# WEST WING GEOTHERMAL PRESENTATION

**ENGR 333** 

DECEMBER 4, 2012

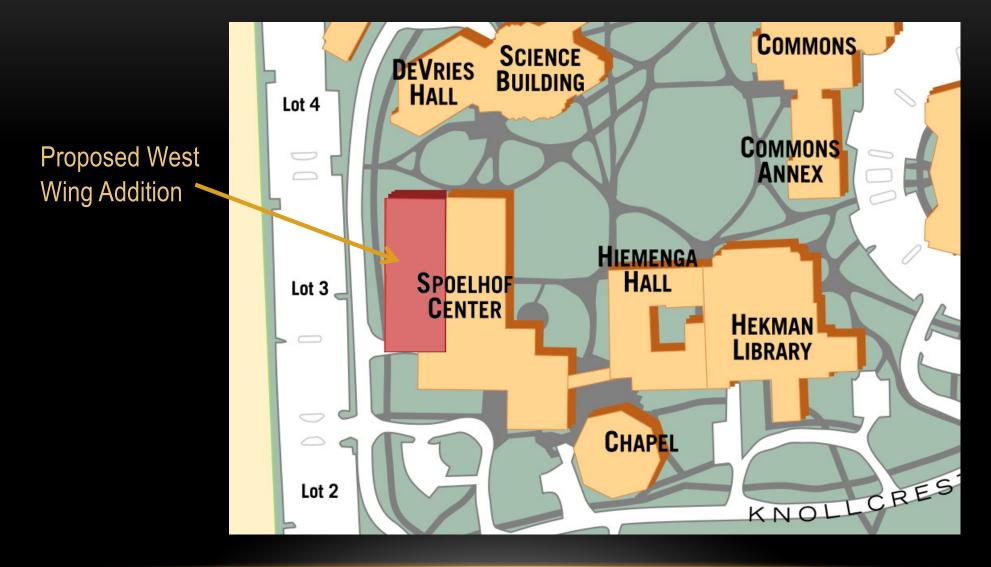
# SPOELHOF CENTER WEST WING ADDITION



IntroductionInfrastructureAbove GroundEnergy ModelingBelow Ground

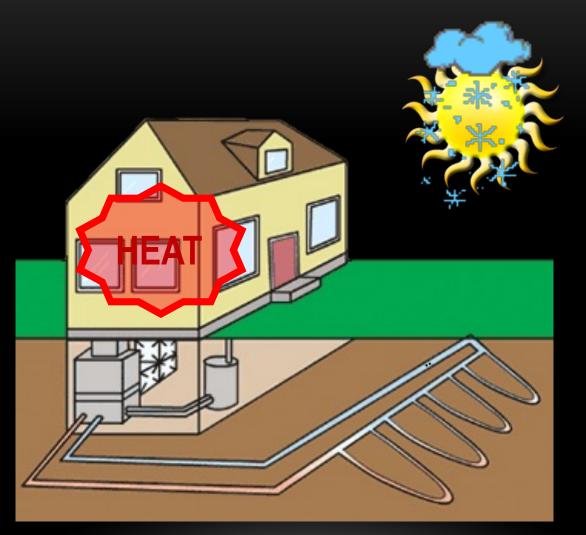
Recommendation Financial

## LOCATION



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### HOW DOES GEOTHERMAL WORK?



http://www.drenergysaver.com/renewable-energy/geothermal-heat.html

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n Infrastructure / Energy Modeling Below Ground

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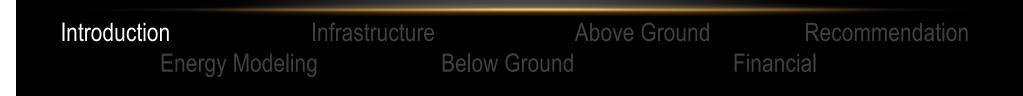
# GEOTHERMAL BENEFITS AND COSTS

#### **Benefits**

- Reduced energy consumption
- Reduced maintenance

#### Costs

- More complex
- Installation



# **PROJECT OVERVIEW**

- Objective:
  - As a class we are to determine what it would take to use a geothermal Heating, Ventilation, and Air Conditioning (HVAC) system in the West Wing Addition
- 5 groups for analysis
  - LEED & Energy Modeling
  - Infrastructure
  - Below Ground
  - Above Ground
  - Financial

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# LEED & ENERGY MODELING

Introduction

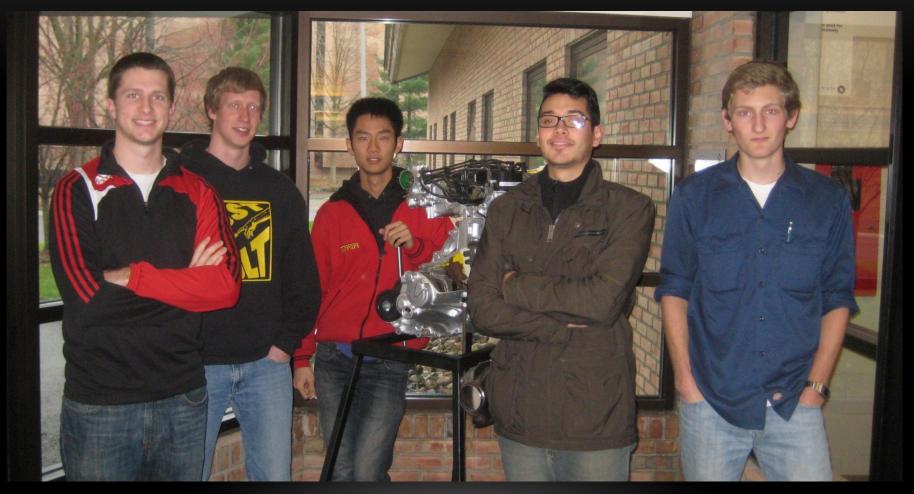
Infrastructure

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Energy Modeling Below Ground

#### **TEAM MEMBERS**



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Energy Modeling

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# **KEY QUESTIONS**

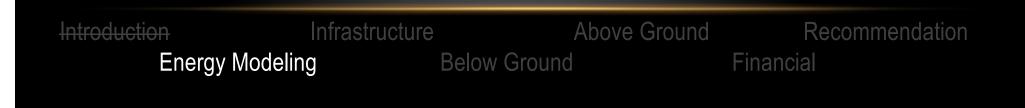
- How will a geothermal system contribute to achieving LEED certification?
- What are the heating & cooling loads for the West Wing addition?

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# LEED RATING SYSTEM

- LEED = Leadership in Energy and Environmental Design
- Aiming for LEED silver rating, according to Henry DeVries
  - Requires 50-59 points out of possible 110 points



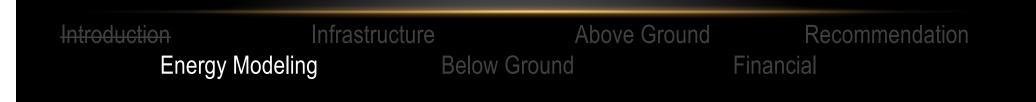


# LEED POINT CATEGORIES

- 6 categories
  - Sustainable Sites
  - Water Efficiency
  - Energy and Atmosphere
  - Materials and Resources
  - Indoor Environmental Quality
  - Innovation in Design



LEED Core Concepts and Strategies Online Couse

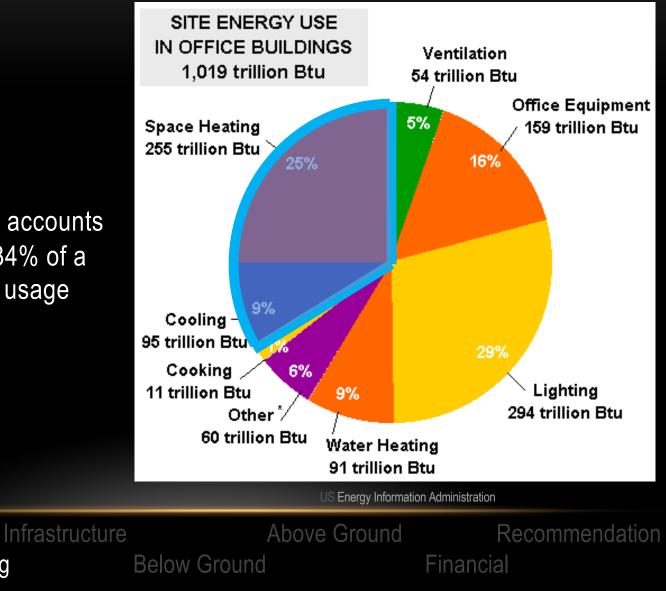


## ENERGY CONSUMPTION BREAKDOWN

Heating and Cooling accounts for approximately 34% of a building's energy usage

**Energy Modeling** 

Introduction



# ON-SITE RENEWABLE ENERGY LEED POINTS

Percentage Renewable Energy	Points
1%	1
3%	2
5%	3
7%	4
9%	5
11%	6
13%	7
From LEED 2009 for New Constructions and Major Renova	tions

FIGHT LEED 2009 TOT NEW COnstructions and Major Re

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# IMPORTANCE OF HEATING/COOLING LOADS

- "Load" is the heat that must be removed in the summer and added in the winter.
- Prevent oversized/undersized HVAC system
- Directly affect the progress of other teams.





# CALCULATION METHOD

# Started with calculations from KHvR geothermal suite

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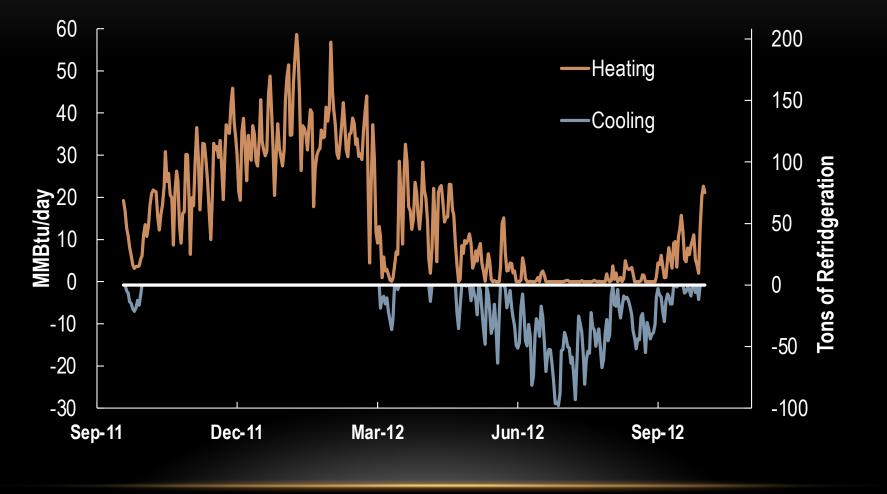
Energy Modeling

Below Ground

Financial

Made additions

### DAILY HEATING & COOLING REQUIREMENTS



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Recommendation

## HEATING & COOLING LOADS BEST ESTIMATE

- Heating: 174 Tons
- Cooling: 86 Tons
- Tons are a standard unit of heating and cooling: 1 ton = 12,000 Btu/hr



# FINAL ANSWERS

• How will a geothermal system contribute to achieving LEED certification?

Above Ground

Recommendation

Financial

• 7 points towards the goal of 50

Infrastructure

Energy Modeling Below Ground

- What are the heating & cooling loads for the West Wing addition?
  - Heating: 174 Tons
  - Cooling: 86 Tons

Introduction

# INFRASTRUCTURE

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Infrastructure

Above Ground

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Energy Modeling

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## **TEAM MEMBERS**







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#### m Infrastructure Energy Modeling

Below Ground

Above Ground

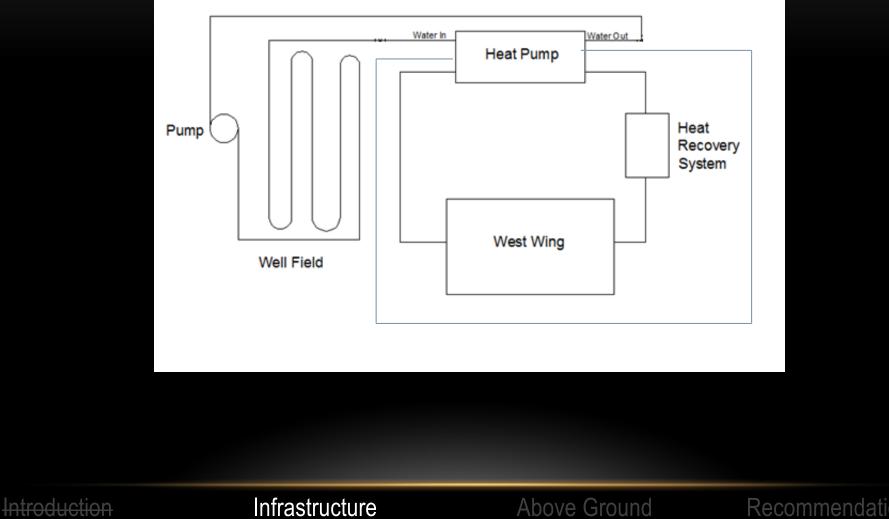
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# **KEY QUESTIONS**

- How will the geothermal system fit in at Calvin College?
- What type of loop configuration will be used?
- Where will the geothermal ground loop be located?

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#### INTEGRATED SYSTEM

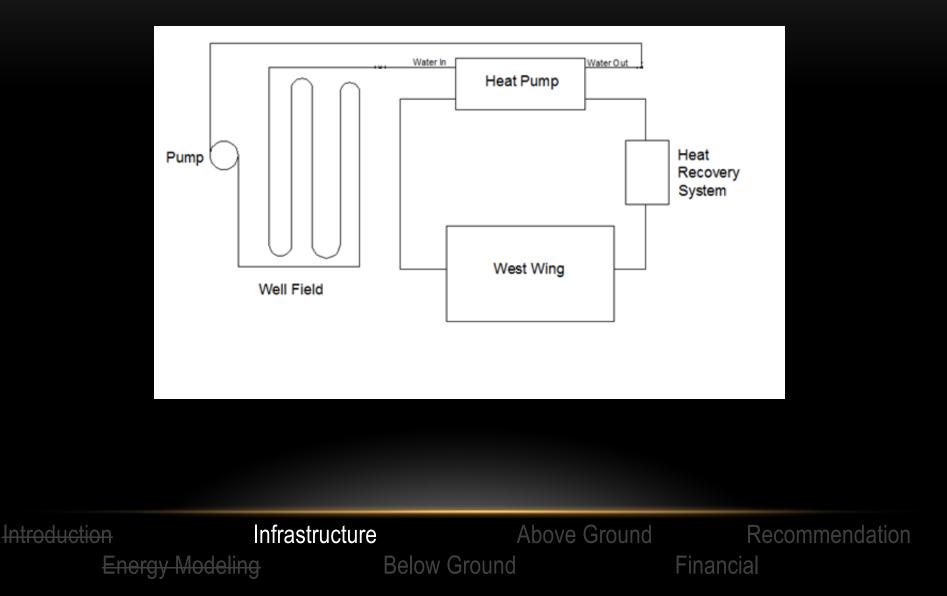


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#### STAND ALONE SYSTEM



## POND LOOP



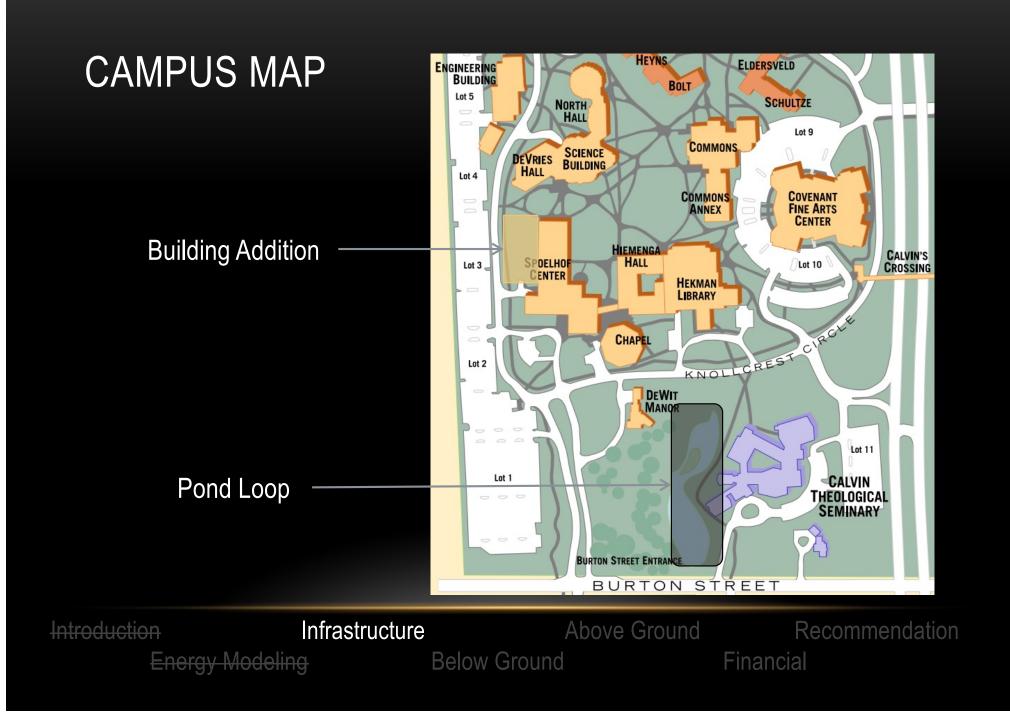
http://www.fhp-mfg.com/files/images/common/coupCx03.jpg

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#### HORIZONTAL LOOP

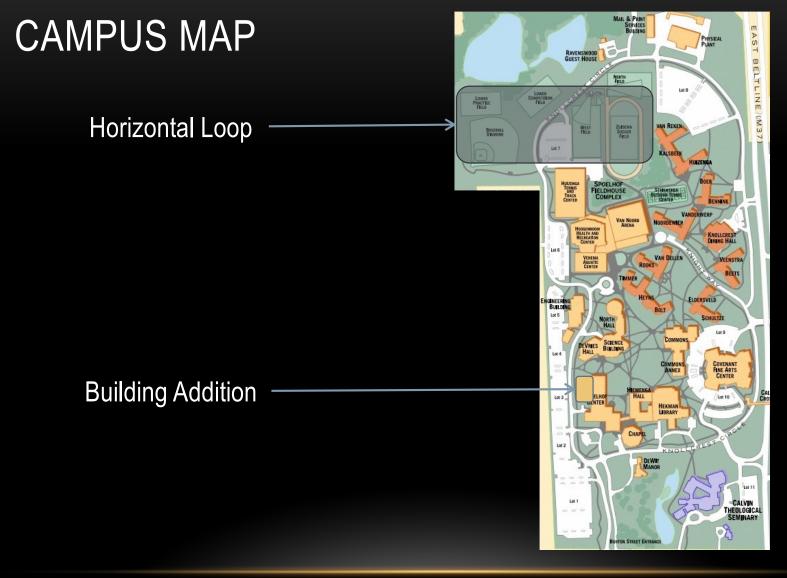


http://www.fhp-mfg.com/files/images/common/coupCx02.jpg

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### VERTICAL LOOP



http://www.fhp-mfg.com/files/images/common/coupCx01.jpg

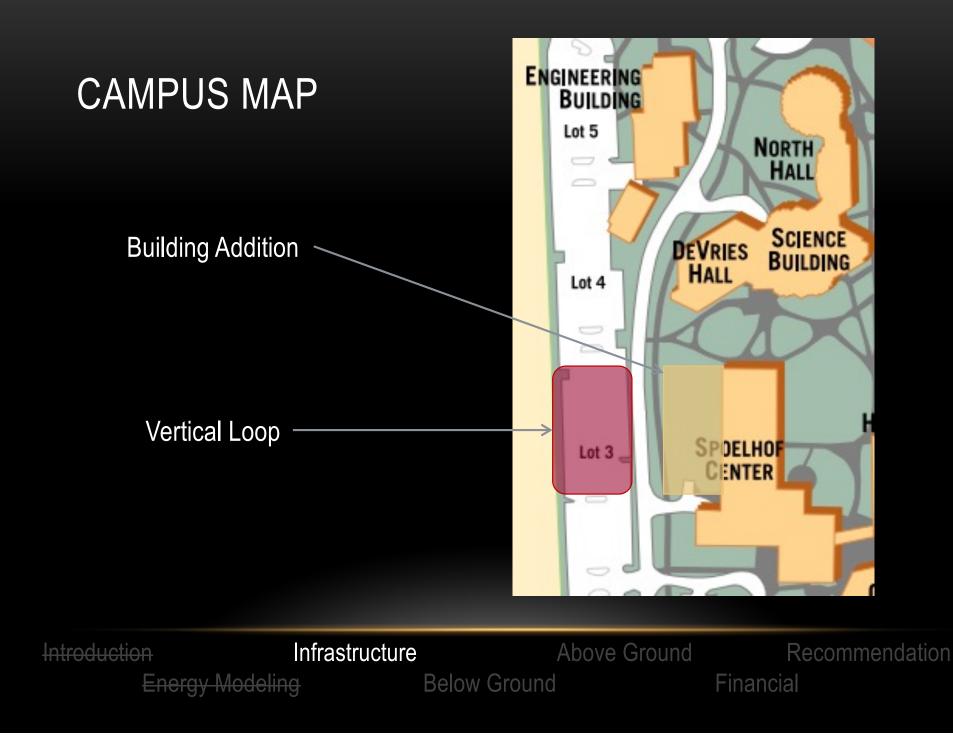
Introduction

#### Infrastructure

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Energy Modeling



# ANSWERS

- How will the geothermal system fit in at Calvin College?
  - Mechanical Separation
- What type of loop configuration will be used?
  - Vertical
- Where will the geothermal ground loop be located?
  - West Parking Lot

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# **BELOW GROUND**

Introduction

Infrastructure

Above Ground

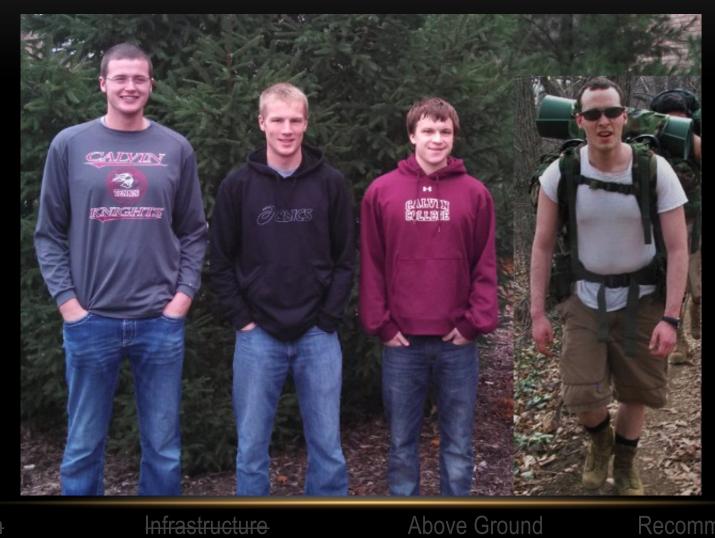
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### **TEAM MEMBERS**

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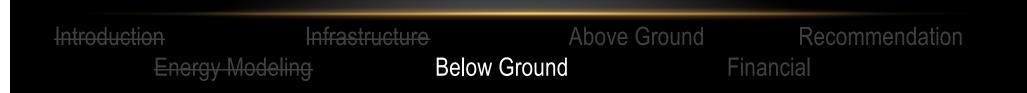
Infrastructure

**Below Ground** 

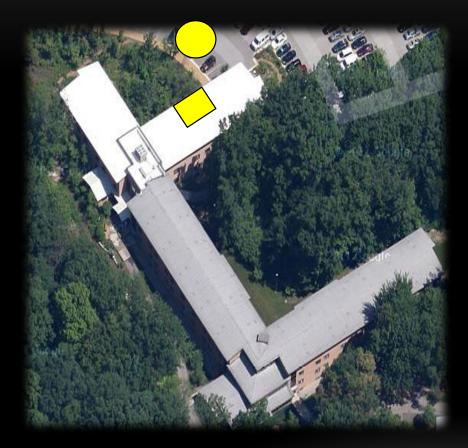
Recommendation Financial

# **KEY QUESTIONS**

- What is the Design of the Borefield?
  - How many bores?
  - How deep?
  - How far apart?
  - Will local geology affect the design?
  - How much will it cost?
  - How long will it last?



# KHVR GEOTHERMAL INSTALLATION



https://maps.google.com/maps?q=calvin+college&aq=f&sugexp=chrome,mod%3D0&um=1&ie=UTF-8&hl=en&sa=N&tab=wl

**Energy Modeling** 

Cleanly Cooling Calvin (Senior Design 2008)

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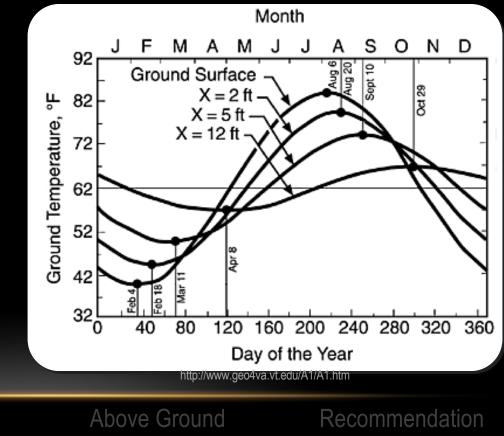
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# THERMAL MODELING - INITIAL

Infrastructure

- Factors to account for:
  - Temperature Gradient vs. Constant Ground Temperature
  - Soil Composition/Location



Energy Modeling

Introduction

**Below Ground** 

Financial

#### THERMAL MODELING - INITIAL SUMMARY

- Heating Load: 140 ton
- Borehole Depth: 300 420 feet
- Number of Boreholes: 175 200



#### **REFINED BOREFIELD DESIGN**



http://mwgeothermal.com/

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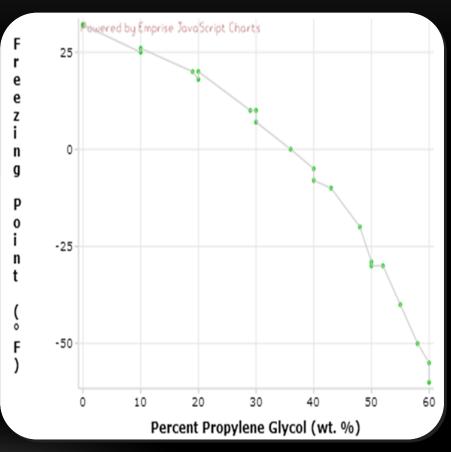
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## **REFINED BOREFIELD DESIGN**

- Thermal Conductivity: 1.35 Btu/hr-ft-°F
- Operating Fluid: Water/Glycol Mix
- Bore Feet needed to accommodate loads
  - 28,447 feet
- Effective Bore Feet
  - 33,180 feet



http://www.xydatasource.com/xy-showdatasetpage.php?datasetcode=234654&dsid=67



n Infrastructure Energy Modeling

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#### PROPOSAL

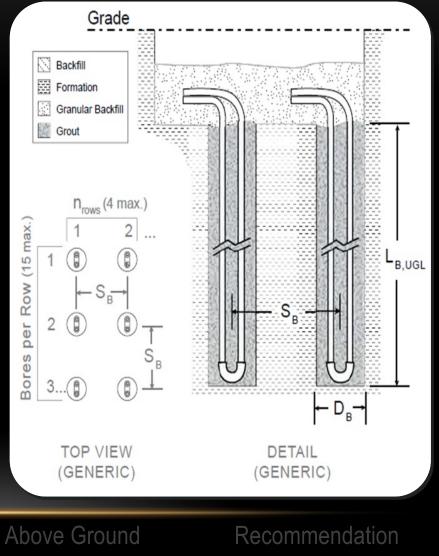
- What is the Design of the Borefield?
  - How many bores?
    - 88 bore holes
  - How deep?
    - 400 feet deep (L<sub>B</sub>)
  - How far apart?
    - 20 feet center-to-center (S<sub>B</sub>)

Infrastructure

• Additional Details:

Introduction

- 5 inch bores (D<sub>B</sub>)
- 1.25 inch HDPE pipe



**Energy Modeling** 

**Below Ground** 

Financial

## **REFINED BOREFIELD DESIGN**

- How must will it cost?
  - Total Installation Costs = **\$478,720** 
    - \$13.60/bore feet
    - Pipe Costs
    - Site Costs
- How long will it last?
  - Economic Life
    - 50 years



# ABOVE GROUND

#### **TEAM MEMBERS**



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## **KEY QUESTIONS**

- What system should be selected to meet the HVAC demands of the new addition?
  - Water to Air vs Water to Water?
  - Centralized vs Distributed System?
  - Energy Recovery Ventilation?



## SYSTEM REQUIREMENTS

- Heating/Cooling Loads
  - Heating Load: 174 Tons
  - Cooling Load: 86 Tons
- Ventilation Requirements
  - Estimated Air Flow Required: 48,000 cfm
    - Michigan Mechanical Codes/ASHRAE Standards

Application	Estimated Maximum Occupancy (people/1000 ft <sup>2</sup> )	Outdoor Air Requirements		
		cfm/person	cfm/ft <sup>2</sup>	
Offices				
Office space	7	20		
Reception areas	60	15		
Telecommunication centers and data entry areas	60	20		
Conference rooms	20	20		

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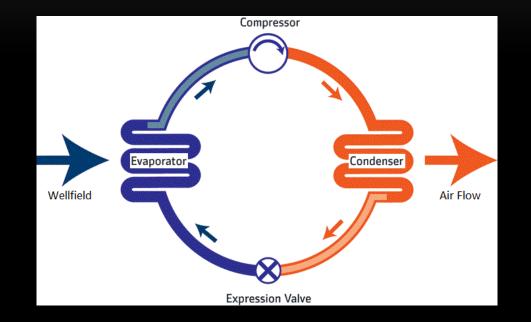
Energy Modeling

**Below Ground** 

Financial

Recommendation

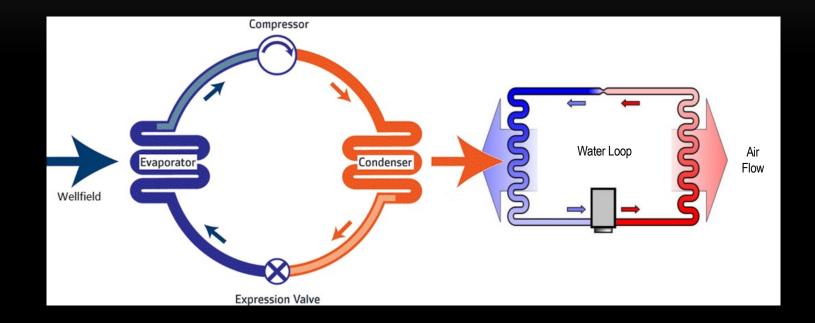
#### WATER TO AIR vs WATER TO WATER SYSTEMS



- Ventilation System
- Lower Cost



#### WATER TO AIR vs WATER TO WATER SYSTEMS



- Ventilation System
- Lower Cost

- Air Handlers and Radiators
- Higher Cost

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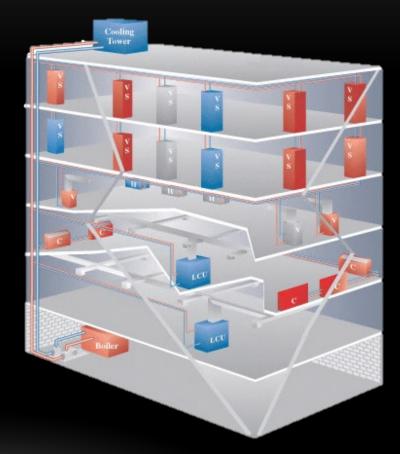
#### CENTRALIZED vs DISTRIBUTED SYSTEMS



http://csmdetroit.com/yahoo\_site\_admin/assets/images/3200\_8.345123502\_large.jpg



http://4mechanical.com/wp-content/uploads/2011/09/Ductwork1.jpg



http://www.geo4va.vt.edu/A3/A3.htm

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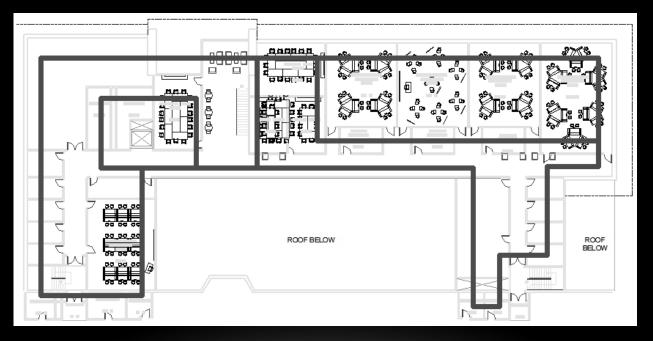
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#### HEAT PUMP SELECTION



## DUCTWORK

- Estimated Length of Ducts Required: 5800ft
  - Cost of Installation and Purchase: \$54,000



Ductwork diagram (third floor)



# ENERGY RECOVERY VENTILATION (ERV)

- Ventilation unit that preheats or precools incoming air using exiting air streams
  - Increases efficiency of the system by roughly 20%
  - Additional cost: \$400,000



http://www.renewaire.com/index.php/products/commercial-products/he8xrt

Above Ground

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#### RECOMMENDATION

- Centralized, Water to Air System
- 175 Ton rooftop heat pump (Trane)
- Energy Recovery Ventilation System
- Total Cost: \$1,300,000





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# FINANCIAL GROUP

#### **TEAM MEMBERS**



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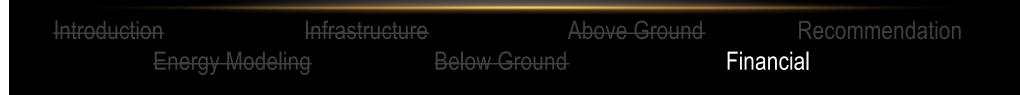
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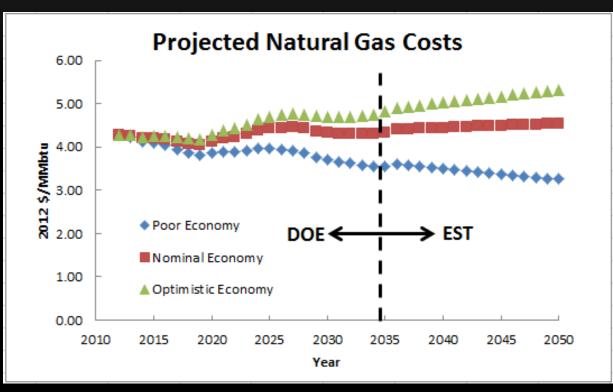
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## **KEY QUESTION**

Is a geothermal system a financially viable option for the West Wing addition?



#### NATURAL GAS PRICES

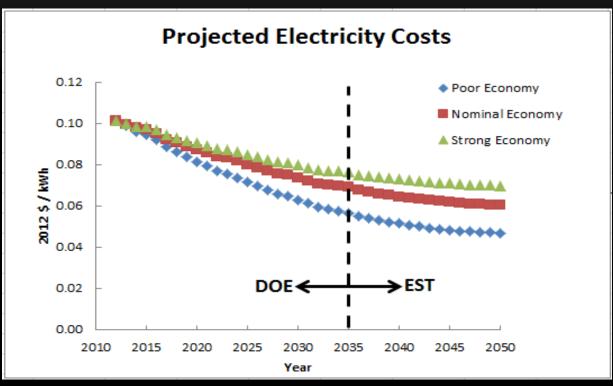


http://www.eia.gov/forecasts/archive/aeo11/source\_natural\_gas.cfm

- 2012-2035: Data from Department of Energy
- 2035- : Data projected based on best-fit trends

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#### ELECTRICITY PRICES



http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2012&subject=0-AEO2012&table=8-AEO2012&region=0-0&cases=ref2012-d020112

- 2012-2035: Data from Department of Energy
- 2035- : Data projected based on best-fit trends

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# INITIAL COSTS

Geothermal S	ystem					
Initial Costs		Conventional HVAC System				
Borefield Cost	\$	478,720	Initial Co	osts		
Piping/Pumps Cost	\$	10,000	Ductwork Cost	1	\$	53,806
Heat Pump Cost	\$	1,240,000	Air Handler Cost		\$	150,000
Total Cost	\$	1,728,720	Total Cost	(	S	203,806

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# ENERGY COSTS

#### • GEOTHERMAL

- Based on Heating/Cooling Loads and pump usage
- Total Energy Required: 562,040 (kWh/yr)

- CONVENTIONAL HVAC
  - Heating Load: 7,316 (MMBtu/yr)
  - Cooling Load: 143,808 (kWh/yr)
  - Total Energy Required: 2,288,350 (kWh/yr)

Geothermal Heating COP	3.68
Geothermal Cooling EER	21.39

Conventional HVAC Heating Eff.	80%
Conventional HVAC Cooling EER	10

http://www.duke-energy.com/pdfs/110371-HVAC-Whitepaper.pdf

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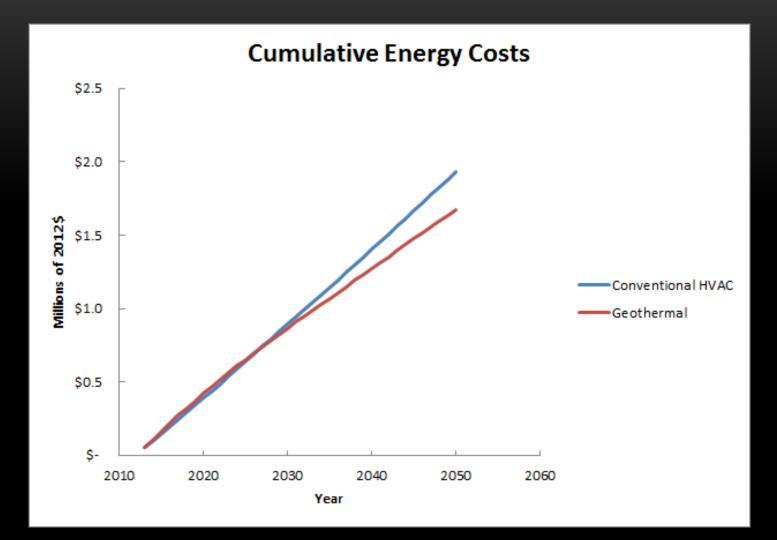
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(optimistic economic conditions)



#### MAINTENANCE COSTS

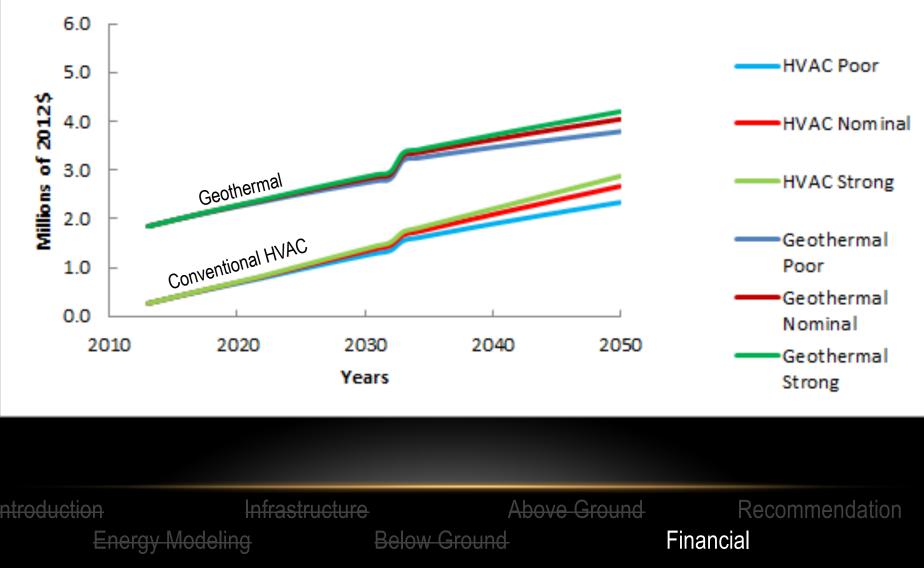
- GEOTHERMAL
  - \$9,000 per year (ASHRAE)
  - Heat Pump replacement after 20 yrs.
- CONVENTIONAL HVAC
  - \$15,000 per year
  - Air Handler replacement after 20 yrs.

Annual Maintenance (\$/yr)	9000	Annual Maintenance (\$/yr)	15000
Later Maintenance (\$/yr)	13500	Later Maintenance (\$/yr)	22500
Heat Pump Replacement Cost (\$)	336000	Air Handler Replacement Cost (\$)	150000

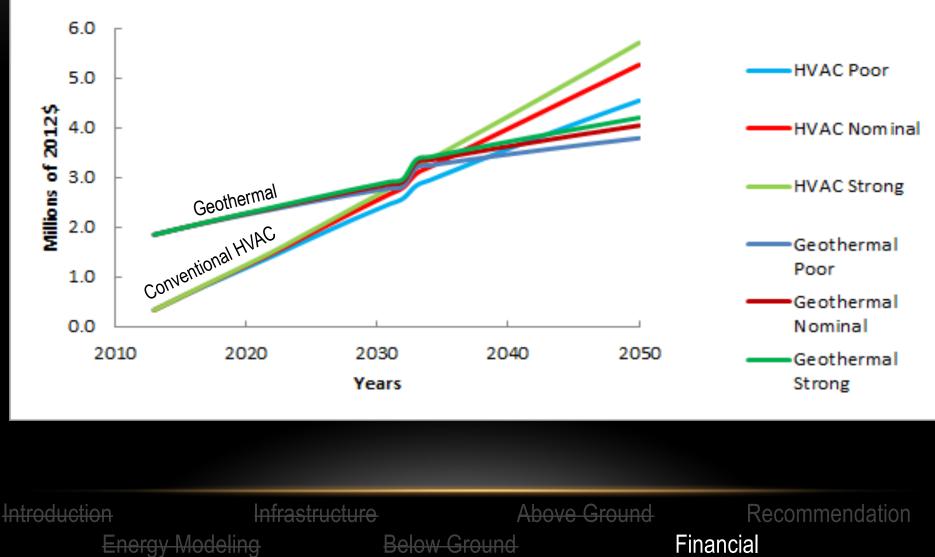
Later Maintenance: costs increase by 50% after 10 yrs.



#### **Cumulative Costs**



#### Cumulative Costs (High Natural Gas Prices)



#### FINANCIAL PROPOSAL

- As Christians, we have a calling to be stewards of Creation and Money (Luke 14:28-30, 1 Corinthians 4:7)
- There is no foreseeable financial payback
- From a solely financial standpoint, the financial group recommends a geothermal system not be constructed until such time as:
  - Natural gas prices rise dramatically
  - Entire campus considered



#### FINAL RECOMMENDATION – ENGR. 333 CLASS

#### **Geothermal Advantages**

- Reduce energy costs
- Lower maintenance costs
- Promotes stewardship of creation
- Contributes to LEED certification
- Small scale example of possible campus wide geothermal
- Enhancement of college image

#### **Proposal: Utilize existing HVAC system**

#### Geothermal Disadvantages

- High initial cost
- Additional construction site well field
  - Coordinate with parking lot construction

#### ACKNOWLEDGEMENTS

Class Advisors

- Trent DeBoer
- Henry DeVries
- Professor Heun
- Paul Pennock

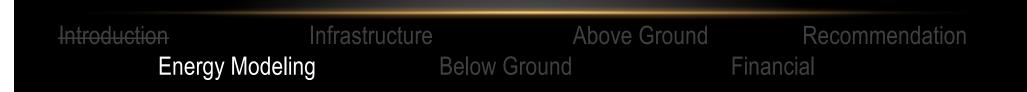
Additional Help

- Phil Beezhold
- Scott Skoog & Kortney Lull, Midwest Geothermal
- Dan Pabst
- Dean Anderson
- Dan Slager

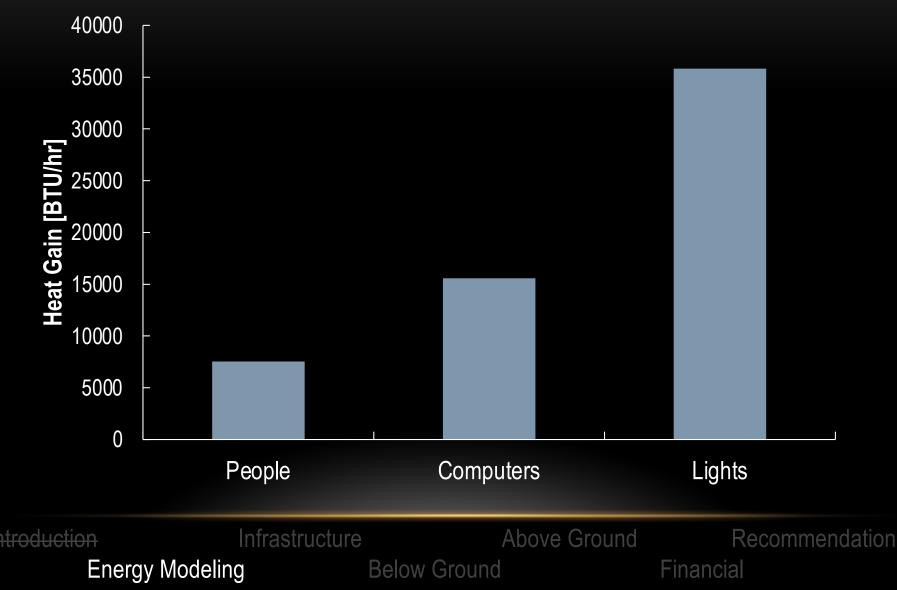
# QUESTIONS

#### HEAT GAINS

- Several factors also provide heat gain to a building
  - Occupants (1 person produces around 400 BTU/day)
  - Equipment in rooms (computers, projectors, etc)
  - Lighting



#### Heat Gains



# EXTERNAL FUNDING

- Direct external funding (tax refunds/incentives) are unavailable as Calvin College is a tax-exempt entity
- However, according to Scott Skoog of Midwest Geothermal, indirect incentives are a possibility.
- In this case, an architect/engineering firm can apply for a tax deduction for designing or building an energy saving building for a non-profit or government agency.
- In this way, the firm saves money on designing/building Calvin's geothermal, and partially passes these savings on to Calvin.

# CALVIN ENERGY RECOVERY FUND (CERF) UTILIZATION

- CERF is a revolving fund used to improve energy efficiency and decrease carbon emissions.
- CERF is currently growing by investing in smaller scale projects (lighting, computer shutdown)
- The scale of this project vs. CERF's budget (~\$65,000) seems to be a bad fit.
- Recommendation: Don't utilize CERF in this project