PART 3

ACHIEVE
RENEWABLE ENERGY

Increasing Awareness of Geoexchange in Massachusetts – Part 3 of 5

Heat pumps are heat pumps are heat pumps, right? While most people seem to picture an air-source mini-split system when they hear 'heat pump' there actually are a variety of heat pump types. These include the common mini-splits and whole house air-to-air but there are also air-to-water heat pumps and my favorite: Ground Source Heat Pumps (GSHPs). GSHPs are used in Geoexchange Systems to efficiently heat and cool buildings and can also provide hot water.

Geoexchange systems offer significant advantages for both homeowners and businesses. In Massachusetts, where weather conditions can be extreme in both winter and summer, geoexchange systems provide distinct benefits over air-source heat pumps (ASHPs). There is some technical complexity in explaining the reasons for this. I have prepared 5 separate posts to explore some of the most compelling advantages of Geoexchange/GSHPs one at a time. The individual posts are written to stand on their own so you can pick and choose the order you read them or just focus on the topic(s) that are important to you right now.

In the Series, I provide information related to:

1. Efficiency and Peak Load Advantages
2. Aesthetic Advantages in Historic Districts
3. Longer Service Life and Lifecycle Cost Advantages of GSHPs
4. Risk from Refrigerant used in GSHPs and ASHPs
5. Potential for Networked Geothermal Systems.

I hope this Series can promote discussion of building electrification using either ASHPs and GSHPs. Here is Part 1 of 5 which considers Service Life and Lifecycle Costs.

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Longer Service Life and Lifecycle Cost Advantages of Ground-Source Heat Pumps

Geoexchange systems are renowned for their longevity. The underground piping system, which is the core of the Geoexchange system, can last for over 50 years. The heat pump itself, located indoors, typically lasts 25 years with proper maintenance. In contrast, air-source heat pumps, which are exposed to harsh outdoor weather conditions in Massachusetts, often have a lifespan of 10-15 years.

The longer service life of Geoexchange systems means fewer replacements and lower long-term costs for property owners, further enhancing their value over time. In the following analysis, we present the framework for comparing the financial aspects of the technologies. This model can be used for analysis of specific projects of interest using project-specific data.

COMPONENT	GEOEXCHANGE *(YEARS)*	AIR-SOURCE HEAT PUMP *(YEARS)*
Heat Pump Unit	**20-25**	**10-15**
Underground Loops	**50+**	**N/A**
Maintenance Frequency	**Low**	**High**
Typical Replacement Time	**Every 25 Years**	**Every 10-15 Years**

SERVICE LIFE DIFFERENCES

GSHPs: The underground loop system, which is a critical component of GSHPs, has a lifespan of 50+ years, as it is buried underground and remains protected from environmental degradation. The heat pump unit itself, located indoors, typically lasts around 20-25 years with regular maintenance.

ASHPs: The components of ASHPs are more exposed to weather, including snow, rain, freezing temperatures, and debris, which results in more wear and tear. ASHPs typically have a lifespan of 10-15 years. The outdoor unit is particularly vulnerable to environmental stress, which shortens the overall life of the system.

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IMPACT OF CLIMATE ON ASHP LIFESPAN

In regions like Massachusetts, where winters are long and cold, ASHPs work harder to extract heat from the outdoor air, leading to faster degradation of components. The same applies in hot summer months when ASHPs must work continuously to cool the building. This makes more frequent repairs and earlier replacements common, which adds to the overall lifecycle cost.

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MAINTENANCE REQUIREMENTS

GSHPs: With their main components protected underground and housed indoors, GSHPs require less frequent maintenance. The heat pump itself requires periodic inspections and standard HVAC service (filter changes, coil cleaning), but the underground heat exchange loops are virtually maintenance-free.

ASHPs: ASHPs are more vulnerable to weather exposure, leading to higher maintenance needs. Outdoor units may require frequent cleaning, refrigerant checks, and mechanical repairs due to exposure to the elements. Indoor units for mini-split or VRF systems each require cleaning and filter changes increasing the required maintenance.

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LIFE CYCLE COST COMPARISON: FINANCIAL EXAMPLE

Let's compare the life cycle cost for both systems over a 25-year period, considering installation, maintenance, and replacement costs. The example below is based on common cost estimates for Massachusetts and assumes a 4-ton system suitable for a medium-sized residential home.

COST COMPONENT	GSHP	ASHP
Installation Cost	**$30,000 (including ground loops)**	**$12,000**
Service Life of System	**25 Years (heat pump)**	**$500**
Average Annual Maintenance	**$200**	**$500**
System Replacement Cost	**None in 25 years**	**$12,000 (after 12 years)**
Total Lifetime Maintenance	**$5,000 ($200 x 25 years)**	**$12,000 ($500 x 25 years)**
Energy Efficiency	**40-60% savings over ASHP**	**Baseline for energy cost**

We will now compare Ground-Source Heat Pumps (GSHPs) and Air-Source Heat Pumps (ASHPs) assuming both systems replace all heating and cooling needs. Here are the key parameters:

GSHP INSTALLATION:

Pre-incentive cost: $75,000

Incentives:

- 30% Federal Tax Credit
- $15,000 rebate from Mass Save
- Exemption from Massachusetts Sales Tax

ASHP INSTALLATION:

Pre-incentive cost: $38,000

Incentives:

- $10,000 rebate from Mass Save
- Massachusetts Sales Tax of 6.25% on the system

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Incentive Calculations

GSHP INCENTIVE BREAKDOWN:

1. Federal Tax Credit (30%):
    - 30% of $75,000 = $22,500 credit.

2. Mass Save Rebate:
    - $15,000 rebate to Homeowner.

3. Sales Tax Exemption
    - Massachusetts sales tax is 6.25%, so exempting $75,000 saves $4,687.50.

Total Incentives for GSHP =
$22,500 (tax credit) + $15,000 (Mass Save) + $0 (tax exemption) = $37,500

ASHP INCENTIVE BREAKDOWN:

1. Mass Save Rebate:
    - $10,000 rebate directly applied to the cost.

2. Massachusetts Sales Tax – No Exemption for ASHP:
    - 6.25% of $38,000 = $2,375 in sales tax.

Total Incentives for ASHP =
$10,000 (rebate) - $2,375 (sales tax) = $7,625

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Post-Incentive Installation Costs

GSHP:

- Pre-incentive cost: **$75,000**
- Total incentives: **$37,500**

Post-incentive cost: $75,000 - $37,500 = **$37,500**

ASHP INSTALLATION:

- Pre-incentive cost: **$38,000**
- Total incentives: **$7,625**

Post-incentive cost: $38,000 - $7,625 = **$30,375**

Maintenance Costs (Over 25 Years)

GSHP:

- Annual maintenance: **$400/year**
- Total maintenance cost over 25 years:
  25 x $400 = **$10,000**

ASHP:

- Annual maintenance: **$600/year**
- Total maintenance cost over 25 years:
  25 x $600 = **$15,000**

Replacement Costs (Over 25 Years)

GSHP:

- Heat pump replacement after 25 years: **$20,000**
  (for the heat pump unit only, the ground loops typically last 50-100+ years)

Total replacement cost: $20,000

ASHP INSTALLATION:

Replacement every 12-15 years. Assume two replacements in 25 years:

- First replacement: **$38,000** (without rebates for replacements)
- Second replacement: **$38,000**

Total replacement cost: $38,000 + $38,000 = $76,000

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ENERGY SAVINGS

We can typically assume GSHPs provide at least 40% energy savings compared to ASHPs. Over 25 years, if average annual energy costs for an ASHP system are estimated at $3,000, the GSHP system will reduce this to $1,800 annually.

- ASHP energy cost over 25 years: 25 x $3,000 = **$75,000.**
- GSHP energy cost over 25 years: 25 x $1,800 = **$45,000.**
- Energy savings with GSHP: $75,000 - $45,000 = **$30,000** saved over 25 years.

Total Life Cycle Cost (Over 25 Years)

With all those calculations done, we can total the results and compare the systems.

GSHP TOTAL LIFE CYCLE COST:

- Post-incentive installation: **$37,500**
- Maintenance over 25 years: **$10,000**
- Replacement after 25 years: **$20,000**
- Energy cost over 25 years: **$45,000**

Total GSHP Life Cycle Cost: $37,500 + $10,000 + $20,000 + $45,000 = $112,500

ASHP TOTAL LIFE CYCLE COST:

- Post-incentive installation: **$30,375**
- Maintenance over 25 years: **$15,000**
- Two replacements: **$76,000**
- Energy cost over 25 years: **$75,000**

Total ASHP Life Cycle Cost: $30,375 + $12,500 + $76,000 + $75,000 = $196,375

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Life Cycle Cost Summary:

COST COMPONENT	GSHP	ASHP
Initial Installation Cost (Pre-Incentive)	$75,000	$38,000
Federal Tax Credit	($22,500) (30%)	N/A
State Rebate (Mass Save)	($15,000)	($10,000)
Sales Tax Exemption	$0 (Exempt)	+$2,375 (6.25%)
Post-Incentive Installation Cost	$37,500	$30,375
Annual Maintenance Cost	$400/year	$600/year
Total Maintenance Over 25 Years	$10,000	$15,000
Replacement Cost After 25 Years	$20,000 (1 replacement)	$76,000 (2 replacements)
Energy Cost Over 25 Years	$45,000	$75,000
Total Life Cycle Cost	$112,500	$196,375

CONCLUSION

Over a 25-year period, GSHPs offer a significantly lower total life cycle cost compared to ASHPs, despite the higher initial investment. Key savings come from:

- **Lower replacement costs:** GSHPs last longer, requiring fewer replacements.
- **Energy savings:** GSHPs are more efficient, reducing annual energy costs by 40%.
- **Maintenance savings:** GSHPs require less maintenance due to their protected components.

Total Savings with GSHPs:

- GSHP Total Life Cycle Cost: $112,500
- ASHP Total Life Cycle Cost: $196,375
- Savings: $196,375 - $112,500 = $83,875

While the GSHP installation costs more up front, it is a preferred solution when lifecycle cost is considered.