Modeling High Performance Schools

Rebuild America

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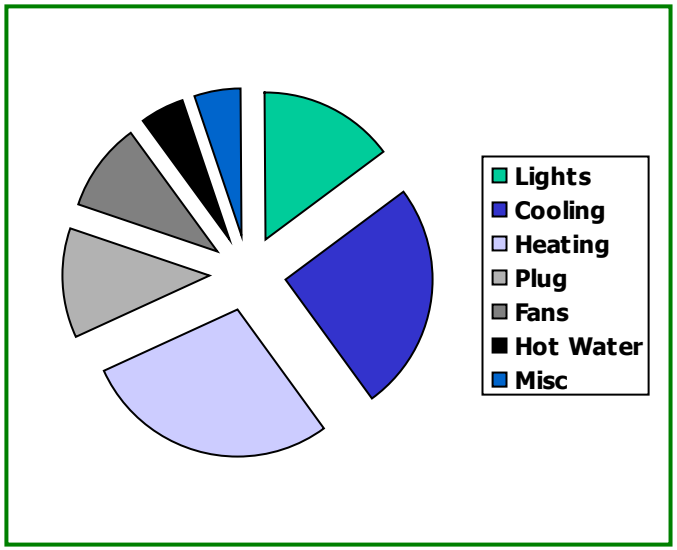
EMO Energy Solutions, LLC

What is Energy Modeling?

- Tool for smart, energy efficient design
- Predicts energy consumption of building every hour of typical (TMY) year
- Uses basic engineering/heat flow/power equations
  - Conduction through walls/roof
  - Solar gain through windows
  - Calculation of all internal heat gains
  - Thermal mass/time lag

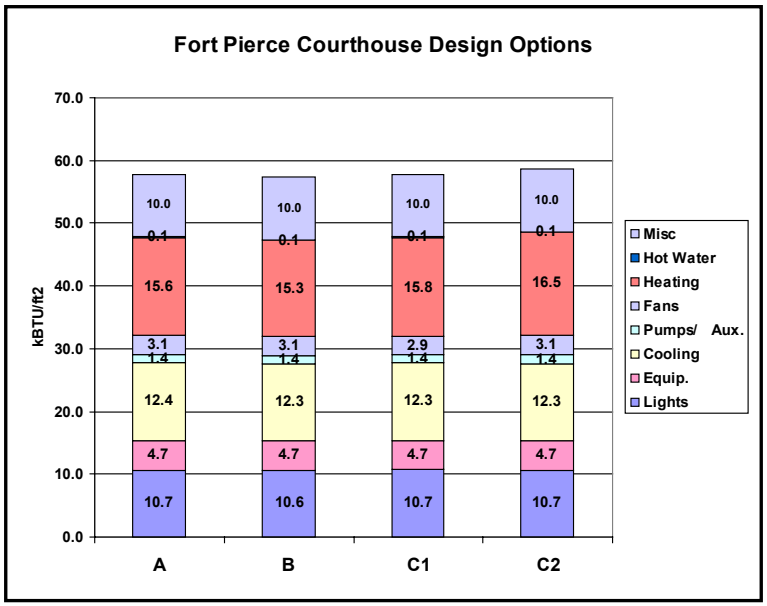
Benefits of Modeling

- Benchmark building
- Quantify Energy Breakdown
- Accurately model ECMs
- Model different rate structures
- Assess impact of changes in equipment and operations



How to use modeling as a tool

- Pre-design analysis*
- Model initial design
- Develop design recommendations
- Model potentially cost effective alternatives
- Model final design
- Model ASHRAE basecase for LEED projects to determine E&A points*

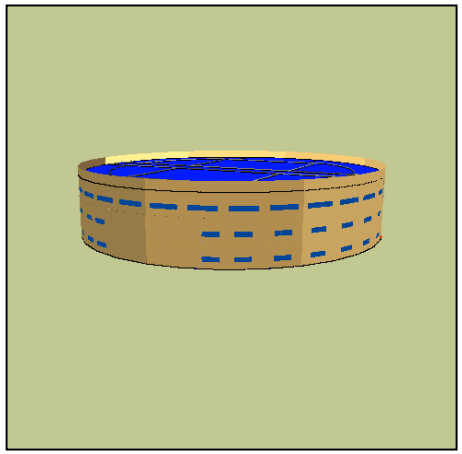


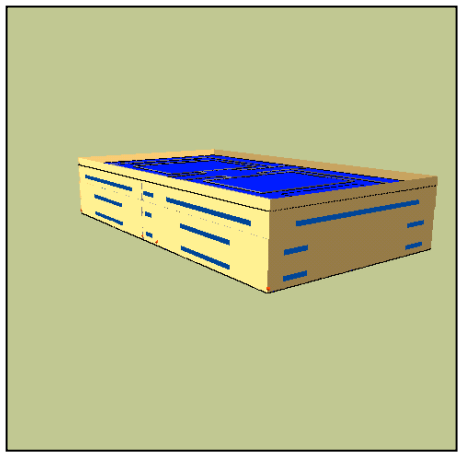
** Optional*

How to use modeling as a tool

Predesign analysis

- Orientation
- Basic shape
- Windows
- Aspect ratio

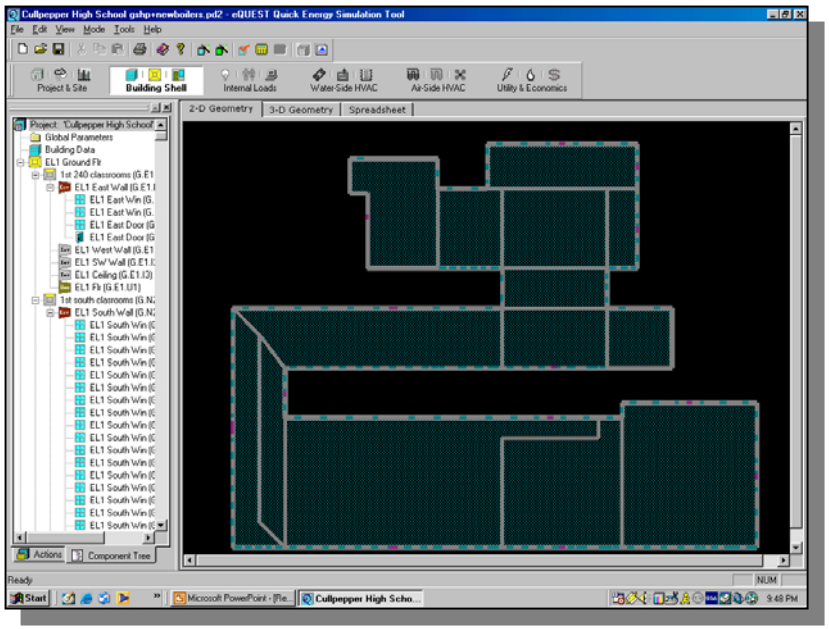




How to use modeling as a tool

Model initial design

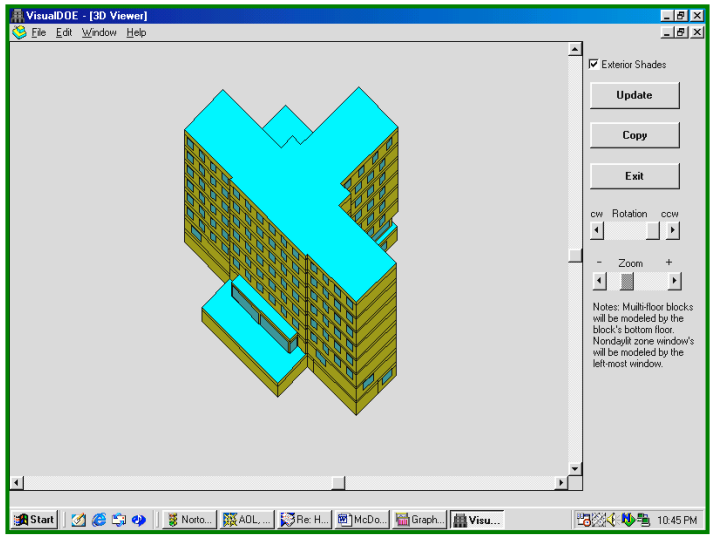
- Floor plans
- Building envelope
- System type
- Many assumptions
  - LPD/EPD
  - Schedules
  - Equipment efficiencies



How to use modeling as a tool

Develop design recommendations

- Lighting
- Windows
- Building envelope
- Equipment
- Distribution systems



How to use modeling as a tool

Model potentially cost effective alternatives

- Different levels of insulation
- Lighting upgrades
- Ground source heat pumps
- Variable speed drives
- Economizer control
  - Etc…

How to use modeling as a tool

Model final design

- Final HVAC zoning
- Actual envelope/window characteristics
- Actual lighting layouts per zone
- Actual equipment efficiencies
- Proposed schedules
- Proposed control strategies

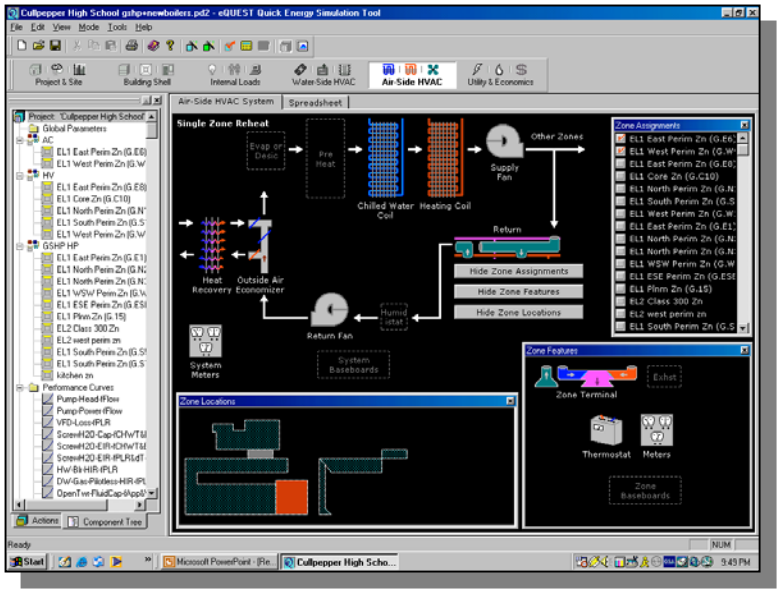
How to use modeling as a tool

Model Basecase

- **Design based on standard practices/requirements for purpose of comparison**
- **LEED – basecase based on ASHRAE 90.1 minimum requirements for comparison**
  - Leadership in Energy and Environmental Design (LEED) program sponsored by USGBC
  - Modeled energy consumption 20% - 60% less than ASHRAE 90.1 basecase: 2 - 10 points

Modeling process

- Create floorplans and elevations
- Input envelope characteristics/window layout
- Create HVAC system types/zones
- Insert LPD/EPD into each zone
- Input equipment types/efficiencies
- Input schedules

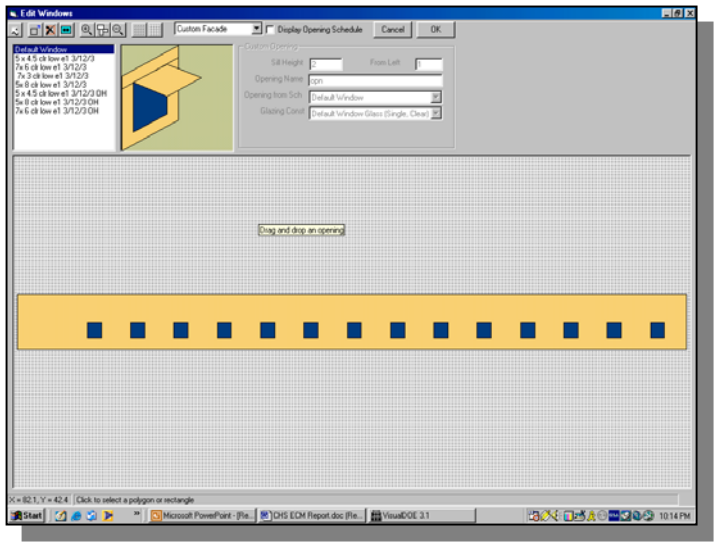


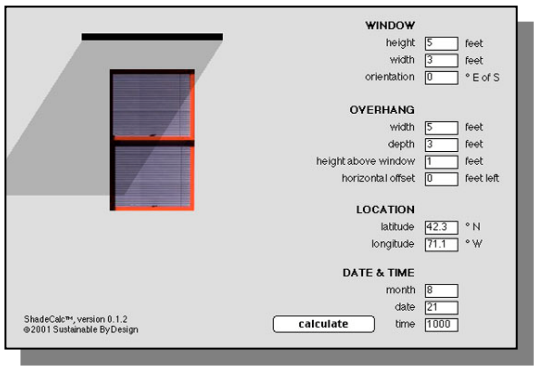
Modeling issues

- **Zoning and floor plan is very important – difficult to change zoning after model completed**
- **Different programs have limitations**
  - More assumptions/defaults, less accuracy
  - More user inputs, more accuracy
- **All programs have some limitations**

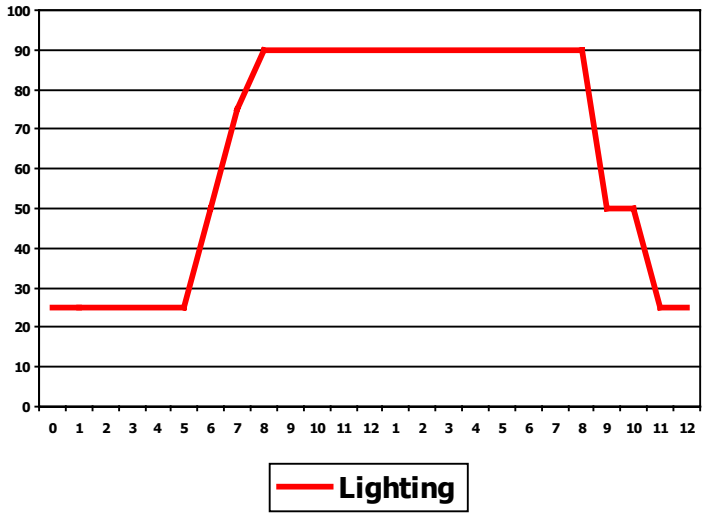
Model energy impact of exterior features

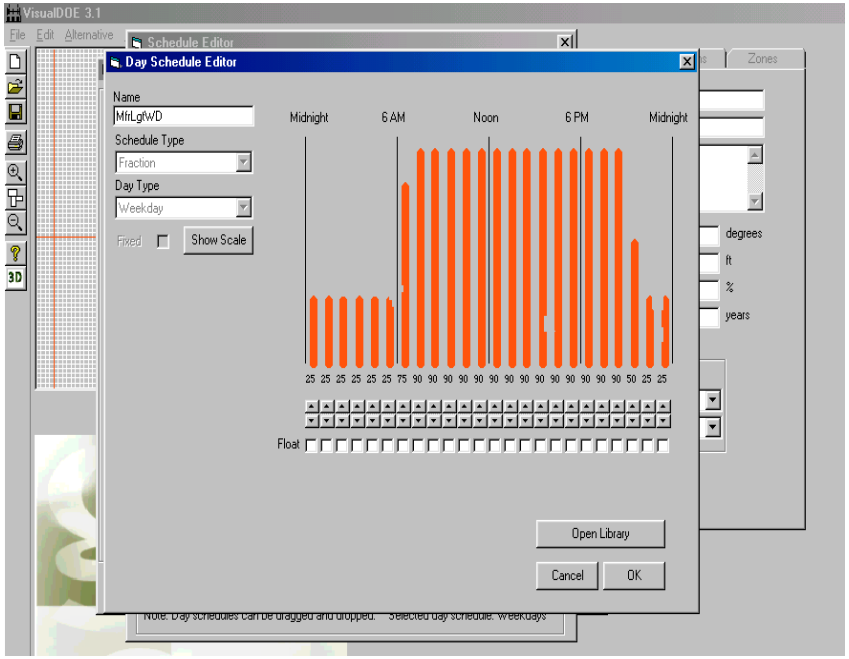
- Window overhangs
- Recessed windows
- Skylights
- fins





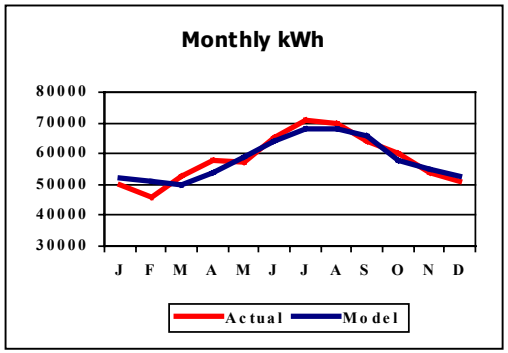
Creating schedules in the model

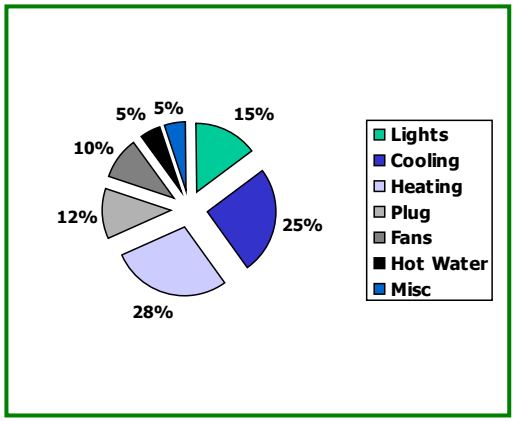




Run the simulation

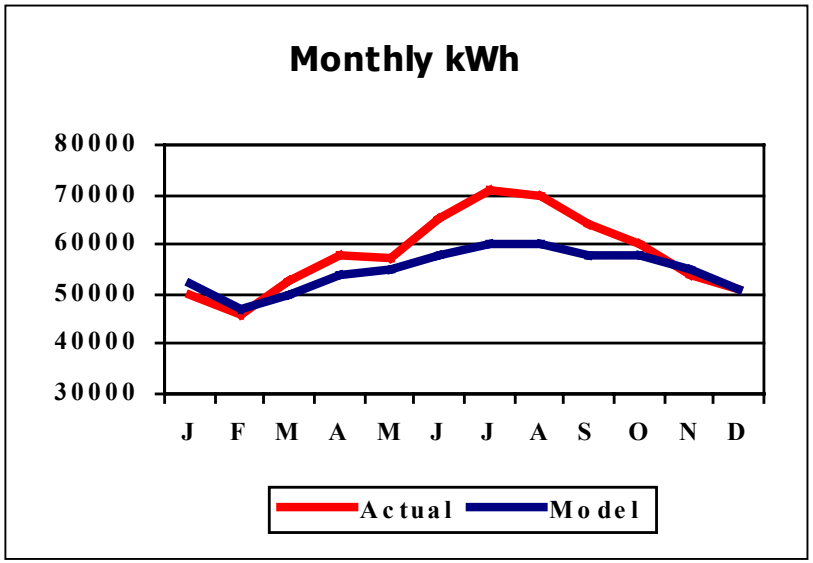
- Estimates energy consumption for every hour of the year
- Monthly summaries
- Peak loads
- End-use breakdown

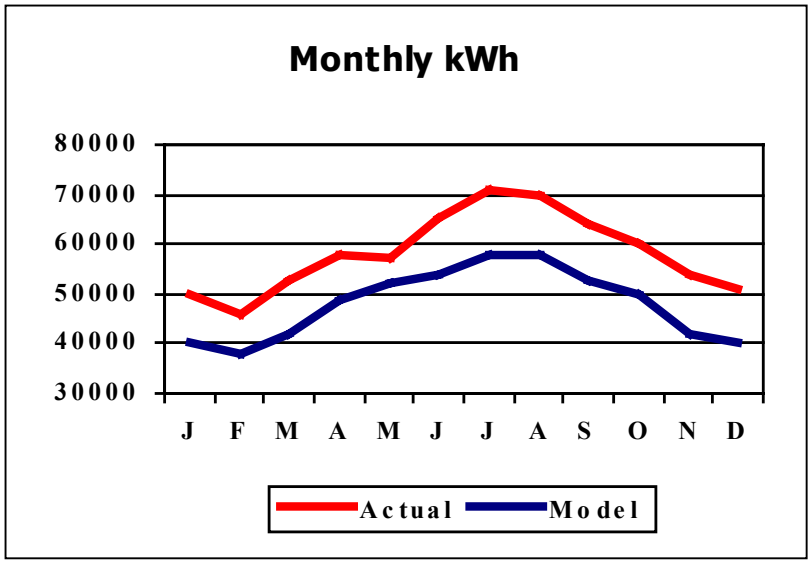




Calibrate to utility bills

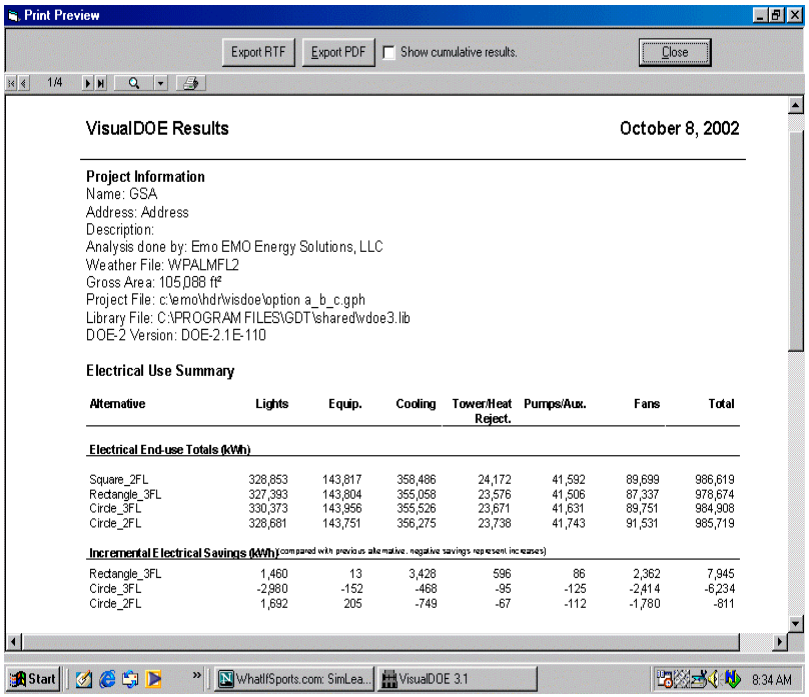
- Change input assumptions
  - Seasonal impact
  - Continuous consumption





Run Alternate Simulations

- Change parameters to simulate ECMs
- Accounts for integrated effects of upgrades
  - Cooling impact of lighting upgrades
  - Classroom/gymnasium daylighting can be controlled by fc level
  - Run alternate with all ECMs, avoid guessing diversity factors



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VisualDOE Results October 8, 2002

Project Information
Name: GSA
Address: Address
Description:
Analysis done by: Emo EMO Energy Solutions, LLC
Weather File: WPALMFL2
Gross Area: 105,088 ft²
Project File: c:\emo\hdr\visdoe\option a_b_c.gph
Library File: C:\PROGRAM FILES\GDT\shared\wdoe3.lib
DOE-2 Version: DOE-2.1E-110

Electrical Use Summary

Alternative	Lights	Equip.	Cooling	Tower/Heat Reject.	Pumps/Aux.	Fans	Total
Electrical End-use Totals (kWh)							
Square_2FL	328,853	143,817	358,486	24,172	41,592	89,699	986,619
Rectangle_3FL	327,393	143,804	355,058	23,576	41,506	87,337	978,674
Circle_3FL	330,373	143,956	355,526	23,671	41,631	89,751	984,908
Circle_2FL	328,681	143,751	356,275	23,738	41,743	91,531	985,719
Incremental Electrical Savings (kWh) (compared with previous alternative. negative savings represent increases)							
Rectangle_3FL	1,460	13	3,428	596	86	2,362	7,945
Circle_3FL	-2,980	-152	-468	-95	-125	-2,414	-6,234
Circle_2FL	1,692	205	-749	-67	-112	-1,780	-811

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Example:
Compare insulation levels

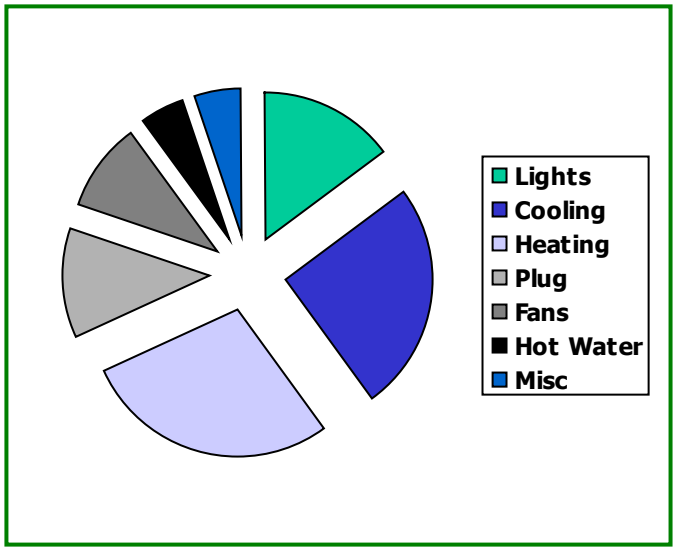
Masonry w/wood framing	**"Design Wall"**	**"Design option"**
Outside layer	4" brick	4" brick
1st layer	1"Air gap/furring	1"Air gap/furring
2nd layer	8" CMU	8" CMU
3rd layer	**R-13 polyiso insulation**	**R-19 polyiso insulation**
Inside layer	Gypsum board	Gypsum board

Energy consumption	**"Design Wall"**	**"Design option"**
Electric	1,843,350 kWh	1,775,908 kWh
Natural gas	66,444 therms	62,300 therms
costs	$213,045	$204,078

Most successful way to use modeling

- Begin process during pre-design phase
- Model initial concept design with several HVAC system types
- Use model to compare energy efficient alternatives
- Use results to make smart design decisions

Good modeling = good results

- Estimate utility budgets
- Quantify Energy Breakdown
- Make design decisions based on quantifiable energy efficiency analysis
- Choose the best utility rate structure for the school

- Poor modeling = useless or detrimental results