NATIONAL ASSOCIATION FOR STATE COMMUNITY SERVICES PROGRAMS

45th ANNIVERSARY

Equity and Electrification

(aka Beneficial Electrification in Weatherization)

HANCOCK SOFTWARE
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SEPTEMBER 25 - 29

GRAND RAPIDS

Equity and Electrification
(aka Beneficial Electrification in Weatherization)

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CHAMPAIGN COUNTY REGIONAL PLANNING COMMISSION

ICRT INDOOR CLIMATE RESEARCH & TRAINING

Electrification is all the rage

- Reduces emissions* to help address climate change and improve health
- Interfaces with renewable energy
- Reduces reliance on foreign fuels
- Improves resiliency since there are multiple ways to generate electricity
- Reduces costs (?)

*Assumes that the source of electricity generation has lower emissions

Electrification and Heat Pumps

- Central to electrification programs and climate plans
- Done right, can often be a good thing for many people
- Done wrong, can hurt people

Source: U.S. DOE

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Water Heating

- From Rewiring America:
  - "Critically, we classify a household as "in the money" if it has at least one electrification project that saves money compared to current bills. In many cases, this electrification project is water heating." (emphasis added)

(https://www.rewiringamerica.org/about/methodology)

Reduce costs?

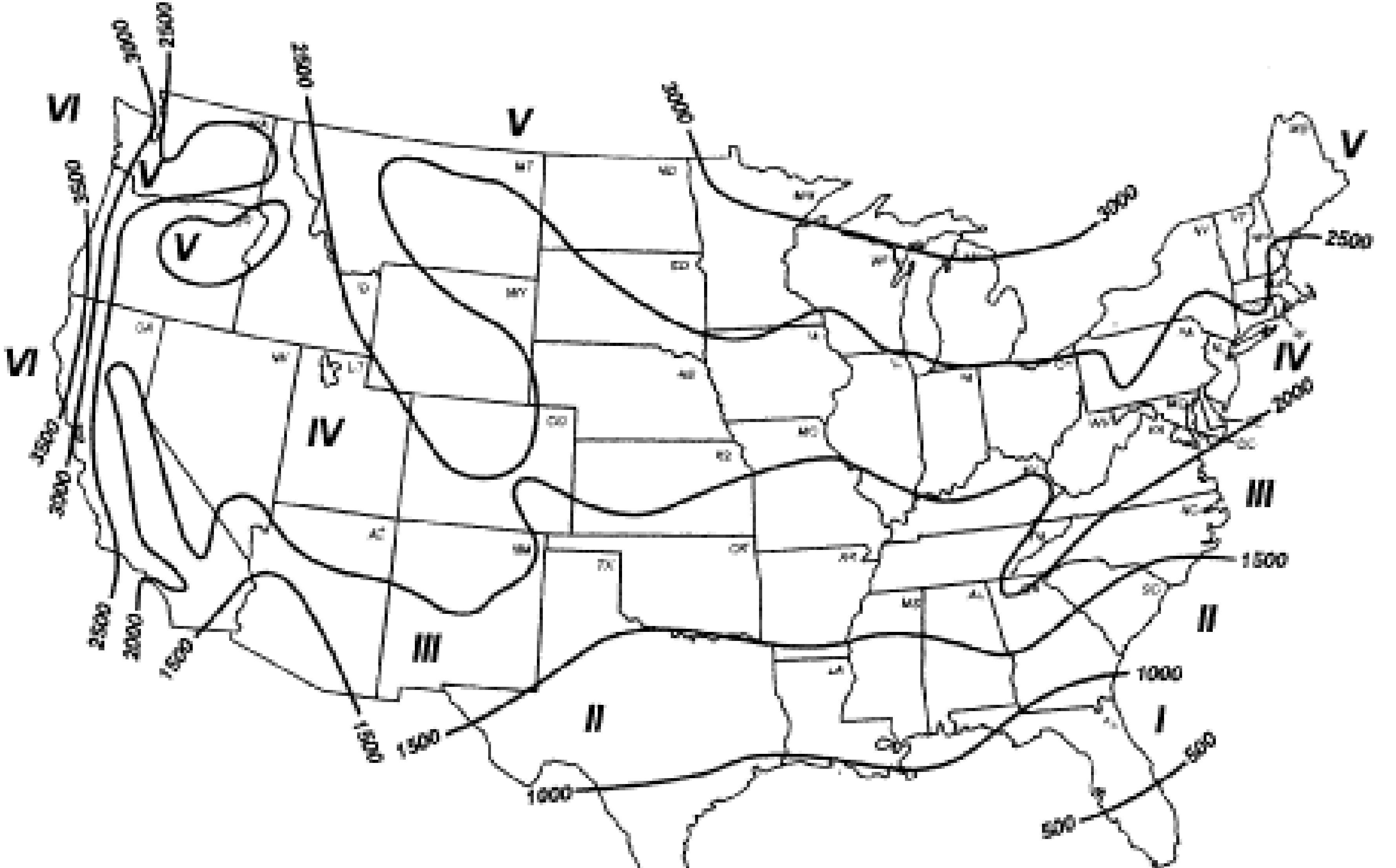
- Let's look at this

- Assumptions:
  – Any new appliance will need to meet Energy Star®
    - NG furnaces 95%/90% (north/south)
    - Heat pumps HSPF2 8.1/7.8 (cold climate/other)

Initial assumptions (to be revisited)

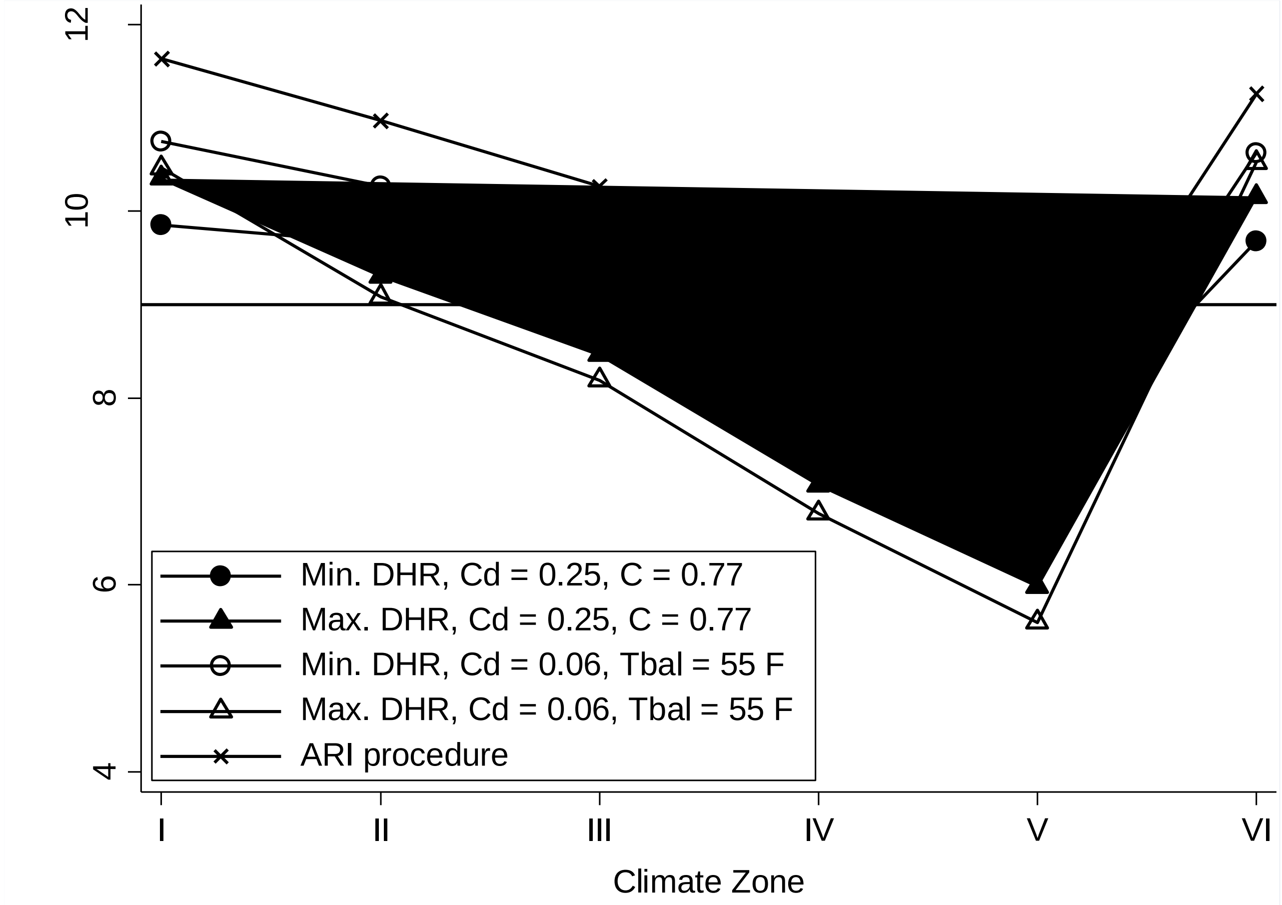
- No duct losses
- Heat pump installed to get maximum beneficial compressor output
- Heat pump HSPF2 is correct for location*
  - HSPF2 came into effect in 2023
  - It more accurately reflects actual performance
  - Efficiencies are lower than HSPF, e.g. Energy Star for HSPF was 8.2, for HSPF it will be 7.8

*Assumes climate zone 4



Source: AHRI Standard 210/240-2023

Climate Zone Assumption Impact



Note: uses old HSPF procedure… newer HSPF2 procedure brings it more in line with actual performance

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Framing

- Can look at fuel cost ratios
- Can look at necessary HSPF2
- Use marginal fuel prices (i.e. per therm/kWh charges)
- If heat pump is more expensive, what else needs to be done to offset?

Equations

- $$\frac{\$/_{therm}}{\$/_{kWh}} = \frac{29.3 * \eta_{gas}}{sCOP}$$ (sets cost ratio; sCOP = HSPF2/3.413)

- $$HSPF2 = 3.413 * sCOP = 3.413 * \frac{29.3 * \eta_{gas} * \$/_{kWh}}{\$/_{therm}}$$

(minimum HSPF2 to make heat pump lower cost)

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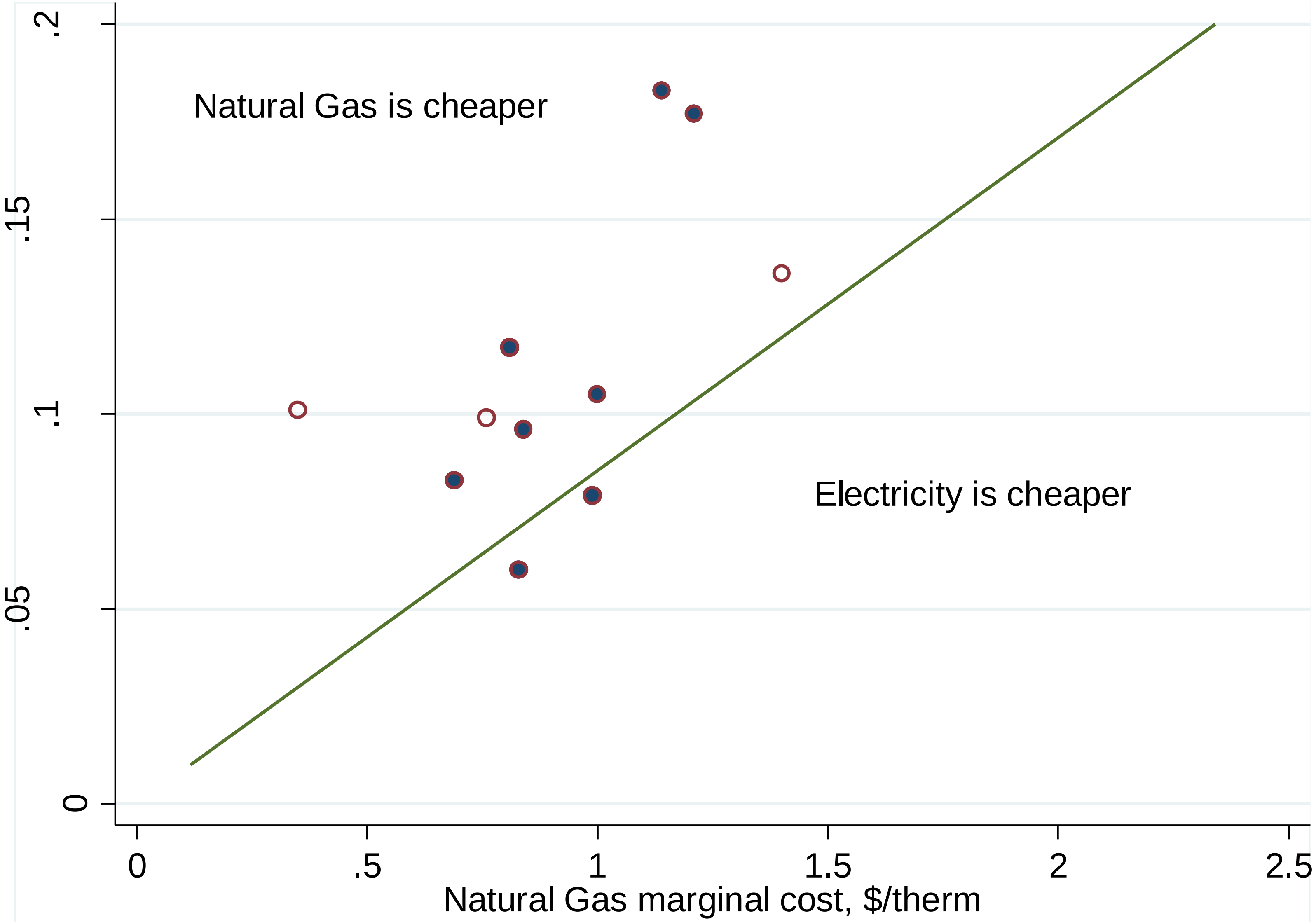
Outcomes (cost ratio)

- For cold climates (95% NG furnace vs. ccHP HSPF2 = 8.1)
  - If $/therm < 11.7*$/kWh, NG furnace is cheaper
  - *(Ratio is about 9.9 if you compare to an 80% furnace)*

- For other (90% NG furnace vs. ccHP HSPF2 = 7.8)
  - If $/therm < 11.5*$/kWh, NG furnace is cheaper

Evaluate 11 locations, January 2022 rates

Location	Natural Gas Cost, $/therm	Electricity Cost, $/kWh
Northern Sites		
Denver, CO	$0.81	$0.117
Chicago, IL	$0.84	$0.096
Baltimore, MD	$0.69	$0.083
Minneapolis, MN	$0.83	$0.060
New York	$1.14	$0.183
Burlington, VT	$1.21	$0.177
Seattle, WA	$1.00	$0.105
Charleston, WV	$0.99	$0.079
Southern Sites		
Tampa, FL	$1.40	$0.136
Atlanta, GA	$0.76	$0.099
Albuquerque, NM	$0.35	$0.101


Natural Gas is cheaper
Electricity is cheaper
0
.05
.1
.15
.2
0
.5
1
1.5
2
2.5
Natural Gas marginal cost, $/therm

Outcomes (needed HSPF2)

Location	Natural Gas Cost, $/therm	Electricity Cost, $/kWh	Minimum HSPF2
Northern Sites			
Denver, CO	$0.81	$0.117	13.7
Chicago, IL	$0.84	$0.096	10.9
Baltimore, MD	$0.69	$0.083	11.4
Minneapolis, MN	$0.83	$0.060	6.9
New York	$1.14	$0.183	15.3
Burlington, VT	$1.21	$0.177	13.9
Seattle, WA	$1.00	$0.105	10.0
Charleston, WV	$0.99	$0.079	7.6
Southern Sites			
Tampa, FL	$1.40	$0.136	8.7
Atlanta, GA	$0.76	$0.099	11.7
Albuquerque, NM	$0.35	$0.101	26.0

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Now about those ducts…

From Ecotope report…

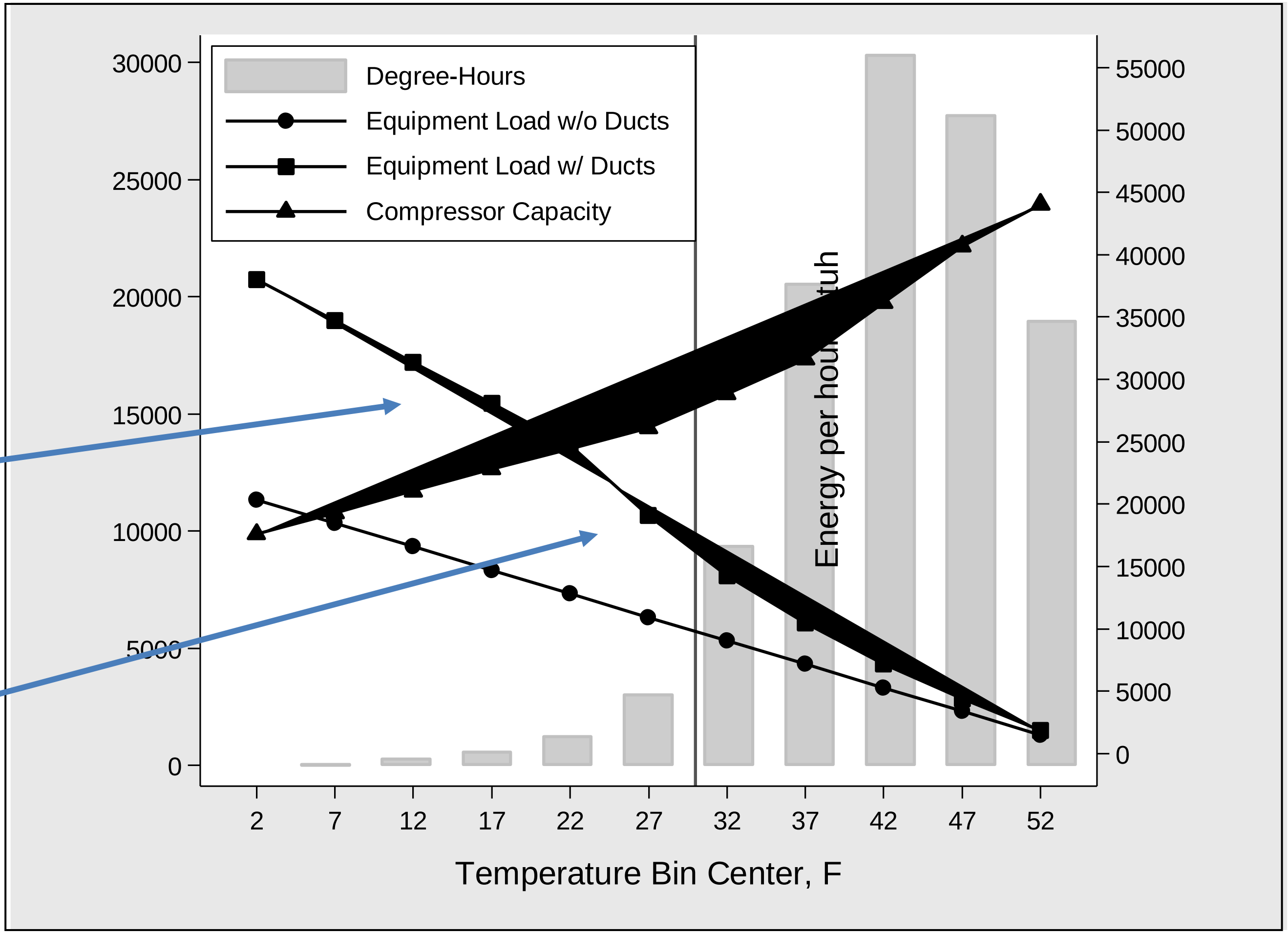
		Leakage (% of airflow)	
	n	**Supply**	**Return**
Bend	28	14.5	10.9
Clark	34	9.7	11.3
Kitsap	40	14.1	14.9
Yakima	33	12.6	13.1
Total	**135**	**12.8**	**12.7**

Baylon et. al. 2005. Analysis of Heat Pump Installation Practices and Performance

Example

- Assume a house with 10% leakage to outside on either supply or return
- Assume the supply ducts are insulated to an effective R-4
- Assume the return ducts are uninsulated (panned?)

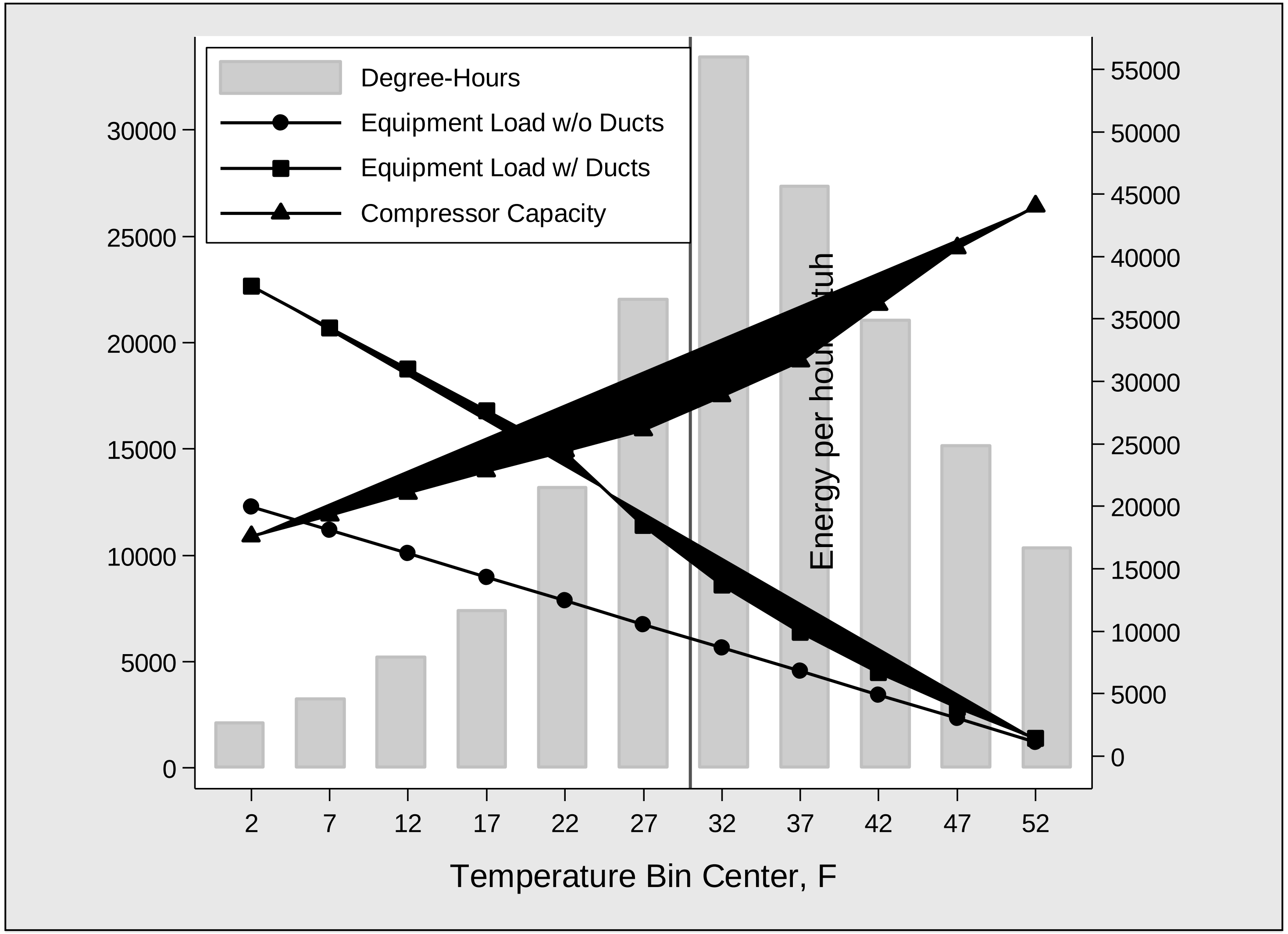
Impact of Ducts - Seattle



This is additional backup use

This is additional compressor use

Impact of Ducts - Spokane



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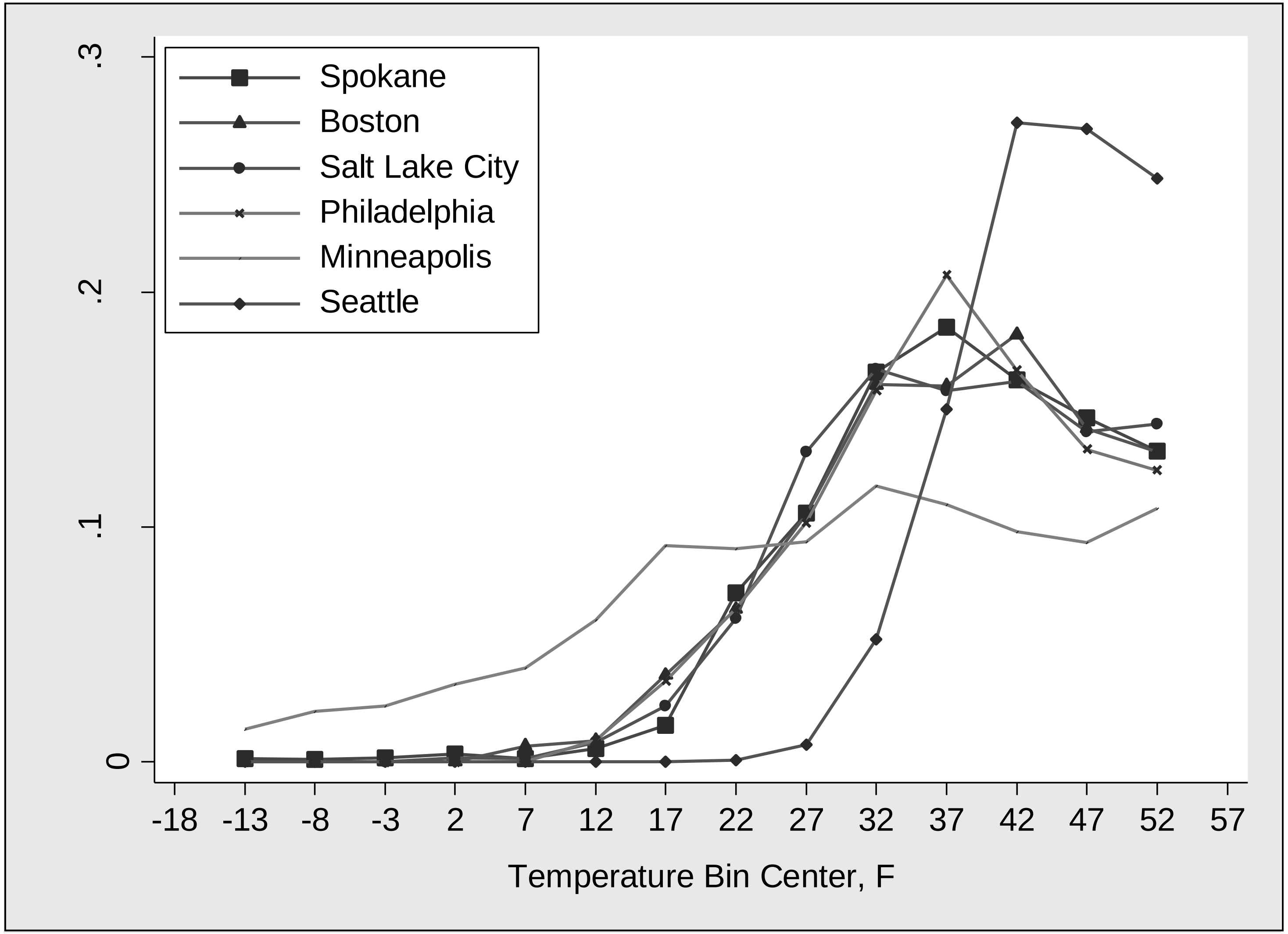
Weather Profiles



Fraction of Heating Season Hours

Implications

- Assume 1500 square foot house
- Assume crawl space with ducts
- Assume 2-ton HP is sized to meet the load (balance point) at 30 °F
- Assume alternative is a furnace

Duct Efficiency Results – Supply Losses

	N. Bend	Portland	Medford	Boise	Spokane	Missoula
Loss Component	**Annual Duct Efficiency (%)**					
Supply – furnace						
20% leak	77.2	78.2	75.9	76.3	76.3	75.8
10% leak	88.7	88.3	88.0	88.2	88.2	88.0
R-1.5 ducts	86.7	86.3	85.9	86.3	86.2	85.8
R-4 ducts	94.8	94.6	94.4	94.5	94.5	94.4
R-8 ducts	97.3	97.2	97.2	97.2	97.2	97.1
Supply – heat pump						
20% leak	72.0	67.9	64.1	59.6	58.9	57.7
10% leak	86.4	84.5	82.5	78.7	78.3	77.0
R-1.5 ducts	83.6	81.5	79.4	75.0	74.6	73.1
R-4 ducts	93.3	92.2	91.4	89.6	88.9	87.9
R-8 ducts	96.6	96.0	95.9	94.6	94.6	94.0

Duct Efficiency Results – Return Losses

	N. Bend	Portland	Medford	Boise	Spokane	Missoula
Loss Component	**Annual Duct Efficiency (%)**					
Return – furnace						
20% leak	96.9	96.6	96.3	96.6	96.4	96.0
10% leak	98.5	98.3	98.2	98.3	98.2	98.0
R-1.5 ducts	98.8	98.6	98.5	98.6	98.6	98.5
R-4 ducts	99.5	99.5	99.4	99.5	99.5	99.4
R-8 ducts	99.8	99.7	99.7	99.7	99.7	99.7
Return – heat pump						
20% leak	92.9	90.8	89.1	85.4	84.4	82.7
10% leak	96.6	95.5	94.9	93.1	92.5	91.4
R-1.5 ducts	97.4	96.5	96.1	94.5	94.4	93.6
R-4 ducts	99.0	98.7	98.5	97.8	97.8	97.5
R-8 ducts	99.5	99.4	99.3	98.9	98.9	98.7

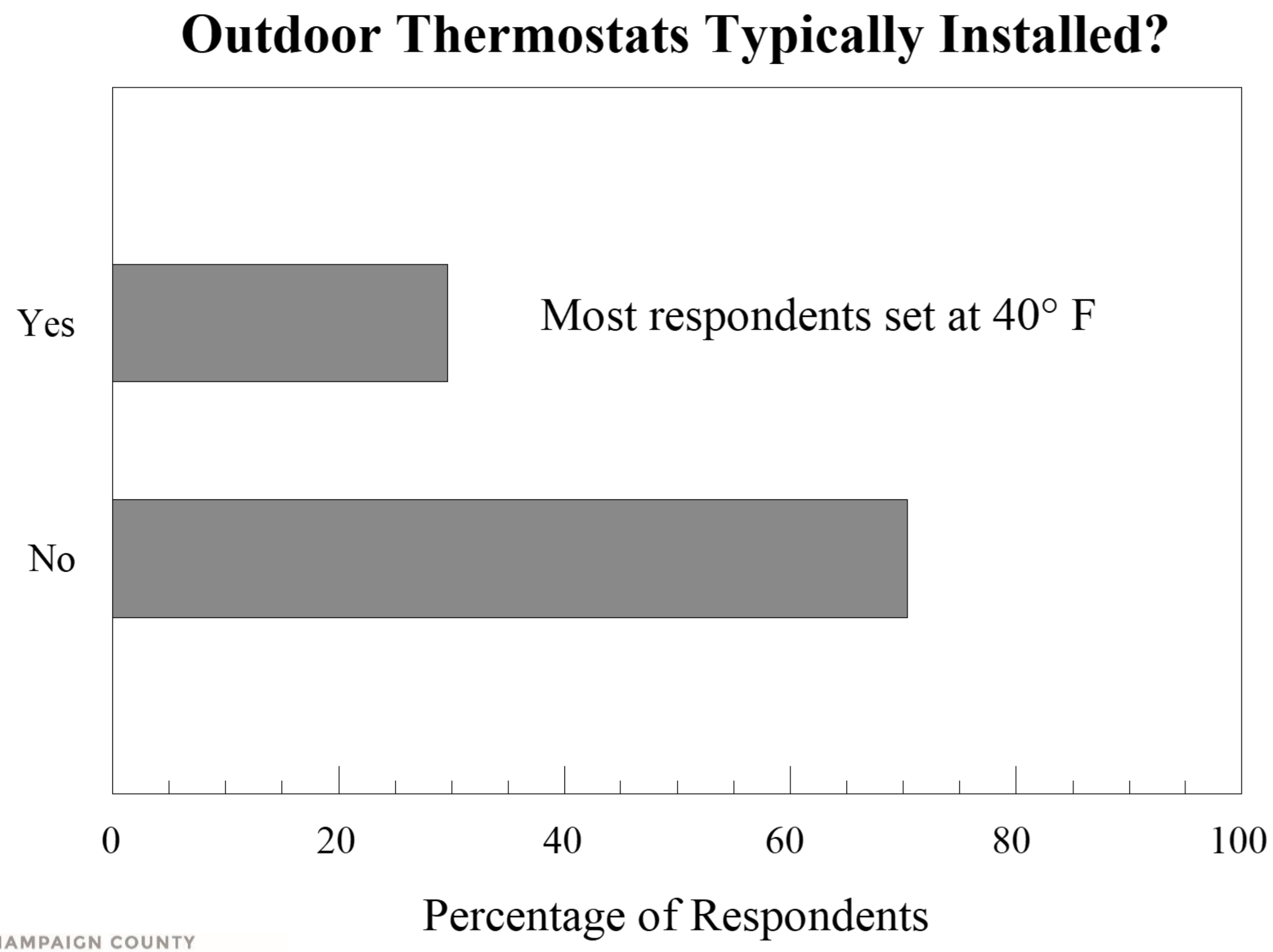
Duct Efficiency Results – Relative Losses

	N. Bend	Portland	Medford	Boise	Spokane	Missoula
Loss Component	**% Worse Duct Efficiency for Heat Pump**					
Supply						
20% leak	123%	147%	149%	170%	173%	175%
10% leak	120%	132%	146%	181%	184%	192%
R-1.5 ducts	123%	135%	146%	182%	184%	189%
R-4 ducts	129%	144%	154%	189%	202%	216%
R-8 ducts	126%	143%	146%	193%	193%	207%
Return						
20% leak	229%	271%	295%	429%	433%	432%
10% leak	227%	265%	283%	406%	417%	430%
R-1.5 ducts	217%	250%	260%	393%	400%	427%
R-4 ducts	200%	260%	250%	440%	440%	417%
R-8 ducts	250%	200%	233%	367%	367%	433%

Controls

- How is the heat pump designed to operate?
- Maximize effective compressor use?
- Outdoor thermostat? – prevents backup above a certain temperature
- Low-ambient lockout? – prevents compressor use below a certain temperature even if it could be useful
- Backup comes on at stage 1?

All following results from Ecotope projects…



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Baylon et. al. 2005. Analysis of Heat Pump Installation Practices and Performance

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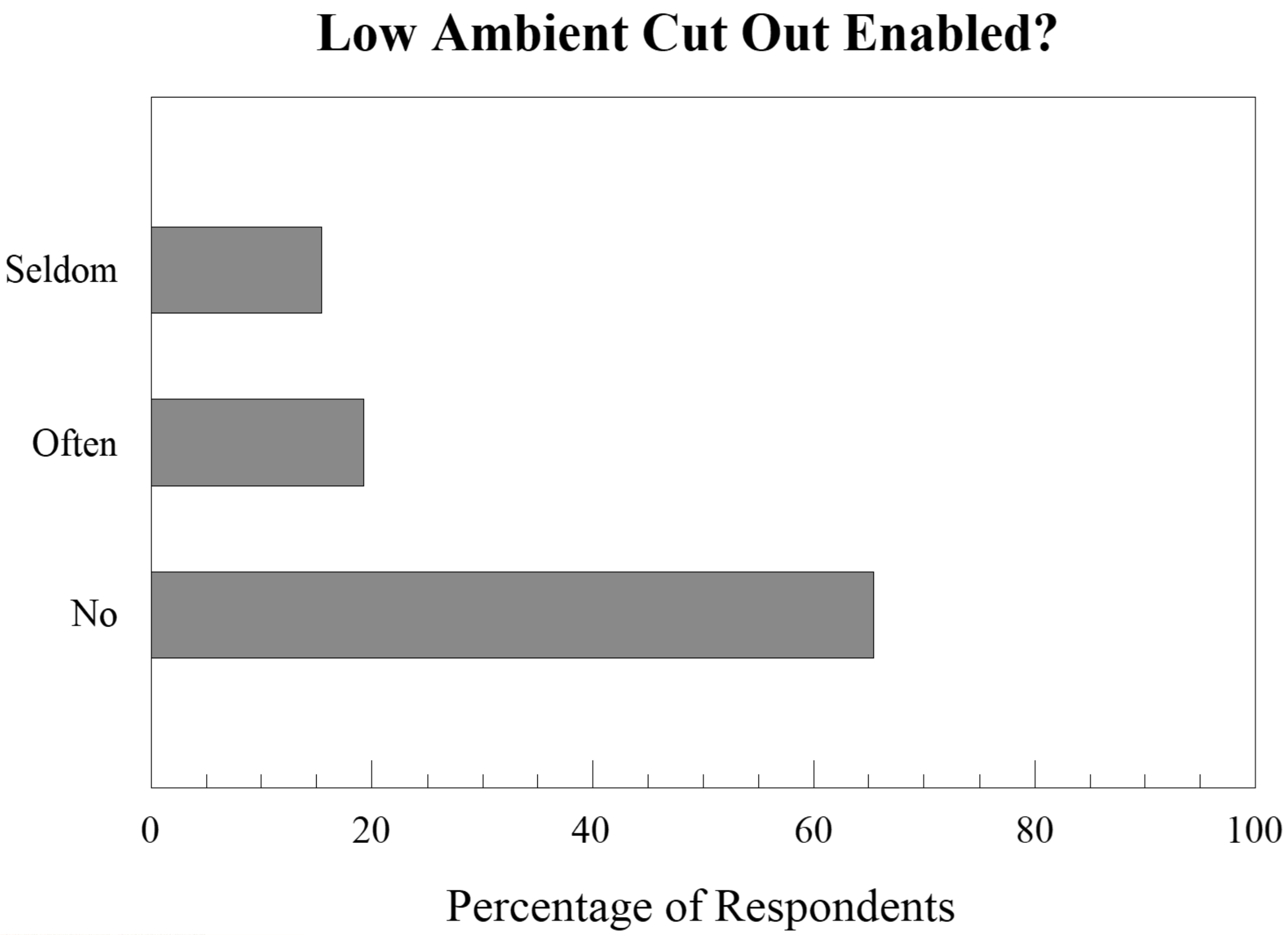
All following results from Ecotope projects…



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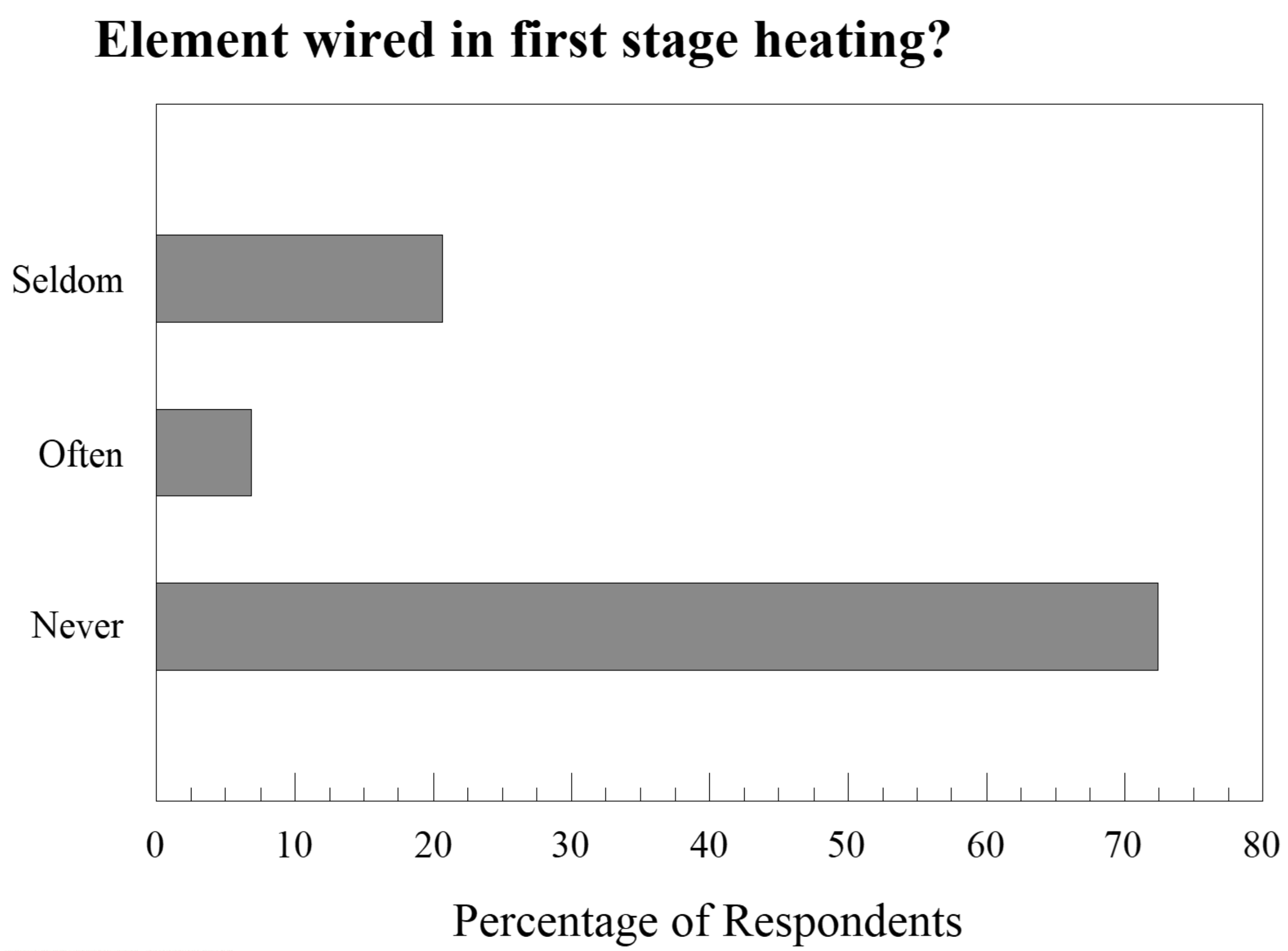

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Baylon et. al. 2005. Analysis of Heat Pump Installation Practices and Performance

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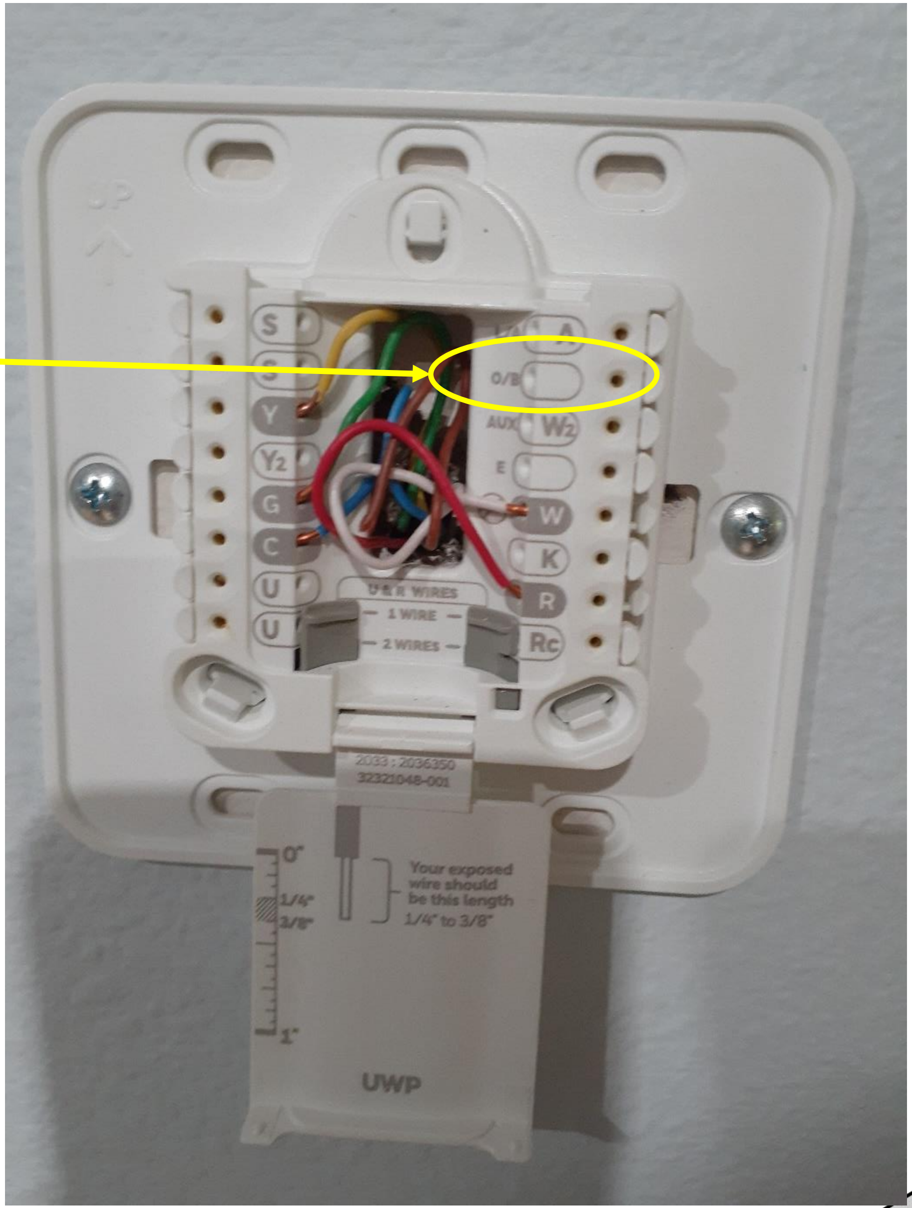
And then there's this…

Needs a wire to tell the reversing valve to activate



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Takeaways on controls

- Goal (and assumption) is to get the most out of the compressor possible
  - Outdoor thermostat enabled
  - No low-ambient cutoff
  - Backup NOT wired to come on in stage 1
  - Make sure the reversing valve is actually wired to activate

- However, there are a substantial number of cases where installations prioritize avoiding comfort complaints over efficiency
  - …or make other mistakes

So… what do we do?

- Quality assurance
- Quality control
- Quality assurance
- Quality control
- Repeat as necessary

So… what ELSE do we do?

- Recognize that many families will see costs go up with heat pumps if nothing else is done

- What policies can be put in place to offset the increase?

- Site solar?

- Is additional energy efficiency a possible solution?

Summary

- Over time, heat pumps will likely be better than fuel-fired heating systems from both climate and cost perspectives
- Right now, they often are not
- Duct losses and control problems (both unintentional and intentional) can further impact heat pumps in a greater way than they impact furnaces – especially vital to evaluate in retrofit situations
- QA/QC should not be optional – it should be a mandatory component of any electrification program that includes heating systems

EVALUATION QR CODE