BIM + Sustainability: Case Study on IES VE Building Performance Simulation

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May 2008

Submitted towards the fulfillment of the requirements for the D.Arch Degree

School of Architecture
University of Hawai'i @ Manoa

D.Arch Project Committee
Fred Creager, Chairperson
Tony Cao
Yoshi Honda

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We certify that we have read this Doctorate Project and that, in our opinion, it is satisfactory in scope and quality as a Doctorate Project for the degree of Doctor of Architecture in the School of Architecture, University of Hawai'i at Manoa.

Doctorate Project Committee

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Fred Creager, Chairperson

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Abstract

The D.Arch project I have chosen is a case study of the IES (Integrated Environmental Solutions Virtual Environment) Software. The objective of this case study is to challenge the software's modules capabilities i.e. Radiance, Suncast, and Apache SIM, in conjunction with the Revit MEP (Mechanical, Electrical, and Plumbing) Modeling software. Revit MEP is a building information modeling software developed by Autodesk. The other component to the D.Arch Project is an entry into an Architecture Student competition called Leading Edge 2007/2008.

Leading Edge Student Competition 2007/2008 is sponsored by UCSB (University of California Santa Barbara). I chose this competition because building performance analysis is a requirement. I will select a base-case building that has satisfactory energy efficiency standards. I will then compare my design to the base case model. I will quantify the comparable results and identify the correlations between design changes and building performance.

I will also do a comparative analysis between IES VE and Green Building Studio. Green Building Studio is a free online service-based company. This analysis results will reveal the true value of the latest attempts to curb climate change via technology. Although this part of my D.Arch Project is not a requirement of the competition, I believe that any new data in the comparison between building simulation software's is valuable to the AEC (Architecture, Engineering, and Construction) community.

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Background/Field of Study

Building Information Modeling and Building Performance Simulation are two fairly new niches being developed in the AEC industry. Still in their infancy relative to other disciplines in the AEC industry, BIM and Simulation tools are becoming more common place in the workplace and classrooms. Sustainability is another topic that many are quick to jump on the proverbial “Bandwagon” but none the less a worth cause. It is important to point out that BIM has not received that same welcome and success as the “Sustainability Movement”. It is obvious that global changes in climate, politics, and resources management will ultimately impact the earth that we live on.

I will first discuss the main concepts and history of building simulation, building information modeling, and sustainability. Then, I will introduce the IES and Revit software’s union. Lastly I will give an explanation of the 2007/2008 Leading Edge Competition.

Building Simulation

History and Concepts

The total spectrum of "building simulation" is very wide as it spans energy and mass flow, structural durability, aging, egress and even construction site simulation. This area of building performance simulation has its foundation in early studies of energy and mass flow processes in the built environment. Meanwhile, the role of simulation tools in the design and engineering of buildings has been firmly established. The early groundwork was done in the 1960s and 1970s, mainly in the energy performance field followed by an expansion into other fields such as lighting, Heating Ventilation and Air-Conditioning (HVAC), air flow, and others.[1]

In the mid-'70s 2nd generation programs began to emerge. These stressed the chronological aspect of the problem, particularly with respect to long time constant elements such as multilayered constructions. The underlying calculation methods remained analytical and slow: time or frequency domain response factors were used to model the dynamic response of constructional elements, while HVAC system modeling was confined to the steady state.

With the advent of more powerful personal computing, 3rd generation programs began to emerged as a practical prospect in the mid-'80s. These assume that only the space and time dimensions are independent variables; all other system parameters are dependent so that no single energy transfer process can be solved in isolation. This signaled the beginning of integrated modeling whereby the thermal, visual and acoustic aspects of performance are considered together.[2]

In the mid-'90's, domain integration work continued apace with the addition of program interoperability and the response to the growing uptake by practitioners, new developments commenced concerned with knowledge-based user interfaces, application quality control and user training. More recent additions relate to combined moisture and heat transfer, acoustics, control systems, and various combinations with urban and micro climate simulations. As tools got better, their proliferation into the consultant's offices across the world accelerated. A new set of challenges presents itself for the next decade. They relate to achieving an increased level of quality control and attaining broad integration of simulation expertise and tools in all stages of the building process. The use of design tools has up till now remained to a "*tool-box*" by which the designer must recognize a particular task,

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[1]Godfried Augenbroe, and Ali M. Malkawi, *Advanced Building Simulation* (New York: Spon Press, 2003).

[2]J A Clarke, *Energy Simulation in Building Design* (Oxford: Heinemann, Butterworth, 2001).

locate a suitable program, apply it and translate its outputs to appropriate modifications to the design. This is a poor model in that the tools are isolated from the process and require the designer to translate between data models. A computer-supported design environment (CSDE) evolves the design hypothesis in such a way that the computer applications are able to automatically access the data describing the design and give feedback on all aspects of performance and cost in terms meaningful to the designer. The attainment of such a CSDE is a not difficult task requiring the development of a computational model of the design process in which the role of each participant, human and otherwise, is clearly defined. Fig 1 shows the tool-box approach and CSDE approach towards simulation.

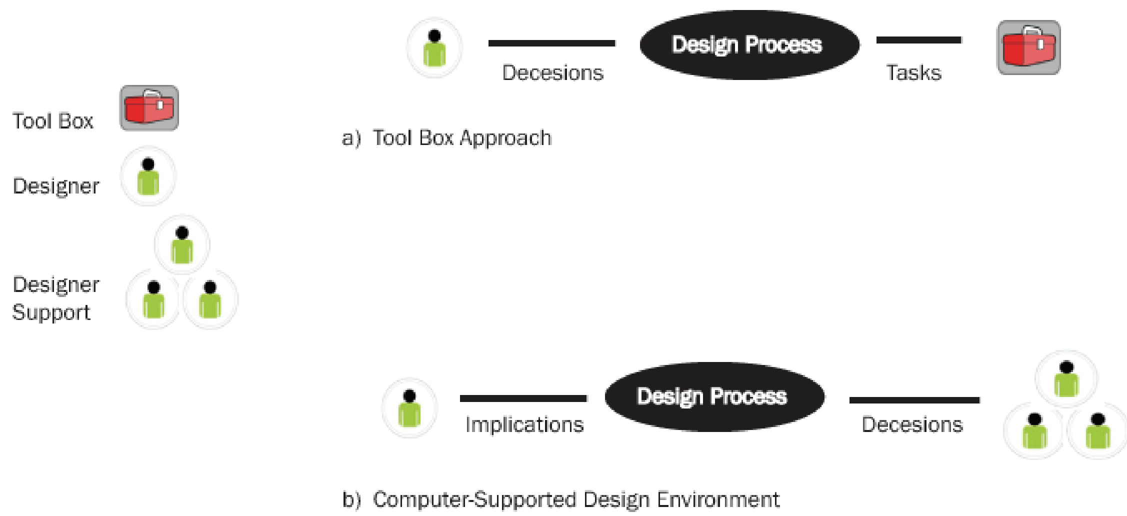

Fig. 1. a) tool-box approach b) CSDE approach

Simulation is credited with speeding up the design process, increasing efficiency, and enabling the comparison of a broader range of design variables. Simulation provides a better understanding of the consequences of design decisions, which increases the effectiveness of the engineering design process as a whole. But the relevance of simulation in the design process is not always recognized by design teams, and if recognized, simulation tools cannot always deliver effective answers. This is particularly true in the early design stages as many early research efforts to implement "simplified" of "designer-friendly" “simulation instruments in design studios have not accomplished their objectives. One of the reasons is the fact that the "designer" and the "design process" are moving targets. The Internet has played an important role in this. The "instant" accessibility of domain experts and their specialized analysis tools through the Internet has de-emphasized the need to import "designer-friendly" tools into the nucleus of the design team. Instead of migrating tools to the center of the team, the opposite migration may now become the dominant trend, which is, delegating a growing number of analysis tasks to (remote) domain experts. The latter trend recognizes that the irreplaceable knowledge of domain experts and their advanced tool sets is very hard to be matched by designer-friendly variants. With this recognition, sustaining complete, coherent and expressive communications between remote simulation experts and other design team members has surfaced as the real challenge.[3]

Simulation is also becoming increasingly relevant in other stages of a project, that is, after the design is completed. Main application opportunities for simulation are expected during the commissioning and operational facility management phases. Meanwhile, the "appearance" of simulation is changing constantly, not in the least as a result of the Internet revolution. This is exemplified by new forms of remote, collaborative and pervasive simulation, enabling the discipline to become a daily instrument in the design and operation of buildings. The traditional consultancy-driven role of simulation in design analysis is also about to change. Design analysis does not exist in isolation. The whole analysis process, from initial design analysis request to model preparation, simulation deployment and interpretation needs to be managed in the context of a pending design, commissioning or maintenance decision. This demands that associations between decisions over the service life of a building and the deployment of building simulation must be managed and enforced openly across all members of the design, engineering and facility management team. A new category of web-enabled groupware is emerging for that purpose. This development may have a big impact on the simulation profession once the opportunities to insert

[3] Augenbroe and Malkawi, *Advanced Building Simulation*.

simulation facilities in this type of groupware are fully recognized.[4]

BIM + Sustainability

BIM vs. IDM

There are many misconceptions on what BIM means. At first glance, it is obvious to say that it means what it says, and that is the absolute truth. BIM or Building Information Modeling is a type of 3D modeling software that uses parametric equations to define relationships between objects that comprise the building. Software's like Revit, Sketchup and ArchiCAD are the most popular titles on the market today. BIM offers a big advantage to designers and engineers alike because BIM allows for less changes need to be made if the design changes and less RFI's. BIM allows the designer to work with consultants seamlessly and earlier in the design phase. Integrated Practice is a new type of practice being seen today and BIM had a major role in it being conceived.

Communication has improved some what over the past few years due to the introduction of BIM, but still a lot of room for improvement. IDM (Integrated Design Model) on the other hand is the "sister" BIM. In European countries BIM is referred to as IDM. This difference in labeling is proof that there is no sense or effort to reach a common ground that will be recognized world-wide.

I've been working with "BIM" (Building Information Modeling) technologies for around 5 years now. It would be longer, but before BIM was known by a variety of other acronyms, none of which adequately summarized what BIM is. Compare this to

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[4] Augenbroe and Malkawi.

using the acronym “CAD” (or CADD as some people refer to it). CAD means Computer Aided Design which is so vague as to be virtually indefinable, yet we all inherently know what CAD means. The context we use it in helps to define it. BIM, on the other hand, has very little context at this point and when it does it is often confused and unclear.

3D alone does not give you a Building Information Modeling solution. Consider a Sketchup model - a representation of a building, project or component in 3D. There is no added intelligence to give you any “data” about the project. To understand what each element represents it is necessary for the person using the model to interpret the geometry. As soon as you add the model into Google Earth it suddenly inherits additional project information: where it exists spatially. The model has now become “BIM”.

Conversely, BIM does not have to be in 3D. It is quite possible to have a BIM model in 2D alone. A simple example is the use of a line and arc to represent a door. Once those elements have been put on a doors layer (e.g. A-G322-G-Door in the AEC CAD Standard) they now have added intelligence; building information that tells someone using the file what those elements represent. Taking that further the elements could be part of a block or cell with attributes (tags) added to them. This is a simple 2D Building Information Modeling concept.

Autodesk have got a powerful marketing machine. For years now I’ve heard people tell me how they would do something in “CAD”. “What software?” I always reply. “CAD, you know, Autodesk CAD”. The same thing appears to be happening with BIM. The terms BIM and Revit are becoming interchangeable. Be aware that Revit, whilst being a BIM solution, is not BIM. Even if you use Revit you can use it without being BIM at all.

BIM is not a single database or “single building model”. This is one of the main confusions with regard to adopting BIM. A lot of people believe BIM has to be a single database from which every party extracts their information in the format they require. Even some software manufacturers describe BIM as having to use a single database in order for it to be BIM:

> "Building information modeling solutions has three characteristics:
> (1) They create and operate on digital databases for collaboration.
> (2) They manage change throughout those databases so that a change to any part of the database is coordinated in all other parts.
> (3) They capture and preserve information for reuse by additional industry-specific applications."

It is better to think of BIM as a series of models. You may have an architectural model (in 3D); you may have a structural model (in 2D). Each of these models may be made up from a series of DGN or DWG references to allow individual access to a package of work. BIM doesn't have to be any different to existing CAD in terms of processes and data management.

BIM is not Project Lifecycle Management. For some reason as soon as BIM is mentioned the assumption is made that "it's only BIM if everyone in the team, from conception to facilities management is involved". While well-managed data will improve the flow of information through the design, construction and post-construction phases, this is not a definitive requirement of BIM. Far from it; I would always recommend anyone starting down the BIM road to consider only their internal benefits in the first instance. Understand where the production "bottlenecks" occur and see if there is a BIM solution that can address them. It may be drawing or schedule production, or the dynamic linking of the two together, or any number of design processes that can be improved internally. Only once you have developed a sound working method for your project can you start to consider the rest of the office. Only once you have developed sound working procedures for your office can you start to consider the implications of including other collaborators into the equation. Take it one simple step at a time; there are an infinite number of shades of grey between black and white.

BIM is not Building Information Modeling. I find it helps to think of BIM as Building Information Management rather than modeling. Just like CAD isn't only vector-based lines, arcs and circles, but is instead a mix of vector elements, raster images, printer configurations, plot styles or pen tables, Word files, spreadsheets, and a whole host of other hybrid formats and data, so is BIM. It's not a single piece of software, it's not a database, it's not a 3D model, and it's not a particular phase in a project - although it can be all of these things.

So what is BIM? In simple terms BIM is the management of project information, both the construction of that data and the iterative process of exchanging it. BIM is the added intelligence to project data that allows anyone to interpret that data correctly, removing the risk of assumptions. BIM is the process by which the right information is made available to the right person at the right time.[5]

Sustainability Paradigm

The concept of sustainability is not new at all. The American Indians were considered one of the most sustainable indigenous people to ever walk the earth. One can argue that climate change is to blame for the sustainability uprising. The creation the internal combustion engine is mainly to blame for the recent climate changes. Climate change is natural occurring event in the earths past, but in recent years large amounts of CO2 and CO gases and other ozone damaging gases are being released into the atmosphere at rate at which will change the natural earth cycles, particularly ocean currents and sea levels changes, and plunge the world into

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[5]Nigel Davis, "(Mis) Understanding BIM," Eat Your CAD (03/26/2007).

chaos.

Many of the world's leaders, leaders of large corporations, and policy makers are taking notice and now everyone and their proverbial "grandmother" wants to slow down climate change. This rapid growth in sustainability has created a market that has been inundated with products claiming to be "green" but they are really not. This kind of abuse on sustainability is becoming more common in today's markets. Nowadays, Designers need to research thoroughly before considering a green product.

The Construction Industry world-wide is the biggest contributor to CO2 and CO being released into the atmosphere. Designers are now being challenged to incorporate green strategies into their buildings. Clients are asking for green design on a regular basis and architects have noticed this trend. Green design is more difficult that conventional design. The considerations within the design process must go far beyond a gut-feeling about performance or the application of popular components such as green walls or bamboo flooring. Energy performance is a changing relationship between interior and exterior factors that influence the systems within a building. Green buildings are best known for the things they do less (use less energy, use less water…have less particles/pollution within the indoor air). The building science behind green building isn't easy to understand. Architecture is, in the end, the act of making building science real…or at least it should be. The way a design team calculates how much fuel is needed to heat, ventilate, light and cool usable space determines the actual efficiency of a building post-construction. Issues such as the length of day, location of the site relative to the equator, building type, wind current, solar exposure, sun azimuth , total heat degree days, total cooling degree days and topography are just a few of the factors needing to be considered. Most design teams, and more importantly – many developers, decide performance levels of the mechanical systems based on a "rule of thumb".[6]

[6]Neil Chambers, "Better Software = Better Buildings," Tree Hugger 06.18.07.

Revit MEP + IES VE = Sustainable Design Integration

Early this year Autodesk announced its partnership with IES VE (Integrated Environmental Solutions Virtual Environment) LTD. This is a big statement by the software giant Autodesk. Autodesk is probably recognized as the leader in Design Software and by joining with IES it has declared IES as the best building performance tool. The AEC industry has been waiting for years for purpose-built-BIM-Building Performance Assessment software that is “user-friendly” and able to be deployed into the design group as early as the conceptual stage.

The integration between the Revit platform and the <VE> features a link between the Revit BIM and the IES analysis software. There's no need to recreate the building geometry, because users can pass the BIM room geometry and data directly to the <VE> and with one mouse click run a variety of analyses without specialized skills, separate analysis packages or separate models for each analysis. This tight integration allows Revit users to quickly and easily analyze alternative green designs. Thermal and Daylighting studies that would have taken weeks (if they were done at all) can be done in minutes, and the results are output in a HTML report. The quality and speed of the technical feedback enables firms to use building analysis tools for sustainable design rather than just equipment sizing. More importantly, these tools can be used in the very earliest stages of the design process to help monitor and guide a design rather than waiting until the end of the design process and using building analysis for just validation when design changes at that point are difficult and costly to accommodate. The integration manifests itself within both Revit and the <VE>. Revit MEP, developed for mechanical, electrical and plumbing engineers and designers, has a native functionality for heating and cooling load analysis that uses established IES methodology. In the <VE> you can use the new Sustainability Toolkit to perform thermal assessments and Daylighting calculations.

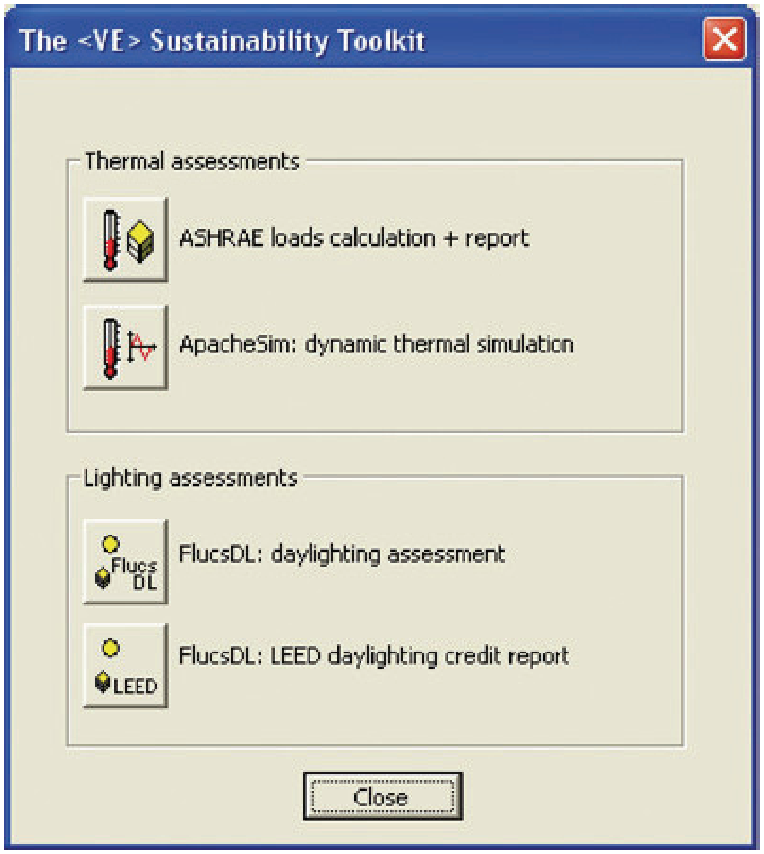

Fig. 2. The Sustainability Toolkit lets designers conduct a variety of analyses all based on Revit BIM.

The Sustainability Toolkit (Fig.2) is an analysis package within the <VE>, unique to the Revit platform, that lets architects conduct a variety of analyses: ASHRAE load calculations, dynamic thermal analysis and Daylighting assessment – and produce a LEED Daylighting credit report, all based on the Revit Building model. As mentioned above, the integration features a link between Revit BIM and the IES analysis software, so there's no need to recreate the building geometry for analysis. The analysis is launched with a single icon, and the feedback is a simple HTML report. This analysis package allows architects to receive quick feedback on their design; feedback such as how much energy the building will use, what are the anticipated CO2 emissions and if the building will pass LEED Daylighting requirements. By giving architects the ability to quickly and easily assess their design for building performance; they can make better informed building-design decisions to iterate on a greener design.

The IES VE software package by itself has a multitude of module that can assist designers in all aspects of green design. The IT Modeler in IES allows you to create vector geometry-based objects instead of using Revit MEP. Although it is possible to design the building in Revit and export it into a gbxml format and open it in IES. There is no longer a need to create separate design models to do isolate analysis on i.e. Daylighting, Thermal Comfort, and CFD. IES and Revit MEP BIM single model concept allow designers make quick changes without the lag of redrawing. IES extracts the physical model in Revit and converts it into an Analytical model that is used to do the complex calculations. The ability for a single model to have both physical and analytical properties is only realized through the BIM.[7]

2007/2008 Leading Edge Competition

The 2007/2008 Leading Edge Student Design Competition seeks to support and enhance the study of sustainable and energy-efficient building practices in architectural education. We Encourage students and instructors of architecture and design to use the competition as a framework to explore the use of new materials and strategies for building, and the integration of aesthetics and technology for high performance, cutting-edge architecture. This year, the competition will focus on the coastal environment of beautiful Santa Barbara. Students entering Challenge 1 will design an Environmental and History Center with display space in an historic barn.

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[7]Rick Rundell, "1-2-3 Revit: BIM and Analysis for Sustainable Design," Cadalyst (4/10/2007).

Fig. 3. The Santa Ynez Mountains north of Santa Barbara. This mountain range, running east to west, parallel with the coast separates Santa Barbara from the interior of California, and provides fresh water in rivers and creeks.

Background and History

The 2007/2008 Leading Edge Student Design Competition site is located in Santa Barbara, California on the West Campus of the University of California a Santa Barbara. Before European arrival, the California coast was home to many groups of native peoples. The Chumash (Fig.4) inhabited the coastal and inland areas between Malibu and Paso Robles from 13,000 years ago until the present. The abundant food supply from the ocean as well as the mild climate made for a relatively gentle environment for a hunter and gatherer culture. The Chumash inhabited villages offshore on the Channel Islands, along the coast, and along creeks in the forested uplands. The mainstay of their diet was fish and shellfish as well as meat from small and large mammals. Similar to other indigenous peoples from California, ground acorns was another important element of their diet. Their population may have exceeded 20,000 people, divided into several language dialects. The Chumash are also known for their use of shell bead money: they are one of the only Native American cultures known to have independently developed the use of money before European contact.

Fig. 4. Chumash Indian

The first Europeans to travel through Santa Barbara were Spanish explorers moving up the coast from Mexico. Juan Rodriguez Cabrillo, generally credited with “discovering” California for Spain, documented his meetings with the Chumash in the area in 1542. More than two hundred years later, in 1782, as the Spanish began to build outposts in California, the Presidio and Mission of Santa Barbara were founded: the presidio to protect the little Spanish settlement of Santa Barbara and the mission to convert the Chumash to Christianity. Mission Santa Barbara is the 10th of 21 missions built in California. While many will claim that the Spanish brought a benevolent civilization to the native peoples, the fact is that the diseases that European settlers inadvertently brought with them, such as measles and small pox, decimated the Chumash people, and along with the enforced loss of their lands and culture, nearly caused their extinction.

Fig. 5. Front façade of Mission Santa Barbara. The two towers are unusual for California Missions. Note the Adobe arcaded building on the left.

The Mission Santa Barbara (Fig.5) has survived to the present, and unlike many other California Missions, has remained a functioning parish since its founding. The stone building was damaged in two earthquakes: 1812 and 1925. It was enlarged and rebuilt after the first quake, and rebuilt and restored to its original appearance after the second earthquake. The Presidio protected a small village and harbor that soon grew into a thriving seaport, and was incorporated as a town in 1850. When the Southern Pacific Railroad arrived in Santa Barbara in 1887, it became a traveler's destination, and its reputation as a beautiful seaside resort town was established. After suffering extensive damage in the same 1925 earthquake that destroyed the mission, city business owners decided to rebuild their downtown entirely in the Spanish Mediterranean Style. This revival style was very popular at the time for residential structures, but was not commonly used in commercial construction. These guidelines have remained in force downtown to this day, resulting in a uniquely-styled downtown business district (Fig.6).

Fig. 6. A section of State Street in downtown Santa Barbara showing the Spanish Mediterranean Revival Style Architecture. This style gives the area a charming feel.

Nestled between the Santa Ynez Mountains and the Pacific Ocean, Santa Barbara is now promoted as "The American Riviera". The Mediterranean climate, sandy beaches, nearby mountains, and high real estate values seem to support this comparison. In fact, Santa Barbara and its neighbor Montecito are home to a disproportionate number of the rich and famous, many seeking respite from Los Angeles and Hollywood, which are a relatively short travel distance away.

UCSB

In 1944 a teacher's college, Santa Barbara College, joined the University of California system as Santa Barbara College of the University of California. This campus was originally envisioned as a liberal arts college, with emphasis on teacher training, however over time, the campus has evolved into a full-fledged university. In 1950 the university purchased the Marine Corps Air Station at Goleta Point outside of the Santa Barbara City limits, and relocated the campus there in 1954. This location is the main campus to this day, a 408-acre site on a mesa above the ocean 9 miles west of Santa Barbara.


fig.8


fig.7

Fig. 7. Storke Tower, the central campus landmark.
Fig. 8. Central UCB Campus with its interconnecting network of bike paths and walkways.

The university consists of 17,000 undergraduate students, 95% of who are from California, 3,000 graduate students and approximately 1,000 faculty members. The university offers approximately 200 majors and degrees to their students.

Fig. 9. Aerial view of the coastline at UCSB. Note the dense development in Isla Vista bordered by West Campus on the left and the main campus on the right. Devereux Slough is the large sandy area above the West Campus text in this image.

Housing students in one of the most expensive real estate markets in the country is a challenge for the university. Santa Barbara County has allowed development to occur in several parcels adjacent to the campus, most notably Isla Vista, an unincorporated town directly west of the main campus. This very dense community of 18,000 residents is comprised of 95% rental housing, and the residents have a median age of 21 years old. Isla Vista School, an elementary school built by the Goleta School District, serves the children of Isla Vista and adjacent housing areas. This school borders our competition site. In addition to Isla Vista, the County also allowed a private developer to build two 10-story dormitory towers off campus. These dorms, Francisco Torres, are the tallest structures in the area, and visible from the competition site.

Demographics

This demographic information obtained form the 2000 US Census suggests that Santa Barbara and Isla Vista are more heavily Caucasian areas relative to the rest of California. It is interesting to note that the student population in Isla Vista is somewhat more diverse than Santa Barbara (more Asians and African Americans), but still less diverse than California as a whole.[8]

Table 1. Demographic chart for Santa Barbara

	Percent of Residents in Santa Barbara	Percent of Residents in Isla Vista	Percent of Residents In California
Whites	74	69.5	59.5
African American	1.8	2.1	6.7
Native American	1.1	0.6	1.0
Asian	2.8	11.6	10.9
Pacific Islander	0.1	0.2	0.3
Other	16.4	10.2	16.9
Mixed-Race	3.8	5.8	3.7
Hispanic Latino	35	20	32
Not Latino	65	80	68
Median Age (yrs)	34.5	21	33

[8] Pat Heatherly, 2007/2008 Leading Edge Competition (Santa Barbara: UCSB, 2007) 5 Oct 2007 <http://www.leadingedgecompettition.org>.

Doctorate Project Statement

The case study on the IES VE is an attempt to examine new building performances assessment tools and compare them to previous tools sets. Green Building Studio's online simulation tool is the first union between Autodesk and simulation software. Green Building Studio is free service for up to 5 runs. I will only do the same amount of runs with IES to make it even. With the recent announcement of the partnering of Autodesk and IES, I find it would be valuable to compare the two quantifiably. The results will show students and professionals alike the advantages in using a user-friendly BIM-based simulation tools that are either reasonable priced (IES VE) or one that is free online (up to 5 runs: additional runs are $4 per run/$0.50 per room).

The Leading Edge Competition gives me a building to test the software's capabilities on and its objectives are well suited for my D.Arch Project and they are:

- Explore energy efficiency as a basic standard of building design.
- Incorporate principles of sustainability in the choice of building materials, water use and building design.
- Investigate new building materials and methodologies that contribute to sustainable or energy-efficient design.
- Understand the impact of solar orientation, wind orientation, building massing, construction methods, and material choices on building function and energy use.
- Develop an awareness of appropriate technology for particular building types, regional climates, and site location.
- Explore state-of-the-art computer modeling tools for predicting and evaluating the impact of design decisions on building performance and energy conservation.

The Competition is open to all undergraduate and graduate students of architecture, engineering, drafting, and environmental design at two-year colleges, technical schools, four- and five-year colleges and universities. Students may enter as individuals or teams. The competition may be treated as a class project or a separate independent study. A faculty member must supervise all participants. The competition is divided into two levels or challenges: Challenge 1 for all students above the second year of their training (i.e. third year through graduate students) and Challenge 2 for first and second year students. Teams comprised of students at both levels must enter Challenge 1. Instructors are responsible for evaluating the students' class standings and determining which challenge the students will enter.

The duration of the competition will be any consecutive ten-week period within an academic quarter or semester. Completed entries may be submitted prior to the submission deadline.

Competition schedule

March 28, 2008 Final Registration Deadline
April 11, 2008 Final Deadline for Submission of Questions Regarding Competition Program, Site, and Submission Requirements
April 18, 2008 Final posting of Questions and Answers on the Website
June 13, 2008 Deadline for Receipt of Entries
August 29, 2008 Winners Notified and Posted on Website
Sept. 12, 2008 Judges Comments for All Entries Posted on the Website

Juries of technical and design experts will evaluate all entries that meet the entrance requirements. The jurors are selected for their design experience and knowledge of energy efficient and environmentally responsive design and construction Jurors are:

Technical Jury

Randall T. Higa, P.E.

Southern California Edison

Chris Scruton

California Energy Commission

Design Jury

Gregg D. Ander, FAIA

Southern California Edison

Alison Kwok, Ph.D., AIA, LEED AP

University of Oregon, Department of Architecture

Nancy Clanton, P.E. FIES, LC, IALD

Clanton & Associates

Sponsors

California Energy Commission www.energy.ca.gov

New Buildings Institute, Inc. www.newbuildings.org

Pacific Gas and Electric www.pge.com

Sacramento Municipal Utility District www.smud.org

Southern California Edison www.sce.com

Entry Format

Entrants in Challenge 1 may submit two or three 30" x 40" boards arranged with the 40" edge vertical. Entrants in Challenge 2 should submit two 30" X 40" boards arranged as above. The boards should be a lightweight rigid material such as illustration or foam core boards. They may not be more than 1/2" thick and no part of the entry may project from the surface or the boundaries of the boards. No Masonite or heavy board material will be accepted. Creative and informative board designs are very important. The best entries will clearly communicate both the design intent and environmental concepts used in the project in a pleasing and appealing fashion. Use of text, titles, and graphic symbols to explain and identify important aspects of the proposal is encouraged. Presentations may be made in any print, drawing, or photographic medium including prints from CAD, 3-D modeling, or rendering programs, however entrants should keep in mind that the boards will be handled by the Competition staff before and during judging and photographed after judging. Any presentation medium should resist smudging or smearing under normal handling conditions and all mounted materials should be attached securely. Entries that consist of more than one board should be clearly marked on the back to indicate the arrangement of the boards (i.e. right, middle, left, top, bottom). All boards and documents must be marked with the entrant's registration number on the back. No other identifying mark is allowed. Any entry that does not maintain the entrant's anonymity will be disqualified.

Narrative

Each entry must include a brief narrative of approximately 500 words somewhere on the face of the boards. The narrative should discuss the overall energy efficiency and environmental sustainability aspects of the design. Each narrative should describe the way in which the design specifically addresses the technical requirements. For example, this discussion might include specific details of the window placement, shading design, thermal mass strategies, natural ventilation applications, Daylighting strategies, water recycling systems, vegetation choice, kinds and placement of paving, and any other approaches used to conserve resources and reduce heating and/or cooling loads. The narrative must defend all choices, including material selections, placement of features, equipment, and ventilation designs, etc. The defense of each feature must have technical merit, which is supported by the diagrams or the calculations included in the presentation. *This is* *very important: The narrative must demonstrate how your technical calculations informed and changed your design.* The narrative must relate to and refer to the plans, sections, elevations and details shown in the presentation. The judges read the narratives carefully as they evaluate the entries; your narrative should clearly present your design intent and process.

Required Drawings & Technical Submittals for Challenge 1

These drawings and technical submittals are required. Failure to submit all the items in this list will result in disqualification. All plans and site plans should be clearly marked with a north arrow. Scale should be indicated on all plans, sections, elevations and cross-sections.

1. Site Plan. Provide an overall site plan of the Environment & History (E&H) Center site. Include any landscaping and site features within boundaries of the “Challenge 1 Site” as well as the plaza and the barn. All energy efficient and resource conserving features of the site plan should be labeled. Scale: 1/16”=1’-0”.

2. Floor Plans. Provide floor plans of all levels of the E&H Center and the Barn. Any energy efficient and sustainable features that are apparent in the floor plans should be labeled. Scale: 1/8”=1’-0”.

3. Detailed Floor Plans. Provide detailed floor plans of one of the E&H Center classrooms. Label all important aspects of the plans, including any energy efficiency, Daylighting, ventilation, or sustainable features. Scale: 1/4”=1’-0”.

4. Elevations. Provide at least two principal exterior elevations of the E&H center that illustrate massing, openings, materials, and related elements. Label all important design elements, and clearly label the elevation’s orientation. Scale: 1/8”=1’-0”.

5. Cross Sections. Provide one longitudinal and one transverse section through the E&H Center, and at least one detailed cross section though the classroom shown in the detailed floor plans. The sections should be chosen to illustrate the different Daylighting and ventilation strategies used for the building and for the classroom. Those elements should be clearly labeled on the drawing. Scale: 1/8”=1’-0” or 1/4”=1’-0”.

6. Wall Section. Provide one detailed wall section (foundation through roof) that illustrates the proposed materials and construction assemblies for the classroom. Label and clearly explain all energy-efficient and sustainable strategies in all construction assemblies (i.e. floors, walls, roof, fenestration, etc.). Scale: 3/4”=1’-0” or 3/8”=1’-0”.

7. Perspective Drawings. Provide at least one pedestrian’s eye level perspective drawing that illustrates important aspects of the design.

8. Supporting Drawings, Graphs, and Diagrams. Include any additional drawings, photos, diagrams, or graphs necessary to convey the design proposal to the jury. This may include images of models, solar angle diagrams, shading diagrams, ventilation diagrams, and summaries of energy performance analyses, calculations and/or any other materials that will illustrate the design intentions. This material must fit on the display surface of the boards. Inclusion of relevant numerical analysis is encouraged to justify design decisions; however, inclusion of multiple sheets of tabulated numerical output is discouraged. Avoid the use of “magic arrows”, ventilation arrows that illustrate air moving as if by magic, on the ventilation diagrams.

9. Technical Requirements. As part of Challenge 1, all students are required to quantify the energy efficiency and sustainability of their projects. These technical requirements will be carried out on a single classroom in the design. This classroom should be the one used for the detailed drawings in Item 3 above and should be chosen to illustrate energy and environmental strategies that are most challenging given the site and orientation. Each entrant is required to submit three of the technical tasks in Part I of the Technical Requirements or submit an energy simulation model. Summaries of the completed technical tasks as well as discussions of the results should be shown on the face of the project boards. Worksheets and calculation sheets may be placed in an envelope and attached to the back of the boards. If an energy simulation model is completed, place relevant summary results on the front of the board, with more complete output attached to the back of the board.

Building Performance Simulation Model

Challenge 1 entrants will model their building design with an energy simulation tool of your choice. Focus on the performance of the classroom shown in your detailed floor plans. Challenge 1 entrants should use a non-residential simulation tool since these spaces are internally loaded, and do not have heating and cooling needs similar to residences.

1. Model a base case building, which meets basic energy efficiency standards. Compare your design to the base case structure.

2. Demonstrate the results of your energy simulation model by including charts, graphs or other outputs that illustrate the energy performance of the building as part of your presentation. Some of these outputs may be included in the graphic presentation; however, a complete set of outputs should be included in an envelope attached to the back of the boards.

3. Include a brief written analysis describing the simulation program that you used and summarizing and interpreting the results. Discuss the design

changes that were made to improve the energy efficiency of your building above the base case. What other changes could be made to the building to improve its performance?[9]

[9] Heatherly.

Research Documentation

This chapter will go into detail the kind of data that will be generated and digested during the course of the D.Arch project. An analysis of a test model for the project was needed to test the basic features of the Revit MEP IES VE integration. A tutorial provide in the software was selected as the test model. Slight modifications in location and weather data input data was made to the analytical model to get more accurate data output. Further analysis maybe done using the Sustainability Toolkit module that is accessible via link to IES. IES is needed to use the Sustainability Toolkit and therefore needs to be installed on to the computer. If IES is not installed, then only the Apache Load Calculation is available for use.

Test Model

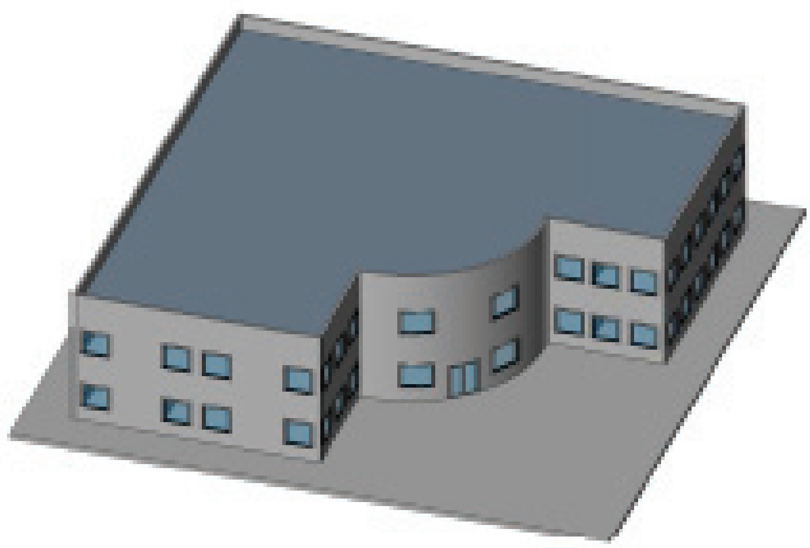

Fig. 10. Test Model 3D

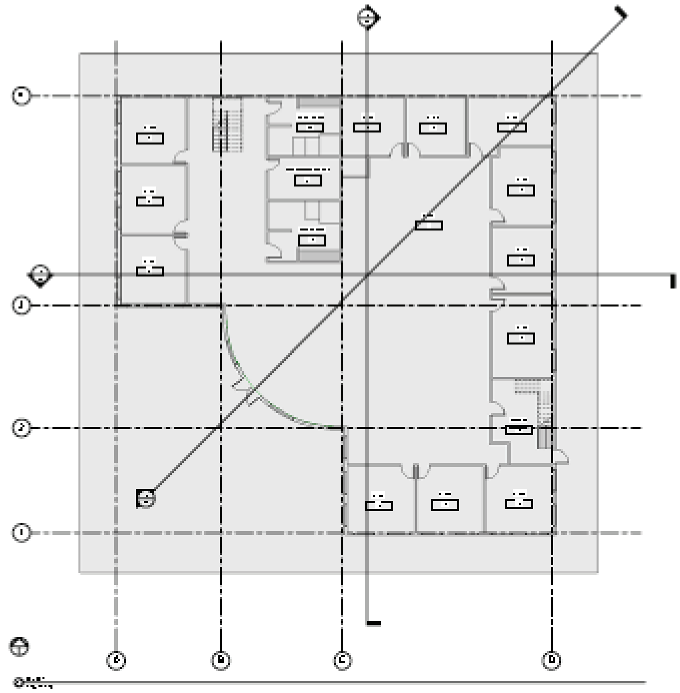

Fig. 11. Level 1

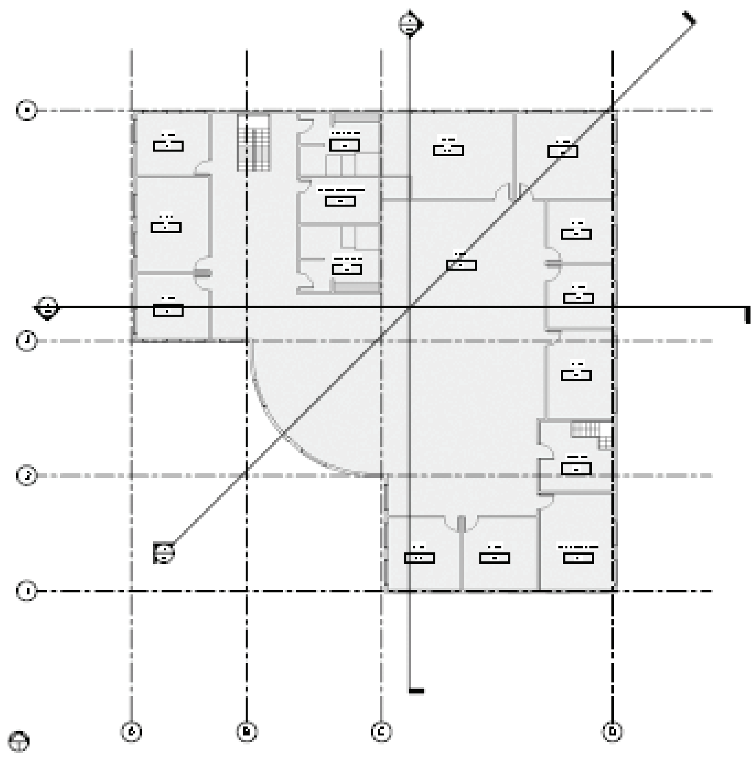

Fig. 12. Level 2

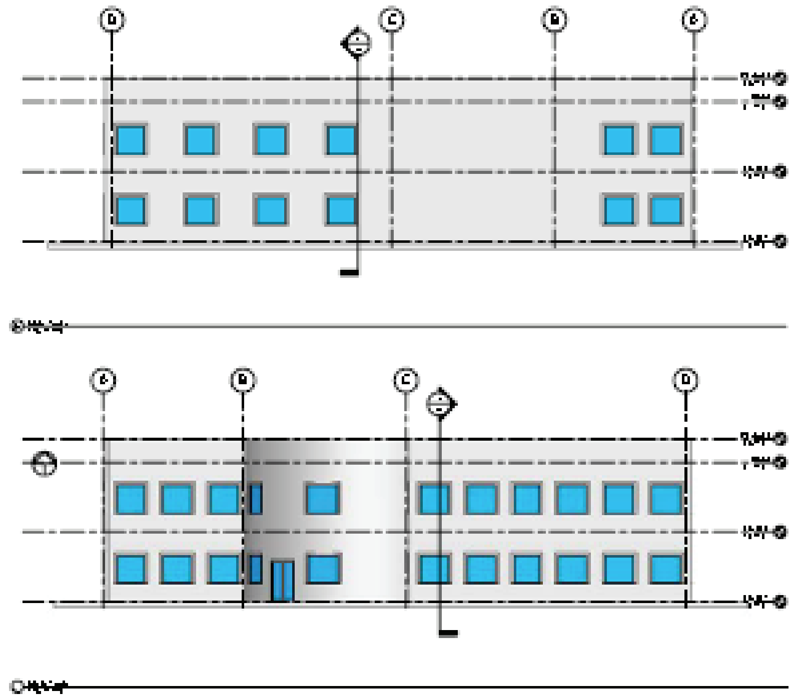

Fig. 13. Elevations Top (East), Bottom (West)

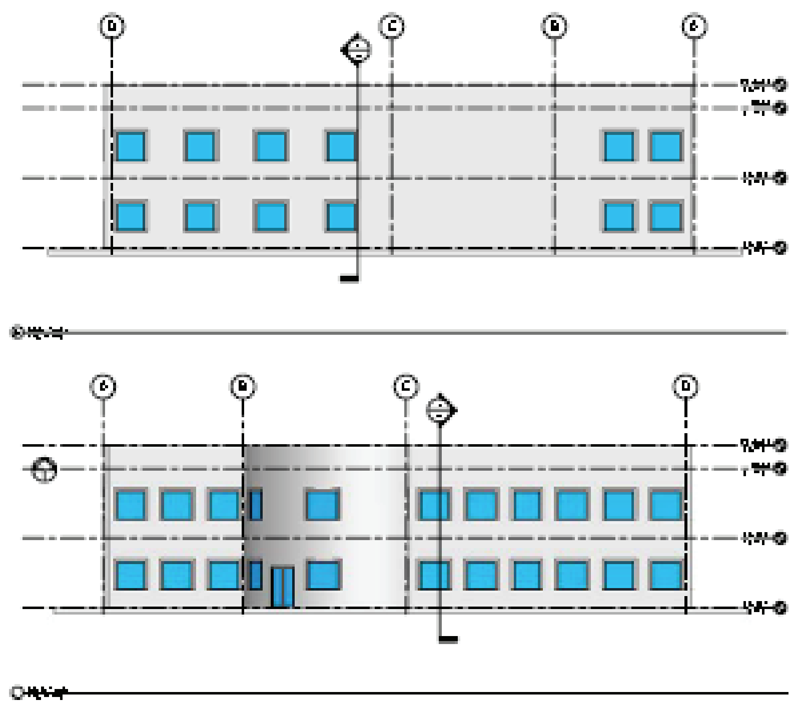

Fig. 14. Elevations Top (North) Bottom (South)

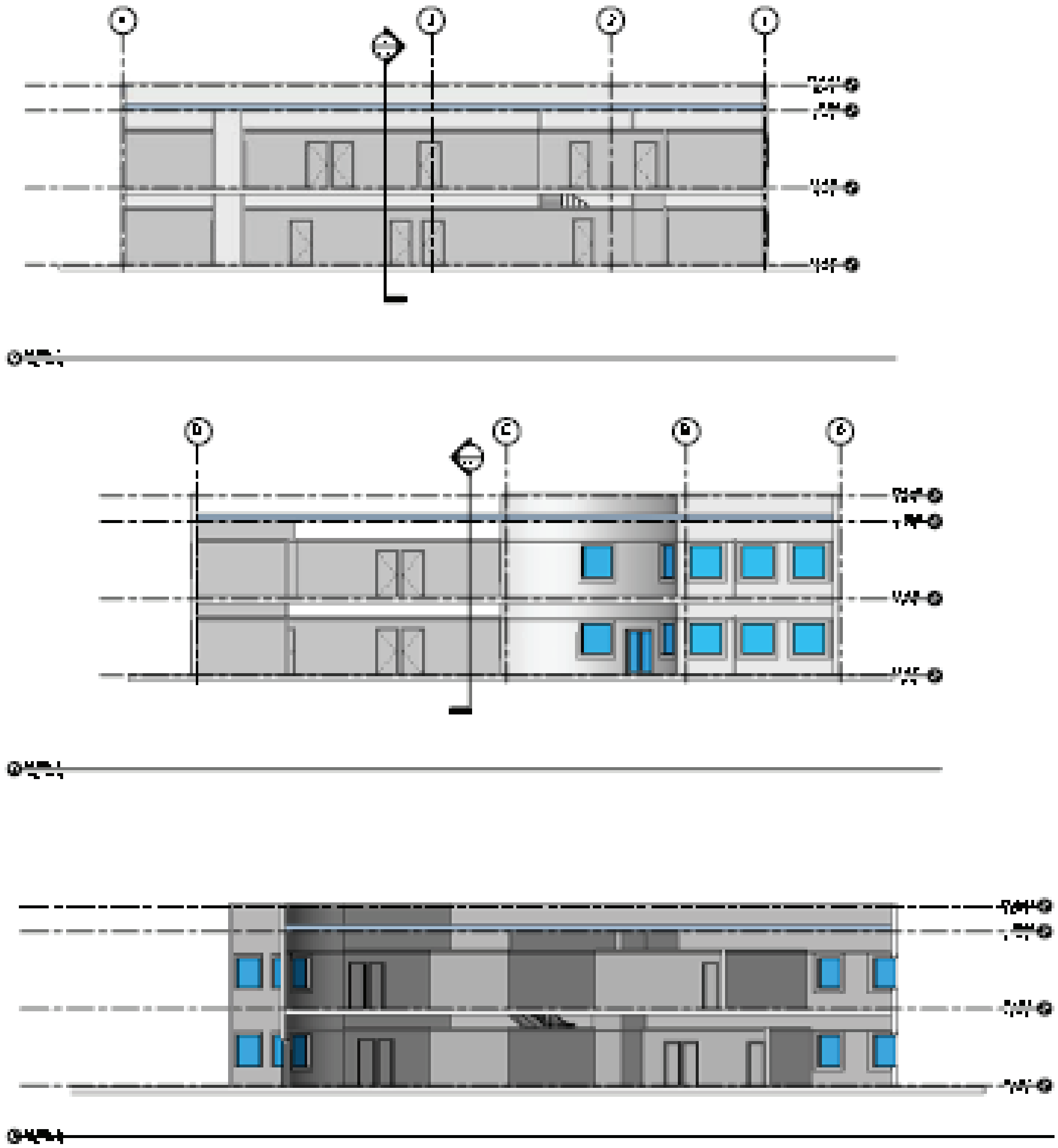

Fig. 15. Sections Top (Section 1) Middle (Section 2) Bottom (Section 3)

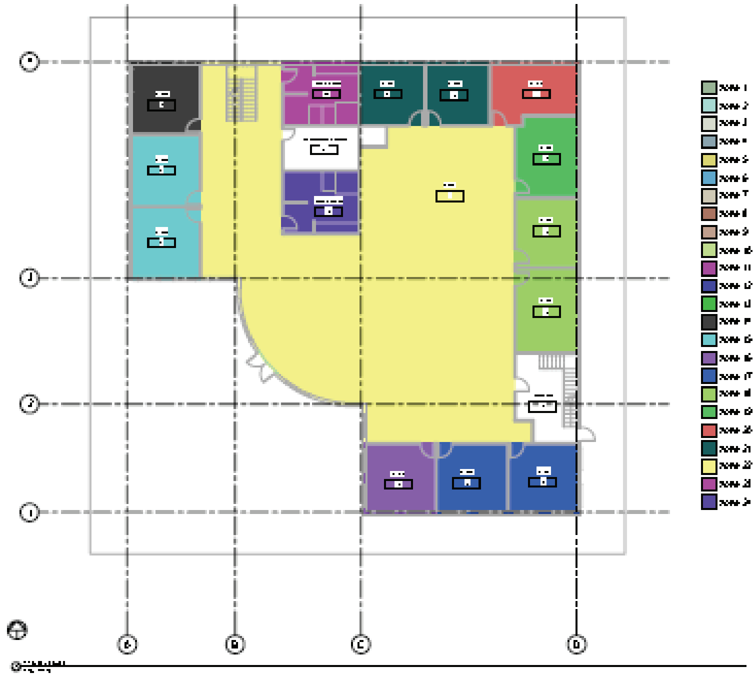

Fig. 16. Mechanical Zones Level 1

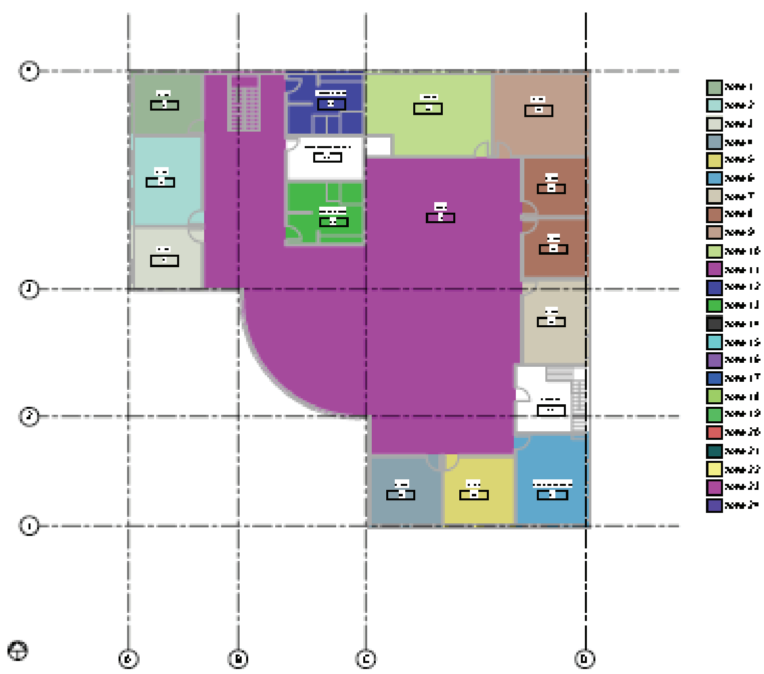

Fig. 17. Mechanical Zones Level 2

Heat & Cool Load Simulation

The tool used for the heating and cooling load is Apache Loads. Apache Loads is the single integrated module into Revit MEP. Apache Loads Apache Loads calculates design heating and cooling loads, using procedures lay down by the American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE). These calculations, based on the ASHRAE Heat Balance Method, are performed in seconds on the model created within the IES <Virtual Environment>. Apache Loads is used internationally where the ASHRAE procedures are recognized.

Apache Loads uses the Integrated Data Model (IDM) generated within the IES <Virtual Environment>. You can make any number of design changes within the APACHE view, which is a series of facilities inside the <Virtual Environment> enabling you to edit the thermal properties of your IDM.

Apache Loads uses the IDM to undertake two principal calculations:

· Steady state heat loss calculations to predict the heating requirements for the building

· A heating loads calculation, based on the ASHRAE Heat Balance Method, to predict the building cooling requirements. The heat gain calculations can be performed for a selected design day of the week, and for a range of design months.

The results from these calculations can be interrogated. Several post-processing calculations can then be performed, such as boiler, chiller sizing and room air supply rates.[10]

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[10] Autodesk, Revit User Guide (USA: Autodesk, 2007).

Analytical Model

Before a load simulation is done, preparation of the physical model needs to be modified. Creation of zones in the physical model will allow the physical model to convert itself to an analytical model. Using the Room & Area tool in Revit is the mode of achieving this kind of model. After creating the zones, the model is ready for simulation. Simulation starts when the user initiates the IES link. Once connected, a window with the analytical model is shown with menu button that allow the user to access specific areas of the building that maybe of interests. The user may change the properties of the building that affect the output data.

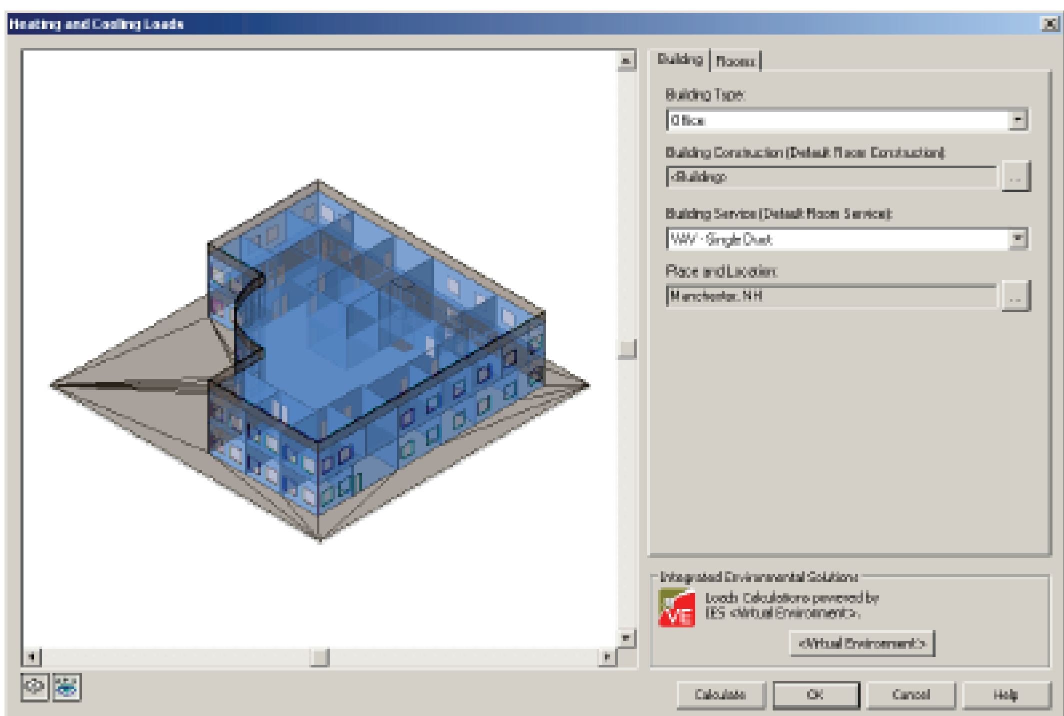

Fig. 18. Heating and Cooling Load Window

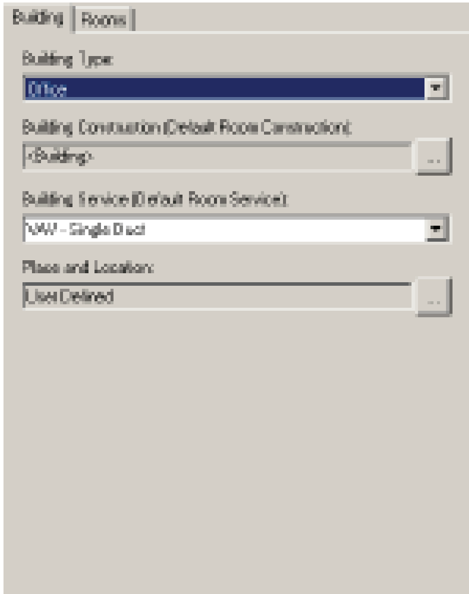

Fig. 19. Building Type Settings

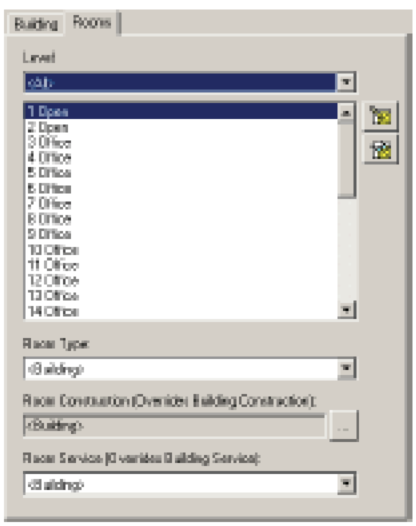

Fig. 20. Room Settings

Loads Report

The loads report contains a load summary for each room (zone) that the user created in the analytical model.

Powered by ies

Loads Report Summary

Project Information

Project:	I Energy Analysis Training
Run Time:	11/29/2007 6:50 PM
Address:	
Latitude:	34° 25' 41"
Longitude:	119° 43' 16"
Building Analytical Area:	15340 SF
Building Analytical Volume:	188460.96 CF

Room Summary

Name	Area	Airflow	Cooling Load (Total)	Heating Load (Total)
1 Open	4077 SF	3036 CFM	68832.5 Btu/h	28496.2 Btu/h
2 Open	3895 SF	3068 CFM	69250.4 Btu/h	19847.5 Btu/h
3 Office	231 SF	380 CFM	8391.2 Btu/h	4424.5 Btu/h
4 Office	233 SF	496 CFM	10897.2 Btu/h	3418.1 Btu/h
5 Office	231 SF	526 CFM	11545.2 Btu/h	4423.7 Btu/h
6 Office	201 SF	375 CFM	8242.2 Btu/h	3974.3 Btu/h
7 Office	293 SF	572 CFM	12574.8 Btu/h	3458.1 Btu/h
8 Office	201 SF	523 CFM	11450.0 Btu/h	3973.3 Btu/h
9 Office	192 SF	153 CFM	3467.6 Btu/h	2385.4 Btu/h
10 Office	190 SF	159 CFM	3600.4 Btu/h	2314.6 Btu/h
11 Office	234 SF	349 CFM	7724.3 Btu/h	4467.9 Btu/h
12 Office	244 SF	473 CFM	10417.3 Btu/h	3471.1 Btu/h
13 Office	211 SF	317 CFM	7027.9 Btu/h	2434.6 Btu/h
14 Office	259 SF	470 CFM	10366.6 Btu/h	3506.1 Btu/h
15 Stairwell	270 SF	196 CFM	4446.2 Btu/h	2540.0 Btu/h
16 Office	231 SF	570 CFM	12486.5 Btu/h	5130.8 Btu/h
17 Office	233 SF	476 CFM	10477.7 Btu/h	3469.5 Btu/h
18 Office	231 SF	639 CFM	13986.4 Btu/h	5154.0 Btu/h
19 Men's Room	225 SF	135 CFM	3102.1 Btu/h	1303.0 Btu/h
20 Ladies Room	223 SF	127 CFM	2931.9 Btu/h	1644.8 Btu/h
21 Mechanical/Electrical	159 SF	94 CFM	2169.1 Btu/h	1015.5 Btu/h
22 Men's Room	225 SF	288 CFM	6399.5 Btu/h	852.1 Btu/h
23 Ladies Room	223 SF	151 CFM	3440.7 Btu/h	1268.2 Btu/h
24 Mechanical/Electrical	159 SF	114 CFM	2584.0 Btu/h	704.5 Btu/h
25 Lounge	475 SF	394 CFM	8865.5 Btu/h	4478.6 Btu/h
26 Office	371 SF	585 CFM	12907.9 Btu/h	5693.8 Btu/h
27 Office	180 SF	314 CFM	6927.1 Btu/h	1967.6 Btu/h
28 Office	183 SF	317 CFM	6976.4 Btu/h	1928.5 Btu/h
29 Office	259 SF	503 CFM	11047.7 Btu/h	3110.2 Btu/h
30 Stairwell	225 SF	180 CFM	4058.4 Btu/h	1387.4 Btu/h
31 Conference Room	309 SF	655 CFM	14379.7 Btu/h	5365.0 Btu/h
32 Office	233 SF	498 CFM	10933.6 Btu/h	3130.5 Btu/h
33 Office	231 SF	671 CFM	14656.6 Btu/h	4923.9 Btu/h
Totals	15340 SF	17807 CFM	396564.6 Btu/h	145663.4 Btu/h

Fig. 21. Loads Report

Item	Description
Project Information	
Project	Project Name
Run Time	Date and time that the report was created
Address	Project address from Settings menu ➤ Project Information ➤ Project Address
Latitude, Longitude	Project longitude and latitude from Settings menu ➤ Manage Places and Location ➤ Latitude/Longitude
Building Analytical Areas	Total analytical area, based on the centerline areas, of all the rooms in the building
Building Analytical Volume	Total analytical volume, based on the centerline volumes of all the rooms in the building
Room Summary	
Name	Room number and name (provides a link to the detailed room data)
Area	Total analytical area, based on the centerline area, of the room
Airflow	Supply airflow required to heat/cool the room, based on heating and cooling loads
Cooling Load (Total)	Total cooling load for the room, including sensible and latent loads
Heating Load (Total)	Total heating load for the room, including sensible and latent loads

Loads Report: 1 Open

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Project Information

Project:	i Energy Analysis
Run Time:	1/3/2007 10:02 AM

Input Data

Room Data

Analytical Floor Area:	3990.68
Analytical Roof Area:	3990.70
Analytical Wall Area:	4037.72
Analytical Window Area:	108.36
Analytical Volume:	48951.78

Electrical Data

Lighting Load:	0.00 W/ft^2
Equipment Load:	0.00 W/ft^2
Misc. Load:	0.00 W/ft^2

People Loads

People:	24.11
Area / Person	165.55
Sensible / Person:	255.9 Btu/h
Latent / Person:	238.8 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	70570.9 Btu/h
Latent Cooling Load:	24006.2 Btu/h
Total Cooling Load:	94577.1 Btu/h

Airflows

Flow Rate:	4235 CFM
Flow Density:	1.06
Air Changes:	5.19

Heating Loads

Sensible Heating Load:	81411.7 Btu/h
Latent Heating Load:	14837.0 Btu/h
Total Heating Load:	96248.7 Btu/h

Item	Description
Project	Project Name
Run Time	Date and time that the report was created
Input Data	
Room Data	
Analytical Floor Area	Total floor surface area for the room
Analytical Roof Area	Total roof surface area for the room
Analytical Wall Area	Total wall area for the room minus the area of openings (windows and doors)
Analytical Window Area	Total window area for the room
Analytical Volume	Total volume for the room
Electrical Loads	
Lighting Load	Lighting power density from the Electrical Loads parameter for the room under Energy Analysis ➤ Room Properties ➤ Element Properties
Equipment Load	Equipment power density from the Electrical Loads parameter for the room under Energy Analysis ➤ Room Properties ➤ Element Properties
Misc. Load	Other power density for the room
People Loads	
People	Number of people from the People parameter for the room under Energy Analysis ➤ Room Properties ➤ Element Properties
Area / Person	Area per person from the People parameter for the room under Energy Analysis ➤ Room Properties ➤ Element Properties
Sensible / Person	Sensible load per person from the People parameter for the room under Energy Analysis ➤ Room Properties ➤ Element Properties
Latent / Person	Latent load per person from the People parameter for the room under Energy Analysis ➤ Room Properties ➤ Element Properties
Load Data	
Cooling Loads	
Sensible Cooling Load	Sensible cooling load for the space
Latent Cooling Load	Latent cooling load for the space
Total Cooling Load	Sum of sensible and latent cooling loads for the space
Heating Loads	
Sensible Heating Load	Sensible heating load for the space
Latent Heating Load	Latent heating load for the space
Total Heating Load	Sum of sensible and latent heating loads for the space
Airflow	
Flow Rate	Total air flow rate for the room
Flow Density	Flow rate for the room divided by the area of the room
Air Changes (per hour)	Flow rate x 60 for the room divided by the volume of the room

[11]

Weather Data

Santa Barbara is at the northern most edge of the California Energy

[11] Autodesk.

Commission's Climate Zone 6, which includes coastal areas from Los Angeles to Santa Barbara. Temperatures in this zone are moderated by the proximity to the ocean and to coastal breezes. This climate is one of the most constant and less subject to extremes of either heat or cold, in all of California.[12]

The weather data summarized below is for the weather station at the Santa Barbara Airport. The data comes from ASHRAE, "Climatic Data for Region X – Arizona, California, Hawaii, and Nevada. Fifth Edition, May 1982. All temperatures are expressed in degrees Fahrenheit.

Latitude 34.42 N

Longitude 19.70 W

Elevation 49 ft

Outdoor Daily Range of Temperature 20 Degrees

Summer Design Temperatures

Percent (see note 1)	Dry Bulb/ Mean Coincident Wet Bulb (°F) (see note 2)	Wet Bulb (°F)
0.1%	90/69	70
0.5%	83/67	68
2.0%	77/65	66

Note 1: The 0.1% 9-hour level (i.e. this design temperature is exceeded only 9 hours of the year) should be used only for extremely conservative work; projects that must hold the desired indoor temperature regardless of outside conditions. The 0.5% 44-hour level is for the average project. The 2.0% 175-hour level is for projects where construction cost containment is more important than the exact maintenance of indoor temperature.

[12] Heatherly.

Note 2: Mean coincident wet bulb (MCWB) temperatures are the average wet bulb temperatures registered at the time of a design dry bulb temperature

Winter Design Temperatures

Percent (see note 3)	(F)
Median of Extremes	34
0.2%	38
0.6%	41

Note 3: It is suggested that the winter values be used as follows: Median of Extremes: Residential projects or projects with large glass area and light construction.

0.2%: 18-hour: Projects of medium constructions that have mainly daytime use.
0.6%, 53-hours: Projects of heavy construction.

Heating Degree Days
Base 65 1474.5
Base 60 501.5
Base 55 61
Base 50 1.5
Cooling Degree Days
Base 80 0
Base 75 0
Base 70 63
Base 65 459.5

References
Most of the following data come from Climate consultant 3.0 – California Climate Zone 6. The Precipitation data comes from WWW.CITY-DATA.COM,

http://www.citydata. com/city/Isla-Vista-California.html. Climate Consultant is available for download at http://www2.aud.ucla.edu/energydesign- tools/

The prevailing winds are described by the following Wind Roses. Note that the prevailing breezes come from the west southwest, and are active year around. These prevailing breezes are cooling in the summer. Winter storm winds tend to come from the east and northeast.

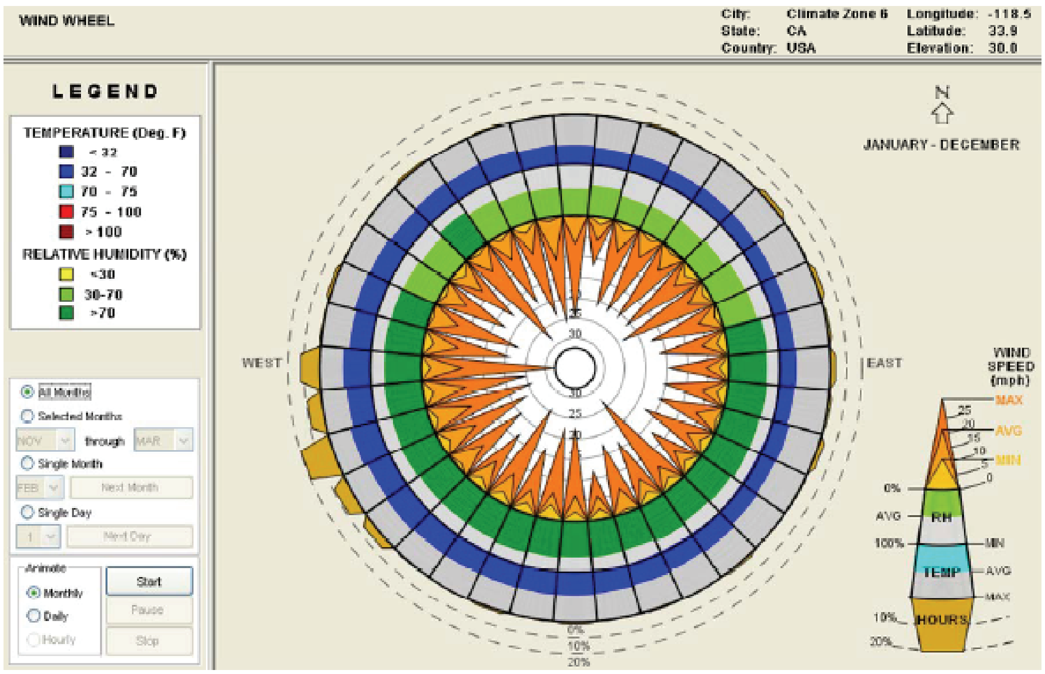


Fig. 22. Weather Data All Months

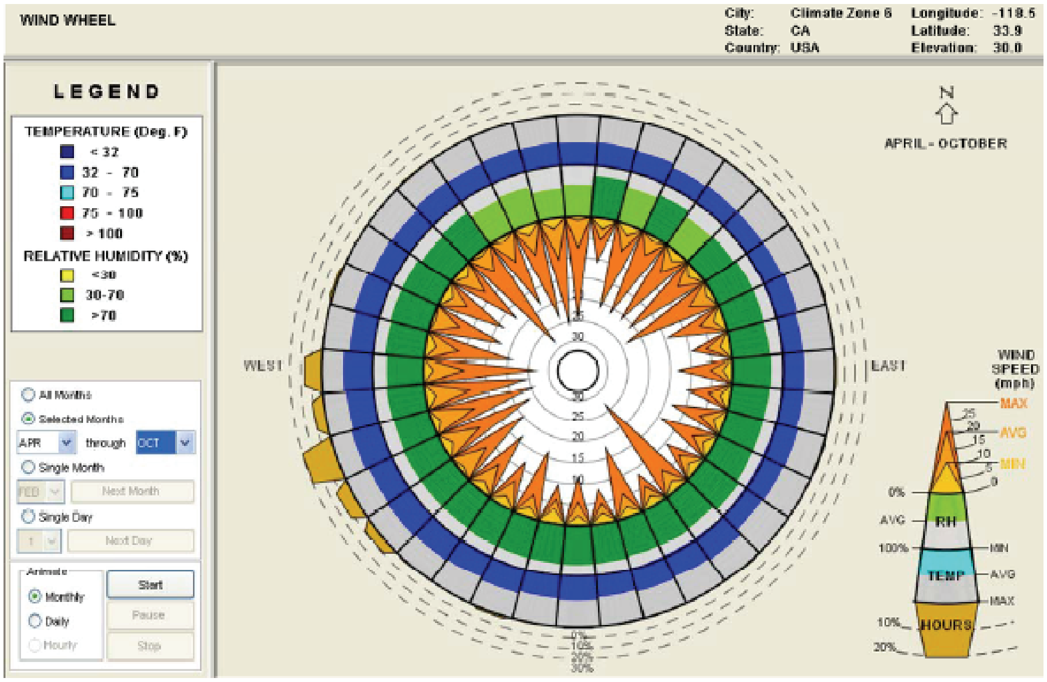


Fig. 23. Weather Data Apr to Oct

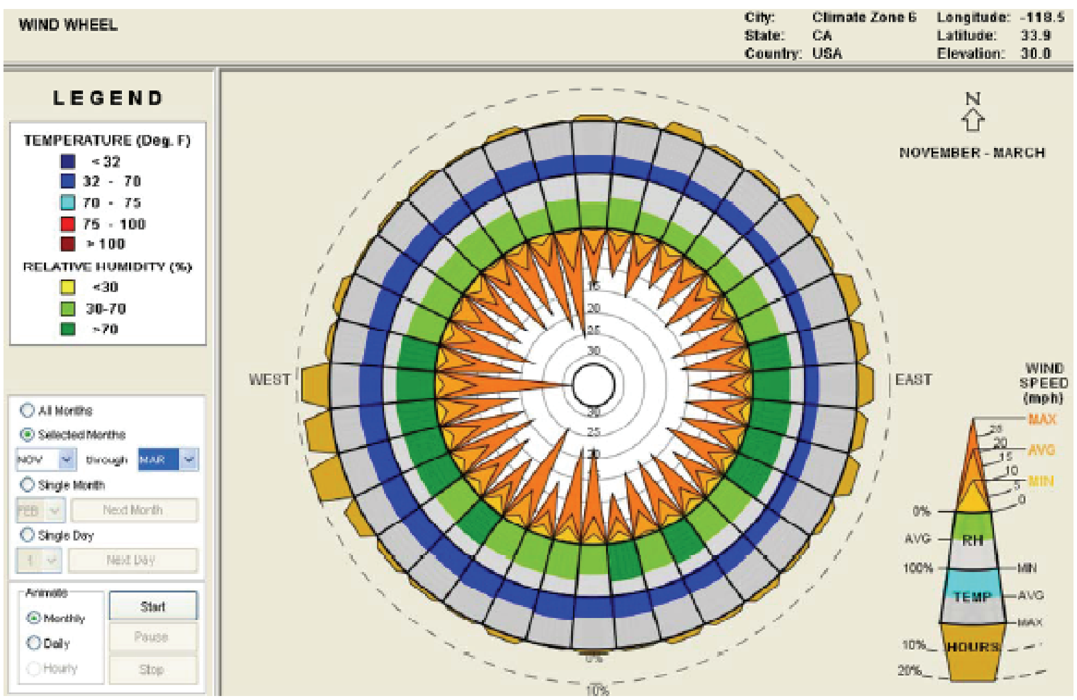


Fig. 24. Weather Data Nov to Mar

MONTHLY WIND SPEEDS

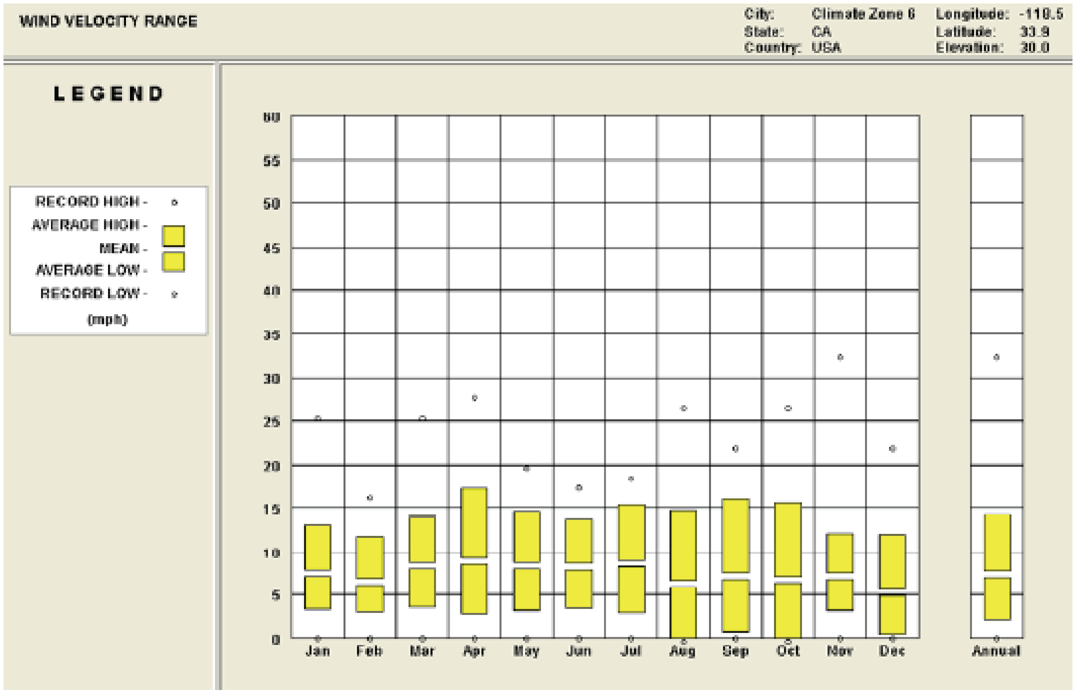


Fig. 25. Annual Wind Speed Graph

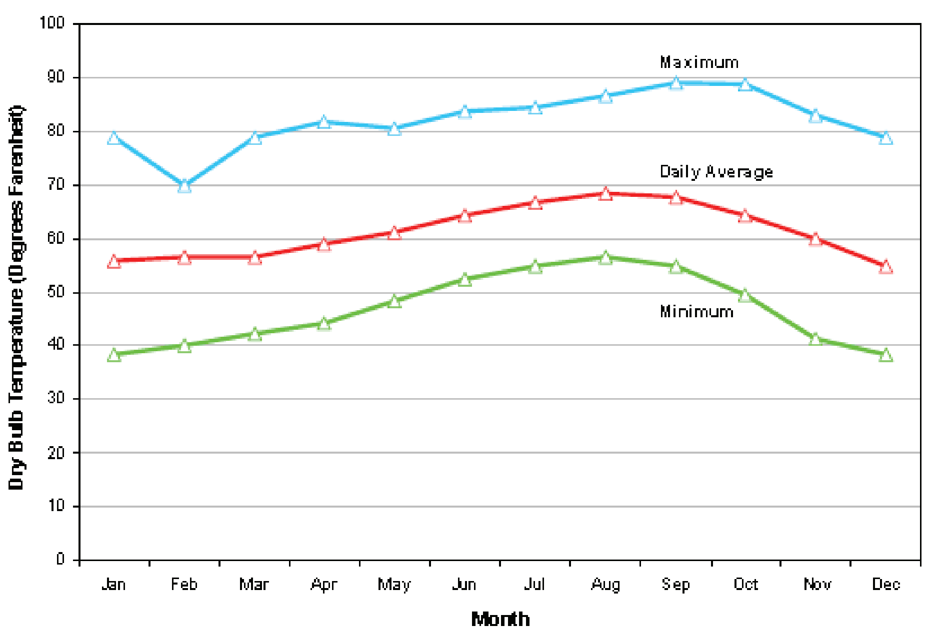
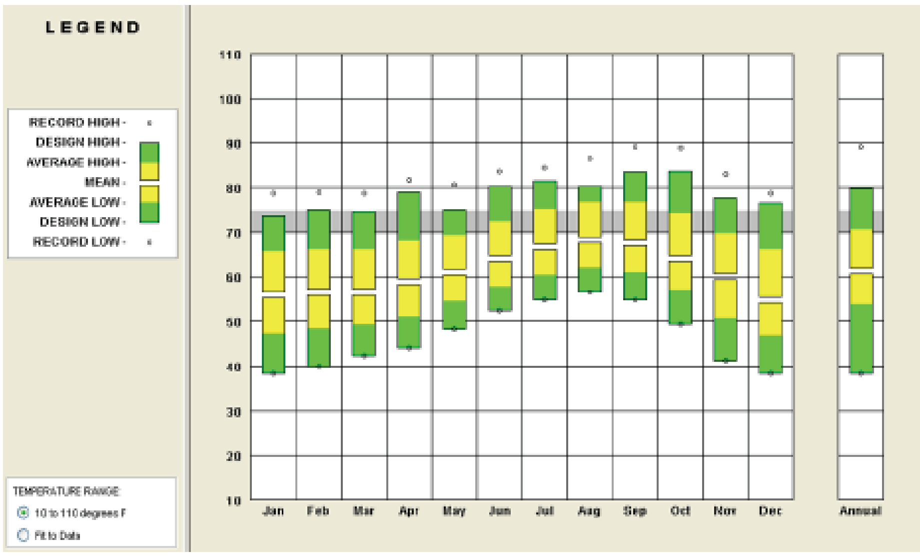


Fig. 26. Monthly Dry Bulb Temp.

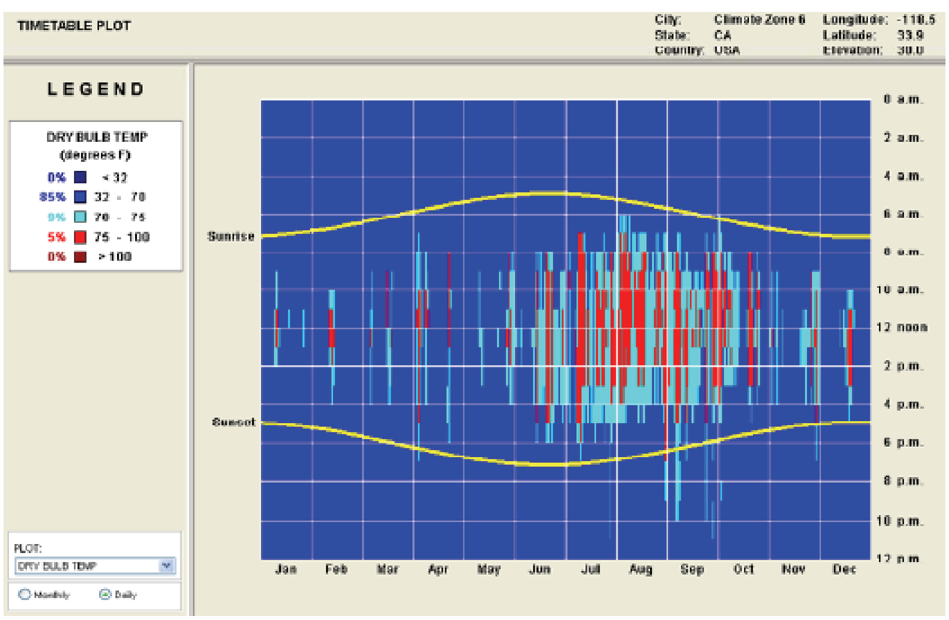
MONTHLY DRY BULB TEMPERATURE



Source: Climate Consultant 3.0 - California Climate Zone 6
Note: Design High assumes only 1% of hours exceed during the month exceed this temperature. The comfort zone is defined as 70 – 75 degrees F.

Fig. 27. Annual Mean Dry Bulb Temp.

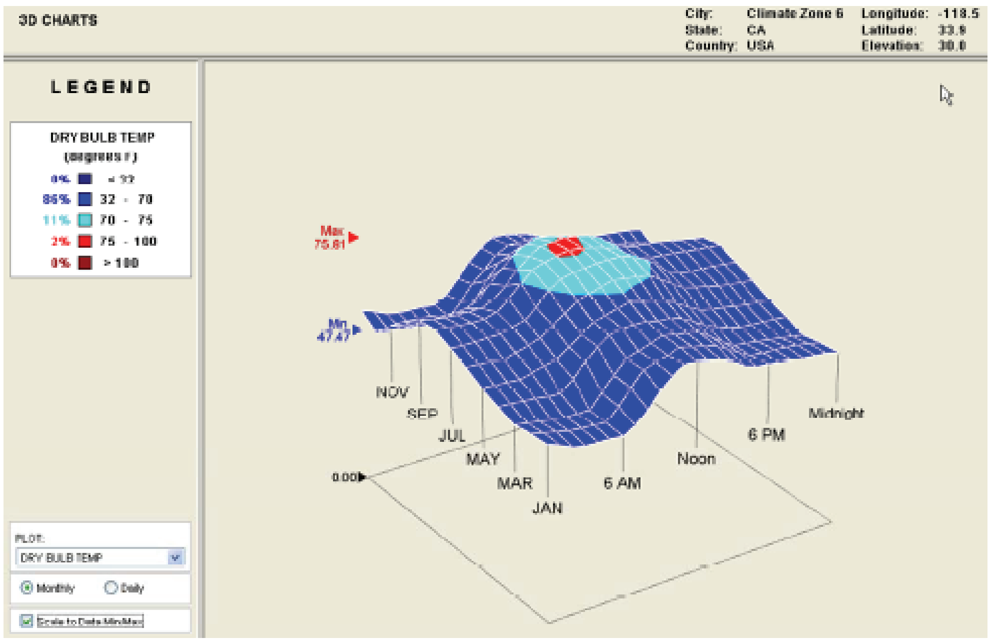
DRY BULB TEMPERATURE VS TIME OF DAY



Source: Climate Consultant 3.0 - California Climate Zone 6

Fig. 28.Annual Dry Bulb Temp vs. Time

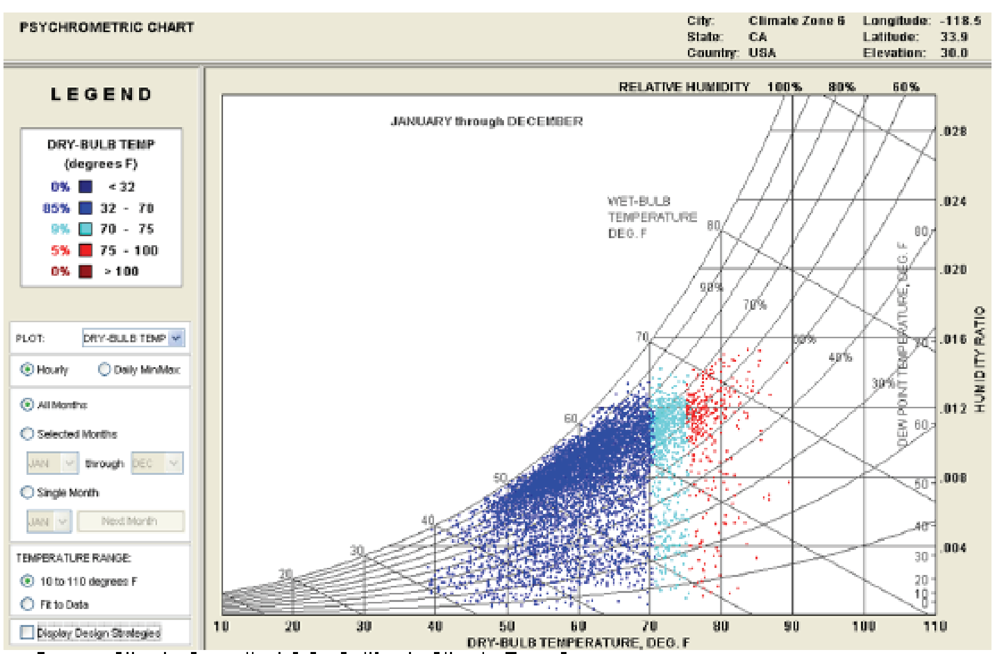
3D PLOT OF DRY BULB TEMPERATURE VS TIME



Source: Climate Consultant 3.0 - California Climate Zone 6

Fig. 29. Dry Bulb 3D Graph

PSYCHROMETRIC CHART



Source: Climate Consultant 3.0 - California Climate Zone 6

Fig. 30. Thermal Comfort Chart

RELATIVE HUMIDITY VS DRY BULB TEMPERATURE

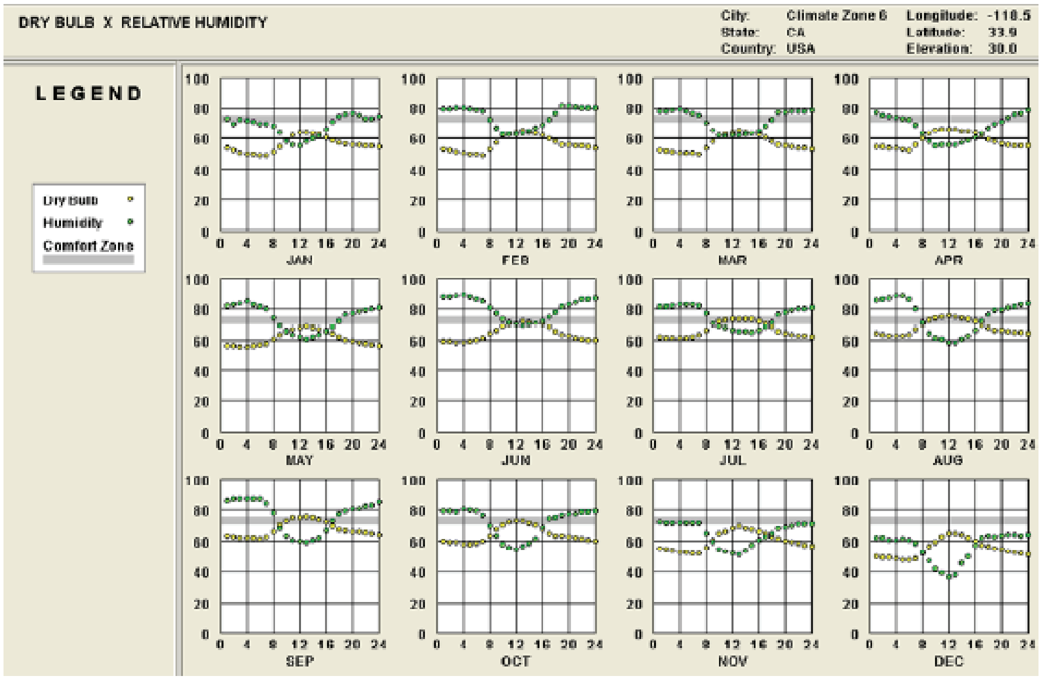
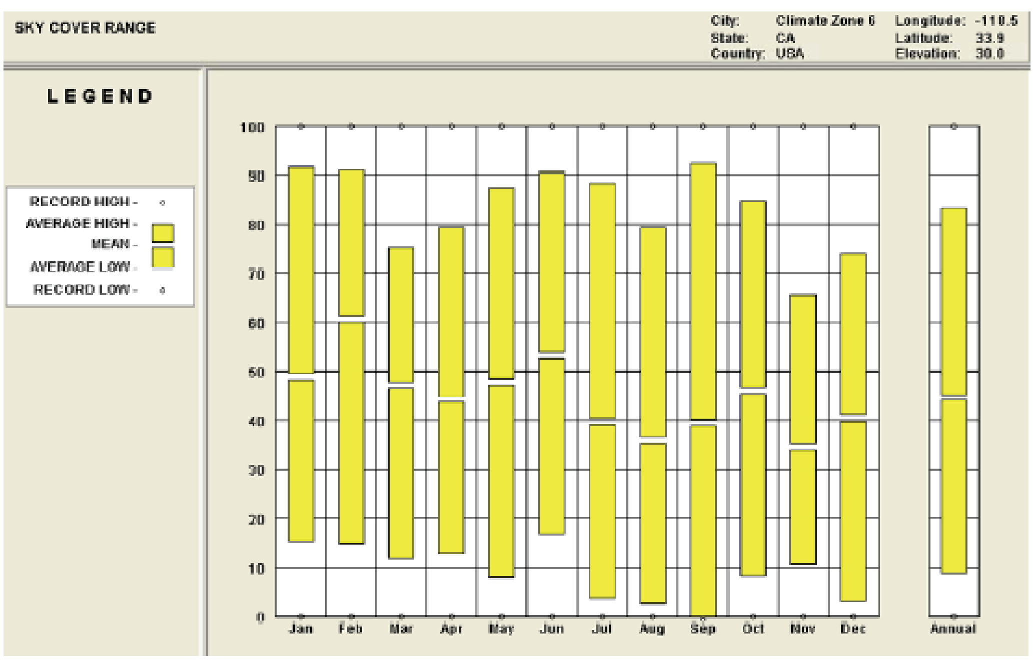


Fig. 31. Annual Relative Humidity vs. Dry Bulb Temp

AVERAGE MONTHLY SKY COVER



Source: Climate Consultant 3.0 - California Climate Zone 6

Fig. 32.Annual Average Sky Cover Graph

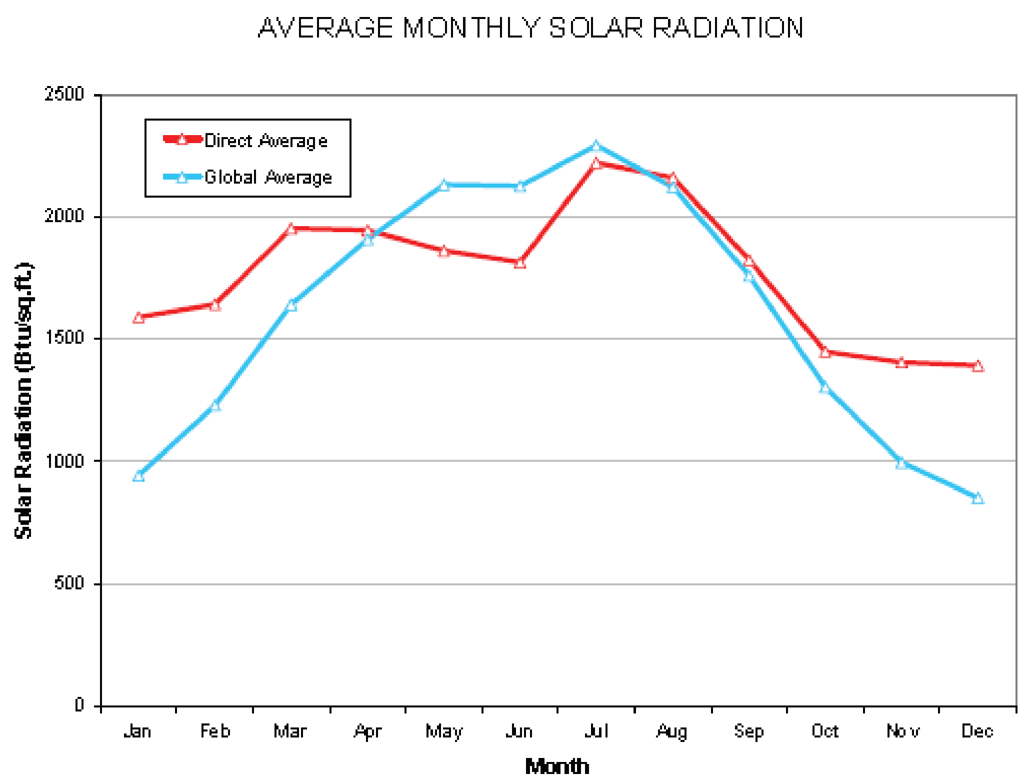


Fig. 33. Annual Average Solar Radiation

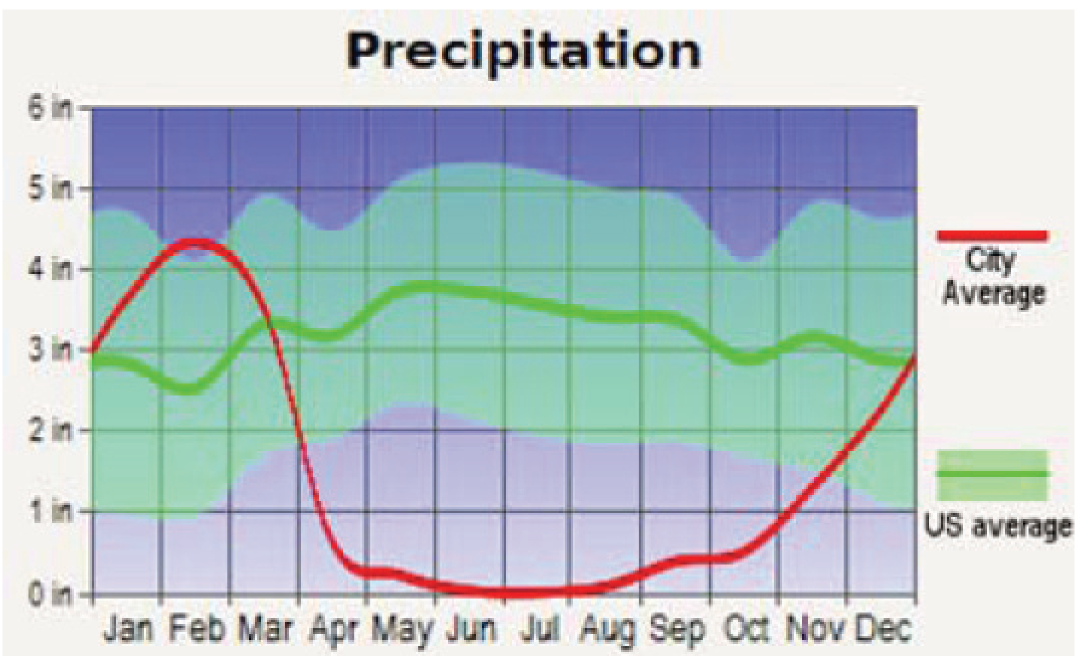


Fig. 34. Annual Precipitation

Site and/or Context Documentation/Analysis

The competition site is located at the intersection of the Isla Vista School Playground, the Camino Corto Open Space, and West Campus area. Just north and west of the site is the UCSB Orfalea Family Children Center, a day care center for children of UCSB students and faculty, and southwest of the site is the remaining Devereux school and residence.

The site for both competitions will be located directly north of the Campbell Barn. An approximately 4,000 sf. plaza of permeable paving and landscaping will be planned in front of the barn. On the north side of the plaza will be the site for the Challenge 1 History and Environment Center. On the west side will be the site for the Challenge 2 Student Residence.

For the purposes of Challenge 1, the site and plaza should be considered flat and free of surface groundwater. Entrants should assume that the three existing buildings within or adjacent to the Challenge 1 site: 364 Rudy House, 359 and 356 West FM and CARP Storage, and 357 Barn (Fig.36) will be removed. The line of Eucalyptus trees to the west of the Challenge 1 site follows the access road and was probably planted by the Campbell family. While these trees are not native to this area, they will be retained adjacent to the site.

West Campus

West of Isla Vista is West Campus, the site for this year's Competition Challenge. This area, located on a mesa above the ocean and bounded by a coastal slough, has a rich natural environment with many historical elements still extant. The mesa hosts upland grassland with riparian fingers feeding the Devereux Slough. It once contained numerous vernal pools which, along with the slough, supported much wildlife including migrating birds and waterfowl. The shores of the slough were also the site of one or more Chumash Villages.

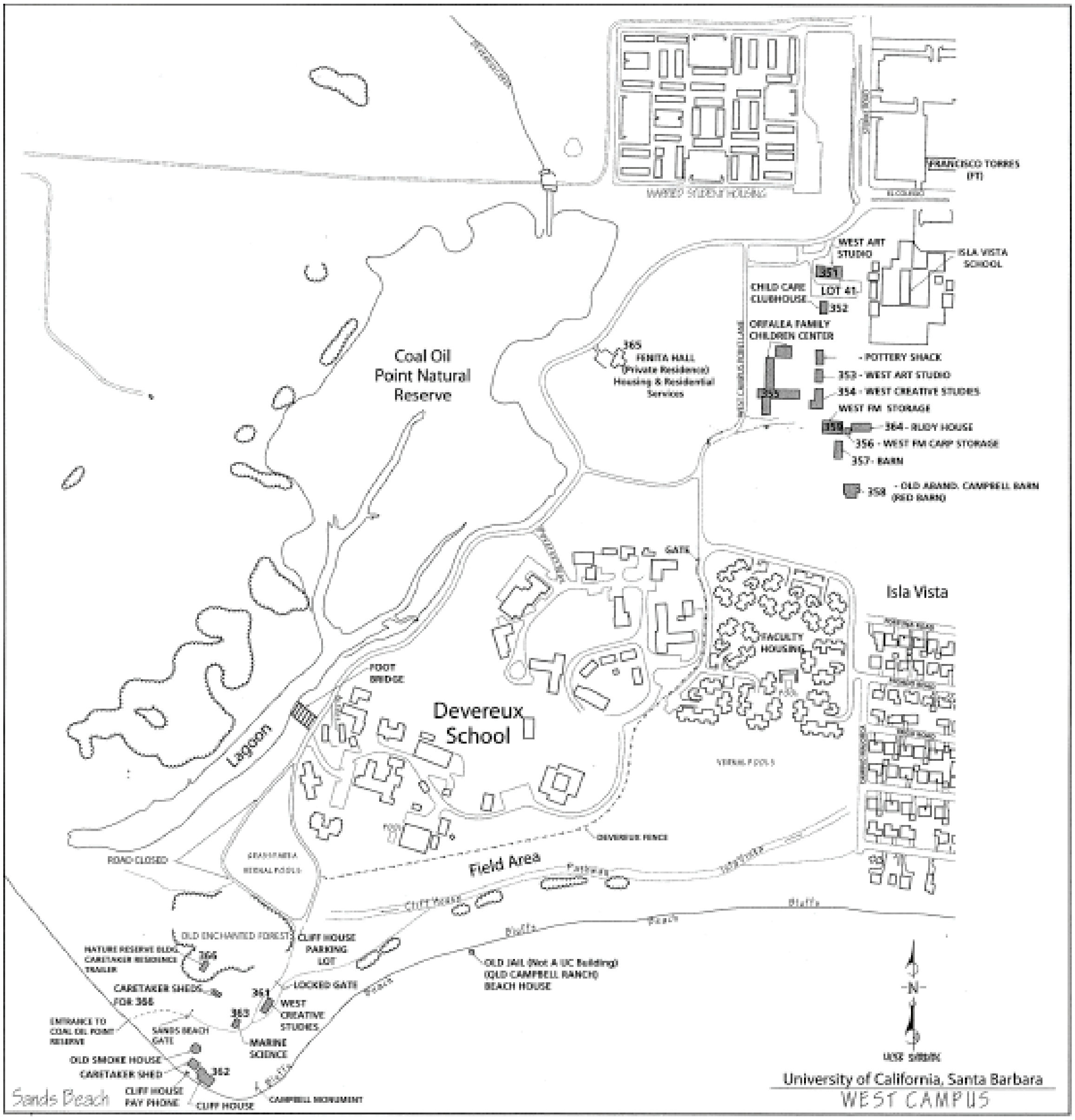


Fig. 35. UCSB West Campus Map

After the Spanish moved into the area it became part of a Spanish Land Grant, Rancho de Los Dos Pueblos. The land was grazed heavily by cattle for many years, destroying most of the vernal pools. In 1919, 500 acres was purchased by Colin Campbell, who built an estate on the mesa overlooking the ocean. Many of the original buildings and roads from the Campbell Ranch are still present on the West Campus, including the Campbell Barn that will be part of Challenge 1. In 1945, the

Campbell Ranch was purchased by Helena Devereux, who established a west coast branch of her Devereux School for physically and emotionally disabled children and adults. The Devereux School used the Mediterranean-style Campbell House (Fig.37) as their administrative building, and built residential buildings around it (See West Campus Plan). In the 1960s, the Devereux Foundation began selling portions of their property to the University, which established West Campus. These sales were completed in March 2007 when the university purchased the last parcel including the buildings. For the near future, the Devereux School will lease back some of the buildings from the university and continue in operation, but the original Campbell House, (now named Jacobs Hall, after a donor who paid for its renovation) will now be under University Control.

Fig. 36. The courtyard of the old Campbell House. It was built in the 1920s in a Spanish or Mission Revival Style. The Devereux School used this building as their main administrative building.

Some portions of the West Campus have been preserved as open space (Fig.38). The university set aside a natural reserve area in the 1970s, Coal Oil Point Reserve. This reserve includes the Devereux Slough and so bounds the current West Campus. The area is named for the Oil Cracking Plant that briefly was in operation on adjacent property. On the other side of West Campus, Isla Vista Parks and Recreation purchased land and is in the process of restoring it as open space: Camino Corto

Open Space and Del Sol Vernal Pool Reserve. These sites are directly adjacent to the Isla Vista Elementary School. Students use paths in the open space to walk to school. The Camino Corto property borders directly on the Competition site.

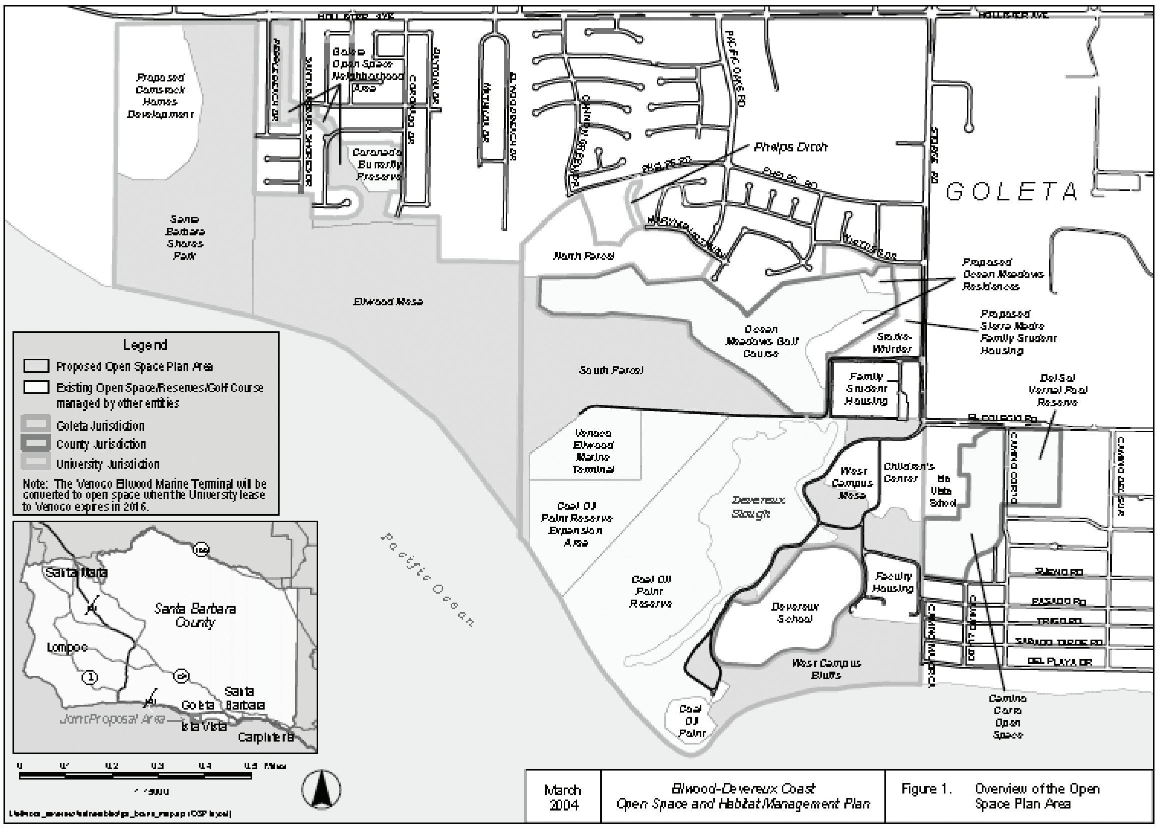


Fig. 37. Open Space Plan

Campbell Barn

The Campbell Barn (Fig.39) was designed in the 1920s, in an English Polo Barn Style, by Mary Craig, an important regional architect. Architectural drawings for the Barn will be available to entrants in the competition. After the university purchased the barn, it was used by student and faculty equestrians to house their horses and hay however an earthquake in 1978 caused significant damage to the barn's foundation. Since that time the building has been “red-tagged” by the local building official, and closed until structural repairs making the barn safe for access have been completed. The barn remains one of the oldest buildings on campus and with its links to the Campbell Ranch and Mary Craig; it qualifies as a historic landmark. The Challenge 1 program will adapt the barn for re-use as a display space, and the Challenge 2 program will design housing and tack rooms for a new university student equestrian program.

Fig. 38. Campbell Barn as seen from Slough Road looking east. Camino Corto Open Space is beyond the white board fence.

The Future

Since the university first acquired the West Campus Property in 1967, there has been much discussion of how to develop it. Expanding housing and services to students and faculty is a very high priority, and so faculty housing was built between Isla Vista and the Devereux School property (Fig.38), and the Child Care Center was built near Isla Vista School. But the university has yet to significantly address the intersection of open space and historical structures in West Campus. This year's competition will serve as a proposal for how to manage some of the competing interests of development, historical preservation, environmental education and open space management on the Old Campbell Barn Site.

Climate

As has been mentioned above, Santa Barbara's weather is the classic Mediterranean climate, with mild temperatures in the winters, warm temperatures in the summer, and about 300 days of sunshine a year. Average high temperatures are 74 degrees, while average lows are in the 50's. Summer high temperatures are mediated by coastal fog in the mornings and cooling breezes from the west in the afternoons. Cold winter winds tend to come from the east or east-southeast as the weather data indicates in the research documentation chapter. Precipitation comes as rain almost exclusively in the winter months. The annual precipitation is approximately 15 inches. Santa Barbara boasts that there is no "offseason" in their weather; it is beautiful year-around.[13]

Utility Providers

Power: Southern California Edison
Gas: Southern California Gas Company
Water: Goleta Water District which uses surface water from the Cachuma Reservoir on the Santa Ynez River as well as ground water from district owned wells.
Solid waste: Santa Barbara County Waste Management District. Solid waste is buried in Tajiguas Landfill.

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[13] Heatherly.

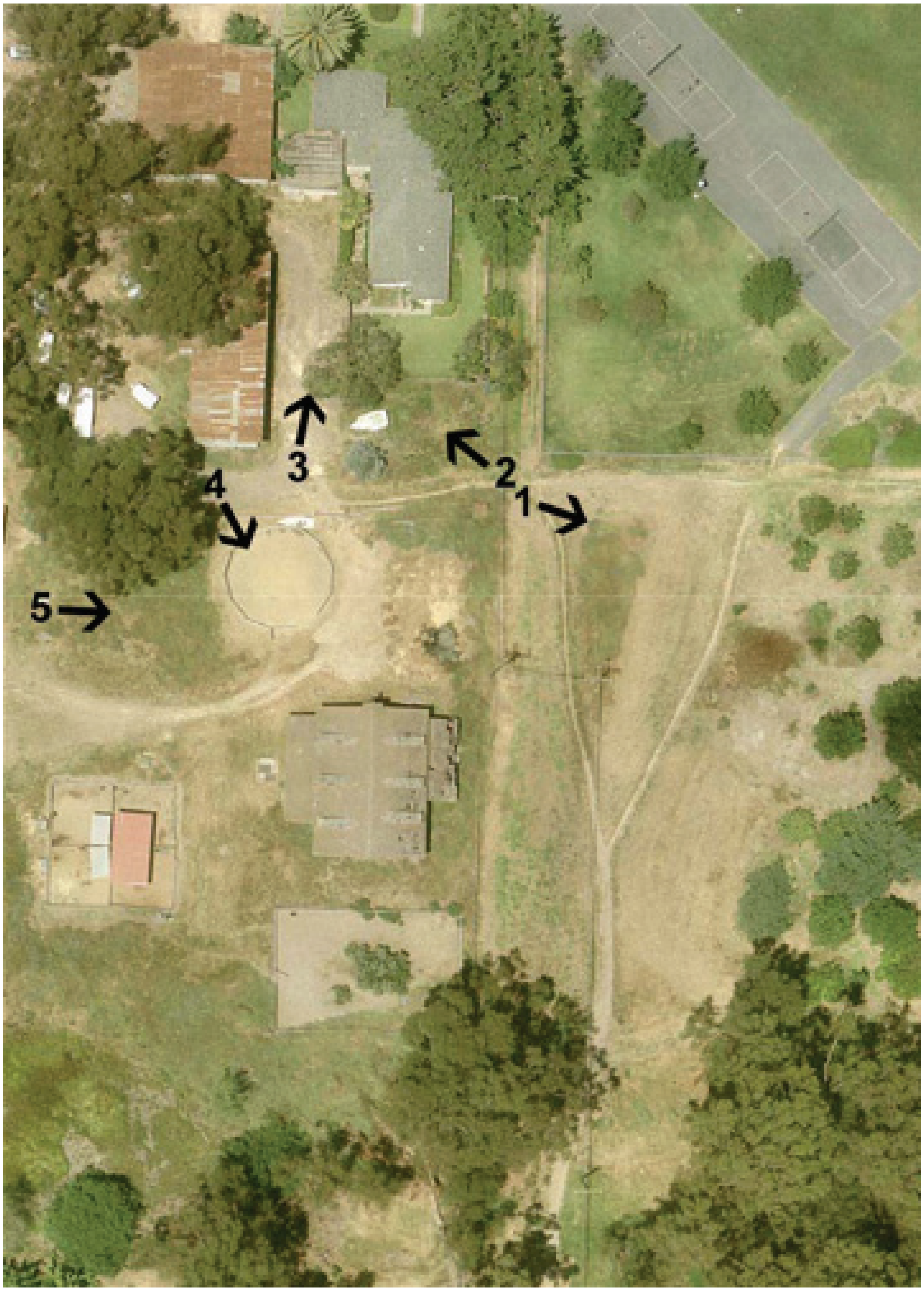


Fig. 39. Aerial View of the Competition Site. North is up in this photo. The numbers and arrows refer to the Site photos which follow. The Campbell Barn is approximately in the center. Damage to the roof of the barn is visible. The trees at the bottom are the edge of a riparian zone which feeds the North Finger of the Devereux Slough. The circular fence at the 4 arrow no longer exists. The Caretakers House (Rudy House) is the gray roofed structure at the top. The black asphalt areas at the top right are paved ball courts for the elementary school playground.

The following images are taken during a recent visit to the site. The context and surround building are shown in multiple images in plan and still images. Also provided are a flood control maps that have numbers that correspond to the images provided, Google Earth satellite images, and interior shots of the Campbell Barn.

Fig. 40. 1) Site 2) Dormitories 3) Panoramic shot of open space 4) Elementary School 5) Faculty Housing 6) Devereux School 7) Devereux Slough Protected Reserve 8) Isla Vista Neighborhood 9) Vernal Pools, Paths, and small playground 10) Open Space

Fig. 41. Google Satellite Image

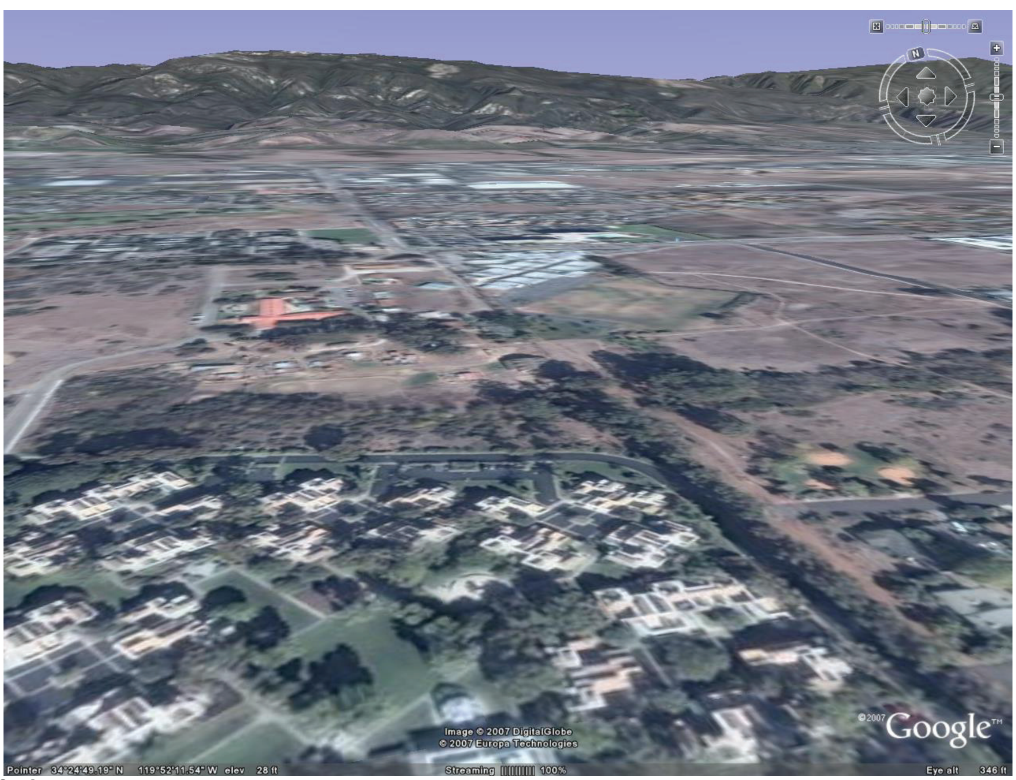


Fig. 42. Google satellite image looking toward the Ynez mountain range

Fig. 43. Google satellite image looking toward the Channel Islands

Fig. 44. Image 1

Fig. 45. Dormitory image 2


Fig. 46. Image 3


Fig. 47. Image 5

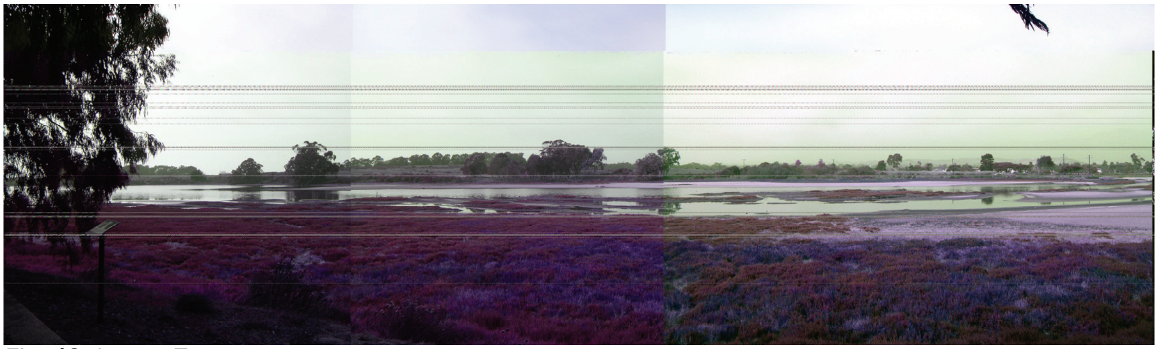


Fig. 48. Image 7

Fig. 49. Image 9

Fig. 50. Vernal Pools

Fig. 51. View of Site from Faculty Housing

Fig. 52. Small Playground for Isla Vista Community

Fig. 53. Interior Hay Stack Loft

Fig. 54. Horse Stables

Fig. 55. Barn Roof Truss System

Program

Design Challenge 1

Students entering Design Challenge 1 are invited to design an Environment and History Center. The center will be comprised of a 25,000 sf. new building, an exterior plaza, and the reuse of an existing approximately 3,500 sf. historic barn building. The new building will be located on the site given in the Competition Site Plan.

The center will serve a dual role of research and education about the environment and history of the West Campus area. It will be open to the public as well as to students and faculty of UCSB and will host programs for UCSB students, adults, and kids, educating them about this special area. It will partially serve as a visitor's center for the Camino Corto Open space, and will explain the special nature of the vernal pools in the area. A new vernal pool will be constructed on the east side of the plaza on the Camino Corto property to serve as a demonstration pool for the center. Example programs that could be hosted or presented in this center could include: Archeology of the Site, History of the Chumash Inhabitants, History of the Mission Rancho Period, History of the Campbell Ranch and the remaining buildings on site, History of the Barn and its construction, Ecology of the Coastal Region, Animals and Plants of this special area, the Devereux Slough and its unique environment, Ecology of Vernal Pools, Ecology of the shoreline, Agriculture on the site throughout history, etc.

Because of its multiple roles of teaching, display, and research, the new building will have a number of classrooms, a library, and two display spaces, one in the lobby entry way. The primary display space, however, will be across the plaza in the Barn.

The original drawings of the barn show a main building with 5 bays, the center aisle for hay storage flanked by two rows of stalls for the animals, and access aisles on the outer side of the stalls. The lean-to structures on the sides of the barn enclosed a separate stall for sick animals, a kitchen, 2 box stalls, and a harness room.

The Barn's status as a potential Landmark Building requires that its exterior construction, color, and finish not be modified. All the existing doors and windows must be maintained and re-used as much as possible. All changes to the building required by the adaptive re-use must be on the interior. In order to be as sustainable as possible, students are encouraged to re-use the interior structure of the barn. Part of the intention of using the Barn as display space is also to display the inside of the barn as it was when it was in use. Thus, retaining the open rafters, the three aisle ways, and the stall construction is desirable when adapting the barn. The lofts that were built over the stall areas were probably accessed by a wood ladder and were most likely used to store hay and additional feed. The program does not require that visitors access these lofts, however if the designers choose to make the lofts part of the display function, then disabled access must be provided by adding either an elevator or a ramp. As this would constitute a significant change to the barn construction, entrants are discouraged from using the barn lofts for a public function. The repair of the barn exterior is not part of the scope of the Competition. Students may assume that the exterior and the roof have been fully restored back to their original condition. Left: Interior of the barn, looking north. Note the stalls on the ground level and the partial lofts above. The high doors were used for ventilation and for bringing in hay to the lofts over the stall areas. Right: Looking south along the west side stalls with the "Runway" or exterior access aisle on the right. Note that the interior partitions that would normally enclose the stalls have been removed over the years.

Any discrepancies between the photos of the barn and the drawings of the barn will be disregarded. In the case of major discrepancies, students are to use the design and dimensions shown in the drawings.

The plaza will be constructed of permeable paving or some other sustainable alternative. Entrants will assume that the plaza can be constructed on grade with the entrance to the barn, so that the main barn doors on the north side may be used as disabled access. The paving material should be strong enough to allow for temporary vehicular access, when deliveries are made to the barn or the student residences of Challenge 2. Appropriate landscaping should be added to the plaza.

As always with public buildings, all public spaces must be accessible to disabled persons. Exterior entrance stairs are to be avoided, and interior elevators or ramps are to be provided in addition to stairs to reach the upper floors. Design judges will be looking for the new building to be sensitive to the barn's design and to acknowledge its agricultural and historic elements without directly copying them. The new building should take its place in the history of the site and the composition of the new plaza without overwhelming the barn or the residences.
A more detailed program of suggested square footage for both buildings is given below:[14]

Table 2. Program for Main Building and Barn

Program Elements	Sf.(each)	SF(total)
Environment and History Building		
Entrance Lobby/display space	2,000	2,000
Entrance Kiosk and Gift Shop	200	200
Classroom (adults)	1,000	1,000
Classroom (kids)	1,500	1,500
Laboratory Classroom (adults)	1,000	1,000
Laboratory Classroom (kids)	1,500	1,500

[14]Heatherly.

Lab Prep Room	500	500
Additional display space	1,500	1,500
Lecture Hall	2,000	2,000
Restrooms (1 of each type for each floor)	350	1,400
Library	1,500	1,500
10 Faculty/staff Offices	150	1,500
Administration Area: reception Director's office, Administration office, Conference room, Copy Room	1,200	1,200
Vending Machine/Break Room	500	500
Receiving Area/Delivery Entrance	500	500
Subtotal Interior space		17,800
Plus 40% for circulation		7,120
Total Interior Space E&H Bldg.		**24,920 sf.**
Barn		
Display Space	2,000	2,000
Entrance Kiosk/office	200	200
Managers Office	150	150
Staff Break Room	200	200
Gift Shop	300	300
One unisex public toilet	150	150

Total Interior Space – Barn*		3,000* sf.

Design Models

Classroom Design

The focus of the Leading Edge 2007/2008 competition is to improve a typical classroom by using a building simulation software tool. The size of a typical classroom is 28' x 32'. The typical height of a classroom a ceiling is 8' 7". These dimensions are being used in the base case model. The base case model is used to provide a base data to improve upon. Also, a selection of construction types and mechanical system will be chosen to gain a better in site into how different assemblies perform under simulated conditions. These construction types and mechanical systems will be discussed in the next section.

Construction Types

A variety of construction types were chosen for this project to determine the performance of each material. Within the REVIT MEP software, I am able to select the material and assembly of a particular design element. These design elements consist of Exterior Walls, Interior Walls, Roofs, Floors, Slabs, Doors, Exterior Windows, Interior Windows, and Skylights.

The selections of the materials for the Construction Types are Wood, Concrete, Steel, Concrete Masonry Units, and a Hybrid. The Hybrid assembly consists of CMU and Wood design elements.

Wood Construction

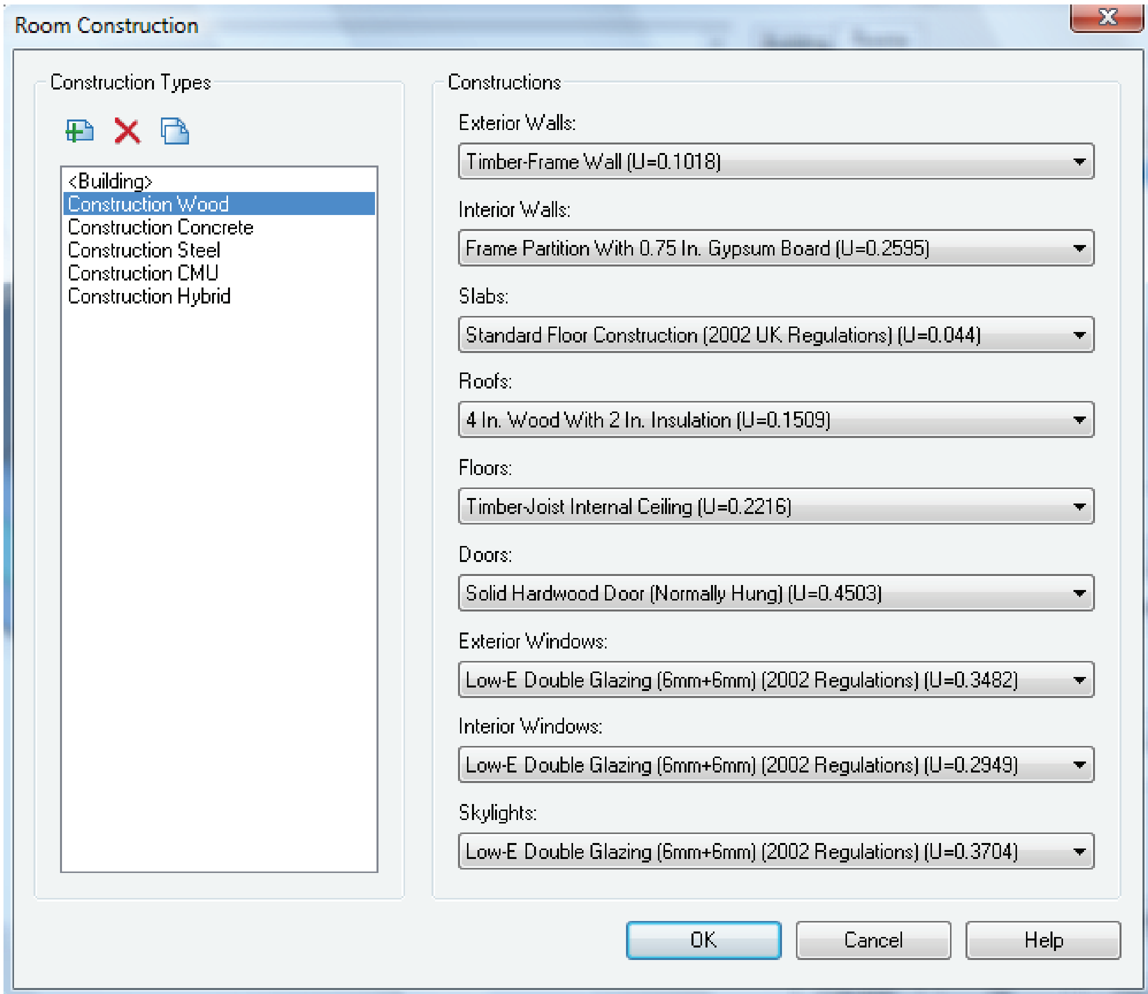


Fig. 56. Wood Construction Assemblies


Fig. 57. Timber Frame Wall

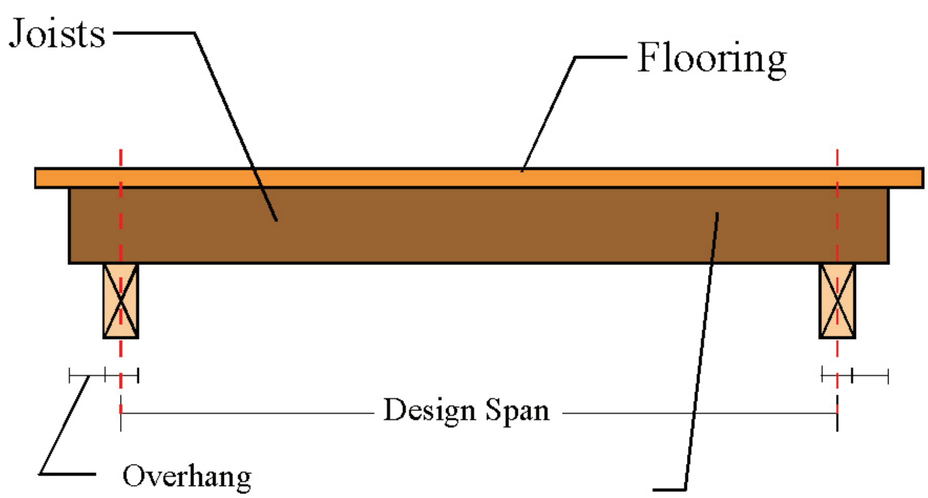


Fig. 58. Wood Floor Construction

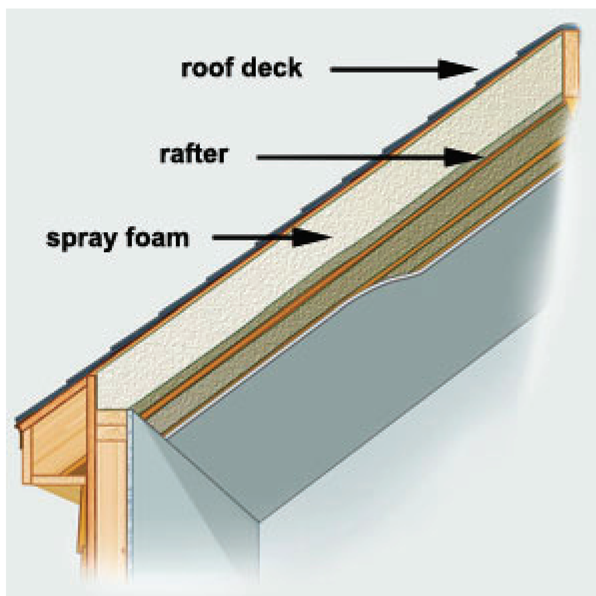


Fig. 59. Wood Roof Construction

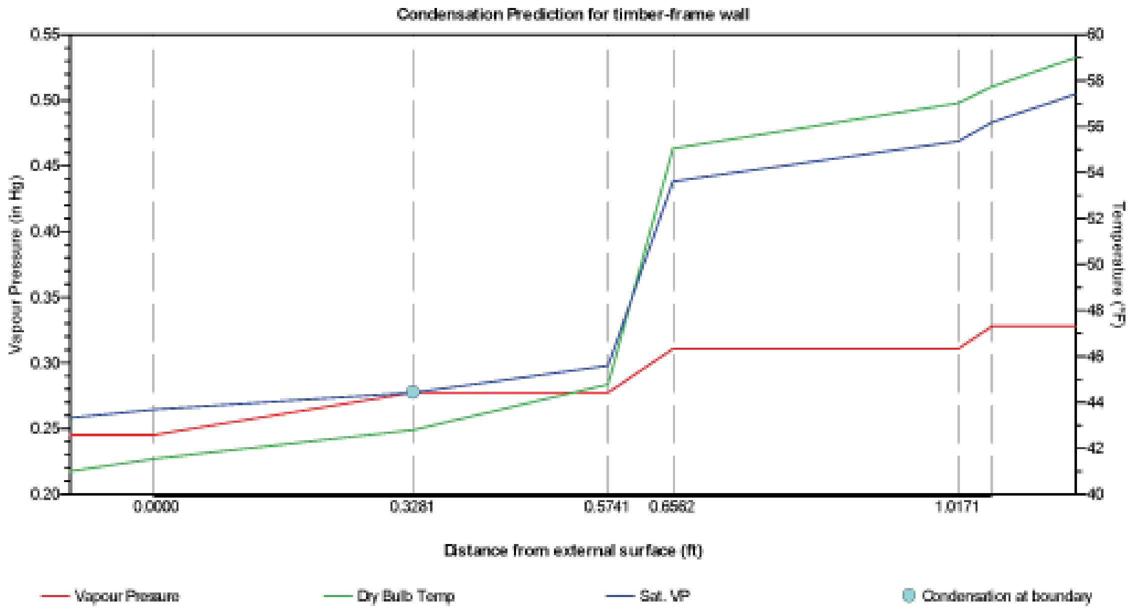


Fig. 60. Wood Wall Construction Condensation Prediction Graph

Concrete Construction

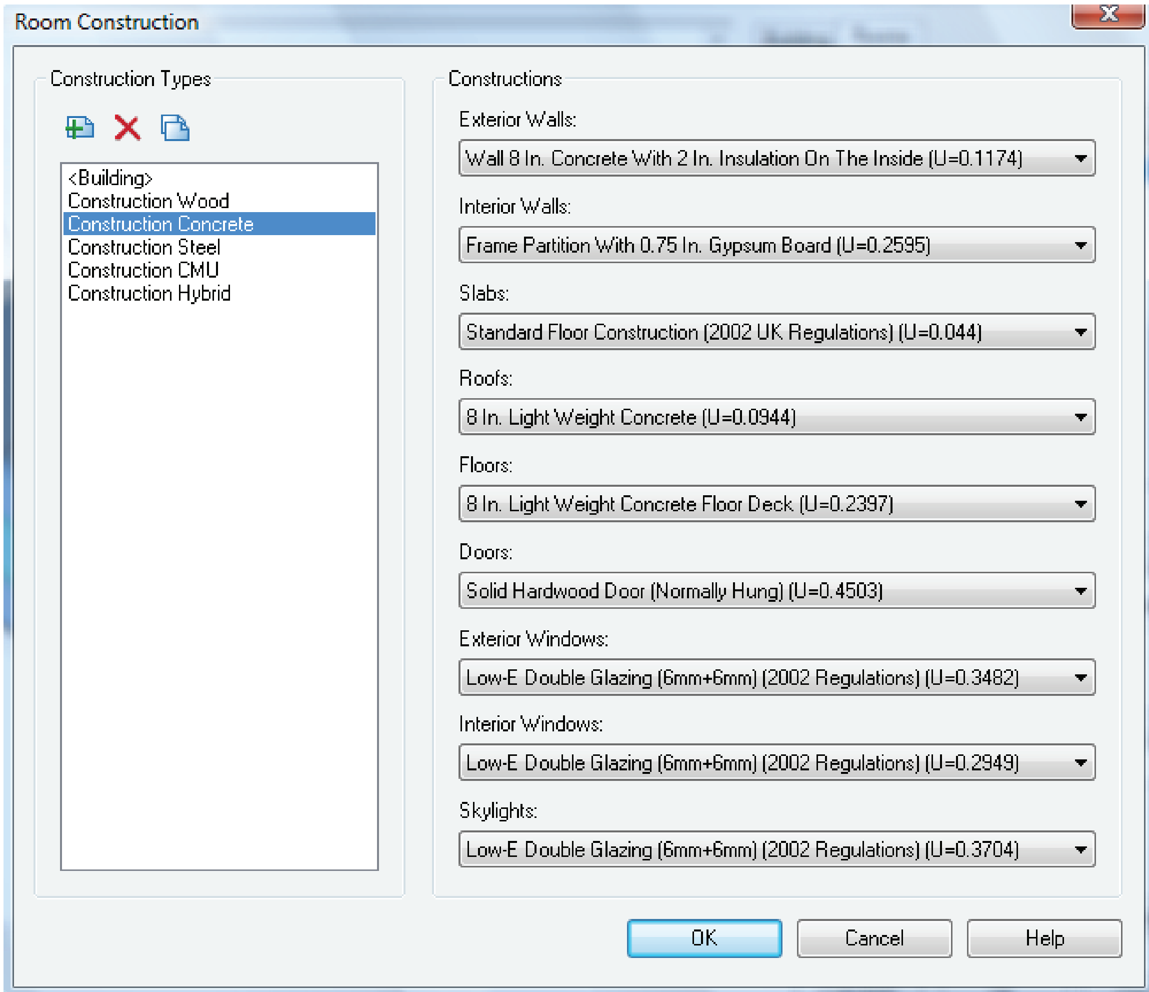


Fig. 61. Concrete Construction Assemblies

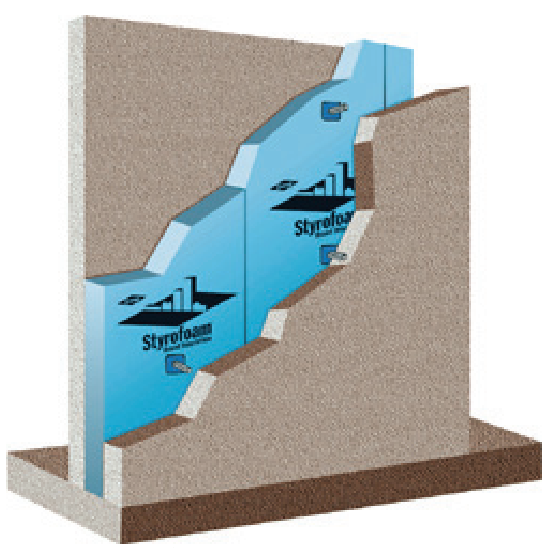


Fig. 62. Concrete Wall

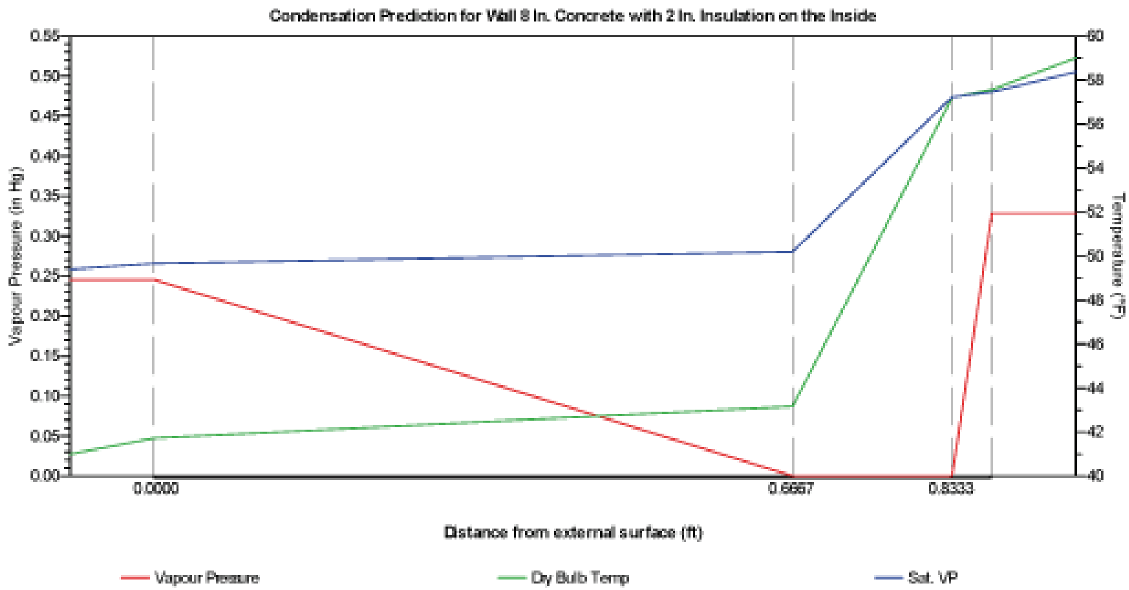


Fig. 63. Concrete Wall Condensation Prediction Graph

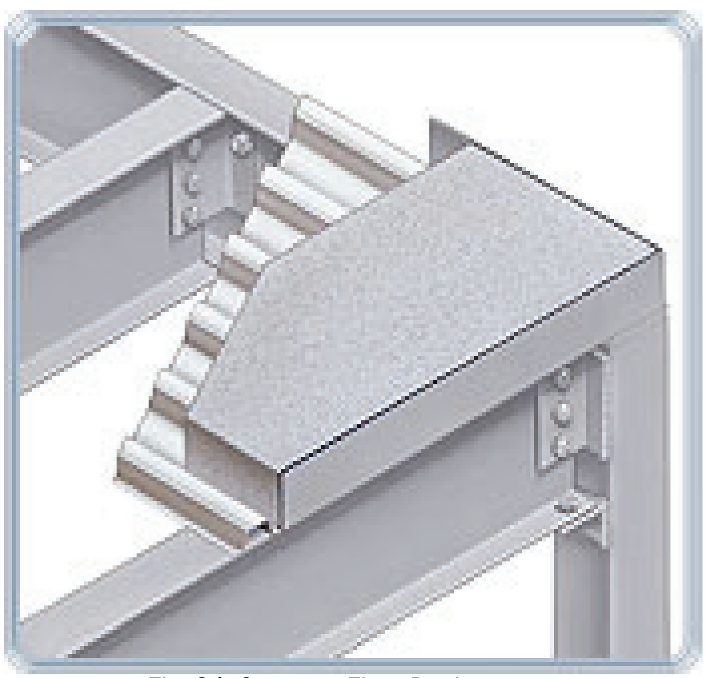


Fig. 64. Concrete Floor Deck

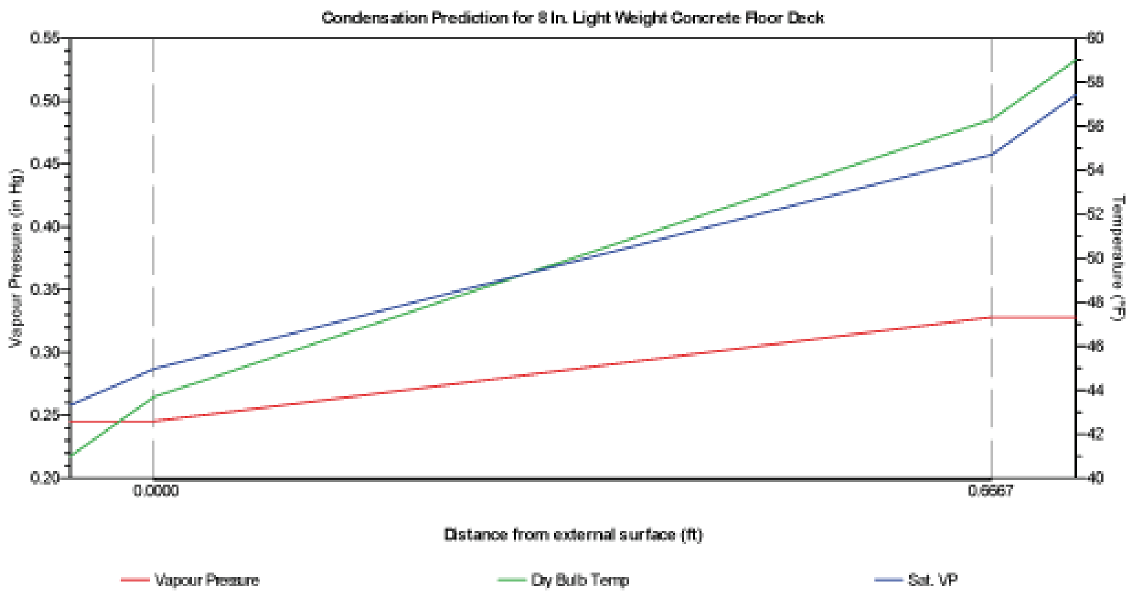


Fig. 65. Concrete Floor Condensation Prediction Graph

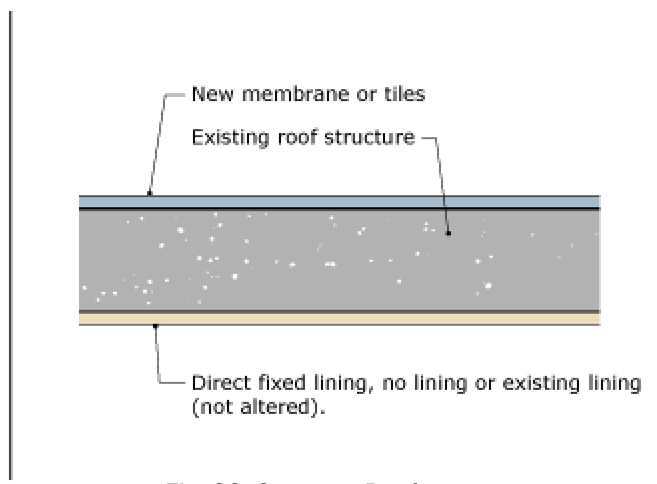


Fig. 66. Concrete Roof

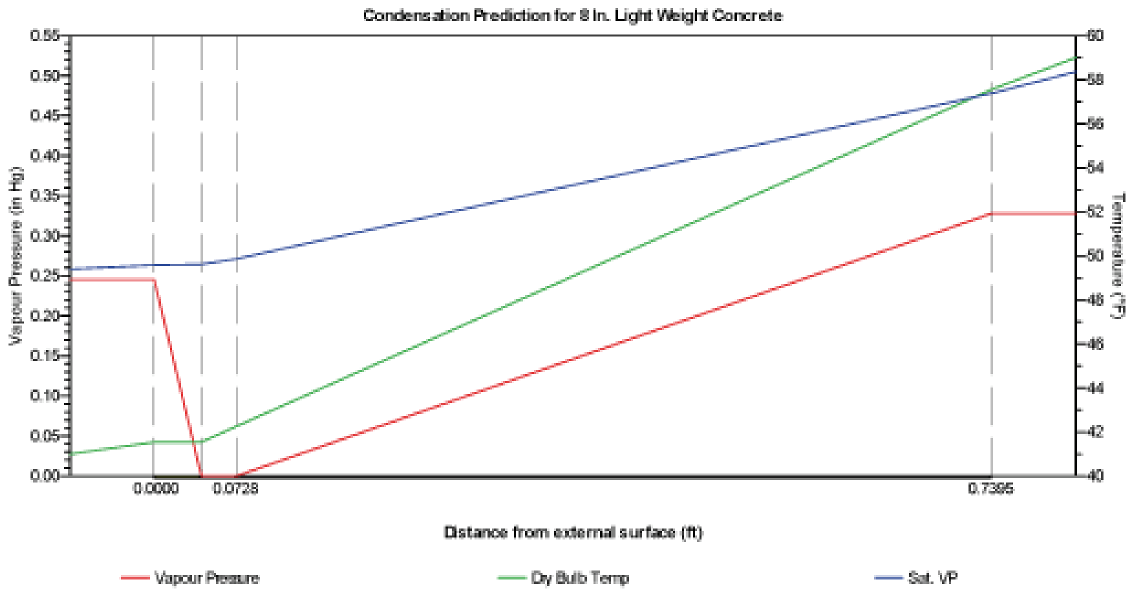


Fig. 67. Concrete Roof Condensation Prediction Graph

Steel Construction

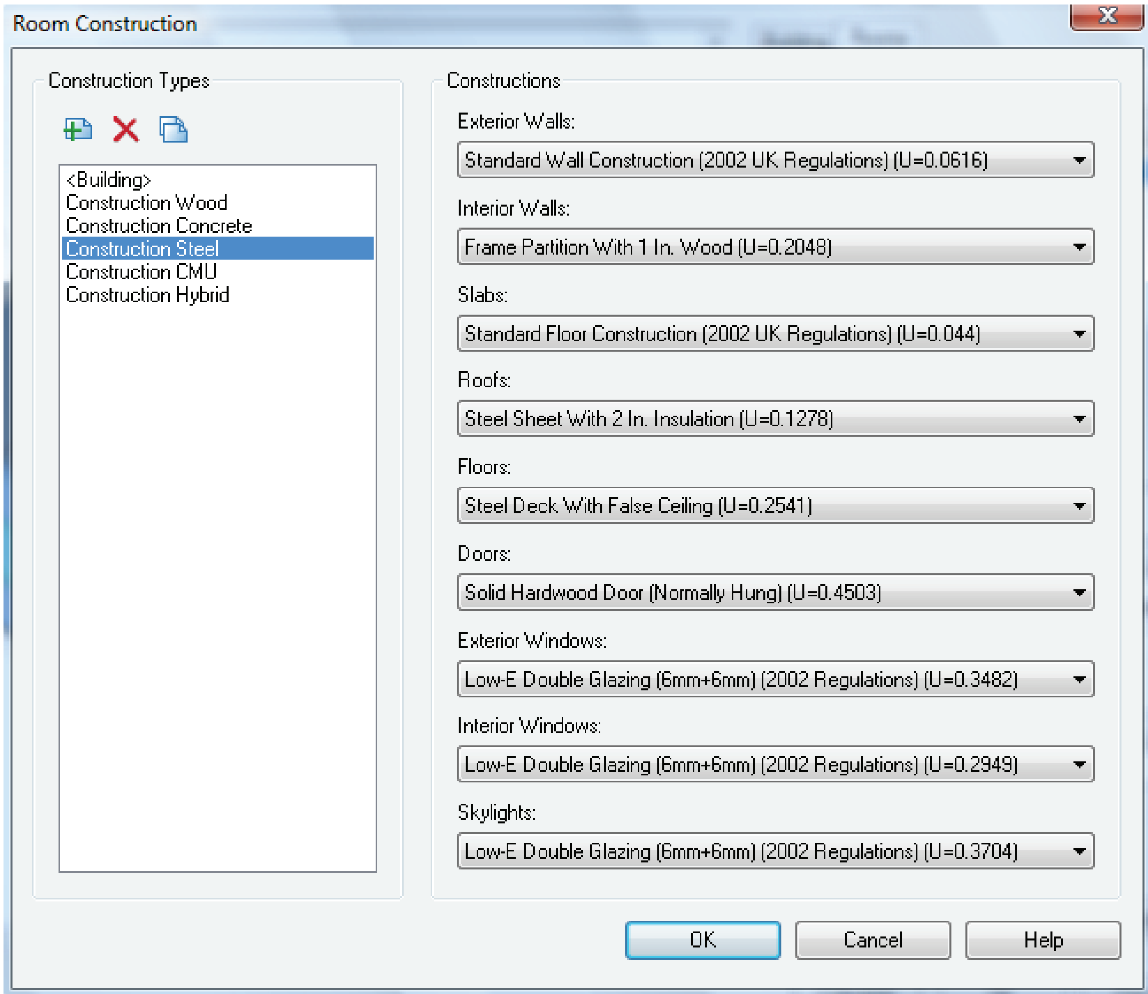


Fig. 68. Steel Construction Assemblies

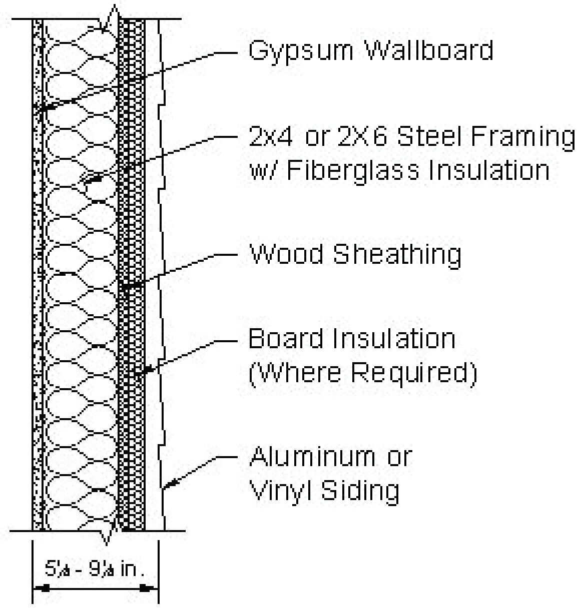


Fig. 69. Steel Wall Construction

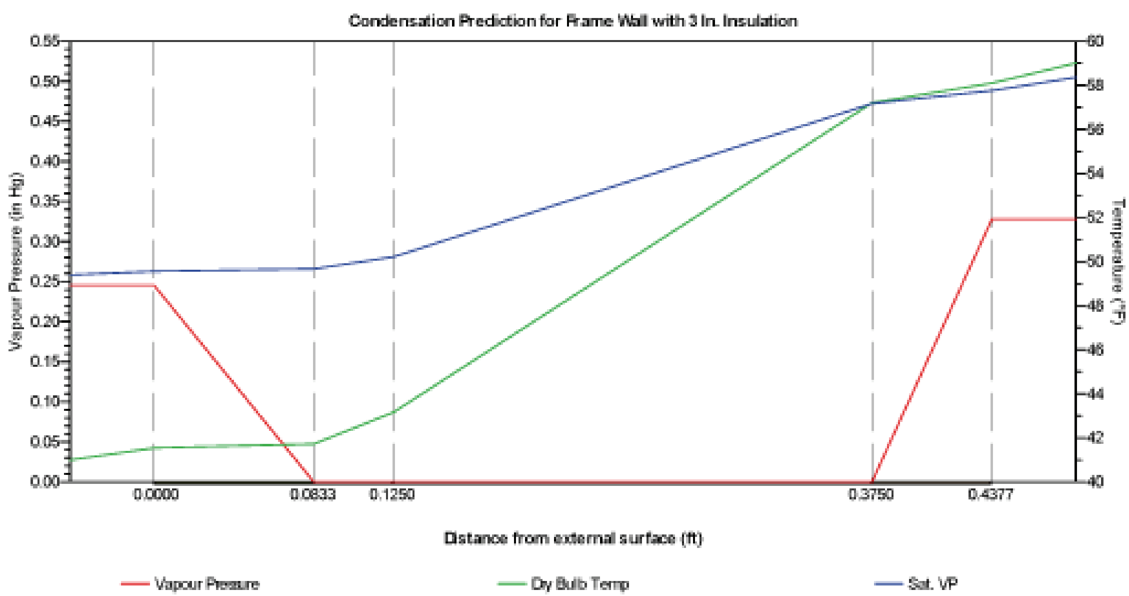


Fig. 70. Steel Wall Condensation Prediction Graph

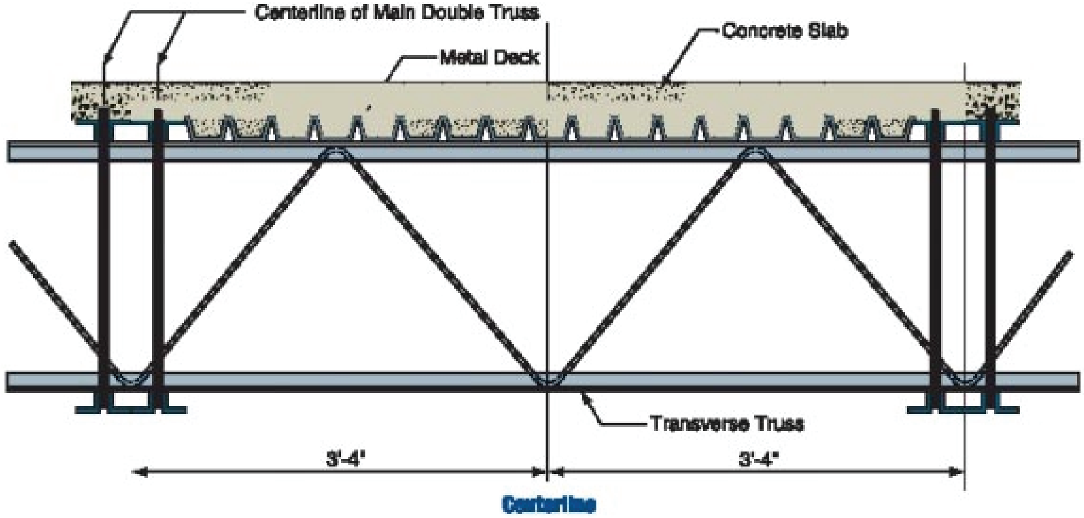


Fig. 71. Steel Floor Construction

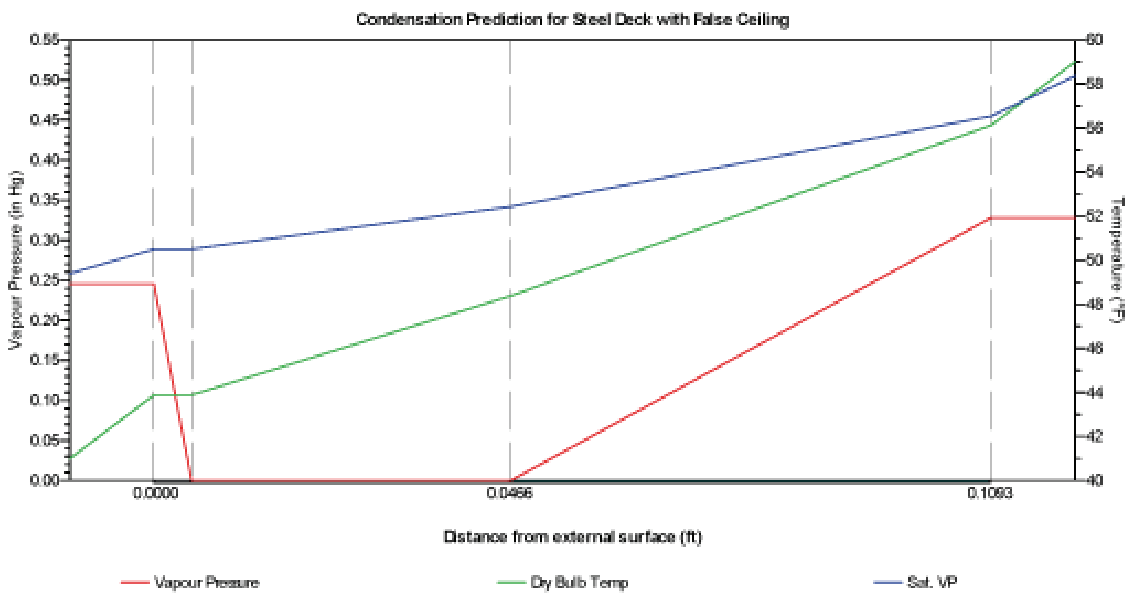


Fig. 72. Steel Floor Condensation Prediction Graph

Fig. 73. Steel Roof Construction

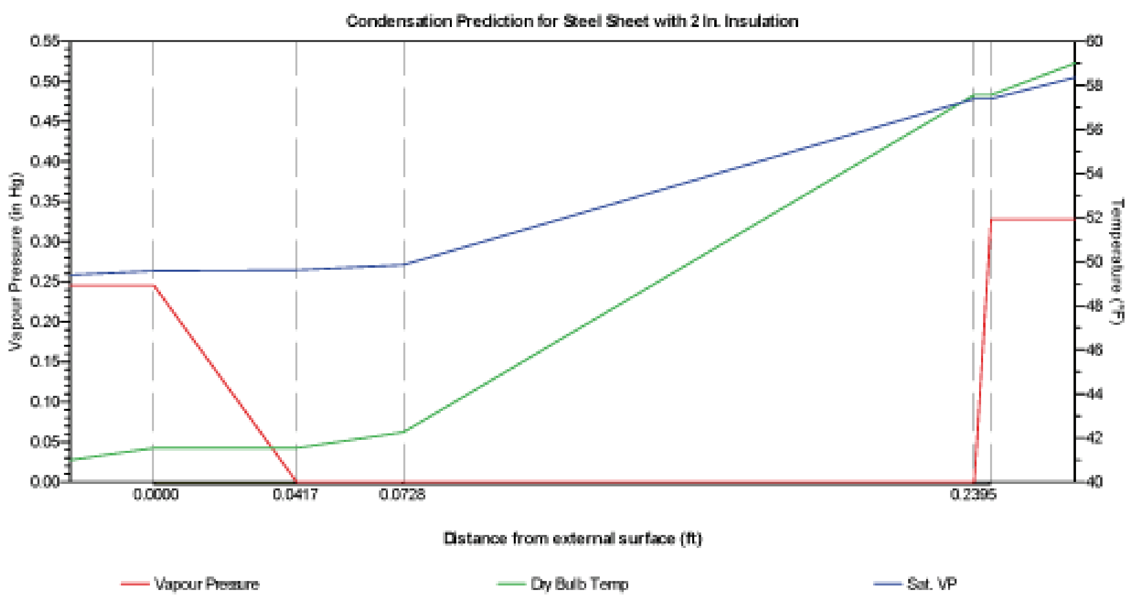


Fig. 74. Steel Floor Condensation Prediction Graph

Concrete Masonry Units

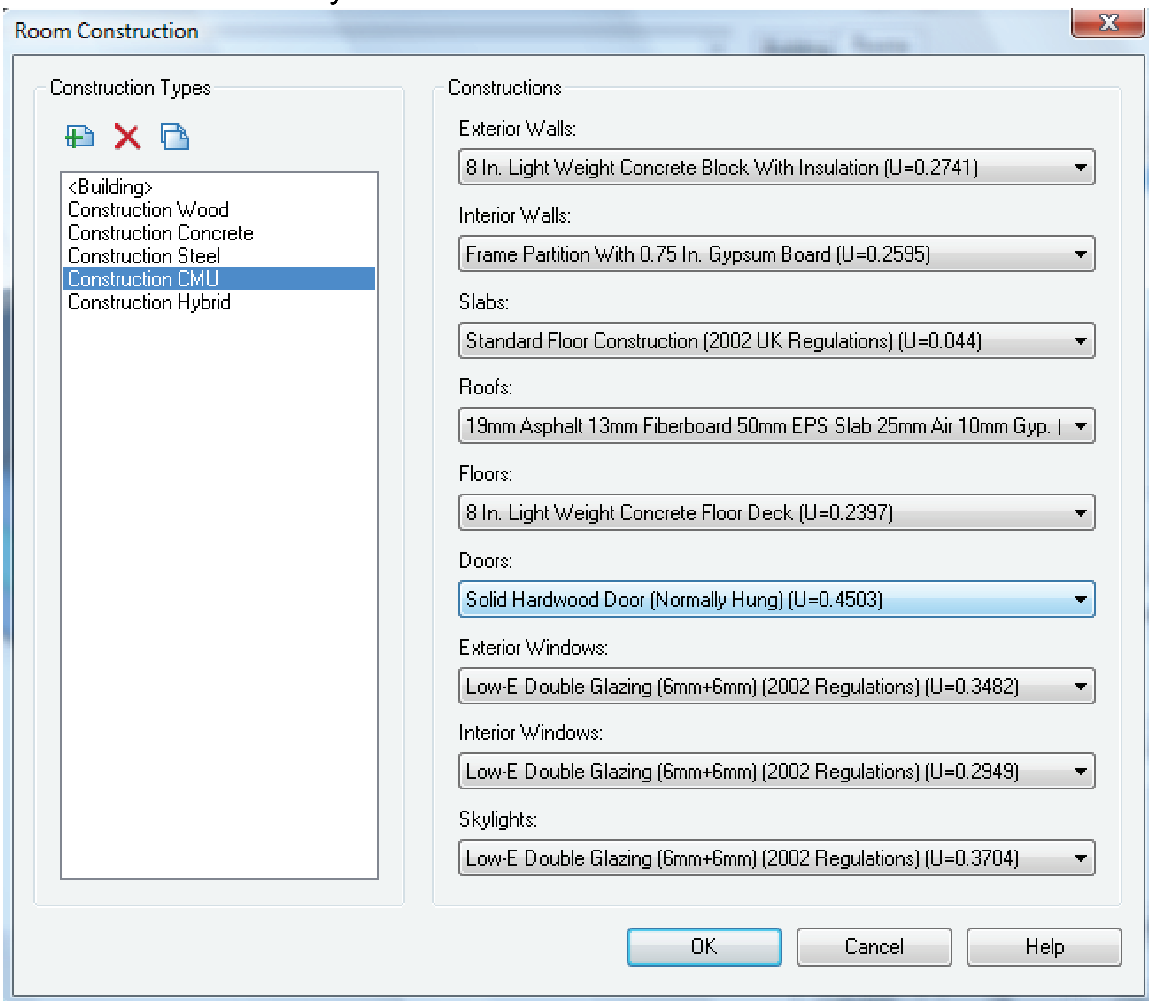


Fig. 75. CMU Construction Assemblies

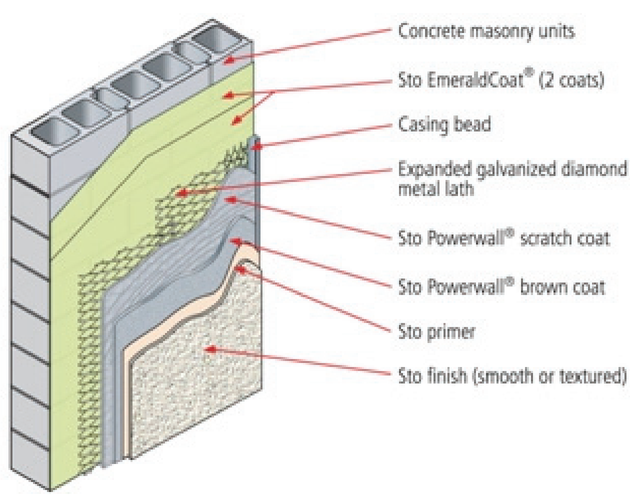


Fig. 76. CMU Wall Construction

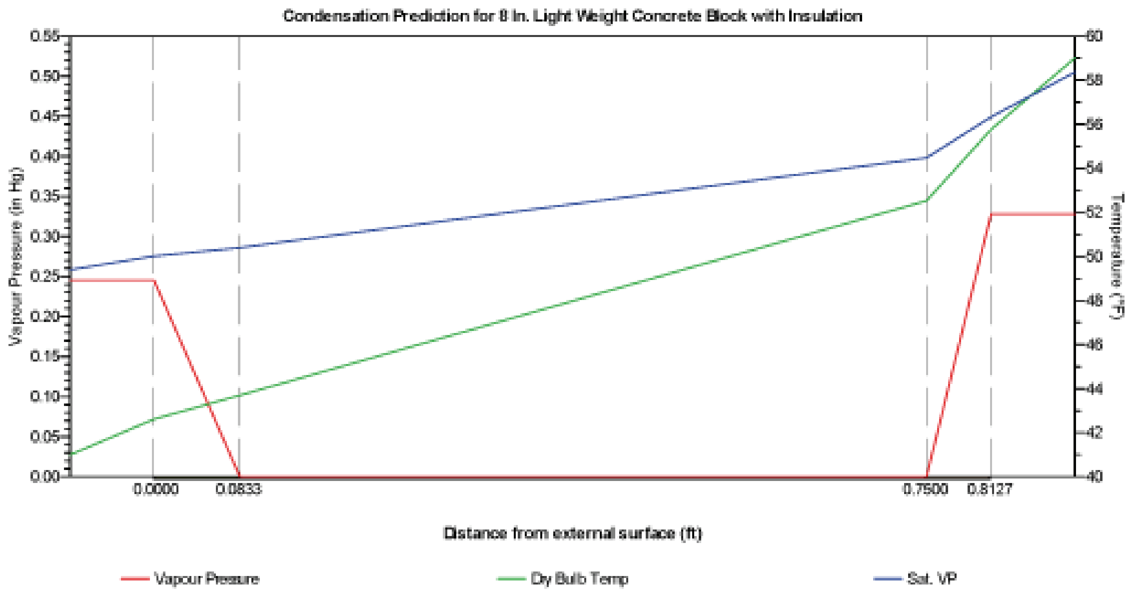


Fig. 77. CMU Condensation Prediction Graph

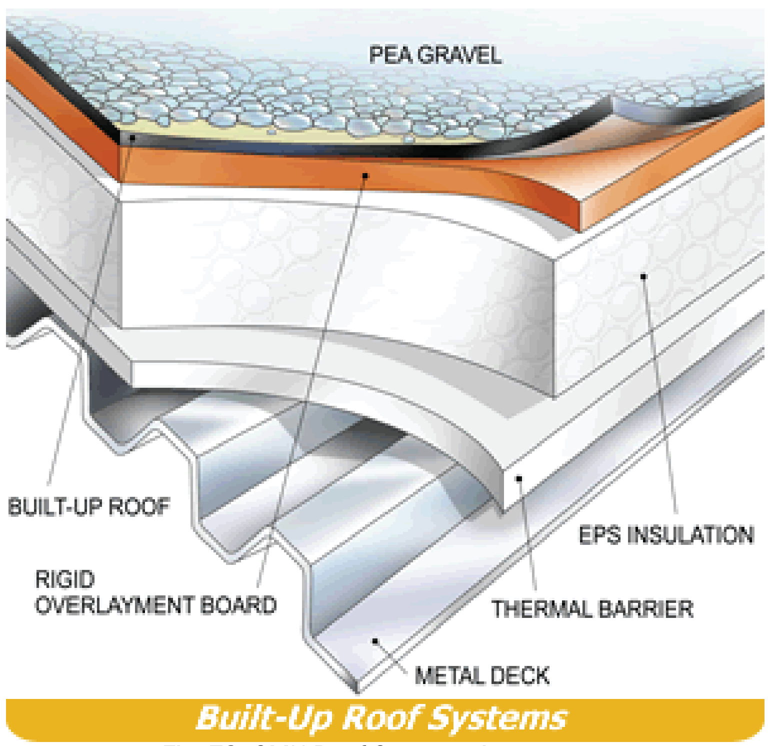


Fig. 78. CMU Roof Construction

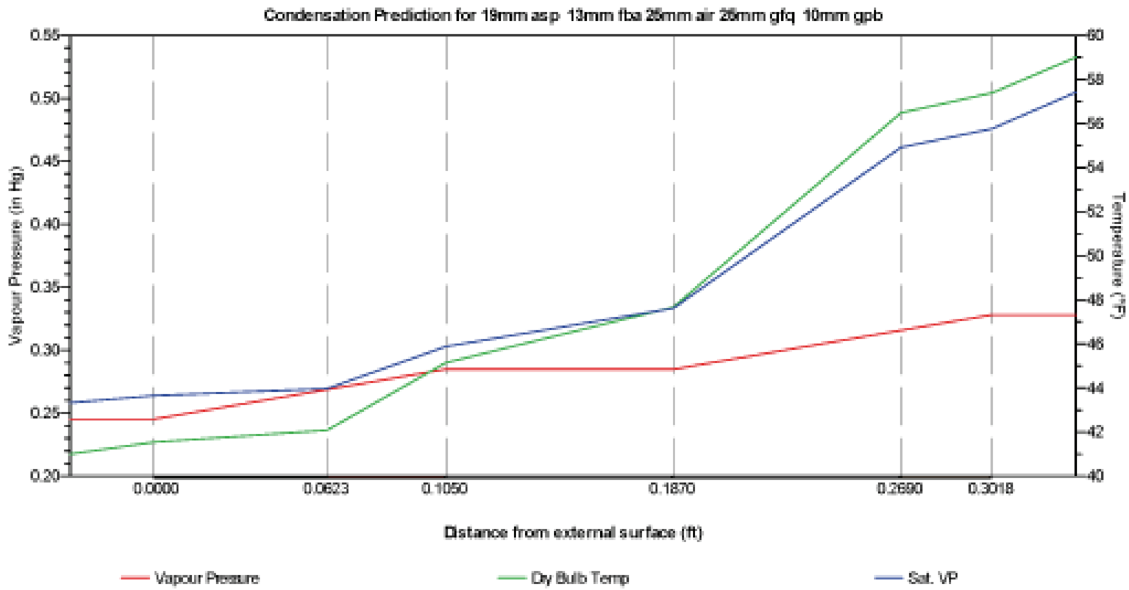


Fig. 79. Built-up Roof Condensation Prediction Graph

Hybrid Construction

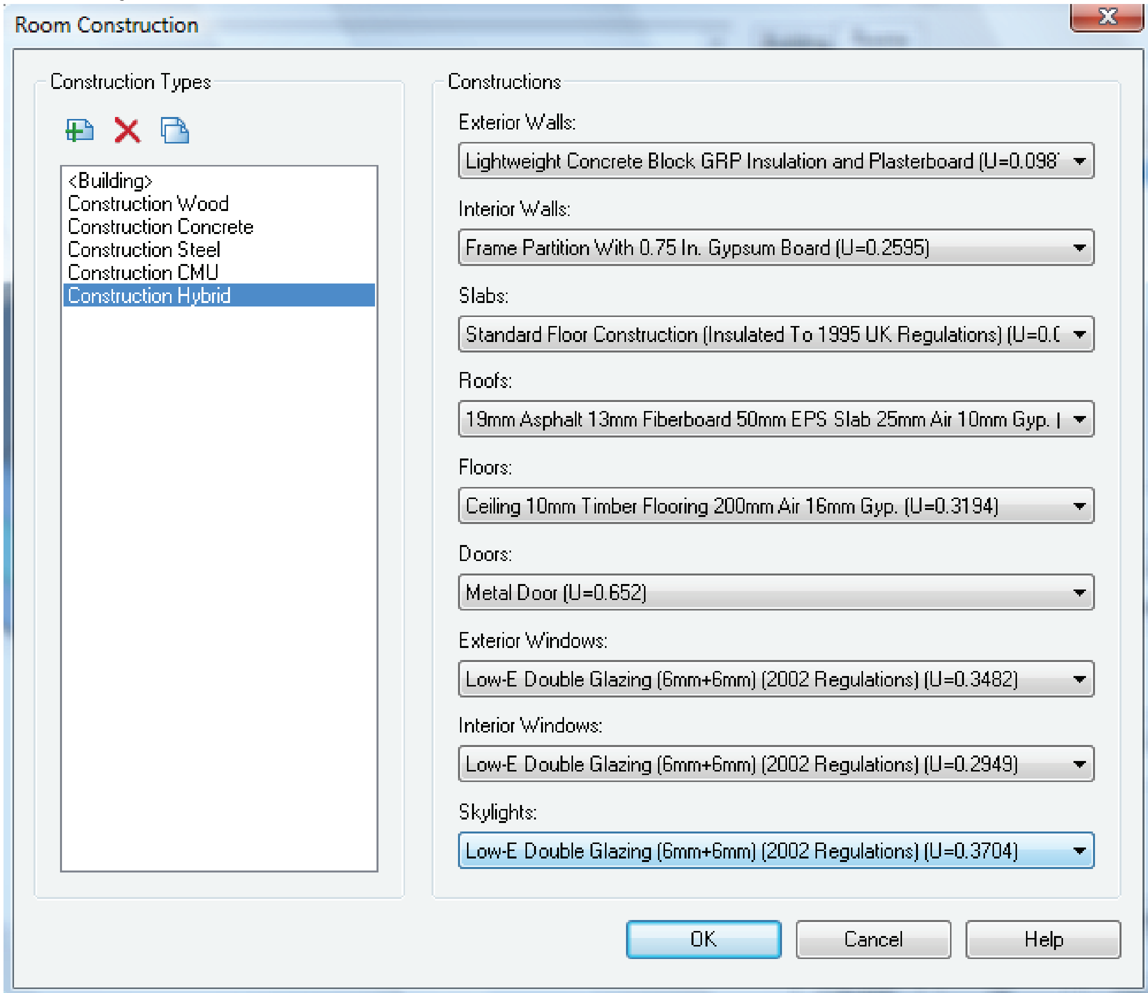


Fig. 80. Hybrid Construction Type Assemblies

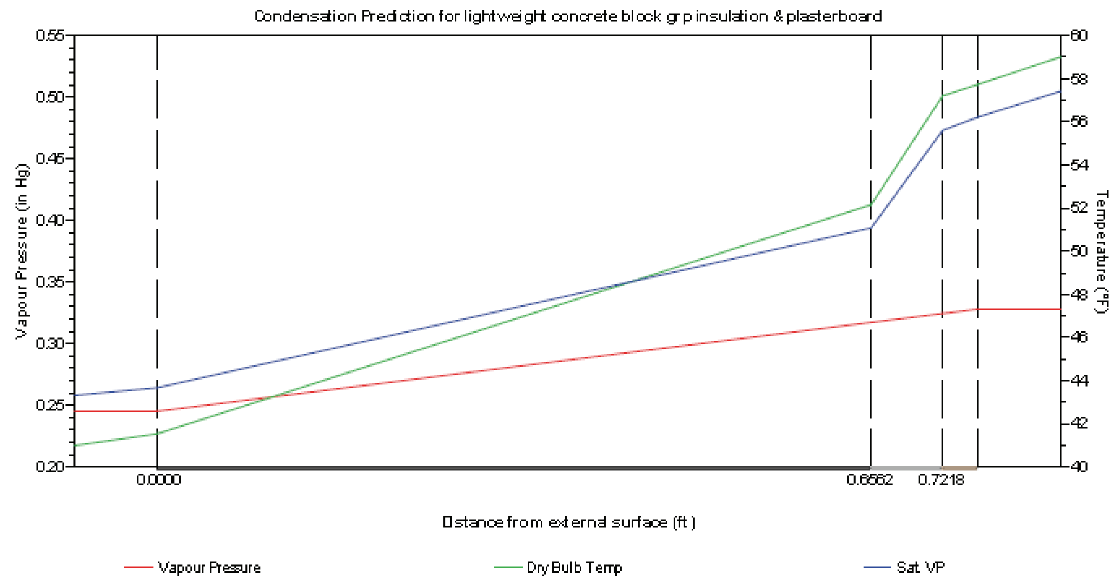


Fig. 81. CMU Wall Condensation Prediction Graph

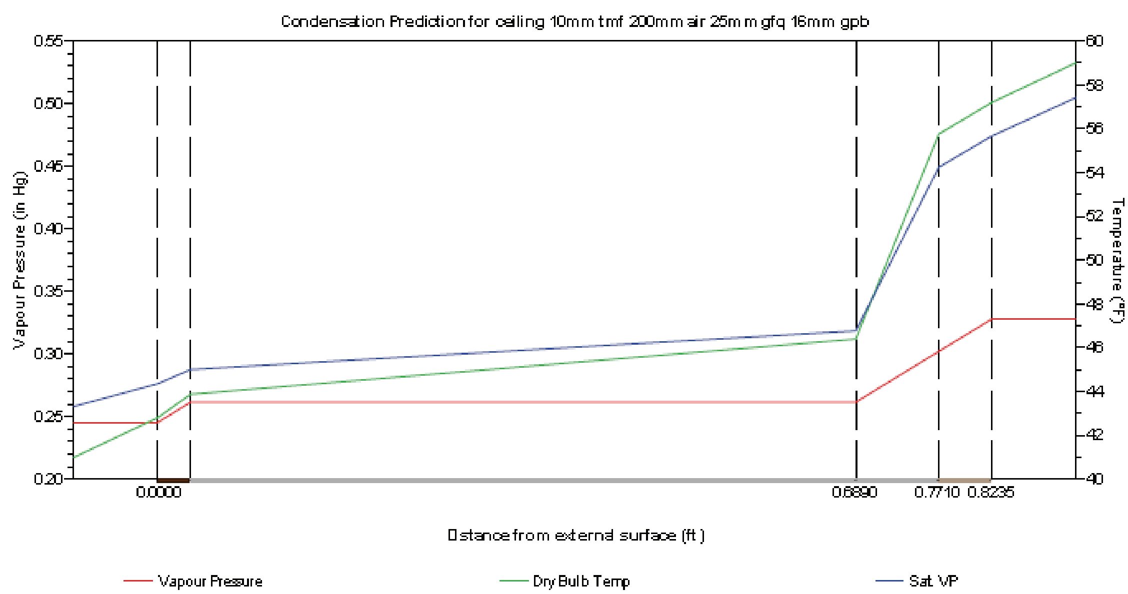


Fig. 82. Composite Floor Condensation Prediction Graph

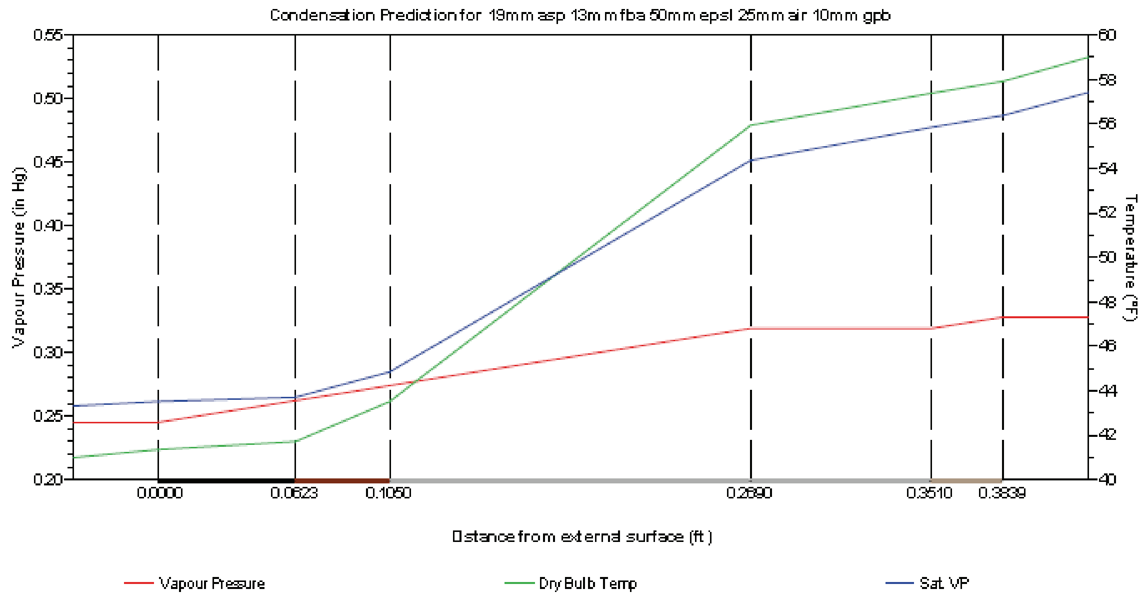


Fig. 83. Built-up Roof Condensation Prediction Graph

Mechanical Systems

The Classrooms mechanical systems were selected based on local climate conditions. The area of Santa Barbara has a slight wind chill that requires most buildings to be heated rather than cooled. The systems selected are Radiant Floor, Variable Air Volume (VAV) Single Duct, and Geothermal Water Heat Loop Pump. The three systems are deployed into each construction type for every prototype tested.

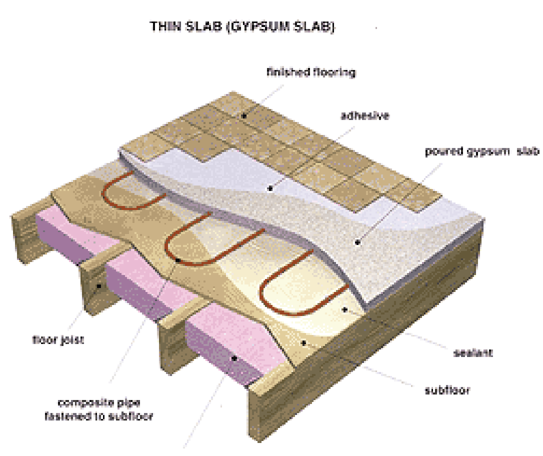


Fig. 84. Radiant Floor

Fig. 85. Geothermal Water Heat Loop Pump

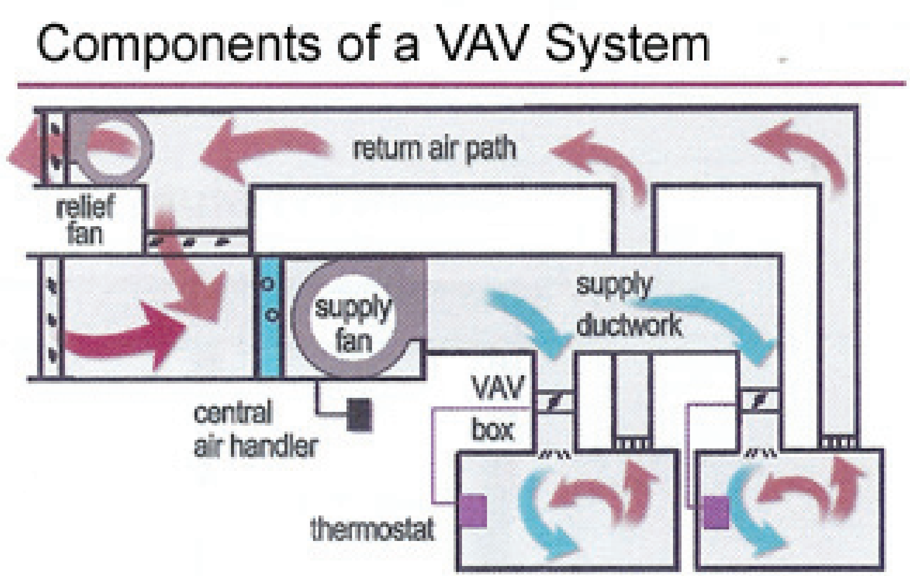


Fig. 86. Variable Air Volume (VAV) Single Duct

Base Case Model

The Base Case model is orientated with windows south facing and the doors north facing. The intention is to allow the maximum amount of daylight into the interior space. The ceiling height is 9 ft with 12 parabolic luminaries installed into the ceiling.

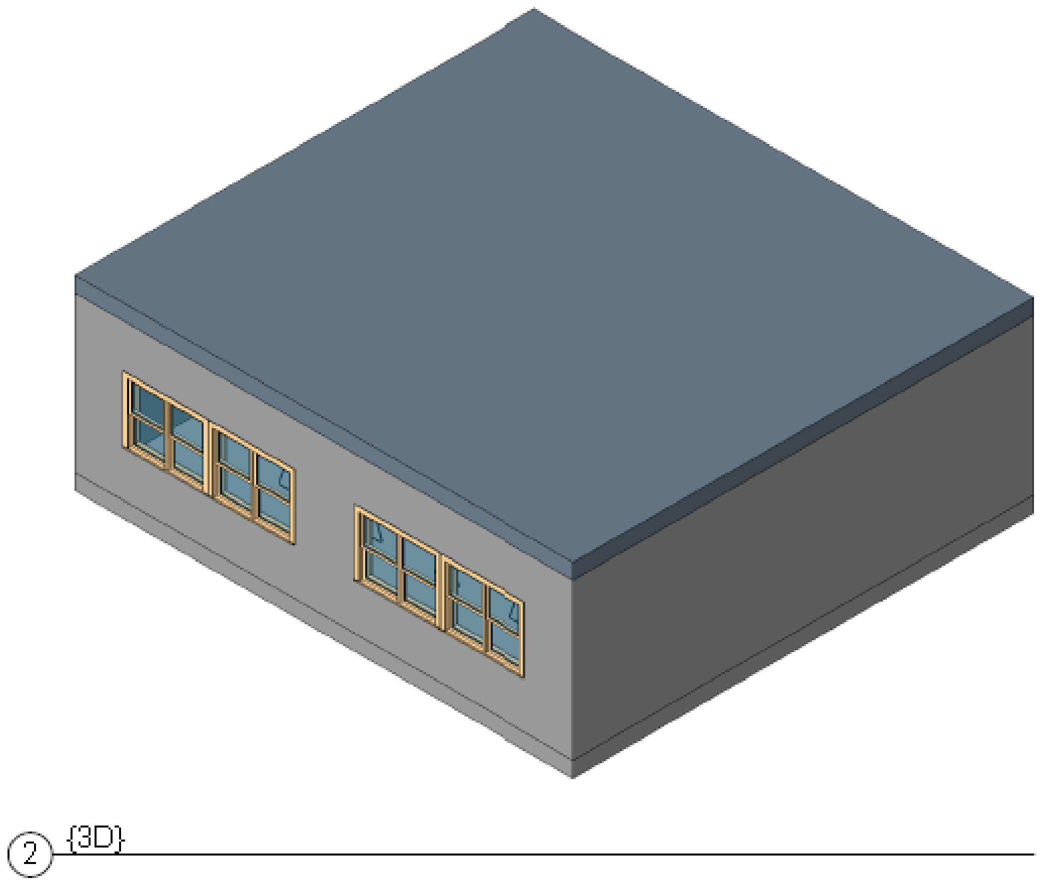


Fig. 87. *Axonometric*

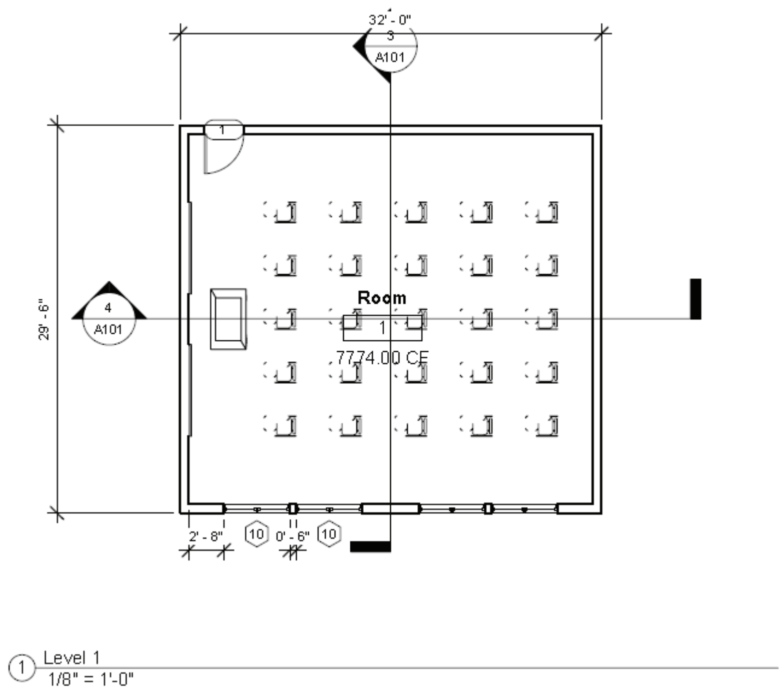


Fig. 88. Level 1

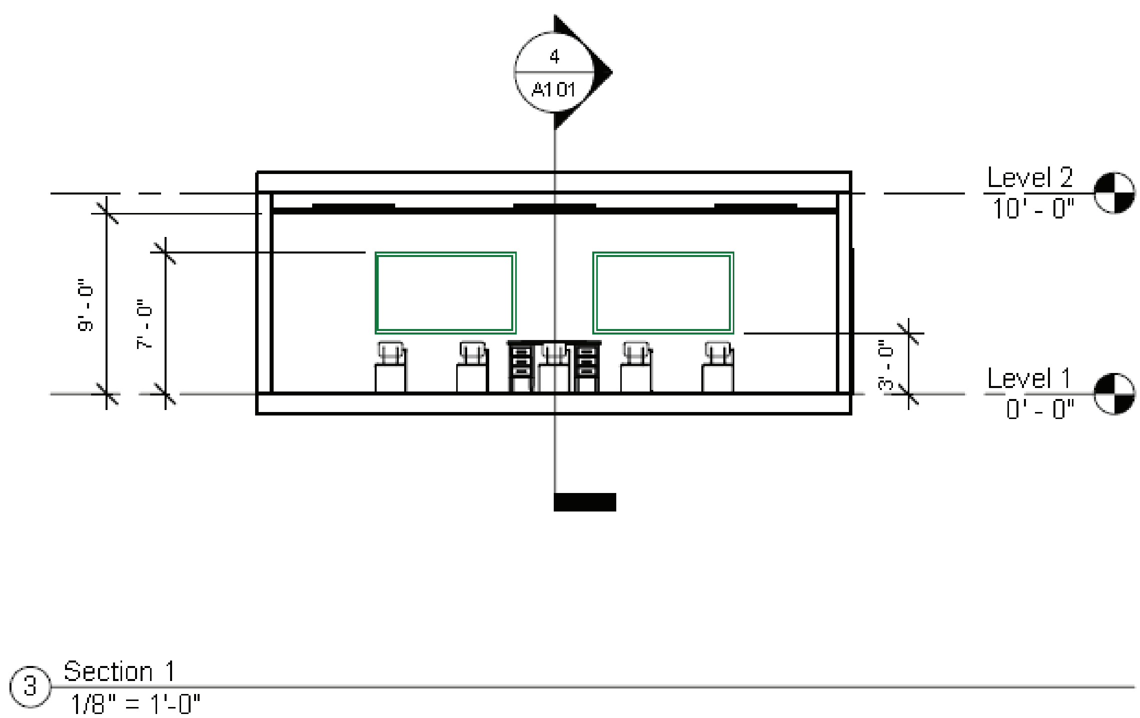


Fig. 89. Section 1

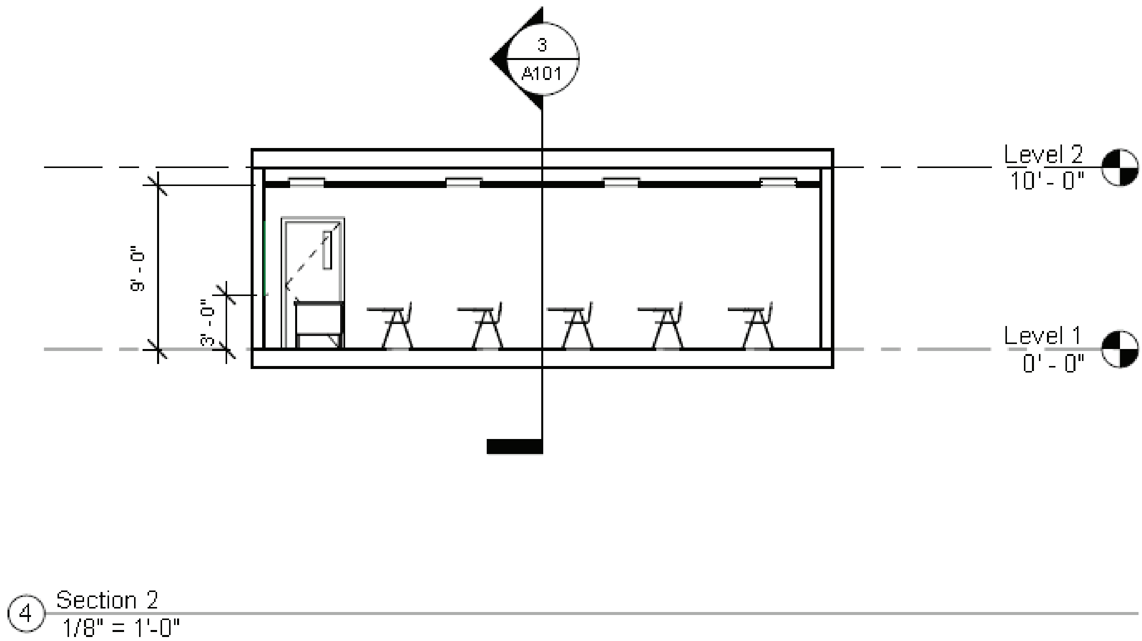


Fig. 90. Section 2

Fig. 91. 3D View 1

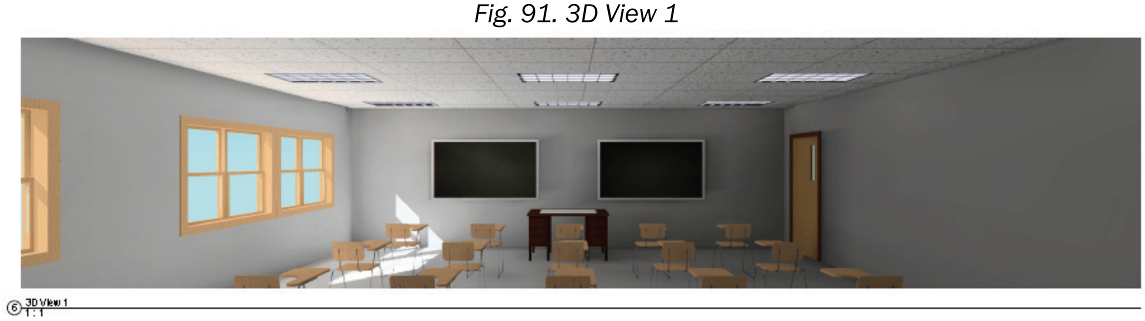


Fig. 92. 3D View 2

Prototype 1

The classroom dimensions for prototype 1 has been slightly altered by adding transom windows 7 feet for the finished floor. The additional windows improvements will increase in Daylighting. The luminaries have not been changed.

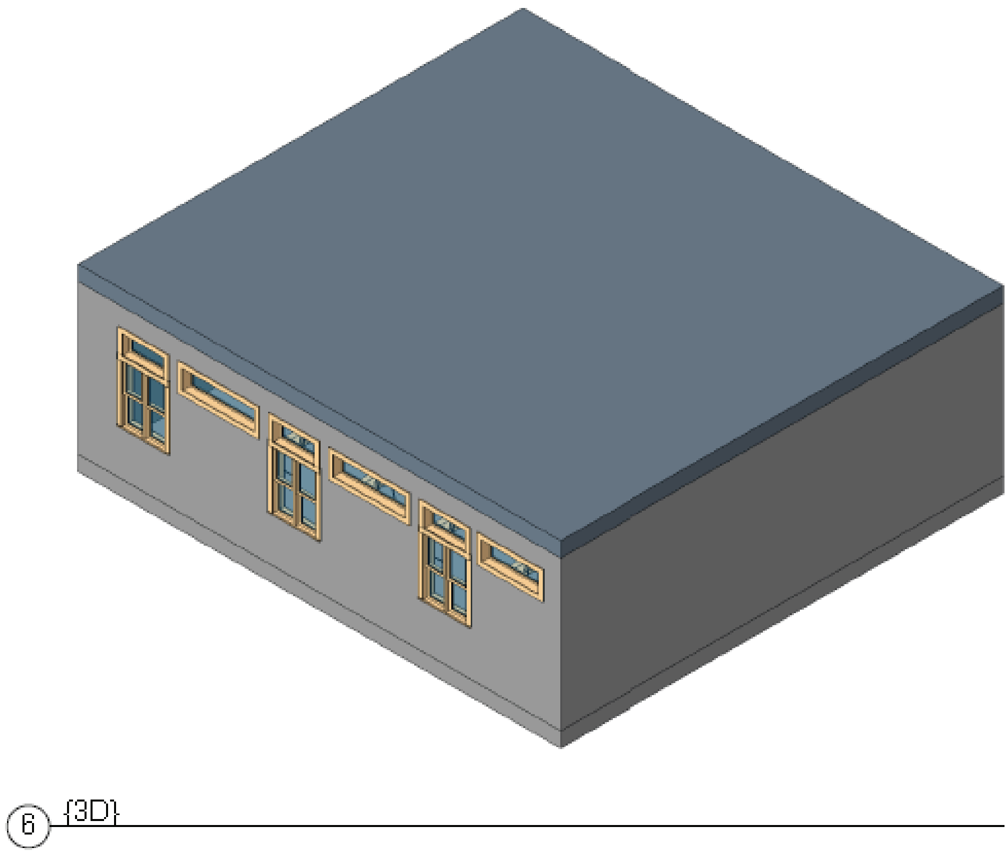


Fig. 93. Axonometric

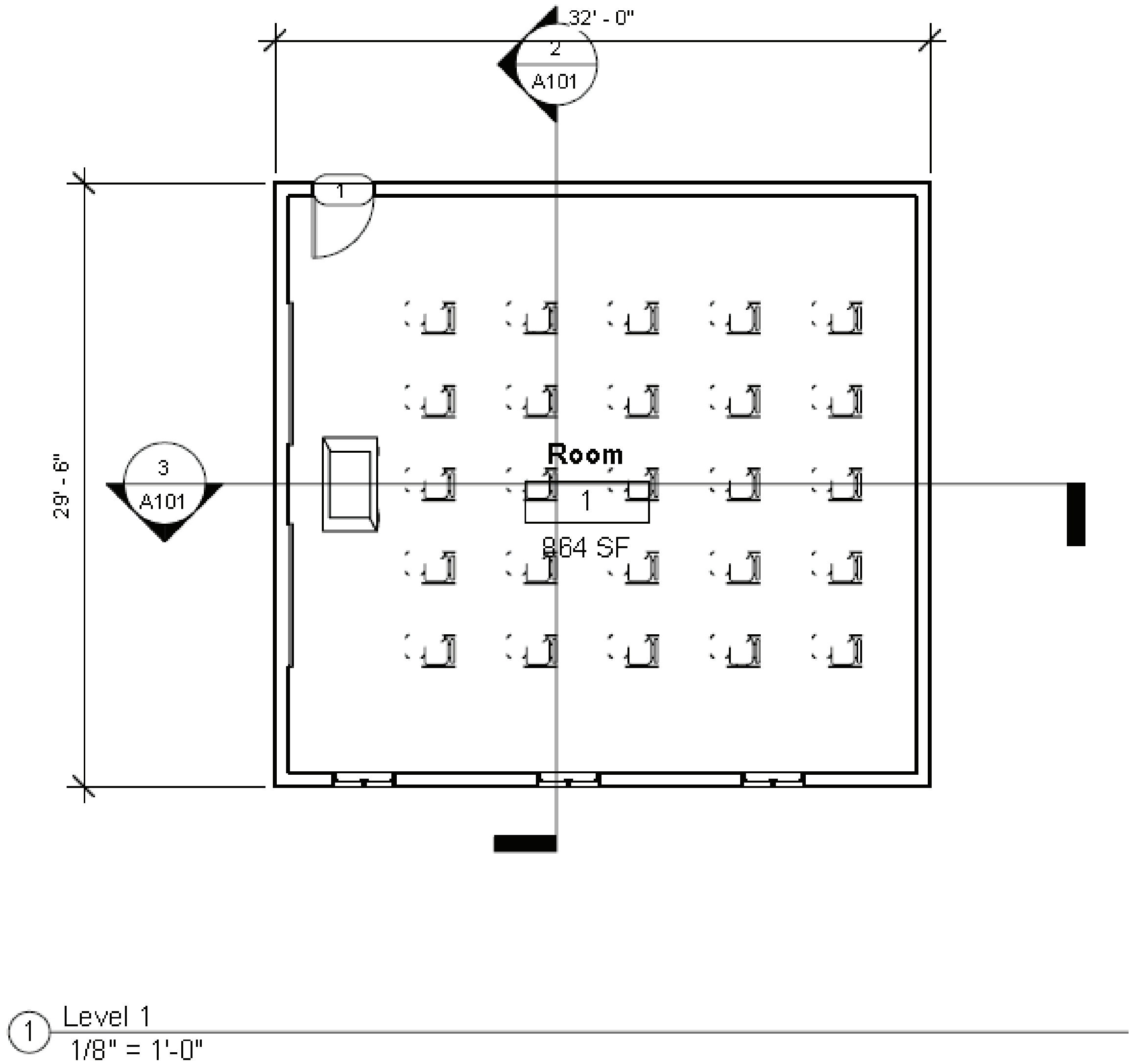


Fig. 94. Level 1

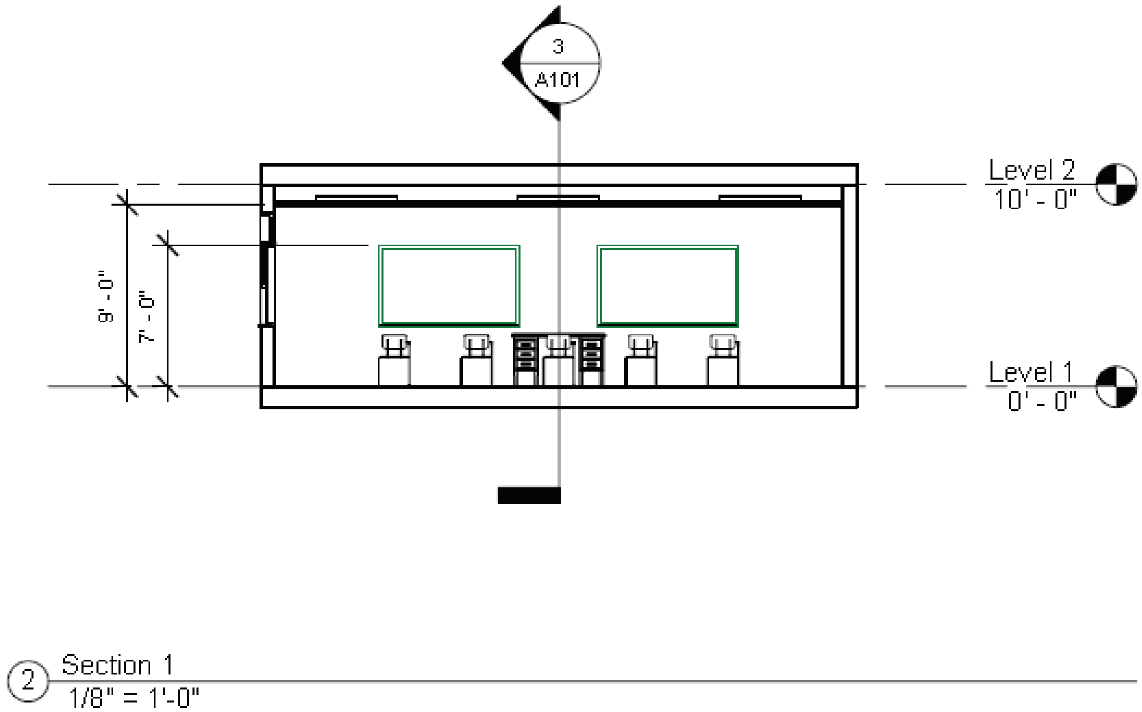


Fig. 95. Section 1

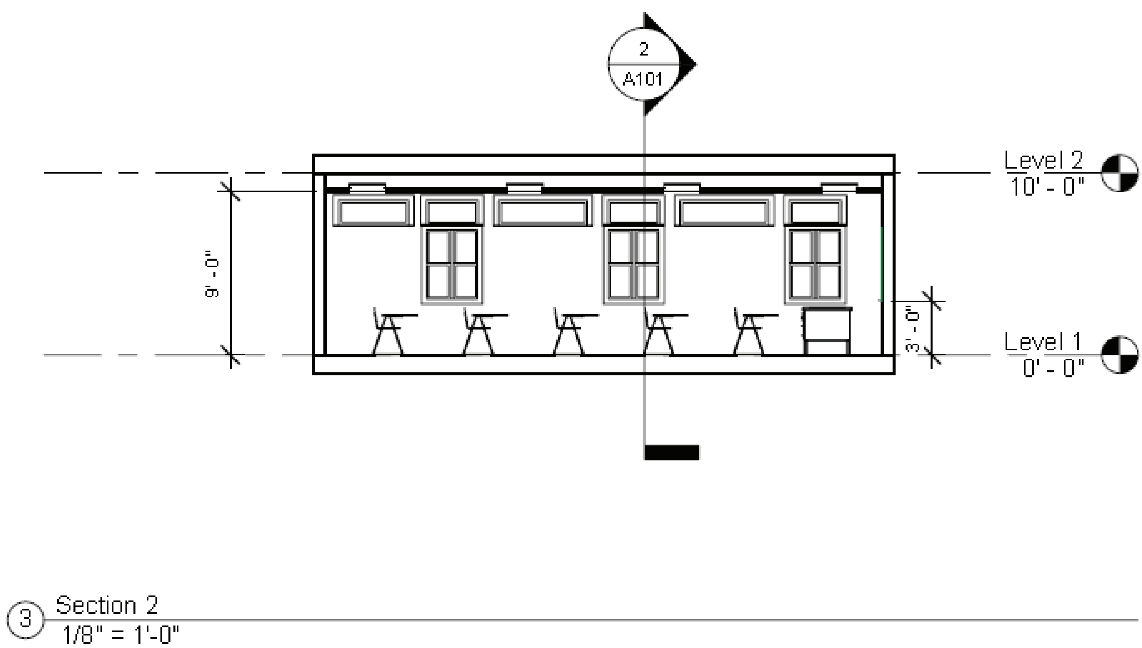


Fig. 96. Section 2

Fig. 97. 3D View 1

Fig. 98. 3D View 2

Prototype 2

The classroom dimensions for prototype 2 are similar to the previous prototype in the fact that the number of windows remains the same. The modifications to the classroom are interior alterations. These changes are in the ceiling height and light fixtures. The ceiling height has been raised to 10' 3" to allow more sunlight into the classroom. The light fixtures have been changed to 6 linear strip luminaries.

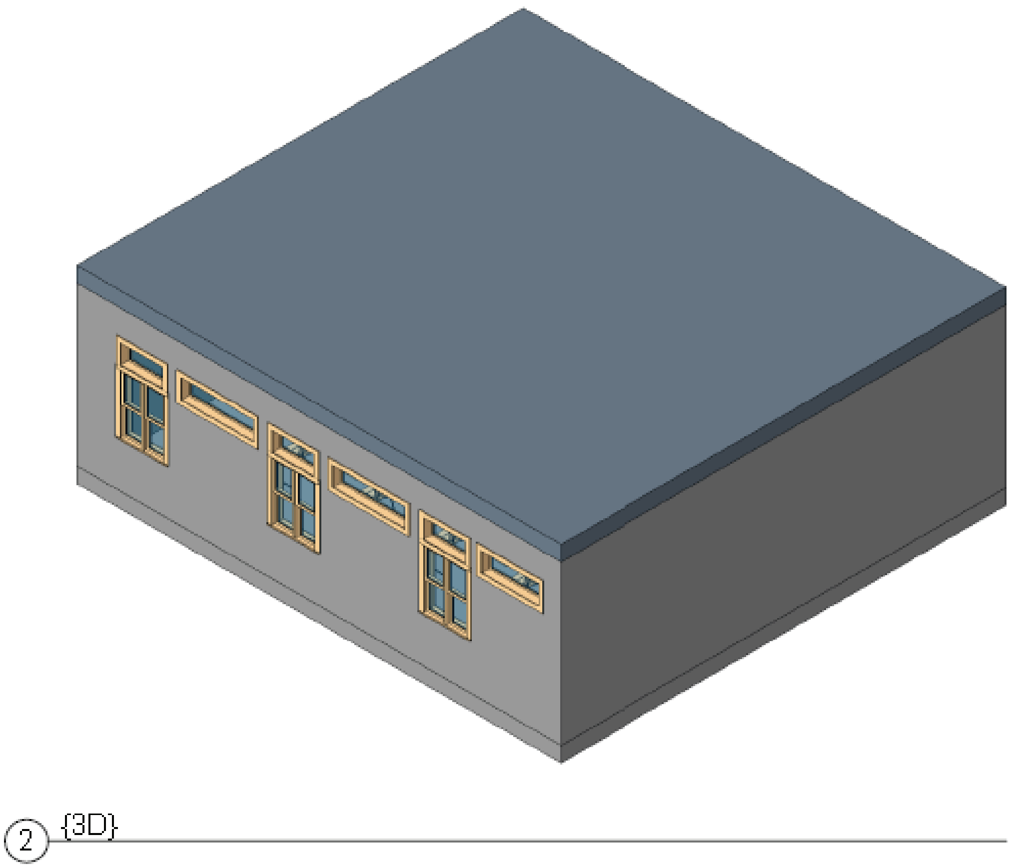


Fig. 99. Axonometric

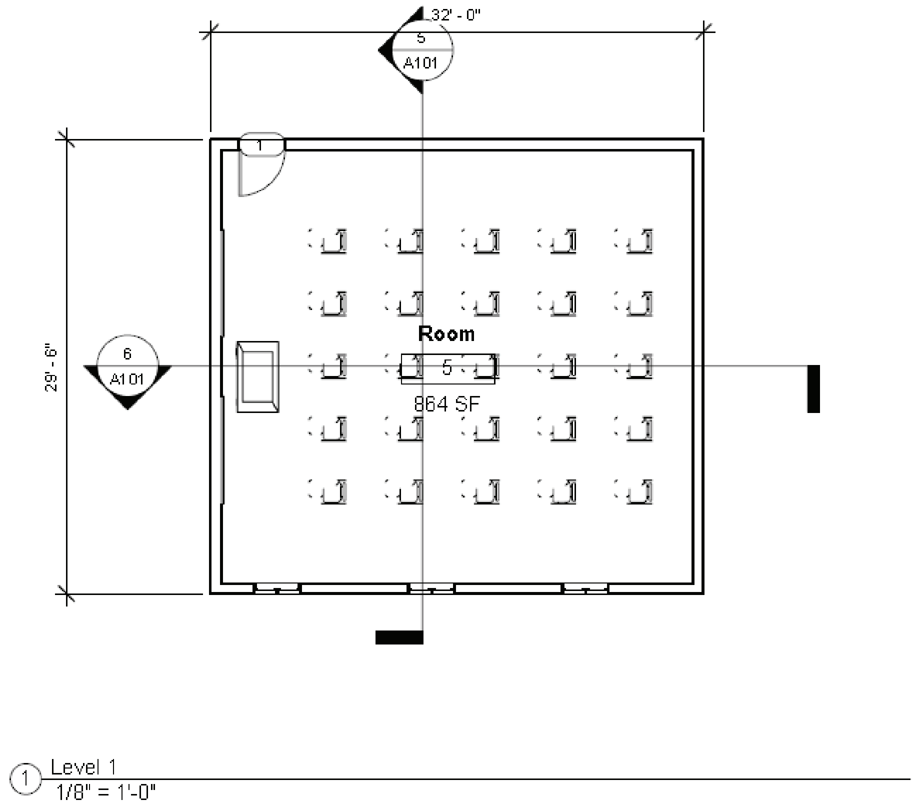


Fig. 100. Level 1

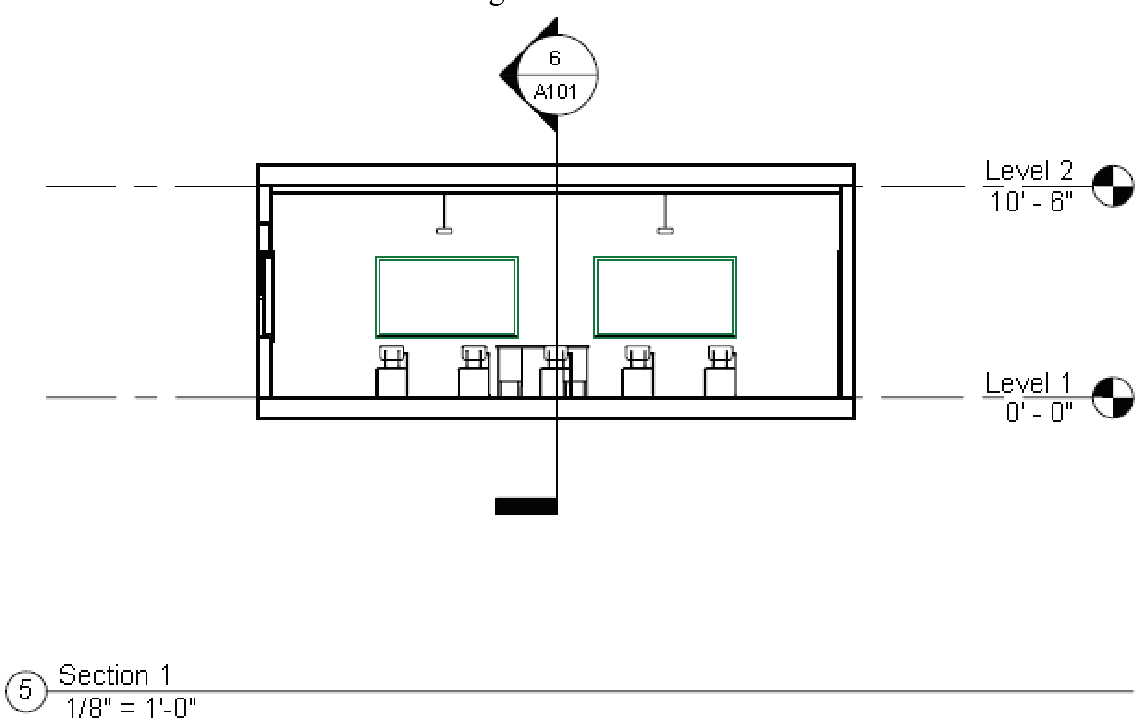


Fig. 101. Section 1

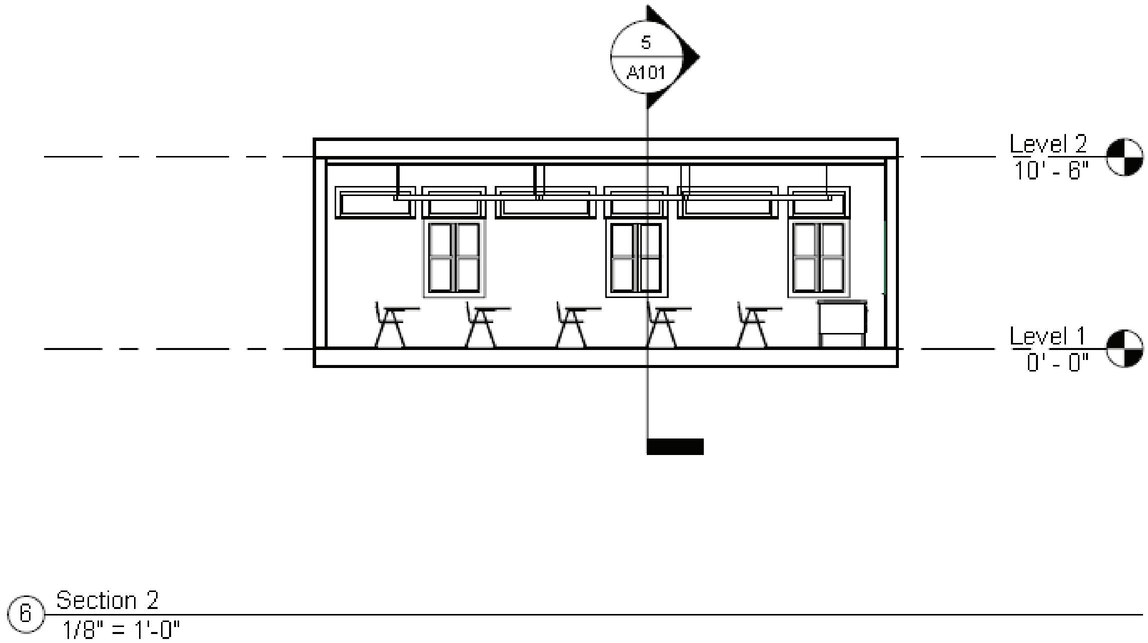


Fig. 102. Section 2

Fig. 103. 3D View 1

Fig. 104. 3D View 2

Prototype 3

The classroom dimensions for prototype 3 have been radically altered from its predecessors. The design incorporates new ideas and technology that is a requirement for modern classrooms. The classroom floor has been slanted at a 15 degree angle to provide optimal views for each student. The windows have been carefully placed to provide ample Daylighting and to decrease glare. The window on the east and west walls wash the interior walls that provides good lighting and less distractions. Light shelves and top lighting has also been added to assist the linear strip luminaries. The ceiling has been design to bounce light into task areas and allow minimal amount of glare onto the chalkboard. A drop-down screen has also been installed with a projector.

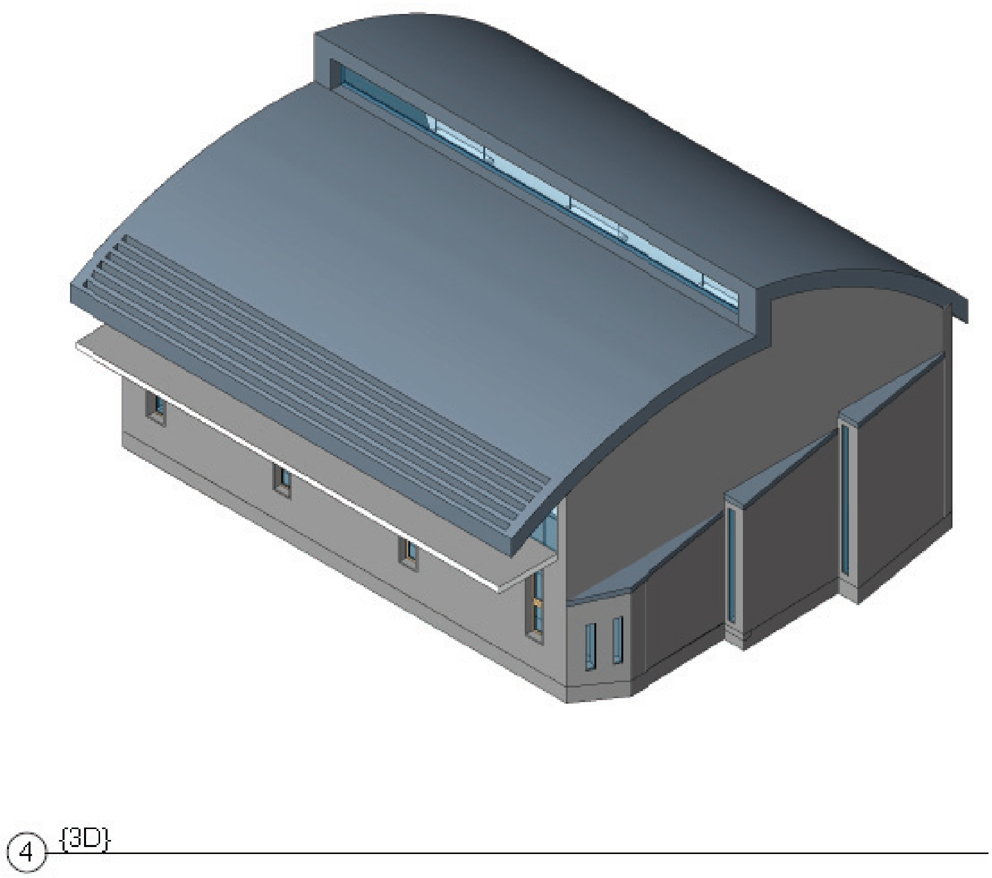


Fig. 105. Axonometric

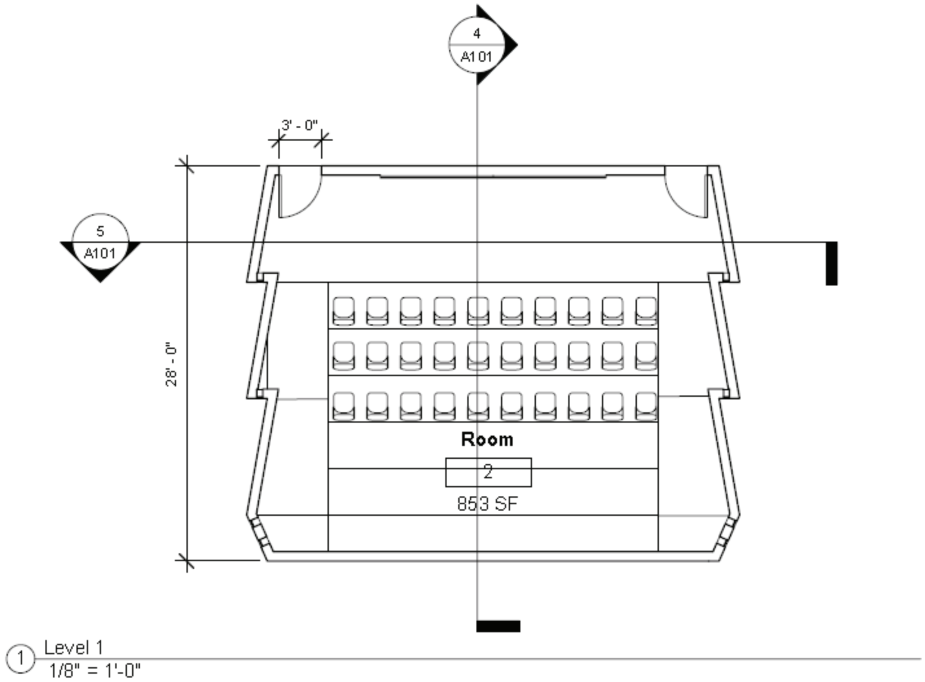


Fig. 106. Level 1

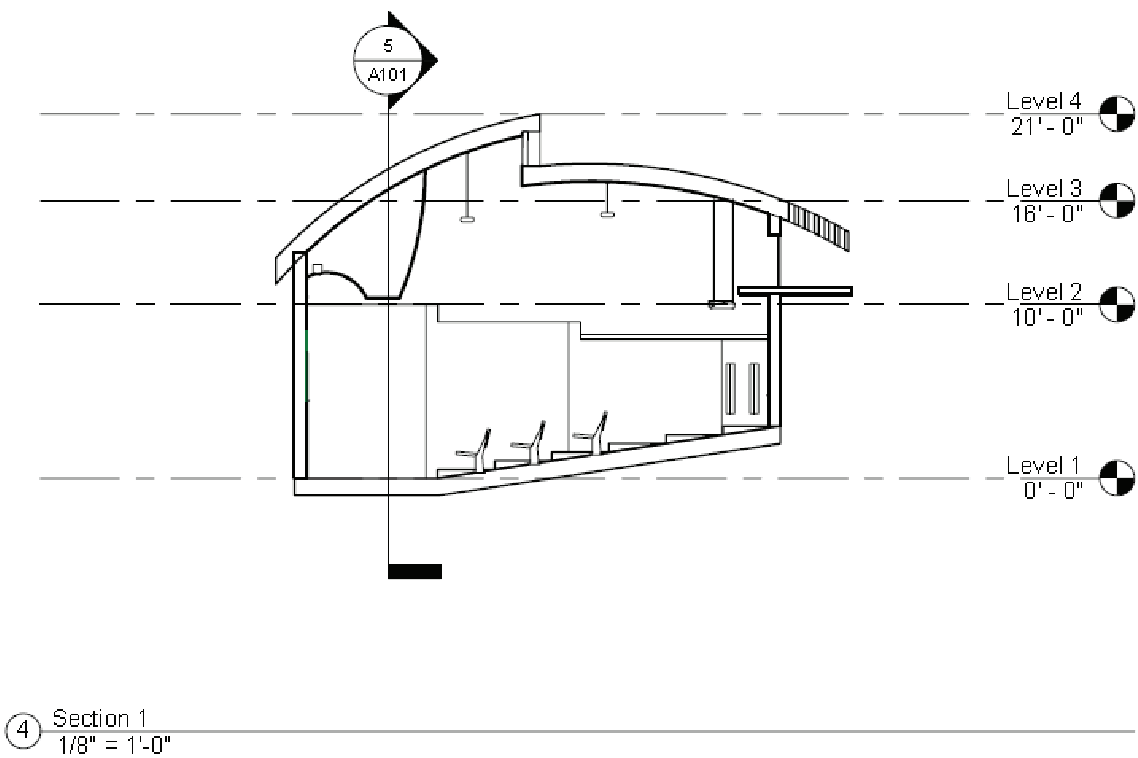


Fig. 107. Section 1

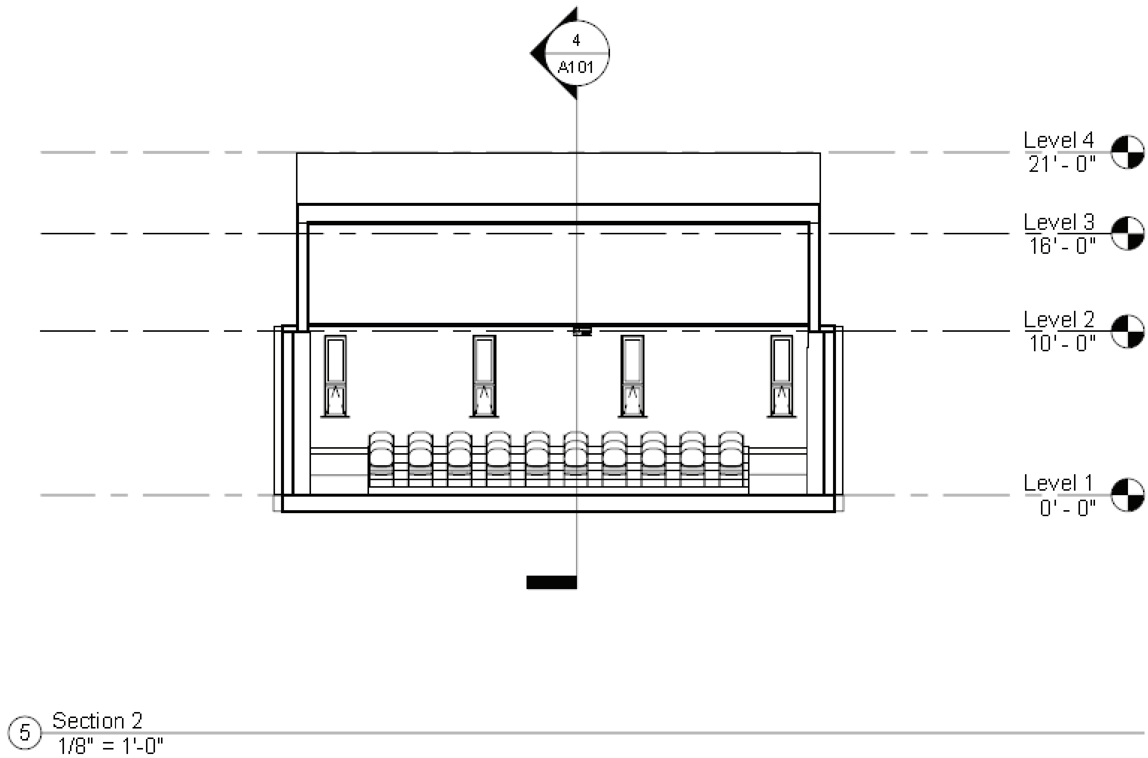


Fig. 108. Section 2

Fig. 109. 3D View 1

Fig. 110. 3D View 2

Load Analysis

Each classroom was simulated with each type of construction and mechanical system. The classrooms were then compared based on their performance. The Heating and Cooling Load Analysis reveals that concrete masonry units combined with a built-up rood is the best combination for this particular climate. This particular construction assembly proved to be 15% more effective when a heating load is applied. Heating is the primary objective for the classrooms; although Cooling is a factor in determining how well each classroom performs. The Cooling load is only 6% improved but it is still an improvement. A detailed log of the data output has been provided to show how the best construction type and system was determined.

BASE CASE

	Wood Construction/Radiant Floor	Wood Construction/Variable Air Volume Single Duct	Wood Construction/Water Loop Heat Pump
Heating Load (Btu/h)	12163.4 Btu/h	11040.8 Btu/h	11040.8 Btu/h
Cooling Load (Btu/h)	7482.9 Btu/h	32203.7 Btu/h	32203.7 Btu/h
CFM	116	864	1177 CFM
Energy (MMBtu)	29.242 MMBtu	81.853 MMBtu	89.436 MMBtu
CO2 Emmisions (lbs)	7703.9 lbCO_2	21178.0 lbCO_2	23514.3 lbCO_2

	Concrete Construction/Radiant Floor	Concrete Construction/Variable Air Volume Single Duct	Concrete Construction/Water Loop Heat Pump
Heating Load (Btu/h)	10963.4 Btu/h	10025.0 Btu/h	10025.0 Btu/h
Cooling Load (Btu/h)	7339.8 Btu/h	30824.7 Btu/h	30824.7 Btu/h
CFM	110	1113	1113
Energy (MMBtu)	27.347 MMBtu	75.948 MMBtu	83.853 MMBtu
CO2 Emmisions (lbs)	7417.7 lbCO_2	20109.8 lbCO_2	22406.3 lbCO_3

	Steel Construction/Radiant Floor	Steel Construction/Variable Air Volume Single Duct	Steel Construction/Water Loop Heat Pump
Heating Load (Btu/h)	9879.9	9104.8	9104.8
Cooling Load (Btu/h)	7374.2	33624.3	33624.3
CFM	111	1234	1234
Energy (MMBtu)	26.849 MMBtu	76.307 MMBtu	84.613 MMBtu
CO2 Emmisions (lbs)	7320.5 lbCO_2	20334.8 lbCO_2	22710.7 lbCO_2

	CMU Construction/Radiant Floor	CMU Construction/Variable Air Volume Single Duct	CMU Construction/Water Loop Heat Pump
Heating Load (Btu/h)	16784.3	14753	14753
Cooling Load (Btu/h)	6807.6	33328.8	33328.8
CFM	85	1229	1229
Energy (MMBtu)	32.340 MMBtu	81.716 MMBtu	88.789 MMBtu
CO2 Emmisions (lbs)	8273.3 lbCO_2	20929.6 lbCO_2	23177.0 lbCO_2

	Hybrid Construction/Radiant Floor	Hybrid Construction/Variable Air Volume Single Duct	Hybrid Construction/Water Loop Heat Pump
Heating Load (Btu/h)	10850.1	14753	14753
Cooling Load (Btu/h)	7713.2	33328.8	33328.8
CFM	127	1229	1229
Energy (MMBtu)	28.452 MMBtu	86.076 MMBtu	94.229 MMBtu
CO2 Emmisions (lbs)	7540.7 lbCO_2	22207.5 lbCO_2	24728.2 lbCO_2

Fig. 111. Base Case Data

Prototype 1

	Wood Construction/Radiant Floor	Wood Construction/Variable Air Volume Single Duct	Wood Construction/Water Loop Heat Pump
Heating Load (Btu/h)	12078.2	10969.9	10969.9
Cooling Load (Btu/h)	7431.1	31593.3	31593.3
CFM	114	1149	1149
Energy (MMBtu)	29.331 MMBtu	81.217 MMBtu	88.713 MMBtu
CO2 Emmisions (lbs)	7722.2 lbCO_2	21010.5 lbCO_2	23321.8 lbCO_2

	Concrete Construction/Radiant Floor	Concrete Construction/Variable Air Volume Single Duct	Concrete Construction/Water Loop Heat Pump
Heating Load (Btu/h)	10883.1	9957	9957
Cooling Load (Btu/h)	7285.2	30097.3	30097.3
CFM	107	1079	1079
Energy (MMBtu)	27.401 MMBtu	75.308 MMBtu	83.125 MMBtu
CO2 Emmisions (lbs)	7430.3 lbCO_2	19940.9 lbCO_2	22212.0 lbCO_2

	Steel Construction/Radiant Floor	Steel Construction/Variable Air Volume Single Duct	Steel Construction/Water Loop Heat Pump
Heating Load (Btu/h)	10393.2	9547.1	9547.1
Cooling Load (Btu/h)	8097.3	35245.4	35245.4
CFM	145	1319	1319
Energy (MMBtu)	29.116 MMBtu	92.628 MMBtu	100.540 MMBtu
CO2 Emmisions (lbs)	7644.3 lbCO_2	23462.8 lbCO_2	26043.0 lbCO_2

	CMU Construction/Radiant Floor	CMU Construction/Variable Air Volume Single Duct	CMU Construction/Water Loop Heat Pump
Heating Load (Btu/h)	12312.6	11154.8	11154.8
Cooling Load (Btu/h)	7115.3	33525.1	33525.1
CFM	99	1239	1239
Energy (MMBtu)	27.400 MMBtu	76.444 MMBtu	84.533 MMBtu
CO2 Emmisions (lbs)	7470.1 lbCO_2	20243.4 lbCO_2	22590.5 lbCO_2

	Hybrid Construction/Radiant Floor	Hybrid Construction/Variable Air Volume Single Duct	Hybrid Construction/Water Loop Heat Pump
Heating Load (Btu/h)	9852.6	9078.2	9078.2
Cooling Load (Btu/h)	7842.8	32410	32410
CFM	133	1187	1187
Energy (MMBtu)	27.562 MMBtu	83.605 MMBtu	91.867 MMBtu
CO2 Emmisions (lbs)	7415.5 lbCO_2	21754.2 lbCO_2	24252.7 lbCO_2

Fig. 112. Prototype 1 Data

Prototype 2

	Wood Construction/Radiant Floor	Wood Construction/Variable Air Volume Single Duct	Wood Construction/Water Loop Heat Pump
Heating Load (Btu/h)	12498.1	11365.1	11365.1
Cooling Load (Btu/h)	7296.4	31822.7	31822.7
CFM	111	1160	1160
Energy (MMBtu)	29.716 MMBtu	82.047 MMBtu	89.387 MMBtu
CO2 Emmisions (lbs)	7782.3 $lbCO_2$	21120.0 $lbCO_2$	23416.5 $lbCO_2$

	Concrete Construction/Radiant Floor	Concrete Construction/Variable Air Volume Single Duct	Concrete Construction/Water Loop Heat Pump
Heating Load (Btu/h)	11421.7	10451.3	9505.4
Cooling Load (Btu/h)	7121.7	30234.1	32530.5
CFM	103	1085	1193
Energy (MMBtu)	27.347 MMBtu	75.948 MMBtu	83.853 MMBtu
CO2 Emmisions (lbs)	7417.7 $lbCO_2$	20109.8 $lbCO_2$	22406.3 $lbCO_3$

	Steel Construction/Radiant Floor	Steel Construction/Variable Air Volume Single Duct	Steel Construction/Water Loop Heat Pump
Heating Load (Btu/h)	9676.9	8959.4	8959.4
Cooling Load (Btu/h)	7862.5	33859.4	33859.4
CFM	137	1255	1255
Energy (MMBtu)	27.642 MMBtu	86.937 MMBtu	94.915 MMBtu
CO2 Emmisions (lbs)	7445.4 $lbCO_2$	22345.0 $lbCO_2$	24840.8 $lbCO_2$

	CMU Construction/Radiant Floor	CMU Construction/Variable Air Volume Single Duct	CMU Construction/Water Loop Heat Pump
Heating Load (Btu/h)	10312.1	9505.4	9505.4
Cooling Load (Btu/h)	7665.8	32530.5	32530.5
CFM	128	1193	1193
Energy (MMBtu)	27.767 MMBtu	83.675 MMBtu	91.836 MMBtu
CO2 Emmisions (lbs)	7445.1 $lbCO_2$	21730.7 $lbCO_2$	24211.5 $lbCO_2$

	Hybrid Construction/Radiant Floor	Hybrid Construction/Variable Air Volume Single Duct	Hybrid Construction/Water Loop Heat Pump
Heating Load (Btu/h)	10260.1	9460.7	9460.7
Cooling Load (Btu/h)	7675.3	32527.7	32527.7
CFM	128	1193	1193
Energy (MMBtu)	27.908 MMBtu	84.092 MMBtu	92.224 MMBtu
CO2 Emmisions (lbs)	7464.7 $lbCO_2$	21802.7 $lbCO_2$	24285.5 $lbCO_2$

Fig. 113. Prototype 2

Prototype 3

	Wood Construction/Radiant Floor	Wood Construction/Variable Air Volume Single Duct	Wood Construction/Water Loop Heat Pump
Heating Load (Btu/h)	11972.8	10808.5	10808.5
Cooling Load (Btu/h)	8646.7	32107.6	32107.6
CFM	125	1132	1132
Energy (MMBtu)	32.914 MMBtu	87.581 MMBtu	95.853 MMBtu
CO2 Emmisions (lbs)	8724.1 lbCO$_2$	22774.2 lbCO$_2$	25290.5 lbCO$_2$

	Concrete Construction/Radiant Floor	Concrete Construction/Variable Air Volume Single Duct	Concrete Construction/Water Loop Heat Pump
Heating Load (Btu/h)	10690.1	9771	9771.1
Cooling Load (Btu/h)	8469.9	31239.6	31239.7
CFM	117	1091	1113
Energy (MMBtu)	31.015 MMBtu	81.618 MMBtu	90.153 MMBtu
CO2 Emmisions (lbs)	8423.3 lbCO$_2$	21678.8 lbCO$_2$	24141.5 lbCO$_2$

	Steel Construction/Radiant Floor	Steel Construction/Variable Air Volume Single Duct	Steel Construction/Water Loop Heat Pump
Heating Load (Btu/h)	12387	11198.2	11198.2
Cooling Load (Btu/h)	9052.3	35952.7	35952.7
CFM	144	1311	1311
Energy (MMBtu)	35.380 MMBtu	103.403 MMBtu	111.583 MMBtu
CO2 Emmisions (lbs)	9023.9 lbCO$_2$	25927.5 lbCO$_2$	28692.4 lbCO$_2$

	CMU Construction/Radiant Floor	CMU Construction/Variable Air Volume Single Duct	CMU Construction/Water Loop Heat Pump
Heating Load (Btu/h)	10391.3	9516.4	9516.4
Cooling Load (Btu/h)	8894.8	32026.3	32026.3
CFM	137	1128	1128
Energy (MMBtu)	31.529 MMBtu	89.210 MMBtu	97.953 MMBtu
CO2 Emmisions (lbs)	8478.3 lbCO$_2$	23268.9 lbCO$_2$	25901.9 lbCO$_2$

	Hybrid Construction/Radiant Floor	Hybrid Construction/Variable Air Volume Single Duct	Hybrid Construction/Water Loop Heat Pump
Heating Load (Btu/h)	9558.8	8804.6	8804.6
Cooling Load (Btu/h)	9122.6	31811.3	31811.3
CFM	148	1118	1118
Energy (MMBtu)	31.164 MMBtu	91.108 MMBtu	100.135 MMBtu
CO2 Emmisions (lbs)	8379.5 lbCO$_2$	23733.3 lbCO$_2$	26455.8 lbCO$_2$

Fig. 114. Prototype 3

Formal Concepts

Santa Barbara Learning Center

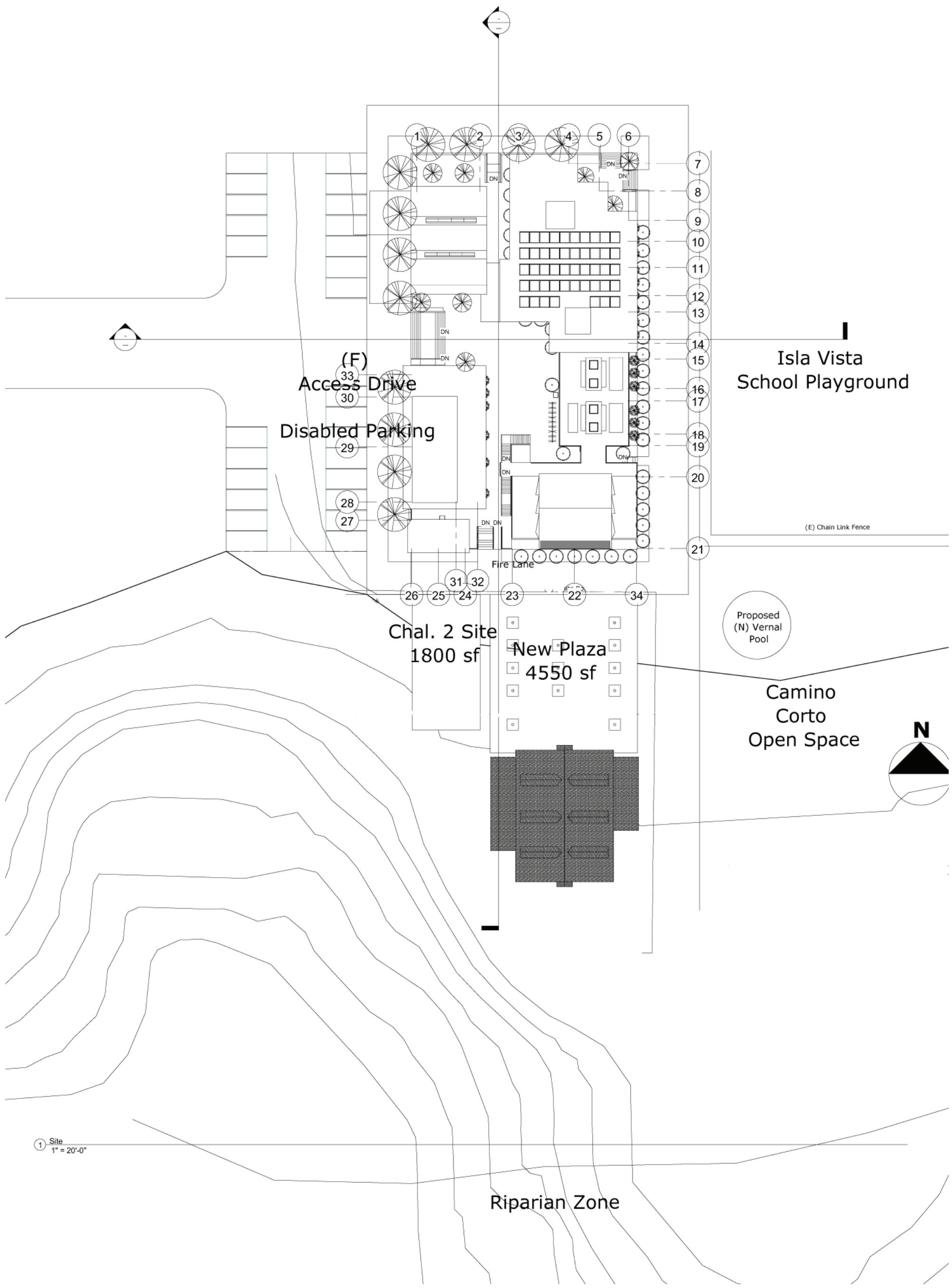


Fig. 115. Site Plan

Fig. 116. Ground Level

Fig. 117. Second Floor

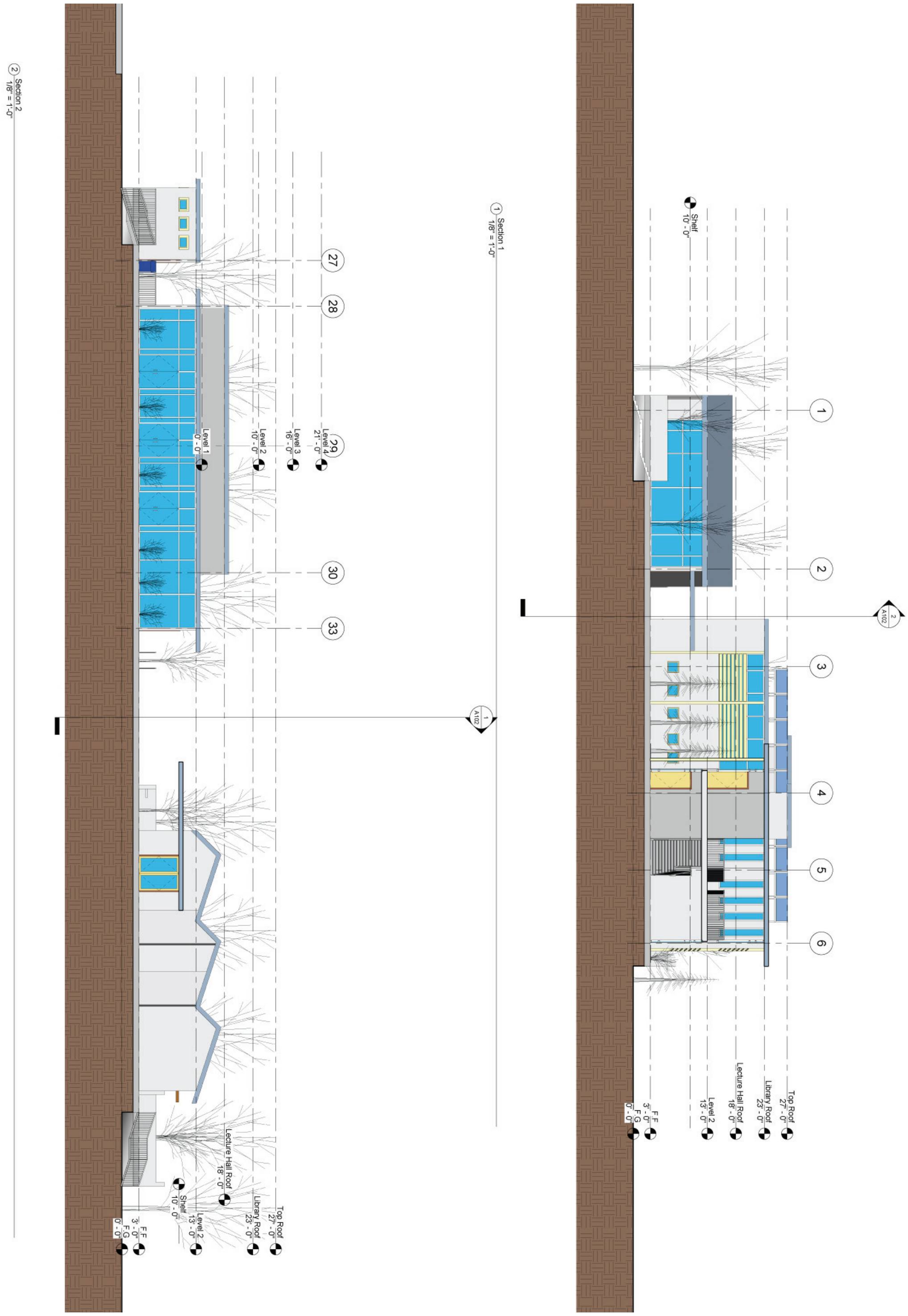


Fig. 118. Site Sections

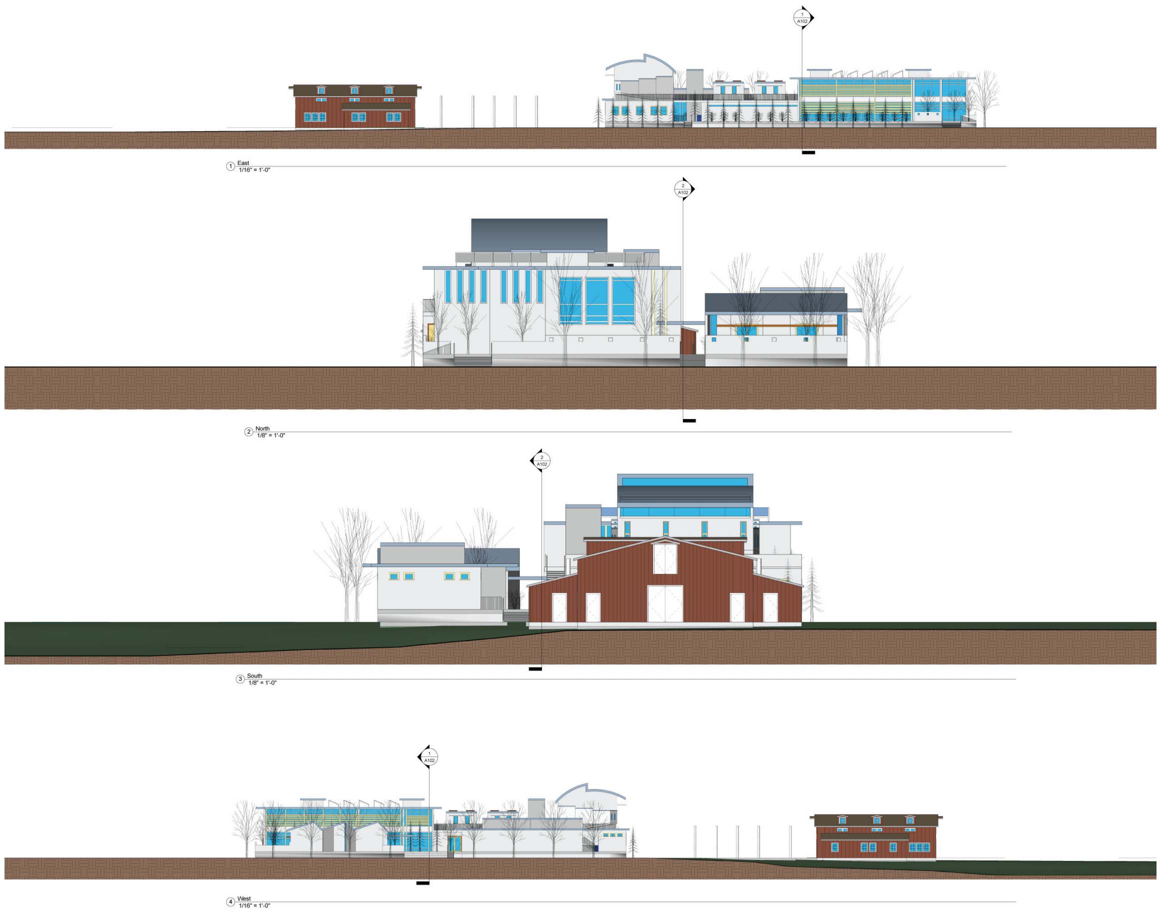


Fig. 119. Site Elevations

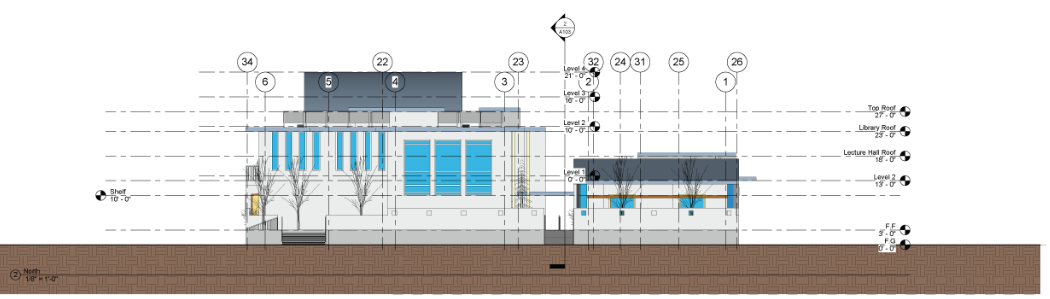


Fig. 120. SBLC North Elevation

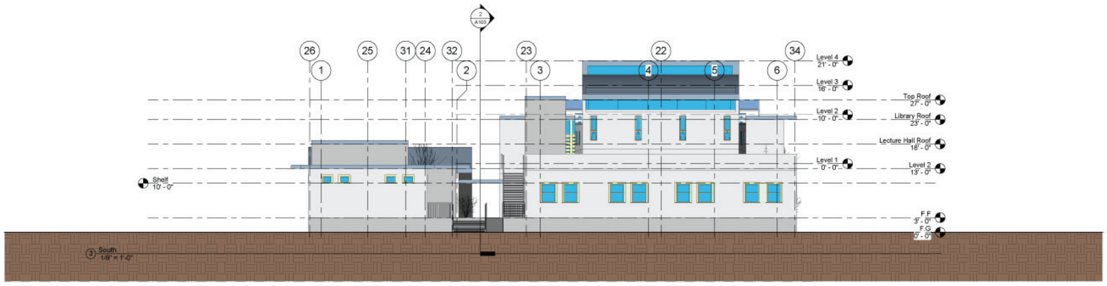


Fig. 121. SBLC South Elevation

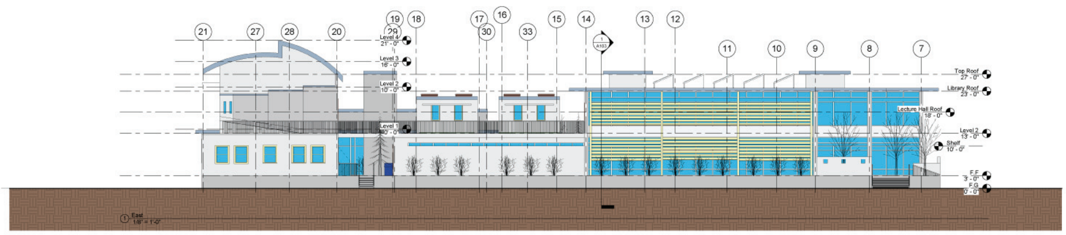


Fig. 122. SBLC East Elevation

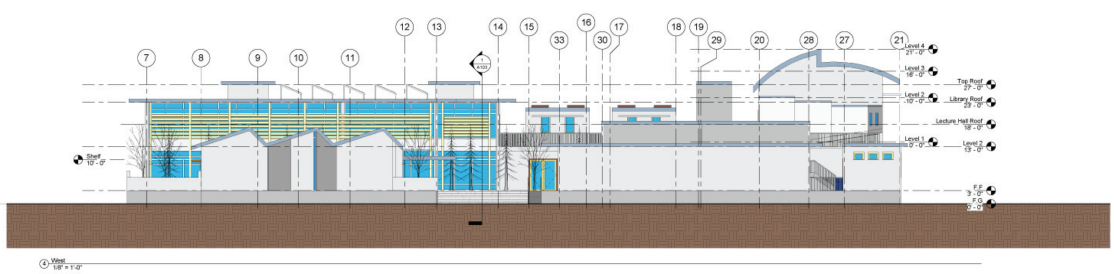


Fig. 123. SBLC West Elevation

Fig. 124. 3D Perspectives

Sustainable Concepts

The sustainable concepts designed into the complex of building are Daylighting, Site Reuse, Renewable Energy, Water Management, Indoor Air Quality, and Recycling. The Daylighting strategies are evident within the Office, Library, and Classrooms. The site has been 100% reused to decrease the amount of building waste attributed to demolition. The roof of the library contains 35 photovoltaic panels that are used to power the most of the complex. The photovoltaic panels contribute to 20% of the energy used to power the buildings. The water run off from the roofs of the building is stored in a cistern and used for irrigation and non-potable water. The remainder of the water is discharged into the ground at a manageable rate. The non smoking law prohibits smoking within 50 feet of the any building. The complex has recycling bins at various locations.

Barn Design

The design of the barn is most interior improvements that allow for the new program. The barn will house exhibits from the presidio era and various artifacts local to ranching in the area. The original stall planks have been reused for exhibit panels. The remaining structural supports that need not been needed were removed and only the necessary members remained. Interior curved walls were added to proved users with a unique experience not inherent with the interior of traditional barns.

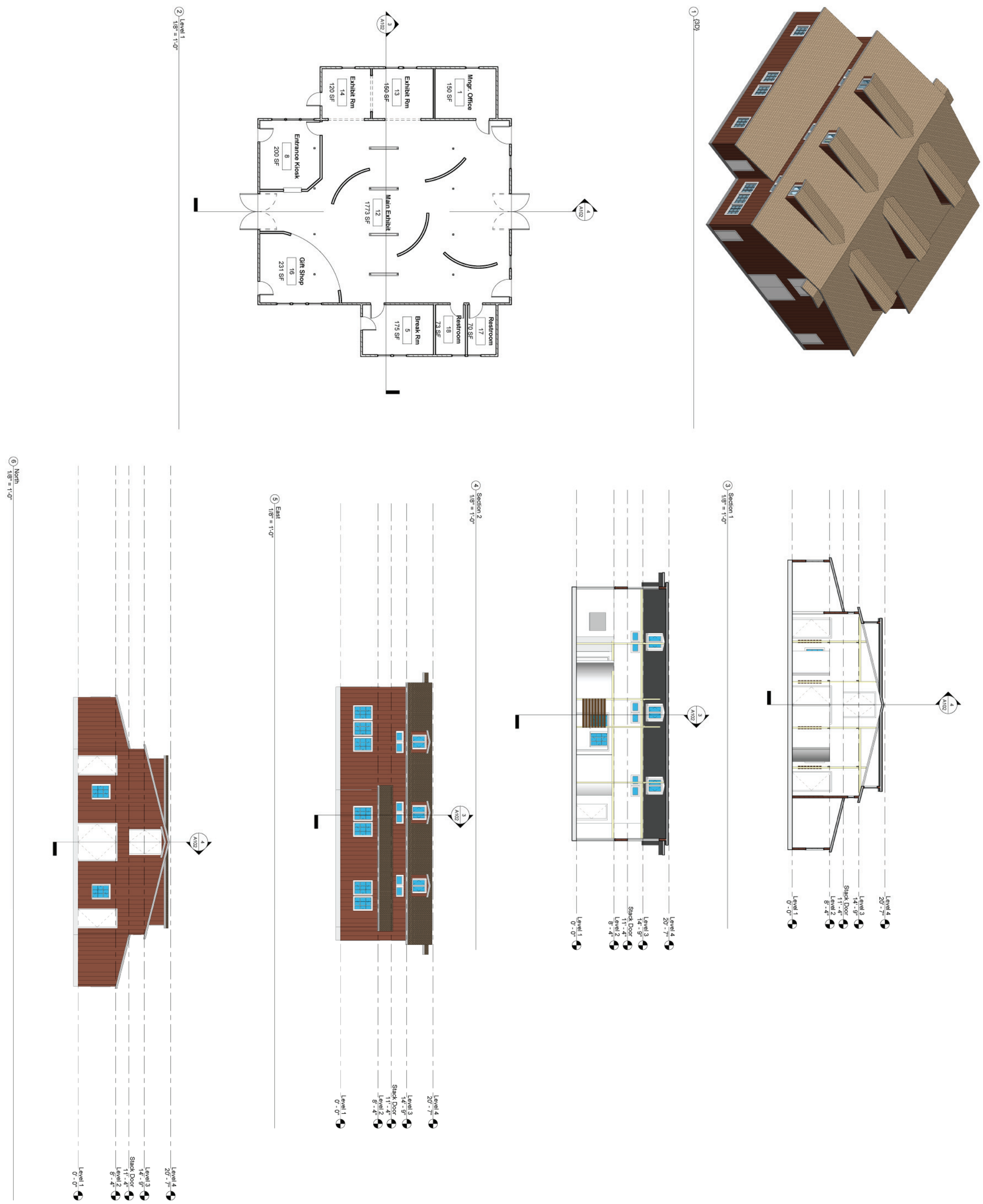


Fig. 125. Barn Design

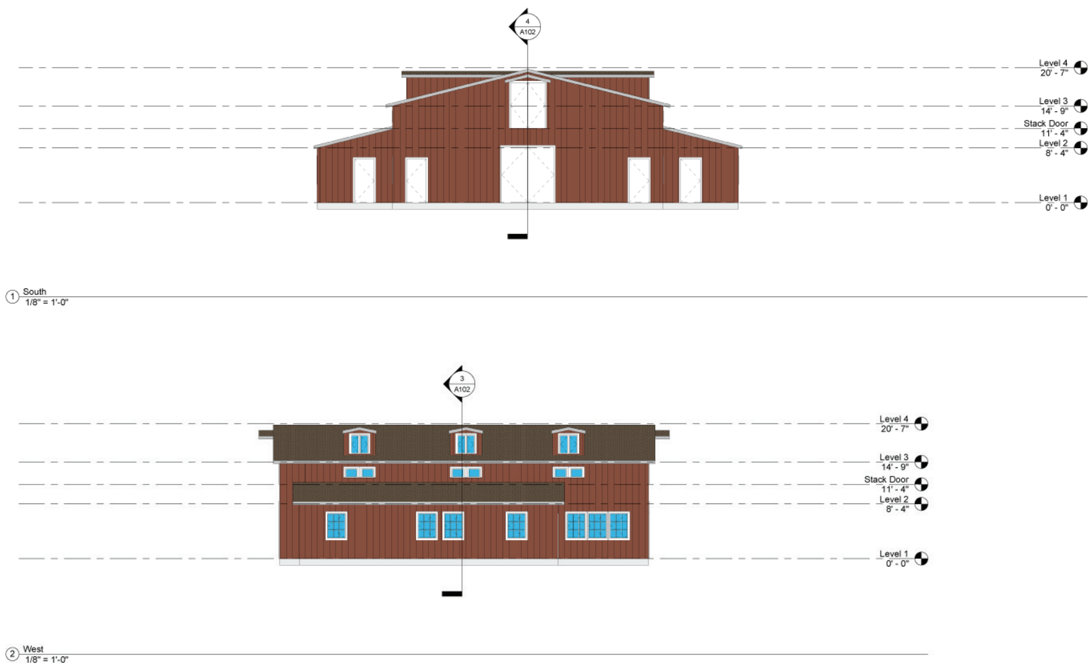


Fig. 126. Barn Elevations

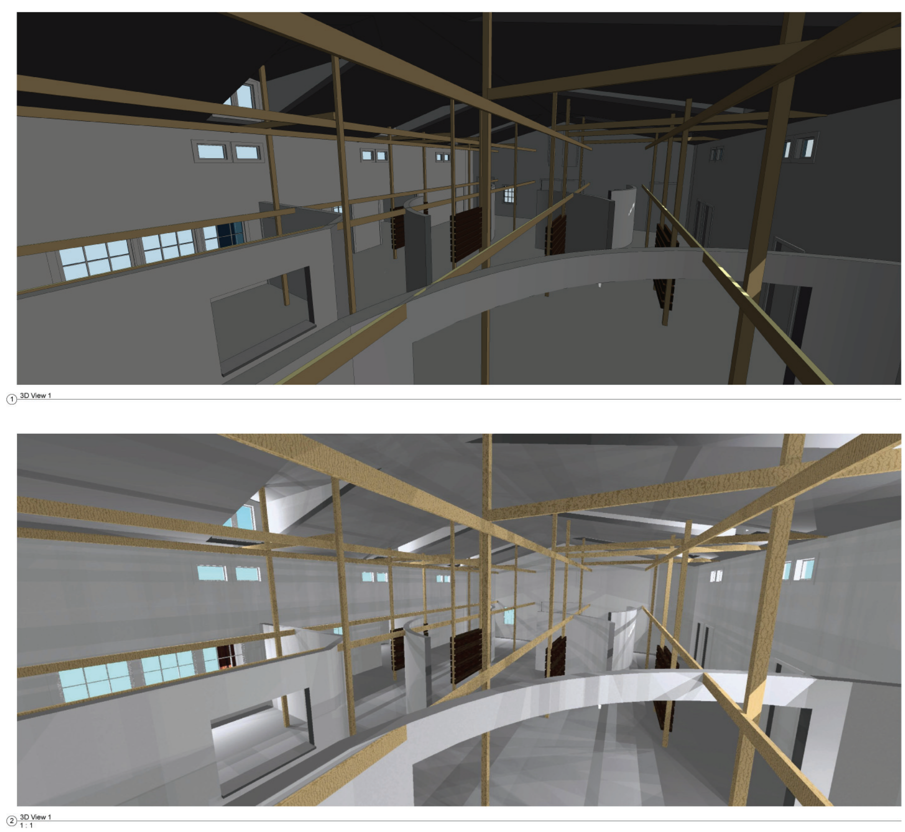


Fig. 127. Interior Renderings

Software Comparison

This portion of the Doctorate Project will examine the two software's used to perform building simulation. The first two sections will provide insight on why students and professionals should use building performance simulation tools to improve design at all levels of design.

Integrated Environmental Solutions

The <Virtual Environment> is easy to learn and easy to use, and can be used by everyone involved in the design process. At its heart is the Integrated Data Model or IDM. This is shared by all the building assessment applications and can be used with your existing CAD systems. Anyone (you don't need to be a CAD user) can construct detailed 3D models, perform advanced building analysis and share data between applications. As well as being better informed, the design team will communicate more effectively and develop designs more quickly, easily and efficiently – which means greater productivity and improved building performance. Below is a list of clients that has used IES in the past with great results.

Architects

Architects	Location	Architects	Location
Burt Hill	USA	Cannon Design	USA
Gensler	USA	SOM	USA
Stantec	Canada	Foster & Partners	UK
Barrett Lloyd Davis Associates	UK	Collett and Farmer Architects	UK
Holmes Partnership	UK	JW Architects	UK
Kling Stubbins	USA	RMJM	UK
Ryders HKS International Ltd	UK	REID architecture	UK

Fig. 128. List of clients

This Doctorate Project is geared toward motivating students to use building simulation as a daily tool in design. The cost of the software is $130 for a student license. This price is very reasonable for the amount of tools in IES. The student license is a fully functional license and can be renewed at the same cost of subscription.

Green Building Studio

Green Building Studio, Inc., an architectural, engineering and construction software company, is the industry's leading provider of building energy analysis tools and web-based sales lead and advertising solutions. Green Building Studio, Inc. introduced the Green Building Studio web service to the A&E user community on April 21, 2004. It is available at no charge and is being aggressively marketed by the major CAD vendors, Autodesk, Graphisoft, and soon Bentley, as well as through trade publication coverage and internal Green Building Studio, Inc. sales and marketing.

GBS removes major barriers to energy efficient and sustainable green building design as well as streamlining everyday engineering tasks. It provides whole building energy analysis using the widely accepted building analysis program, DOE-2, at no charge to the design team. With Version 3.0 we introduced two versions of our service. The Pay-Per-Run version of GBS has limited features and the Corporate Account is the full-featured version. The features and prices are listed in the table below.

GBS Web Service Version 3.0

Feature	Corporate Account	Pay-Per-Run	Typical Consulting Fees*
Annual Cost	$6,995 (two users)	Free	per Project
Number of Runs	Unlimited	5 free for each project	
Whole Building Energy Results (DOE-2.2)	✓	✓	$5,000
DOE-2.2 BDL File	✓	✓	
EnergyPlus IDF File	✓	✓	$6,000
gbXML File	✓	✓	
VRML File	✓	✓	
50,000+ US Weather Locations	✓	✗	
Weather Graphs & Details	✓	✗	$1,500
Download Weather File	✓	✗	$1,000
Carbon Emissions	✓	✓	
Electric Power Plant Sources	✓	✓	
Carbon Neutral Potential	✓	✗	$1,500
Water Usage & Measures	✓	✗	$3,000
Water LEED Credits	✓	✗	$1,000
Daylight LEED Credit	✓	✗	$3,000
Photovoltaic Potential	✓	✗	$5,000
Wind Energy Potential	✓	✗	$1,000
Natural Ventilation Potential	✓	✗	$3,000
US EPA ENERGY STAR Score	✓	✓	
Design Alternatives	✓	✓	$1,000
Additional User License	$1,695 per year	NA	
Cost for additional runs	Included	$4+$0.50/room	
Included Support Incidents	5 per user per year	None	
Additional Support	$195/hr.	$195/hr.	

✓ Included ✗ Not included

✗ sum:	$20,000
✓ sum:	$12,000
Total:	$32,000

* These are the fees that it would typically cost to do these analyses without GBS.

Fig. 129. Price list for GBS online service

Benchmark

This section will compare software's on a benchmark system. The key factors are ***time***, ***cost***, and ***accuracy***. The *time* factor is meant to determine the speed at which the outputs can be delivered to the user. The *cost* factor will determine the monetary value of attributed to the Doctorate Project. The *accuracy* factor will establish the amount of control the user has over the physical and analytical model.

Time - "How long does it take to receive output data?"

IES – The simulations are immediately outputted to the user.

GBS - The simulations are immediately outputted to the user.

Note: This feature is now available in 3.1v.

The recent update of GBS is to counter IES ability to output the data immediately.

Results - Both IES and GBS perform equally well based on the amount of time needed to wait for the output data. The result is a tie.

Cost – "What is the cost of the output data?"

IES - The cost of the Software is $130. This includes a year license and unlimited runs. The renewal of the license is half of the total cost of the software.

GBS - The cost for the first 5 runs on a personal account on GBS is free, any additional runs is $10.00 per run. There is a corporate account that cost $1,000 per workstation. The corporate account has unlimited runs and the renewal for a year subscription is the same as the purchase price. The corporate account includes more featured outputs like PV potential analysis and Carbon Neutral potential.

Results = IES is more economical than GBS in all aspects.

Accuracy – "How much control do I have over 3D model?"

IES - IES is a plug-in to Revit Building. The plug-in allows the user to make quick changes to the design and see how those changes affect the performance of the building. The IES software allows the user to test unlimited amount of construction material and assemblies.

GBS - GBS is similar to IES in that it uses a BIM Modeler to generate site specific details about the project. The control of the model is only limited to what can be created in the BIM modeler. GBS has a model control feature similar to IES. It's the Design Alternative option. These options can only be available after you have made your first run.

Results – IES offers more control over BIM models than GBS because IES offers the capability to customize building material assemblies and building systems. GBS will default the material assembly settings and cannot be modified to fit the user's needs. Therefore, IES out performs GBS in accuracy.

Conclusion

The results based on the benchmark reveals that IES out performs GBS in Cost and Accuracy. These factors are the most important aspects of building performance software. Although the outputs vary somewhat in type, there are similarities between the two software's outputs'. This variance in output reveals that if both software's are to be used, the designer's will have a holistic understanding of how site specific factors will impact design decision making.

I believe that IES is the best building performance tool available on the market today based on its Cost and Accuracy. We will see IES and more building performance tools start to develop into more user friendly tools and will eventual become main stream within the next two years.

Appendix A

Heating & Cooling Loads Reports

Base Case

Wood Construction with Radiant Floor

Loads Report: 1 Room

Powered by ies

Project Information

Project:	Base Case
Run Time:	4/9/2008 12:53 PM

Input Data

Room Data		Electrical Data	
Analytical Floor Area:	864 SF	Lighting Load:	1.40 W/ft²
Analytical Roof Area:	864 SF	Equipment Load:	0.00 W/ft²
Analytical Wall Area:	1076 SF	Misc. Load:	1.00 W/ft²
Analytical Window Area:	80 SF	**People Loads**	
Analytical Volume:	8637.79 CF	People:	34.55
		Area / Person	25 SF
		Sensible / Person:	250.0 Btu/h
		Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads		Heating Loads	
Sensible Cooling Load:	2507.9 Btu/h	Sensible Heating Load:	12163.4 Btu/h
Latent Cooling Load:	4975.0 Btu/h	Latent Heating Load:	0.0 Btu/h
Total Cooling Load:	7482.9 Btu/h	Total Heating Load:	12163.4 Btu/h

Airflows

Flow Rate:	116 CFM
Flow Density:	0.13
Air Changes:	0.81

Wood Construction with Variable Air Volume Single Duct

Loads Report: 1 Room

Powered by ies

Project Information

Project:	Base Case
Run Time:	4/10/2008 1:46 AM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1076 SF
Analytical Window Area:	80 SF
Analytical Volume:	8637.79 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person:	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	25401.3 Btu/h
Latent Cooling Load:	6802.4 Btu/h
Total Cooling Load:	32203.7 Btu/h

Heating Loads

Sensible Heating Load:	11040.8 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	11040.8 Btu/h

Airflows

Flow Rate:	1177 CFM
Flow Density:	1.36
Air Changes:	8.18

Wood Construction with Water Heat Loop Pump

Loads Report: 1 Room

Powered by ies

Project Information

Project:	Base Case
Run Time:	4/10/2008 1:42 AM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1076 SF
Analytical Window Area:	80 SF
Analytical Volume:	8637.79 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	25401.3 Btu/h
Latent Cooling Load:	6802.4 Btu/h
Total Cooling Load:	32203.7 Btu/h

Heating Loads

Sensible Heating Load:	11040.8 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	11040.8 Btu/h

Airflows

Flow Rate:	1177 CFM
Flow Density:	1.36
Air Changes:	8.18

Concrete Construction with Radiant Floor

Loads Report: 1 Room

Powered by ies

Project Information

Project:	Base Case
Run Time:	4/11/2008 6:32 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1076 SF
Analytical Window Area:	80 SF
Analytical Volume:	8637.79 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	2364.6 Btu/h
Latent Cooling Load:	4975.1 Btu/h
Total Cooling Load:	7339.8 Btu/h

Heating Loads

Sensible Heating Load:	10963.4 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	10963.4 Btu/h

Airflows

Flow Rate:	110 CFM
Flow Density:	0.13
Air Changes:	0.76

Concrete Construction with Variable Air Volume Single Duct

Loads Report: 1 Room

Powered by ies

Project Information

Project:	Base Case
Run Time:	4/11/2008 6:33 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1076 SF
Analytical Window Area:	80 SF
Analytical Volume:	8637.79 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	24008.7 Btu/h
Latent Cooling Load:	6815.9 Btu/h
Total Cooling Load:	30824.7 Btu/h

Heating Loads

Sensible Heating Load:	10025.0 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	10025.0 Btu/h

Airflows

Flow Rate:	1113 CFM
Flow Density:	1.29
Air Changes:	7.73

Concrete Construction with Water Heat Loop Pump

Loads Report: 1 Room

Powered by ies

Project Information

Project:	Base Case
Run Time:	4/11/2008 6:34 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1076 SF
Analytical Window Area:	80 SF
Analytical Volume:	8637.79 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	24008.7 Btu/h
Latent Cooling Load:	6815.9 Btu/h
Total Cooling Load:	30824.7 Btu/h

Heating Loads

Sensible Heating Load:	10025.0 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	10025.0 Btu/h

Airflows

Flow Rate:	1113 CFM
Flow Density:	1.29
Air Changes:	7.73

Steel Construction with Radiant Floor

Loads Report: 1 Room

Powered by ies

Project Information

Project:	Base Case
Run Time:	4/9/2008 12:55 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1076 SF
Analytical Window Area:	80 SF
Analytical Volume:	8637.79 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	2398.7 Btu/h
Latent Cooling Load:	4975.5 Btu/h
Total Cooling Load:	7374.2 Btu/h

Heating Loads

Sensible Heating Load:	9879.9 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	9879.9 Btu/h

Airflows

Flow Rate:	111 CFM
Flow Density:	0.13
Air Changes:	0.77

Steel Construction with Variable Air Volume Single Duct

Loads Report: 1 Room

Powered by ies

Project Information

Project:	Base Case
Run Time:	4/11/2008 6:35 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1076 SF
Analytical Window Area:	80 SF
Analytical Volume:	8637.79 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	26829.7 Btu/h
Latent Cooling Load:	6794.6 Btu/h
Total Cooling Load:	33624.3 Btu/h

Heating Loads

Sensible Heating Load:	9104.8 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	9104.8 Btu/h

Airflows

Flow Rate:	1243 CFM
Flow Density:	1.44
Air Changes:	8.64

Steel Construction with Water Heat Loop Pump

Loads Report: 1 Room

Powered by ies

Project Information

Project:	Base Case
Run Time:	4/11/2008 6:34 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1076 SF
Analytical Window Area:	80 SF
Analytical Volume:	8637.79 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	26829.7 Btu/h
Latent Cooling Load:	6794.6 Btu/h
Total Cooling Load:	33624.3 Btu/h

Heating Loads

Sensible Heating Load:	9104.8 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	9104.8 Btu/h

Airflows

Flow Rate:	1243 CFM
Flow Density:	1.44
Air Changes:	8.64

CMU Construction with Radiant Floor

Loads Report: 1 Room

Powered by ies

Project Information

Project:	Base Case
Run Time:	4/9/2008 12:55 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1076 SF
Analytical Window Area:	80 SF
Analytical Volume:	8637.79 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	1833.1 Btu/h
Latent Cooling Load:	4974.5 Btu/h
Total Cooling Load:	6807.6 Btu/h

Heating Loads

Sensible Heating Load:	16784.3 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	16784.3 Btu/h

Airflows

Flow Rate:	85 CFM
Flow Density:	0.10
Air Changes:	0.59

CMU Construction with Variable Air Volume Single Duct

Loads Report: 1 Room

Powered by ies

Project Information

Project:	Base Case
Run Time:	4/11/2008 6:37 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1076 SF
Analytical Window Area:	80 SF
Analytical Volume:	8637.79 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	26523.2 Btu/h
Latent Cooling Load:	6805.6 Btu/h
Total Cooling Load:	33328.8 Btu/h

Heating Loads

Sensible Heating Load:	14753.0 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	14753.0 Btu/h

Airflows

Flow Rate:	1229 CFM
Flow Density:	1.42
Air Changes:	8.54

CMU Construction with Water Heat Loop Pump

Loads Report: 1 Room

Powered by ies

Project Information

Project:	Base Case
Run Time:	4/11/2008 6:38 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1076 SF
Analytical Window Area:	80 SF
Analytical Volume:	8637.79 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	26523.2 Btu/h
Latent Cooling Load:	6805.6 Btu/h
Total Cooling Load:	33328.8 Btu/h

Heating Loads

Sensible Heating Load:	14753.0 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	14753.0 Btu/h

Airflows

Flow Rate:	1229 CFM
Flow Density:	1.42
Air Changes:	8.54

Hybrid Construction with Radiant Floor

Loads Report: 1 Room

Powered by ies

Project Information

Project:	Base Case
Run Time:	4/14/2008 8:29 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1076 SF
Analytical Window Area:	80 SF
Analytical Volume:	8637.79 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	2737.7 Btu/h
Latent Cooling Load:	4975.5 Btu/h
Total Cooling Load:	7713.2 Btu/h

Heating Loads

Sensible Heating Load:	10850.1 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	10850.1 Btu/h

Airflows

Flow Rate:	127 CFM
Flow Density:	0.15
Air Changes:	0.88

Hybrid Construction with Variable Air Volume Single Duct

Loads Report: 1 Room

Powered by ies

Project Information

Project:	Base Case
Run Time:	4/14/2008 8:30 PM

Input Data

Room Data		Electrical Data	
Analytical Floor Area:	864 SF	Lighting Load:	1.40 W/ft²
Analytical Roof Area:	864 SF	Equipment Load:	0.00 W/ft²
Analytical Wall Area:	1076 SF	Misc. Load:	1.00 W/ft²
Analytical Window Area:	80 SF	**People Loads**	
Analytical Volume:	8637.79 CF	People:	34.55
		Area / Person	25 SF
		Sensible / Person:	250.0 Btu/h
		Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads		Heating Loads	
Sensible Cooling Load:	26323.5 Btu/h	Sensible Heating Load:	9908.3 Btu/h
Latent Cooling Load:	6791.0 Btu/h	Latent Heating Load:	0.0 Btu/h
Total Cooling Load:	33114.5 Btu/h	Total Heating Load:	9908.3 Btu/h

Airflows

Flow Rate:	1220 CFM
Flow Density:	1.41
Air Changes:	8.47

Hybrid Construction with Water Heat Loop Pump

Loads Report: 1 Room

Powered by ies

Project Information

Project:	Base Case
Run Time:	4/14/2008 8:31 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1076 SF
Analytical Window Area:	80 SF
Analytical Volume:	8637.79 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	26323.5 Btu/h
Latent Cooling Load:	6791.0 Btu/h
Total Cooling Load:	33114.5 Btu/h

Heating Loads

Sensible Heating Load:	9908.3 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	9908.3 Btu/h

Airflows

Flow Rate:	1220 CFM
Flow Density:	1.41
Air Changes:	8.47

Prototype 1

Wood Construction with Radiant Floor

Loads Report: 1 Room

Powered by ies

Project Information

Project:	Prototype_1
Run Time:	4/14/2008 8:35 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1085 SF
Analytical Window Area:	70 SF
Analytical Volume:	8637.79 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	2456.2 Btu/h
Latent Cooling Load:	4974.9 Btu/h
Total Cooling Load:	7431.1 Btu/h

Heating Loads

Sensible Heating Load:	12078.2 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	12078.2 Btu/h

Airflows

Flow Rate:	114 CFM
Flow Density:	0.13
Air Changes:	0.79

Wood Construction with Variable Air Volume Single Duct

Loads Report: 1 Room

Powered by ies

Project Information

Project:	Prototype_1
Run Time:	4/14/2008 8:36 PM

Input Data

Room Data		Electrical Data	
Analytical Floor Area:	864 SF	Lighting Load:	1.40 W/ft²
Analytical Roof Area:	864 SF	Equipment Load:	0.00 W/ft²
Analytical Wall Area:	1085 SF	Misc. Load:	1.00 W/ft²
Analytical Window Area:	70 SF	**People Loads**	
Analytical Volume:	8637.79 CF	People:	34.55
		Area / Person	25 SF
		Sensible / Person:	250.0 Btu/h
		Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads		Heating Loads	
Sensible Cooling Load:	24790.9 Btu/h	Sensible Heating Load:	10969.9 Btu/h
Latent Cooling Load:	6802.4 Btu/h	Latent Heating Load:	0.0 Btu/h
Total Cooling Load:	31593.3 Btu/h	Total Heating Load:	10969.9 Btu/h

Airflows

Flow Rate:	1149 CFM
Flow Density:	1.33
Air Changes:	7.98

Wood Construction with Water Heat Loop Pump

Loads Report: 1 Room

Powered by ies

Project Information

Project:	Prototype_1
Run Time:	4/14/2008 8:37 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1085 SF
Analytical Window Area:	70 SF
Analytical Volume:	8637.79 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	24790.9 Btu/h
Latent Cooling Load:	6802.4 Btu/h
Total Cooling Load:	31593.3 Btu/h

Heating Loads

Sensible Heating Load:	10969.9 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	10969.9 Btu/h

Airflows

Flow Rate:	1149 CFM
Flow Density:	1.33
Air Changes:	7.98

Concrete Construction with Radiant Floor

Loads Report: 1 Room

Powered by ies

Project Information

Project:	Prototype_1
Run Time:	4/14/2008 8:39 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1085 SF
Analytical Window Area:	70 SF
Analytical Volume:	8637.79 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	2310.1 Btu/h
Latent Cooling Load:	4975.1 Btu/h
Total Cooling Load:	7285.2 Btu/h

Heating Loads

Sensible Heating Load:	10883.1 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	10883.1 Btu/h

Airflows

Flow Rate:	107 CFM
Flow Density:	0.12
Air Changes:	0.74

Concrete Construction with Variable Air Volume Single Duct

Loads Report: 1 Room

Powered by ies

Project Information

Project:	Prototype_1
Run Time:	4/14/2008 8:39 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1085 SF
Analytical Window Area:	70 SF
Analytical Volume:	8637.79 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	23281.3 Btu/h
Latent Cooling Load:	6816.0 Btu/h
Total Cooling Load:	30097.3 Btu/h

Heating Loads

Sensible Heating Load:	9957.0 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	9957.0 Btu/h

Airflows

Flow Rate:	1079 CFM
Flow Density:	1.25
Air Changes:	7.49

Concrete Construction with Water Heat Loop Pump

Loads Report: 1 Room

Powered by ies

Project Information

Project:	Prototype_1
Run Time:	4/14/2008 8:40 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1085 SF
Analytical Window Area:	70 SF
Analytical Volume:	8637.79 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	23281.3 Btu/h
Latent Cooling Load:	6816.0 Btu/h
Total Cooling Load:	30097.3 Btu/h

Heating Loads

Sensible Heating Load:	9957.0 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	9957.0 Btu/h

Airflows

Flow Rate:	1079 CFM
Flow Density:	1.25
Air Changes:	7.49

Steel Construction with Radiant Floor

Loads Report: 1 Room

Powered by ies

Project Information

Project:	Prototype_1
Run Time:	4/14/2008 8:42 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1085 SF
Analytical Window Area:	70 SF
Analytical Volume:	8637.79 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	3121.7 Btu/h
Latent Cooling Load:	4975.5 Btu/h
Total Cooling Load:	8097.3 Btu/h

Heating Loads

Sensible Heating Load:	10393.2 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	10393.2 Btu/h

Airflows

Flow Rate:	145 CFM
Flow Density:	0.17
Air Changes:	1.00

Steel Construction with Variable Air Volume Single Duct

Loads Report: 1 Room

Powered by ies

Project Information

Project:	Prototype_1
Run Time:	4/14/2008 8:43 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1085 SF
Analytical Window Area:	70 SF
Analytical Volume:	8637.79 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	28465.2 Btu/h
Latent Cooling Load:	6780.3 Btu/h
Total Cooling Load:	35245.4 Btu/h

Heating Loads

Sensible Heating Load:	9547.1 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	9547.1 Btu/h

Airflows

Flow Rate:	1319 CFM
Flow Density:	1.53
Air Changes:	9.16

Steel Construction with Water Heat Loop Pump

Loads Report: 1 Room

Powered by ies

Project Information

Project:	Prototype_1
Run Time:	4/14/2008 8:43 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1085 SF
Analytical Window Area:	70 SF
Analytical Volume:	8637.79 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	28465.2 Btu/h
Latent Cooling Load:	6780.3 Btu/h
Total Cooling Load:	35245.4 Btu/h

Heating Loads

Sensible Heating Load:	9547.1 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	9547.1 Btu/h

Airflows

Flow Rate:	1319 CFM
Flow Density:	1.53
Air Changes:	9.16

Hybrid Construction with Radiant Floor

Loads Report: 1 Room

Powered by ies

Project Information

Project:	Prototype_1
Run Time:	4/14/2008 8:54 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1085 SF
Analytical Window Area:	70 SF
Analytical Volume:	8637.79 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	2867.1 Btu/h
Latent Cooling Load:	4975.7 Btu/h
Total Cooling Load:	7842.8 Btu/h

Heating Loads

Sensible Heating Load:	9852.6 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	9852.6 Btu/h

Airflows

Flow Rate:	133 CFM
Flow Density:	0.15
Air Changes:	0.92

Hybrid Construction with Variable Air Volume Single Duct

Loads Report: 1 Room

Powered by ies

Project Information

Project:	Prototype_1
Run Time:	4/14/2008 8:55 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1085 SF
Analytical Window Area:	70 SF
Analytical Volume:	8637.79 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	25616.6 Btu/h
Latent Cooling Load:	6793.4 Btu/h
Total Cooling Load:	32410.0 Btu/h

Heating Loads

Sensible Heating Load:	9078.2 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	9078.2 Btu/h

Airflows

Flow Rate:	1187 CFM
Flow Density:	1.37
Air Changes:	8.25

Hybrid Construction with Water Heat Loop Pump

Loads Report: 1 Room

Powered by ies

Project Information

Project:	Prototype_1
Run Time:	4/14/2008 8:55 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1085 SF
Analytical Window Area:	70 SF
Analytical Volume:	8637.79 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	25616.6 Btu/h
Latent Cooling Load:	6793.4 Btu/h
Total Cooling Load:	32410.0 Btu/h

Heating Loads

Sensible Heating Load:	9078.2 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	9078.2 Btu/h

Airflows

Flow Rate:	1187 CFM
Flow Density:	1.37
Air Changes:	8.25

Prototype 2

Wood Construction with Radiant Floor

Loads Report: 5 Room

Powered by ies

Project Information

Project:	Prototype_2
Run Time:	4/14/2008 9:04 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1144 SF
Analytical Window Area:	70 SF
Analytical Volume:	9069.65 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	2392.2 Btu/h
Latent Cooling Load:	4904.2 Btu/h
Total Cooling Load:	7296.4 Btu/h

Heating Loads

Sensible Heating Load:	12498.1 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	12498.1 Btu/h

Airflows

Flow Rate:	111 CFM
Flow Density:	0.13
Air Changes:	0.73

Wood Construction with Variable Air Volume Single Duct

Loads Report: 5 Room

Powered by ies

Project Information

Project:	Prototype_2
Run Time:	4/14/2008 9:05 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1144 SF
Analytical Window Area:	70 SF
Analytical Volume:	9069.65 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	25026.4 Btu/h
Latent Cooling Load:	6796.4 Btu/h
Total Cooling Load:	31822.7 Btu/h

Heating Loads

Sensible Heating Load:	11365.1 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	11365.1 Btu/h

Airflows

Flow Rate:	1160 CFM
Flow Density:	1.34
Air Changes:	7.67

Wood Construction with Water Heat Loop Pump

Loads Report: 5 Room

Powered by ies

Project Information

Project:	Prototype_2
Run Time:	4/14/2008 9:05 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1144 SF
Analytical Window Area:	70 SF
Analytical Volume:	9069.65 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	25026.4 Btu/h
Latent Cooling Load:	6796.4 Btu/h
Total Cooling Load:	31822.7 Btu/h

Heating Loads

Sensible Heating Load:	11365.1 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	11365.1 Btu/h

Airflows

Flow Rate:	1160 CFM
Flow Density:	1.34
Air Changes:	7.67

Concrete Construction with Radiant Floor

Loads Report: 5 Room

Powered by ies

Project Information

Project:	Prototype_2
Run Time:	4/14/2008 9:06 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1144 SF
Analytical Window Area:	70 SF
Analytical Volume:	9069.65 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	2217.3 Btu/h
Latent Cooling Load:	4904.4 Btu/h
Total Cooling Load:	7121.7 Btu/h

Heating Loads

Sensible Heating Load:	11421.7 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	11421.7 Btu/h

Airflows

Flow Rate:	103 CFM
Flow Density:	0.12
Air Changes:	0.68

Concrete Construction with Variable Air Volume Single Duct

Loads Report: 5 Room

Powered by ies

Project Information

Project:	Prototype_2
Run Time:	4/14/2008 9:06 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1144 SF
Analytical Window Area:	70 SF
Analytical Volume:	9069.65 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	23422.8 Btu/h
Latent Cooling Load:	6811.2 Btu/h
Total Cooling Load:	30234.1 Btu/h

Heating Loads

Sensible Heating Load:	10451.3 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	10451.3 Btu/h

Airflows

Flow Rate:	1085 CFM
Flow Density:	1.26
Air Changes:	7.18

Concrete Construction with Water Heat Loop Pump

Loads Report: 5 Room

Powered by ies

Project Information

Project:	Prototype_2
Run Time:	4/14/2008 9:07 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1144 SF
Analytical Window Area:	70 SF
Analytical Volume:	9069.65 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	23422.8 Btu/h
Latent Cooling Load:	6811.2 Btu/h
Total Cooling Load:	30234.1 Btu/h

Heating Loads

Sensible Heating Load:	10451.3 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	10451.3 Btu/h

Airflows

Flow Rate:	1085 CFM
Flow Density:	1.26
Air Changes:	7.18

Steel Construction with Radiant Floor

Loads Report: 5 Room

Powered by ies

Project Information

Project:	Prototype_2
Run Time:	4/14/2008 9:09 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1144 SF
Analytical Window Area:	70 SF
Analytical Volume:	9069.65 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	2957.6 Btu/h
Latent Cooling Load:	4904.9 Btu/h
Total Cooling Load:	7862.5 Btu/h

Heating Loads

Sensible Heating Load:	9676.9 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	9676.9 Btu/h

Airflows

Flow Rate:	137 CFM
Flow Density:	0.16
Air Changes:	0.91

Steel Construction with Variable Air Volume Single Duct

Loads Report: 5 Room

Powered by ies

Project Information

Project:	Prototype_2
Run Time:	4/14/2008 9:08 PM

Input Data

Room Data		Electrical Data	
Analytical Floor Area:	864 SF	Lighting Load:	1.40 W/ft²
Analytical Roof Area:	864 SF	Equipment Load:	0.00 W/ft²
Analytical Wall Area:	1144 SF	Misc. Load:	1.00 W/ft²
Analytical Window Area:	70 SF	**People Loads**	
Analytical Volume:	9069.65 CF	People:	34.55
		Area / Person	25 SF
		Sensible / Person:	250.0 Btu/h
		Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads		Heating Loads	
Sensible Cooling Load:	27084.5 Btu/h	Sensible Heating Load:	8959.4 Btu/h
Latent Cooling Load:	6774.9 Btu/h	Latent Heating Load:	0.0 Btu/h
Total Cooling Load:	33859.4 Btu/h	Total Heating Load:	8959.4 Btu/h

Airflows

Flow Rate:	1255 CFM
Flow Density:	1.45
Air Changes:	8.30

Steel Construction with Water Heat Loop Pump

Loads Report: 5 Room

Powered by ies

Project Information

Project:	Prototype_2
Run Time:	4/14/2008 9:07 PM

Input Data

Room Data		Electrical Data	
Analytical Floor Area:	864 SF	Lighting Load:	1.40 W/ft²
Analytical Roof Area:	864 SF	Equipment Load:	0.00 W/ft²
Analytical Wall Area:	1144 SF	Misc. Load:	1.00 W/ft²
Analytical Window Area:	70 SF	**People Loads**	
Analytical Volume:	9069.65 CF	People:	34.55
		Area / Person	25 SF
		Sensible / Person:	250.0 Btu/h
		Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads		Heating Loads	
Sensible Cooling Load:	27084.5 Btu/h	Sensible Heating Load:	8959.4 Btu/h
Latent Cooling Load:	6774.9 Btu/h	Latent Heating Load:	0.0 Btu/h
Total Cooling Load:	33859.4 Btu/h	Total Heating Load:	8959.4 Btu/h

Airflows

Flow Rate:	1255 CFM
Flow Density:	1.45
Air Changes:	8.30

CMU Construction with Radiant Floor

Loads Report: 5 Room

Powered by ies

Project Information

Project:	Prototype_2
Run Time:	4/14/2008 9:09 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1144 SF
Analytical Window Area:	70 SF
Analytical Volume:	9069.65 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	2760.7 Btu/h
Latent Cooling Load:	4905.1 Btu/h
Total Cooling Load:	7665.8 Btu/h

Heating Loads

Sensible Heating Load:	10312.1 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	10312.1 Btu/h

Airflows

Flow Rate:	128 CFM
Flow Density:	0.15
Air Changes:	0.85

CMU Construction with Variable Air Volume Single Duct

Loads Report: 5 Room

Powered by ies

Project Information

Project:	Prototype_2
Run Time:	4/14/2008 9:09 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1144 SF
Analytical Window Area:	70 SF
Analytical Volume:	9069.65 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	2760.7 Btu/h
Latent Cooling Load:	4905.1 Btu/h
Total Cooling Load:	7665.8 Btu/h

Heating Loads

Sensible Heating Load:	10312.1 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	10312.1 Btu/h

Airflows

Flow Rate:	128 CFM
Flow Density:	0.15
Air Changes:	0.85

CMU Construction with Water Heat Loop Pump

Loads Report: 5 Room

Powered by ies

Project Information

Project:	Prototype_2
Run Time:	4/14/2008 9:10 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1144 SF
Analytical Window Area:	70 SF
Analytical Volume:	9069.65 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	25742.2 Btu/h
Latent Cooling Load:	6788.3 Btu/h
Total Cooling Load:	32530.5 Btu/h

Heating Loads

Sensible Heating Load:	9505.4 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	9505.4 Btu/h

Airflows

Flow Rate:	1193 CFM
Flow Density:	1.38
Air Changes:	7.89

Hybrid Construction with Radiant Floor

Loads Report: 5 Room

Powered by ies

Project Information

Project:	Prototype_2
Run Time:	4/14/2008 9:12 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1144 SF
Analytical Window Area:	70 SF
Analytical Volume:	9069.65 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	2770.2 Btu/h
Latent Cooling Load:	4905.1 Btu/h
Total Cooling Load:	7675.3 Btu/h

Heating Loads

Sensible Heating Load:	10260.1 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	10260.1 Btu/h

Airflows

Flow Rate:	128 CFM
Flow Density:	0.15
Air Changes:	0.85

Hybrid Construction with Variable Air Volume Single Duct

Loads Report: 5 Room

Powered by ies

Project Information

Project:	Prototype_2
Run Time:	4/14/2008 9:11 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1144 SF
Analytical Window Area:	70 SF
Analytical Volume:	9069.65 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	25739.4 Btu/h
Latent Cooling Load:	6788.4 Btu/h
Total Cooling Load:	32527.7 Btu/h

Heating Loads

Sensible Heating Load:	9460.7 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	9460.7 Btu/h

Airflows

Flow Rate:	1193 CFM
Flow Density:	1.38
Air Changes:	7.89

Hybrid Construction with Water Heat Loop Pump

Loads Report: 5 Room

Powered by ies

Project Information

Project:	Prototype_2
Run Time:	4/14/2008 9:11 PM

Input Data

Room Data

Analytical Floor Area:	864 SF
Analytical Roof Area:	864 SF
Analytical Wall Area:	1144 SF
Analytical Window Area:	70 SF
Analytical Volume:	9069.65 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	34.55
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	25739.4 Btu/h
Latent Cooling Load:	6788.4 Btu/h
Total Cooling Load:	32527.7 Btu/h

Heating Loads

Sensible Heating Load:	9460.7 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	9460.7 Btu/h

Airflows

Flow Rate:	1193 CFM
Flow Density:	1.38
Air Changes:	7.89

Prototype 3

Wood Construction with Radiant Floor

Loads Report: 2 Room

Powered by ies

Project Information

Project:	Protoytpe_3
Run Time:	4/15/2008 12:34 AM

Input Data

Room Data

Analytical Floor Area:	974 SF
Analytical Roof Area:	892 SF
Analytical Wall Area:	1082 SF
Analytical Window Area:	27 SF
Analytical Volume:	7828.27 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	38.95
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	2707.9 Btu/h
Latent Cooling Load:	5938.9 Btu/h
Total Cooling Load:	8646.7 Btu/h

Heating Loads

Sensible Heating Load:	11912.8 Btu/h
Latent Heating Load:	-0.0 Btu/h
Total Heating Load:	11912.8 Btu/h

Airflows

Flow Rate:	125 CFM
Flow Density:	0.13
Air Changes:	0.96

Wood Construction with Variable Air Volume Single Duct

Loads Report: 2 Room

Powered by ies

Project Information

Project:	Protoytpe_3
Run Time:	4/15/2008 12:35 AM

Input Data

Room Data

Analytical Floor Area:	974 SF
Analytical Roof Area:	892 SF
Analytical Wall Area:	1082 SF
Analytical Window Area:	27 SF
Analytical Volume:	7828.27 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	38.95
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	24416.5 Btu/h
Latent Cooling Load:	7691.0 Btu/h
Total Cooling Load:	32107.6 Btu/h

Heating Loads

Sensible Heating Load:	10808.5 Btu/h
Latent Heating Load:	-0.0 Btu/h
Total Heating Load:	10808.5 Btu/h

Airflows

Flow Rate:	1132 CFM
Flow Density:	1.16
Air Changes:	8.67

Wood Construction with Water Heat Loop Pump

Loads Report: 2 Room

Powered by ies

Project Information

Project:	Protoytpe_3
Run Time:	4/15/2008 12:36 AM

Input Data

Room Data

Analytical Floor Area:	974 SF
Analytical Roof Area:	892 SF
Analytical Wall Area:	1082 SF
Analytical Window Area:	27 SF
Analytical Volume:	7828.27 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	38.95
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	24416.5 Btu/h
Latent Cooling Load:	7691.0 Btu/h
Total Cooling Load:	32107.6 Btu/h

Heating Loads

Sensible Heating Load:	10808.5 Btu/h
Latent Heating Load:	-0.0 Btu/h
Total Heating Load:	10808.5 Btu/h

Airflows

Flow Rate:	1132 CFM
Flow Density:	1.16
Air Changes:	8.67

Concrete Construction with Radiant Floor

Loads Report: 2 Room

Powered by ies

Project Information

Project:	Protoytpe_3
Run Time:	4/15/2008 12:37 AM

Input Data

Room Data

Analytical Floor Area:	974 SF
Analytical Roof Area:	892 SF
Analytical Wall Area:	1082 SF
Analytical Window Area:	27 SF
Analytical Volume:	7828.27 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	38.95
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	2530.9 Btu/h
Latent Cooling Load:	5938.9 Btu/h
Total Cooling Load:	8469.9 Btu/h

Heating Loads

Sensible Heating Load:	10690.1 Btu/h
Latent Heating Load:	-0.0 Btu/h
Total Heating Load:	10690.1 Btu/h

Airflows

Flow Rate:	117 CFM
Flow Density:	0.12
Air Changes:	0.90

Concrete Construction with Variable Air Volume Single Duct

Loads Report: 2 Room

Powered by ies

Project Information

Project:	Protoytpe_3
Run Time:	4/15/2008 12:37 AM

Input Data

Room Data

Analytical Floor Area:	974 SF
Analytical Roof Area:	892 SF
Analytical Wall Area:	1082 SF
Analytical Window Area:	27 SF
Analytical Volume:	7828.27 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	38.95
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	23537.1 Btu/h
Latent Cooling Load:	7702.5 Btu/h
Total Cooling Load:	31239.6 Btu/h

Heating Loads

Sensible Heating Load:	9771.0 Btu/h
Latent Heating Load:	-0.0 Btu/h
Total Heating Load:	9771.0 Btu/h

Airflows

Flow Rate:	1091 CFM
Flow Density:	1.12
Air Changes:	8.36

Concrete Construction with Water Heat Loop Pump

Loads Report: 2 Room

Powered by ies

Project Information

Project:	Protoytpe_3
Run Time:	4/15/2008 12:36 AM

Input Data

Room Data

Analytical Floor Area:	974 SF
Analytical Roof Area:	892 SF
Analytical Wall Area:	1082 SF
Analytical Window Area:	27 SF
Analytical Volume:	7828.24 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	38.95
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	23537.1 Btu/h
Latent Cooling Load:	7702.5 Btu/h
Total Cooling Load:	31239.7 Btu/h

Heating Loads

Sensible Heating Load:	9771.1 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	9771.1 Btu/h

Airflows

Flow Rate:	1091 CFM
Flow Density:	1.12
Air Changes:	8.36

Steel Construction with Radiant Floor

Loads Report: 2 Room

Powered by ies

Project Information

Project:	Protoytpe_3
Run Time:	4/15/2008 12:38 AM

Input Data

Room Data

Analytical Floor Area:	974 SF
Analytical Roof Area:	892 SF
Analytical Wall Area:	1083 SF
Analytical Window Area:	27 SF
Analytical Volume:	7828.20 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	38.95
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	3113.4 Btu/h
Latent Cooling Load:	5939.0 Btu/h
Total Cooling Load:	9052.3 Btu/h

Heating Loads

Sensible Heating Load:	12387.0 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	12387.0 Btu/h

Airflows

Flow Rate:	144 CFM
Flow Density:	0.15
Air Changes:	1.11

Steel Construction with Variable Air Volume Single Duct

Loads Report: 2 Room

Powered by ies

Project Information

Project:	Protoytpe_3
Run Time:	4/15/2008 12:38 AM

Input Data

Room Data

Analytical Floor Area:	974 SF
Analytical Roof Area:	892 SF
Analytical Wall Area:	1082 SF
Analytical Window Area:	27 SF
Analytical Volume:	7828.27 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	38.95
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	28281.6 Btu/h
Latent Cooling Load:	7671.1 Btu/h
Total Cooling Load:	35952.7 Btu/h

Heating Loads

Sensible Heating Load:	11198.2 Btu/h
Latent Heating Load:	-0.0 Btu/h
Total Heating Load:	11198.2 Btu/h

Airflows

Flow Rate:	1311 CFM
Flow Density:	1.35
Air Changes:	10.05

Steel Construction with Water Heat Loop Pump

Loads Report: 2 Room

Powered by ies

Project Information

Project:	Protoytpe_3
Run Time:	4/15/2008 12:39 AM

Input Data

Room Data		Electrical Data	
Analytical Floor Area:	974 SF	Lighting Load:	1.40 W/ft²
Analytical Roof Area:	892 SF	Equipment Load:	0.00 W/ft²
Analytical Wall Area:	1082 SF	Misc. Load:	1.00 W/ft²
Analytical Window Area:	27 SF	**People Loads**	
Analytical Volume:	7828.27 CF	People:	38.95
		Area / Person	25 SF
		Sensible / Person:	250.0 Btu/h
		Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads		Heating Loads	
Sensible Cooling Load:	28281.6 Btu/h	Sensible Heating Load:	11198.2 Btu/h
Latent Cooling Load:	7671.1 Btu/h	Latent Heating Load:	-0.0 Btu/h
Total Cooling Load:	35952.7 Btu/h	Total Heating Load:	11198.2 Btu/h
Airflows			
Flow Rate:	1311 CFM		
Flow Density:	1.35		
Air Changes:	10.05		

CMU Construction with Radiant Floor

Loads Report: 2 Room

Powered by ies

Project Information

Project:	Protoytpe_3
Run Time:	4/15/2008 12:41 AM

Input Data

Room Data

Analytical Floor Area:	974 SF
Analytical Roof Area:	892 SF
Analytical Wall Area:	1082 SF
Analytical Window Area:	27 SF
Analytical Volume:	7828.66 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	38.95
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	2955.9 Btu/h
Latent Cooling Load:	5938.9 Btu/h
Total Cooling Load:	8894.8 Btu/h

Heating Loads

Sensible Heating Load:	10391.3 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	10391.3 Btu/h

Airflows

Flow Rate:	137 CFM
Flow Density:	0.14
Air Changes:	1.05

CMU Construction with Variable Air Volume Single Duct

Loads Report: 2 Room

Powered by ies

Project Information

Project:	Protoytpe_3
Run Time:	4/15/2008 12:40 AM

Input Data

Room Data		Electrical Data	
Analytical Floor Area:	974 SF	Lighting Load:	1.40 W/ft²
Analytical Roof Area:	892 SF	Equipment Load:	0.00 W/ft²
Analytical Wall Area:	1082 SF	Misc. Load:	1.00 W/ft²
Analytical Window Area:	27 SF	**People Loads**	
Analytical Volume:	7828.27 CF	People:	38.95
		Area / Person	25 SF
		Sensible / Person:	250.0 Btu/h
		Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads		Heating Loads	
Sensible Cooling Load:	24342.3 Btu/h	Sensible Heating Load:	9516.4 Btu/h
Latent Cooling Load:	7684.0 Btu/h	Latent Heating Load:	-0.0 Btu/h
Total Cooling Load:	32026.3 Btu/h	Total Heating Load:	9516.4 Btu/h

Airflows

Flow Rate:	1128 CFM
Flow Density:	1.16
Air Changes:	8.65

CMU Construction with Water Heat Loop Pump

Loads Report: 2 Room

Powered by ies

Project Information

Project:	Protoytpe_3
Run Time:	4/15/2008 12:40 AM

Input Data

Room Data

Analytical Floor Area:	974 SF
Analytical Roof Area:	892 SF
Analytical Wall Area:	1082 SF
Analytical Window Area:	27 SF
Analytical Volume:	7828.27 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	38.95
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	24342.3 Btu/h
Latent Cooling Load:	7684.0 Btu/h
Total Cooling Load:	32026.3 Btu/h

Heating Loads

Sensible Heating Load:	9516.4 Btu/h
Latent Heating Load:	-0.0 Btu/h
Total Heating Load:	9516.4 Btu/h

Airflows

Flow Rate:	1128 CFM
Flow Density:	1.16
Air Changes:	8.65

Hybrid Construction with Radiant Floor

Loads Report: 2 Room

Powered by ies

Project Information

Project:	Protoytpe_3
Run Time:	4/15/2008 12:41 AM

Input Data

Room Data

Analytical Floor Area:	974 SF
Analytical Roof Area:	892 SF
Analytical Wall Area:	1082 SF
Analytical Window Area:	27 SF
Analytical Volume:	7828.24 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	38.95
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	3183.4 Btu/h
Latent Cooling Load:	5939.2 Btu/h
Total Cooling Load:	9122.6 Btu/h

Heating Loads

Sensible Heating Load:	9558.8 Btu/h
Latent Heating Load:	0.0 Btu/h
Total Heating Load:	9558.8 Btu/h

Airflows

Flow Rate:	148 CFM
Flow Density:	0.15
Air Changes:	1.13

Hybrid Construction with Variable Air Volume Single Duct

Loads Report: 2 Room

Powered by ies

Project Information

Project:	Protoytpe_3
Run Time:	4/15/2008 12:42 AM

Input Data

Room Data

Analytical Floor Area:	974 SF
Analytical Roof Area:	892 SF
Analytical Wall Area:	1082 SF
Analytical Window Area:	27 SF
Analytical Volume:	7828.27 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	38.95
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	24129.1 Btu/h
Latent Cooling Load:	7682.1 Btu/h
Total Cooling Load:	31811.3 Btu/h

Heating Loads

Sensible Heating Load:	8804.6 Btu/h
Latent Heating Load:	-0.0 Btu/h
Total Heating Load:	8804.6 Btu/h

Airflows

Flow Rate:	1118 CFM
Flow Density:	1.15
Air Changes:	8.57

Hybrid Construction with Water Heat Loop Pump

Loads Report: 2 Room

Powered by ies

Project Information

Project:	Protoytpe_3
Run Time:	4/15/2008 12:42 AM

Input Data

Room Data

Analytical Floor Area:	974 SF
Analytical Roof Area:	892 SF
Analytical Wall Area:	1082 SF
Analytical Window Area:	27 SF
Analytical Volume:	7828.27 CF

Electrical Data

Lighting Load:	1.40 W/ft²
Equipment Load:	0.00 W/ft²
Misc. Load:	1.00 W/ft²

People Loads

People:	38.95
Area / Person	25 SF
Sensible / Person:	250.0 Btu/h
Latent / Person:	200.0 Btu/h

Load Data

Cooling Loads

Sensible Cooling Load:	24129.1 Btu/h
Latent Cooling Load:	7682.1 Btu/h
Total Cooling Load:	31811.3 Btu/h

Heating Loads

Sensible Heating Load:	8804.6 Btu/h
Latent Heating Load:	-0.0 Btu/h
Total Heating Load:	8804.6 Btu/h

Airflows

Flow Rate:	1118 CFM
Flow Density:	1.15
Air Changes:	8.57

Building Performance Summaries

Base Case

Wood Construction with Radiant Floor

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	0.580	0.033	0.128	1.279	0.914
Feb	0.429	0.039	0.117	1.155	0.825
Mar	0.287	0.034	0.117	1.279	0.914
Apr	0.095	0.050	0.107	1.238	0.884
May	0.014	0.044	0.101	1.279	0.914
Jun	0.000	0.039	0.094	1.238	0.884
Jul	0.000	0.014	0.087	1.279	0.914
Aug	0.000	0.015	0.087	1.279	0.914
Sep	0.000	0.015	0.084	1.238	0.884
Oct	0.000	0.026	0.092	1.279	0.914
Nov	0.049	0.027	0.095	1.238	0.884
Dec	0.374	0.032	0.118	1.279	0.914
Total	**1.828**	**0.368**	**1.227**	**15.061**	**10.758**

Total energy consumption = 29.242 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	116.6	348.8	249.1
Feb	96.3	315.0	225.0
Mar	77.0	348.8	249.1
Apr	54.8	337.5	241.1
May	41.3	348.8	249.1
Jun	36.5	337.5	241.1
Jul	27.5	348.8	249.1
Aug	27.6	348.8	249.1
Sep	26.9	337.5	241.1
Oct	32.1	348.8	249.1
Nov	39.6	337.5	241.1
Dec	87.8	348.8	249.1
Total	**664.1**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 7703.9 $lbCO_2$

Wood Construction with Variable Air Volume Single Duct

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.593	1.685	2.297	1.279	0.914
Feb	1.343	1.590	2.079	1.155	0.825
Mar	1.185	1.812	2.254	1.279	0.914
Apr	0.658	1.792	2.000	1.238	0.884
May	0.381	1.999	1.987	1.279	0.914
Jun	0.156	2.017	1.819	1.238	0.884
Jul	0.010	2.324	1.777	1.279	0.914
Aug	0.019	2.459	1.849	1.279	0.914
Sep	0.031	2.296	1.776	1.238	0.884
Oct	0.213	2.219	1.987	1.279	0.914
Nov	0.778	1.964	2.188	1.238	0.884
Dec	1.373	1.818	2.307	1.279	0.914
Total	**7.739**	**23.976**	**24.320**	**15.061**	**10.758**

Total energy consumption = 81.853 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1285.3	348.8	249.1
Feb	1168.8	315.0	225.0
Mar	1257.2	348.8	249.1
Apr	1116.4	337.5	241.1
May	1134.6	348.8	249.1
Jun	1065.4	337.5	241.1
Jul	1119.4	348.8	249.1
Aug	1177.2	348.8	249.1
Sep	1114.1	337.5	241.1
Oct	1173.5	348.8	249.1
Nov	1229.5	337.5	241.1
Dec	1296.8	348.8	249.1
Total	**14138.2**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 21178.0 $lbCO_2$

Wood Construction with Water Heat Loop Pump

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.218	1.953	2.854	1.279	0.914
Feb	1.026	1.843	2.580	1.155	0.825
Mar	0.905	2.100	2.793	1.279	0.914
Apr	0.503	2.077	2.469	1.238	0.884
May	0.291	2.317	2.443	1.279	0.914
Jun	0.119	2.337	2.226	1.238	0.884
Jul	0.007	2.694	2.158	1.279	0.914
Aug	0.015	2.851	2.243	1.279	0.914
Sep	0.023	2.661	2.158	1.238	0.884
Oct	0.163	2.572	2.431	1.279	0.914
Nov	0.595	2.276	2.700	1.238	0.884
Dec	1.049	2.107	2.860	1.279	0.914
Total	**5.913**	**27.790**	**29.914**	**15.061**	**10.758**

Total energy consumption = 89.436 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1463.1	348.8	249.1
Feb	1334.6	315.0	225.0
Mar	1447.6	348.8	249.1
Apr	1302.5	337.5	241.1
May	1334.2	348.8	249.1
Jun	1259.3	337.5	241.1
Jul	1323.7	348.8	249.1
Aug	1390.8	348.8	249.1
Sep	1316.8	337.5	241.1
Oct	1384.6	348.8	249.1
Nov	1431.5	337.5	241.1
Dec	1485.9	348.8	249.1
Total	**16474.5**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 23514.3 $lbCO_2$

Concrete Construction with Radiant Floor

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	0.110	0.029	0.104	1.279	0.914
Feb	0.049	0.035	0.093	1.155	0.825
Mar	0.032	0.024	0.094	1.279	0.914
Apr	0.004	0.030	0.091	1.238	0.884
May	0.000	0.019	0.089	1.279	0.914
Jun	0.000	0.012	0.083	1.238	0.884
Jul	0.000	0.002	0.082	1.279	0.914
Aug	0.000	0.002	0.082	1.279	0.914
Sep	0.000	0.001	0.079	1.238	0.884
Oct	0.000	0.008	0.084	1.279	0.914
Nov	0.000	0.013	0.084	1.238	0.884
Dec	0.068	0.027	0.098	1.279	0.914
Total	**0.263**	**0.203**	**1.062**	**15.061**	**10.758**

Total energy consumption = 27.347 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	50.0	348.8	249.1
Feb	41.1	315.0	225.0
Mar	36.1	348.8	249.1
Apr	33.6	337.5	241.1
May	29.4	348.8	249.1
Jun	26.0	337.5	241.1
Jul	22.8	348.8	249.1
Aug	23.0	348.8	249.1
Sep	21.7	337.5	241.1
Oct	25.1	348.8	249.1
Nov	26.4	337.5	241.1
Dec	42.6	348.8	249.1
Total	**377.9**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 7417.7 $lbCO_2$

Concrete Construction with Variable Air Volume Single Duct

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.034	1.654	2.195	1.279	0.914
Feb	0.833	1.554	1.977	1.155	0.825
Mar	0.660	1.745	2.095	1.279	0.914
Apr	0.279	1.751	1.804	1.238	0.884
May	0.096	1.941	1.755	1.279	0.914
Jun	0.009	1.978	1.611	1.238	0.884
Jul	0.000	2.302	1.740	1.279	0.914
Aug	0.000	2.432	1.793	1.279	0.914
Sep	0.000	2.286	1.708	1.238	0.884
Oct	0.023	2.192	1.739	1.279	0.914
Nov	0.322	1.919	1.957	1.238	0.884
Dec	0.804	1.777	2.167	1.279	0.914
Total	**4.059**	**23.529**	**22.540**	**15.061**	**10.758**

Total energy consumption = 75.948 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1178.9	348.8	249.1
Feb	1067.0	315.0	225.0
Mar	1129.6	348.8	249.1
Apr	1004.3	337.5	241.1
May	1019.9	348.8	249.1
Jun	979.6	337.5	241.1
Jul	1101.9	348.8	249.1
Aug	1151.9	348.8	249.1
Sep	1088.8	337.5	241.1
Oct	1074.7	348.8	249.1
Nov	1097.2	337.5	241.1
Dec	1176.1	348.8	249.1
Total	**13070.0**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 20109.8 $lbCO_2$

Concrete Construction with Water Heat Loop Pump

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	0.790	1.917	2.725	1.279	0.914
Feb	0.636	1.801	2.451	1.155	0.825
Mar	0.504	2.022	2.593	1.279	0.914
Apr	0.213	2.030	2.220	1.238	0.884
May	0.074	2.250	2.148	1.279	0.914
Jun	0.007	2.292	1.963	1.238	0.884
Jul	0.000	2.668	2.111	1.279	0.914
Aug	0.000	2.818	2.173	1.279	0.914
Sep	0.000	2.649	2.071	1.238	0.884
Oct	0.018	2.540	2.116	1.279	0.914
Nov	0.246	2.225	2.407	1.238	0.884
Dec	0.615	2.060	2.683	1.279	0.914
Total	**3.102**	**27.272**	**27.660**	**15.061**	**10.758**

Total energy consumption = 83.853 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1364.6	348.8	249.1
Feb	1239.1	315.0	225.0
Mar	1321.5	348.8	249.1
Apr	1185.5	337.5	241.1
May	1208.5	348.8	249.1
Jun	1161.0	337.5	241.1
Jul	1302.9	348.8	249.1
Aug	1360.9	348.8	249.1
Sep	1287.0	337.5	241.1
Oct	1271.8	348.8	249.1
Nov	1293.8	337.5	241.1
Dec	1370.2	348.8	249.1
Total	**15366.5**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 22406.3 $lbCO_2$

Steel Construction with Radiant Floor

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	0.000	0.016	0.087	1.279	0.914
Feb	0.000	0.010	0.077	1.155	0.825
Mar	0.000	0.004	0.082	1.279	0.914
Apr	0.000	0.008	0.081	1.238	0.884
May	0.000	0.001	0.081	1.279	0.914
Jun	0.000	0.000	0.078	1.238	0.884
Jul	0.000	0.000	0.081	1.279	0.914
Aug	0.000	0.000	0.081	1.279	0.914
Sep	0.000	0.000	0.078	1.238	0.884
Oct	0.000	0.001	0.081	1.279	0.914
Nov	0.000	0.001	0.078	1.238	0.884
Dec	0.000	0.015	0.087	1.279	0.914
Total	**0.000**	**0.056**	**0.974**	**15.061**	**10.758**

Total energy consumption = 26.849 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	28.2	348.8	249.1
Feb	23.8	315.0	225.0
Mar	23.6	348.8	249.1
Apr	24.2	337.5	241.1
May	22.4	348.8	249.1
Jun	21.3	337.5	241.1
Jul	22.0	348.8	249.1
Aug	22.0	348.8	249.1
Sep	21.3	337.5	241.1
Oct	22.4	348.8	249.1
Nov	21.6	337.5	241.1
Dec	27.9	348.8	249.1
Total	**280.7**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 7320.5 $lbCO_2$

Steel Construction with Variable Air Volume Single Duct

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	0.814	1.689	2.188	1.279	0.914
Feb	0.656	1.596	1.992	1.155	0.825
Mar	0.538	1.813	2.139	1.279	0.914
Apr	0.247	1.835	1.896	1.238	0.884
May	0.094	2.045	1.856	1.279	0.914
Jun	0.007	2.086	1.662	1.238	0.884
Jul	0.000	2.404	1.782	1.279	0.914
Aug	0.000	2.529	1.833	1.279	0.914
Sep	0.000	2.359	1.738	1.238	0.884
Oct	0.020	2.255	1.761	1.279	0.914
Nov	0.203	1.953	1.912	1.238	0.884
Dec	0.619	1.811	2.158	1.279	0.914
Total	**3.198**	**24.375**	**22.915**	**15.061**	**10.758**

Total energy consumption = 76.307 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1159.2	348.8	249.1
Feb	1060.7	315.0	225.0
Mar	1145.0	348.8	249.1
Apr	1048.1	337.5	241.1
May	1075.2	348.8	249.1
Jun	1022.8	337.5	241.1
Jul	1141.2	348.8	249.1
Aug	1189.4	348.8	249.1
Sep	1117.2	337.5	241.1
Oct	1097.5	348.8	249.1
Nov	1079.3	337.5	241.1
Dec	1159.5	348.8	249.1
Total	**13295.0**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 20334.8 $lbCO_2$

Steel Construction with Water Heat Loop Pump

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	0.622	1.958	2.714	1.279	0.914
Feb	0.502	1.850	2.469	1.155	0.825
Mar	0.411	2.102	2.645	1.279	0.914
Apr	0.189	2.126	2.333	1.238	0.884
May	0.072	2.370	2.272	1.279	0.914
Jun	0.005	2.418	2.022	1.238	0.884
Jul	0.000	2.786	2.159	1.279	0.914
Aug	0.000	2.931	2.219	1.279	0.914
Sep	0.000	2.735	2.106	1.238	0.884
Oct	0.015	2.614	2.140	1.279	0.914
Nov	0.155	2.264	2.348	1.238	0.884
Dec	0.473	2.099	2.669	1.279	0.914
Total	**2.443**	**28.253**	**28.098**	**15.061**	**10.758**

Total energy consumption = 84.613 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1351.9	348.8	249.1
Feb	1240.5	315.0	225.0
Mar	1345.9	348.8	249.1
Apr	1239.7	337.5	241.1
May	1274.6	348.8	249.1
Jun	1211.3	337.5	241.1
Jul	1348.5	348.8	249.1
Aug	1404.3	348.8	249.1
Sep	1319.8	337.5	241.1
Oct	1298.1	348.8	249.1
Nov	1277.0	337.5	241.1
Dec	1359.3	348.8	249.1
Total	**15670.9**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 22710.7 $lbCO_2$

CMU Construction with Radiant Floor

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.074	0.117	0.183	1.279	0.914
Feb	0.848	0.120	0.169	1.155	0.825
Mar	0.615	0.121	0.171	1.279	0.914
Apr	0.242	0.125	0.149	1.238	0.884
May	0.051	0.125	0.139	1.279	0.914
Jun	0.000	0.119	0.128	1.238	0.884
Jul	0.000	0.059	0.105	1.279	0.914
Aug	0.000	0.053	0.103	1.279	0.914
Sep	0.000	0.052	0.100	1.238	0.884
Oct	0.003	0.074	0.112	1.279	0.914
Nov	0.145	0.096	0.134	1.238	0.884
Dec	0.719	0.105	0.165	1.279	0.914
Total	**3.696**	**1.168**	**1.657**	**15.061**	**10.758**

Total energy consumption = 32.340 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	216.5	348.8	249.1
Feb	185.0	315.0	225.0
Mar	156.5	348.8	249.1
Apr	105.1	337.5	241.1
May	78.6	348.8	249.1
Jun	67.3	337.5	241.1
Jul	44.6	348.8	249.1
Aug	42.6	348.8	249.1
Sep	41.5	337.5	241.1
Oct	51.0	348.8	249.1
Nov	80.9	337.5	241.1
Dec	163.8	348.8	249.1
Total	**1233.5**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 8273.3 $lbCO_2$

CMU Construction with Variable Air Volume Single Duct

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.968	1.451	2.299	1.279	0.914
Feb	1.670	1.383	2.100	1.155	0.825
Mar	1.447	1.612	2.292	1.279	0.914
Apr	0.817	1.656	2.056	1.238	0.884
May	0.450	1.888	2.027	1.279	0.914
Jun	0.177	1.931	1.834	1.238	0.884
Jul	0.008	2.296	1.765	1.279	0.914
Aug	0.015	2.430	1.824	1.279	0.914
Sep	0.018	2.256	1.744	1.238	0.884
Oct	0.181	2.105	1.929	1.279	0.914
Nov	0.827	1.790	2.159	1.238	0.884
Dec	1.592	1.602	2.296	1.279	0.914
Total	**9.170**	**22.400**	**24.326**	**15.061**	**10.758**

Total energy consumption = 81.716 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1269.2	348.8	249.1
Feb	1159.0	315.0	225.0
Mar	1245.7	348.8	249.1
Apr	1114.6	337.5	241.1
May	1123.9	348.8	249.1
Jun	1048.8	337.5	241.1
Jul	1108.3	348.8	249.1
Aug	1161.9	348.8	249.1
Sep	1092.9	337.5	241.1
Oct	1122.6	348.8	249.1
Nov	1180.5	337.5	241.1
Dec	1262.5	348.8	249.1
Total	**13889.8**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 20929.6 $lbCO_2$

CMU Construction with Water Heat Loop Pump

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.504	1.682	2.868	1.279	0.914
Feb	1.276	1.603	2.617	1.155	0.825
Mar	1.105	1.869	2.851	1.279	0.914
Apr	0.625	1.920	2.547	1.238	0.884
May	0.344	2.188	2.499	1.279	0.914
Jun	0.135	2.239	2.249	1.238	0.884
Jul	0.006	2.662	2.143	1.279	0.914
Aug	0.011	2.817	2.213	1.279	0.914
Sep	0.014	2.615	2.119	1.238	0.884
Oct	0.138	2.439	2.363	1.279	0.914
Nov	0.632	2.075	2.672	1.238	0.884
Dec	1.217	1.857	2.857	1.279	0.914
Total	**7.007**	**25.964**	**30.000**	**15.061**	**10.758**

Total energy consumption = 88.789 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1429.1	348.8	249.1
Feb	1310.5	315.0	225.0
Mar	1425.3	348.8	249.1
Apr	1296.2	337.5	241.1
May	1321.1	348.8	249.1
Jun	1240.6	337.5	241.1
Jul	1310.9	348.8	249.1
Aug	1372.8	348.8	249.1
Sep	1292.4	337.5	241.1
Oct	1326.8	348.8	249.1
Nov	1373.6	337.5	241.1
Dec	1437.8	348.8	249.1
Total	**16137.2**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 23177.0 $lbCO_2$

Hybrid Construction with Radiant Floor

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	0.488	0.009	0.123	1.279	0.914
Feb	0.352	0.007	0.107	1.155	0.825
Mar	0.244	0.006	0.111	1.279	0.914
Apr	0.076	0.008	0.092	1.238	0.884
May	0.009	0.003	0.084	1.279	0.914
Jun	0.000	0.000	0.078	1.238	0.884
Jul	0.000	0.000	0.081	1.279	0.914
Aug	0.000	0.000	0.081	1.279	0.914
Sep	0.000	0.000	0.078	1.238	0.884
Oct	0.000	0.003	0.082	1.279	0.914
Nov	0.025	0.004	0.085	1.238	0.884
Dec	0.280	0.008	0.111	1.279	0.914
Total	**1.473**	**0.048**	**1.112**	**15.061**	**10.758**

Total energy consumption = 28.452 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	97.0	348.8	249.1
Feb	75.1	315.0	225.0
Mar	62.4	348.8	249.1
Apr	36.8	337.5	241.1
May	25.0	348.8	249.1
Jun	21.5	337.5	241.1
Jul	22.0	348.8	249.1
Aug	22.1	348.8	249.1
Sep	21.3	337.5	241.1
Oct	23.0	348.8	249.1
Nov	27.1	337.5	241.1
Dec	67.7	348.8	249.1
Total	**500.9**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 7540.7 $lbCO_2$

Hybrid Construction with Variable Air Volume Single Duct

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.633	1.801	2.481	1.279	0.914
Feb	1.403	1.696	2.264	1.155	0.825
Mar	1.290	1.908	2.484	1.279	0.914
Apr	0.824	1.901	2.275	1.238	0.884
May	0.558	2.089	2.282	1.279	0.914
Jun	0.296	2.102	2.131	1.238	0.884
Jul	0.030	2.377	1.865	1.279	0.914
Aug	0.029	2.513	1.932	1.279	0.914
Sep	0.044	2.361	1.867	1.238	0.884
Oct	0.270	2.313	2.179	1.279	0.914
Nov	0.802	2.055	2.386	1.238	0.884
Dec	1.385	1.928	2.499	1.279	0.914
Total	**8.565**	**25.045**	**26.647**	**15.061**	**10.758**

Total energy consumption = 86.076 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1372.2	348.8	249.1
Feb	1255.5	315.0	225.0
Mar	1359.3	348.8	249.1
Apr	1242.0	337.5	241.1
May	1261.6	348.8	249.1
Jun	1191.4	337.5	241.1
Jul	1160.5	348.8	249.1
Aug	1215.8	348.8	249.1
Sep	1158.3	337.5	241.1
Oct	1258.6	348.8	249.1
Nov	1311.5	337.5	241.1
Dec	1380.8	348.8	249.1
Total	**15167.7**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 22207.5 $lbCO_2$

Hybrid Construction with Water Heat Loop Pump

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.248	2.087	3.084	1.279	0.914
Feb	1.072	1.966	2.811	1.155	0.825
Mar	0.986	2.211	3.083	1.279	0.914
Apr	0.630	2.203	2.815	1.238	0.884
May	0.426	2.421	2.815	1.279	0.914
Jun	0.226	2.437	2.621	1.238	0.884
Jul	0.023	2.756	2.267	1.279	0.914
Aug	0.022	2.913	2.347	1.279	0.914
Sep	0.034	2.737	2.270	1.238	0.884
Oct	0.206	2.681	2.673	1.279	0.914
Nov	0.613	2.382	2.950	1.238	0.884
Dec	1.058	2.235	3.101	1.279	0.914
Total	**6.545**	**29.029**	**32.836**	**15.061**	**10.758**

Total energy consumption = 94.229 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1566.4	348.8	249.1
Feb	1436.8	315.0	225.0
Mar	1567.0	348.8	249.1
Apr	1447.3	337.5	241.1
May	1481.0	348.8	249.1
Jun	1407.4	337.5	241.1
Jul	1372.5	348.8	249.1
Aug	1437.0	348.8	249.1
Sep	1369.4	337.5	241.1
Oct	1485.4	348.8	249.1
Nov	1530.6	337.5	241.1
Dec	1587.5	348.8	249.1
Total	**17688.4**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 24728.2 $lbCO_2$

Prototype 1

Wood Construction with Radiant Floor

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	0.589	0.036	0.130	1.279	0.914
Feb	0.439	0.043	0.119	1.155	0.825
Mar	0.294	0.037	0.119	1.279	0.914
Apr	0.095	0.053	0.109	1.238	0.884
May	0.014	0.047	0.102	1.279	0.914
Jun	0.000	0.042	0.096	1.238	0.884
Jul	0.000	0.016	0.087	1.279	0.914
Aug	0.000	0.016	0.087	1.279	0.914
Sep	0.000	0.016	0.085	1.238	0.884
Oct	0.000	0.029	0.093	1.279	0.914
Nov	0.053	0.031	0.097	1.238	0.884
Dec	0.384	0.035	0.120	1.279	0.914
Total	**1.868**	**0.401**	**1.243**	**15.061**	**10.758**

Total energy consumption = 29.331 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	119.2	348.8	249.1
Feb	99.1	315.0	225.0
Mar	79.3	348.8	249.1
Apr	56.1	337.5	241.1
May	42.5	348.8	249.1
Jun	37.5	337.5	241.1
Jul	28.0	348.8	249.1
Aug	28.3	348.8	249.1
Sep	27.5	337.5	241.1
Oct	33.0	348.8	249.1
Nov	41.5	337.5	241.1
Dec	90.4	348.8	249.1
Total	**682.4**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 7722.2 $lbCO_2$

Wood Construction with Variable Air Volume Single Duct

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.584	1.639	2.278	1.279	0.914
Feb	1.337	1.548	2.062	1.155	0.825
Mar	1.178	1.775	2.238	1.279	0.914
Apr	0.652	1.765	1.988	1.238	0.884
May	0.377	1.977	1.975	1.279	0.914
Jun	0.155	1.998	1.808	1.238	0.884
Jul	0.010	2.303	1.768	1.279	0.914
Aug	0.019	2.432	1.838	1.279	0.914
Sep	0.030	2.262	1.761	1.238	0.884
Oct	0.211	2.175	1.967	1.279	0.914
Nov	0.777	1.917	2.169	1.238	0.884
Dec	1.367	1.769	2.287	1.279	0.914
Total	**7.699**	**23.560**	**24.139**	**15.061**	**10.758**

Total energy consumption = 81.217 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1266.8	348.8	249.1
Feb	1152.0	315.0	225.0
Mar	1242.0	348.8	249.1
Apr	1105.0	337.5	241.1
May	1124.9	348.8	249.1
Jun	1057.0	337.5	241.1
Jul	1111.2	348.8	249.1
Aug	1166.6	348.8	249.1
Sep	1100.6	337.5	241.1
Oct	1155.9	348.8	249.1
Nov	1211.4	337.5	241.1
Dec	1277.2	348.8	249.1
Total	**13970.7**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 21010.5 $lbCO_2$

Wood Construction with Water Heat Loop Pump

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.211	1.900	2.832	1.279	0.914
Feb	1.022	1.795	2.560	1.155	0.825
Mar	0.900	2.057	2.775	1.279	0.914
Apr	0.498	2.045	2.455	1.238	0.884
May	0.288	2.292	2.428	1.279	0.914
Jun	0.119	2.315	2.213	1.238	0.884
Jul	0.007	2.670	2.147	1.279	0.914
Aug	0.015	2.818	2.230	1.279	0.914
Sep	0.023	2.622	2.140	1.238	0.884
Oct	0.162	2.520	2.408	1.279	0.914
Nov	0.594	2.222	2.678	1.238	0.884
Dec	1.044	2.051	2.837	1.279	0.914
Total	**5.883**	**27.308**	**29.703**	**15.061**	**10.758**

Total energy consumption = 88.713 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1442.1	348.8	249.1
Feb	1315.4	315.0	225.0
Mar	1430.4	348.8	249.1
Apr	1289.6	337.5	241.1
May	1323.0	348.8	249.1
Jun	1249.5	337.5	241.1
Jul	1314.2	348.8	249.1
Aug	1378.4	348.8	249.1
Sep	1301.2	337.5	241.1
Oct	1364.2	348.8	249.1
Nov	1410.6	337.5	241.1
Dec	1463.4	348.8	249.1
Total	**16282.0**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 23321.8 $lbCO_2$

Concrete Construction with Radiant Floor

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	0.115	0.033	0.106	1.279	0.914
Feb	0.053	0.039	0.096	1.155	0.825
Mar	0.034	0.028	0.096	1.279	0.914
Apr	0.004	0.033	0.092	1.238	0.884
May	0.000	0.022	0.090	1.279	0.914
Jun	0.000	0.014	0.084	1.238	0.884
Jul	0.000	0.003	0.082	1.279	0.914
Aug	0.000	0.003	0.082	1.279	0.914
Sep	0.000	0.002	0.079	1.238	0.884
Oct	0.000	0.009	0.084	1.279	0.914
Nov	0.000	0.015	0.085	1.238	0.884
Dec	0.071	0.030	0.099	1.279	0.914
Total	**0.278**	**0.230**	**1.075**	**15.061**	**10.758**

Total energy consumption = 27.401 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	52.2	348.8	249.1
Feb	43.4	315.0	225.0
Mar	37.8	348.8	249.1
Apr	34.8	337.5	241.1
May	30.3	348.8	249.1
Jun	26.8	337.5	241.1
Jul	23.0	348.8	249.1
Aug	23.1	348.8	249.1
Sep	21.9	337.5	241.1
Oct	25.5	348.8	249.1
Nov	27.3	337.5	241.1
Dec	44.2	348.8	249.1
Total	**390.5**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 7430.3 $lbCO_2$

Concrete Construction with Variable Air Volume Single Duct

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.024	1.608	2.176	1.279	0.914
Feb	0.827	1.511	1.960	1.155	0.825
Mar	0.654	1.707	2.077	1.279	0.914
Apr	0.274	1.724	1.789	1.238	0.884
May	0.094	1.919	1.742	1.279	0.914
Jun	0.009	1.959	1.603	1.238	0.884
Jul	0.000	2.281	1.731	1.279	0.914
Aug	0.000	2.404	1.782	1.279	0.914
Sep	0.000	2.252	1.694	1.238	0.884
Oct	0.023	2.147	1.720	1.279	0.914
Nov	0.319	1.872	1.936	1.238	0.884
Dec	0.797	1.728	2.145	1.279	0.914
Total	**4.022**	**23.112**	**22.355**	**15.061**	**10.758**

Total energy consumption = 75.308 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1160.2	348.8	249.1
Feb	1050.1	315.0	225.0
Mar	1113.9	348.8	249.1
Apr	992.2	337.5	241.1
May	1010.0	348.8	249.1
Jun	972.2	337.5	241.1
Jul	1093.9	348.8	249.1
Aug	1141.3	348.8	249.1
Sep	1075.8	337.5	241.1
Oct	1057.2	348.8	249.1
Nov	1078.3	337.5	241.1
Dec	1155.9	348.8	249.1
Total	**12901.1**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 19940.9 $lbCO_2$

Concrete Construction with Water Heat Loop Pump

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	0.783	1.864	2.703	1.279	0.914
Feb	0.632	1.752	2.431	1.155	0.825
Mar	0.499	1.979	2.572	1.279	0.914
Apr	0.210	1.998	2.203	1.238	0.884
May	0.072	2.225	2.132	1.279	0.914
Jun	0.007	2.270	1.953	1.238	0.884
Jul	0.000	2.644	2.101	1.279	0.914
Aug	0.000	2.786	2.160	1.279	0.914
Sep	0.000	2.610	2.054	1.238	0.884
Oct	0.017	2.489	2.093	1.279	0.914
Nov	0.244	2.170	2.383	1.238	0.884
Dec	0.609	2.002	2.658	1.279	0.914
Total	**3.073**	**26.789**	**27.444**	**15.061**	**10.758**

Total energy consumption = 83.125 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1343.4	348.8	249.1
Feb	1219.7	315.0	225.0
Mar	1303.5	348.8	249.1
Apr	1171.6	337.5	241.1
May	1197.0	348.8	249.1
Jun	1152.3	337.5	241.1
Jul	1293.7	348.8	249.1
Aug	1348.6	348.8	249.1
Sep	1271.9	337.5	241.1
Oct	1251.5	348.8	249.1
Nov	1271.9	337.5	241.1
Dec	1347.0	348.8	249.1
Total	**15172.2**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 22212.0 $lbCO_2$

Steel Construction with Radiant Floor

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	0.603	0.014	0.121	1.279	0.914
Feb	0.451	0.015	0.108	1.155	0.825
Mar	0.325	0.013	0.112	1.279	0.914
Apr	0.120	0.020	0.097	1.238	0.884
May	0.017	0.016	0.090	1.279	0.914
Jun	0.000	0.014	0.084	1.238	0.884
Jul	0.000	0.003	0.082	1.279	0.914
Aug	0.000	0.004	0.082	1.279	0.914
Sep	0.000	0.005	0.080	1.238	0.884
Oct	0.005	0.014	0.087	1.279	0.914
Nov	0.075	0.012	0.092	1.238	0.884
Dec	0.404	0.016	0.114	1.279	0.914
Total	**1.999**	**0.146**	**1.152**	**15.061**	**10.758**

Total energy consumption = 29.116 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	112.4	348.8	249.1
Feb	90.0	315.0	225.0
Mar	74.7	348.8	249.1
Apr	47.2	337.5	241.1
May	31.2	348.8	249.1
Jun	26.7	337.5	241.1
Jul	23.1	348.8	249.1
Aug	23.6	348.8	249.1
Sep	23.1	337.5	241.1
Oct	28.4	348.8	249.1
Nov	37.9	337.5	241.1
Dec	86.1	348.8	249.1
Total	**604.5**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 7644.3 $lbCO_2$

Steel Construction with Variable Air Volume Single Duct

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.964	1.892	2.507	1.279	0.914
Feb	1.718	1.784	2.290	1.155	0.825
Mar	1.626	2.031	2.534	1.279	0.914
Apr	1.173	2.017	2.350	1.238	0.884
May	0.878	2.230	2.405	1.279	0.914
Jun	0.621	2.238	2.311	1.238	0.884
Jul	0.186	2.487	2.164	1.279	0.914
Aug	0.212	2.619	2.225	1.279	0.914
Sep	0.233	2.441	2.142	1.238	0.884
Oct	0.587	2.394	2.396	1.279	0.914
Nov	1.197	2.139	2.473	1.238	0.884
Dec	1.778	2.022	2.546	1.279	0.914
Total	**12.172**	**26.295**	**28.342**	**15.061**	**10.758**

Total energy consumption = 92.628 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1445.6	348.8	249.1
Feb	1326.2	315.0	225.0
Mar	1448.5	348.8	249.1
Apr	1337.8	337.5	241.1
May	1374.0	348.8	249.1
Jun	1318.2	337.5	241.1
Jul	1291.4	348.8	249.1
Aug	1347.0	348.8	249.1
Sep	1278.6	337.5	241.1
Oct	1379.8	348.8	249.1
Nov	1407.5	337.5	241.1
Dec	1468.3	348.8	249.1
Total	**16423.0**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 23462.8 $lbCO_2$

Steel Construction with Water Heat Loop Pump

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.501	2.193	3.112	1.279	0.914
Feb	1.313	2.068	2.840	1.155	0.825
Mar	1.243	2.354	3.140	1.279	0.914
Apr	0.896	2.338	2.906	1.238	0.884
May	0.671	2.585	2.965	1.279	0.914
Jun	0.475	2.595	2.844	1.238	0.884
Jul	0.142	2.883	2.644	1.279	0.914
Aug	0.162	3.035	2.715	1.279	0.914
Sep	0.178	2.829	2.618	1.238	0.884
Oct	0.449	2.775	2.946	1.279	0.914
Nov	0.914	2.479	3.057	1.238	0.884
Dec	1.359	2.344	3.155	1.279	0.914
Total	**9.301**	**30.477**	**34.943**	**15.061**	**10.758**

Total energy consumption = 100.540 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in lbCO_2

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1634.6	348.8	249.1
Feb	1502.8	315.0	225.0
Mar	1653.7	348.8	249.1
Apr	1542.0	337.5	241.1
May	1597.5	348.8	249.1
Jun	1542.4	337.5	241.1
Jul	1524.8	348.8	249.1
Aug	1588.2	348.8	249.1
Sep	1507.5	337.5	241.1
Oct	1616.1	348.8	249.1
Nov	1624.0	337.5	241.1
Dec	1669.7	348.8	249.1
Total	**19003.2**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 26043.0 lbCO_2

CMU Construction with Radiant Floor

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	0.004	0.089	0.119	1.279	0.914
Feb	0.000	0.079	0.106	1.155	0.825
Mar	0.000	0.077	0.112	1.279	0.914
Apr	0.000	0.045	0.097	1.238	0.884
May	0.000	0.028	0.092	1.279	0.914
Jun	0.000	0.009	0.082	1.238	0.884
Jul	0.000	0.001	0.081	1.279	0.914
Aug	0.000	0.000	0.081	1.279	0.914
Sep	0.000	0.000	0.078	1.238	0.884
Oct	0.000	0.011	0.085	1.279	0.914
Nov	0.000	0.034	0.092	1.238	0.884
Dec	0.002	0.068	0.110	1.279	0.914
Total	**0.005**	**0.441**	**1.135**	**15.061**	**10.758**

Total energy consumption = 27.400 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	57.2	348.8	249.1
Feb	50.4	315.0	225.0
Mar	51.6	348.8	249.1
Apr	38.6	337.5	241.1
May	32.6	348.8	249.1
Jun	24.8	337.5	241.1
Jul	22.5	348.8	249.1
Aug	22.0	348.8	249.1
Sep	21.3	337.5	241.1
Oct	26.1	348.8	249.1
Nov	34.3	337.5	241.1
Dec	48.8	348.8	249.1
Total	**430.3**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 7470.1 $lbCO_2$

CMU Construction with Variable Air Volume Single Duct

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.055	1.525	2.286	1.279	0.914
Feb	0.861	1.450	2.087	1.155	0.825
Mar	0.693	1.670	2.252	1.279	0.914
Apr	0.303	1.741	1.948	1.238	0.884
May	0.109	1.968	1.879	1.279	0.914
Jun	0.004	2.037	1.627	1.238	0.884
Jul	0.000	2.382	1.773	1.279	0.914
Aug	0.000	2.505	1.824	1.279	0.914
Sep	0.000	2.320	1.722	1.238	0.884
Oct	0.020	2.156	1.730	1.279	0.914
Nov	0.235	1.822	1.944	1.238	0.884
Dec	0.790	1.649	2.257	1.279	0.914
Total	**4.070**	**23.225**	**23.329**	**15.061**	**10.758**

Total energy consumption = 76.444 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1171.5	348.8	249.1
Feb	1072.4	315.0	225.0
Mar	1156.2	348.8	249.1
Apr	1043.7	337.5	241.1
May	1062.6	348.8	249.1
Jun	999.5	337.5	241.1
Jul	1132.8	348.8	249.1
Aug	1180.4	348.8	249.1
Sep	1101.9	337.5	241.1
Oct	1062.1	348.8	249.1
Nov	1056.3	337.5	241.1
Dec	1164.2	348.8	249.1
Total	**13203.6**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 20243.4 $lbCO_2$

CMU Construction with Water Heat Loop Pump

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	0.806	1.768	2.848	1.279	0.914
Feb	0.658	1.681	2.597	1.155	0.825
Mar	0.529	1.936	2.797	1.279	0.914
Apr	0.232	2.017	2.405	1.238	0.884
May	0.083	2.281	2.306	1.279	0.914
Jun	0.003	2.360	1.980	1.238	0.884
Jul	0.000	2.761	2.149	1.279	0.914
Aug	0.000	2.904	2.208	1.279	0.914
Sep	0.000	2.689	2.087	1.238	0.884
Oct	0.015	2.499	2.106	1.279	0.914
Nov	0.180	2.112	2.396	1.238	0.884
Dec	0.604	1.912	2.805	1.279	0.914
Total	**3.110**	**26.920**	**28.684**	**15.061**	**10.758**

Total energy consumption = 84.533 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1359.7	348.8	249.1
Feb	1248.9	315.0	225.0
Mar	1356.8	348.8	249.1
Apr	1234.8	337.5	241.1
May	1261.1	348.8	249.1
Jun	1184.0	337.5	241.1
Jul	1338.7	348.8	249.1
Aug	1393.9	348.8	249.1
Sep	1302.1	337.5	241.1
Oct	1257.5	348.8	249.1
Nov	1251.6	337.5	241.1
Dec	1361.7	348.8	249.1
Total	**15550.7**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 22590.5 $lbCO_2$

Hybrid Construction with Radiant Floor

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	0.257	0.006	0.108	1.279	0.914
Feb	0.168	0.005	0.094	1.155	0.825
Mar	0.092	0.003	0.093	1.279	0.914
Apr	0.021	0.005	0.084	1.238	0.884
May	0.001	0.001	0.082	1.279	0.914
Jun	0.000	0.000	0.078	1.238	0.884
Jul	0.000	0.000	0.081	1.279	0.914
Aug	0.000	0.000	0.081	1.279	0.914
Sep	0.000	0.000	0.078	1.238	0.884
Oct	0.000	0.001	0.081	1.279	0.914
Nov	0.002	0.002	0.080	1.238	0.884
Dec	0.135	0.007	0.097	1.279	0.914
Total	**0.676**	**0.031**	**1.037**	**15.061**	**10.758**

Total energy consumption = 27.562 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	63.3	348.8	249.1
Feb	48.1	315.0	225.0
Mar	37.8	348.8	249.1
Apr	26.8	337.5	241.1
May	22.7	348.8	249.1
Jun	21.3	337.5	241.1
Jul	22.0	348.8	249.1
Aug	22.0	348.8	249.1
Sep	21.3	337.5	241.1
Oct	22.4	348.8	249.1
Nov	22.6	337.5	241.1
Dec	45.3	348.8	249.1
Total	**375.7**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 7415.5 $lbCO_2$

Hybrid Construction with Variable Air Volume Single Duct

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.392	1.790	2.425	1.279	0.914
Feb	1.192	1.684	2.213	1.155	0.825
Mar	1.073	1.902	2.416	1.279	0.914
Apr	0.668	1.895	2.201	1.238	0.884
May	0.428	2.088	2.197	1.279	0.914
Jun	0.209	2.097	2.031	1.238	0.884
Jul	0.017	2.371	1.829	1.279	0.914
Aug	0.020	2.495	1.892	1.279	0.914
Sep	0.030	2.338	1.819	1.238	0.884
Oct	0.203	2.281	2.083	1.279	0.914
Nov	0.662	2.029	2.300	1.238	0.884
Dec	1.174	1.910	2.431	1.279	0.914
Total	**7.069**	**24.880**	**25.837**	**15.061**	**10.758**

Total energy consumption = 83.605 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1323.9	348.8	249.1
Feb	1211.9	315.0	225.0
Mar	1312.0	348.8	249.1
Apr	1200.5	337.5	241.1
May	1222.0	348.8	249.1
Jun	1151.7	337.5	241.1
Jul	1147.3	348.8	249.1
Aug	1198.6	348.8	249.1
Sep	1137.1	337.5	241.1
Oct	1215.4	348.8	249.1
Nov	1263.4	337.5	241.1
Dec	1330.6	348.8	249.1
Total	**14714.4**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 21754.2 $lbCO_2$

Hybrid Construction with Water Heat Loop Pump

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.064	2.075	3.012	1.279	0.914
Feb	0.911	1.951	2.747	1.155	0.825
Mar	0.820	2.205	2.996	1.279	0.914
Apr	0.511	2.196	2.721	1.238	0.884
May	0.327	2.420	2.706	1.279	0.914
Jun	0.160	2.431	2.493	1.238	0.884
Jul	0.013	2.748	2.222	1.279	0.914
Aug	0.015	2.892	2.296	1.279	0.914
Sep	0.023	2.709	2.211	1.238	0.884
Oct	0.155	2.644	2.551	1.279	0.914
Nov	0.506	2.352	2.841	1.238	0.884
Dec	0.897	2.213	3.014	1.279	0.914
Total	**5.401**	**28.837**	**31.809**	**15.061**	**10.758**

Total energy consumption = 91.867 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1520.5	348.8	249.1
Feb	1395.2	315.0	225.0
Mar	1520.8	348.8	249.1
Apr	1404.7	337.5	241.1
May	1438.7	348.8	249.1
Jun	1362.6	337.5	241.1
Jul	1356.7	348.8	249.1
Aug	1416.4	348.8	249.1
Sep	1344.4	337.5	241.1
Oct	1435.9	348.8	249.1
Nov	1479.3	337.5	241.1
Dec	1537.7	348.8	249.1
Total	**17212.9**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 24252.7 $lbCO_2$

Prototype 2

Wood Construction with Radiant Floor

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	0.665	0.039	0.133	1.279	0.914
Feb	0.502	0.046	0.122	1.155	0.825
Mar	0.348	0.039	0.122	1.279	0.914
Apr	0.118	0.058	0.112	1.238	0.884
May	0.019	0.053	0.105	1.279	0.914
Jun	0.000	0.049	0.098	1.238	0.884
Jul	0.000	0.020	0.089	1.279	0.914
Aug	0.000	0.020	0.089	1.279	0.914
Sep	0.000	0.020	0.086	1.238	0.884
Oct	0.001	0.033	0.095	1.279	0.914
Nov	0.073	0.034	0.101	1.238	0.884
Dec	0.445	0.037	0.124	1.279	0.914
Total	**2.172**	**0.449**	**1.276**	**15.061**	**10.758**

Total energy consumption = 29.716 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	130.3	348.8	249.1
Feb	108.7	315.0	225.0
Mar	87.6	348.8	249.1
Apr	61.1	337.5	241.1
May	45.5	348.8	249.1
Jun	40.1	337.5	241.1
Jul	29.6	348.8	249.1
Aug	29.8	348.8	249.1
Sep	28.9	337.5	241.1
Oct	34.9	348.8	249.1
Nov	46.1	337.5	241.1
Dec	99.8	348.8	249.1
Total	**742.5**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 7782.3 $lbCO_2$

Wood Construction with Variable Air Volume Single Duct

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.717	1.616	2.282	1.279	0.914
Feb	1.455	1.528	2.068	1.155	0.825
Mar	1.287	1.759	2.250	1.279	0.914
Apr	0.730	1.751	2.004	1.238	0.884
May	0.432	1.970	1.993	1.279	0.914
Jun	0.189	1.992	1.834	1.238	0.884
Jul	0.015	2.303	1.775	1.279	0.914
Aug	0.027	2.434	1.850	1.279	0.914
Sep	0.041	2.261	1.776	1.238	0.884
Oct	0.252	2.168	1.990	1.279	0.914
Nov	0.862	1.905	2.183	1.238	0.884
Dec	1.486	1.750	2.294	1.279	0.914
Total	**8.491**	**23.436**	**24.301**	**15.061**	**10.758**

Total energy consumption = 82.047 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1278.1	348.8	249.1
Feb	1163.0	315.0	225.0
Mar	1254.3	348.8	249.1
Apr	1115.3	337.5	241.1
May	1134.7	348.8	249.1
Jun	1066.9	337.5	241.1
Jul	1113.7	348.8	249.1
Aug	1171.4	348.8	249.1
Sep	1105.8	337.5	241.1
Oct	1165.3	348.8	249.1
Nov	1222.7	337.5	241.1
Dec	1289.0	348.8	249.1
Total	**14080.2**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 21120.0 $lbCO_2$

Wood Construction with Water Heat Loop Pump

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.312	1.873	2.838	1.279	0.914
Feb	1.112	1.772	2.569	1.155	0.825
Mar	0.983	2.038	2.790	1.279	0.914
Apr	0.558	2.030	2.476	1.238	0.884
May	0.330	2.283	2.452	1.279	0.914
Jun	0.145	2.309	2.247	1.238	0.884
Jul	0.011	2.669	2.156	1.279	0.914
Aug	0.020	2.821	2.246	1.279	0.914
Sep	0.031	2.620	2.160	1.238	0.884
Oct	0.192	2.513	2.438	1.279	0.914
Nov	0.659	2.208	2.698	1.238	0.884
Dec	1.135	2.029	2.847	1.279	0.914
Total	**6.488**	**27.165**	**29.916**	**15.061**	**10.758**

Total energy consumption = 89.387 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1449.1	348.8	249.1
Feb	1322.9	315.0	225.0
Mar	1439.8	348.8	249.1
Apr	1298.3	337.5	241.1
May	1332.3	348.8	249.1
Jun	1260.3	337.5	241.1
Jul	1317.1	348.8	249.1
Aug	1384.0	348.8	249.1
Sep	1307.2	337.5	241.1
Oct	1373.9	348.8	249.1
Nov	1420.1	337.5	241.1
Dec	1471.8	348.8	249.1
Total	**16376.7**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 23416.5 $lbCO_2$

Concrete Construction with Radiant Floor

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	0.167	0.039	0.112	1.279	0.914
Feb	0.090	0.047	0.102	1.155	0.825
Mar	0.051	0.035	0.100	1.279	0.914
Apr	0.007	0.043	0.097	1.238	0.884
May	0.000	0.030	0.093	1.279	0.914
Jun	0.000	0.023	0.088	1.238	0.884
Jul	0.000	0.005	0.083	1.279	0.914
Aug	0.000	0.005	0.083	1.279	0.914
Sep	0.000	0.004	0.080	1.238	0.884
Oct	0.000	0.013	0.086	1.279	0.914
Nov	0.000	0.021	0.087	1.238	0.884
Dec	0.098	0.037	0.104	1.279	0.914
Total	**0.413**	**0.304**	**1.115**	**15.061**	**10.758**

Total energy consumption = 27.651 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	62.1	348.8	249.1
Feb	51.7	315.0	225.0
Mar	43.5	348.8	249.1
Apr	39.0	337.5	241.1
May	33.7	348.8	249.1
Jun	30.3	337.5	241.1
Jul	24.0	348.8	249.1
Aug	24.1	348.8	249.1
Sep	22.8	337.5	241.1
Oct	27.2	348.8	249.1
Nov	29.6	337.5	241.1
Dec	50.7	348.8	249.1
Total	**438.7**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 7478.5 $lbCO_2$

Concrete Construction with Variable Air Volume Single Duct

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.094	1.579	2.172	1.279	0.914
Feb	0.886	1.486	1.956	1.155	0.825
Mar	0.704	1.683	2.078	1.279	0.914
Apr	0.301	1.703	1.791	1.238	0.884
May	0.107	1.903	1.746	1.279	0.914
Jun	0.011	1.945	1.602	1.238	0.884
Jul	0.000	2.276	1.729	1.279	0.914
Aug	0.000	2.401	1.762	1.279	0.914
Sep	0.000	2.247	1.691	1.238	0.884
Oct	0.026	2.133	1.720	1.279	0.914
Nov	0.350	1.853	1.937	1.238	0.884
Dec	0.854	1.702	2.141	1.279	0.914
Total	**4.334**	**22.912**	**22.345**	**15.061**	**10.758**

Total energy consumption = 75.410 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1159.6	348.8	249.1
Feb	1049.5	315.0	225.0
Mar	1113.7	348.8	249.1
Apr	990.4	337.5	241.1
May	1008.4	348.8	249.1
Jun	968.8	337.5	241.1
Jul	1092.2	348.8	249.1
Aug	1140.7	348.8	249.1
Sep	1073.8	337.5	241.1
Oct	1053.9	348.8	249.1
Nov	1077.1	337.5	241.1
Dec	1154.9	348.8	249.1
Total	**12882.9**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 19922.7 $lbCO_2$

Concrete Construction with Water Heat Loop Pump

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	0.836	1.830	2.699	1.279	0.914
Feb	0.677	1.722	2.427	1.155	0.825
Mar	0.538	1.951	2.573	1.279	0.914
Apr	0.230	1.974	2.206	1.238	0.884
May	0.082	2.206	2.138	1.279	0.914
Jun	0.009	2.255	1.953	1.238	0.884
Jul	0.000	2.639	2.099	1.279	0.914
Aug	0.000	2.783	2.160	1.279	0.914
Sep	0.000	2.604	2.052	1.238	0.884
Oct	0.020	2.472	2.094	1.279	0.914
Nov	0.267	2.147	2.385	1.238	0.884
Dec	0.652	1.972	2.654	1.279	0.914
Total	**3.312**	**26.557**	**27.441**	**15.061**	**10.758**

Total energy consumption = 83.128 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1339.5	348.8	249.1
Feb	1216.3	315.0	225.0
Mar	1301.1	348.8	249.1
Apr	1168.5	337.5	241.1
May	1194.8	348.8	249.1
Jun	1148.4	337.5	241.1
Jul	1291.7	348.8	249.1
Aug	1348.0	348.8	249.1
Sep	1269.5	337.5	241.1
Oct	1247.6	348.8	249.1
Nov	1269.3	337.5	241.1
Dec	1343.3	348.8	249.1
Total	**15138.0**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 22177.8 $lbCO_2$

Steel Construction with Radiant Floor

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	0.243	0.018	0.106	1.279	0.914
Feb	0.151	0.021	0.095	1.155	0.825
Mar	0.083	0.016	0.095	1.279	0.914
Apr	0.016	0.022	0.089	1.238	0.884
May	0.000	0.015	0.087	1.279	0.914
Jun	0.000	0.010	0.082	1.238	0.884
Jul	0.000	0.002	0.081	1.279	0.914
Aug	0.000	0.002	0.082	1.279	0.914
Sep	0.000	0.001	0.079	1.238	0.884
Oct	0.000	0.008	0.084	1.279	0.914
Nov	0.001	0.011	0.083	1.238	0.884
Dec	0.127	0.017	0.097	1.279	0.914
Total	**0.621**	**0.143**	**1.060**	**15.061**	**10.758**

Total energy consumption = 27.642 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	64.1	348.8	249.1
Feb	50.4	315.0	225.0
Mar	40.5	348.8	249.1
Apr	32.3	337.5	241.1
May	27.6	348.8	249.1
Jun	25.3	337.5	241.1
Jul	22.6	348.8	249.1
Aug	22.8	348.8	249.1
Sep	21.8	337.5	241.1
Oct	25.2	348.8	249.1
Nov	25.6	337.5	241.1
Dec	47.2	348.8	249.1
Total	**405.7**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 7445.4 $lbCO_2$

Steel Construction with Variable Air Volume Single Duct

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.616	1.849	2.402	1.279	0.914
Feb	1.402	1.739	2.189	1.155	0.825
Mar	1.314	1.969	2.408	1.279	0.914
Apr	0.880	1.940	2.202	1.238	0.884
May	0.626	2.140	2.229	1.279	0.914
Jun	0.396	2.145	2.120	1.238	0.884
Jul	0.067	2.400	1.927	1.279	0.914
Aug	0.090	2.535	2.026	1.279	0.914
Sep	0.104	2.371	1.940	1.238	0.884
Oct	0.367	2.328	2.188	1.279	0.914
Nov	0.919	2.092	2.341	1.238	0.884
Dec	1.444	1.979	2.433	1.279	0.914
Total	**9.227**	**25.489**	**26.402**	**15.061**	**10.758**

Total energy consumption = 86.937 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1361.8	348.8	249.1
Feb	1246.6	315.0	225.0
Mar	1358.2	348.8	249.1
Apr	1239.7	337.5	241.1
May	1269.7	348.8	249.1
Jun	1212.5	337.5	241.1
Jul	1188.1	348.8	249.1
Aug	1254.9	348.8	249.1
Sep	1188.5	337.5	241.1
Oct	1277.3	348.8	249.1
Nov	1323.9	337.5	241.1
Dec	1383.8	348.8	249.1
Total	**15305.2**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 22345.0 $lbCO_2$

Steel Construction with Water Heat Loop Pump

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.235	2.144	2.980	1.279	0.914
Feb	1.071	2.016	2.713	1.155	0.825
Mar	1.004	2.282	2.982	1.279	0.914
Apr	0.673	2.249	2.719	1.238	0.884
May	0.478	2.481	2.744	1.279	0.914
Jun	0.303	2.486	2.605	1.238	0.884
Jul	0.051	2.782	2.345	1.279	0.914
Aug	0.069	2.939	2.465	1.279	0.914
Sep	0.080	2.748	2.364	1.238	0.884
Oct	0.280	2.698	2.683	1.279	0.914
Nov	0.702	2.425	2.890	1.238	0.884
Dec	1.103	2.294	3.013	1.279	0.914
Total	**7.050**	**29.544**	**32.502**	**15.061**	**10.758**

Total energy consumption = 94.915 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1551.9	348.8	249.1
Feb	1423.5	315.0	225.0
Mar	1561.2	348.8	249.1
Apr	1439.0	337.5	241.1
May	1484.6	348.8	249.1
Jun	1426.0	337.5	241.1
Jul	1404.3	348.8	249.1
Aug	1482.1	348.8	249.1
Sep	1403.8	337.5	241.1
Oct	1502.3	348.8	249.1
Nov	1537.2	337.5	241.1
Dec	1585.2	348.8	249.1
Total	**17801.0**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 24840.8 $lbCO_2$

CMU Construction with Radiant Floor

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	0.312	0.008	0.111	1.279	0.914
Feb	0.213	0.007	0.098	1.155	0.825
Mar	0.120	0.005	0.097	1.279	0.914
Apr	0.032	0.006	0.086	1.238	0.884
May	0.003	0.001	0.082	1.279	0.914
Jun	0.000	0.000	0.078	1.238	0.884
Jul	0.000	0.000	0.081	1.279	0.914
Aug	0.000	0.000	0.081	1.279	0.914
Sep	0.000	0.000	0.078	1.238	0.884
Oct	0.000	0.002	0.081	1.279	0.914
Nov	0.005	0.003	0.081	1.238	0.884
Dec	0.170	0.008	0.100	1.279	0.914
Total	**0.855**	**0.039**	**1.054**	**15.061**	**10.758**

Total energy consumption = 27.767 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	71.8	348.8	249.1
Feb	55.1	315.0	225.0
Mar	42.7	348.8	249.1
Apr	29.1	337.5	241.1
May	23.0	348.8	249.1
Jun	21.3	337.5	241.1
Jul	22.0	348.8	249.1
Aug	22.0	348.8	249.1
Sep	21.3	337.5	241.1
Oct	22.6	348.8	249.1
Nov	23.5	337.5	241.1
Dec	50.9	348.8	249.1
Total	**405.3**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 7445.1 $lbCO_2$

CMU Construction with Variable Air Volume Single Duct

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.454	1.765	2.419	1.279	0.914
Feb	1.245	1.662	2.209	1.155	0.825
Mar	1.117	1.882	2.411	1.279	0.914
Apr	0.693	1.878	2.195	1.238	0.884
May	0.442	2.075	2.191	1.279	0.914
Jun	0.215	2.087	2.024	1.238	0.884
Jul	0.018	2.368	1.828	1.279	0.914
Aug	0.021	2.494	1.891	1.279	0.914
Sep	0.031	2.334	1.818	1.238	0.884
Oct	0.210	2.270	2.080	1.279	0.914
Nov	0.689	2.012	2.296	1.238	0.884
Dec	1.223	1.887	2.423	1.279	0.914
Total	**7.358**	**24.713**	**25.784**	**15.061**	**10.758**

Total energy consumption = 83.675 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in lbCO_2

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1322.8	348.8	249.1
Feb	1211.3	315.0	225.0
Mar	1310.5	348.8	249.1
Apr	1197.4	337.5	241.1
May	1218.6	348.8	249.1
Jun	1148.0	337.5	241.1
Jul	1146.3	348.8	249.1
Aug	1198.2	348.8	249.1
Sep	1135.9	337.5	241.1
Oct	1212.3	348.8	249.1
Nov	1261.1	337.5	241.1
Dec	1328.5	348.8	249.1
Total	**14690.9**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 21730.7 lbCO_2

Steel Construction with Water Heat Loop Pump

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.111	2.045	3.006	1.279	0.914
Feb	0.951	1.926	2.742	1.155	0.825
Mar	0.854	2.181	2.990	1.279	0.914
Apr	0.530	2.177	2.713	1.238	0.884
May	0.338	2.405	2.699	1.279	0.914
Jun	0.164	2.419	2.486	1.238	0.884
Jul	0.014	2.745	2.220	1.279	0.914
Aug	0.016	2.891	2.295	1.279	0.914
Sep	0.024	2.705	2.209	1.238	0.884
Oct	0.160	2.631	2.547	1.279	0.914
Nov	0.527	2.333	2.836	1.238	0.884
Dec	0.935	2.187	3.005	1.279	0.914
Total	**5.623**	**28.645**	**31.749**	**15.061**	**10.758**

Total energy consumption = 91.836 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1516.4	348.8	249.1
Feb	1392.0	315.0	225.0
Mar	1516.9	348.8	249.1
Apr	1399.8	337.5	241.1
May	1434.0	348.8	249.1
Jun	1357.9	337.5	241.1
Jul	1355.5	348.8	249.1
Aug	1415.9	348.8	249.1
Sep	1342.9	337.5	241.1
Oct	1432.0	348.8	249.1
Nov	1475.3	337.5	241.1
Dec	1532.9	348.8	249.1
Total	**17171.7**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 24211.5 $lbCO_2$

Hybrid Construction with Radiant Floor

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	0.350	0.009	0.114	1.279	0.914
Feb	0.245	0.007	0.100	1.155	0.825
Mar	0.141	0.005	0.099	1.279	0.914
Apr	0.040	0.007	0.087	1.238	0.884
May	0.004	0.001	0.082	1.279	0.914
Jun	0.000	0.000	0.078	1.238	0.884
Jul	0.000	0.000	0.081	1.279	0.914
Aug	0.000	0.000	0.081	1.279	0.914
Sep	0.000	0.000	0.078	1.238	0.884
Oct	0.000	0.002	0.082	1.279	0.914
Nov	0.008	0.003	0.081	1.238	0.884
Dec	0.195	0.008	0.103	1.279	0.914
Total	**0.982**	**0.043**	**1.065**	**15.061**	**10.758**

Total energy consumption = 27.908 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	77.2	348.8	249.1
Feb	59.7	315.0	225.0
Mar	46.0	348.8	249.1
Apr	30.6	337.5	241.1
May	23.2	348.8	249.1
Jun	21.3	337.5	241.1
Jul	22.0	348.8	249.1
Aug	22.0	348.8	249.1
Sep	21.3	337.5	241.1
Oct	22.7	348.8	249.1
Nov	24.2	337.5	241.1
Dec	54.6	348.8	249.1
Total	**424.9**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 7464.7 $lbCO_2$

Hybrid Construction with Variable Air Volume Single Duct

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.498	1.761	2.426	1.279	0.914
Feb	1.285	1.659	2.216	1.155	0.825
Mar	1.153	1.880	2.422	1.279	0.914
Apr	0.723	1.878	2.208	1.238	0.884
May	0.464	2.077	2.205	1.279	0.914
Jun	0.231	2.089	2.043	1.238	0.884
Jul	0.020	2.370	1.834	1.279	0.914
Aug	0.024	2.496	1.901	1.279	0.914
Sep	0.036	2.335	1.827	1.238	0.884
Oct	0.226	2.270	2.097	1.279	0.914
Nov	0.720	2.011	2.310	1.238	0.884
Dec	1.263	1.885	2.433	1.279	0.914
Total	**7.642**	**24.710**	**25.921**	**15.061**	**10.758**

Total energy consumption = 84.092 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1329.5	348.8	249.1
Feb	1217.4	315.0	225.0
Mar	1317.4	348.8	249.1
Apr	1204.8	337.5	241.1
May	1225.6	348.8	249.1
Jun	1155.7	337.5	241.1
Jul	1148.7	348.8	249.1
Aug	1201.8	348.8	249.1
Sep	1139.1	337.5	241.1
Oct	1219.1	348.8	249.1
Nov	1268.2	337.5	241.1
Dec	1335.4	348.8	249.1
Total	**14762.9**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 21802.7 $lbCO_2$

Hybrid Construction with Water Heat Loop Pump

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.144	2.041	3.015	1.279	0.914
Feb	0.982	1.923	2.751	1.155	0.825
Mar	0.881	2.179	3.004	1.279	0.914
Apr	0.553	2.177	2.731	1.238	0.884
May	0.354	2.407	2.717	1.279	0.914
Jun	0.176	2.422	2.510	1.238	0.884
Jul	0.016	2.747	2.228	1.279	0.914
Aug	0.018	2.893	2.307	1.279	0.914
Sep	0.027	2.706	2.220	1.238	0.884
Oct	0.173	2.631	2.569	1.279	0.914
Nov	0.550	2.331	2.854	1.238	0.884
Dec	0.965	2.184	3.017	1.279	0.914
Total	**5.840**	**28.641**	**31.925**	**15.061**	**10.758**

Total energy consumption = 92.224 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1522.2	348.8	249.1
Feb	1397.4	315.0	225.0
Mar	1523.6	348.8	249.1
Apr	1407.4	337.5	241.1
May	1441.6	348.8	249.1
Jun	1366.7	337.5	241.1
Jul	1358.4	348.8	249.1
Aug	1420.1	348.8	249.1
Sep	1346.7	337.5	241.1
Oct	1439.7	348.8	249.1
Nov	1482.6	337.5	241.1
Dec	1539.3	348.8	249.1
Total	**17245.7**	**4106.5**	**2933.3**

Total carbon dioxide emissions = 24285.5 $lbCO_2$

Prototype 3

Wood Construction with Radiant Floor

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	0.545	0.071	0.157	1.442	1.030
Feb	0.413	0.078	0.144	1.302	0.930
Mar	0.258	0.067	0.141	1.442	1.030
Apr	0.070	0.074	0.126	1.395	0.997
May	0.007	0.064	0.119	1.442	1.030
Jun	0.000	0.054	0.110	1.395	0.997
Jul	0.000	0.021	0.100	1.442	1.030
Aug	0.000	0.024	0.101	1.442	1.030
Sep	0.000	0.025	0.098	1.395	0.997
Oct	0.000	0.046	0.110	1.442	1.030
Nov	0.045	0.058	0.119	1.395	0.997
Dec	0.361	0.063	0.144	1.442	1.030
Total	**1.698**	**0.645**	**1.469**	**16.976**	**12.126**

Total energy consumption = 32.914 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	130.5	393.1	280.8
Feb	112.3	355.1	253.6
Mar	89.1	393.1	280.8
Apr	63.4	380.4	271.7
May	50.6	393.1	280.8
Jun	44.8	380.4	271.7
Jul	33.1	393.1	280.8
Aug	34.0	393.1	280.8
Sep	33.5	380.4	271.7
Oct	42.4	393.1	280.8
Nov	53.9	380.4	271.7
Dec	101.6	393.1	280.8
Total	**789.1**	**4628.8**	**3306.1**

Total carbon dioxide emissions = 8724.1 $lbCO_2$

Wood Construction with Variable Air Volume Single Duct

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.548	1.667	2.493	1.442	1.030
Feb	1.315	1.569	2.254	1.302	0.930
Mar	1.154	1.847	2.454	1.442	1.030
Apr	0.626	1.878	2.186	1.395	0.997
May	0.360	2.134	2.174	1.442	1.030
Jun	0.147	2.166	1.986	1.395	0.997
Jul	0.009	2.479	1.940	1.442	1.030
Aug	0.017	2.579	1.998	1.442	1.030
Sep	0.026	2.366	1.901	1.395	0.997
Oct	0.198	2.227	2.112	1.442	1.030
Nov	0.765	1.943	2.348	1.395	0.997
Dec	1.340	1.783	2.489	1.442	1.030
Total	**7.504**	**24.639**	**26.336**	**16.976**	**12.126**

Total energy consumption = 87.581 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1328.3	393.1	280.8
Feb	1207.2	355.1	253.6
Mar	1317.5	393.1	280.8
Apr	1186.6	380.4	271.7
May	1219.7	393.1	280.8
Jun	1150.5	380.4	271.7
Jul	1206.2	393.1	280.8
Aug	1250.2	393.1	280.8
Sep	1166.6	380.4	271.7
Oct	1208.0	393.1	280.8
Nov	1265.7	380.4	271.7
Dec	1332.9	393.1	280.8
Total	**14839.3**	**4628.8**	**3306.1**

Total carbon dioxide emissions = 22774.2 $lbCO_2$

Wood Construction with Water Heat Loop Pump

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.163	1.932	3.106	1.442	1.030
Feb	1.005	1.818	2.805	1.302	0.930
Mar	0.882	2.141	3.047	1.442	1.030
Apr	0.478	2.177	2.703	1.395	0.997
May	0.275	2.473	2.674	1.442	1.030
Jun	0.112	2.510	2.433	1.395	0.997
Jul	0.007	2.874	2.359	1.442	1.030
Aug	0.013	2.989	2.428	1.442	1.030
Sep	0.020	2.743	2.313	1.395	0.997
Oct	0.151	2.581	2.591	1.442	1.030
Nov	0.585	2.252	2.906	1.395	0.997
Dec	1.024	2.067	3.095	1.442	1.030
Total	**5.734**	**28.558**	**32.459**	**16.976**	**12.126**

Total energy consumption = 95.853 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1521.8	393.1	280.8
Feb	1386.6	355.1	253.6
Mar	1525.1	393.1	280.8
Apr	1390.3	380.4	271.7
May	1438.0	393.1	280.8
Jun	1361.9	380.4	271.7
Jul	1427.6	393.1	280.8
Aug	1478.6	393.1	280.8
Sep	1381.0	380.4	271.7
Oct	1429.2	393.1	280.8
Nov	1479.6	380.4	271.7
Dec	1535.7	393.1	280.8
Total	**17355.6**	**4628.8**	**3306.1**

Total carbon dioxide emissions = 25290.5 $lbCO_2$

Concrete Construction with Radiant Floor

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	0.090	0.069	0.131	1.442	1.030
Feb	0.041	0.075	0.119	1.302	0.930
Mar	0.028	0.056	0.117	1.442	1.030
Apr	0.001	0.048	0.108	1.395	0.997
May	0.000	0.032	0.104	1.442	1.030
Jun	0.000	0.021	0.097	1.395	0.997
Jul	0.000	0.004	0.093	1.442	1.030
Aug	0.000	0.005	0.093	1.442	1.030
Sep	0.000	0.004	0.090	1.395	0.997
Oct	0.000	0.016	0.098	1.442	1.030
Nov	0.000	0.034	0.102	1.395	0.997
Dec	0.066	0.052	0.119	1.442	1.030
Total	**0.225**	**0.417**	**1.271**	**16.976**	**12.126**

Total energy consumption = 31.015 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	65.8	393.1	280.8
Feb	58.1	355.1	253.6
Mar	50.7	393.1	280.8
Apr	42.8	380.4	271.7
May	37.3	393.1	280.8
Jun	32.2	380.4	271.7
Jul	26.4	393.1	280.8
Aug	26.6	393.1	280.8
Sep	25.4	380.4	271.7
Oct	31.1	393.1	280.8
Nov	36.9	380.4	271.7
Dec	55.0	393.1	280.8
Total	**488.4**	**4628.8**	**3306.1**

Total carbon dioxide emissions = 8423.3 $lbCO_2$

Concrete Construction with Variable Air Volume Single Duct

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	0.991	1.638	2.382	1.442	1.030
Feb	0.811	1.535	2.144	1.302	0.930
Mar	0.638	1.782	2.278	1.442	1.030
Apr	0.262	1.840	1.966	1.395	0.997
May	0.090	2.079	1.919	1.442	1.030
Jun	0.009	2.128	1.771	1.395	0.997
Jul	0.000	2.457	1.904	1.442	1.030
Aug	0.000	2.552	1.943	1.442	1.030
Sep	0.000	2.358	1.834	1.395	0.997
Oct	0.021	2.203	1.845	1.442	1.030
Nov	0.310	1.899	2.082	1.395	0.997
Dec	0.773	1.744	2.328	1.442	1.030
Total	**3.904**	**24.216**	**24.397**	**16.976**	**12.126**

Total energy consumption = 81.618 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1220.4	393.1	280.8
Feb	1104.6	355.1	253.6
Mar	1187.0	393.1	280.8
Apr	1070.4	380.4	271.7
May	1101.2	393.1	280.8
Jun	1064.1	380.4	271.7
Jul	1189.1	393.1	280.8
Aug	1225.8	393.1	280.8
Sep	1143.1	380.4	271.7
Oct	1106.5	393.1	280.8
Nov	1124.2	380.4	271.7
Dec	1207.3	393.1	280.8
Total	**13743.8**	**4628.8**	**3306.1**

Total carbon dioxide emissions = 21678.8 $lbCO_2$

Concrete Construction with Water Heat Loop Pump

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	0.757	1.899	2.965	1.442	1.030
Feb	0.619	1.779	2.666	1.302	0.930
Mar	0.487	2.066	2.825	1.442	1.030
Apr	0.200	2.133	2.423	1.395	0.997
May	0.069	2.409	2.351	1.442	1.030
Jun	0.007	2.467	2.159	1.395	0.997
Jul	0.000	2.848	2.313	1.442	1.030
Aug	0.000	2.958	2.359	1.442	1.030
Sep	0.000	2.733	2.229	1.395	0.997
Oct	0.016	2.554	2.250	1.442	1.030
Nov	0.237	2.201	2.568	1.395	0.997
Dec	0.591	2.022	2.891	1.442	1.030
Total	**2.983**	**28.068**	**30.000**	**16.976**	**12.126**

Total energy consumption = 90.153 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1421.1	393.1	280.8
Feb	1289.4	355.1	253.6
Mar	1394.6	393.1	280.8
Apr	1267.1	380.4	271.7
May	1306.5	393.1	280.8
Jun	1262.1	380.4	271.7
Jul	1407.3	393.1	280.8
Aug	1449.9	393.1	280.8
Sep	1353.0	380.4	271.7
Oct	1311.9	393.1	280.8
Nov	1330.1	380.4	271.7
Dec	1413.5	393.1	280.8
Total	**16206.6**	**4628.8**	**3306.1**

Total carbon dioxide emissions = 24141.5 $lbCO_2$

Steel Construction with Radiant Floor

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.071	0.044	0.163	1.442	1.030
Feb	0.874	0.047	0.149	1.302	0.930
Mar	0.676	0.036	0.150	1.442	1.030
Apr	0.313	0.052	0.136	1.395	0.997
May	0.106	0.051	0.126	1.442	1.030
Jun	0.010	0.051	0.112	1.395	0.997
Jul	0.000	0.026	0.102	1.442	1.030
Aug	0.000	0.028	0.103	1.442	1.030
Sep	0.000	0.034	0.102	1.395	0.997
Oct	0.044	0.052	0.117	1.442	1.030
Nov	0.300	0.042	0.131	1.395	0.997
Dec	0.834	0.041	0.155	1.442	1.030
Total	**4.228**	**0.505**	**1.545**	**16.976**	**12.126**

Total energy consumption = 35.380 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	190.9	393.1	280.8
Feb	162.8	355.1	253.6
Mar	135.6	393.1	280.8
Apr	90.2	380.4	271.7
May	61.7	393.1	280.8
Jun	45.8	380.4	271.7
Jul	34.9	393.1	280.8
Aug	35.7	393.1	280.8
Sep	37.0	380.4	271.7
Oct	51.5	393.1	280.8
Nov	84.7	380.4	271.7
Dec	158.1	393.1	280.8
Total	**1089.0**	**4628.8**	**3306.1**

Total carbon dioxide emissions = 9023.9 $lbCO_2$

Steel Construction with Variable Air Volume Single Duct

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	2.414	1.872	2.757	1.442	1.030
Feb	2.127	1.765	2.516	1.302	0.930
Mar	2.010	2.078	2.809	1.442	1.030
Apr	1.466	2.116	2.629	1.395	0.997
May	1.115	2.389	2.707	1.442	1.030
Jun	0.817	2.415	2.612	1.395	0.997
Jul	0.275	2.686	2.467	1.442	1.030
Aug	0.308	2.795	2.516	1.442	1.030
Sep	0.337	2.565	2.416	1.395	0.997
Oct	0.785	2.448	2.679	1.442	1.030
Nov	1.525	2.148	2.728	1.395	0.997
Dec	2.206	2.007	2.798	1.442	1.030
Total	**15.384**	**27.284**	**31.633**	**16.976**	**12.126**

Total energy consumption = 103.403 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1564.8	393.1	280.8
Feb	1434.0	355.1	253.6
Mar	1584.4	393.1	280.8
Apr	1477.3	380.4	271.7
May	1529.3	393.1	280.8
Jun	1473.0	380.4	271.7
Jul	1439.4	393.1	280.8
Aug	1486.6	393.1	280.8
Sep	1400.3	380.4	271.7
Oct	1496.3	393.1	280.8
Nov	1520.5	380.4	271.7
Dec	1586.5	393.1	280.8
Total	**17992.6**	**4628.8**	**3306.1**

Total carbon dioxide emissions = 25927.5 $lbCO_2$

Steel Construction with Water Heat Loop Pump

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.845	2.170	3.433	1.442	1.030
Feb	1.625	2.046	3.130	1.302	0.930
Mar	1.536	2.409	3.489	1.442	1.030
Apr	1.120	2.452	3.257	1.395	0.997
May	0.852	2.769	3.344	1.442	1.030
Jun	0.624	2.799	3.221	1.395	0.997
Jul	0.210	3.113	3.022	1.442	1.030
Aug	0.235	3.239	3.079	1.442	1.030
Sep	0.257	2.973	2.963	1.395	0.997
Oct	0.599	2.837	3.305	1.442	1.030
Nov	1.166	2.490	3.382	1.395	0.997
Dec	1.685	2.326	3.479	1.442	1.030
Total	**11.755**	**31.624**	**39.102**	**16.976**	**12.126**

Total energy consumption = 111.583 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1758.9	393.1	280.8
Feb	1615.1	355.1	253.6
Mar	1800.6	393.1	280.8
Apr	1697.0	380.4	271.7
May	1773.5	393.1	280.8
Jun	1719.6	380.4	271.7
Jul	1699.0	393.1	280.8
Aug	1752.3	393.1	280.8
Sep	1650.7	380.4	271.7
Oct	1749.9	393.1	280.8
Nov	1746.9	380.4	271.7
Dec	1794.0	393.1	280.8
Total	**20757.4**	**4628.8**	**3306.1**

Total carbon dioxide emissions = 28692.4 $lbCO_2$

CMU Construction with Radiant Floor

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	0.291	0.042	0.133	1.442	1.030
Feb	0.208	0.047	0.121	1.302	0.930
Mar	0.112	0.040	0.118	1.442	1.030
Apr	0.020	0.042	0.108	1.395	0.997
May	0.000	0.032	0.104	1.442	1.030
Jun	0.000	0.026	0.099	1.395	0.997
Jul	0.000	0.007	0.094	1.442	1.030
Aug	0.000	0.007	0.094	1.442	1.030
Sep	0.000	0.008	0.091	1.395	0.997
Oct	0.000	0.021	0.100	1.442	1.030
Nov	0.004	0.030	0.102	1.395	0.997
Dec	0.168	0.037	0.120	1.442	1.030
Total	**0.804**	**0.339**	**1.284**	**16.976**	**12.126**

Total energy consumption = 31.529 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	84.0	393.1	280.8
Feb	72.0	355.1	253.6
Mar	57.1	393.1	280.8
Apr	43.4	380.4	271.7
May	37.3	393.1	280.8
Jun	33.9	380.4	271.7
Jul	27.5	393.1	280.8
Aug	27.7	393.1	280.8
Sep	27.1	380.4	271.7
Oct	32.9	393.1	280.8
Nov	36.5	380.4	271.7
Dec	64.0	393.1	280.8
Total	**543.4**	**4628.8**	**3306.1**

Total carbon dioxide emissions = 8478.3 $lbCO_2$

CMU Construction with Variable Air Volume Single Duct

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.413	1.773	2.565	1.442	1.030
Feb	1.223	1.664	2.335	1.302	0.930
Mar	1.107	1.937	2.562	1.442	1.030
Apr	0.667	1.971	2.335	1.395	0.997
May	0.421	2.215	2.335	1.442	1.030
Jun	0.200	2.237	2.151	1.395	0.997
Jul	0.016	2.527	1.983	1.442	1.030
Aug	0.018	2.626	2.032	1.442	1.030
Sep	0.025	2.423	1.931	1.395	0.997
Oct	0.191	2.301	2.175	1.442	1.030
Nov	0.680	2.022	2.409	1.395	0.997
Dec	1.199	1.883	2.556	1.442	1.030
Total	**7.161**	**25.579**	**27.367**	**16.976**	**12.126**

Total energy consumption = 89.210 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1359.9	393.1	280.8
Feb	1243.7	355.1	253.6
Mar	1365.4	393.1	280.8
Apr	1257.7	380.4	271.7
May	1293.2	393.1	280.8
Jun	1221.4	380.4	271.7
Jul	1231.8	393.1	280.8
Aug	1272.3	393.1	280.8
Sep	1190.0	380.4	271.7
Oct	1244.4	393.1	280.8
Nov	1293.4	380.4	271.7
Dec	1360.7	393.1	280.8
Total	**15334.0**	**4628.8**	**3306.1**

Total carbon dioxide emissions = 23268.9 $lbCO_2$

CMU Construction with Water Heat Loop Pump

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.080	2.055	3.192	1.442	1.030
Feb	0.934	1.929	2.904	1.302	0.930
Mar	0.846	2.245	3.181	1.442	1.030
Apr	0.510	2.285	2.888	1.395	0.997
May	0.322	2.567	2.876	1.442	1.030
Jun	0.153	2.593	2.640	1.395	0.997
Jul	0.013	2.929	2.411	1.442	1.030
Aug	0.013	3.044	2.469	1.442	1.030
Sep	0.019	2.808	2.349	1.395	0.997
Oct	0.146	2.667	2.667	1.442	1.030
Nov	0.520	2.344	2.980	1.395	0.997
Dec	0.916	2.182	3.176	1.442	1.030
Total	**5.472**	**29.649**	**33.731**	**16.976**	**12.126**

Total energy consumption = 97.953 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1566.0	393.1	280.8
Feb	1434.8	355.1	253.6
Mar	1585.3	393.1	280.8
Apr	1474.3	380.4	271.7
May	1524.4	393.1	280.8
Jun	1445.9	380.4	271.7
Jul	1457.6	393.1	280.8
Aug	1504.8	393.1	280.8
Sep	1408.5	380.4	271.7
Oct	1472.8	393.1	280.8
Nov	1516.8	380.4	271.7
Dec	1575.8	393.1	280.8
Total	**17966.9**	**4628.8**	**3306.1**

Total carbon dioxide emissions = 25901.9 $lbCO_2$

Hybrid Construction with Radiant Floor

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	0.289	0.015	0.126	1.442	1.030
Feb	0.208	0.016	0.112	1.302	0.930
Mar	0.110	0.009	0.109	1.442	1.030
Apr	0.021	0.009	0.096	1.395	0.997
May	0.000	0.002	0.092	1.442	1.030
Jun	0.000	0.000	0.088	1.395	0.997
Jul	0.000	0.000	0.091	1.442	1.030
Aug	0.000	0.000	0.091	1.442	1.030
Sep	0.000	0.000	0.088	1.395	0.997
Oct	0.000	0.002	0.092	1.442	1.030
Nov	0.005	0.007	0.092	1.395	0.997
Dec	0.165	0.012	0.114	1.442	1.030
Total	**0.798**	**0.072**	**1.192**	**16.976**	**12.126**

Total energy consumption = 31.164 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	74.7	393.1	280.8
Feb	61.0	355.1	253.6
Mar	45.9	393.1	280.8
Apr	31.3	380.4	271.7
May	25.8	393.1	280.8
Jun	24.1	380.4	271.7
Jul	24.8	393.1	280.8
Aug	24.9	393.1	280.8
Sep	24.0	380.4	271.7
Oct	25.5	393.1	280.8
Nov	27.7	380.4	271.7
Dec	55.0	393.1	280.8
Total	**444.6**	**4628.8**	**3306.1**

Total carbon dioxide emissions = 8379.5 $lbCO_2$

Hybrid Construction with Variable Air Volume Single Duct

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.449	1.811	2.671	1.442	1.030
Feb	1.258	1.698	2.437	1.302	0.930
Mar	1.133	1.972	2.678	1.442	1.030
Apr	0.712	2.007	2.458	1.395	0.997
May	0.464	2.248	2.458	1.442	1.030
Jun	0.238	2.268	2.281	1.395	0.997
Jul	0.023	2.548	2.021	1.442	1.030
Aug	0.025	2.643	2.083	1.442	1.030
Sep	0.036	2.440	1.985	1.395	0.997
Oct	0.228	2.331	2.281	1.442	1.030
Nov	0.721	2.052	2.527	1.395	0.997
Dec	1.235	1.918	2.668	1.442	1.030
Total	**7.523**	**25.936**	**28.548**	**16.976**	**12.126**

Total energy consumption = 91.108 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1403.7	393.1	280.8
Feb	1285.3	355.1	253.6
Mar	1409.9	393.1	280.8
Apr	1306.8	380.4	271.7
May	1341.2	393.1	280.8
Jun	1270.2	380.4	271.7
Jul	1248.7	393.1	280.8
Aug	1291.6	393.1	280.8
Sep	1211.1	380.4	271.7
Oct	1285.9	393.1	280.8
Nov	1338.8	380.4	271.7
Dec	1405.2	393.1	280.8
Total	**15798.4**	**4628.8**	**3306.1**

Total carbon dioxide emissions = 23733.3 $lbCO_2$

Hybrid Construction with Water Heat Loop Pump

1.1 Building systems energy summary

Energy totals in MMBtu

Month	Heating (boilers etc.)	Cooling (chillers etc.)	Fans, pumps and controls	Lights	Equip.
Jan	1.108	2.099	3.326	1.442	1.030
Feb	0.962	1.968	3.032	1.302	0.930
Mar	0.866	2.286	3.327	1.442	1.030
Apr	0.544	2.327	3.044	1.395	0.997
May	0.355	2.605	3.032	1.442	1.030
Jun	0.182	2.629	2.804	1.395	0.997
Jul	0.017	2.953	2.459	1.442	1.030
Aug	0.019	3.063	2.533	1.442	1.030
Sep	0.027	2.828	2.418	1.395	0.997
Oct	0.174	2.701	2.801	1.442	1.030
Nov	0.551	2.378	3.130	1.395	0.997
Dec	0.944	2.224	3.316	1.442	1.030
Total	**5.748**	**30.062**	**35.223**	**16.976**	**12.126**

Total energy consumption = 100.135 MMBtu

1.2 Building systems carbon dioxide summary

Carbon dioxide totals in $lbCO_2$

Month	System (boilers, chillers, fans, pumps etc.)	Lights	Equip.
Jan	1618.0	393.1	280.8
Feb	1484.0	355.1	253.6
Mar	1638.9	393.1	280.8
Apr	1532.5	380.4	271.7
May	1581.4	393.1	280.8
Jun	1504.3	380.4	271.7
Jul	1477.8	393.1	280.8
Aug	1528.2	393.1	280.8
Sep	1433.9	380.4	271.7
Oct	1522.2	393.1	280.8
Nov	1570.8	380.4	271.7
Dec	1628.8	393.1	280.8
Total	**18520.9**	**4628.8**	**3306.1**

Total carbon dioxide emissions = 26455.8 $lbCO_2$

Green Building Studio Output Data

Base Case

General Information

Project Title: BaseCase
Run Title: Base Case Hybrid RF.xml
Building Type: SchoolOrUniversity
Floor Area: 864 ft²

Location Information

Building: Isla Vista, CA 93117
Electric Cost: $0.131/kWh
Fuel Cost: $1.000/Therm
Weather: Zone 5 - Santa Maria

Estimated Energy & Cost Summary

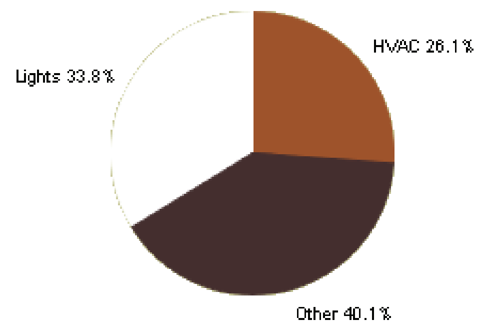
Annual Energy Cost		$2,507
Lifecycle* Cost		$34,141
Annual CO_2 Emissions		
	Electric†	6.5 tons
	Onsite Fuel	3.6 tons
	H3 Hummer Equivalent	0.9 Hummers
Annual Energy		
	Electric	14,419 kWh
	Fuel	618 Therms
Annual Peak Electric Demand		4.2 kW
Lifecycle* Energy		
	Electric	432,565 kWh
	Fuel	18,535 Therms

* 30 -year life and 6.1 % discount rate for costs. † Does not include electric transmission losses.

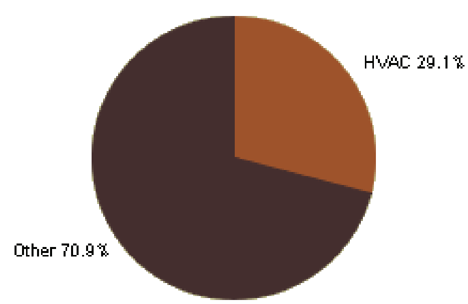
Energy End-Use Charts

Click on chart for more or less detail.

Annual Electric End Use



Annual Fuel End Use



Electric Power Plant Sources[2]

Fossil:	61%
Nuclear:	14%
Hydroelectric:	15%
Renewable:	10%
Other:	0%

2. Based on US EPA EGRID 2006 Data (2004 Plant Level Data).

Building Summary

Quick Stats

If values are red or blue they appear to be higher or lower then typical ranges, respectively.

Number of People	21 people
Average Lighting Power Density	1.25 W/ft²
Average Equipment Power Density	1.05 W/ft²
Specific Fan Flow	0.5 cfm/ft²
Specific Fan Power	0.677 W/cfm
Specific Cooling	592 ft²/ton
Specific Heating	21 ft²/kBtu
Total Fan Flow	452 cfm
Total Cooling Capacity	1 tons
Total Heating Capacity	41 kBtuh

Constructions

U-Value: Btu/(hr-ft²-F°)

Roofs	
R10 over Roof Deck U-value: 0.08	903 ft²
Exterior Walls	
R2 CMU Wall U-value: 0.21	1,203 ft²
Slabs On Grade	
Uninsulated concrete slab U-value: 0.03	903 ft²
Nonsliding Doors	
R2 Default Door (1 doors) U-value: NaN	21 ft²
Operable Windows	
Dbl Grey 3/6 Air (4 windows) U-value: 3.23 W/(m²-K), SHGC: 0.61, Vlt: 0.55	80 ft²

Hydronic Equipment

Note: The information below should not be used for sizing purposes.

Domestic Hot Water	
Water Heater Capacity	30,000 BTU

Air Equipment

Note: The information below should not be used for sizing purposes.

Packaged Single Zone	
Cooling Capacity	17 kBtuPerHour
Heating Capacity	41 kBtuPerHour
Supply Fan Flow	452 CFM
Annual Supply Fan Run Time	5,110 Hours

Prototype 1

General Information

Project Title: Prototypes 1
Run Title: Prototype 1 CMU RF.xml
Building Type: SchoolOrUniversity
Floor Area: 864 ft²

Location Information

Building: ISLA VISTA, CA 93117
Electric Cost: $0.131/kWh
Fuel Cost: $1.000/Therm
Weather: Zone 5 - Santa Maria

Estimated Energy & Cost Summary

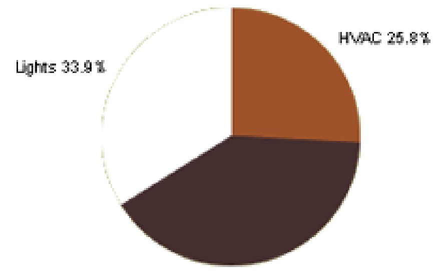
Annual Energy Cost		$2,499
Lifecycle* Cost		$34,040
Annual CO_2 Emissions		
	Electric†	6.4 tons
	Onsite Fuel	3.6 tons
	H3 Hummer Equivalent	0.9 Hummers
Annual Energy		
	Electric	14,348 kWh
	Fuel	620 Therms
Annual Peak Electric Demand		4.2 kW
Lifecycle* Energy		
	Electric	430,433 kWh
	Fuel	18,592 Therms

* 30 -year life and 6.1 % discount rate for costs. † Does not include electric transmission losses.

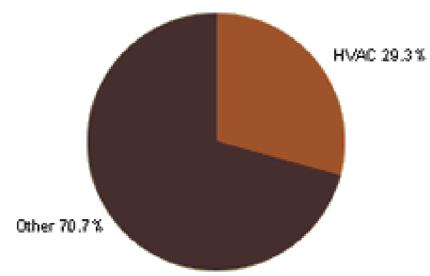
Energy End-Use Charts

Click on chart for more or less detail.

Annual Electric End Use



Annual Fuel End Use



Electric Power Plant Sources[2]

Fossil:	61%
Nuclear:	14%
Hydroelectric:	15%
Renewable:	10%
Other:	0%

2. Based on US EPA EGRID 2006 Data (2004 Plant Level Data).

Building Summary

Quick Stats

If values are red or blue they appear to be higher or lower then typical ranges, respectively.

Number of People	21 people
Average Lighting Power Density	1.25 W/ft²
Average Equipment Power Density	1.05 W/ft²
Specific Fan Flow	0.5 cfm/ft²
Specific Fan Power	0.677 W/cfm
Specific Cooling	592 ft²/ton
Specific Heating	21 ft²/kBtu
Total Fan Flow	452 cfm
Total Cooling Capacity	1 tons
Total Heating Capacity	41 kBtuh

Constructions

U-Value: Btu/(hr-ft²-F°)

Roofs

R10 over Roof Deck U-value: 0.08	903 ft²

Exterior Walls

R2 CMU Wall U-value: 0.21	1,203 ft²

Slabs On Grade

Uninsulated concrete slab U-value: 0.03	903 ft²

Nonsliding Doors

R2 Default Door (1 doors) U-value: NaN	21 ft²

Operable Windows

Dbl Grey 3/6 Air (9 windows) U-value: 3.23 W/(m²-K), SHGC: 0.61, Vlt: 0.55	71 ft²

Hydronic Equipment

Note: The information below should not be used for sizing purposes.

Domestic Hot Water

Water Heater Capacity	30,000 BTU

Air Equipment

Note: The information below should not be used for sizing purposes.

Packaged Single Zone

Cooling Capacity	17 kBtuPerHour
Heating Capacity	41 kBtuPerHour
Supply Fan Flow	452 CFM
Annual Supply Fan Run Time	5,110 Hours

Prototype 2

General Information

Project Title: Prototype 2
Run Title: Prototype_2 Hybrid.xml
Building Type: SchoolOrUniversity
Floor Area: 864 ft²

Location Information

Building: SANTA BARBARA, CA 93107
Electric Cost: $0.131/kWh
Fuel Cost: $1.000/Therm
Weather: Zone 5 - Santa Maria

Estimated Energy & Cost Summary

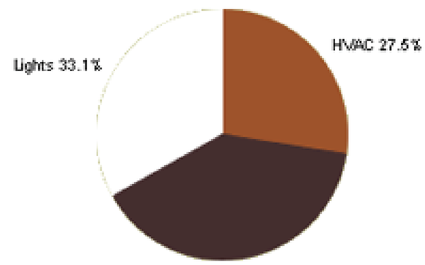
Annual Energy Cost		$2,537
Lifecycle* Cost		$34,556
Annual CO_2 Emissions		
	Electric†	6.6 tons
	Onsite Fuel	3.6 tons
	H3 Hummer Equivalent	0.9 Hummers
Annual Energy		
	Electric	14,684 kWh
	Fuel	614 Therms
Annual Peak Electric Demand		4.2 kW
Lifecycle* Energy		
	Electric	440,522 kWh
	Fuel	18,406 Therms

* 30 -year life and 6.1 % discount rate for costs. † Does not include electric transmission losses.

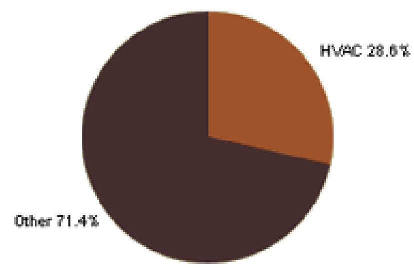
Energy End-Use Charts

Click on chart for more or less detail.

Annual Electric End Use



Annual Fuel End Use



Electric Power Plant Sources[2]

Fossil:	61%
Nuclear:	14%
Hydroelectric:	15%
Renewable:	10%
Other:	0%

2. Based on US EPA EGRID 2006 Data (2004 Plant Level Data).

Building Summary

Quick Stats

If values are red or blue they appear to be higher or lower then typical ranges, respectively.

Number of People	21 people
Average Lighting Power Density	1.25 W/ft²
Average Equipment Power Density	1.05 W/ft²
Specific Fan Flow	0.5 cfm/ft²
Specific Fan Power	0.677 W/cfm
Specific Cooling	592 ft²/ton
Specific Heating	21 ft²/kBtu
Total Fan Flow	452 cfm
Total Cooling Capacity	1 tons
Total Heating Capacity	41 kBtuh

Constructions

U-Value: Btu/(hr-ft²-F°)

Roofs	
R10 over Roof Deck U-value: 0.08	903 ft²
Exterior Walls	
R2 CMU Wall U-value: 0.21	1,384 ft²
Slabs On Grade	
Uninsulated concrete slab U-value: 0.03	903 ft²
Nonsliding Doors	
R2 Default Door (1 doors) U-value: NaN	21 ft²
Operable Windows	
Dbl Grey 3/6 Air (9 windows) U-value: 3.23 W/(m²-K), SHGC: 0.61, Vlt: 0.55	71 ft²

Hydronic Equipment

Note: The information below should not be used for sizing purposes.

Domestic Hot Water	
Water Heater Capacity	30,000 BTU

Air Equipment

Note: The information below should not be used for sizing purposes.

Packaged Single Zone	
Cooling Capacity	17 kBtuPerHour
Heating Capacity	41 kBtuPerHour
Supply Fan Flow	452 CFM
Annual Supply Fan Run Time	5,110 Hours

Prototype 3

General Information

Project Title: Prototype 3
Run Title: Protoytpe_3 Wood.xml
Building Type: SchoolOrUniversity
Floor Area: 853 ft²

Location Information

Building: SANTA BARBARA, CA 93107
Electric Cost: $0.131/kWh
Fuel Cost: $1.000/Therm
Weather: Zone 5 - Santa Maria

Estimated Energy & Cost Summary

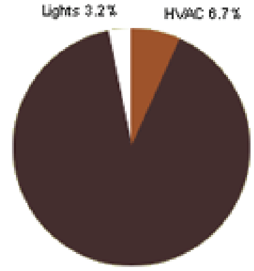
Annual Energy Cost		$5,770
Lifecycle* Cost		$78,590
Annual CO_2 Emissions		
	Electric†	17.1 tons
	Onsite Fuel	4.5 tons
	H3 Hummer Equivalent	2.0 Hummers
Annual Energy		
	Electric	38,163 kWh
	Fuel	771 Therms
Annual Peak Electric Demand		12.5 kW
Lifecycle* Energy		
	Electric	1,144,893 kWh
	Fuel	23,125 Therms

* 30 -year life and 6.1 % discount rate for costs. † Does not include electric transmission losses.

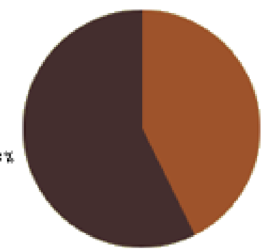
Energy End-Use Charts

Click on chart for more or less detail.

Annual Electric End Use



Annual Fuel End Use



Electric Power Plant Sources[2]

Fossil:	61%
Nuclear:	14%
Hydroelectric:	15%
Renewable:	10%
Other:	0%

2. Based on US EPA EGRID 2006 Data (2004 Plant Level Data).

Building Summary

Quick Stats

If values are red or blue they appear to be higher or lower then typical ranges, respectively.

Number of People	22 people
Average Lighting Power Density	1.10 W/ft²
Average Equipment Power Density	1.13 W/ft²
Specific Fan Flow	0.5 cfm/ft²
Specific Fan Power	0.677 W/cfm
Specific Cooling	607 ft²/ton
Specific Heating	21 ft²/kBtu
Total Fan Flow	427 cfm
Total Cooling Capacity	1 tons
Total Heating Capacity	41 kBtuh

Constructions

U-Value: Btu/(hr-ft²-F°)

Roofs

R10 over Roof Deck U-value: 0.08	421 ft²
R11 Wood Frame Floor U-value: 0.08	426 ft²

Exterior Walls

R2 CMU Wall U-value: 0.21	1,517 ft²

Raised Floors

R6.3 Mass Floor U-value: 0.10	681 ft²

Slabs On Grade

Uninsulated concrete slab U-value: 0.03	346 ft²

Nonsliding Doors

R2 Default Door (2 doors) U-value: NaN	42 ft²

Air Openings

Unglazed opening (2 doors) U-value: 0.00 SHGC: 1.00 Vlt: 1.00	3 ft²

Operable Windows

Dbl Grey 3/6 Air (4 windows) U-value: 3.23 W/(m²-K), SHGC: 0.61, Vlt: 0.55	27 ft²

Hydronic Equipment

Note: The information below should not be used for sizing purposes.

Domestic Hot Water

Water Heater Capacity	30,000 BTU

Air Equipment

Note: The information below should not be used for sizing purposes.

Packaged Single Zone

Cooling Capacity	17 kBtuPerHour
Heating Capacity	41 kBtuPerHour
Supply Fan Flow	427 CFM
Annual Supply Fan Run Time	5,110 Hours

Glossary

AEC - Architecture, Engineering, and Construction

BIM – Building Information Management

ECOTECT – Simulation Software developed by Square One

GBS – Green Building Studio

gbxml – file extension format used to import files from Revit

LEED – Leadership in Energy and Environmental Design

IDM – Integrated Design Model

IES VE – Integrated Environmental Solutions Virtual Environment

Revit MEP – Revit Mechanical, Electrical, and Plumbing

RF – Radiant Floor

UCSB – University of California @ Santa Barbara

USGBC – United States Green Building Council

VAV SD– Variable Air Volume Single Duct

WHLP – Water Heat Loop Pump

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Style Guidelines

The style chosen for this thesis paper is the MLA Style. All document borders and margins conform to the rules in Appendix 5 of the "Policies and Procedures" guide book provide by the faculty.