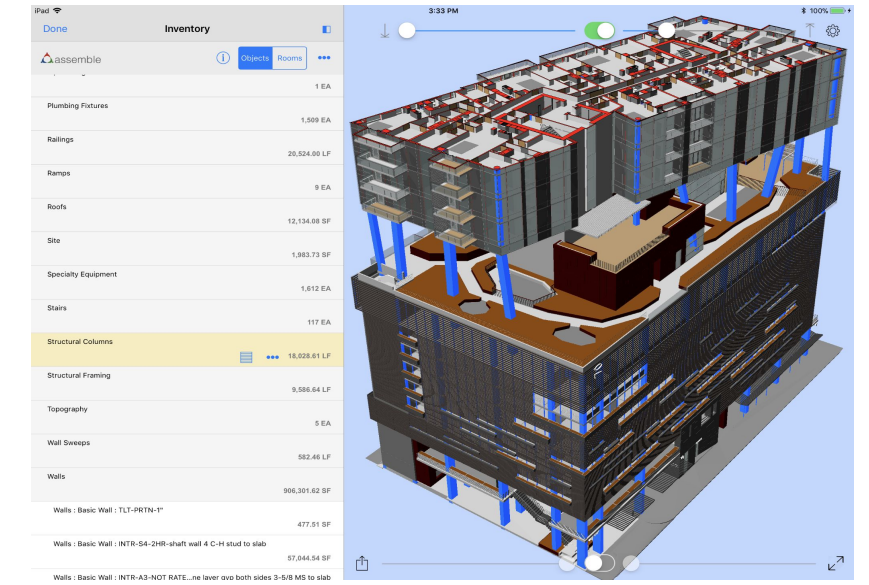
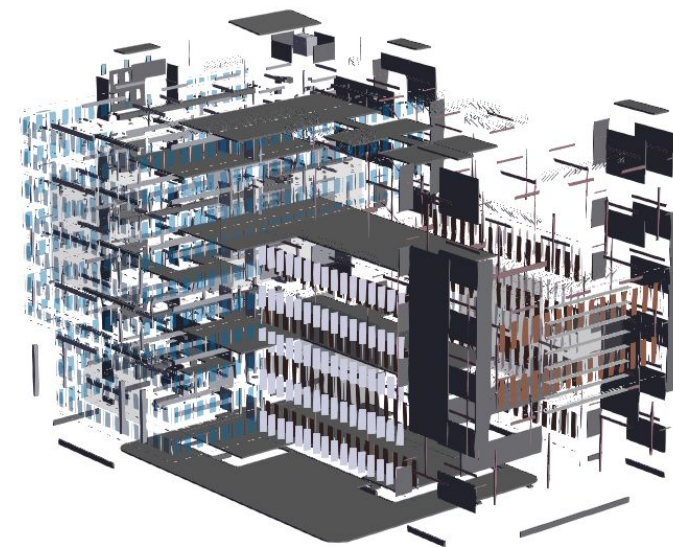


Autodesk Assemble

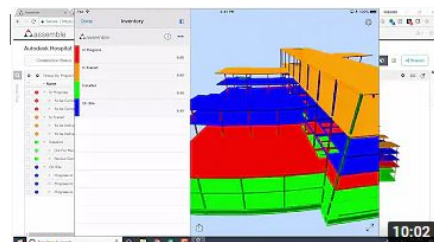
Assemble is an Autodesk company and stand alone cloud based software that allows BIM data management to be made easy with model conditioning, model-based takeoff and change management, work-in-place tracking, and being able to integrate BIM data from design to construction. All of these tools help contractors manage costs, minimize risk, and improve project efficiency.

Obtains material quantities from design model

- Compatible with Autodesk Revit
- Estimates cost based on the local prices
- Used in over 160 countries by companies such as AECOM and Turner Construction
- 3 week free trial and demo available

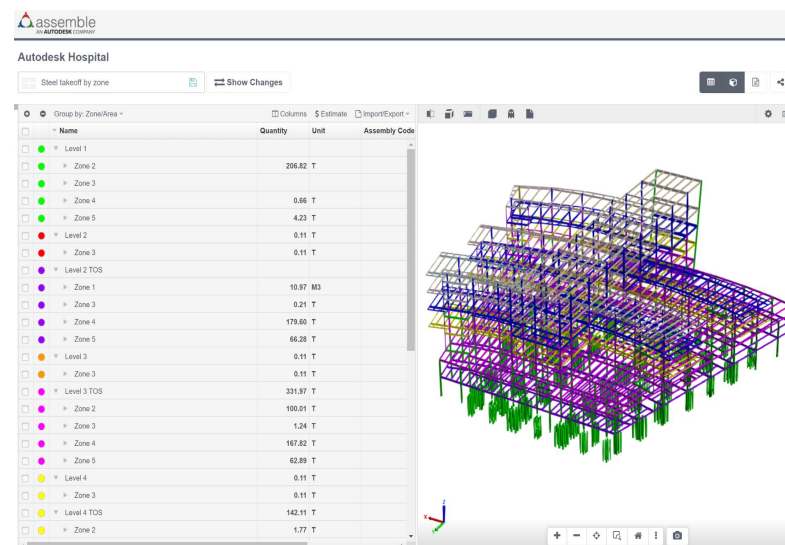


Tutorials



Tutorial 1: Using Assemble to Mobile Track in the Field

(Click image to see tutorial)



(Click image to see Promotional Video)

RSMMeans

RSMMeans data is a database of current construction cost estimates. RSMMeans data is used by construction professionals to create budgets, estimate projects, validate their own cost data and plan for ongoing facilities maintenance. Localized, accurate and complete, RSMMeans data is the construction industry standard.

National Standard for Construction Cost Estimates

Allows you to create an accurate square foot estimate in a matter of minutes.

RSMMeans has predictive cost data in order to budget confidently for projects that take place years in the future.

The database contains more than 92,000 line items. Cost engineers spend more than 30,000 hours researching and validating the costs every year.

Tutorials



Tutorial 1: Getting Started with RS Means Data

(Click image to see tutorial)

COMMERCIAL/INDUSTRIAL/ INSTITUTIONAL **M.340** **Hospital, 4-8 Story**

Costs per square foot of floor area

	S.F. Area	100000	125000	150000	175000	200000	225000	250000	275000	300000
Exterior Wall	L.F. Perimeter	594	705	816	783	866	950	1033	1116	1200
Fiber Cement	Rigid Steel	282.50	280.25	278.65	274.75	273.80	273.10	272.55	272.00	271.60
Curtain Wall	Rigid Steel	301.60	298.50	296.40	289.95	288.55	287.55	286.75	286.00	285.50
Metal Panel	Rigid Steel	286.10	283.80	282.20	278.25	277.25	276.50	275.95	275.45	275.05
Brick Veneer	Reinforced Concrete	302.50	299.55	297.50	291.40	290.10	289.10	288.30	287.65	287.15
Stone Veneer	Reinforced Concrete	314.50	310.95	308.50	300.45	298.85	297.70	296.70	295.85	295.25
E.I.F.S.	Reinforced Concrete	295.45	292.80	291.05	286.05	285.00	284.10	283.40	282.85	282.40
Perimeter Adj., Add or Deduct	Per 100 L.F.	3.25	2.60	2.20	1.90	1.60	1.50	1.25	1.20	1.05
Story Hgt. Adj., Add or Deduct	Per 1 Ft.	1.10	1.05	1.05	0.90	0.85	0.85	0.75	0.80	0.75

For Basement, add \$39.80 per square foot of basement area

The above costs were calculated using the basic specifications shown on the facing page. These costs should be adjusted where necessary for design alternatives and owner's requirements.

RSMMeans data from GORDIAN

Search Data | Manage Estimates | Square Foot Estimator | Life Cycle Cost | Cost Alerts and Trends | Reference Items

Cost Data: Commercial New Construction | Type: Unit | Labor Type: Open Shop | Location: FAIRFAX (220-221)

Search: What are you searching for? | All | Search | Include My Custom

MasterFormat 2018 | 262913.10 Contactors, AC

Line Number	Description
262913100010	CONTACTORS, AC Enclosed (NEMA 1)
262913100050	Lighting, 600 volt 3 pole, electrically held
262913100100	20 amp
262913100200	30 amp
262913100300	60 amp
262913100400	100 amp
262913100500	200 amp
262913100600	300 amp
262913100800	600 volt 3 pole, mechanically held, 30 amp
262913100900	60 amp
262913101000	75 amp
262913101100	100 amp
262913101200	150 amp
262913101300	200 amp

RSMMeans data from GORDIAN®

RSMMeans data from GORDIAN

Search Data | Manage Estimates | Square Foot Estimator | Life Cycle Cost | Cost Alerts and Trends | Reference Items | My Favorites

Creating quick conceptual estimates is easy with RSMMeans Online's powerful Square Foot Estimator. With more than 100 commercial and residential models available, you can develop cost estimates and reports in minutes for virtually any location in the U.S. and Canada.

Square Foot Estimator

Calculate Building Cost | Quick View | Save Estimate | Custom/View Report | Clear All

Model: Apartment, 1-3 Story with Brick Veneer / Reinforced Concrete

Default Building Image

\$3,653,176.48 Building Cost | FAIRFAX, VA Location

\$162.36 Cost per S.F. | 22,500 Floor Area

Estimate Header Information

Building Category: Commercial New Construction | Labor Type: Open Shop | Baseline Quarter: Year 2020 Quarter 1

* Estimate Name: | Client Name: | * Folder: Current Estimates

State/Province: | City: | Zip/Postal Code:

Predictive Data

Predictive Quarter: None



(Click image to see Promotional Video)



MS Project

MS project is a project management software product used in the construction industry for project planning. It is designed to assist a project manager in developing a schedule, assigning resources to tasks, tracking progress, managing the budget, and analyzing workloads.

Scheduling Software for Project Managers

Gantt Chart: A type of bar chart that illustrates a project schedule and shows the dependency relationships between activities and the current schedule status

Schedules from MS Project can be imported to softwares like Navisworks and Procore to create construction simulations models.

Pricing

- Project Plan 1: \$10/month
- Project Plan 2: \$30/month
- Project Plan 3: \$55/month

Tutorials

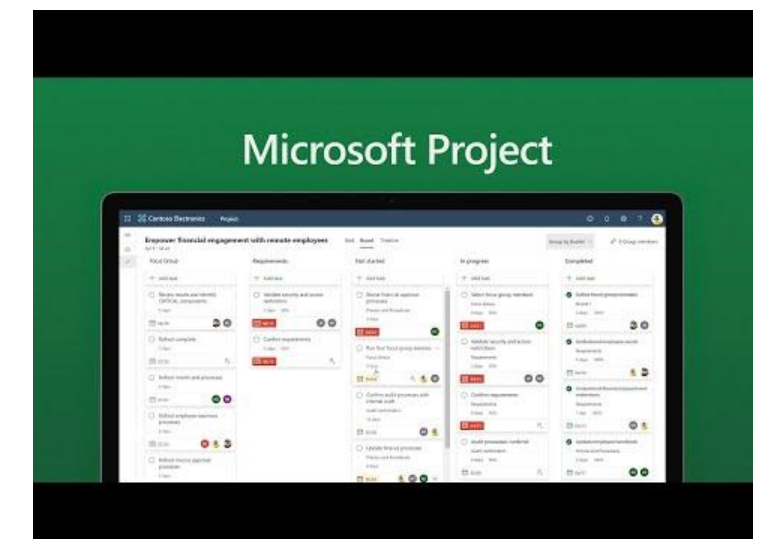
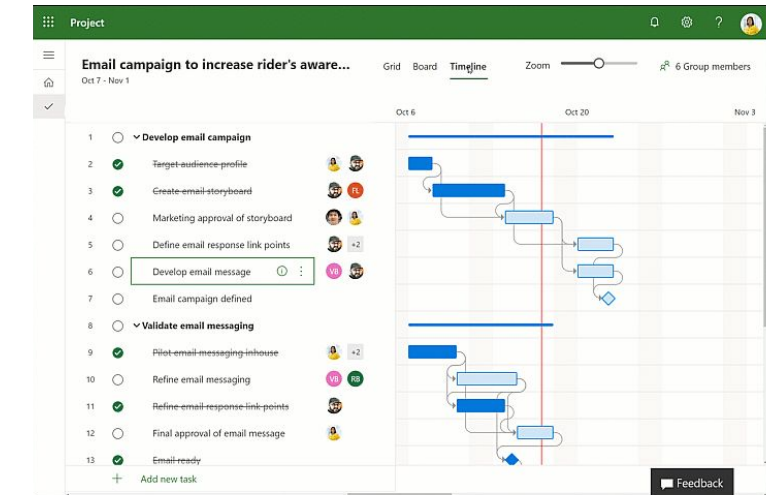
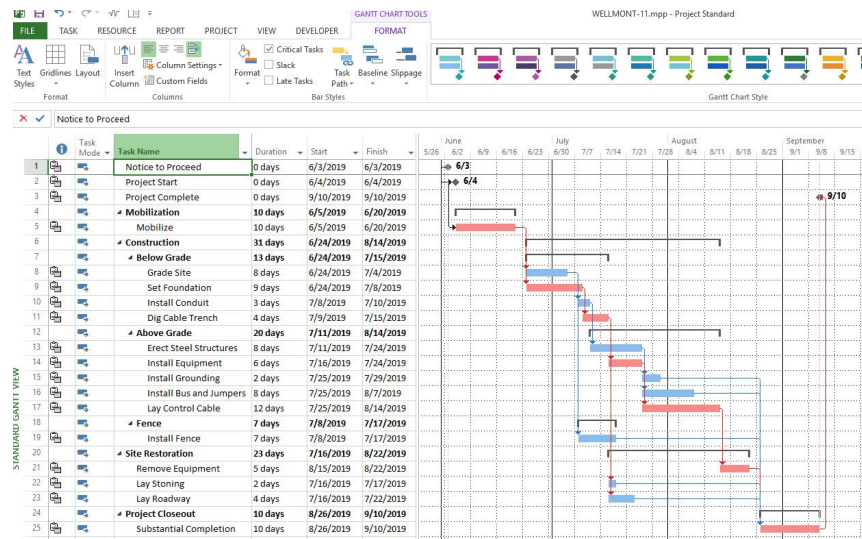
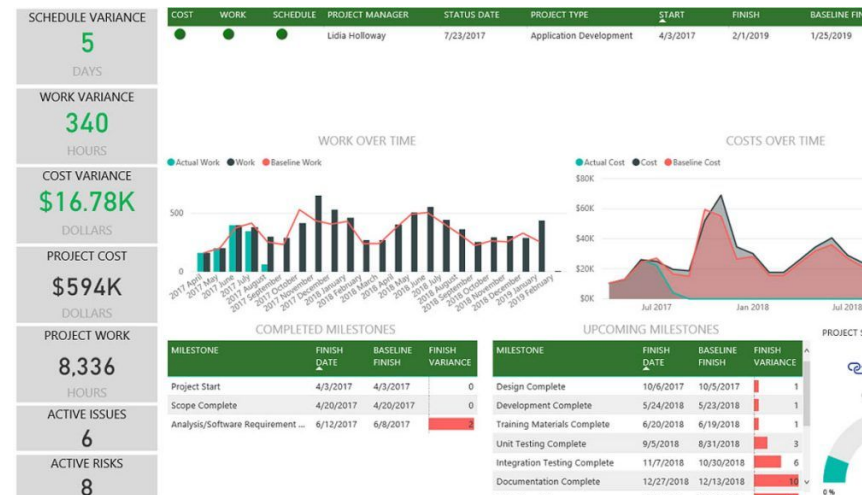


Tutorial 1: Project Beginner Tutorial



Tutorial 2: How to Create a Project Schedule in MS Project

(Click image to see tutorial)



(Click image to see Promotional Video)



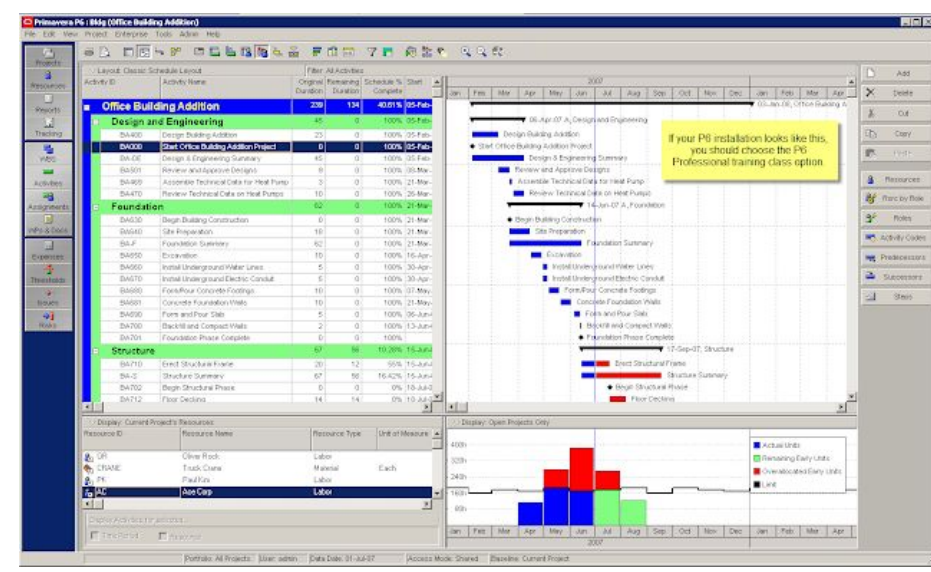
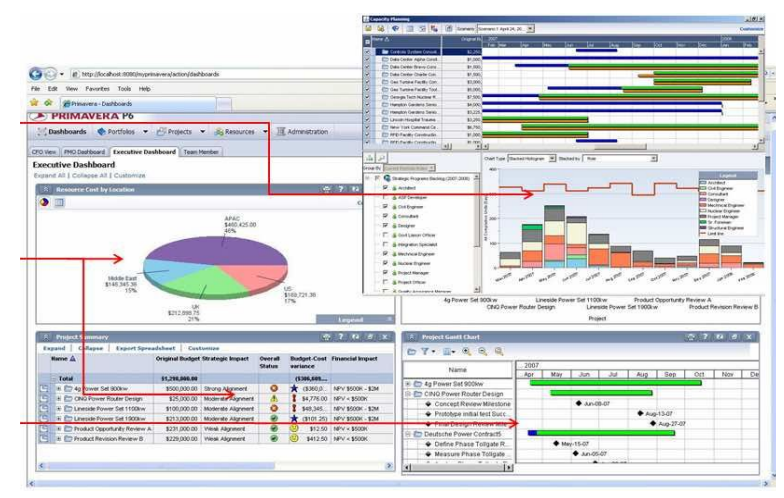
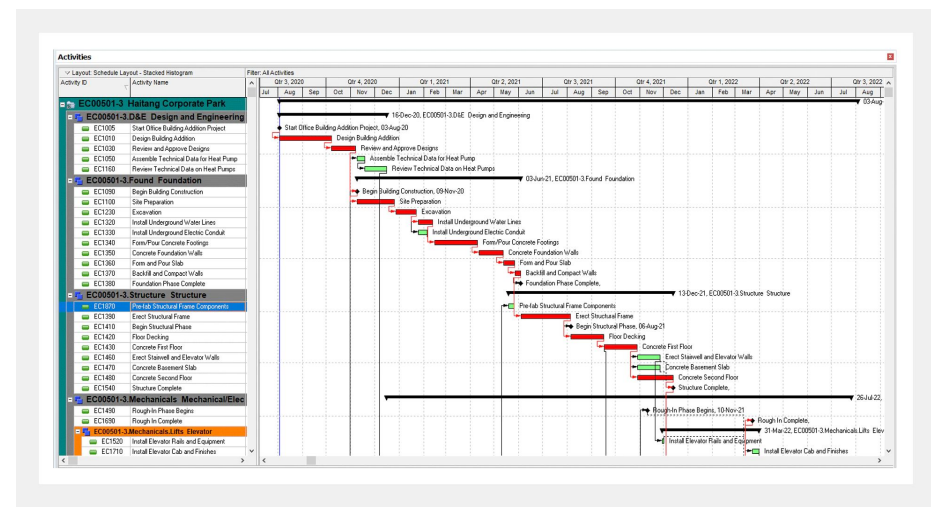
Primavera P6

Oracle's Primavera P6 Enterprise Project Portfolio Management (Primavera P6 EPPM) is a powerful and easy-to-use solution for prioritizing, planning, managing and evaluating projects, programs, and portfolios. Oracle's Primavera P6 EPPM is a cloud-based, software-as-a-service solution backed by a global network of Oracle Project Portfolio Management professionals and the assured security, scalability, performance, and support from one of the world's largest cloud vendors.

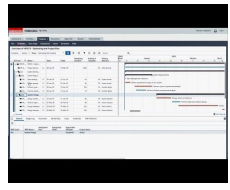
Solution for prioritizing, planning, managing and evaluating projects, programs, and portfolios.

Primavera P6 EPPM is an integrated project portfolio management (PPM) application that includes role-based functionality to match each team member's needs and responsibilities. Primavera P6 EPPM can easily scale from a single user on a small project to tens of thousands of users engaged in millions of activities across hundreds of projects both on premise and in the cloud. The solution is built on a robust architecture and is designed to deliver high performance with tight security, flexible integration and real time reporting and analytics.

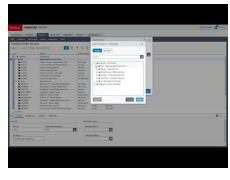
Purchase for \$4,200



Tutorials



Tutorial 1: Overview and Navigation Tutorial



Tutorial 2: Creating a New Project

(Click image to see tutorial)

(Click image to see Promotional Video)

Student Author: Aron Mishkin

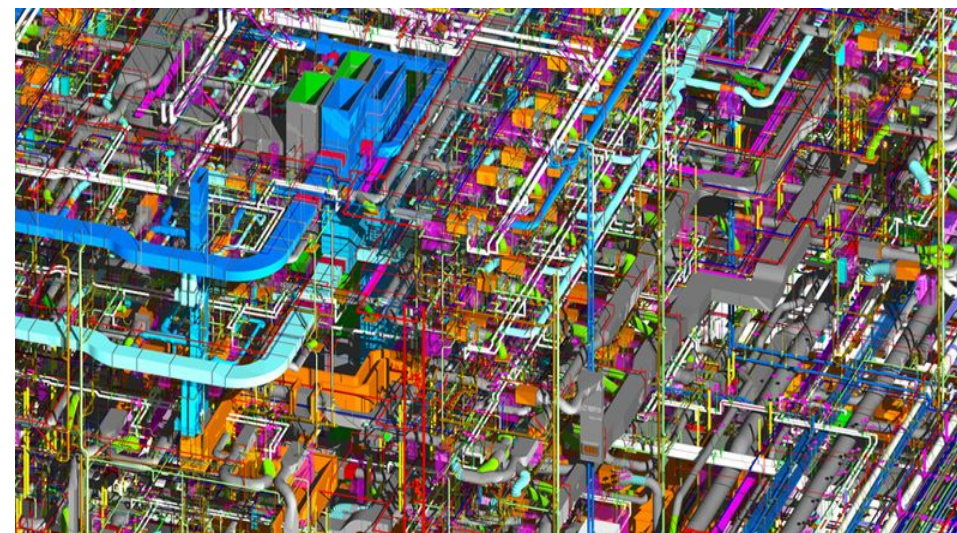
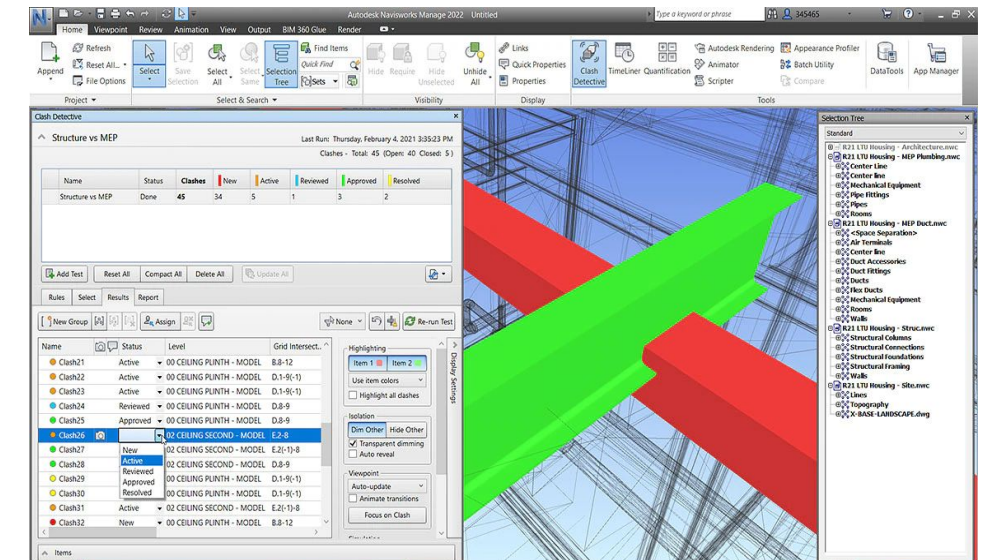
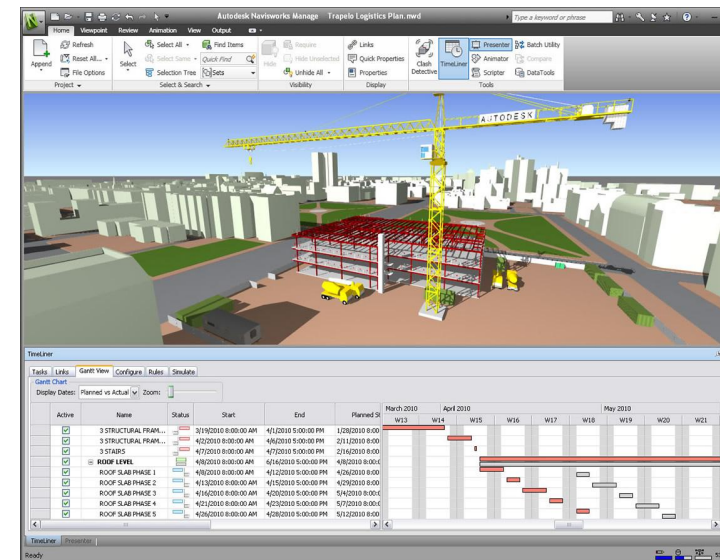


Navisworks

Navisworks is stand alone planning software/3D review package from Autodesk. Firms use this software to complement 3D design packages. You can review and coordinate your software to improve BIM projects and deliver by being able to navigate through the models in real time and getting to use tools such as comments, redlining, viewpoint, etc. Navisworks also allows you to control schedules and costs using 4D and 5D simulation, easily capture material quantities from 2D or 3D designs, as well as run projects along with other Autodesk project delivery tools.

Clash Detection Software

- Designed by Autodesk, communicates with Revit, Rhino, AutoCAD, Microstation, etc
- Used to access, review and animate 3D models
- Plug-ins allow for interference detection, 4D time simulation, rendering, etc
- Deep component-by-component analysis
- Allows for relatively quick pricing and construction scheduling
- Great for communicating with clients or other team members on a project
- For students, Navisworks is available with free trial. For professional use, Navisworks Simulate is available for \$2905 every 3 years and Navisworks Manage is available for \$7180 every 3 years, which are the best value deals.



Tutorials



Tutorial 1: Getting Started with NavisWorks

(Click image to see tutorial)

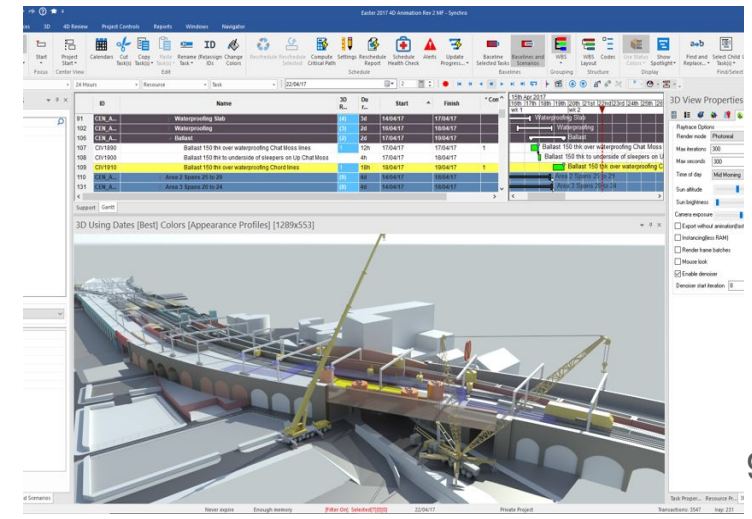
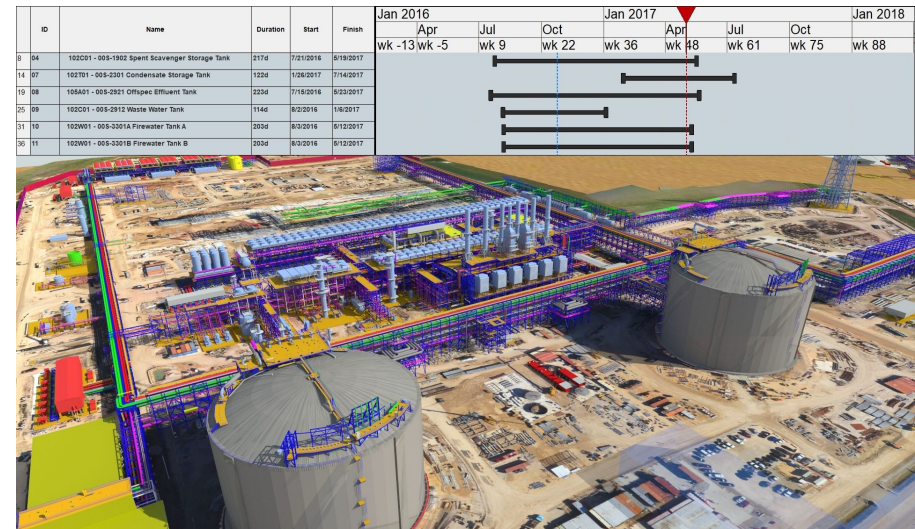


Synchro

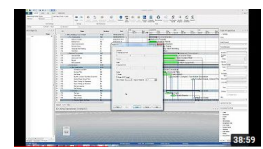
SYNCHRO 4D is an application designed for construction modeling, planning and scheduling, visualization, simulation, and project controls. 4D scheduling combines a 3D model and a project schedule. You can directly link activity bars on a Gantt chart to corresponding elements of a 3D model using SYNCHRO 4D. You can create graphic representations to understand time-based processes, foresee conflicts, and study potential solutions.

Construct, plan, and track projects based on a model

- Users can easily communicate and present the construction plan and schedule, allowing for trade partner collaboration and commitment with confidence, on-time execution and delivery, and quicker approval for payment
- Synchro 4D works as a stand alone application but it interoperates with all major 3D modeling and scheduling tools in the market. This tool works best for Project Planners, Engineers, and Estimators.
- 12-month subscription license: \$4,000



Tutorials

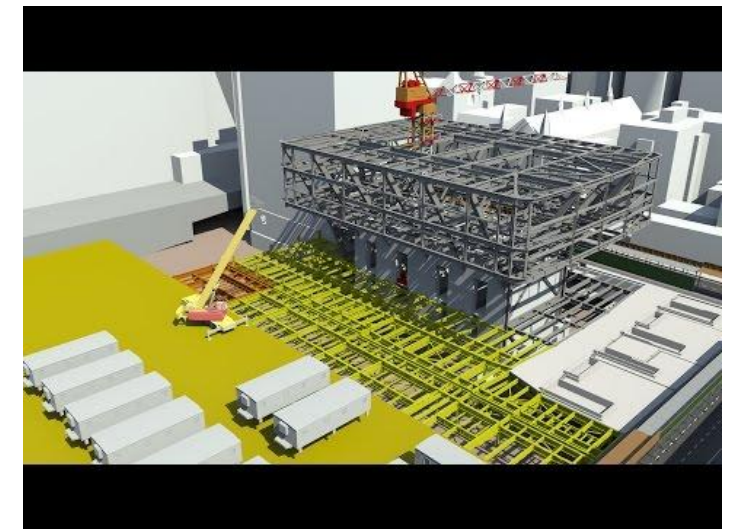
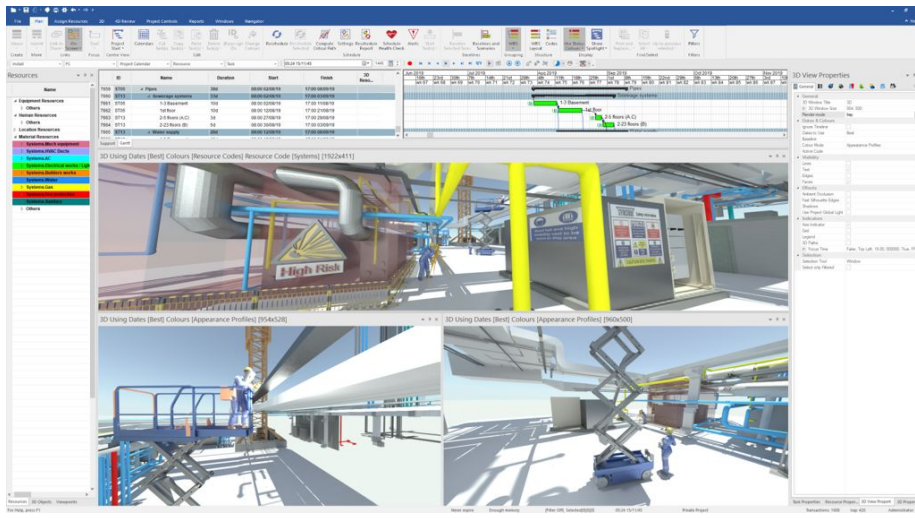


Tutorial 1: Synchro 4D Introductory Tutorial



Tutorial 2: Basic 4D Navigation

(Click image to see tutorial)



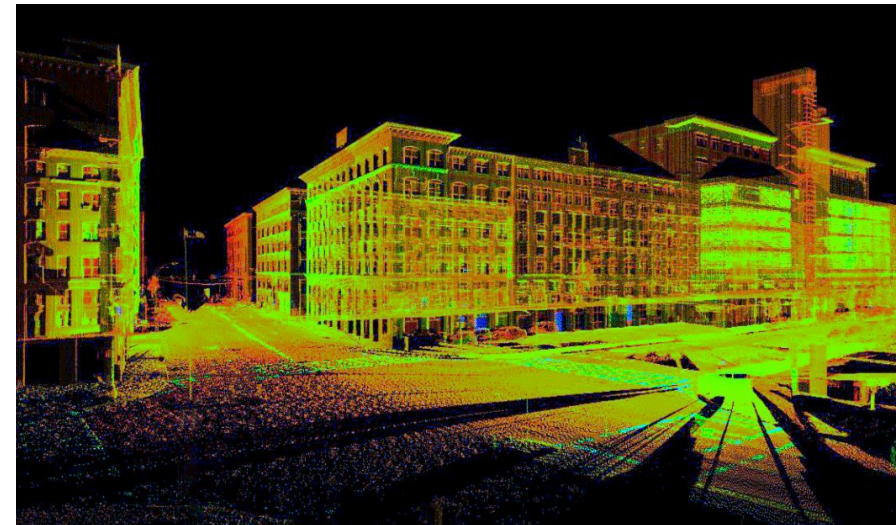
(Click image to see Promotional Video)

On-Site Analysis - Reality Capture

It has become more common for firms to utilize 3D laser scanners, drones, and augmented reality applications to more accurately and efficiently collect data from and analyze a construction site. Lasers provide large sums of data that can be quickly expressed in a BIM model. On the other hand, drones provide a more general look at a site, but at angles that would not be feasible otherwise.

Collect accurate and usable data efficiently

- Using 3D laser scanning, engineers are able to get a very accurate “point cloud” representing the area scanned. These clouds are taken throughout the building, and then combined and brought into Revit or Navisworks to create an accurate model of a site.
- Drones can be used to get quick aerial views of a construction site. These drones can be mounted with a wide range of cameras to gather various sets of information relevant to the construction process.
- Laser scanning systems can cost up to 50 - 150k. A new drone would cost around 1,500 - 6k



94

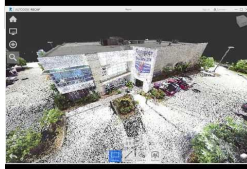


(Click image to see Promotional Video)

Videos



Video 1: Drone Flyover Example



Video 2: Laser Scanning into Revit

(Click image to see tutorial)

Acknowledgements

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- and -

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