*Quiet Revolution in Energy Savings

*Smart Buildings NJ

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* Smart Buildings NJ, Division of Scientific Air

* Third Generation in HVAC, 2 Electrical Engineers
  * Steam, Oil, Gas, Electric, Heat, AC (electric and absorption)…
  * Office Buildings, Factories, Warehouses, Schools, Churches,…
* Saving energy before it was 'in' or Green.

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Presentation

- Basis of the revolution, enabling technologies
- Energy Use by year of construction
- How they sell you energy, KWH
- How to Save Energy
  - Where are you now?
  - How to get to where you are going
- Free Lunch
  - Comfort levels go up
  - Complaints go down
  - Productivity improved
  - Remote monitoring & diagnostics

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* New Tools and Systems, “As large a change as AC in the 1960’s”
  * Sophisticated Solutions now cost effective under 200k ft. Electronics and network software.
    * VFDs
    * BACnet, (IOT, Internet of Things, M2M)
    * Sensors, Temperature, CO2, Enthalpy
    * LEDs
    * Building Simulation

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* Linear Energy Savings

* ASHRAE codes

Cheat Sheet	Item	90.1-2004	90.1-2007	90.1-2010	189.1-2011	Worst to best
	Heating Efficiency	80%	80%	80%	81%	
Energy Eff Ratio	Cooling Efficiency (EER)	10.3	11.2	11	11.2	9%
Integrated Part Load Value	Cooling IPLV			11.4		
	Economizer	NR	Yes	Yes	Yes	
Service Water Heating	SWH Efficiency	80%	80%	90%	80%	0%
	Roof Insulation (R value)	15	15	20	25	67%
Delta T / Heat Flux	Wall (R Value)	13	13	13	13	0%
Continuous	CI (R value)	3.8	7.7	7.5	10	163%
	Slab				10	
BTU/SF	Window U Factor	0.57	0.55	0.42	0.45	27%
Solar Heat Gain Coeff. Fraction of solar into building	Window SHGC	0.39	0.4	0.46	0.35	11%
Lighting Power Density	LPD (W/SF)	1.0	1.0	0.9	0.9	11%
Energy Use Intensity	Avg EUI (kBTU/SF/Yr)	51	47	36	25	104%
Operating Cost	Dollars / ft/yr	$ 3.98	$ 3.67	$ 2.81	$ 1.95	
Excess Energy Cost	Penalty	$ 2.03	$ 1.72	$ 0.86	$ -	

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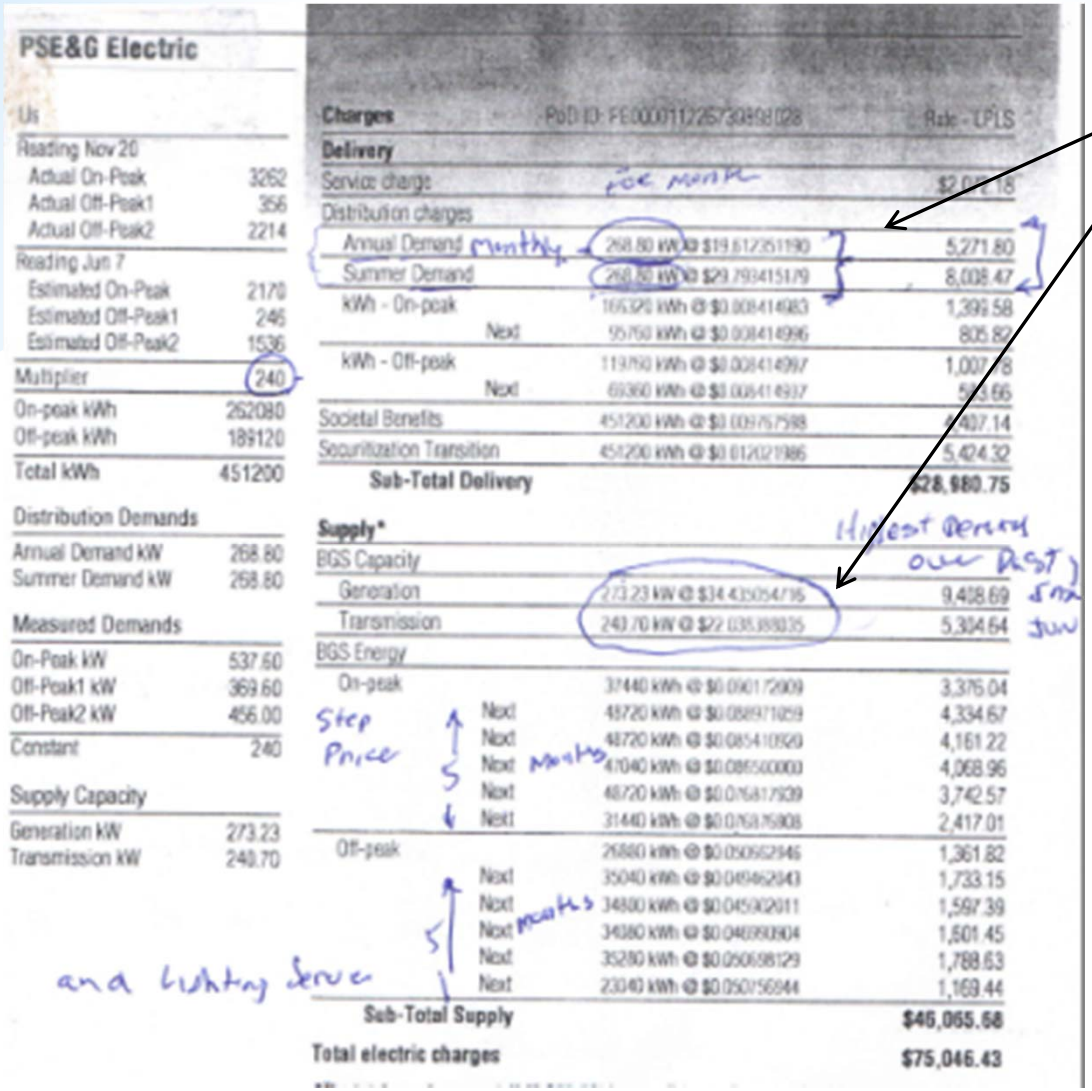
* PSE&G Bill



PSE&G Electric

Us

Reading Nov 20	
Actual On-Peak	3262
Actual Off-Peak1	356
Actual Off-Peak2	2214
Reading Jun 7	
Estimated On-Peak	2170
Estimated Off-Peak1	246
Estimated Off-Peak2	1536
Multiplier	240
On-peak kWh	262080
Off-peak kWh	189120
Total kWh	451200
Distribution Demands	
Annual Demand kW	268.80
Summer Demand kW	268.80
Measured Demands	
On-Peak kW	537.60
Off-Peak1 kW	369.60
Off-Peak2 kW	456.00
Constant	240
Supply Capacity	
Generation kW	273.23
Transmission kW	240.70

Charges		
Delivery		
Service charge		$2.0[illegible].18
Distribution charges		
Annual Demand	268.80 kW @ $19.612351190	5,271.80
Summer Demand	268.80 kW @ $29.793415179	8,008.47
kWh - On-peak	[illegible] kWh @ $0.00414983	1,399.58
Next	[illegible] kWh @ $0.00414996	805.80
kWh - Off-peak	[illegible] kWh @ $0.00414997	1,007.78
Next	[illegible] kWh @ $0.00414937	583.66
Societal Benefits	451200 kWh @ $0.00375588	1407.14
Securitization Transition	451200 kWh @ $0.012021986	5,424.32
Sub-Total Delivery		**$28,980.75**
Supply*		
BGS Capacity		
Generation	273.23 kW @ $34.435054716	9,408.69
Transmission	240.70 kW @ $22.[illegible]	5,304.64
BGS Energy		
On-peak	37440 kWh @ $0.090172909	3,376.04
Next	48720 kWh @ $0.088971059	4,334.67
Next	48720 kWh @ $0.085410569	4,161.22
Next	47040 kWh @ $0.086500003	4,068.96
Next	48720 kWh @ $0.076817539	3,742.57
Next	31440 kWh @ $0.076875808	2,417.01
Off-peak	26880 kWh @ $0.050562946	1,361.82
Next	35040 kWh @ $0.049462843	1,733.15
Next	34800 kWh @ $0.045902011	1,597.39
Next	34080 kWh @ $0.048898804	1,601.45
Next	35280 kWh @ $0.050658129	1,788.63
Next	23040 kWh @ $0.050756944	1,169.44
Sub-Total Supply		**$46,065.68**
Total electric charges		**$75,046.43**

KW Charges

Summer Peak
Winter Peak

KW 5 month peak
KW, 12 month peak
KWH, On Peak
KWH, Off Peak
KW, Transmission
KW, Generation

23 line items on bill

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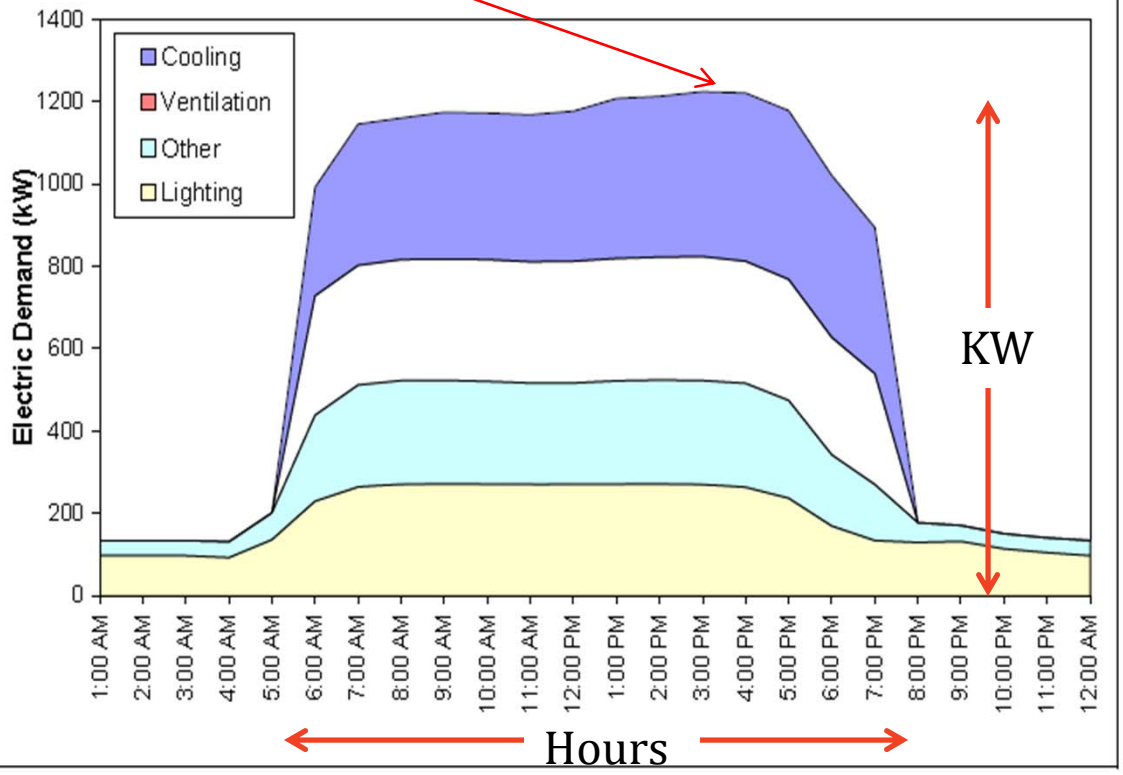
* Electric Bill
  * Pay two buckets, KW (kilowatt) & KWH (kilowatt hours)
  * Reduce KW, Hours, or both

Figure 3 - Typical Office Building Load Profile – Baseline Scenario

Assumptions

- High rise office building
- 250,000 square feet
- Centrifugal chiller / gas-fired hot water boiler
- 7:00am – 6:00pm, Mon-Fri
- Chicago, Illinois
- Typical summer day



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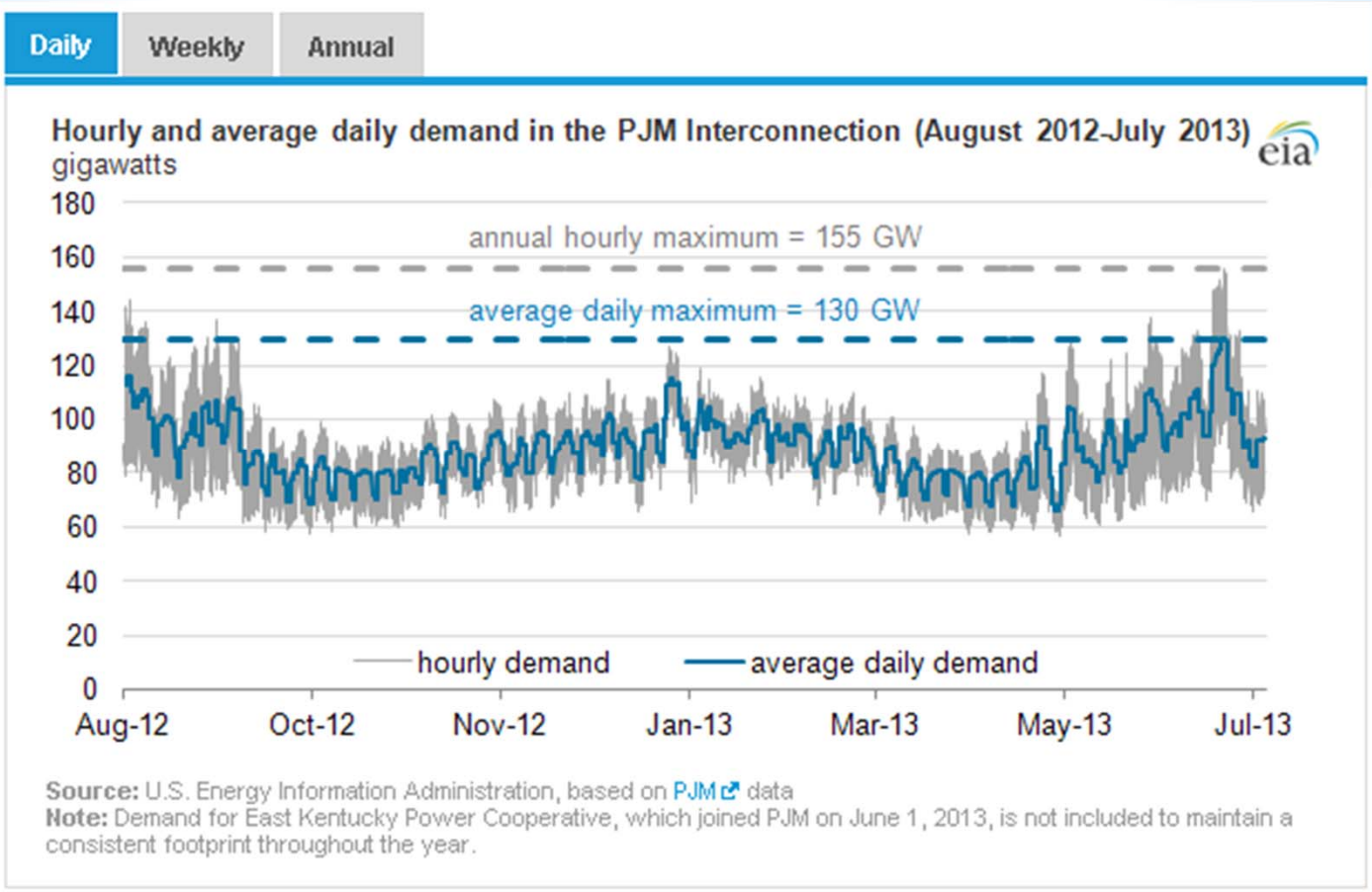
* KW Charges, 5 month peak and 12 month peak
  * PSE&G is part of PJM



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* ASHRAE Audits

* 1. Walk through, almost worthless
* 2. Model with BSO and compare bills to expected
* 3. Difference analysis, "What's wrong and how to fix"
  * Need detailed 'as is' plan.
  * Model expected savings

Type of Audit	Brief Description
Level 1	• Brief on-site survey of the building • Savings and cost analysis of low-cost/no-cost Energy Conservation Measures (ECMs) • Identification of potential capital improvements meriting further consideration
Level 2	• More detailed building survey • Breakdown of energy use • Savings and cost analysis of all ECMs • Identification of ECMs requiring more thorough data collection and analysis (Level 3)
Level 3	• Attention to capital-intensive projects identified during the Level 2 audit • More detailed field analysis • More rigorous engineering analysis • Cost and savings calculations with a high level of accuracy

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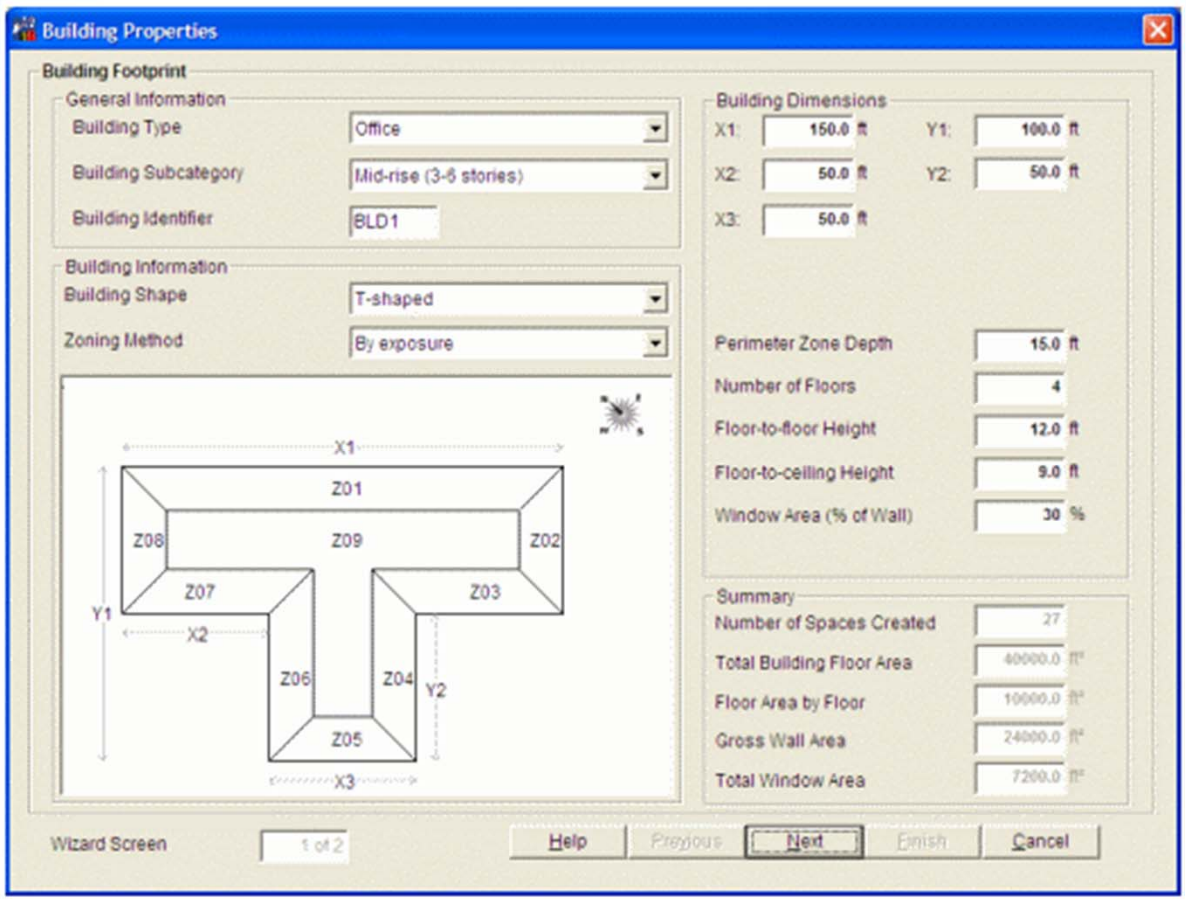
* Plan, Building System Optimization
  * Model building with real world data for region.



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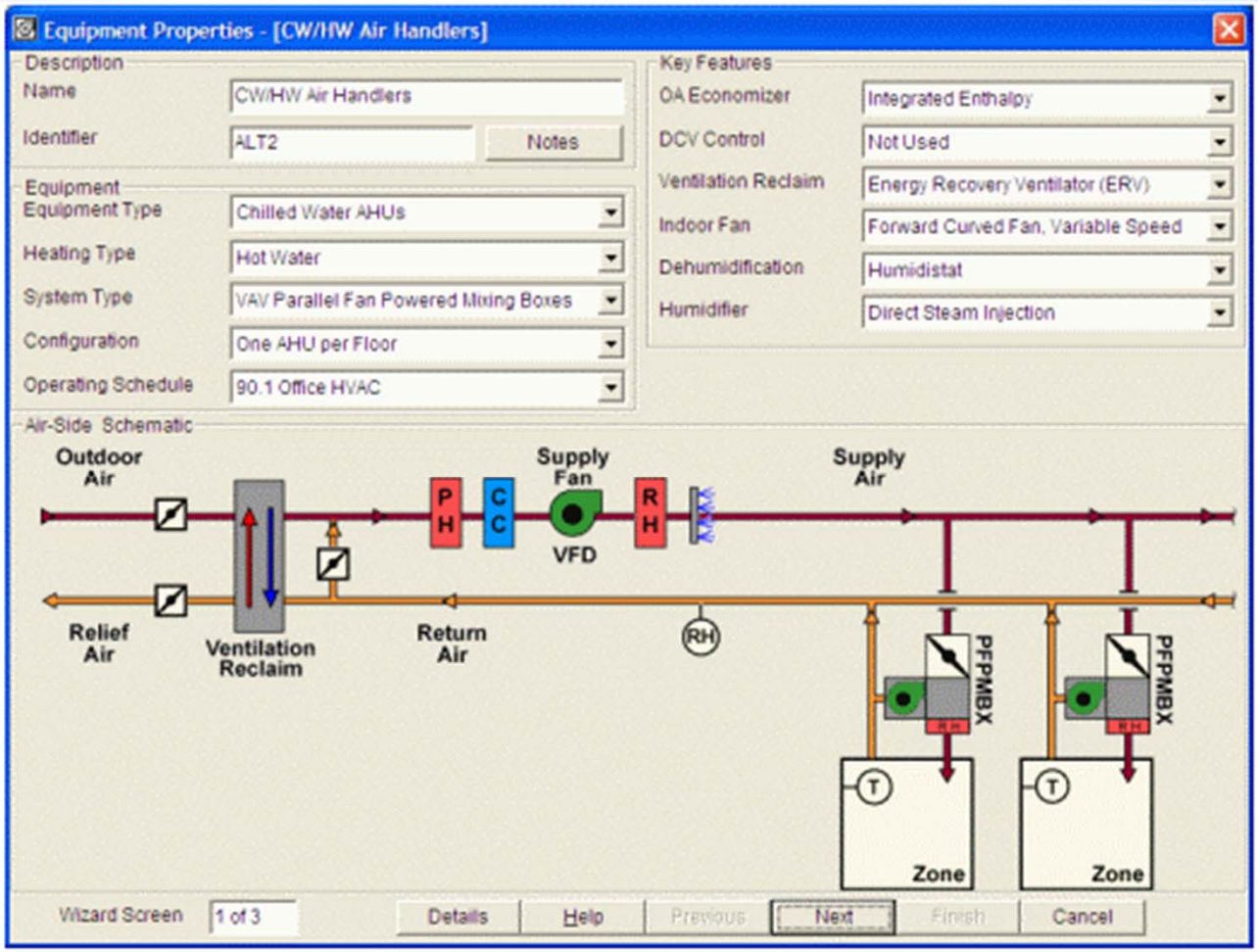
* Plan, Building System Optimization



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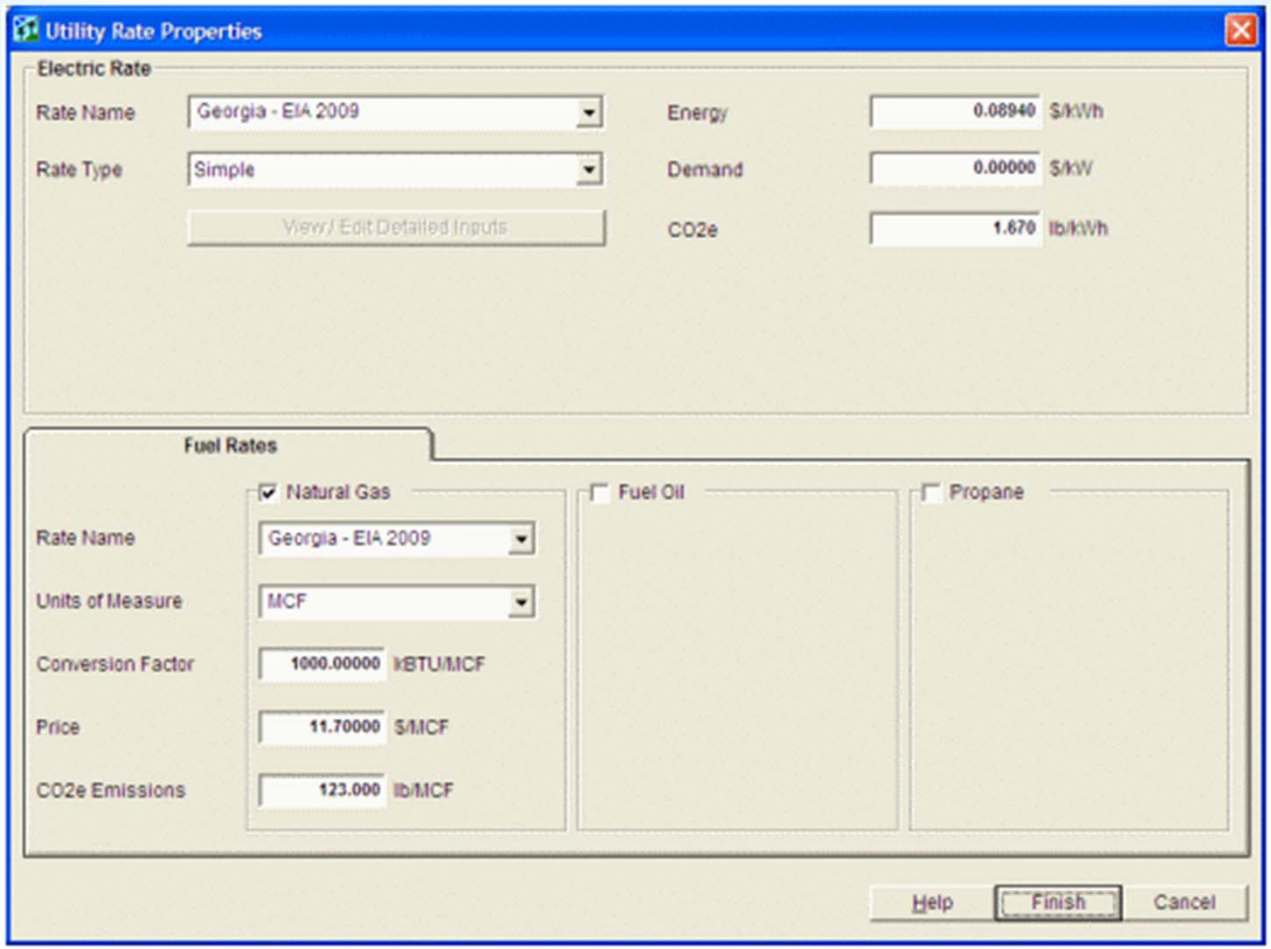
* Plan, Building System Optimization



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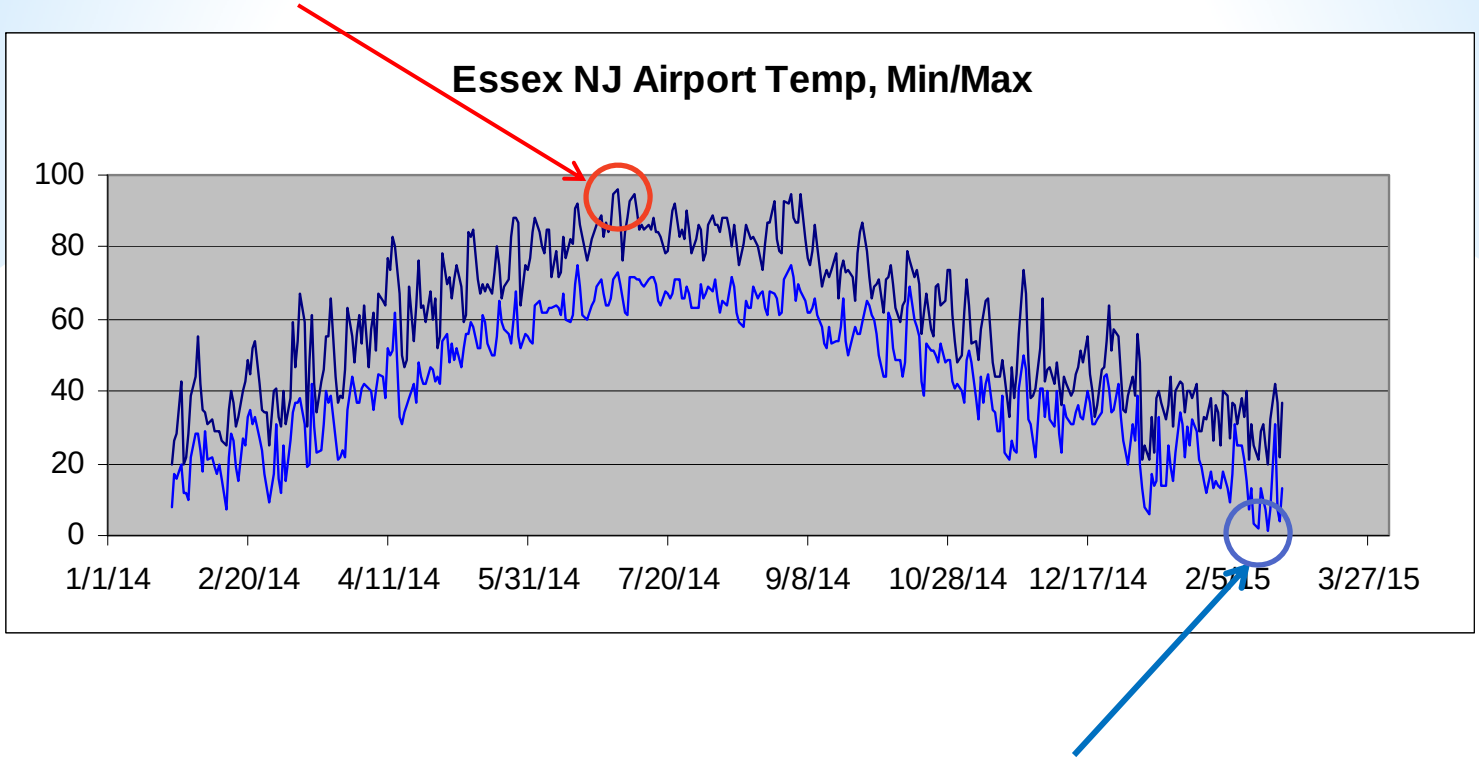
* Other Input into Simulation Model



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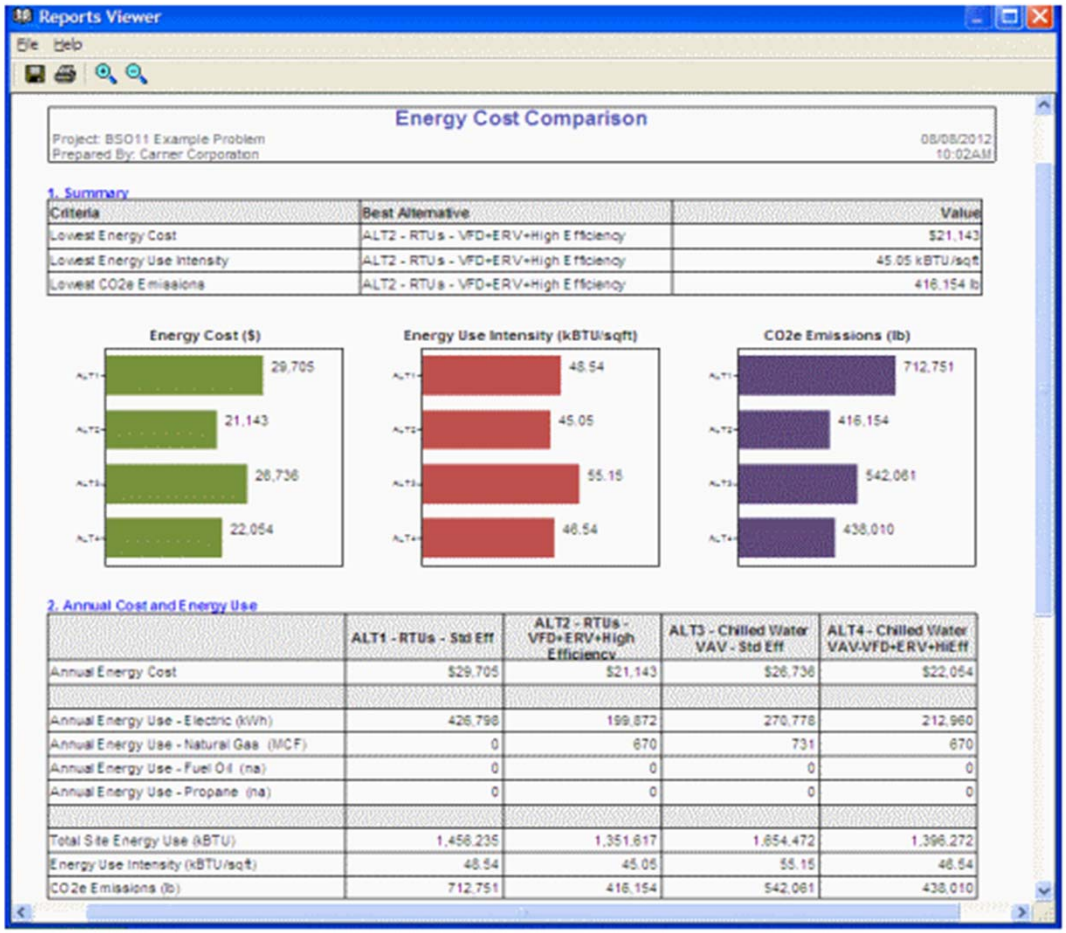
* Plan, Building System Optimization
  * Accuracy is within ~ 5% of the bill for existing modeling
    * Relative changes very accurate
  * Do we need to fix things to get back to the baseline?



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* Building Automation and Control Network, BAC-net

BACnet Applications

- HVAC control
- Fire detection and alarm
- Lighting control
- Security
- "Smart" elevators
- Utility company interface

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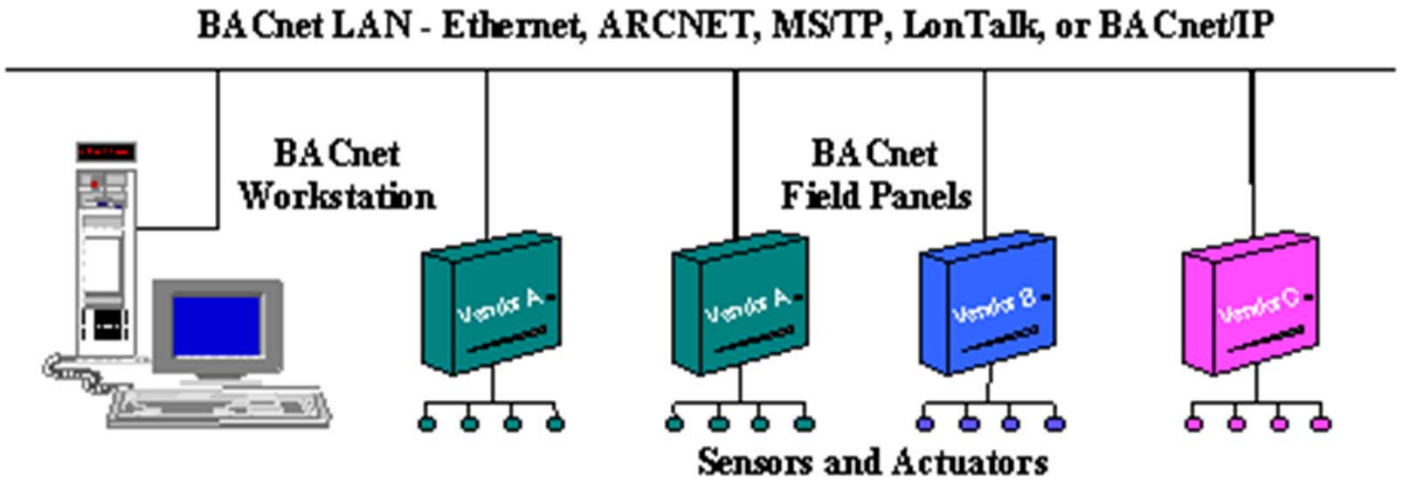
"Native" BACnet



Native BACnet devices provide BACnet communications directly, device to device

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* BacNet Electric Monitoring

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* New Sensors and Systems
  * Old temperature control was simple on/off
    * Temperature sensors allow for partial load control
    * CO2 sensors allow building to auto adjust to load
    * Enthalpy Sensors allow 'free' cooling
  * Requires Communications, BACnet
  * ***Partial Load is where the big savings are***
    * ***Where control makes a difference***

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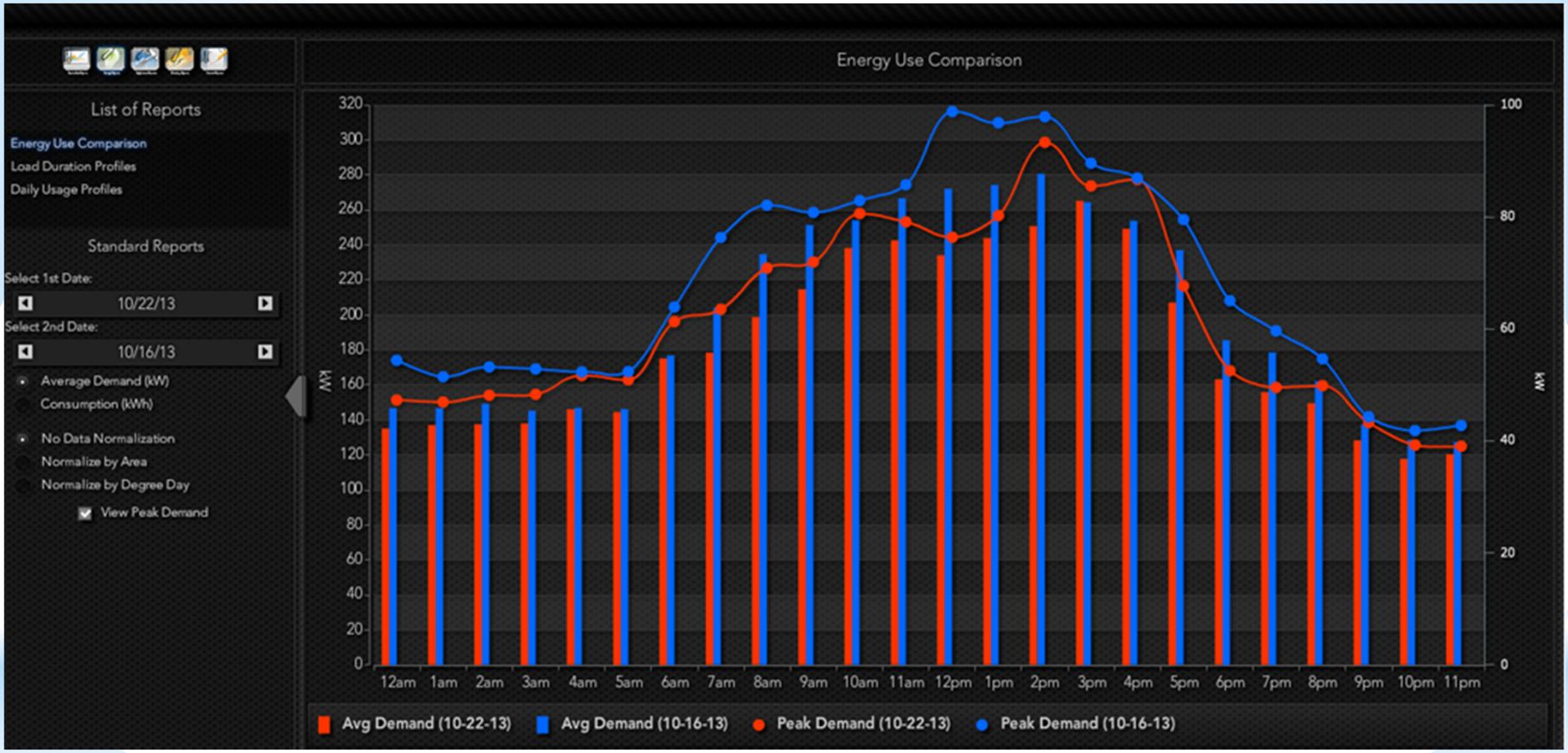
* Monitoring, Is it doing what it supposed to do?



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* Model Office Building, 30K ft. total, 2 story
  * Requires a Building Mgmt. System, BACnet
  * Demand Control Reset
    * Measures worst case VAV box, throttle wide open
  * Integrated Enthalpy
    * Economizer
  * Demand Control
    * CO2 sensor for fresh air makeup

2. Annual Cost and Energy Use

	VAV00 - Sample	VAV04 - Sample	VAV07 - Sample	VAV07E - Sample
Annual Energy Cost ($)	$102,259	$100,322	$99,253	$81,092
Annual Energy Use - Electric (kWh)	480,833	471,973	467,043	358,779
Annual Energy Use - Natural Gas (na)	0	0	0	0
Annual Energy Use - Fuel Oil (na)	0	0	0	0
Annual Energy Use - Propane (na)	0	0	0	0
Total Site Energy Use (kBTU)	1,640,603	1,610,371	1,593,552	1,224,153
Energy Use Intensity (kBTU/sqft)	54.69	53.68	53.12	40.81
CO2e Emissions (lb)	802,992	788,195	779,963	599,160

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* **Previous Building, $81,092 Energy Costs**
* Out of date maintenance, nothing crazy
  * Dirty filters (Raises static pressure)
  * Dirty coil, (Lowers EER)
  * Economizer not working

$8,442 Excess energy cost, +10%

- A lot more than a few filter changes
- BMS System allows you to spot changes

1. Summary

Criteria	Best Alternative	Value
Lowest Energy Cost	VAV00 - Sample	$89,534
Lowest Energy Use Intensity	VAV00 - Sample	45.29 kBTU/sqft
Lowest CO2e Emissions	VAV00 - Sample	664,992 lb

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* **What we do with a building management system**
  * Elevates level of control and comfort possible
    * Advanced Scheduling,
    * Integrated Enthalpy, Use free cooling
    * Demand Control / CO2, auto adjust building
    * Peak Shaving
    * Demand Anticipation
    * Lighting
    * Security
  * Monitors actual versus expected performance
    * Optimize to building limits
  * Monitors actual versus historical performance
    * Guides maintenance and trouble resolution
  * ***Allows remote access and control***

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* **Implementation 1**
* 3 Floors Office Building, 70K ft. total, Cooling Tower, 300 ton, Paramus
* No VFDs, 75 heat pumps, 2 - 20 HP fans, staged
  * 1 Clock per floor
  * $4.20/ft. -> $3.66/ft., $.54/ft. savings, 13%, $37,800

  * Network Thermostat system
    * View whole building on PC
    * Better 'stats
    * Reloads program every night, Turn all off on Sunday
    * ***Number of tenet complaints plummeted***
    * Free Lunch, Something / Nothing

Stage 2 Project (1/12/15)
- New Cooling Tower
- 2 VFD drives, Circulating pump & Fan

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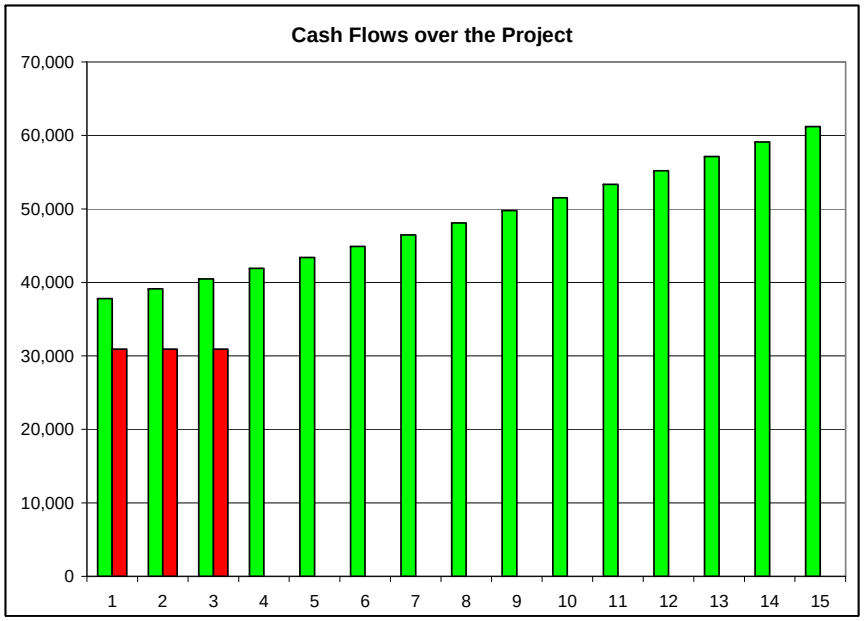
* A CFO look at the previous project
  * $80K investment / Good Savings
  * How do I pay for it?
    * Our job to help you understand

Investment	$	80,000
Annual Savings	$	37,800
Equipment Life		15
LifeCycle Savings	$	649,377
Simple Payback		2.12
IRR		51%
NPV	$	413,014
Discount Rate		5%
Utility Increase		3.50%

Term	3.00
Rate	7.8%
Yearly Payment	($30,903)
Total Finance Cost	($92,708)



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Questions

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* Implementation 2
  * 50,000 ft, 2 story, Class B, Paramus NJ
  * Water source, Cooling tower
    * Fix night set back, didn't work
    * 50 units, 7 clocks, 2 were working
    * Didn't have a pre-bill
      * Post bill $3.20 / ft vs $3.67 std

Investment	**$**	**2,500**
Annual Savings	**$**	**23,500**
Equipment Life		**15**
LifeCycle Savings	**$**	**450,949**
Simple Payback		**0.11**
IRR		**943%**
NPV	**$**	**301,754**
Discount Rate		**5%**
Utility Increase		**3.50%**

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* **Implimentation 3**
* **Three buildings, Rental Apts, 12/unit**
* "Gas Bills killing us", "People have windows open"
  * $85K for 3 new boilers
  * Heat Timer from 60's, open loop
  * Replaced windows & insulated
  * No zone valves

  * What we did, No change of physical plant
    * **$30K of Controls**
      * **PID control loop with 4 internal sensors**
      * **Staged boilers**
      * **# 4, 30 minutes all year**
      * **# 3, 45 minutes all year**
      * **# 2, October to May**
      * **# 1, always on**

Gas Bill dropped by 2/3's
Complaints dropped to zero

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* Common Theme on all the Implementations
  * You have to know what a system is capable of
  * Easy money is getting building back to 'as built'.
    * Update maintenance
    * Fix controls
    * Update sensors and systems
  * Systems degrade slow, people don't know how bad
    * Overrides
    * Economizers
    * Staged performance
  * Comfort is a free by product
    * Comfort higher
    * Costs lower
  * New Technologies give us another 15-20% potential
    * VFD Drive, Sensors, LED lights
    * Building Management Systems

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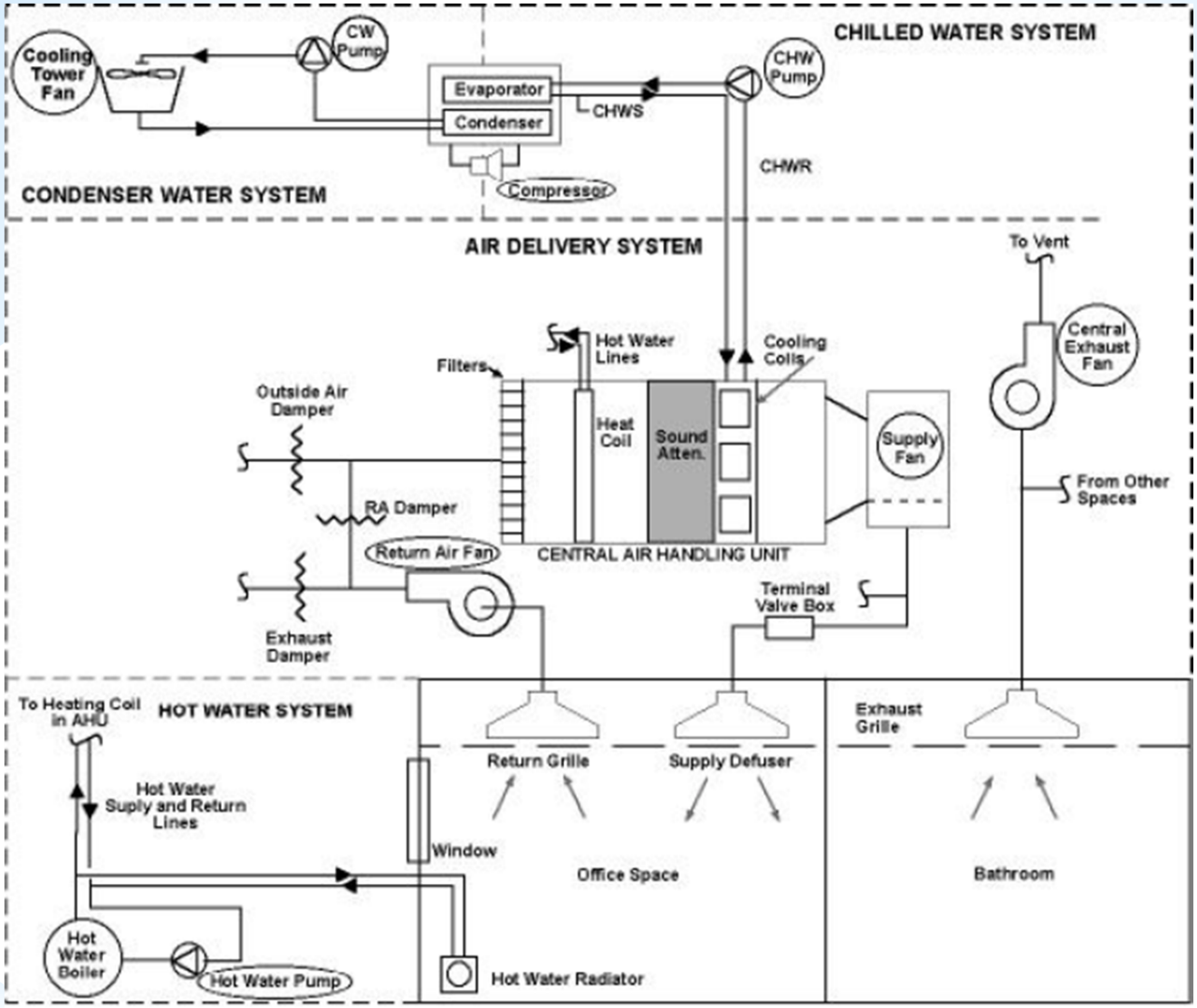
* Central System



Note: Power-using components are circled

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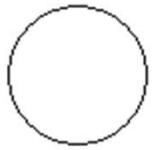
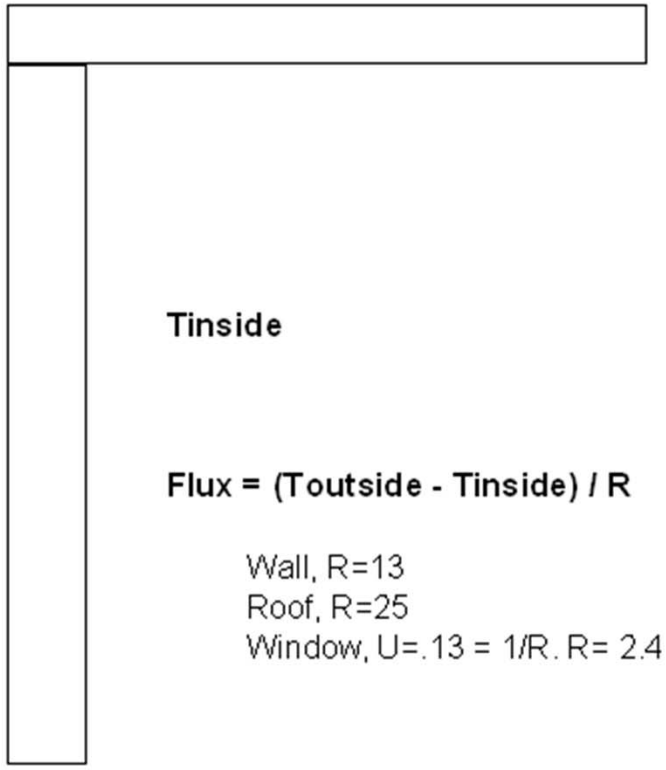
* Linear Energy Savings



Energy Use is Proportional to Delta T



Toutside

Tinside

Summer

92 out, 72 in = Delta 20
10% savings, Bump stat up to 74

Winter

22 out, 72 in = Delta 50
10% savings, Bump stat down to 67

Flux = (Toutside - Tinside) / R

Wall, R=13
Roof, R=25
Window, U=.13 = 1/R. R= 2.4

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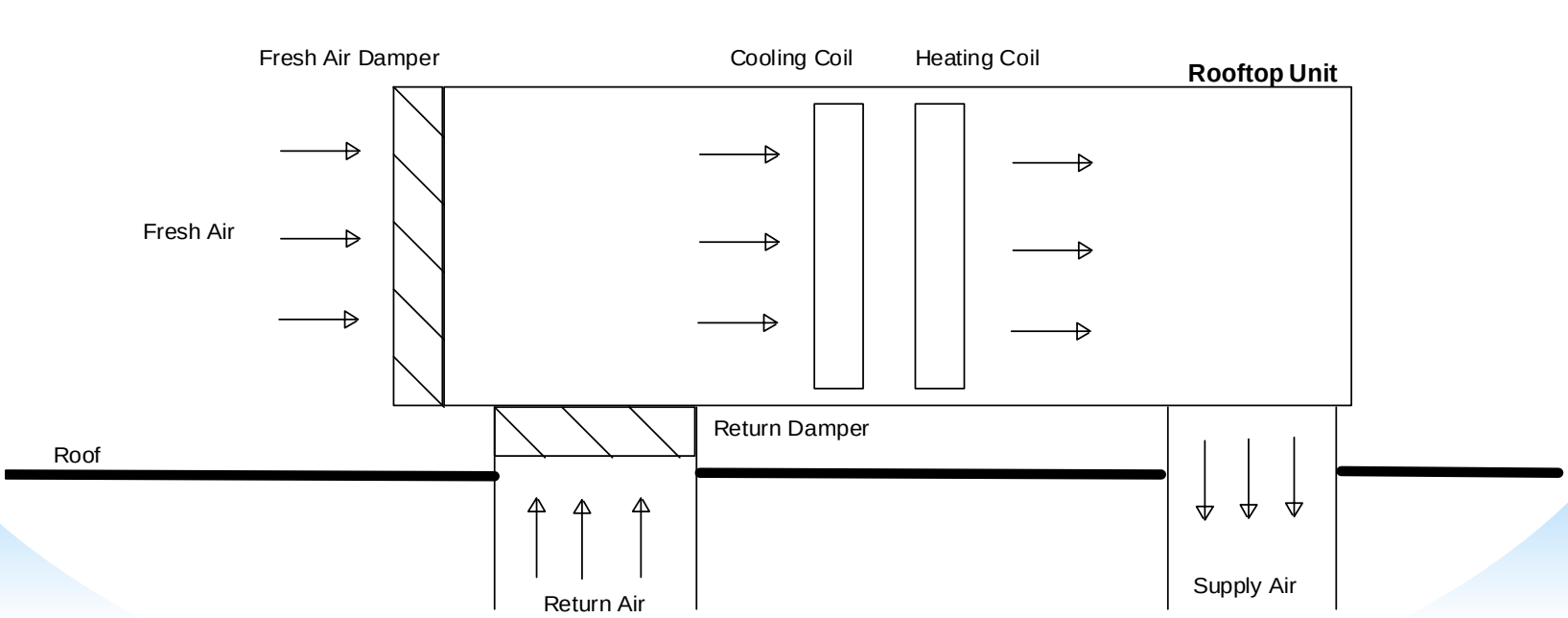
* Economizer

- * Cooling has two loads, internal & external
- * Certain conditions cheaper to use outside air
  - * Outside air has to have a lower enthalpy, temp & humidity
  - * Measure inside and outside
  - * Use exhaust air to preheat incoming, 50% reclaim



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