

# Pool Heating Analysis

## ET24SWG0001

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Saurabh Shekhar

Senior Energy Engineer



# Project Team

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**Saurabh Shekhar, CEM, CDCP, EIT**  
Energy Engineer



**Steven Long, P.E.**  
Director of Engineering (West)



**Evan Davis**  
Program Manager



**Ava Donald**  
GET Program Manager

# Agenda

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- Background
- Project Objectives
- Literature Review and Subject Matter Expert (SME) Interview Findings
- Pool Heating Analytical Tool Development and Updates
- Parametric Analysis
- Results and Recommendations



# Introduction

# Introduction– Pool Heater Market Characterization

- About 97% of the pools in the U.S. are residential (10.4 million) [1]
- California: second highest number of pools per state in the U.S. (1.34 million) [2]
- Most of the pools in California are outdoors
- Typical season for swimming: May through September
- Total Estimated Impact Cost Saving Potential: ~ 78 million USD for GAHP, ~ 70 million USD for Hybrid Pool Heater (Assumption of 60% adoption in California) [3]



[1] Swimming Pool Statistics, Report by RubyHome, January 2024.

[2] Open Pool Time, Report by Pool Research, August 2023.

[3] Hybrid pool heater combines an electric heat pump and a gas-fired heater paired with integrated titanium heat exchanger

# Objectives

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- Synthesizing insights from literature and subject matter expert (SME) interviews
- Updating an existing excel-based tool to model hourly energy use, costs, and GHG emissions for alternative pool heating technologies
- Assessing the energy, cost, and GHG emissions saving potential of different pool heating technologies in California climate zones

# Pool Heat Losses

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- Evaporation heat loss is one of the major contributors to overall pool heat loss (approximately 60% of total heat loss)
- Factors affecting evaporation heat loss: air temperature, wind speed, humidity, pool water temperature
- Convective heat loss- due to temperature differences between the ambient air and pool
- Solar radiation- adds heat to the pool, reducing the pool heating energy requirements
- Conductive heat loss to surrounding materials is small and can be neglected
- Typical pool water setpoint temperatures: 78°F to 82°F
- Typical pool heater size: about 250 kBTU/h for 30,000 gallons average sized pool; range between 75 to 450 kBTU/h

# Pool Heating Technologies

## Traditional gas pool heater

- Typical efficiencies: 82% to 90%
- Useful life: 10 years
- Costs of outdoor pool gas heating by location [4]

Location	Season	78°F	80°F	82°F
San Francisco	6/1-8/31	\$2,126	\$2,529	\$2,954
Los Angeles	5/1-10/31	\$2,540	\$3,237	\$3,957

## -Notes:

1. These are heating costs for a 1,000 sq. ft. swimming pool with an 80% efficient gas pool heater at \$1.09 per therm (Reference: US DOE website)
2. Average rates as per utility (\$/therm): \$1.54 for SoCalGas, \$1.71 for PG&E, and \$2.21 for SDG&E [5]

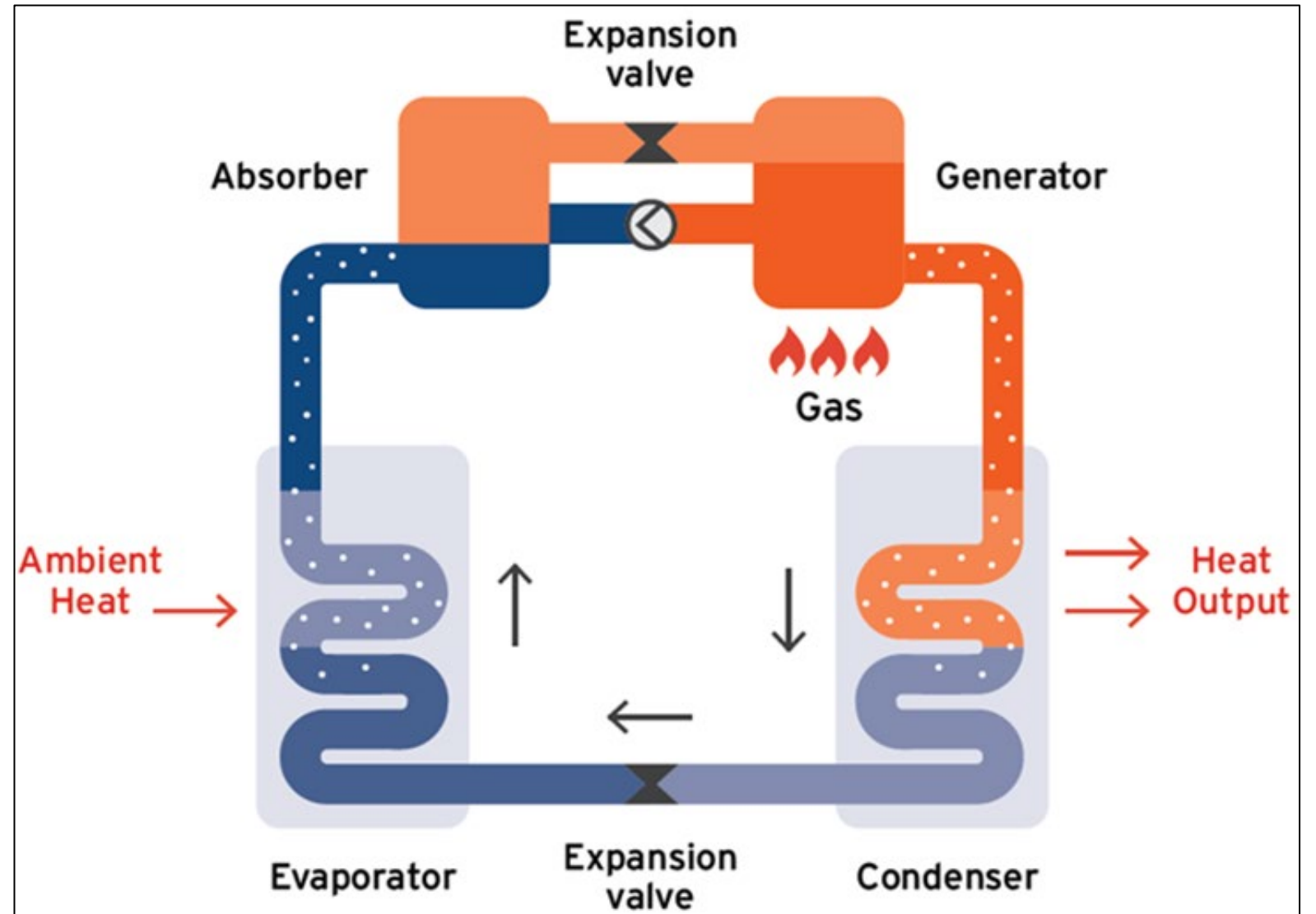
[4] <https://www.energy.gov/energysaver/gas-pool-heaters>

[5] Utility Rates Compilation by Lincus, Energy Modeling of Single Family Homes in California- ET23SWG0005 (2023)

# Pool Heating Technologies

## Gas Absorption Heat Pump (GAHP)

- Heating output between 80 kBTU/h and 123 kBTU/h depending upon manufacturer
- Electrical draw of unit less than 1 kW
- Typical COPs between 1.2-1.4
- GAHPs would require external heat exchanger in the pool water loop and require outdoor installation
- Maintain high efficiencies at lower ambient temperatures
- GAHPs are ideal for base loads, integration of units with existing pool heater



[5] Gas Absorption Heat Pumps Best Practices Guide, Report by FortisBC, October 2023.

# High Level Comparison of Pool Heating Technologies

Technology	Traditional gas heater	Gas absorption heat pump (GAHP)	Electric heat pump pool heater	Solar pool heater
<b>Advantages</b>	<ul style="list-style-type: none"> <li>Speed of heating</li> <li>Low first cost</li> <li>Heating capacity ranging from 75 to 450 <u>kBTU</u></li> <li>Can supply peak heating needs</li> <li>Modulation capacity</li> </ul>	<ul style="list-style-type: none"> <li>Can achieve COP values up to 1.4</li> <li>Lower GHG emissions</li> <li>Lower fuel operating costs</li> <li>Heating capacity up to 123 <u>kBTU</u></li> <li>Modulation capacity in some models</li> <li>High performance at lower ambient temperatures</li> </ul>	<ul style="list-style-type: none"> <li>Lower GHG emissions</li> <li>COP values range between 3 to 7</li> <li>High fuel operating cost in California</li> <li>Heating capacity up to 125 <u>kBTU</u></li> </ul>	<ul style="list-style-type: none"> <li>No emissions post-installation</li> <li>No usage cost</li> <li>High efficiency</li> </ul>
<b>Disadvantages</b>	<ul style="list-style-type: none"> <li>Higher operating cost than GAHP</li> <li>High GHG emissions</li> <li>Low efficiency</li> </ul>	<ul style="list-style-type: none"> <li>Lower speed of heating</li> <li>May not be able to supply peak heating needs</li> <li>Highest first cost</li> </ul>	<ul style="list-style-type: none"> <li>Lower heating capacity per unit traditional gas heaters</li> <li>High first cost</li> <li>Low speed of heating</li> <li>May not be able to supply peak heating needs</li> <li>Reduced performance at low ambient temperatures</li> </ul>	<ul style="list-style-type: none"> <li>High first cost</li> <li>Speed of heating is location and sun-dependent-large space requirements</li> <li>May not be able to supply peak heating needs</li> <li>Low energy output and heating capacity at off-peak solar times</li> </ul>

**Note: Comparison based on metrics such as fuel operating costs, GHG emissions, and speed of heating is with respect to baseline- traditional gas fired pool heaters**



# Analytical Tool Development and Updates

# Pool Heating Analytical Tool Development and Updates

## Assumptions and Inputs:

- Swim season length assumptions per CA climate zone
- Built-in ASHRAE reference values of pool dimensions, pool activity factor, pool type
- Sizing of pool heater (BTU) – using pool temperature setpoint, average temperature of coldest month of pool use, pool surface area
- Effectiveness of GAHP Heat Exchanger– 0.97
- Same pool cover assumptions for both baseline and measure cases
- Minimum solar collector surface area– 65% of pool area

**Comprehensive Heated Pool Energy Savings Model**
Developed by ICF

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**Overall Pool Characteristics**

**Location and Weather Data**

Climate Zone	CZ09
Simulation Year	2025

**Pool Specifications**

Pool Type	Residential Pool	
Pool Location	Outdoor Pool	Recommended
Area (sq. ft.)	600	600
Average Depth (ft)	4.50	4.50
Solar Shading Factor	30%	30%
Wind Shielding Factor	50%	50%
Pool Activity Factor	0.50	0.50

**Pool Schedule**

Annual Opening Day	5/15/2025	5/15/2025
Annual Closing Day	10/31/2025	10/31/2025
Start of Summer Hours	5/15/2025	5/15/2025
Start of Winter Hours	10/31/2025	10/31/2025
Summer Opening Time	12:00 PM	12:00 PM
Summer Closing Time	8:00 PM	8:00 PM
Winter Opening Time	12:00 PM	12:00 PM
Winter Closing Time	12:00 PM	12:00 PM

**For Indoor Pools Only**

Open Hours Room Temp (°F)	n/a
Winter Off Hours Room Temp (°F)	n/a
Summer Off Hours Room Temp (°F)	n/a
Room Humidity (%)	n/a

**Pool Heater Information**

**Pool Setpoint and Schedule**

Pool Setpoint (°F)	80	80
Pool Heater Start Day	5/15/2025	5/15/2025
Pool Heater End Day	10/31/2025	10/31/2025

**Existing Pool Heater Specifications**

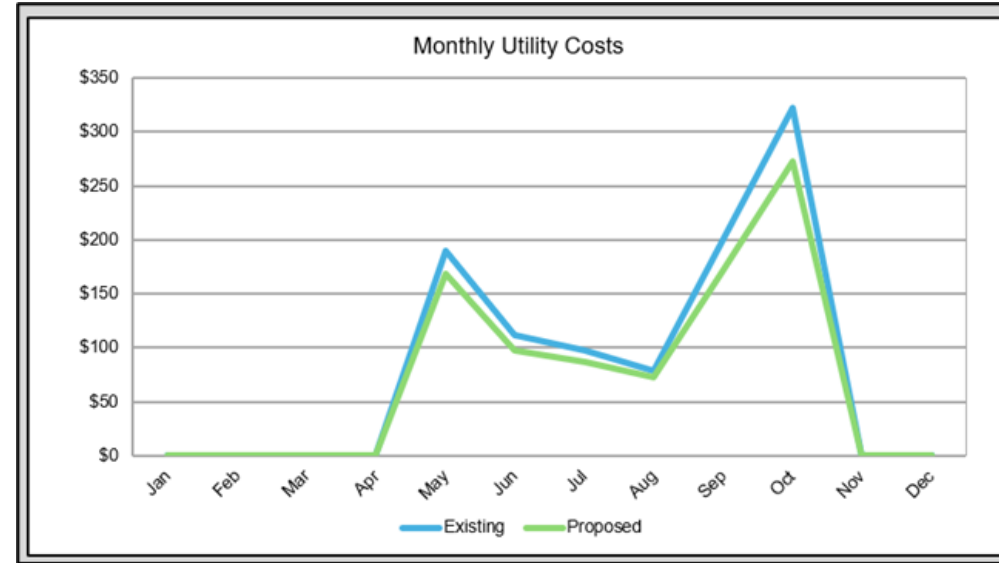
Existing Heater Type	None	None
Existing Input Capacity (kBtu/h)	125	125
Existing Thermal Efficiency (%)	82%	82%
Existing Cover Type	None	None
Existing R-Value (hr-ft <sup>2</sup> -°F/Btu)	0	0
Existing Coverage (% of area)	0%	0%

**Proposed Pool Heater Specifications**

Proposed Heater Type	GAHP + Gas Pool Heater	
GAHP Quantity	1	1
Gas Heater Input Capacity (kBtu/h)	125	125
Proposed Thermal Efficiency (%)	82%	82%
Heat Exchanger Effectiveness (%)	90%	90%
GAHP + Gas Concurrent Running?	TRUE	
Proposed Cover Type	None	None
Proposed R-Value (hr-ft <sup>2</sup> -°F/Btu)	0	0
Proposed Coverage (% of area)	0%	100%
Proposed Solar Thermal Area (sq. ft.)	0	360
Average Collector Efficiency (%)	60%	60%

# Parametric Analysis

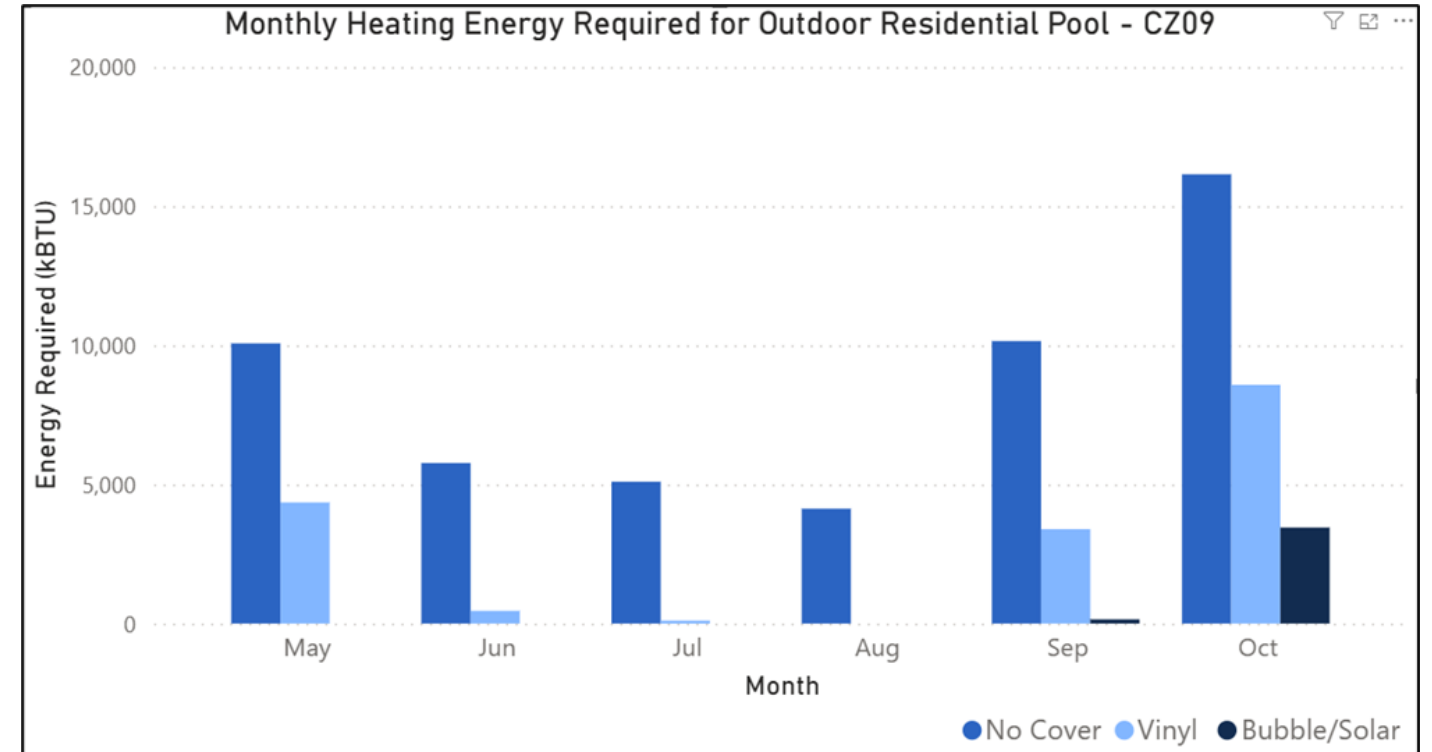
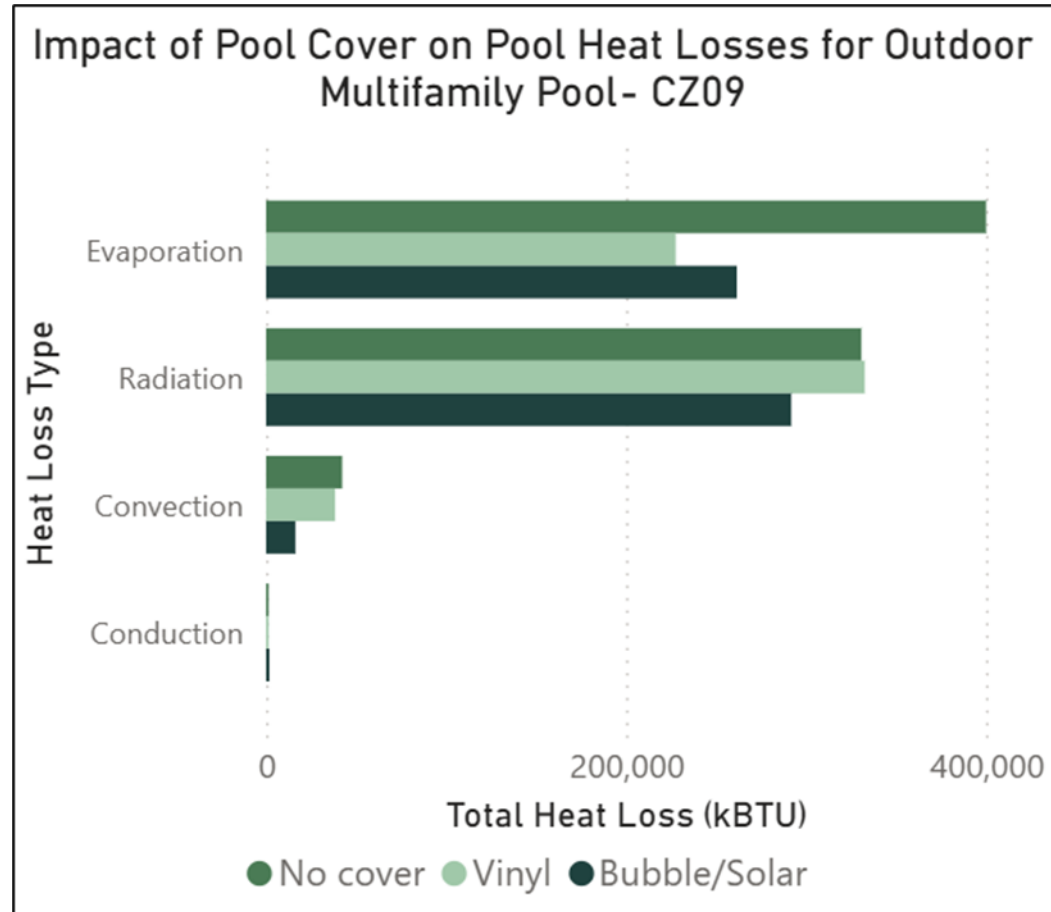
Parametric Analysis is a systematic approach used to analyze how variations in input parameters influence the outputs of the model. The goal is to identify critical parameters that significantly affect energy and emissions saving potential of pool heating technologies.



Parameter	Level
1 Climate Zone (16)	CZ01-CZ16 (16)
2 Pool or Building Type (5)	Residential
	Multi-family Residence
	Hotel
	Schools/Colleges- Recreation Pool
3 Existing and Proposed Cover Type (3) (assumed same for baseline and measure cases)	Private Health Club- Large Pool
	None
	Vinyl
4 Proposed Heater Type (4)	Bubble/Solar
	GAHP + Gas Pool Heater
	Heat Pump
	Hybrid Heat Pump- Cost Mode
5 Proposed Solar Thermal Area (2)	Hybrid Heat Pump- Efficiency Mode
	0
6 Effectiveness of GAHP Heat Exchanger (6)	Recommended
	0.5, 0.6, 0.7, 0.8, 0.9, 1

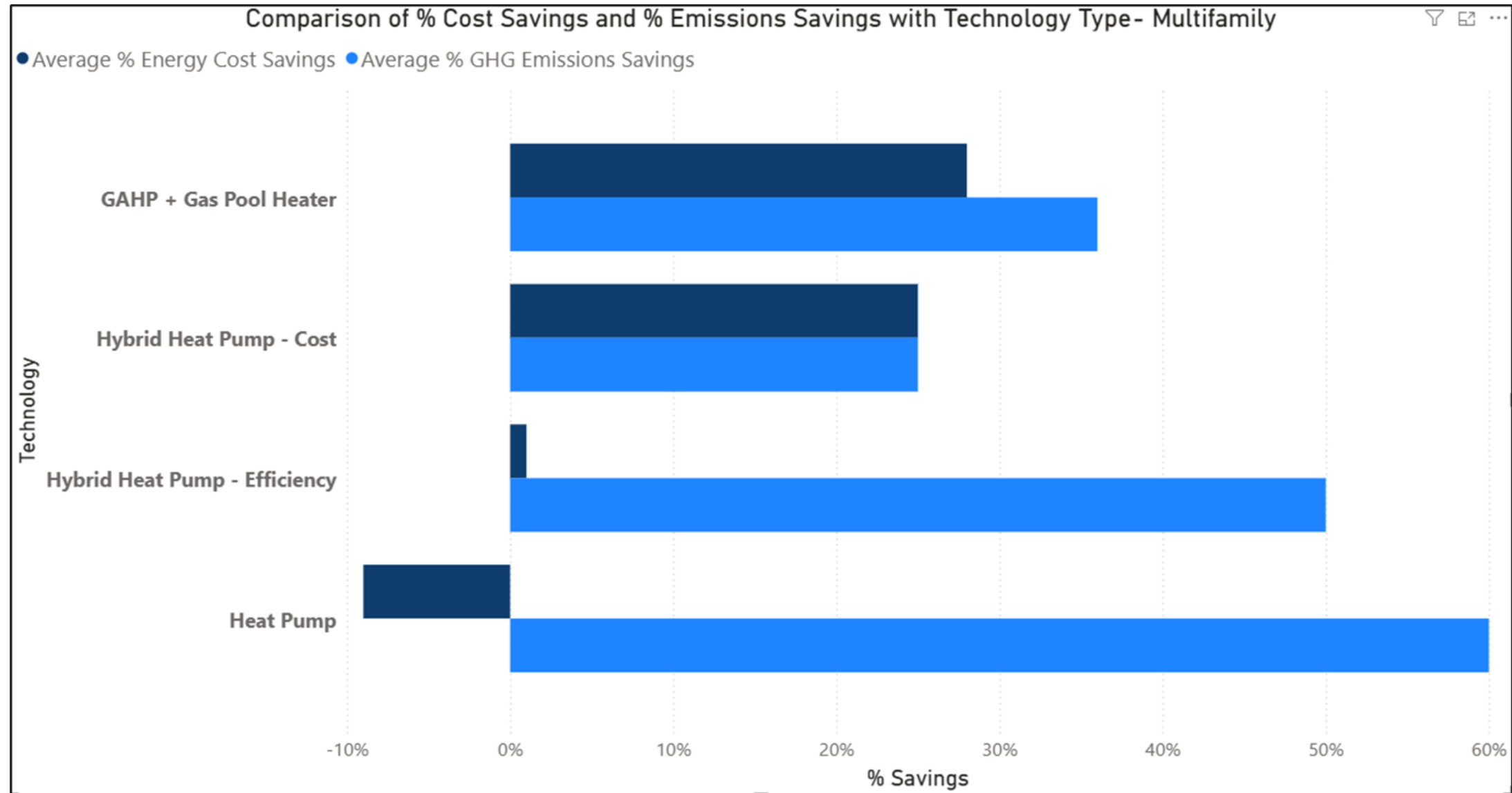
Output Variables	
1	Baseline and Measure <u>Therms Usage</u>
2	Measure kWh Usage
3	Baseline and Utility Costs
4	Baseline and Measure GHGs
5	% of load from GAHP (for GAHP Measure Case Equipment only)

# Impact of Pool Cover- Outdoor Pools

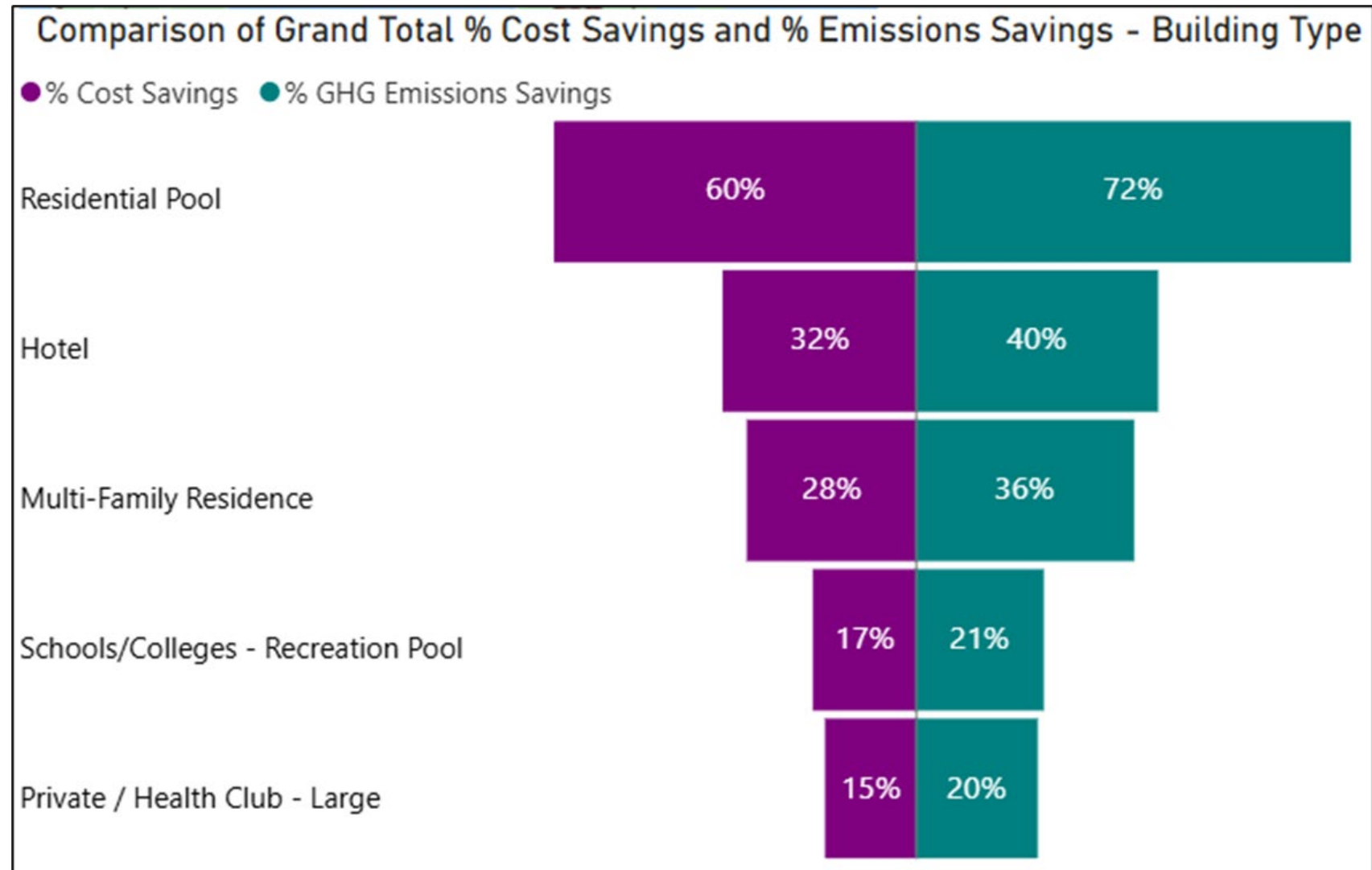


**Remarks:** Significant reduction in evaporation heat loss when pool cover is in place during the night or unoccupied pool hours. There is no or minimal heating required for outdoor residential pool, except October.

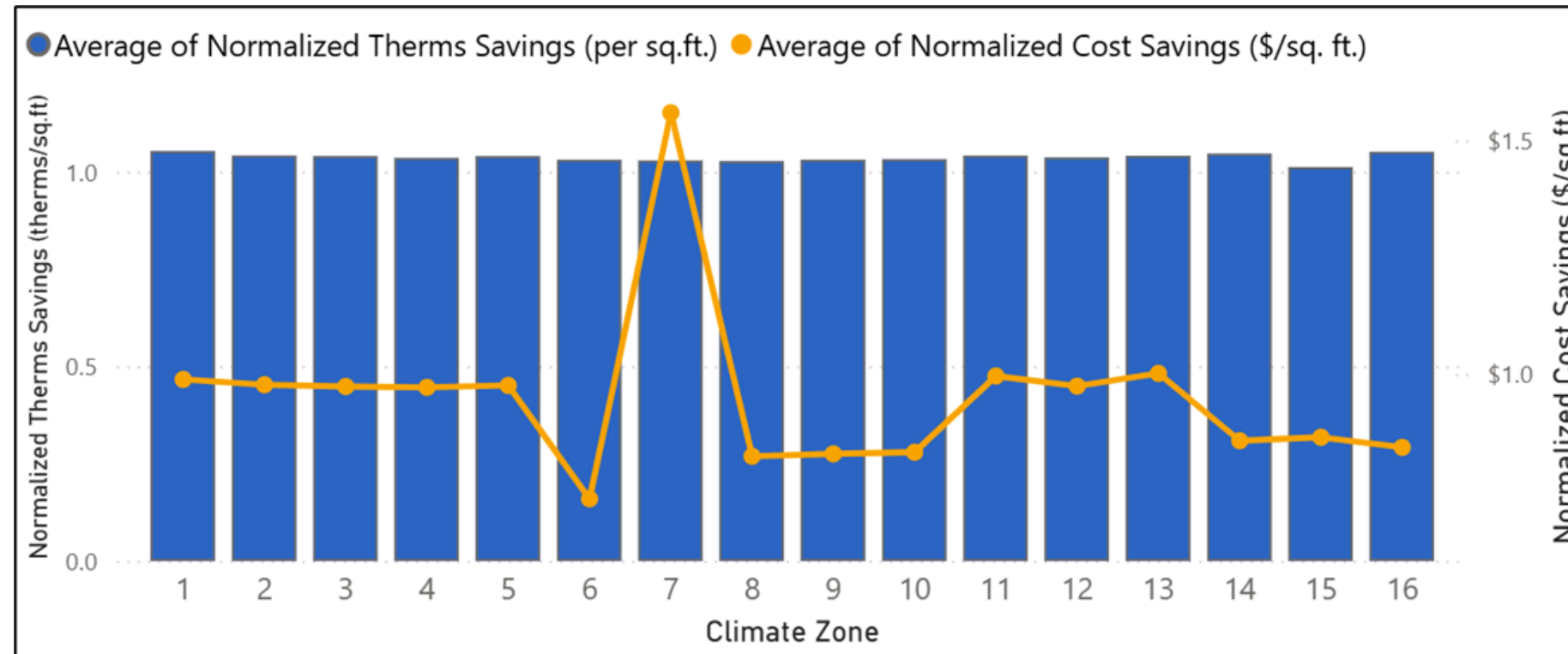
# Comparison of energy and emissions savings- Outdoor Pools-Multifamily



# Comparison of energy and emissions savings– GAHP for Outdoor Pools

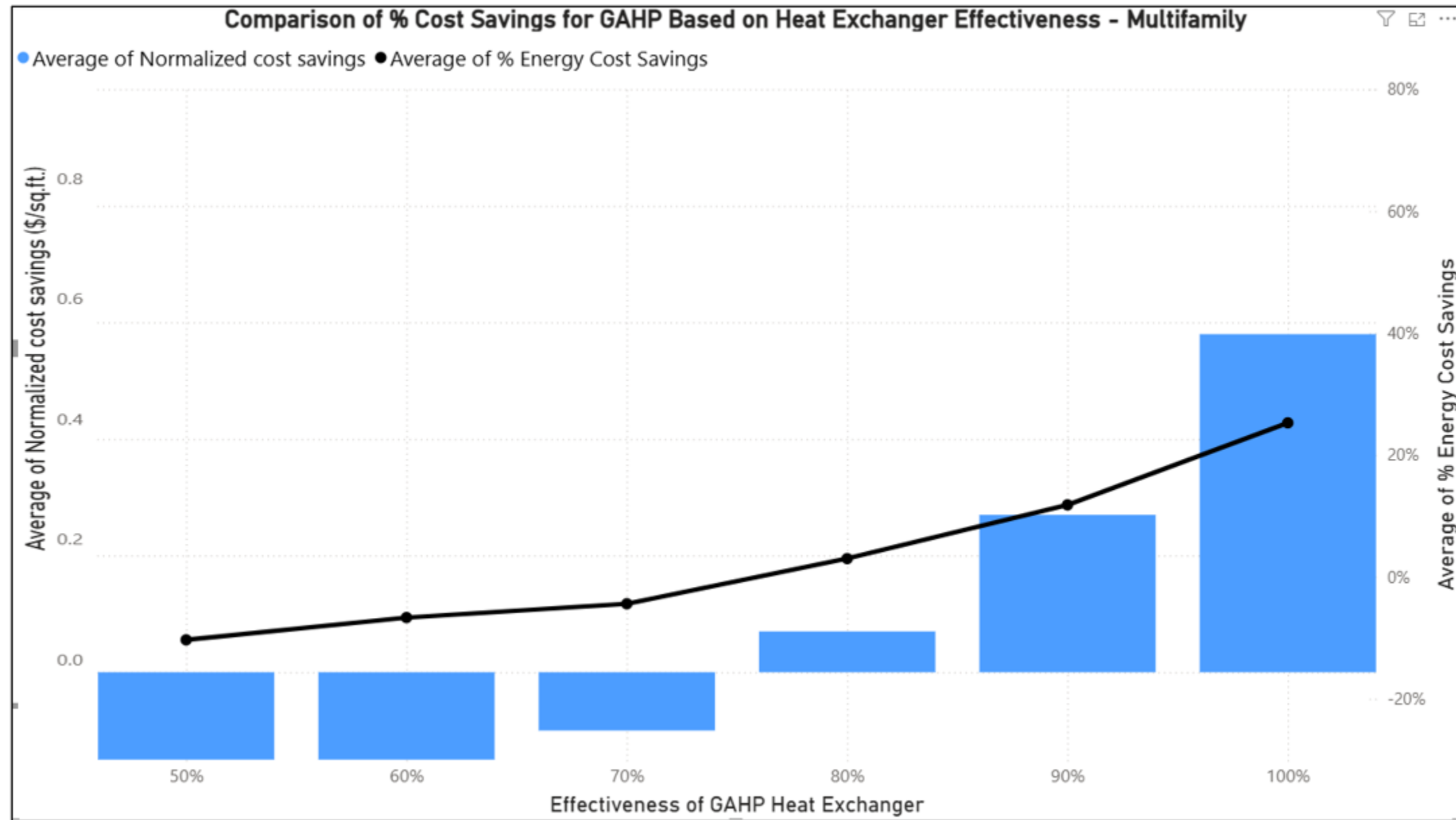


# GAHP for Outdoor Pools- Multifamily

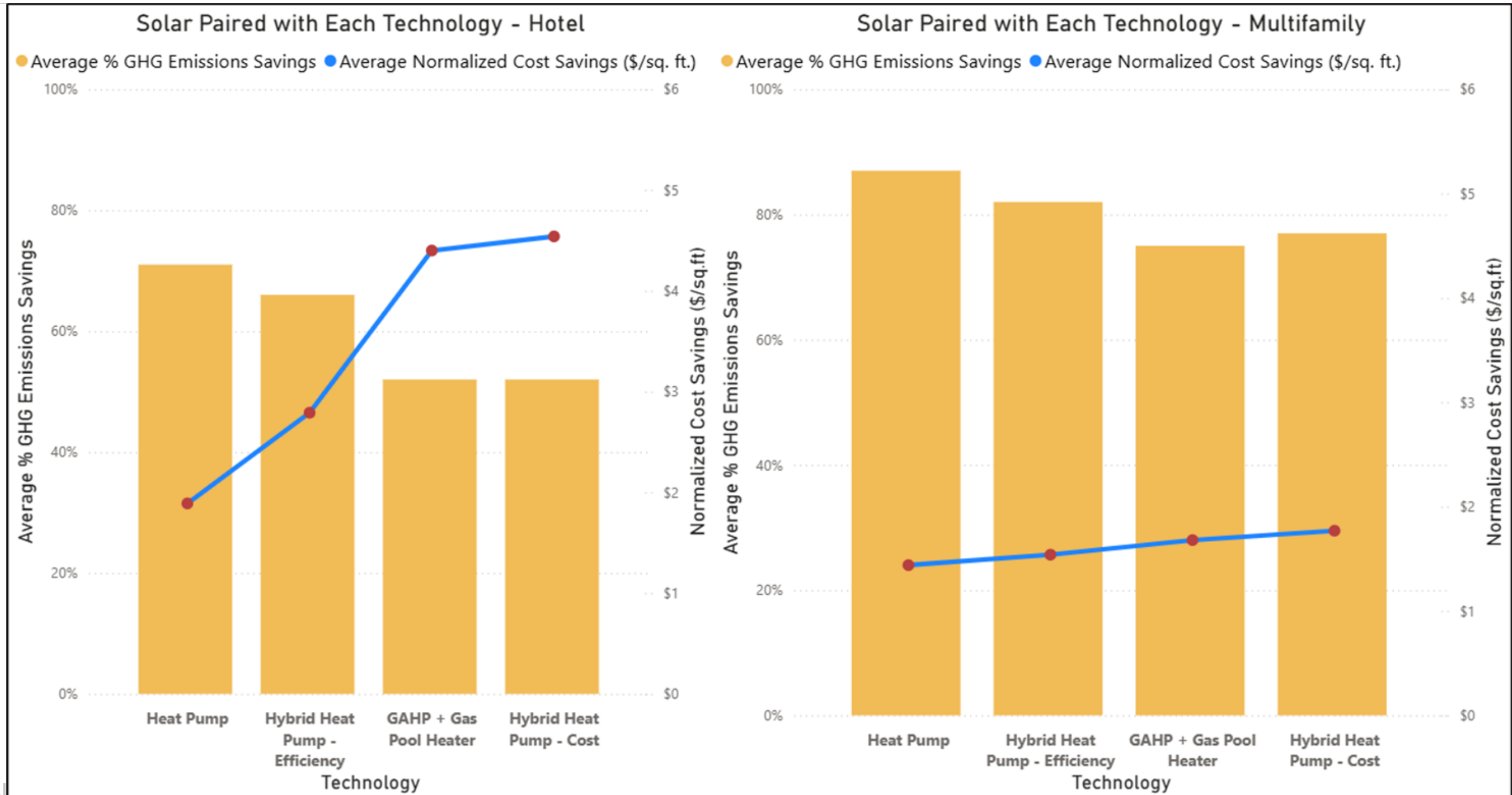


- Normalization of therms and cost savings w.r.t. pool surface area (sq. ft.)
- CZ07 (San Diego): highest normalized cost savings for multifamily and hotel sectors

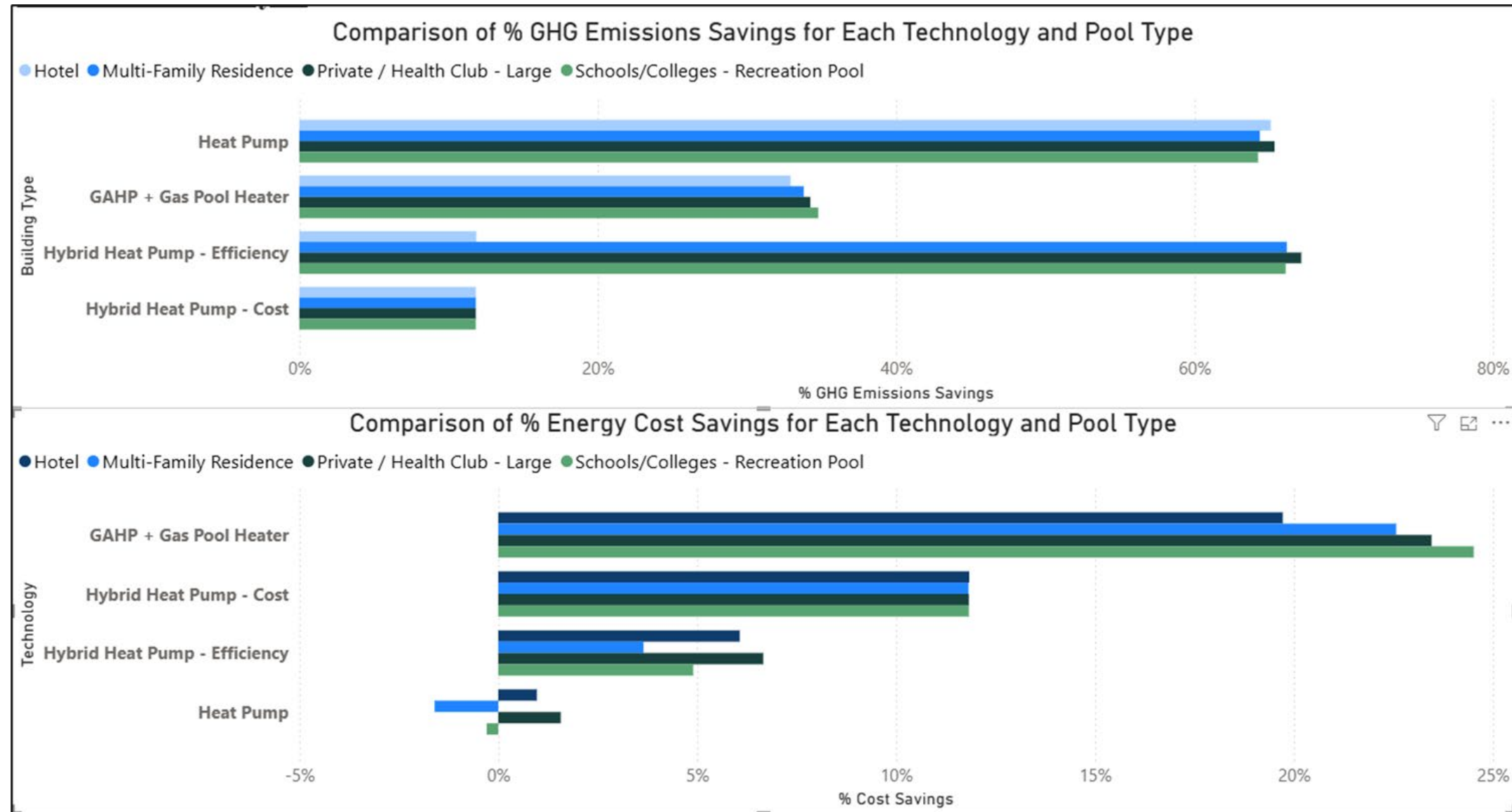
# Impact of Effectiveness of GAHP Heat Exchanger on Cost Savings



# Solar Thermal- Paired with each Outdoor Pool Heater Type



# Comparison of energy and emissions savings– Indoor Pools





## Results and Recommendations

# Conclusions and Recommendations

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## Key Takeaways

- Impact of pool cover on heating energy required
- GAHPs demonstrate the highest cost saving potential (~28%) followed by hybrid pool heater (~25%) for multifamily sector
- Heat pump pool heater and 'Hybrid pool heater- efficiency mode' demonstrates the highest GHG emissions savings for all pool types
- Effectiveness of GAHP Heat Exchanger is a critical system design parameter. Effectiveness should be greater than equal to 80% for positive energy savings
- 'Hybrid pool heater- cost mode' has the highest normalized cost savings, when paired with solar
- Cost saving potential of GAHP is the highest for Private/health club and School/colleges- recreational indoor pools

## Recommendations- Future Studies

- Field Study of GAHP and Hybrid Pool Heater for pool heating application
- Tool updates for adding above ground residential spa/hot tubs and pool+spa configurations in multifamily/hotel sector
- Tool updates for other climate zones/states and other GAHP manufacturer/field tested data



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## Get in touch with us: Ava Donald

Program Manager  
Ava.Donald@icf.com

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