# BEDFORD AREA SCHOOL DISTRICT

February 27, 2024

Re: Engineering Economic Analysis--Geothermal vs. Conventional HVAC Systems for BHS Renovation Project

An Engineering Economic Analysis was completed to compare the financial, operational, and environmental specifications of a Geothermal HVAC system versus a Conventional HVAC system. A brief summary shows Geothermal has higher upfront costs and potential energy savings. The Conventional system has lower upfront costs and higher energy costs. We encourage community members to review the report to gain industry-provided knowledge of this particular topic.

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# ENGINEERING ECONOMIC ANALYSIS

# HVAC SYSTEMS - SUMMARY REPORT

for the

# BEDFORD AREA SCHOOL DISTRICT

BEDFORD, PENNSYLVANIA

Comparison
of a

Geothermal Heat Pump System

Versus

Traditional Boiler/Chiller/Tower System


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## INTRODUCTION:

The primary purpose of this report is to demonstrate the engineering economic comparison of a Geothermal Heat Pump System in contrast to that of a traditional Boiler/Chiller/Tower HVAC system, for the Bedford High School 2024 project. Information is also provided herein relative to operational and environmental advantages/disadvantages of each system type.

To perform an economic analysis, a direct comparison must be made with sound engineering judgement and consideration to relative capital costs, energy costs, plus maintenance and repair costs.

## CAPITAL COST DATA:

Capital costs used within this report, to arrive at the upfront systems equipment and installation cost differentials, were derived by sourcing costs for each system from contractors, vendors and construction management firms. All contractors and vendors used in sourcing these costs are familiar with the District, have provided services to the District, and are familiar with current planning. As an additional check, to substantiate the order-of-magnitude of the added construction cost associated with implementing a Geothermal HVAC system versus a traditional Boiler/Chiller/Tower system, a 3rd party construction firm was engaged to provide cursory review of the cost differential. For this study, an added construction cost for a Geothermal system was determined to be $707,000. This value is conservatively high, so as not to favor Geothermal.

## TOTAL OPERATING COSTS

Two operating cost perspectives were performed within the analysis as follows:

Analysis 1 – District Records Basis

Use of actual utility costs, preventative maintenance, repair records and available data were sourced from District records to arrive at Total Operating Cost of the systems.

Analysis 2 – Energy Model & District Records Basis

Use of Energy Modeling Software to model energy consumption, combined with District records were sourced to arrive at Total Operating Cost of the systems.

## EXISTING SYSTEMS - HIGH SCHOOL AND MIDDLE SCHOOL

Note, the existing High School primarily uses a boiler chiller-tower HVAC system for heating and cooling, while the existing Middle School primarily uses a geothermal heat pump system for heating and cooling.

## RECORD DATA – USED FOR BOTH ANALYSIS 1 AND 2:

The district shared the preventative maintenance, repairs and utility cost record data including electric, gas and water for the most recent two years, for both the High School and Middle School. Information from both schools have been integrated into the engineering analysis contained within this report.

## ENERGY MODELING SOFTWARE FOR ANALYSIS 2:

Software utilized was Trane Trace 700v6.3.5. This software is recognized by the IRS, DOE, ASHRAE, USGBC and other organizations as meeting the rigors of compliance for both energy and financial calculations. This software uses 8760 hour-by-hour simulation, using NOAA hourly weather data.

## KNOWNS AND GIVENS:

- Baseline conditioned space analysis: 160,000 SF
- High School average electric cost/kwhr: 11.5 cents
- High School average NG cost/therm: $1.04
- High School average water cost/gallon: $.029472/gallon
- Location: Bedford, Pennsylvania
- Annual PM & repair costs: Sourced from District Records
- Annual energy consumption costs:
  - Analysis 1 - uses District sourced record data only
  - Analysis 2 - uses District sourced record data combined with Modeling Software analysis.

## BUILDING SQUARE FOOT DATA:

Where overall building square footage differentials occur between the existing Middle School (Geothermal) and the existing High School (Boiler/Chiller/Tower), actual district record-data was utilized to account for the variances in order to arrive at an engineering basis of equality. Likewise, where heating and cooling square footages differ between the existing High School and existing Middle School, actual district record data was utilized to account for the variances in order to arrive at an engineering basis of equality.

# PAYBACK CALCULATIONS:

In this report, two forms of payback/ROI are utilized as follows:

1) Simple Payback Method:

This method does not consider the "time value of money". It is simply a factor of initial costs divided by annual savings to arrive at a payback period (years). In general, this method should only be considered prudently applied whenever a project or investment provides a very rapid rate of return. Generally, this method becomes exceedingly less prudent as a decision-making factor anytime the resulting payback approaches 9 years. Simple payback in this report is only used to quickly identify a project's financial standing, prior to performing a "time value of money calculation".

1) Net Present Value (NPV) Method:

$$NPV = \sum_{t=0}^{N} \frac{NCF_t}{(1+i_t)^t} \qquad [+RV]$$

As a commonly known principle of finance, money in hand now is more valuable than money received years later. Thus, future money is less valuable than current money because time erodes buying power, hence the term "time value of money". In this case, to compare the value of money now with the value of future money, NPV calculations in concert with the value of expected cash savings were applied and tabulated herein. Knowing NPV predictions of return on initial investment, time period and discount rate serves to facilitate the basis for prudent financial decision-making.

# ANALYSIS 1 – District Records Based

## BEDFORD - HIGH SCHOOL

### HVAC System Comparisions

2/22/2024

GATTER & DIEHL, Inc.

| Option # | HVAC System Types | Compartive Added Construction Cost | Annual Energy Cost | Annual PM & Repair Cost | Total Annual Operating Cost | Simple Payback Years |
|---|---|---|---|---|---|---|
| Option 1 | Chiller/Boiler/Tower | Base System | $ 181,822 | $ 66,129 | $ 247,951 | Base System |
| Option 2 | WSHP - Geothermal | $707,000 | $ 122,497 | $ 20,840 | $ 143,337 | 6.8 |
| Notes: | | *Annual $ Savings* | *$ 59,325* | *$ 45,289* | *$ 104,614* | |

All system options used the same data, building attributes, operational characteristics, ASHRAE standards, etc.

PM = Preventative Maintenance

Chiller/Boiler/Tower - Total Operating Cost /SF = $1.55

Geothermal - Total Operating Cost/SF = 90 cents

$$NPV = \sum_{t=0}^{N} \frac{NCF_t}{(1+i_t)^t} \qquad [+RV]$$

**ANALYSIS 1**

**NPV - Years 1-50 at Various Discount Rates**

| Year | Rate = 4.10% Value | Rate = 5.00% Value | Rate = 7.00% Value | Rate = 9.00% Value | Rate = 14.00% Value |
|---|---|---|---|---|---|
| 0 | -707,000 | -707,000 | -707,000 | -707,000 | -707,000 |
| 1 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 2 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 3 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 4 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 5 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 6 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 7 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 8 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 9 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 10 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 11 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 12 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 13 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 14 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 15 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 16 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 17 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 18 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 19 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 20 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 21 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 22 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 23 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 24 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 25 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| | **NPV 1-25 yrs = $910,150** | **NPV 1-25 yrs = $767,424** | **NPV 1-25 yrs = $512,128** | **NPV 1-25 yrs = $320,579** | **NPV 1-25 yrs = $12,004** |
| 26 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 27 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 28 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 29 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 30 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 31 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 32 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 33 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 34 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 35 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 36 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 37 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 38 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 39 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 40 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 41 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 42 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 43 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 44 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 45 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 46 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 47 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 48 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 49 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| 50 | $104,614 | $104,614 | $104,614 | $104,614 | $104,614 |
| | **NPV 1- 50 yrs = $2,209,369** | **NPV 1- 50 yrs = $1,909,825** | **NPV 1- 50 yrs = $1,443,751** | **NPV 1- 50 yrs = $1,146,745** | **NPV 1- 50 yrs = $746,176** |

**Added First Cost - Geothermal**

**But yields Savings**

**Continued Savings of Geothermal**

**Not included above:** Future long term avoided capitol costs, unique to Geothermal Systems

1. Years 15 - 20: Tower Replacement added cost $200,000
2. Years 26 - 30: Chiller/Boiler System added cost $900,000 (because Geothermal borefields last 50+ years, thus no Boilers, Chillers or Tower would exist to be replaced)

# ANALYSIS 2 – Energy Model and District Records Based

## BEDFORD - HIGH SCHOOL

### HVAC System Comparisions

2/22/2024

**GATTER & DIEHL, Inc.**

| Option # | HVAC System Types | Compartive Added Construction Cost | Annual Energy Cost | Annual PM & Repair Cost | Total Annual Operating Cost | Simple Payback Years |
|---|---|---|---|---|---|---|
| Option 1 | Chiller/Boiler/Tower | Base System | $ 181,599 | $ 66,129 | $ 247,728 | Base System |
| Option 2 | WSHP - Geothermal | $707,000 | $ 104,493 | $ 20,840 | $ 125,333 | 5.8 |
| Notes: | | *Annual $ Savings* | *$ 77,106* | *$ 45,289* | *$ 122,395* | |

All system options used the same data, building attributes, operational characteristics, ASHRAE standards, etc.

PM = Preventative Maintenance

Chiller/Boiler/Tower - Total Operating Cost /SF = $1.55

Geothermal - Total Operating Cost/SF = 78 cents

$$NPV = \sum_{t=0}^{N} \frac{NCF_t}{(1+i_t)^t} \qquad [+RV]$$

**ANALYSIS 2**

**NPV - Years 1-50 at Various Discount Rates**

| Rate = | 4.10% | | Rate = | 5.00% | | Rate = | 7.00% | | Rate = | 9.00% | | Rate = | 14.00% | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Value | | Year | Value | | Year | Value | | Year | Value | | Year | Value | |
| 0 | -707,000 | | 0 | -707,000 | | 0 | -707,000 | | 0 | -707,000 | | 0 | -707,000 | |
| 1 | $122,395 | | 1 | $122,395 | | 1 | $122,395 | | 1 | $122,395 | | 1 | $122,395 | |
| 2 | $122,395 | | 2 | $122,395 | | 2 | $122,395 | | 2 | $122,395 | | 2 | $122,395 | |
| 3 | $122,395 | | 3 | $122,395 | | 3 | $122,395 | | 3 | $122,395 | | 3 | $122,395 | |
| 4 | $122,395 | | 4 | $122,395 | | 4 | $122,395 | | 4 | $122,395 | | 4 | $122,395 | |
| 5 | $122,395 | | 5 | $122,395 | | 5 | $122,395 | | 5 | $122,395 | | 5 | $122,395 | |
| 6 | $122,395 | | 6 | $122,395 | | 6 | $122,395 | | 6 | $122,395 | | 6 | $122,395 | |
| 7 | $122,395 | | 7 | $122,395 | | 7 | $122,395 | | 7 | $122,395 | | 7 | $122,395 | |
| 8 | $122,395 | | 8 | $122,395 | | 8 | $122,395 | | 8 | $122,395 | | 8 | $122,395 | |
| 9 | $122,395 | | 9 | $122,395 | | 9 | $122,395 | | 9 | $122,395 | | 9 | $122,395 | |
| 10 | $122,395 | | 10 | $122,395 | | 10 | $122,395 | | 10 | $122,395 | | 10 | $122,395 | |
| 11 | $122,395 | | 11 | $122,395 | | 11 | $122,395 | | 11 | $122,395 | | 11 | $122,395 | |
| 12 | $122,395 | | 12 | $122,395 | | 12 | $122,395 | | 12 | $122,395 | | 12 | $122,395 | |
| 13 | $122,395 | | 13 | $122,395 | | 13 | $122,395 | | 13 | $122,395 | | 13 | $122,395 | |
| 14 | $122,395 | | 14 | $122,395 | | 14 | $122,395 | | 14 | $122,395 | | 14 | $122,395 | |
| 15 | $122,395 | | 15 | $122,395 | | 15 | $122,395 | | 15 | $122,395 | | 15 | $122,395 | |
| 16 | $122,395 | | 16 | $122,395 | | 16 | $122,395 | | 16 | $122,395 | | 16 | $122,395 | |
| 17 | $122,395 | | 17 | $122,395 | | 17 | $122,395 | | 17 | $122,395 | | 17 | $122,395 | |
| 18 | $122,395 | | 18 | $122,395 | | 18 | $122,395 | | 18 | $122,395 | | 18 | $122,395 | |
| 19 | $122,395 | | 19 | $122,395 | | 19 | $122,395 | | 19 | $122,395 | | 19 | $122,395 | |
| 20 | $122,395 | | 20 | $122,395 | | 20 | $122,395 | | 20 | $122,395 | | 20 | $122,395 | |
| 21 | $122,395 | | 21 | $122,395 | | 21 | $122,395 | | 21 | $122,395 | | 21 | $122,395 | |
| 22 | $122,395 | | 22 | $122,395 | | 22 | $122,395 | | 22 | $122,395 | | 22 | $122,395 | |
| 23 | $122,395 | | 23 | $122,395 | | 23 | $122,395 | | 23 | $122,395 | | 23 | $122,395 | |
| 24 | $122,395 | | 24 | $122,395 | | 24 | $122,395 | | 24 | $122,395 | | 24 | $122,395 | |
| 25 | $122,395 | | 25 | $122,395 | | 25 | $122,395 | | 25 | $122,395 | | 25 | $122,395 | |
| | NPV 1-25 yrs = | $1,185,014 | | NPV 1-25 yrs = | $1,018,028 | | NPV 1-25 yrs = | $719,340 | | NPV 1-25 yrs = | $495,235 | | NPV 1-25 yrs = | $134,212 |
| 26 | $122,395 | | 26 | $122,395 | | 26 | $122,395 | | 26 | $122,395 | | 26 | $122,395 | |
| 27 | $122,395 | | 27 | $122,395 | | 27 | $122,395 | | 27 | $122,395 | | 27 | $122,395 | |
| 28 | $122,395 | | 28 | $122,395 | | 28 | $122,395 | | 28 | $122,395 | | 28 | $122,395 | |
| 29 | $122,395 | | 29 | $122,395 | | 29 | $122,395 | | 29 | $122,395 | | 29 | $122,395 | |
| 30 | $122,395 | | 30 | $122,395 | | 30 | $122,395 | | 30 | $122,395 | | 30 | $122,395 | |
| 31 | $122,395 | | 31 | $122,395 | | 31 | $122,395 | | 31 | $122,395 | | 31 | $122,395 | |
| 32 | $122,395 | | 32 | $122,395 | | 32 | $122,395 | | 32 | $122,395 | | 32 | $122,395 | |
| 33 | $122,395 | | 33 | $122,395 | | 33 | $122,395 | | 33 | $122,395 | | 33 | $122,395 | |
| 34 | $122,395 | | 34 | $122,395 | | 34 | $122,395 | | 34 | $122,395 | | 34 | $122,395 | |
| 35 | $122,395 | | 35 | $122,395 | | 35 | $122,395 | | 35 | $122,395 | | 35 | $122,395 | |
| 36 | $122,395 | | 36 | $122,395 | | 36 | $122,395 | | 36 | $122,395 | | 36 | $122,395 | |
| 37 | $122,395 | | 37 | $122,395 | | 37 | $122,395 | | 37 | $122,395 | | 37 | $122,395 | |
| 38 | $122,395 | | 38 | $122,395 | | 38 | $122,395 | | 38 | $122,395 | | 38 | $122,395 | |
| 39 | $122,395 | | 39 | $122,395 | | 39 | $122,395 | | 39 | $122,395 | | 39 | $122,395 | |
| 40 | $122,395 | | 40 | $122,395 | | 40 | $122,395 | | 40 | $122,395 | | 40 | $122,395 | |
| 41 | $122,395 | | 41 | $122,395 | | 41 | $122,395 | | 41 | $122,395 | | 41 | $122,395 | |
| 42 | $122,395 | | 42 | $122,395 | | 42 | $122,395 | | 42 | $122,395 | | 42 | $122,395 | |
| 43 | $122,395 | | 43 | $122,395 | | 43 | $122,395 | | 43 | $122,395 | | 43 | $122,395 | |
| 44 | $122,395 | | 44 | $122,395 | | 44 | $122,395 | | 44 | $122,395 | | 44 | $122,395 | |
| 45 | $122,395 | | 45 | $122,395 | | 45 | $122,395 | | 45 | $122,395 | | 45 | $122,395 | |
| 46 | $122,395 | | 46 | $122,395 | | 46 | $122,395 | | 46 | $122,395 | | 46 | $122,395 | |
| 47 | $122,395 | | 47 | $122,395 | | 47 | $122,395 | | 47 | $122,395 | | 47 | $122,395 | |
| 48 | $122,395 | | 48 | $122,395 | | 48 | $122,395 | | 48 | $122,395 | | 48 | $122,395 | |
| 49 | $122,395 | | 49 | $122,395 | | 49 | $122,395 | | 49 | $122,395 | | 49 | $122,395 | |
| 50 | $122,395 | | 50 | $122,395 | | 50 | $122,395 | | 50 | $122,395 | | 50 | $122,395 | |
| | NPV 1- 50 yrs = | $2,584,891 | | NPV 1- 50 yrs = | $2,234,434 | | NPV 1- 50 yrs = | $1,689,142 | | NPV 1- 50 yrs = | $1,341,655 | | NPV 1- 50 yrs = | $873,001 |

Added First Cost - Geothermal

But yields Savings

Continued Savings of Geothermal

**Not included above:** Future long term avoided capitol costs, unique to Geothermal Systems

1. Years 15 - 20: Tower Replacement added cost $200,000
2. Years 26 - 30: Chiller/Boiler System added cost $900,000 (because Geothermal borefields last 50+ years, thus no Boilers, Chillers or Tower would exist to be replaced)

# OPERATIONAL & ENVIRONMENTAL

The following Operational and Environmental characteristics should be considered as a part of a final decision-making process.

**BEDFORD - HIGH SCHOOL**
**HVAC System Comparisions**

GATTER & DIEHL, Inc. 2/22/2024

| Analysis | HVAC System Types | Typical Exchanger Life Expectancy | Backup Heat Required | Weather Independence | Aesthetically Friendly? | Legionella Concerns/ Treatment Required? | Site noise/ Interior Noise | Winterization Needed? | Emissions Site NOx | Humidity Reduction Control | Reliability |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Chiller/Boiler/Tower | 14-16 years | No | Very good | Cooling Tower 17' tall | Yes/Yes | Max site /moderate interior | Yes | Yes | Yes - requires additional coil | Good |
| 2 | WSHP - Geothermal | 50+ years | No | Very good | No visual detriments | No/No | No site noise/low interior | No | None | Yes - Inherent | Better |

# SUMMARY AND RECOMMENDATIONS

The results of the Engineering Economic Analysis demonstrate that a Geothermal HVAC system is a prudent financial use of funds for the district, as proven by its rapid Simple Payback and Net Present Value ROI at various rates of return, up to and including double-digit discount rates far in excess of 10%. Similar studies by state, federal, university, independent and industry organizations have yielded the very same conclusions with respect to energy efficiency, financial investment, environmental quality and long-term sustainability.

Note that future capital replacement costs, financially detrimental to the use of the Chiller/Boiler/Tower system, were intentionally left out of this analysis. Those costs being the avoided replacement costs of the Tower Heat Exchanger in the first 25 years, and the capital costs beyond 25 years whereby Chiller/Boiler/Tower upgrades require capital expenditures far exceeding Geothermal, given that Geothermal heat exchangers last 50+ years. Throughout the analysis process, the Chiller/Boiler/Tower scenario has received all of the cost-benefits. Hence, the actual ROI expected over the entire life cycle of the Geothermal system could very reasonably exceed the values shown in this report, all while providing real tangible operational and environmental benefits to the district.

It's also worth noting that Geothermal lends itself to satisfy eligibility for clean energy grant programs when such plans are open and available for application, while Boiler/Chiller/Tower systems do not.