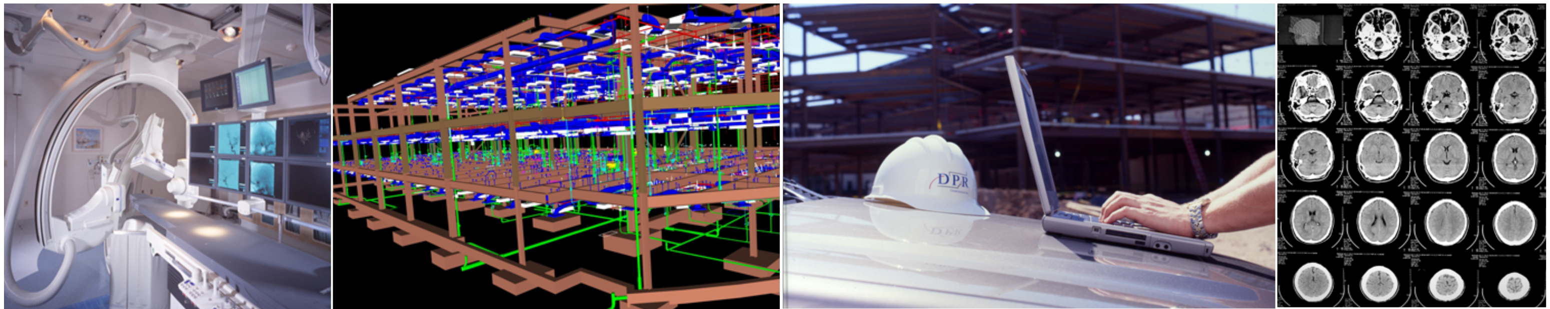

Building Information Modeling

- Energy Modeling, Lifecycle Energy Usage & Cost Analysis

EcoBuild/AEC-ST S600

May 22, 2008 L.A.

Presented By Christopher Rippingham, DPR Construction, Inc.

Moderated By Andy Fuhrman, OSCRE Americas, Inc.

BIM for Energy Analysis and Modeling

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Agenda

- What is energy modeling
- How is BIM incorporated
- Process
- Case Study – Roche Project
- Case Study – DPR Sacramento Office
- Software

When just 1% of a project's up front costs are spent … up to 70% of it's life-cycle costs may have already been committed."

- Joseph Romm

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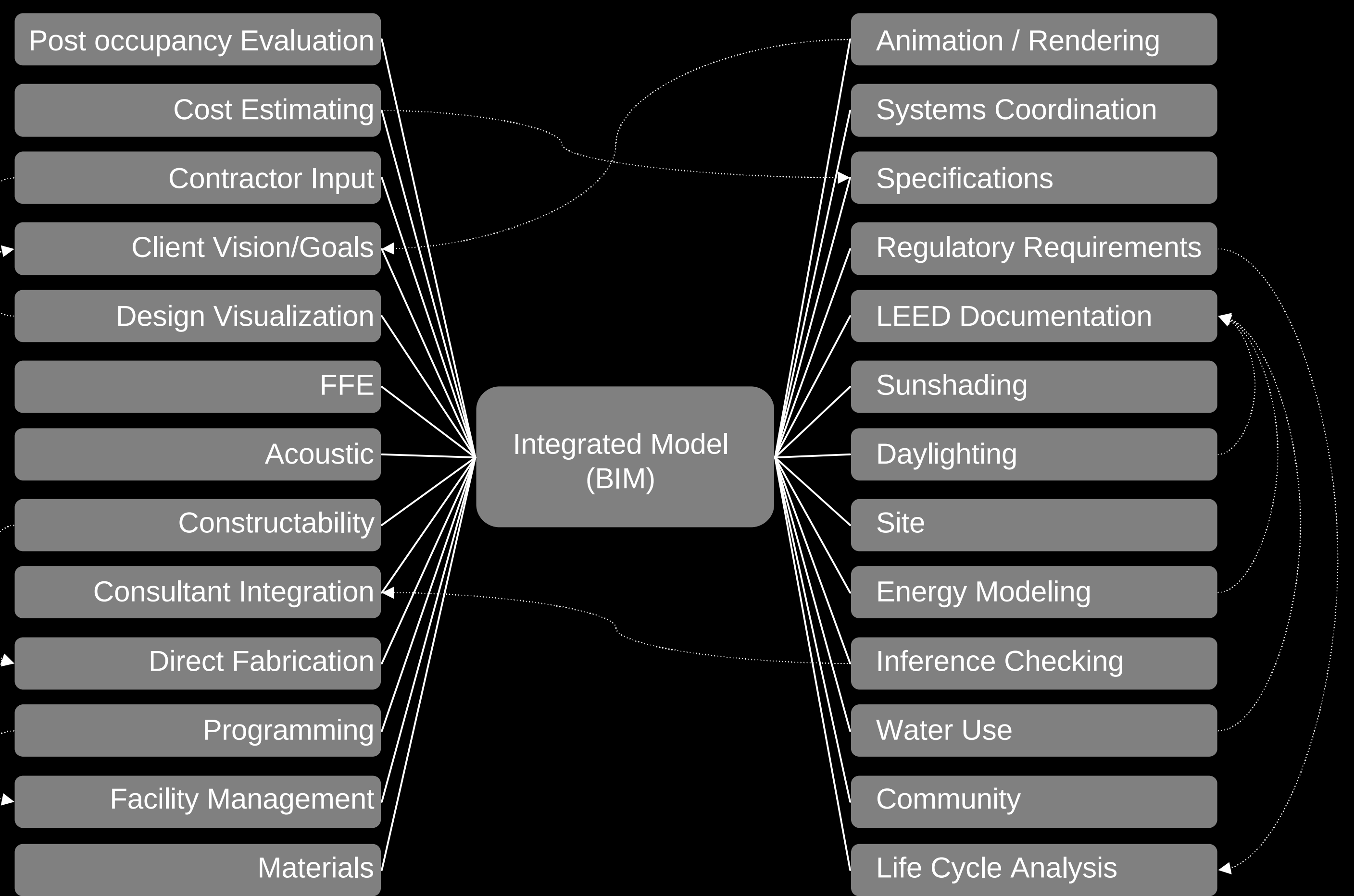

Diagram courtesy of Eddy Krygiel and Bradley Nies, Green BIM

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Energy modeling is a design tool

Insulation
Construction
Window type
Window size
Window treatments
Building orientation
Building shape
Programming
Lighting
HVAC system type
Heat recovery
Fuels
Specific product
Operation schedules
Natural ventilation

Energy use, demand, and cost
Daylight levels
Saving from daylight usage
Thermal comfort
Environmental impact

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Using energy modeling effectively

Pre- Design ↔
- Climatic Analysis
- US EPA Target Finder Analysis
- Identify infrastructure and site issues

↓

Design Charrette ↔
- Identify strategies
- Goal setting

↓

Schematic Design ↔
- Develop high-performance vision
- Shape or form of the building
- Daylighting
- Windows and Building envelope
- HVAC option

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Using energy modeling effectively

Schematic Design

- "Wizard" level models
- Load reduction iterations
- Combination runs
- Revised base case
- HVAC system comparisons

Design Development

- Fine-tune system details
- Check progress – LEED points
- True "value engineering"
- Final model
- Documents for LEED

Commissioning

- Calibrate the model
- Troubleshoot operation

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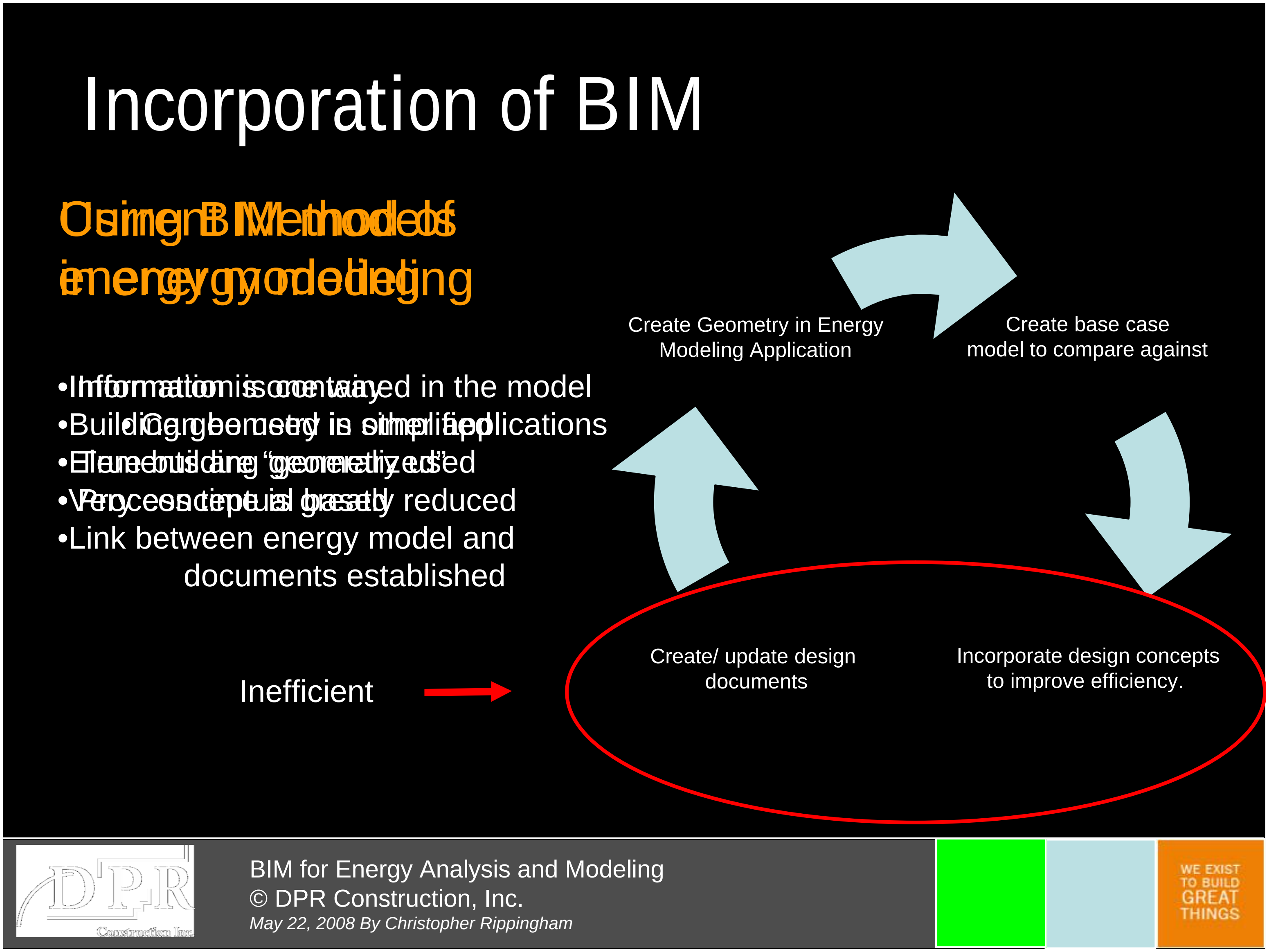
Incorporation of BIM
•Link between energy model and
documents established
Inefficient
Create Geometry in Energy
Modeling Application
Create base case
model to compare against
Create/ update design
documents
Incorporate design concepts
to improve efficiency.
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Energy Modeling Process

- Step 1 – Develop Goals for the Energy Modeling process
- Step 2 – Develop Building Information Model to meet needs for energy analysis
- Step 3 – Gather data needed for energy analysis
- Step 4 – Merge the BIM and data into an energy simulation program
- Step 5 – Generate predictive results for energy consumption

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Case Study – Roche Project

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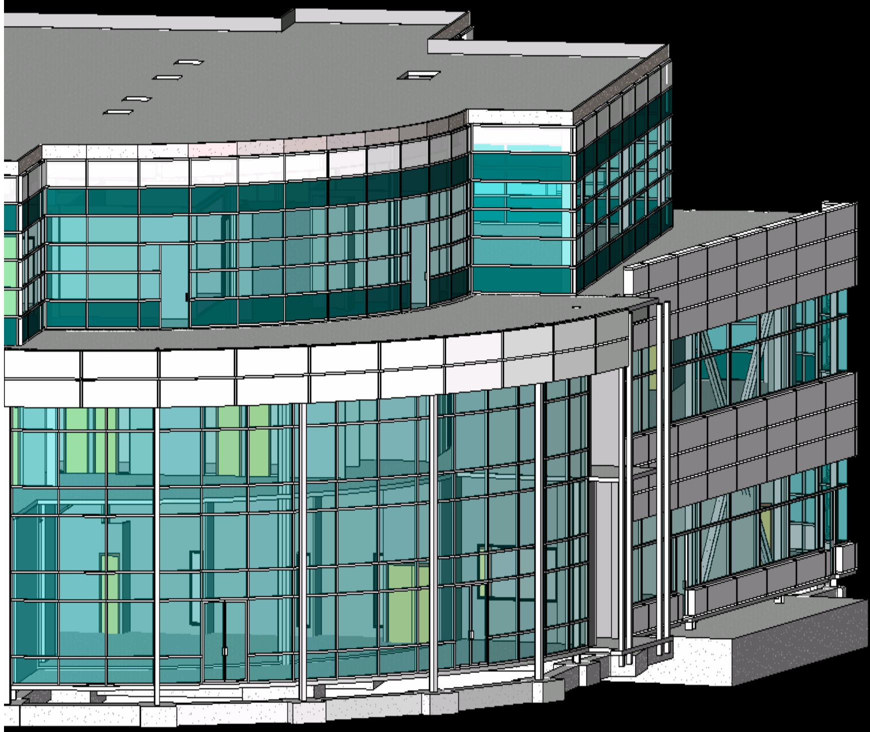
Roche Project Background



- Project under construction in Bay Area
- Office and Lab building
- DPR developed the Building Information model using Revit from 100% CD's

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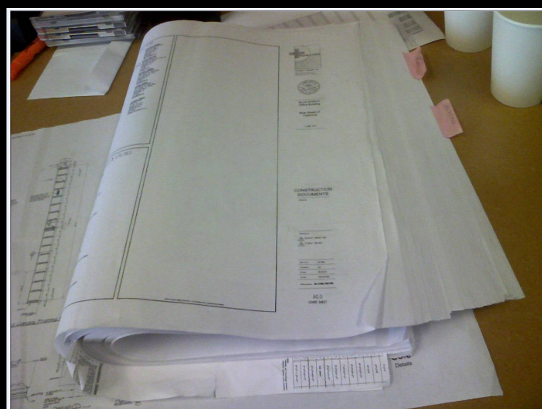
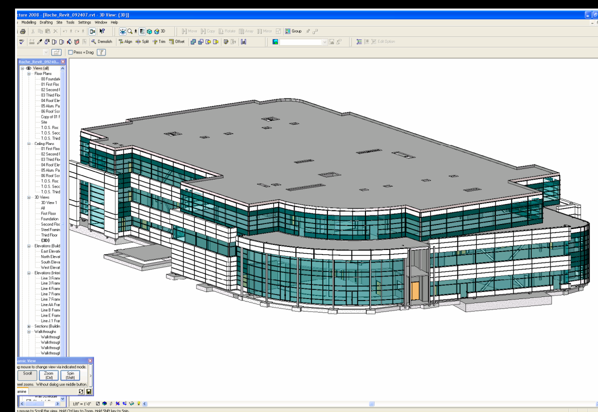
STEP 1 – Develop Goals

- Roche project goals
  - Compare the energy use for the Roche project to the ASHRAE standards
  - Compare energy use for two different building orientations
  - Pilot the Energy Analysis software – We selected Riuska from Olof Granlund of Finland after consulting with CIFE, Stanford

STEP 2: Develop Building Information Model



10 Days



2D Drawings of the project. 100% CD's with Plans, Elevations and Sections + specification info.

Object Oriented Parametric Model that includes information needed for Energy Analysis

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STEP 3 – Gather data needed for Analysis

- Type of data needed
  - Building occupancy loads (# of people)
  - Lighting and equipment characteristics
  - Type and nature of spaces
  - Use of spaces during working hours
  - Data and description of the Central plant, HVAC equipment etc.
  - E value for window wall system
  - Wall types, room designation, areas, use of space
  - Building orientations (actual / desired)
  - Location of building (Latitude / Longitude)

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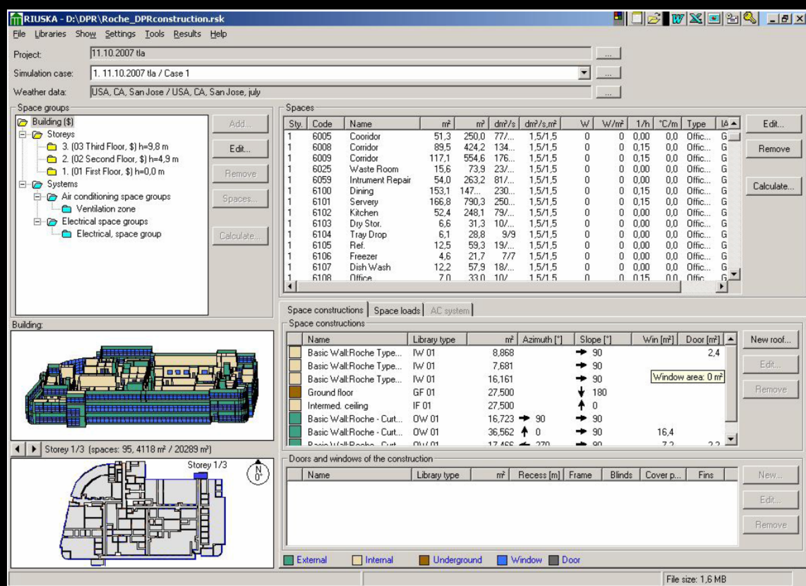
STEP 4 – Energy Simulation (Riuska)



- Import model from modeling software
  - Geometry
  - Space definitions
  - Doors
  - Windows
- Input data collected
  - HVAC System
  - Area Types
  - Orientation
    - Desired / Actual

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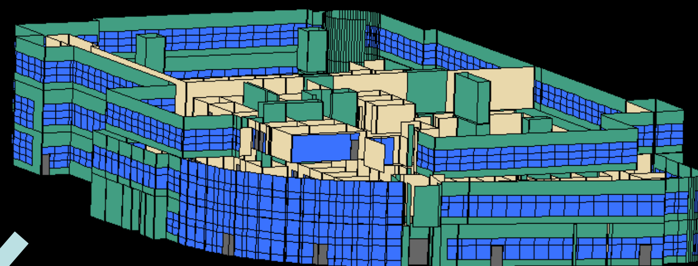
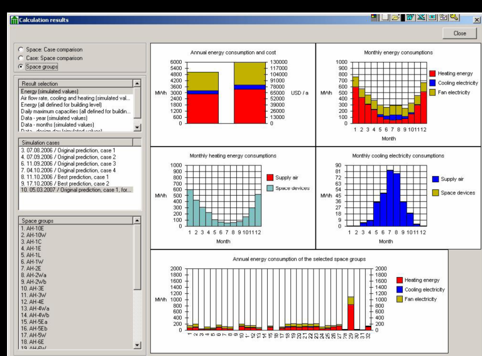
STEP 5 – Generate predictive results

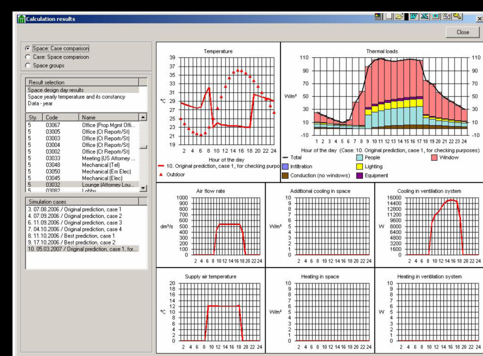


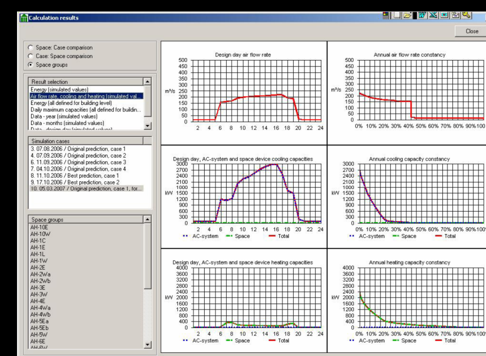
Energy Usage / Cost

Temperature / Thermal Loads

Air Flow for Heating / Cooling







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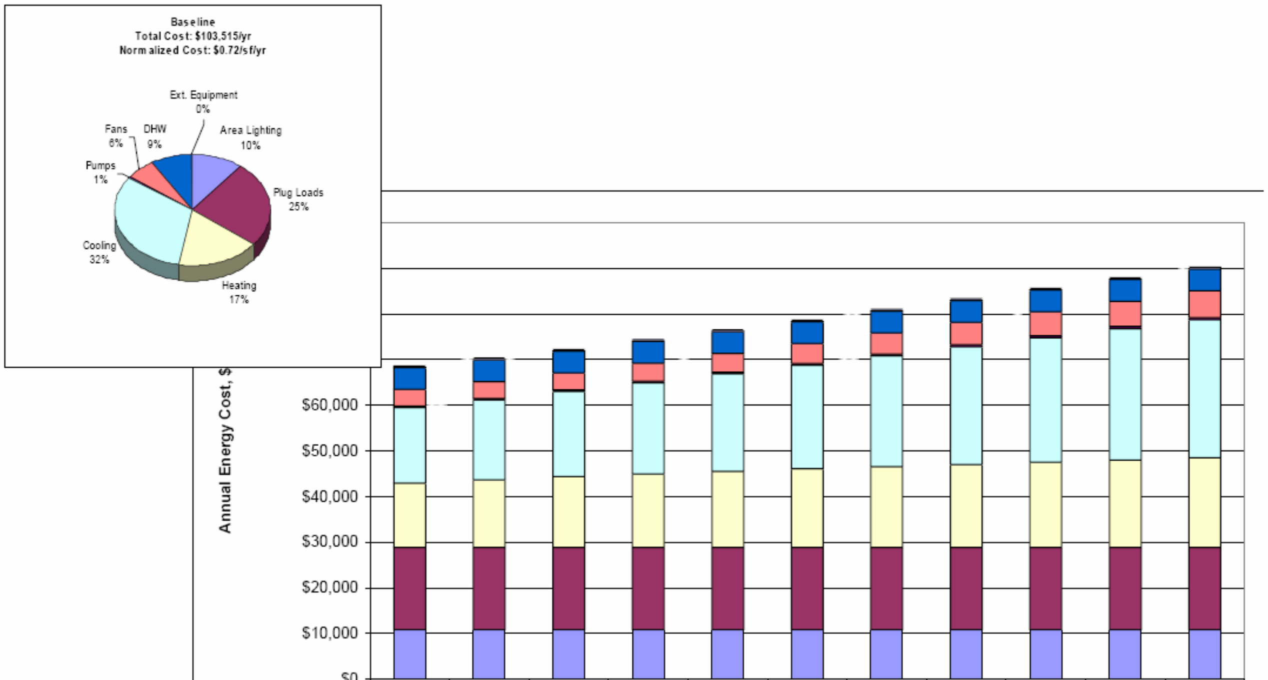

	Win-0	Win-5	Win-10	Win-15	Win-20	Win-25	Win-30	Win-35	Win-40	Win-45	Win-50
Ext. Equipment	$378	$378	$378	$378	$378	$378	$378	$378	$378	$378	$378
DHW	$4,760	$4,760	$4,761	$4,760	$4,761	$4,761	$4,761	$4,760	$4,761	$4,761	$4,760
Fans	$3,643	$3,663	$3,746	$3,917	$4,091	$4,311	$4,612	$4,914	$5,211	$5,523	$5,835
Pumps	$317	$312	$326	$344	$362	$384	$412	$435	$462	$491	$514
Cooling	$16,570	$17,539	$18,696	$20,023	$21,331	$22,718	$24,259	$25,775	$27,260	$28,754	$30,218
Heating	$14,121	$14,828	$15,511	$16,102	$16,707	$17,267	$17,732	$18,211	$18,703	$19,180	$19,667
Plug Loads	$18,007	$18,007	$18,007	$18,007	$18,007	$18,007	$18,007	$18,007	$18,007	$18,007	$18,007
Area Lighting	$10,844	$10,845	$10,845	$10,845	$10,844	$10,845	$10,844	$10,844	$10,844	$10,844	$10,845

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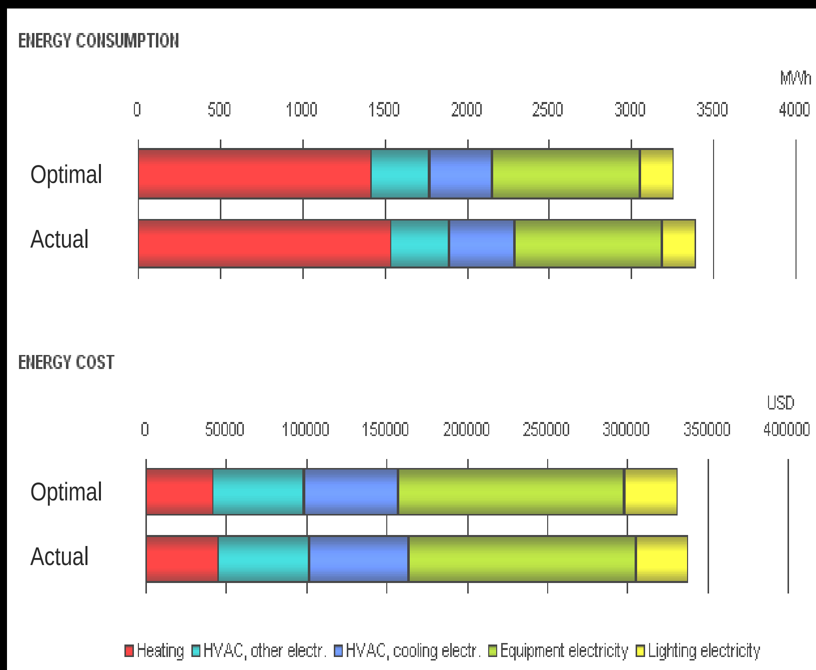
Overall Results



- Comparative analysis of actual orientation to optimal orientation
- Results show that optimal angle improved energy consumption by 4%.

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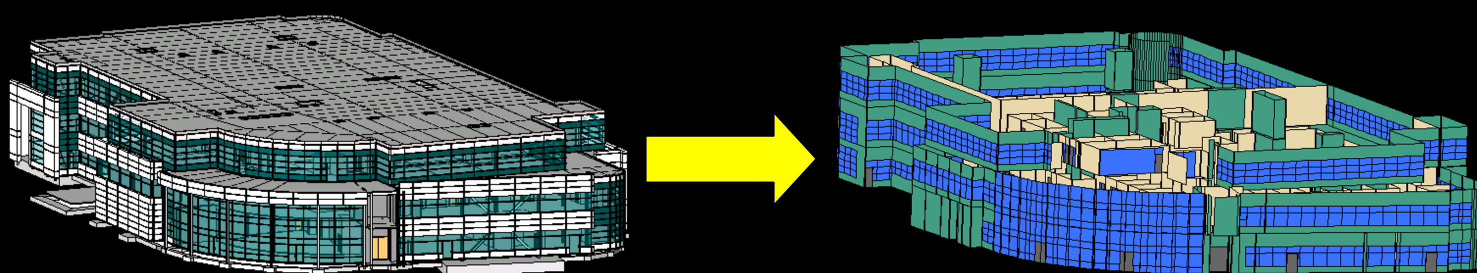
BIM Lessons Learned

- What is useful/not useful to model
- Spaces / Space bounding elements
- Window Wall System
- IFC Interface between Revit and Riuska



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Case Study – DPR Sacramento Office

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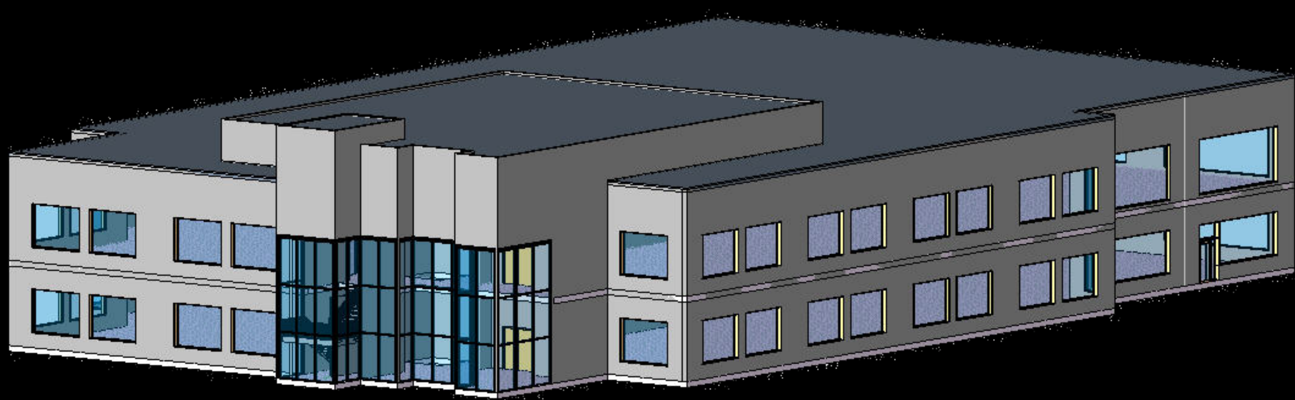
Sac Office Background

- Office opened **date**
- Job received LEED Silver certification
- Lifecycle Energy Usage data collected



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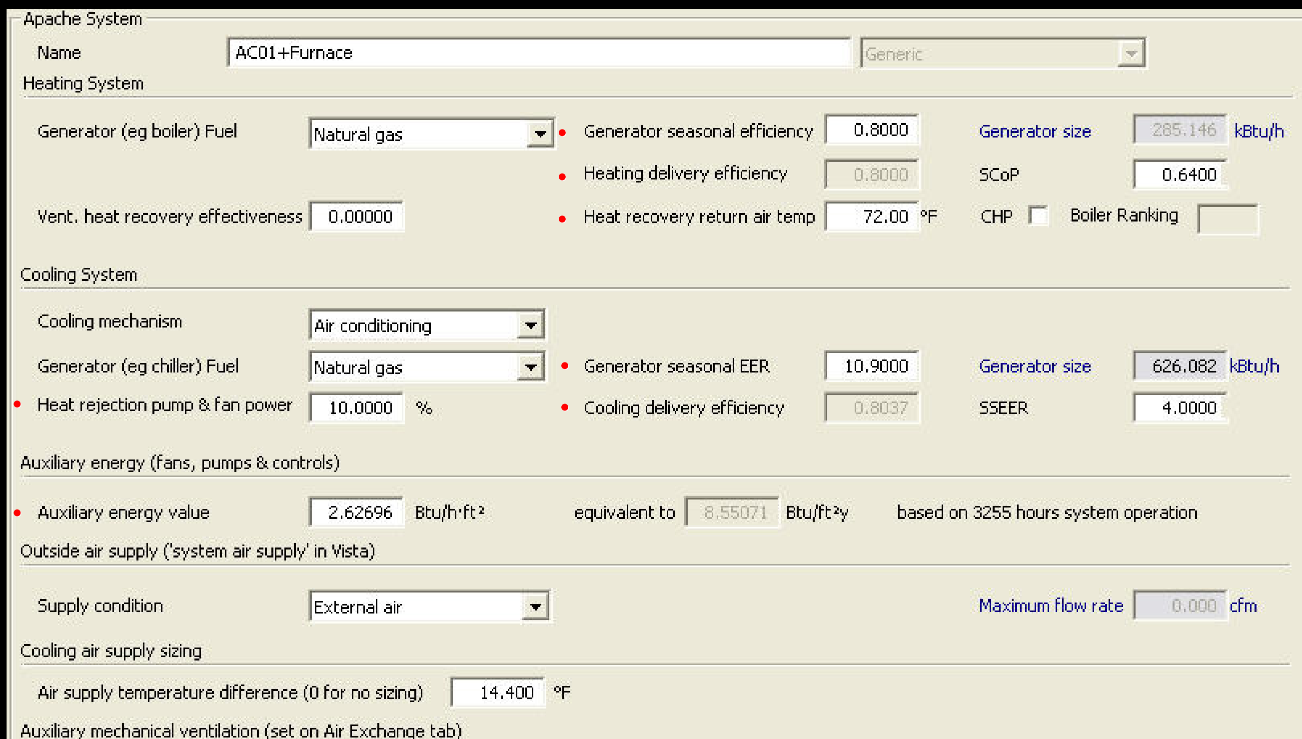
Step One – Establish Goals

- Compare results from energy model to actual usage data
  - Thermal Analysis
  - Daylighting Analysis
  - Solar Shading Analysis
- Pilot Virtual Environment - IES
- Make suggestions to improve space

STEP 3 – Gather Thermal System Data


Apache System
Name: AC01+Furnace | Generic

Heating System
Generator (eg boiler) Fuel: Natural gas
• Generator seasonal efficiency: 0.8000
Generator size: 285.146 kBtu/h
• Heating delivery efficiency: 0.8000
SCoP: 0.6400
Vent. heat recovery effectiveness: 0.00000
• Heat recovery return air temp: 72.00 °F
CHP
Boiler Ranking

Cooling System
Cooling mechanism: Air conditioning
Generator (eg chiller) Fuel: Natural gas
• Generator seasonal EER: 10.9000
Generator size: 626.082 kBtu/h
• Heat rejection pump & fan power: 10.0000 %
• Cooling delivery efficiency: 0.8037
SSEER: 4.0000

Auxiliary energy (fans, pumps & controls)
• Auxiliary energy value: 2.62696 Btu/h·ft²
equivalent to 8.55071 Btu/ft²y
based on 3255 hours system operation

Outside air supply ('system air supply' in Vista)
Supply condition: External air
Maximum flow rate: 0.000 cfm

Cooling air supply sizing
Air supply temperature difference (0 for no sizing): 14.400 °F

Auxiliary mechanical ventilation (set on Air Exchange tab)

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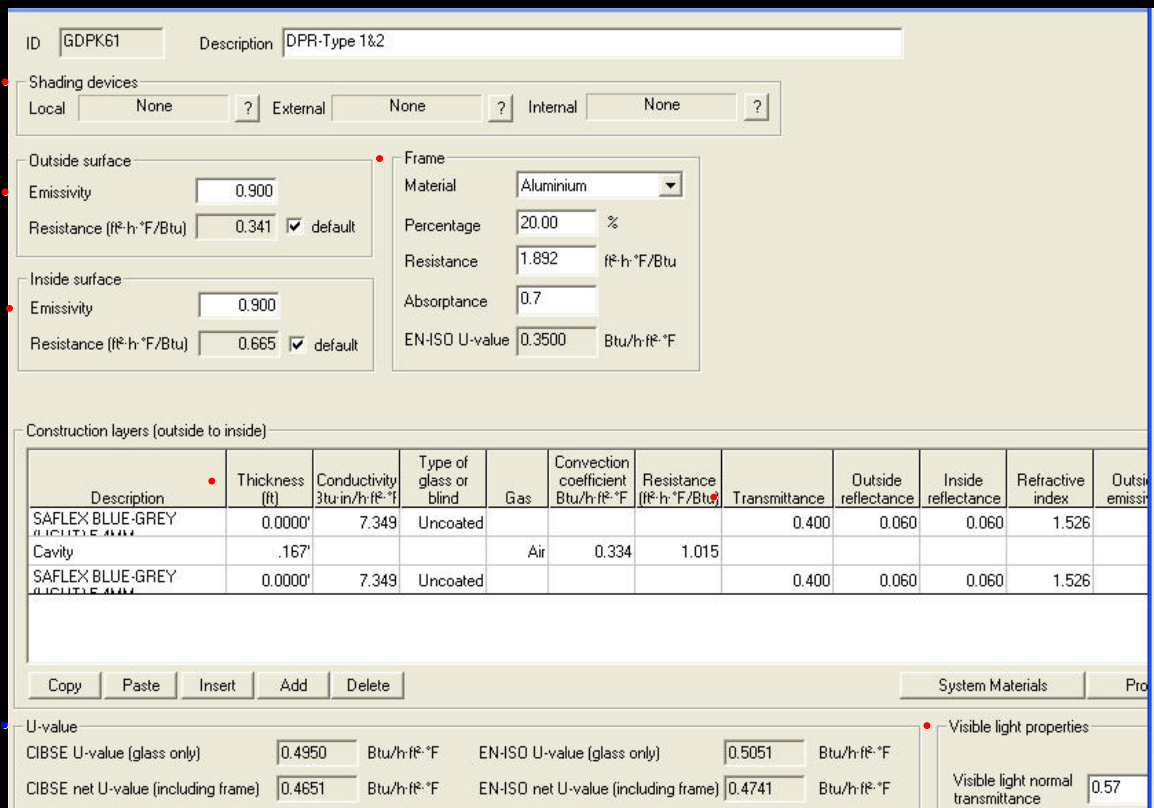
STEP 3 – Gather Glazing Properties



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STEP 3 – Gather Material Properties

External Walls

Construction layers (outside to inside)

Material	Thickness ft	Conductivity Btu·in/h·ft²·°F	Density lb/ft³	Specific Heat Capacity Btu/lb·°F	Resistance ft²·h·°F/Btu	Vapour Resistivity (perm·in)^-1	Category
GYPSUM PLASTERING	0.0518'	2.912	74.914	0.1999			Plaster
CONCRETE BLOCK (LIGHTWEIGHT)	0.9170'	1.317	37.457	0.2388			Concretes
Cavity	0.2500'				1.022		
INSULATION BOARD - HF-B2	0.2500'	0.298	1.998	0.1999		0.000	Insulating Materials
GYPSUM PLASTERING	0.0518'	2.912	74.914	0.1999			Plaster

Copy | Paste | Cavity | Insert | Add | Delete | Flip | System Materials | Project Materials

Construction thickness 1.5210' ft

U-value (Btu/h·ft²·°F): CIBSE U-value 0.0479 Btu/h·ft²·°F; EN-ISO U-value 0.0480 Btu/h·ft²·°F

Internal Partitions

Construction layers (outside to inside)

Material	Thickness ft	Conductivity Btu·in/h·ft²·°F	Density lb/ft³	Specific Heat Capacity Btu/lb·°F	Resistance ft²·h·°F/Btu	Vapour Resistivity (perm·in)^-1	Category
GYPSUM/ PLASTER BOARD - HF-E1	0.0518'	1.109	50.005	0.1999		0.000	Plaster
GLASS-FIBRE QUILT	0.2920'	0.277	0.749	0.2006			Insulating Materials
GYPSUM/ PLASTER BOARD - HF-E1	0.0518'	1.109	50.005	0.1999		0.000	Plaster

Copy | Paste | Cavity | Insert | Add | Delete | Flip | System Materials | Project Materials

Construction thickness 0.3960' ft

U-value (Btu/h·ft²·°F): CIBSE U-value 0.0663 Btu/h·ft²·°F; EN-ISO U-value 0.0656 Btu/h·ft²·°F

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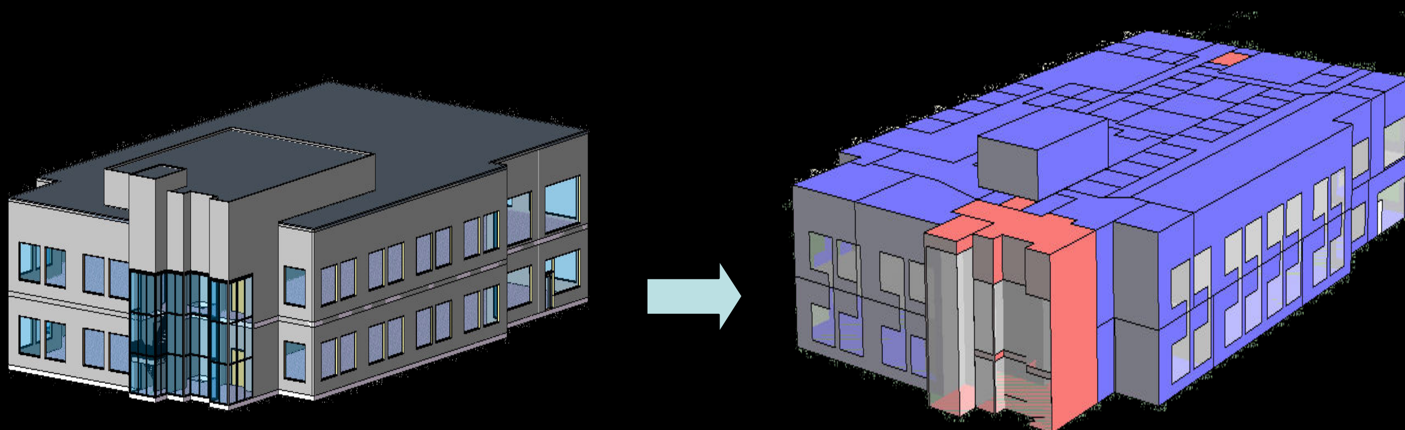
Step 4 – Energy Simulation (IES)

- Import as much data from Revit model as possible into VE Integrated Environmental Solutions using gbXML



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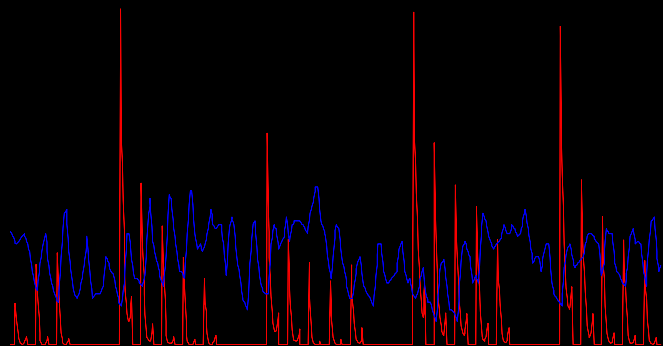
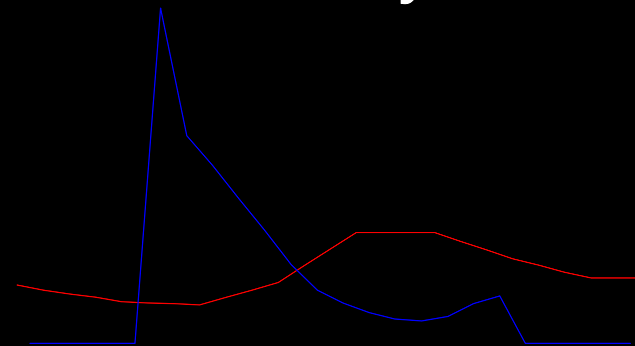
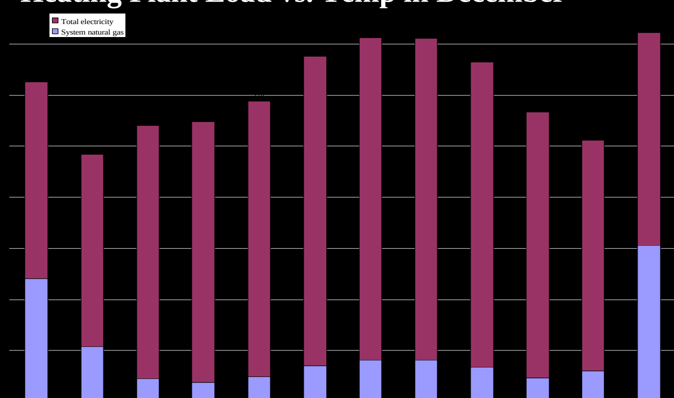
STEP 5 – Results – Thermal Analysis



Heating Plant Load vs. Temp in December



Peak day Heating Plant Load vs. Temp



Energy Consumption by Fuel

(lb of CO_2)	Nat gas	Elec.	Total
Jan	6,038	6,082	12,120
Feb	2,721	6,246	8,967
Mar	1,127	10,633	11,760
Apr	929	12,177	13,106
May	1,231	14,421	15,652
Jun	1,751	17,372	19,123
Jul	2,034	18,761	20,795
Aug	2,040	18,641	20,681
Sep	1,700	16,872	18,572
Oct	1,176	13,446	14,622
Nov	1,517	8,922	10,439
Dec	7,664	6,338	14,003
Total	**29,930**	**149,910**	**179,840**

Carbon Emission by Fuel

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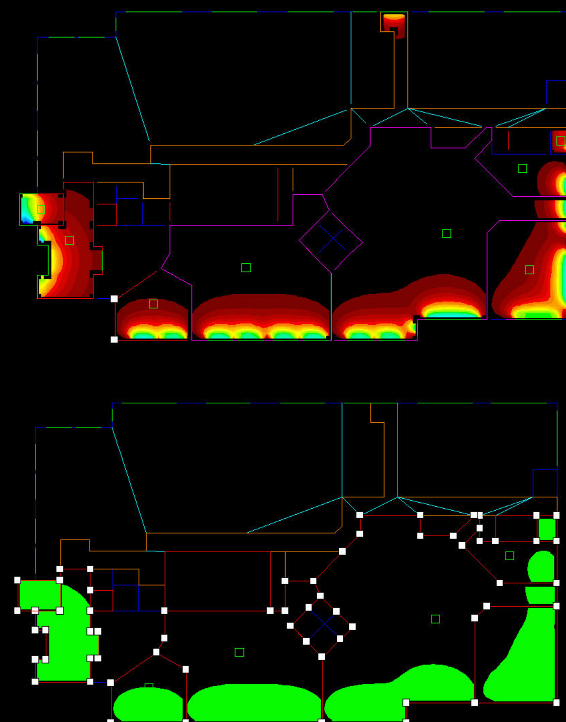
STEP 5 – Results – Daylight Analysis

LEED NC 2.2 Credit 8.1

Room Name	Floor Area	Area Above Threshold	Percentage
Conference	706	377	53%
Kitchen	545	147	27%
Lobby	85	81	95%
Training	1,290	823	64%
Lobby	833	352	42%
Stair	216	136	63%
Open Office	4,830	1,015	21%
Open Office	2,701	794	29%
Total	**11,206**	**3,725**	**33%**



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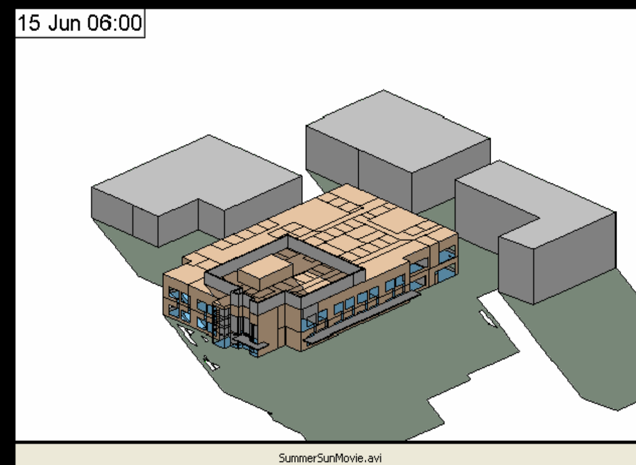
STEP 5 – Results – Solar Shading

- Without shading 48.17% results achieved
- With shading devices 67.12% was achieved

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			

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			



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Lessons Learned

- At times it may be easier to model geometry in IES
- Little to no information transferred from BIM model with the exception of geometry
- IES is very particular with advanced features
- gbXML was difficult to work with

Software

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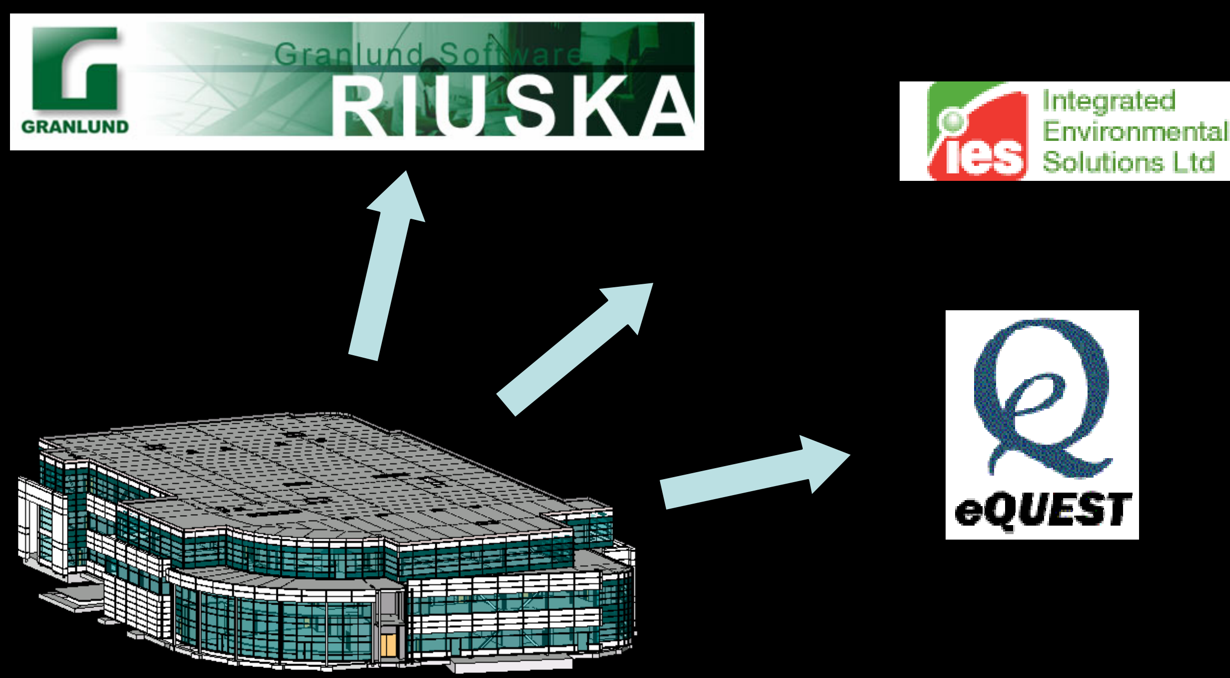
Software - BIM Compatible



NOTE: There are many other software; these are the ones DPR has worked with

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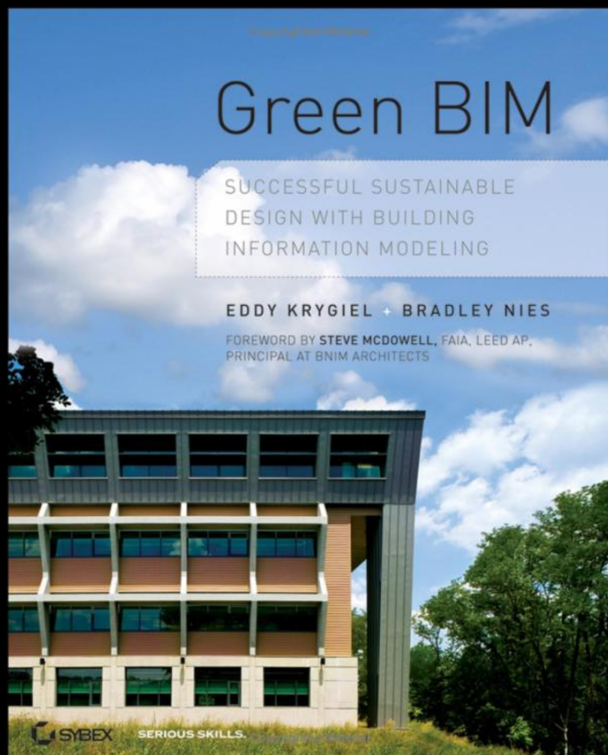
Recommended Reading



- Building Information Modeling
- Integrated Teams
- BIM – Concept -> Building
- Water Harvesting
- Energy Modeling
- Renewable Energy
- Sustainable Materials

BIM for Energy Analysis and Modeling

May 22, 2008 By Christopher Rippingham

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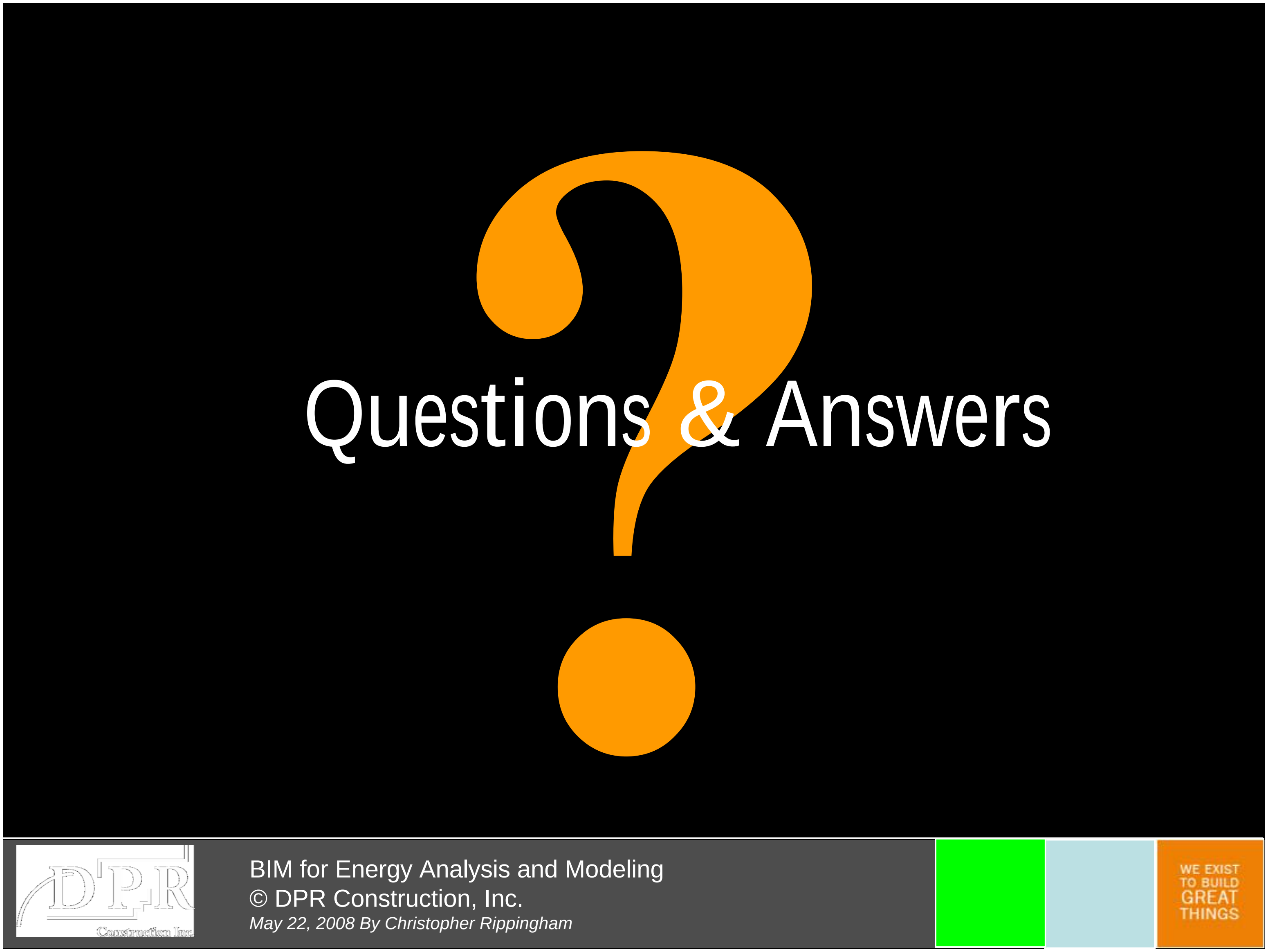
Questions & Answers
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