



Geothermal in Alaska: Summary of Recent NREL Efforts

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Talk organization

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- I. Findings from geothermal resilience evaluation
 - II. Geothermal stakeholder engagement in Alaska
 - I. Overview of stakeholder identification process
 - II. Identified challenges to geothermal deployment
 - III. Discussion: future stakeholder engagement in Alaska

Arctic Geothermal Resilience Evaluation

Project goals

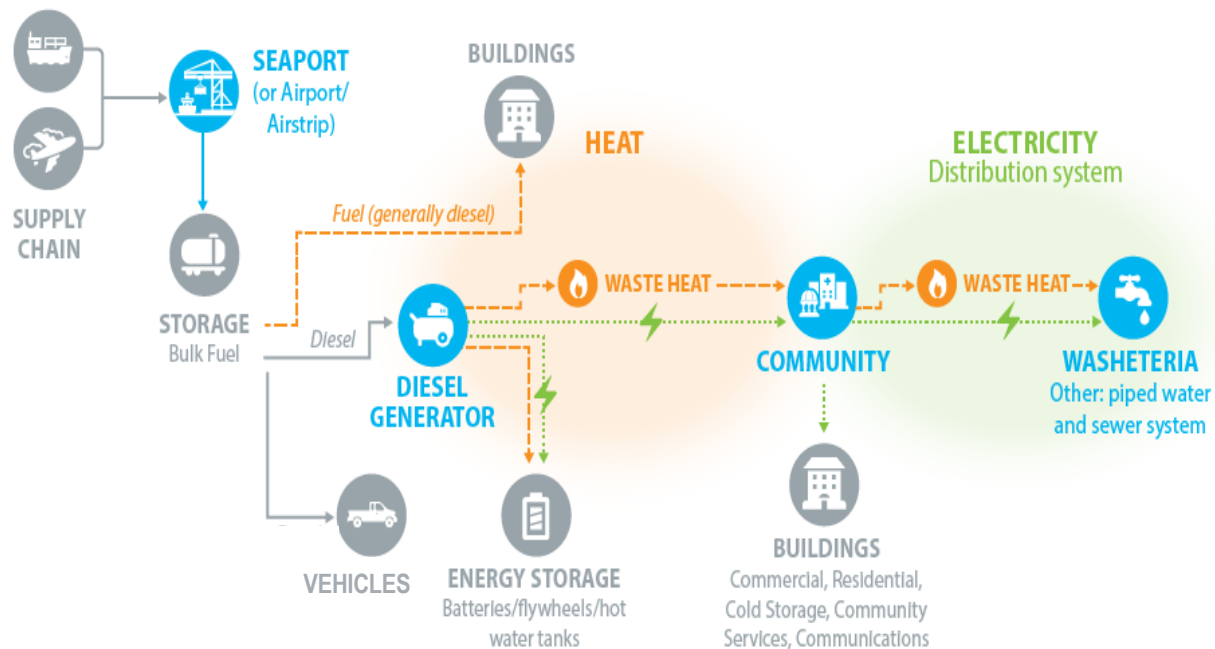
- ✓ Define attributes of resilient thermal and electrical energy systems with a focus on baseload renewable microgrids and district heating systems
- ✓ Document whether geothermal microgrids are technically possible
- ✓ Evaluate resilience of geothermal-based grid (utility-scale)
 - ✓ Theoretical and case study (Puna, HI)
- ✓ Evaluate resilience of geothermal-based microgrid
 - ✓ Theoretical and case study (Chena, AK)
- ✓ Evaluate resilience of geothermal-based district heating system
 - ✓ Theoretical and case study (Reykjavik, Iceland)
- ✓ Explore integration of thermal energy (heat) into community microgrids
 - ✓ Identify economic factors for geothermal heat and power (CHP) microgrids

Next steps: Run TEA simulations for geothermal CHP case studies (costs and performance)

Next steps: work with stakeholder communities on geothermal deployment (CHP, DES, GHP, power)

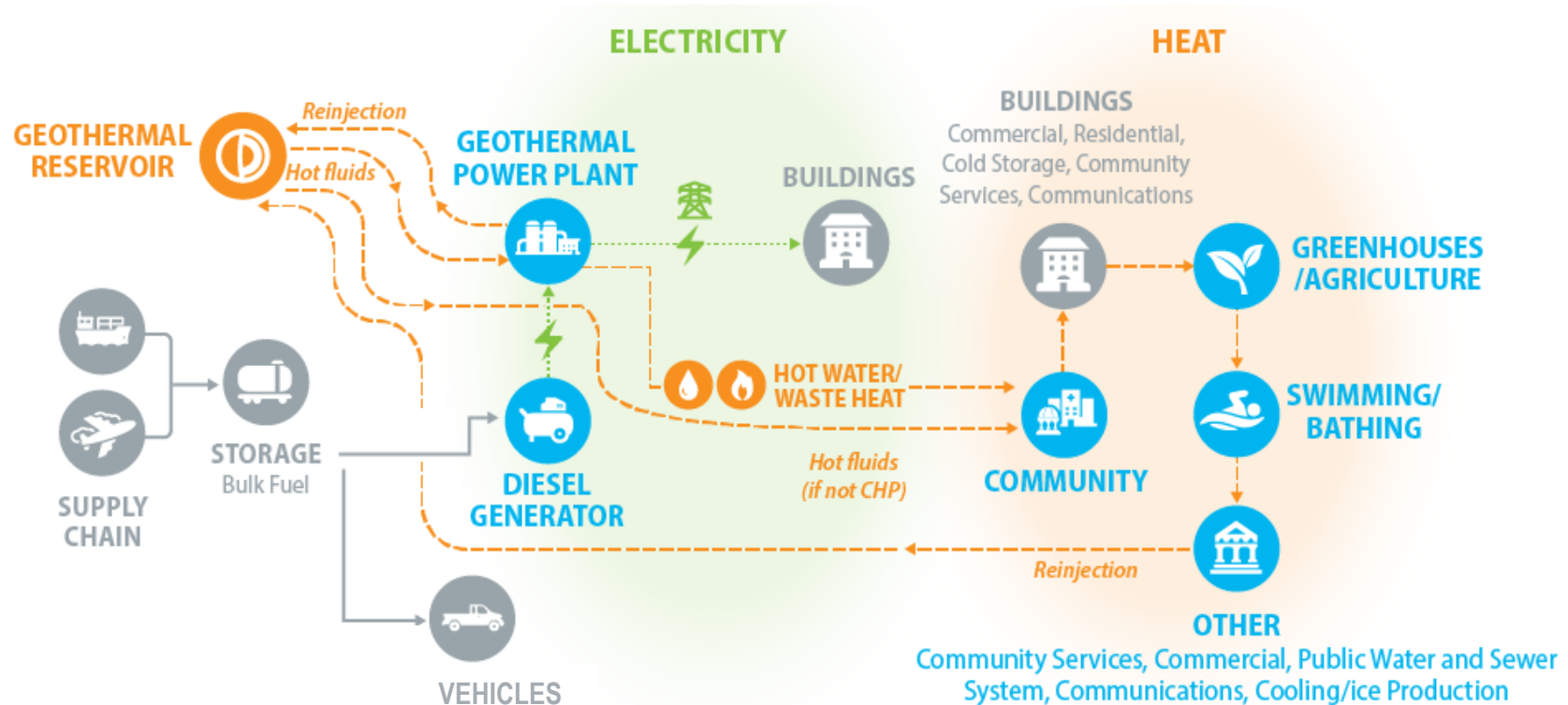
Context: Vulnerabilities in Remote Energy Systems (Microgrids)

- Vulnerability (lack of resilience) from dependence on imported diesel fuel
- Energy equity:
 - Expensive (cost of energy, cost of fuel spills, cost of outages, etc.)
 - Energy scarcity, expense, and disruptions → “heat or eat”
- Environmental justice:
 - Pollution from diesel generators, fuel transport, storage and other local handling issues
 - Energy scarcity/cost can mean lack of basic sanitation and water needs
- Climate justice: Arctic communities “frontline” in facing threats from climate changes despite low contributions to causes
 - Many communities affected by rising sea level, melting permafrost
 - New infrastructure rebuilt around fossil-based energy systems



Remote Geothermal Energy System (CHP Microgrid)

Where are the vulnerabilities?



Resilience of Geothermal Power: Utility Scale

	Resilient	Neutral	Vulnerable	
Resilience Attribute	Component	Performance of the Puna Flexible Geothermal Grid (HI)		
Reliability: How does it perform in typical conditions?	Wellfield	No known issues		
	Generation equipment	Mature technology (Ormat ORC)		
	Balance of system equipment	Not evaluated		
	Low-load operation	Flexible within typical grid requirements. Low-load operation unknown (beyond turndown from 38 to 22 MWe) but likely possible.		
Redundancy: Are there single points of failure?	Fuel storage	Not implemented		
	Number of generators	12		
	Critical transportation routes for fuel and supplies	No fuel supply chain after construction.		
	Power sector workforce	Not evaluated		
Resourcefulness: How are the needed resources utilized?	Variation in resource	Low variability. Large timescales. Can design plant to operate at end-of-life well conditions to maximize total output & minimize variability		
	Infrastructure needs	Not evaluated		
	Natural disasters (weather-related)	No outages due to weather-related disasters reported		
	Natural disasters (geologic hazards)	Offline 2018-2020 due to volcanic eruption		
Response (Recovery: Can the system bounce back from disruption?)	Response to variation in resource	Modular systems can operate at different set points		
	Spare parts	Available but long supply chain vulnerable to disruptions		
	Black start	Has technical capability. Unknown if this is exploited.		
	Switching capability	Yes		
Response (Operations: Is the power system stable and able to provide ancillary services?)	Ramp up/down	Yes		
	Reserve capacity/spinning reserve	Yes		
	Inertial response	Yes (synchronous)		
	Frequency response	Yes		
	Voltage response	Yes		

Resilience of Geothermal Power: Microgrid Scale

	Resilient	Neutral	Vulnerable	
Resilience Attribute	Component	Performance of the Chena Hot Springs Geothermal Microgrid (AK)		
Reliability: How does it perform in typical conditions?	Wellfield	Initial reservoir management issues now resolved		
	Generation equipment	Diesel generators + 3 binary geothermal modules (custom built modules replaced with mass-produced modules)		
	Balance of system equipment	Not evaluated		
	Low-load operation	Custom units were difficult to ramp down/up but new mass-produced units perform well under low loads.		
Redundancy: Are there single points of failure?	Fuel storage	Not evaluated		
	Number of generators	3 small modules allow redundancy		
	Critical transportation routes for fuel and supplies	No fuel supply chain after construction.		
Resourcefulness: How are the needed resources utilized?	Power sector workforce	Initial need for specialized technicians but O&M managed by local staff		
	Variation in resource	Low variability. Large timescales. Can design plant to operate at end-of-life well conditions to maximize total output & minimize variability		
	Infrastructure needs	No significant transmission needs		
Response (Recovery: Can the system bounce back from disruption?)	Natural disasters (weather-related)	No outages due to weather-related disasters reported		
	Natural disasters (geologic hazards)	No negative effects from historical earthquakes		
	Response to variation in resource	Modular systems can operate at different set points		
	Spare parts	Readily available for mass produced modules		
Response (Operations: Is the power system stable and able to provide ancillary services?)	Black start	Black start provided by diesels and batteries		
	Switching capability	Can switch and synchronize within seconds		
	Ramp up/down	Ramp geothermal with throttle valves		
	Reserve capacity/spinning reserve	Diesels serve as spinning reserve		
	Inertial response	Yes (synchronous)		
	Frequency response	Not evaluated		
	Voltage response	Not evaluated		

Resilience of Geothermal District Heating (CHP example)

Resilience Attribute	Component	Performance of Reykjavik GDH	Resilient	Neutral	Vulnerable
Reliability: How does it perform in typical conditions?	Maintenance plans				
	Performance monitoring				
	Age of system/components				
	Maintain outage stats				
	Leakage detection system				
Redundancy: Are there single points of failure?	Multiple heat plants				
	Multiple heat sources				
	Redundant workforce				
	Redundant pumps				
	Building level thermal resilience				
Resourcefulness: Are there diverse and flexible options?	Meshed distribution systems				
	Ability to exceed design capacity in extreme cold events				
	Ability to meet multiple temperature delivery needs				
	Time to recovery—thermal resilience of buildings				
Recovery: Can system bounce back	Ease of recovery—supply chain flexibility				
	Standardized parts and supplies				

Market externalities related to energy resilience

Energy Externality	Business as Usual (BAU)	BAU Vulnerabilities	Geothermal Energy Alternative	Metric
Energy Security		Disruptions impact operation of facilities, communications, cold storage for food, etc.	Locally produced power, added survivability from locally produced heating	
Energy Equity	High and/or fluctuating fuel prices	Affordability, dependence on associated state aid such as PCE in Alaska	Fixed energy prices,	Avoided subsidies such as PCE
Job Security and Food Security		Declining O&G sector	Jobs: energy systems O&M (heat & power)	Number of jobs replaced
	Jobs indirectly related to energy (fuel transport, storage, etc.)	Declining O&G sector	Jobs related to food production and other economic opportunities from surplus heat (tourism, industrial use of process heat, etc.	Number of jobs lost vs. created. Revenue or projected revenue from tourism, industrial activities, etc.
	Imported food	Supply chain disruptions impact imports	Locally produced food from clean greenhouses	Revenue from food sales and/or avoided costs of food purchases, days per year of access to fresh food
Environmental and Climate Justice	Climate change from fossil fuel combustion	Indigenous and remote communities face the worst consequences of climate change, but contribute little to its causes and are powerless to change them	Eliminating local sources of GHG emissions. Widespread deployment of geothermal energy could reduce worldwide GHG emissions	Cost of avoided emissions
	Community health impacts of fossil fuel extraction, transport and use	Underserved communities face disproportionate health consequences from fossil fuel extraction, transport, electricity production and transmission	Eliminating local sources of GHG emissions, fuel handling and storage	Costs and other measures of impacts on air, water, and land (e.g., reduction in contaminants)
		Environmental degradation, habitat loss, etc.	Environmental benefits of eliminating fuel use	Emissions reductions plus other fuel-related costs
Economic Development Opportunities				

Alaska Stakeholder Engagement

Stakeholder Engagement in Alaska

Community Outreach/Stakeholder Identification (FY21-FY22)

Data from the following sources was collected and reviewed:

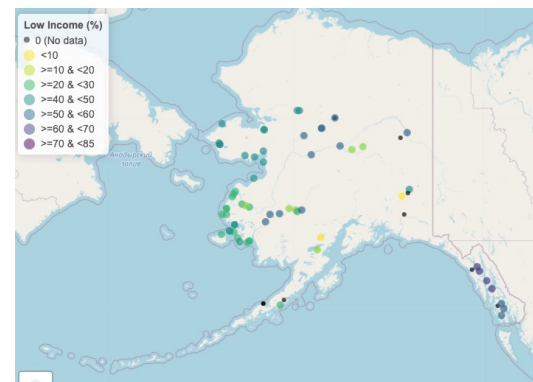
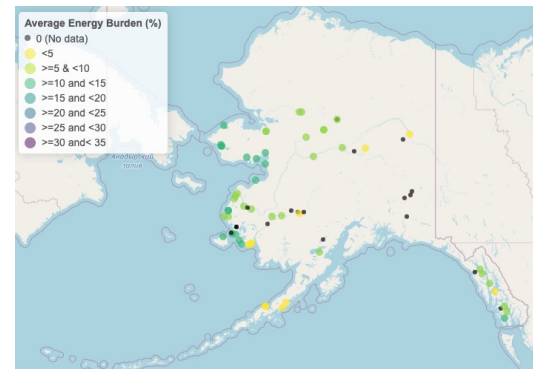
- The Alaska Division of Community and Regional Affairs (DCRA) – DCRA Community Database
- Alaska Department of Labor and Workforce Development (DOLWD) – Distressed Communities List
- Alaska Finance Housing Corporation – 2014 Alaska Housing Assessment
- United States Government Accountability Office – Relocation data
- Alaska Division of Geological & Geophysical Surveys

Stakeholder Engagement in Alaska, cont.

An interactive map was created so that the project team could look at data from multiple sources to help identify communities that could potentially benefit from geothermal.

Filters included:

- Power Cost Equalization (PCE) Eligible
- Distressed Status (2019 & 2020)
- Population size
- Proximity to known geothermal features (<50 miles)
- Average Energy Burden (%)
- Low Income (%)
- Annual Fuel Oil Consumed (gal/household)



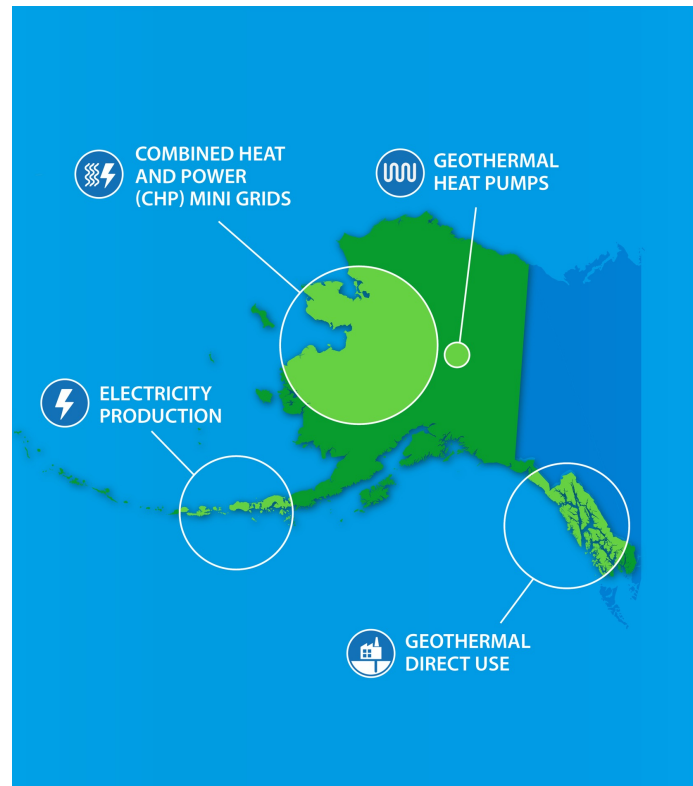
Stakeholder Engagement in Alaska, cont.

Based on the data in the interactive map, along with conversations with the following organizations:

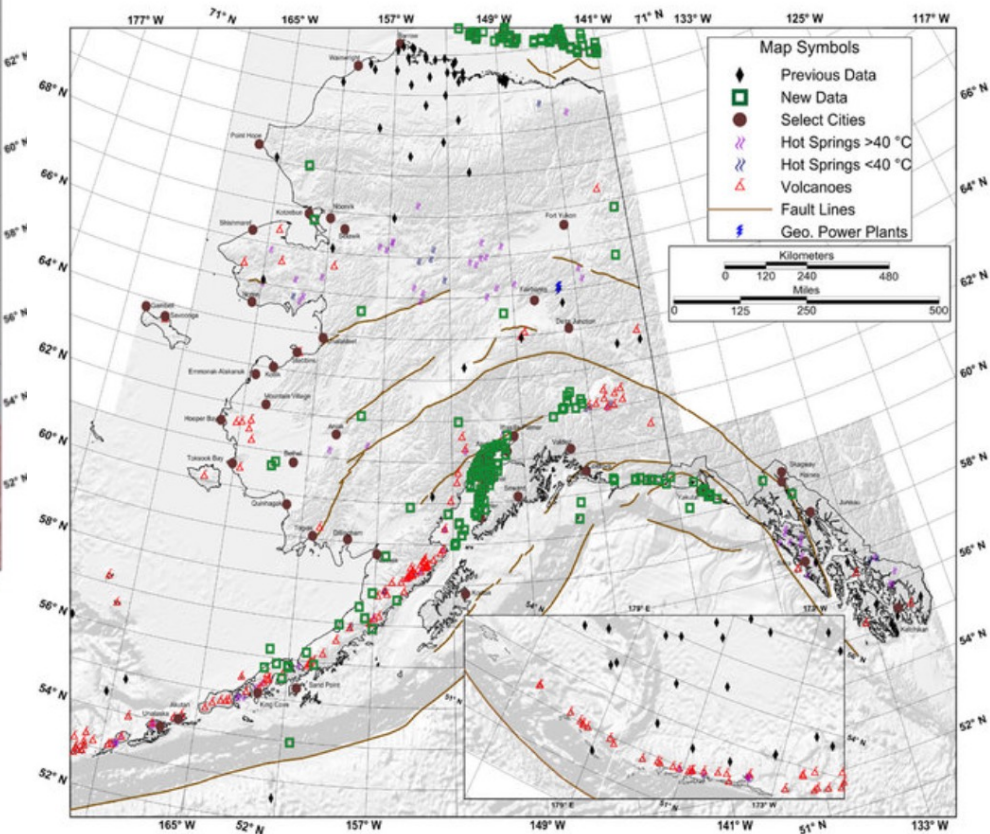
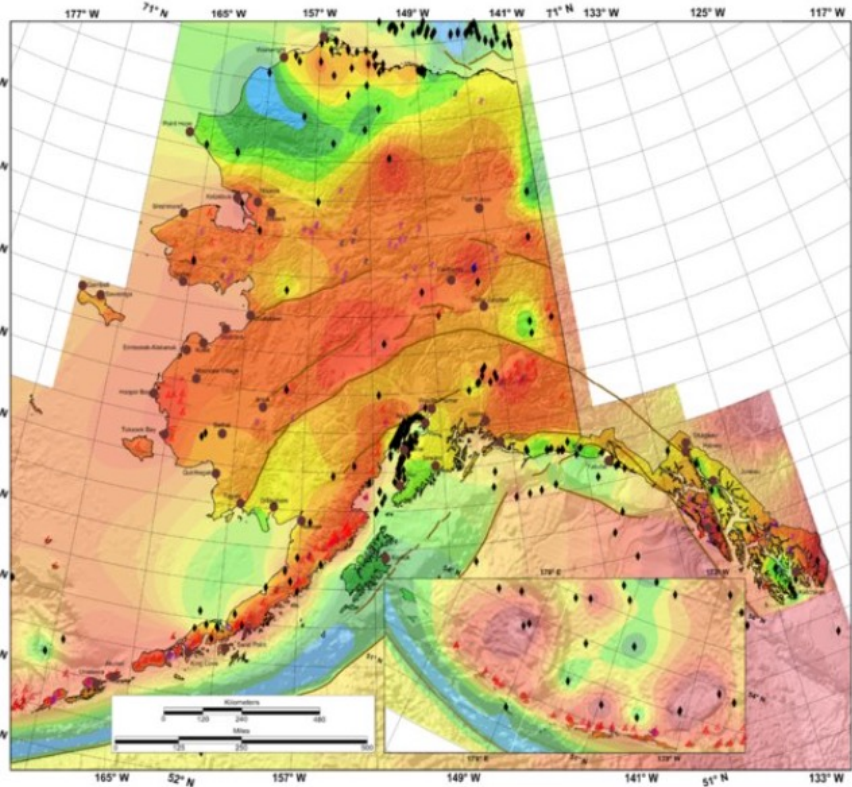
- Alaska Peninsula Corporation
- Akutan Geothermal Project
- Alaska Energy Authority (AEA)
- Renewable Energy Alaska Project (REAP)
- Tanana Chiefs Conference
- Homer Electric Board
- Cold Climate Housing Research Center (CCHRC)

It was determined that the project outreach would take a multi-pronged approach:

- Geothermal Heat Pumps – Workforce Development in Interior Alaska (Fairbanks and urban centers)
- Geothermal Direct Use – Industrial Processing (Southeast Alaska)
- Combined Heat and Power (CHP) mini grids – Remote communities in Interior and Western Alaska
- Electricity Production – Remote communities in Aleutians, Railbelt



Challenges: subsurface data quality & uncertainty in Alaska



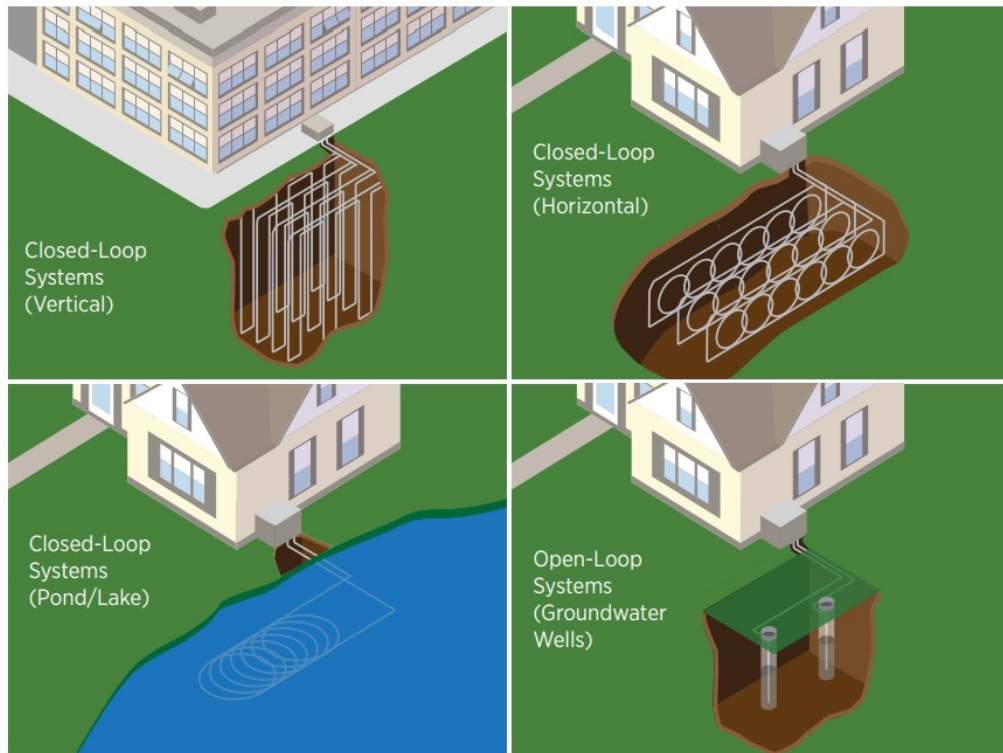
Map Legend



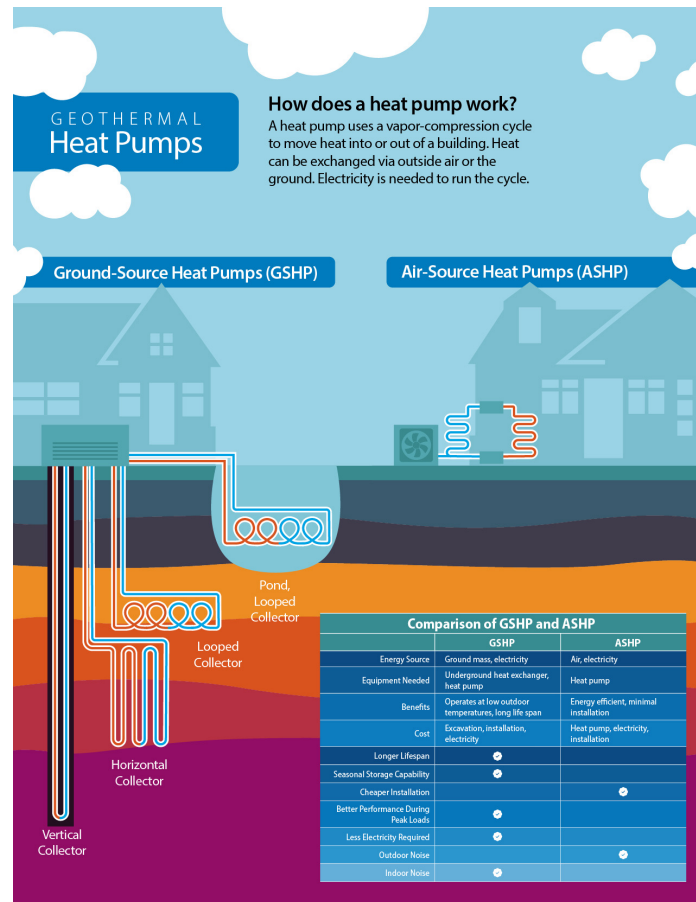
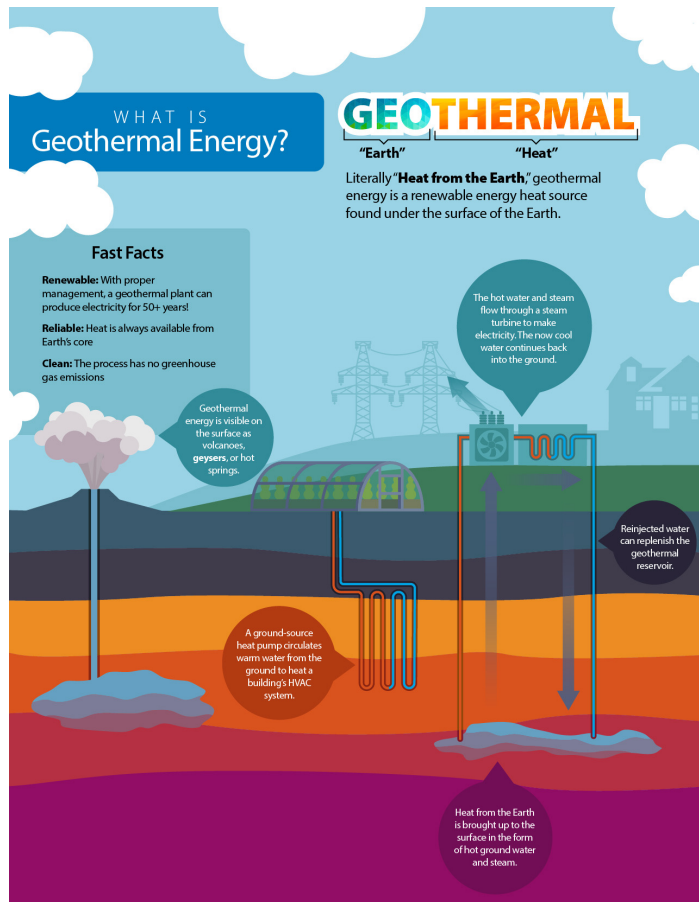
Source
 : Batir
 et al.
 (2015)

Challenge: Lack of Workforce

- No trained workforce for installation or O&M of geothermal heat pump systems for interior Alaska.
- Remote villages need a heating solution that is reliable and that can be easily fixed in the winter months if something breaks or malfunctions.



Geothermal Fact Sheets Developed



Discussion
