Field Testing Results for Ductless Heat Pumps in Cold Climates

Syracuse COE Symposium

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What is a Heat Pump (HP)?

- Air conditioner that "reverses cycle"
  - Pumps heat from outdoors to indoors
- Well-developed market, for 30-40 years
  - Annual sales of air-source HPs in US more than 1 million units
  - Nearly all in Southern US (areas with no gas available) or where electricity is very low cost (Pacific NW)
- Geothermal heat pumps are a variation
  - Heating COPs are 2-3 (i.e., 2-3 times more efficient than electric heat)
  - But much higher installed costs

What's new about Heat Pumps?

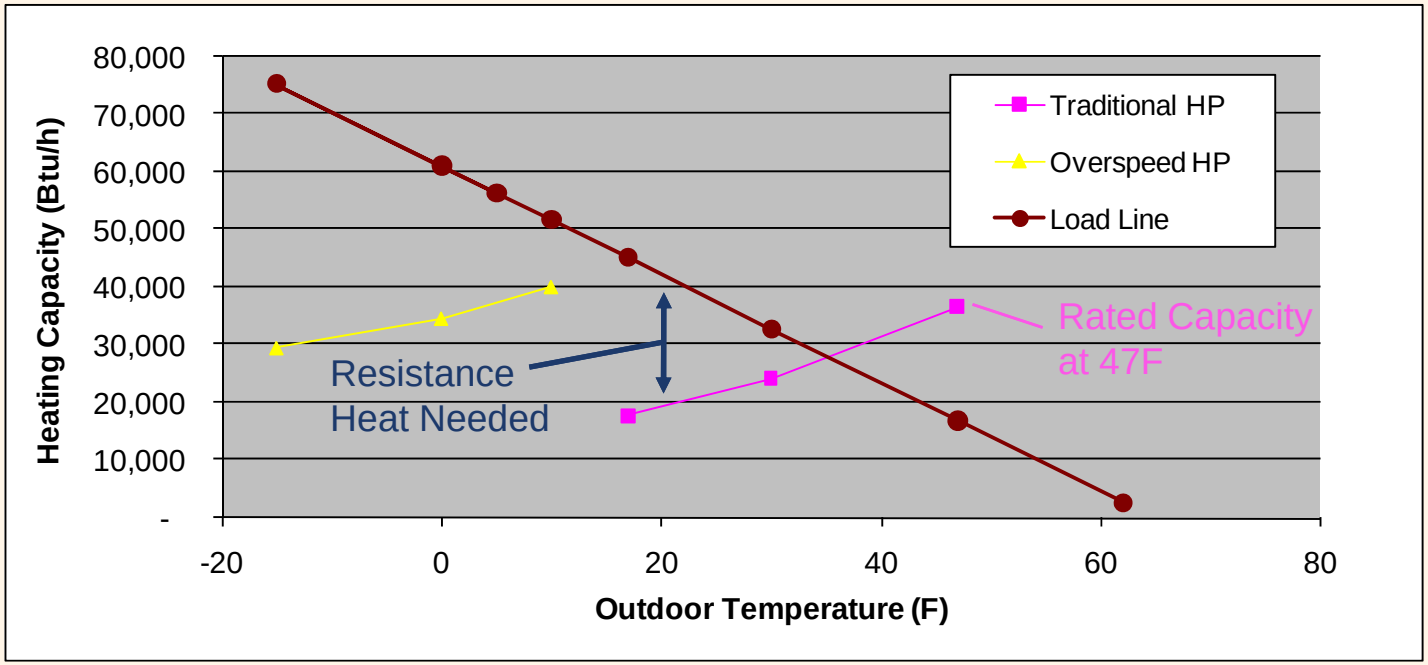
- Variable speed heat pumps now have the ability to "overspeed"
  - Maintain high heating capacity at low temperatures
  - Minimize need for backup electric resistance heat
  - Seasonal Coefficient of Performance (COP) for combined system can be much higher
- Small ductless HPs have been the first to implement this strategy
  - Mitsubishi FE "HyperHeat" series
  - Fujitsu RLS series
  - Not in multi-split or VRF systems yet

Market Potential in Cold Climates

- Big potential for Northeast US
  - Many houses do not have natural gas available; fuel oil costs are high
  - New higher-efficiency houses have smaller loads
  - Consumer gets “cooling for free”
  - Lower installed cost than geothermal HPs
- Ductless HPs have been the first to implement this strategy
  - Mitsubishi “HyperHeat”
  - Fujitsu RLS series
  - Not in multi-split or VRF products yet

Benefits of HP "Overspeeding"

- Provides more heating capacity at low temperatures
  - Example: Provide 100% of rated capacity at 5° F
- Reduces the need for backup or resistance heat
- COPs are still near 2 at low temperatures
- Overall COPs are highly application dependent (rated HSPF of 11 implies seasonal COP ~ 3.2)



Ductless Heat Pump Test Sites

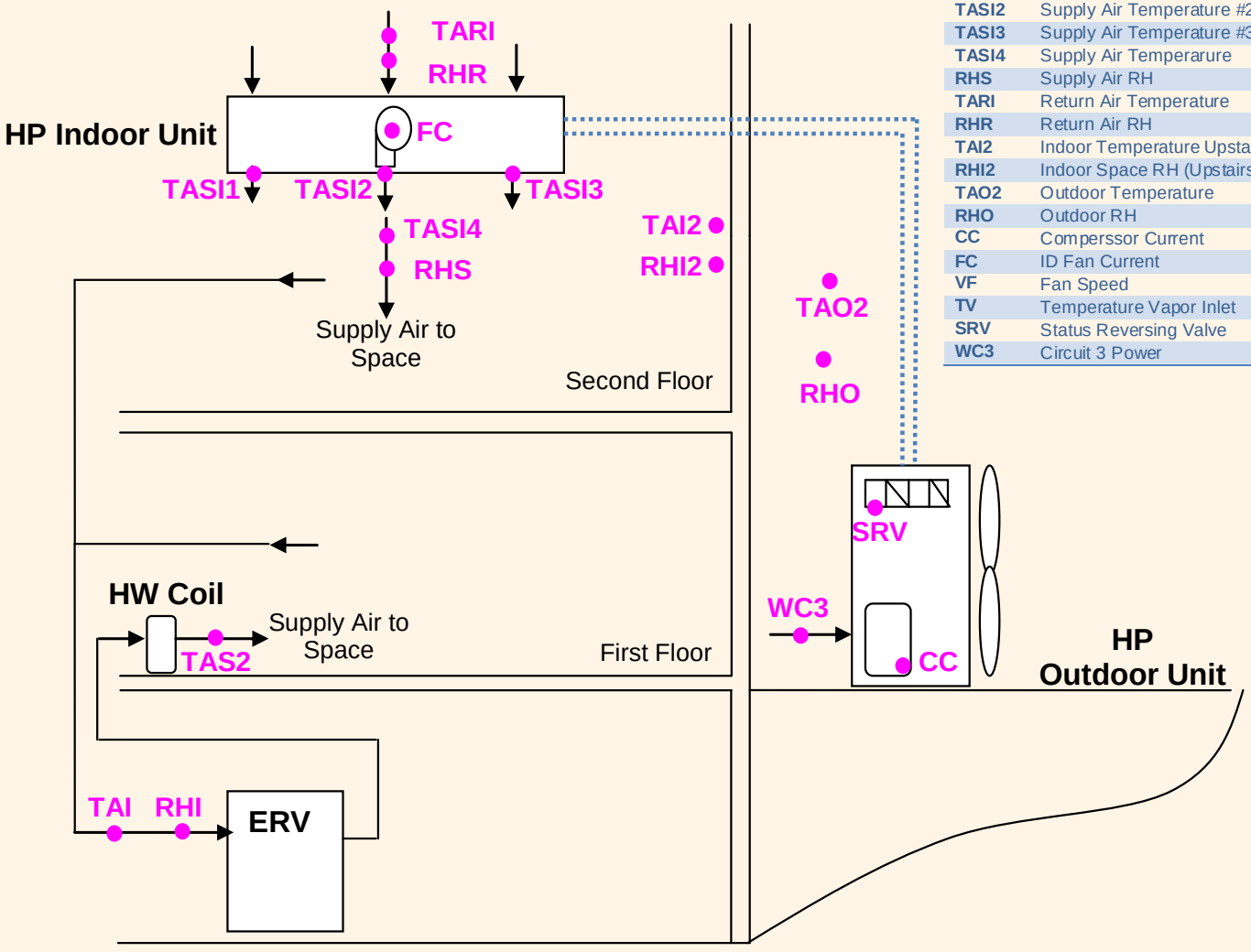
Gould

Fujitsu ASU9RLS (3/4 ton)

R-House

Mitsubishi MUZ-FE18NA (1-½ ton)

Typical Field Measurements on each HP

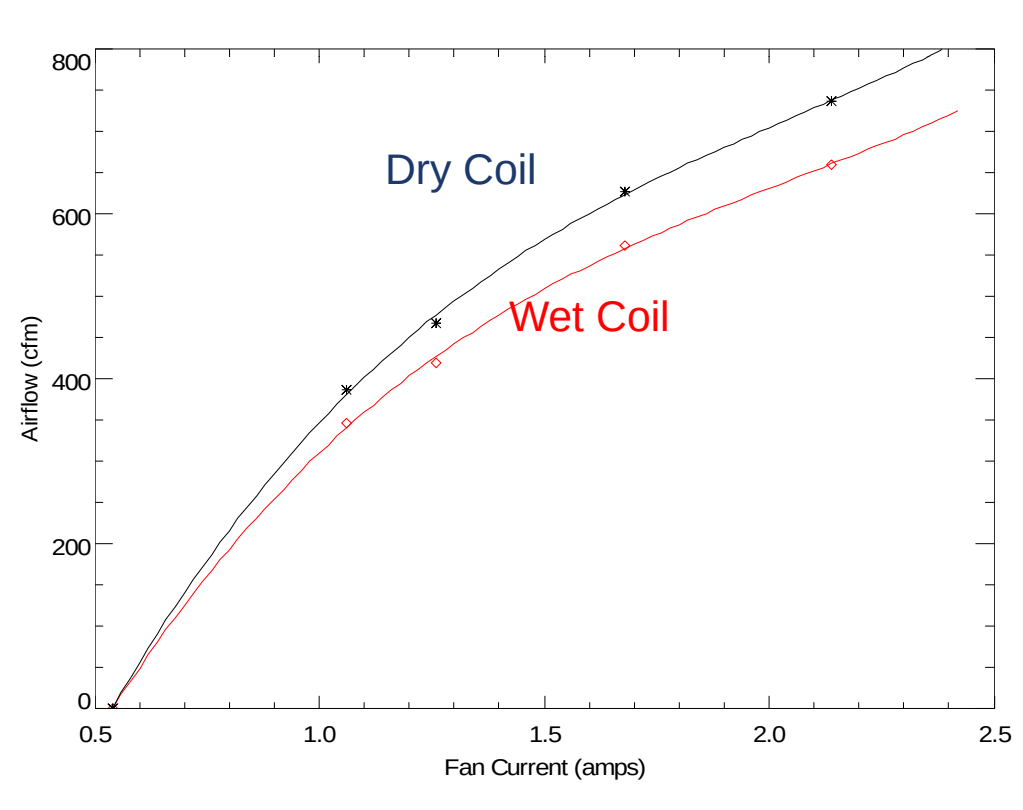


Data Point	Description	Eng Units	Instrument / Transducer
TASI1	Supply Air Temperature #1	F	Minco-10k-type2-Thermistor
TASI2	Supply Air Temperature #2	F	Minco-10k-type2-Thermistor
TASI3	Supply Air Temperature #3	F	Minco-10k-type2-Thermistor
TASI4	Supply Air Temperarure	F	Vaisala Thermocouple
RHS	Supply Air RH	%	Vaisala RH Transducer
TARI	Return Air Temperature	F	CS215
RHR	Return Air RH	%	CS215
TAI2	Indoor Temperature Upstairs	F	4-20 sensor
RHI2	Indoor Space RH (Upstairs)	%	4-20 sensor
TAO2	Outdoor Temperature	F	Vaisala Thermocouple
RHO	Outdoor RH	%	Vaisala RH Transducer
CC	Comperssor Current	amps	Veries 721 Current sensor
FC	ID Fan Current	amps	Veries 721 Current sensor
VF	Fan Speed		Monach
TV	Temperature Vapor Inlet	F	Minco-10k-type2-Thermistor
SRV	Status Reversing Valve		Veris H300
WC3	Circuit 3 Power	kwh	Wattnode WNB-208-Y-P

Used wireless dataloggers to reach remote indoor and outdoor locations

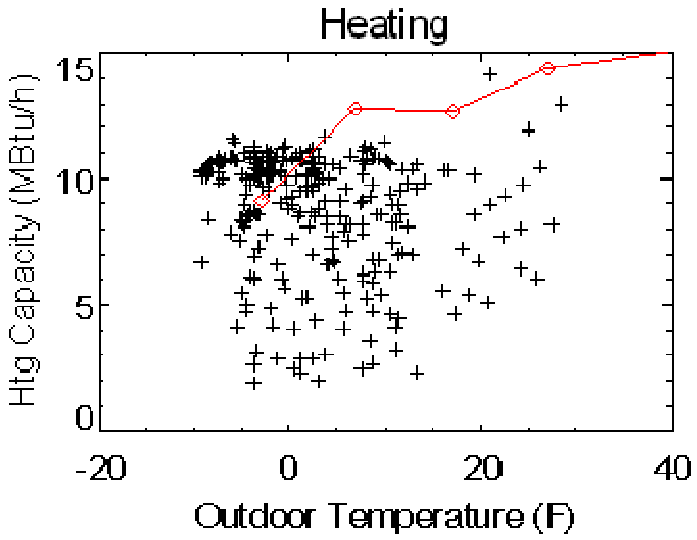
Estimating Indoor Unit Airflow

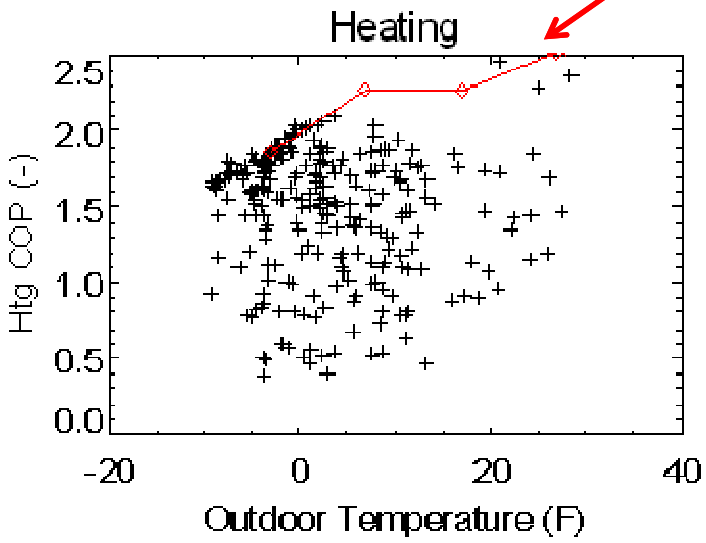
- Used Manufacturers specs and Duct Blaster to estimate air flow through ducless unit
- Correlated fan amps → cfm

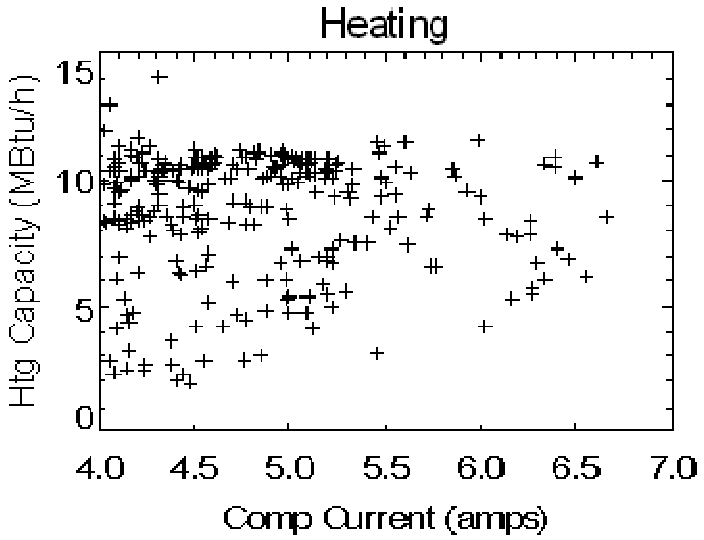


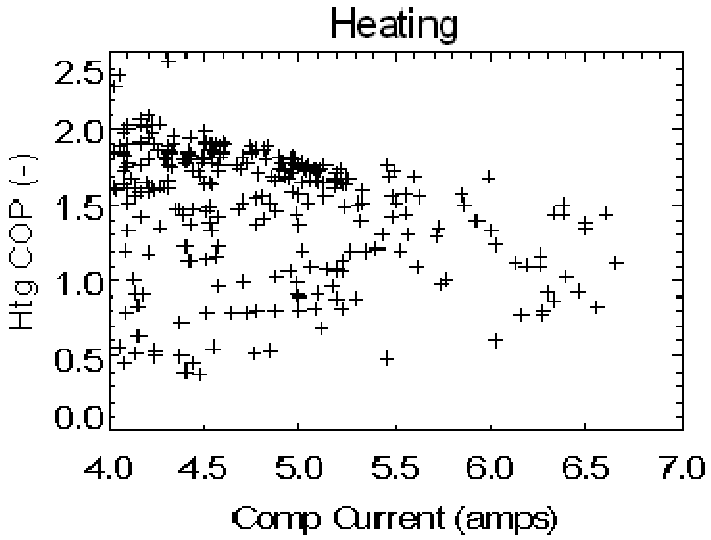
Gould - Heating Performance

NREL Lab Test Data (high spd, steady state)

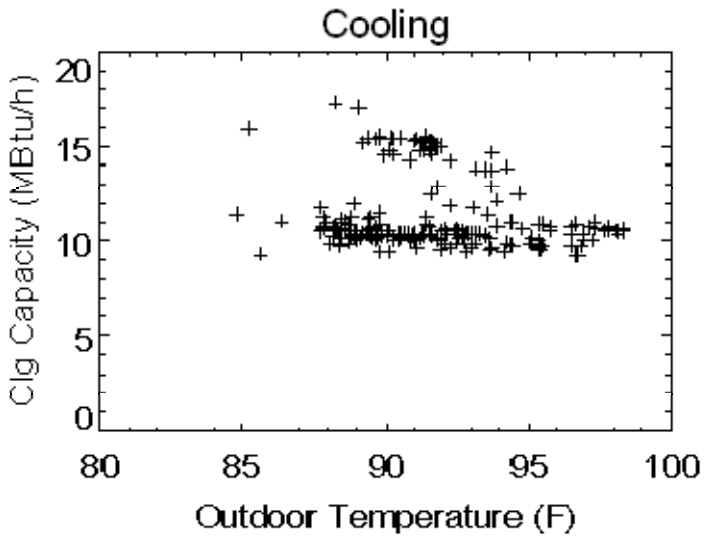


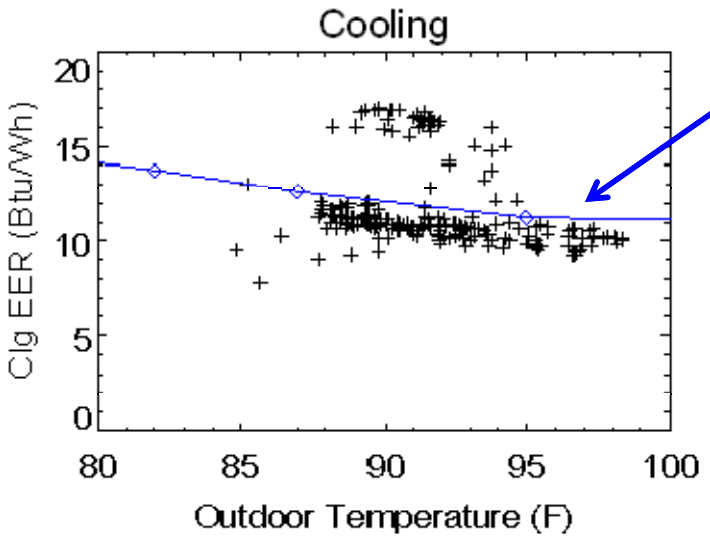




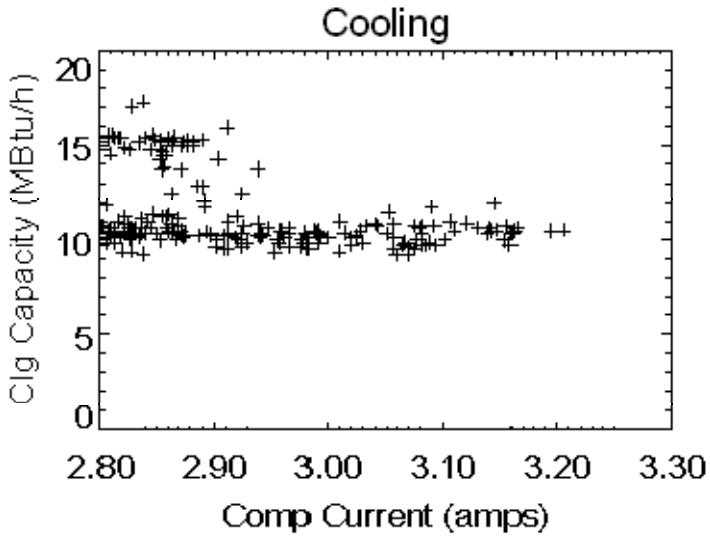


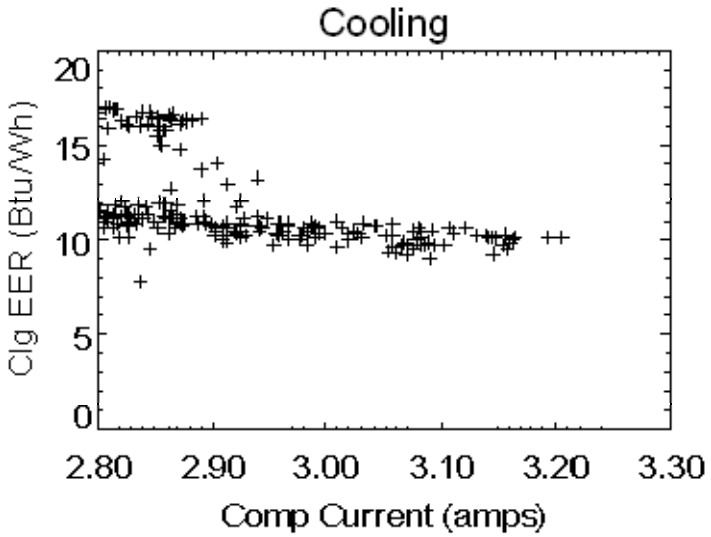
Gould – Cooling Performance





NREL Lab Test Data (high spd, steady state)

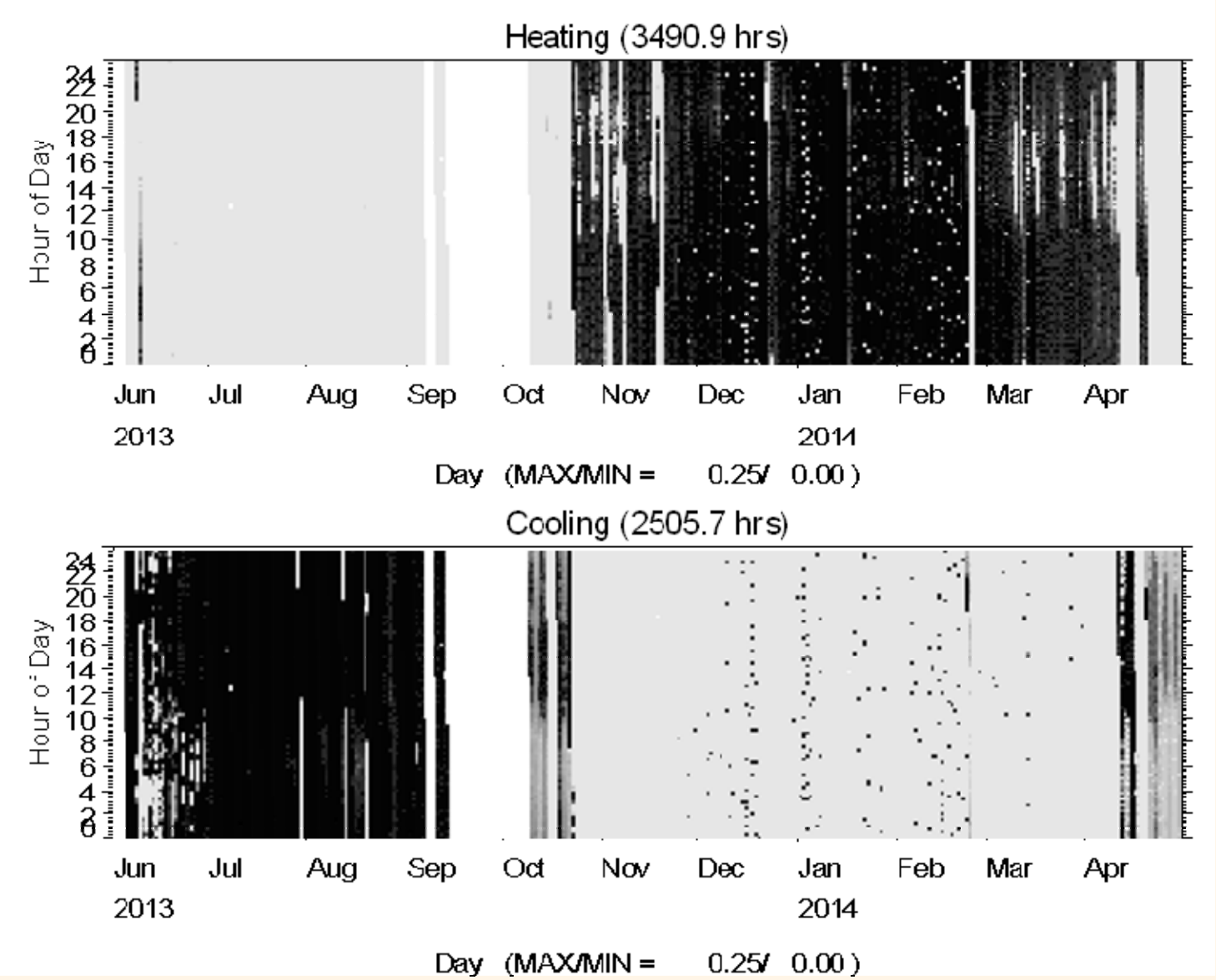




Gould Overall Performance

		Heating				Cooling			
Month	Ambient Temp.	Runtime	Load	HP Energy	COP	Runtime	Load	HP Energy	EER
	(F)	(hrs)	(MBtu)	(kWh)		(hrs)	(MBtu)	(kWh)	(Btu/Wh)
Jun-13	67.1	9.8	34.1	3.2	3.2	513.8	3516.8	181.9	19.3
Jul-13	75.6	-	-	-	-	726.0	7123.1	446.9	15.9
Aug-13	69.5	-	-	-	-	695.2	6814.4	262.3	26.0
Sep-13	61.6	-	-	4.1	-	208.3	3525.6	184.0	30.6
Oct-13	52.8	175.4	354.2	52.6	2.0	141.8	434.8	67.7	13.6
Nov-13	38.0	497.9	1339.3	193.5	2.0	-	-	-	-
Dec-13	28.2	697.3	3131.6	413.2	2.2	-	-	-	-
Jan-14	20.7	750.3	3459.7	525.6	1.9	-	0.7	-	-
Feb-14	22.7	608.7	2153.0	363.2	1.7	-	25.4	-	-
Mar-14	28.4	611.1	1254.0	266.8	1.4	-	-	-	-
Apr-14	47.6	209.9	282.8	70.0	1.2	154.0	452.6	35.3	12.8
May-14	60.1	45.7	39.1	15.7	0.7	409.2	1606.2	119.0	13.5
Total		***3,606.0***	***12,047.9***	***1,907.8***	***1.9***	***2,848.3***	***23,499.5***	***1,297.2***	***19.7***

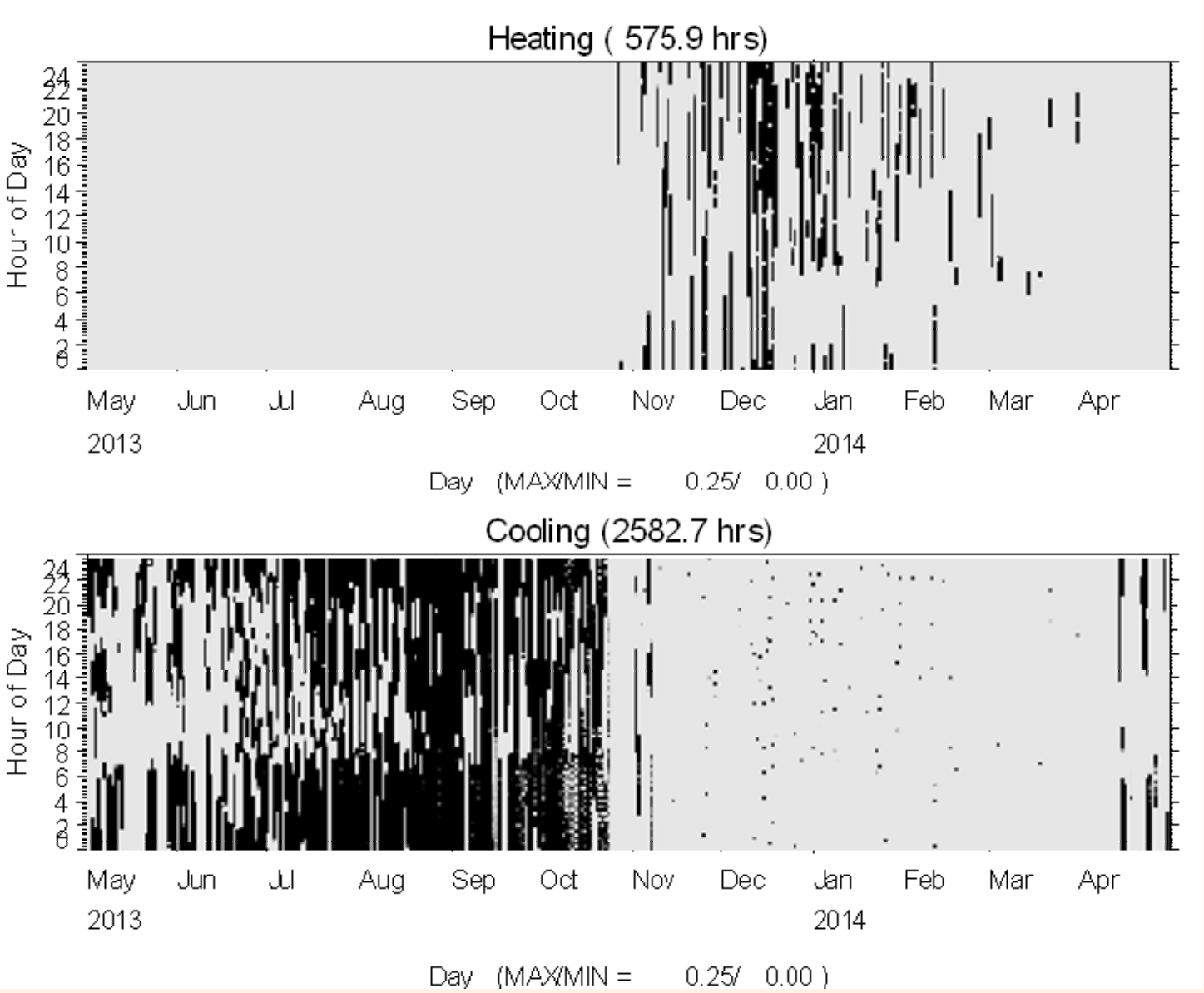
Gould – Operating Pattern



R-House - Overall Performance

		Heating				Cooling			
Month	Ambient Temp. (F)	Runtime (hrs)	Load (MBtu)	HP Energy (kWh)	COP	Runtime (hrs)	Load (MBtu)	HP Energy (kWh)	EER (Btu/Wh)
May-13	64.9	-	-	-	-	234.9	-	190.6	-
Jun-13	69.1	-	-	-	-	284.9	-	208.8	-
Jul-13	76.0	-	-	-	-	487.7	-	296.7	-
Aug-13	71.6	-	-	-	-	581.8	7,404.8	278.1	26.6
Sep-13	64.3	-	-	-	-	504.6	6,316.4	239.4	26.4
Oct-13	56.2	8.8	38.7	4.4	2.6	364.9	3,053.8	158.7	19.2
Nov-13	42.0	134.8	489.4	79.3	1.8	35.3	415.0	23.3	17.8
Dec-13	33.6	239.7	725.4	146.9	1.4	8.7	5.7	5.1	-
Jan-14	25.9	121.8	548.0	93.7	1.7	7.2	5.8	4.1	-
Feb-14	28.1	53.3	222.9	37.1	1.8	2.4	0.8	1.2	-
Mar-14	32.7	17.6	94.6	13.1	2.1	0.8	0.3	0.4	-
Apr-14	50.5	-	-	-	-	69.5	663.4	39.2	16.9
Total		*575.9*	*2,119.1*	*374.4*	*1.7*	*2,582.7*	*17,866.*	*1,445.6*	*24.2*

R-House HP Operating Pattern

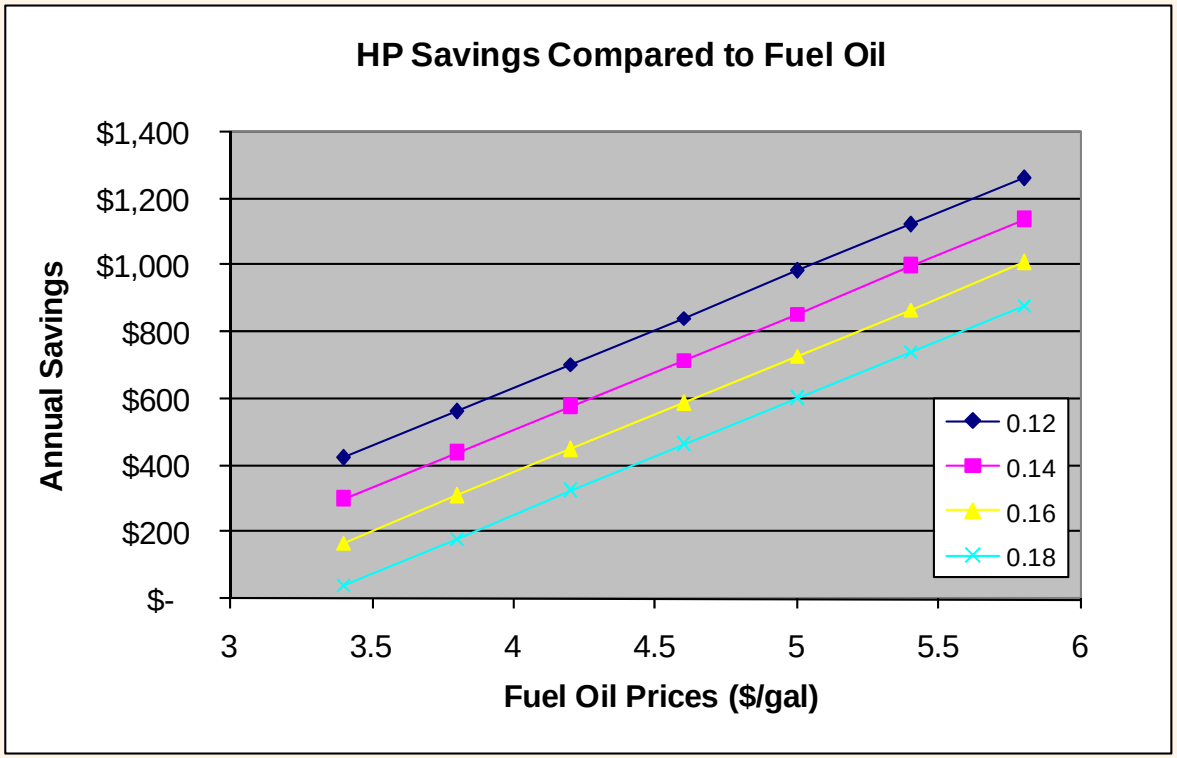


Summary of Measured HP Performance

- Gould – Fujitsu (3/4 ton)
  - COP is 1.9 for this Hudson Valley Location
  - Energy Use: Htg = 1,910 kWh, Clg = 1,300 kWh
- R-House – Mitsubishi (1–½ ton)
  - COP is 1.7 for Syracuse Location
  - Energy Use: Htg = 380 kWh, Clg = 1,450 kWh
  - Unit is oversized; HW coil does some heating
- Cooling loads bigger than expected
  - HRV may hurt – loose economizer function

Economics of Heat Pumps

- Heat Pump can provide savings compared to fuel oil heating at current fuel costs



Assumptions:
COP=1.9
Load = 41 MMBtu

Summary

- New HPs deliver seasonal COPs near two
  - ½ cost of electric heat
- fraction of the cost of geothermal heat pumps
  - Especially appropriate for smaller efficient homes
- Cooling loads were significant in these two Passive Houses
- Point source of heating / cooling works well in highly efficient homes
- Offers an alternative to fuel oil in rural homes in cold climates