



SteelStacks



Michael Dean
Mechanical Option
Thesis Advisor- Dr. Treado

Introduction

- I. Introduction
 - I. **Building Background**
 - II. Architecture/Layout
- II. Existing Conditions
- III. Proposed New Design
- IV. Breadth
- V. Recommendations
- VI. Questions

- I. Introduction
- II. Existing Conditions
- Owner- Arts & Recreation Authority
- Proposed New Design
- Location- Bethlehem, Pa
- Site- Former Bethlehem Steel Plant with views of Blast Furnace
- VI. Questions
- Use- Year round concerts and festivals
- Cost- \$26 million
- Size- 67,000 square feet
- Construction Dates- January 2010- April 2011

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Introduction

Steelstacks Performing Arts Center
 Bethlehem , Pa



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Building Background

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Open floor plan
Exposed Elements
Structural/Electrical/Mechanical
Large Viewing Windows

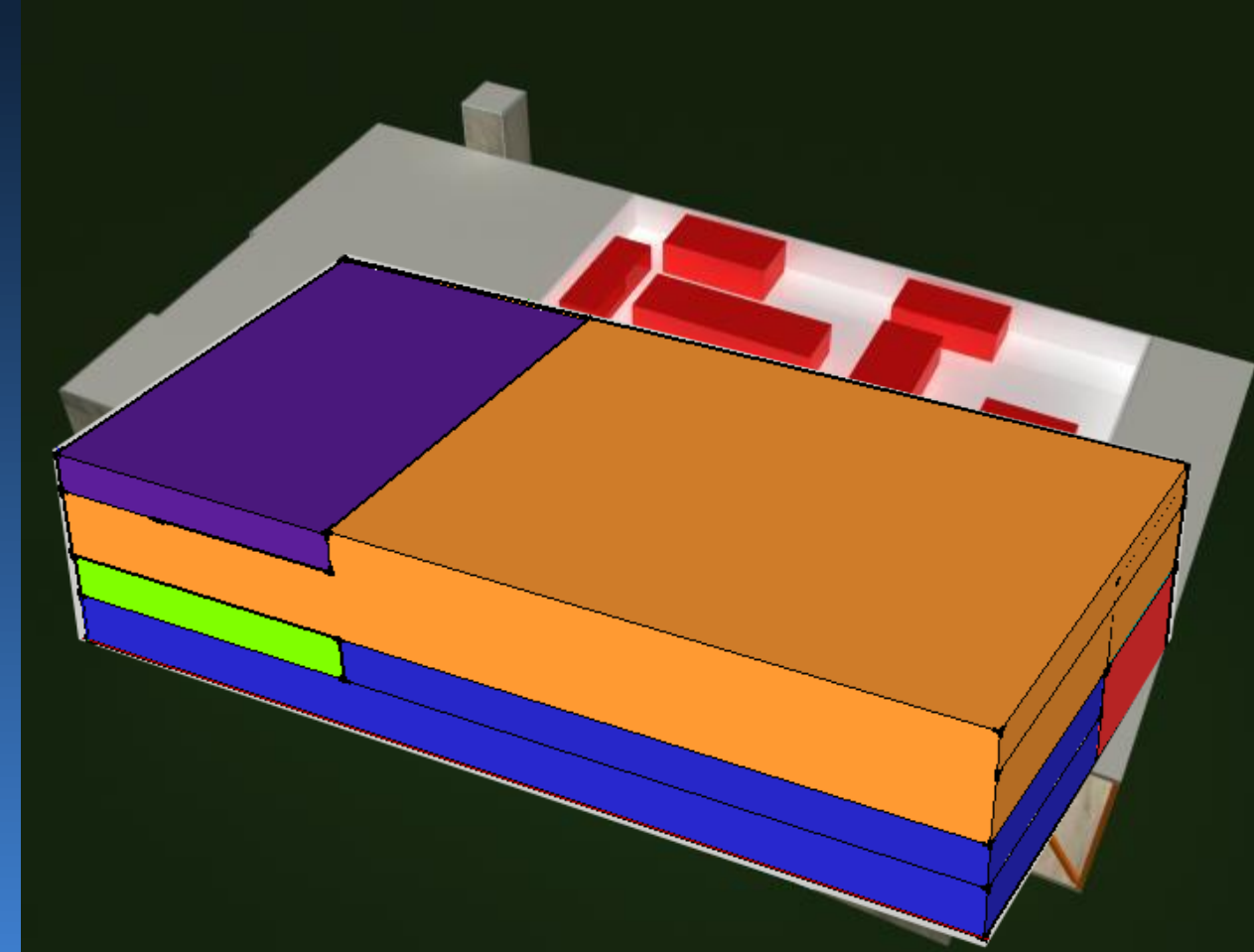
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Architecture/Layout

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- I. Introduction
- II. Existing Conditions
 - I. AHU
 - II. Energy Consumption
- III. Proposed New Design
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- Six Roof-top units
- 2-53 tons
- One indoor AHU
- Serves Blast Furnace Room

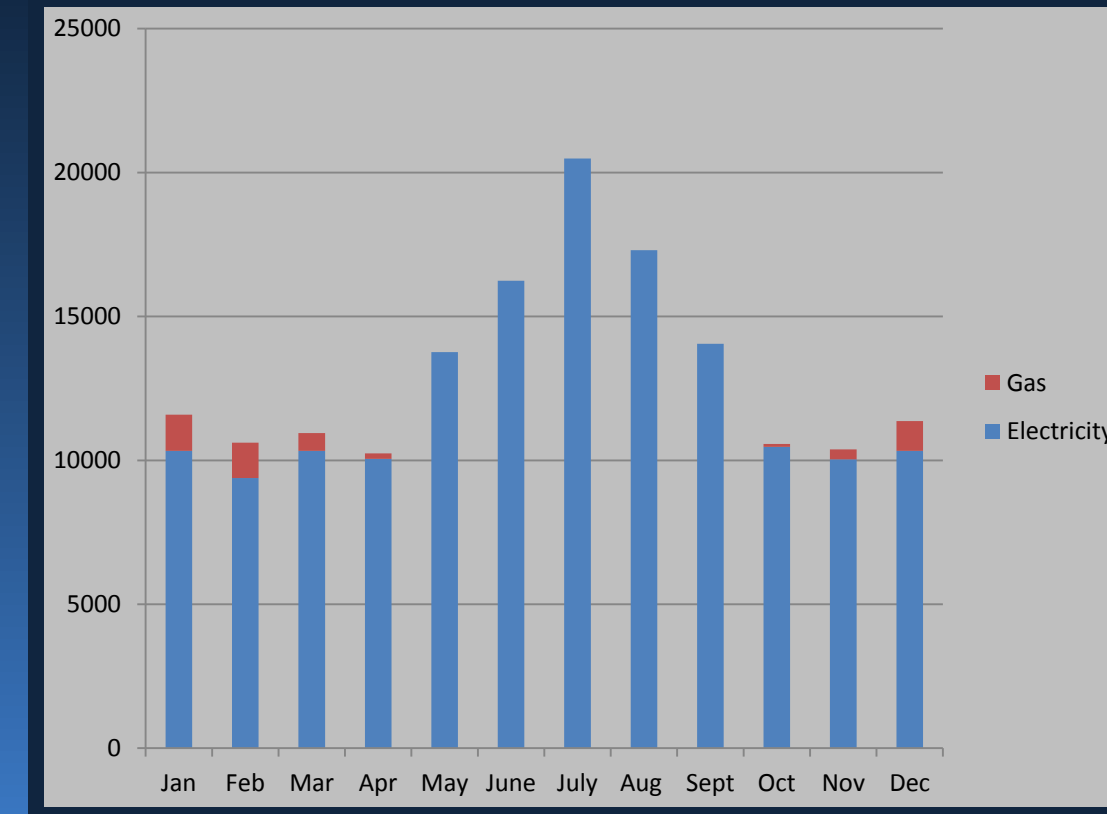
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AHU

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Energy Cost

- \$154,988
- \$2.31/sq. ft.

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Energy Consumption

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- I. Introduction
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Goals

- Minimize Energy Cost
- Make building more efficient
- Ease of Operability

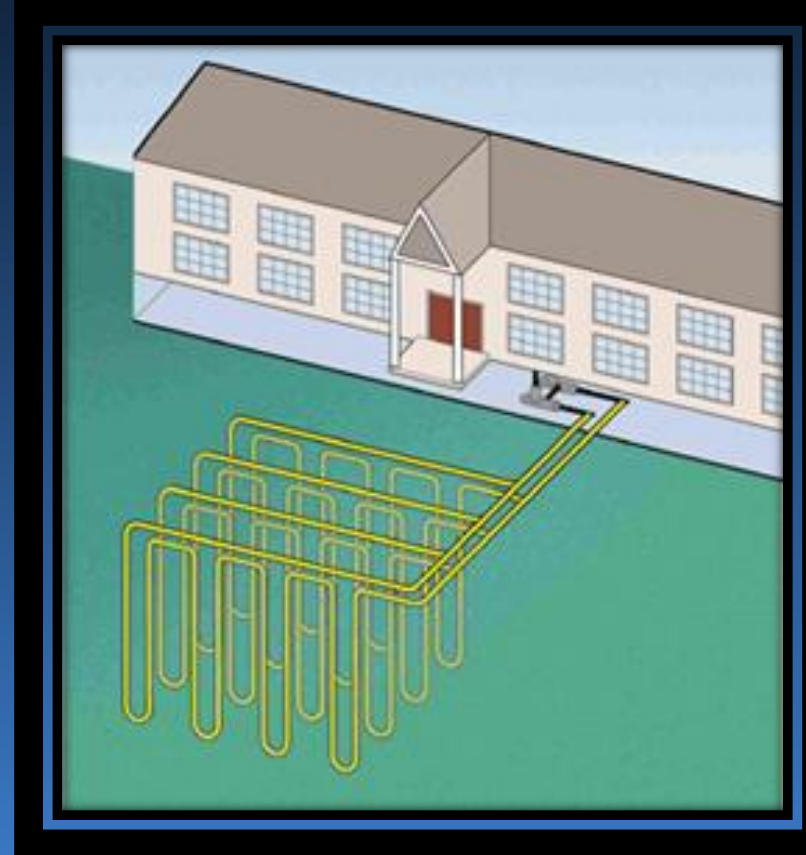
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Proposed New Design

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- I. Introduction
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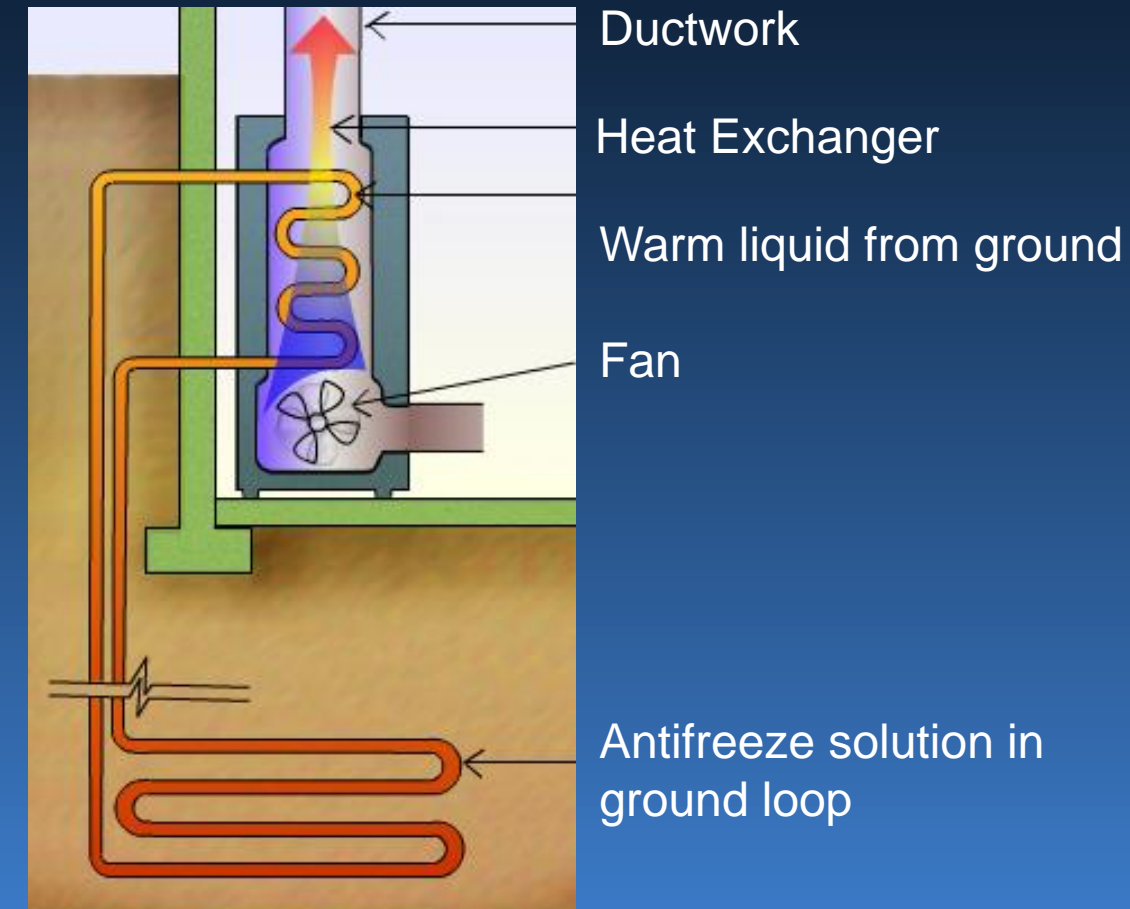
Advantages

- Thermal Comfort
- Low maintenance
- Quiet system

Disadvantages

- High first cost

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How GSHP works

- Use constant ground temperature as a heat source in winter and heat sink in summer
- Refrigerant changes temperature through the ground and is used as the heat coil in the heat pump

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GSHP

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Site Considerations

- 35,325 sq. ft. available for well field
- No plans for possible new buildings
- Field located close which reduces piping cost

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Modeling

Loads



Boreholes



Initial Information

Ground conductivity - 1.00 Btu/(hr.*ft.*F)
Undisturbed Ground Temperature - 53 F
Borehole Spacing- 15 ft.
Borehole Diameter- 6 in
Borehole Thermal Resistance-0.3339 F/(Btu/(hr.*ft.))

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GSHP

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Sizing

-Loops

- 300 ft. wells
- 85 wells

Heat Pumps

- Sized to designed specification
- Same ductwork was used

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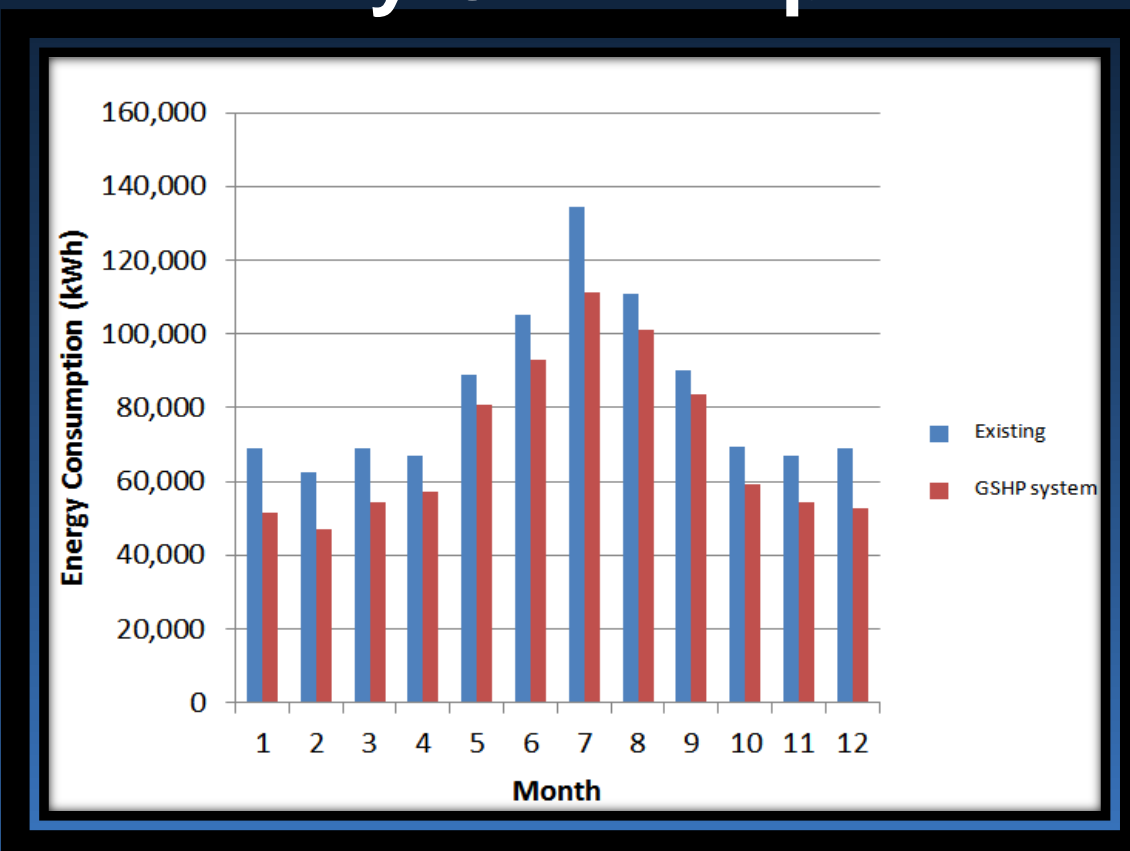
GSHP

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Yearly Consumption



\$23,495

Cost Comparison

Name	Capacity (ton)	Bore (feet)	Estimated Cost*	
			GSHP	Existing
GSHP-1	0	10.6	Payback period	\$22,200
GSHP-2				\$10,600
GSHP-3	5	9	Payback period	\$10,600
GSHP-4				\$39,600
GSHP-5	10	7.5	Payback period	\$39,600
GSHP-6				\$2,025
GSHP-7	20	6.2	Payback period	\$22,200
Total				\$146,825

GSHP

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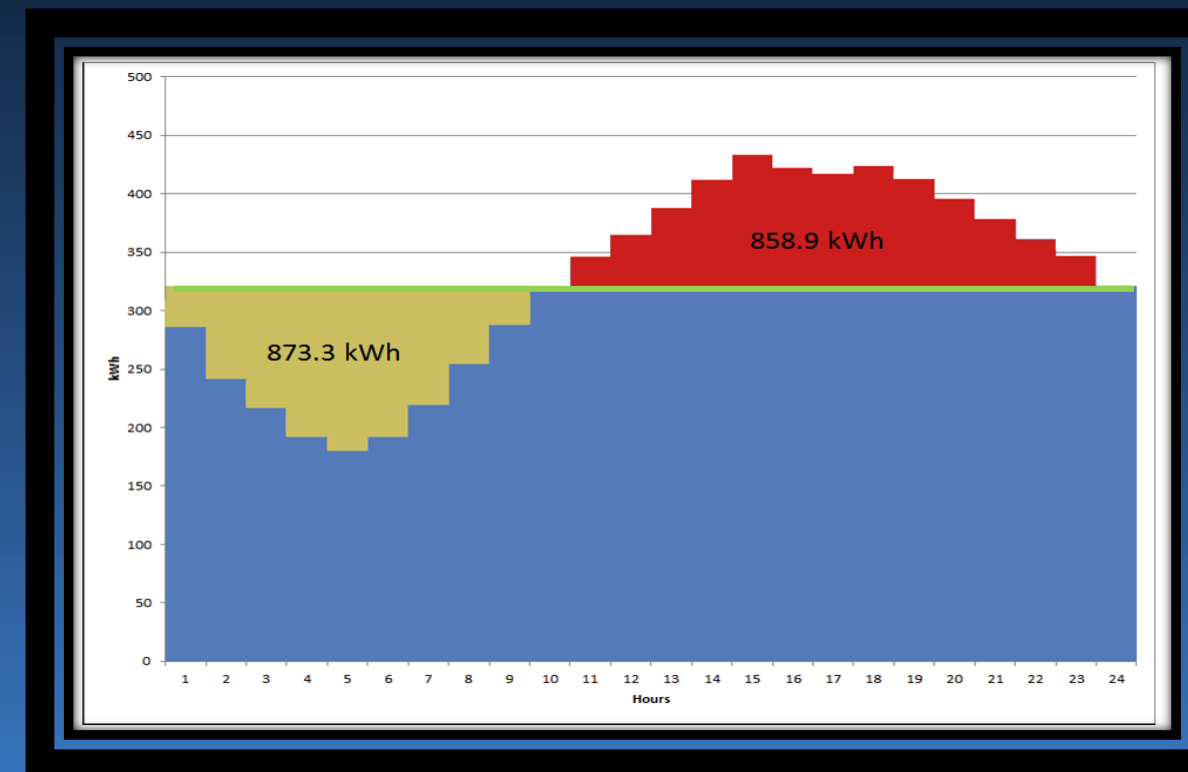
Advantages

- Constant Loads
- Higher efficiencies

Disadvantages

- First cost
- Space

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Abilit Savings Storage

- Based on the savings efficiency
- keep storage capacity levels shifting electric utility
- On Peak and Off Peak shift water to be sized on a daily basis

\$7,627 per year

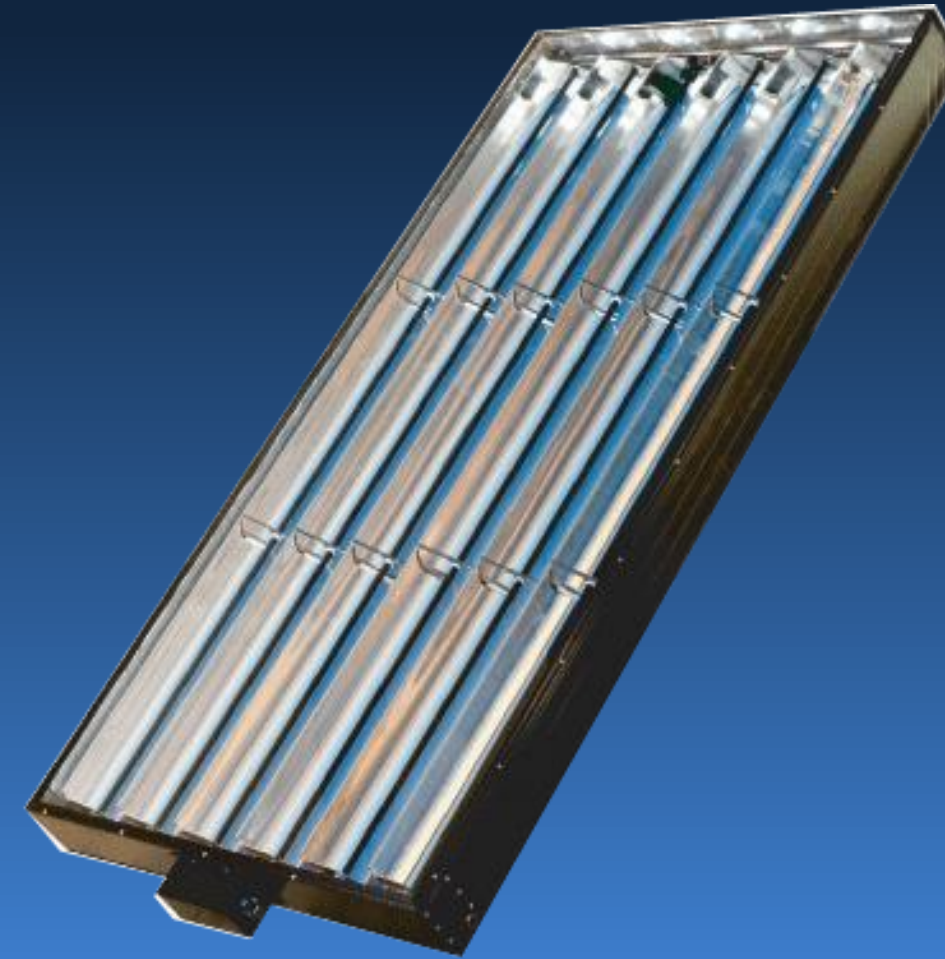
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Payback Period

- 248 ton-hours of cooling capacity
- 10,000 gallon tank
- Chillers remained, & were left oversized to allow for redundancy

Initial Investment: \$32,125
Payback Period: 4.2 years

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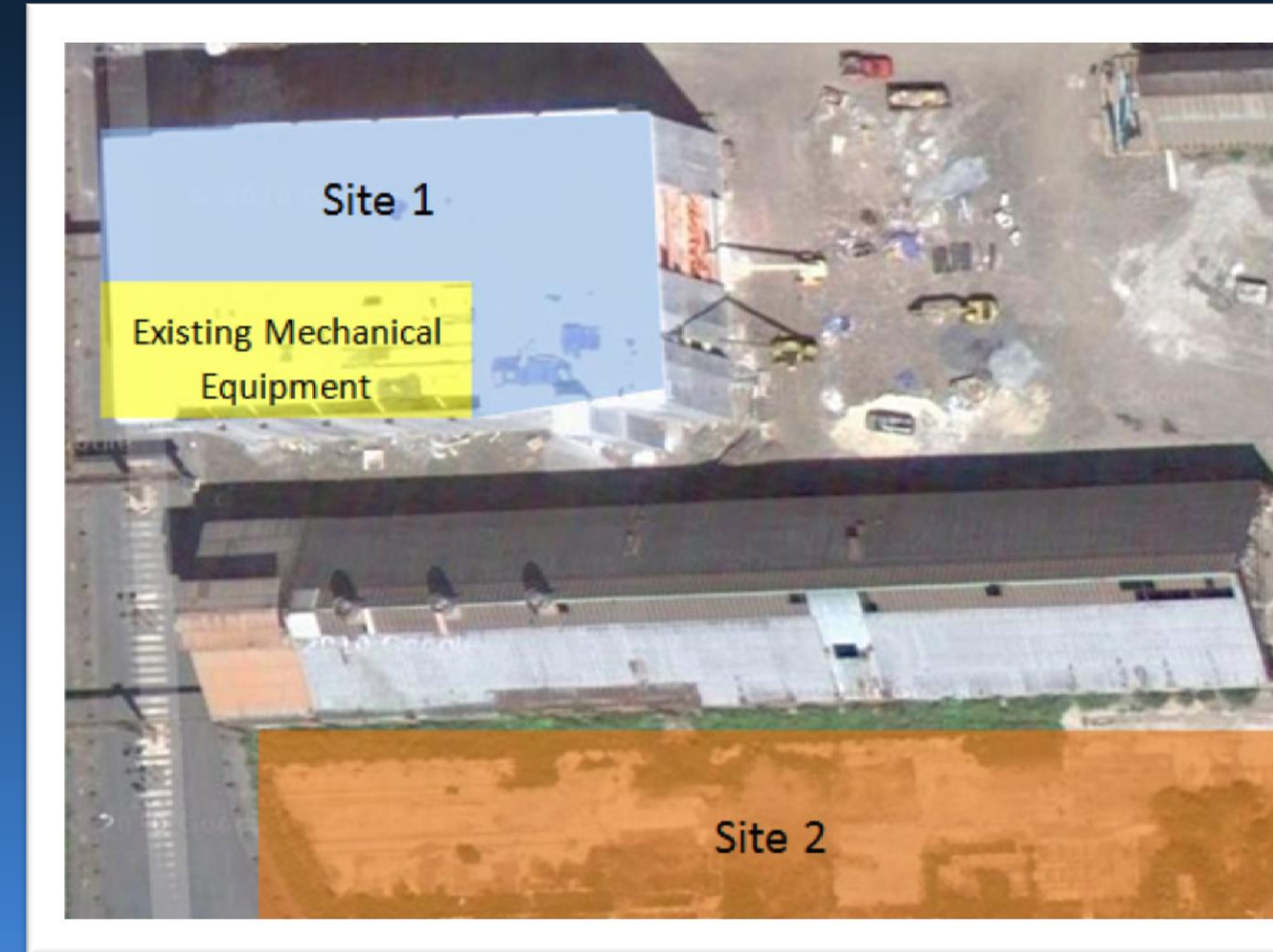
Advantages

- Lowers Energy Cost

Disadvantages

- High first cost
- Architecture effects

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Site Considerations

- Site 1- 15,690 sq. ft.
- Site 2- Unlimited (~150 ft. from building)

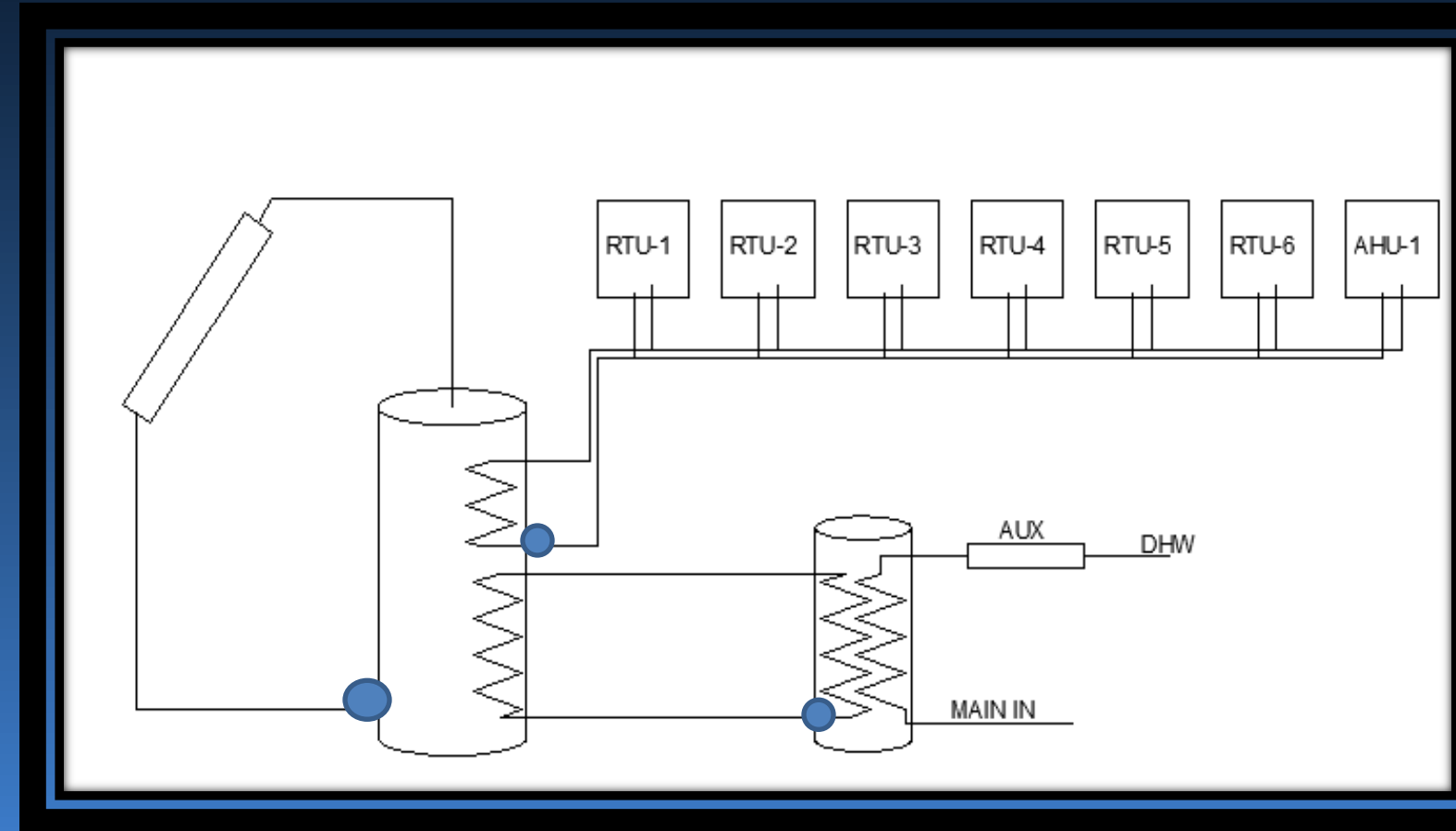
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Solar

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Calculation

$$UA = \frac{\dot{q}_H}{T_{DH} - T_{OA}}$$

\dot{q}_H - hour load of the largest heating use (from TRACE software)
 T_{DH} -heating design set point
 T_{OA} -outside air temperature at when heating design occurs.



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Solar

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Savings

- Full load could not fit on roof(538 panels)
- 75% load covered entire room(404 panels)
 - Not effective due to low DHW load
- Most cost effective system was very small (50 panels)
 - Could not effectively cover space heating load

Payback

	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8	Run 9	Run 10
Collector Area	1600	1200	800	600	400	200	150	100	60	20
Storage Unit Size	75	75	75	75	75	75	75	75	75	75
Collector Slope	60	60	60	60	60	60	60	60	60	60
kJ	1.84E+06	4714479	1.90E+07	3.31E+07	5.45E+07	8.97E+07	1.03E+08	1.18E+08	1.33E+08	1.53E+08
kWh	5.10E+02	1309.5775	5.28E+03	9.20E+03	1.52E+04	2.49E+04	2.85E+04	3.28E+04	3.71E+04	4.24E+04
therm	1.74E+01	44.684633	1.80E+02	3.14E+02	5.17E+02	8.51E+02	9.72E+02	1.12E+03	1.27E+03	1.45E+03
Cost Natural Gas \$	1.74E+02	446.84633	9.02E+02	1.57E+03	2.59E+03	4.25E+03	4.86E+03	5.60E+03	6.33E+03	7.23E+03
Cost Electricity \$	571.54253	1466.7268	2959.2314	150.5174	8485.2805	13960.411	15950.816	18378.61	20761.5741	2.37E+04
Collectors	538	404	269	202	135	67	50	34	20	7
Payback	177	139	99	84	69	55	53	54	67	251
Natural Gas Rates	1.25 \$/therm									
Electricity Rates	0.14 \$/kWh									

Number of solar collectors (32 sq ft)

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Solar

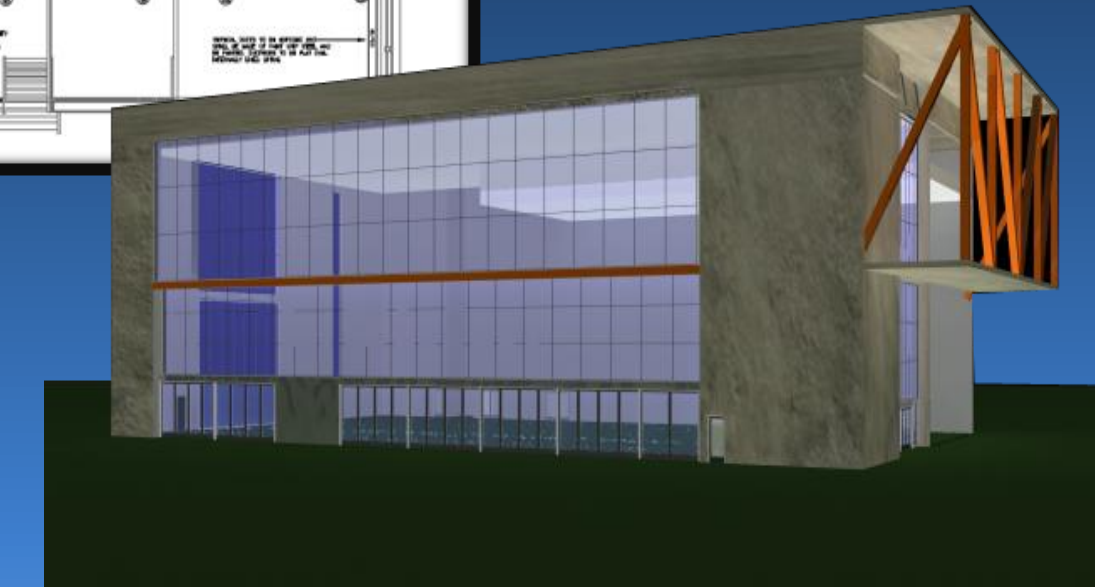
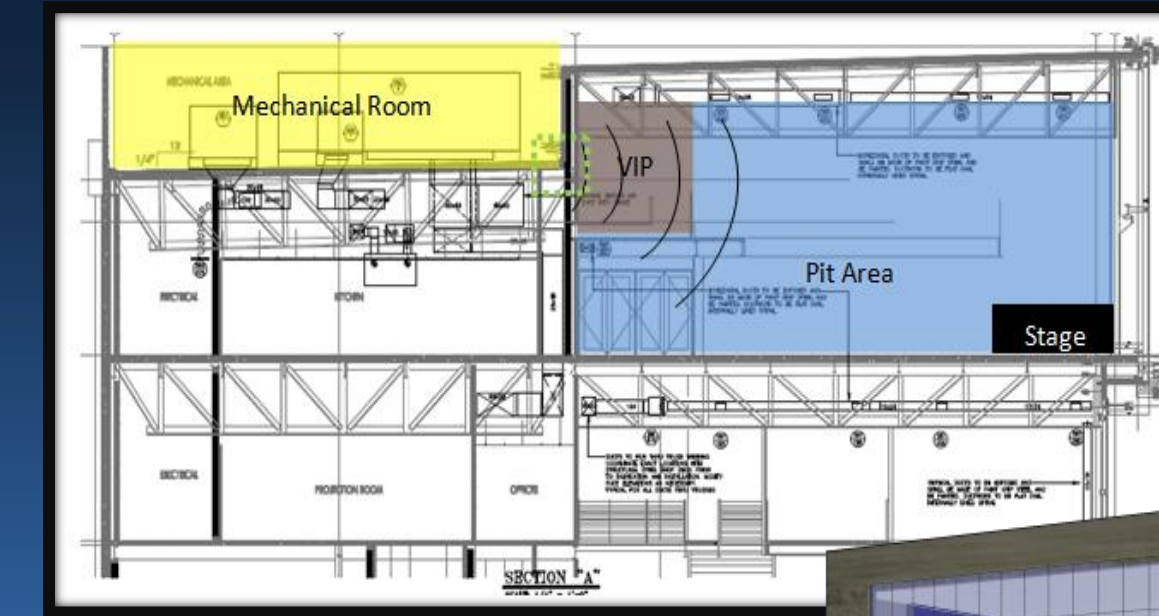
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Breadth

- Acoustical
- Architectural



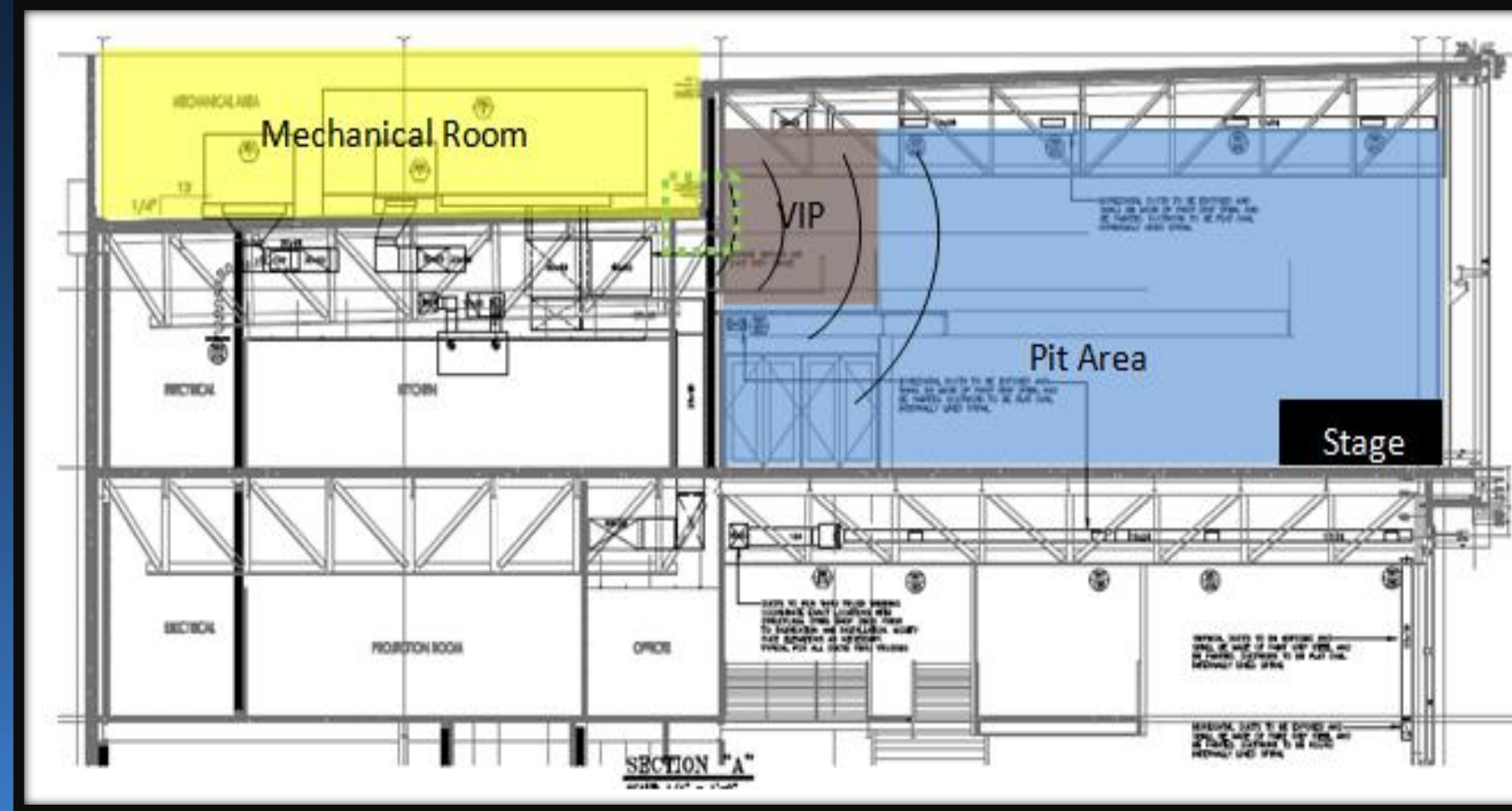
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Breadth

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Breadth

- Improper installation of RTU
- Vibration on roof could translate into the concert area
- Effect the view experience

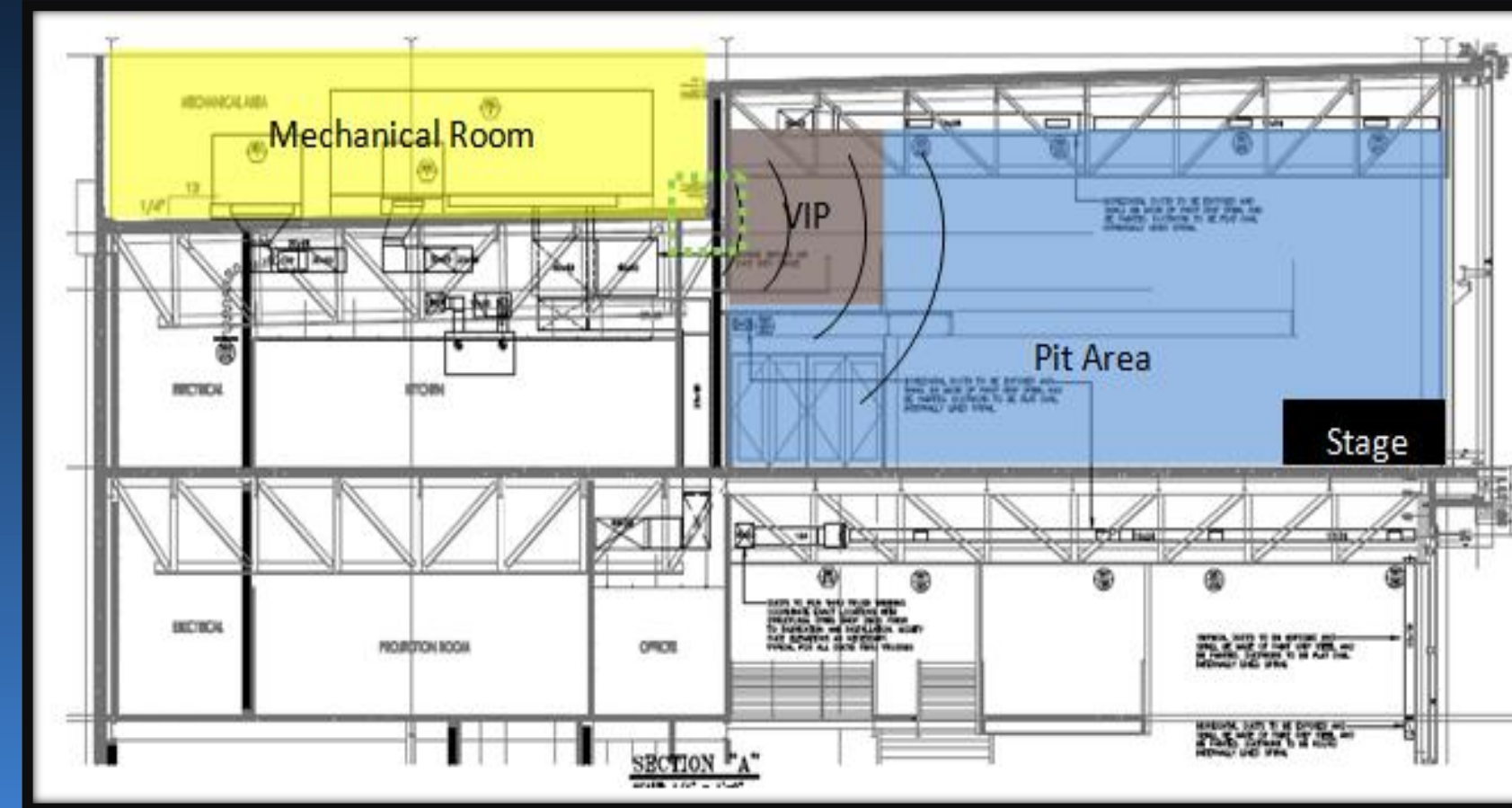
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Acoustic Breadth

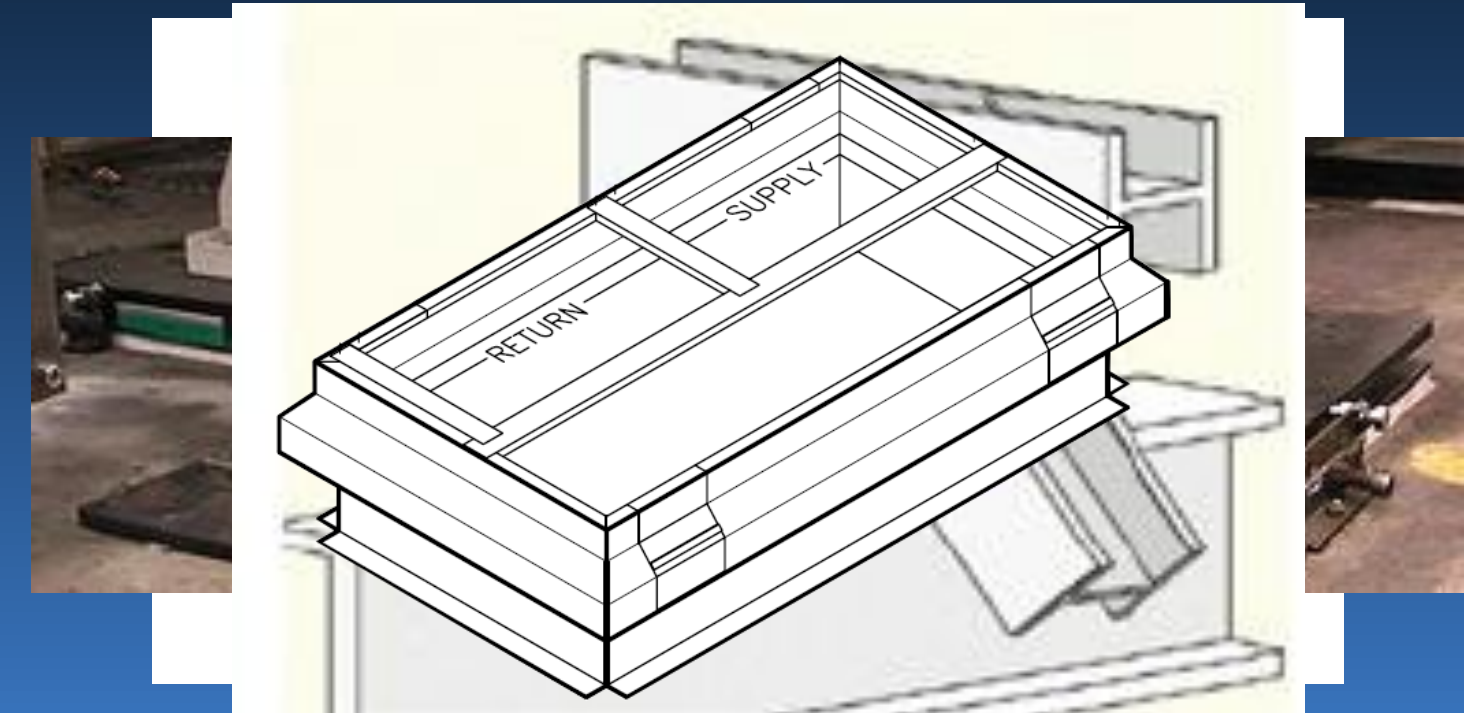
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Solutions



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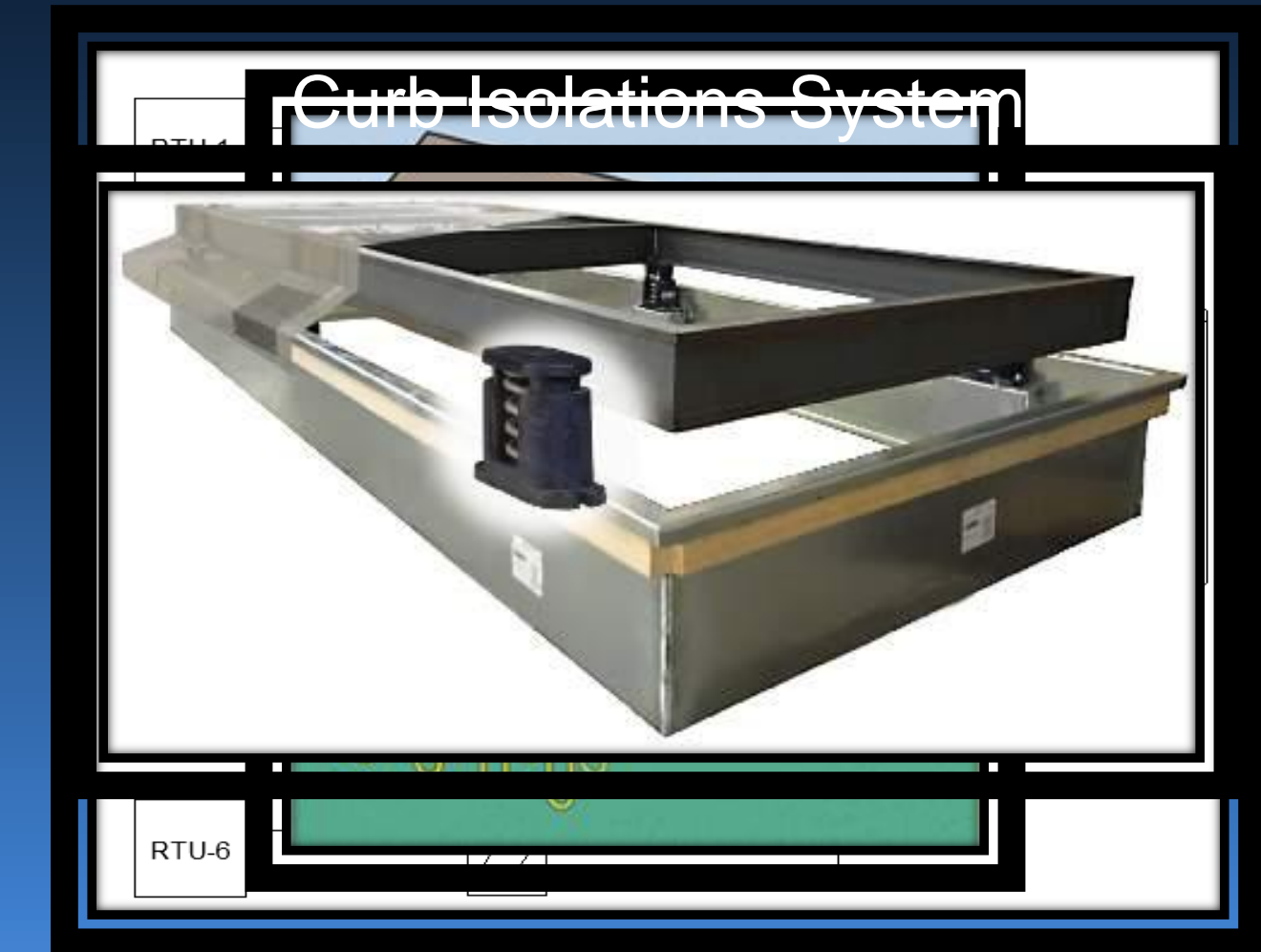
Acoustic Breadth

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Payback Period	
• GSHP	10.6
• Solar	50
• Thermal Storage	4.2
Profit Over Expected Life	
• GSHP	\$338,328
• Solar	\$0
• Thermal Storage	\$158,641



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Recommendations

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Questions??



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END

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