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Transforming ENERGY

Geothermal in Alaska: Summary of Recent NREL Efforts

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Talk organization

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

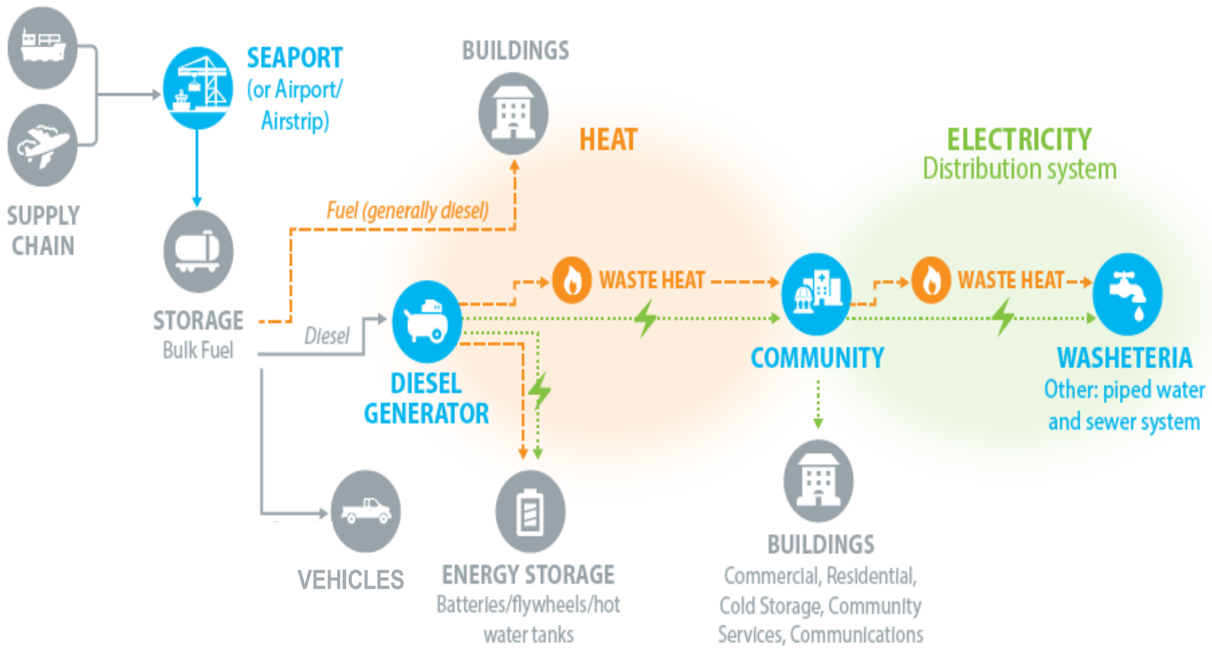
- ✓ Define attributes of resilient thermal and electrical energy systems with a focus on baseload renewable microgrids and district heating systems
- ✓ Document whether geothermal microgrids are technically possible
- ✓ Evaluate resilience of geothermal-based grid (utility-scale)
    - ✓ Theoretical 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 (Reyjkavik, 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)

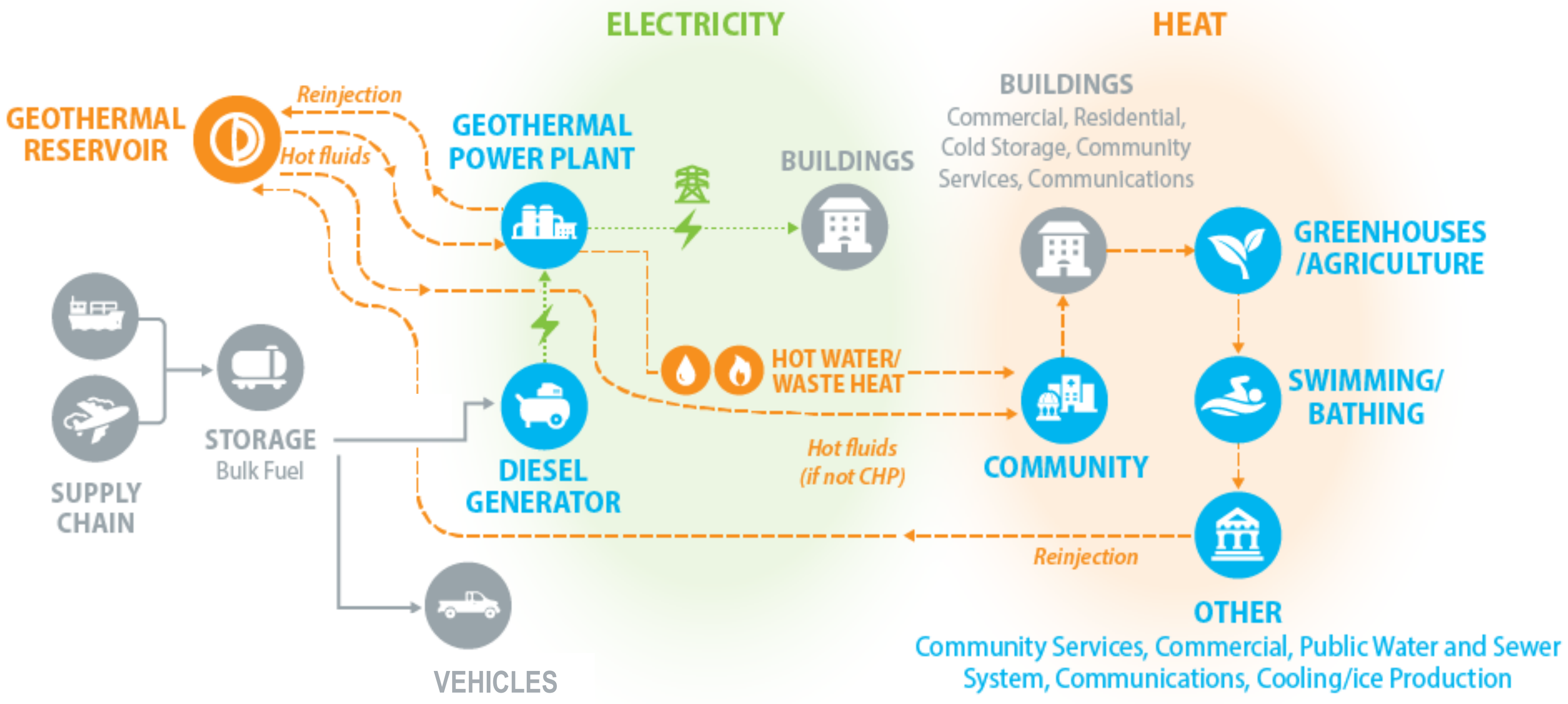
Context: Vulnerabilities in Remote Energy Systems (Microgrids)

- 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.
Resourcefulness: How are the needed resources utilized?	Power sector workforce	Not evaluated
	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
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)	Offline 2018-2020 due to volcanic eruption
	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.
Response (Operations: Is the power system stable and able to provide ancillary services?)	Switching capability	Yes
	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
Resourcefulness: How are the needed resources utilized?	Critical transportation routes for fuel and supplies	No fuel supply chain after construction.
	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)

Resilient | Neutral | Vulnerable

Resilience Attribute	Component	Performance of Reykjavik GDH
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	
	Meshed distribution systems	
Resourcefulness: Are there diverse and flexible options?	Ability to exceed design capacity in extreme cold events	
	Ability to meet multiple temperature delivery needs	
Recovery: Can system bounce back	Time to recovery—thermal resilience of buildings	
	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:

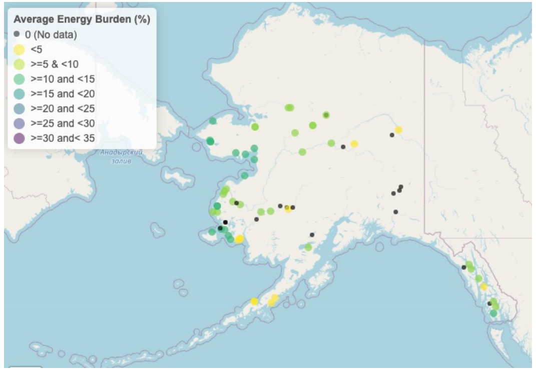
- The Alaska Division of Community and Regional Affairs (DCRA) – DCRA Community Database
- Alaska Department of Labor and Workforce Development (DOLWD) – Distressed Communities List
- Alaska Finance Housing Corporation – 2014 Alaska Housing Assessment
- United States Government Accountability Office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

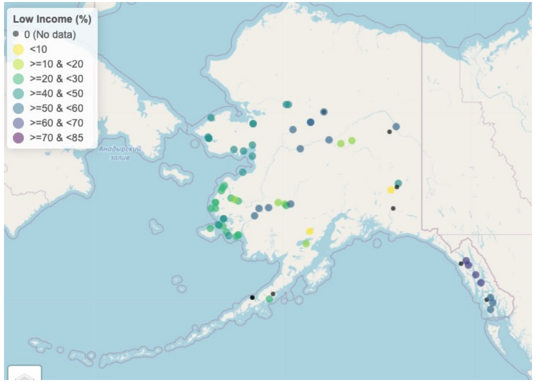
Stakeholder Engagement in Alaska, cont.

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

-Alaska Energy Authority (AEA)

-Tanana Chiefs Conference

-Cold Climate Housing Research Center (CCHRC)

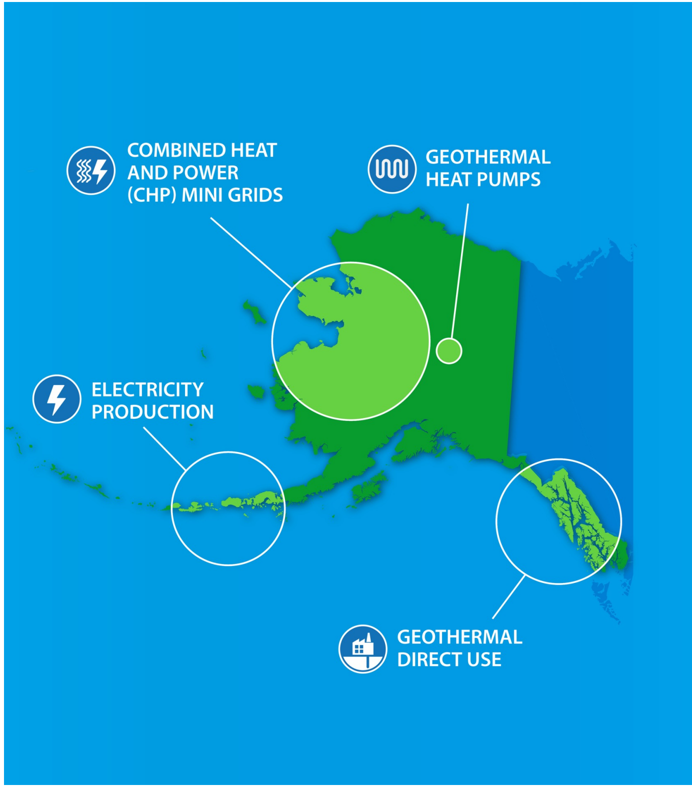
-Akutan Geothermal Project

-Renewable Energy Alaska Project (REAP)

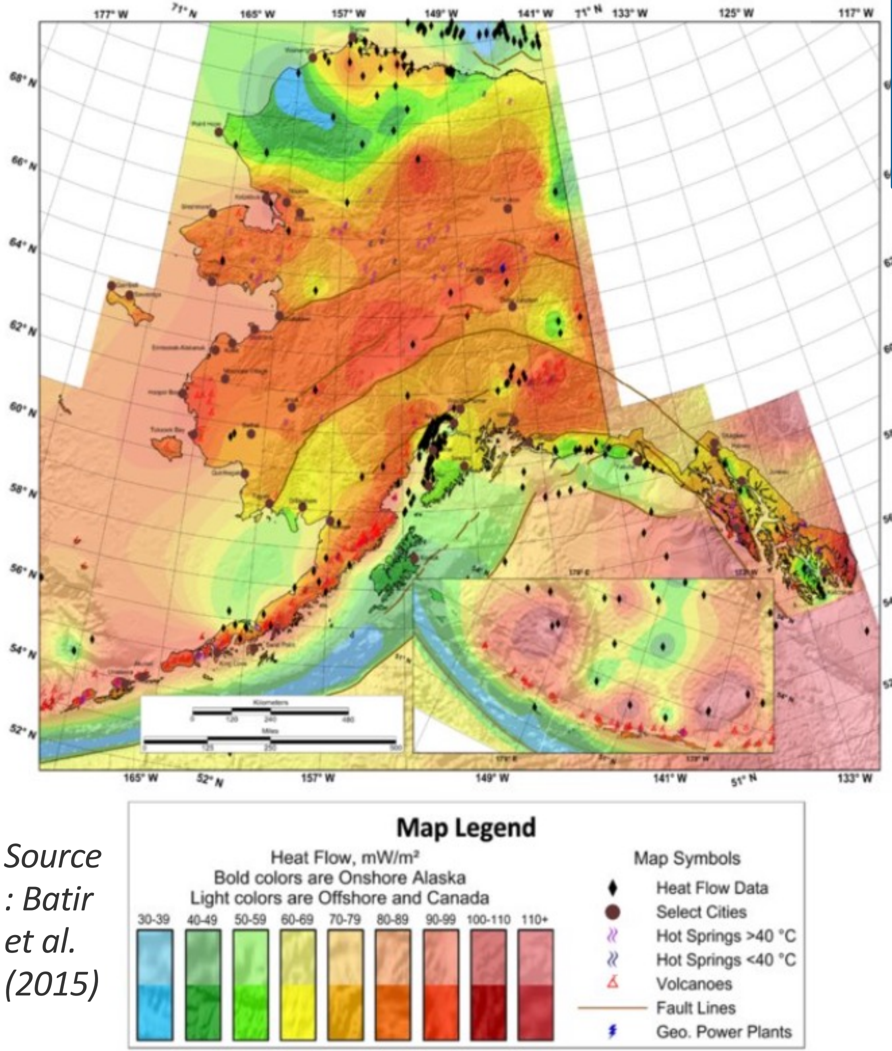
-Homer Electric Board

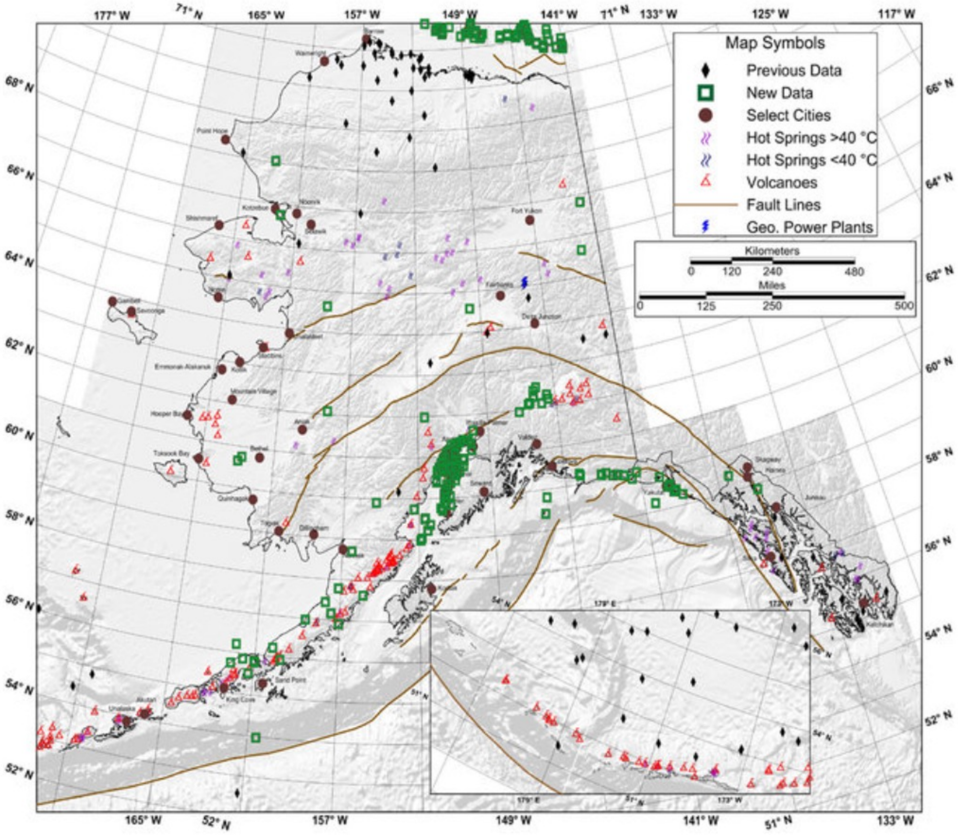
It was determined that the project outreach would take a multi-pronged approach:

- 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

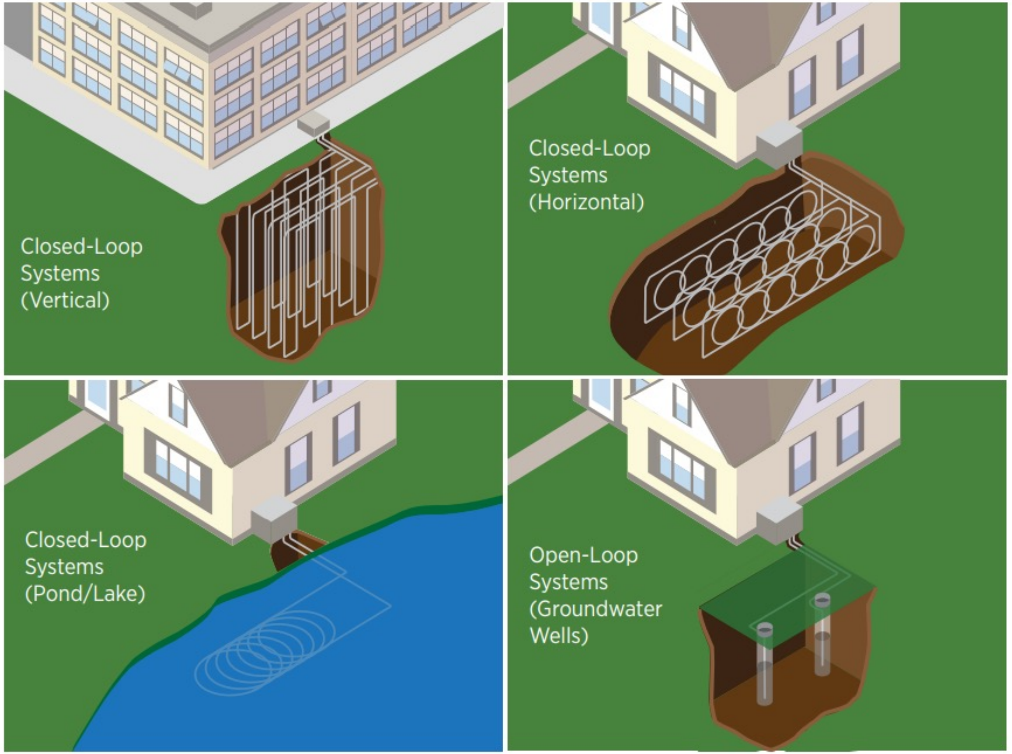




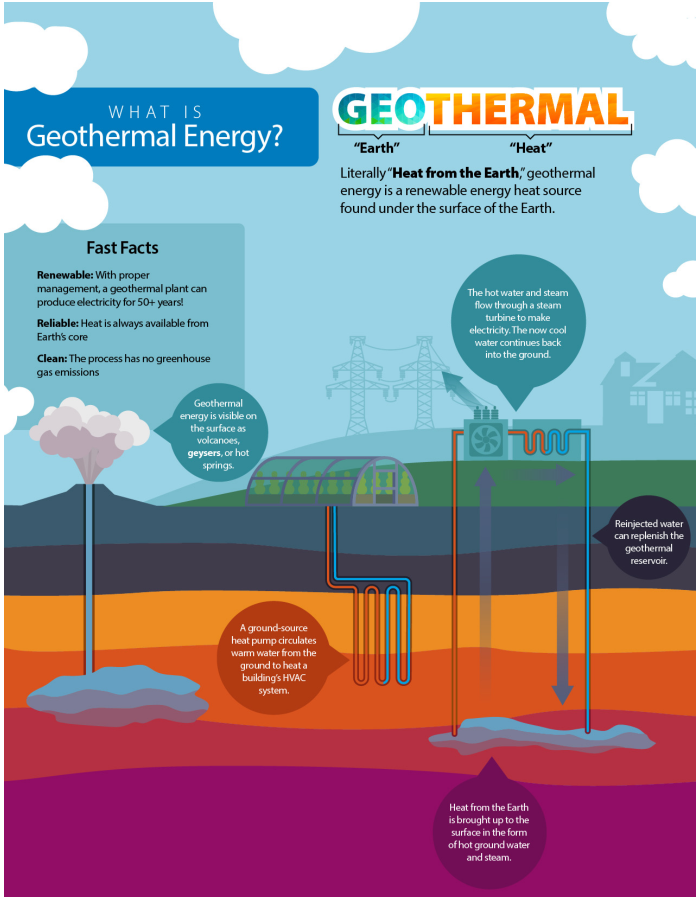
Source: Batir et al. (2015)

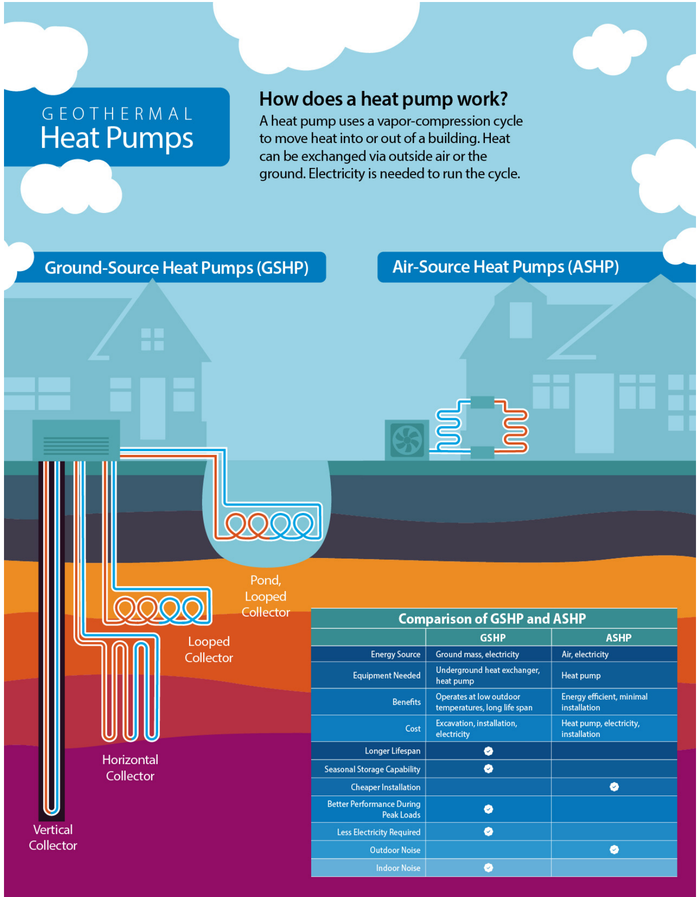
Challenge: Lack of Workforce

- 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





Comparison of GSHP and ASHP

	GSHP	ASHP
Energy Source	Ground mass, electricity	Air, electricity
Equipment Needed	Underground heat exchanger, heat pump	Heat pump
Benefits	Operates at low outdoor temperatures, long life span	Energy efficient, minimal installation
Cost	Excavation, installation, electricity	Heat pump, electricity, installation
Longer Lifespan	✓	
Seasonal Storage Capability	✓	
Cheaper Installation		✓
Better Performance During Peak Loads	✓	
Less Electricity Required	✓	
Outdoor Noise		✓
Indoor Noise	✓	

Discussion