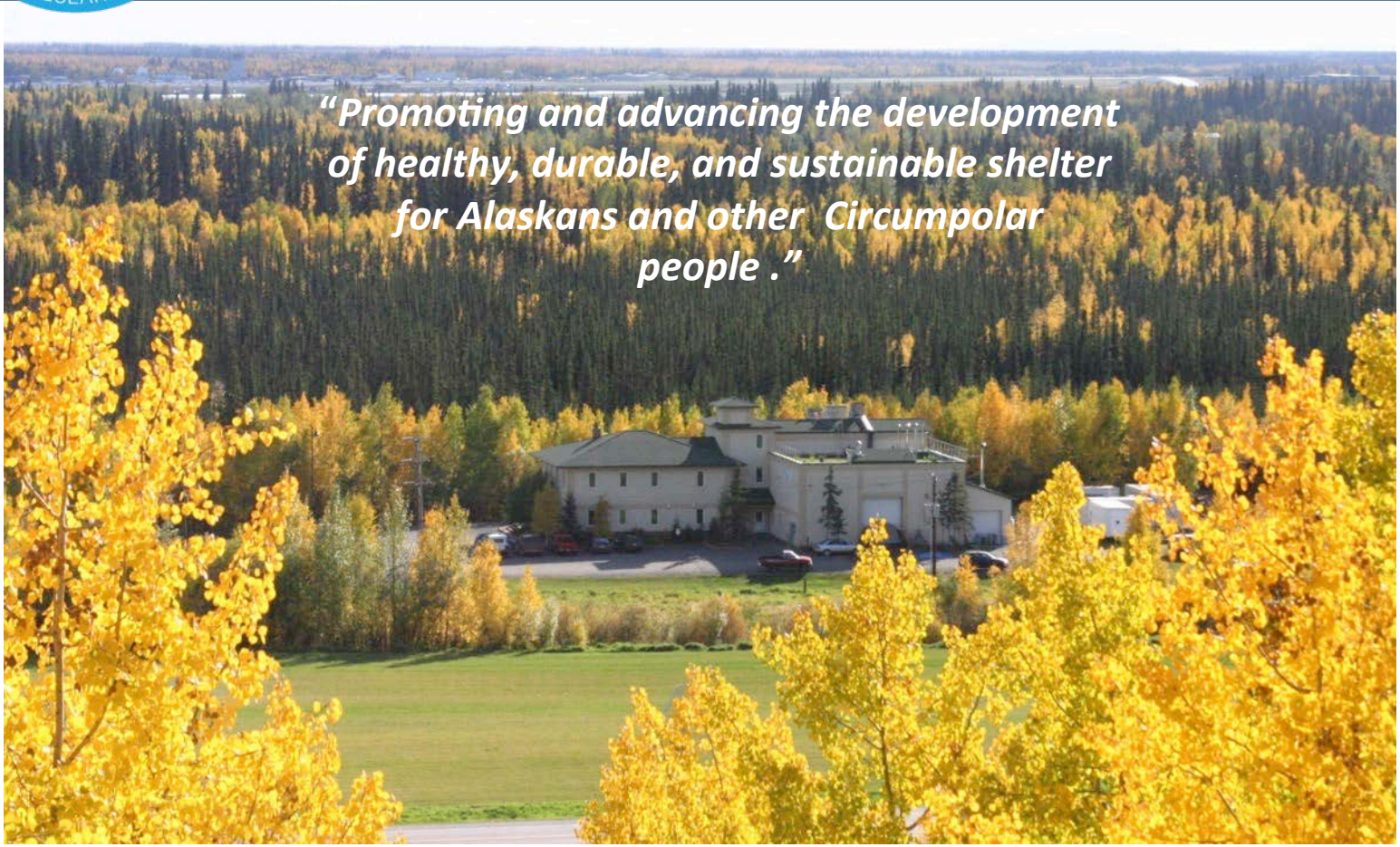
CCHRC study of Air Source Heat Pumps in Cold Climates

Discuss progress on report on NRC partnership

Technology of net zero ready home, lessons learned

Air Source Heat Pump Performance in Alaska



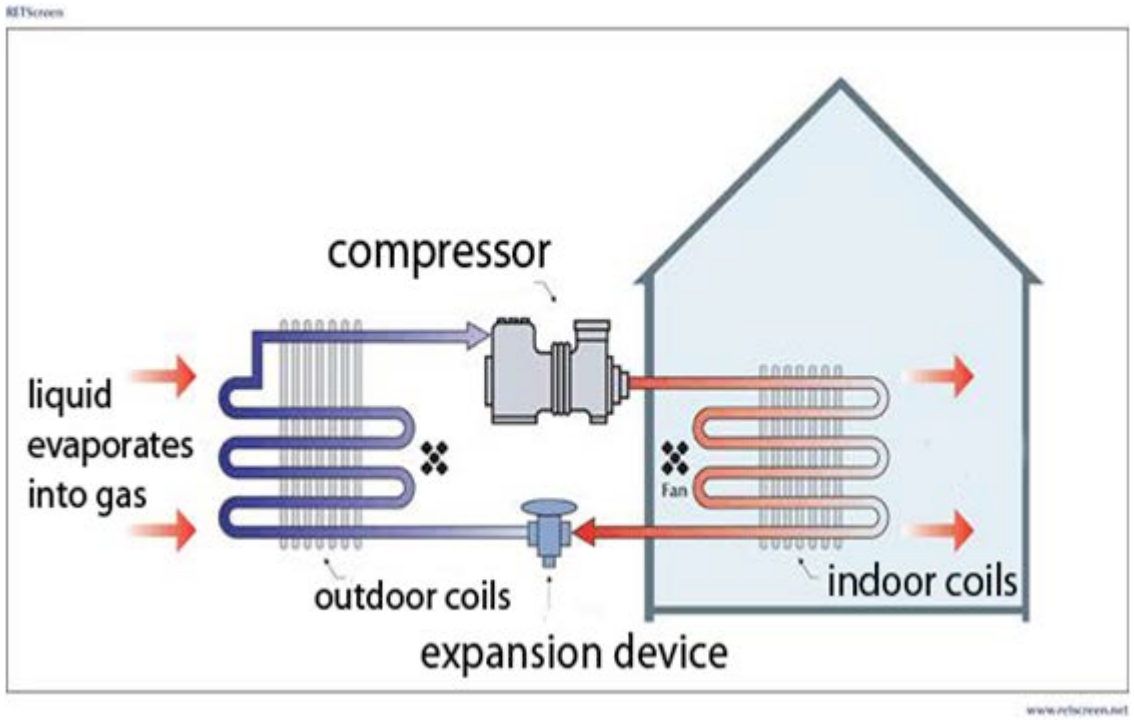
Bruno C. Grunau, PE

How does a heat pump work?

Heat pumps use a **refrigeration cycle** to move heat energy from one place to another. They can be used for **heating or cooling**.

When used for heating, the heat pump **gathers heat from a source**, then uses an **electrically-run compressor** to step that heat pump to a higher temperature.

Heat sources:
Outside air
Body of water
Ground



An ASHP refrigeration cycle moves heat from the outside air to the inside of a home.

There are two main types of heat pumps: ASHPs and GSHPs.

ASHP Outdoor Coils

Air source heat pumps use the **outside air as a heat source**. They can distribute heat via traditional forced air systems, ductless heads, or via hot water.

Ductless ASHP Interior Head

Heat pumps in homes offer several advantages:

Wrangell City Hall is heated by an ASHP.

Heat pumps provide **partially renewable heat** to buildings at efficiencies **greater than 100%**. They are totally renewable if the electricity comes from a renewable resource.

Heat pumps are **low-maintenance, no-combustion appliances** that often can offer **lower energy costs for heating and cooling** for homeowners.

Utilities have explored using heat pumps in **demand-side management strategies**, replacing electric resistance heat.

Heat pump efficiency (Coefficient of Performance)

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

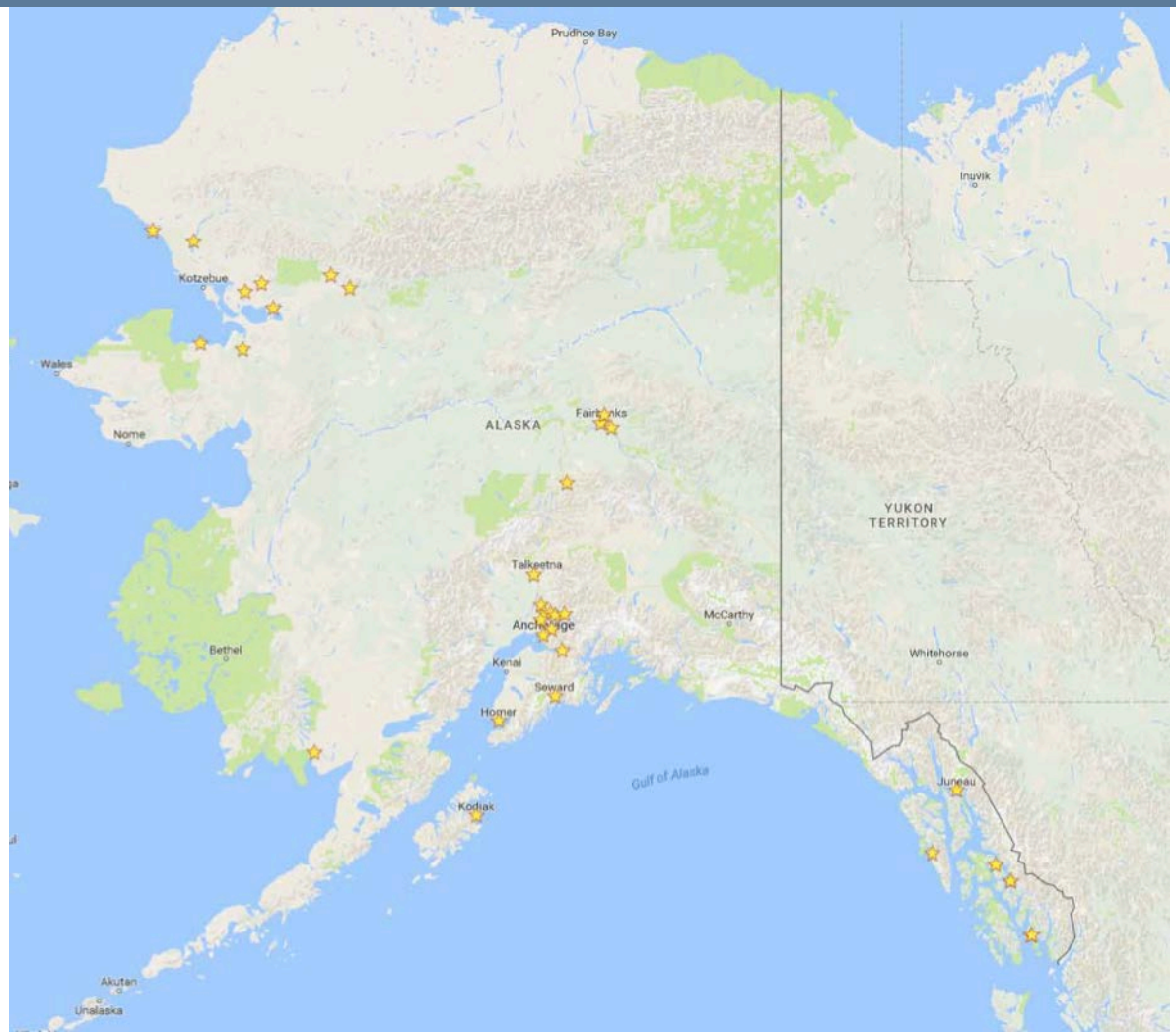
Heat pumps are an emerging technology in cold climates.

Outdoor coils of an ASHP in North Pole, AK

Heat pump COP depends on the temperature of the heat source, so it is less in colder climates and soils. None-the-less, **the trend is toward more installations** of both ASHPs and GSHPs in Alaska.

Challenges for ASHPs:
Need for back-up heat
Defrost strategies
Outdoor coils exposed to inclement weather

ASHPs are increasingly being used in Alaska for space conditioning and hot water.



Air Source Heat Pumps

- The low temp energy reservoir is the air
- They work to minimum temperature of about -15°F
- They lose efficiency as the temperature drops
- They also deliver less heat as the outdoor temperature drops
- There are colder temperature models in development

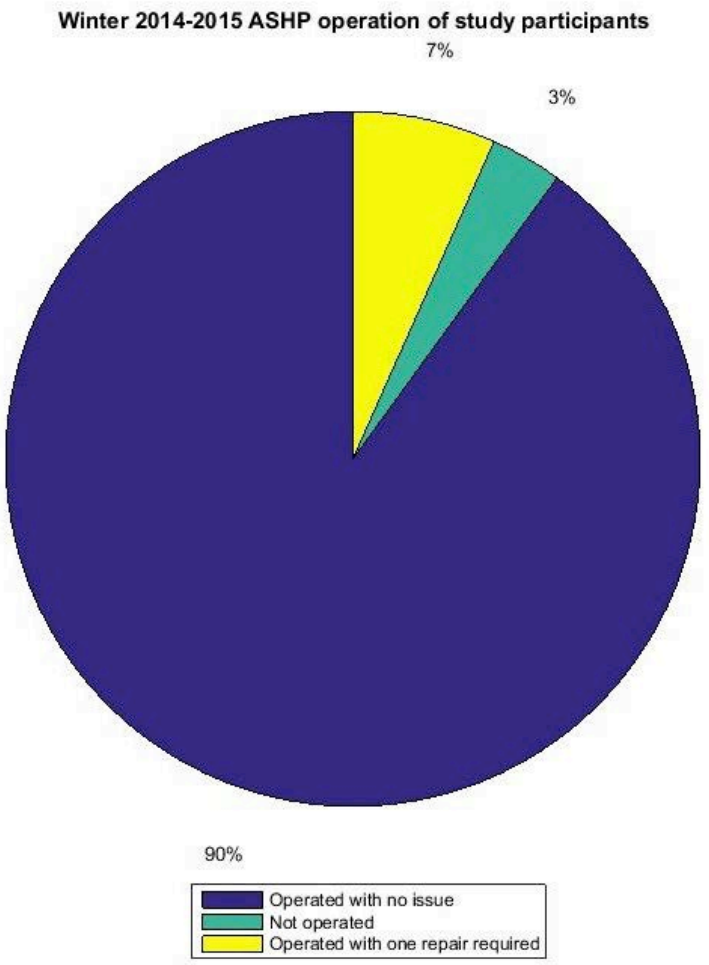
A survey of 30 ASHP users in Alaska indicated that they are satisfied with the appliances.

The study interviewed thirty building and homeowners about ASHP use in the winter 2014-2015:

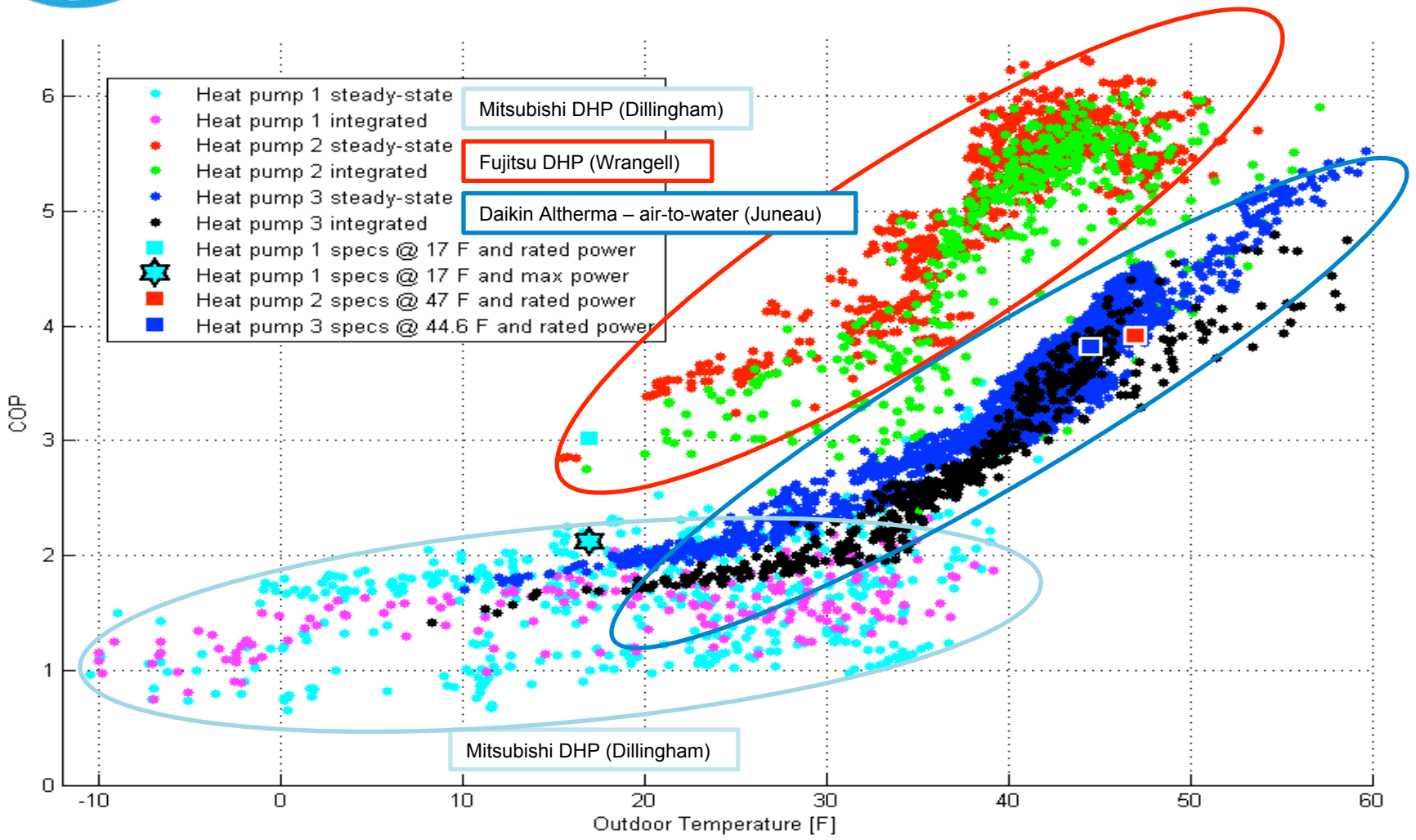
- Mix of ductless ASHPs, forced air ducted ASHPs, and air-to-water systems, commercial and residential systems, retrofit appliances and new installations

Findings:

- **29** out of 30 systems provided adequate or expected heat.
- **2** repairs needed, both fixed at no 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)



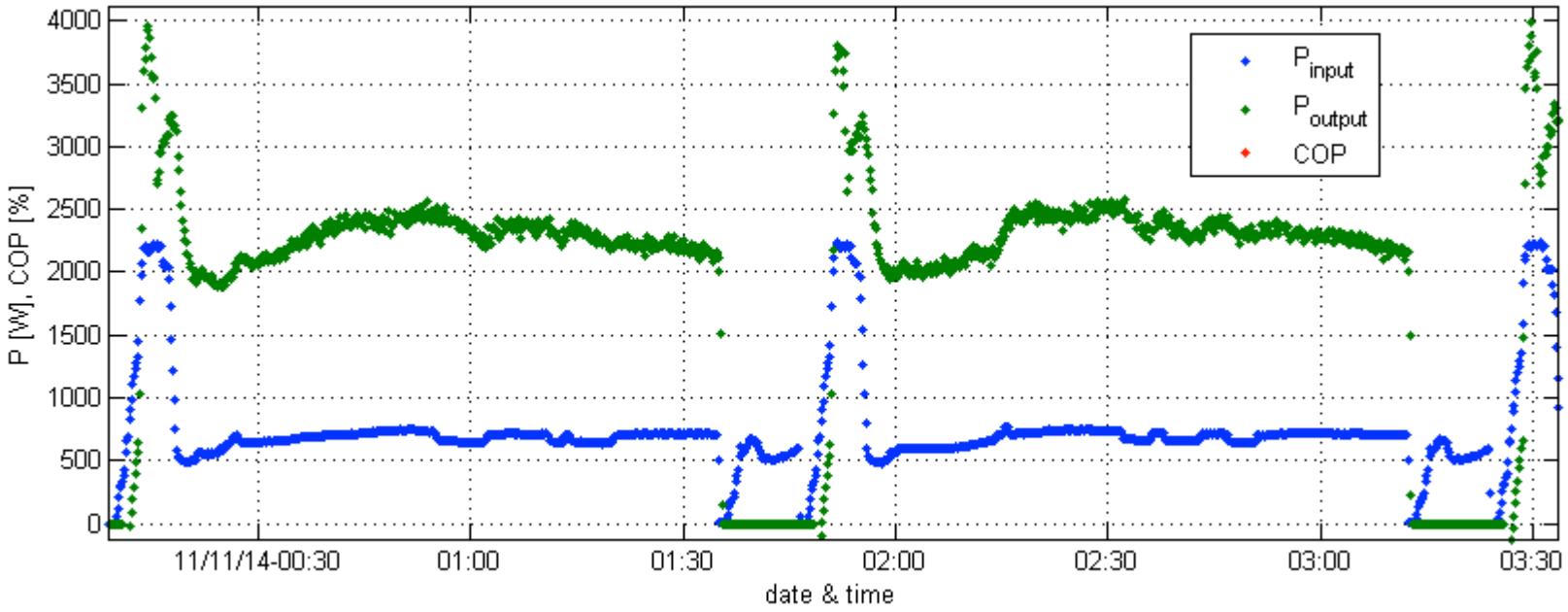
Summary of results for 3 ASHPs selected for detailed monitoring



ASHPs detailed monitoring - general conclusions

- Manufacturer's specifications are not always correct
- Most documentation focuses on steady-state performance, but integrated performance data is needed for more accurate representation of cold-climate operation (includes defrost cycles)
- Large variations in efficiency among individual models

Defrost Cycles

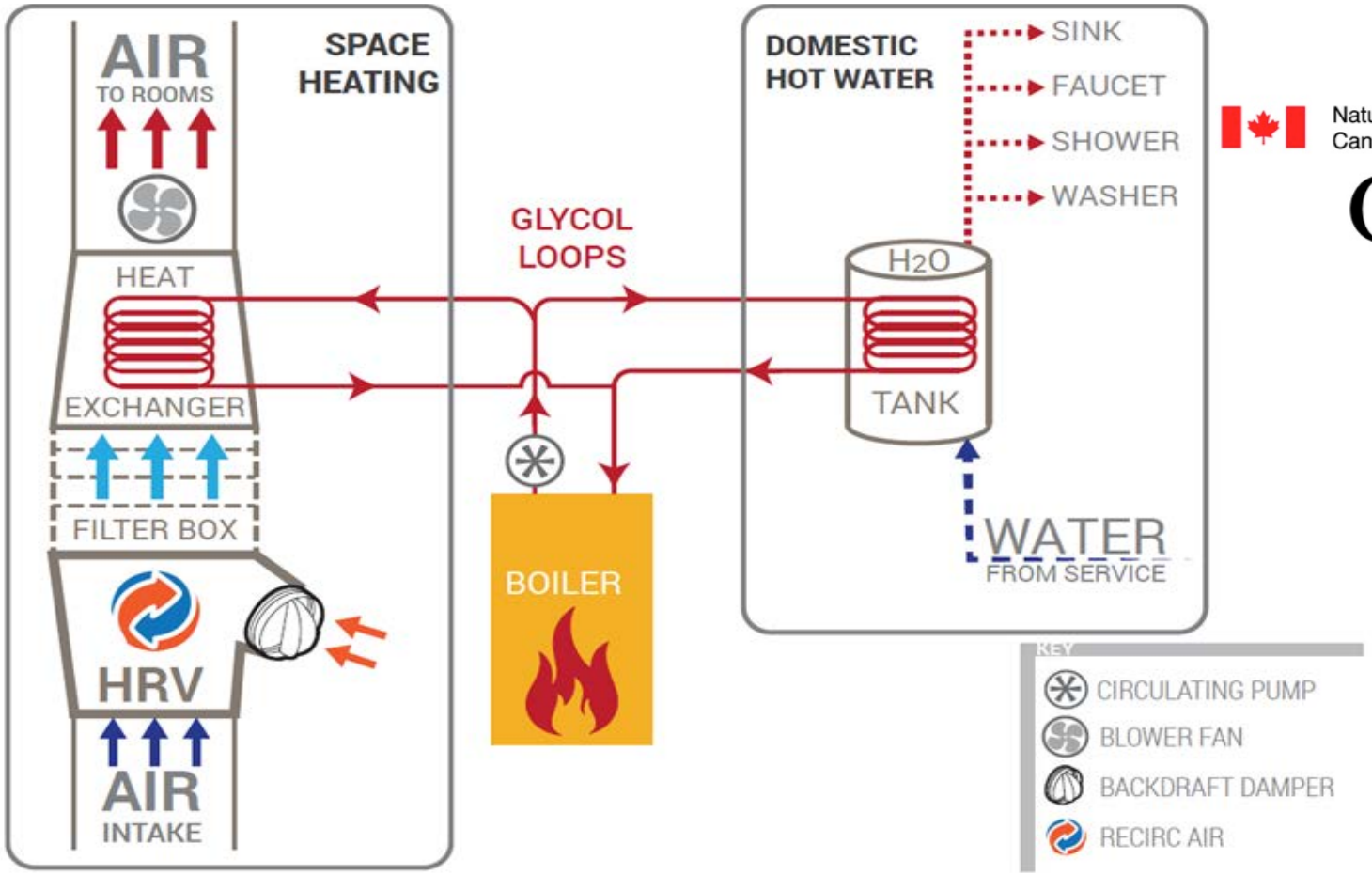


Future of cold climate ASHPs

Current research is still being conducted on ASHPs with the aim of adapting the technology to work in even lower temperatures.

- Strategies include multiple stage refrigeration cycles, cooling the oil in the compressor, and new refrigerants
- Current prototype ASHPs have operating limits down to -25°F

ASHP integrated BrHEAThe System



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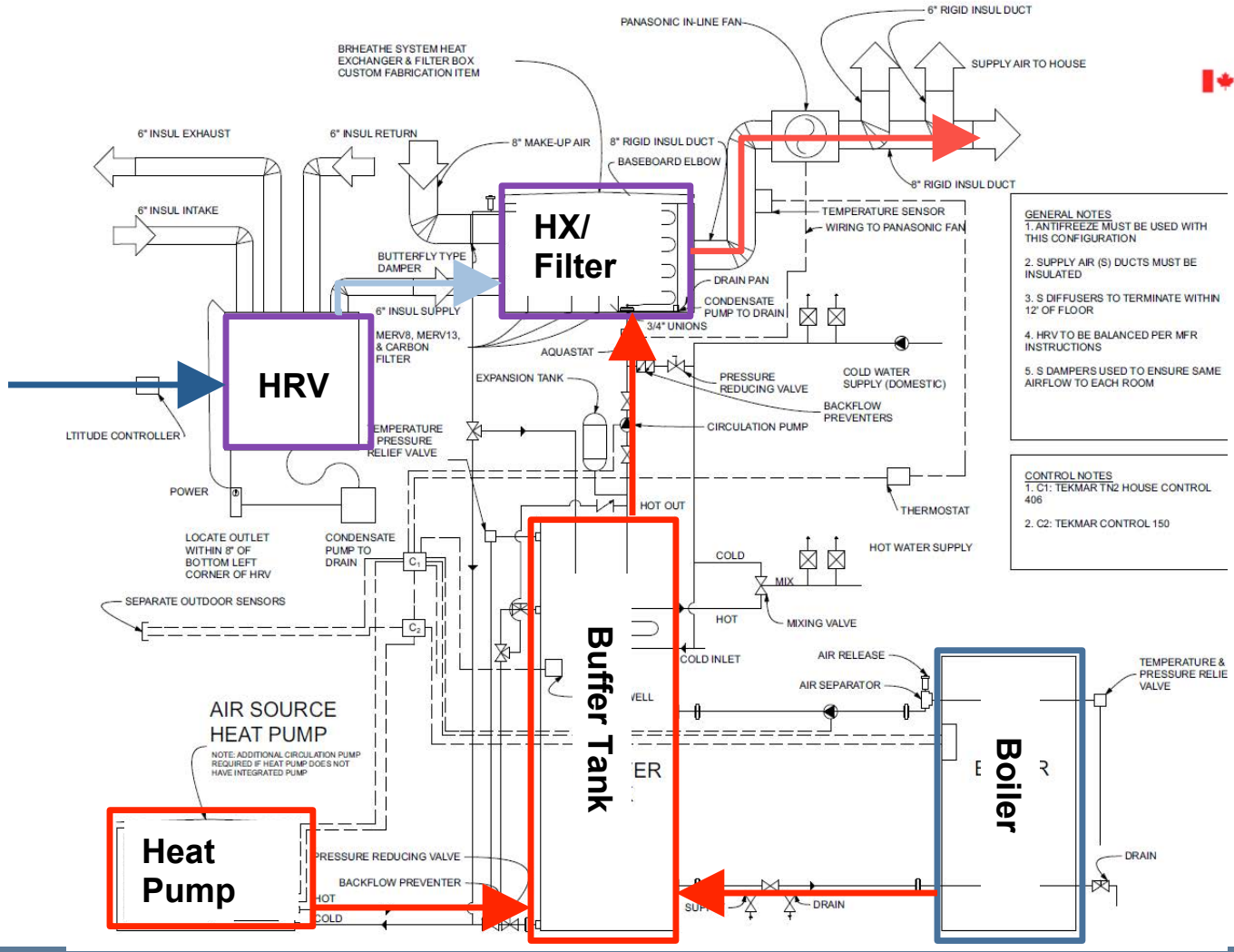
ASHP integrated BrHEAThe System



ASHP integrated BrHEAThe System

Sanden (CO_2)

Chiltrix
(R-410A)

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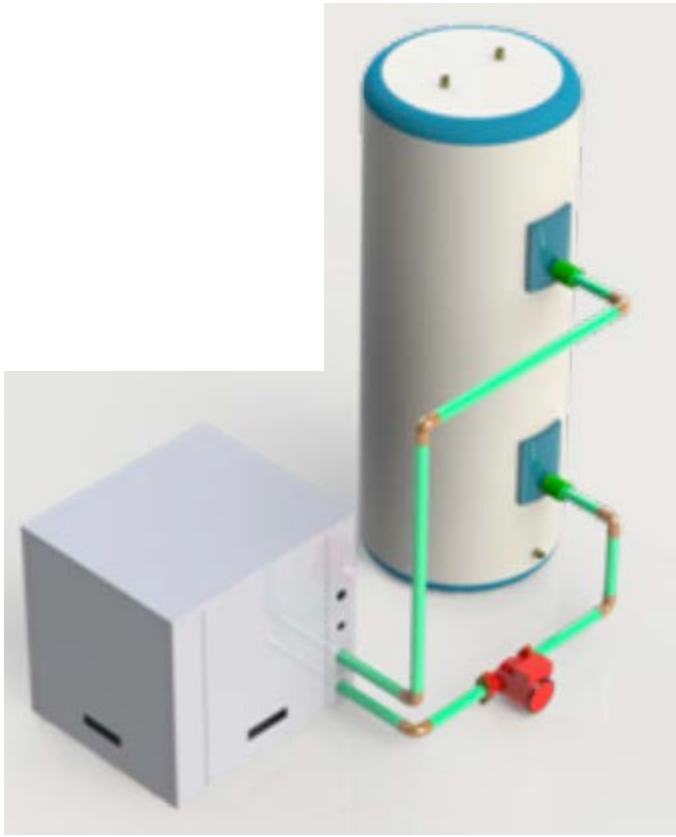


Ecologix
(R-410A)

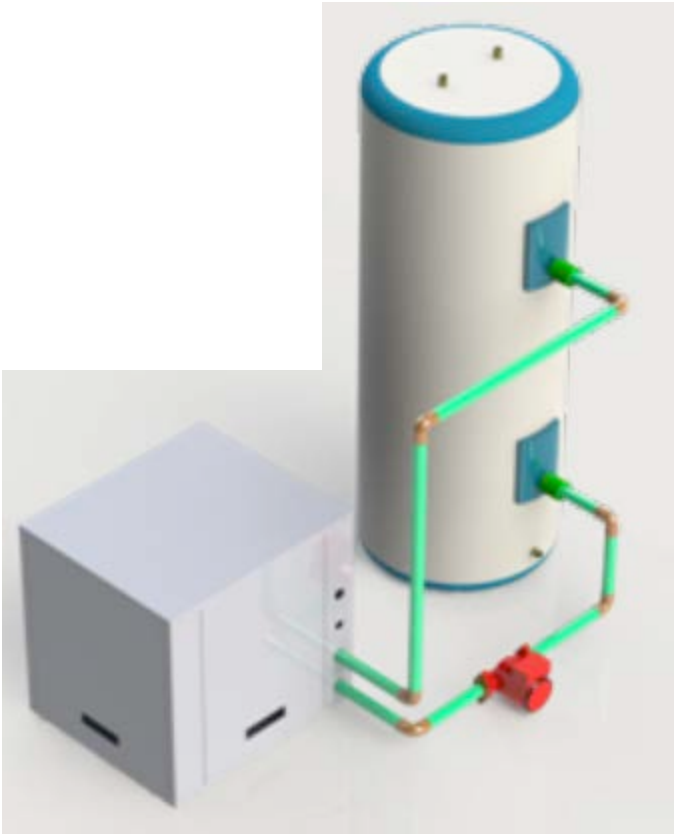
ASHP integrated BrHEAThe System

Sanden (CO_2)

Estimated Annual Fuel Savings of using Sanden ASHP (USD)			
	BrHEAThe Systems without Heat Pump		
City	Natural Gas 95% Boiler	Oil 95% Boiler	Electric Resistance
Calgary	($207.83)	$592.94	$613.88
Edmonton	($242.23)	$504.47	$579.48
Halifax	$353.62	$541.24	$1,156.78
Montreal	$292.91	$946.73	$505.28
Ottawa	($349.18)	$531.74	$950.21
Vancouver	$199.51	$1,055.83	$755.10
Winnipeg	($150.06)	$631.15	$388.28

ASHP integrated BrHEAThe System

Estimated Annual Fuel Savings of using Ecologix ASHP (USD)			
	BrHEAThe Systems without Heat Pump		
City	Natural Gas 95% Boiler	Oil 95% Boiler	Electric Resistance
Calgary	($293.03)	$507.74	$528.68
Edmonton	($308.25)	$438.45	$513.46
Halifax	$162.98	$350.60	$966.14
Montreal	$225.16	$878.98	$437.54
Ottawa	($473.58)	$407.34	$825.81
Vancouver	$64.51	$920.84	$620.11
Winnipeg	($163.27)	$617.93	$375.06



Ecologix
(R-410A)

ASHP integrated BrHEAThe System

Chiltrix
(R-410A)

Estimated Annual Fuel Savings of using Chiltrix ASHP (USD)			
	BrHEAThe Systems without Heat Pump		
City	Natural Gas 95% Boiler	Oil 95% Boiler	Electric Resistance
Calgary	($295.30)	$505.48	$526.41
Edmonton	($326.45)	$420.25	$495.26
Halifax	$198.76	$386.38	$1,001.93
Montreal	$221.24	$875.06	$433.61
Ottawa	($484.19)	$396.73	$815.20
Vancouver	$105.10	$961.42	$660.69
Winnipeg	($212.42)	$568.79	$325.92

ASHP integrated BrHEAThe System

Sanden (CO_2)

Chiltrix
(R-410A)

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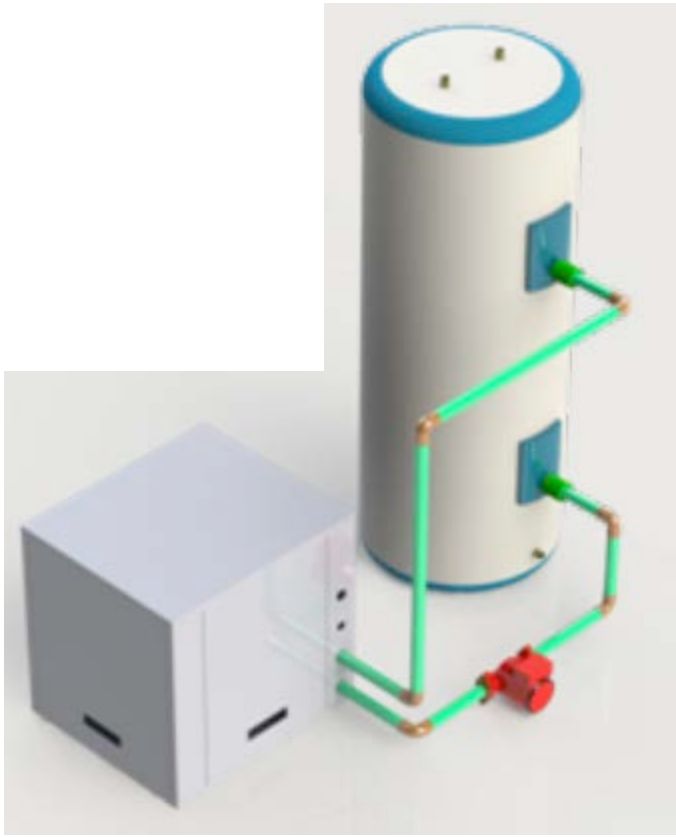

Ecologix
(R-410A)

Heat Pumps: The Path to Net Zero

Peter Amerongen & Gordon Howell

Questions?

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