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· August 15-18, 2010 · Dallas, Texas ·
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Energy Modeling: Does it Work?

TRADITIONAL versus BIM

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Raj Setty, P.E., CxA, LEED AP, Principal-in-Charge

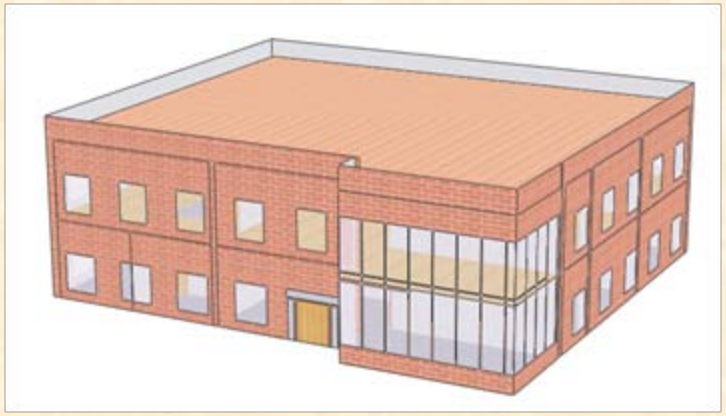
- *18+ Years Experience*
- *Developed 100's of Energy Budget Target Data and Computer Simulations using DOE-2.1E, Visual DOE, eQUEST, and NIST Projects*
- *Presented at ASHRAE Winter Meeting in Orlando, Florida 2010 on BIM and Commissioning*

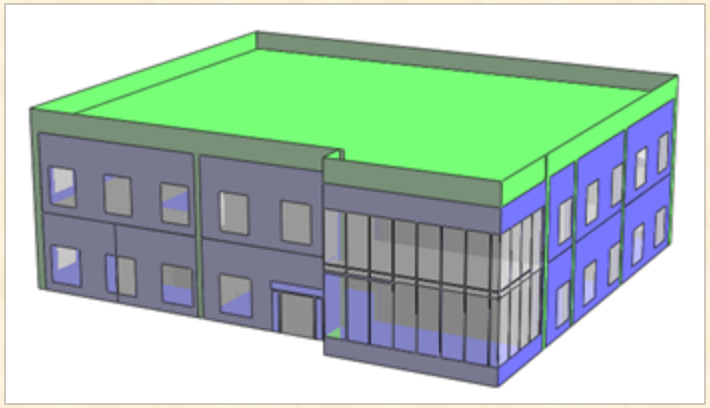
Presentation Overview

- Traditional Energy Modeling Defined
- History of Energy Modeling
- Energy Modeling Programs
- Modeling Intent
- Traditional – Example
- Other Modeling Features
- Towards BIM
- Modeling through BIM
- General High-Level Issues

Traditional Energy Modeling Defined

- Building a Computer Model to Analyze Buildings' Energy Related Features
- Final Goal: Guide Architects, Engineers, Developers, and Consumers Towards More-Energy-Efficient Buildings
- Energy Model Helps Show How Some of the Important Design Decisions Impact Building Energy Performance.
- Early Considerations of These Issues is One of the Keys to Achieve More Efficient Buildings





History of Energy Modeling

- Over the Past 50 Years, Literally Dozens of Building Energy Programs have been Developed, Enhanced and are In Use:
  - Text-Based Inputs
  - Graphical Interface
  - BIM
- Core Tools in the Building Energy Field are the Whole-Building Energy Simulation Programs
- Energy Policy Act of 2005 [10 CFR Part 433] Requires New Federal Buildings to Meet a Target of at least 30% Energy Savings (Over 90.1. 2004 Appendix G), if Cost-Effective

  http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&tpl=/ecfrbrowse/Title10/10cfr433_main_02.tpl

Energy Modeling Programs

http://apps1.eere.energy.gov/buildings/tools_directory/alpha_list.cfm

- DOE-2.1 (Recognized as the Industry Standard)
- ENERGY-10
- EnergyPlus
- eQUEST/DOE-2.2 (the Most Popular in the U.S.)
- ESP-r
- HAP
- IES <VE>
- TRACE 700
- TRNSYS

Modeling Intent
How it Works Behind the Scene

Generally 8,760 Iterations of Calculations are used to Simulate the Performance of All Energy Flows in a Building:

- Building Loads
  - Solar Gains & Heat Conduction through Envelope
  - Infiltration
  - Heat from People, Lights and Internal Equipment
  - Interaction Building - Climate
- HVAC Systems
  - Simulates Interaction of Equipment with Loads
- Plant
  - Primary Equipment (Chillers, Boilers, Cooling Towers)
- Economics
  - Utility Rate Structures
  - Life Cycle Analysis

Modeling Intent
How it Works Behind the Scene

Month	Day	Hour	Building cool load from wall conduction	Building cool load from roof conduction	Building cool load from window conduction	Building cool load from solar radiation through windows	Building cool sensible infiltration load	Building light cool load	Building elec equip cool load (sensible)	Building people cool load (sensible)	Building people cool load (latent)	Building elec total	Building equip elec total	Building light elec total
7	9	7	2289	1877	13649	30333	2706	31022	4598	7600	6712	61110	7950	53160
7	9	8	4213	1922	25886	55247	2462	33221	4837	8470	7708	65094	8259	56835
7	9	9	6828	2290	31821	64362	2938	34043	4906	8807	7962	66643	8361	58282
7	9	10	9194	2977	38302	64933	3986	35142	5015	9267	8426	68241	8484	59757
7	9	11	11208	3878	40301	62073	3984	36259	5125	9737	8890	70271	8629	61642

EXAMPLE: Sensible Infiltration Load Calculation

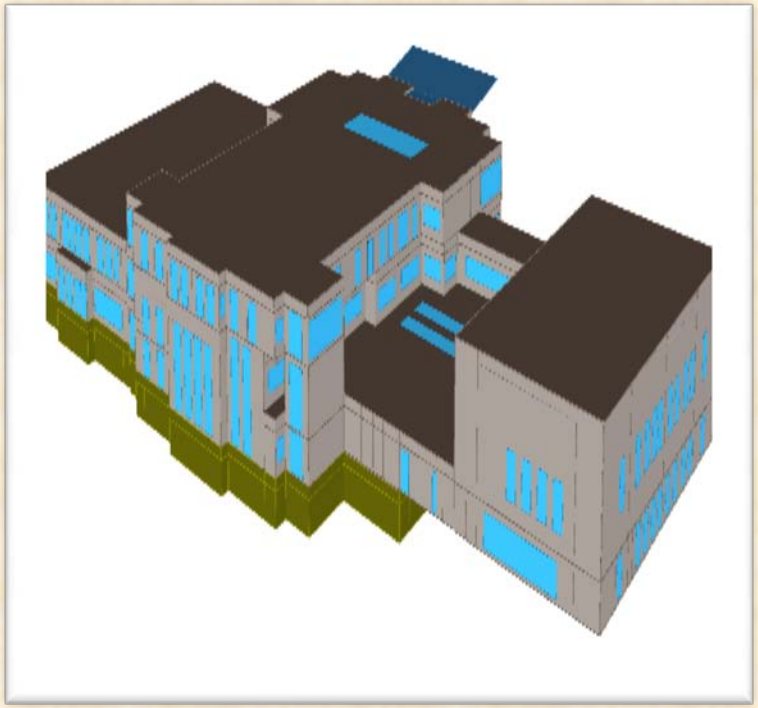
$$Q = 1.10 \times CFM \times \Delta T \quad \text{(Btu)}$$

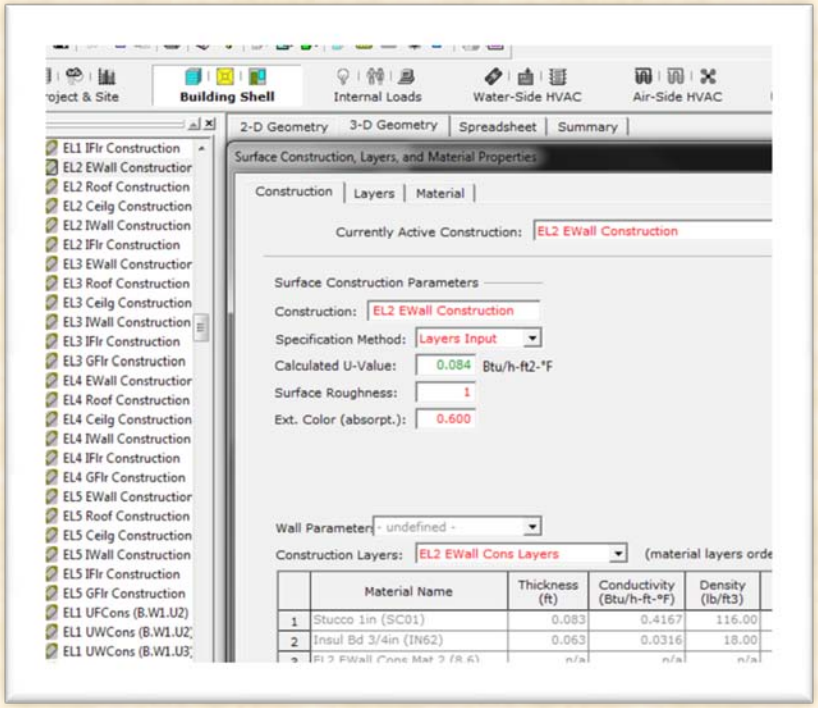
where:

- CFM: total infiltration for the hour (cfm)
- ΔT: inside-outside air temperature difference (°F)

Traditional Modeling Example

- Pros:
  - Easy to Use
  - Uses DOE-2 Simulation Engine (the Industry Standard)
  - Available Free of Charge Online - Easily Reviewed by Engineers, Owners, and Other Consultants

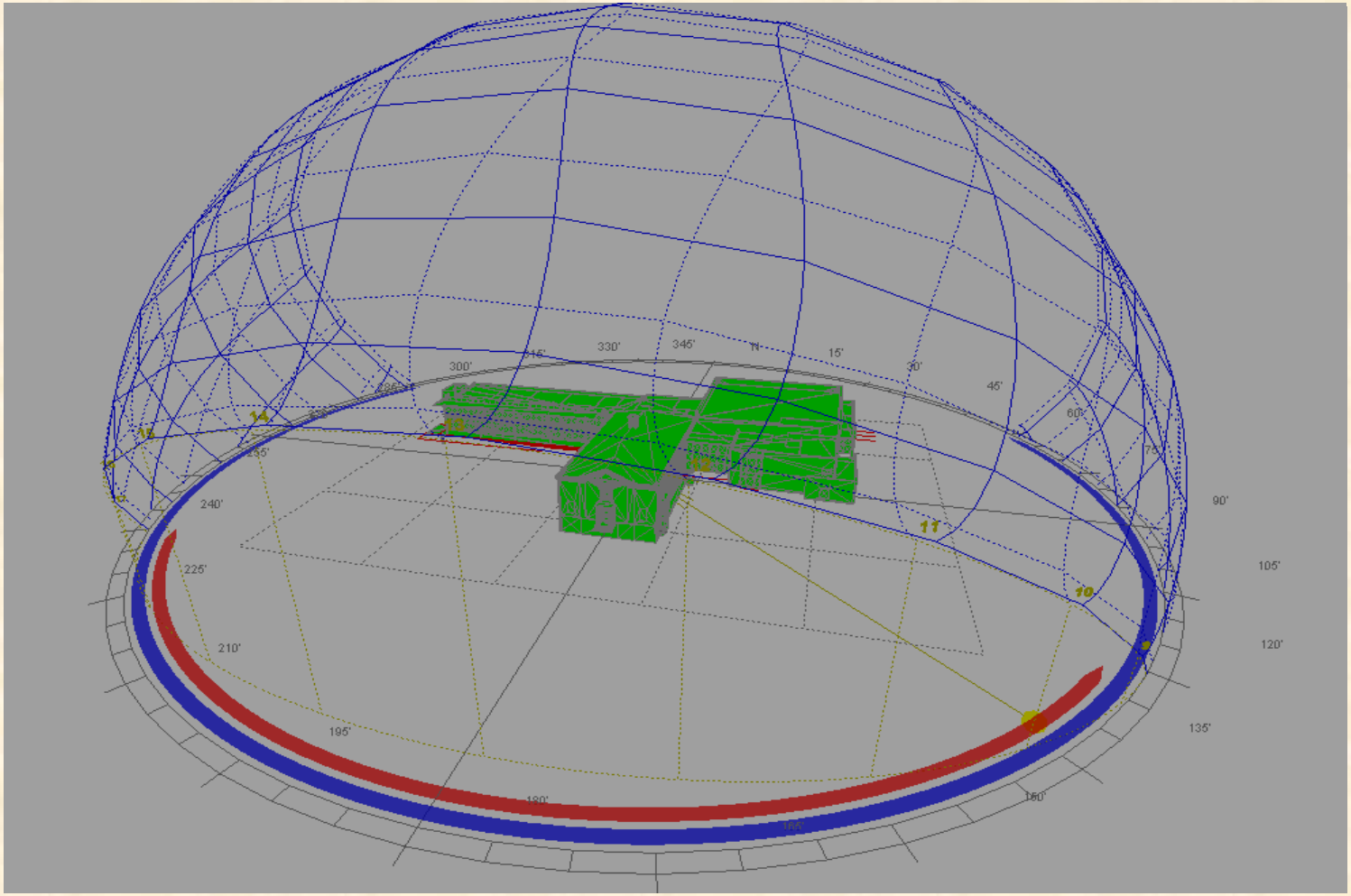




Traditional Modeling Example

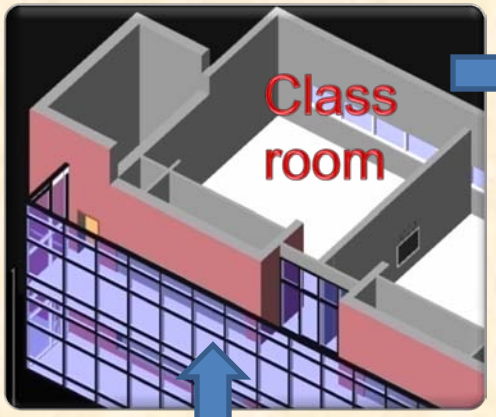
- Cons:
  - Does not Model Airflow Patterns Within Zones
  - Displacement Ventilation Cannot Really be Modeled
  - Some New Systems Cannot Be Modeled Explicitly:
    - Radiant Systems
    - UFAD
    - Variable Refrigerant Volume
  - Building Geometry Model can be Very Time Consuming
  - Daylight Analysis, Natural Ventilation Cannot be Performed
  - No Air Stratification
  - No Radiant Cooling System (Modeled Through Work-around)
  - One HVAC System Per Zone
- Some hidden capabilities are recognizable by more experienced users

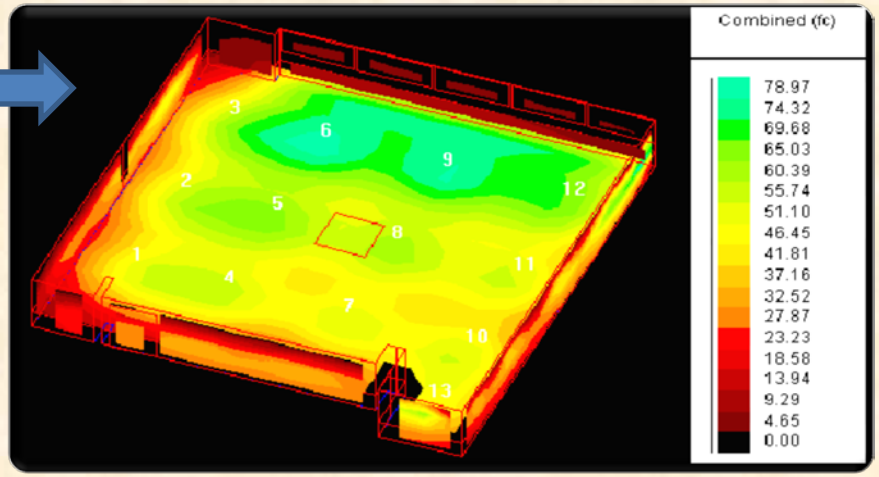
Other Modeling Features



Sun Track and Shading – Winter

Other Modeling Features





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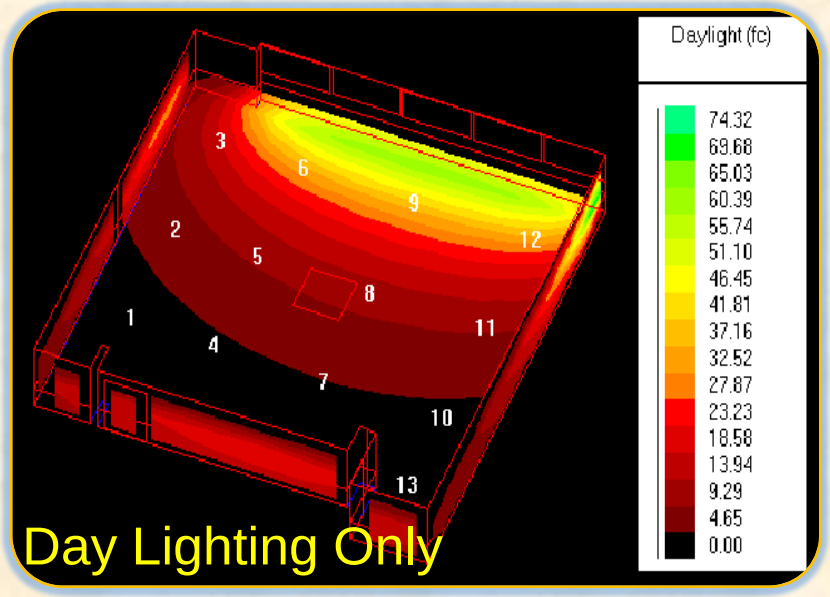
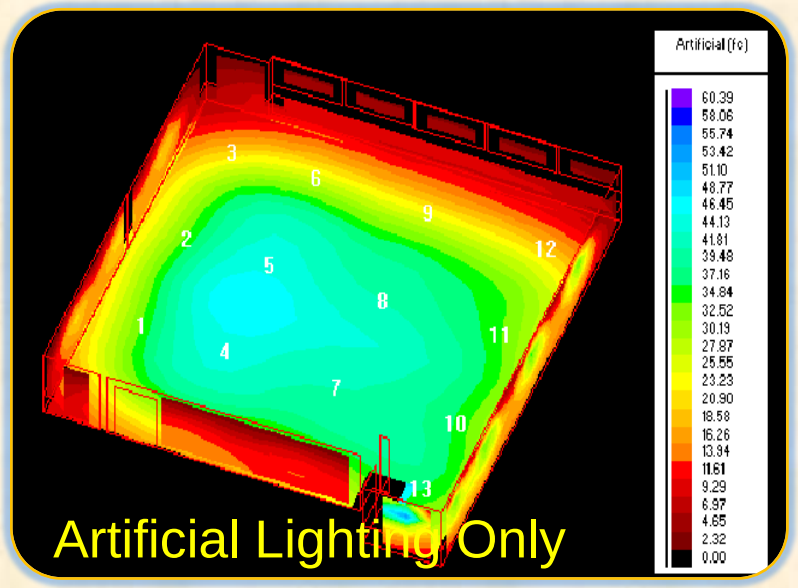
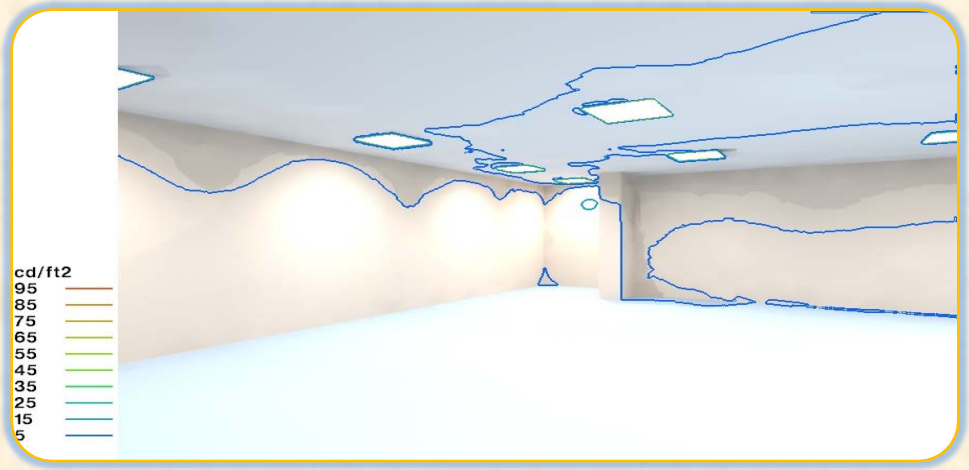
Other Modeling Features

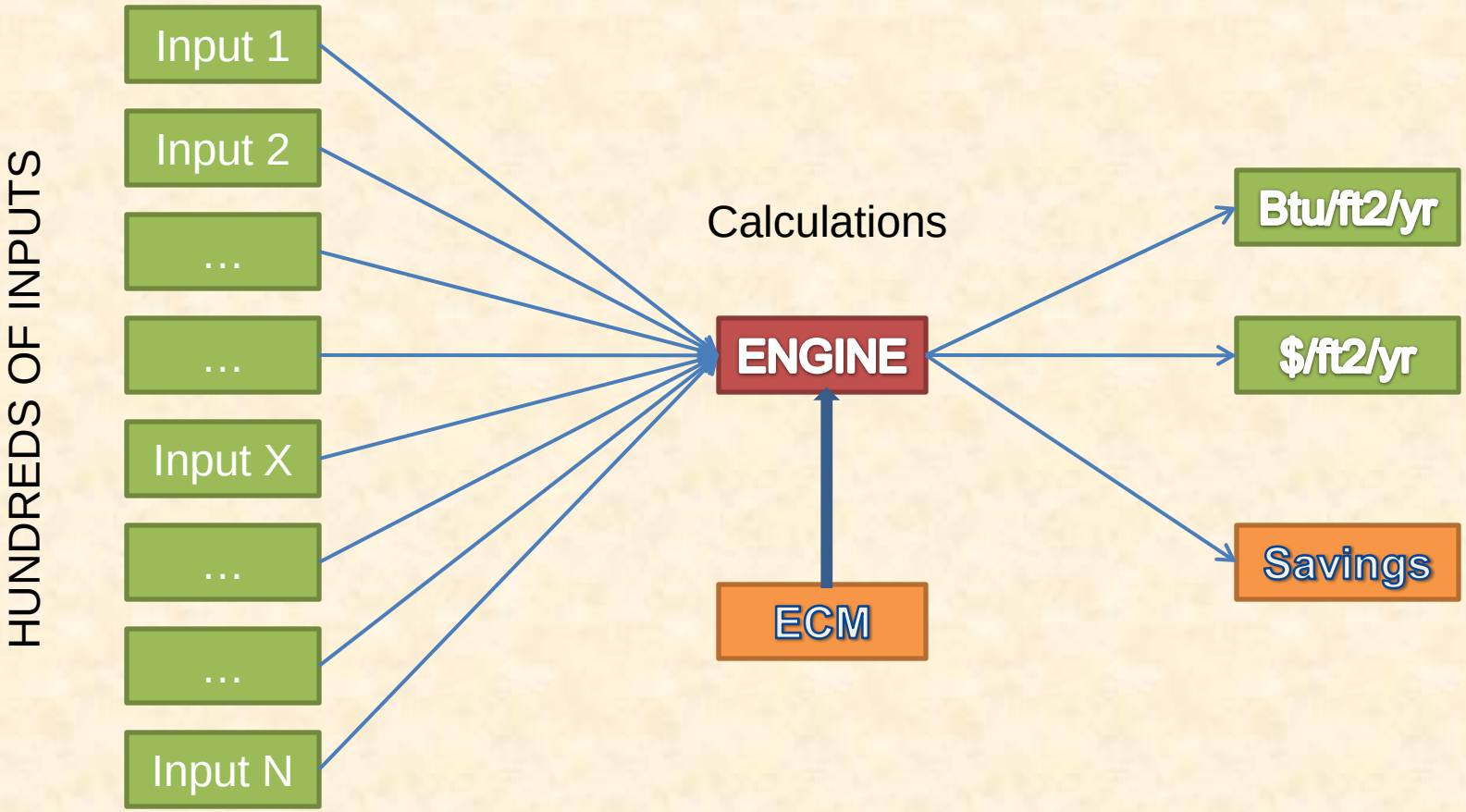






Illuminance Contour Level

Traditional Modeling



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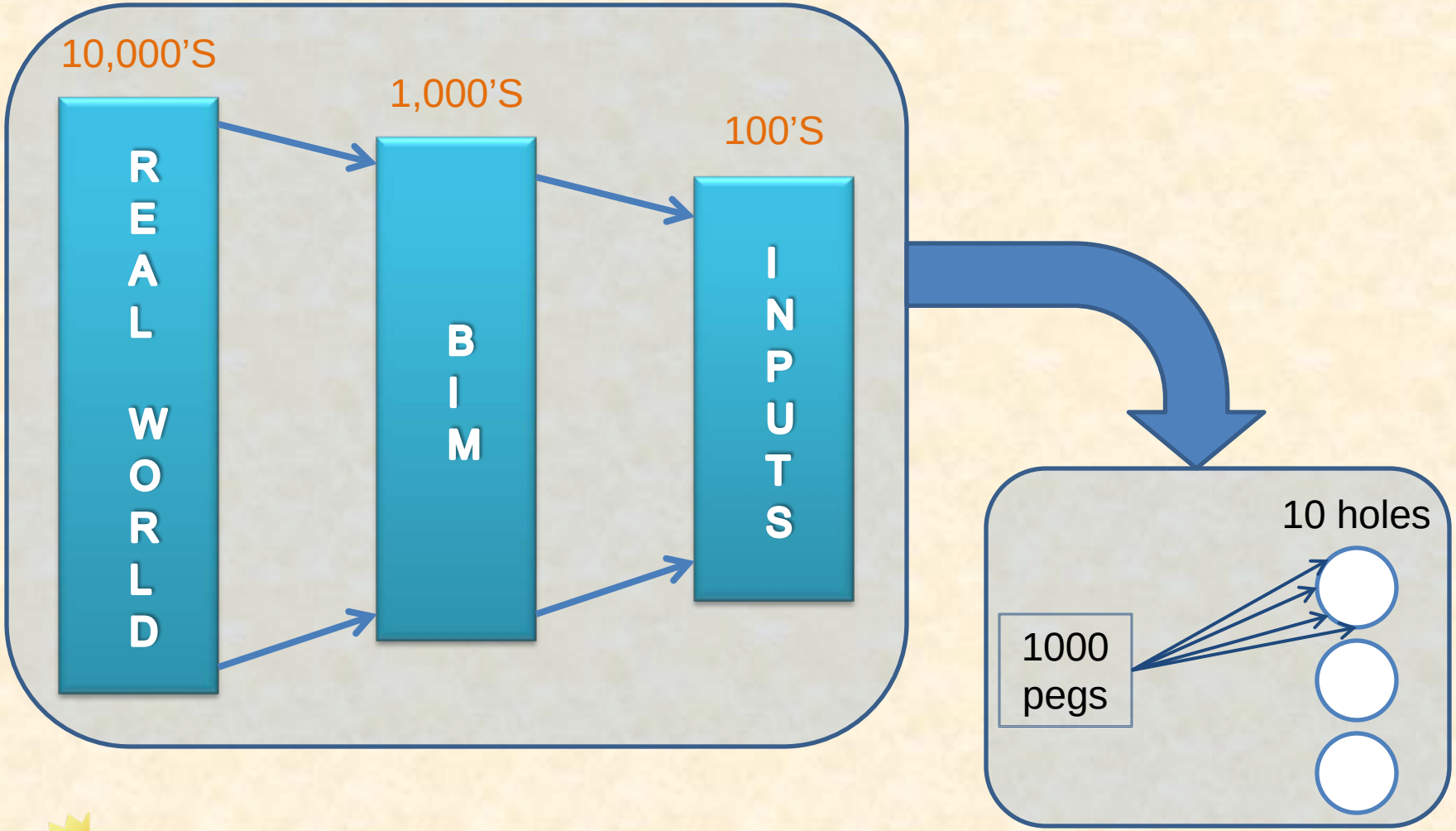
Towards BIM



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Modeling through BIM
Where We Are Today

- Issues with Load Calculations

DC Engine Company #22

	Cooling		Heating	
	MBH (Tons)	Delta vs. BIM	MBH	Delta vs. BIM
BIM	638.6 (54 tons)	-	895.2	-
Load Software	669.3 (56 Tons)	30.7 MBH (2 Tons)	477.3	417.9 MBH

Modeling through BIM
Where We Are Today

- Limited Modeling Capabilities Inside BIM Tool (Few of the Inputs Required for Energy Analysis are Included in the BIM Model)
- Detailed Modeling Requires Transfer of Data to Conventional Energy Analysis Tools like DOE-2: Example, thru gbXML
  - Complicated Process since BIM Models Contain Unnecessary Info
  - Material Properties may be Inputted in BIM Model, but cannot be Exported
  - Absence of Two-way Capabilities (Changes Made in gbXML cannot be re-exported back to the BIM Model)
  - Limitations in the Handling of Zones from the Host Energy Model Program are not Well Handled
  - Unconditioned Plenum Spaces are Difficult to Export as such

Modeling through BIM
Where We Are Today

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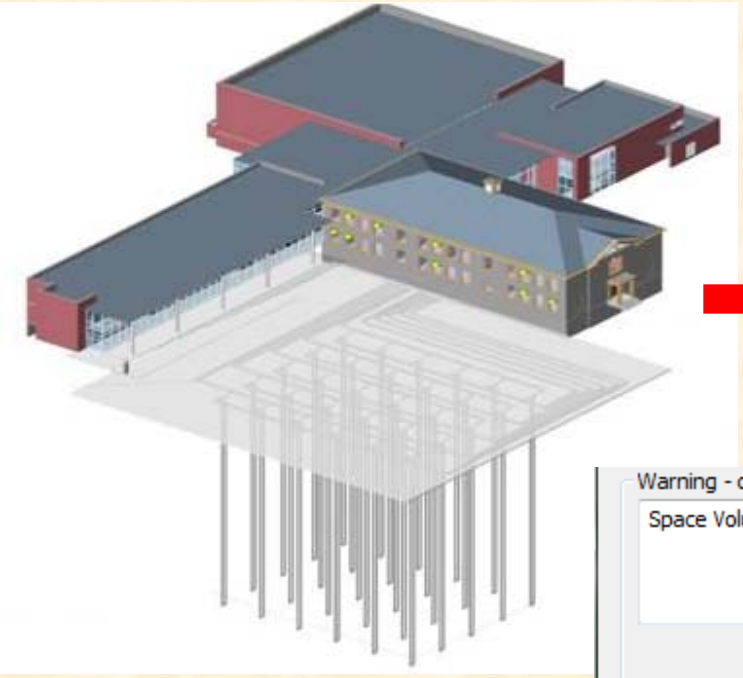

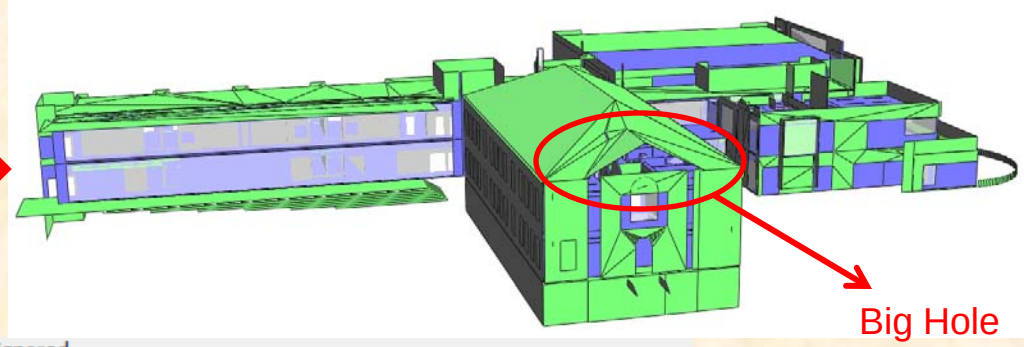

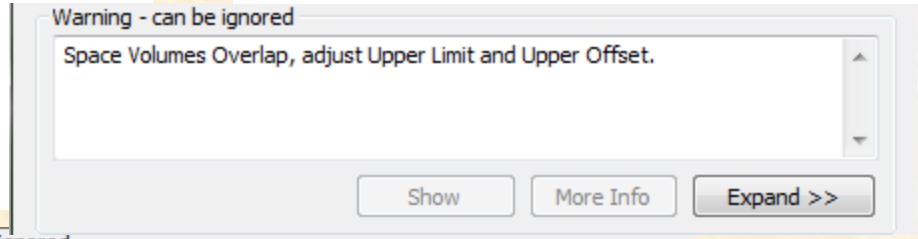

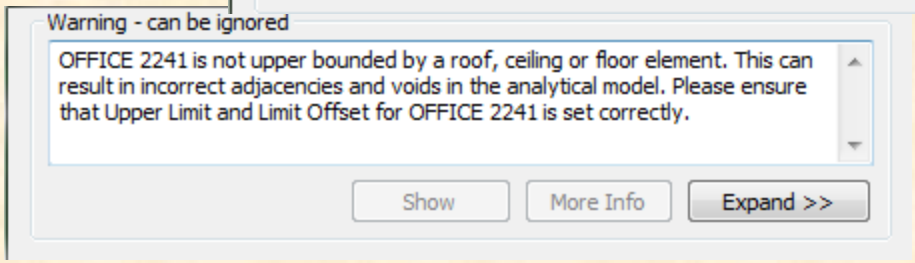

Modeling through BIM
Where We Are Today

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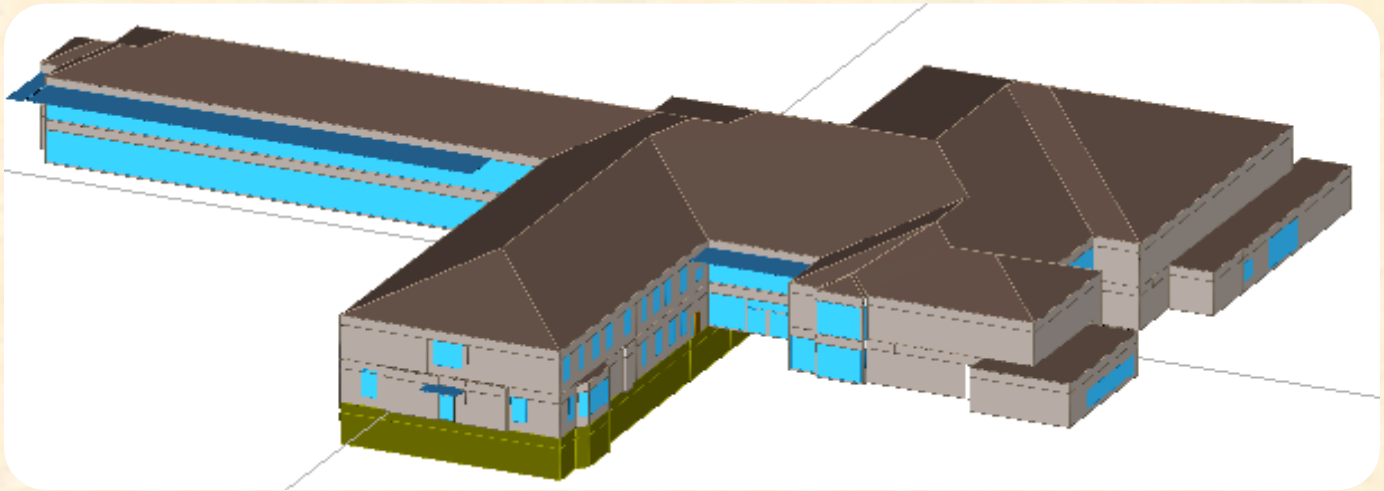

- Proposed Design Achieved 30.5 % Cost Savings
- Per LEED for Schools: 7 Points under EA Credit 1
- Design Measures Included in the Proposed Design:
  - DOAS VAV Unit for OA
  - Ground Source Heat Pumps

Modeling through BIM
Where We Are Today

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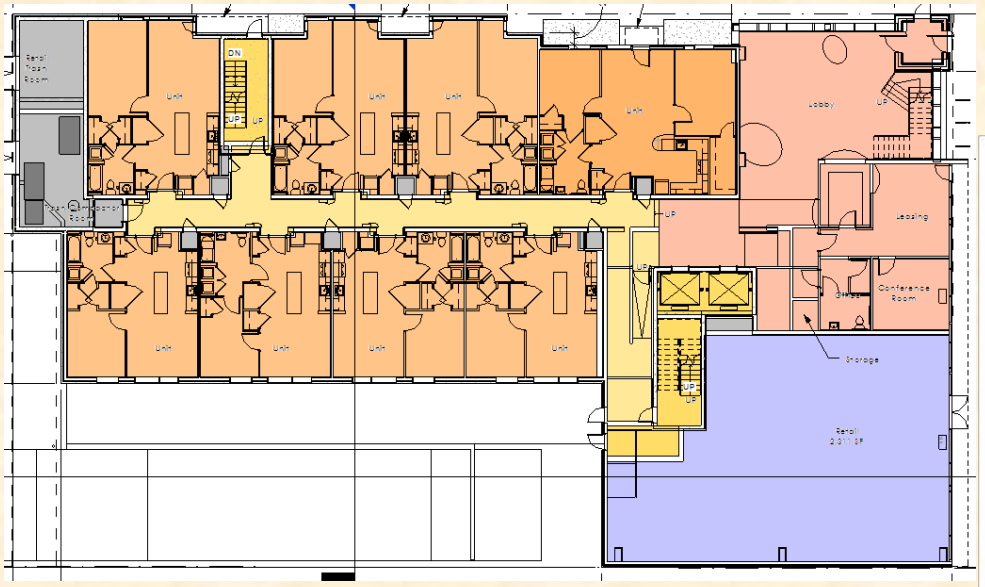
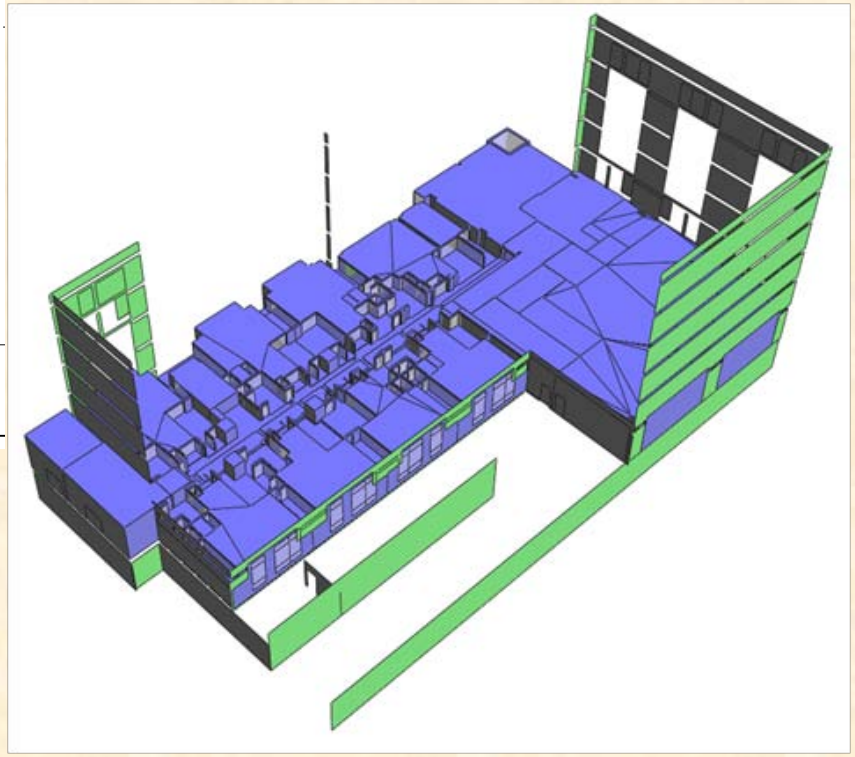


No Error in BIM Software!



- Try Export with Spaces Automatically Created
- In Modeling Program, Holes Showing where Ceilings Expected

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Modeling through BIM
Where We Are Today

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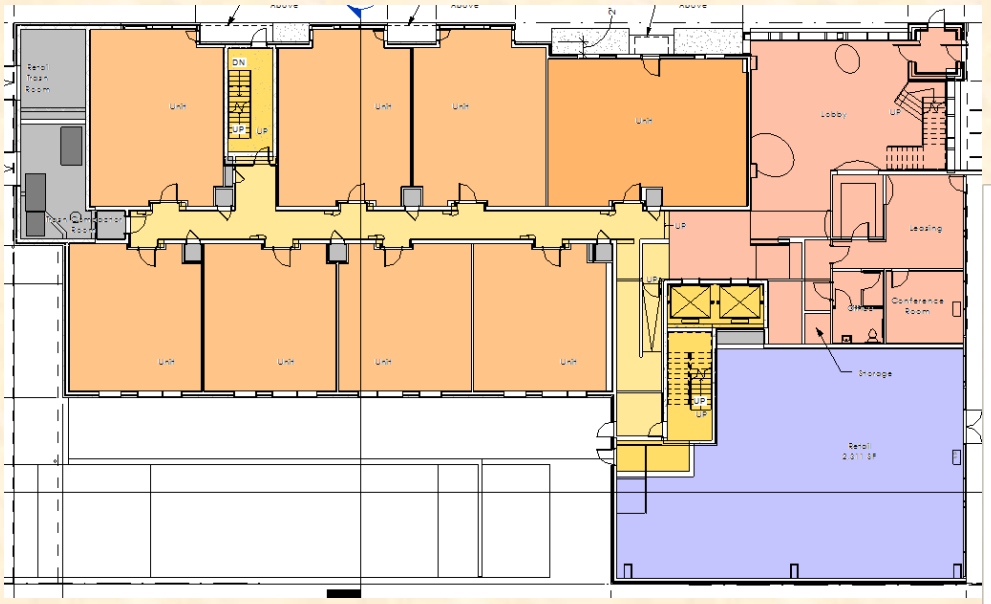

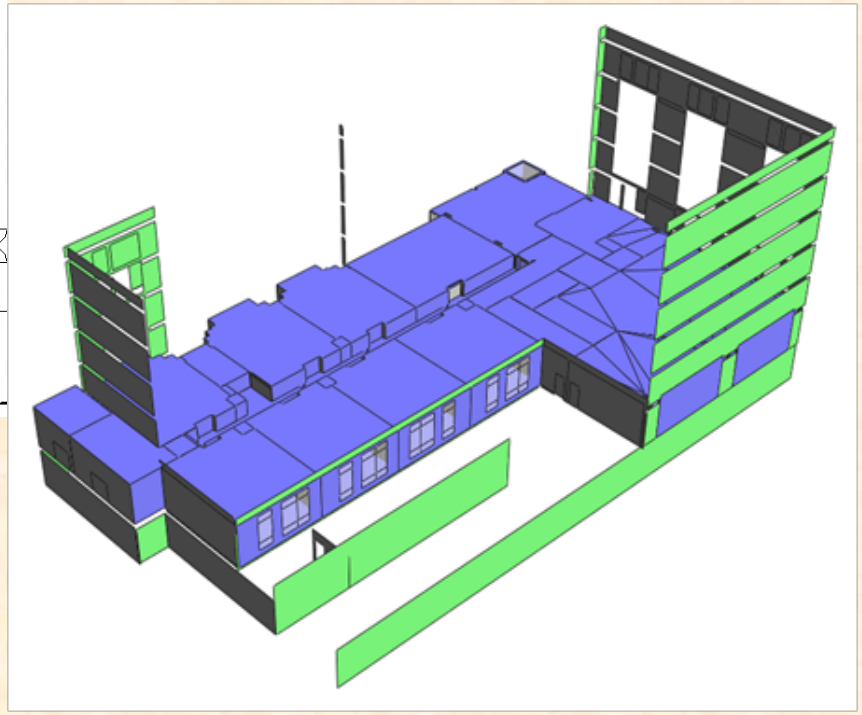

- Deleted Internal Partitions in Apartments in BIM Software
- Better Results
- BIM Model Must Be “Cleaned” (TIME)

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General High-Level Issues

- Software Revisions Occurring Faster than Users Understanding of a Program's Capabilities
- Software Revisions Occurring Slower than Advances in New Building Technologies
- Unknown Energy Data. Arises from Multiple Reasons:
  - Energy Efficiency Websites Having Target Audience of Consumers and not Energy Modeling Professionals
  - Design Engineers Sizing Equipment to Peak Demand and Seldom Considering Yearly Energy Use
  - Conflicting Information Being Abundant Even Among Modeling Advise Sources
  - Possible Solution: The Building Simulation Community Gathering Information and Evaluating it on a Wikipedia Type Forum

Conclusion

- Energy Performance Simulation Tools mostly used During Design, but Use during Commissioning and Operations Phase has Additional Value:
  - Data Exchange to Become More Applicable and Usable in Other Phases of a Building's Life-cycle, not only in the Design Phase
- Issues with Modeling through BIM:
  - e.g. Transfer of Building Info through gbXML
- No Real Dichotomy Right Now between Traditional and BIM:
  - BIM Presently Relies on Traditional for Energy Modeling

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