GLHEPRO Inputs
Heat pump model

Part 1

Jeffrey D. Spitler
spitler@okstate.edu
https://hvac.okstate.edu/

OKLAHOMA STATE UNIVERSITY

GSHP

Outline

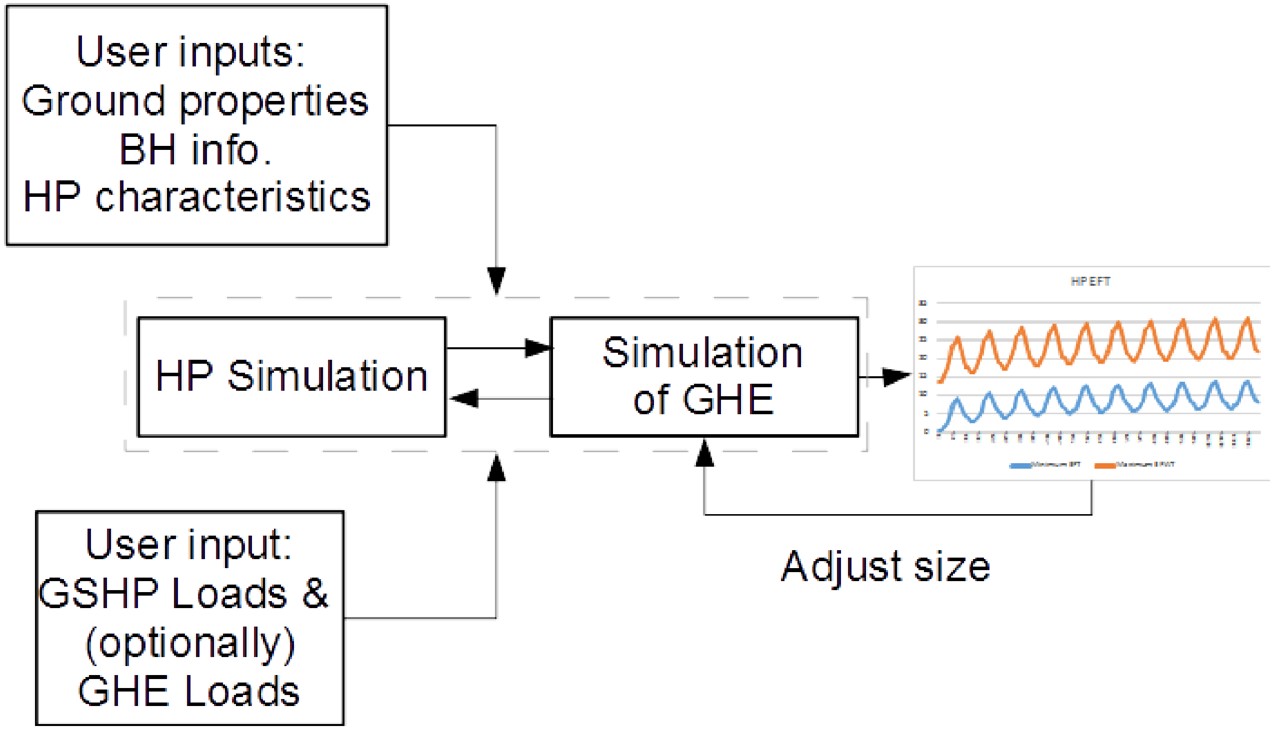
- Why do we need a heat pump (HP) model?
- What are the limited purposes of the HP model?
- What are some common misconceptions regarding the heat pump model?
- What are the limitations of the HP model?
- How do I use the HP model?

Goals

- The main goals of this lecture are to introduce:
  - Modeling of heat pumps in GLHEPRO.
  - How to use the heat pump model in GLHEPRO
  - What to do if I have more than one kind of input.
- This lecture is not intended to:
  - Explain how to read manufacturer's catalog data.

Purpose of the Heat Pump Model

- For given building heating and cooling loads, how much heat must be extracted or rejected?



Heat Pump Model

- Purposes:
  - Primary: Determine heat rejection/extraction more accurately than assuming a fixed COP
  - Secondary: Make a rough estimate of the electrical energy consumption.
- The HP model does not:
  - Determine whether the design has sufficient capacity. (In fact, it assumes that it does.)

Other limitations of the HP model

- Performance only depends on HP EFT; does not account for:
  - Time-varying source-side flow rate.
  - Load-side conditions changing.
  - (Including multi-mode operation: Htg + DHW htg)
  - Multi-stage or variable speed operation of the heat pump
  - Transient (cycling) effects.
- Nor does the energy calculation account for:
  - Circulating pump energy consumption.
(If CP is slaved to HP, it could be included in equation fit)
  - Other parasitic losses.
  - Running fan independently from compressor.

Other limitations of the HP model

- GLHEPRO does not have any automatic way to account for the use of multiple different heat pumps.
  (With different performance characteristics.)
  The user may:
  - Create a composite heat pump.
  - Simply try sizing the ground heat exchanger with the different heat pump models in use – that will show the possible effects of the heat pump.

HP model

- Four equation fits, based on manufacturer's data.
  - Ratio of the heat of rejection to the cooling provided:

$$\frac{\dot{q}_{rejection}}{\dot{q}_{cooling}} = a + b \cdot EFT + c \cdot EFT^2$$

  - Ratio of the electrical power to the cooling provided

$$\frac{Power}{\dot{q}_{cooling}} = d + e \cdot EFT + f \cdot EFT^2$$

HP model

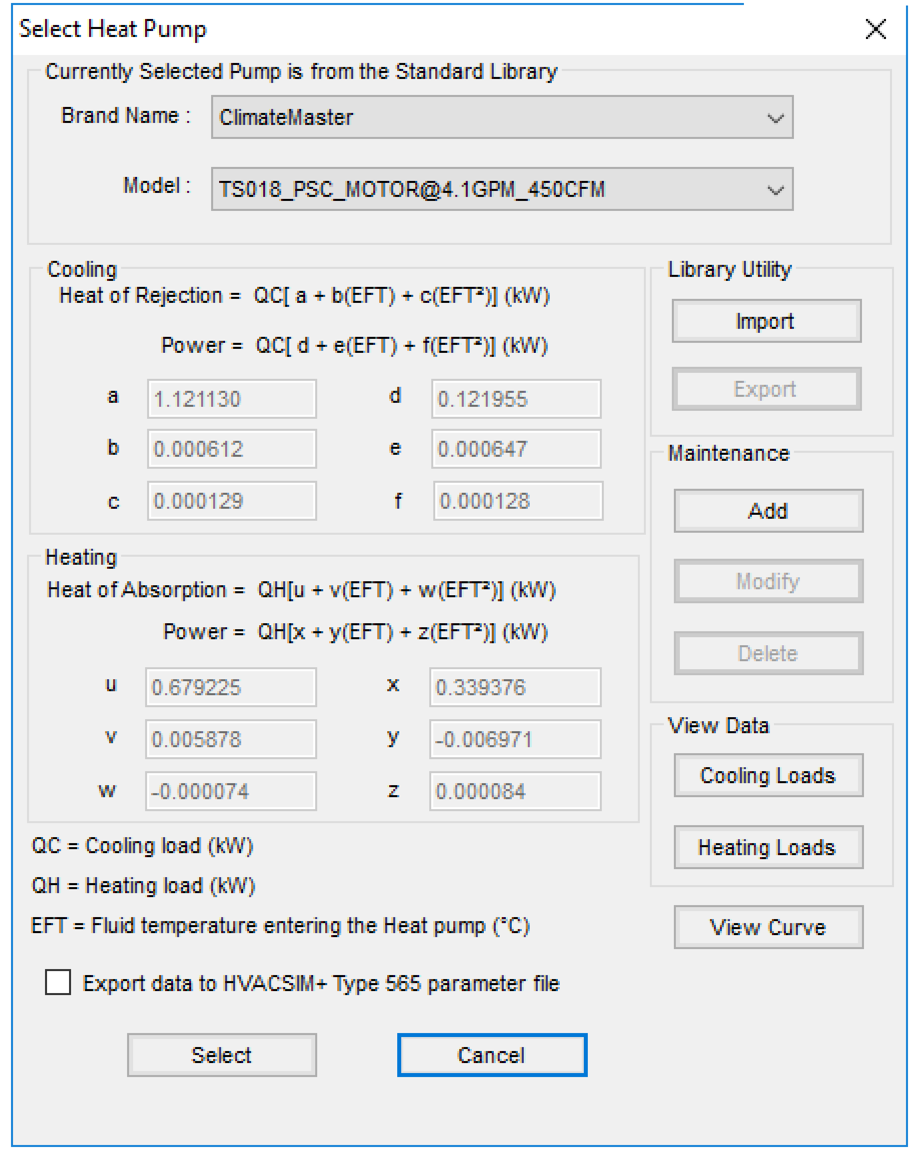
- Four equation fits, based on manufacturer's data.
  - Ratio of the heat extracted to the heating provided:

$$\frac{\dot{q}_{absorption}}{\dot{q}_{heating}} = u + v \cdot EFT + w \cdot EFT^2$$

  - Ratio of the electrical power to the heating provided

$$\frac{Power}{\dot{q}_{heating}} = x + y \cdot EFT + z \cdot EFT^2$$


Select Heat Pump
Currently Selected Pump is from the Standard Library
Brand Name : ClimateMaster
Model : TS018_PSC_MOTOR@4.1GPM_450CFM
Cooling
Heat of Rejection = QC[a + b(EFT) + c(EFT²)] (kBtu/hr)
Power = QC[d + e(EFT) + f(EFT²)] (kBtu/hr)
a 1.151152
d 0.044268
b -0.002216
e -0.000638
c 0.000040
f 0.000012
Library Utility
Import
Export
Maintenance
Add
Modify
Delete
Heating
Heat of Absorption = QH[u + v(EFT) + w(EFT²)] (kBtu/hr)
Power = QH[x + y(EFT) + z(EFT²)] (kBtu/hr)
u 0.551505
x 0.143532
v 0.004717
y -0.001619
w -0.000023
z 0.000008
View Data
Cooling Loads
Heating Loads
QC = Cooling load (kBtu/hr)
QH = Heating load (kBtu/hr)
EFT = Fluid temperature entering the Heat pump (°F)
View Curve
Export data to HVACSIM+ Type 565 parameter file
Select
Cancel


Select Heat Pump
Currently Selected Pump is from the Standard Library
Brand Name : ClimateMaster
Model : TS018_PSC_MOTOR@4.1GPM_450CFM
Cooling
Heat of Rejection = QC[a + b(EFT) + c(EFT²)] (kW)
Power = QC[d + e(EFT) + f(EFT²)] (kW)
a 1.121130
d 0.121955
b 0.000612
e 0.000647
c 0.000129
f 0.000128
Library Utility
Import
Export
Maintenance
Add
Modify
Delete
Heating
Heat of Absorption = QH[u + v(EFT) + w(EFT²)] (kW)
Power = QH[x + y(EFT) + z(EFT²)] (kW)
u 0.679225
x 0.339376
v 0.005878
y -0.006971
w -0.000074
z 0.000084
View Data
Cooling Loads
Heating Loads
QC = Cooling load (kW)
QH = Heating load (kW)
EFT = Fluid temperature entering the Heat pump (°C)
View Curve
Export data to HVACSIM+ Type 565 parameter file
Select
Cancel

GLHEPRO Inputs Heat pump model

Part 2 - example

Jeffrey D. Spitler
spitler@okstate.edu
https://hvac.okstate.edu/

Water-to-air heat pump

- Manufacturers such as ClimateMaster give fairly complete maps of performance as a function of:
  - Source-side water flow rate
  - Load-side air flow rate
  - And there are corrections for different inlet air conditions, antifreeze.
- A generic example taken from a nominal 3-ton heat pump.

Cooling data (uncorrected)

EFT (°F)	TC (1000 Btuh)	kW	HR (1000 Btuh)
30	33.7	1.32	38.2
40	36.8	1.43	41.6
50	38.1	1.57	43.4
60	38.2	1.73	44.1
70	37.3	1.91	43.8
80	35.7	2.12	42.9
85	34.7	2.24	42.3
90	33.7	2.35	41.7
100	31.4	2.60	40.2
110	29.0	2.88	38.8
120	26.6	3.19	37.5

EFT (°C)	TC (kW)	kW	HR (kW)
-1.1	9.87	1.32	11.19
4.4	10.78	1.43	12.19
10.0	11.16	1.57	12.72
15.6	11.19	1.73	12.92
21.1	10.93	1.91	12.83
26.7	10.46	2.12	12.57
29.4	10.17	2.24	12.39
32.2	9.87	2.35	12.22
37.8	9.20	2.60	11.78
43.3	8.50	2.88	11.37
48.9	7.79	3.19	10.99

EFT = Heat pump Entering Fluid Temperature
TC = Total Cooling (i.e. sensible + latent)
kW = heat pump power in kW
HR = Heat rejection rate (to the ground)

Cooling data (corrected)

EWT (°F)	TC (1000 Btuh)	kW	HR (1000 Btuh)
30	30.16	1.32	34.68
40	32.93	1.43	37.83
50	34.10	1.57	39.47
60	34.19	1.73	40.11
70	33.38	1.92	39.92
80	31.95	2.13	39.20
85	31.06	2.25	38.72
90	30.16	2.36	38.20
100	28.10	2.61	37.00
110	25.95	2.89	35.81
120	23.81	3.20	34.72

EWT (°C)	TC (kW)	kW	HR (kW)
-1.1	8.84	1.32	10.16
4.4	9.65	1.43	11.08
10.0	9.99	1.57	11.56
15.6	10.02	1.73	11.75
21.1	9.78	1.92	11.70
26.7	9.36	2.13	11.49
29.4	9.10	2.25	11.35
32.2	8.84	2.36	11.19
37.8	8.23	2.61	10.84
43.3	7.60	2.89	10.49
48.9	6.98	3.20	10.17

Corrections applied:

- For use of 15% methanol instead of water.
- For entering air condition being 72°F/60°F instead of 80°F/67°F (22.2°C/15.6°C instead of 26.7°C/19.4°C)

Heating data (uncorrected)

EFT	HC (1000 Btuh)	kW	HE (1000 Btuh)
30	26.5	2.13	19.2
40	30.5	2.18	23.1
50	34.8	2.24	27.2
60	39.2	2.30	31.4
70	43.5	2.37	35.4
80	47.5	2.44	39.1
85	49.1	2.50	40.7
90	50.8	2.50	42.3

EFT (°C)	HC (kW)	kW	HE (kW)
-1.1	7.76	2.13	5.63
4.4	8.94	2.18	6.77
10.0	10.20	2.24	7.97
15.6	11.49	2.30	9.20
21.1	12.75	2.37	10.37
26.7	13.92	2.44	11.46
29.4	14.39	2.50	11.93
32.2	14.88	2.50	12.39

EFT = Heat pump Entering Fluid Temperature
HC = Heating Capacity
kW = heat pump power in kW
HE = Heat extraction rate (from the ground)

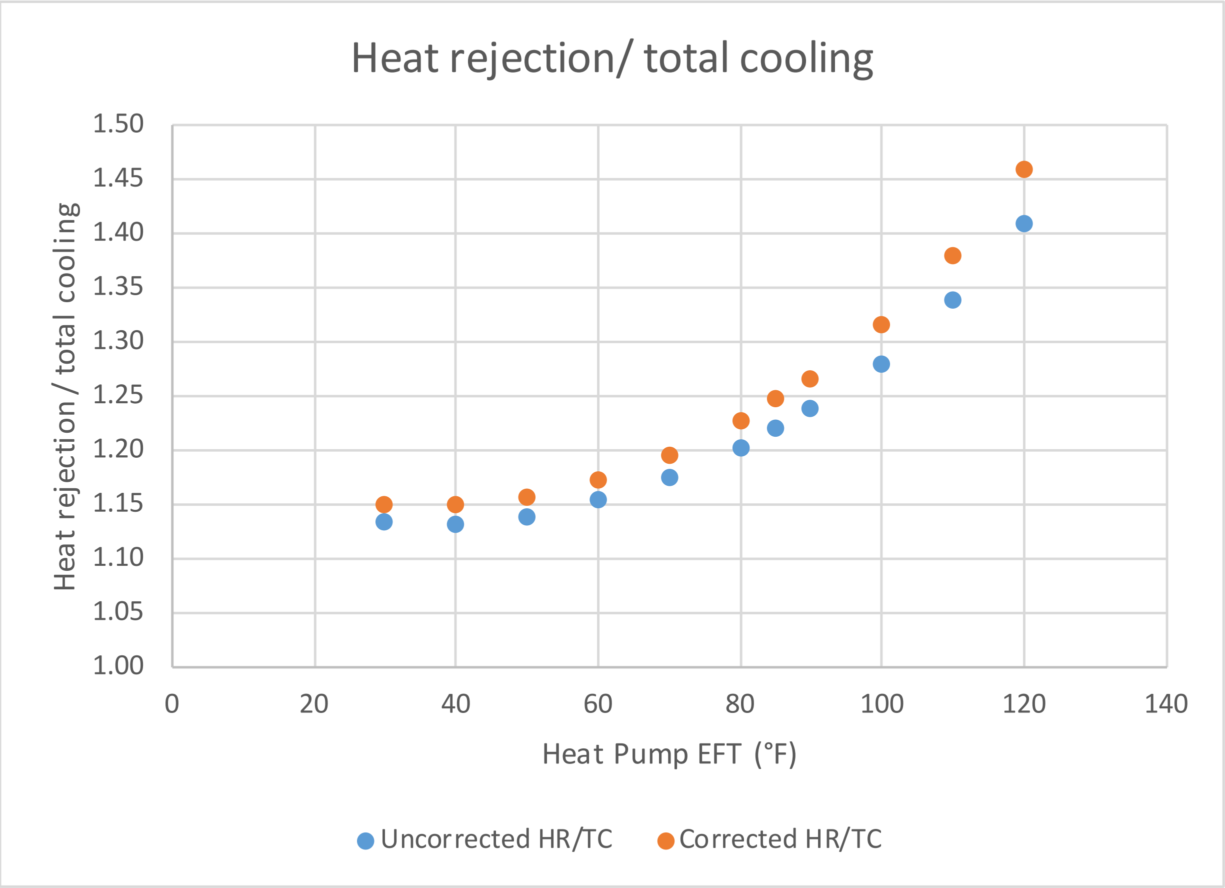
Heating data (corrected)

EWT	HC (1000 Btuh)	kW	HE (1000 Btuh)
30	26.5	2.13	19.2
40	30.5	2.18	23.1
50	34.8	2.24	27.2
60	38.65	2.28	30.88
70	42.89	2.35	34.88
80	46.84	2.42	38.59
85	48.41	2.48	39.97
90	50.09	2.48	41.64

EWT (°C)	HC (kW)	kW	HE (kW)
-1.1	7.76	2.13	5.63
4.4	8.94	2.18	6.77
10.0	10.20	2.24	7.97
15.6	11.32	2.28	9.05
21.1	12.57	2.35	10.22
26.7	13.72	2.42	11.31
29.4	14.18	2.48	11.71
32.2	14.68	2.48	12.20

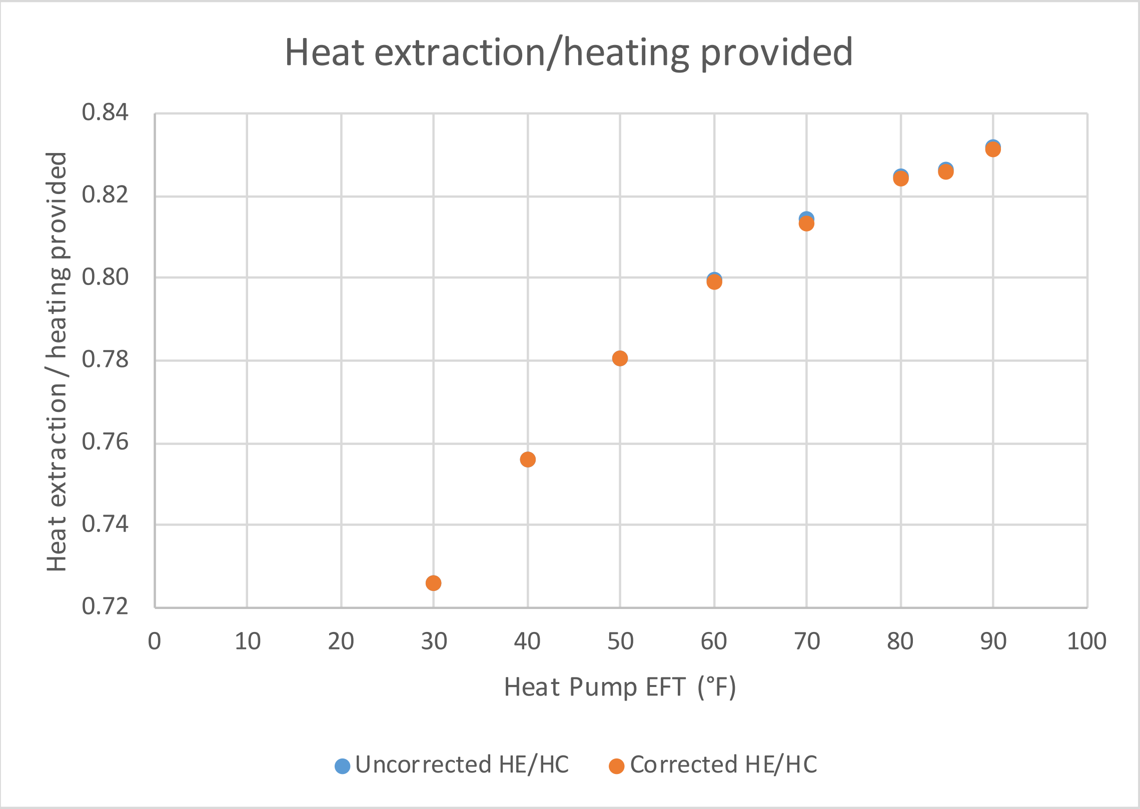
Correction applied to shaded region for use of 15% methanol instead of water.

Cooling



Heat rejection/ total cooling
Heat rejection / total cooling
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0
20
40
60
80
100
120
140
Heat Pump EFT (°F)
Uncorrected HR/TC
Corrected HR/TC

Heating


Heat extraction/heating provided
Heat extraction / heating provided
0.84
0.82
0.80
0.78
0.76
0.74
0.72
0
10
20
30
40
50
60
70
80
90
100
Heat Pump EFT (°F)
Uncorrected HE/HC
Corrected HE/HC

GLHEPRO

- We could in Excel develop curve fit equations.
- But GLHEPRO will do it for us.

GLHEPRO Inputs
Heat pump model

Part 3 – example using GLHEPRO

Jeffrey D. Spitler
spitler@okstate.edu
https://hvac.okstate.edu/

Live demo here

References

- Software
  - GLHEPRO: https://hvac.okstate.edu/glhepro/overview
- References
  - Spitler, J. D. 2000. *GLHEPRO -- A Design Tool For Commercial Building Ground Loop Heat Exchangers. Fourth International Heat Pumps in Cold Climates Conference, Aylmer, Québec.**
  - GLHEPRO Manual*

* available at https://hvac.okstate.edu

Possible additional material: Scandinavian system

- Water-to-water heat pump.
- Load-side temperature may change due to:
  - Control curve that changes heating temperature with outdoor air temperature.
  - Switching between heating the building and domestic hot water.
- Backup electric resistance heating.
  - That can be handled with a pre-processing step, possibly iteratively.