The New Student Housing Building

at

The Mount St. Mary's University

Emmitsburg, Maryland

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Advisor: Dr. Srebric

Mechanical Option

Spring 2007

Presentation Outline

- **Project Background**
- Current Mechanical Systems
- Mechanical Alternatives – Depth
- Life Cycle vs. First Cost Analysis
- Electrical Generation – Breadth
- Final Recommendation

Project Background

Project Overview

- Site: Emmitsburg, Maryland
- Size: 60,000 SF / 3 Stories / 180 Beds
- Cost: $10,800,000 Total / $3,400,000 MEP

Primary Project Team

- Owner: The Mount St. Mary's University
- Architect: Ayers / Saint / Gross Architects
- Construction Manager: Gilbane
- Civil Engineer: Harris, Smariga, & Associates, Inc.
- Structural Engineer: Keast & Hood Co.
- MEP Engineer: Burdette, Koehler, Murphy, and Associates, Inc.

Project Background

Architecture

- Designed to create the appearance of a village
- Comprised primarily of 4-bedroom suites, each with a shared bathroom and living area
- Small lounge area provided on each floor
- Designed to achieve LEED Certification

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Current Mechanical Systems

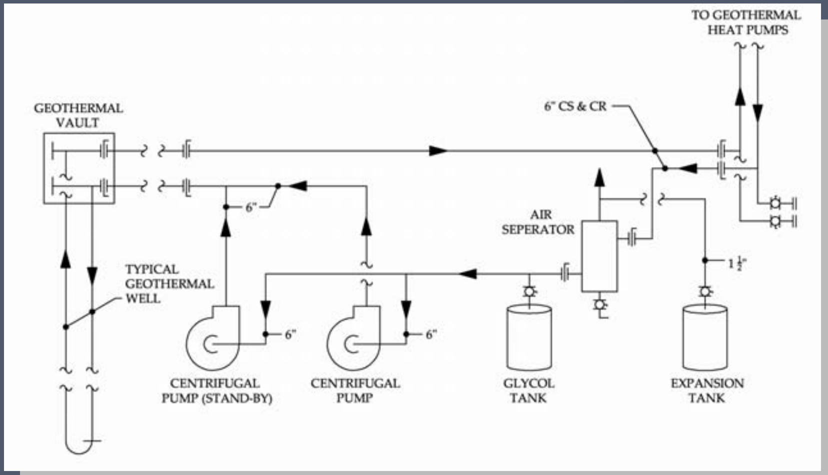
Geothermal Heat Pump System

- Exterior
  - Originally designed with 125, 200 ft deep vertical wells
  - Redesigned with 64, 400 ft deep vertical wells
  - Wells located in the courtyard in front of the building
  - Stem from distribution vault and connected to building mechanical room

Current Mechanical Systems

Geothermal Heat Pump System

- Interior
  - 58 water-source heat pumps linked to the ground loops
  - Individual units ranging from 1 – 2.5 tons for each space
  - Condenser water pumps (2) rated at 375 GPM
  - No need for boiler or cooling tower



Current Mechanical Systems

Ventilation System

- Building designed for natural ventilation
- Exhaust fans exchanged for (3) 1050 CFM energy recovery units
  - Each heat pump closet receives 50 CFM of ventilation air
  - Can reduce outdoor air conditioning loads by 80%
- Supplemental ventilation achieved from energy recovery of exhaust air
  - Building pressurization
  - Additional ventilation when windows are closed

Domestic Service Water System

- (1) 750 GPH, 600 MBH domestic water heater with (1) 35 gallon expansion tank
- Hot water recirculated by a 15 GPM in-line pump

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Mechanical Depth

Goals:

- Perform analysis of yearly energy usage and cost of geothermal system
- Select comparable alternative units to model in HAP
- Evaluate results in order to determine merits of each
- Perform first cost and life cycle analyses
- Critique geothermal system based on results

Purpose:

- University very interested in green design
- Geothermal uses less energy but first costs are high
- Are first costs justified?

Mechanical Depth

Was geothermal really the best choice for this project?

Proposed Alternatives

- Traditional Water-Source Heat Pumps
- Mini-Split DX Air-Source Heat Pumps

Mechanical Depth

Case 1: Geothermal Heat Pump System

- Reject heat to and extract heat from the earth at stable temperatures year-round
- Most efficient in cooling mode, especially at part load conditions
- Requires less maintenance, but has a very high first cost due to the wells

Case 2: Water-Source Heat Pump System

- Reject heat to cooling tower and extract heat from boiler
- Less efficient in cooling mode, but greater efficiencies when heating
- Requires additional equipment

Case 3: Air-Source DX Split Heat Pump System

- Reject heat to and extract heat from exterior condensing units via refrigerant
- Less efficient than water-source applications
- Eliminates need for condenser water pumps, cooling tower, and boiler

Mechanical Depth

McQuay Water Source Heat Pumps

- Ground Loop – Enfinity Model FCW Vertical Units (1 – 2.5 Ton)
- Closed Loop – Enfinity Model FCV Vertical Units (1 – 2.5 Ton)

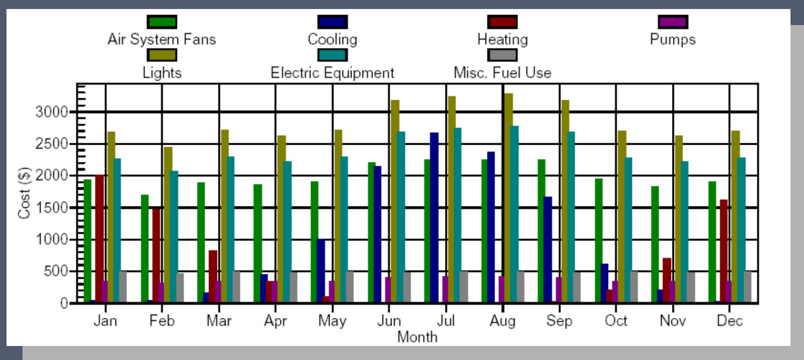
McQuay Split System Air Handlers

- Condenser – Model HCC Heat Pump (1.5 – 2.5 Ton)
- Evaporator – Model SAH Air Handler (1.5 – 2.5 Ton)

Mechanical Depth

Case 1: Existing Geothermal System Results

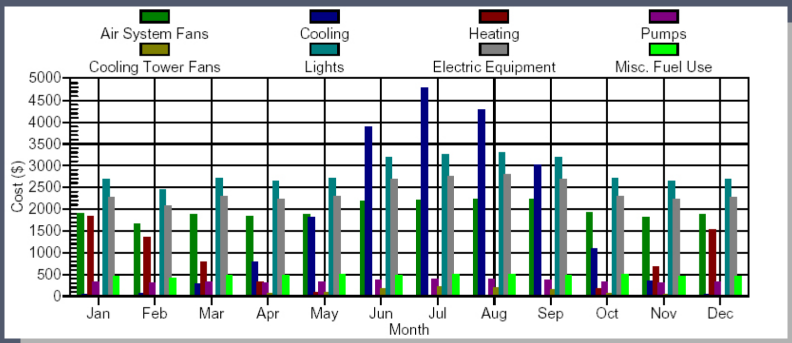
- Annual Operating Costs: $115,002
- MEP Annual Operating Costs: $46,604



Mechanical Depth

Case 2: Proposed Water-Source System Results

- Annual Operating Costs: $123,709
- MEP Annual Operating Costs: $55,340



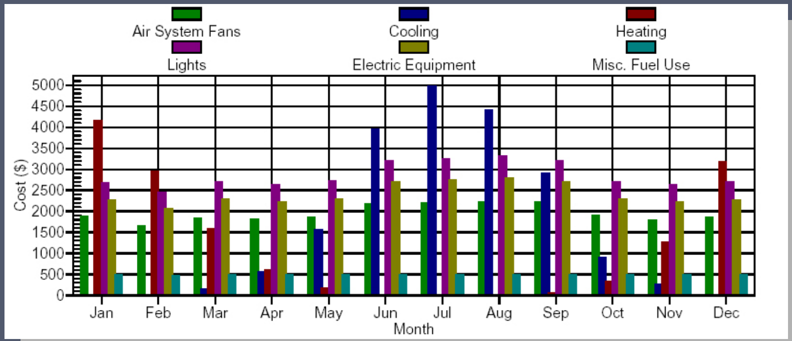
- Water-Source 8% more efficient when heating
- Geothermal 40% more efficient when cooling

	Air System Fans	Cooling	Heating	Pumps	Boiler	Cooling Tower Fans	Total
Water-Source	$23,479	$18,580	$6,717	$3,934	$1,726	$904	$55,340
Ground-Source	$23,764	$11,302	$7,225	$4,313	$0	$0	$46,604
Savings	-$285	$7,278	-$508	-$379	$1,726	$904	$8,736

Mechanical Depth

Case 3: Proposed Air-Source System Results

- Annual Operating Costs: $125,971
- MEP Annual Operating Costs: $57,299

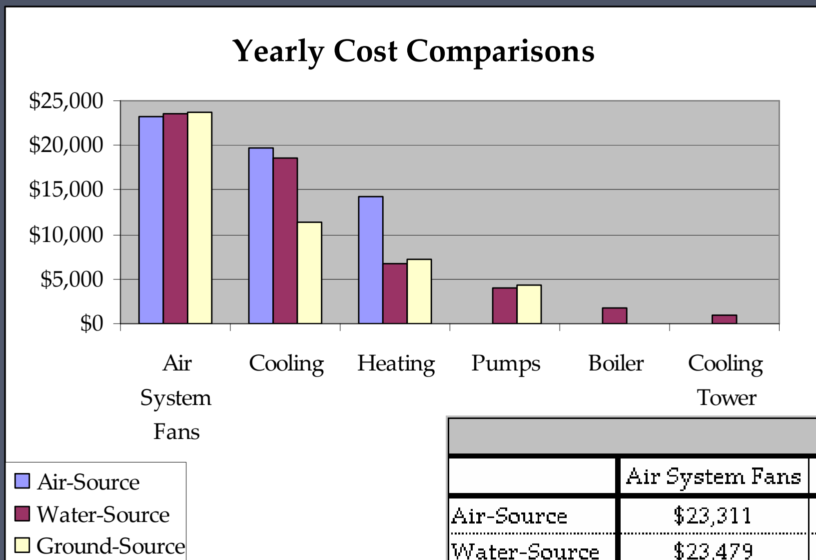


- Geothermal 50% more efficient when heating
- Geothermal 43% more efficient when cooling

	Air System Fans	Cooling	Heating	Pumps	Boiler	Cooling Tower Fans	Total
Air-Source	$23,311	$19,686	$14,302	$0	$0	$0	$57,299
Ground-Source	$23,764	$11,302	$7,225	$4,313	$0	$0	$46,604
Savings	-$453	$8,384	$7,077	-$4,313	$0	$0	$10,695

Mechanical Depth

Annual Cost Comparisons



- Geothermal savings of 15.8% annually over water-source
- Geothermal savings of 18.7% annually over air-source

HVAC System Components

	Air System Fans	Cooling	Heating	Pumps	Boiler	Cooling Tower Fans	Total
Air-Source	$23,311	$19,686	$14,302	$0	$0	$0	$57,299
Water-Source	$23,479	$18,580	$6,717	$3,934	$1,726	$904	$55,340
Ground-Source	$23,764	$11,302	$7,225	$4,313	$0	$0	$46,604

Ground-Source savings over Air-Source:	$10,695
Ground-Source savings over Water-Source:	$8,736
Water-Source savings over Air-Source:	$1,959

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Life Cycle vs. First Costs

First Cost Comparisons

System Type	Equipment Costs	Installation Costs	Overhead and Profit	Total Installed First Cost
Ground-Source Heat Pumps	$121,575	$152,560	$22,540	$296,675
Water-Source Heat Pumps	$130,050	$31,490	$28,985	$190,525
Air-Source Heat Pumps	$104,675	$39,065	$30,160	$173,900

Equipment Costs

- Air-Source cheapest – no boiler, cooling tower, or condenser water pumps

Installation Costs

- Geothermal most expensive – excavation and installation of the wells
- 4 times more expensive than Air-Source
- 5 times more expensive than Water-Source

Total Installed First Cost

- Geothermal over $100,000 more expensive than other systems

Life Cycle vs. First Costs

Life Cycle Cost Comparisons

25 Year Life Cycle

- Geothermal saves $17,000 over Water-Source
- Geothermal saves $28,000 over Air-Source

	Ground-Source	Water-Source	Air-Source
Equipment First Costs	$121,575	$130,050	$104,675
Installation Costs	$152,560	$31,490	$39,065
Overhead and Profit	$22,540	$28,985	$30,160
Annual Energy Consumption Costs	$46,604	$55,340	$57,299
Discount Rate	0.05	0.05	0.05
System Life (Years)	25	25	25
Life Cycle Cost	$953,509	$970,484	$981,469

Life Cycle vs. First Costs

Life Cycle Cost Comparisons

Payback Period for Geothermal

- 17.5 years for Air-Source
- 19.2 years for Water-Source

Other Issues

- Relocation of water utility line
- Lengthening of schedule
- Possible need for supplemental heating and cooling at extra cost

Even So…

- Dormitory could have a expected life of more than 50 years
- Long term savings will be substantial
- Savings would increase if electrical costs went up

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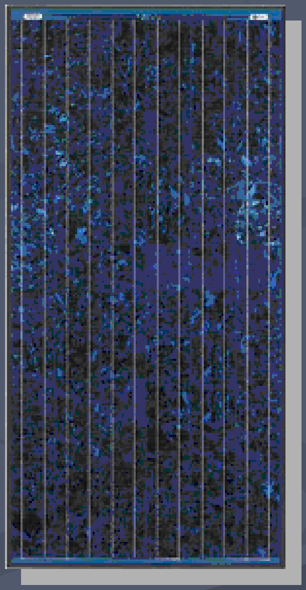
Electrical Breadth

Goals:

- Determine the available roof space for PV panels
- Perform analysis of possible electrical generation using RETScreen
- Decide whether a PV system would be worth the investment



Purpose:

- University very interested in green design
- Environmental solar system tempting for LEED points
- Offset some of the 860 MWh of annual building energy use
- Could a PV system be economically designed for this project?

Electrical Breadth

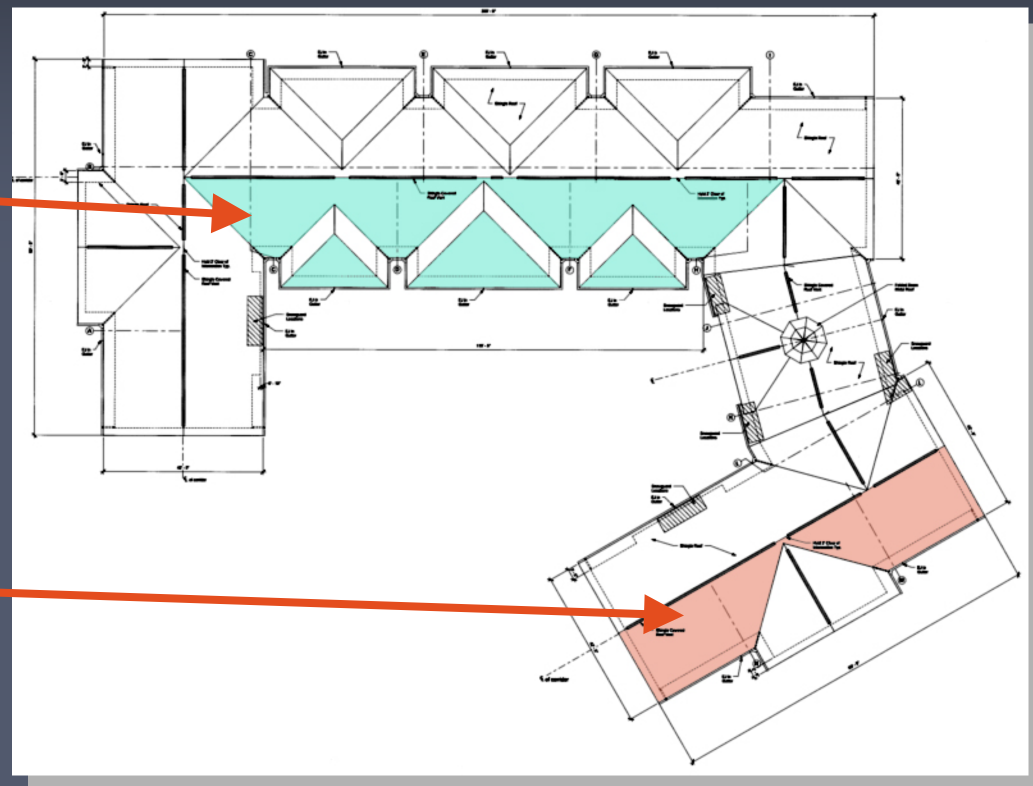
Available Roof Space

Primary Case

- 3255 ft^2 available space
- 65% Usable
- 155 Panels
- South-Facing

Alternate Case

- 1942 ft^2 available space
- 80% Usable
- 112 Additional Panels
- Southeast-Facing



Electrical Breadth

Photovoltaic Analysis Results

Case	Nominal kW Produced	Yearly MWh	Installed Cost	Grants & Incentives	First Cost (Adjusted)	Annual Energy Savings	Payback Period (Years)
Base	24.80	33.79	$168,728	$55,519	$113,209	$4,562	28.2
Alternate	42.72	57.98	$287,894	$91,268	$196,626	$7,827	27.0

Primary Case

- 33.79 MWh useful energy generated annually
- 4% of annual energy usage – savings of $4,562

Alternate Case

- 57.98 MWh useful energy generated annually
- 7% of annual energy usage – savings of $7,827

Payback Period Not Acceptable!

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Final Recommendation

Mechanical Heating and Cooling System

- Geothermal system best alternative
- Most efficient system
- Higher first costs offset by possible long term savings
- Environmentally friendly and innovative

Photovoltaic Electrical Generation

- Very expensive first cost
- Inefficient system with very long payback period
- Not worth the investment at present

Questions?

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