Presentation Outline

Project Background
Existing Mechanical Summary
Re-design Objectives
Re-design Alternative Systems
Ground Source Heat Pump
Solar Panels
Ventilation Sensors
Lighting Breadth
System Comparison
Final Recommendations

Freetown Elementary School

Matthew Buda
Mechanical Option
Faculty Adviser: Dr. Treado
April 12, 2011

Project Background

Size: 83,000 sq ft
Location: Glen Burnie, MD
Construction Dates: March 2008 – May 2010
Delivery Method: Design Bid Build
Cost: $17 million

Project Team

Owner: Anne Arundel County Public Schools
Architect: Rubeling & Associates
Structural Engineer: Columbia Engineering
MEP Engineer: James Posey Associates
Construction Manager: Jacobs Engineering Group

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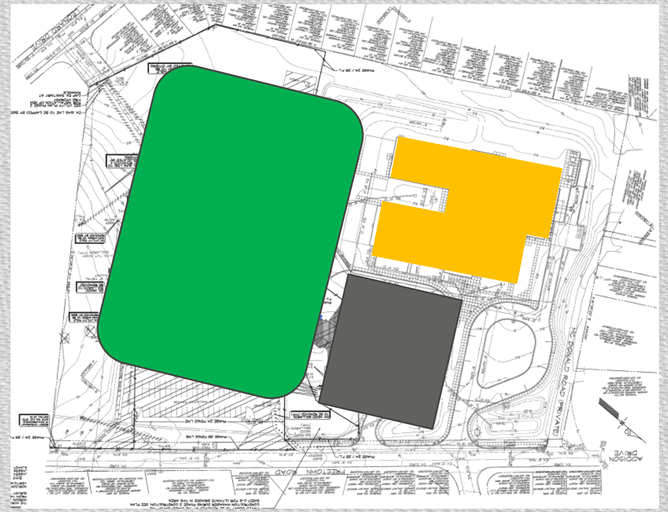
Site Layout



Old School

New School

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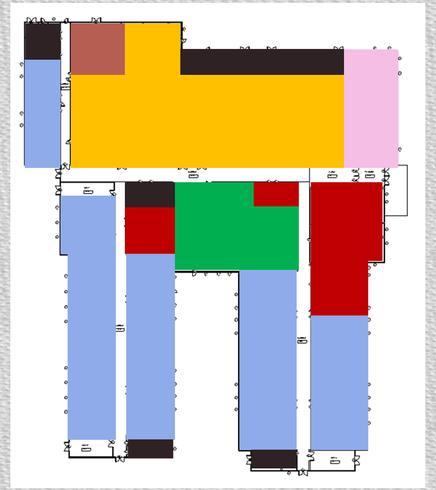
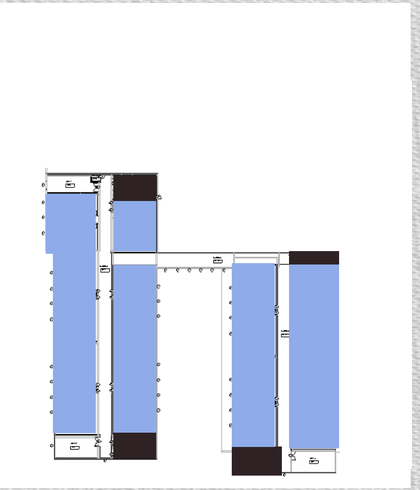
Building Layout

First Floor
Classrooms
Administration
Media/Computer Lab
Extended Daycare
Cafeteria/Kitchen/Gym
Mechanical Room
Storage



Second Floor
Classrooms
Storage



Mechanical Room

2 pipe changeover system

Two Natural Gas Boilers rotated monthly

Domestic Water Heater

Air Cooled Chiller

Existing Mechanical Systems

Air Handling Units

Constant Volume – Rooftop Air Handling Unit
- AHU-1 : General Music Classroom
- AHU-2 : Instrumental Music Classroom
- AHU-3 : Cafeteria
- AHU-4A : Gymnasium
- AHU-6: Media Center

Variable Volume/ Variable Temperature - Rooftop Air Handling Unit
- AHU-5 : Administration

Air Source Heat Pump
- HPU-1A – Extended Daycare

Energy Recovery Units – Rooftop Air Handling Units with Fan Coil Units
- ERU-1 : Classrooms
- ERU-2 : Classrooms

Mechanical Room

2 pipe changeover system

Two Natural Gas Boilers rotated monthly

Domestic Water Heater

Air Cooled Chiller

Existing Mechanical Systems

Modeled in TRACE

Annual Energy Consumption

Electric : 2,529,487 kWh

Gas : 1,222 therms

Building : 114,845 BTU/(ft^2-year)

Lighting 52% of Total Building Energy

Primary Cooling 22% of Total Building Energy

Air Handling Units

Constant Volume – Rooftop Air Handling Unit
- AHU-1 : General Music Classroom
- AHU-2 : Instrumental Music Classroom
- AHU-3 : Cafeteria
- AHU-4A : Gymnasium
- AHU-6: Media Center

Variable Volume/ Variable Temperature - Rooftop Air Handling Unit
- AHU-5 : Administration

Air Source Heat Pump
- HPU-1A – Extended Daycare

Energy Recovery Units – Rooftop Air Handling Units with Fan Coil Units
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Re-design Objectives

Reduce energy consumption

Reduce emissions

Maintain a comfortable environment

Be more sustainable

Re-design Alternative Systems

Selected Depth Systems

Ground Source Heat Pump

Solar Panels

Ventilation Sensors

Breadths

Occupancy Sensors with Daylighting

Rainwater collection system

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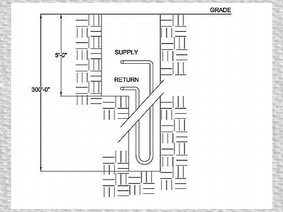
Ground Source Heat Pump

Selection

Vertical Closed Loop
Peak Cooling Load > Peak Heating Load
231 tons

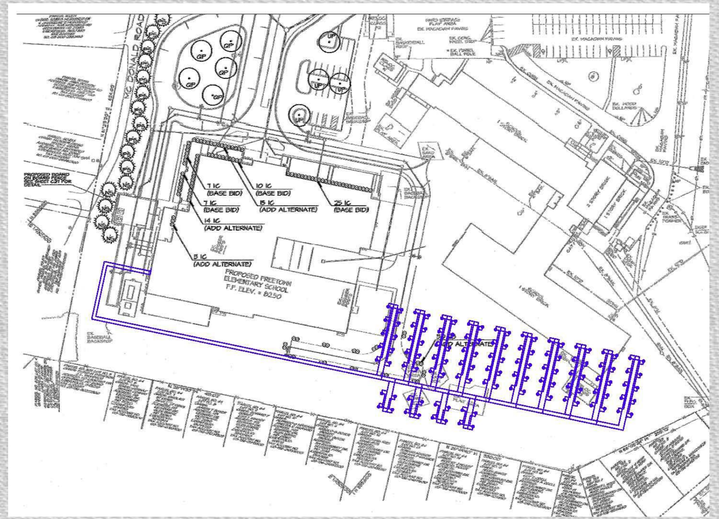
Layout

2 tons per 300ft = 116 bores
20 ft spacing between bores



Bore Detail

Layout



Ground Source Heat Pump

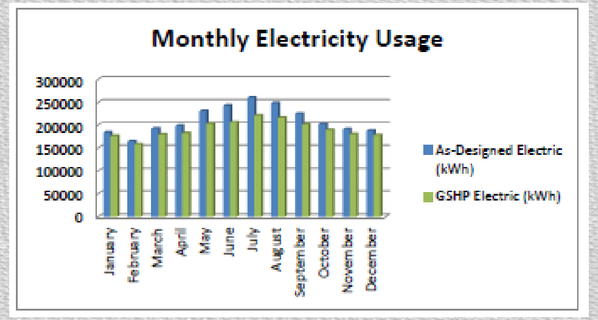
Modeled in TRACE

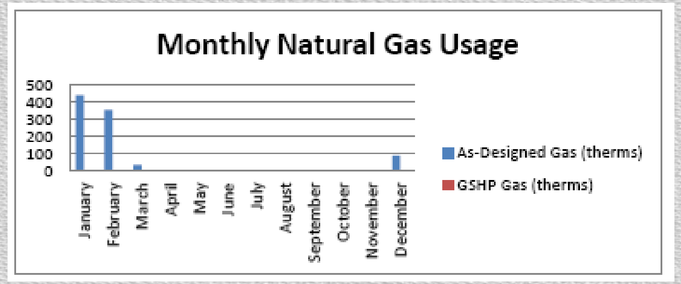
Annual Energy Consumption

Electric : 2,294,989 kWh

Gas : 0 therms

Building : 103,100 BTU/(ft^2-year)





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Ground Source Heat Pump

Payback

Existing Equipment	First Cost of GSHP	Net First Cost	Savings/yr
$ 412,080	$ 601,333	$ 189,253	$ 30,550
Payback	6.2		

Emissions

Environmental Impact Analysis			
	CO2 (lbm/year)	SO2 (gm/year)	NOX (gm/year)
As-designed	3,305,591	28,210	6,327
GSHP	2,885,957	24,629	5,524
Savings	13%		

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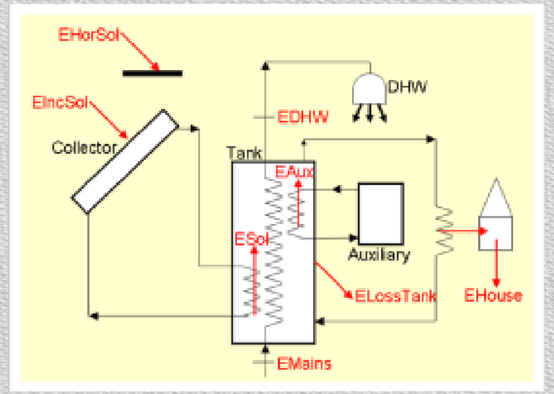
Solar Panels



Modeled in Combisys: TRNSED

Analysis

100% of Space Heating and Domestic Hot Water

Compare to 1,222 therms of Natural Gas

Peak in January : 265,250 BTU/hr

UA = qhl / (Tbp-Tout)

Tbp =65 deg F
Tout = 27 deg F

UA = 3267W/K

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Solar Panels

Footprint and Cost

Solar Panels		
Number of panels	#	471
Footprint required for system	ft2	15,072
Price per panel	$	2,000
Total installed system cost:	$	942,000

Comparison

Comparison		Existing Boiler	Solar Panels	Energy Savings
Energy Use	therms/yr	1222	796	35%
Total Charge	$/therm	0.86	0.86	
Monthly Meter Fee	$	35	35	Cost Savings
Total cost	$/yr	1471	1105	25%

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Solar Panels

Solar Panels for Domestic Hot Water Load								
	payback	89	109	80	66	50	38	47
	first cost	$ 10,088	$ 12,609	$ 9,079	$ 7,061	$ 5,044	$ 2,522	$ 5,044
	savings	$ 113	$ 116	$ 114	$ 108	$ 100	$ 67	$ 106
	# panels	7	8	6	5	3	2	3
Collector size	ft2	215.2	269	193.68	150.64	107.6	53.8	107.6
Collector size	m2	20	25	18	14	10	5	10
Storage tank	l/m2	20	18	25	25	30	30	40

Analysis

100% Domestic Hot Water

Used year round

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Ventilation Sensors

Volatile Organic Compounds (VOC)

Humans – breath, cosmetics – acetone/ethanol/CO2

Office Equipment – printers, computers – benzene, styrene

Building materials – paints, carpets – formaldehyde, ketones

VOC Ranges

Source: BAPI

Table 2 Some Typical VOCs and the Individual Concentrations Needed for 100% output

Compound	Formula	Range	Potential sources of indoor pollutants
Carbon monoxide	CO	0-10 ppm	Car exhaust, fuel-based heating, cooking appliances, smoking
Methane	CH_4	0-200 ppm	Natural Gas
Propane	C_3H_8	0-20 ppm	Fuel-based heating, cooking appliances, cleaners
Ethyl Alcohol	C_2H_6O	0-3 ppm	Cosmetics, cleaners, disinfectants, paints, coatings, breath
Acetaldehyde	C_2H_4O	0-20 ppm	Adhesives, coatings, plastics, lubricants, ripening of fruit, smoking, rosin core solder
Methyl Ethyl Ketone	C_4H_8O	0-20 ppm	Adhesives, coatings, plastics, lubricants
Toluene	C_7H_8	0-5 ppm	Paints, coatings, cleaners, detergents, smoking, polyurethane lacquers

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Source: BAPI

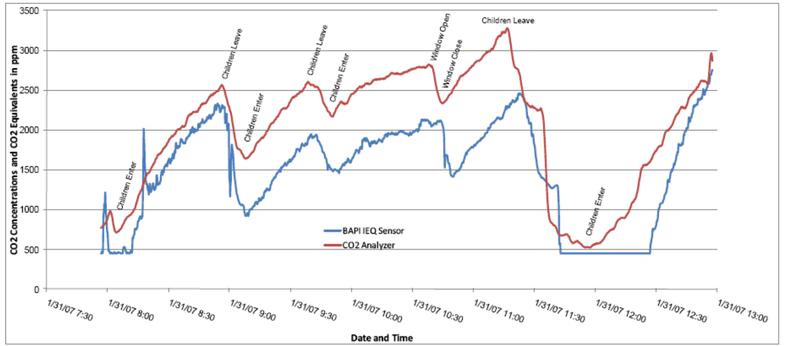


Chart 3: VOCs in an elementary school classroom

Study of a 6,000 cubic foot elementary classroom
1 teacher and 30 students

Slightly lower because students not wearing cologne, perfume and lotions

IEQ output direct indication of occupancy

Presentation Outline

Lighting Breadth

Occupancy Sensors with Daylighting controls

Infrared
Ultrasonic
Dual Technology/Hybrid

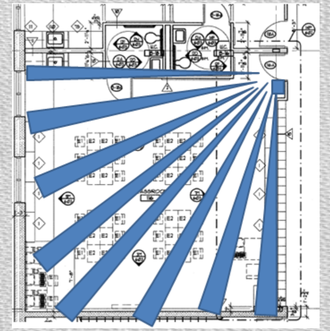
Typical Classroom

Control

Automatic switching
Manual switching
Dimming ballast for daylighting
Dimming of different zones

Sensor

LC-100 Power Pack
DT-200 Dual Tech. Occ. Sensor
LS-201 Dimming Photosensor



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Lighting Breadth

Occupancy Sensors with Daylighting controls

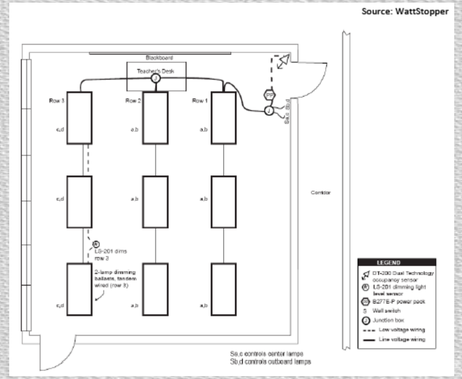
Infrared
Ultrasonic
Dual Technology/Hybrid

Lighting Against Windows
2-lamp dimming ballast
Tandem wiring

DT-200
18 minute time delay

LS-201
Mount between 5 and 8 feet from window

Source: WattStopper



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Lighting Breadth

Modeled in TRACE as Standard Stepped Controller

Compared to the as-designed lighting controls

Savings

5% energy reduction
$14,029 a year in utilities

Total First Cost $7,463
37 Sensors - $5,644
Labor - $1,819

Simple Payback

6 months

Effect

Energy reduction from controls

Increase in energy use for heating with decrease in lighting load

System Comparison

Ground Source Heat Pump

Advantages

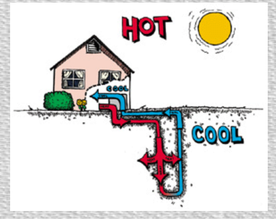
13% total energy savings

Relatively quick payback

Disadvantages

Schedule

Weather during construction



Solar Panels

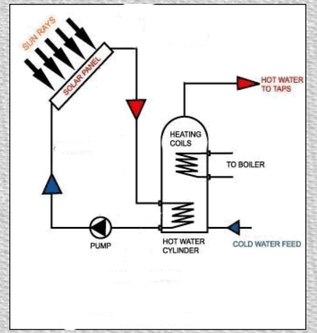
Advantages

35% Energy Savings on heating

Disadvantages

Very expensive

Long Payback



Ventilation Sensors

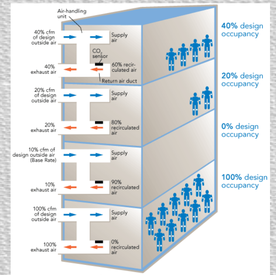
Advantages

Quick payback

Better air quality

Disadvantages

Extra cost



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Ground Source Heat Pump

Reasonable Payback at 6.2 years

Ventilation Sensors

Better indoor air quality
increase in productivity

Lighting Occupancy Sensors

Daylighting

Thank you

Dr. Treado, Adviser

Siman Sinai, Jacobs

Matt Tressler, McClure

Fellow Students

Questions?