Gas Absorption Heat Pumps Best Practices Guide

Developed by:
CLEAResult®

Developed for:
FORTIS BC™

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Foreword

As an energy delivery company providing electricity and natural gas to 135 communities, and 58 Indigenous communities in British Columbia, FortisBC is committed to deliver energy safely, reliably, and affordably every day to more than 1.2 million British Columbian, while helping them achieve their climate action goals. In its "Clean Growth Pathway to 2050", FortisBC specifies four pillars in our energy systems to foster market transformation and transition to low-carbon and renewable energy future: (1) Liquified natural gas (LNG) for marine fueling & global markets; (2) zero & low-carbon transportation, such as electric vehicles; (3) renewable gas and (4) energy efficiency. With respect to the energy efficiency pillar, we continue to invest in energy efficiency in the built environment and utilizing innovative conservation and energy efficiency technologies in the residential, commercial, and industrial sectors. Investing in commercial Gas Absorption Heat Pump (GAHPs) technology is one of the many ways we intend to achieve this goal. We hope this Best Practices guide will allow stakeholders to understand this technology better. ***Saleh Lavaee, FortisBC.***

CLEAResult is the largest provider of energy efficiency, transition and decarbonization solutions in North America. We guide businesses, utilities and more toward equitable environmental sustainability. This Best Practices guide is a result of a two-year-long collaboration with FortisBC and first-hand project knowledge shared by Building Energy Solutions. We believe the guide will help answer key questions about GAHP technology. ***CLEAResult Canada Inc.***

This guideline has been written using the knowledge gained from the FortisBC Gas Absorption Heat Pump (GAHP) Pilot. It has been our privilege to be the measurement and verification implementation consultant for the pilot program, which has provided extremely useful insights into this emerging technology. We are excited to be part of the continuing story in the advancement of the installation of this equipment with the goal of reducing greenhouse gas emissions. ***Steven Arnold, BES-Building Energy Solutions Ltd.***

Robur Corporation is excited to partner with FortisBC in their efforts to bring highly efficient gas equipment to the marketplace. FortisBC is the North American utility leader when it comes to creating awareness, promotion, and greater adoption of gas heat pump technology. The development of a "Best Practices" guide provides a valuable resource for understanding the features and benefits of this emerging segment. ***Bert Warner, Robur Corporation.***

Homy Building Solutions, the North American distributor of Vicot Gas Heat Pumps is pleased to support the efforts of CLEAResult and applaud FortisBC for being a leader in publishing the Gas Heat Pump Best Practices guide. Vicot Gas Heat Pump equipment provides solutions for a sustainable future. We are pleased to partner on the right projects that assist in reducing your carbon footprint and energy costs. ***Houman Ameri, Homy Building Solutions.***

Disclaimer

Version History

Version No.	Date	Author	Description of the change
1	16-May-23	CLEAResult Canada Inc. and BES-Building Energy Solutions Ltd.	Version 1 of the Best Practices Guide for Gas Absorption Heat Pumps

Table of Contents

List of Tables

List of Figures

Executive Summary

FortisBC is British Columbia's largest energy provider, with more than 100 years of knowledge and experience in delivering energy to its customers. FortisBC delivers safe, reliable, and cost-effective natural gas, electricity and renewable and low-carbon fuels, such as Renewable Natural Gas to its customers across the province. FortisBC has more than 2,600 employees proudly serving approximately 1.2 million customers in 135 British Columbian communities and 58 Indigenous communities across 150 Traditional Territories.

In 2018, FortisBC released its "Clean Growth Pathway to 2050"[1], which presents FortisBC's pathway to align with the provincial government's goal to significantly reduce greenhouse gas emissions (GHG) while supporting economic growth and maintaining affordability and customer choice. FortisBC's proposed pathway highlights four pillars requiring significant energy system transformation to meet the growing demand for clean energy[2]. One of these areas highlights the need for increasing the investment in energy efficiency in the built environment and developing innovative technologies in this space in BC. Investing in promotion of Gas Absorption Heat Pumps (GAHP) technology was one of the many ways FortisBC aims to achieve this goal.

In 2019, FortisBC's Innovative Technologies team, as part of the Conservation and Energy Management (C&EM) department initiated a pilot program to verify the operational performance of commercial GAHPs and installed 14 Robur-A units at seven commercial sites across BC, serving domestic hot water. The program was designed to demonstrate the energy savings potential, address any issues associated with the installation and operation, and test the compatibility of commercial GAHPs with local climate zones in commercial (Part 3) buildings. The pilot program served as an opportunity to learn about the customer experience and market readiness of the GAHP technology. These projects helped FortisBC verify the manufacturers' published performance data for GAHP units and apply it at a system level. Commercial Air-to-water GAHP units were installed in Multi-Unit Residential Buildings (MURBs) and school facilities in the Lower Mainland climate zone (i.e., Climate Zone 4) under live conditions.

GAHPs offer a resilient space and hot water heating option for facilities that are/will be connected to the natural gas grid. The technology is also compatible with renewable and low-carbon fuels, such as Renewable Natural Gas (RNG) and hydrogen blend of up to 20% with natural gas.

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[1] "Clean growth pathway to 2050" FortisBC - 2018

[2] The four pillars are as follows: Liquified natural gas (LNG) for marine fueling & global markets; zero & low-carbon transportation; renewable gas and, energy efficiency.

GAHPs operate on a heat-activated absorption cycle. The cycle relies on the absorption of refrigerant (ammonia[3]) by a transport medium (water). The circulation of water-ammonia (diluted) solution is limited to the refrigeration loop inside the outdoor unit. The heat is transferred through water running in a separate piping loop. Since the units come pre-charged and sealed with ammonia-water solution, there is little chance that operations, maintenance, or installation personnel will ever come into contact with the refrigerant. Through proper guidance from the manufacturers during the field demonstrations, FortisBC was able to mitigate concerns about the use of ammonia.

In July 2021, FortisBC launched a limited-time GAHP early adopter offer to support a select commercial early adopters of this technology implement it in their facilities. There are currently more than 15 commercial customers throughout the province who have completed the design phase and are actively working with their design and contractor teams for completion and commissioning of their GAHP systems. These enthusiastic organizations include but are not limited to a healthcare centre, a university education facility, a number of MURBs and schools, a recreational centre, and a fire hall.

In June 2022, FortisBC became the first utility in Canada to introduce gas absorption heat pump prescriptive rebates for its commercial customers. Product rebates are offered for installing GAHPs, with additional rebates for adding smart controls and other performance optimizations. The rebates also provide support for customers with the cost of conducting a detailed engineering feasibility study for their facilities to ensure customers are able to do their own due diligence with peace of mind. GAHPs range in price, and the units alone can cost between $20,000 and $30,000[4]. Project-specific factors such as the number of units, controls, integration with existing equipment, installation requirements, piping and insulation can impact the overall total project cost.

The aim of this Best Practices guide is to provide a comprehensive and informative resource for individuals and organizations interested in adopting gas absorption technology. The guide is designed to introduce the technology in a clear and concise manner, while also addressing critical questions that may arise during the adoption and implementation process. The guide covers important aspects of gas absorption technology, including the principles behind the process, the equipment and materials required, and the best practices for implementing the technology. It also addresses common challenges that may arise during the adoption process and how to optimize the process conditions for maximum efficiency.

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[3] Refer to the Refrigerant Safety section and Table-1 for more details on ammonia.

[4] "What are gas heat pumps and how can they save money and energy?". Article posted on FortisBC webpage on June 21, 2022.

Overall, the goal of this guide is to provide a valuable resource for those interested in gas absorption technology, with the aim of promoting broader market adoption and helping to increase efficiency, profitability, and sustainability across a wide range of industries.

CLEAResult Canada Inc. developed this guide in collaboration with Building Energy Solutions Ltd. for FortisBC.

Image: GAHP units being commissioned at a facility for a FortisBC pilot project in Vancouver, British Columbia. Courtesy of Building Energy Solutions Ltd.

Overview

Climate change mitigation is one of the most pressing challenges faced by today's consumers, businesses, and policymakers. Market-ready technologies and solutions are available today to help customers meet their greenhouse gas (GHG) emissions reduction targets. Deployment of energy-efficient equipment has been a proven strategy to support climate action. GAHP is a promising technology that can help consumers and energy providers reduce GHG emissions at low costs.

Although GAHPs have been commercially available for many years, they have not been used to their fullest advantage for several reasons. One of the reasons is the market availability of other lower cost and code-compliant equipment, (albeit with lower efficiency), such as condensing boilers. GAHP systems can perform at levels that exceed the traditional efficiency barrier for gas-fired equipment and offer a pathway to reduce GHG emissions for residential and commercial applications substantially.

GAHPs have been successfully deployed across Europe, Asia, and the United States for several years because of their energy-saving potential. In recent years, several North American utilities, such as FortisBC have also conducted field tests and pilot projects to assess the energy conservation potential of this technology. FortisBC is a BC-based, shareholder-owned gas and electric utility that is at the forefront of the advancement of GAHP technology adoption and promotion in Canada.

This best practice guide aims to answer critical questions about the workings and application of GAHPs, establish practical and realistic expectations and share insights to help with the adoption of GAHPs in the province. The document offers support to decision-makers, designers and installers considering efficient building services systems that may benefit from implementation of GAHPs systems.

This guide draws upon third-party measurement and verification results during the three-year-long pilot projects that FortisBC ran from 2019 to 2021 for domestic water heating and other phases that are being continued to date for various other end-uses. These pilot projects were installed at a number of MURBs and commercial facilities in the Lower Mainland. The pilot units were exposed to actual climate conditions and end-use loads in several different configurations. Through these projects, FortisBC verified the merits and addressed any challenges associated with this technology.

Introduction to the Gas Absorption Heat Pump (GAHP) Technology

Heat pumps have been around for decades and are proven to support heating operations with very high efficiencies. Most common heat pump applications are powered by electricity. In contrast, thermally driven heat pumps can run on natural gas, hydrogen, or renewable and low-carbon fuels, such as Renewable Natural Gas[5] (RNG) to make complex heating systems more efficient by replacing legacy boiler systems for space heating and hot water applications. In particular, facilities located in electric grid-constrained areas that are dealing with electrical capacity issues and have access to gas supply networks may consider thermal heat pumps to lower operating costs and reduce their emissions over conventional natural gas equipment.

Background and History

The absorption heat pump technology has been available globally to end users for the past two decades. It was introduced in Europe much earlier than in North America. The Asian market has also seen rapid growth of the technology in the last five years. Unlike traditional heat pumps that operate on a vapour compression cycle, GAHP units work on an absorption cycle. The working principle of ammonia-water based absorption was originally patented in 1859 and has since been widely used in refrigeration systems. One of the earliest pilot projects for GAHPs was run in Germany during the mid-1980s for residential applications[6].

More recently, California's Energy Commission Natural Gas Research & Development Program also funded the demonstration and assessment of GAHP technologies between 2017 and 2021. GAHP units were installed at two full-service restaurants and residential sites in Los Angeles. This pilot confirmed the possibility of quick paybacks in less complicated retrofits, with gas savings up to 45%[7].

In Canada, Toronto Metropolitan University[8] has run a technology review project in the last five years. The university collaborated with The Atmospheric Fund, Toronto and Region Conservation Authority (TRCA) and Enbridge Gas[9]. The project tested Robur's 36 kW GAHP units across different water and

[5] Renewable Natural Gas is produced in a different manner than conventional natural gas. It is derived from biogas, which is produced from decomposing organic waste from landfills, agricultural waste, and wastewater from treatment facilities. The biogas is captured and cleaned to create carbon-neutral Renewable Natural Gas (also called biomethane). Visit fortisbc.com/RNG for more information.

[6] European commission report – "20 SMALL GAS-FIRED ABSORPTION HEAT PUMPS."

[7] Results from Gas-Fired Heat Pump Demonstrations and Research-California.

[8] Formerly known as Ryerson University.

[9] Evaluation of a Gas Absorption Heat Pump - Toronto and Region Conservation Authority.

space heating configurations in cold ambient conditions and confirmed its viability in decarbonizing the conventional boiler-based systems. This project identified the best applications and locations for GAHP technology, which can be deployed in engineering design. The study concluded that Domestic Hot Water (DHW) applications have strong potential for notable operational cost and carbon reductions. Annual cost savings of $1500 for residential DHW preheating were estimated.

In 2019, FortisBC started a pilot program to test Robur's 36 kW GAHP-A units in MURBs and school facilities under live conditions in the Lower Mainland (Climate Zone 4). These projects helped FortisBC verify the manufacturers' published performance data for GAHP units and apply it at a system level. The project has since expanded to test the GAHP application with different end-uses. The results from the pilot program are discussed in the later sections.

Other prominent groups that have either successfully tested the technology or are contemplating the launch of GAHP pilots include National Energy Action (NEA) UK, Northwest Energy Efficiency Alliance (NEEA), Gas Technology Institute (GTI Energy), Energy Solutions Center, Southern California Gas and SEMCO Energy Gas in Michigan, USA.

Working Principle of the GAHP Technology

GAHPs operate on a heat-activated absorption cycle. The cycle relies on the absorption of refrigerant (ammonia[10]) by a transport medium (water). GAHPs need three energy inputs to run the absorption cycle and transfer heat from the heat source to the heat sink.

1. Renewable heat source in the environment: All heat pumps require a source of heat to operate. This heat can be extracted from the surrounding air, a water source, or the ground.[11]

2. Combustion heat: The generator carries the ammonia-water solution that is separated into water and ammonia by introducing thermal energy. Today, this energy is mainly provided through the combustion of natural gas or renewable and low-carbon gases, such as RNG. According to some manufacturers, the units can also operate on a blend of natural gas with 20% hydrogen[12].
   In addition to the available heat in the environment, GAHPs can capture supplemental heat from the combustion process. This improves the overall system efficiency and makes GAHPs operation effective in colder climates.

[10] Refer to the Refrigerant Safety section and Table-1 for more details on ammonia.
[11] Most of the discussion in this document is limited to air-to-water gas absorption heat pumps.
[12] Based on conversations with Robur and Homy (on behalf of Vicot).

3. Electricity: The absorption cycle does not require work input of compressors like most vapour-compression refrigeration cycles. Instead of a compressor, the refrigerant is cycled between the evaporator and condenser using an absorber, a pump, and a generator. Since liquid is pumped instead of vapour, the electrical work required for pumping in the absorption systems is minimal. A condenser fan on the external unit also consumes electricity.

The following schematic explains the operating heating cycle in more detail. In cooling mode, the cycle is reversed.

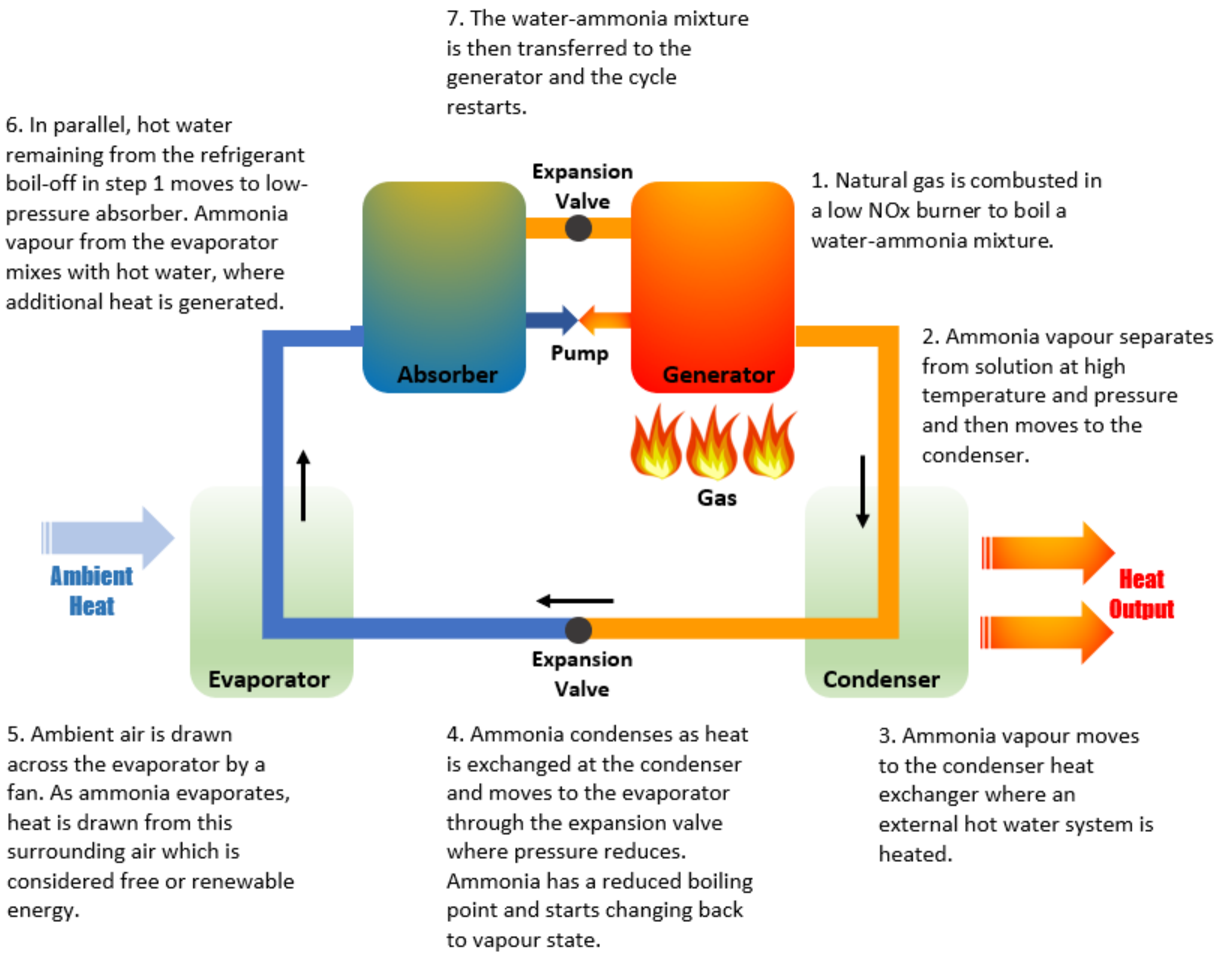

Figure 1: A simplified schematic of the GAHP operating in heating mode

Application End Uses

GAHP units perform at their peak when supporting systems that require continuous heating loads. GAHPs are best suited to support any hydronic hot water heating systems that are alternatively served by conventional or condensing boilers. Preferably, closed loop hydronic systems (non-potable water) with an operating set point between 40-60°C (104-140°F) are more compatible with GAHP technology. GAHPs have also demonstrated promising results when hot water coils are connected with make-up air units.

Moreover, GAHPs have also been deployed in hybrid configurations for high temperature (> 60°C/140°F) applications where GAHP units pre-heat the water and high-efficiency boilers provide the additional heating. Some manufacturers also offer hybrid systems where GAHPs and condensing boilers are built into a single package. Another example of hybrid configuration involves connecting GAHP units with solar water heaters.[13]

The following are some of the examples where GAHPs can be successfully applied:

- Multi-unit residential buildings (MURBs)
- Assisted living facilities (Healthcare)
- Schools
- Dormitories (Education)
- Office buildings
- Hotels
- Restaurants
- Swimming pools and spas
- Laundromats
- Process heat

Some GAHP manufacturers also offer units with dual capability of heating and cooling. In those cases, chilled water can also be used for space cooling applications.

[13] Demonstration of Gas Heat Pump with Scalable Solar Thermal Array in Multi-Family Central Water Heating – Emerging Technologies Coordinating Council.

Equipment Manufacturers

GAHPs are manufactured by many leading Heating, Ventilation and Air Conditioning (HVAC) brands, which include:

- Robur (Italy)
- Vicot (China)
- Anesi – SMTI (USA)
- Remeha (UK)
- Lochinvar (UK)
- Worcester Bosch (UK)
- Energy Concepts (USA)

Two well-established brands, Robur and Vicot, are commercially available for installation in Canada. Robur is represented by JSA Sales Inc. in Coquitlam, BC and retailed through major retailers such as Emco, Andrew Sheret, Noble Supplies to name a few. Vicot Group is represented by Homy Building Solutions in Toronto, ON, while Anesi (formally known as SMTI) is represented by Equipco Ltd. across Canada.

GAHP Performance

Coefficient of Performance (COP) is the main parameter for comparing different types of heat pumps. COP is a ratio of useful heating or cooling produced and the energy input provided to the heat pump.

$$\text{COP}_{\,Heating} = \frac{\text{Useful heating produced}}{\text{Total energy input}}$$

and

$$\text{COP}_{\,Cooling} = \frac{\text{Useful cooling produced}}{\text{Total energy input}}$$

GAHPs units perform at higher than COP of 1 under most ambient temperatures i.e., more heating or cooling is produced than energy input. While the overall performance is highly dependent on the ambient conditions, the flowrate, and the temperature difference of water flowing through the GAHP units, most models have been rated to deliver a COP over 1.2 for heating.

For example, Figure 2 demonstrates the performance of a heating-only unit at different ambient air and water output temperatures. Regardless of the water output temperature, the unit performs at a COP of higher than 1 until the dry bulb temperature drops to -7°C (19°F). In temperatures above 0°C (32°F), the unit performance improves considerably.

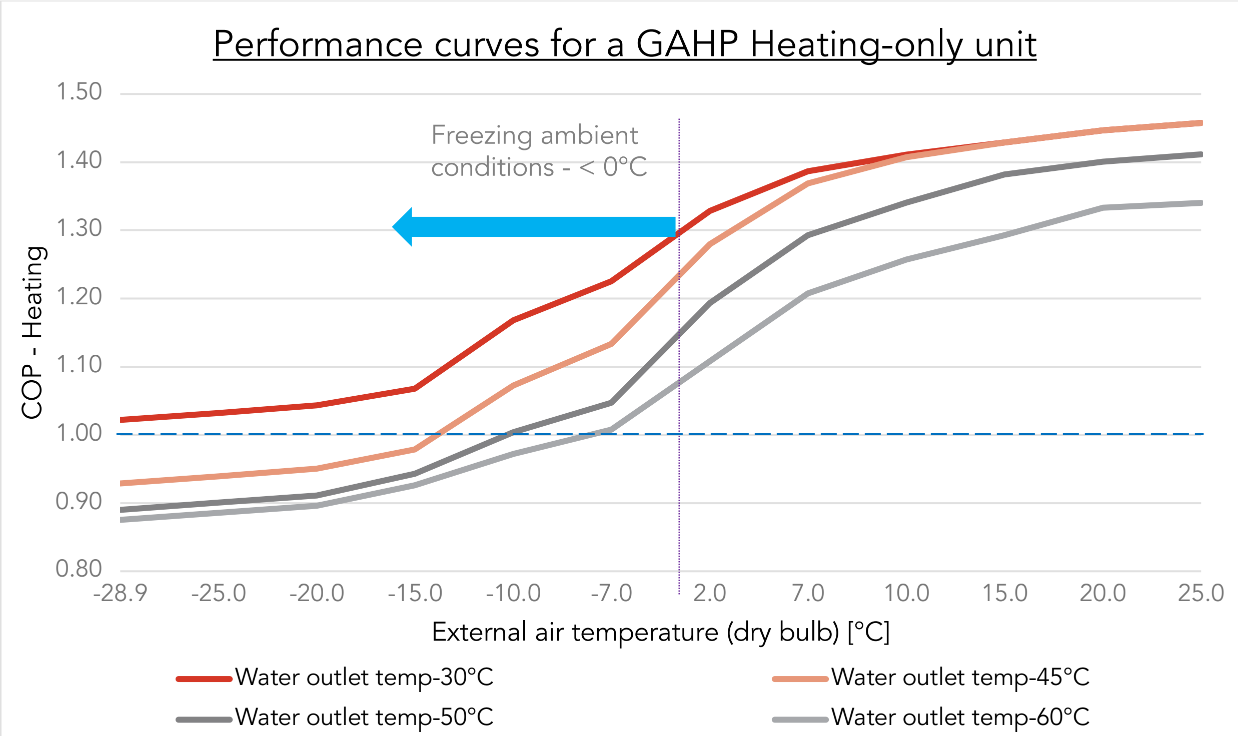

Figure 2: Example of GAHP heating performance relative to ambient air and hot water supply temperatures[14]

When comparing different heat pumps, care must be taken to consider the COPs at relevant operating conditions. As demonstrated in Figure 2, the COP of the unit operating at a given ambient condition varies due to difference in the water output temperature. As a general principle, the lower the difference between the heat source and the output, the higher the COP of the heat pump.

In cases where the GAHPs are deployed to replace legacy mid-efficiency boiler systems (up to 83% efficiency), the system-level performance improvement can be more than 30%. For applications where GAHPs are compared with high-efficiency boilers and rooftop units (> 92% efficiency), the seasonal system-level efficiency can be improved by at least 20%. This improvement is a result of higher system efficiency in shoulder seasons where there is no need for a supplementary boiler system to boost the GAHP output.

According to some manufacturers, the GAHP units have been tested to operate between -30°C (-22°F) and +45°C (113°F) dry bulb temperature between elevations of 0 – 12,000 ft (3,656 m)[15]. In heating mode, the units can provide hot water at 60°C (140°F) or above.

[14] Based on manufacturer published performance data for Robur's GAHP-A unit.
[15] Operating range for different elevations taken from Robur.

For units capable of cooling, the COP is typically 0.6 in cooling mode[16].

In all air-to-water type GAHP systems, the units must be located outside a facility, usually on a concrete pad at ground level or on structural supports on the roof. In most Canadian climate zones, the units will be exposed to sub-zero temperatures in winter; therefore, glycol antifreeze (ethylene or propylene) is required to prevent the system water from freezing. Depending upon the concentration of antifreeze and design minimum temperature, the output capacity of the GAHPs deteriorates and so does the performance.

Noise Levels

Since the air-to-water GAHPs are installed outdoors, there is an inherent increase in noise levels compared to boilers installed indoors. For outdoor applications, compliance with local municipal noise bylaws is imperative to successful installation and customer acceptance. GAHPs have been in operation at several sites in British Columbia as part of the FortisBC pilot program. In all instances of installation, there were no (i.e., zero) noise complaints.

For reference, Vicot GAHPs have a sound level of 40 dB(A) and 54 dB(A) at 5-meter distance for its 20 kW and 65 kW units, respectively.[17] Robur's 36 kW GAHP units have a sound level from 46 dB(A) to 56 dB(A) at 5 meters.[18]

Refrigerant Safety

The GAHP units rely on water-ammonia solution as a refrigerant to operate. Ammonia is considered a natural refrigerant with high thermodynamic efficiency and minimal environmental impact[19].

In GAHP applications, the circulation of water-ammonia solution is limited to the refrigeration loop inside the outdoor unit. The heat is transferred through water running in a separate piping loop. Manufacturers are responsible for charging all systems. Since the units come sealed with pre-filled ammonia-water solution, there is little chance that operation, maintenance, or installation personnel will ever come into contact with the refrigerant. Contractors do not require a refrigeration ticket to service the unit.

While high concentrations of pure ammonia can cause injury, it is easy to detect a potential ammonia leakage due to its pungent and irritating odour. The ammonia-water solution is only harmful if directly

[16] Robur's GAHP-AR unit can operate in cooling mode to produce chilled water.
[17] Based on Vicot GAHP technical information for V20 and V65 units.
[18] Based on information shared by Robur.
[19] ASHRAE – position documents on refrigerants version 2020 and 2006.

contacted, inhaled, or ingested. Table 1 provides information on how much ammonia and water is contained in different GAHP units.

Table 1: Weight of Ammonia and Water in GAHP Units

Manufacturer	Unit Size kW	Amount of Ammonia kg (lbs.)	Amount of Water kg (lbs.)
Robur[20]	36	6.7 (15)	10 (22)
Vicot[21]	20	5.5 (12)	7 (15)
Vicot[20]	140	20 (44)	24 (53)

In the unlikely event of a leakage in the refrigerant loop of a GAHP unit, since ammonia is lighter than air, leaked ammonia would evaporate into the environment before causing any harm to human health. Manufacturers' guidance must always be followed, and the outdoor units should be installed at recommended safe distances from the air intakes of a facility, per Building Codes and/or ASHRAE Standards.

Since the ammonia-water solution is housed in the outdoor unit, no special risk assessments were required for FortisBC's pilot projects. Through field demonstrations, FortisBC was able to mitigate concerns with the use of ammonia for school districts through proper education lead by the manufacturer. The GAHP manufacturer, Robur claims to have never received a liability claim due to refrigerant leakage in the last twenty years.

Licenses and Certifications

All responsible manufacturers test their equipment through rigorous testing and compliance with applicable standards. The requirements outlined in the standards are intended to ensure minimum performance levels and to protect people, property, and the environment. Project designers are recommended to review the required certifications for respective jurisdictions when specifying GAHPs for a project. Some of the relevant standards for GAHP certifications include:

- ANSI Z21.40.1 – CGA 2.91 – Gas-Fired, Heat Activated Air Conditioning and Heat Pump Appliances: This is the standard for safe operation, substantial and durable construction, and acceptable performance of gas-fired, heat-activated air conditioning and heat pump appliances.
- ANSI Z21.40.4 – CGA 2.94 – Performance Testing and Rating of Gas-Fired, Air Conditioning and Heat Pump Appliances: This standard refers to performance tests to cover a wide range of unitary

[20] Robur – GAHP Installation, use and maintenance manual.
[21] Based on data shared by Homy building solutions.

gas-fired technologies, such as absorption, adsorption, and engine-driven equipment cycles. The test results are used to generate performance curves, estimate efficiency (seasonal COP), and electric power consumption.

Comparing GAHPs with Competing Technologies

Along with other technologies, GAHPs can offer a decarbonization pathway for facilities that were designed to operate with conventional HVAC systems; however, based on the existing design configuration of a facility, the rationale for installing GAHPs may differ. For example, depending upon the existing electric load profiles and location of a facility, switching space and water heating loads from natural gas to electricity results in a need for electric service upgrades. The timing and costs of these upgrades vary from one facility to another. Every facility must compare the timing and costs of service upgrades and the incremental electricity charges versus the cost of operating GAHPs on natural gas with increasing carbon tax rates and/or renewable and low-carbon fuels, such as RNG..

We reviewed different technologies for domestic hot water heating, space heating and cooling that may be compared with GAHPs when considering a project. These include condensing and non-condensing boilers, air conditioners, and electric heating pumps (EHPs). An effort was made to compare the market-ready options based on technical information published by manufacturers. Tables 2 and 3 present high-level features of different technologies.

Table 2: Comparison of GAHP with other technologies

Parameter	Technology				
	Non-condensing boiler	Condensing boiler	GAHP	EHP	Air Conditioner
Operating Technology	Combustion	Combustion	Thermal absorption cycle	Vapour compression cycle	Vapour compression cycle
Energy Source	Natural gas or renewable and low-carbon fuel, such as RNG	Natural gas or renewable and low-carbon fuel, such as RNG	Natural gas or renewable and low-carbon fuel, such as RNG + ambient heat from air, water, or ground	Electricity + ambient heat from air or ground	Electricity
Energy Sink	Water	Water	Water	Water or Air	Air
Space Heating	Yes	Yes	Yes	Yes	n/a
Hydronic Space Heating	Yes	Yes	Yes	Yes	No
DHW Heating	Yes	Yes	Yes	Yes	No
Thermal Efficiency	up to 80%	up to 98%	n/a	n/a	n/a
COP – Heating	n/a	n/a	~ 1.3 [a]	~ 2.8 [b]	n/a
COP – Cooling	n/a	n/a	~0.6 [c]	~3.2 [d]	~3.6 [e]
Estimated Useful Life	25 [f]	18 [g]	20 [h]	15-20 [i]	15 [f]

Notes:

a: Assessed at 6.7°C ambient air (dry bulb) and 45°C water output.

b: Assessed at 8.3°C ambient air (dry bulb) and 47°C air supply.

c: Assessed at 35°C ambient air (dry bulb) and 7°C water output.

d: Assessed at 35°C ambient air.

e: Assessed at 35°C ambient air.

f: Illinois Technical Reference Manual (TRM) – Version 11.

g: Ontario energy board TRM for natural gas demand side management – Version 5.

h: Based on conversations with manufacturers and 2018 whitepaper by The Atmospheric Fund

i: NRCan publication "Heating and Cooling with a Heat Pump" – 2022.

Table 3: Comparison of GAHP with other technologies - continued

Parameter	Technology				
	Non-condensing boiler	Condensing boiler	GAHP	EHP	Air Conditioner
Installation Location for Main Components	Mechanical room	Mechanical room	Outdoor	Outdoor	Outdoor
Is Antifreeze Protection Required?	No [j]	No [j]	Yes [k]	Yes – Air to water systems only.	No
Is Back-Up Heat Required?	No	No	Not required for most space heating applications. Back-up may be required for high-temperature hydronic heating systems, DHW systems or for installations in very cold climate zones.	May be required for installations in very cold climate zones.	n/a
Is the Equipment Available in BC?	Yes	Yes	Yes	Yes	Yes
Rebate Availability [l]	Yes	Yes	Yes	Yes	No
Are Carbon Taxes Applicable?	Yes (No, if run on RNG)	Yes (No, if run on RNG)	Yes (No, if run on RNG)	Negligible [q]	No
Is 12% PST Applicable? [m]	Yes	Yes	No	No	No
Refrigerant Type	n/a	n/a	Ammonia-water solution	R410a	R410a [n]
Refrigerant Charge [o]	n/a	n/a	~6.8 kg (15 lbs.)	~9.1 kg (20 lbs.)	~7.3 kg (16 lbs.)
Is Refrigerant Handling Required? [p]	n/a	n/a	No	Yes	Yes
Environmental Impact	Emissions are associated with the consumption of natural gas. These emissions can be significantly lowered with renewable and low-carbon fuels, such as RNG. New units are equipped with Low NOx burners.			Emissions may be associated with a non-electric back-up heating system or in the case of a refrigerant leak. Emissions associated with electricity consumption in BC are minimal due to low emission intensity of the electricity grid.	

Notes:

j: Assuming that piping is not exposed to outside conditions.
K: Specific to climate zones in BC.
l: Different rebates are available for different technologies. These may include funding for new equipment, equipment upgrades, and feasibility studies.
m: BC provincial sales tax (PST) notice effective April 1, 2022. Revision July 2022.
n: Some air conditioner models may operate with other refrigerants, such as R22.
o: Specific to the models specified in Table 4.
p: Refrigerant handling required at commissioning or during operations and maintenance.
q: In cold climate zones, a non-electric back-up system may be required.

The following table provides a list of makes and models that were considered for this analysis where model-specific data was required.

Table 4: Make/Model used for Comparison of GAHP with other technologies

Technology	Make / Model
Non-condensing boiler	Fulton – ICW6
Condensing boiler	Rheem – GHE80SU/SS-130(A)
Absorption heat pump (GAHP)	Robur – GAHP-A and GAHP-AR
Electric heat pump (EHP)	Trane – TWA073D
Air Conditioner	Lennox – LCM074U4E

While Tables 2 and 3 offer a non-exhaustive list of potential comparison points for these technologies, facility owners may also compare other factors such as, global warming potential and ozone depletion potential of refrigerants, project lifetime costs and the overall decarbonization potential.

Decarbonization Potential

The decarbonization potential of different refrigerant-based technologies can be classified under direct and indirect impacts[22].

[22] ASHRAE Position Document on Refrigerants and Their Responsible Use - Jun 2020

- The direct impact can be achieved through the type of refrigerant that is exposed to the atmosphere in the event of a leak, accident, handling, or disposal. The ammonia-water solution used as the refrigerant in GAHPs has zero global warming potential and zero ozone depletion potential.
- The indirect impact is delivered through the savings in energy consumption in operating the technology over a complete season. Compared to conventional water and space heating equipment running on natural gas, GAHPs can deliver the same output with a COP higher than 1, through most of the year. This reduction in natural gas consumption helps reduce the GHG emissions intensity associated with traditional heating systems. Moreover, most of the manufacturers offer low-NOx burners on GAHP units.

  According to some manufacturers, GAHP units are compliant to run renewable and low-carbon fuels, such as RNG and a blend of natural gas or RNG with 20% hydrogen. At the time of publishing this guide, the manufacturers are researching the development of a burner that can operate on 100% hydrogen. The compatibility of GAHPs to operate on higher blends of hydrogen or pure hydrogen in the future can add to the decarbonization benefits of the GAHP technology.

FortisBC customers can further reduce their GHG emissions today by signing up to receive various blends of renewable and low-carbon fuels, such as RNG up to 100 percent.

Operating and Unit Costs

Lifetime operating costs mainly consist of energy costs, maintenance costs, carbon taxes and potential decommissioning costs. BC's carbon tax applies to the purchase of fuels such as natural gas[23]. BC's effective carbon tax since April 2022 is $50[24] per tCO_2e[25] or approximately $2.5 per GJ of natural gas consumption. This tax rate is expected to increase in the coming years to meet the federal government's carbon pricing rate of $170 per tCO_2e by the year 2030. Switching to high-efficiency equipment such as GAHP, not only allows facilities to reduce the carbon footprint of their operations, but also helps save on applicable carbon taxes over the equipment's lifetime.

GAHPs range in price, and the units alone can cost between $20,000 and $30,000[26]. Project-specific factors such as the number of units, controls, integration with existing equipment, installation

[23] Specific exemptions exist. Refer to https://www2.gov.bc.ca/gov/content/environment/climate-change/clean-economy/carbon-tax/programs

[24] https://www2.gov.bc.ca/gov/content/environment/climate-change/clean-economy/carbon-tax

[25] Tonnes of carbon dioxide equivalent.

[26] "What are gas heat pumps and how can they save money and energy?". Article posted on FortisBC webpage on June 21, 2022.

requirements, piping and insulation can impact the overall project costs. GAHP prices are expected to decrease with more commercialization and market adoption of the technology.

In 2022, the province also introduced an additional provincial sales tax (PST) on the purchase or lease price of all fossil fuel combustion equipment. While the conventional combustion systems are subject to 12% PST (previously 7%), gas heat pumps were excluded from PST altogether. This solidifies the position of GAHP technology as an accepted pathway for decarbonization by the province.

To demonstrate the savings potential of the technologies presented in Table 2, high-level modelling of energy use is currently being conducted. For equivalence, the energy use, carbon taxes and emissions for each technology is being calculated over the lifetime of deployment at a medium-sized commercial office building. The full result of this costing analysis will be presented in the next version of the Best Practices guide.

Compliance with BC's Current Climate and Energy Policies

BC is ranked among the leading jurisdictions in North America when it comes to climate action and policies to support climate change mitigation and adaptation. The province is a net exporter of electricity, more than 90% of which is generated through renewable resources, such as hydropower[27]. While electrification, among other measures, is considered one of the strategies for deep decarbonization, most facilities across the province rely on natural gas for their heating needs. Moreover, with ever-increasing demand for electric vehicles, the electrification of space and water heating systems can lead to rapid increases in electrical peak demand in buildings[28]. Tackling the peak demand issue requires additional dispatchable electrical power and substation upgrades that can be expensive. The expected near-term growth in electrical demand due to switching of heating loads to electricity requires a carefully thought-out strategy.

While some municipalities are accelerating their electrification journey, others are considering alternative solutions to this complex problem, which indeed includes some level of electrification. In 2018, FortisBC released the "Clean Growth Pathway to 2050"[29] report to demonstrate its commitment to climate change solutions. FortisBC's proposed pathway highlighted four areas requiring significant energy system shifts to meet the growing demand for clean energy. These include continued investment

[27] Canada energy regulator – Provincial and Territorial energy profile of British Columbia
[28] "Cost and capacity requirements of electrification or renewable gas transition options that decarbonize building heating in Metro Vancouver, British Columbia" by Palmer-Wilson et.al. in Energy Strategy Reviews, vol 42, 2022
[29] "Clean growth pathway to 2050" FortisBC - 2018

in energy efficiency in the built environment and developing innovative energy projects in BC's communities.

This approach is consistent with CleanBC's 2030 roadmap that highlights the need for all new space and water heating equipment sold and installed in BC after 2030 to be at least 100% efficient. GAHP technology with a COP of higher than 1 COP perfectly aligns with the province's decarbonization strategy.

FortisBC's Pilot Program Experience

In line with the Federal Pan Canadian Framework and FortisBC's Clean growth pathway to 2050, FortisBC's Innovative Technologies team in the Conservation and Energy Management (C&EM) department initiated a pilot program to verify the performance of GAHPs. The program was designed to demonstrate the energy savings potential, address any issues associated with the installation and operation, and test the compatibility of GAHPs within Climate Zone 4. The program offered great insights into the customer experience and market readiness of the GAHP technology.

For the commercial sector, GAHP installations under the pilot program were completed in 2019 and Measurement and Verification (M&V) were conducted in 2020. A total of seven facilities (5 MURBs and 2 Schools) located in the lower mainland were selected to participate in the program. The initial focus of the pilots was to support the DHW systems using a hybrid approach. Each facility was retrofitted with two Robur GAHP-A (air-to-water type, heating-only) units. While the GAHP units were installed outside the buildings, a buffer tank (80 gallons), a double-walled heat exchanger, and circulation pumps were installed inside the utility rooms.

Figure 3: Left: Robur GAHP-A units installed on a rooftop. Right: Pump skid with a buffer tank and glycol feeder

The projects were designed to cover up to 70% of the DHW load capacity for each facility and rely on the existing boiler systems to meet the remaining load. The baseline systems were non-condensing boilers with up to 80% efficiency.

Upon successful commissioning of the units, the projects were evaluated in line with Retrofit Isolation Key Parameter (Option A) as per the International Performance Measurement and Verification Protocol (IPMVP)[30]. Figure 4 shows a typical data measurement strategy applied during the pilot program.

[30] IPMVP is owned by Efficiency Valuation Organization (EVO®) and serves as a measurement and verification framework.

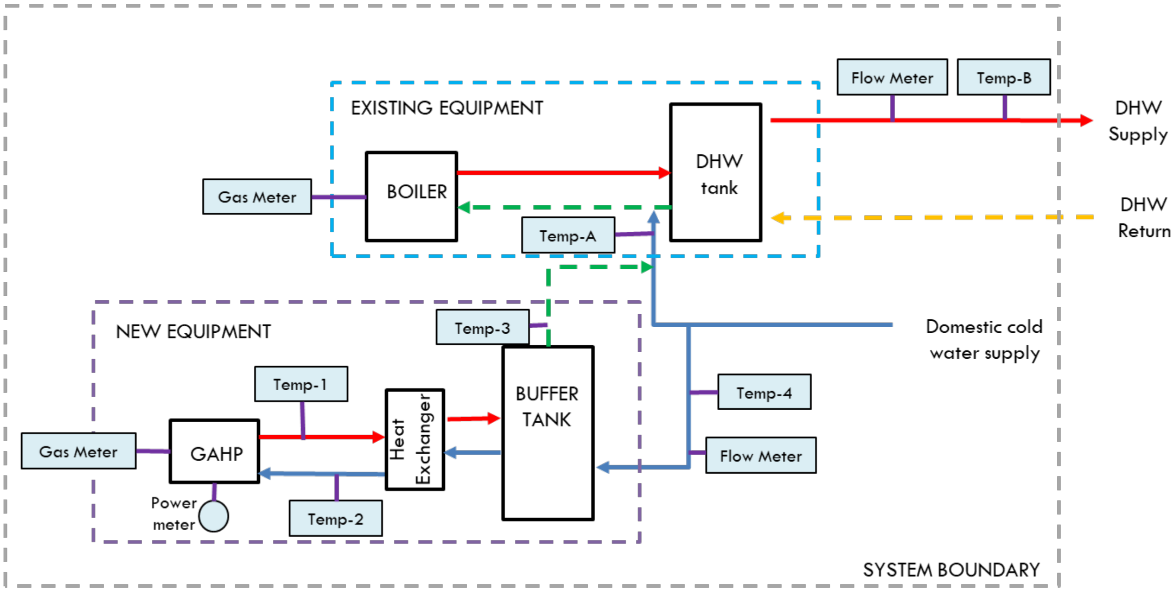

Figure 4: Example of a measurement strategy for savings calculations for GAHPs supporting DHW systems

The quality of collected data was reviewed to establish confidence in the results. To reduce uncertainty in the data from one of the facilities, Whole Facility IPMVP Option C was also considered since most of the natural gas consumption was attributed to DHW use at that location.

The overall efficiency of a hybrid system can be calculated by dividing the useful work done by the GAHP and boiler system in raising the water temperature by the energy input to the system (natural gas and electricity).

For consistency with other gas equipment, the gas utilization efficiency (GUE) of the hybrid systems in the pilot projects was calculated by dividing the system output by the natural gas consumption of the existing boiler and GAHP units.

$$\text{GUE} = \frac{\text{Heat produced by the system}}{\text{Gas energy consumed by the system}}$$

The useful work done by this system is proportional to the water flow rate through the system and the temperature rise of the water. During the pilots, the heating outlet temperature of the GAHPs was generally in the region of 55-58°C (131-136°F).

The GAHPs rejected heat to the buffer tank through a double-walled heat exchanger. Glycol or another anti-freeze agent is required in the GAHP primary loop where the GAHP is subject to freezing temperatures. During the pilots, approximately 6% thermal losses were experienced across this heat exchanger using glycol in the lower mainland, and up to 12% can be expected in other geographical areas of the province.

To achieve a GUE greater than 1.0, the pilot results revealed the importance of maintaining a differential temperature across the GAHP of greater than 5°C. At a differential temperature greater than 6 to 7°C, the units achieved a GUE of 1.2 to 1.4. Figure 5 demonstrates this from the data recorded during the pilot projects. Hydronic systems with a constant flow or constant demand are therefore preferred systems where this condition can be easily achieved.

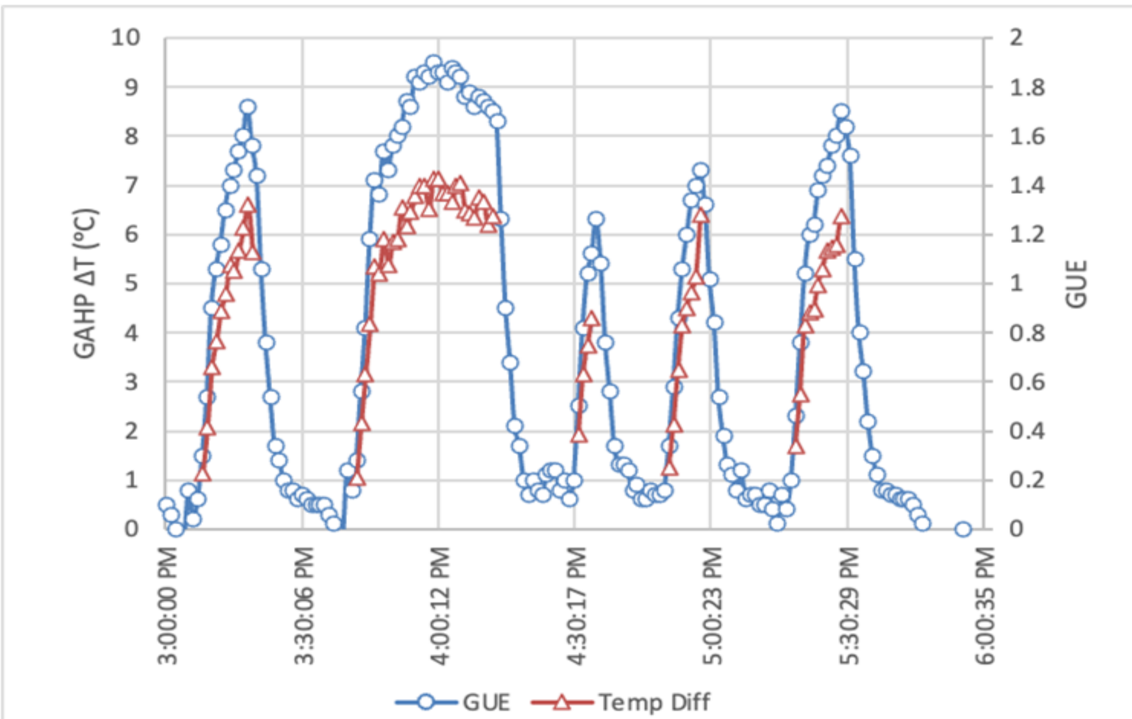

Figure 5: The effect of GAHP differential temperature on GUE

Enhancements Made During the Pilot Program

Based on learnings from the initial phases of the pilot program, enhancements were made to the GAHP configurations to improve the system-level performance. Some of the key improvements made during the pilot are discussed here.

1. Even though all pilot sites installed two GAHP units each, it was discovered that rightsizing of the units was essential. The sizing of the GAHP system affects the energy output, response time and temperature differential across the heat pumps. The intermittent nature of DHW loads can provide undesirable conditions for the heat pump performance due to constant cycling based on the

temperature differential. Subsequently, some of the facilities were changed to operate on a single GAHP unit at a higher loading and the performance improved.

2. It was noted that the existing boiler systems often performed inefficiently as the GAHPs met most of the heating load. Each test site had standard efficiency boilers varying in age. These older boiler systems have a poor turndown ratio and do not operate efficiently when cycled at part load. When the GAHPs were operating, the existing boiler fired to top up the DHW temperature to 60°C (140°F). As the GAHP system took the load off the boiler, the short cycling effect was exaggerated, causing a further drop in boiler efficiency and thus reducing the system efficiency. Therefore, subsequent pilot tests were conducted by adding a high efficiency condensing boiler to back up the GAHPs. Due to the high turn-down ratios of these boilers, the system could perform at a much higher COP.
3. The initial tests also highlighted the need for an advanced control system capable of integrating the GAHPs and the existing boiler system. The controls improved GAHP and system efficiency through superior flow sequencing and temperature differential management.

Figure 6 demonstrates the performance improvement due to different enhancements to the pilot configurations.

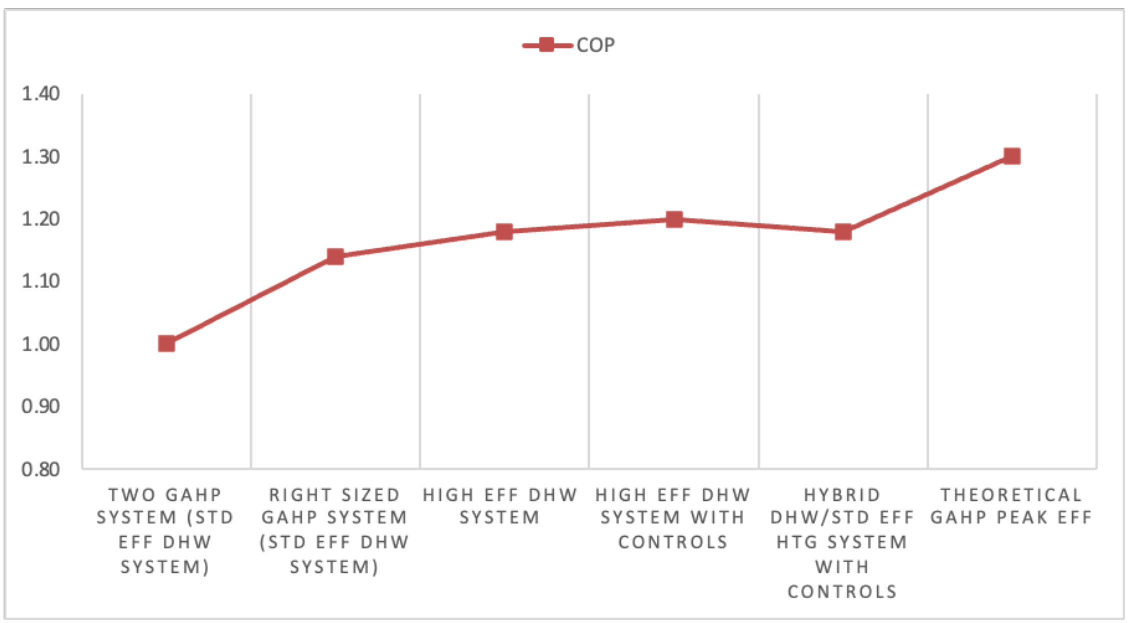

Figure 6: GAHP COPs measured at different phases of the pilot program[31]

Building upon the confidence in GAHP's performance for DWH systems, the pilot was later extended to test space heating configurations. The GAHP technology is currently being tested with a direct

[31] System COPs were calculated by accounting for natural gas and electric power inputs.

connection to a 100% outdoor make-up air unit as well as for supplemental cooling. For make-up air heating, a hot water heating coil was sized and selected to provide 100% heating load to the make-up air unit when connected to rightly sized GAHPs. The hydronic coil was carefully chosen to ensure the hot water flow rate and entering/leaving water temperatures were conducive to GAHP specifications. While this pilot phase is ongoing, initial findings indicate that the system COP is greater than 1.25. Due to its simplicity compared to hot water systems, this configuration is the most cost-effective application of the GAHPs tested in the pilot program.

Design Best Practices

This section builds upon the hands-on experience of designers and installers of GAHP units in BC. Most of this experience was acquired during FortisBC's multi-year pilot programs and subsequent early adopter offer[32]. Note that this information is presented for guidance to help the readers learn about the design considerations of this technology. This information is not intended to provide project-specific advice and should not be relied on as such. Designers should follow recommendations from manufacturers, conduct due diligence and comply with the applicable codes and regulations. The information is also not intended to replace the need for engineering analysis.

Considerations for Integrating GAHPs with Other Systems

While GAHPs can be installed to operate independently in small systems, most of the larger applications will require integration with other space and/or hot water heating systems. The following should be kept in mind while designing integrated or hybrid GAHP systems.

1. Right sizing of the GAHP system is critical to maintain a reasonable temperature difference and to prevent short cycling of the units.
2. Controls are essential for high system efficiency by maintaining the ideal temperature differential.
3. Glycol is required to prevent the freezing of any outdoor piping and equipment.
4. It is recommended that thermal insulation be installed on all piping and that the distance between the GAHP and the existing system is kept to a minimum to reduce the loss of hot water temperature in the loop connecting the GAHP.
5. A backup or peaking boiler may be required to ensure peak loads are met. If so, consideration should be given to utilizing a high efficiency boiler (such as, a condensing boiler or a tankless water heater for domestic hot water application) with a good turndown ratio to prevent short cycling and system inefficiencies. If an existing cast iron boiler is used, there may be a requirement to protect the boiler from 'cold' inlet temperatures. It should also be noted that if a high temperature (> 60°C/140°F) boiler is used for peak load, the GAHPs will not operate at those temperatures. Therefore, the boiler needs to be capable of providing 100% heating load.
6. Designers should also pay attention to system balance points[33] when integrating GAHPs with other systems that provide peak load or backup options.

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[32] In 2021-22, FortisBC introduced an early adopter offer to more than 15 facilities for their GAHP installation projects.

[33] Balance point refers to the temperature at which a backup system is designed to take over the system load.

Considerations for Integration with Air Handling Systems

When GAHPs are combined with air-handling units (AHU), the following additional considerations should be kept in mind:

1. GAHPs are expected to meet most of the heating loads in this configuration. Therefore, a backup or peaking boiler may or may not be required to ensure peak load is met.
2. The hot water coils must be sized correctly to maintain the desired temperature difference and flow rate across the GAHP unit(s).
3. Due to constant heating load and relative simplicity of these systems (GAHP+AHU) compared to domestic hot water systems, some projects in this configuration may experience shorter payback periods.

Figures 7 and 8 present a sample schematic for integrating GAHPs into air handling systems.

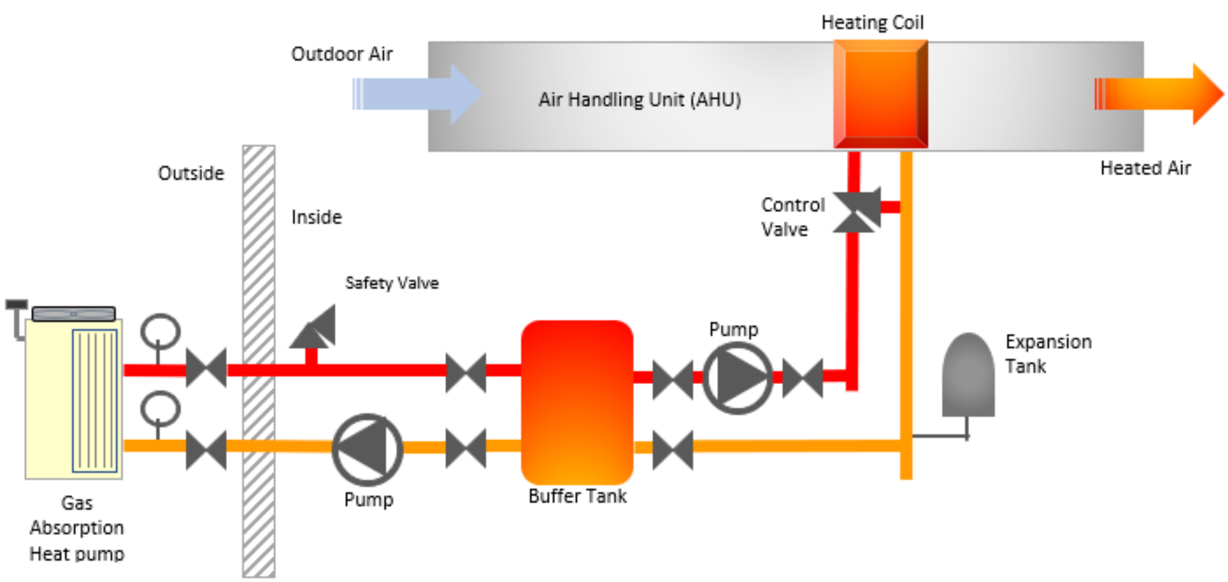

Figure 7: Sample schematic for GAHP heating application with an air handling system

GAHP units capable of cooling can also be connected with air handling units to provide cooling.

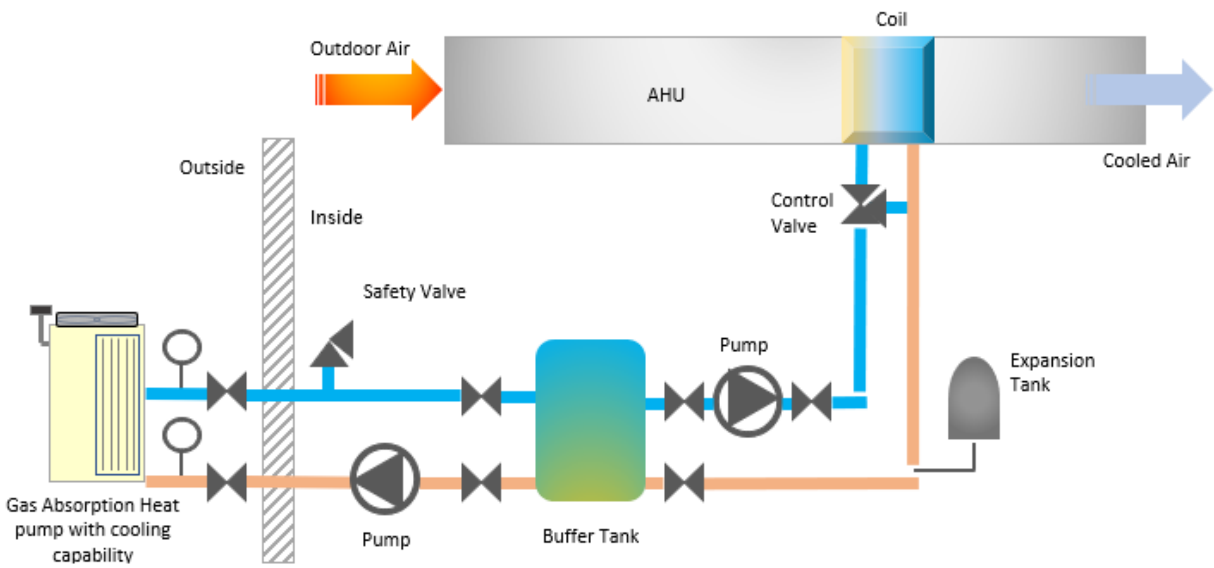

Figure 8: Sample schematic for GAHP cooling application with an air handling system

Considerations for Integration with Domestic Hot Water (DHW) Systems

When GAHPs are combined with the domestic hot water system, the following additional considerations should be kept in mind:

1. A double wall heat exchanger between the non-potable and potable water systems may be required by local codes.
2. A DHW Preheat tank is the preferred methodology for integration of a GAHP into an existing DHW system.

Figure 9 presents a sample schematic for the domestic hot water heating system application.

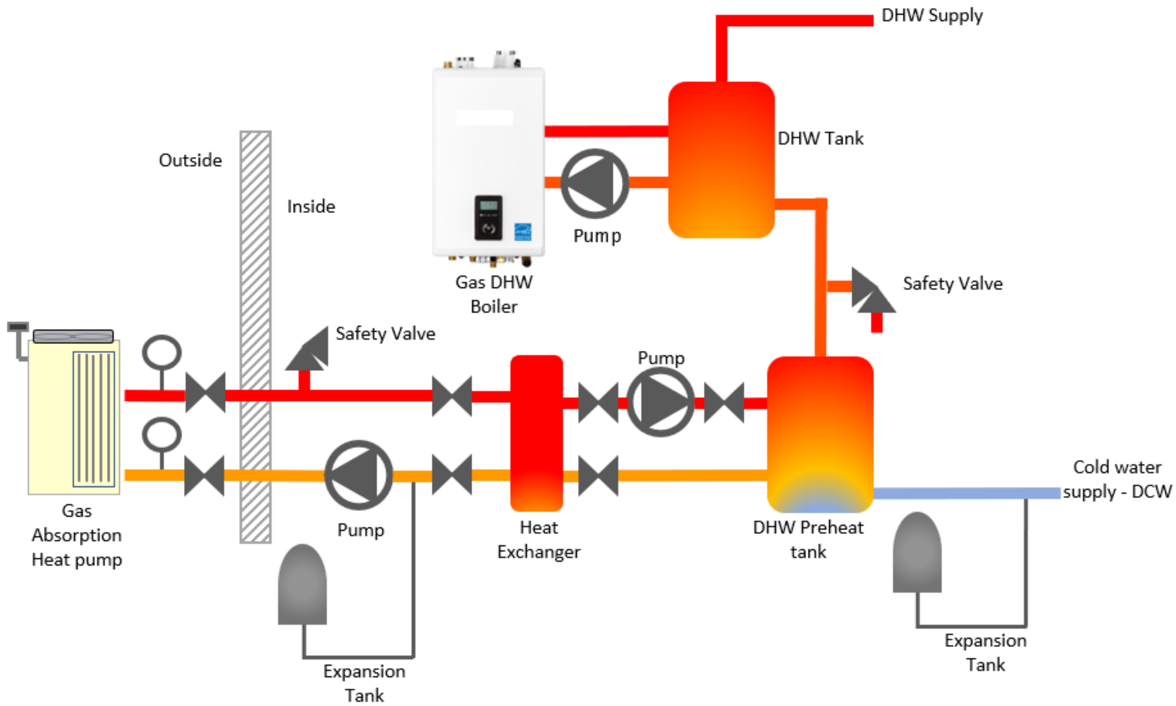

Figure 9: Sample schematic for GAHP application in a DHW system

Considerations for Integration with Hot Water (Hydronic) Systems

When GAHPs are combined with hot water heating systems such as hydronic space heating, the following considerations should be kept in mind:

1. The maximum output temperature of several GAHPs is around 60°C (140°F). Some older buildings have hot water heating systems sized for above 80°C (176°F), which is only required for peak load heating or when the outdoor temperature falls below 0°C (32°F). Therefore, GAHPs can still be incorporated into older buildings without the need for a complete heating system retrofit, as long as there are 'peak-load' boilers installed. During those times when the peak load boilers operate, the GAHPs may not operate due to high return water temperatures.
2. The type of existing terminal unit should be reviewed to ensure heat requirement can be met at lower hot water temperatures supplied through GAHPs.

Figure 10 presents a sample schematic for the hot water heating system application.

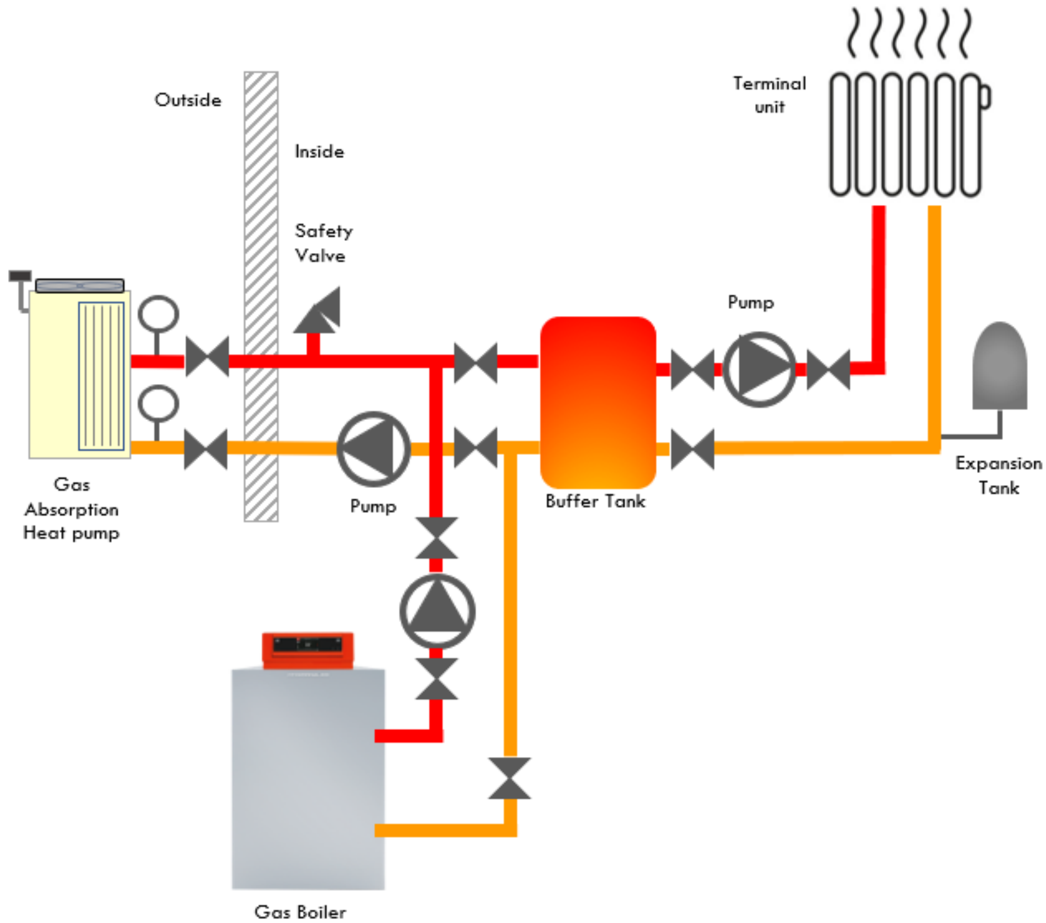

Figure 10: Sample schematic of a GAHP applied to a hot water system

System Right-Sizing

The rightsizing (engineering) of the GAHPs is critical for optimum performance and resultant energy savings. It is necessary because the load profile of a facility considering GAHP installation can significantly differ from another, depending on a number of variables. Some of the variables specific to DHW and hydronic heating systems include but are not limited to the following:

1. Building age and type
2. End uses (domestic hot water, space heating, etc.)
3. Efficiency and condition of the existing equipment
4. Flowrates and temperature (delta T) requirements for integrating systems
5. Heating profile for ventilation systems or hydronic systems
6. Domestic hot water fixture specification (low flow fixtures)
7. Thermal losses of the DHW system (type of insulation/return piping size)

The figure below presents an example of rightsizing demonstrates the possible effective range of GUE of the GAHP through right-sizing as determined through the tests carried out at one of the FortisBC pilot facilities. GAHP units were operated in single- and double-unit modes during similar operating conditions to substantiate the impact of right sizing.

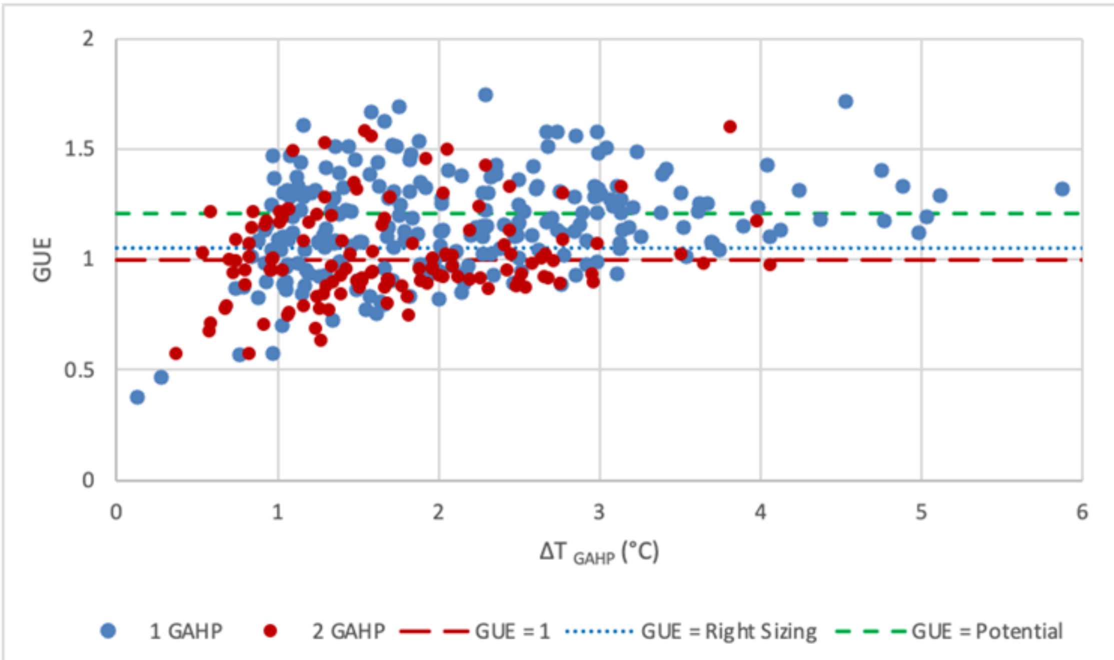

Figure 11: Effect of rightsizing on natural gas utilization efficiency of GAHPs for a DHW system

When heat pumps are primarily designed to deliver heating, the COP of potential units at low ambient conditions is an important factor in selection and right-sizing.

Designers are encouraged to review the right-sizing opportunities for their specific project and avoid oversizing the GAHP systems.

Integration with a Controls System

Integration of advanced dynamic controls for pilot projects presented excellent insights into the operation of the GAHP systems. A control system allows the staging of each GAHP unit depending on the thermal energy load. Two of the most critical control parameters of the GAHP equipment are the heating (temperature) setpoint and the dead band. A dead band (also known as a dead zone or a neutral zone) is a band of input values in the domain of a transfer function in a control system or signal processing system where the output is zero (the output is 'dead' - no action occurs). These parameters determine when the unit is operating or not. These advanced controls offer improved energy savings by automatically sequencing, scheduling, and changing setpoints of the GAHPs and interconnected systems.

For example, the control philosophy applied during the pilot projects required extensive system testing to identify the set points for optimum performance of GAHP units. The following control parameters were implemented during the pilot projects:

- Heating plant remote enable/disable
- Individual GAHP status
- Individual GAHP control
- Fluid inlet and outlet temperatures from each module
- GAHP gas meter digital input
- Pump Status and fan status/speed for each unit
- Plant hot water setpoint temperature
- Plant dead band temperature range
- Control (On/Off) of GAHP circulation pumps
- Plant temperature sensors[34]

Additional Considerations

Noise and Vibration Control

The GAHP units may require vibration isolators. Using anti-vibration pads reduces noise, especially in rooftop applications. Based on the findings from the FortisBC pilot, no complaints were noted from the contractors or building owners. In addition, no noise complaints were recorded, whether the equipment was installed at ground level 6m (20ft) from an apartment or on the roof of the building.

Electrical Connection

Most GAHP units do not require an enhancement of electrical service. Model-specific guidance from manufacturers should be followed for every project. For reference, the GAHP-A (36 kW) manufactured by Robur requires a single power connection 208-230 V/1ph/60 Hz with 0.9 Minimum Circuit Amps (MCA) and Maximum Over-Current Protection (MOP) of 10.9 A. Vicot's V20 (20 kW) unit requires a power supply of 220 V/1ph/60 Hz and V65 (65 kW) unit requires a supply of 240 V/3ph/60 Hz.

[34] Refer to Figure 4 for an example of potential temperature measurement points.

Buffer Tanks

GAHPs have been tested with and without buffer tanks. Typically, the system design should avoid low "delta T" situations because if the loop circulation time is too short, the condenser water does not have a chance to dispose of, exhaust, or transfer much heat. This can result in the GAHP short cycling and lead to potential nuisance trips.

For example, hydronic heating requires a lower flow rate than the effective flow rate of a GAHP unit. In such a situation, the GAHP may quickly heat the volume of liquid and then shut down if a buffer tank is not installed.

Piping

Piping for GAHP systems is very similar to boiler systems. The simplest way to describe a GAHP is as an outdoor boiler capable of performing at a COP of greater than 1. Therefore, there is a hot water supply and return pipe and a gas pipe with associated valves. All of these items are typical for a gas-fired boiler.

Venting

Since the units must be located outside, the venting requirements are more straightforward than a boiler system. Caution must be taken to maintain clearance from combustibles and air intakes surrounding the outdoor units.

Gas Pressure

Manufacturers' installation guidance should be adhered to. However, a GAHP typically has a 5.0 to 14.0 inches of water column (in. WC) inlet natural gas pressure requirement (like most natural gas boilers). This may differ if a different fuel source is used.

Location Considerations

GAHP units must be located outside the buildings, on the ground or the roof. If located on the roof, a structural assessment by a professional engineer may be required to ensure that the roof can handle the weight of the GAHP units. In some cases, cranes may be required to hoist the units into position.

The GAHP units should be installed close to the mechanical room to minimize pipe lengths and resultant installation costs. While the GAHPs are installed outside, the pump(s) and buffer tank need to be located inside and therefore, some mechanical room space is still required.

Drainage

Drainage is required for all external units. For the non-condensing GAHPs, drainage is only needed during the defrost cycle, which is minimal in the lower mainland, even when tested with outdoor temperatures below -11°C (12°F). For condensing GAHPs, there is a requirement to provide a drain and acid neutralizer to the bottom of the combustion flue. Consideration is needed to heat trace this line to prevent freezing and to route this condensate pipe to a sanitary drain.

GAHP Installation, Operations and Maintenance

This section provides general guidance for installers and facility operators. The information is based on experience acquired during FortisBC's multi-year pilot program and conversations with equipment manufacturers. The information is not intended to replace project-specific insights that experienced contractors have or override any applicable regulations and laws specific to the project jurisdiction.

Installation

Mechanical/plumbing contractors usually carry out the installation. These companies must have a competent class-B ticket gas fitter on their team. Guidance from manufacturers must always be adhered to.

Permits

A gas and an electrical permit are typically required. Gas permits need to be coordinated with the local municipality. Typically for connected boiler loads greater than 399,000 Btuh (117 kW), permitting is required with Technical Safety BC (TSBC).

A development permit/building permit may also be required, depending on where the equipment is located. Refer to the local municipality bylaws.

Equipment Availability and Project Support Services

In BC, JSA Sales is the manufacturer's representative for Robur. Homy Building Solutions, based in Toronto, ON, represents Vicot in North America. Equipco Ltd. is the manufacturer's representative for Anesi Gas Heat Pumps (formerly known as SMTI) across Canada.

While established manufacturers offer equipment warranties, technical support teams are locally available with their representatives. Engineering consultancies registered with EGBC can provide engineering design for GAHP projects.

Operation

Basic equipment training for facility operators is recommended during project commissioning. Operators should also refer to equipment manuals to learn about model/make specific instructions.

The operation of the GAHPs is generally free of any intervention. A well-designed system with controls can maintain constant loads and prevent short cycling or issues related to output temperature. GAHPs were tested to maintain a consistent output temperature through peak winter and summer conditions during FortisBC's pilot projects in the lower mainland.

General housekeeping should always be maintained to ensure that finned coils are clean, and vents are not blocked.

Maintenance

GAHPs require no additional maintenance when compared to a traditional gas-fired boiler, an electric heat pump or any other vapour compression HVAC equipment. Maintenance is usually carried out by the installer or gas contractor, as is typically the case in a traditional boiler installation. According to the manufacturers' data, GAHPs have an effective useful life of about twenty years.

Manufacturers specify the exact preventive maintenance requirements for each model, but typical annual maintenance activities may include:

- Checking for any errors on the controller
- Inspecting coils of the GAHP for cleanliness, debris, leaks, blockages
- Inspecting hydraulic pump belts
- Checking pump oil level
- Checking condenser fan height
- Checking gas pressure
- Inspecting hydronic water circuit for leaks and levels of chemicals (inhibitor/glycol)
- Checking igniter and flame sensors

Additionally, facility managers:

- may consider replacing pump belts, burner, ignitor, and flame sensors and checking the generator every 12,000 hours.
- are recommended to replace the condenser, hydraulic pump, combustion blower, pump motor pulley, spark ignition module and pressure switch around 50,000 hours.

Note that the maintenance recommendations are provided for planning purposes only. Equipment-specific guidance must always be followed.

FortisBC's GAHP Rebate Program

In June 2022, FortisBC became the first utility in Canada to introduce GAHP prescriptive rebates for its commercial customers. The rebate program is being offered to commercial, MURBs and institutional buildings, from office buildings, hotels and schools to hospitals, recreation centers and care homes, to name a few.

Through an extensive pilot program, the utility gained deep insights into this promising technology that can be immediately deployed in the market to reduce GHG emissions. While the pilot projects helped validate the performance of GAHP technology, they also gave a clear picture of the incremental costs, the need for engineering evaluations, controls required for different configurations, installation requirements and market readiness. While GAHPs are available to recover heat from air, ground, or water, the rebate program is currently limited to air-source GAHP units.

Product rebates are offered for installing GAHPs, with additional rebates for adding smart controls and other performance optimizations.

The rebates also offer support for customers with the cost of conducting a detailed engineering feasibility study for their facilities. The study can help customers verify whether the installation of GAHP unit(s) will help achieve energy savings before committing to a project.

For specific information about the FortisBC's GAHP prescriptive rebate offer, please contact FortisBC at businessrebates@fortisbc.com or visit the webpage at:

www.fortisbc.com/rebates/business/gas-absorption-heat-pump-rebates

Conclusion

FortisBC is a leading energy provider in British Columbia that delivers natural gas, electricity, and renewable and low-carbon fuels, such as renewable natural gas to over 1.2 million customers across the province. FortisBC's Clean Growth Pathway to 2050 highlights FortisBC's roadmap for reducing GHG emissions while supporting economic growth and maintaining affordability and customer choice by investing in LNG for marine fueling & global markets, zero & low-carbon transportation, renewable gas, and energy efficiency.

In the energy efficiency area, FortisBC's pilot program and the launch of its early adopter offer on commercial GAHP systems have shown promising results in verifying the operational performance of these systems. These activities also provided insights into the customer experience and market readiness of GAHP technology and along with the introduction of the GAHP prescriptive offer, shows FortisBC's commitment to promoting the adoption of this technology in British Columbia.

Overall, FortisBC's efforts to promote the adoption of GAHP technology in commercial buildings is a step in the right direction toward increasing efficiency, profitability, and sustainability across a wide range of industries to add another tool to the customers' GHG emissions reduction toolbox. It is encouraging to see a leading energy provider like FortisBC taking the initiative to explore and promote innovative technologies to meet the growing demand for clean energy while supporting economic growth and maintaining affordability and customer choice.

This Best Practices guide developed by CLEAResult Canada Inc. in collaboration with Building Energy Solutions Inc. for FortisBC is a valuable resource for individuals and organizations interested in adopting gas absorption technology. The guide provides comprehensive information on gas absorption technology, including its principles, equipment and materials required, best practices for implementation, and common challenges that may arise during the adoption and implementation process.

Appendix A: Glossary

AHU	Air Handling Unit
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
Btuh	British Thermal Units per Hour
COP	Coefficient of Performance
C&EM	Conservation and Energy Management (a department at FortisBC)
DHW	Domestic Hot Water
EHP	Electric Heat Pump
GAHP	Gas Absorption Heat Pump
GHG	Greenhouse Gas
GJ	Gigajoule
GUE	Gas Utilization Efficiency
HVAC	Heating, Ventilation, and Air Conditioning
IPMVP	International Performance Measurement and Verification Protocol
kW	Kilowatt
LNG	Liquified Natural Gas
M&V	Measurement and Verification
MURB	Multi-Unit Residential Building
NRCan	Natural Resources Canada
PST	Provincial Sales Tax
RNG	Renewable Natural Gas
tCO_2e	Tonnes of Carbon Dioxide equivalent
TRM	Technical Reference Manual