GSHP Systems
Fundamentals of Commercial Applications

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Pikes Peak ASHRAE

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Major Geothermal
www.majorgeothermal.com

- Colorado Geo Energy Heat Pump Association (CoGEHPA) – *www.gogeonow.org*
  - State heat pump industry association, private sector member-driven
    - Mechanical, excavation and drilling contractors
    - Vendors
    - Architects, Engineers
  - Providing value to membership – continuing education, legislative and regulatory voice, industry events, referrals
  - "Non-denominational" resource for end-users, utilities, schools and government

GSHP Systems – Fundamental of Commercial Applications

Heat Pumps – Outline

- Introduction – history of GSHP technology and how it works
- Types of heat pumps, efficiency
- Heat pump and loop configurations, residential and commercial
- Design methodology
- Quality control
- Rocky Mountain examples

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GSHP Systems – Fundamental of Commercial Applications

Heat Pumps – Definition, History

- What is a heat pump?
  - According to the second law of thermodynamics heat cannot spontaneously flow from a colder location to a hotter area
  - Any mechanical device that moves energy from one space to another is considered a 'heat pump'
  - Modern heat pumps rely on refrigerants that easily change phase from liquid to gas and back to achieve heat transfer
- Examples:
  - Brine plants used to make ice
  - Ice rink plants
  - Refrigerators
  - Air conditioners
  - Reversing air conditioners – air source heat pumps
  - Ground source heat pumps

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Heat Pumps: Advantages

GSHP systems offer other advantages in addition to energy efficiency

- No externally exposed mechanical equipment
  - No external noise
  - No impact from weather, vandalism
- Less mechanical room space, reduced infrastructure
- May reduce structural components
- May increase zoning and comfort at little additional cost
- Reduced controls complexity
- Reduced maintenance

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Heat Pumps: Advantages

LEED, green advantages

- 2 to 8 energy points typical of most LEED projects using GSHP systems
- Reduced CO_2 emissions, even considering point source of electrical power
- No noise pollution from external equipment (eliminated)
- Load sharing

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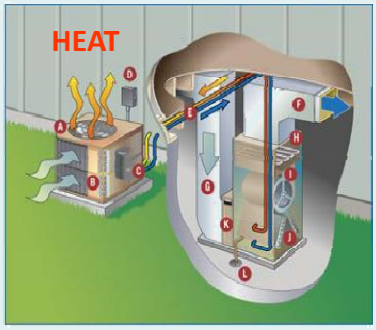
Heat Pumps – Definition, History

Air conditioners and air-source heat pumps transfer heat from inside houses to the air outside.



Refrigerators transfer heat from food into the kitchen.

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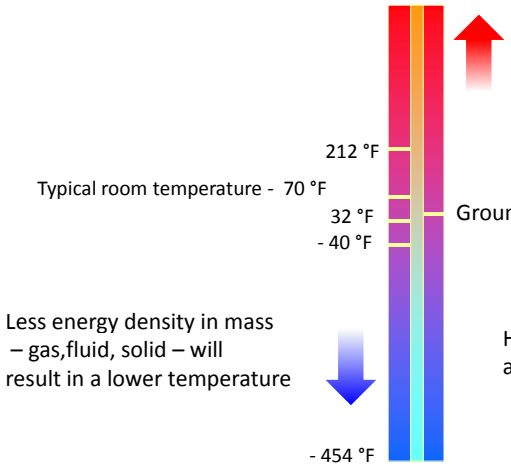
Heat Pumps – The Amount of Energy in Mass Determines Temperature



Greater energy density in mass – gas,fluid, solid – will result in a higher temperature

Ground temperature about 40-60 °F

Less energy density in mass – gas,fluid, solid – will result in a lower temperature

Heat can be taken from anything above absolute zero

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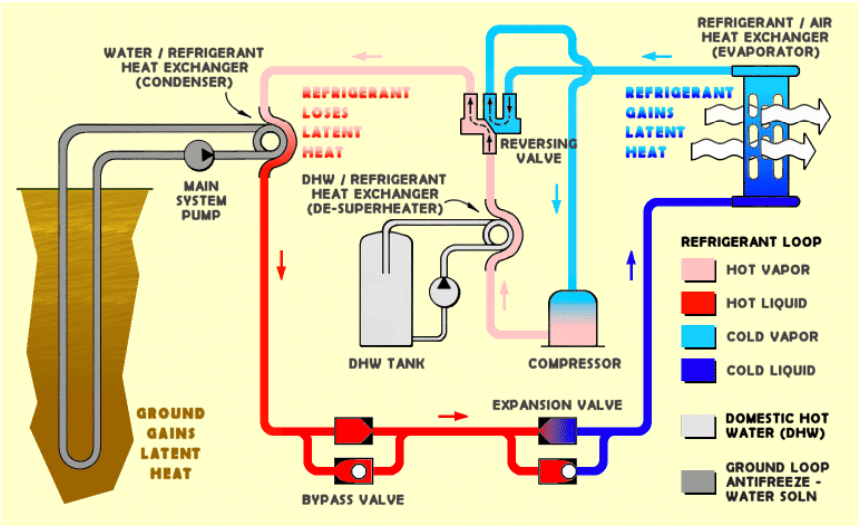
Fundamental Operation – Refrigeration Cycle, Cooling



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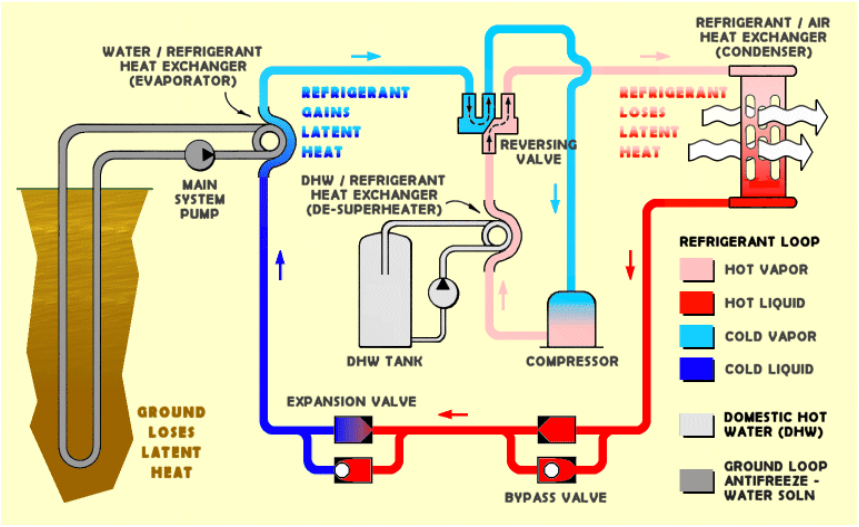
Fundamental Operation – Refrigeration Cycle, Heating



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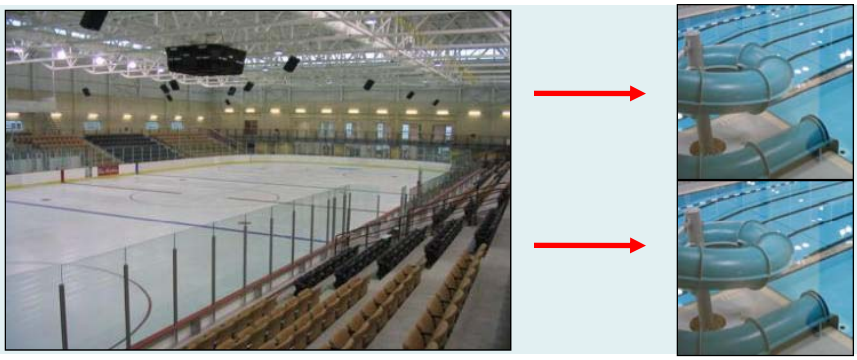
Heat Pumps - Examples

- The average sheet of ice for a hockey rink can heat two or more Olympic size swimming pools, with heat to spare, the only cost being pumping to heat the pools



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Heat Pumps – History

- Heat pumps are not new -
  - 1748: William Cullen demonstrates artificial refrigeration
  - 1834: Jacob Perkins builds a practical refrigerator with diethyl ether
  - 1852: Lord Kelvin describes heat pump theory
  - 1855–1857: Peter Ritter von Rittinger develops and builds the first heat pump
  - Ice-making ammonia brine plants were in use in the latter part of the 19th century

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Heat Pumps – History

Mr. Bill Loosley, designed and installed a direct exchange geothermal system in his home in Burlington, ON in 1950

Courtesy Mr. Ed Lohrenz, CGD, GeoXergy

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Heat Pumps – History

Belt drive compressor

Air coil in old oil furnace

Desuperheater added to hot water tank

Courtesy Mr. Ed Lohrenz, CGD, GeoXergy

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Heat Pumps – History

Compressor was initially powered by hand crank diesel motor… changed to electric motor (still being used!!) in 1953 when his wife couldn't start it.

Courtesy Mr. Ed Lohrenz, CGD, GeoXergy

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Heat Pumps – Outline

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Heat Pumps – Earth Coupled

- Ground source heat pumps are tied to the earth for better efficiency, regardless of climate
  - Most GSHPs rely on water to carry energy to and from the earth instead of exchanging heat with the air
  - Some GSHP units utilize direct exchange (DX) by placing metallic lines in the earth to carry the refrigerant to achieve a phase change directly
  - The amount of energy consumed to heat or cool with this technology is far less than any conventional mechanical system
- Transferring energy
  - Acquiring heat – space heating - is a renewable cycle, as GSHPs capture energy from near-surface solar gain and natural thermal gradient
  - Rejecting heat – space cooling – utilizes the nearly unlimited capacity of the earth to dissipate energy, and in some situations, permit a GSHP system to store energy to be reclaimed later

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GSHP Equipment – GSHP vs. Conventional WSHP

- Conventional WSHP equipment will only tolerate EWT ranges of 50°F to 80°F – this product is commonly used in commercial applications using a boiler and chiller
- GSHP equipment is designed to accept a wide range of EWT, typically an extended range of 20°F to 120°F
  - This wider temperature bandwidth capability allows for the economic installation of closed loop ground heat exchangers

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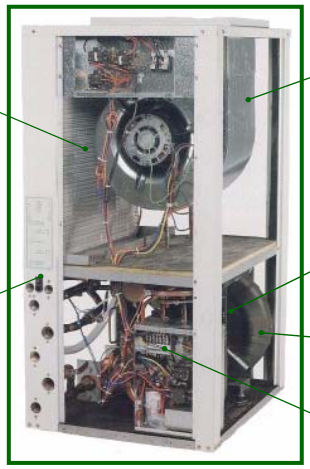
GSHP – Typical Unit



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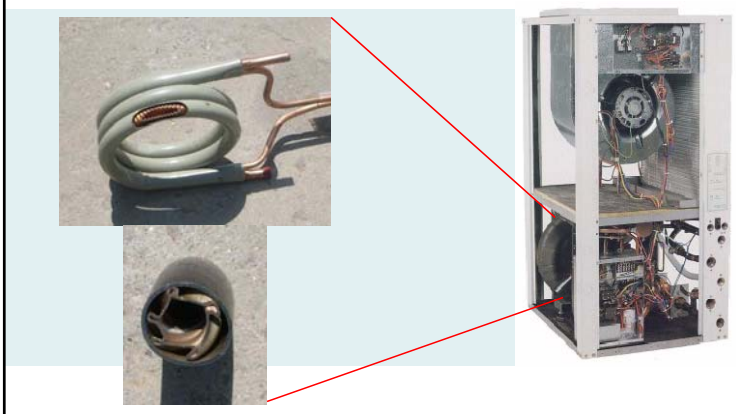
GSHP – Water-to-Refrigerant Heat Exchanger

Typical coaxial water-refrigerant HX used in most GSHP equipment



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GSHP Efficiency

Most energy ratings or calculations describe:

What you pay for

vs.

What you get

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GSHP Efficiency - Heating

- GSHP systems routinely operate at efficiencies exceeding 300% in the heating mode, regardless of altitude or outside climate conditions
- For a comparison, the best conventional furnaces and boilers operate at 90% efficiency, at sea level
- Heating performance is usually rated by a ratio expressed as COP (coefficient of performance):

  COP = Btuh delivered / Btuh consumed

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GSHP Efficiency - Cooling

- GSHP systems routinely operate at efficiencies exceeding 15 EER in the cooling mode, regardless of altitude or outside climate conditions
  - EER = Energy Efficient Ratio, or
    EER = Cooling Btuh capacity / Watts
- For a comparison, the best conventional air conditioners operate at 14 to 15 SEER, but are dependent upon outside air temperature for efficiency
  - SEER = Seasonal Energy Efficient Ratio, or
    SEER = Seasonal Cooling Energy (Btu) removed / WattsHr
- EER and SEER **are not** the same!

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GSHP Efficiency – Residential Examples

- GSHP efficiency, the real world:
  - 3,200 ft² residence, Montrose, Colorado, $325 per year to heat and cool – forced air, water-air HP, new construction
  - 3,600 ft² residence, Gunnison, Colorado, $250 per year to heat – radiant floor, water-water HP, new construction
  - 2,700 ft² residence, Golden, Colorado, $355 per year to heat, cool & make 100% of the domestic hot water – forced air, water-air/water HP, retrofit of 25+ year old home
- Each of these examples use separate power meters to monitor the electricity consumed for the GSHP system

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Heat Pumps – Mechanical System Comparisons

Example analysis – 70,000 ft² assisted living facility:

Annual Costs ($)

	Geothermal	Air-cooled Chiller / Boiler	Savings
Total Power:	11,960.56	27,032.18	15,071.62
CO2 Emissions:	1.14	2.53	1.39
CO2 (tons):	*114.0*	*253.0*	*139.0*
Water:	0.00	1,295.45	1,295.45
Water (Gallons):	*0.0*	*518,181.0*	*518,181.0*
Maintenance:	5,600.00	31,500.00	25,900.00
Mechanical Room Lease:	0.00	3,125.00	1,875.00
TOTAL:	**18,811.70**	**62,955.16**	**44,143.46**

A "professional" energy evaluation service predicted the GSHP system would cost double the conventional system operating cost, yet later admitted they did not understand how to model the GSHP option on their eQuest software; consider also that the client paid a substantial amount for this evaluation. Client compared the conventional operating cost with a similar sized building with equivalent use/occupancy and confirmed our estimate to be more accurate.

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Heat Pumps – Mechanical System Comparisons

Example analysis – 70,000 ft² assisted living facility:

NPV Lifecycle Costs ($) - 25 years

	Geothermal	Air-cooled Chiller / Boiler	Savings
Total Power:	269,402.02	608,877.95	339,475.93
CO2 Emissions:	19.15	42.66	23.51
CO2 (tons):	*2,850.0*	*6,325.0*	*3,475.0*
Water:	0.00	32,386.31	32,386.31
Water (Gallons):	*0.0*	*12,954,525.0*	*12,954,525.0*
Maintenance:	94,398.31	530,990.51	436,592.20
Mechanical Room Lease:	21,071.05	52,677.63	31,606.58
Installation:	1,280,000.00	1,835,000.00	555,000.00
Tax Incentives:	0.00	0.00	0.00
Salvage:	0.00	(1,638.51)	(1,638.51)
TOTAL:	**1,664,890.54**	**3,058,336.56**	**1,393,446.02**

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GSHP –Commercial Applications – Costing

- Typical operating cost ranges, commercial closed loop systems
  - $0.15 to $0.50 per ft² per year operating cost
  - $0.05 to $0.15 per ft² per year maintenance
- Typical installation (1st cost) ranges, commercial
  - $15 to $20 per ft², 2-pipe system, packaged heat pumps, with ground loop
  - $18 to $25 per ft², 4-pipe system with hydronic fan coils, central water-water heat pumps, with ground loop
- These install costs are often within the same ranges as conventional mechanical applications. GSHP systems may be competitive on a 1st cost basis for larger commercial applications!

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Heat Pumps: Commercial Example, Retrofit

Example – Hirschfeld Towers, Denver Housing Authority

- Originally built in 1960's, remodeled in 2008
- DHA architect wanted **no** external mechanical equipment
  - Neighbors complained for 20+ years about condenser noise
- Original system very high maintenance (low bid design, low bid installation – highest operating and service cost after employee overhead!)
- Pre-modeling determined that 100% loop driven system would be a wash with loop+combined chiller hybrid; hybrid system also added back more maintenance, op. cost, controls and infrastructure (ESCO wanted this option but was reminded by client that outside equipment was unacceptable!)
- Optimum system – decoupled GSHP design

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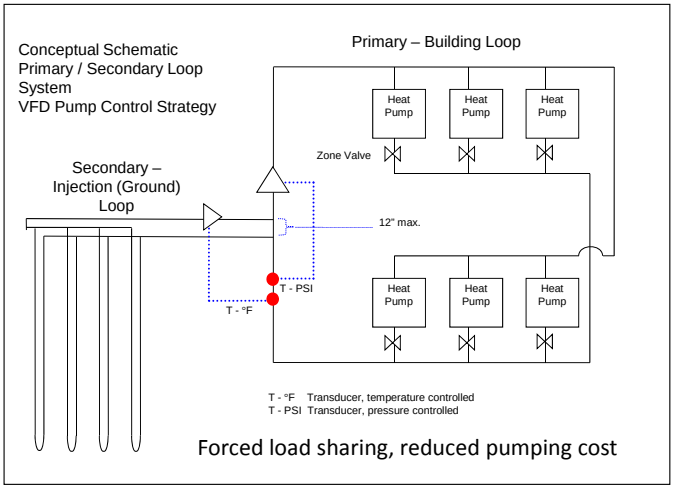
Heat Pumps: Commercial Example, Retrofit

Example of de-coupled configuration, forced load sharing



Forced load sharing, reduced pumping cost

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Heat Pumps: Commercial Example, Retrofit

Hirschfeld Towers, Denver, CO
140,000 ft², 9 stories

110 tons
Vertical loop
81 boreholes x 450' depth

- Client estimates operating cost cut by half
- Maintenance reduced by over 75%
- Ground loop injection only active about 55% of time annually due to forced load sharing
- Noise complaints from neighbors eliminated!

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Types of GSHP Systems – Applications

- Water-to-Air
  - Forced air space heating and cooling
- Water-to-Water
  - Forced air heating & cooling using hydronic fan coils
  - Radiant floor heat, baseboard, radiators
  - Domestic hot water
  - Process water conditioning
  - Specialized – ice sheet conditioning, thermal energy storage, other
- Direct Exchange
  - DX-to-Air
  - DX-to-Water

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Types of GSHP Systems – Water-Air Packaged

Ground Source Heat Pumps
Sizes and configurations for every application


Upflow & Downflow Packaged

Water-to-Water

Outdoor Split

Indoor Split

Horizontal Packaged

Console

Commercial Roof Top

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Typical commercial configurations

Vertical ground heat exchanger

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GSHP Systems – Fundamental of Commercial Applications

Typical commercial configurations

Horizontal ground heat exchanger

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Typical commercial configurations

Surface water ground heat exchanger

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GSHP Systems – Fundamental of Commercial Applications

Typical commercial configurations

Open loop ground heat exchanger

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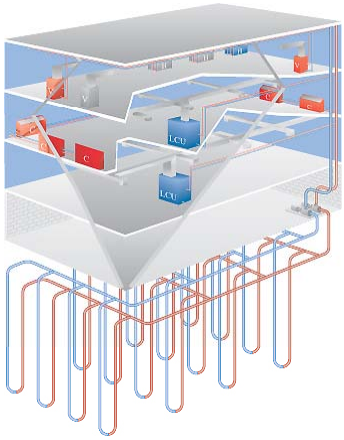
GSHP Systems – Fundamental of Commercial Applications

Typical commercial configurations



Ground heat exchanger under building footprint

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GSHP Systems – Design Methodology

- GSHP Systems require the following determinations for sizing:
  - Load calculations for the application – how much energy is required for heating and cooling to meet setpoint
  - Match the HP equipment to the load and application specifics
  - Ground loop
    - Closed loop – sufficient closed loop heat exchanger design
    - Open loop – sufficient water flow rate to meet HP and load requirements

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- Note: Closed loop ground heat exchangers require that the ground loop have sufficient capacity to maintain a specific range of EWT to the equipment to operate indefinitely – they cannot be treated as an unlimited pipeline of energy
- Most closed loop systems are designed to feed GSHP equipment with an EWT range from 30°F to 90°F, although most equipment will tolerate extreme EWT ranges of 20°F to 120°F if sufficient fluid flow is maintained
- Closed loop design require calculations involving loads, equipment performance and knowledge of the host geology
- **One size does not fit all – *rule of thumb methods cannot be used for the design of these systems!***

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- Load Calculations – Residential
  - Usually a load that is driven by climate
  - Peak heat loss and heat gain are typically sufficient
  - Load durations for ground loop calculations are determined by seasonal durations
- Load Calculations – Commercial
  - Typically defined as internally driven
    - For example, most commercial buildings and schools are cooling dominated, even in winter
  - Requires a monthly energy load calculation

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Residential load output example

Room Name	Area Sq. Ft.	Htg Btuh	Sens. Clg Btuh	Tot. Clg. Btuh	CFM Req.
1 MASTER BATH	223	5,631	2,129	2,129	113
2 GUEST BED	284	4,388	1,420	1,420	88
3 GUEST BATH	89	1,370	323	323	27
4 GARAGE ENTRY	157	1,871	570	570	37
5 FOYER	94	5,875	2,219	2,219	118
6 OFFICE	336	5,030	1,753	1,753	101
7 KITCHEN	380	4,691	1,264	1,264	94
8 LIVING ROOM	352	13,794	6,003	6,003	276
9 DINNING ROOM	200	7,814	3,436	3,436	156
10 MASTER BED	310	5,835	2,061	2,061	117
11 BONUS ROOM	420	4,452	1,236	1,236	89
12	0	0	0	0	0
13	0	0	0	0	0
14	0	0	0	0	0
15	0	0	0	0	0
16	0	0	0	0	0
17	0	0	0	0	0
18	0	0	0	0	0
19	0	0	0	0	0
20	0	0	0	0	0
Entire House	2,845	60,752	22,413	22,413	1,215
Ventilation Air		0	0	0	
RSM Adjustment			0	0	
Totals	2,845	60,752	22,413	22,413	1,215

Peak loads, design conditions

ClimateMaster, Inc. GeoDesigner® 2/12/2010 Sheridan-Slinky Pit Page 4

Temperature Bin Analysis

TT 072 Vspd / Slinky Horz - 8 ft/ft trench 0.75"

Outdoor Air Temp	Annual Weather Hours	Space Load Btu/Hr	Hot Water Load Btu/Hr	Geo Source Temp	Htg - Clg Capacity Btu/Hr	H.W. Gen Capacity Btu/Hr	Geo Run Time	Geo Operating Cost	Aux Heating Cost	Aux Hot Water Cost
112										
107										
102										
97										
92	3	29,201	2,217	57	60,784	3,217	48%	$0.32		$0.13
87	51	23,544	2,217	54	61,407	2,874	38%	$4.30		$3.75
82	204	17,888	2,217	52	62,030	2,531	29%	$12.65		$20.01
77	301	12,231	2,217	49	62,654	2,188	20%	$12.34		$35.53
72	393	9,989	2,217	48	62,904	2,051	16%			$49.04
67	508		2,217							$74.28
62	637		2,217							$93.14
57	656	-850	2,217	45	45,640	4,761	2%	$4.07		$92.08
52	619	-5,011	2,217	46	46,548	4,811	11%	$22.10		$89.36
47	602	-9,172	2,217	45	45,668	4,762	20%	$39.60		$50.05
42	662	-13,333	2,217	44	44,792	4,713	30%	$63.74		$35.54
37	765	-17,494	2,217	42	43,919	4,665	40%	$97.31		$18.11
32	853	-21,656	2,217	41	43,268	4,429	50%	$134.65		
27	753	-25,817	2,217	40	43,159	3,706	60%	$140.34		
22	640	-29,978	2,217	39	42,878	3,171	70%	$137.74		
17	488	-34,139	2,217	38	42,478	2,769	80%	$111.92		
12	288	-38,300	2,217	37	41,998	2,431	91%	$78.87		
7	171	-42,461	2,217	36	42,461	2,217	100%	$51.81		
2	103	-46,622	2,217	35	46,622	2,217	100%	$33.99		
-3	49	-50,783	2,217	34	50,783	2,217	100%	$17.50		
-8	26	-54,944	2,217	33	53,869	2,217	100%	$9.82	$0.57	
-13	12	-59,105	2,217	33	53,869	2,217	100%	$4.53	$1.29	
-18	5	-63,267	2,217	33	53,869	2,217	100%	$1.89	$0.96	
-23	1	-67,428	2,217	33	53,869	2,217	100%		$0.26	
-28										
-33										
	8760							$980	$3	$541

Load durations are calculated based upon peak loads against climate bin data

GSHP Systems – Fundamental of Commercial Applications

GSHP Systems – Design Methodology, Commercial

- Common mistakes with commercial "design" efforts
  - Operating and LCA calculations completed by people with no design experience, no competence with defining or identifying variables
  - Loop design completed by asking looping contractor how many holes will be needed (looping contractor responds with hard number without even asking for the loads, equipment flow rate, etc.)
  - Number of circuits and depth based on rule of thumb "design"; ie, one hole per ton….
  - Run TC test without knowing anything about the building (loads, equipment) or consideration of drilling parameters (depth, pipe size)
- A ground loop is a ***key*** part of the mechanical system – ***budgeting, evaluation, design and testing efforts are the last things that should be based on rule-of-thumb assumptions and guess-work by unqualified assets!***

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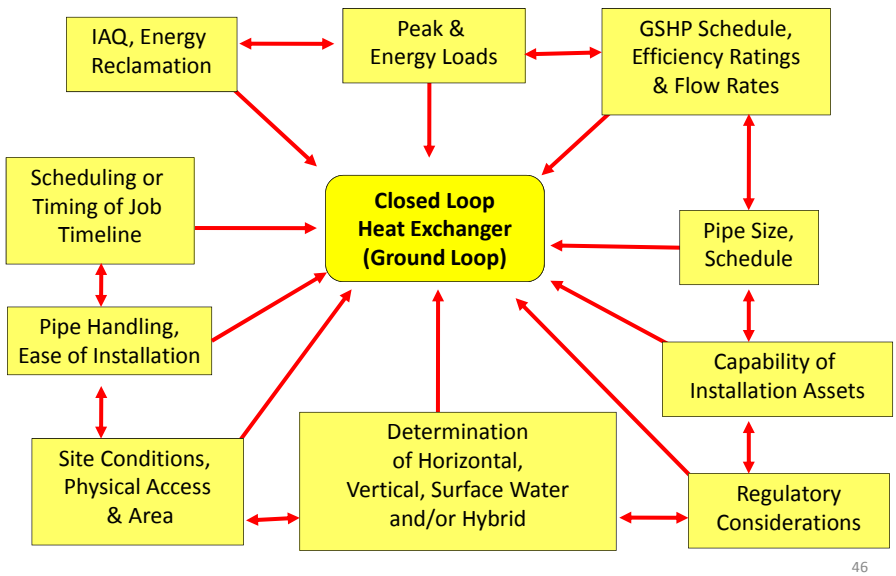
GSHP Systems – Fundamental of Commercial Applications

GSHP Systems – Design Methodology, Commercial - Considerations



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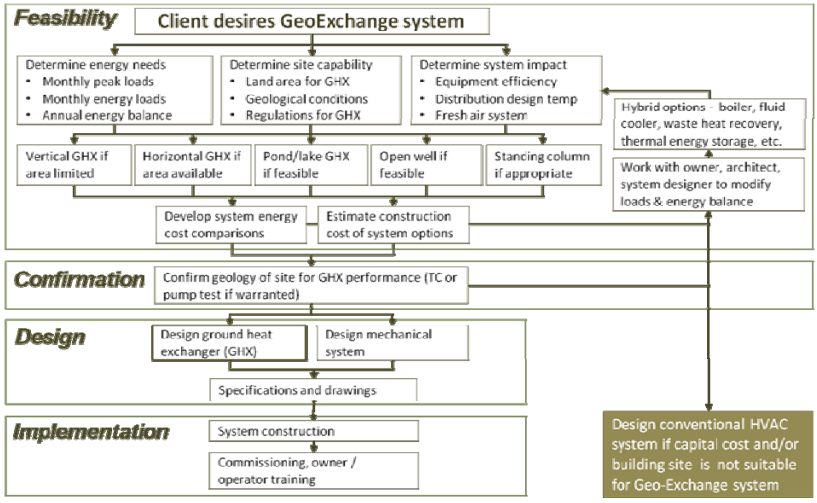

Commercial load output example

	TOTAL COOLING	PEAK COOLING	TOTAL HEATING	PEAK HEATING	Monthly Load Factor	
	mbtu	mbtuh	mbtu	mbtuh	Cooling	Heating
January	91620	975.7	60001	876.5	0.13	0.09
February	81846	1005.9	60016	901.6	0.12	0.10
March	133518	1528.4	25908	629.0	0.12	0.06
April	160963	1906.2	7293	253.5	0.12	0.04
May	377044	2735.0	29	0.7	0.19	0.06
June	295396	3171.9	0	0.0	0.13	0.00
July	333676	3322.8	0	0.0	0.13	0.00
August	284150	3136.2	4	0.2	0.12	0.03
September	353318	2818.3	30	0.9	0.17	0.05
October	191111	2029.9	6502	278.4	0.13	0.03
November	141033	1709.1	16273	525.1	0.11	0.04
December	97041	1001.8	36753	721.1	0.13	0.07

Delaware School for the Deaf, 110,000 ft², Newark, Delaware

- Heat Pump Selection
- Must be sized to meet peak heating and cooling load of the application
- Load performance is balanced between Delivery variables of the system (ducting, radiant tubing, controls, other)
- Water flow rate
- EWT range

Example performance sheet cut, nominal 5.0 ton GSHP

1825 CFM Nominal (Rated) Airflow Cooling, 2050 CFM Nominal (Rated) Airflow Heating — Performance capacities shown in thousands of Btuh

EWT °F	GPM	WPD		Cooling - EAT 80/67°F							Heating - EAT 70°F						
		PSI	FT	Airflow CFM	TC	SC	kW	HR	EER	HWC	Airflow CFM	HC	kW	HE	LAT	COP	HWC
20	15.0	5.0	11.6	Operation not recommended							1750	41.0	3.87	28.3	91.7	3.10	4.0
	15.0	5.0	11.6								2050	41.8	3.71	29.2	88.9	3.30	3.5
30	7.5	0.6	1.5	1580	65.8	41.6	2.78	75.1	23.7	-	1750	44.6	3.96	31.5	93.6	3.29	4.1
	7.5	0.6	1.5	1825	67.3	45.6	2.90	77.2	23.2	-	2050	45.4	3.8	32.6	90.5	3.50	3.6
	11.3	2.3	5.3	1580	66.7	42.1	2.65	75.7	25.2	-	1750	46.4	4.01	33.1	94.6	3.39	4.1
	11.3	2.3	5.3	1825	68.3	46.2	2.77	77.8	24.7	-	2050	47.3	3.85	34.3	91.4	3.60	3.5
	15.0	4.8	11	1580	68.1	42.9	2.60	76.8	26.2	-	1750	47.4	4.04	34.0	95.1	3.44	4.0
	15.0	4.8	11	1825	69.7	47.1	2.71	78.9	25.7	-	2050	48.3	3.88	35.2	91.8	3.65	3.5
90	7.5	0.2	0.4	1825	57.5	43.9	4.99	74.6	11.5	6.6	2050	84.7	4.88	68.1	108.3	5.09	5.6
	11.3	1.9	4.3	1580	58.7	41.0	4.46	73.9	13.2	5.5	1750	87.8	5.24	70.0	116.5	4.91	6.4
	11.3	1.9	4.3	1825	60.0	44.9	4.65	75.9	12.9	5.6	2050	89.5	5.02	72.4	110.4	5.22	5.5
	15.0	3.5	8.0	1580	59.9	41.4	4.31	74.6	13.9	4.6	1750	90.5	5.32	72.3	117.9	4.98	6.3
	15.0	3.5	8.0	1825	61.3	45.4	4.49	76.6	13.6	4.6	2050	92.2	5.10	74.8	111.7	5.30	5.4
100	7.5	0.1	0.3	1580	52.4	38.6	5.32	70.7	9.8	8.0	Operation not recommended						
	7.5	0.1	0.3	1825	53.6	42.3	5.55	72.6	9.7	8.2							
	11.3	1.8	4.2	1580	54.9	39.6	4.96	71.9	11.1	6.8							
	11.3	1.8	4.2	1825	56.2	43.4	5.18	73.9	10.9	6.9							
	15.0	3.3	7.6	1580	56.1	40.1	4.79	72.5	11.7	5.6							
	15.0	3.3	7.6	1825	57.5	43.9	5.00	74.6	11.5	5.7							
110	7.5	0.1	0.2	1580	48.6	37.1	5.95	69.0	8.2	9.7							
	7.5	0.1	0.2	1825	49.7	40.7	6.21	71.0	8.0	9.9							
	11.3	1.8	4.0	1580	51.0	38.1	5.54	70.0	9.2	8.2							
	11.3	1.8	4.0	1825	52.2	41.7	5.78	72.0	9.0	8.4							
	15.0	3.1	7.2	1580	52.2	38.6	5.34	70.6	9.8	6.7							
	15.0	3.1	7.2	1825	53.5	42.3	5.58	72.5	9.6	6.9							
120	7.5	0.1	0.1	1580	44.9	35.7	6.67	67.9	6.7	11.5							
	7.5	0.1	0.1	1825	46.0	39.2	6.97	69.8	6.6	11.7							
	11.3	1.7	3.9	1580	47.1	36.6	6.21	68.5	7.6	9.8							
	11.3	1.7	3.9	1825	48.3	40.1	6.48	70.5	7.4	9.9							
	15.0	2.9	6.8	1580	48.3	37.0	5.99	69.0	8.1	8.0							
	15.0	2.9	6.8	1825	49.5	40.6	6.25	70.9	7.9	8.1							

Closed Loop Design

- Starts with understanding the site and system requirements
- Load calculations, HP equipment schedule
- Required flow rate of the HP equipment
  - Number and size of circuits is a balance between flow resistance (pressure drop) and turbulence (Reynolds #)
  - The Reynolds number is significant for heat transfer for heating dominated loads
  - Pressure drop and Reynolds # are directly effected by temperature and fluid type – pure water, water with antifreeze (type and %)
- The length of the ground loop circuits is determined by:
  - Load duration
  - Thermal performance of the geology that the loop is installed in. Three key values are required to determine thermal performance:
    - Undisturbed temperature - °F
    - Thermal conductivity – Btuh/ft/°F
    - Diffusivity – ft^2/day
- Thermal conductivity test **IS** **NOT** done until pre-design effort is complete to select best test parameters
- Final design once all variables are accounted for

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GSHP Systems – Fundamental of Commercial Applications
GSHP Systems – Design Methodology, Commercial

Open Loop Design

- Starts with the required flow rate of the HP equipment
  - Water source must meet the minimum equipment flow rates
  - An open loop system design assumes a relatively constant water temperature
- Requires that the water be returned to the source aquifer in most cases
  - Most states and provinces have strict regulations for the implementation of these types of heat exchangers
  - Some jurisdictions permit the water to be returned to streams or lakes

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GSHP Systems – Fundamental of Commercial Applications

GSHP Systems – Execution

Drilling*

Pipe Loop Insertion

Fusing Piping

Loops Ready for Unit

Installed Heat Pump

* or horizontal, surface water

GSHP Systems – Fundamental of Commercial Applications

GSHP Systems – Execution

Do you know what contractor resources are available?

Sometimes a horizontal loop can be installed – *fast!*
- 600+ hp Super Witch IV
- 6' deep trench @ 20+ mph

- Introduction – history of GSHP technology and how it works
- Types of heat pumps, efficiency
- Heat pump and loop configurations, residential and commercial
- Design methodology
- Quality control
- Rocky Mountain examples

As the primary representative of the Client, insist on quality control of the loop and mechanical installation!

Contaminated header lines – Imagine what else might be in the rest of the ground loop!

Pin flags marking borehole locations being "relocated" by driller's pet lab – improper and unauthorized redesign!

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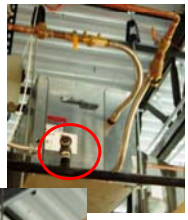
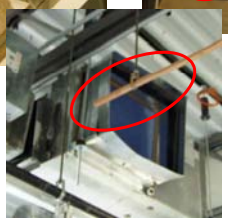
Pressure/temperature ports critical for testing, service efforts – they must remain accessible!





Maintain service clearances for air filters, control boards, large component change outs and Functional Performance Testing

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GSHP Systems – Fundamental of Commercial Applications

GSHP Systems – Quality Control

Completion of your project - consider functional performance testing (FPT) of the heat pump system:

- Confirms system is operating as designed and as per equipment manufacturer's specs
- May be a warranty requirement!
- Establishes a service baseline
- Often reveals 'hiccups' that could become **issues** with the client!
- Eliminates conflicts and finger pointing between design team and contractors!

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GSHP Systems – Fundamental of Commercial Applications

Heat Pumps – Outline

- Introduction – history of GSHP technology and how it works
- Types of heat pumps, efficiency
- Heat pump and loop configurations, residential and commercial
- Design methodology
- Quality control
- Rocky Mountain examples

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GSHP Systems – Fundamental of Commercial Applications

GSHP System Example Installations – Colorado

Schools:

- CSSD #11 – Colorado Springs area
- D38 – Colorado Springs area
- Fountain-Ft. Carson
- Denver Public Schools
- Aurora
- Mesa State College
- Fort Collins
- Canon City
- Mosca
- Pueblo
- Calhan
- Rangely
- Oak Creek
- Yampa
- Weld County
- Animas
- Fleming
- Monte Vista
- Other……

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GSHP Systems – Fundamental of Commercial Applications

GSHP System Example Installations – Colorado

Military installations in Colorado:

- Fort Carson Army Base (5..?)
- Buckley Air Force Base (3..?)
- USAF Academy (2..?)
- National Guard (Ft. Lupton, Alamosa)
- Colorado VA (Monte Vista)
- Other…..

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GSHP Systems – Fundamental of Commercial Applications

GSHP System Example Installations – Colorado

Other commercial in Colorado:

- Lakewood FD (4 installations current)
- Arvada FD (1 installation pending)
- United Power (Brighton)
- Windsor PD
- Pikes Peak Library District (Falcon)
- Mt. View Electric (Falcon)
- Salud Clinic (Ft. Morgan)
- Maple Leaf Medial Clinic (Pueblo West)
- Citizenship & Immigration (Centennial)
- National Renewal Laboratories (Golden)
- University Corporation for Atmospheric Research (Boulder)
- Doerr-Hosier Events Center, Aspen Institute (Aspen)
- Water Treatment Admin. Facility (Glenwood Springs)
- Observatory (Gunnison)
- Senior Recreation Facility (Brighton)

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GSHP Systems – Fundamental of Commercial Applications

GSHP System Example Installations – Colorado

Other commercial in Colorado:

- Water Treatment Admin. Facility (Aspen)
- Conoco/Wendys (Frisco)
- Auto Museum (Gateway)
- Homeless Shelter (Boulder)
- Salud Clinic (Commerce City)
- Hirschfeld Towers (Denver)
- Pioneer Museum (Hotchkiss)
- Holy Cross Lutheran Church (Wheat Ridge)
- Larimer County Waste Management (Ft. Collins)
- Water Treatment Admin. Facility (Rifle)
- M & M Ranch, Elk Processing Barn (Steamboat Springs)
- Green Mountain Events Center (Golden)
- Condominiums Complex (Snowmass Village)
- Golf Clubhouse (Snowmass Village)
- Western Dynamics (Golden)
- Paepke Center, Aspen Institute (Aspen)

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GSHP System Example Installations – Colorado

Other commercial in Colorado:

- Eureka Lodge (Silverton)
- Major Geothermal (Wheat Ridge)
- Housing Authority (Boulder)
- Midland Center (Glenwood Springs)
- Vitamin Cottage (Thornton)
- Art Museum (Carbondale)
- City Hall (Montrose)
- Bowling Alley (Nucla)
- Monkey House, Zoo (Pueblo)
- Ft. Lupton FD
- Candelas Community Center (Arvada)
- Swanbrat Professional Center (Littleton)
- Housing Authority (Loveland)
- Fairmont FD (Arvada)
- IKEA – 420,000 ft² (Centennial)
- Other…..

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GSHP Systems – Fundamental of Commercial Applications

GSHP System Example Installations – West Metro Fire Station #10, Lakewood, CO

Ground loop sited under driveway and landscaping

GSHP Systems – Fundamental of Commercial Applications

GSHP System Example Installations – Colorado Springs School District 11

Four schools
Two administration facilities

GSHP Systems – Fundamental of Commercial Applications

GSHP System Example Installations – Horizontal Loop Installations

Oak Creek School, CO

Fleming School, CO

Las Animas School, CO

GSHP Systems – Fundamental of Commercial Applications

GSHP System Example Installations – Pond Loop Installations

Scottsbluff, Nebraska

Aspen, Colorado

GSHP Systems – Fundamental of Commercial Applications

GSHP System Example Installations – Church Retrofit

Holy Cross
Lutheran Church
Wheat Ridge, CO

GSHP Systems – Fundamental of Commercial Applications

GSHP System Example Installations – Church Retrofit

Holy Cross Lutheran Church
Wheat Ridge, CO

GSHP Systems – Fundamental of Commercial Applications

GSHP System Example Installations – Church Retrofit

Conoco / Wendy's, Frisco, CO

40 tons water to water & water to air provides space conditioning, domestic hot water, snowmelt and radiant floor heating

Heat recovery to GHX from store refrigeration

54 x 400' vertical bores

Dual bay car wash

60 tons water to water heat pump

Snowmelt at vehicle entry and exit

Auxiliary gas boiler for snowmelt to account for unknown durations

Designed by Major Geothermal
Installed by Major Heating

GSHP Systems – Fundamental of Commercial Applications

GSHP System Example Installations – Wyoming

Greybull Elementary – Mechanical room under glass, LEED silver

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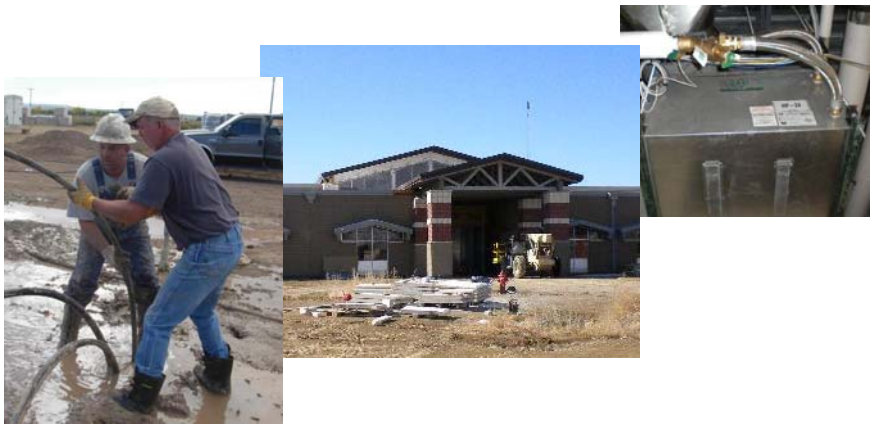
GSHP Systems – Fundamental of Commercial Applications

GSHP System Example Installations – Wyoming



Rocky Mountain High School – 72,000 ft²

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GSHP Systems – Fundamental of Commercial Applications

GSHP System Example Installations – Wyoming

Aspen Park Elementary School – 54,000 ft²

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GSHP Systems – Fundamental of Commercial Applications

GSHP System Example Installations – Wyoming

West Elementary School – 55,000 ft²

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GSHP Systems – Fundamental of Commercial Applications

GSHP System Example Installations – Wyoming

Joint Forces Readiness Center – 150,000 ft²

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GSHP Systems – Fundamental of Commercial Applications

GSHP System Example Installations – Wyoming

Nat'l Guard Aviation Support Facility – 92,000 ft²

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GSHP Systems – Fundamental of Commercial Applications

GSHP System Example Installations – Lake Loop Installation

Resort lodge, Manitoba, Canada

GSHP Systems – Fundamental of Commercial Applications

GSHP System Example Installations – Recreational Facilities

Port Hawkesbury Civic Centre, Port Hawkesbury, NS

265 tons
Horizontal loop

Courtesy of Practical GeoExchange Solutions

East Bayfield Recreation Centre, Barrie, ON

480 tons
Vertical loop

GSHP Systems
Fundamentals of Commercial Applications

January 20, 2011
Pikes Peak ASHRAE

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