BrHEAThe
motivation, history, and evaluation

“Promoting and advancing the development of healthy, durable, and sustainable shelter for Alaskans and other Circumpolar people.”
The BrHEAThe system is one method to ensure that homes have affordable heat and adequate ventilation.
14,600 homes in Alaska have a 1-star energy rating.
Over half of Alaskan homes are at risk for poor indoor air quality.
BrHEAThe is a combined heating and ventilation system.

Objective:
Provide affordable, comfortable space heating and good indoor air quality to small, airtight, energy efficient homes in Alaska.

Goals:
Safe
Efficient
Affordability
Simple
Modular
Flexible
CCHRC worked with the occupants of an energy efficient prototype home in Anaktuvuk Pass to install the first BrHEAThe system.
The first iteration of BrHEAThe...provided valuable experience and lessons learned.
The second iteration of BrHEAThe... provided valuable experience and lessons learned.
The third iteration of BrHEAThe...
The current version of BrHEAThe remains true to the original goals but looks a lot different than that first system.
The current BrHEAThe system is made up of four main mechanical components, and...
The final, most important piece is user-education.
BrHEAThe is an ongoing, collaborative system.
In 2017, CCHRC began a project to formally evaluate the BrHEAThe system.
User survey: Are homeowners satisfied with BrHEAThe?

“Ventilation is great. The air feels fresh. There is no ice on the windows.”

“The upstairs is constantly cool. If we are sitting in the living room doing homework, we put on extra clothes.”

“The bedroom closest to the mechanical room is too hot with door closed”
User survey: Are installers satisfied with BrHEATHe?

“Due to the critical nature of indoor air quality and minimal heat requirements in extremely tight buildings, I feel this is an excellent approach.”

“Efficiency, comfort, design, quiet, robust components, comfortable.”

“Not turning off ventilation is a key component. Especially in rural housing, which has a small footprint and high density, ventilation is important for health and safety.”

“This thing is accidentally working, almost, because the building so [air]tight.”

“With the BrHEATHe system, it is designed to be ‘one-size-fits-all’.”

“Homeowner maintenance is a design factor.”

“It is very difficult to control temperatures in a [single] zone set-up.”

“Delays with other contractors not completing work or being behind schedule.”

“Expectations meeting reality in first installs. Also have to learn how much to order, and what quality.”

“Heat exchanger is difficult to acquire because of the cost and time required to purchase it through a specific vendor..”
User survey: How can we improve BrHEAThe? (mechanically)

1) It’s possible to put BrHEAThe into larger homes.

“Zoning is possible.”

“A bigger fan and ductwork to adapt BrHEAThe to bigger homes.”

2) We can solve uneven heating in current homes.

“Improve air controls, monitor airflow to each room and regulate.”

“Add a modulating zone valve with a duct temperature sensor in the downstream ducts. This would help with overheating by modulating water temperature when the air stream was too hot. These houses are so small they overheat quickly.”

“In the Tanana installation, a major change to the control and plumbing design was incorporated. This resulted in much lower and steady heating air temperature.”
User survey: How can we improve BrHEAThe? (education)

“Better instructions for new installers. For instance – a comprehensive list of maintenance tasks and schedules, a guide of common issues (how to diagnose and fix), system walkthrough tailored to each iteration of the system either in video form or in a print-out with pictures, captions, and descriptions.”

“Discussing maintenance with homeowners is hard…they only think about it when it breaks.”

“Homeowners are not adequately trained and this is an area that can be improved.”

“[BrHEAThe] could really benefit from streamlining and better literature (education) with homeowners and housing authorities (any teams that are left on the ground after the construction)”
CCHRC monitored the performance of the BrHEAThe system in the Birch house over the 2017-2018 academic year.

<table>
<thead>
<tr>
<th>Variables</th>
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<tbody>
<tr>
<td>Outside temperature</td>
</tr>
<tr>
<td>House pressure</td>
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<tr>
<td>Carbon dioxide concentration of the supply and exhaust streams of the HRV</td>
</tr>
<tr>
<td>Fuel oil consumption</td>
</tr>
<tr>
<td>Temperature, relative humidity, and carbon dioxide concentration of 6 indoor locations</td>
</tr>
<tr>
<td>Electrical consumption of the HRV defrost element</td>
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<tr>
<td>Electrical consumption of the DHW tank</td>
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<tr>
<td>Electrical consumption of the booster fan</td>
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Does BrHEAThe maintain healthy indoor air quality?

Birch house indoor air quality

% time in excess of study standards

Bedroom 1, Bedroom 2, Bedroom 3, Bedroom 4, Upstairs living space, Downstairs hallway

- Carbon dioxide
- Temperature
- RH
Uneven temperatures were an issue for several locations in the Birch house.

Birch house indoor temperature

- Temp below setpoint - 5°F
- Temp above setpoint + 5°F

% time outside of temperature setpoint + / - 5°F
What is BrHEAThe’s seasonal energy use?

<table>
<thead>
<tr>
<th></th>
<th>Energy use (MMBTU)</th>
<th>Energy use (fuel oil #1 gallons equivalent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel oil #1 from dipstick measurement</td>
<td>42.0 MMBTU</td>
<td>318.5 gallons</td>
</tr>
<tr>
<td>Electricity for DHW tank</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Electricity for HRV defrost element</td>
<td>6.1 MMBTU</td>
<td>46 gallons</td>
</tr>
<tr>
<td>Total</td>
<td>48.1 MMBTU</td>
<td>365 gallons</td>
</tr>
<tr>
<td>AkWarm Prediction</td>
<td>47.3 MMBTU</td>
<td>358 gallons</td>
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What is the effect of the distribution portion of BrHEAThe on the overall mechanical system of the home?
Is there an energy penalty to using this booster fan to distribute heat?

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<th>Energy use (MMBTU)</th>
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<tbody>
<tr>
<td>Pump distributing hot water to the radiant floor in NE house</td>
<td>193 kWh</td>
</tr>
<tr>
<td>Booster fan in BrHEAThe system in NW house</td>
<td>164 kWh</td>
</tr>
</tbody>
</table>

![Booster fan electrical use](chart.png)
Are there safety concerns from high supply air temperatures?
Does the booster fan turning on cause the HRV to become out of balance in normal operation?
Does the booster fan turning on cause the HRV to become out of balance in normal operation?
What effect does the booster fan have on the house pressurization if a supply or exhaust duct becomes blocked?

<table>
<thead>
<tr>
<th>Test</th>
<th>House pressure relative to outdoors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control – HRV on level 2</td>
<td>House at 0.9 Pa to outside (positive pressure)</td>
</tr>
<tr>
<td>HRV on level 2, inline booster fan on</td>
<td>House at 3.9 Pa to outside (positive pressure)</td>
</tr>
<tr>
<td>HRV on level 2 with supply stream blocked, inline booster fan off</td>
<td>House at -4 Pa to outside (negative pressure)</td>
</tr>
<tr>
<td>HRV on level 2 with supply stream blocked, inline booster fan on</td>
<td>House at -3.8 Pa to outside (negative pressure)</td>
</tr>
<tr>
<td>HRV on level 2 with exhaust stream blocked, inline booster fan off</td>
<td>House at 5.7 Pa to outside (positive pressure)</td>
</tr>
<tr>
<td>HRV on level 2 with exhaust stream blocked, inline booster fan on</td>
<td>House at 11 Pa to outside (positive pressure)</td>
</tr>
</tbody>
</table>
BrHEAThe is meeting the goals of the system in the Birch house, but the Birch house is at the limit of the current system’s capability.
<table>
<thead>
<tr>
<th>Project Goals</th>
<th>Results and Timelines</th>
</tr>
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<tbody>
<tr>
<td>Select compatible air source heat pump to integrate into BrHEAThe system</td>
<td>Sanden 43 Gen 3 CO2 ASHP water heater chosen for the study in Fall 2017</td>
</tr>
<tr>
<td>Build an off-the-shelf iteration of the coil/filter box</td>
<td>Generic sheet metal components from Gensco with a coil from Rothman used for coil/filter box in Fall 2017</td>
</tr>
<tr>
<td>Install air source heat pump w/ boiler backup in South Lab at CCHRC</td>
<td>Successfully installed Fall 2017</td>
</tr>
<tr>
<td>Test system’s ability to provide space heat in Fairbanks wintertime conditions</td>
<td>Successfully tested over Winter 2017/2018</td>
</tr>
<tr>
<td>Integrate domestic hot water components into the system</td>
<td>Summer/Fall 2018</td>
</tr>
<tr>
<td>Test system’s ability to provide space heat and domestic hot water in Fairbanks wintertime conditions</td>
<td>Winter 2018/2019</td>
</tr>
</tbody>
</table>
Components: Coil/Filter Box
Components: Water tank, fan, HRV

Chiltrix 80 gallon dual coil heat exchanger tank

Panasonic FV inline fan

HRV2-300DDP
Components: ASHP and South Lab install

Sanden 43 Gen 3 CO2 ASHP water heater

South Lab installation
ASHP input and output liquid temperatures during test period.
Outside temp between -3F and 32F
Flow and energy rate from the ASHP.

The flow is varied due to variable speed pump on the coil side of the system.

The ASHP pump is pumping at less than 0.5 gpm.

Stop, America Time

1 kW =~ 3412 BTU/hr
1 liter =~ 0.26 gallons
Lessons Learned and Conclusions

Plastic!

Cracked plastic!
Lessons Learned and Conclusions

Cracked plastic leads to spilled glycol

Not cold climate ready out of the box
Thank you!