Geothermal Optimization: Planning and Design HAGeotherm01

Presented to:
KZF
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Presented by:
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Course Description

This course will review and discuss in detail planning and design criteria necessary to support the proper application and optimization of geoexchange systems.

Learning Objectives

1. Understand the types of geoexchange systems and decision making criteria for choosing one over another.

2. Understand how to integrate geoexchange into the typical design process for a successful outcome.

3. Understand how complimentary HVAC building loads, site conditions and integrated system design can be used to optimize geoexchange systems.

4. Understand how *SmartSizing* impacts Life Cycle Cost benefit analysis for geoexchange systems.

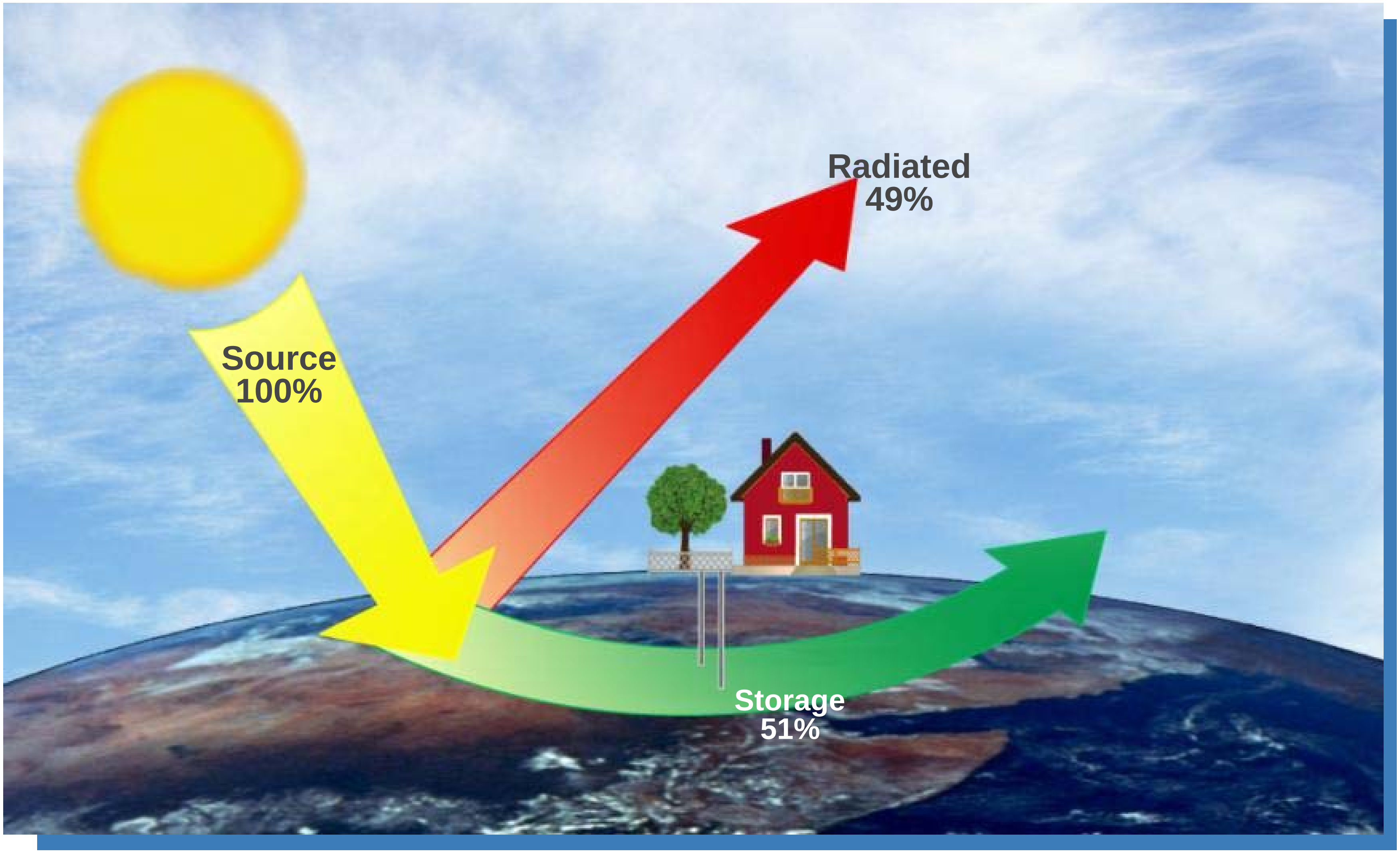
Outline for Today

- Geothermal Geoexchange Basics
- Fitting Geothermal in Design Process
- Important Inputs
- Building and Geology Influences
- Case Studies

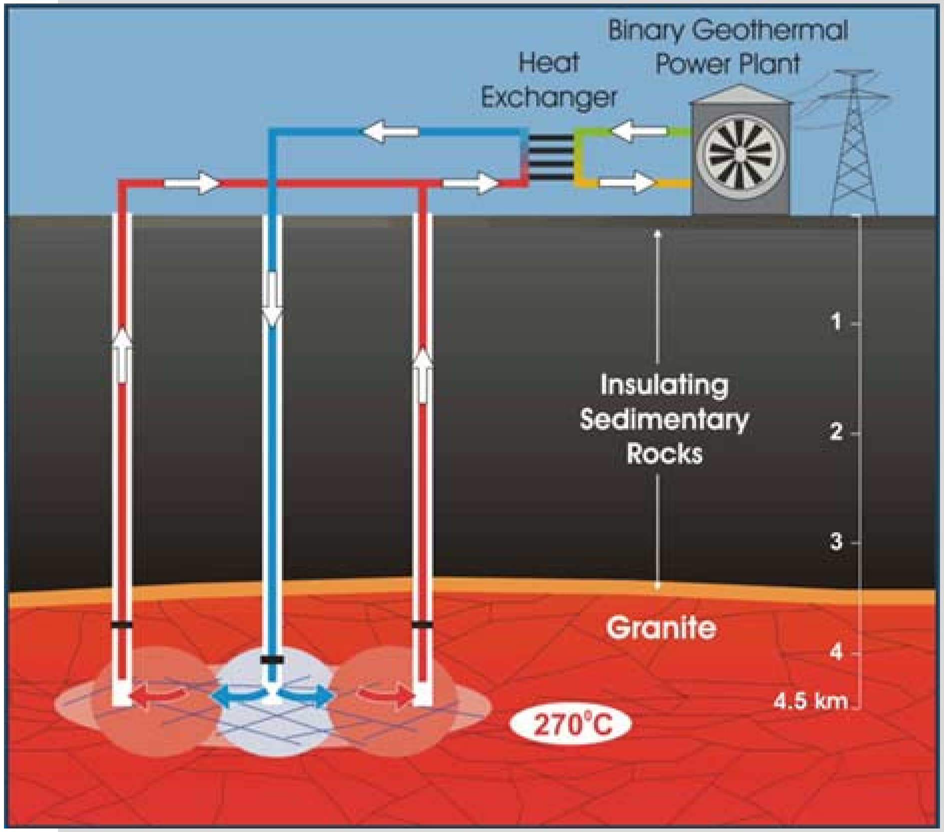
Audience Poll….

- What are your big questions relating to applying geothermal?
- Where do you think Geothermal is applicable?

The Earth – A Thermal Battery



Klamath Falls, Oregon

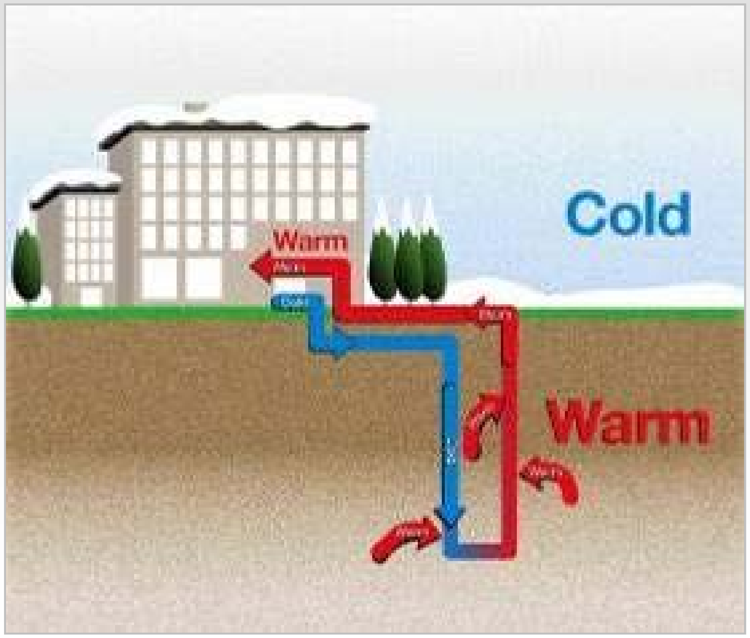


Source: treehugger.com

Ground Source Heat Pump Basics

HEATING

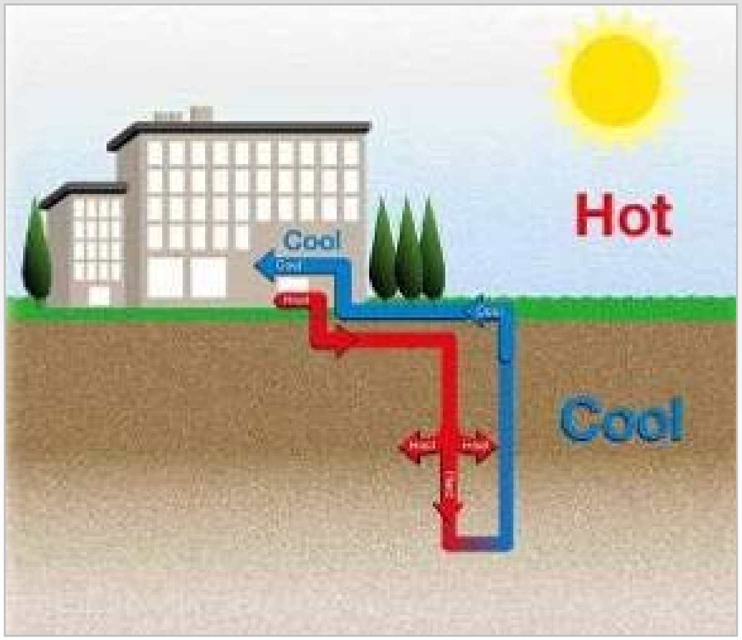
Heat source for ground source heat pumps to extract heat



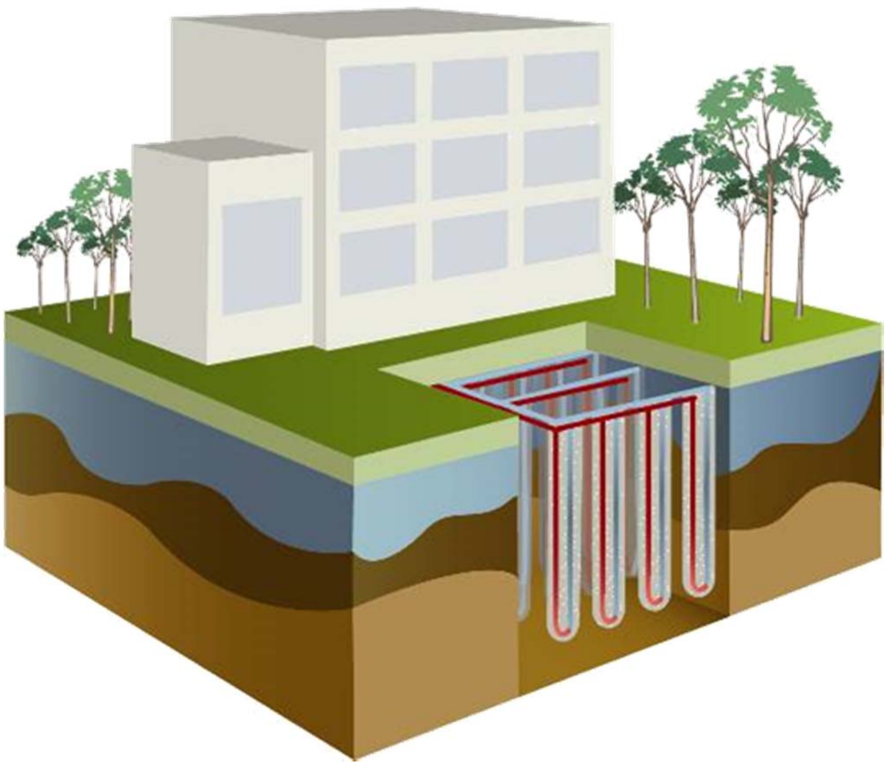
VS.

COOLING

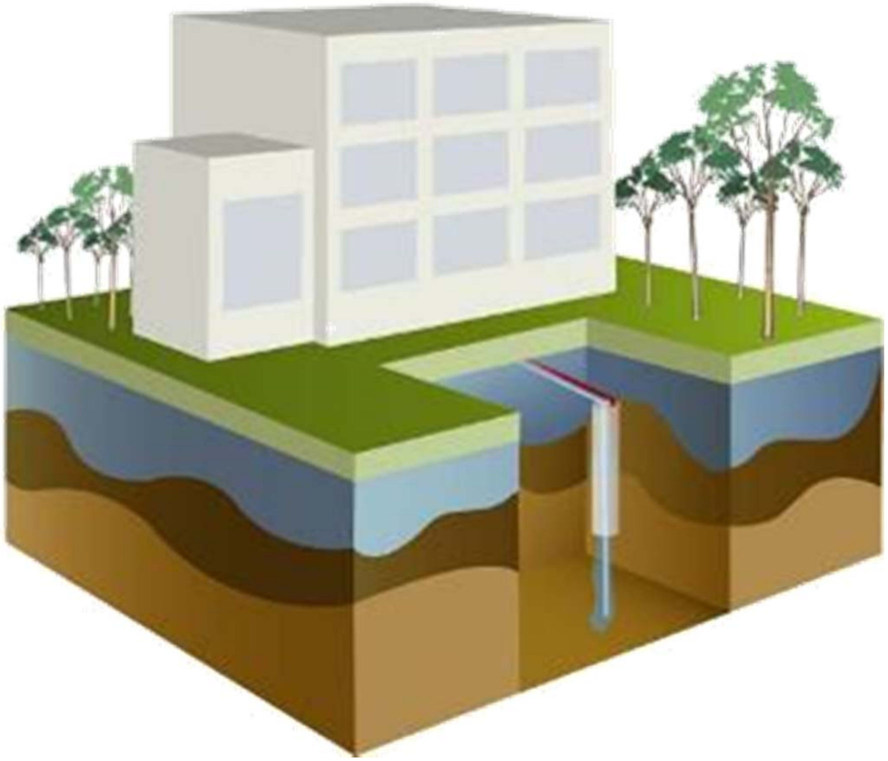
Heat sink for ground source heat pump to inject heat

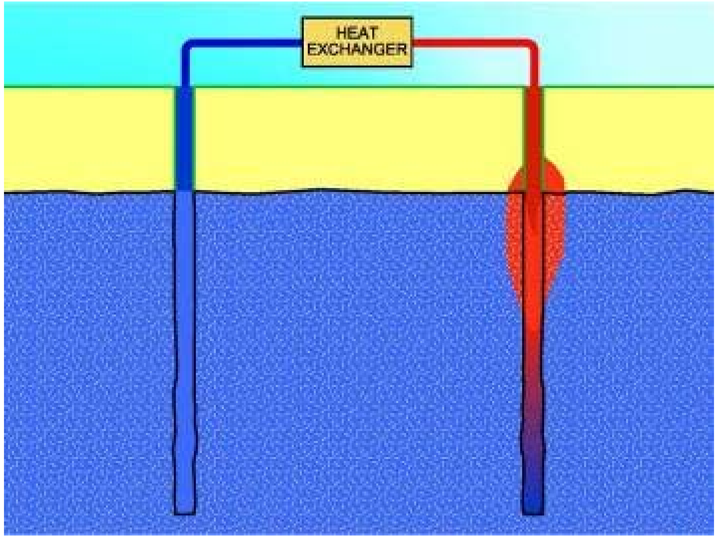


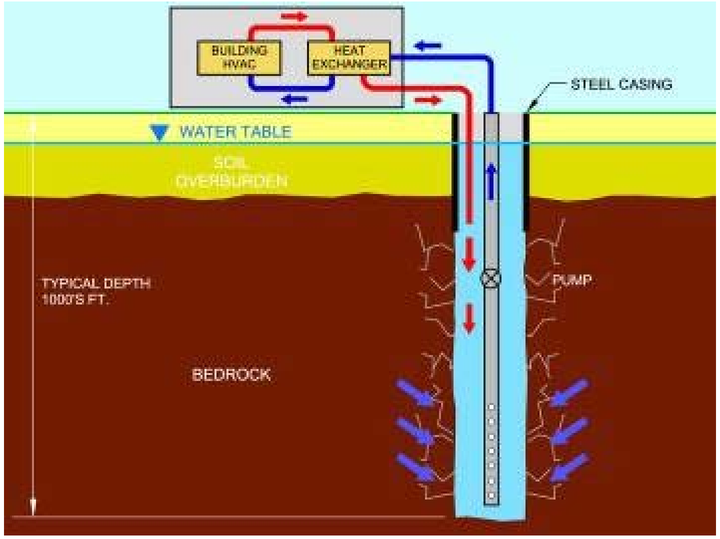
Closed Systems



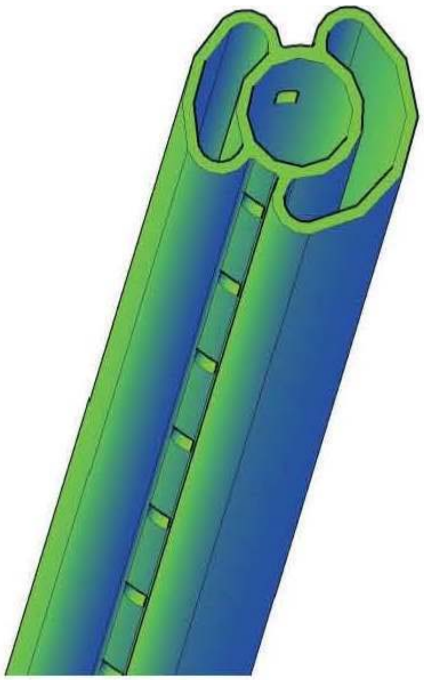
Open Systems



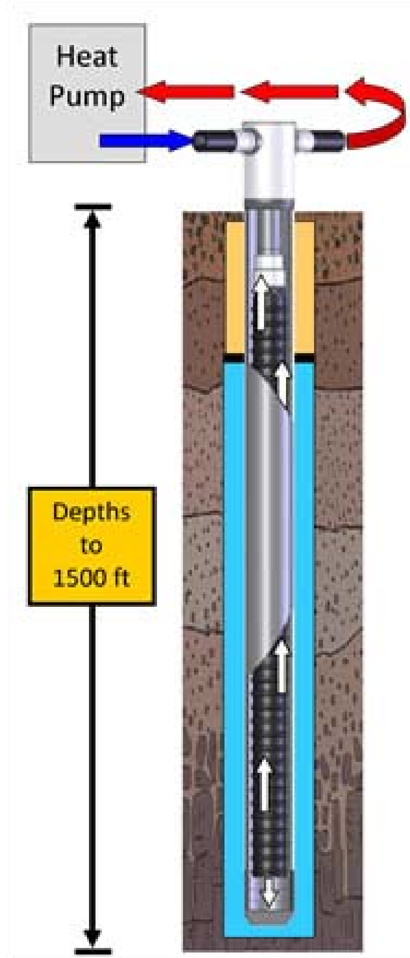




New Well Designs



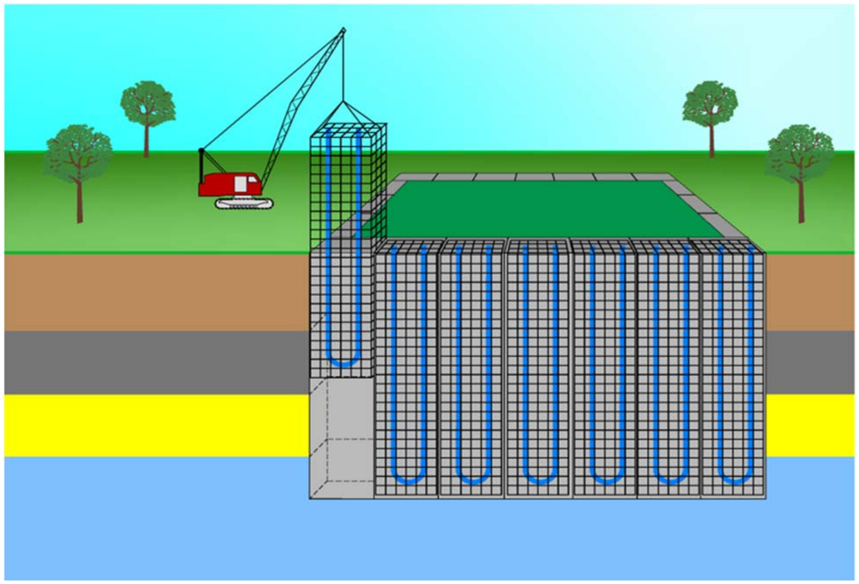
Hardin Geotechnologies



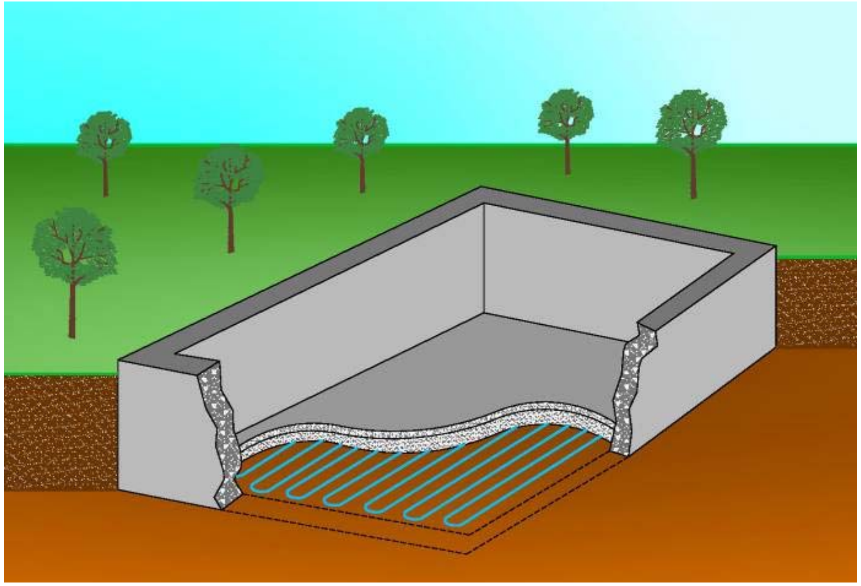
HPGX RYGAN Green Made Easy

REHAU
Unlimited Polymer Solutions

Integrate into Foundations



In Slurry Wall



Loop Under Foundation Slab

Energy Piles and Slabs

Fitting in the D&C process

Conceptual Design
Site Evaluation; System Choices

Schematic Design
Schematic Pricing

Rough ROI

Benefit Quantification

- 6-10 Scenarios
- Non-linear

Design Development
Pilot Thermal Test; Sizing and Modeling

Construction Documents
Specification and Drawings; Final Pricing

Construction and Post Construction
Commissioning, Training, Monitoring

- Chosen Scenario

SmartSizing Geothermal Systems

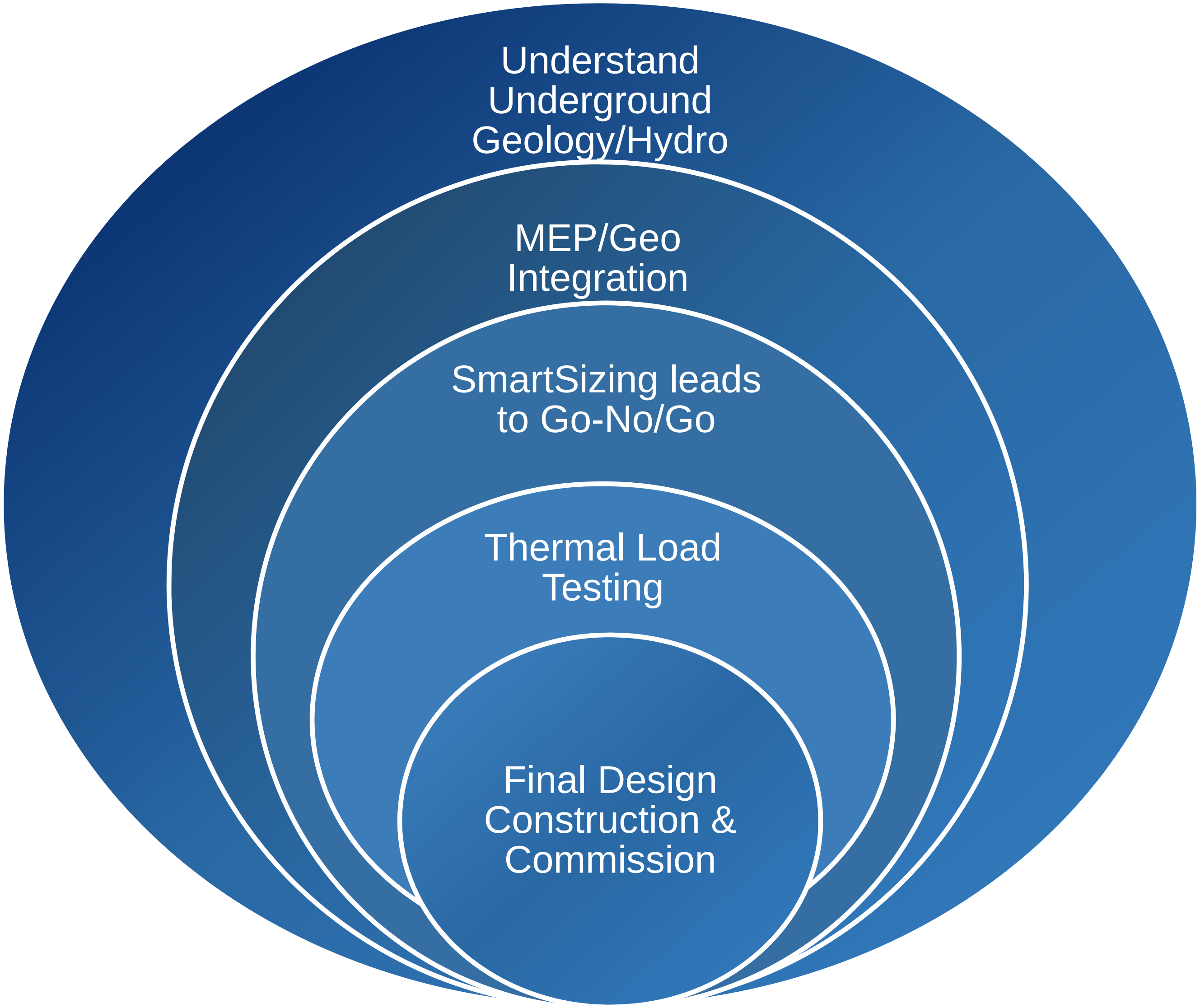
What is *SmartSizing* ?

- A process that explores multiple scenarios
- Find scenario that minimizes number of wells and achieves key benefits

Why *SmartSizing*?

- System cost 20% while providing 80% the same benefits
- Financial returns are greater
  - We minimize number of wells
  - We focus on benefits not “tons”

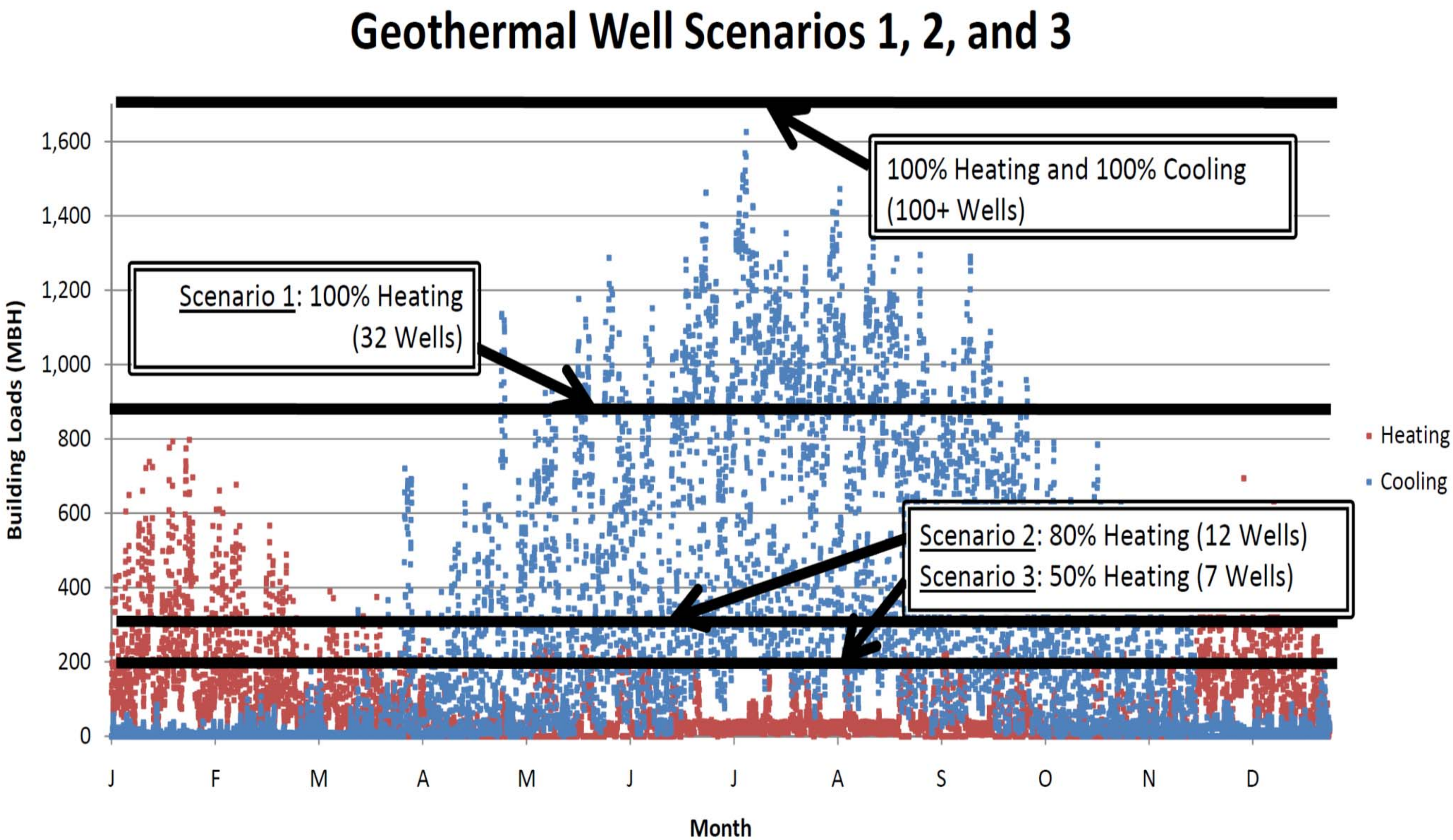
SmartSizing



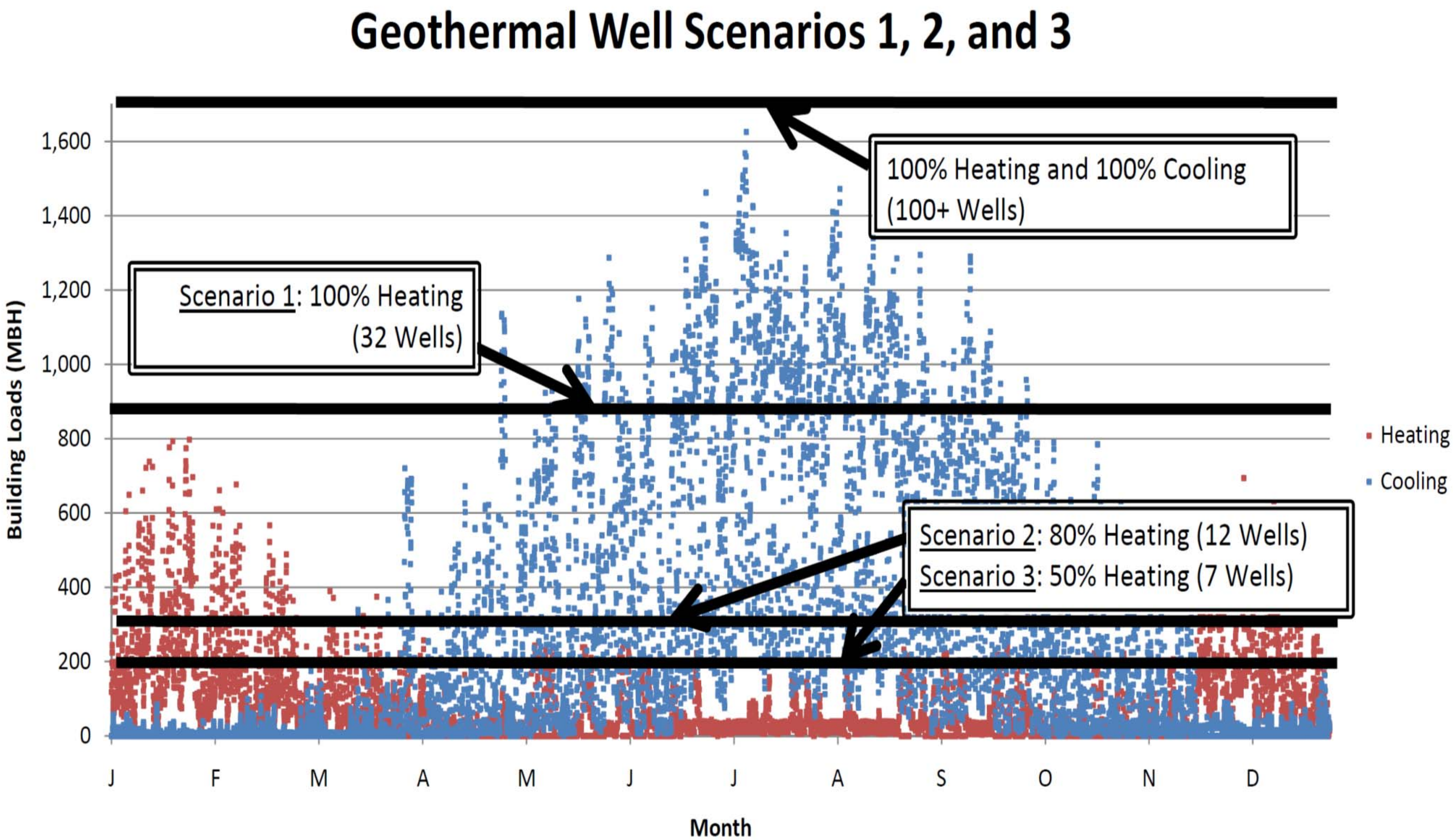
Inputs to Get Started

- Desired Outcome/Goals
- Geology/Hydrogeology
- Building systems/CHP
- Load Profiles
- Building energy models
- Aesthetic Requirements
- Financial Goals
- Underground Structure/Features

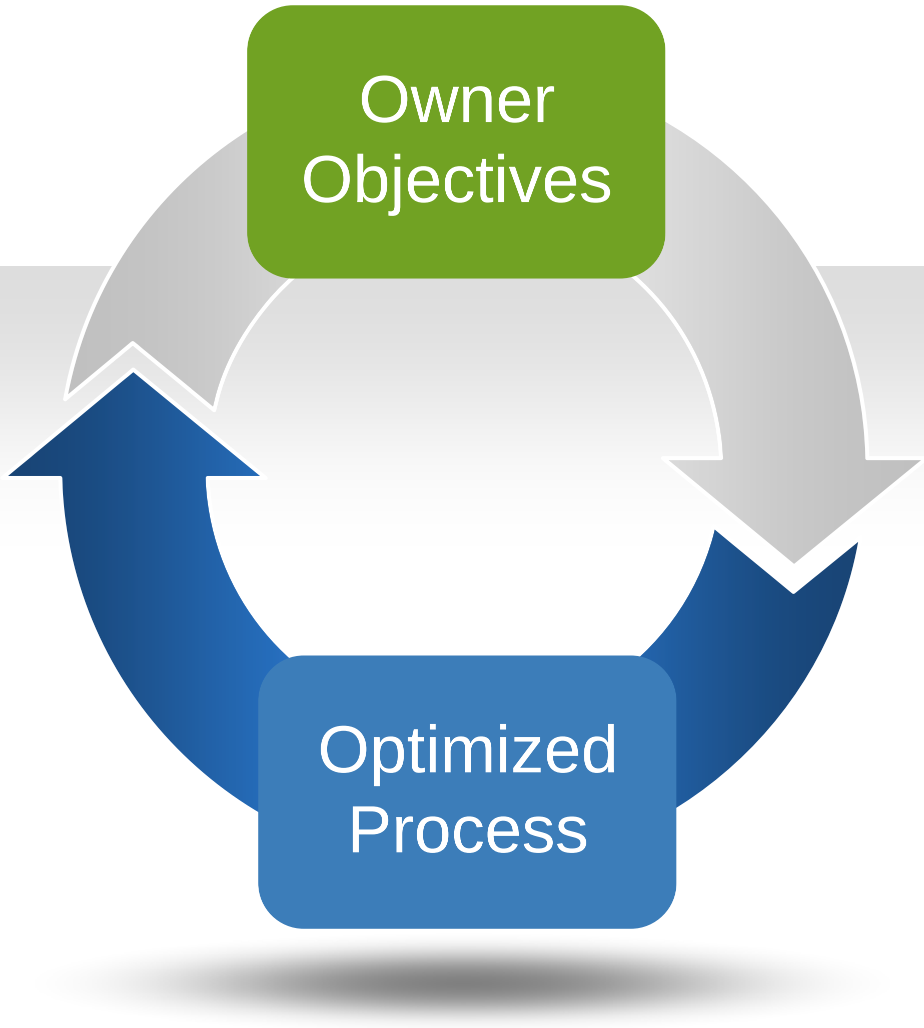
Example of *SmartSizing* Impacts



Building Systems Matter



Benefits: Optimization Pays



Go – No/Go

- 30% No-Go's
- Site Conditions/Regulatory
- Goals and Objectives
- Building Load Profiles
  - Heating/Cooling Centric
  - Non-district
- Space

"Go" influencers

- Existing Heating is Electric, Heating Oil, Steam or Propane
- Net zero; High Performance Buildings
- High Standard; Stretch Code
  - =>30% greater than ASHRAE 90.1 2007
- Historic Retrofit; Preservation
- Aesthetics
- Long term ownership (Life Cycle Cost)
- Residential; Mixed Use; Office

“Go” influencers

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Design & Construction

Conceptual Design
Site Evaluation; System Choices

Schematic Design
Schematic Pricing

Rough ROI

Benefit Quantification

Design Development
Pilot Thermal Test; Sizing and Modeling

Construction Documents
Specification and Drawings; Final Pricing

Construction and Post Construction
Commissioning, Training, Monitoring

Influence: *SmartSizing* > Field Test

Thermal Load Test
- Less influential
- 125 vs. 100 wells

Smart-Sizing
- Major Influence
- 125 vs. 25 wells

Field Testing

- Thermal response testing
- Follow ASHRAE/IGSHPA
- Hydrogeologic testing
- Do early as possible
- Geology can vary in 500’
- “Check” in Plan Do Check Act
- For both open and closed

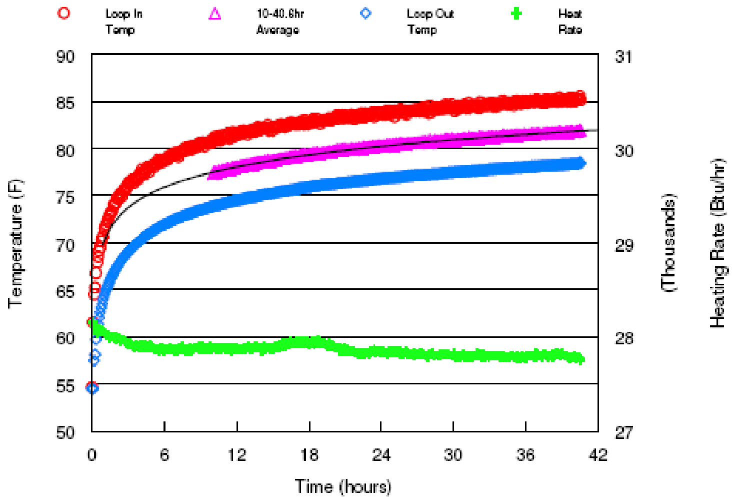
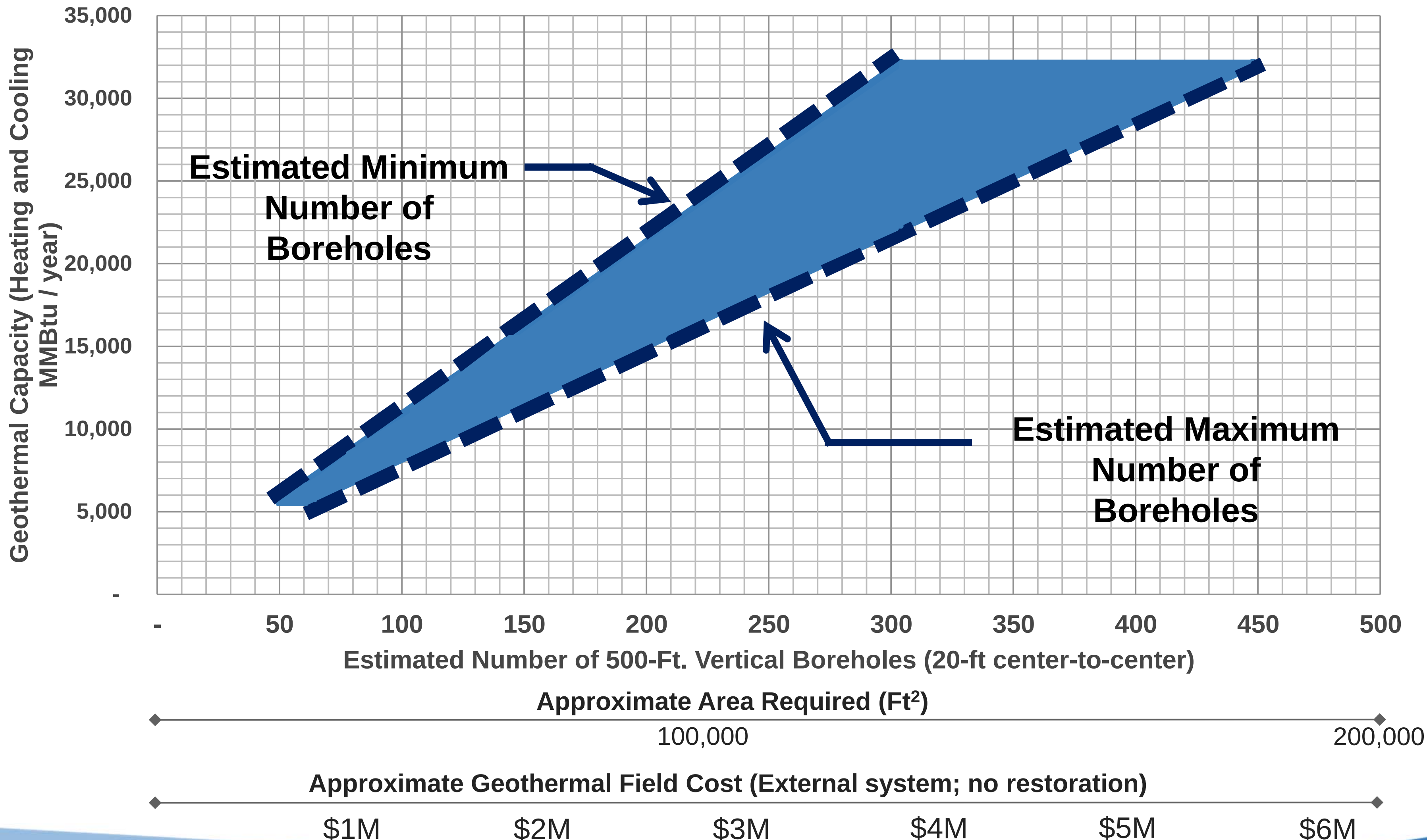


Figure 1: Temperature versus Time Data

Design/Build Delivery

Area Number	Area (sf)	Estimated Number of Boreholes
1	31,200	70
2	8,400	20
3	12,600	25
4	13,200	30
5	40,200	95
6	57,600	140
7	21,600	50
8	60,000	130

Design/Build Area Vs. Capacity Pricing Tools



PHASE III - Construction

- Construction Documents
- Drilling Specification
- High Quality ASTM testing
- Commissioning and Verification
- Third Party Monitoring
- Drilling Water Management

Drilling the Installations

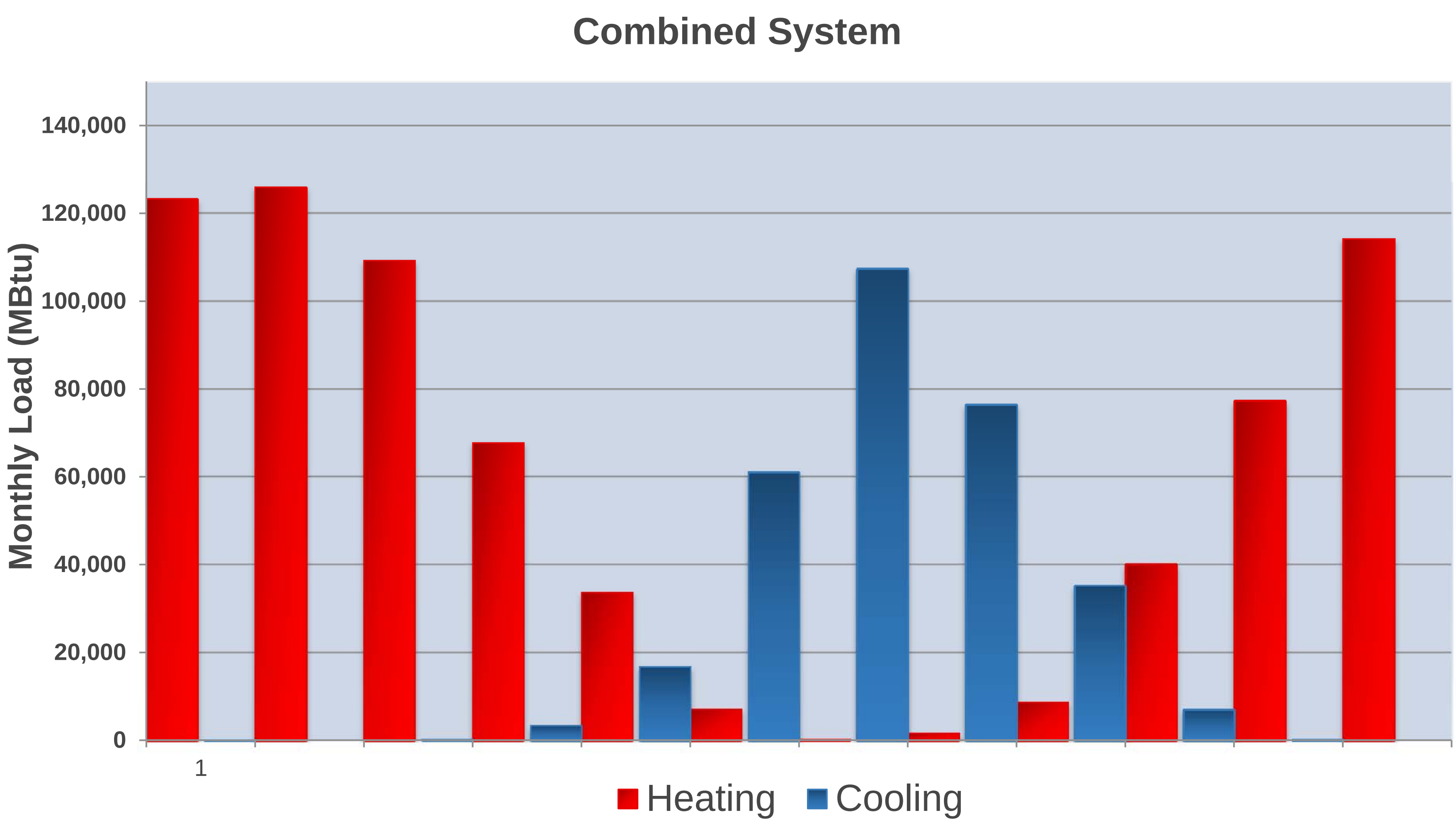
Audience Poll….

- Questions so far?

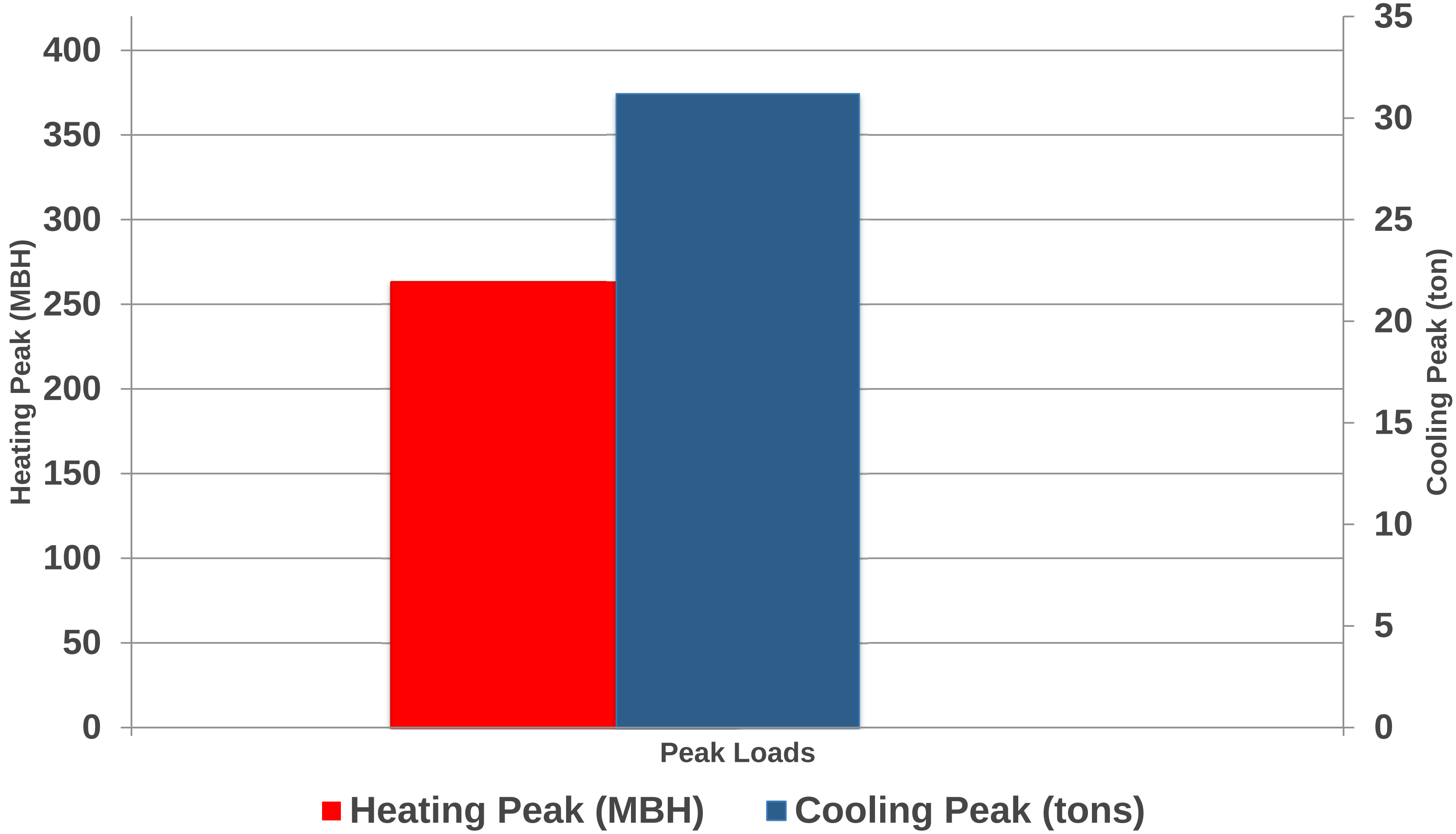
- Experiences related to what we've just covered?

CASE STUDIES

Load Profiles Matter



High End Residential – Size on Bldg Loads



Using Conventional Sizing Rules

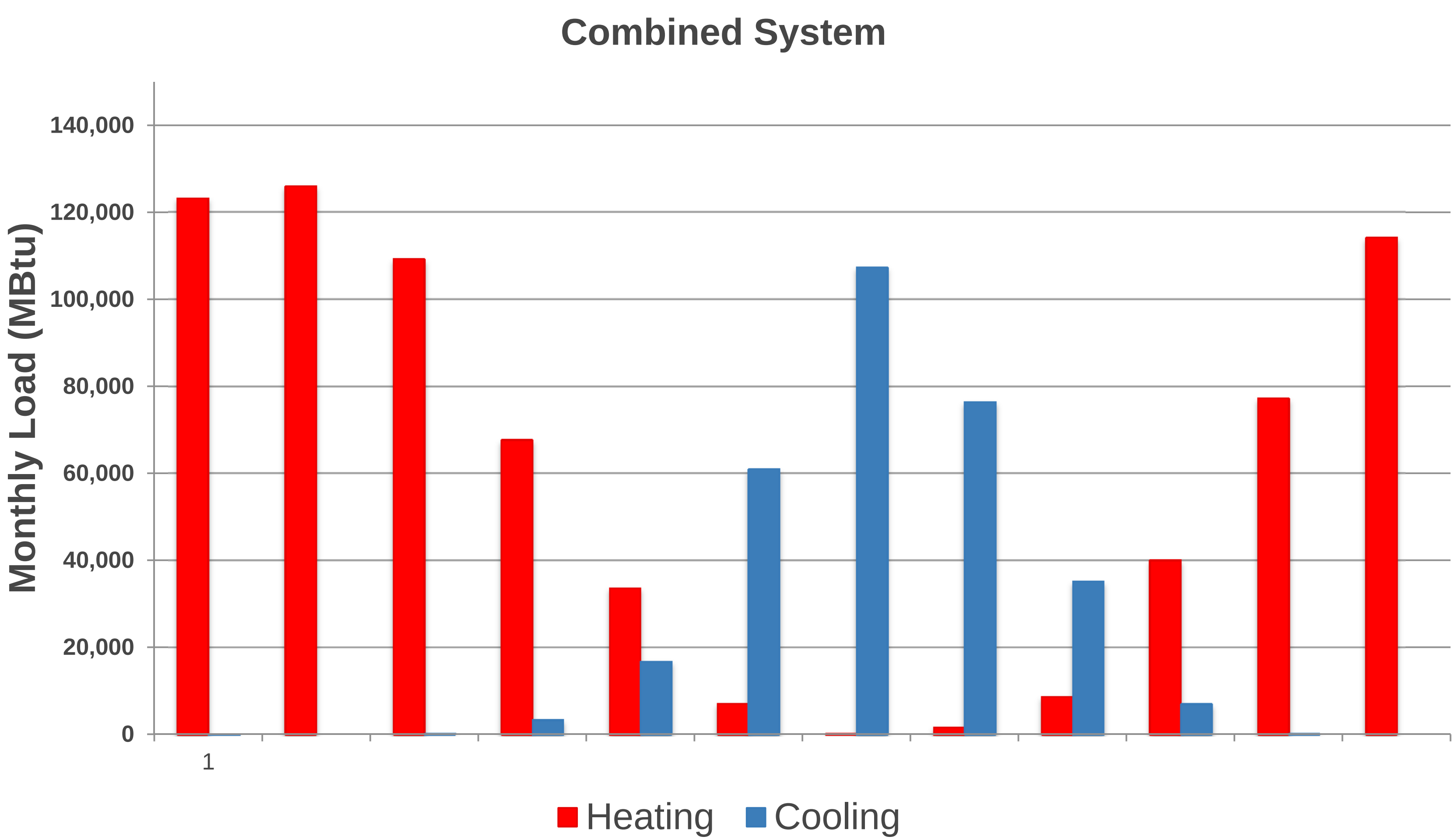
Cooling Load: **31 Tons**

Heating Load: **263 MBH (….22 Tons equivalent)**

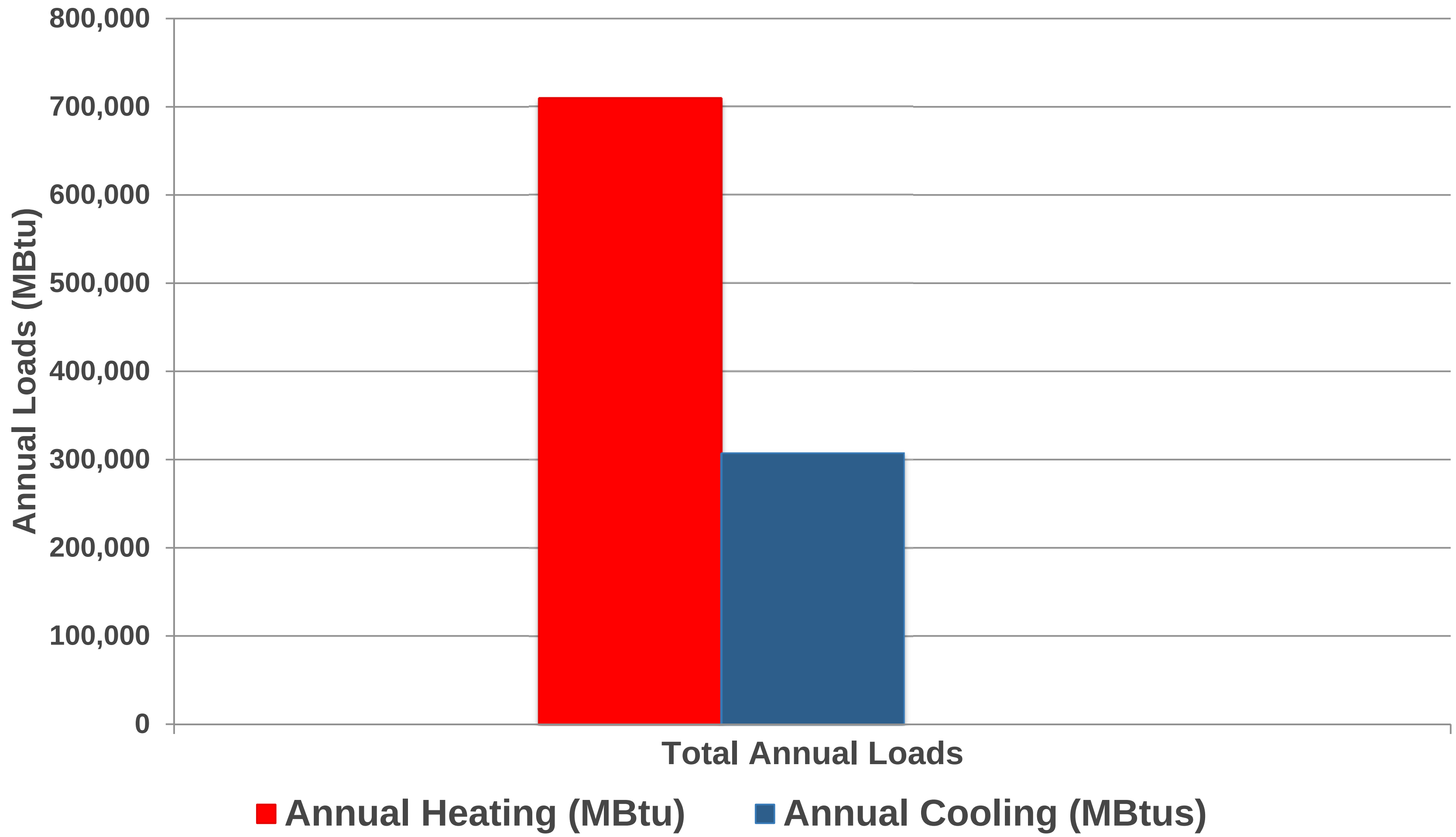
"Cooling Centric"

Rule of Thumb	Number of 400-ft Wells
2 tons/400-ft well	16
3 tons/400-ft well	10

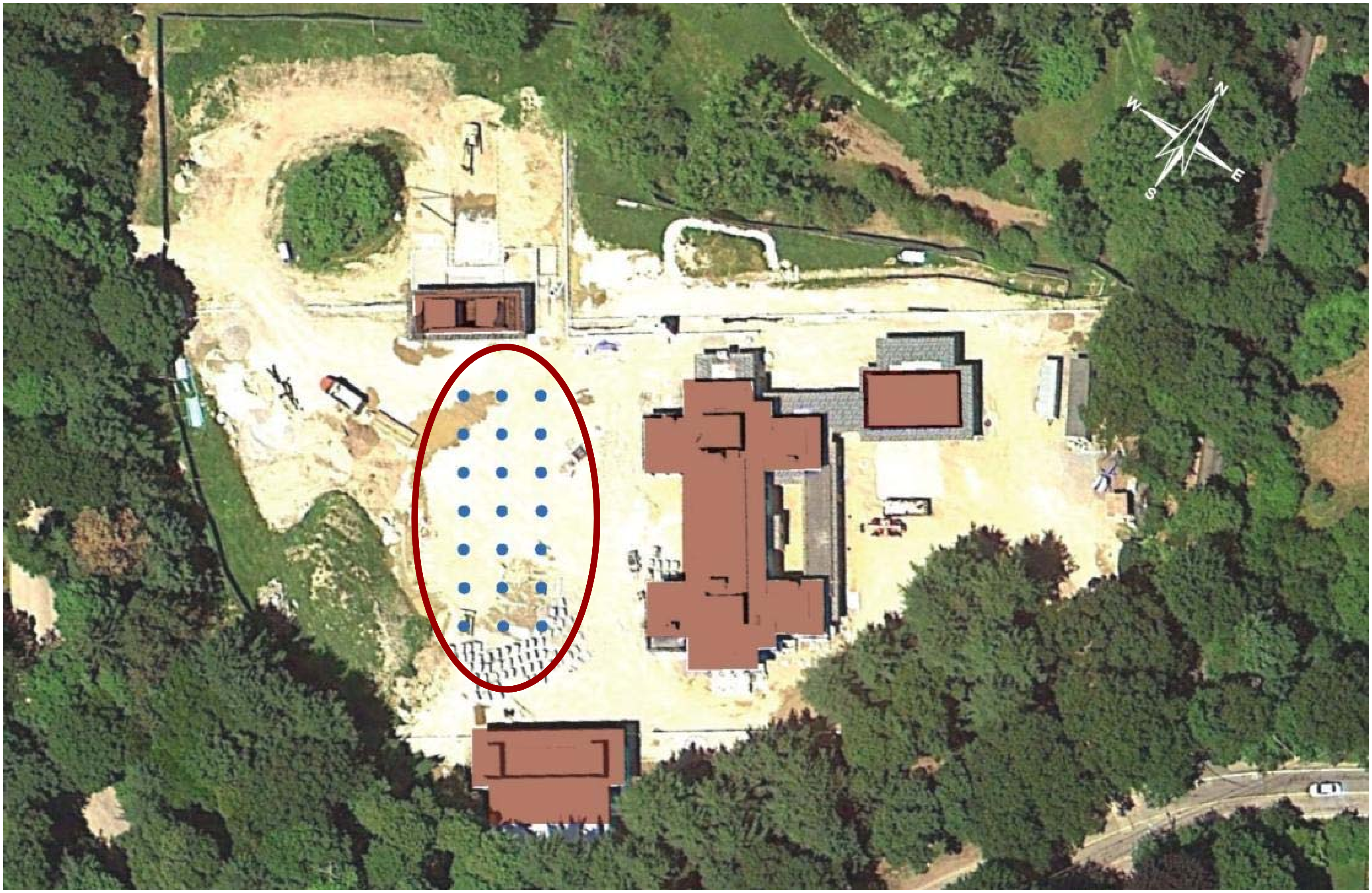
...building is actually ***heating-centric***



Total Loads

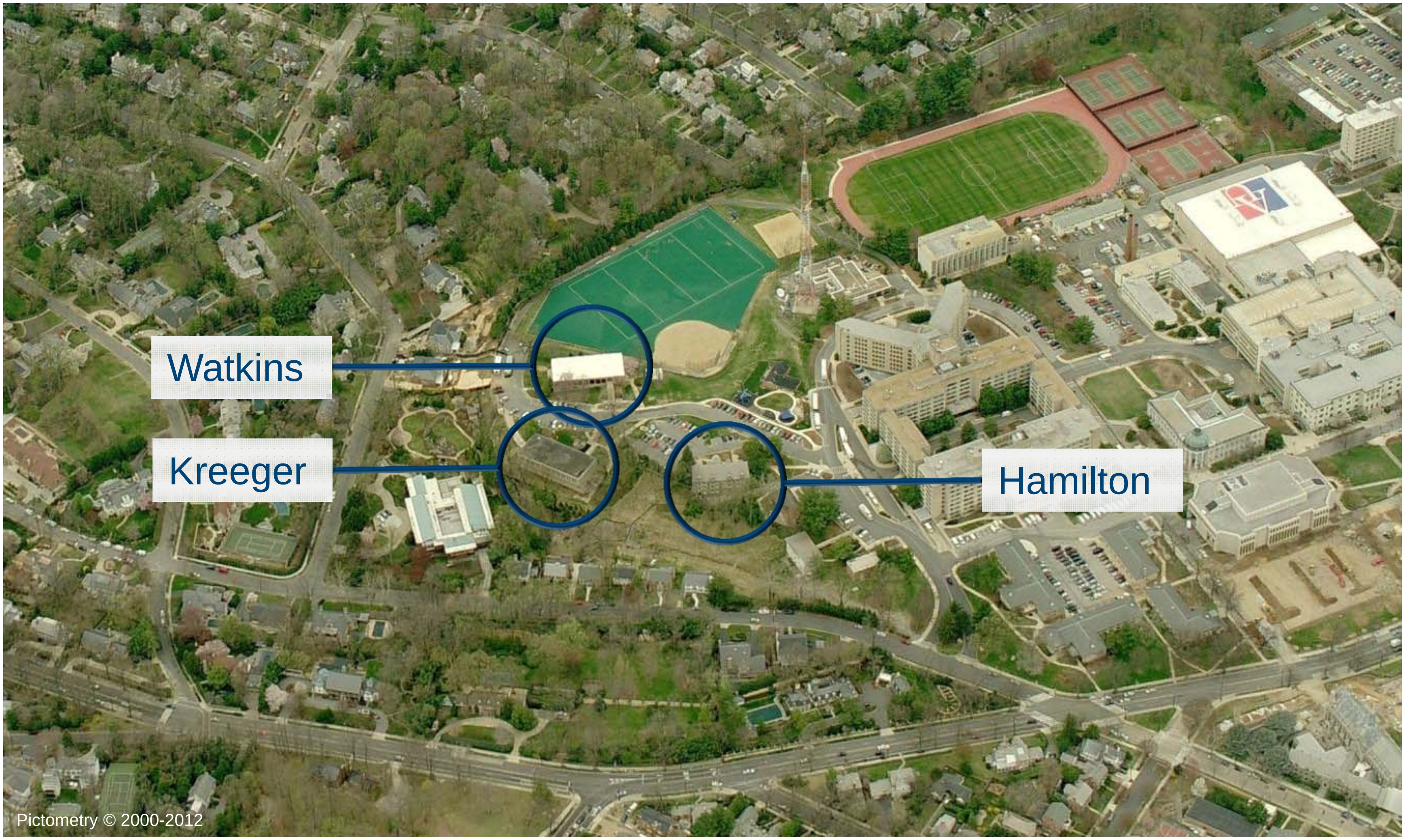

800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Annual Loads (MBtu)
Total Annual Loads
Annual Heating (MBtu)
Annual Cooling (MBtus)

Actual Design: 21 Boreholes > 10-16



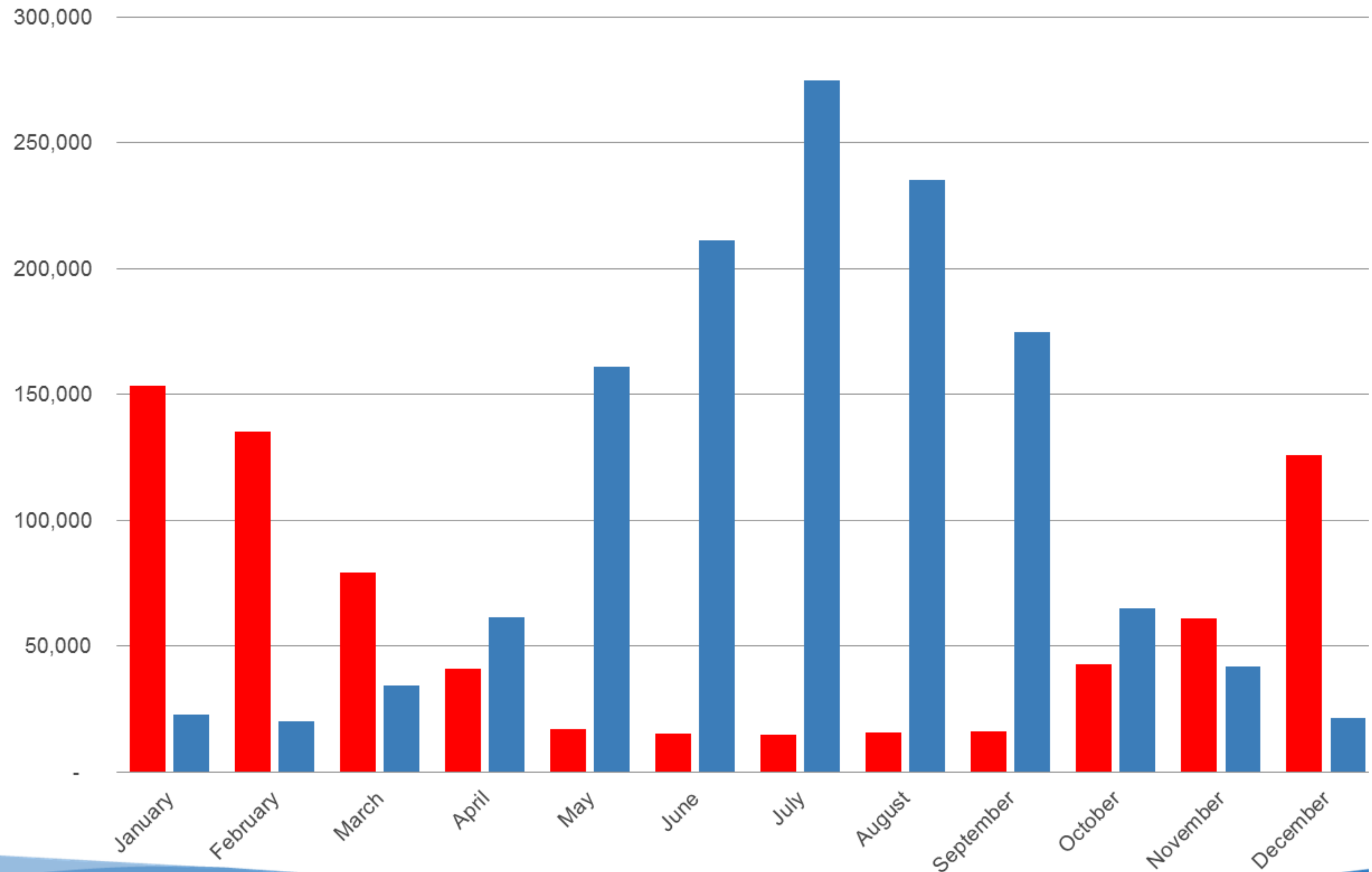
American University

Washington D.C.

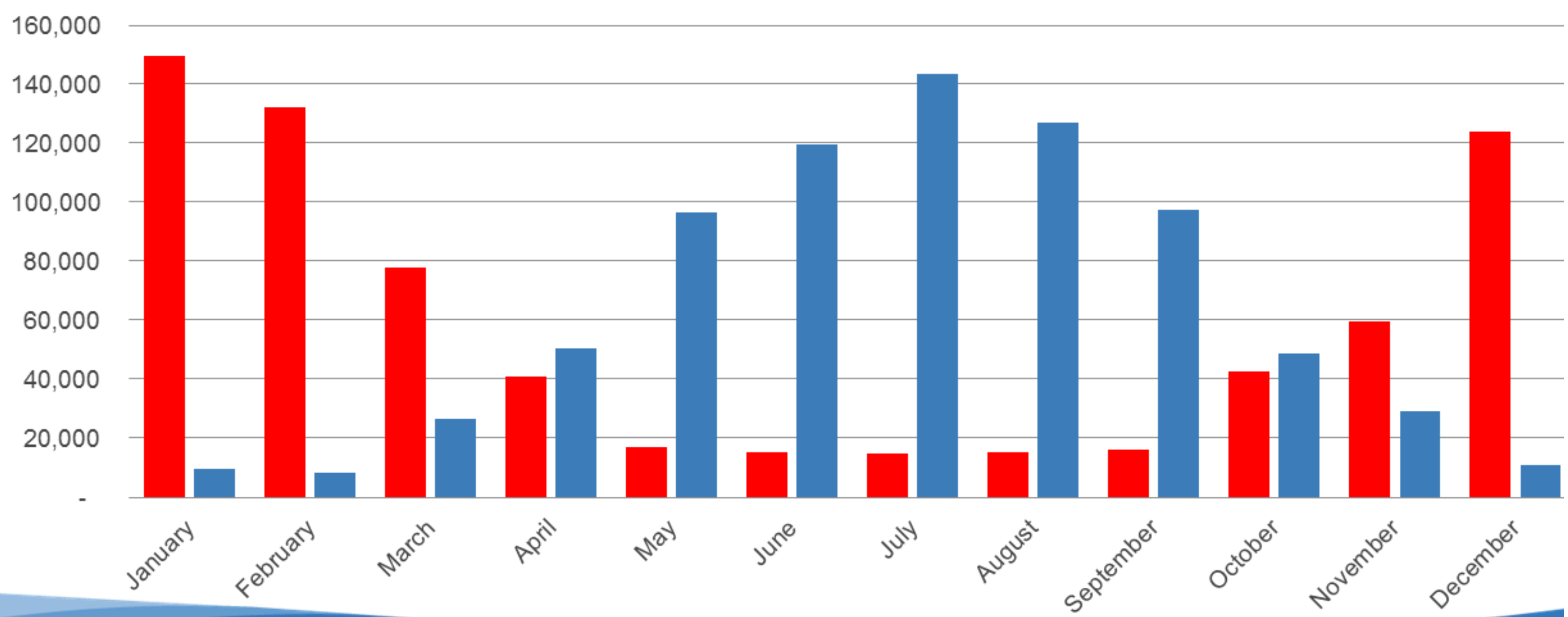


District –

100% Heating and Cooling



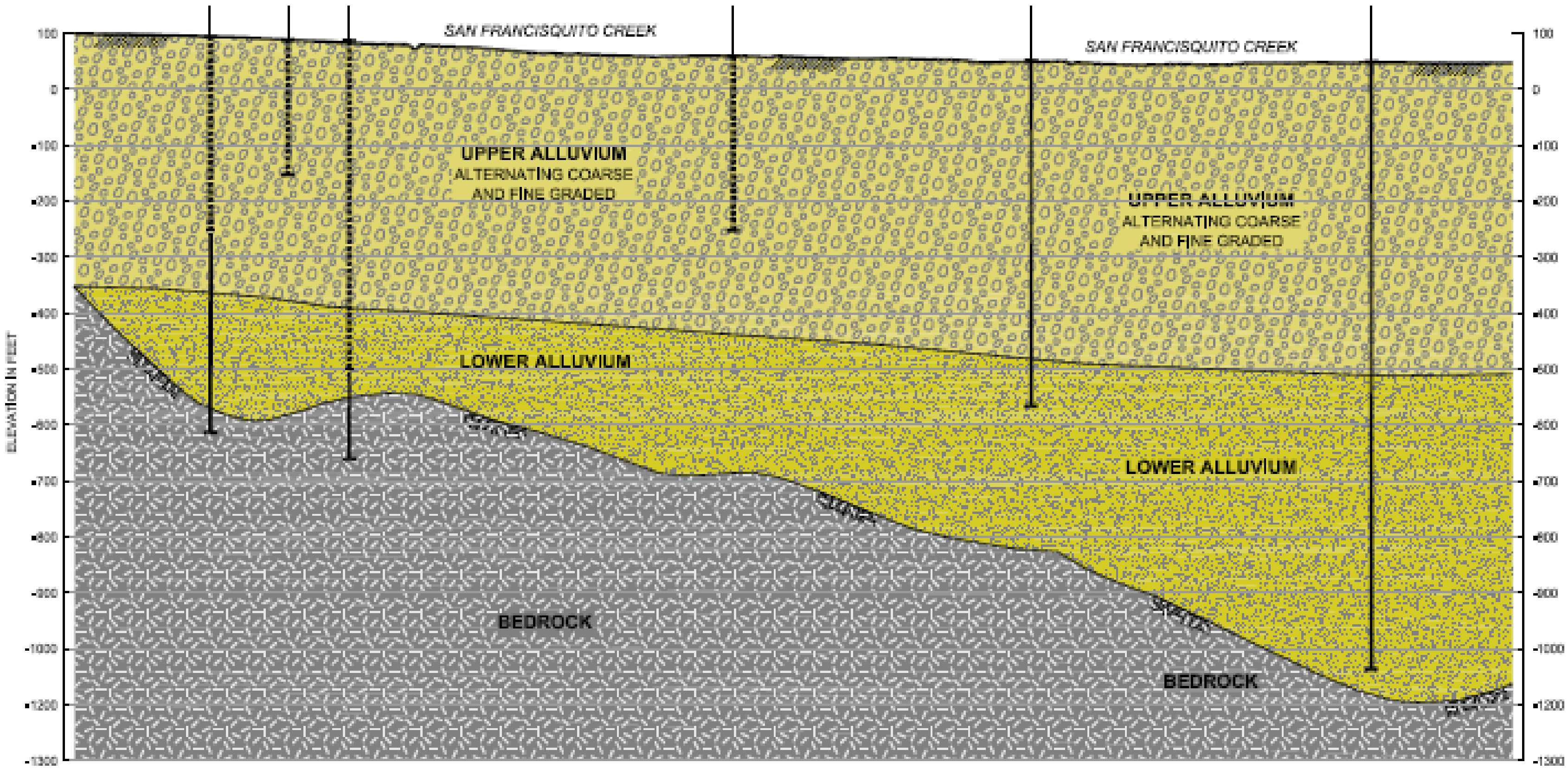
District –
50% Heating with Balanced Cooling



Advantage of SmartSizing & District

- 60 to 30 Boreholes
- Flexible Operation
- 90% of benefit@50% cost
- Single mobilization
- Avoid central plant costs
- Improves return on borefield investment

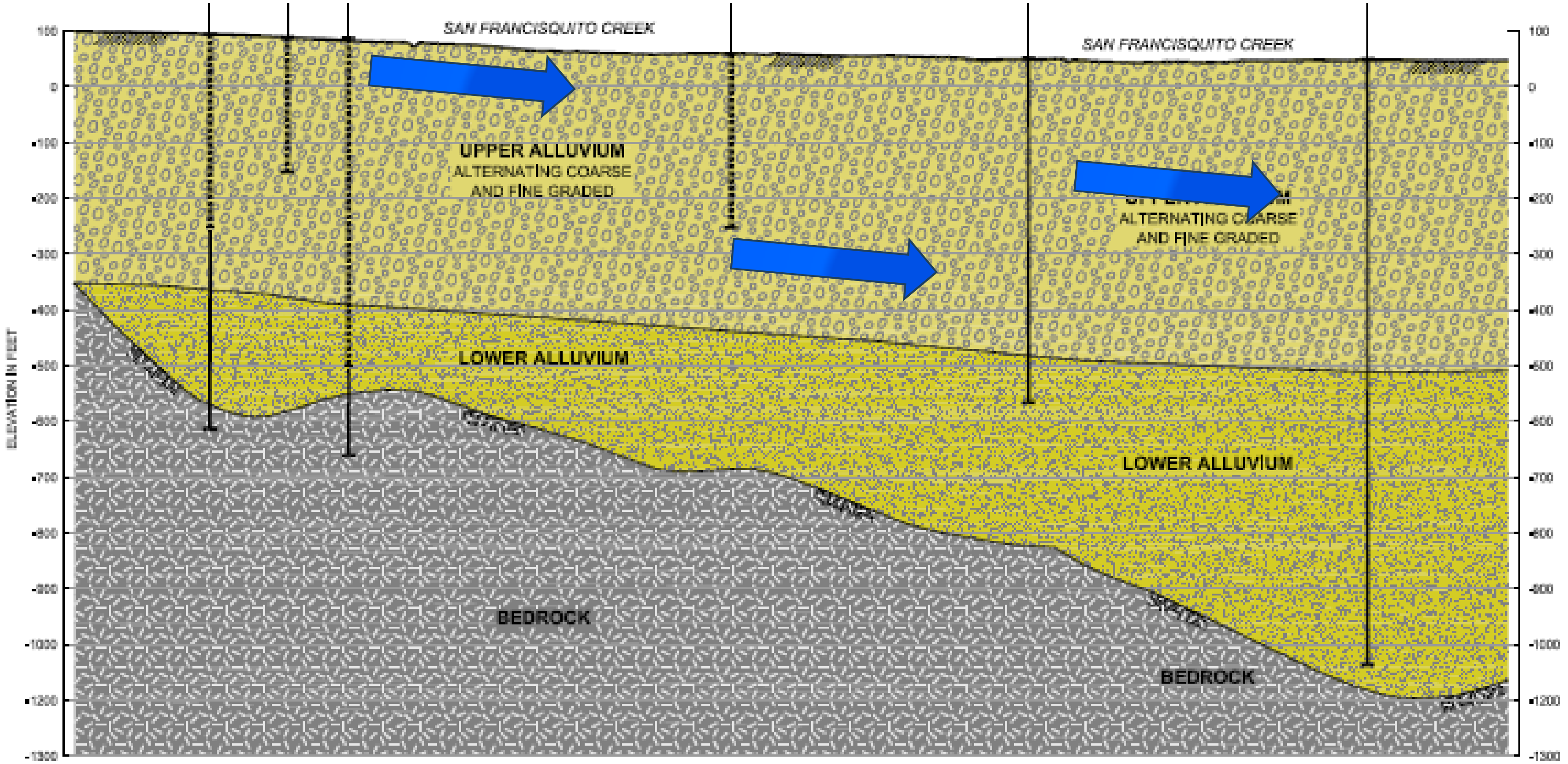
Geology Matters



Stanford University: District

- 75 retrofitted buildings
- Several thousand tons cooling load
- Initial closed loop design: 800 wells
- *Geology really matters!*

Stanford University



Stanford University

No Flow

- Industry Standard/Rule of Thumb Sizing
- 800+ Closed Loop Boreholes

Flow

- *Smart-Sized*
- 480 Closed Loop Boreholes

Flow

- Hydrogeology Modeling
- 32 Open Boreholes

Results

- ~3.2M in savings
- Major savings in time and disruption

Owners Goals Matter

- Off-Grid/Self Sufficient
- Net Zero
- Utilizes “Green” Electricity
- Stretch code
- LEED points
- GHG reduction
- Historic preservation
- Reduce central plant growth
- Cache/Aesthetics

Yale Achieving Project Commitments

- Commitment to regulatory approval authority:

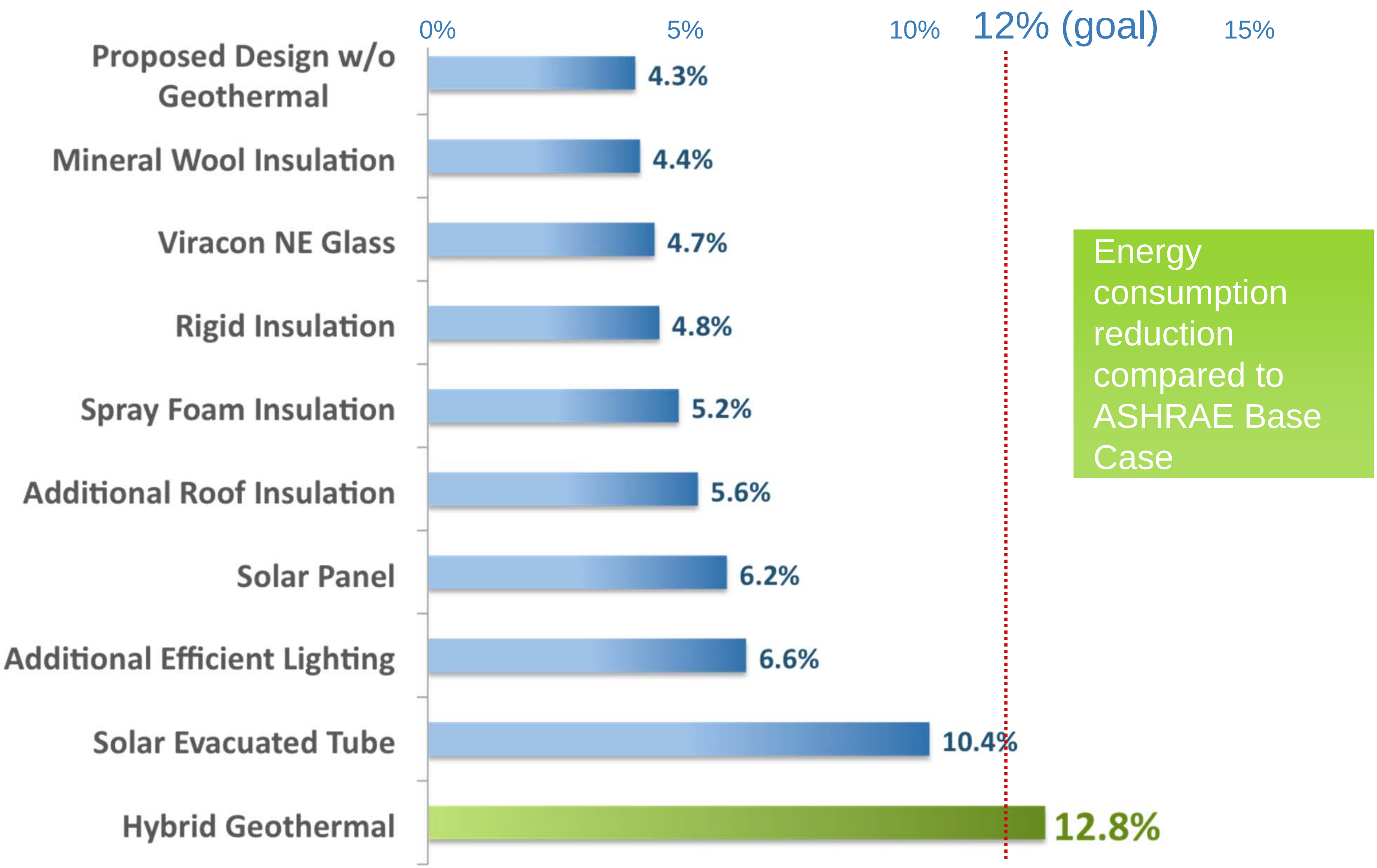
"Build building that is at least 12% more energy efficient than latest ASHRAE 90.1 base case"

Yale Achieving Project Commitments

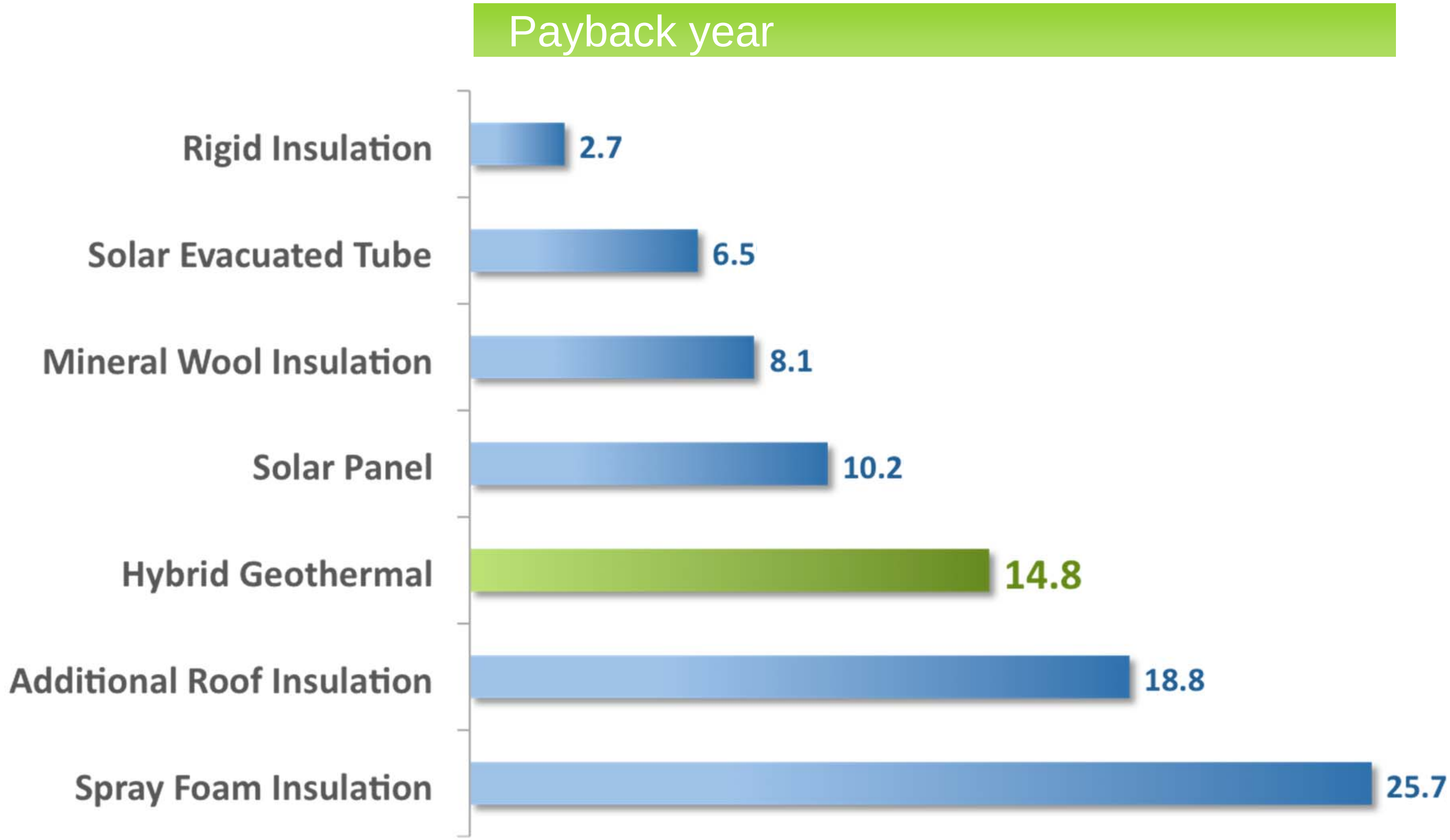
Background:

- Very large residential
- Over 800 tons cooling load
- Significant building envelop and roof area/sq. ft.
- Many Energy Conservation Measures (ECMs) considered
- Sol’n: geothermal system consisting of 55 well installations within courtyards

Energy Efficiency Gains of ECMs



Compare "Apples to Apples"

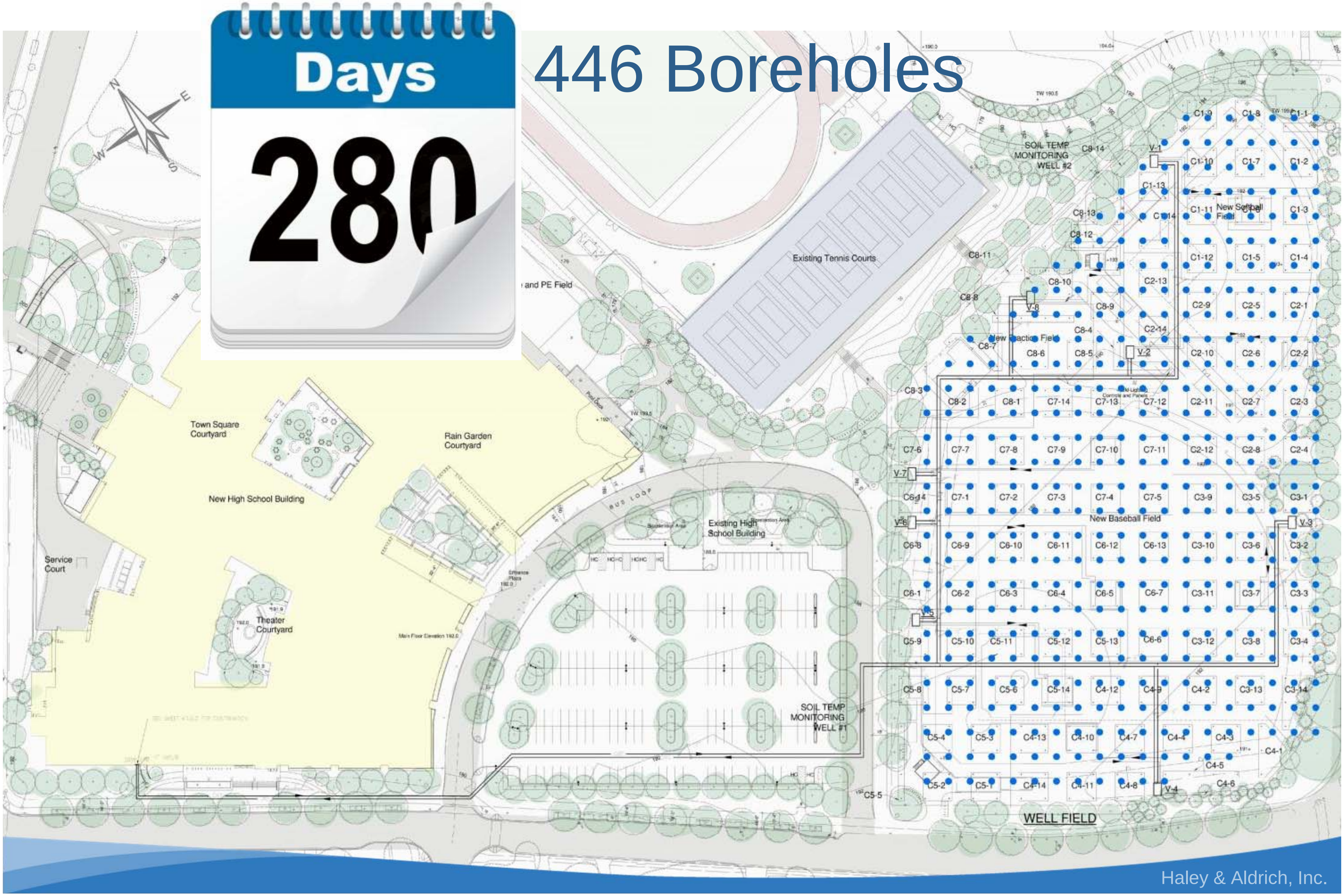


Wakefield High School: Save Space

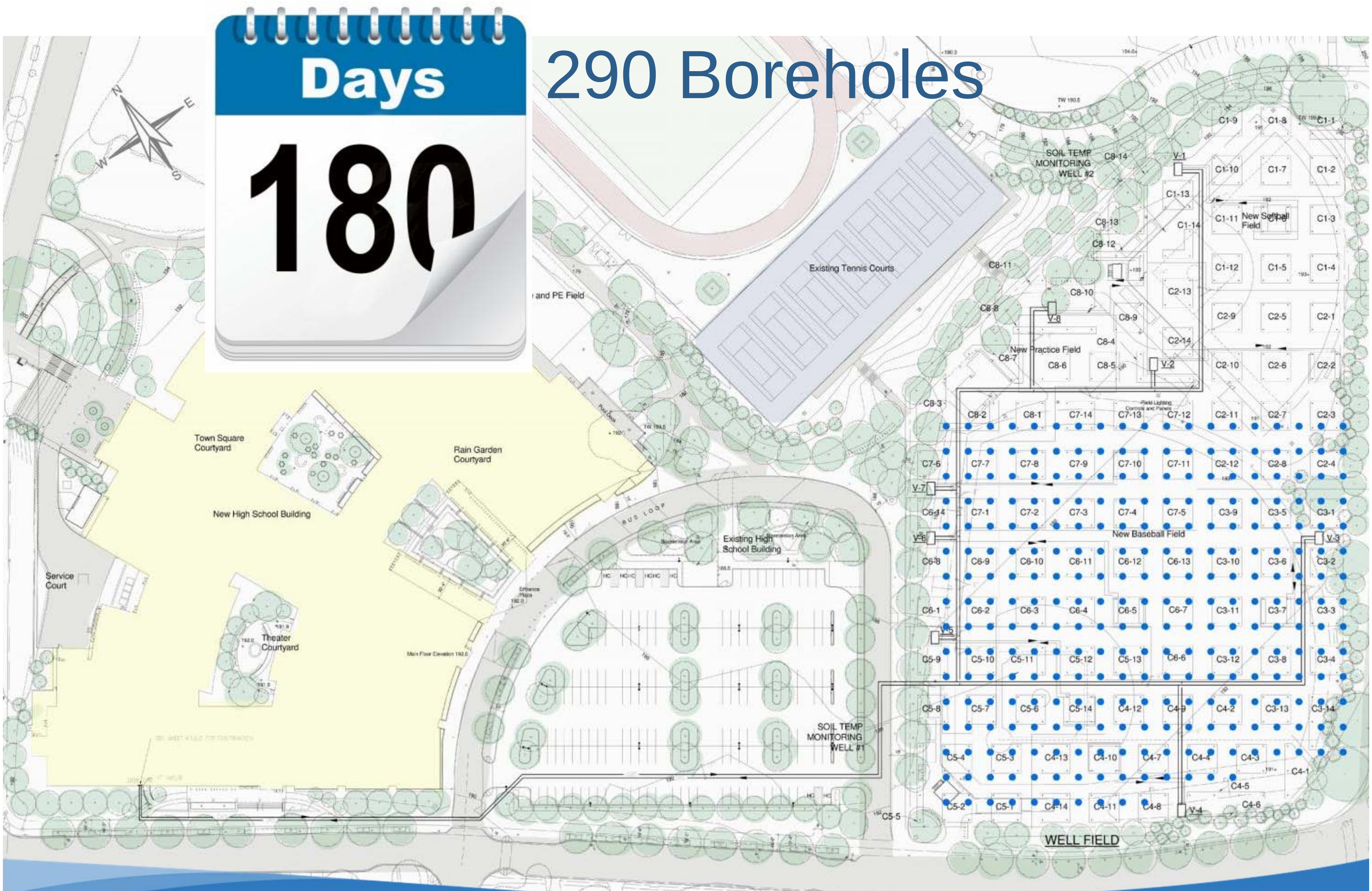
Solution:

- Reduce redundancy
- Deeper Wells
- More Heating Load
- Innovative Well Design
- Integrated with existing HVAC system

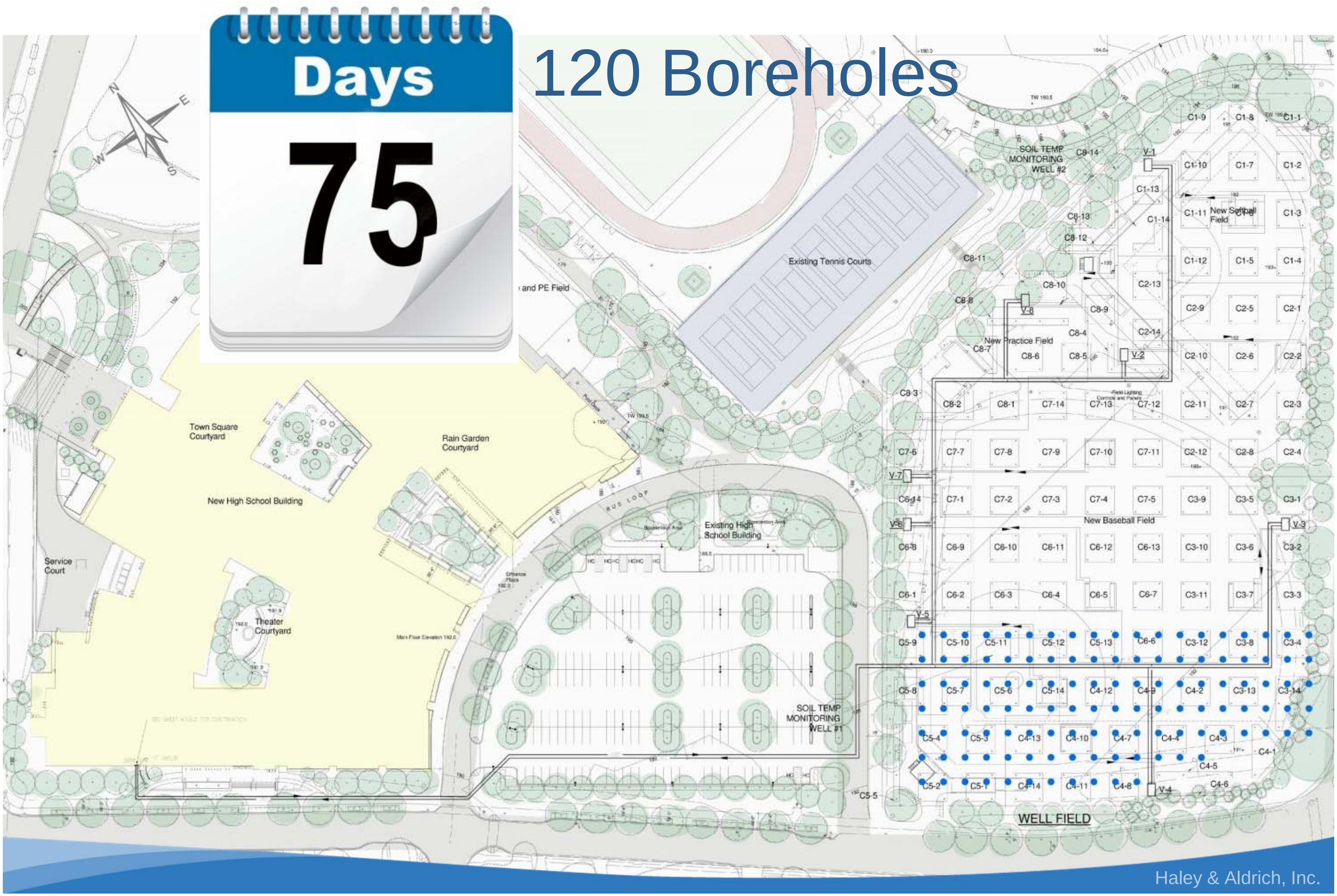
100% Geothermal Rule of Thumb



Informed Ground Conditions



Estimated Smart Sizing



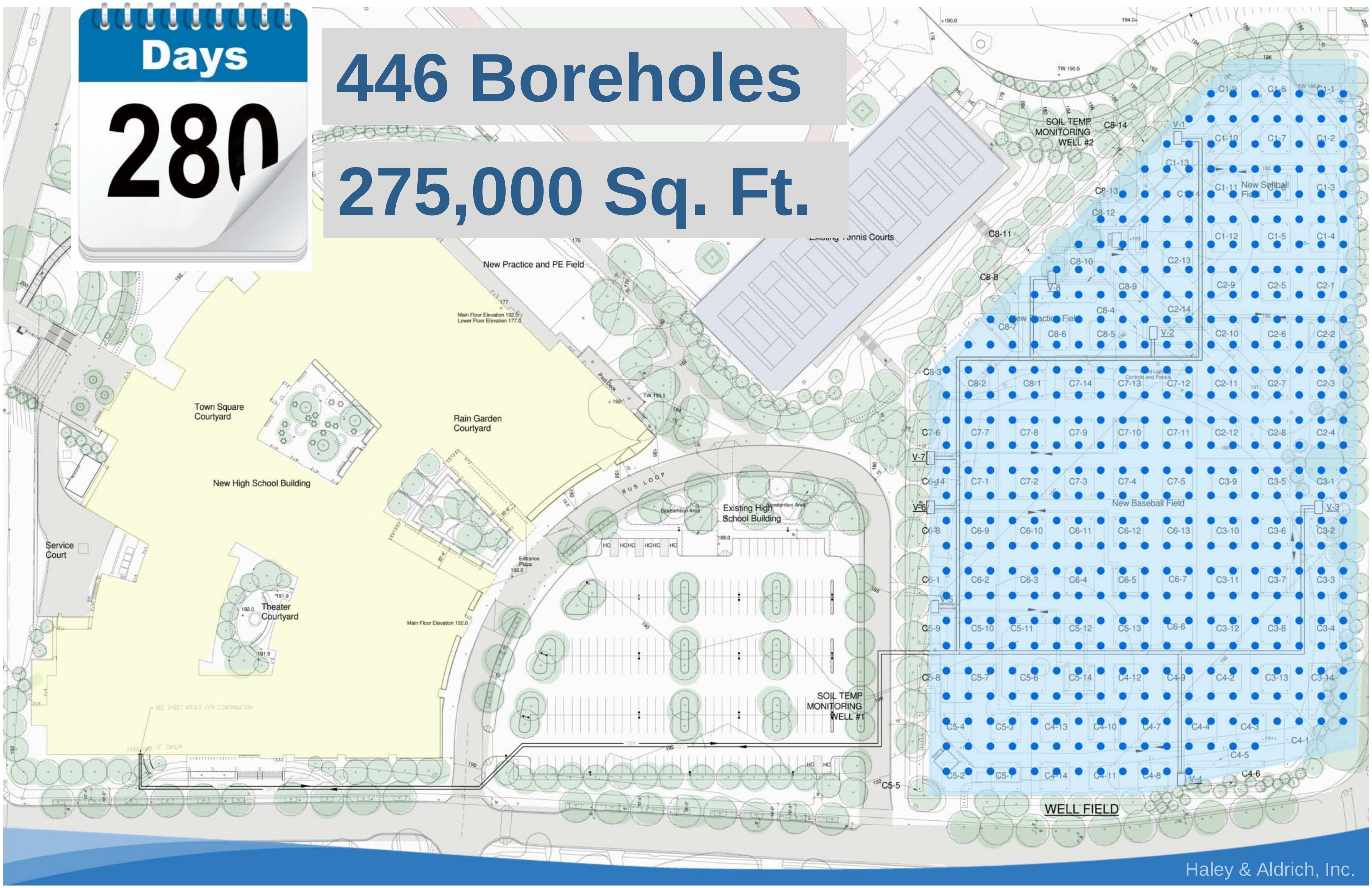
100% Geothermal Rule of Thumb

Days

280

446 Boreholes

275,000 Sq. Ft.



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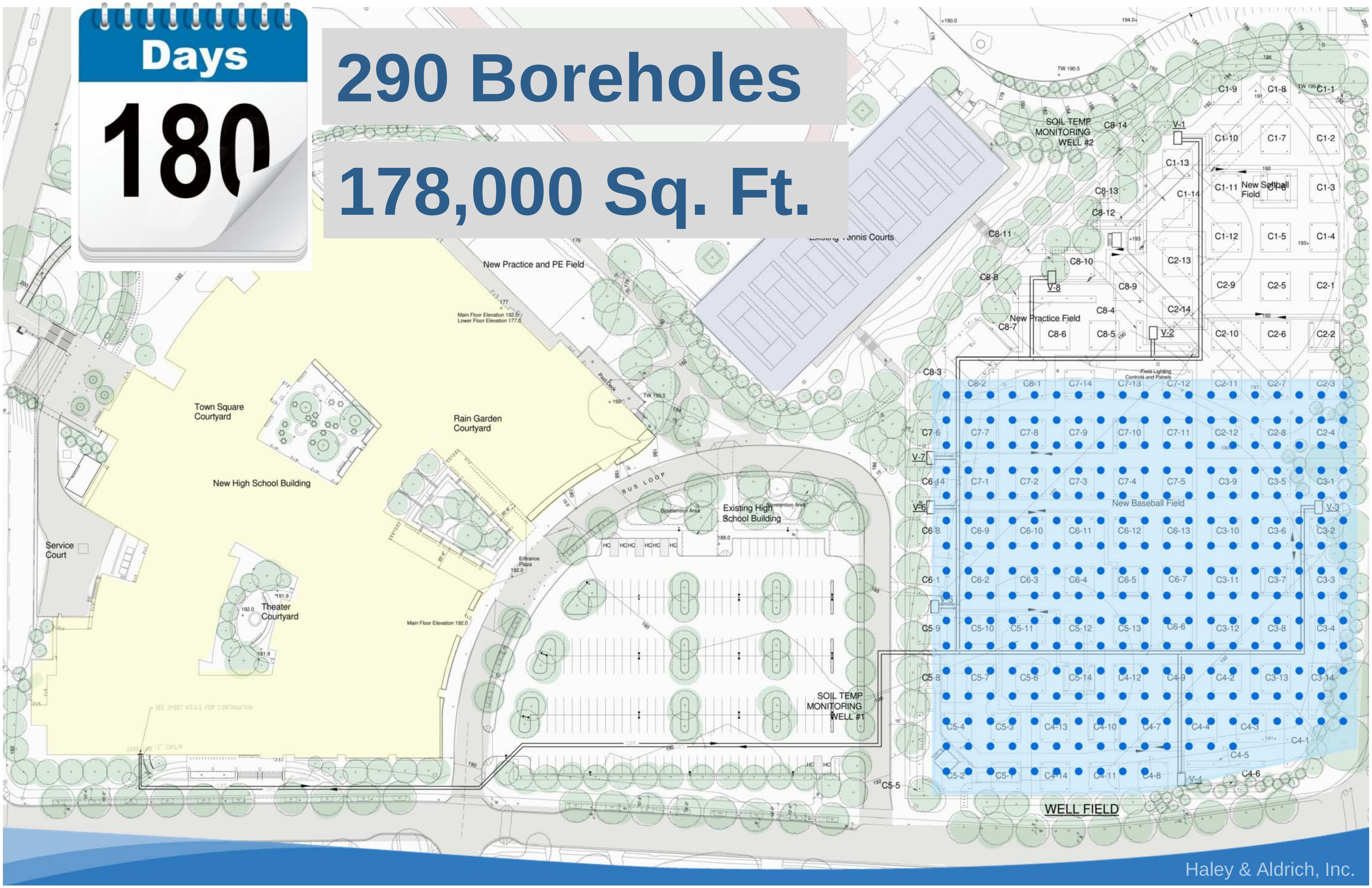
Informed Ground Conditions

290 Boreholes

178,000 Sq. Ft.



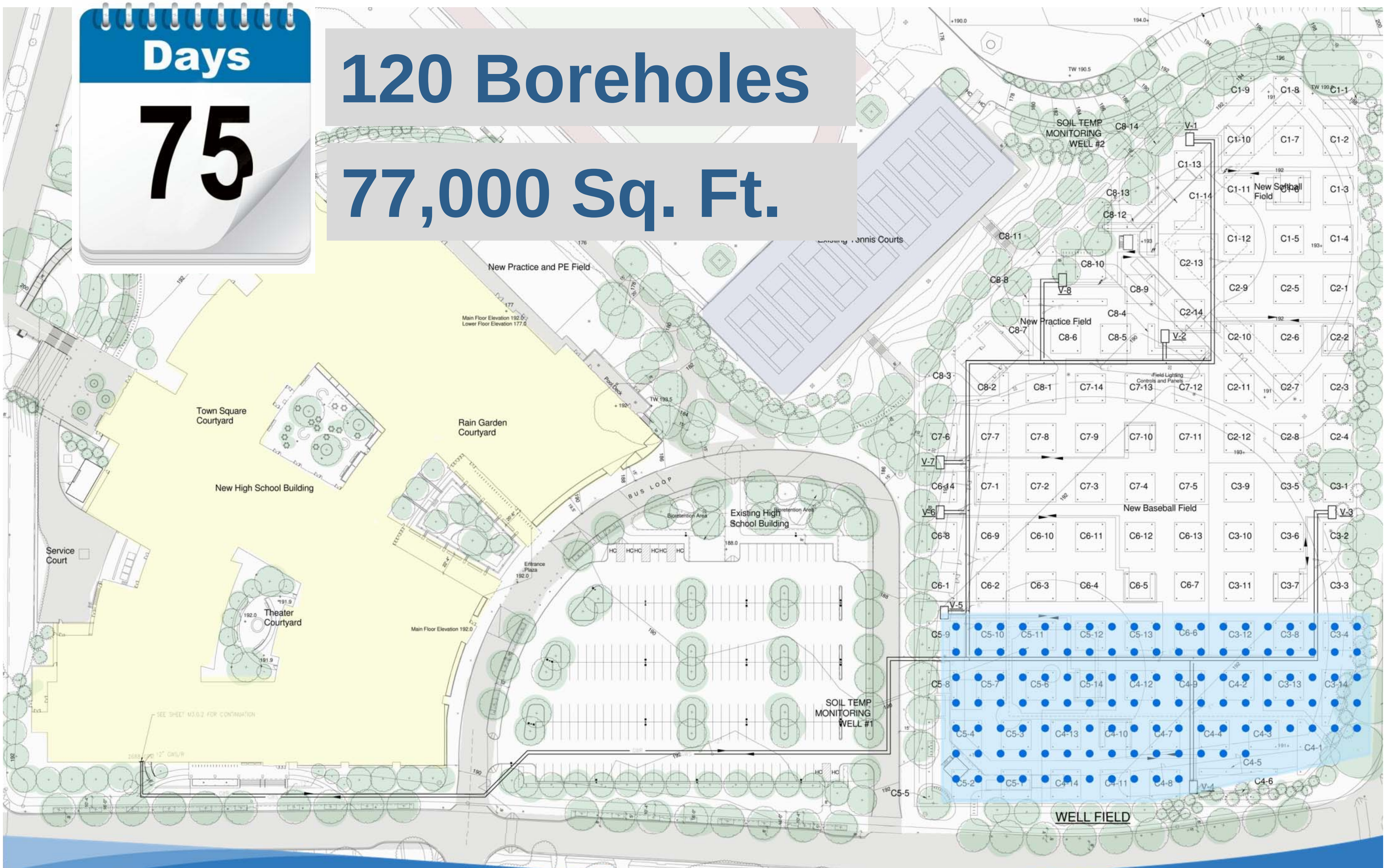
Estimated Smart Sizing

Days

75

120 Boreholes

77,000 Sq. Ft.



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Other Goals

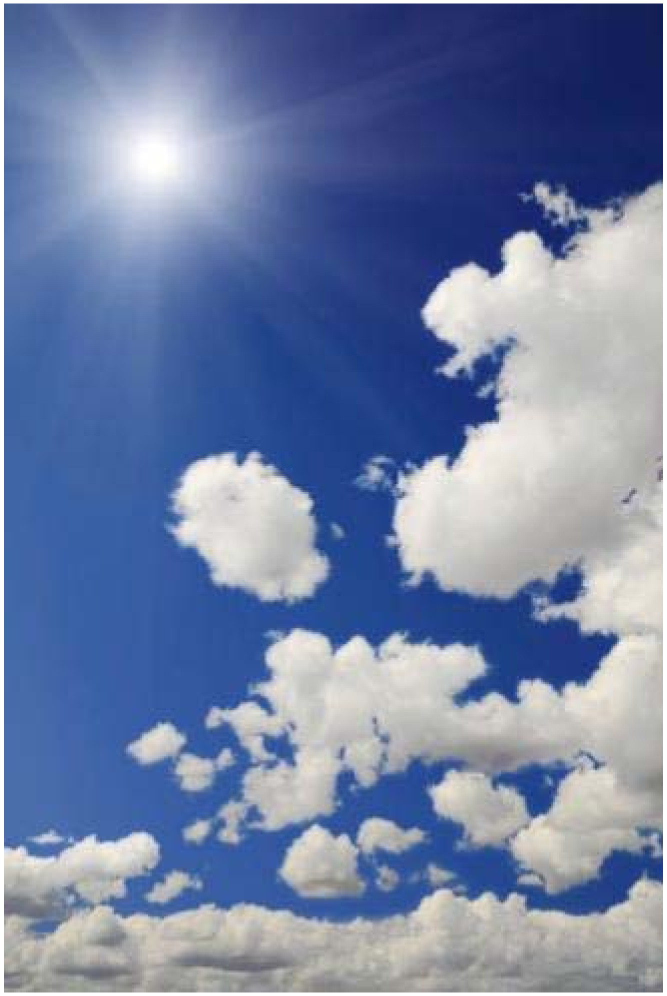
- Utilizes "Green" Electricity
- Stretch code
- LEED points
- GHG reduction
- Historic preservation
- Reduce central plant growth
- Emission reductions

Avoid Aesthetic Impacts

Preserve & Create Campus Aesthetic

Take Aways…

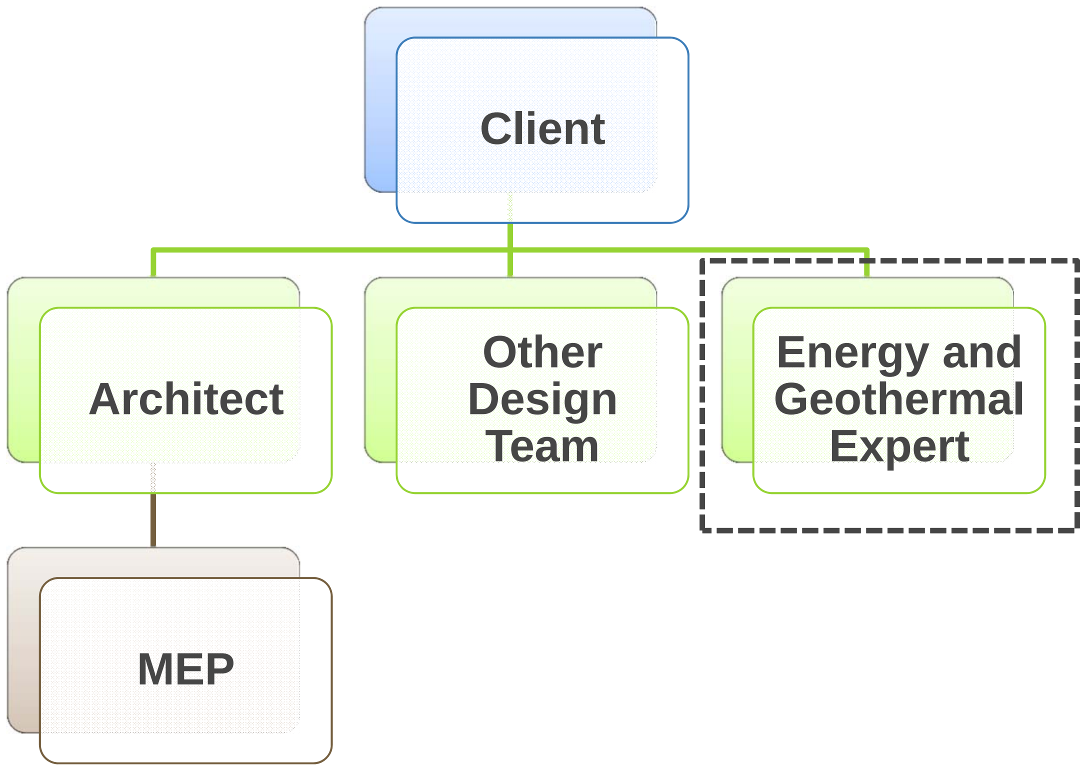
- Powerful ECM
- Possible in most locations
- Understand Ground + Building
- *SmartSize* multiple scenarios early
- Lower Life Cycle Cost
- Huge Range of Feasibility



Questions

This concludes The American Institute of Architects Continuing Education Systems Course

Team Composition



Best method to support the client goals

Partner Qualifications: What to look for..

- Geologists and Hydrogeologists
- P. E. certified designs
- Mechanical engineering/modeling experts
- Significant experience on higher ed campuses
- Client value driven philosophy