ENERGY SOLUTIONS CENTER

Track: Residential Natural Gas

Unit # 4: Residential Heat Pumps

Understanding the Technology and the Competition

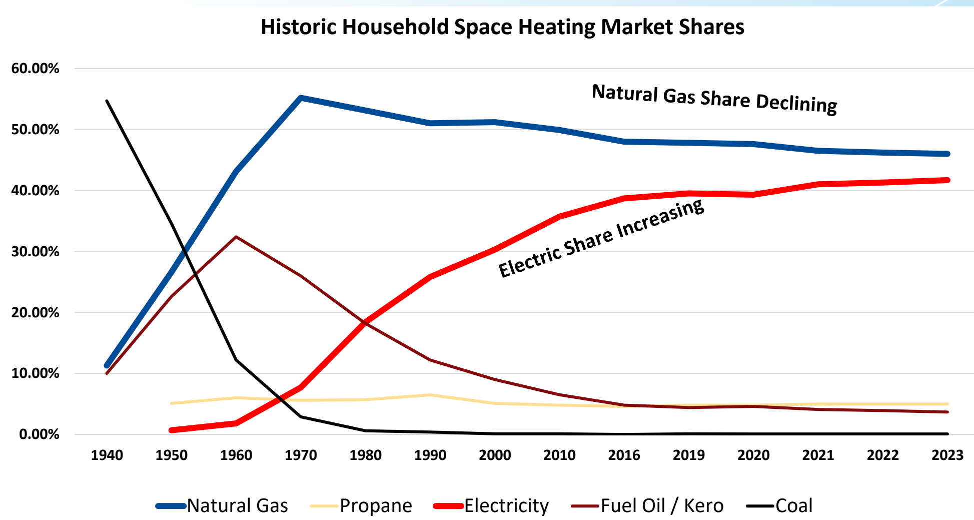
Eric Burgis, Energy Solutions Center

Presentation Outline

- Heating Market Stats
- About Heat Pumps
  - Air Source
  - Ground Source
- Natural Gas Technologies
  - Absorption Heat Pumps
  - Engine Drive Heat Pumps
- Future GHPs
- Case Studies

Heating Market Stats & Trends

Historical Trend in Heating Fuel Type



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U.S. Bureau of Census & U.S. Census Bureau American Community Survey 1 yr estimates through 2023

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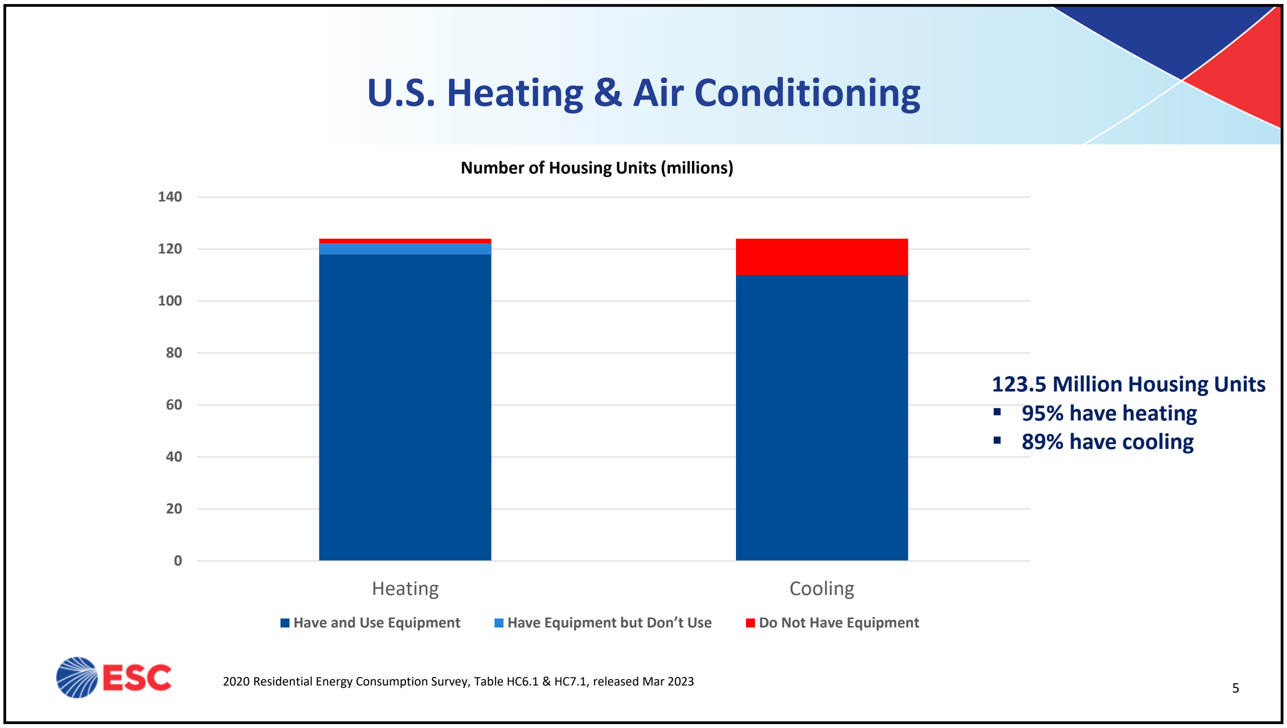
U.S. Heating & Air Conditioning
Number of Housing Units (millions)
140
120
100
80
60
40
20
0
Heating
Cooling
Have and Use Equipment
Have Equipment but Don't Use
Do Not Have Equipment
123.5 Million Housing Units
95% have heating
89% have cooling
2020 Residential Energy Consumption Survey, Table HC6.1 & HC7.1, released Mar 2023
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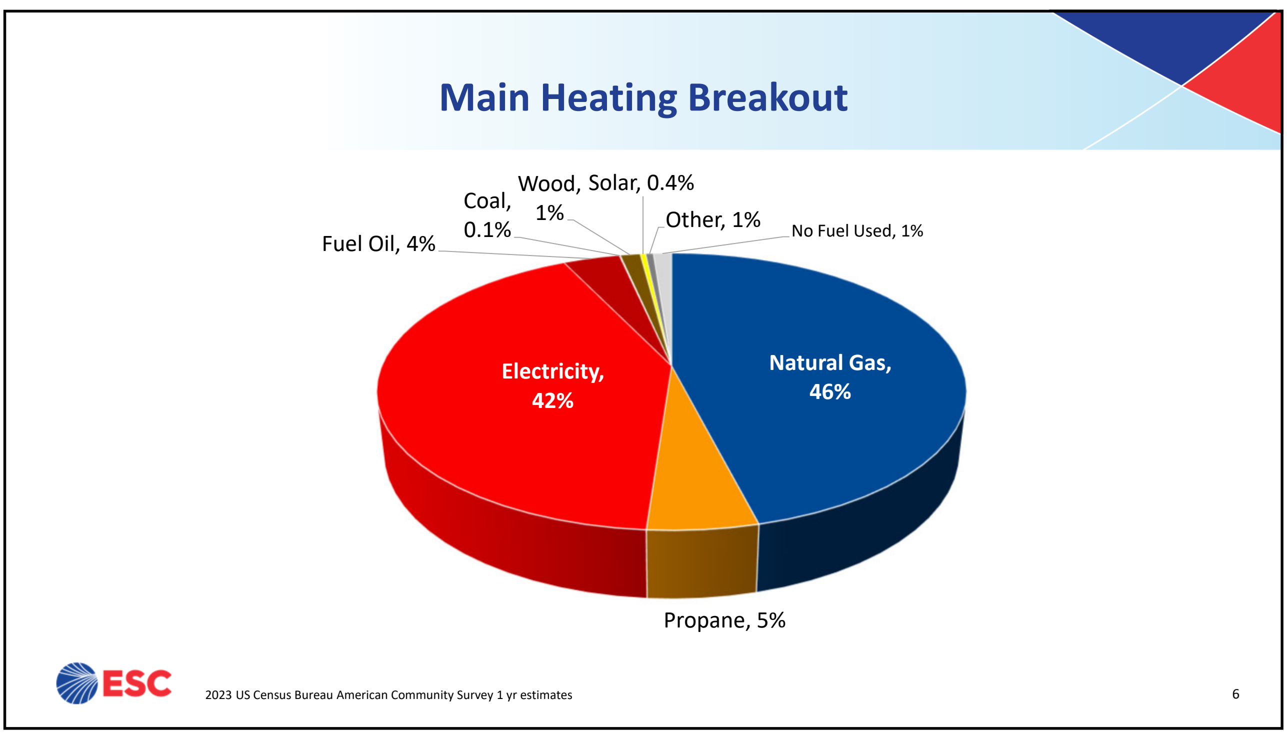
Main Heating Breakout
Wood, Solar, 0.4%
Coal, 0.1%
1%
Other, 1%
No Fuel Used, 1%
Fuel Oil, 4%
Electricity, 42%
Natural Gas, 46%
Propane, 5%
2023 US Census Bureau American Community Survey 1 yr estimates
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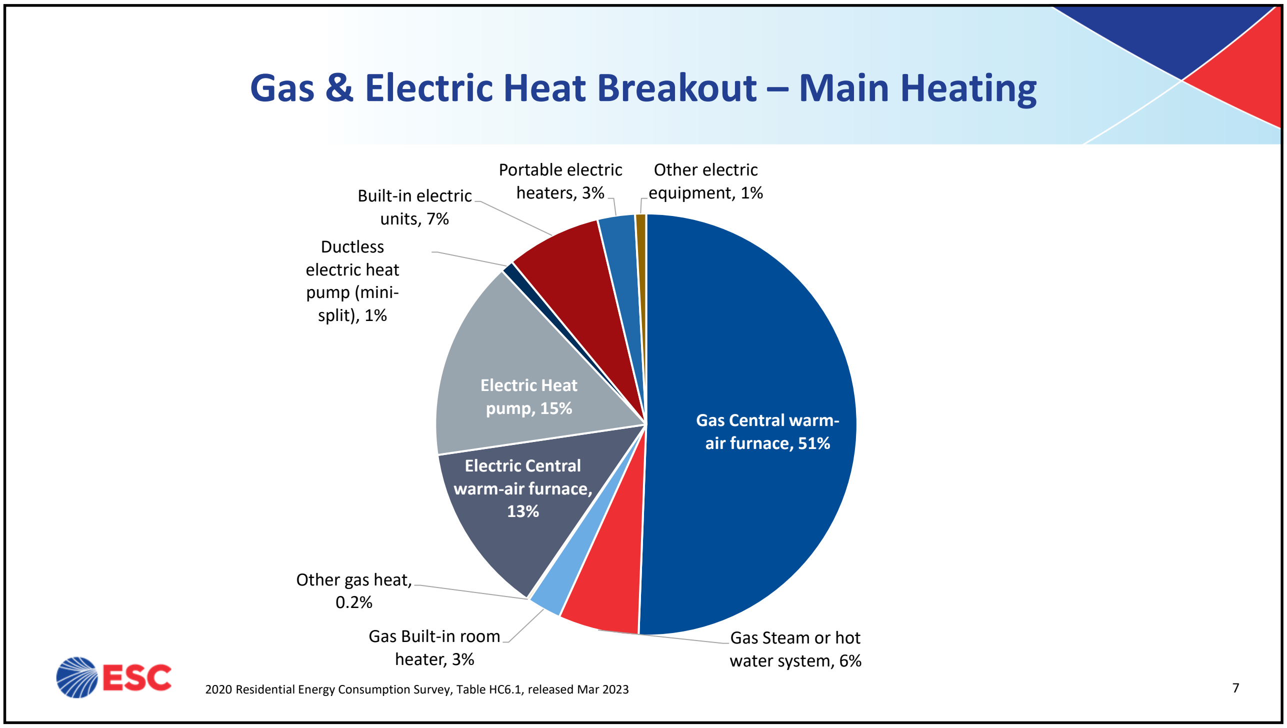
Gas & Electric Heat Breakout – Main Heating
Portable electric heaters, 3%
Other electric equipment, 1%
Built-in electric units, 7%
Ductless electric heat pump (mini-split), 1%
Electric Heat pump, 15%
Gas Central warm-air furnace, 51%
Electric Central warm-air furnace, 13%
Other gas heat, 0.2%
Gas Built-in room heater, 3%
Gas Steam or hot water system, 6%
ESC
2020 Residential Energy Consumption Survey, Table HC6.1, released Mar 2023
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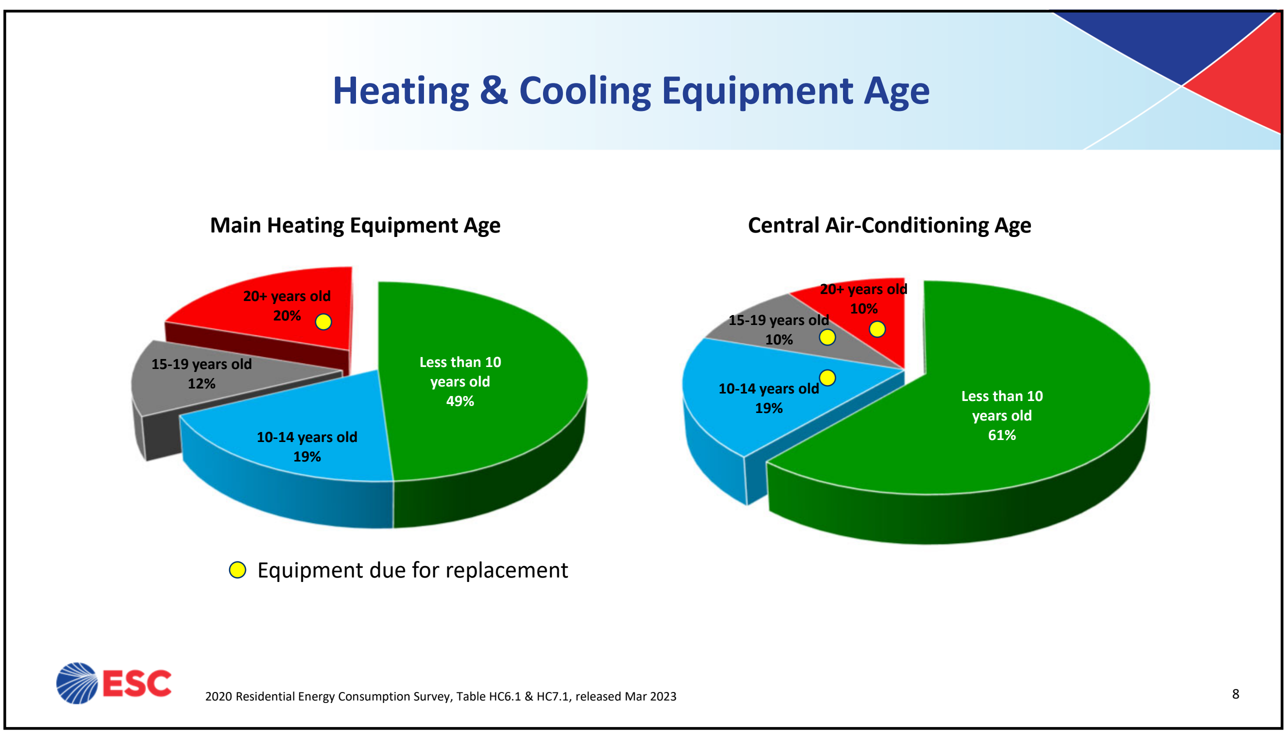
Heating & Cooling Equipment Age
Main Heating Equipment Age
20+ years old 20%
15-19 years old 12%
Less than 10 years old 49%
10-14 years old 19%
Central Air-Conditioning Age
20+ years old 10%
15-19 years old 10%
10-14 years old 19%
Less than 10 years old 61%
Equipment due for replacement
ESC
2020 Residential Energy Consumption Survey, Table HC6.1 & HC7.1, released Mar 2023
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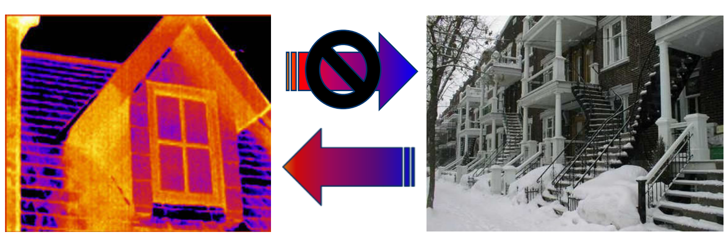
Heat Pumps

Heat Pumps
How they "trick" nature

Thermodynamic Laws
Heat flows naturally from a **higher-temperature** region to a **lower-temperature** region



Indoor : 72°F (22°C)   Outdoor: -8°F (-22°C)

Heat Pump
They "trick" nature by using **low-temperature** heat (outdoor) and transferring it to a **high-temperature** region (indoor)

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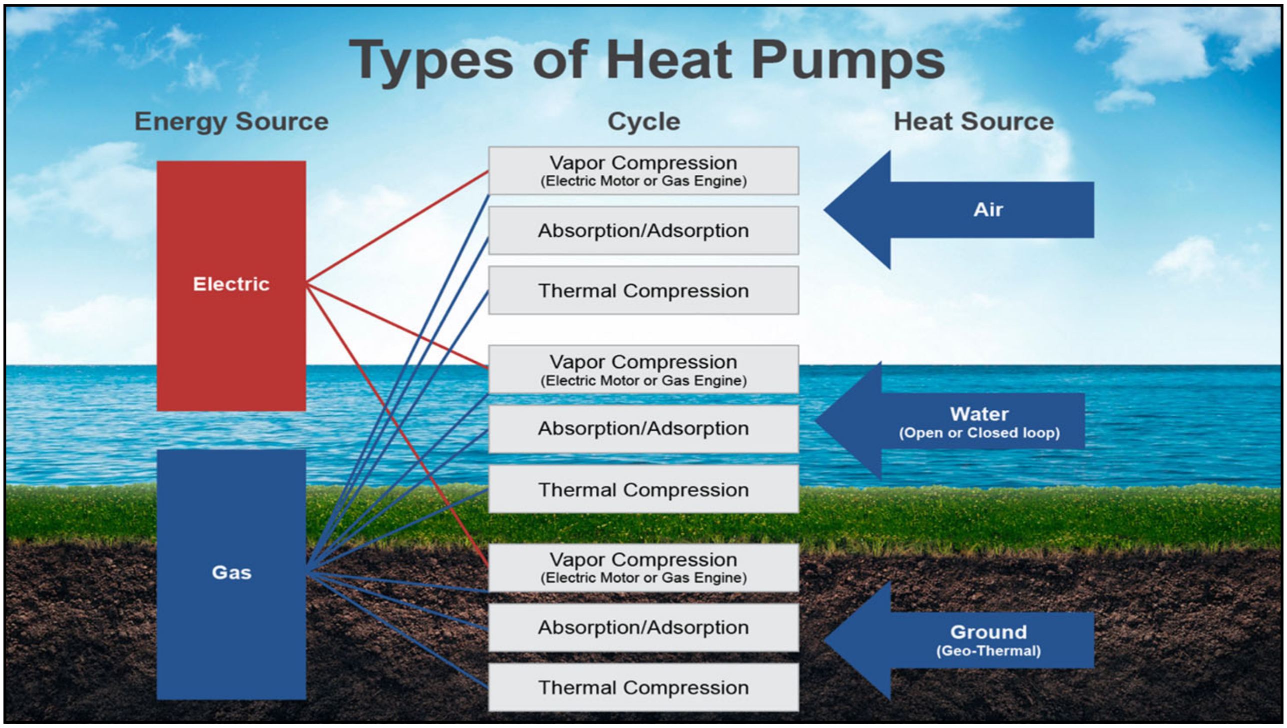
What is a "Heat Pump"

- Device that transfers thermal energy from a heat source to a heat sink
- Moves thermal energy in a direction which is opposite to the direction of spontaneous heat flow
- Uses energy to accomplish the desired transfer of thermal energy from heat source to heat sink

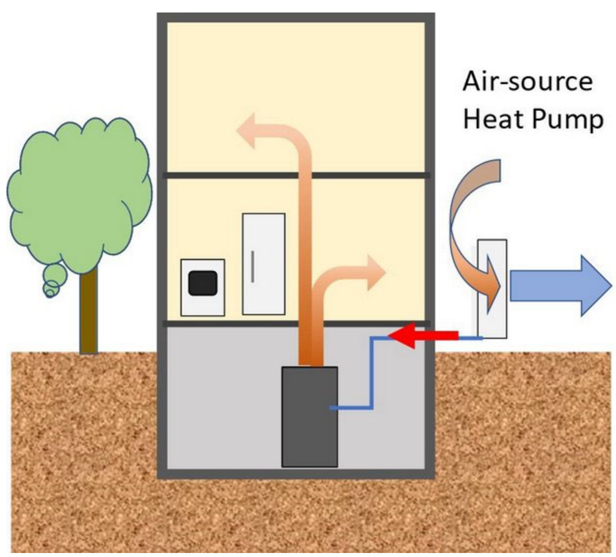
Types of Heat Pumps

- The standard vapor compressions cycle can be driven by:
  - Electric motor
  - Natural gas engine
- Variable Refrigerant Flow (VRF)
  - Electric motor
  - Natural gas engine
- Absorption cycle can be driven by:
  - Natural gas
  - Propane
  - Oil
  - Steam / Hot Water



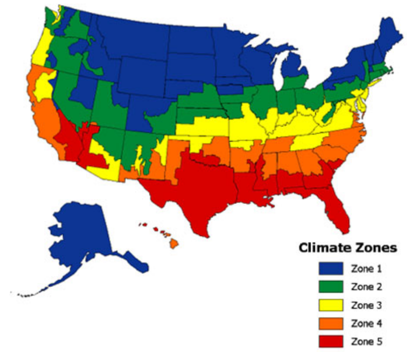
Air Source

- Takes heat from air in the winter and uses it to heat the house
- Takes heat from the house in the summer to cool the indoor air
- Outside unit could be electric, gas engine or absorber
- Lines to house could be refrigerant or hydronic



Electric Heat Pump Air Source Climate Issues

- Air source heat pumps used mainly in Zones 4 & 5
- Limited heat needs in these zones makes traditional gas furnaces comparatively less attractive
- Have been actively promoted by electric utilities in the past



- Zone 1 is less than 2,000 CDD and greater than 7,000 HDD
- Zone 2 is less than 2,000 CDD and 5,500 – 7,000 HDD
- Zone 3 is less than 2,000 CDD and 4,000 – 5,499 HDD
- Zone 4 is less than 2,000 CDD and less than 4,000 HDD
- Zone 5 is 2,000 CDD or more and less than 4,000 HDD

Note that gas heat pumps work well in Zones 1-3

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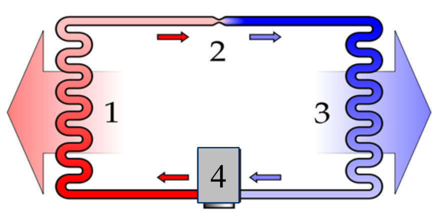
Vapor Compression Systems
Cooling Mode for Electric and Gas Engine Heat Pumps

Outside Space



Conditioned Space

1. Condenser coil (hot side heat exchanger, refrigerant {gas} cools and liquefies)
2. Metering Device / Expansion Valve (liquid expands and cools)
3. Evaporator coil (cold side heat exchanger, liquid vaporizes and heats up)
4. Compressor (refrigerant is compressed and heats up)
   - Compressor can run off electric motor or gas engine

Red = Gas at high pressure and very high temperature
Pink = Liquid at high pressure and high temperature
Blue = Liquid at low pressure and very low temperature
Light Blue = Gas at low pressure and low temperature

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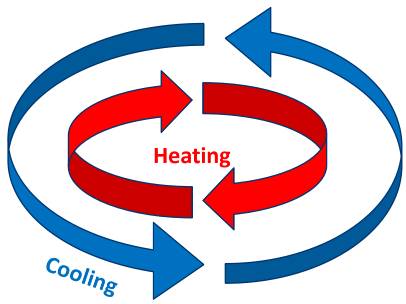
How it Works in Heating Mode

Vapor Compression for Electric and Gas Engine Heat Pumps

- Refrigerant flow is reversed via a valve in the system
  - Reversing valve rotates 90°
  - Changes the direction of the flow of the refrigerant
  - Flow is in the opposite direction – the reverse of the cooling cycle



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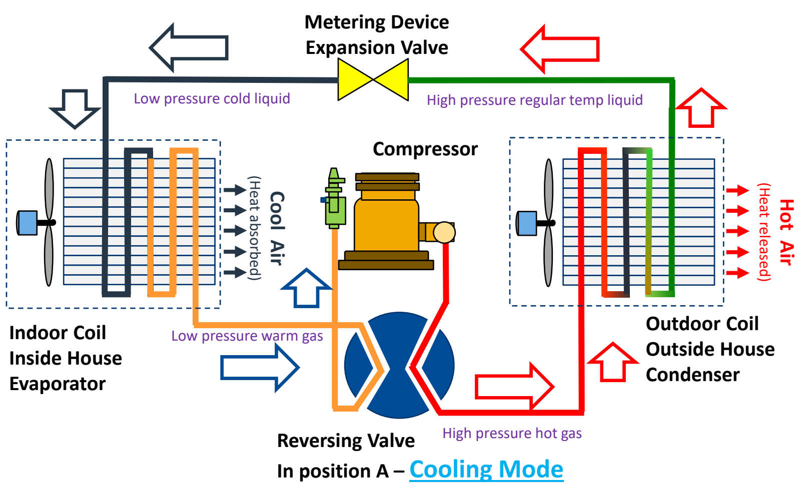
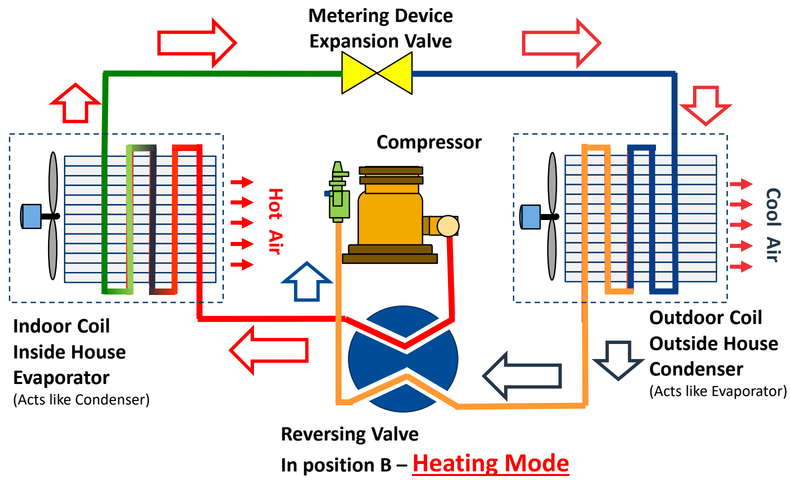
Air Source System in Cooling Mode

(Typical Electric or Engine Driven Air Conditioning)



Air Source Heating Mode



Simply Put

- When we cool the home, heat from the home is rejected to the outdoors through the condenser
- When the heat pump is used for heating the home, heat is extracted from the outdoors and rejected inside through the evaporator (inside coil)
  - The heat outside needs to come from somewhere such as the air itself, ground, or body of water

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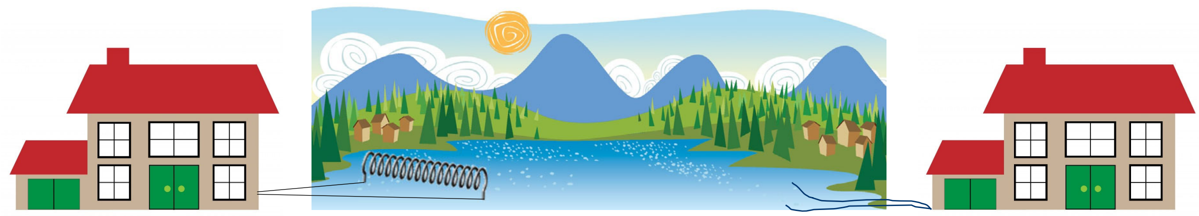
Water Source Heat Pumps

- Closed Loop
  - Just like ground source, antifreeze solution is in a closed circuit and completely isolated from the water source
  - Water from a close by lake or pond is used as the heat source/sink
- Open Loop
  - Lake or pond water is circulated directly through the loop



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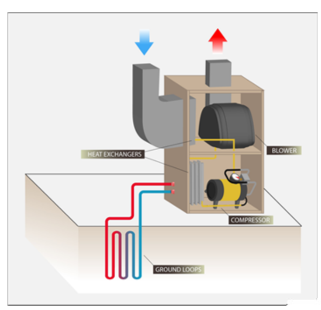
Ground Source Heat Pumps

- Soil temperature is almost constant year round
  - Warmer than air in the winter
  - Cooler than air in the summer
- Types of Ground Source Heat Pumps
  - Electric heat pumps
  - Gas engine heat pumps
  - Absorption heat pumps



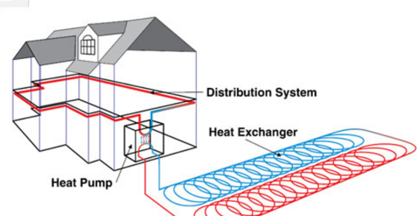


Figure 2. Three components

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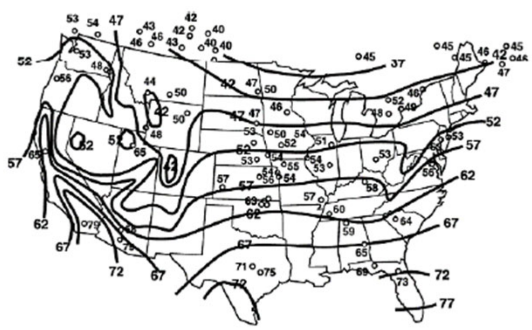
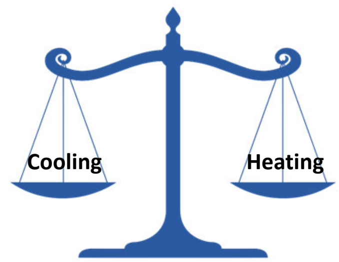
Geothermal Installation

- In-Ground temperatures are warm and stable throughout the year.

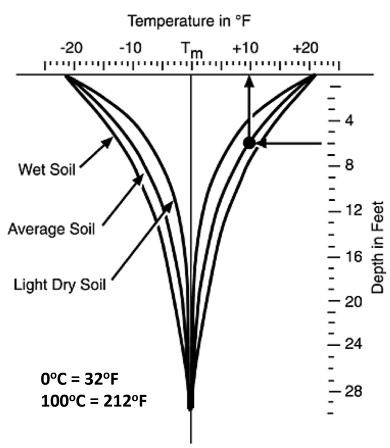


(a) Mean earth temperature, T_M (°F)



- If heating and cooling are balanced the well balances every year.
- More heat or cooling year after year changes the well temperature year after year and impacts efficiency.
- Heat islands or wells freezing over time

Soil Temperature is Function of Depth



Soil temperature varies by month depending on:

- Air temperature
- Vegatation cover
- Type of soil
- Depth in the earth

At soil depths greater than 30 feet below the surface, the soil temperature is relatively constant

Builditsolar.com

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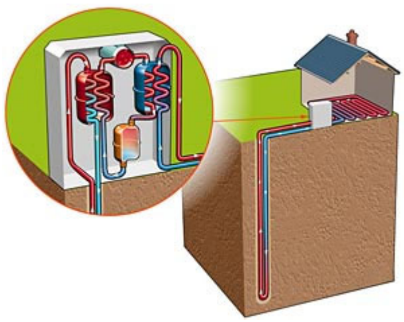
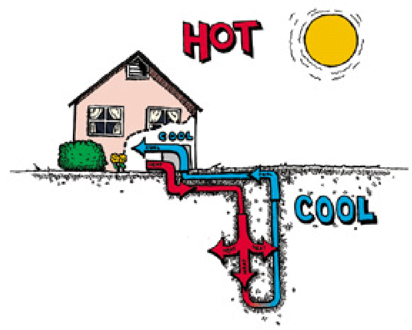
Geothermal Systems

Heat pump to transfer heat between ground loop and building



Source:
www.geothermie-perspectives.fr



Source:
www.igshpa.okstate.edu

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Types of Geothermal Systems

- Closed Loop Systems
  - Horizontal
  - Vertical
  - Pond/Lake
- Open Loop System

The determination of which system to use depends on climate, soil conditions and available land.

https://www.energy.gov/energysaver/geothermal-heat-pumps

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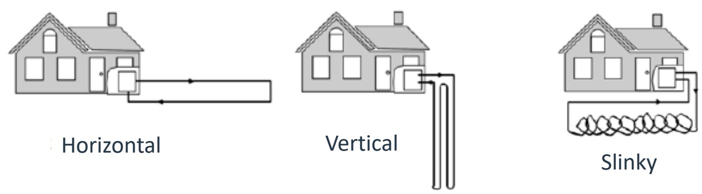
Ground Source

- Closed Loop
  - Antifreeze solution is in a closed circuit and completely isolated from the ground
- Trenches 4 to 8 feet (1.5 to 2.5 m) deep
- Boreholes 100 to 550 feet (30 to 150 m) deep



Source: http://www.energysavers.gov

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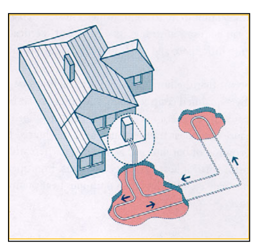
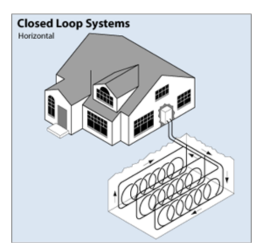
Ground Source

- Closed loop – horizontal
  - Trenchs at least 4 feet (1.5 m) deep (region dependent)
  - Single or multiple pipes, slinkies
  - Requires longer loops and large lots





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Ground Source

- Closed loop – vertical
  - Most common
  - Single or multiple boreholes
  - 4" – 6" (101.6-152.4 mm) diameter
  - 100' – 500' (30.5 – 152.4 m) deep
  - 20' (508 mm) spacing between boreholes
  - 1.25" (31.75 mm) HDPE U-tubes in boreholes
  - Grout for thermal contact between soil & pipe to avoid groundwater contamination
  - Requires relatively small lots

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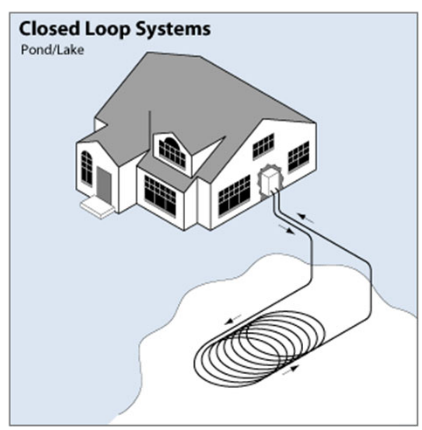
Water Source

- Closed Loop
  - Just like ground source, antifreeze solution is in a closed circuit and completely isolated from the water source
  - Water from a close by lake or pond is used as the heat source/sink



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Water Source

- Open Loop
  - Lake or pond water is circulated directly through the loop

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Open Loop Water Source Cont.

- Water extracted and rejected from/to lake or pond
- Heat exchanger between loop and heat pump
- Requires sufficient quantities of water
- Must comply with local groundwater use regulations
- More maintenance required to prevent equipment clogging

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Pros & Cons of Geothermal vs. ASHPs

	Geo-Thermal Heat Pump	Air-Source Heat Pump (ASHP)
Energy Efficiency	More Efficient than electric ASHPs	Capacity Drops as outside temperature drops
Initial Cost	Much higher than air source heat pumps	Lower installed cost and faster installation than Geo-thermal systems
Maintenance	Equipment underground and indoors	Outdoor equipment requires cleaning and maintenance
System Life	25 years	15 years
Space requirements	Requires extensive excavating	Require minimal space

Pros and cons are different between electric and gas heat pumps.

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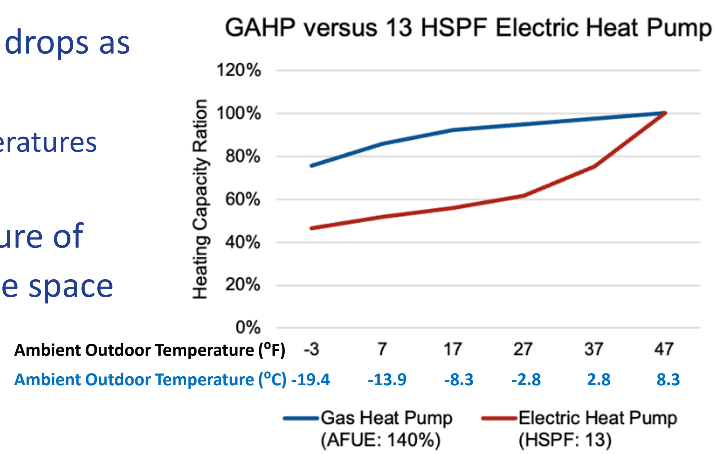
GHP vs EHP Heating Capacity at Various Outdoor Temperatures

- Air source heating capacity drops as outdoor air temp declines
  - Inadequate capacity as temperatures approach freezing
- Indoor supply air temperature of 90°-95°F (32-35°C) heats the space but feels cool to skin



* Courtesy of Stone Mountain Technologies

Cons of Vapor Compression Heat Pumps (Electric)

The lower delivered air temperature of the electric heat pump means that the blower must deliver more air to achieve the same heating level, more than twice as much air as a standard efficiency gas furnace. The air being moved is cooler which tends to be noted by the occupants as lukewarm or even cold drafts.

Heating System	Design Delivered Air Temperature
Electric Heat Pump (w/o Resistance Heater)	90-95ºF (32-35°C)

Compare to:

Standard Efficiency Gas Furnace	~120ºF (48.8°C)
Gas absorption heat pump	105-120ºF (60°C)

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Cons of Vapor Compression Heat Pumps (Electric Air Source)

- Condensing unit is typically sized for heating load which means it is oversized for the cooling load
  - Oversized cooling equipment leads to:
    - Cycling
    - Temperature fluctuations
    - Less humidity control
- Defrost Cycle on condenser uses energy
  - No defrost issues for geo-thermal systems

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Cons of Air Source Heat Pumps
(Vapor Compression)

- Night set-back can lead to requirement of supplemental resistance heat for morning warm-up thus added costs
- Larger condensing units vs. straight A/C
- Heat pump condensers run year round outside = noise versus a furnace and air conditioner.
- Condensers must be kept clear of snow to perform in heating mode

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Cons of Ground Source Heat Pumps

- High ground source installed costs
  - Ground loops alone cost up to $2,000/ton or more
- Improper sizing of ground source system can lead to:
  - Frozen wells (remove too much heat from ground and ground water freezes)
  - Heat islands (too much heat is rejected into the ground)
- At current gas/electric rates in most areas of the North America, it is less expensive to heat with a condensing furnace than an electric geothermal heat pump.

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Cons of Water Source Heat Pumps

- Possible water contamination
- Poor water quality causes operational problems
- Equipment clogging
- Heightened regulations thus additional permits may be required

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Halocarbons
(Applies to Vapor Compression Systems)

- Halocarbons are carbon compounds containing halogens such as chlorine, fluorine, and bromine – almost entirely anthropogenic (produced by human activities). These gases are ozone destroyers. For this reason, their emissions have been controlled under the Montreal Protocol (1987) and their increase in concentration since then has steadily declined
- However, they are long-lived and they will continue with their radiative forcing and ozone depletion for at least the next century
- The following are sources of halocarbons:
  - Chlorofluorocarbons (CFCs): Refrigerants (Freon) used in air conditioners and refrigerators, propellants in aerosol spray cans, and industrial solvents.
  - Other halocarbons: Insulation and foam used in fire extinguishers

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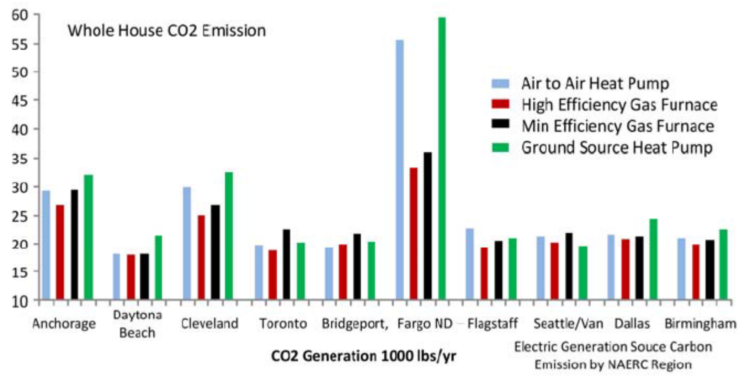
Carbon Emissions



- Carbon emissions depend on climate and generation source
- High efficiency gas furnaces are competitive with heat pumps in most regions
- In some cases, the air source system is more efficient than the ground source system

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Carbon Emission Comparison Between Residential Heating and Cooling Options, William Ryan Ph.D., P.E.

Cost to Eliminate 1,000 # CO2

Heating and Cooling System	Total Installed Cost	Incremental Installed Cost
80% AFUE Furnace and 13 SEER Air Conditioner	$3,500	Baseline
95% AFUE Furnace and 13 SEER Air Conditioner	$4,000	$500
Electric Air Source Heat Pump (HSPF 8.1/ SEER 13)	$4,000	$500
Ground Source Heat Pump (13-15.0 EER / 3.2 COP)	$10,000	$6,500
High Eff. Ground Source Heat Pump (18 EER / 3.8 COP)	$17,000	$13,500

Study: Carbon Emission Comparison Between Residential Heating and Cooling Options by Bill Ryan, UIC

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Cost to Eliminate 1,000 # CO_2

FIRST COST OF ELIMINATING 1000 LB OF CO2 EMISSIONS PER YEAR					
Location	Region	Converting to a High Efficiency Gas Furnace	Converting to a Air Source Heat Pump	Converting to a Median Efficiency GSHP	Converting to a High Efficiency GSHP
Anchorage	ASCC	$195	$3,125	NR	NR
Daytona Beach	FRCC	$2,381	$25,000	NR	NR
Cleveland	RFC	$282	NR	NR	NR
Toronto	NPCC	$128	$185	$2,866	$2,825
Bridgeport, CT	NPCC	$289	$211	$4,672	$3,818
Fargo ND	MRO	$187	NR	NR	NR
Flagstaff	WECC	$382	NR	NR	$8,532
Seattle/ Vancouver	WECC	$321	$980	$2,912	$3,855
Dallas	ERCOT	$921	NR	NR	NR
Birmingham	SERC	$758	NR	NR	$3,384

Carbon Emission Comparison Between Residential Heating and Cooling Options, William Ryan Ph.D., P.E.

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Natural Gas Options

GHPs and Gas Cooling

Most gas heat pumps can provide cooling as well as heating.

Natural gas cooling reduces electric peak demands which helps avoid higher summertime electric rates and helps stabilize the electric grid.

Gas cooling is generally less efficient than electric cooling, but also generally less expensive for energy.

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Gas Fired Absorption Heat Pumps

- Similar to a gas boiler
- Able to supply high temperature hot water both for heating and domestic hot water production
- Can move heat from air, water and ground sources to the home
- Do not use environmentally harmful refrigerants
- Have negligible electrical consumption
- Can also provide cold water for summer cooling
- Produces a smaller carbon footprint than other gas appliances

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Gas Fired Absorption Heat Pumps

- Available as water-source and air-source units
- Stable operation between ~120°F (48.8°C) & -20°F (-28.8°C)
- Reduces the need of electric power by approximately 92% in comparison with electric compression units
- Single phase power requirements
- System is typically sized in Tons of cooling even though it heats and cools. Will soon see these systems start to be sized in thousands of BTUs for the heating side
  - Note a 5-Ton Robur system provides approx. 130,000 BTU/Hr heat whereas a 5-ton electric heat pump only provides around 60,000 BTU/hr

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Gas Fired – Absorption

- The absorption cycle is similar to the vapor compression cycle in that there is still an evaporator and condenser
- Compressor is replaced by a generator, absorber and liquid pump
- Requires minimal electrical energy
- Uses natural and environmentally friendly refrigerants instead of CFCs or HCFCs which damage the ozone layer and contribute to global warming

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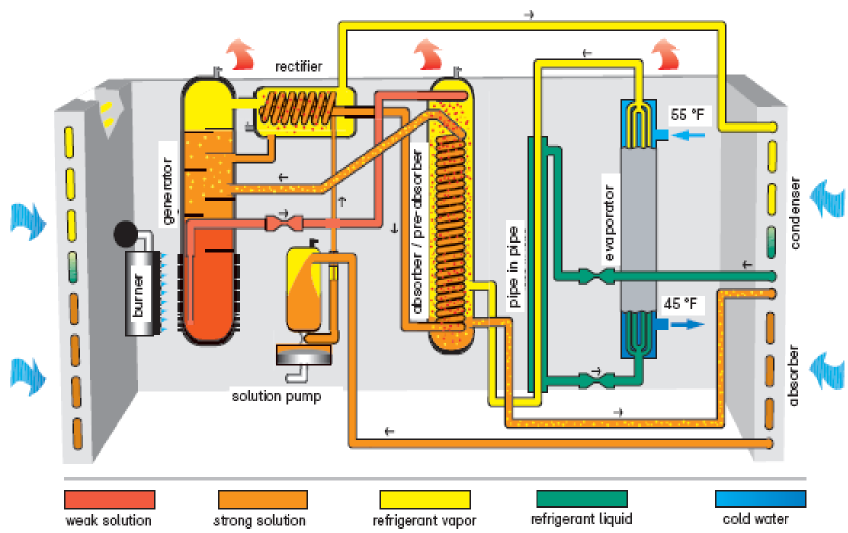
Ammonia – Water Absorption Cycle



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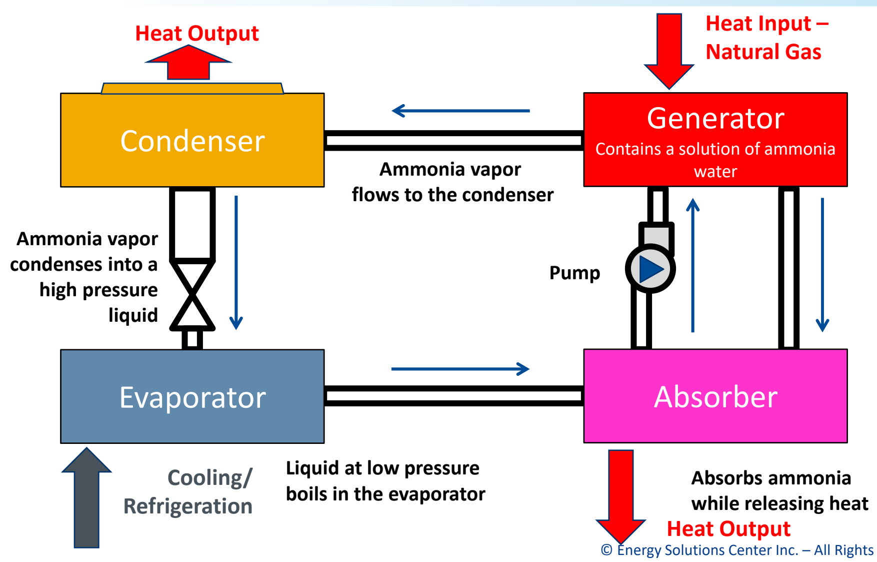
Absorption Process



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Water-ammonia absorption advantages
(Cooling Benefits)

- Environmentally friendly:
  - No use of harmful refrigerants (water and ammonia used)
  - Very high efficiency recovering thermal energy from the ambient
  - Low NOx emissions premixed burner
- Complete modularity
  - Unit staging effect for a better building load match
- Drastic reduction in electrical power consumption:
  - Single Phase Power – No Compressors
  - Avoid electric upgrades – Minimize electric demand charges
  - Much smaller standby generator for emergency cooling

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Efficiency Comparison
(Heating Benefit)

Heating Product Category	Maximum Thermal Efficiency
Non-Condensing Boilers	88%
Condensing Boilers	99%
Gas Absorption Heat Pumps (Heating)	~140%

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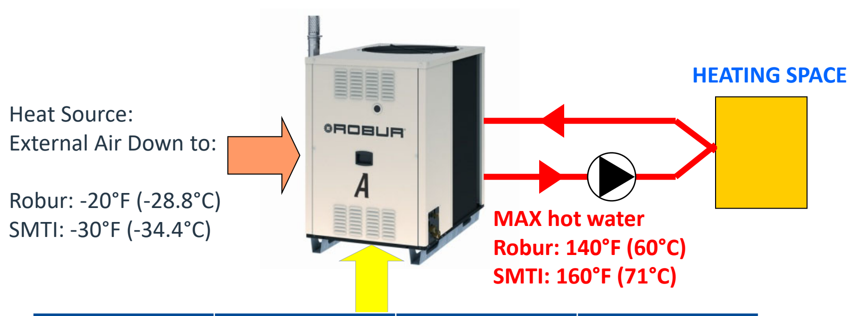
What is a Gas Absorption Heat Pump?

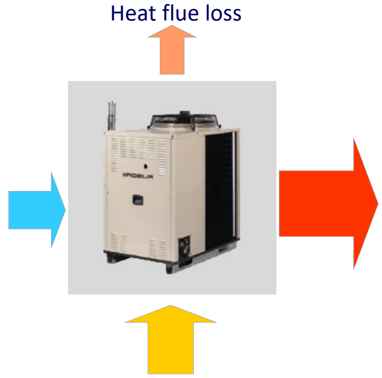
- Produces **HOT** [about 150°F (65°C)] or **COLD** water [37 ° F (2 ° C)
- GAHPs can pull "renewable" energy from the air or ground through the evaporator
- Hydronic product, but can be applied to a forced-air system

Gas Absorption Heat Pump
Operating Conditions - Heating



	Robur	SMTI	SMTI
Gas input	95,500 BTU/Hr	55,000 BTU/Hr	96,500 BTU/Hr
Heat Output	130,000 BTU/Hr	80,000 BTU/Hr	140,000 BTU/Hr
Electric Input	.9 kW	~.5kW	.5kW

Achieving >100% Thermal Efficiency
How is this possible?



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Ideal Markets

- Gas Absorption Heat Pumps (GAHP's) are ideal for applications with:
  - Heating dominant energy requirements
  - Colder climates
  - High electricity rates
  - Customers looking for renewable energy

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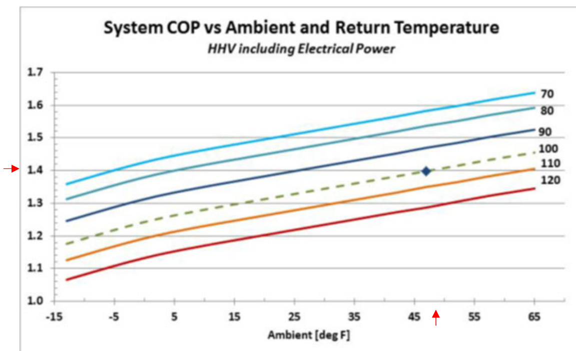
Gas Fired Absorption Advantages

- Versus Electric Heat Pumps
  - Comfort – warmer air distribution temperature
  - Operate in all climates
  - Does not require an emergency heat system
  - Lower annual operating costs
  - Heating efficiency up to 140% (at 47°F standard rating temp.)
    - Even >110% efficient heating at -5 °F



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Absorption: The GREEN Choice

- Absorption has no CFC's, HFC's or HCFC's which deplete the Earths ozone and contribute to Green House Gas emissions
  - R-717 (ammonia) Ozone Depletion Potential (ODP) = 0
  - R-717 (ammonia) Global Warming Potential (GWP)= 0
- Refrigerant Normally used in Electric Heat Pumps & air conditioners:
  - R-22 (phased out in 2020 but can be found in older units)
    - ODP = .05, GWP = 1810
  - **R-32** (latest refrigerant for electric heat pumps, mini-splits and window units)
    - ODP = 0, GWP = 675
  - R-134a (typically used in chillers & water source heat pumps)
    - ODP = 0, GWP = 1430
  - **R-410A** (typically found in electric heat pumps, mini-splits, window and portable air conditioners)
    - ODP = 0, GWP = 2088.

https://aircondlounge.com/types-of-refrigerant-in-air-conditioning/

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U.S. Department Of Energy

Heat pumps in use today are electrically driven, operating on the conventional vapor-compression refrigeration cycle. **Thermally activated heat pumps that operate on natural gas fuel have the potential to revolutionize the way residential and commercial buildings are heated and cooled.**

Such natural gas driven heat pumps can achieve substantial improvements in energy efficiency by avoiding the energy conversion losses (approximately 70%) associated with electric power generation and distribution. **Highly efficient heat pumps could outperform the best natural gas furnaces, reducing energy use by as much as 50%, while also providing gas-fired air conditioning.**

In large commercial-size absorption chillers, energy efficiency can be improved by 50% with advanced high-temperature cycles and novel fluids. Working with industry and utilities, DOE is developing and testing thermally activated technologies in residential absorption heat pumps, such as the generator absorber heat exchange (GAX) cycle heat pump and the "Hi-Cool" heat pump; and in large commercial chillers with double-condenser-coupled cycles.

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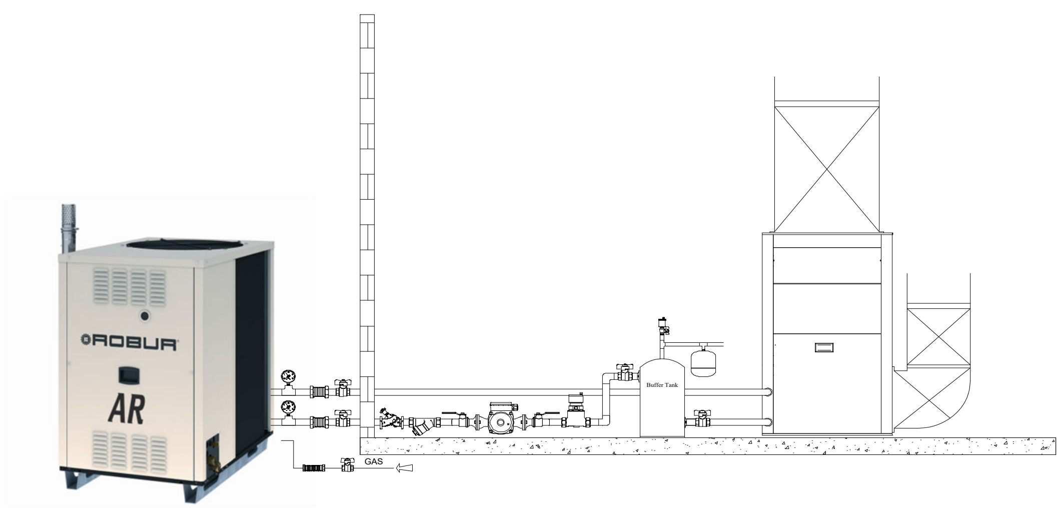
Each module is capable of singular / independent operation providing chilled and/or hot water for various application types



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Gas Fired Engine Driven Heat Pump

- Limited residential application
  - For larger homes ~4,000+ Ft^2 (371.6 m^2)
- Smallest size is 8 Tons
- Heating and Cooling
- Heating COP is 1.4
  - Equivalent to 140% efficient

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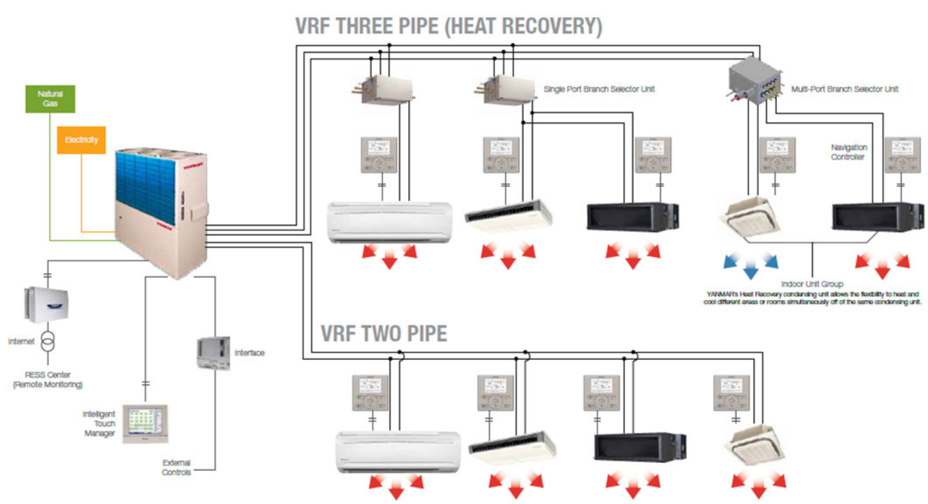
Gas Fired Engine Driven Heat Pump



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Pros & Cons of Gas Engine Driven Heat Pump

Pros:

- Higher efficiency 120% - 140% depending on outdoor air and outlet water temperatures
- Generally lower operating cost
- Higher delivered air temperature
- Typically a much lower cooling energy cost

Cons:

- High installation costs
- Ongoing maintenance costs

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Why Do Electric Heat Pumps Sell?

- Lower first cost versus hybrid system (gas furnace/standard AC unit)
- Customer perception of high efficiency
- Convenience – one appliance does both heating & cooling
- Special utility rates offered for HP systems
- Only one utility service required
  - Lowers cost of the home
- Work well in moderate climate areas

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Economics

Natural Gas vs. Electric Cooling Analysis

ENERGY SOLUTIONS CENTER

	Standard Electric Heat Pump (Base system)	Standard Electric AC with Gas Furnace	Electric Heat Pump (Multi-Zone and VRF)	Gas Absorption Heat Pump (AR Series)	Gas Engine Driven Heat Pump (Multi-Zone & VRF)
Total Size System Installed (Tons)	5	5	5	5	5
Total Installed Cost	$8,500	$9,700	$22,500	$20,000	$21,250
Electric Cost	$2,618	$1,530	$1,913	$255	$211
Natural Gas Cost	$0	$600	$0	$1,528	$1,220
Maintenance Cost	$38	$38	$38	$56	$113
Total Energy & Maint Costs (/year)	**$2,656**	**$2,168**	**$1,950**	**$1,839**	**$1,543**
Savings vs. Base System	Base	$488	$706	$816	$1,112
Incremental Cost vs Base System	Base	$1,200	$14,000	$11,500	$12,750
Simple Payback (Years)	Base	**2.46**	**19.84**	**14.09**	**11.46**
20 Year Positive Cash flow	Base	**$9,956**		**$1,618**	**$6,829**
Net Present Value	Base	**$5,673**	**$3,142**	**$8,333**	**$14,274**
Internal Rate of Return	Base	**43%**	**2%**	**5%**	**8%**
20 Year Capital Costs	$13,463	$15,364	$35,638	$31,678	$33,658
20 Year Maintenance Costs	$911	$911	$911	$1,367	$2,733
20 Year Energy Costs	$63,611	$51,753	$46,469	$43,322	$34,765
20 Year Life Cycle Cost	**$77,985**	**$68,028**	**$83,017**	**$76,367**	**$71,156**

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ESC's Gas Cooling & Heat Pump Calculator using 1500 hours of cooling and 1000 hours of heating, $.17/KWH and $.80/Therm gas.

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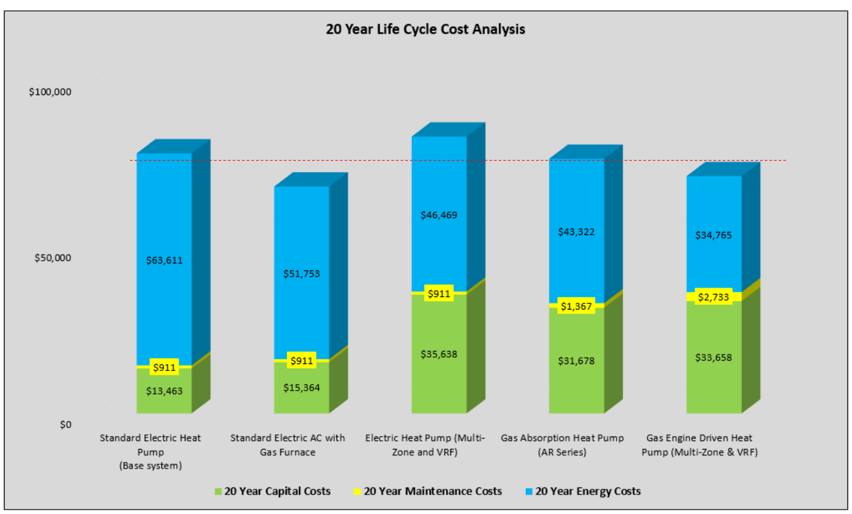
Life Cycle Cost (5 Tons)



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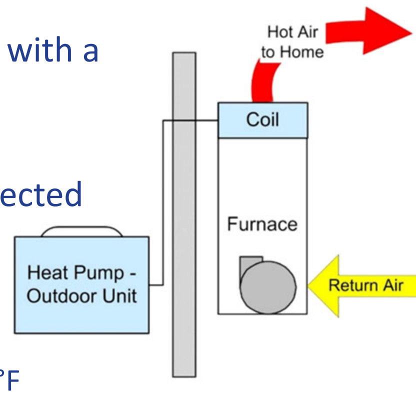
Add-On Heat Pumps

- Replace air handler of an electric heat pump with a gas furnace.
  - Gas heat handles the coldest months
- Replace electric AC (condenser) that is connected to a gas furnace with an electric heat pump.
  - Loose some of the gas heat load
    - In shoulder months
    - When winter outdoor temperature is above 35°F



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Add-On Heat Pumps

- Converting a furnace with standard A/C to a furnace with add-on heat pump is fairly simple
  - Replace condensing unit and A-coil
- Converting an all-electric furnace and add-on heat pump system to furnace and standard A/C is more costly
  - Replace inside air handle with gas furnace
  - Replace heat pump condenser and A-coil with standard A/C condenser and A-coil

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Heat Pump Innovations

- Staged or Multi-Speed Compressors
  - Allow heat pumps to operate close to the heating and/or cooling capacity required at any outdoor temperature
  - Save energy through reduced on/off and compressor wear
  - Inverter-driven systems can modulate speed/capacity at practically infinite degrees between low and high settings, allowing the system to operate efficiently and maintain consistent comfort

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Heat Pump Innovations (cont'd)

- Variable-Speed or Dual-Speed Motors
  - The majority of newer heat pumps and furnace blowers come equipped with electrically commutated motors (ECM) variable-speed or dual-speed motors on indoor fans, outdoor fans or both
  - The variable speed controls keep the air moving at a comfortable rate
  - This minimizes cool drafts and reduces noise while increasing electrical savings

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Heat Pump Innovations (cont'd)

- Desuperheater
  - Some high efficiency heat pumps are equipped with a desuperheater
  - A desuperheater recovers heat waste heat from the unit's cooling mode and then uses it to heat water
  - A heat pump with a desuperheater heats water 2 – 3 times more efficiently than a electric-resistance water heater

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Heat Pump Innovations (cont'd)

- Dual-Fuel or Hybrid Systems
  - Combines a heat pump with a gas furnace
  - Heat pump heats and cools your home during warmer months
  - Automatically switches to natural gas when the temperature drops
  - Both systems share the same ductwork
  - Commonly found in the Mid-Atlantic region; provides reliable and affordable heat and maximizes energy savings

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Heat Pump Innovations (cont'd)

- Cold-Climate Heat Pumps
  - These units are designed to operate in very cold temperatures, down to 5 ° F (-15 ° C)
  - Provide heat pump efficiency to cold climate areas
  - Can last 15 – 20 years
  - Aside from energy savings, these units are expensive to install

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Potential Future Products

Anesi: Residential GHPWH

UEF:	1.20 *(expected)*
Capacity (output):	10,000 BTU/hour *(input = 6,000 BTU/hr)*
First Hour Rating:	tank capacity (60-80 gallons)
Refrigerant:	NH_3 / H_2O
Global Warming Potential:	None
Max Supply Temp (steady):	140°F
Electrical Requirement:	115 VAC, approx. 1 amp
Gas Supply Line:	¼ - ½ ”
NOx Emissions:	SCAQMD compliant (<10 ng/j)
Venting:	PVC pipe – 3/4 - 1"
Dimensions:	76”H x 24”W x 24”D (80 gal)
Weight:	360 lbs.

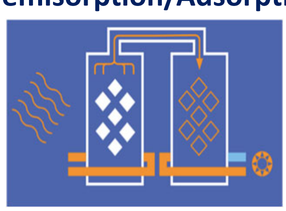
HeatAmp

High performance 40-50 gal. drop-in replacement gas-fired heat pump water heater for the residential market in North America with a UEF >1.25.

- 35 kBTU/hr (10 kW) Direct-Firing at condensing efficiency
- Triple-state sorption is neither absorption nor adsorption cycle: intentionally crystallizes salt in reactor, for high energy density
- Ammonia refrigerant, housed in outdoor unit with no moving seals (fully hermetic), enables high delivery temperature at low ambient

Field testing

Chemisorption/Adsorption



Draft rendering of a final GHP HeatAmp product

Current Alfa prototype under testing

HeatAmp

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Homy / Vicot

Residential
Model: V20
Capacity: 68 MBH GAHP
Application: Heating/Domestic Homes

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ThermoLift

Capacity: Fully Modulated Capacity

- Full Load – 10 to 15 gal/min Water Flow:
  - Heating Capacity (Btu/hr.) 55,000 to 75,000
  - Cooling Capacity (Btu/hr.) 27,500 to 37,000
  - Storage Enabled Peak Cooling Capacity (Btu/hr.) 48,000 to 60,000
- Partial Load – 5 to 7.5 gal/min Water Flow:
  - Heating Capacity (Btu/hr.) 27,500 to 37,500
  - Cooling Capacity (Btu/hr.) 13,500 to 18,500

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boostHEAT

Heating & water heating unit

boostHEAT

Residential sizes 1.14 to 5.69 Tons

Technology	Natural Gas fueled Air-Source CO_2 Heat Pump
Total Capacity	82 MBTU/H at 15 °F Outdoor Air Temp. 133 MBTU/H at 60 °F
Heat Pump Capacity	14 MBTU/H at 15 °F Outdoor Air Temp. 65 MBTU/H at 60 °F
Heat Pump Modulation	20 % - 100 %
Integrated Boost Burner Capacity	14 - 68 MBTU/H (Integrated boost burner to provide additional output if needed)
Domestic Hot Water Supply Temperature	120 - 140+ °F (Internal 185°F DHW storage tank with adjustable mixing valve)
DHW Specific Flow Rate	≥ 4.75 gal/min (EN 13203) "XL" load capacity
Indoor Unit Dimensions	H 79" x W 24" x D 32"
Outdoor Unit Dimensions	H 46" x W 34" x D 20"

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Case studies

Residential Applications

ROBUR
caring for the environment

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Custom Residential

- Improved comfort with zoning
- Fewer cooling tons required
- Quieter operation (48 - 57 dB)
- Long life (2-3 X Compression Systems)
- Chilled water coils may be utilized with conventional gas furnaces
- Maintain home’s aesthetics & architectural integrity

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Custom Residential Applications

GAHP-AR Air Source Heat Pump

Heating Capacity 120,400 Btu/h
Cooling Capacity 57,700 Btu/h

Southern Illinois

- 5,000 Ft^2 (464.5m^2)
- Two Floors
- Environmentally Friendly
- Low gas rates

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Custom Residential Applications (cont'd)

Michigan Residence

- 5 Ton Robur Unit
- Cooling Addition to Custom Home
- No Electrical Upgrade Required

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Custom Residential Applications (cont'd)

25 Ton Cooling System
Remote Equip. Location
***Smaller Standby Generator**

New Jersey Home

- 11,000 Ft^2 ($1021.9m^2$) / 13 Comfort Zones
- Maintained Aesthetics (Internally & Externally)
- Multiple Zoning Comfort Control
- Avoided Electrical Upgrade Costs
- Virtually No Noise

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Custom Residential Applications (cont'd)

15 Ton Cooling System
Located 200'+ (61 m) from house

Chappaquiddick Bay Home

- 15,000 Ft^2 ($1393.5m^2$)
- Three Floors
- 12 Comfort Zones
- Virtually No Noise
- Multiple Electric AC Units

  Not an Option!

The Exterior quality & appearance remain the focal point of the property.

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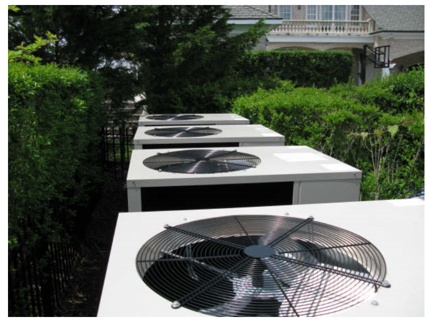
Custom Residential Applications (cont'd)

Long Island Residence

- 20 Ton Cooling System
- Located away from Home
- Single Phase Service



- Quiet Operation
- Comfort Zoning
- Modular Staging
- Reduced Ductwork

AFC60-HR Chiller with Heat Recovery

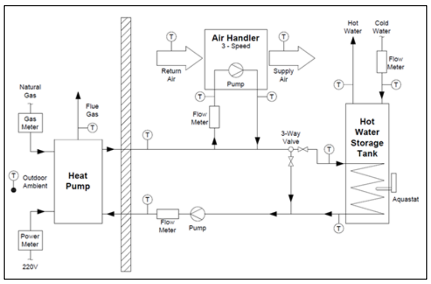
Pennsylvania Residence

- 15 Ton Modular Chiller with Heat Recovery
- Factory Assembled, Single Point Connections
- Dumping of Unused Hot Water Not Required

- Replaced Engine Driven Chiller
- Quieter Operation

Residential Combi Field Test Site
(SMTI in Tennessee)

- 2,200 sqft home built in 1947 | March 2016 Installation
- 80 kbtu/hr, 4:1 modulating GAHP + 80 gallon indirect DHW storage tank
- GAHP serves both space and hot water loads (DHW priority)
- Replaced 80 kbtu/hr 92% gas furnace, 50 gallon electric water heater
- Warm supply air temperatures (105 – 120°F), ambient reset built-in
- 3-stage hydronic air-handler – quiet, long, even heating cycles



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Thank You

Consider taking the on-line test while course material is fresh in your mind

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