BrHEAThe Data Management Plan

July 4, 2018

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# Context

## BrHEAThe

Purpose: To evaluate a new air handler for the BrHEAThe system and to combine the BrHEAThe boiler with an air source heat pump.

The questions for this project are:

1. What is the maximum space heating capacity of the BrHEAThe system based on outside temperature?
2. What is the heat pump COP based on outside temperature?
3. What is the heat pump defrost frequency?
4. What is the DHW capacity of the system?

Funders: AHFC and CanmetENERGY Ottawa

**Duration: Feburary 2018 to March 2019**

Folder Locations: Building Science Research\Projects\NRCan-17-BrHEAThe 2017-275 (9045)

Proposal Documents: Building Science Research\Projects\NRCan-17-BrHEAThe 2017-275 (9045)\New Proposal Documents\NRCan BrHEAThe 2

## Data Collection

In order to meet the objectives digital data will be collected, stored, and analyzed. A Campbell Scientific CR1000 data logger will be used to collect data on flow rate, temperature, and electrical usage.

## Policies

The data will be collected by the loggers in 10 second, 2, 30, and 60 minute averages and saved in the data folder for the project.

## Responsibilities

The project manager, is responsible for making certain this data is being collected and is in an error free format.

# Organization of data

#### File structure

The CSI loggers output .csv files organized by date. The .csv files can be exported to Excel for analysis

#### Naming conventions

Each file will include a descriptor of the data and the averaging internal. Each data point name will be based on location and end in \_units. There are 9 system locations: ASHP, Boiler, Coil, Tank, HRV, HRVSupply, Box, BoxSupply, and Fan that will be at the beginning of each variable name.

#### Formats and Units

All numbers will be no longer than 4 values after the decimal place. The data will be stored as a .csv.

#### Data analysis formats

.csv will be converted into Excel for analysis.

#### Versioning

Raw data files will be saved in the data file within the project file. Any analyzed data will have the date of the analyzed data in its name. Data should not be overwritten if new analysis takes place, a new version of the data should be saved with a new name that includes the date.

# Documentation and Metadata

## Data Documentation

All digital data and documentation for this project will be stored in Building Science Research\Projects\NRCan-17-BrHEAThe 2017-275 (9045)\Data Collection

Each researcher on this project maintains an independent lab notebook where they may record information related to this project in the form of rough notes. That information will get a label “NRCAN” to make those notes easy to find if they become necessary.

## Metadata

Data on the sensors in this project will follow a very specific format. There is an overall data standards document outlined below. Detailed data standards are appended to this document. The data standards include details about each sensor, its purpose, and location.

# Storage and Security

Sensor data will be stored here Building Science Research\Projects\NRCan-17-BrHEAThe 2017-275 (9045)\Data Collection

# Preservation and Sharing

Sensor data will be stored on the CCHRC internal server and on CCHRC’s data site, http://cchrc.rcs.alaska.edu/

## Data Measurement and Recording Standards

**Weather Data**

The existing MET station on the RTF roof will be used. This data is housed on http://cchrc.rcs.alaska.edu/

Data-Collection Objectives: Monitor the lab installed combined BrHEAThe and ASHP system to determine efficiencies and to optimize the system as possible.

Time Recording Standard: **Always** Alaska Standard Time (UTC – 9).

Datalogger Scan Interval Standard: 1 second

Time Measurement Standards:

* Hourly readings are recorded at the end of the hour; therefore, the hourly average air temperature, for example, with a 5-second scan interval and a time stamp of 14:00 is measured from 13:00:05 to 14:00:00. Instantaneous readings are taken at the time specified by the time stamp.
* A day begins at midnight (00:00:00) and ends at midnight (23:59:55). All daily data are from the day prior to the date of the time stamp. For example, if the time stamp reads 09/09/2007 00:00 or 09/09/2007 12:00:00 AM, the data are from 09/08/2007.

Data Downloading: Data will be uploaded to <http://cchrc.rcs.alaska.edu/> every night.

Figure 2 shows a rough schematic of data points in the system. Table 1 describes each data point.



Figure 2. Schematic of system. The system is divided into 9 subsystems for the naming of sensors: ASHP, Boiler, Coil, Tank, HRV, HRV Supply, Box, Box Supply, and Fan.

Variable Names

| Variable | Purpose | Sensor | | | Unit | | Location |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ASHP\_Power\_watts\_ | Heat pump electric use/and defrost cycle | Magnelab SPT-0375-300 and CRmagnetics CR8420-1000 | | | W | | In the ASHP switch box |
| ASHP\_pump | Pump on and off cycles | Onset U9-004 | | | On/off | | On the AUX AHSP pump |
| ASHP\_flow\_lmin | Fluid flow in pipe | Onicon System 10 with F-1300 flow meter | | | l/min | | In the return line to the ASHP |
| ASHP\_cold\_C | Return temp | °C | | In the return line to the ASHP |
| ASHP\_hot\_C | Delivery temp | °C | | In the supply line from the ASHP |
| ASHP\_defost\_C | To determine when the defrost cycle runs | Thermistor | | | °C | | On the AHSP outside coil |
| ASHPflow\_gpm | Fluid flow in pipe back up | SM6001, electro300 | | | Gpm | | In return pipe to ASHP |
|  |  |  | | |  | |  |
| COIL\_pumppower\_watts\_Avg | Pump electrical use | Magnelab SPT-0375-150 and CRmagnetics CR8410-1000-G | | | W | | On the pump hot wire |
| Coil\_flow\_lmin | Fluid flow in pipe | Onicon System 10 with F-1300 flow meter | | | l/min | | In the return line from the coil |
| Coil\_return\_C | Return temp | °C | | In the return line from the coil |
| Coil\_supply\_C | Delivery temp | °C | | In the supply line to the coil |
|  |  |  | | |  | |  |
| Pump on and off cycles | Pump on and off cycles | Onset U9-004 | | | On/off | | On the pump motor |
| Boiler\_flow\_gpm | Fluid flow in pipe | SM6001, electro300 | | | gpm | | In the return line to the boiler |
| Boilerreturn\_C | Return temp | Thermistor | | | °C | | In the return line to the boiler |
| Boilersupply\_C | Delivery temp | Thermistor | | | °C | | In the supply line from the boiler |
|  |  |  | | |  | |  |
| HRV\_power\_watts\_Avg | Electrical use of the HRV | | Magnelab SPT-0375-150 and CRmagnetics CR8410-1000-G | W | | In the HRV plug box | |
| HRV\_exhaust\_C | Exhaust temp | | Thermistor | °C | | In the HRV exhaust to outside duct | |
| HRV\_intake\_C | Fresh intake air temp | | Thermistor | °C | | In the HRV fresh air intake duct | |
| HRV\_return\_C | Return from space temp | | Thermistor | °C | | In the HRV duct returning from the building | |
|  |  | |  |  | |  | |
| HRVsupply\_C | Supply air temp | | Thermistor | °C | | In the HRV supply to building duct | |
| HRVsupply\_flow\_cfm | Air flow from the HRV to to the coil box | | Nailor 36FMS | cfm | | In the HRV supply to building duct | |
|  |  | |  |  | |  | |
| Box\_makeup\_C | To verify if makeup damper is open | | Thermistor | °C | | Behind the makeup damper in the coil box | |
| Box\_mix\_C | Pre-filter coil box temperature | | Thermistor | °C | | Upstream of the filter in the box | |
| Box\_postfilter\_C | Post-filter coil box temperature | | Thermistor | °C | |  | |
|  |  | |  |  | |  | |
| Boxsupply\_C | Temperature supplied from the filter box | | Thermistor | °C | | In the supply duct from the filter box to the fan | |
| Boxsupply\_flow\_cfm | Flow leaving the filter box | | Nailor 36FMS | cfm | | In the supply duct from the filter box to the fan | |
|  |  | |  |  | |  | |
| Fan\_C | Air Temperature supplied to the house | | Thermistor | °C | | In the duct after the booster fan | |
| Fan\_flow\_cfm | The flow of air to the house | | Nailor 36FMS | cfm | | The flow of air to the house | |
|  |  | |  |  | |  | |
| Uppertank\_C | Water tank upper temp | | Thermistor | °C | | In the upper temp well | |
| Lowertank\_C | Water tank lower temp | | Thermistor | °C | | In the lower temp well | |
| Uppertankair\_C | The air temp near the tank | | Thermistor | °C | | Outside the upper temp well | |
| Lowertankair\_C | The air temp near the tank | | Thermistor | °C | | Outside the lower temp well | |

Sensors Used

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Flow meter | Temperature | Flow Meters | Flow Temperature | Electrical | Air Flow |
| Flow meter, SM6001, electro300, http://www.ifm.com/products/us/ds/SM6001.htm | US Sensor PS103J2 NTC Thermistors | Onicon F-1300 | Onicon System 10 | Magnelab SPT-0375-150 and CRmagnetics CR8420-1000 | Nailor 36FMS with Setra 256 pressure transducer |
| 0 to 6.6 gpm | -80°C to 150°C | 0.8 to 38 GPM | 32 to 200°F |  |  |
| ±0.8% MW | ±0.1°C | +-2% | +-0.15°F differential |  |  |
| VoltDiff (volt(i),1,AutoRange,4,False,0,\_60Hz,1,0)  ASHPflow\_gpm=(0.0041\*volt(13)-1.6135)  boilerflow\_gpm=(0.0041\*volt(14)-1.6135) | Const a=0.001125308852122  Const b=0.000234711863267  Const c=0.000000085663516  BrHalf(therm(j),1,mV2500,10,Vx2,1,2500,True,0,\_60Hz,1.0,0)  thermkohm(j)=10\*(therm(j)/(1-therm(j)))  Ln\_thermkohm(j) = LN(1000\*thermkohm(j))  temp\_C(j) = (1/(a+(b\*(Ln\_thermkohm(j)))+(c\*((Ln\_thermkohm(j))^3))))-273.15 | PortSet (1,1) '  i = 1  SubScan (0,Sec,12)  PulsePort(4,10000) VoltDiff (volt(i),1,AutoRange,4,False,0,\_60Hz,1,0)  i=i+1  NextSubScan  PortSet (1,0) ' turn mux off.  Onicon(1)=(0.0237\*volt(1)-9.4635)  Onicon(2)=(0.055\*volt(2)-21.98)  Onicon(3)=(0.0382\*volt(3)+5.8333)  Onicon(4)=(0.0382\*volt(4)-5.8333)  )  Onicon(9)=(0.0118\*volt(9)-4.7318)  Onicon(10)=(0.011\*volt(10)-4.3961)  Onicon(11)=(0.0556\*volt(11)-28.889)  Onicon(12)=(0.0556\*volt(12)-28.889) | | ACPower (Electrical(),1,60,2,115/333,115,4,30/333,10,3) | VoltSe (setra\_V(),3,mV5000,14,1,0,250,.001,0)  setra\_inH2O()=(0.1\*setra\_V())-0.25  'for first run assume air density at 68F and 50%RH 0.075lbm/ft3  Airflow\_cfm(1)=((setra\_inH2O(1)/0.0751)^.5)\*1096.7\*22/7\*(3/12)^2 |

## 

## Program

## 'Program Name BrHEAThe\_labdemo

## 'date 3/12/18

## Public LoggerTemp\_C, BattVolts\_V

## Public Onicon(12), volt(14), ASHPflow\_gpm, boilerflow\_gpm

## Public ElectricalHP(7), ASHPelectric\_kWh

## Public ElectricalHRV(7), ElectricalCOIL(7), ElectricalFAN(7)

## Public Therm\_kOhm(42), Temp\_C(42), therm(42)

## Public setra\_V(3),setra\_inH2O(3), Airflow\_cfm(3)

## Public Coil\_kWh, AHSP\_kWh

## Dim i, J(30), disableCOIL, disableBOILER, disableASHP, disablefan

## ' For thermistors -- conversion of kOHM to deg C

## Const a = 0.00114288192250106

## Const b = 0.000231314273877631

## Const c = 0.00000010934242301857

## Const d=-0.0000000000725110851146496

## Alias Temp\_C (1)=ASHP\_defrost\_C1

## Alias Temp\_C (2)=ASHP\_defrost\_C2

## Alias Temp\_C (3)=ASHP\_defrost\_C3

## Alias Temp\_C (4)=HRV\_exhaust\_C1

## Alias Temp\_C (5)=HRV\_exhaust\_C2

## Alias Temp\_C (6)=HRV\_exhaust\_C3

## Alias Temp\_C (7)=HRV\_intake\_C1

## Alias Temp\_C (8)=HRV\_intake\_C2

## Alias Temp\_C (9)=HRV\_intake\_C3

## Alias Temp\_C (10)=HRV\_return\_C1

## Alias Temp\_C (11)=HRV\_return\_C2

## Alias Temp\_C (12)=HRV\_return\_C3

## Alias Temp\_C (13)=BOXsupply\_C1

## Alias Temp\_C (14)=BOXsupply\_C2

## Alias Temp\_C (15)=BOXsupply\_C3

## Alias Temp\_C (16)=FAN\_C1

## Alias Temp\_C (17)=FAN\_C2

## Alias Temp\_C (18)=FAN\_C3

## Alias Temp\_C (19)=BOX\_postfilter\_C1

## Alias Temp\_C (20)=BOX\_postfilter\_C2

## Alias Temp\_C (21)=BOX\_postfilter\_C3

## Alias Temp\_C (22)=HRVsupply\_C1

## Alias Temp\_C (23)=HRVsupply\_C2

## Alias Temp\_C (24)=HRVsupply\_C3

## Alias Temp\_C (25)=BOX\_makeup\_C1

## Alias Temp\_C (26)=BOX\_makeup\_C2

## Alias Temp\_C (27)=BOX\_makeup\_C3

## Alias Temp\_C (28)=BOX\_mix\_C1

## Alias Temp\_C (29)=BOX\_mix\_C2

## Alias Temp\_C (30)=BOX\_mix\_C3

## Alias Temp\_C (31)=boilersupply\_C1

## Alias Temp\_C (32)=boilersupply\_C2

## Alias Temp\_C (33)=boilersupply\_C3

## Alias Temp\_C (34)=boilerreturn\_C1

## Alias Temp\_C (35)=boilerreturn\_C2

## Alias Temp\_C (36)=boilerreturn\_C3

## Alias Temp\_C (37)=uppertank\_C1

## Alias Temp\_C (38)=uppertank\_C2

## Alias Temp\_C (39)=uppertankair\_C

## Alias Temp\_C (40)=lowertank\_C1

## Alias Temp\_C (41)=lowertank\_C2

## Alias Temp\_C (42)=lowertankair\_C

## Alias Onicon(1)=COIL\_flowrate\_lmin

## Alias Onicon(2)=COIL\_energyrate\_kW

## Alias Onicon(3)=COIL\_returntemp\_C

## Alias Onicon(4)=COIL\_supplytemp\_C

## Alias Onicon(9)=AHSP\_flowrate\_lmin

## Alias Onicon(10)=ASHP\_energyrate\_kW

## Alias Onicon(11)=ASHP\_cold\_C

## Alias Onicon(12)=ASHP\_hot\_C

## Alias ElectricalHP(1)= ASHP\_Power\_watts

## Alias ElectricalHP(4)= ASHP\_current\_amps

## Alias ElectricalHRV(1)=HRV\_power\_watts

## Alias ElectricalCOIL(1)=COIL\_pumppower\_watts

## Alias ElectricalFAN(1)=FAN\_power\_watts

## Alias Airflow\_cfm(1)=FAN\_flow\_cfm

## Alias Airflow\_cfm(2)=BOXsupply\_flow\_cfm

## Alias Airflow\_cfm(3)=HRVsupply\_flow\_cfm

## 'STATION ID

## StationName (BrHEAThe\_Lab)

## '\\\\\\\\\\\\\\\\\\\\\\\\ OUTPUT SECTION ////////////////////////

## DataTable(HourlyRAW, true, -1)

## DataInterval(0,60,Min,10)

## Average (1,LoggerTemp\_C,FP2,False)

## Average (1,BattVolts\_V,FP2,False)

## Average (36,therm(),FP2,False)

## Average (3,setra\_V(),FP2,False)

## Average (14,volt(),FP2,False)

## EndTable

## DataTable(Hourly, true, -1)

## DataInterval(0,60,Min,10)

## Average (42,Temp\_C(),FP2,False)

## Average (3,Airflow\_cfm(),FP2,False)

## Average (1,Onicon(1),FP2,disableCOIL)

## Average (1,Onicon(2),FP2,disableCOIL)

## Average (1,Onicon(3),FP2,disableCOIL)

## Average (1,Onicon(4),FP2,disableCOIL)

## Average (1,Onicon(9),FP2,disableASHP)

## Average (1,Onicon(10),FP2,disableASHP)

## Average (1,Onicon(11),FP2,disableASHP)

## Average (1,Onicon(12),FP2,disableASHP)

## Average (1,ASHPflow\_gpm,FP2,disableASHP)

## Average (1,boilerflow\_gpm,FP2,disableBOILER)

## Average (1,ASHP\_Power\_watts, FP2, disableASHP)

## Average (1,HRV\_power\_watts, FP2, false)

## Average (1,COIL\_pumppower\_watts, FP2, disableCOIL)

## Average (1,FAN\_power\_watts, FP2, disablefan)

## EndTable

## DataTable(minute, true, -1)

## DataInterval(0,1,Min,10)

## Average (42,Temp\_C(),FP2,False)

## Average (3,Airflow\_cfm(),FP2,False)

## Average (1,Onicon(1),FP2,disableCOIL)

## Average (1,Onicon(2),FP2,disableCOIL)

## Average (1,Onicon(3),FP2,disableCOIL)

## Average (1,Onicon(4),FP2,disableCOIL)

## Average (1,Onicon(9),FP2,disableASHP)

## Average (1,Onicon(10),FP2,disableASHP)

## Average (1,Onicon(11),FP2,disableASHP)

## Average (1,Onicon(12),FP2,disableASHP)

## Average (1,ASHPflow\_gpm,FP2,disableASHP)

## Average (1,boilerflow\_gpm,FP2,disableBOILER)

## Average (1,ASHP\_Power\_watts, FP2, disableASHP)

## Average (1,HRV\_power\_watts, FP2, false)

## Average (1,COIL\_pumppower\_watts, FP2, disableCOIL)

## Average (1,FAN\_power\_watts, FP2, disablefan)

## EndTable

## DataTable(tensecond, true, -1)

## DataInterval(0,10,Sec,10)

## Average (42,Temp\_C(),FP2,False)

## Average (3,Airflow\_cfm(),FP2,False)

## Average (1,Onicon(1),FP2,disableCOIL)

## Average (1,Onicon(2),FP2,disableCOIL)

## Average (1,Onicon(3),FP2,disableCOIL)

## Average (1,Onicon(4),FP2,disableCOIL)

## Average (1,Onicon(9),FP2,disableASHP)

## Average (1,Onicon(10),FP2,disableASHP)

## Average (1,Onicon(11),FP2,disableASHP)

## Average (1,Onicon(12),FP2,disableASHP)

## Average (1,ASHPflow\_gpm,FP2,disableASHP)

## Average (1,boilerflow\_gpm,FP2,disableBOILER)

## Average (1,ASHP\_Power\_watts, FP2, disableASHP)

## Average (1,HRV\_power\_watts, FP2, false)

## Average (1,COIL\_pumppower\_watts, FP2, disableCOIL)

## Average (1,FAN\_power\_watts, FP2, disablefan)

## EndTable

## '\\\\\\\\\\\\\\\\\\\\\\\\\\\ PROGRAM ////////////////////////////

## BeginProg

## Scan(10,Sec,0, 0)

## Battery(BattVolts\_V)

## PanelTemp(LoggerTemp\_C, 250)

## 

## 'Measure Electricals

## ACPower (ElectricalHP(),1,60,1,230/333,208,3,30/333,50,1)

## ACPower (ElectricalHRV(),1,60,2,115/333,115,4,30/333,10,1)

## ACPower (ElectricalCOIL(),1,60,2,115/333,115,5,30/333,10,1)

## ACPower (ElectricalFAN(),1,60,2,115/333,115,6,50/333,10,1)

## 

## 'Measure Air flow

## VoltSe (setra\_V(),3,mV5000,14,1,0,250,.001,0)

## setra\_inH2O()=(0.1\*setra\_V())-0.25

## 'for first run assume air density at 68F and 50%RH 0.075lbm/ft3

## Airflow\_cfm(1)=((setra\_inH2O(1)/0.0751)^.5)\*1096.7\*22/7\*(3/12)^2

## Airflow\_cfm(2)=((setra\_inH2O(2)/0.0751)^.5)\*1096.7\*22/7\*(3/12)^2

## Airflow\_cfm(3)=((setra\_inH2O(3)/0.0751)^.5)\*1096.7\*22/7\*(3/12)^2

## 'measure thermistors

## PortSet(2,1)

## i=1

## SubScan(0,Sec,14)

## PulsePort(5,10000) ' Clock mux

## BrHalf(therm(i),3,mV2500,9,Vx2,2,2500,True,0,\_60Hz, 1.0, 0)

## i=i+3

## NextSubScan

## 

## 

## For i=1 To 42

## Therm\_kOhm(i) = (10\*therm(i))/(1-therm(i))

## J(i) = LN (1000\*Therm\_kOhm(i)) 'ln resistance (ohm)

## Temp\_C(i) = (1/(a + b\*J(i) + c\*(J(i))^3)+d\*(J(i)^4)) - 273.15 'Steinhart & Hart Equation

## Next i

## PortSet (2,0) ' turn mux off.

## 

## 'measure flow meters

## PortSet (1,1) ' Turn on mux

## i = 1

## SubScan (0,Sec,14)

## PulsePort(4,10000) ' Clock mux

## VoltDiff (volt(i),1,AutoRange,4,False,0,\_60Hz,1,0)

## i=i+1

## NextSubScan

## PortSet (1,0) ' turn mux off.

## 'these need to be corrected once on the Onicons are online

## Onicon(1)=(0.0237\*volt(1)-9.4635)

## Onicon(2)=(0.055\*volt(2)-21.98)

## Onicon(3)=(0.0382\*volt(3)+5.8333)

## Onicon(4)=(0.0382\*volt(4)+5.8333)

## Onicon(5)=(0.0118\*volt(5)-4.7318)

## Onicon(6)=(0.011\*volt(6)-4.3961)

## Onicon(7)=(0.0556\*volt(7)-28.889)

## Onicon(8)=(0.0556\*volt(8)-28.889)

## Onicon(9)=(0.0118\*volt(9)-4.7318)

## Onicon(10)=(0.011\*volt(10)-4.3961)

## Onicon(11)=(0.0556\*volt(11)-28.889)

## Onicon(12)=(0.0556\*volt(12)-28.889)

## ASHPflow\_gpm=(0.0041\*volt(13)-1.6135)

## boilerflow\_gpm=(0.0041\*volt(14)-1.6135)

## 

## 'Convert energy rate to total energy

## Coil\_kWh=COIL\_energyrate\_kW\*10/3600000

## 'BOiLER\_kWh=BOILER\_energyrate\_kW\*10/3600000

## ASHPelectric\_kWh=ASHP\_Power\_watts\*10/3600000/1000

## AHSP\_kWh=ASHP\_energyrate\_kW\*10/3600000

## disableASHP = true

## If ASHP\_Power\_watts > .1 Then disableASHP = false

## disableCOIL = true

## If COIL\_pumppower\_watts> .1 Then disableCOIL = false

## disableBOILER = true

## If boilerflow\_gpm > .1 Then disableBOILER = false

## disablefan=true

## If FAN\_power\_watts>.1 Then disablefan=false

## 'OUTPUT

## CallTable HourlyRAW

## CallTable hourly

## CallTable minute

## CallTable tensecond

## NextScan

## EndProg

## Diagram

