Ground Source Heat Pumps in the Department of Defense

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GovEnergy

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Presentation Outline

- Technology Overview
- Discuss DOD GSHP Report to Congress
  - DOD current GSHP installations, what type and where
  - DOD GSHP economics
  - Recommendations for further implementing GSHPs at DOD facilities

Definition of ground-source heat pump

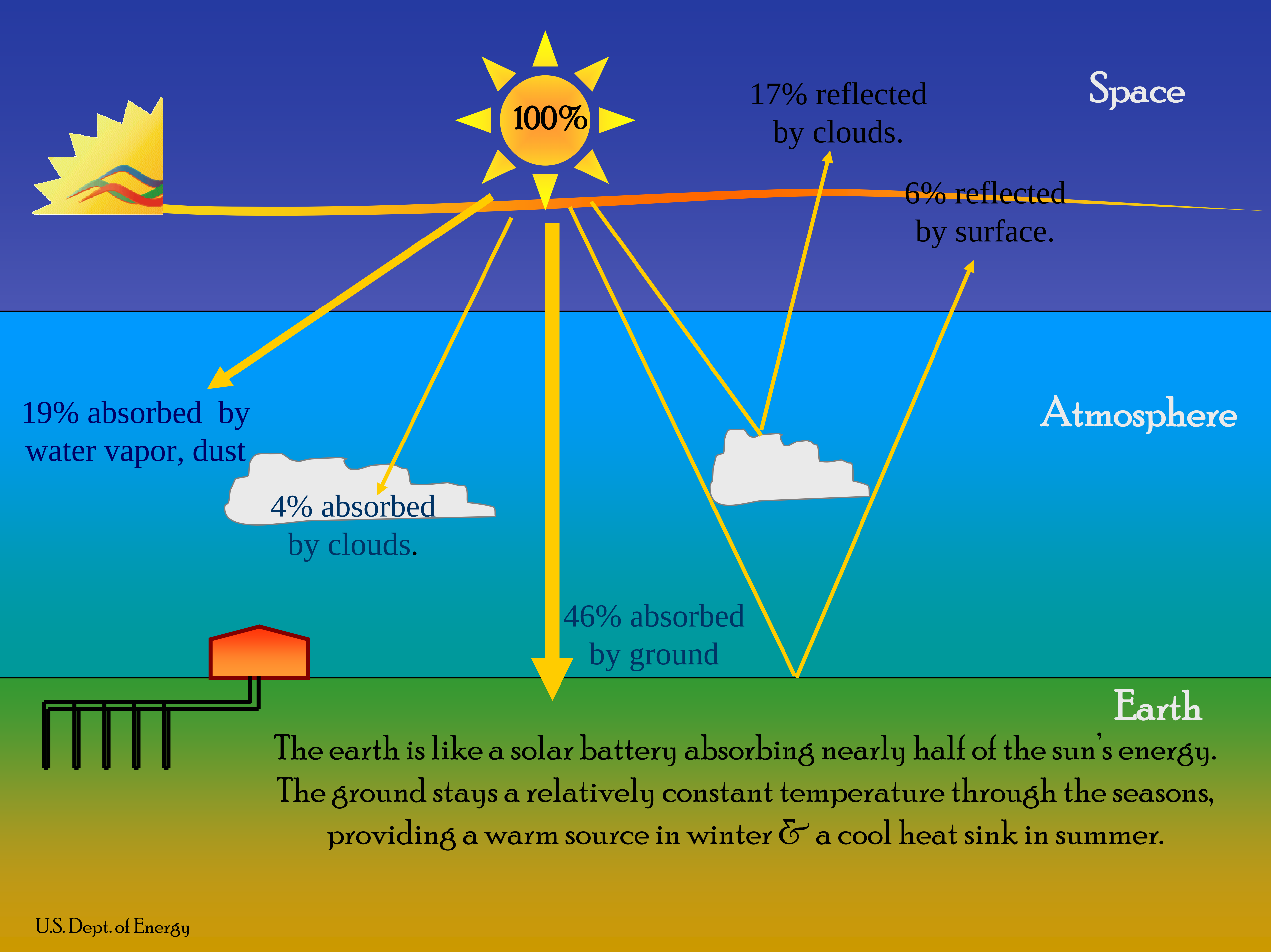
- A geothermal heat pump is a heat pump that uses the ground, groundwater, or surface water as a heat source and heat sink, as opposed to ambient air.

Same technology, different names

- Ground source heat pumps (GSHP)
- Ground coupled heat pumps (GCHP)
- Geothermal heat pumps (GHP)
- GeoExchange
- Earth energy systems

GSHP efficiency vs. traditional HVAC

- GHPs exchange heat with the earth, rather than with ambient air
- Earth provides a much better heat exchange medium
  - Stable year-round temperature
  - Generally cooler than ambient air when cooling is needed, and warmer than ambient air when heating is needed
- Water is a better heat transfer medium than air


100%
17% reflected by clouds.
Space
6% reflected by surface.
19% absorbed by water vapor, dust
Atmosphere
4% absorbed by clouds.
46% absorbed by ground
Earth
The earth is like a solar battery absorbing nearly half of the sun's energy.
The ground stays a relatively constant temperature through the seasons,
providing a warm source in winter & a cool heat sink in summer.
U.S. Dept. of Energy

Average Air Temperatures
Stillwater, OK USA

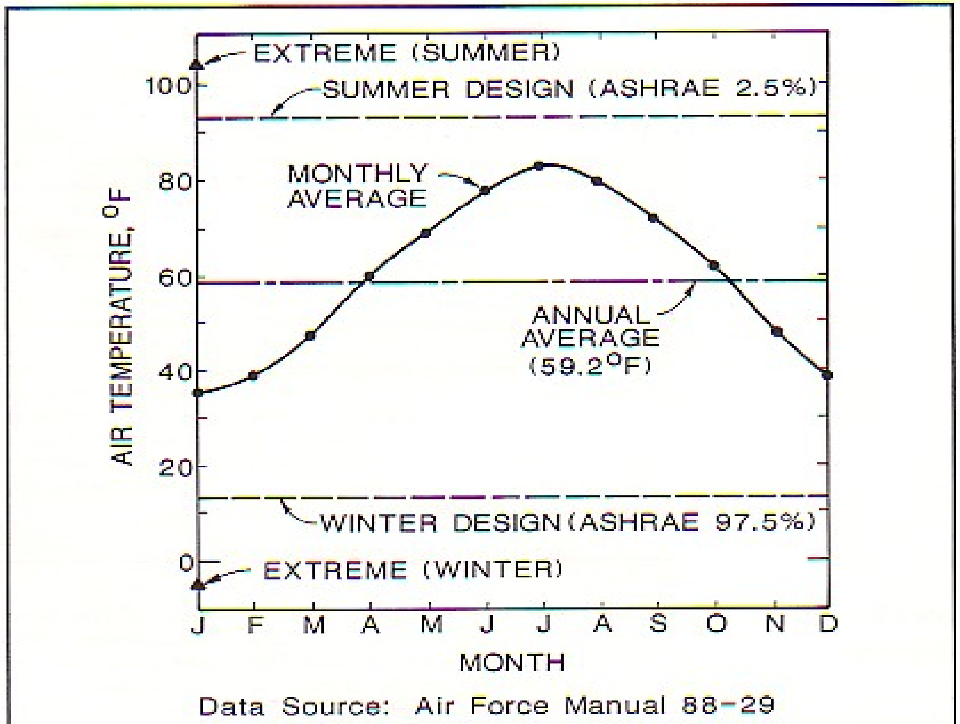


FIGURE 1.1: Annual Air Temperature Variation, Stillwater, Oklahoma

Annual Soil Temperature Variation Stillwater, OK USA

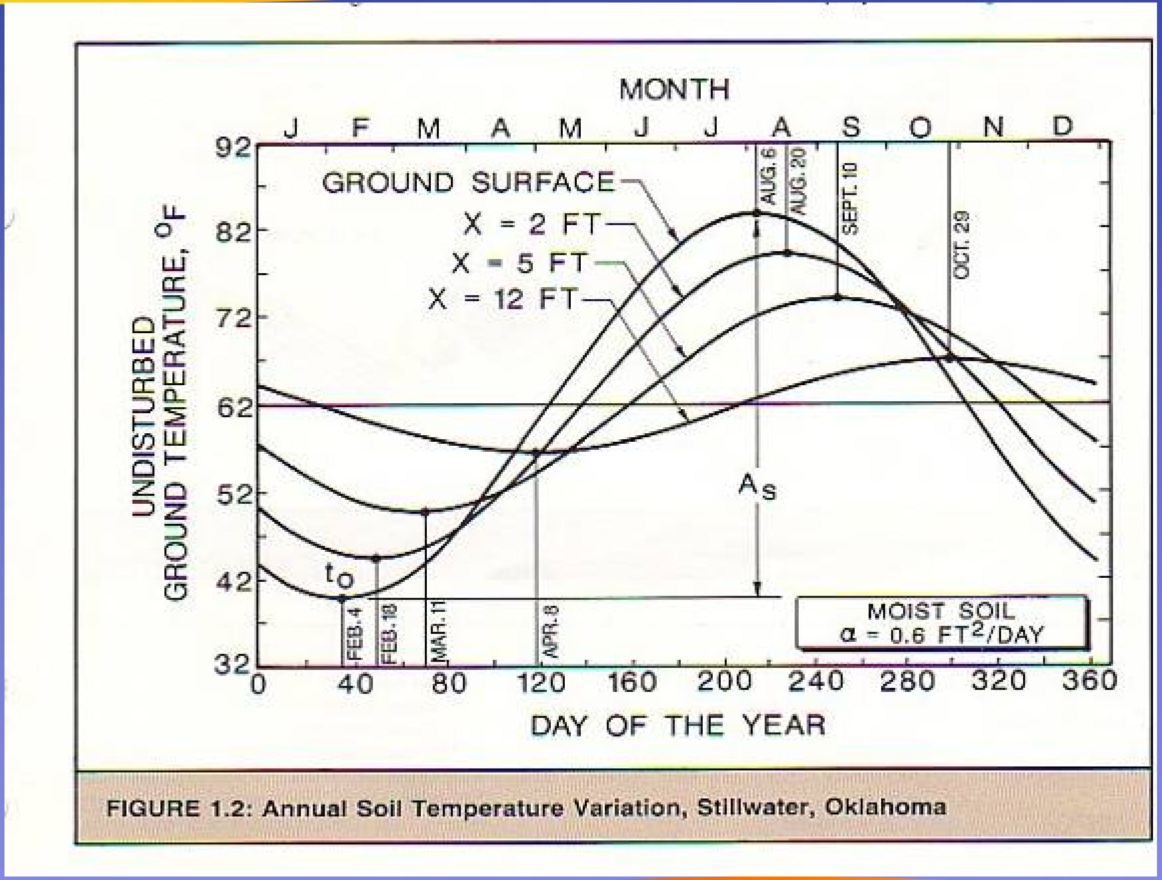
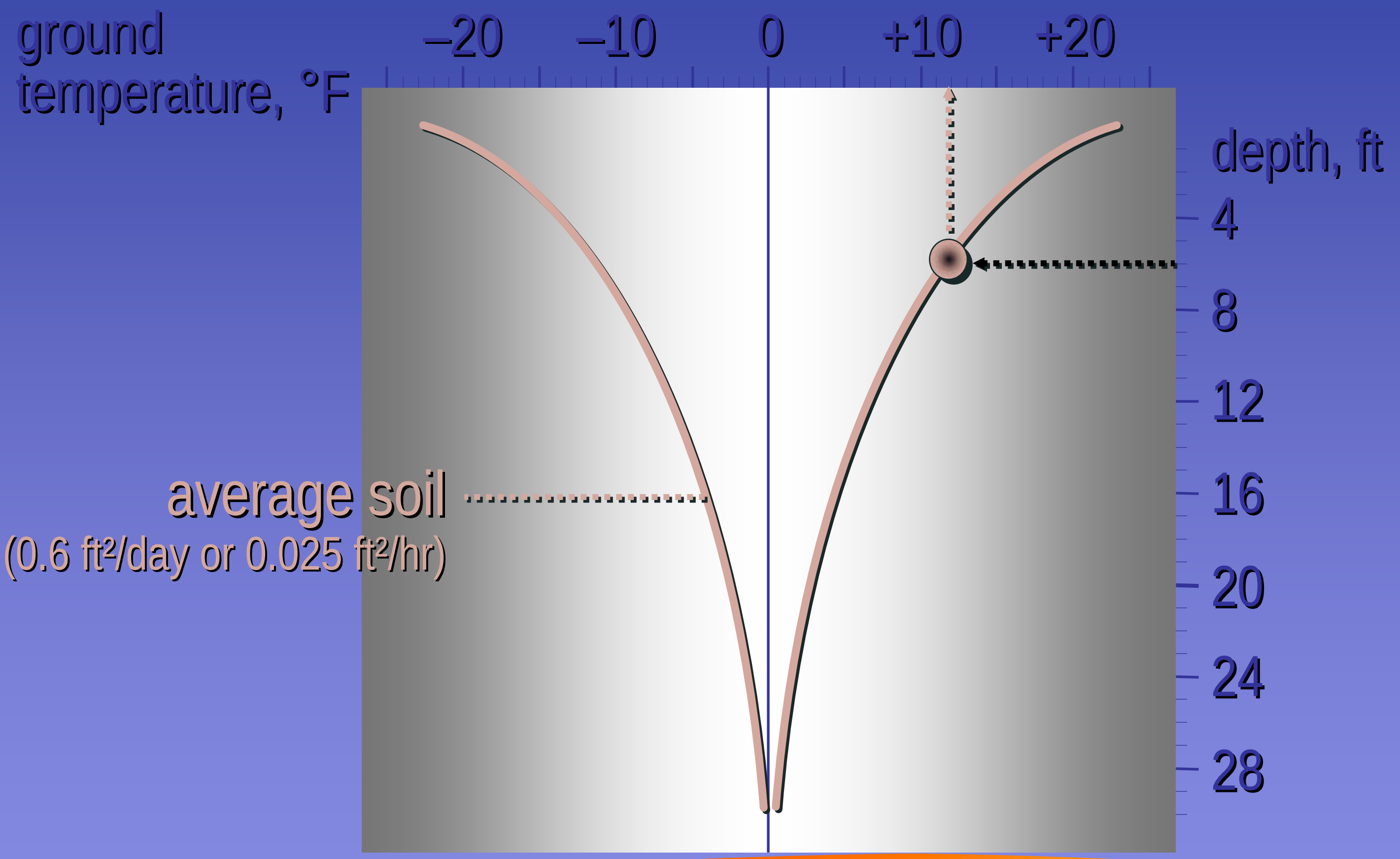
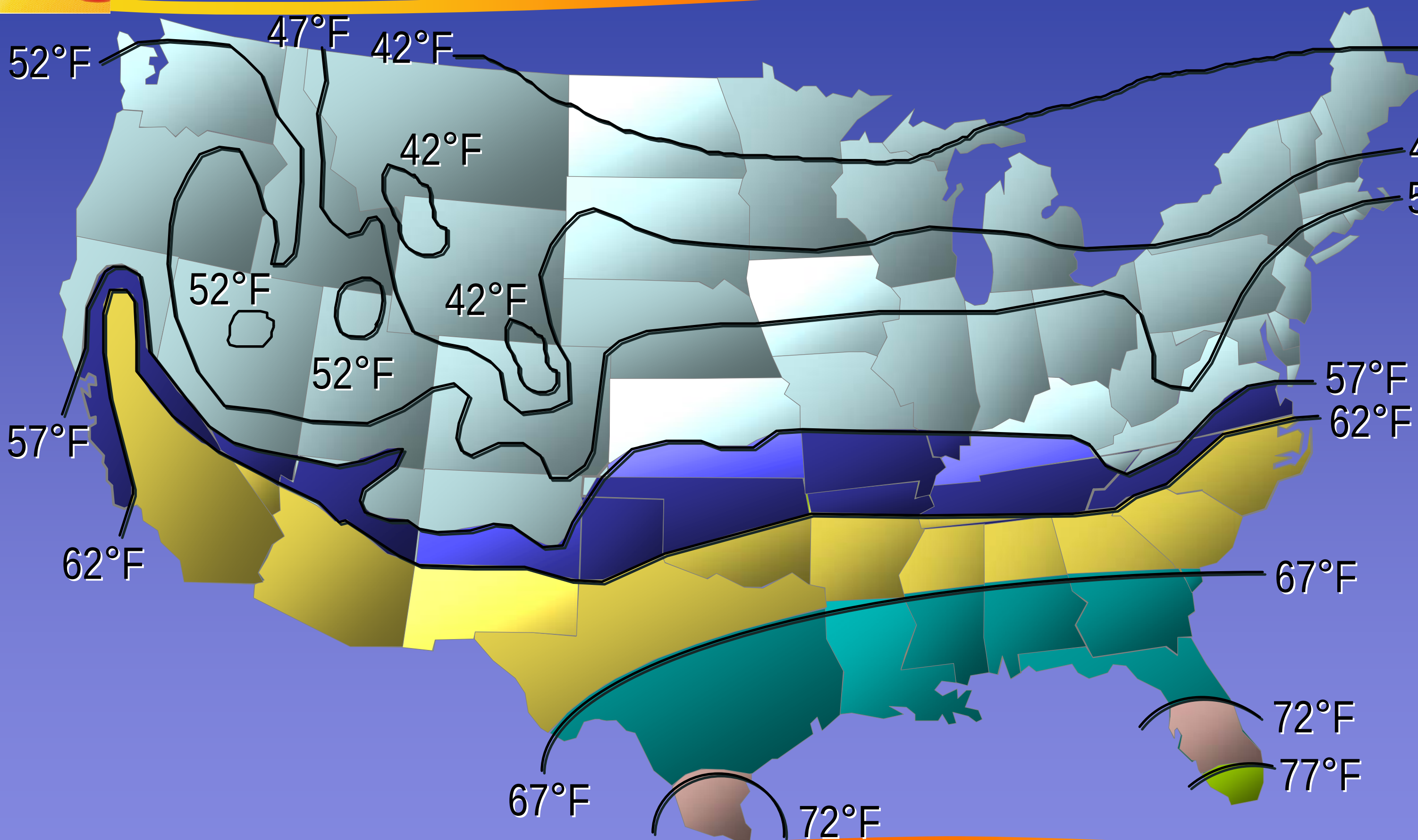


FIGURE 1.2: Annual Soil Temperature Variation, Stillwater, Oklahoma

Mean Temperature Variations

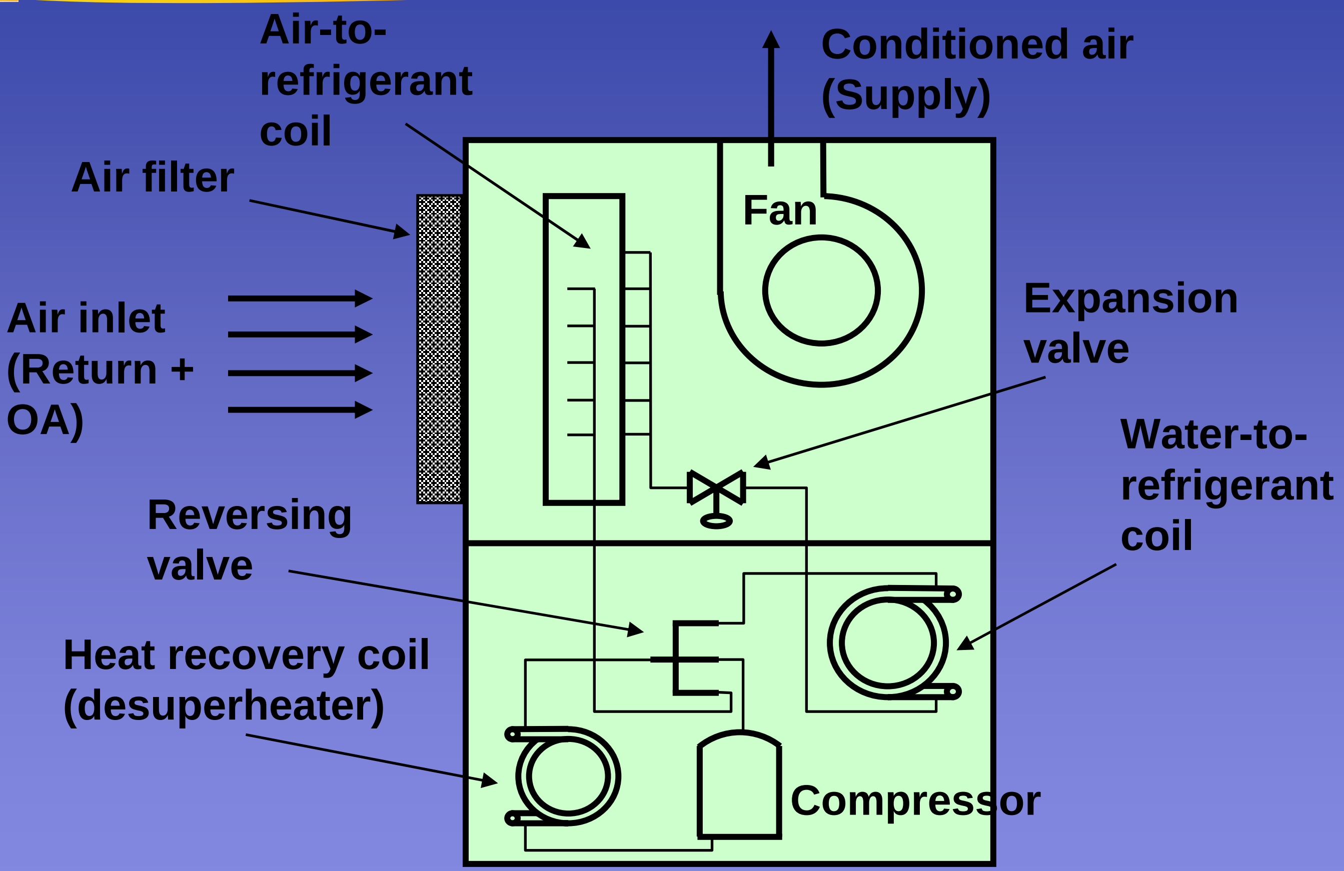


Ground Water Temperatures



At well depths
of 30 to 60 ft

Typical "Guts" of a GSHP



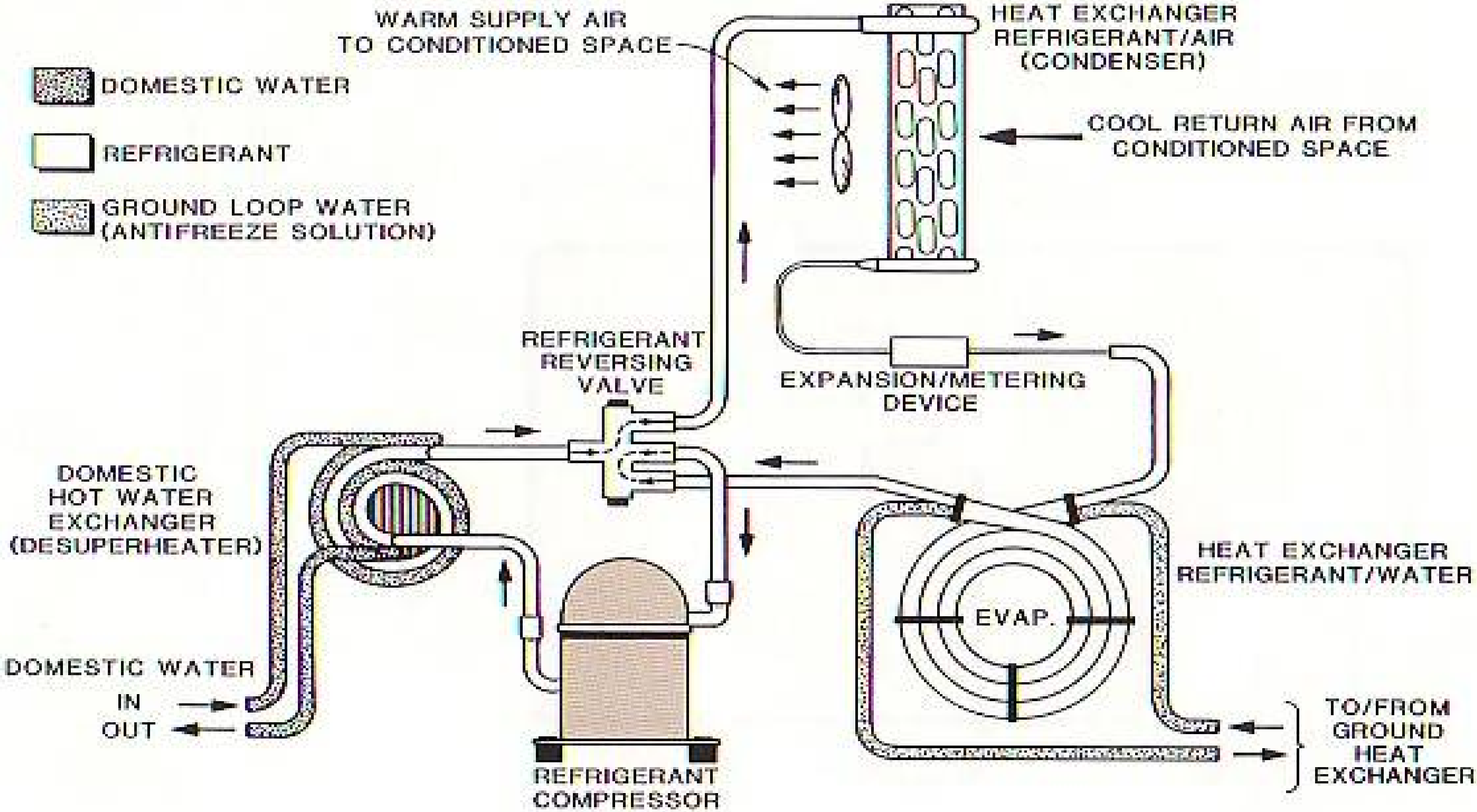


FIGURE 1.6: Heating Cycle

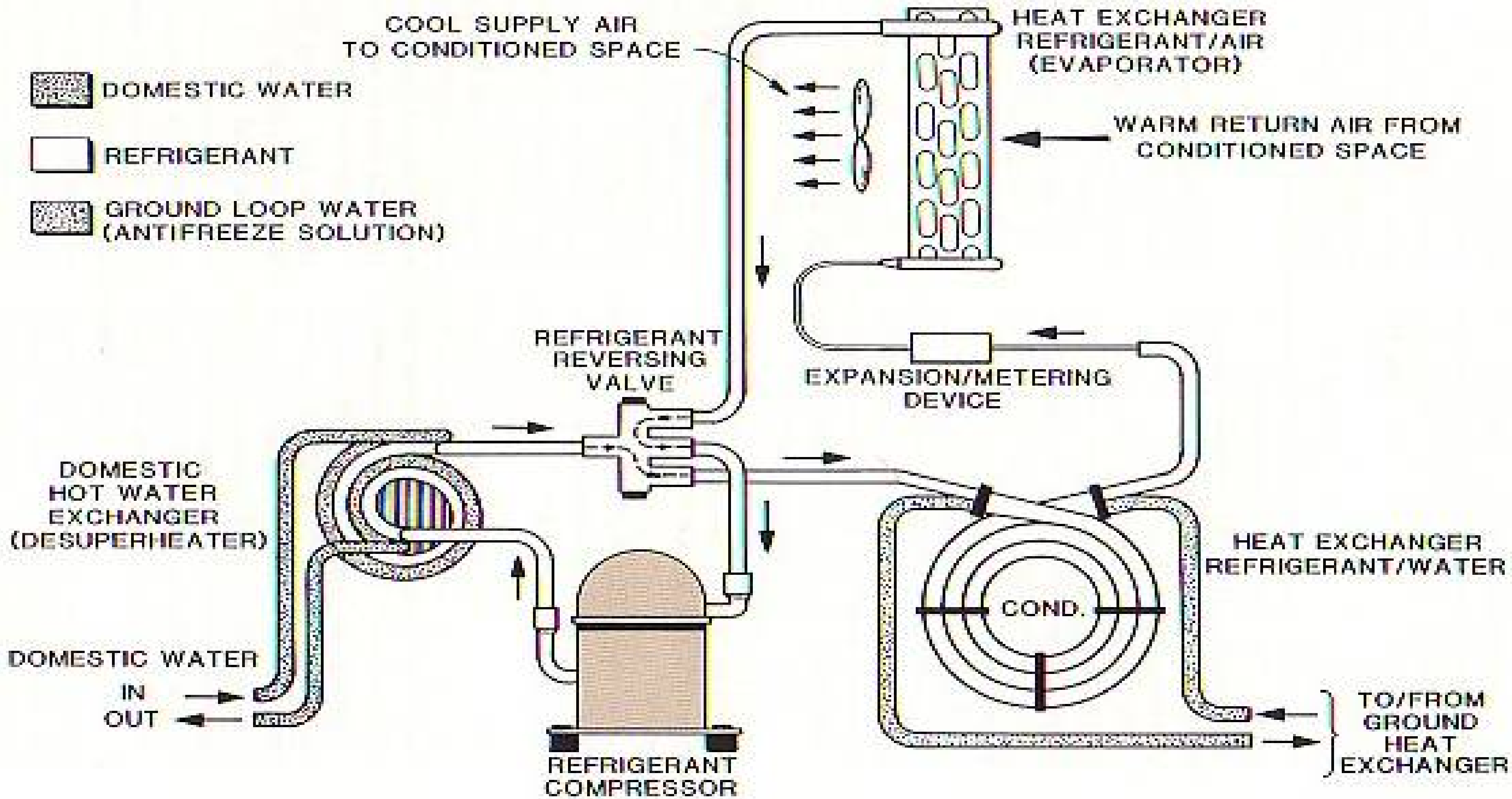
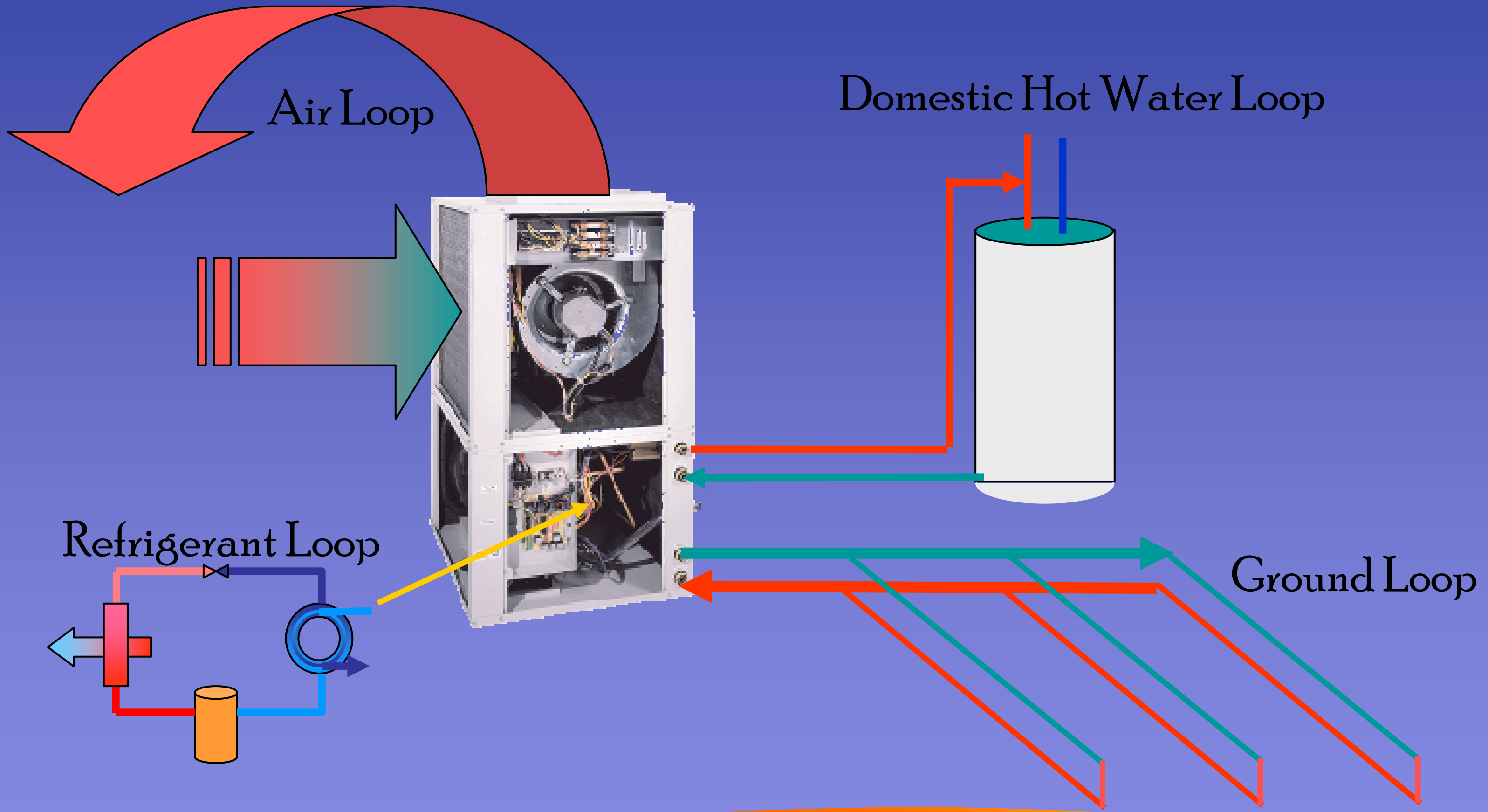
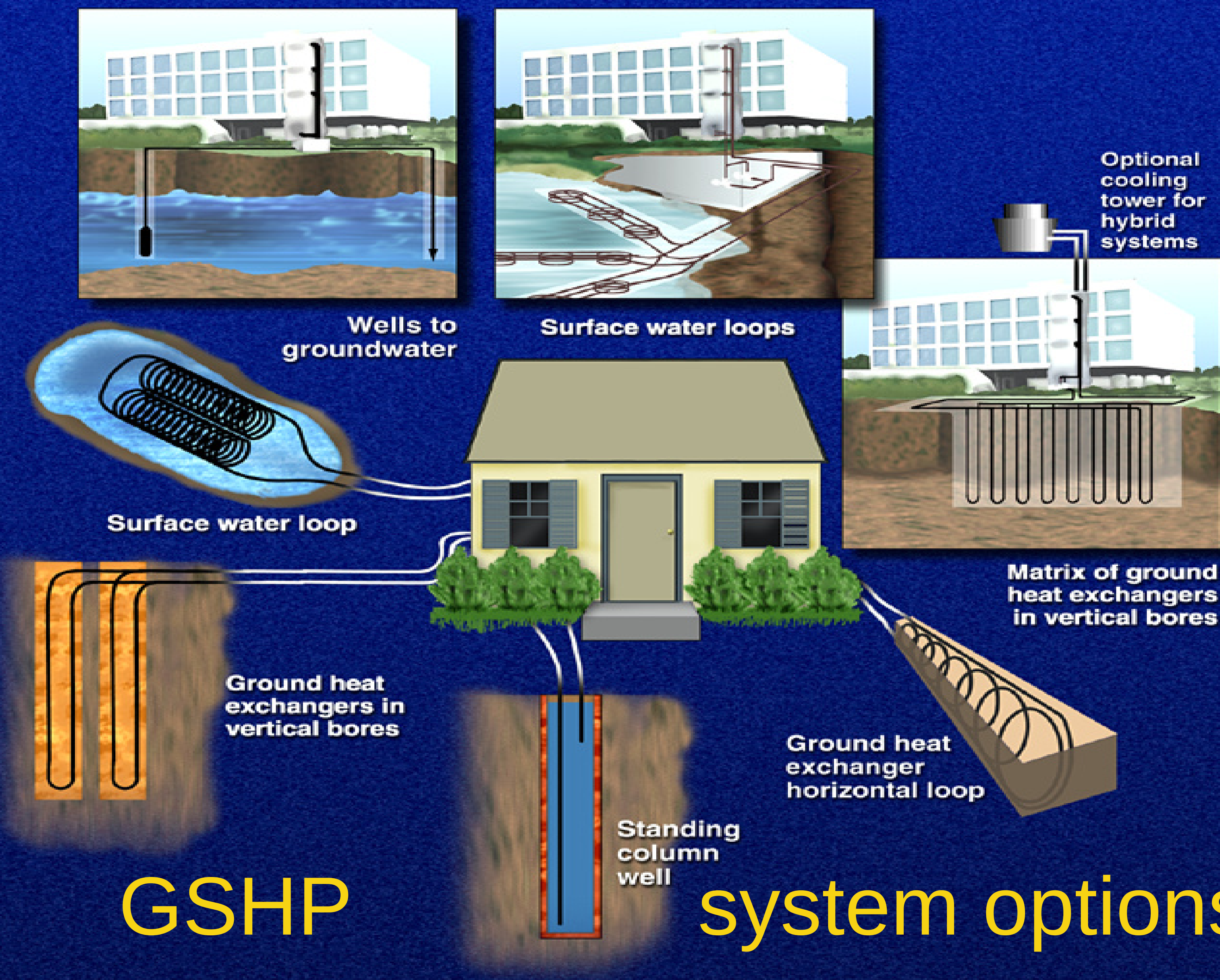


FIGURE 1.7: Cooling Cycle

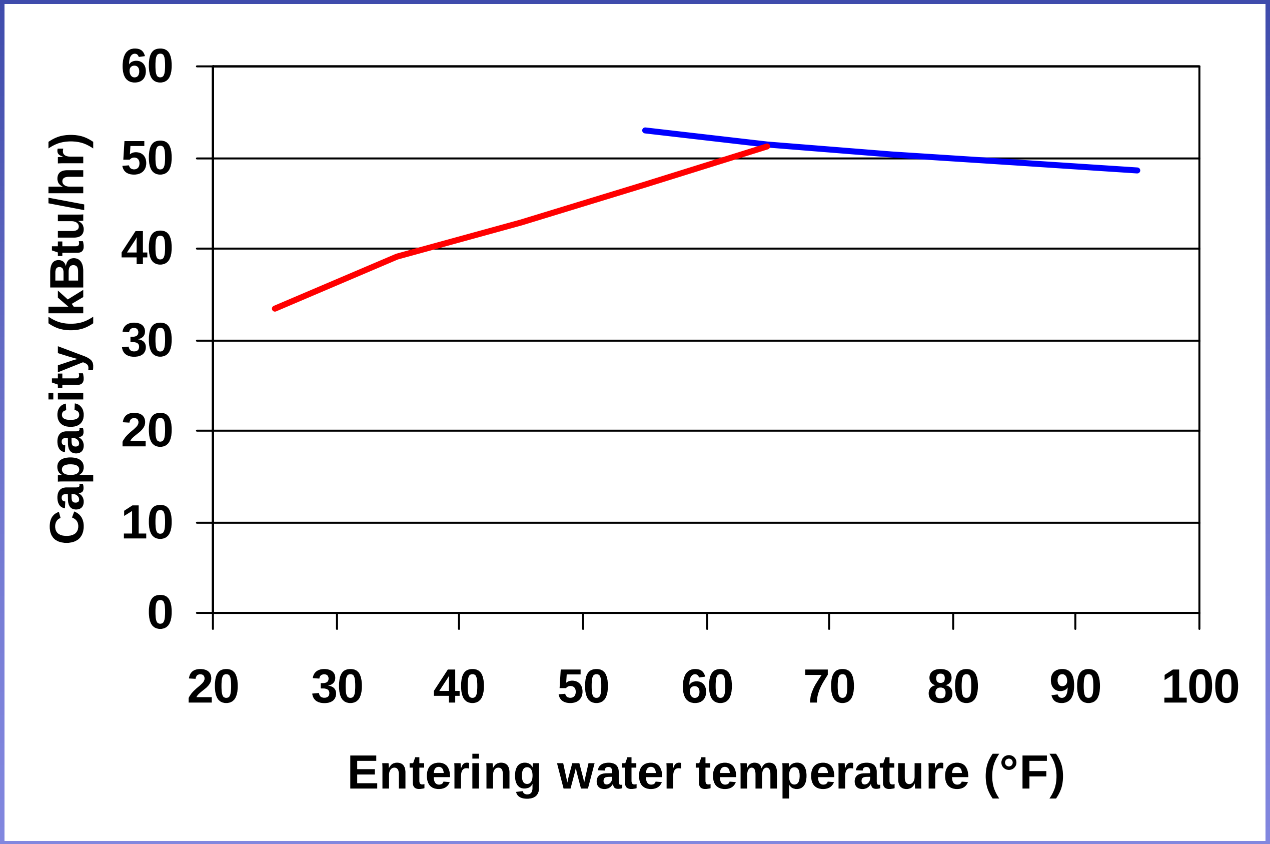
Geothermal System "Loops"



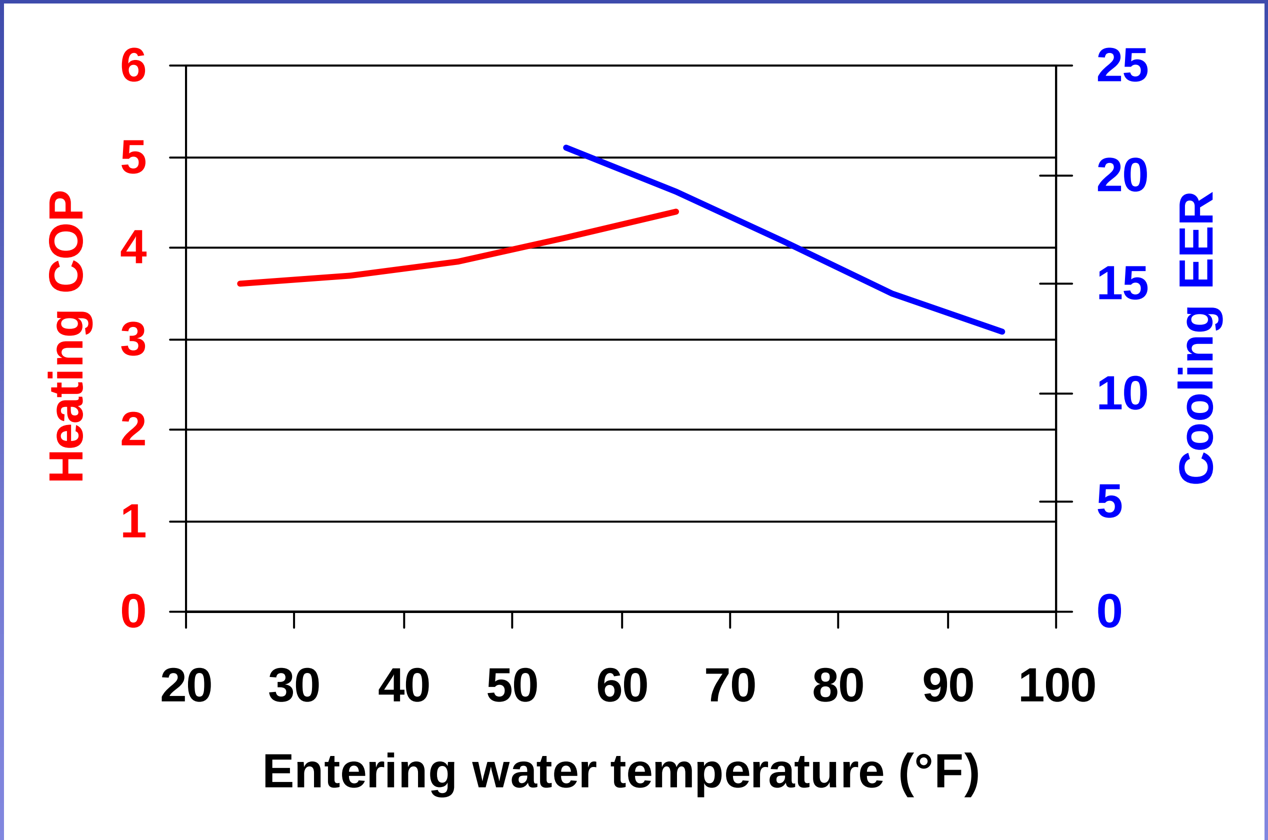


GSHP system options

Capacity of a typical 4-ton geothermal heat pump vs. EWT



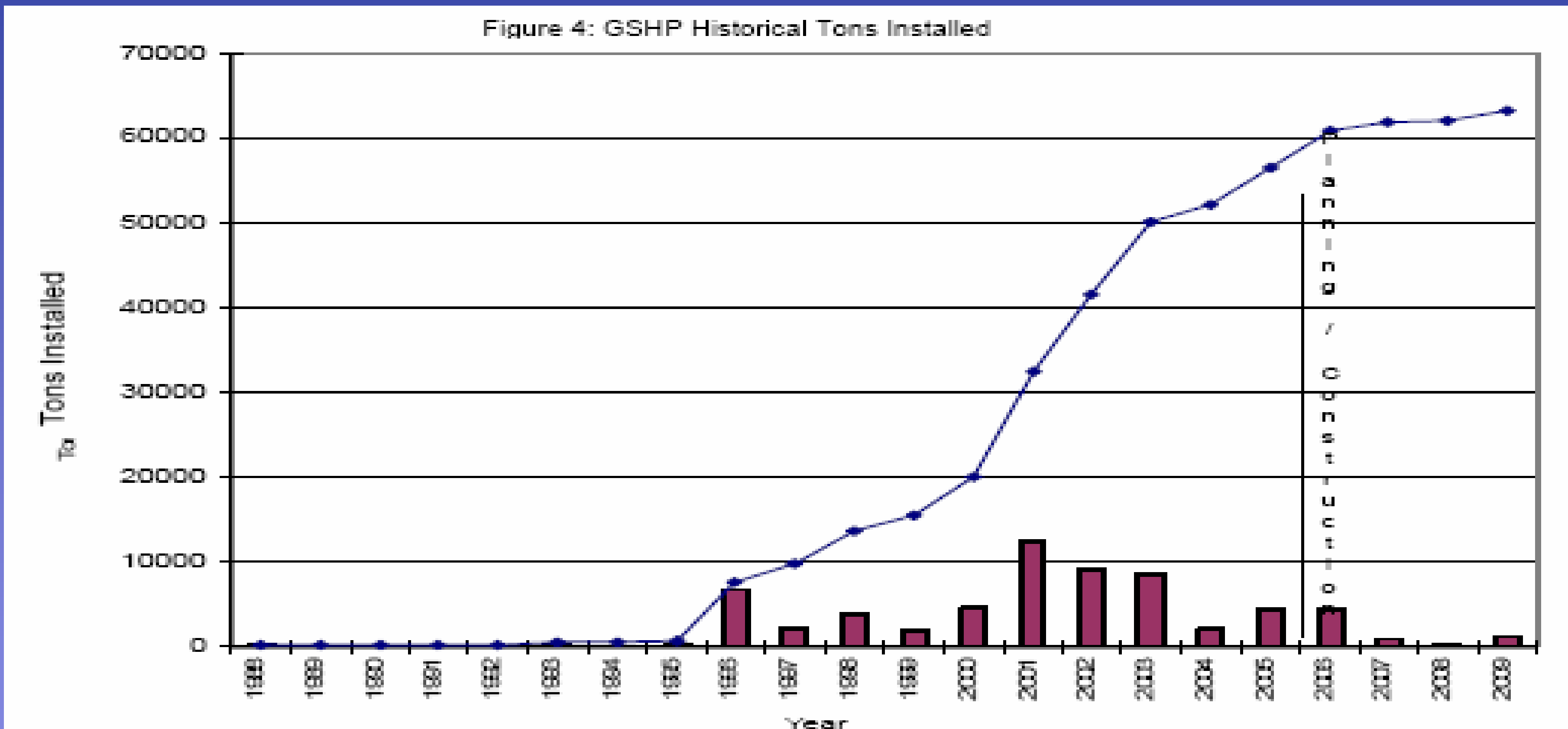
Efficiency of a typical 4-ton GHP as a function of EWT



DOD GSHP Report to Congress

- DAA 2006 requested report on GSHPs usage in the DOD
  - Types of DOD facilities
  - Cost effectiveness of GSHPs for CONUS
  - New Construction Vs. Retrofit
  - Recommendations for further encouraging GSHPs in the DOD

DOD GSHP Historical Tons Installed

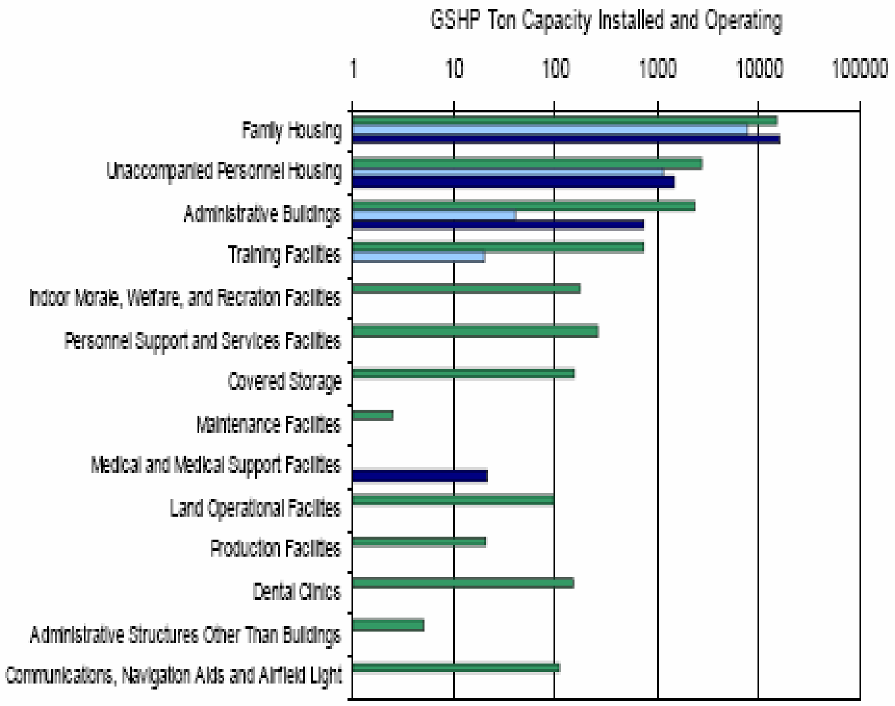


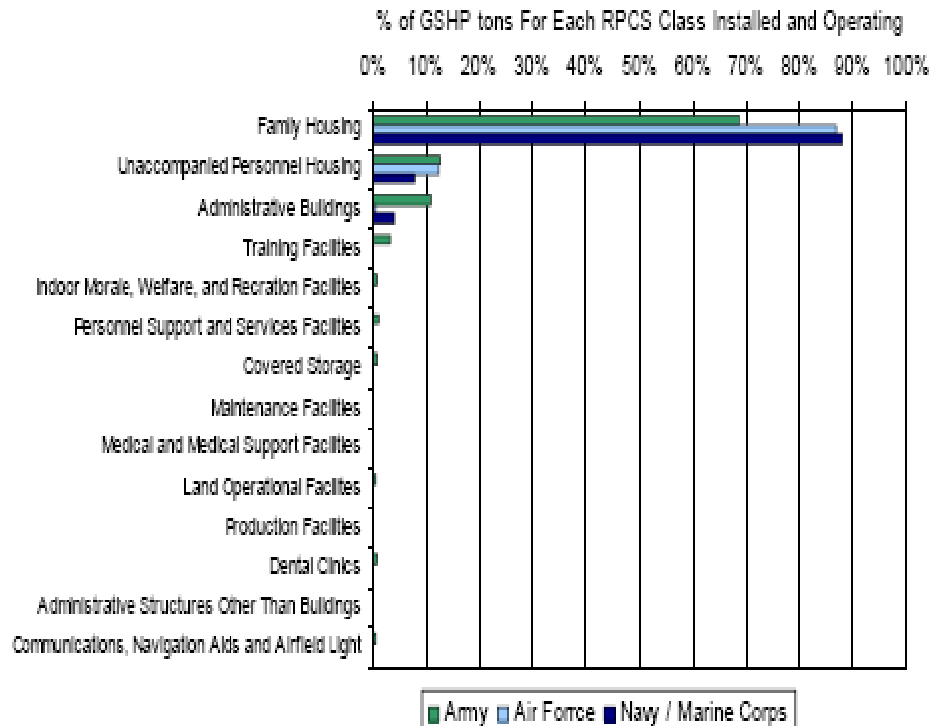
DOD GSHP Service Split

Table 2. DOD CONUS GSHPs Installed Pertinent Information

DOD Branch	Total # Of GSHP Projects Reported	Total Reported GSHP's Operational[1] (#) / (installed Ton Capacity)	Total Reported Annual Savings[3] (kWh)	% Projects Per Finance Mechanism[4]		
				App / Other	UESC	ESPC
ARMY	193	9,534 / 22,553	77,748,424	58%	34%	8%
AIRFORCE	27	3,934 / 9,091	Not Sufficient Data to Report	50%	43%	7%
NAVY / MARINE CORPS	44	7,679 / 20,406	80,546,656	32%	43%	24%
TOTAL	264	21,147 / 52,050	158,345,080	53%	36%	11%

Types of DOD Facilities using GSHPs





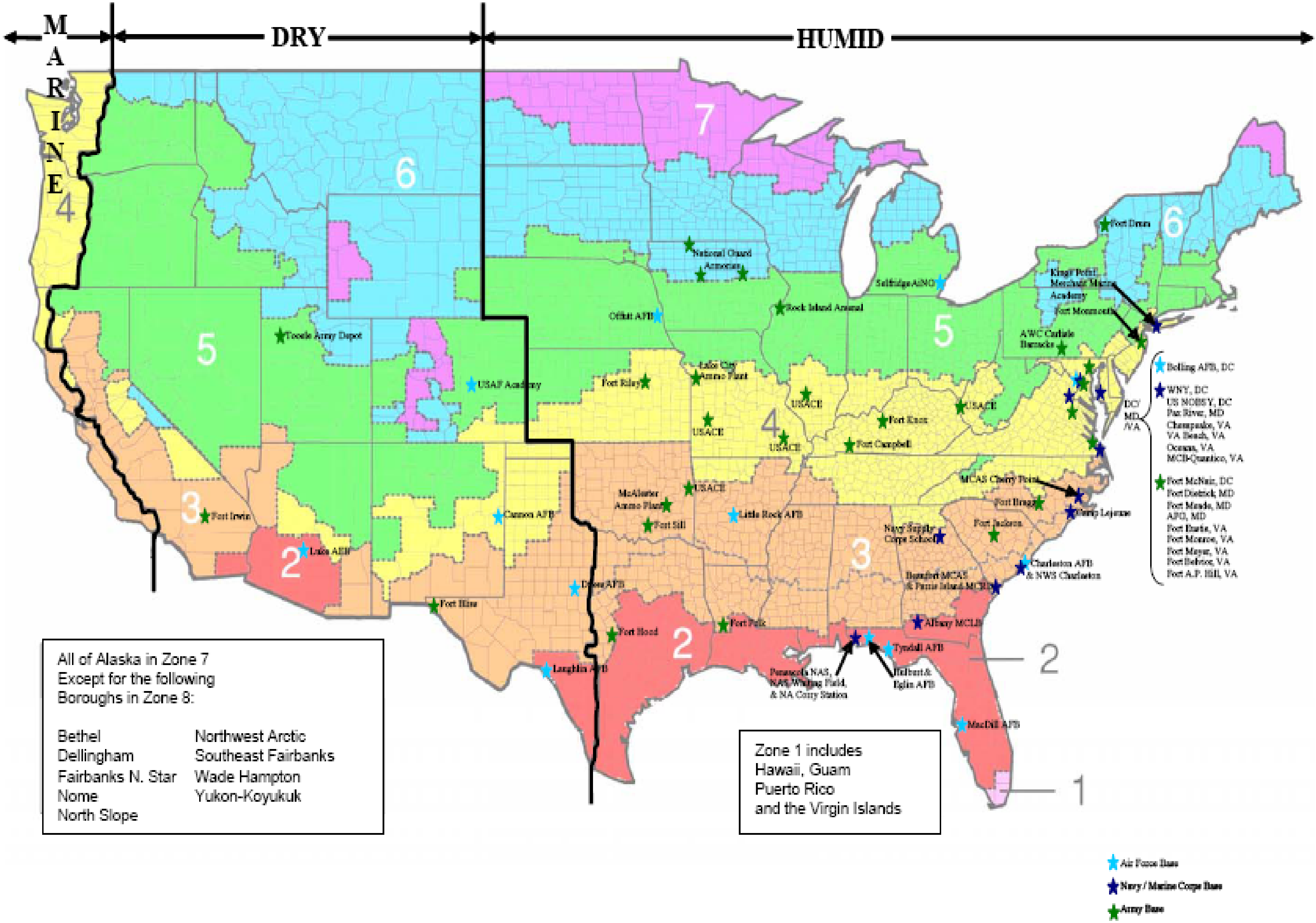


Figure 2: DOD Installations with GSHPs Currently Installed or Planned to be Installed (Shown on DOE IECC Climate Classification Map) (Briggs *et. al.*, 2002)

DOD GSHP Geographic info

Table 4(b): DOD GSHP Projects Geographical Information (cont'd) and Cost Effectiveness Estimates

Climate Zone No.[1]	Climate Zone Name / Type[1]	Representative US City	DOD Bldgs Owned[2] (KSF)	DOD Reported GSHP Installed (KSF)	DOD % Building square Footage using GSHP	Average Cost Effectiveness[3] (Annual Savings (kWh) / Ton Installed)	Average Project Payback Period (yrs)
1A	Very Hot - Humid	Miami, FL	78,716	0	0.00%	N/A	N/A
1B	Very Hot - Dry	--		0	0.00%	N/A	N/A
2A	Hot - Humid	Houston, TX	153,252	374	0.24%	1,304.67	12.20
2B	Hot - Dry	Phoenix, AZ	22,967	1 Project	No Data	No Data	No Data
3A	Warm - Humid	Memphis, TN	361,013	17,186	4.76%	4,941.33	8.60
3B	Warm - Dry	El Paso, TX	205,839	4 Projects	No Data	No Data	No Data
3C	Warm - Marine	San Francisco, CA	70,089	0	0.00%	N/A	N/A
4A	Mixed - Humid	Baltimore, MD	377,642	3,444	0.91%	9,682.90	12.00
4B	Mixed - Dry	Albuquerque, NM	14,385	1 Project	No Data	No Data	No Data
4C	Mixed - Marine	Salem, OR	50,039	0	0.00%	N/A	N/A
5A	Cool - Humid	Chicago, IL	184,607	276	0.15%	511.06	15.10
5B	Cool - Dry	Boise, ID	100,140	25	0.02%	No Data	No Data
6A	Cold - Humid	Burlington, VT	55,527	104	0.19%	16.22	27.30
6B	Cold - Dry	Helena, MT	5,488	0	0.00%	N/A	N/A
7	Very Cold	Duluth, MN	15,543	0	0.00%	N/A	N/A
8	Subartic	Fairbanks, AK	-	0	0.00%	N/A	N/A

Report Modeling Results

Table 5(a): Bldg 137 (classroom): Simple payback (years) of vertical bore GSHP and hybrid GSHP systems in various cities, and with various soil types

	Vertical bore GSHP			Hybrid GSHP		
	Soil type			Soil type		
City	Heavy sat	Damp heavy	Damp light	Heavy sat	Damp heavy	Damp light
Boston, MA	11	15	19	12	16	19
Fresno, CA	20	> 25	> 25	12	14	16
Great Falls, MT	13	20	> 25	10	11	13
Honolulu, HI	> 25	> 25	> 25	> 25	> 25	> 25
Minot, ND	22	> 25	> 25	11	13	14
Portland, ME	6	9	13	5	7	8
San Diego, CA	> 25	> 25	> 25	> 25	> 25	> 25
Santa Maria, CA	> 25	> 25	> 25	> 25	> 25	> 25
Seattle, WA	17	23	> 25	19	23	21
Tucson, AZ	> 25	> 25	> 25	12	14	16

Table 5(b): Bldg 1264 (admin): Simple payback (years) of vertical bore GSHP and hybrid GSHP systems in various cities, and with various soil types

	Vertical bore GSHP			Hybrid GSHP		
	Soil type			Soil type		
City	Heavy sat	Damp heavy	Damp light	Heavy sat	Damp heavy	Damp light
Boston, MA	12	19	> 25	12	16	19
Fresno, CA	11	15	19	12	15	18
Great Falls, MT	13	22	> 25	6	7	8
Honolulu, HI	> 25	> 25	> 25	17	17	17
Minot, ND	24	> 25	> 25	7	8	9
Portland, ME	7	11	16	4	4	5
San Diego, CA	> 25	> 25	> 25	> 25	> 25	> 25
Santa Maria, CA	12	16	23	13	16	19
Seattle, WA	11	17	> 25	8	10	11
Tucson, AZ	12	18	> 25	8	10	12

Table 5(c): Bldg 1150 (barracks): Simple payback (years) of vertical bore GSHP and hybrid GSHP systems in various cities, and with various soil types

	Vertical bore GSHP			Hybrid GSHP		
	Soil type			Soil type		
City	Heavy sat	Damp heavy	Damp light	Heavy sat	Damp heavy	Damp light
Boston, MA	14	22	> 25	11	14	16
Fresno, CA	11	17	23	9	11	13
Great Falls, MT	16	25	> 25	5	6	6
Honolulu, HI	> 25	> 25	> 25	24	24	24
Minot, ND	> 25	> 25	> 25	6	7	7
Portland, ME	8	13	18	3	4	4
San Diego, CA	> 25	> 25	> 25	> 25	> 25	> 25
Santa Maria, CA	14	22	> 25	14	17	20
Seattle, WA	11	17	> 25	8	10	11
Tucson, AZ	12	18	> 25	8	10	12

Figure 5(a): Project Cost (Dollars) vs. Installed Capacity (Tons)
(Commercial Projects, Log Scale)

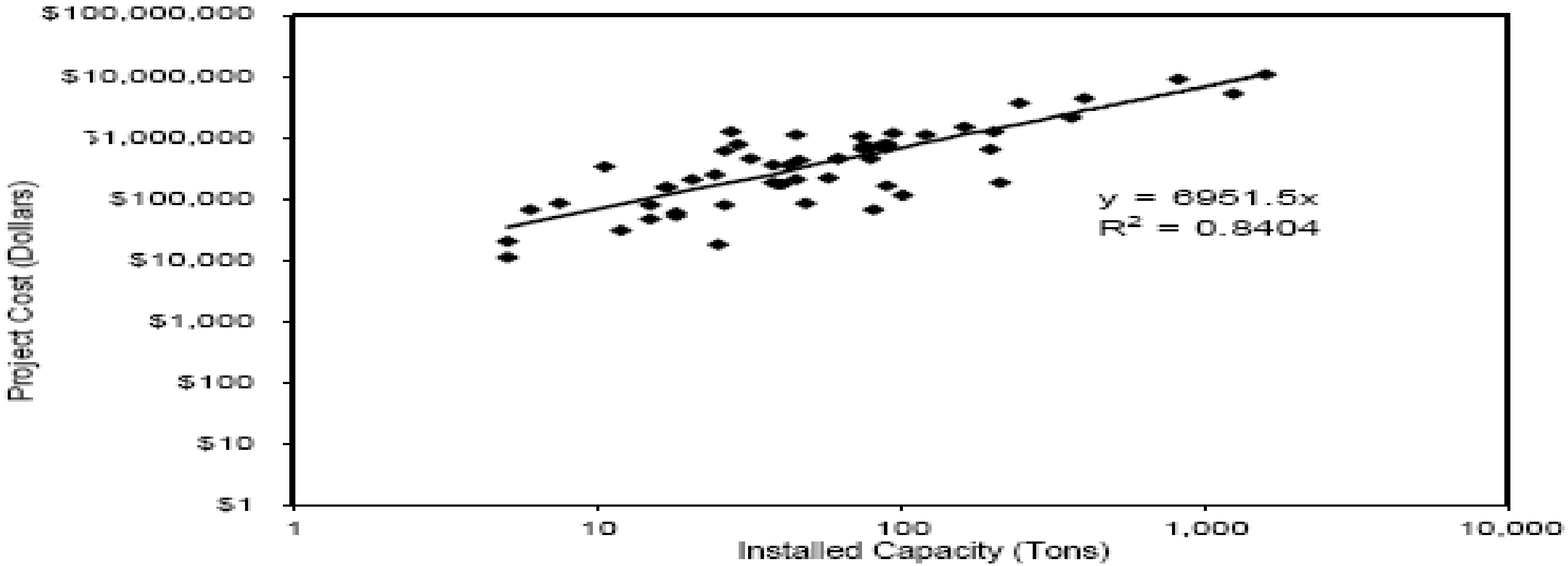
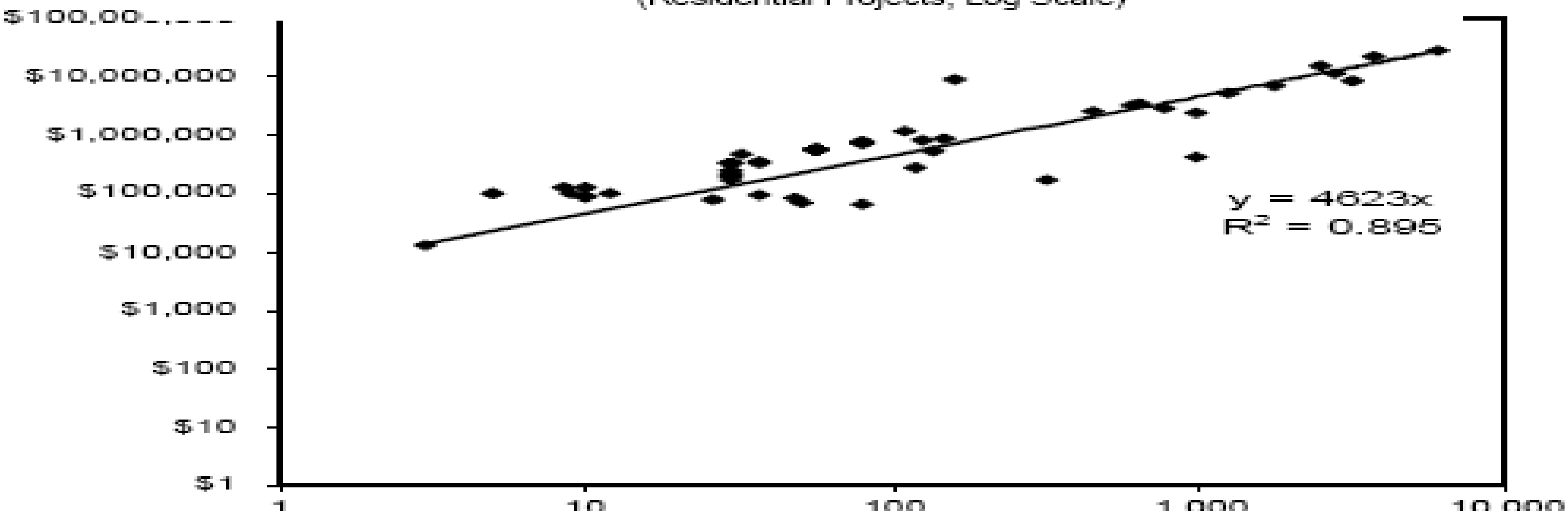


Figure 5(b): Project Cost (Dollars) vs. Installed Capacity (Tons)
(Residential Projects, Log Scale)



Report Recommendations

- *Train Designers and Energy Managers*
- *Design Assistance*. Establish a center of expertise either within DoD or in collaboration with one of the (DoE) laboratories
- *Specifications*. Conduct periodic reviews of DoD UFGS covering GSHP systems for consistency
- *Design Manual*. (ASHRAE) published HVAC design manual in 1997, and updated design manual is needed
- *Soil Thermal Properties Database*. Collect soil thermal properties data and maintain a database of this information.
- *Continue DoD Screening Feasibility Analyses*

DOD GSHP POCs

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- Marine Corps: Neil Tisdale, belton.tisdale@usmc.mil

References and Acknowledgements

- John Shonder, ORNL Slides
- IGSHPA, Slides
- TRANE, Slides
- DOD GSHP Report to Congress:
  ”Ground-Source Heat Pumps at Department of Defense Facilities”
  Can be found at: https//energy.navy.mil, also on OSD website
  - Gerry Doddington, USAF, AFCESA
  - CDR Brad Hancock, OSD
  - Bryan Long, USN, NFESC
  - Gary Phetteplace, US Army CREEL
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Don’t forget to fill out and drop off your evaluations

QUESTIONS??