ACEP
Alaska Center for Energy and Power

CCHRC
Cold Climate Housing Research Center

Statewide Ground Source Heat Pump Assessment

A REPORT FOR THE
DENALI COMMISSION

Report Overview

- GSHP technology used extensively in the Lower 48 and internationally
- Limited cold climate applications
- Little is known about GSHP technology in AK
- GSHP technology could be very useful to AK, given heating costs in the state

Report Overview

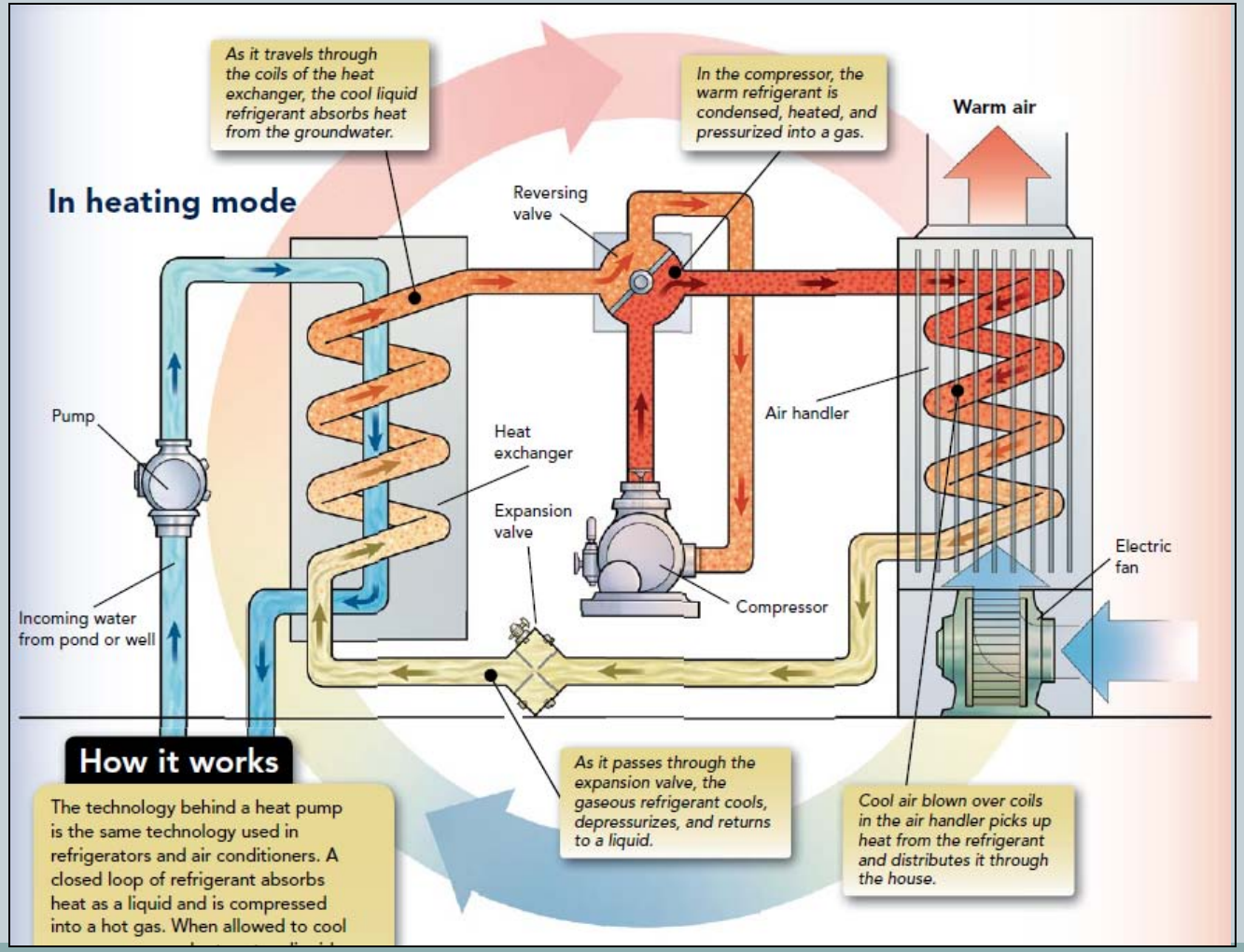
- 1st cut assessment
  - What projects were/are installed in Alaska
  - What does the industry look like
  - What research has been done, either in AK or other cold climates
  - What are the challenges associated with cold climate applications
  - Data analysis with any available project data
  - What are the preliminary economics of GSHP in AK?

Report Overview

Assessment divided between three major tasks:

- Task 1: Information review, synthesis, and identification of knowledge gap
- Task 2: Database of existing GSHP installations in Alaska
- Task 3: Preliminary economic assessment

Technology Primer – Heat Pump

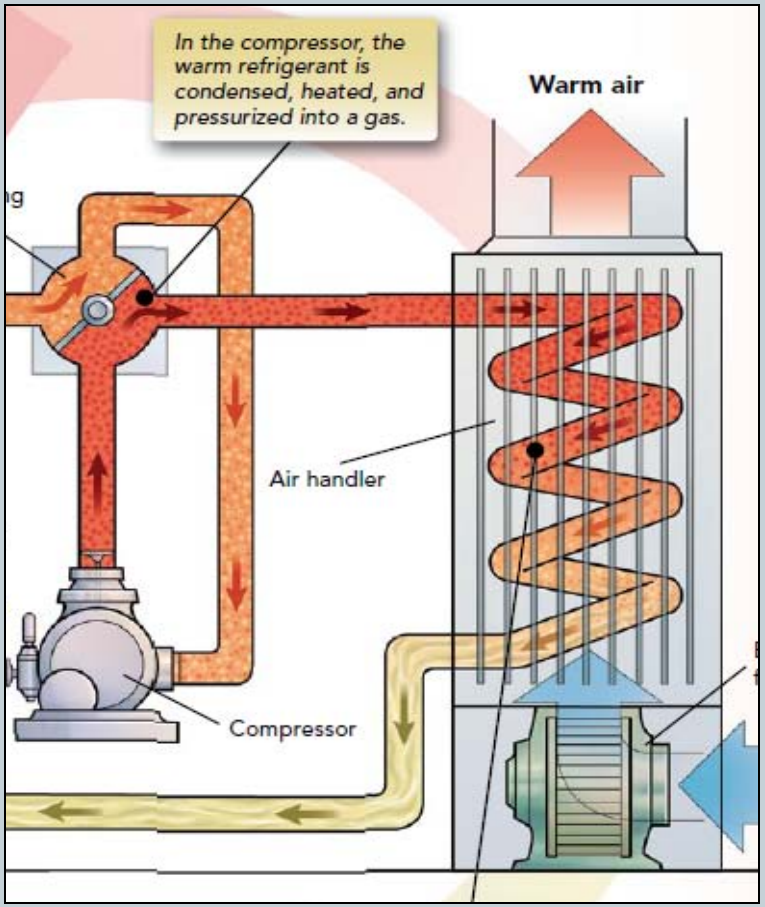


Source: Gibson, S. /Fine Homebuilding

Technology Primer – Heat Pump

Familiar technology, different application:

- Fridge or air conditioner
- Space heat by air or hydronic
- Partial load for hot water



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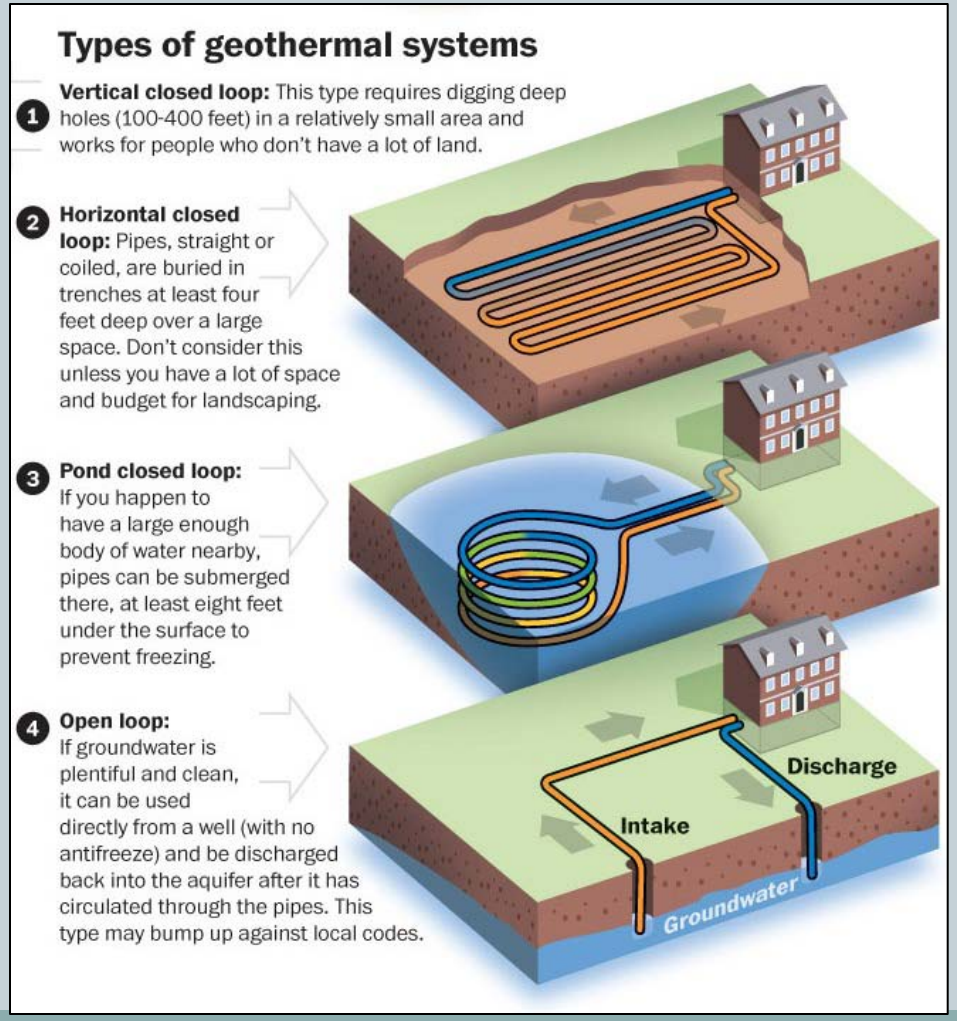
Technology Primer – Ground Loop

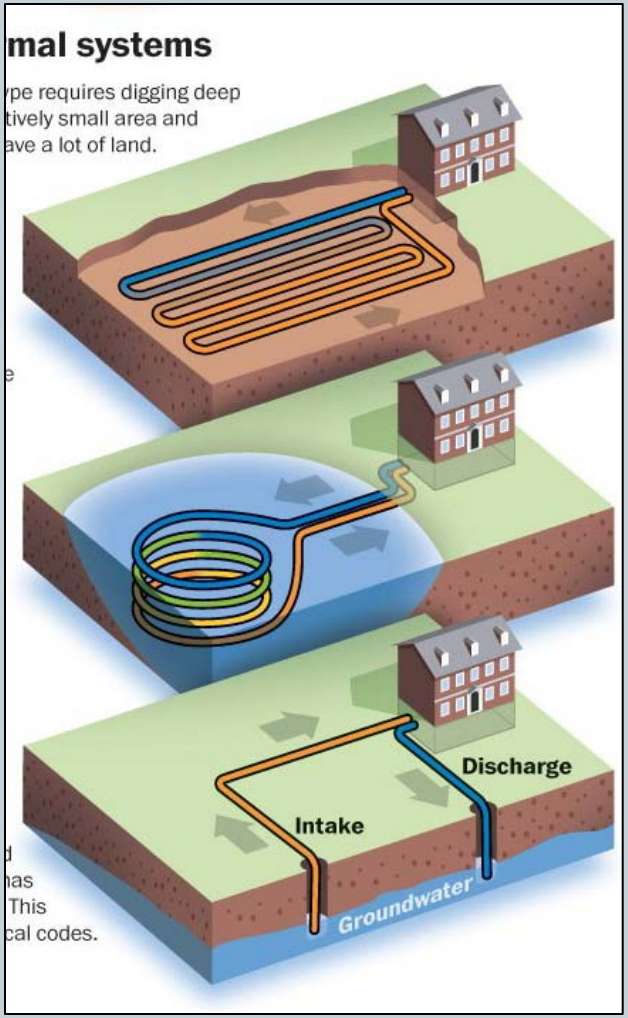


Source: Bonnie Berkowitz and Laura Stanton/The Washington Post

Technology Primer – Ground Loop

Many options:

- Vertical well or field of wells
- Shallow trench in soil
- Coil on lake bottom
- Open system drawing groundwater

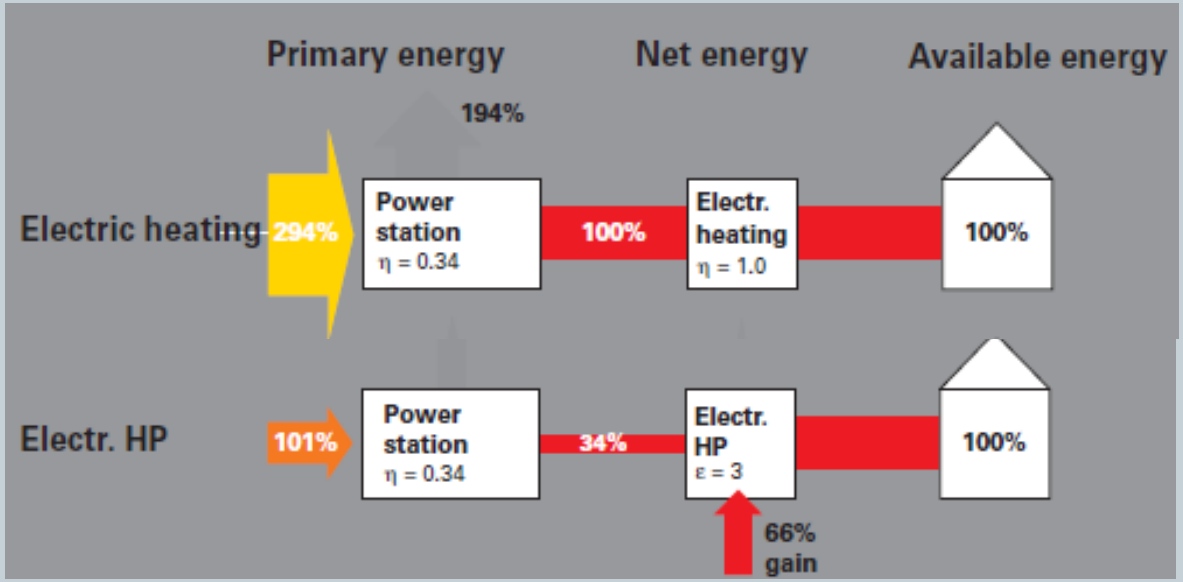


Source: Bonnie Berkowitz and Laura Stanton/The Washington Post

Technology Primer – Efficiency Metric

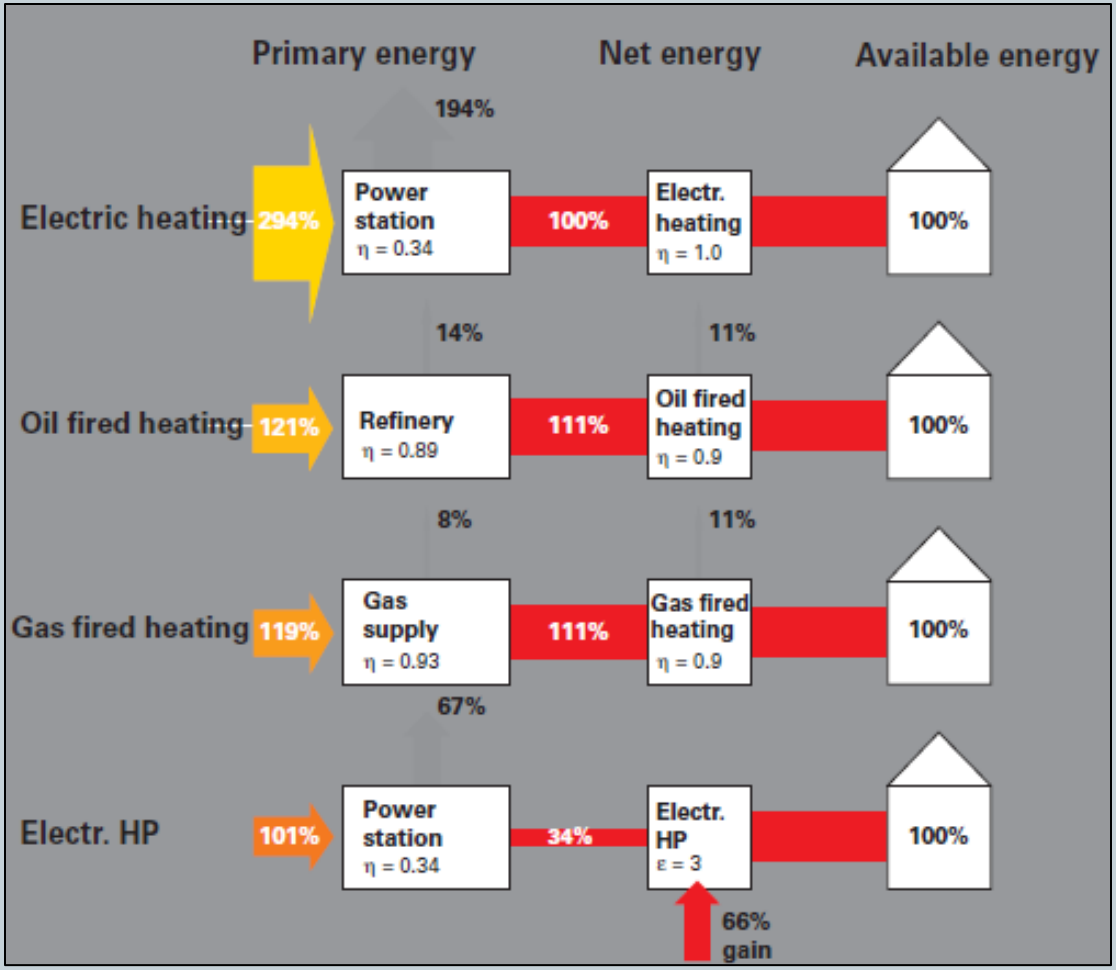
For heating - Coefficient of Performance ("COP")

- COP = Heat output / Power consumption



Source: Technical Information, Heat Pumps/Viessmann

Technology Primer – Efficiency Metric



Source: Technical Information, Heat Pumps/Viessmann

Task 1: Literature Findings from Alaska

Study	Duration	Heat Source	COP	Financial Analysis	Soil Thermal Response	Maintenance Problems
Zarling (1976)	-	Treated wastewater	3.7 (SPF)	Favorable	-	-
Jacobsen (1980)	-	Water of variable source	2.25-2.5	Comparable to other systems	-	Possible with sea water
Nielsen and Zarling (1983)	1 ½ year	Soil	2-3	-	Favorable	None
Juneau WSHP Program (1984)	3 year	Sea water	2.53	Favorable	-	None
Williams and Zarling (1994)	1 winter	Soil	2.0	Not favorable	More heat pipes needed if heat load increases	Few
Mueller and Zarling (1996)	1 winter	Lake water and soil	2.16-3.89	-	Need longer study	None
McFadden (2000)	15 years	Soil	-	-	Permafrost maintained	Several

Task 1: Summary of Findings

- Adequate system design is critical
- Success of a system is location dependent
- Hybrid applications may enable adoption

Task 1: Summary of Findings

- High capital costs hinder the technology
- Lack of developed market in Alaska
- Lack of long-term research studies

Task 1: Summary of Findings

- Thermal imbalance in soil is possible
- Nevertheless - success is widely reported across Alaska

Task 2: Database

- Detailed database of all GSHP projects in the state
  - Historical
  - Current
  - Planned
- COP values (where available), system type, location, installer, etc

Task 3: Economic Analysis

- Energy and capital cost comparison between GSHP systems and traditional heating sources
  - Juneau, Anchorage, Fairbanks, Bethel, Seward
  - Electric resistance, natural gas furnace, oil-fired unit
- NPV analysis
- Fuel price sensitivity analysis
- Federal and state incentives and rebates
- Case study for a commercial-scale project
  - Juneau Airport

Task 3: Economic Analysis

Table 1. Space heating energy use by population center

Community	Average Home Size	Average Btu/ft^2	Average annual Btu	Heating degree days
Juneau	1,730	75,818	131,165,140	8,897
Anchorage	2,074	87,894	182,292,156	10,570
Fairbanks	1,882	90,013	169,404,466	13,940
Bethel	1,000	91,486	49,171,000	12,769
Seward	1,730	75,818	131,165,140	9,007

Task 3: Economic Analysis

Table 3. Comparison of energy cost and fuel consumption by population center

		GSHP	Electric Resistance	Oil-fired unit	Natural gas furnace
Anchorage					
	Unit cost ($)	0.11/kWh	0.11/kWh	N/A	0.81/CCF
	Actual cost ($/kWh)	0.03-0.04	0.11	N/A	0.03
	Fuel consumption (kWh)	15,260-17,804	53,951	N/A	55,063-68,476
	Heating cost ($)	1,679-1,958	5,935	N/A	1,487-1,849
Fairbanks					
	Unit cost ($)	0.17/kWh	0.17/kWh	2.87/gal	N/A
	Actual cost ($/kWh)	0.05-0.06	0.17	0.08-0.09	N/A
	Fuel consumption (kWh)	14,181-16,545	50,136	55,150-62,044	N/A
	Heating cost ($)	2,411-2,813	8,523	3,894-4,380	N/A

Task 3: Economic Analysis

Table 4. Comparison of energy and capital costs and net present value for heating systems by population center

		GSHP	Electric resistance	Oil-fired boiler/ Toyo stove (Bethel)	Natural Gas
Anchorage					
	Capital Costs ($)	42,130	4,064	N/A	8,525
	Annual heating energy costs ($)	1,679-1,958	5,935	N/A	1,487-1,849
	Net present value ($)	73,705-78-899	114,137	N/A	63,116-76,077
Fairbanks					
	Capital Costs ($)	23,000	3,700	13,750	N/A
	Annual heating energy costs ($)	2,411-2,813	8,523	4,123-4,436	N/A
	Net present value ($)	68,601-76,061	161,845	84,574-89,745	N/A

Task 3: Economic Analysis

Table 9. Government Incentives and Rebates

	State	Federal
Residential	• Home Energy Rebate Program • Second Mortgage Program for Energy Conservation	• Residential Renewable Energy Tax Credit
Commercial	• Renewable Energy Grant Program	• Modified Accelerated Cost-Recovery System • Business Energy Investment Tax Credit • USDA- Rural Energy for America Program Grant • USDA- Rural Energy for America Program Loan Guarantee

Questions?

- Funded by the Denali Commission
- Final report will be available April 2011
- Project Partners include:
  - Alaska Energy Authority
  - National Renewable Energy Laboratory

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