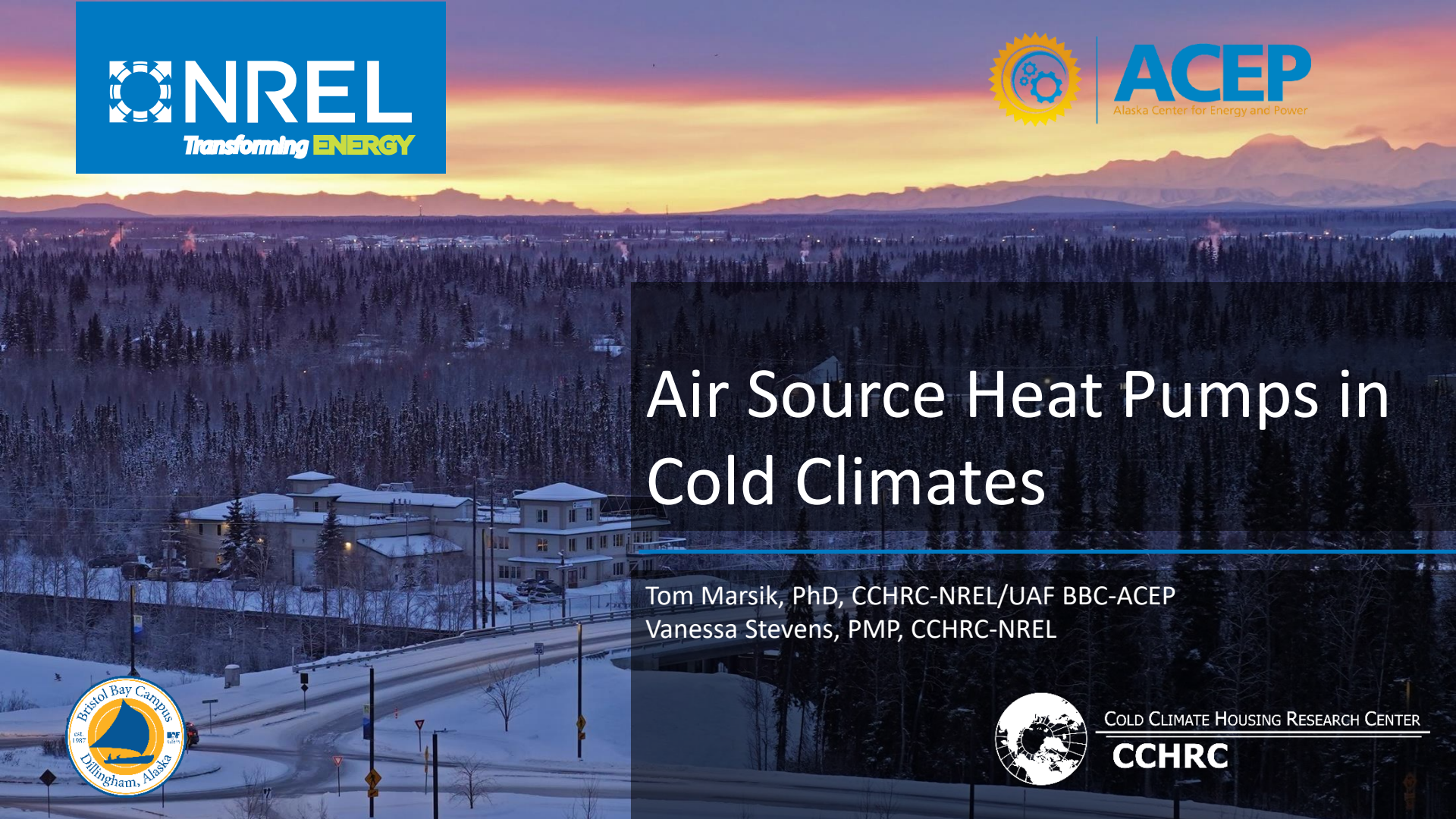

NREL Transforming ENERGY

ACEP Alaska Center for Energy and Power

# Air Source Heat Pumps in Cold Climates

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Cold Climate Housing Research Center
CCHRC

# Outline

1. Intro to heat pumps
2. Heat pump comparisons
3. Air source heat pump special considerations
4. Air source heat pump performance in Alaska
5. System approach (heat pump + efficient envelope)
6. Main conclusions
7. Additional resources

# How does a heat pump work?

Heat sources:

outside air

body of water

ground

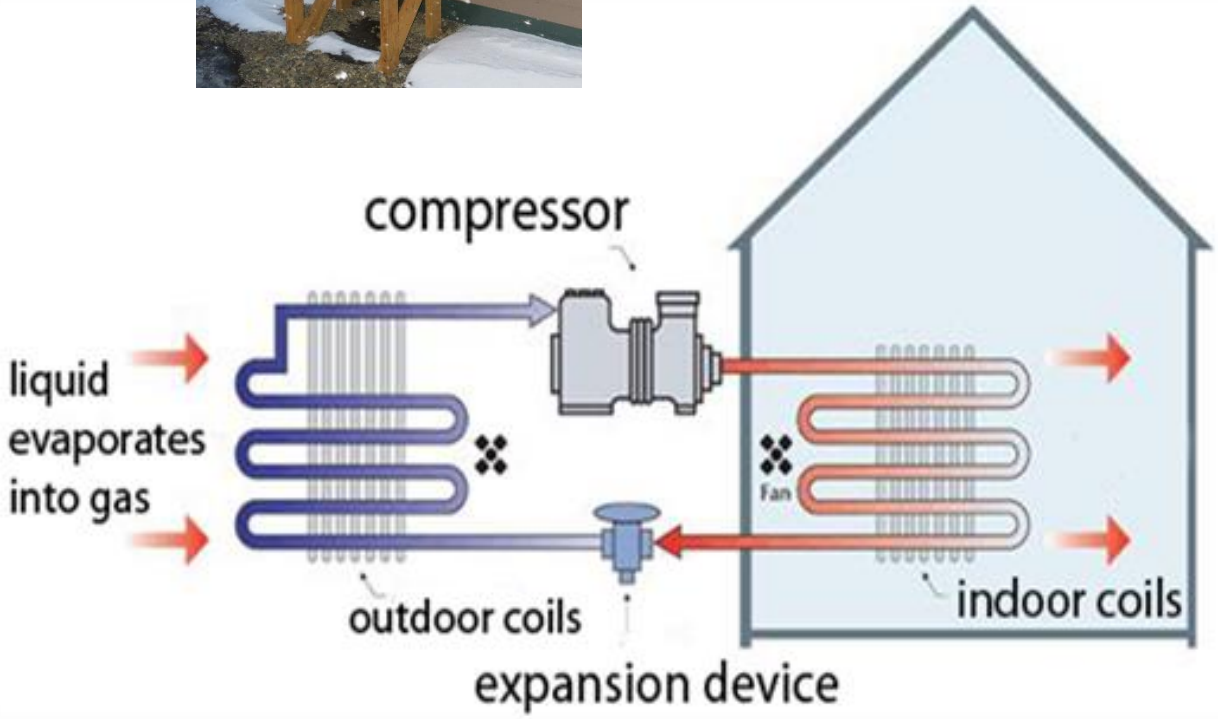



*Image courtesy of RETSCREEN.*

# Advantages of Heat Pumps

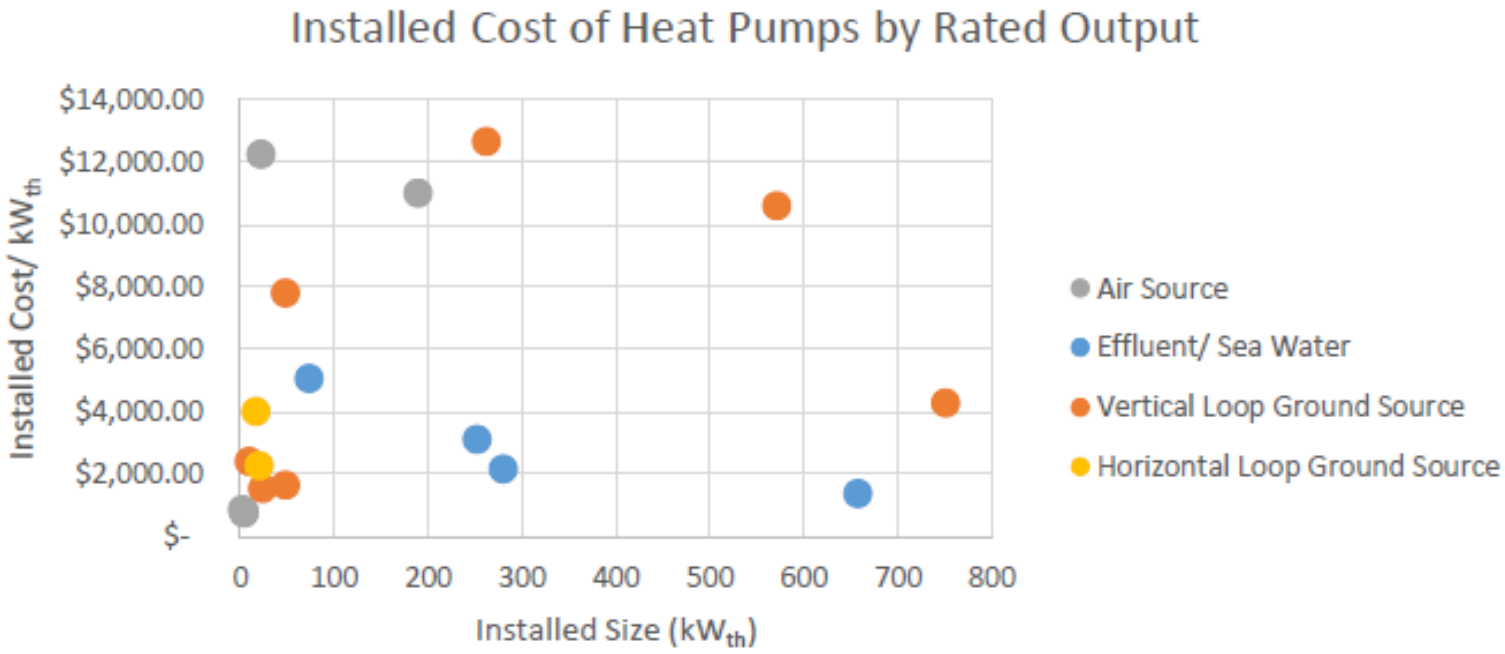

- Low maintenance
- No combustion
- Partially renewable
- Potential for lower energy costs

"Efficiencies" over 100%

# Coefficient of Performance (COP)

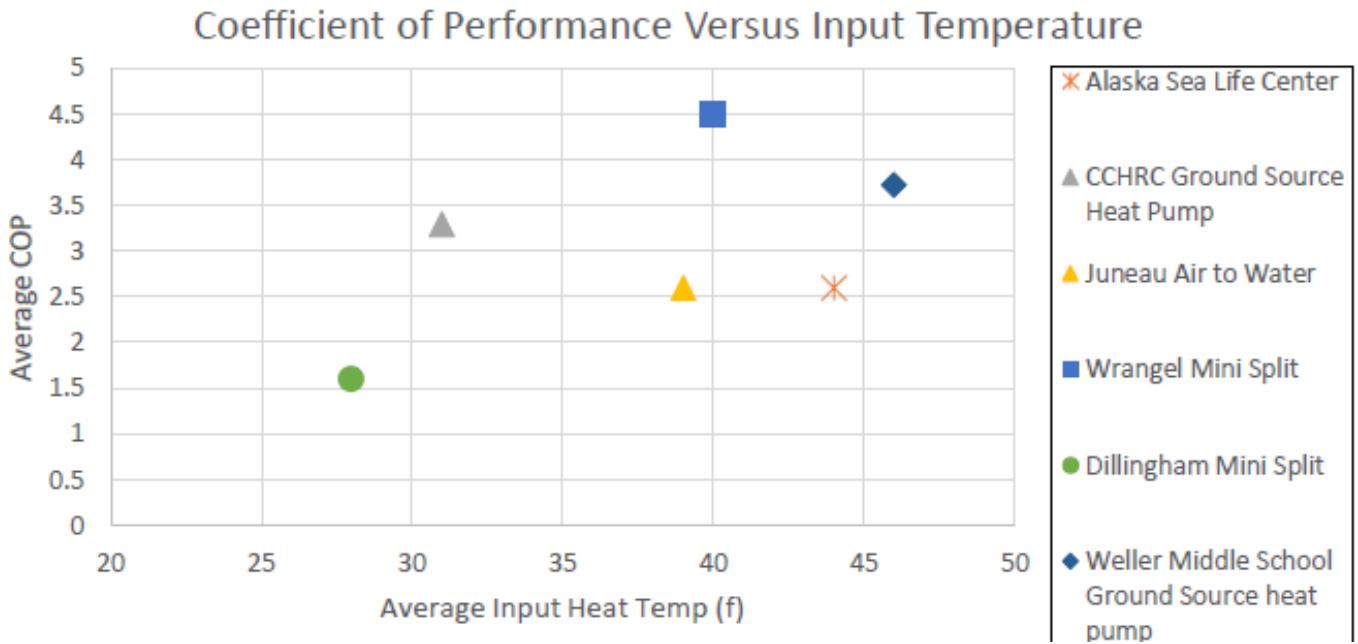
$$COP = \frac{heat\ delivered\ by\ the\ heat\ pump}{electrical\ energy\ supplied\ to\ the\ heat\ pump}$$

Note: Heating Seasonal Performance Factor (HSPF) = 3.41 x seasonal COP




# Comparison by Installed Cost

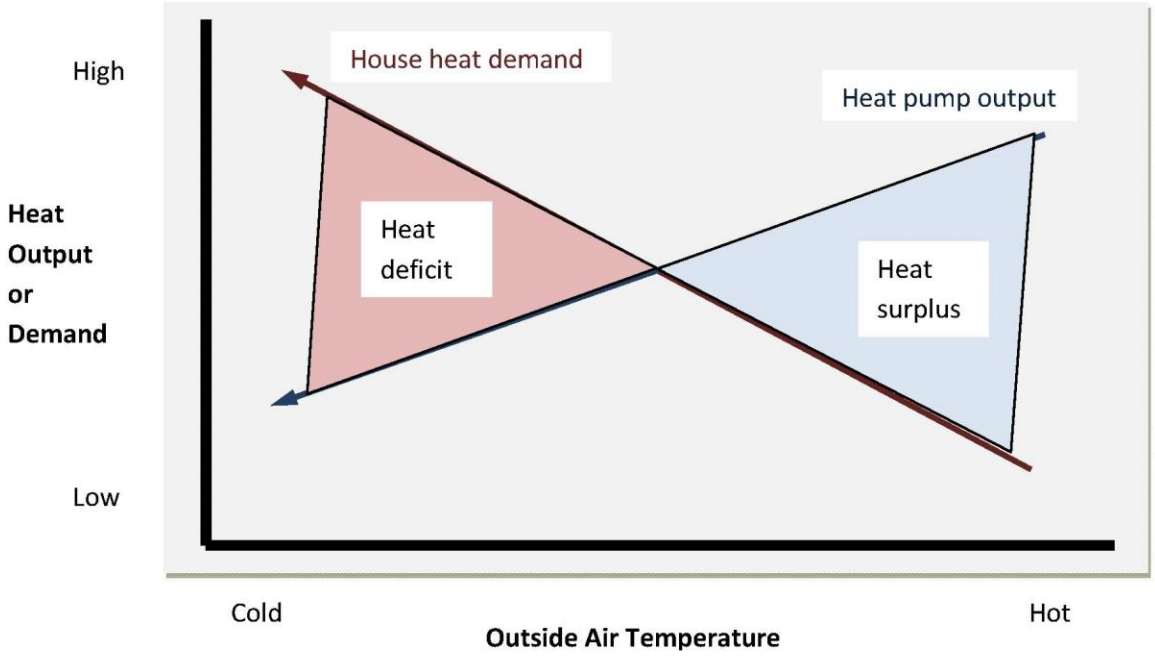
Source: University of Alaska Fairbanks Alaska Center for Energy & Power, Alaska Energy Technology Reports




# Comparison by Efficiency

Source: University of Alaska Fairbanks Alaska Center for Energy & Power, Alaska Energy Technology Reports

# Air-Source Heat Pumps: Fundamental Challenge



# ASHPs – Special Considerations

- Need for a backup heat source in cold climates
- What is the source of electricity and its efficiency?
- Air-to-air versus air-to-water
- For air-to-air: ducted versus ductless
- External thermostat vs. built-in thermostat for ductless
- Outside air cutoff temperature

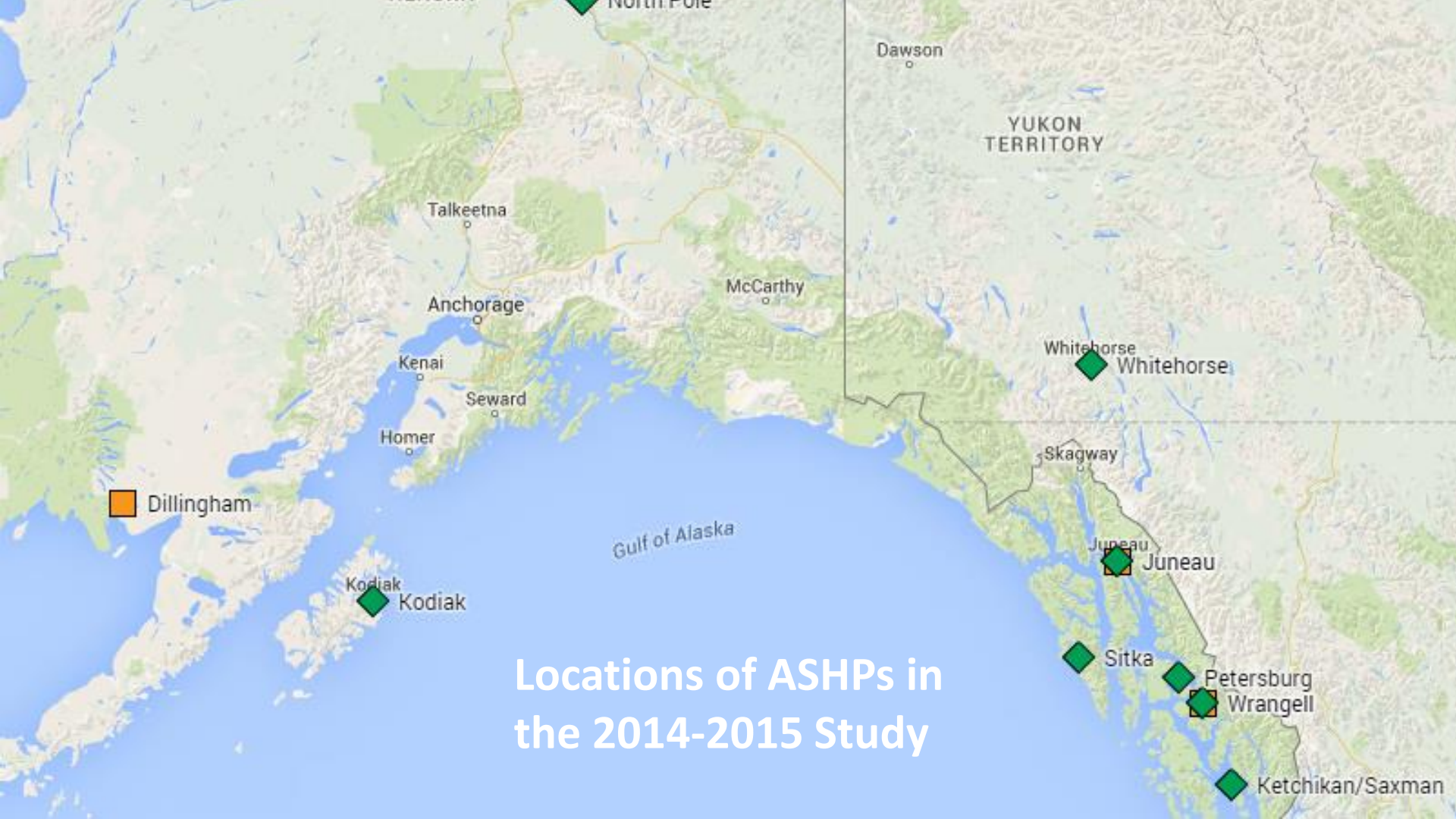
# Emerging Energy Technology Fund Grant

Air Source Heat Pump Potential in Alaska: CCHRC, UAF Bristol Bay Campus, Wrangell Municipal Light & Power

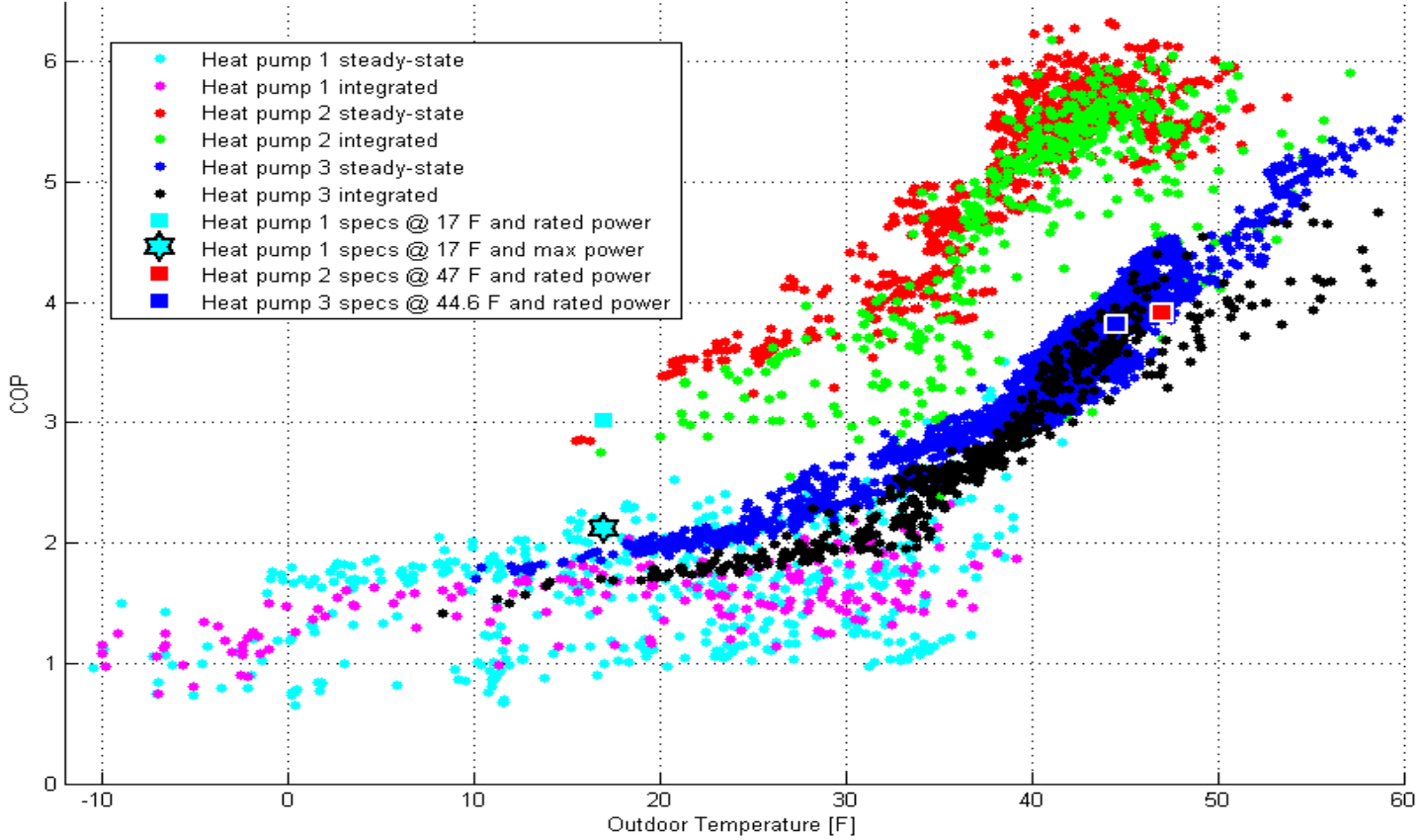
## Main Objectives

- Study the field performance of ASHPs in Alaskan conditions
- Study the behavior of ASHPs around cut-off temperatures
- Study the potential of using ASHPs as an electrical demand management tool by replacing resistive heating systems (primarily in Southeast Alaska)

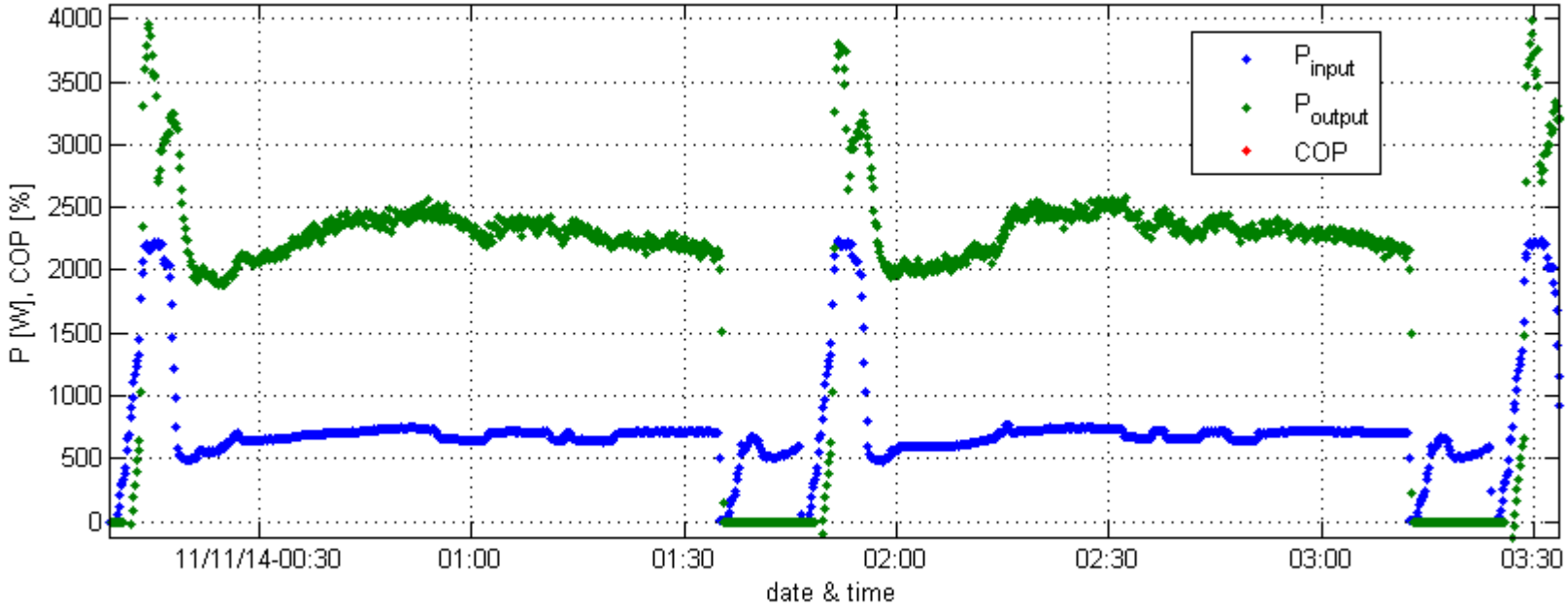

*Wrangell City Hall in Southeast Alaska is heated by a heat pump.*




# Locations of ASHPs in the 2014-2015 Study



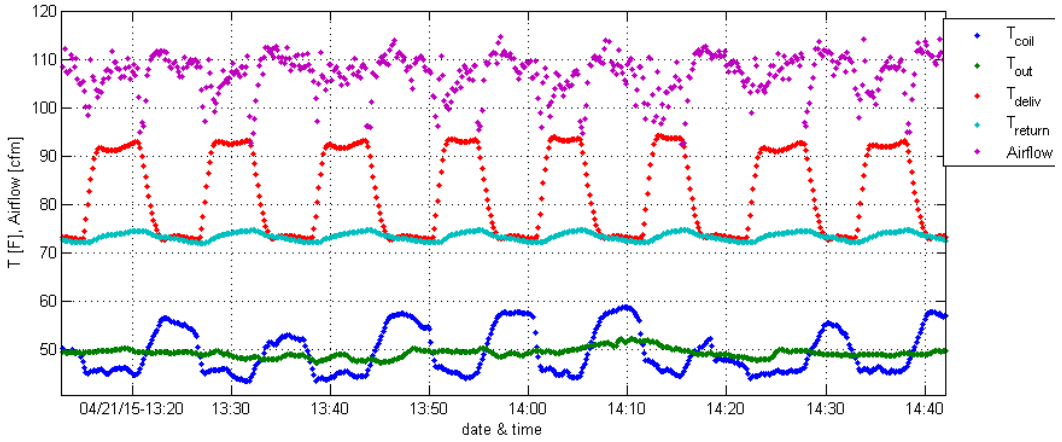

# ASHP Detailed Monitoring Results

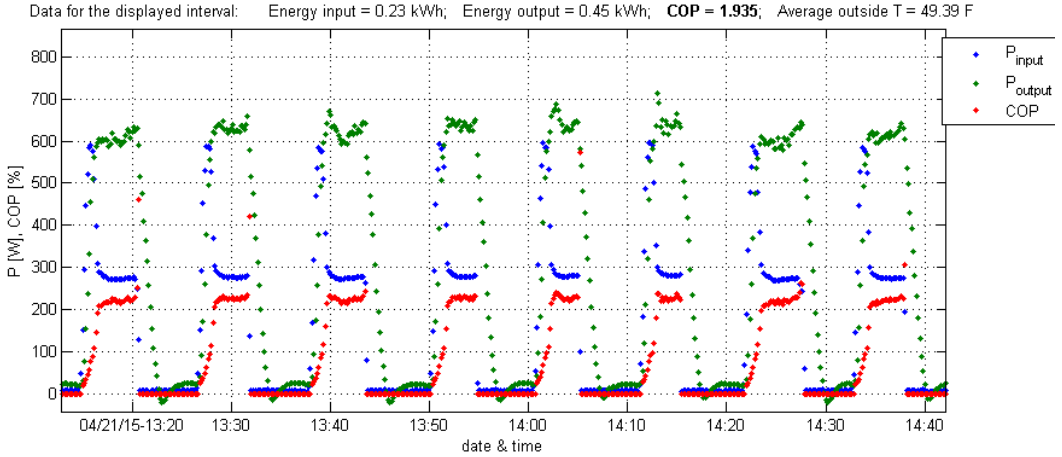



## ASHP detailed monitoring – general conclusions

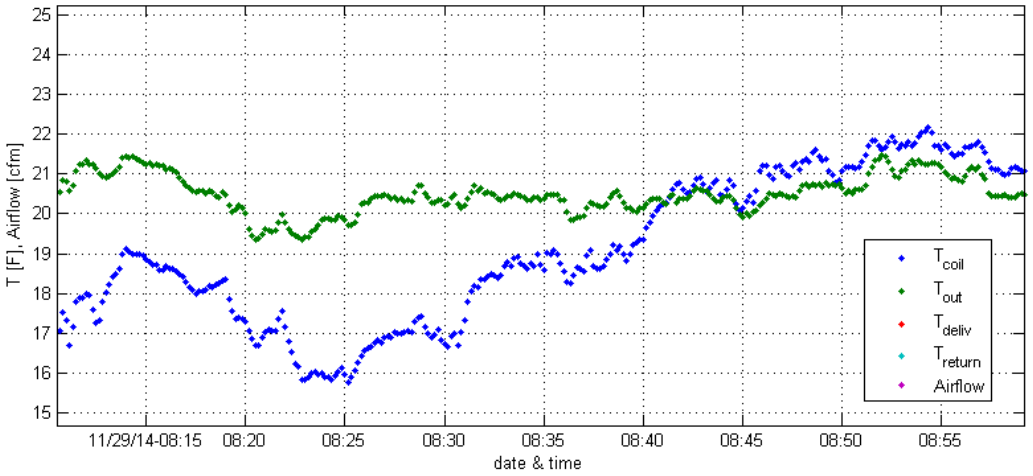
- Manufacturer's specifications do not always correctly reflect field performance
- Most documentation focuses on steady-state performance, but integrated performance data is needed for more accurate representation of cold-climate operation (includes cycling due to defrost)
- Large variations in efficiency among individual models

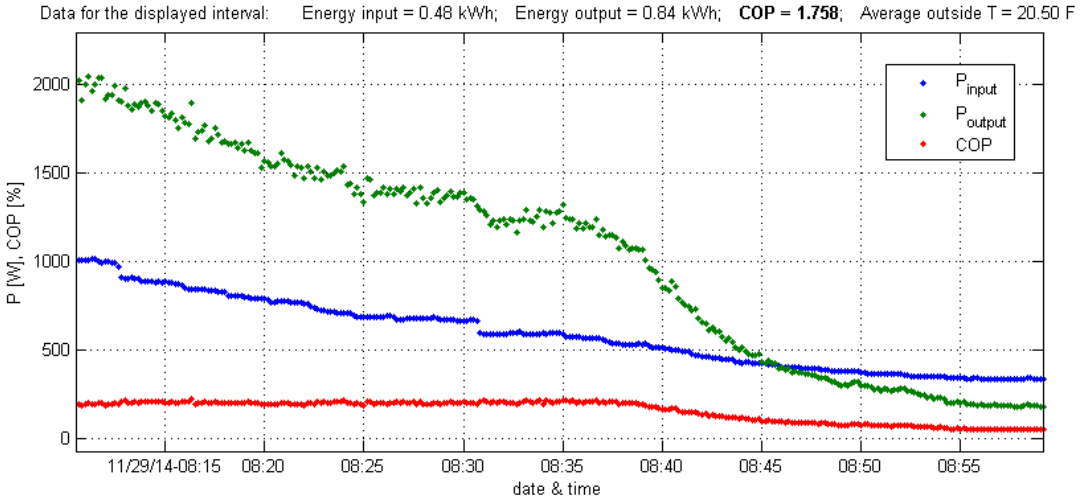
# ASHP Short-Cycling in Low-Load Conditions



# Rare Occurrence When COP Drops Below 1



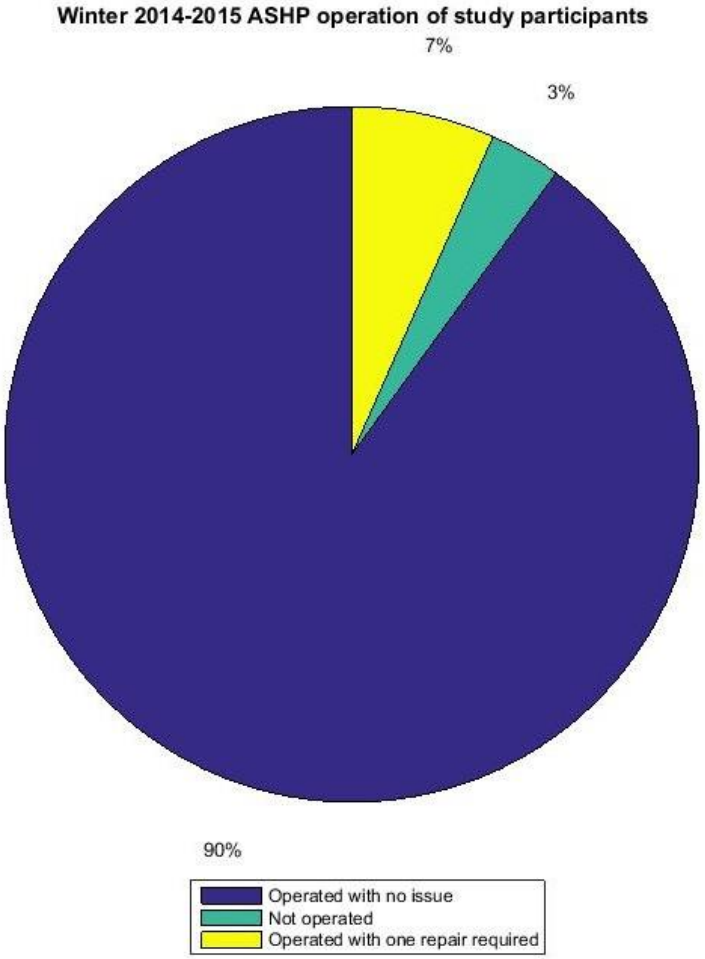
# ASHP General Monitoring - Results

30 building owners interviewed about ASHP use

- Commercial/Residential systems
- Ductless/Ducted/Air-to-water ASHP systems
- Retrofit/New Installations

**Findings**

- 29/30 systems provided adequate or expected heat
- 2 repairs needed, fixed at zero cost to the building owner
- 11 people performed maintenance on the system
- 12 people used their back-up heating system (29 had back-up heat available)



# ASHP General Monitoring - Results

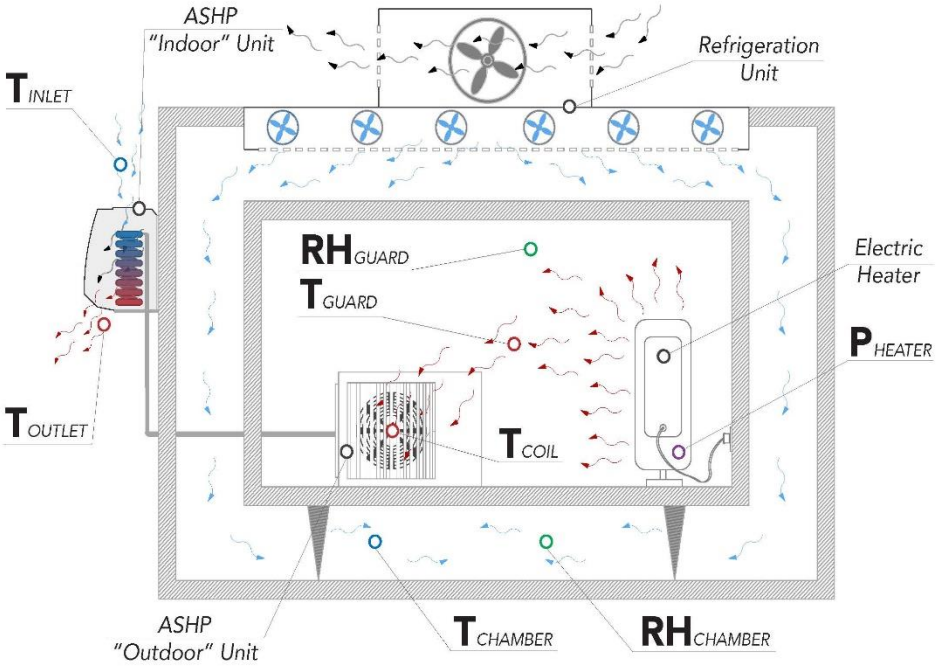
Selected Sites – direct and/or indirect monitoring of ASHP electricity

**Main findings**

- Limited data does not confirm that ASHPs will always reduce electrical energy use, even when replacing electric resistance heat.
- ASHPs have only a small effect on peak power demand.
- Demand-side management programs should include measures other than ASHPs.

# Current Research

Evaluating ASHP performance at different levels of thermal loading



# System Approach: Heat Pump + Efficient Envelope

# ASHPs – Main Conclusions

- ASHPs can significantly reduce energy use and energy costs when used in appropriate situations and done right.
- More research needed to gain better understanding of ASHP performance in cold climates to guide future deployment.
- System approach yields biggest savings.

# Credits

**Individuals:**

Colin Craven
Robbin Garber-Slaght
Bruno Grunau
Clay Hammer
Jim Rehfeldt
Chris Pike
Erin Whitney
Alan Mitchell
Dirk Baker
Others

**Organizations:**

Golden Valley Electric Association
Alaska Energy Authority
National Science Foundation
U. S. Dept. of Agriculture
Alaska Housing Finance Corporation
U.S. Dept. of Defense
U.S. Dept. of Energy
Others

# Thank you!

# Questions ?

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# Additional Resources

## Alaska Mini-Split Heat Pump Calculator

**by Analysis North**

https://heatpump.cf

## Air Source Heat Pump Installer and Consumer Resources

**By Northeast Energy Efficiency Partnerships**

https://neep.org/high-performance-air-source-heat-pumps/air-source-heat-pump-installer-and-consumer-resources