DPR Construction Inc.

# Building Great Green Things

**S409: BIM for Energy Modeling, Lifecycle Energy Usage & Cost Analysis**

# Agenda

- Discover how Building Information Models can be used for the purpose of Energy Analysis.
- Hear guidelines for building a model for the purpose of energy analysis, data required for energy analysis
- Lessons learned in exporting BIM to energy analysis software


# DPR Fast Facts

## RANKINGS

| | | | |
|---|---|---|---|
| ENR Top 400 Contractors | #35 | Annual Volume | $2.3B (2008) |
| ENR Top Green Contractors | #5 | Mid-Atlantic Volume | $280M (2008) |

## RESOURCES

| | | | |
|---|---|---|---|
| National: | 1450 Overall | 980 Professional | 260+ LEED® AP |
| Mid-Atlantic: | 240 Overall | 105 Professional | 29+ LEED® AP |

# Mission Statement

To be **one** of the ***Most Admired Companies*** by the year 2030.

Guiding Philosophy

# Core Values

**INTEGRITY** We conduct all business with the highest standards of honesty and fairness; we can be trusted.

**ENJOYMENT** We believe work should be fun and intrinsically satisfying; if we are not enjoying ourselves, we are doing something wrong.

**UNIQUENESS** We must be different from and more progressive than all other construction companies; we stand for something.

**EVER FORWARD** We believe in continual self-initiated change, improvement, learning and the advancement of standards for their own sake.

DPR Construction Inc.

Sustainable & Smart

ecobuild fall

Sustainable, Green and High Performance Solutions for the Built Environment

AEC–ST fall

Science & Technology for Architecture, Engineering & Construction

S409: BIM for Energy Modeling, Lifecycle Energy Usage & Cost Analysis

WE EXIST TO BUILD GREAT THINGS

# Energy Modeling – What Is It?

Generally, Energy Modeling is the use of software to predict a building's energy usage based on its design parameters. These parameters include building location, orientation, building envelope, HVAC, lighting, and electrical loads.

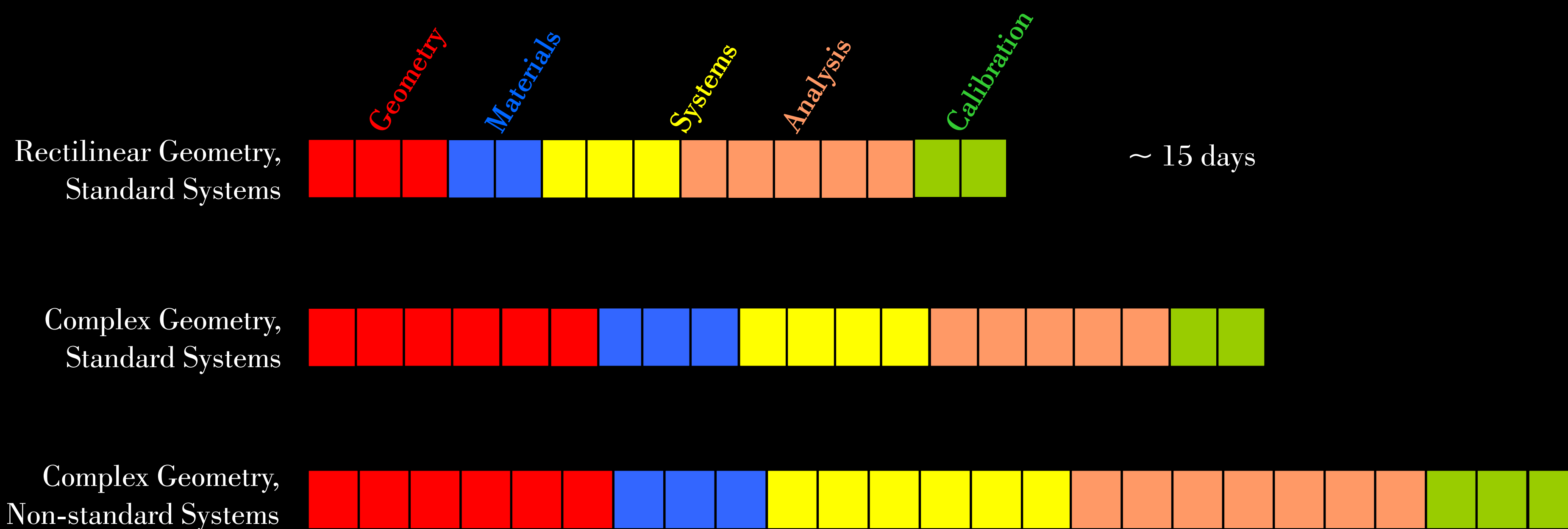

# Energy Analysis

*Time and Effort*

- **Passive thermal systems** *(radiant floors, chilled beams, earth tubes)*
- **Natural ventilation**
- **Non Standard HVAC systems** *(evaporative cooling systems)*
- **Sunshading Devices**
- **Fenestration Geometry**
- **Impact of various building materials**
- **Renewable energy sources**
- **Daylighting levels: LEED Credit**
- **Impact of Site Orientation**

# Energy Analysis

## Time Requirement for Complete Analysis

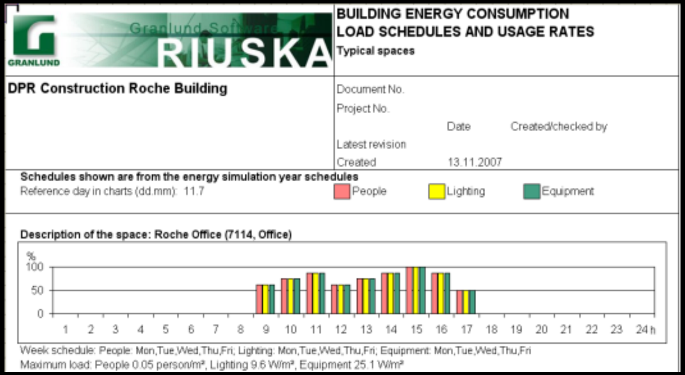




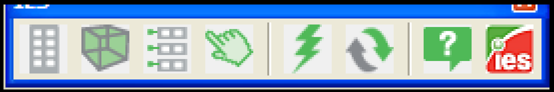



# Software-Used

- **Riuska**
  - Imports 3D models
  - Roche Laboratories
- **IES Virtual Environment**
  - Revit-to-IES plugin
  - Daylighting credit, comprehensive analysis software
  - DPR Sacramento Office, Confidential Client




Integrated Environmental Solutions Ltd



**SketchUp Plug-in**


**IES Revit Plug-in**

# Software-Trial

- **Autodesk Green Building Studios**
  - Web based service using GbXML format
  - Conceptual stage analysis
- **Ecotect**
  - Acquired by Autodesk
    - Revit integration in future
  - Used by architects, designers

Autodesk Green Building Studio

ECOTECT BUILDING ANALYSIS FOR DESIGNERS

# College of Nursing and Healthcare
## Phoenix, AZ

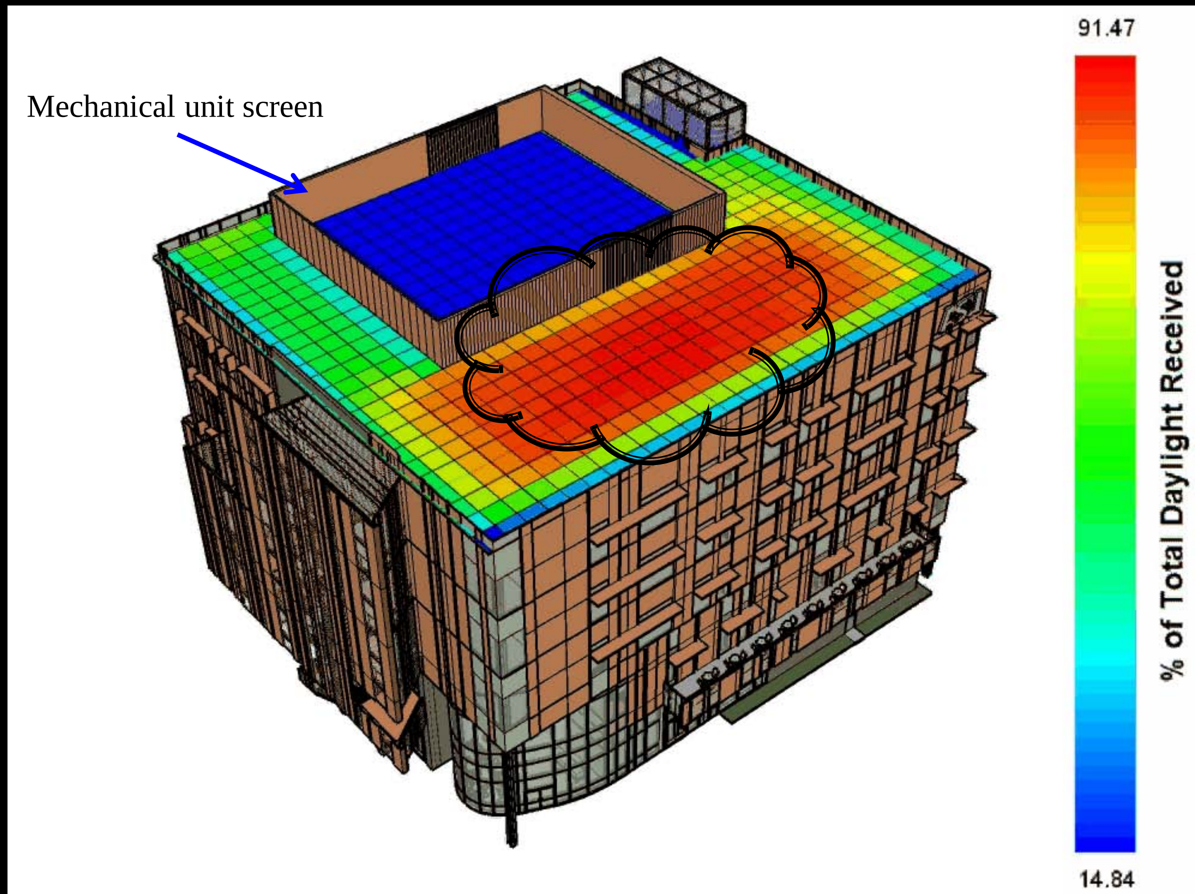
## Objectives

1. Optimize roof top PV location
   - Effect of shadows of neighboring building, as project site is located in downtown
   - Effect of other rooftop elements, especially the screen wall and parapet on rooftop PV’s
2. Review daylighting on each floor to verify possibility of LEED credit eligibility



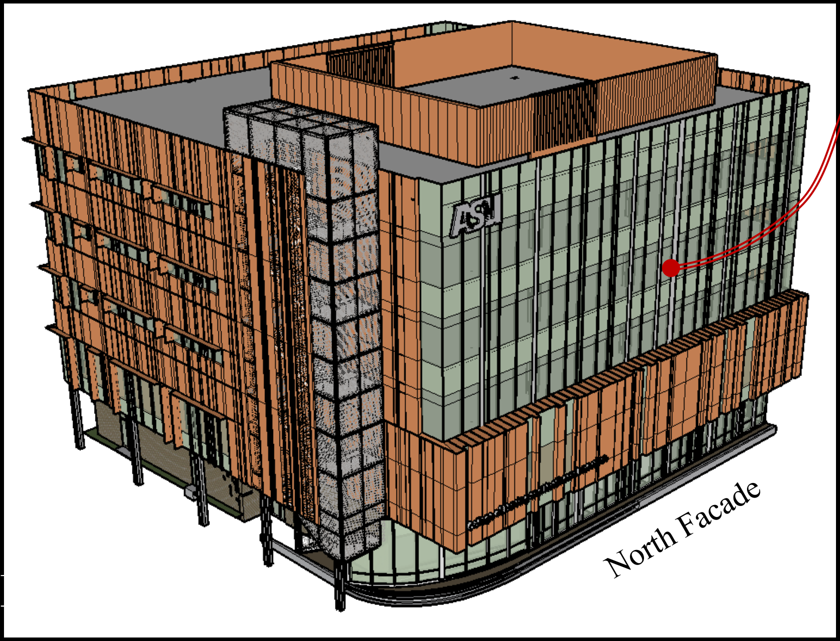


# CoNHI2 – Sun Shading Analysis for PV location




Architectural Model Created by SmithGroup

# CoNHI2 – Daylighting Analysis

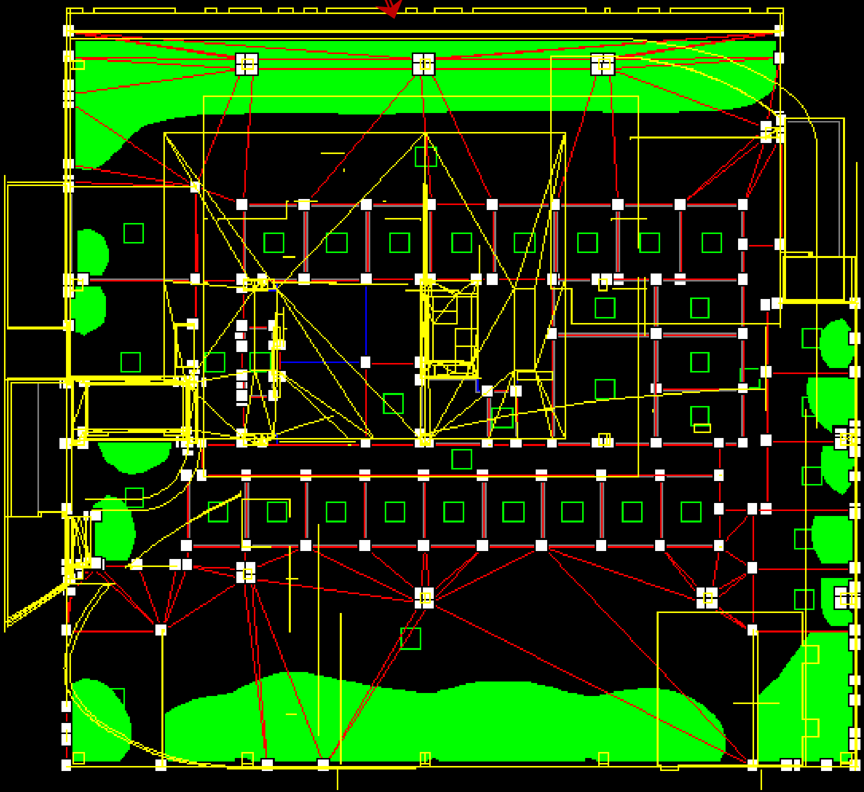



| Total area (ft²) | 14730.268 |
|---|---|
| Total area above threshold (ft²) | 3877.495 |
| Percentage | 26.3% |

| LEED NC 2.2 EQ Credit 8.1 daylight and views: | FAIL |
|---|---|

A pass requires 75% or more of the total area to be over the threshold.

Areas achieving 25 fc threshold

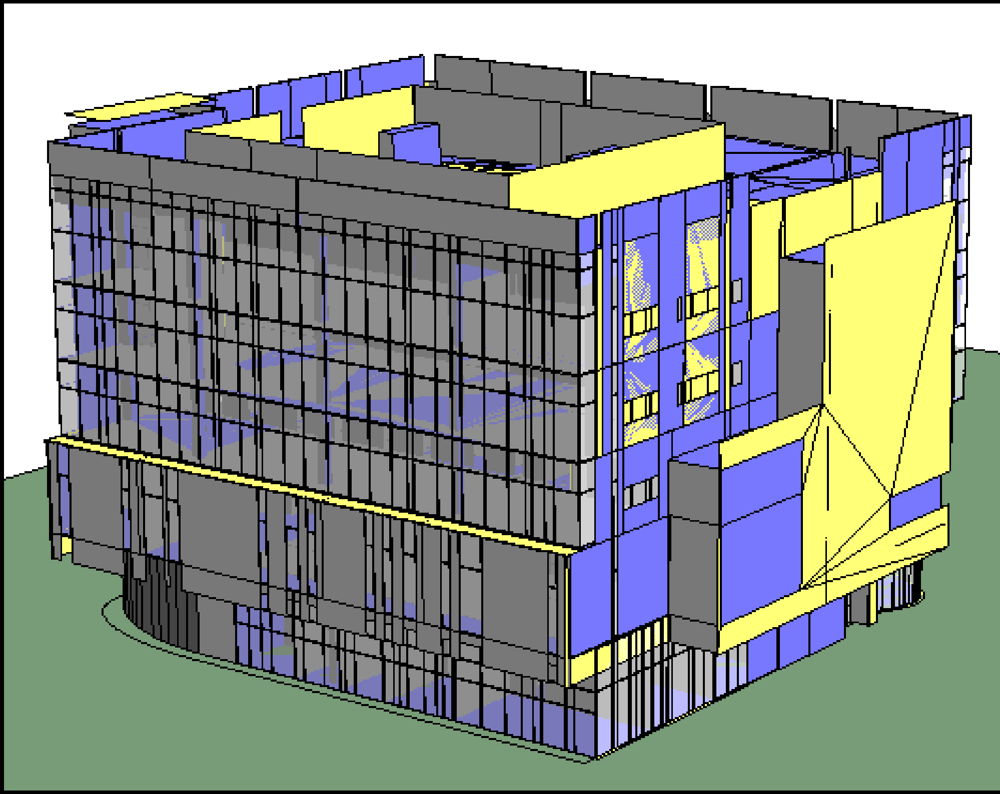


Analysis used Revit model imported into IES

# Lessons Learned: Modeling

## Revit-gbXML conversion

- Plus
  - Leverages existing model
  - IES plug-in exists
- Minus
  - Not seamless
  - careful modeling/ pre-processing
- Best Application
  - Standard geometry
  - Less detail in model
    - Preliminary analysis Concept/SD stage

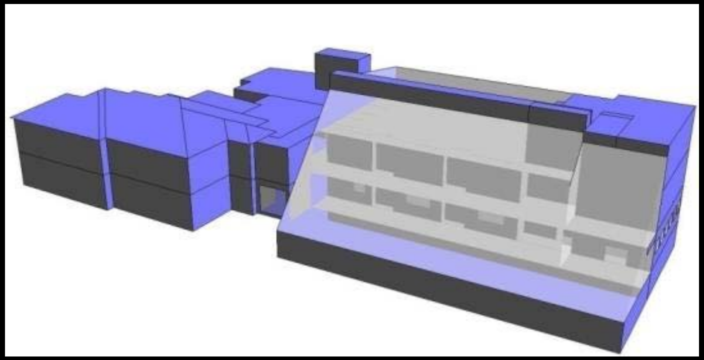


ASU CoNHI2, Phoenix, AZ

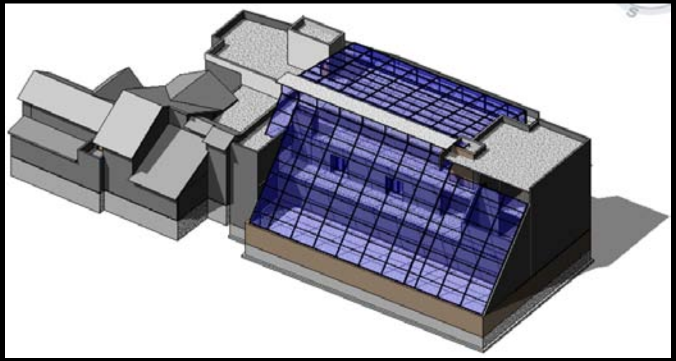
# Confidential Client

## Energy Modeling

- Built initial energy model
- Load Calculation
- Helped the architect with
  - Thermal impact of the south facing greenhouse
  - Shading analysis on the green roof



Energy Model in IES

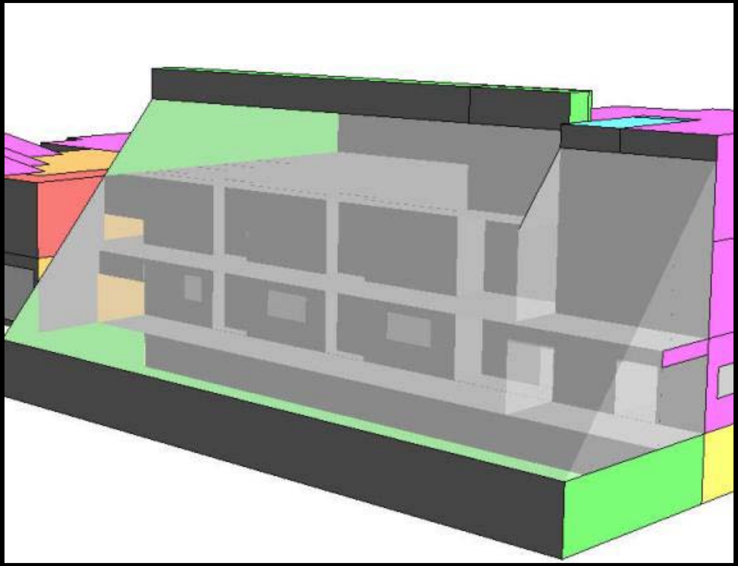


Architectural Model in Revit

# Lessons Learned: Modeling

## Energy Modeling

- A different modeling paradigm
- Thermal zones vs. physical spaces
- Simpler model
  - Envelope Geometry
  - Bound spaces
  - Architectural features may be ignored
    - Column enclosure, closets, open alcoves



Greenhouse was broken up into three levels to simulate thermal impact of vertical displacement



# Lessons Learned-IES

- Pros
  - Friendly interface
    - Spatial model based, Templates, Groups
  - Iterative analysis
    - Easy to run analysis, once model is set up
  - Comprehensive, one-platform analysis
    - Architectural features, site orientation
  - Powerful
    - Allows for accurate simulation of thermal systems
- Cons
  - Not fully compliant with Revit or other modeling tool
    - gbXML export not seamless
  - Does not communicate with other modeling softwares
  - Does not support multiple users



# Lessons Learned

- Energy model is different from architectural model
  - Planning and pre-processing
- Reassign Material
  - Material assignment in Revit/SketchUp not preserved in IES/Ecotect
  - Templates (IES) help reduce the rework-Planning
- Limited interoperability w/other softwares



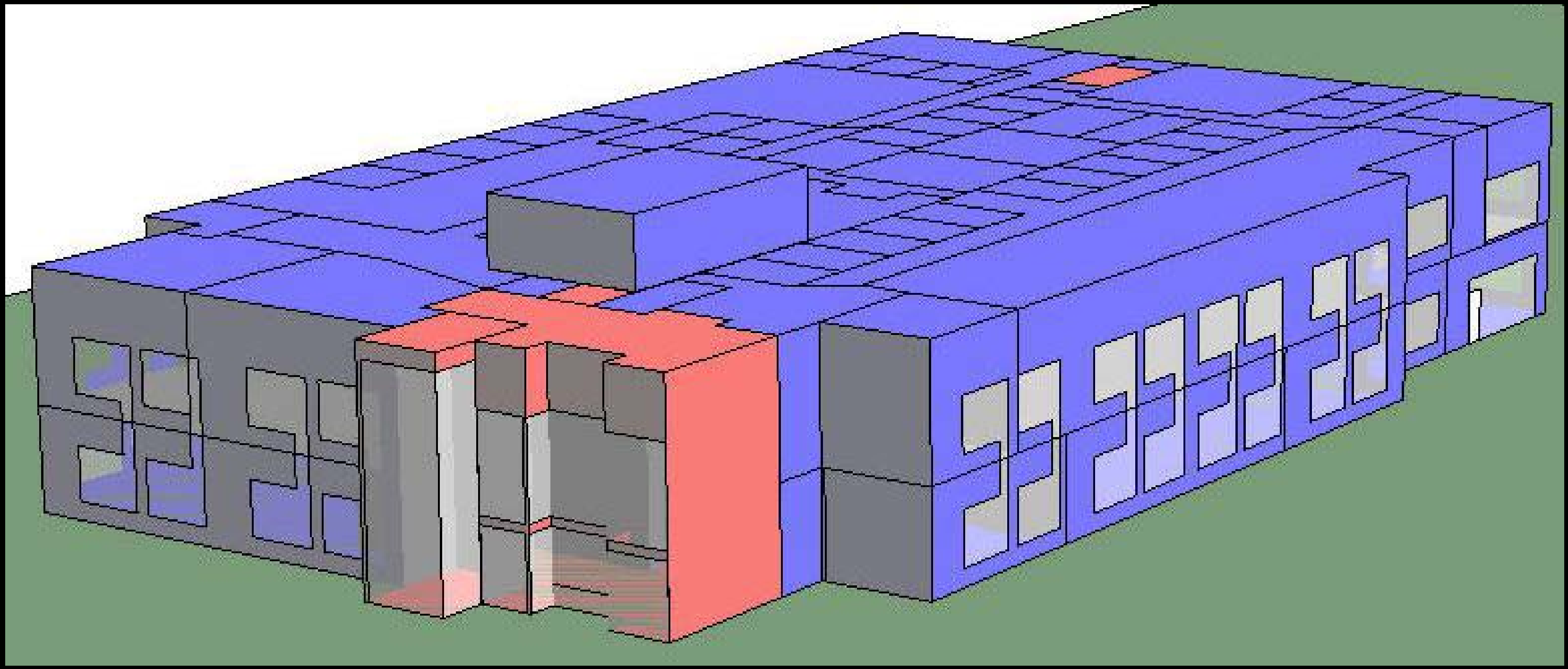


# DPR Sacramento Energy Analysis

- Goal
  - Evaluate IES for energy analysis
- Calibrate using utility bills
  - Energy consumption for one year (2007) documented
- Revit-to-IES import


# DPR Sacramento Energy Analysis

- 50,000 sft, 2 story office building
- C&S Silver, CI Gold certified, EB Silver

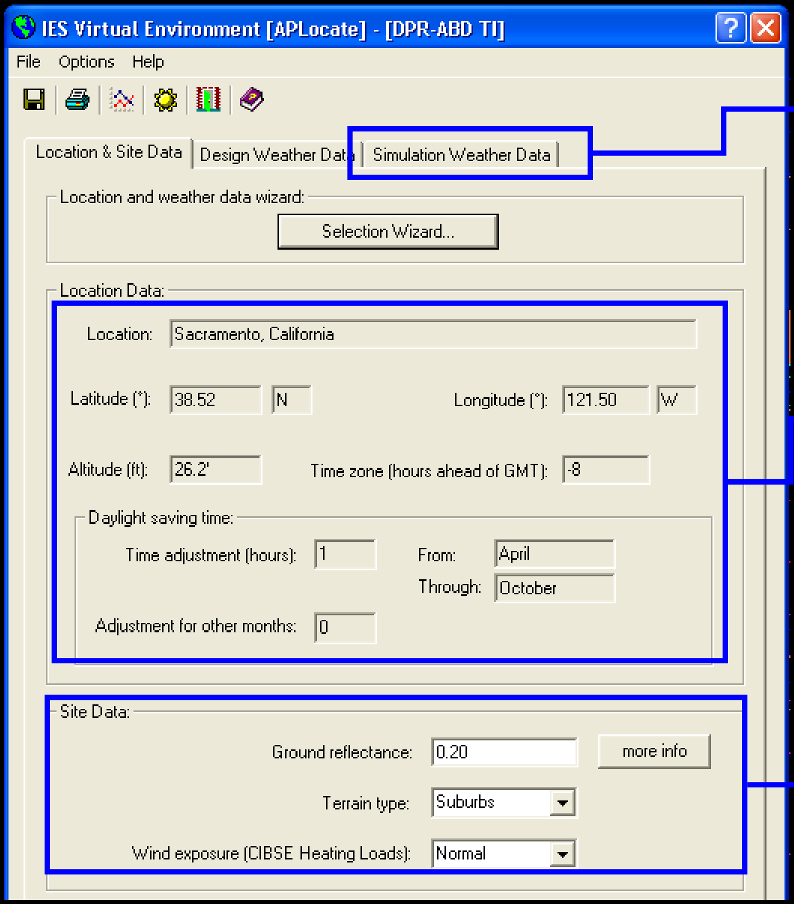


# DPR Sacramento Energy Analysis

- Information Input
  - Site Location and Orientation
  - HVAC Systems
  - Building Materials
  - Operation Schedules
  - Function/ Use


# DPR Sacramento Energy Analysis

- Site Location




Weather data for typical year

Site Location

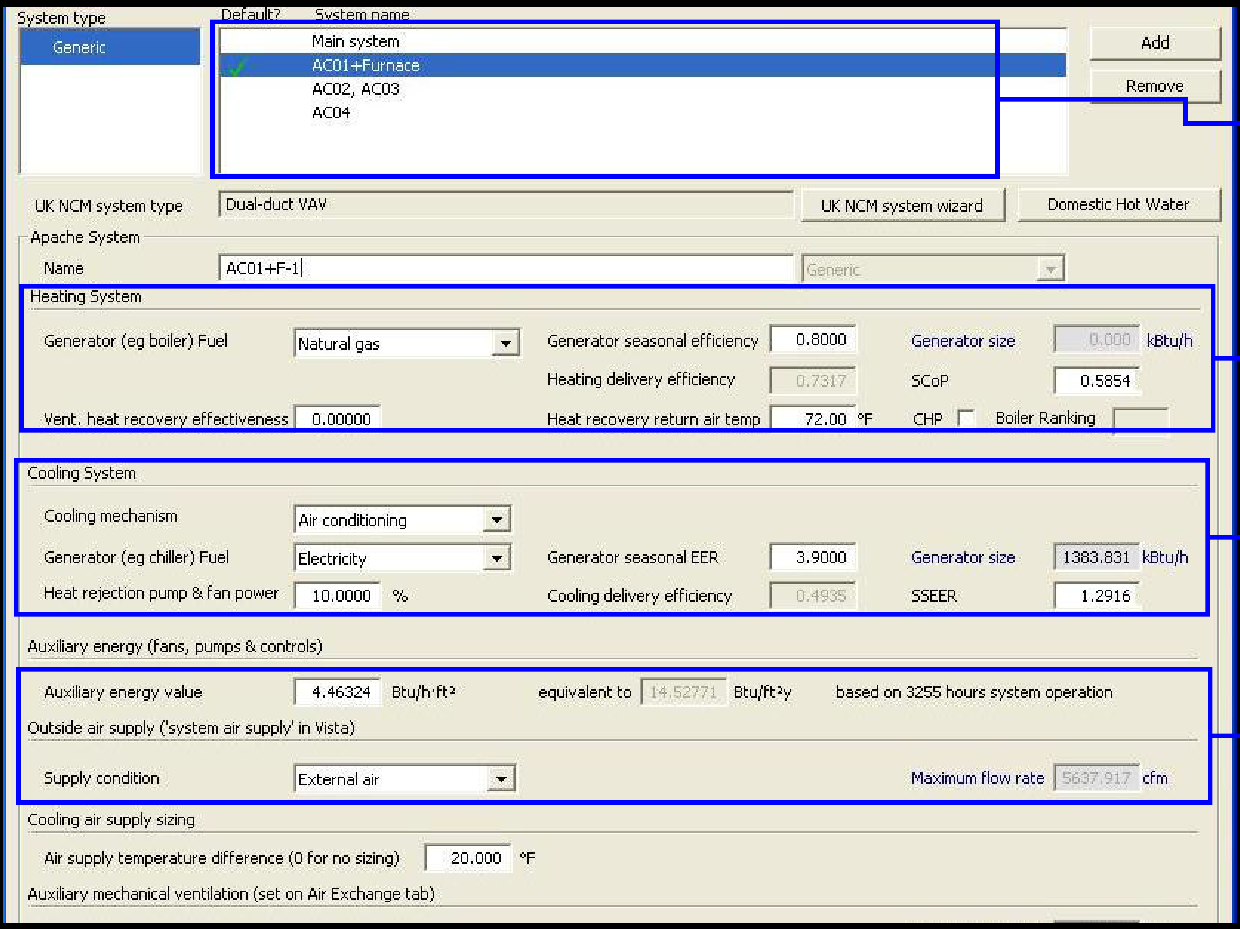
Surrounding Impacts





# DPR Sacramento Energy Analysis

## HVAC Systems




User defined System Type

Heating

Cooling

Fans, Pumps

# DPR Sacramento Energy Analysis

## Building Envelope Material

Opaque Constructions | Glazed Constructions

Internal Ceilings/Floors · Doors · Internal Partitions
Roofs · Ground/Exposed Floors · External Walls

| ID | Description | CIBSE U-value Btu/h·ft²·°F | EN-ISO U-value Btu/h·ft²·°F |
|---|---|---|---|
| STD_WAL2 | standard wall construction (2002 regs) | 0.0614 | 0.0616 |
| STEELP | sheet steel | 0.9944 | 1.0358 |
| ALUMP | sheet aluminium | 0.9945 | 1.0359 |
| STD_WAL1 | DPR External Wall | 0.0479 | 0.0480 |
| W24 | Type 1 - Brick/block cavity wall | 0.0613 | 0.0615 |
| W25 | Type 2 - Metal clad wall | 0.0614 | 0.0616 |
| W26 | Type 3 - Glass clad wall | 0.0610 | 0.0611 |
| W27 | Type 4 - Stone clad wall | 0.0609 | 0.0611 |
| TYP10000 | Type 1 - Brick/block cavity wall | 0.0613 | 0.0615 |
| WALL | External Wall | 0.4012 | 0.4077 |

User defined material assembly

## Space Usage

Standard Internal Gain Library

Space Type

| Type | Gain Reference | Maximum Sensible | Maximum Latent G | Occupancy | Max Power C | Radia |
|---|---|---|---|---|---|---|
| Fluorescent Lighting | General Office | 1.115 W/ft² | - | - | 1.115 W/ft² | 0.45 |
| People | General Office | 307.093 Btu/h per | 204.728 Btu/h per | 150.695 ft²/p | - | - |
| Computers | Meeting Room | 0.465 W/ft² | - | - | 0.465 W/ft² | 0.20 |
| Fluorescent Lighting | Meeting Room | 1.115 W/ft² | - | - | 1.115 W/ft² | 0.45 |
| People | Meeting Room | 307.093 Btu/h per | 204.728 Btu/h per | 75.347 ft²/pe | - | - |
| Computers | Call Centre | 1.858 W/ft² | - | - | 1.858 W/ft² | 0.20 |
| Fluorescent Lighting | Call Centre | 0.743 W/ft² | - | - | 0.743 W/ft² | 0.45 |
| People | Call Centre | 307.093 Btu/h per | 204.728 Btu/h per | 75.347 ft²/pe | - | - |
| Computers | Computer Room | 50.000 W/ft² | - | - | 50.000 W/ft² | 0.20 |

Add Internal Gain · Remove Internal Gain

# DPR Sacramento Energy Analysis

- Functions / Usage
  - Internal Gains

**Internal Gains**

| Type | Gain Reference | Maximum Sensible | Maximum Latent G | Occupancy | Max Power C | Radiant Fractic | Fuel | Varia |
|---|---|---|---|---|---|---|---|---|
| Fluorescent Lighting | General Office | 1.115 W/ft² | - | - | 1.115 W/ft² | 0.45 | Electricity | Light |
| People | General Office | 307.093 Btu/h·per: | 204.728 Btu/h·per: | 150.695 ft²/p | - | - | - | DPR |
| Computers | Meeting Room | 0.465 W/ft² | - | - | 0.465 W/ft² | 0.20 | Electricity | Equi |
| Fluorescent Lighting | Meeting Room | 1.115 W/ft² | - | - | 1.115 W/ft² | 0.45 | Electricity | Light |
| People | Meeting Room | 307.093 Btu/h·per: | 204.728 Btu/h·per: | 75.347 ft²/pe | - | - | - | Occu |
| Computers | Call Centre | 1.858 W/ft² | - | - | 1.858 W/ft² | 0.20 | Electricity | Equi |
| Fluorescent Lighting | Call Centre | 0.743 W/ft² | - | - | 0.743 W/ft² | 0.45 | Electricity | Light |
| People | Call Centre | 307.093 Btu/h·per: | 204.728 Btu/h·per: | 75.347 ft²/pe | - | - | - | Occu |
| Computers | Computer Room | 50.000 W/ft² | - | - | 50.000 W/ft² | 0.20 | Electricity | on c |

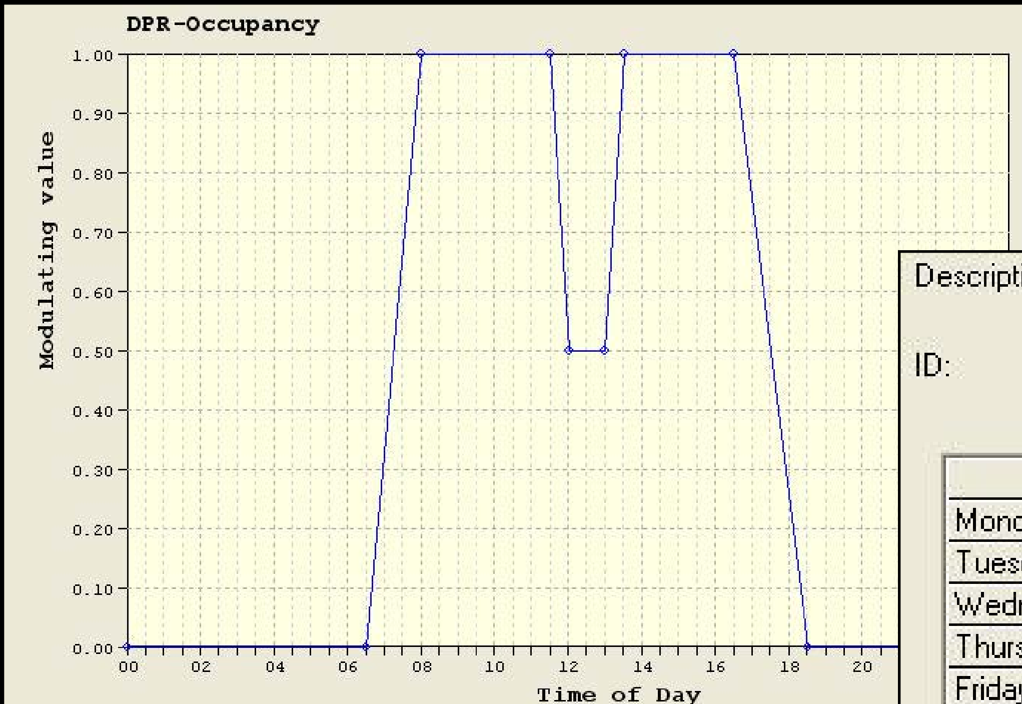
Add Internal Gain | Remove Internal Gain

Gain Type

Space Type

# DPR Sacramento Energy Analysis

- Occupancy Schedules / Profiles




Daily

Weekly

Description: DPR-Occupancy

ID: WEEK0024 — Modulating — Absolute

☑ Same Profile for each day

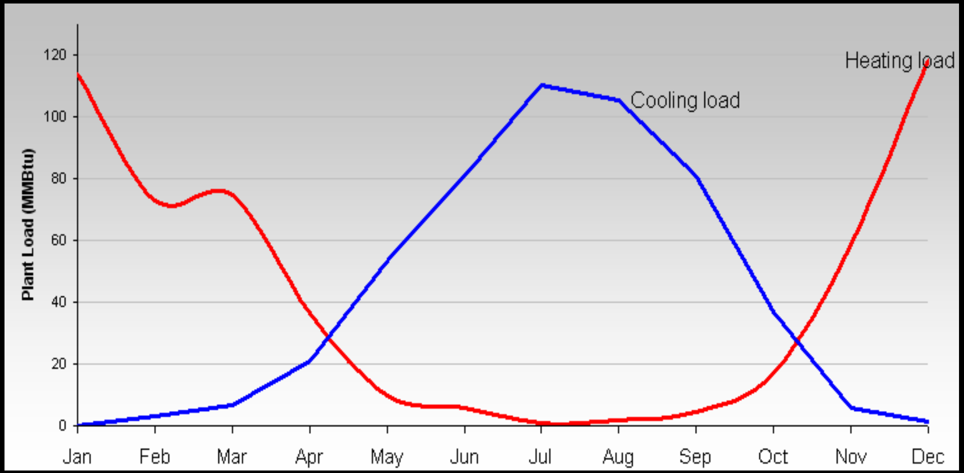
| | Daily Profile: |
|---|---|
| Monday | DPR-Occupancy [DAY_0023] |
| Tuesday | DPR-Occupancy [DAY_0023] |
| Wednesday | DPR-Occupancy [DAY_0023] |
| Thursday | DPR-Occupancy [DAY_0023] |
| Friday | DPR-Occupancy [DAY_0023] |
| Saturday | Always Off (0%) [OFF] |
| Sunday | Always Off (0%) [OFF] |
| Holiday | DPR Occupancy Reduced [DAY_0027] |





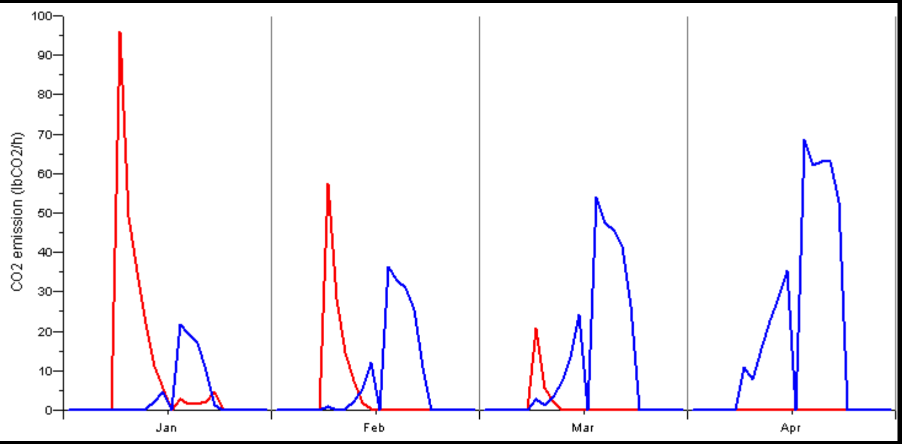
# DPR Sacramento Energy Analysis

## Results




Heating and Cooling Loads

Heating and Cooling System $CO_2$ Emissions

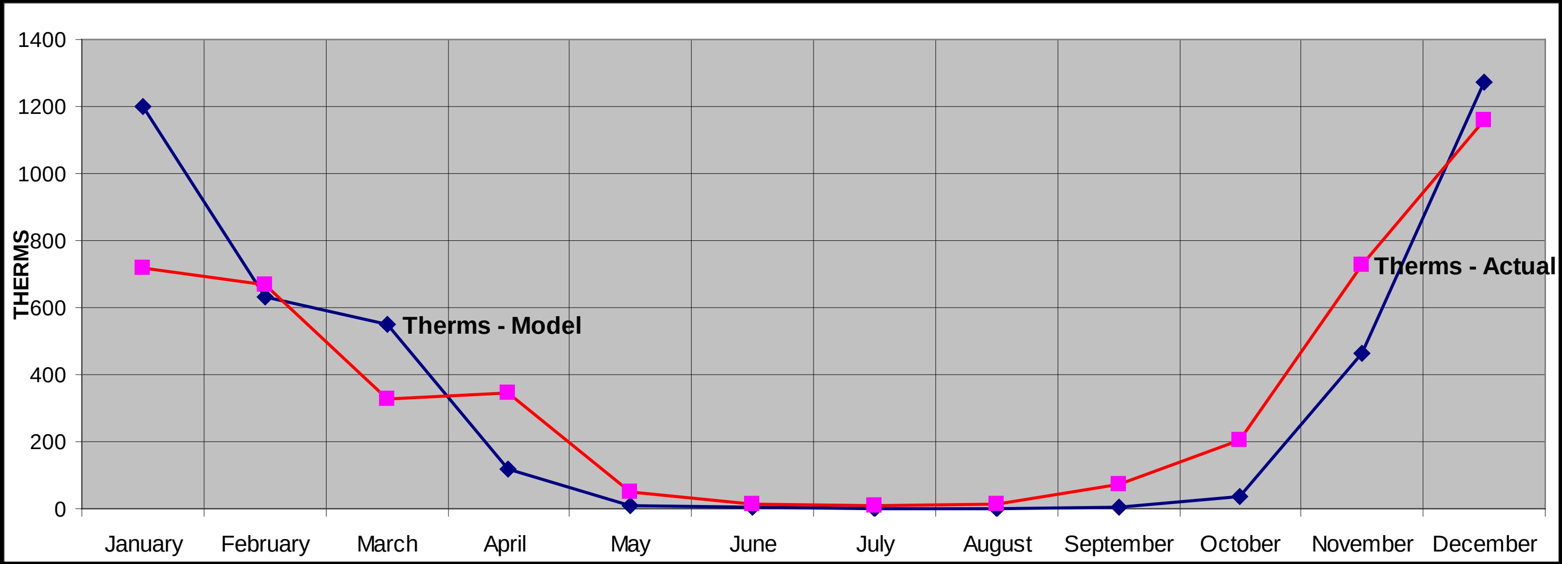





S409: BIM for Energy Modeling, Lifecycle Energy Usage & Cost Analysis

# DPR Sacramento Energy Analysis

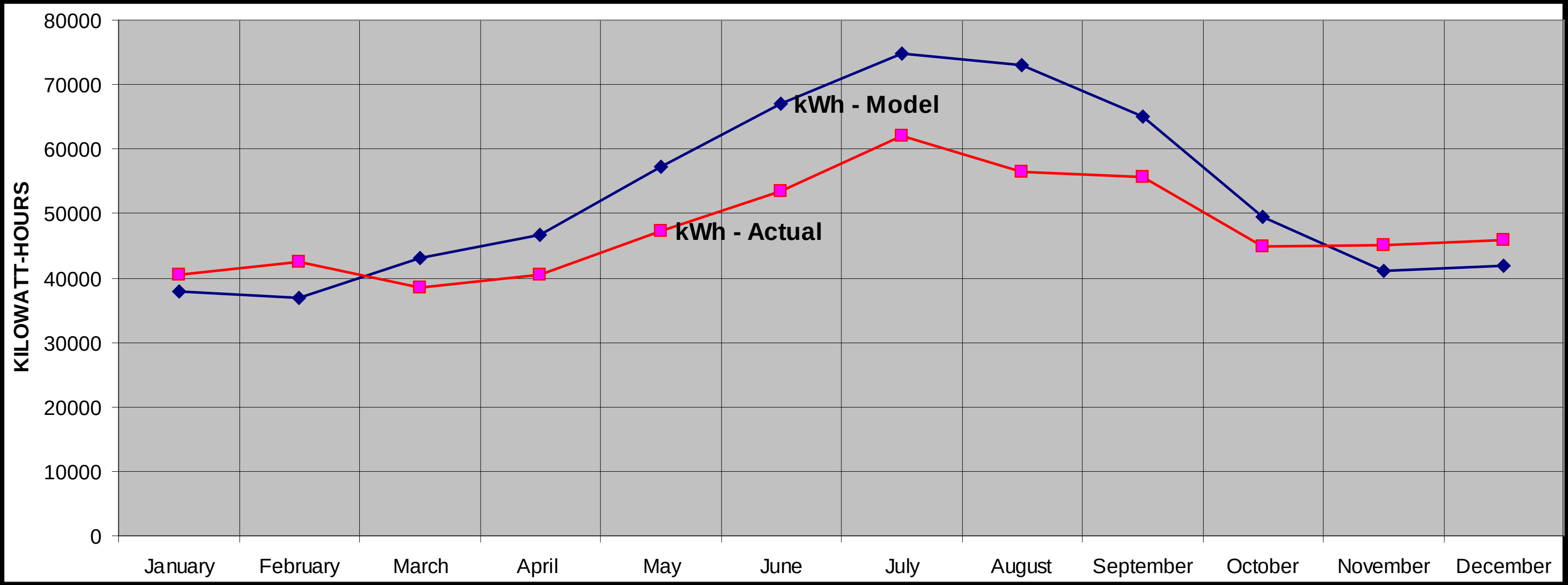
## Energy Usage by Fuel-Natural Gas




| Energy Type | Model Value | Actual Value | % Difference |
|---|---|---|---|
| Natural Gas | 4,297 | 4,310 | 0.3% |
| Electricity | 634,140 | 572,760 | -10.7% |

# DPR Sacramento Energy Analysis

## Energy Usage by Fuel-Electricity




| Energy Type | Model Value | Actual Value | % Difference |
|---|---|---|---|
| Natural Gas | 4,297 | 4,310 | 0.3% |
| **Electricity** | **634,140** | **572,760** | **-10.7%** |





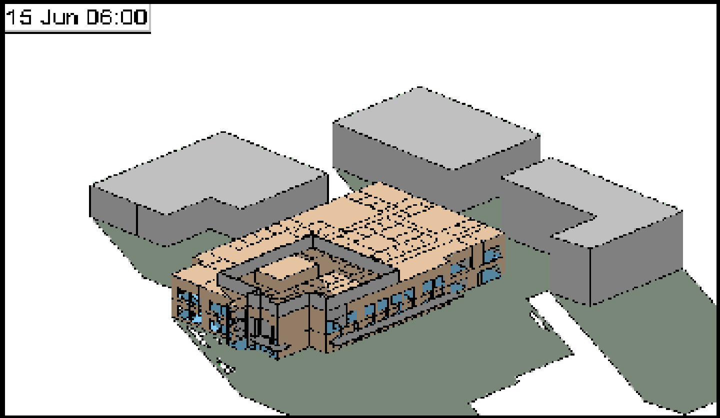
# DPR Sacramento Energy Analysis

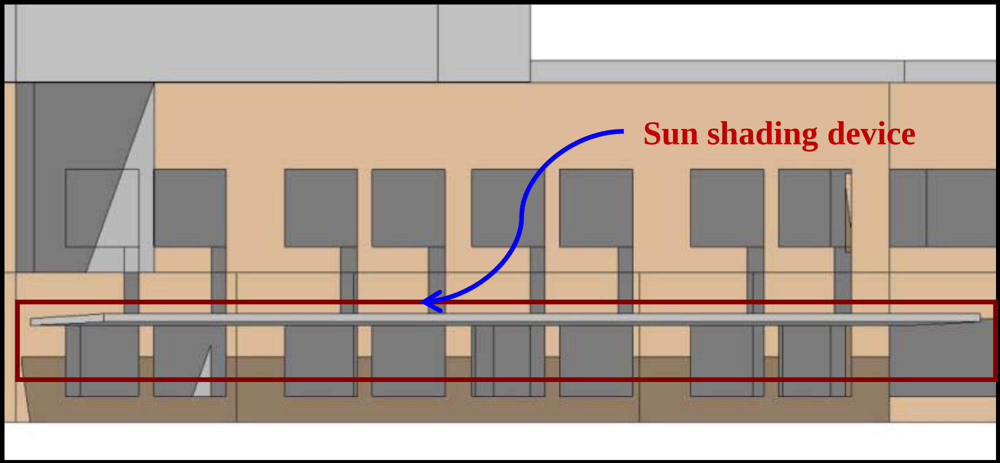
How good are the results?

- Comparing to only one year data
- Natural gas for heating: metered
- The model did not include
  - Control efficiencies
  - Daylight sensor controlled dimmers

| Energy Type | Model Value | Actual Value | % Difference |
|---|---|---|---|
| **Natural Gas** | **4,297** | **4,310** | **0.3%** |
| Electricity | 634,140 | 572,760 | -10.7% |


# Solar Shading Device Analysis




**% Area of Direct Solar Incidence**

| Month | 07:00 | 08:00 | 09:00 | 10:00 | 11:00 | 12:00 | 13:00 | 14:00 | 15:00 | 16:00 | 17:00 | 18:00 | 19:00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan | | 0.0 | 0.0 | 59.0 | 53.1 | 50.9 | 69.6 | 82.4 | 87.6 | 92.9 | 93.7 | | |
| Feb | | 0.0 | 0.0 | 100.0 | 57.6 | 53.2 | 51.1 | 68.1 | 82.6 | 88.6 | 94.8 | | |
| Mar | 0.0 | 0.0 | 0.0 | 0.0 | 66.0 | 56.6 | 53.1 | 51.1 | 68.3 | 83.3 | 90.2 | 96.1 | |
| Apr | 0.0 | 0.0 | 0.0 | 0.0 | 100.0 | 62.2 | 56.2 | 53.2 | 51.2 | 66.5 | 83.8 | 92.5 | |
| May | 0.0 | 0.0 | 0.0 | 0.0 | 100.0 | 72.3 | 60.0 | 55.7 | 53.1 | 51.3 | 66.7 | 85.1 | 97.4 |
| Jun | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 100.0 | 63.5 | 57.7 | 54.6 | 52.5 | 50.8 | 78.7 | 91.0 |
| Jul | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 100.0 | 62.9 | 57.2 | 54.2 | 52.2 | 50.5 | 80.4 | 91.9 |
| Aug | 0.0 | 0.0 | 0.0 | 0.0 | 100.0 | 66.8 | 58.2 | 54.5 | 52.2 | 50.5 | 79.7 | 88.5 | |
| Sep | 0.0 | 0.0 | 0.0 | 100.0 | 67.6 | 57.4 | 53.7 | 51.5 | 60.9 | 81.9 | 89.3 | 96.9 | |
| Oct | 0.0 | 0.0 | 0.0 | 69.2 | 56.6 | 52.9 | 50.9 | 70.9 | 83.5 | 89.7 | 96.5 | | |
| Nov | 0.0 | 0.0 | 100.0 | 57.2 | 52.7 | 50.7 | 72.7 | 83.3 | 88.6 | 94.2 | | | |
| Dec | | 0.0 | 84.7 | 55.2 | 51.8 | 56.6 | 79.7 | 84.9 | 89.8 | 95.1 | | | |

With Shading
48.17%

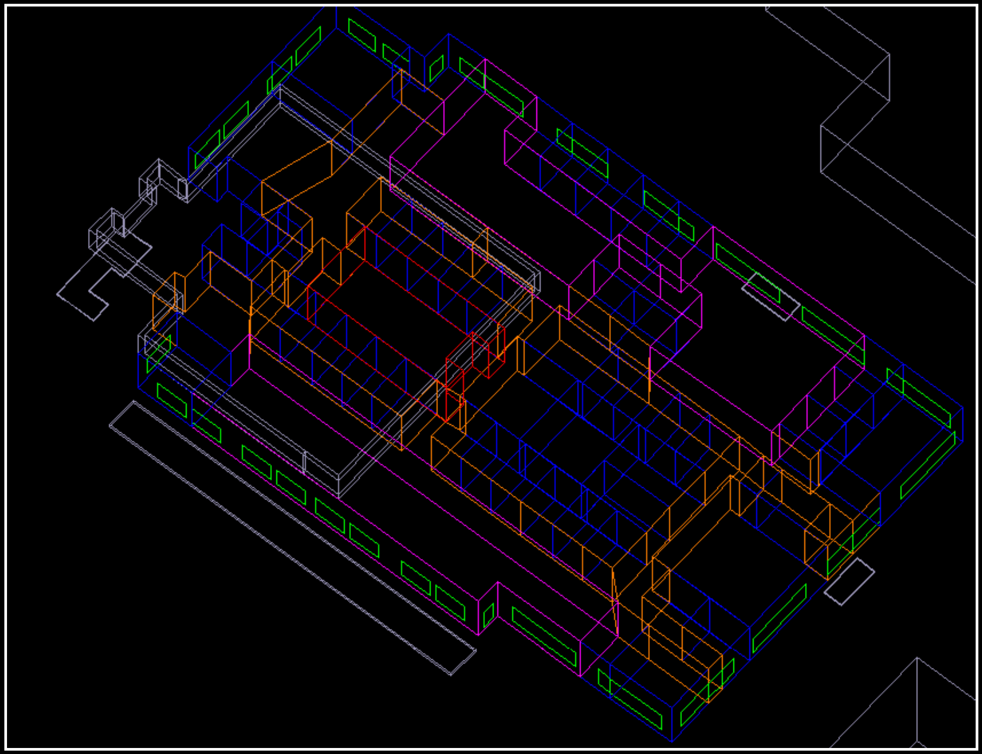
| Month | 07:00 | 08:00 | 09:00 | 10:00 | 11:00 | 12:00 | 13:00 | 14:00 | 15:00 | 16:00 | 17:00 | 18:00 | 19:00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan | | 0.0 | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | | |
| Feb | | 0.0 | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | | |
| Mar | 0.0 | 0.0 | 0.0 | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | |
| Apr | 0.0 | 0.0 | 0.0 | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | |
| May | 0.0 | 0.0 | 0.0 | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Jun | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Jul | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Aug | 0.0 | 0.0 | 0.0 | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | |
| Sep | 0.0 | 0.0 | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | |
| Oct | 0.0 | 0.0 | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | | |
| Nov | 0.0 | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | | | |
| Dec | | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | | | |

Without Shading
67.12%

# Lessons Learned: Modeling

## 2D DXF

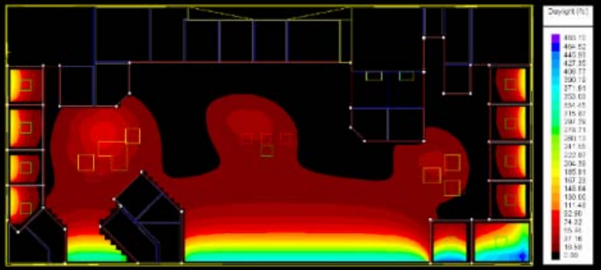
- Plus
  - Uses 2D CAD drawings, no 3D model
- Minus
  - Only “cubes”
  - Pre-processing: Centerline drawings
- Best Application
  - Simple geometry
  - Less variation in elevation
  - Many rooms

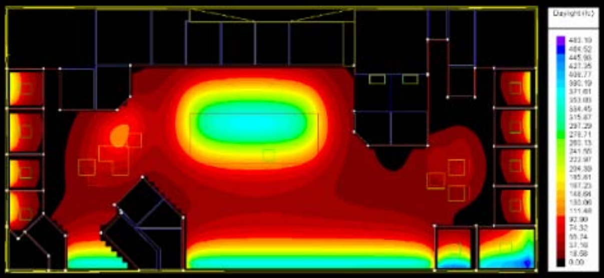


DPR, Sacramento, CA

# Energy Modeling as a Tool

- Tremendous opportunities to affect design
  - Cost effective
  - Shifts brain power
  - Better more informed solutions
  - Environmental benefits
  - Improved indoor environment
- Financial benefits
  - Upfront investment
  - Long term payback



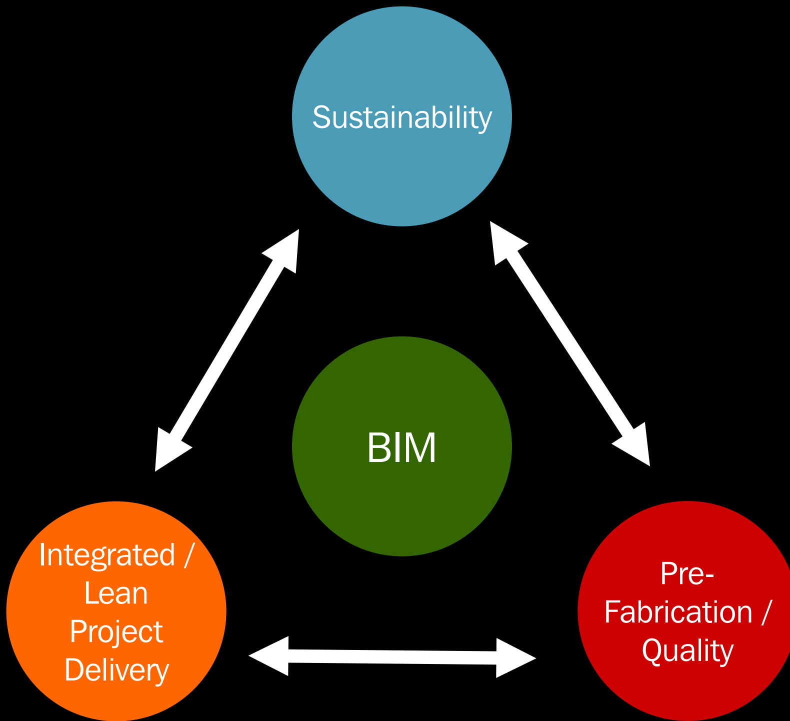






# BIM is an Enabler

- Energy Analysis
- Model based LEED ROI
- LEED Submissions




- Conceptual Design
- Implementation Documents
- Digital Data exchange
- BIM enabled Lean Project Delivery

- BIM based Prefabrication
- Just in time delivery
- Accurate instructions
- Reduction of natural resources





# BIM is an Enabler

Autodesk

Company Contact Us Partners Search

Industries | Products | Purchase | Services & Support | Communities

United States Worldwide Sites

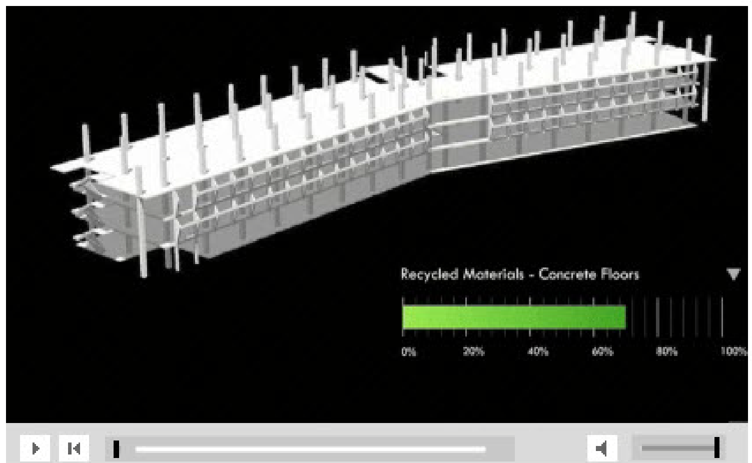
Home > Company > Building Information Modeling

## Building Information Modeling

- Experience BIM
- Integrated Project Delivery
- Sustainability
- News
- Products for BIM

### Green Building Research

Print Email




**Our Latest Research on Sustainable Design Technology***
Autodesk and the U.S. Green Building Council (USGBC) are committed to a future where design process and technology are integrated in support of our common goal: a sustainable tomorrow.

DPR Construction Inc.

Sustainable & Smart

ecobuild® fall

Sustainable, Green and High Performance Solutions for the Built Environment

AEC–ST fall® Science & Technology for Architecture, Engineering & Construction

S409: BIM for Energy Modeling, Lifecycle Energy Usage & Cost Analysis

WE EXIST TO BUILD GREAT THINGS