Value of Air Source Heat Pumps in Light of Variable Energy Prices

Jeff Haase

Energy Design Conference | February 27, 2013

GREAT RIVER ENERGY®
A Touchstone Energy® Cooperative

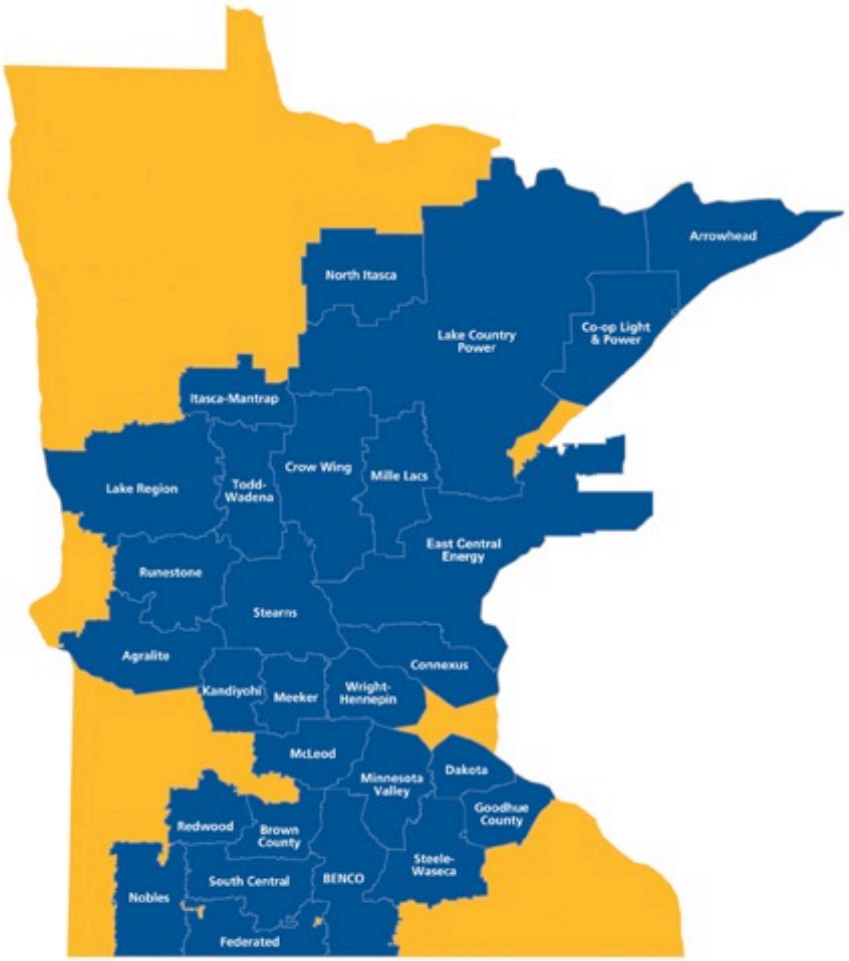
Agenda

- Overview of Air Source Heat Pump Technologies
  - History, General
- Comparison of Operating Costs to Other Space Heating Technologies
  - Electricity, Natural Gas and Delivered Fuels
- Cold Climate Performance
  - Do ASHP Technologies work in Minnesota?
- Electric system compatibility of ASHPs
- Future Technology Developments
  - Will the performance of ASHPs improve over time?

No Silver Bullets Presented

- I have yet to find a technology that works for everyone, every time.
- It would be great this existed.
- Individual conditions need to be taken into account to determine the applicability of any technology.
- Individuals have different motivations and different levels of cost risk and technology acceptance.

Great River Energy



- Not for profit generation & transmission cooperative providing wholesale electricity to 28 distribution cooperatives in Minnesota and into Wisconsin.
- Second largest utility in Minnesota, our member cooperatives distribute electricity to families, farms and businesses servings almost 1.7 million people.

GREAT RIVER ENERGY®
A Touchstone Energy® Cooperative

Successful Portfolio of EE Programs

- Residential & Commercial Lighting
- Energy Efficient Appliances
- Commercial & Industrial Efficiency Programs
- Quality Installed Air Conditioning Systems
- Quality Installed Air Source Heat Pump Systems
- Ground Source Heat Pumps
- Agricultural Programs
- Heat Pump Water Heating
- Electric Thermal Storage Water & Space Heating
- Load Management Programs

Heat Pumps Generate Significant Energy Savings

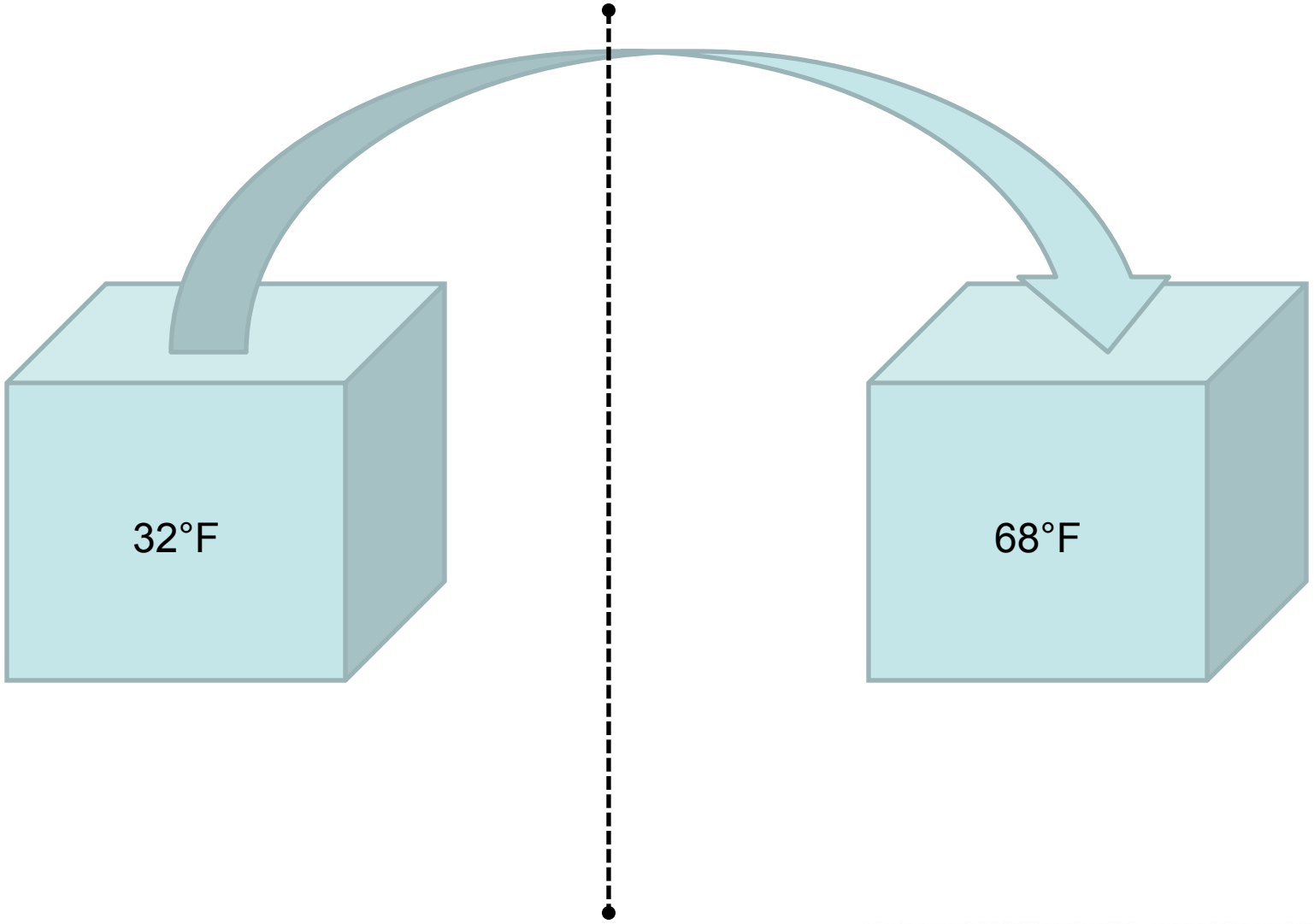
Program	Energy Savings (kWh)	Percent of Total Energy Savings
Residential Lighting	29,638,551	19.8%
Comm. Lighting	20,134,718	13.4%
GSHPs	17,724,829	11.8%
Appliances	15,284,509	10.2%
ASHPs	5,978,073	4.0%
Air Conditioning	1,630,582	1.1%
Load Management	804,584	0.5%
Total	**91,195,846**	**60.8%**

- Heat Pump Technologies account for nearly 15% of our annual energy savings achievements.
- These savings are largely based on energy savings over electric resistance heating.

How many of you have an air source heat pump?

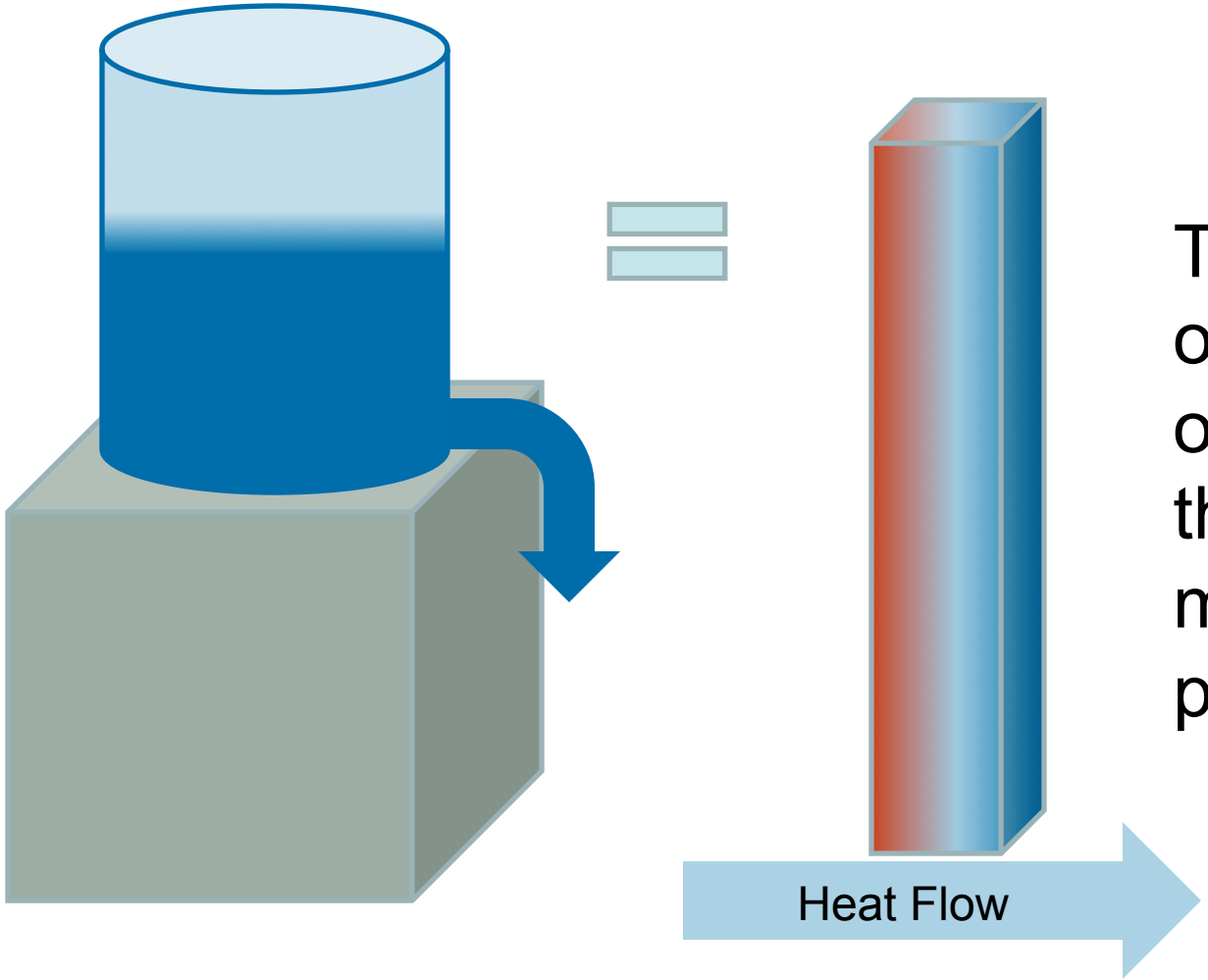
- Air conditioners
- Refrigerators
- Freezers
- Dehumidifiers

How does an ASHP “Pump” Heat?



Energy Naturally Flows Downhill

Always True



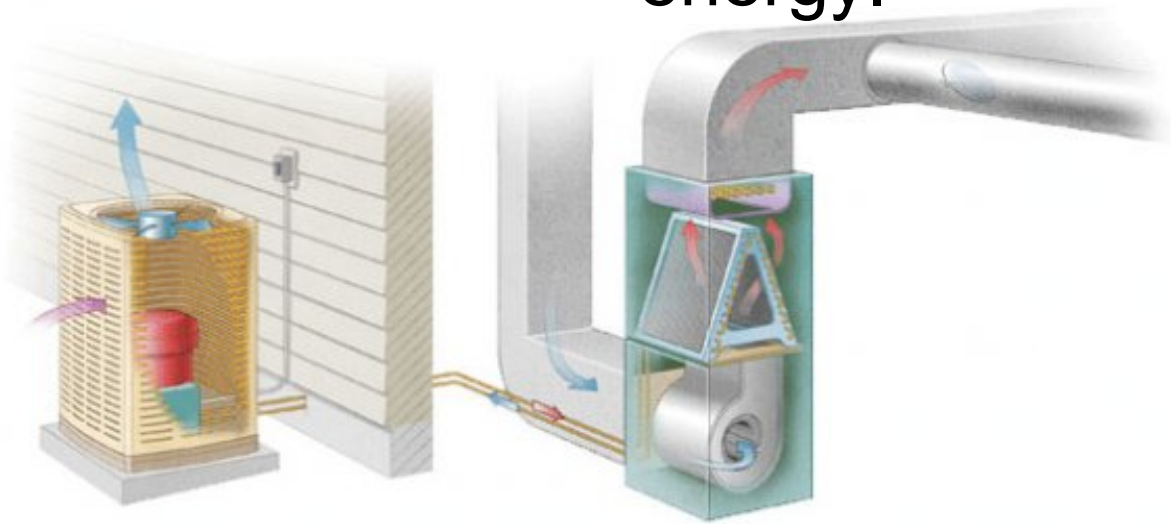
The natural flow of energy can only be reversed through a mechanical process.

Heat Pumps are Analogous to Pumps

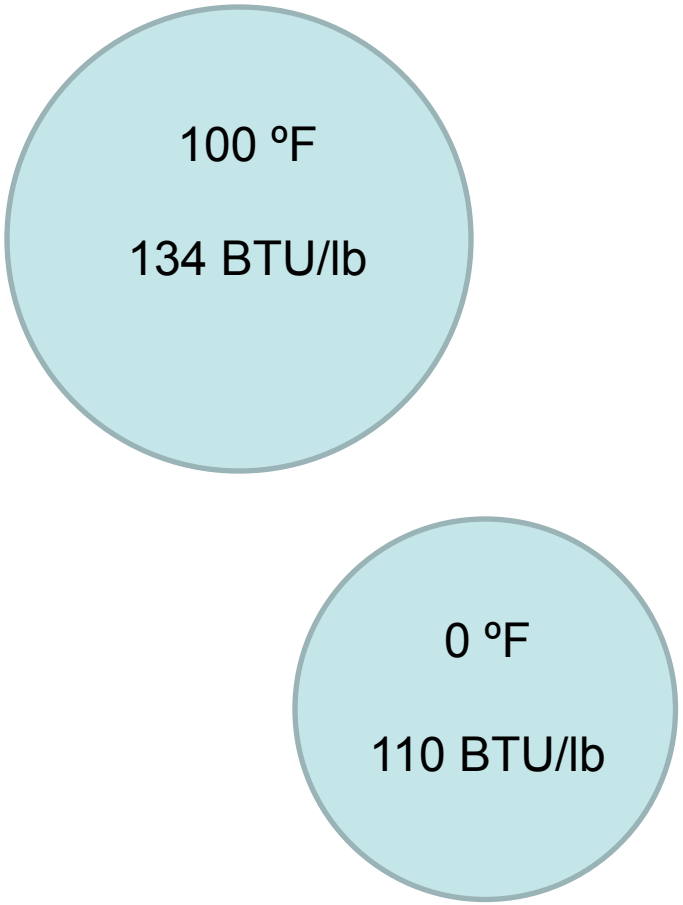
- Pumps move fluids from one place to another, they do not create the fluid.
- Pumps are incredibly efficient at doing this, but we refer to their ability to do work in terms of capacity and efficiency.

Heat & Heat Pumps

- A heat pump does not create heating or cooling energy.
- This is enabled by the vapor compression cycle.
- Heat pumps move heat from lower to higher temperatures, using a small amount of high quality drive energy.

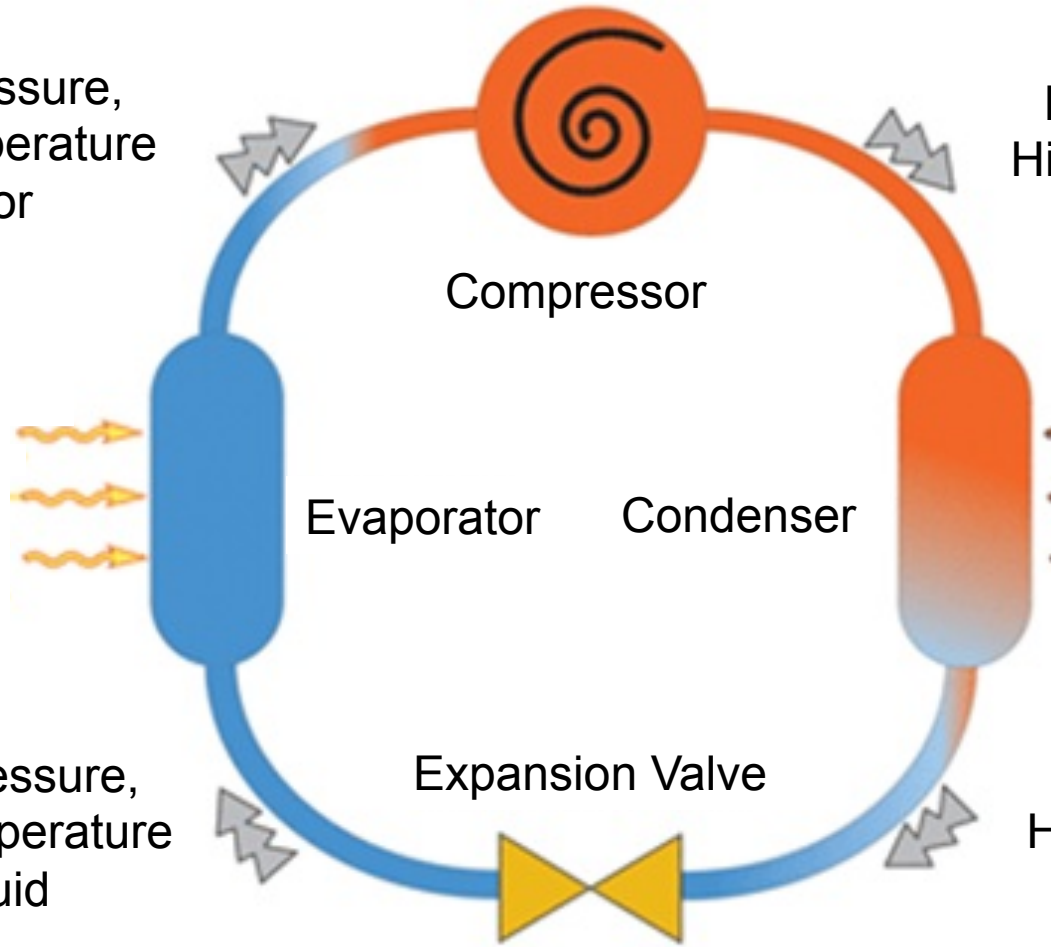


There is Heat in “Cold” Air



- At 100ºF one pound of dry air contains approximately 134 BTUs.
- At 0ºF one pound of dry air contains approximately 110 BTUs.
- At -460ºF one pound of dry air contains 0 BTUs

Vapor Compression Cycle



Bin Temperature Data

Duluth, MN

Bin	Total Hours
90|95	6.7
85|90	28.6
80|85	86.6
75|80	237.7
70|75	317.3
65|70	494.4
60|65	717
55|60	660
50|55	709.4
45|50	612.5
40|45	531.3
35|40	628.3
30|35	783.1
25|30	635.5
20|25	568.3
15|20	411.6
10|15	351.3
5|10	279.6
0|5	216.1
-5|0	172.3
-10|-5	136.5
-15|-10	84.6
-20|-15	55.5
-25|-20	25.2
-30|-25	9.6
-35|-30	1.8
-40|-35	0.1

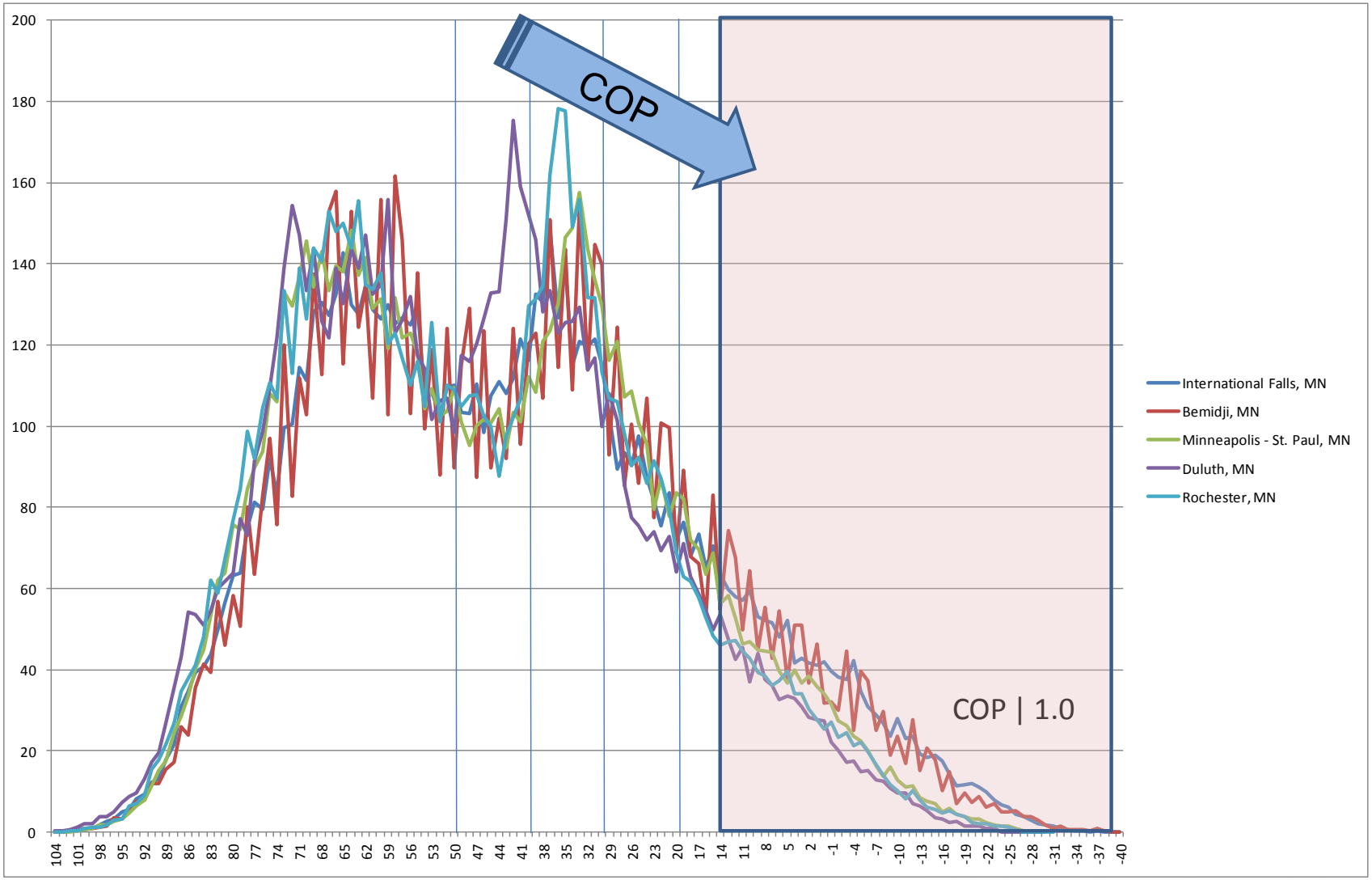
79% of all heating hours occur when ambient conditions are above 15°F

Rochester, MN

Bin	Total Hours
95|100	4.3
90|95	21.3
85|90	90.8
80|85	223.8
75|80	386.4
70|75	547.9
65|70	663.1
60|65	750.4
55|60	649.6
50|55	572.8
45|50	532.4
40|45	495.6
35|40	604.1
30|35	822.9
25|30	589.8
20|25	458.4
15|20	360.1
10|15	251.8
5|10	212.3
0|5	181.1
-5|0	133.9
-10|-5	104.3
-15|-10	54.5
-20|-15	29.4
-25|-20	15
-30|-25	4.5
-35|-30	0.2

81% of all heating hours occur when ambient conditions are above 15°F

System Performance will Decrease with the Outdoor Temperature

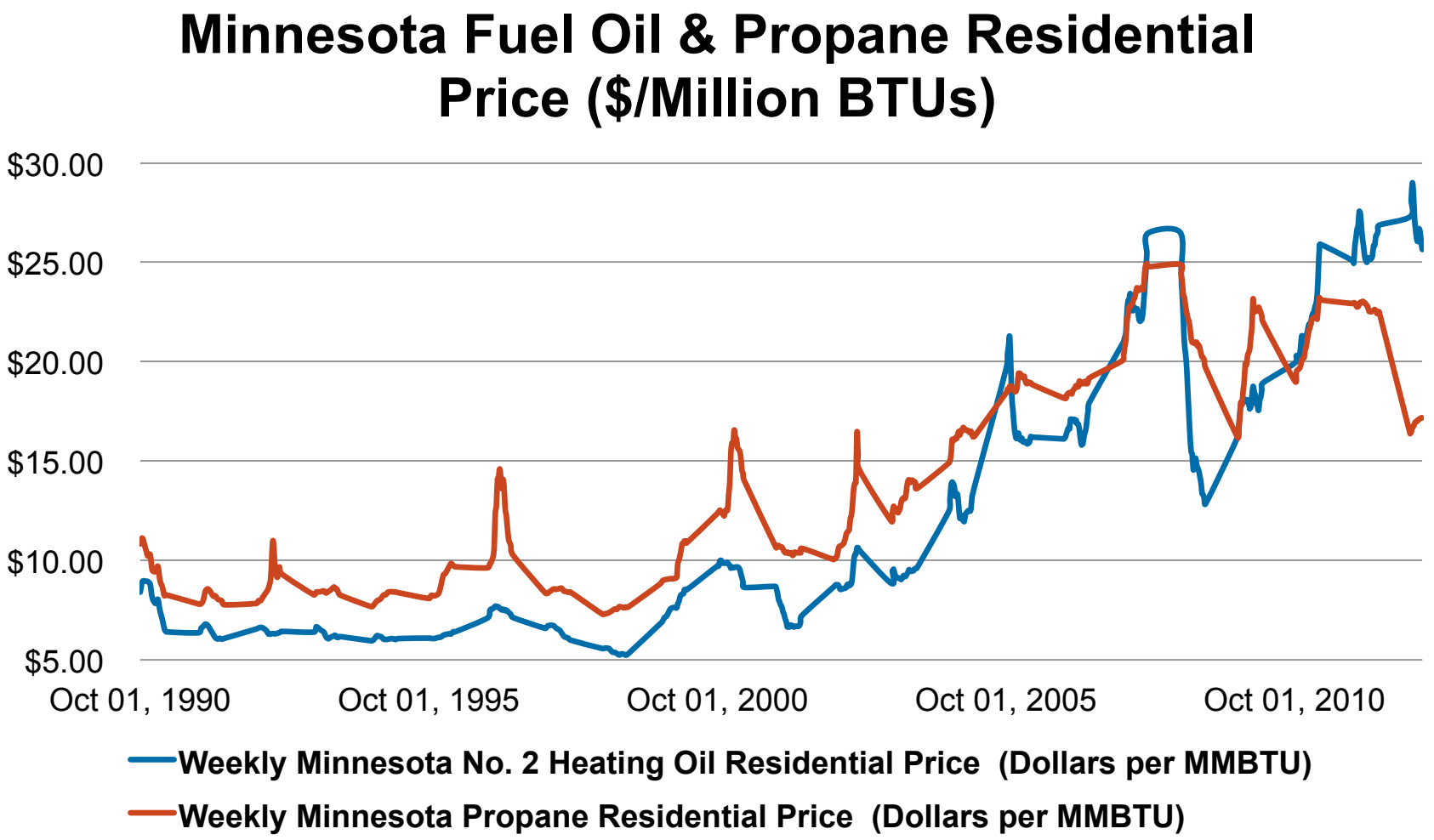


GREAT RIVER ENERGY®
A Touchstone Energy® Cooperative

Air Supply

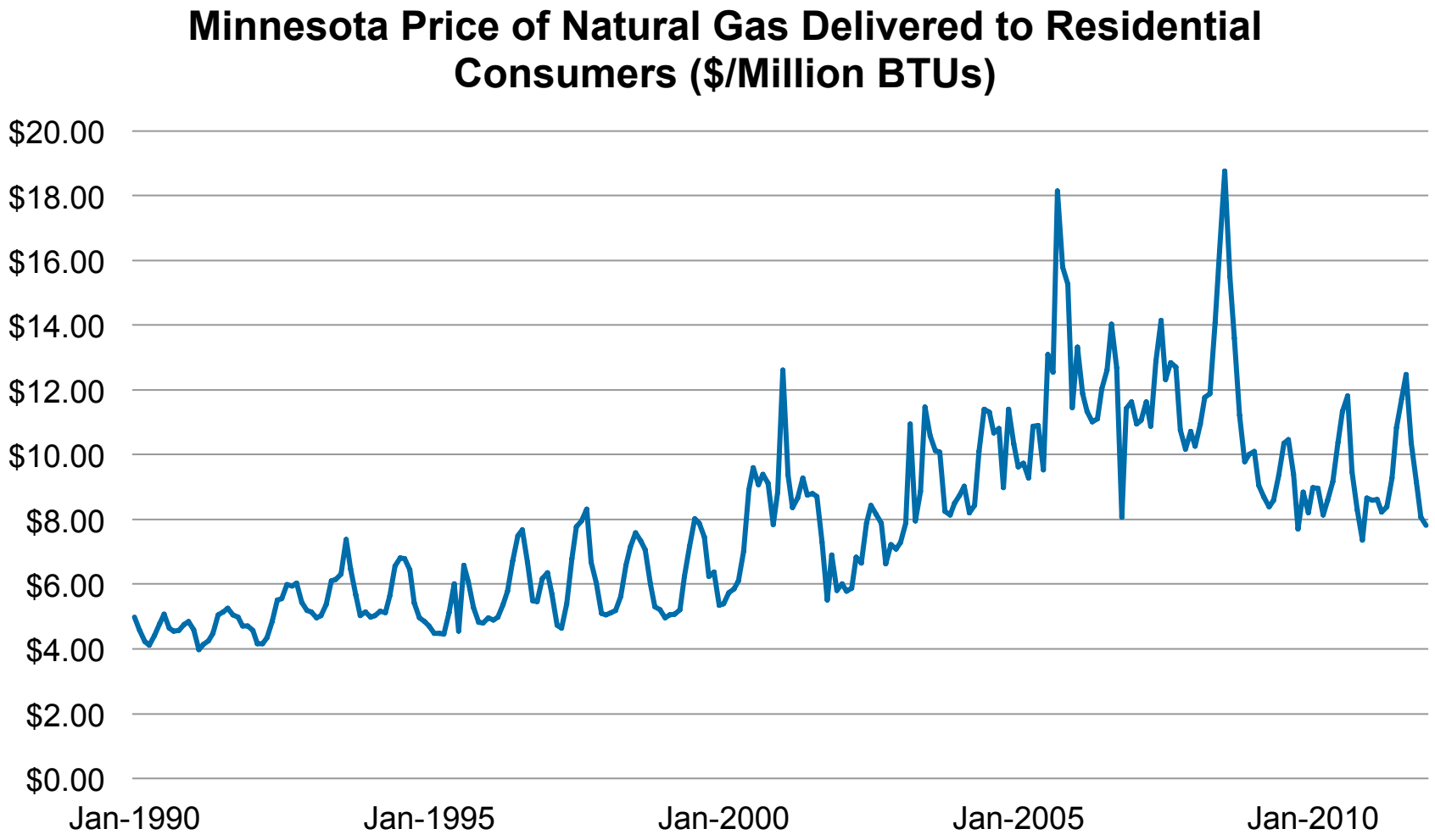
- All out of hot air?
  - Air supply temps will vary with outdoor temperature.
- Supply temps from an Air Source Heat Pump are lower than a combustion furnace.
- This tends to cause the heat pump to operate for a longer period of time to meet the heating load.
  - Provides constant heat
  - Operation is at steady state, i.e. higher efficiency

Price Variability of Delivered Fuels



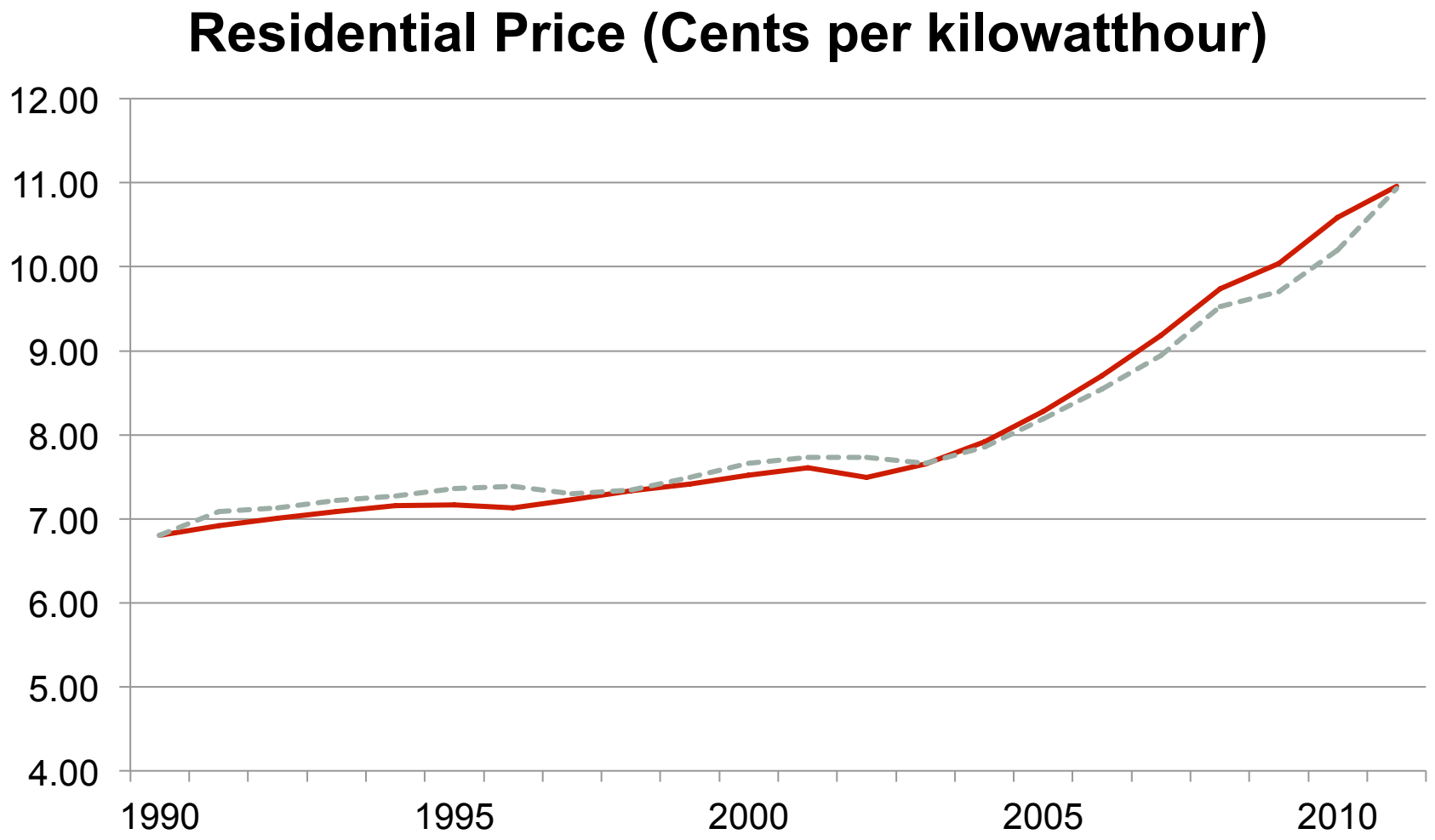
GREAT RIVER ENERGY®
A Touchstone Energy® Cooperative

Price Variability of Natural Gas



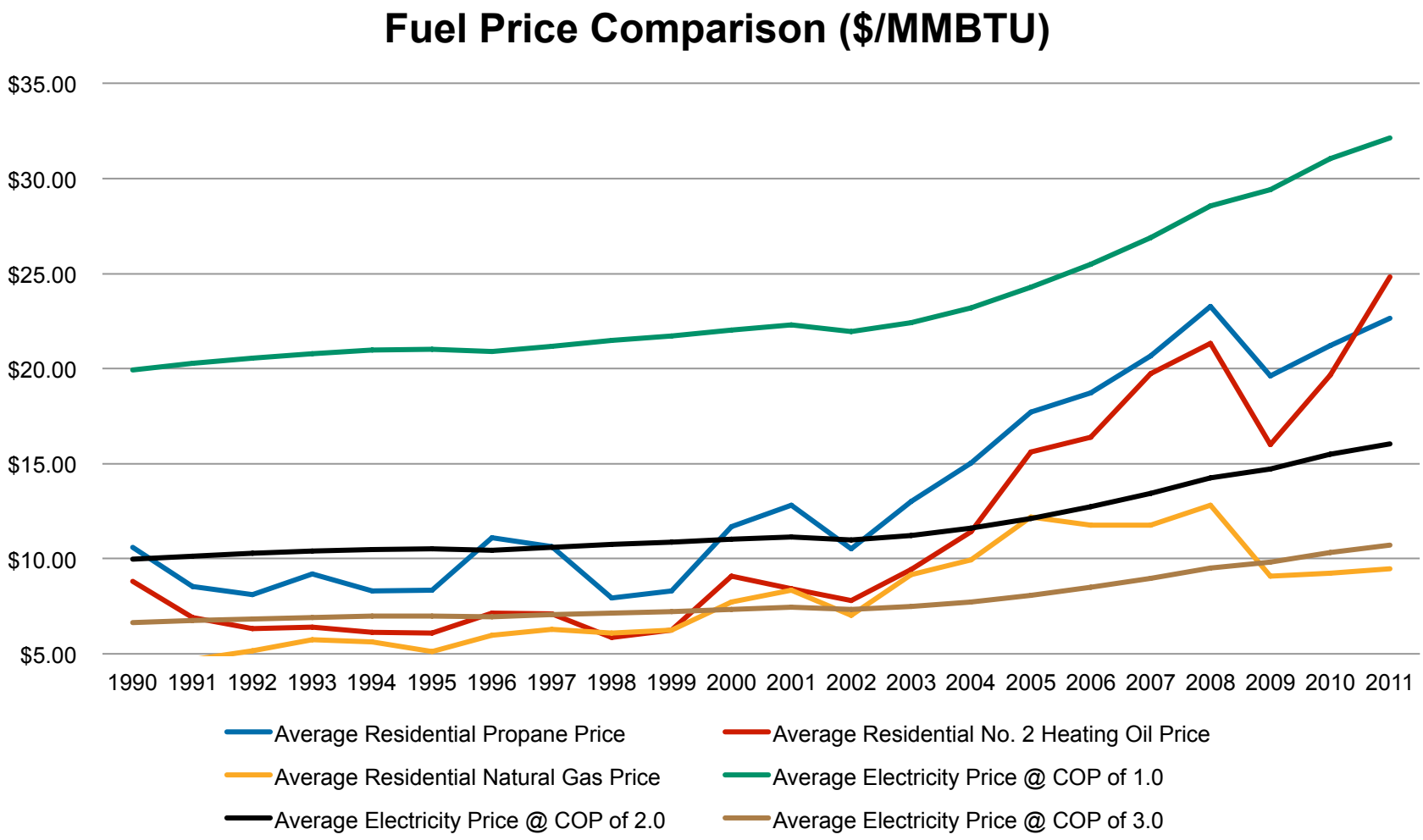
GREAT RIVER ENERGY®
A Touchstone Energy® Cooperative

Price Variability of Electricity



GREAT RIVER ENERGY®
A Touchstone Energy® Cooperative

Fuel Price Comparison



GREAT RIVER ENERGY®
A Touchstone Energy® Cooperative

Dual Fuel Electric Rates

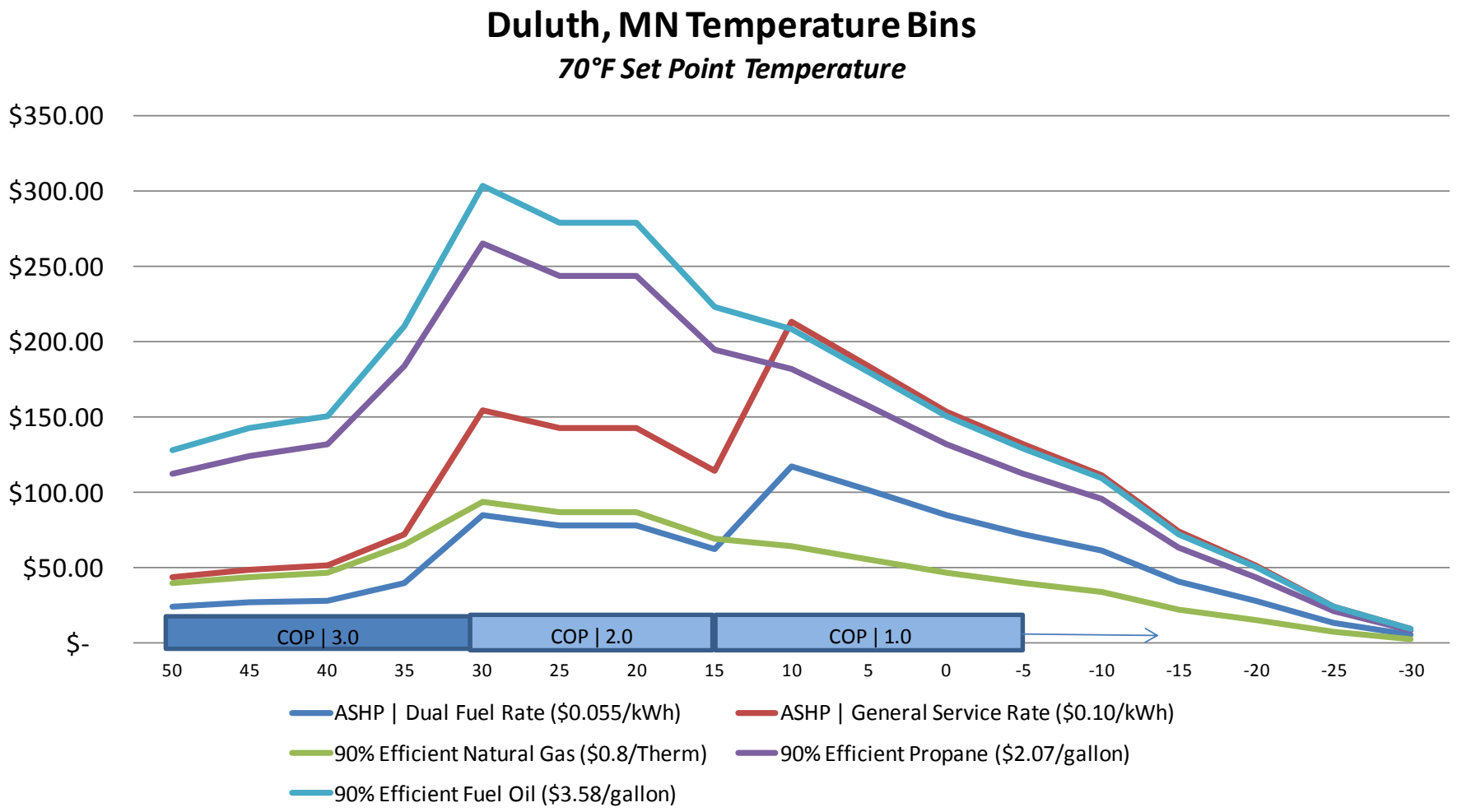
- Dual Fuel Rates are Offered by many utilities.

- Example | Mille Lacs Electric Cooperative
  - Dual Fuel rate of 5.5¢ per kWh (3412 BTU/kWh)
  - Comparable to:
    - $1.48 per gallon of propane (91,500 BTU/Gallon)
    - $1.61 per therm of natural gas (100,000 BTU/therm)
    - $2.24 per gallon of fuel oil (138,700 BTU/Gallon)
    - These prices reflect 100% efficiency

Comparing Fuel Options using an "Assumed" Home

- 3,000 Square Foot
- 3 ton heat load | -30°F
- Generalized heat loss
  R 8.3 | U 0.12
- Temperature Bin Data
  Duluth, MN
- Setpoint | 70°F

Heating Cost Profile



GREAT RIVER ENERGY®
A Touchstone Energy® Cooperative

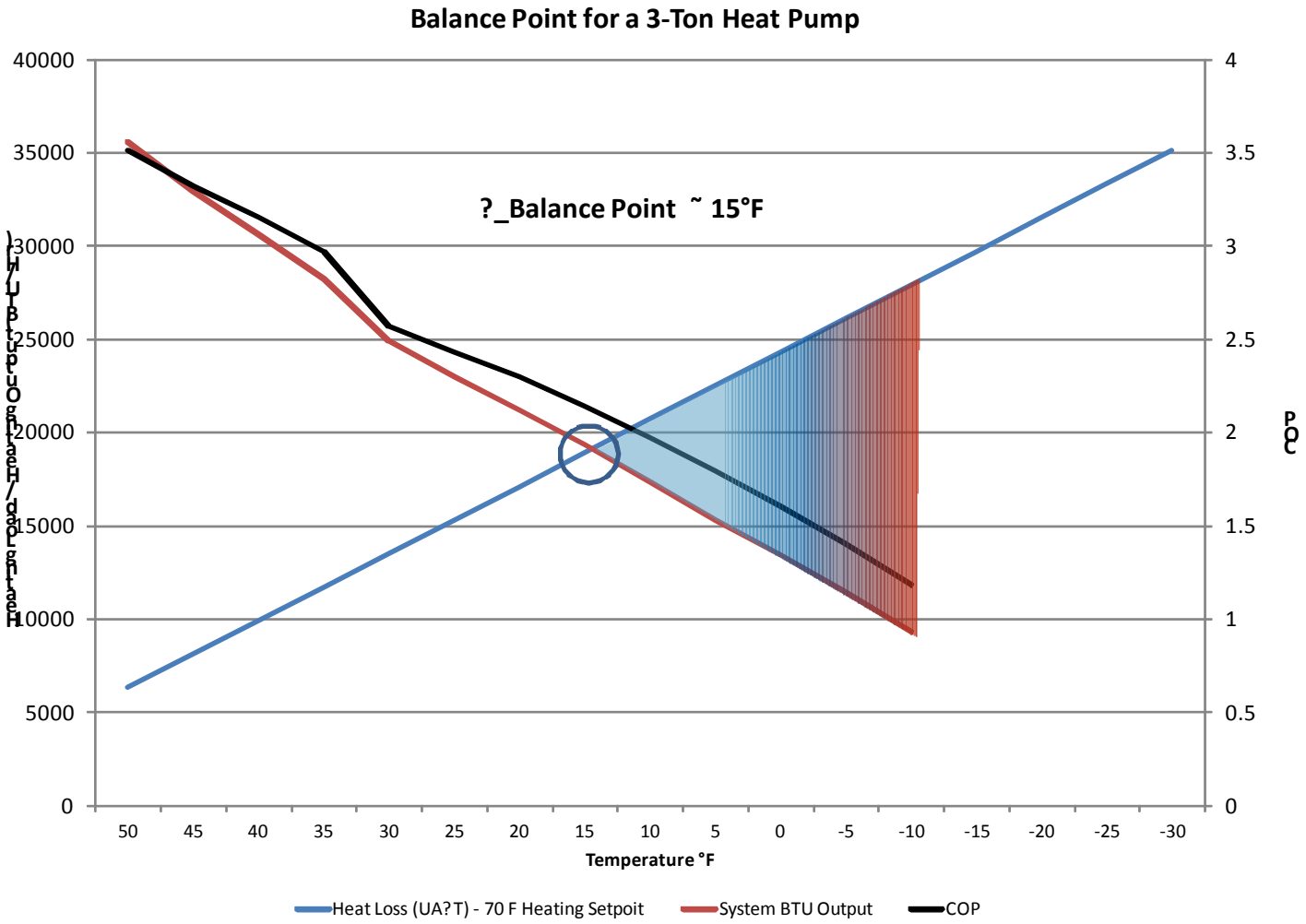
ASHP Heating Performance Data

EXPANDED HEATING DATA (CONT.)

ASZ130361A* / AR*F364216**

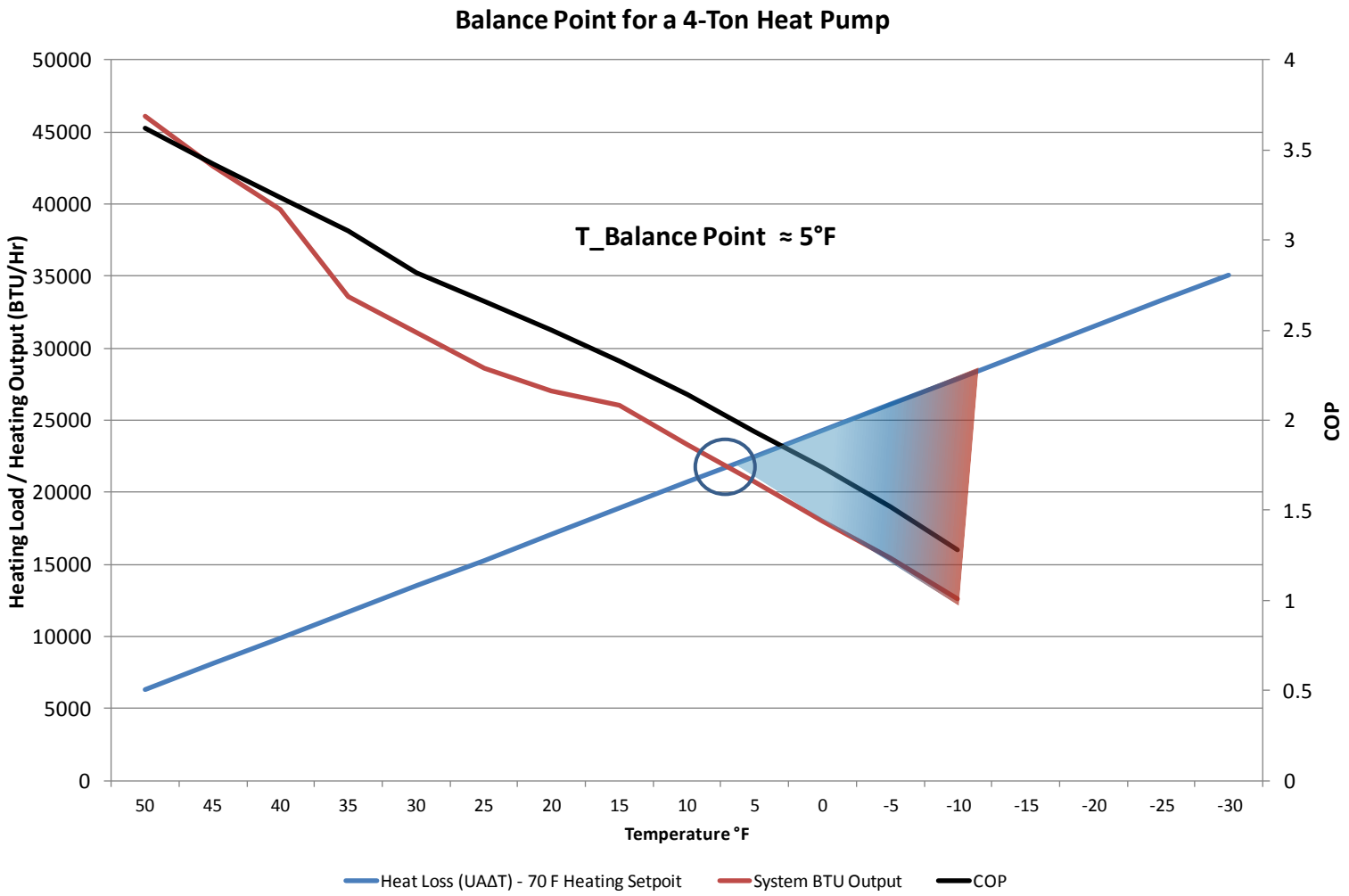
	OUTDOOR AMBIENT TEMPERATURE																	
	65	60	55	50	47	45	40	35	30	25	20	17	15	10	5	0	-5	-10
MBh	42.7	40.5	38.1	35.6	**34.0**	32.9	30.6	28.2	24.9	23.0	21.2	20.0	19.3	17.3	15.3	13.4	11.4	9.3
ΔT	31.0	29.4	27.7	25.9	24.7	23.9	22.2	20.5	18.1	16.7	15.4	14.5	14.0	12.5	11.1	9.7	8.3	6.8
KW	3.15	3.09	3.03	2.97	**2.93**	2.90	2.84	2.78	2.83	2.77	2.70	2.66	2.64	2.57	2.51	2.44	2.38	2.31
Amps	14.7	13.6	12.7	12.0	11.5	11.3	10.7	10.1	9.7	9.2	8.8	8.6	8.5	8.0	7.5	7.0	6.5	5.8
COP	3.97	3.83	3.68	3.51	3.39	3.32	3.15	2.97	2.57	2.43	2.29	2.20	2.14	1.97	1.79	1.60	1.40	1.18
EER	13.5	13.1	12.6	12.0	11.6	11.3	10.8	10.1	8.8	8.3	7.8	7.5	7.3	6.7	6.1	5.5	4.8	4.0

Example Balance Point
3-Ton System (13 SEER)



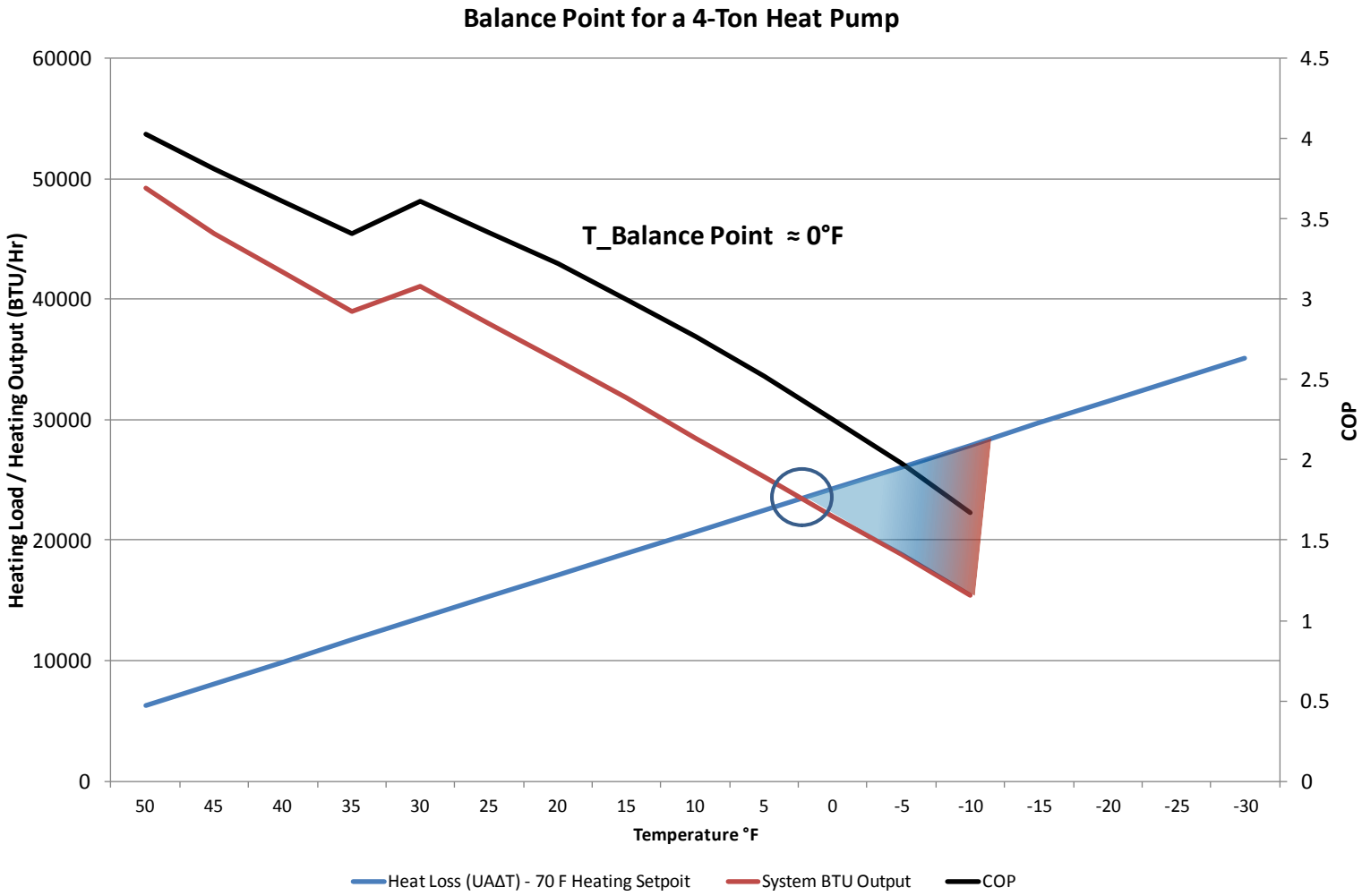
GREAT RIVER ENERGY®
A Touchstone Energy® Cooperative

Example Balance Point
4-Ton System (13 SEER)



GREAT RIVER ENERGY®
A Touchstone Energy® Cooperative

Example Balance Point
4-ton System (16 SEER)



GREAT RIVER ENERGY®
A Touchstone Energy® Cooperative

Annual Heating Costs

- ASHP
  - Dual Fuel Rate ($0.055/kWh) - $948
  - General Service Rate ($0.10/kWh) - $1,724

- 90% Efficient Natural Gas ($0.80/therm) | $822
- 90% Efficient Propane ($2.07/gallon) | $2,317
- 90% Efficient Fuel Oil ($3.58/gallon) | $2,650

Detailed Cost Analysis

3 ton, 13 SEER System

	Dual Fuel	General Service	Fossil System
Natural Gas	$ 657.74	$ 959.12	$ 821.25
Propane	$ 1,186.71	$ 1,488.09	$ 2,322.37
Fuel Oil	$ 1,302.04	$ 1,603.42	$ 2,649.66

4 ton, 13 SEER System

	Dual Fuel	General Service	Fossil System
Natural Gas	$ 636.37	$ 1,018.91	$ 821.25
Propane	$ 944.98	$ 1,327.51	$ 2,322.37
Fuel Oil	$ 1,012.26	$ 1,394.79	$ 2,649.66

Detailed Cost Analysis

4 ton, 16 SEER System

	Dual Fuel	General Service	Fossil System
Natural Gas	$ 522.39	$ 849.85	$ 821.25
Propane	$ 745.67	$ 1,073.14	$ 2,322.37
Fuel Oil	$ 794.35	$ 1,121.82	$ 2,649.66

- Incremental heat pump costs will be in the neighborhood of $800 to $2000 over a comparable SEER Air Conditioner.
- Tax Credits and Utility Rebates are available that can offset the incremental cost.

The Answer…

It Depends

- What is your electric rate?
- What are your rate options?
- What are your interests?
- What do you think the price of fuel and electricity is going to be in the next 5, 10, and 15 years?

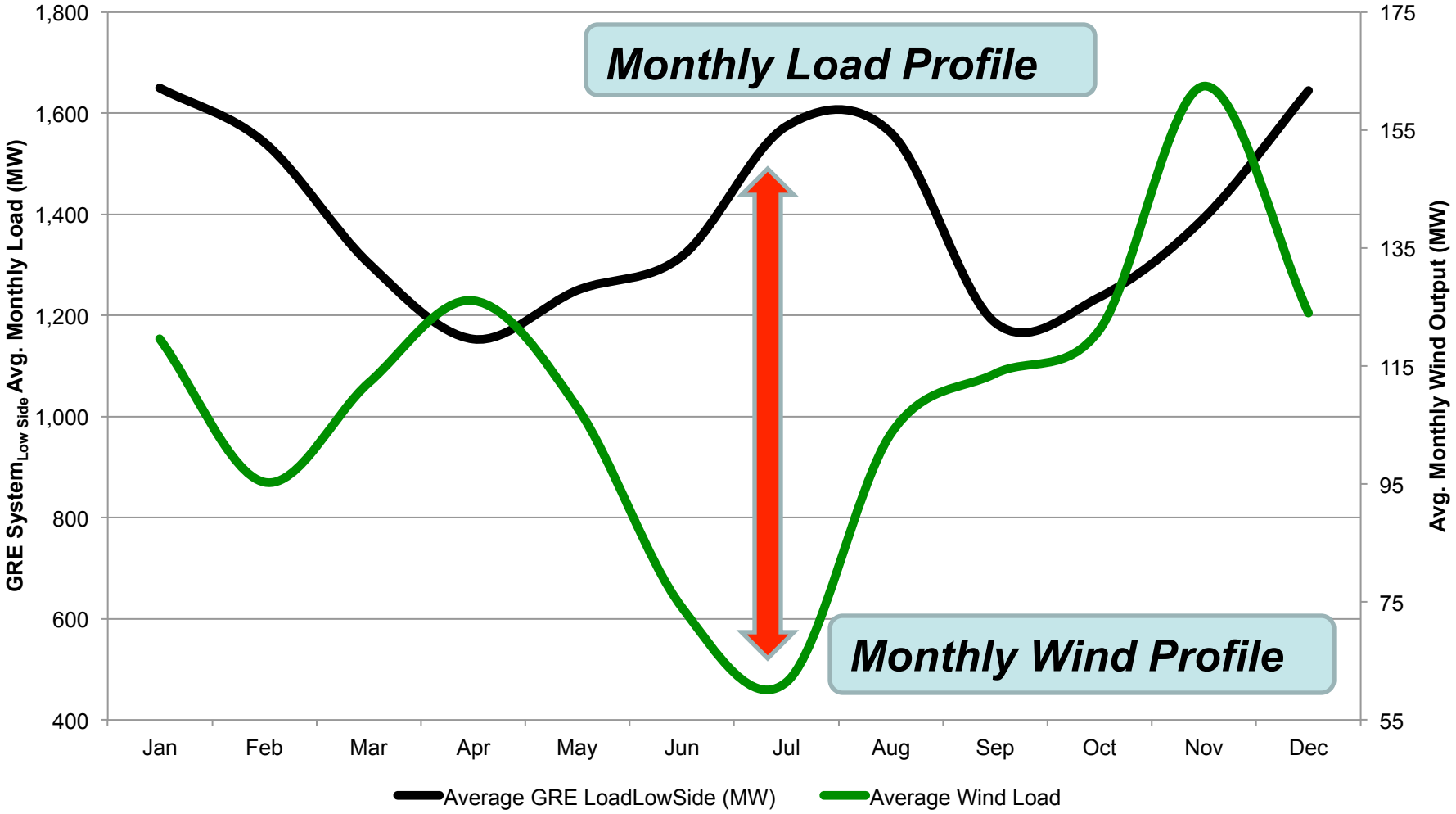
Conducting a comparison analysis

- Conduct a full load analysis
  - Bin temperature load analysis
  - Reducing the load is generally the most cost effective option for the consumer, i.e. insulation & air sealing
- Look for AHRI Expanded Heating Data that shows performance over a range of temperatures:
  - BTU/hr output and COP for each temperature
- Understand the trade-offs.

Cold Climate Heat Pumps

- Heat pumps are available that have the ability to operate at lower temperatures (< 0°F), these have the ability to deliver higher heat at lower ambient temperatures.
  - Multi-stage or modulating compressors
  - Tied to a variable speed furnace
  - Check the BTU/hr output
  - Automatic defrost features for <45°F
- Technology developments will continue to improve the efficiency and performance of these units.

System Compatibility of ASHPs
Wind output compared to load



GREAT RIVER ENERGY®
A Touchstone Energy® Cooperative

ASHP COP Improves Total System Efficiency

40% System Efficiency

COP = 3.0

=

120% End Use Efficiency

Other ASHP Applications

- Ductless Mini-Splits
  - High SEER Values, retrofit applications
- Variable Refrigerant Flow Systems
  - Emerging in the US, efficient heating in cold climates, ambient conditions, very efficient commercial retrofit application
- ASHP tied to supplemental ETS Heating
  - Minnesota Division of Energy Resources

http://mn.gov/commerce/energy/images/CIP-AirSource-Pump-Report.pdf

The Future is Bright for ASHPs

- Technologies will continue to develop that improve the cold climate performance of ASHPs
  - Multi-stage compression, variable refrigerant flows, new refrigerants (CO_2) will all improve the overall performance and efficiency of ASHPs.

- ASHPs are complementary to our changing energy systems that include more renewables

- Improvements in Heat Pump Water Heater technologies are naturally transferable to ASHPs

Thank you!

Jeff Haase

jhaase@grenergy.com | 763.445.6106

GREAT RIVER ENERGY®
A Touchstone Energy® Cooperative