Is your Refrigerator Running? Load shapes for (mostly) Appliances and other fun facts as measured in RBSA Metering

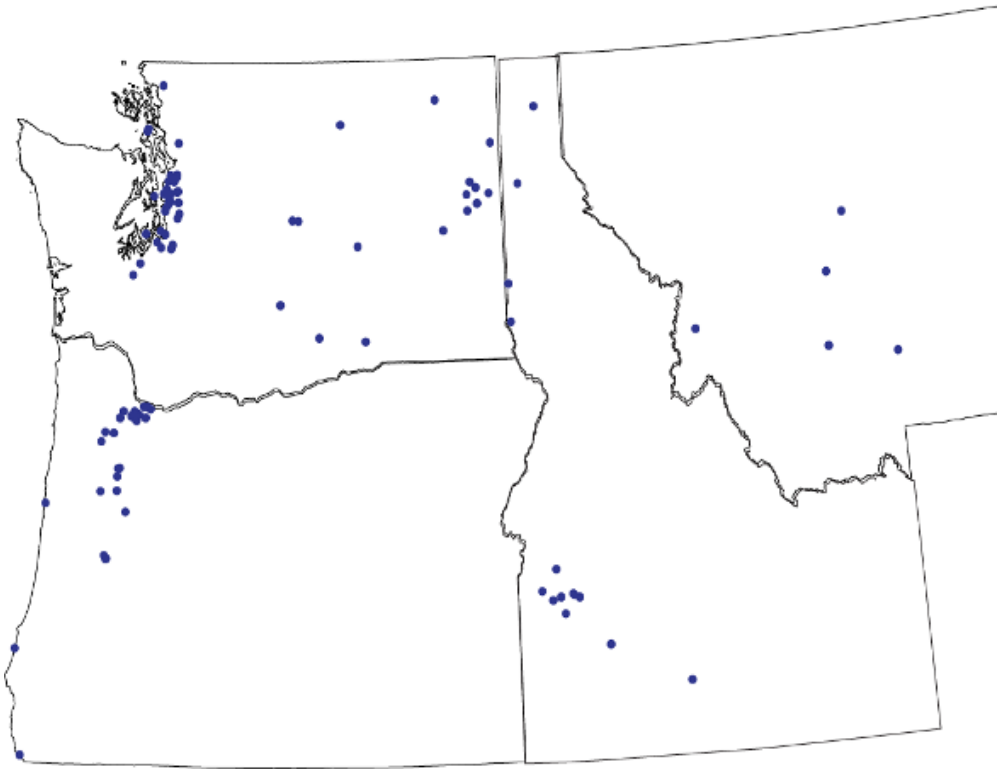
Data not Dogma, July 2014

Ben Larson, Ecotope

ECOTOPE
CONSULTING
RESEARCH
DESIGN

RBSA Metering Background

- 104 sites
- 5-minute intervals
- 2+ years
- End-uses
  - HAC
  - DHW
  - Appliances
  - Lights
  - Consumer electronics

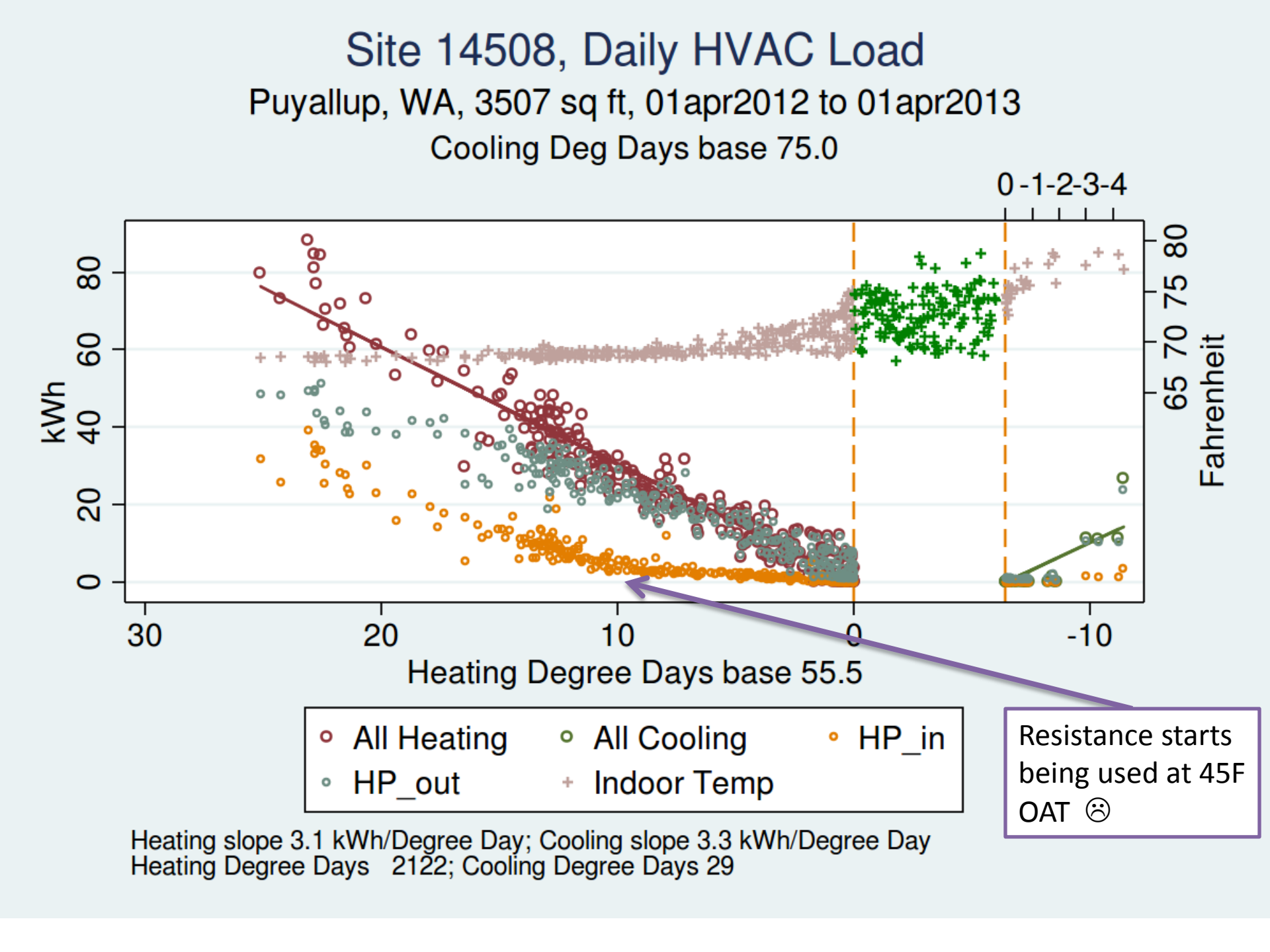


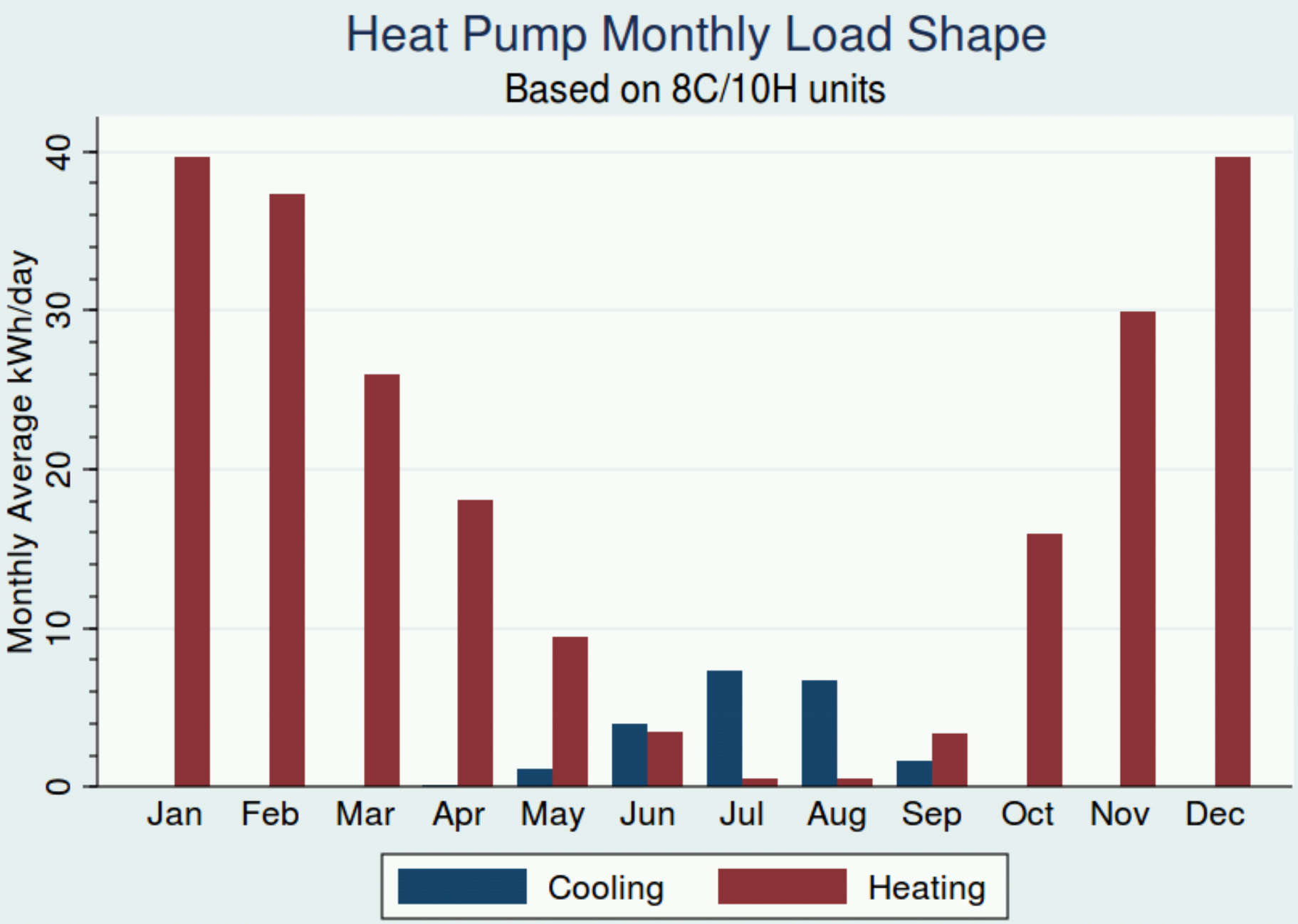
More RBSA Background

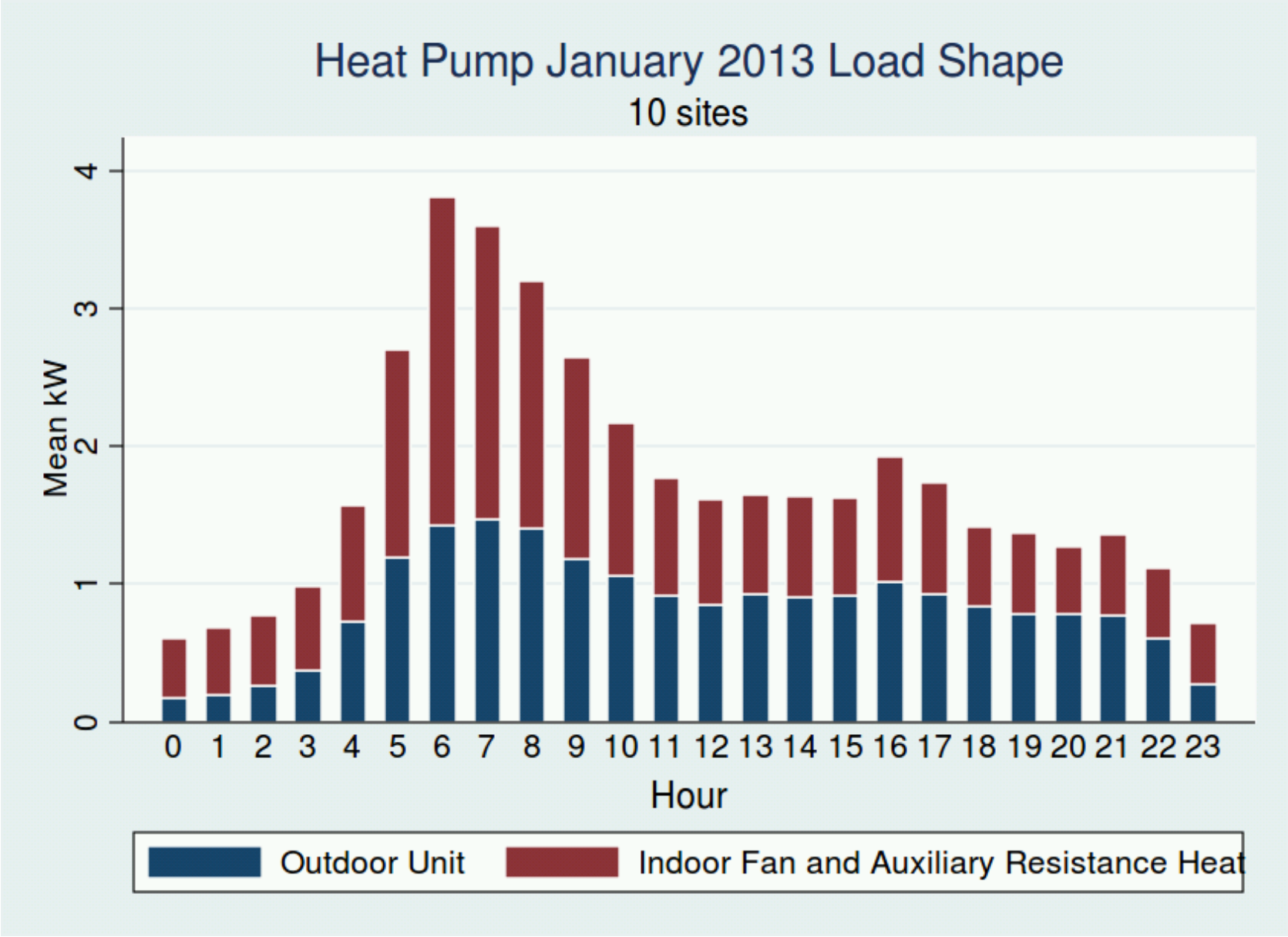
- First comprehensive end use metering studying since ELCAP (which is now nearly 30 years old)
- RBSA Metering is scheduled to end on September 30, 2014.
  - We will have collected ~1/4 of the end use load information the region needs by then.
    - http://rtf.nwcouncil.org/subcommittees/enduseload/RTF%20Executive%20Summary%2030%20SEP%202012%20v04-1.docx


1250 CALORIES
CHOOSE LESS.
680
REGAL
CLEANERS
SPECIAL
PANTS ONLY
DRY CLEAN
Endeavour
United States
30

Findings: Heat Pumps


Site 14508, Daily HVAC Load
Puyallup, WA, 3507 sq ft, 01apr2012 to 01apr2013
Cooling Deg Days base 75.0
0 -1-2-3-4
kWh
0
20
40
60
80
Fahrenheit
65
70
75
80
30
20
10
0
-10
Heating Degree Days base 55.5
All Heating
All Cooling
HP_in
HP_out
Indoor Temp
Resistance starts being used at 45F OAT ☹
Heating slope 3.1 kWh/Degree Day; Cooling slope 3.3 kWh/Degree Day
Heating Degree Days 2122; Cooling Degree Days 29


Heat Pump Monthly Load Shape
Based on 8C/10H units
Monthly Average kWh/day
0
10
20
30
40
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Cooling
Heating

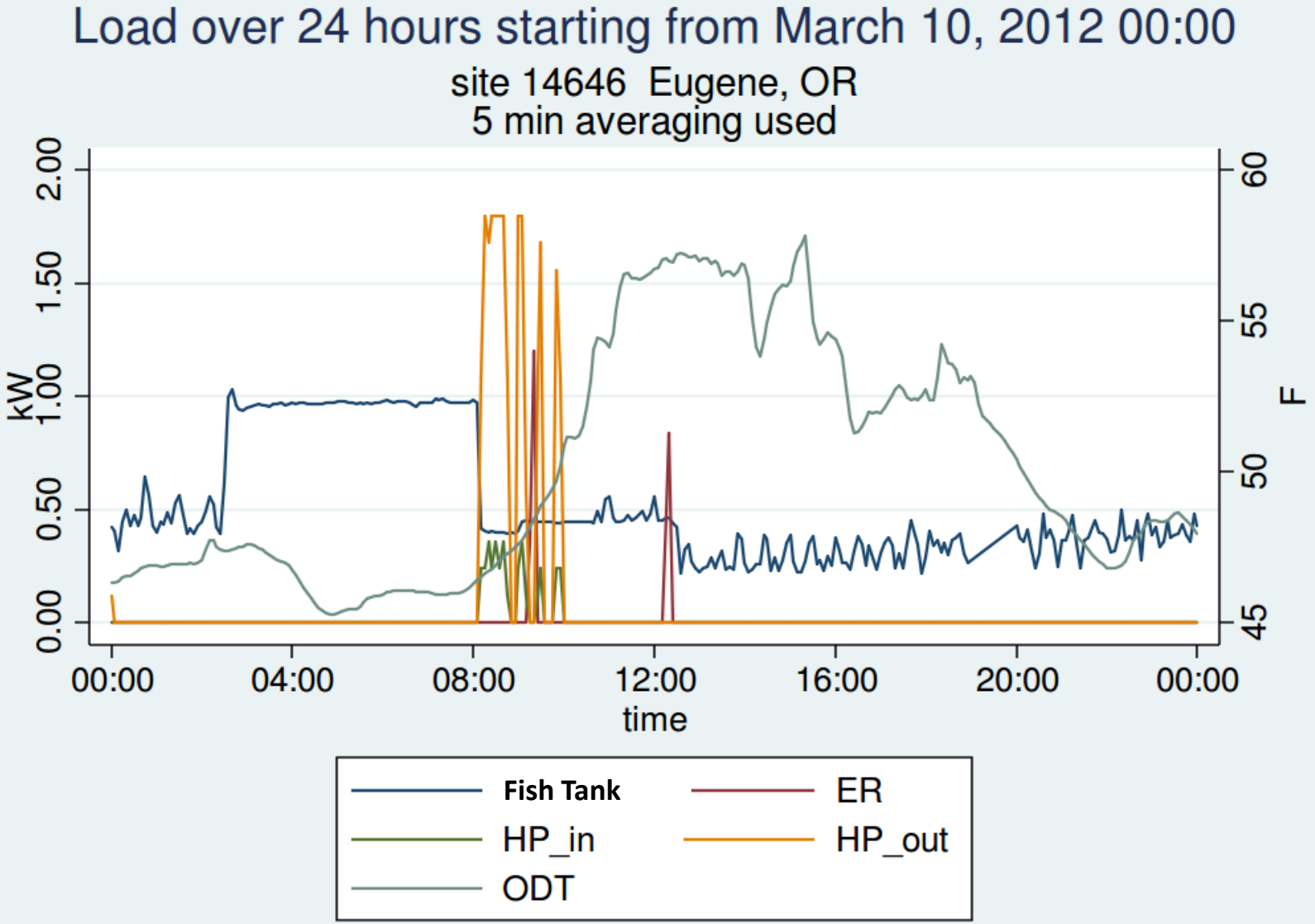


- Heat pumps still have a long way to go
- Go ductless???

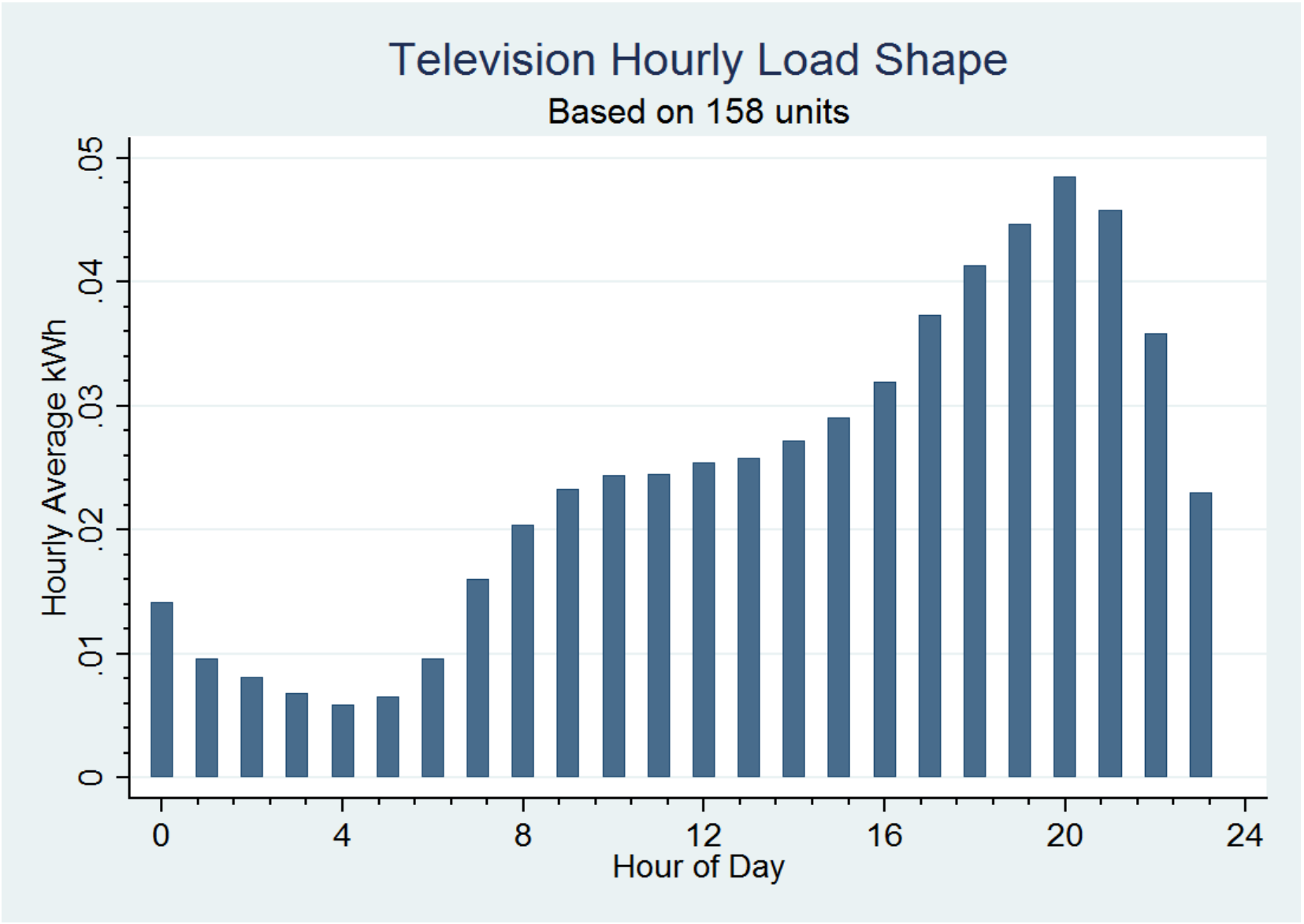
We've Got One…

- Nissan Leaf: 10.25 kWh/day = 3,741 kWh/yr
- Wine cooler: 0.38 kWh/day = 139 kWh/yr
- Fish tank: 12.8 kWh/day = 4,672 kWh/yr
  - 78°F, 60 gallon, tropical reef:
    - pumps, skimmer, lights, fans, heater

Fish Tank


Load over 24 hours starting from March 10, 2012 00:00
site 14646 Eugene, OR
5 min averaging used
kW
0.00
0.50
1.00
1.50
2.00
F
45
50
55
60
00:00
04:00
08:00
12:00
16:00
20:00
00:00
time
Fish Tank
ER
HP_in
HP_out
ODT

Findings: TVs – Nielsen is Right



Findings: Appliances

- Near census achieved in appliance metering (excluded gas dryers and ranges)

Appliance	Number of appliances		
	On site	Metered	Viable data
Clothes Washer	103	102	97
Clothes Dryer	103	99	93
Dishwasher	93	64	58
Freezer	60	52	46
Range (Electric or Gas)	103	71	63
Refrigerator	133	131	120

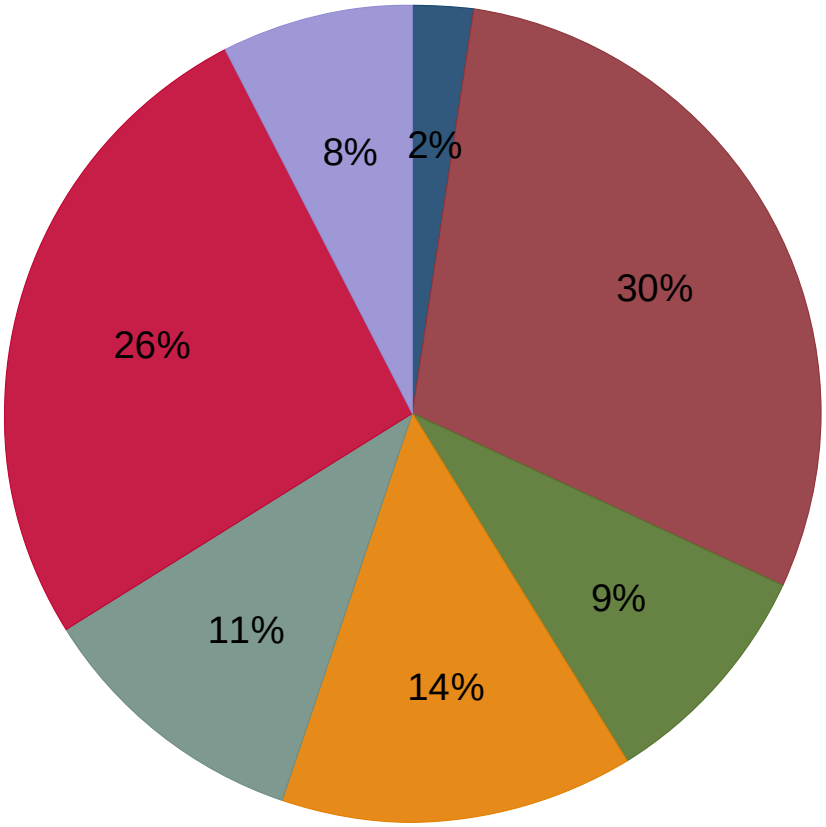
Appliance Energy Use

Appliance	Energy Use per Appliance	RBSA Single-Family Survey	Energy Use per House	Percent of Total Energy
	kWh/yr	Saturation	kWh/yr	%
Clothes Washer	55	0.99	54	2%
Clothes Dryer	725	0.94	679	30%
Dishwasher	239	0.89	213	9%
Freezer	609	0.53	323	14%
Electric Range	314	0.80	251	11%
Refrigerator (primary)	604	1.00	604	26%
Refrigerator (secondary)	600	0.29	174	8%
Overall	na	na	2,298	100%

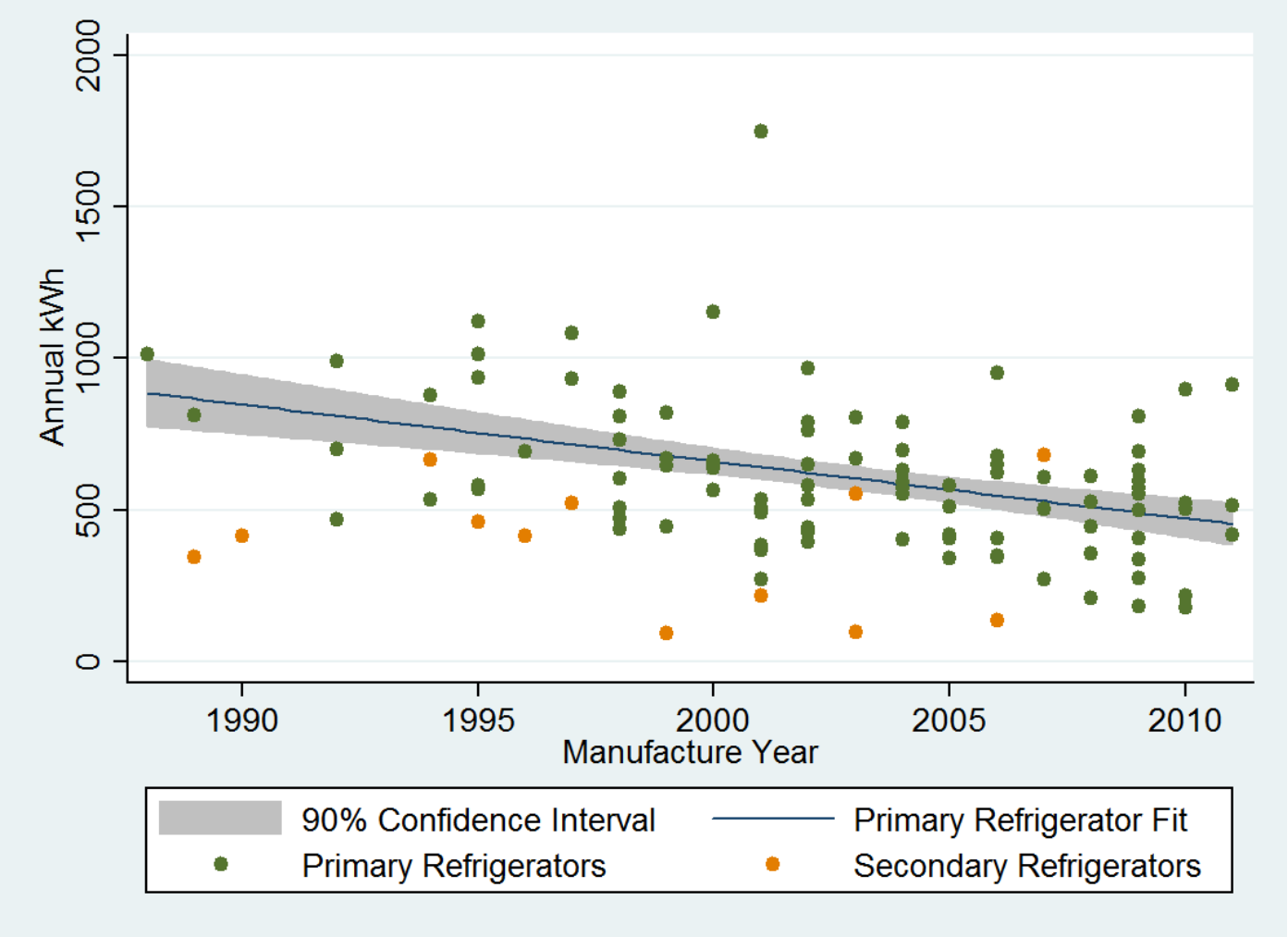
Approximately 5% of all houses have gas-fueled dryers. The table reports on electricity only.
Seventy-five percent of houses have electric ranges and 85% have electric ovens. The table assumes a combined effective saturation of 80%.

Average House Appliance Energy Distribution

2298 Total Annual kWh

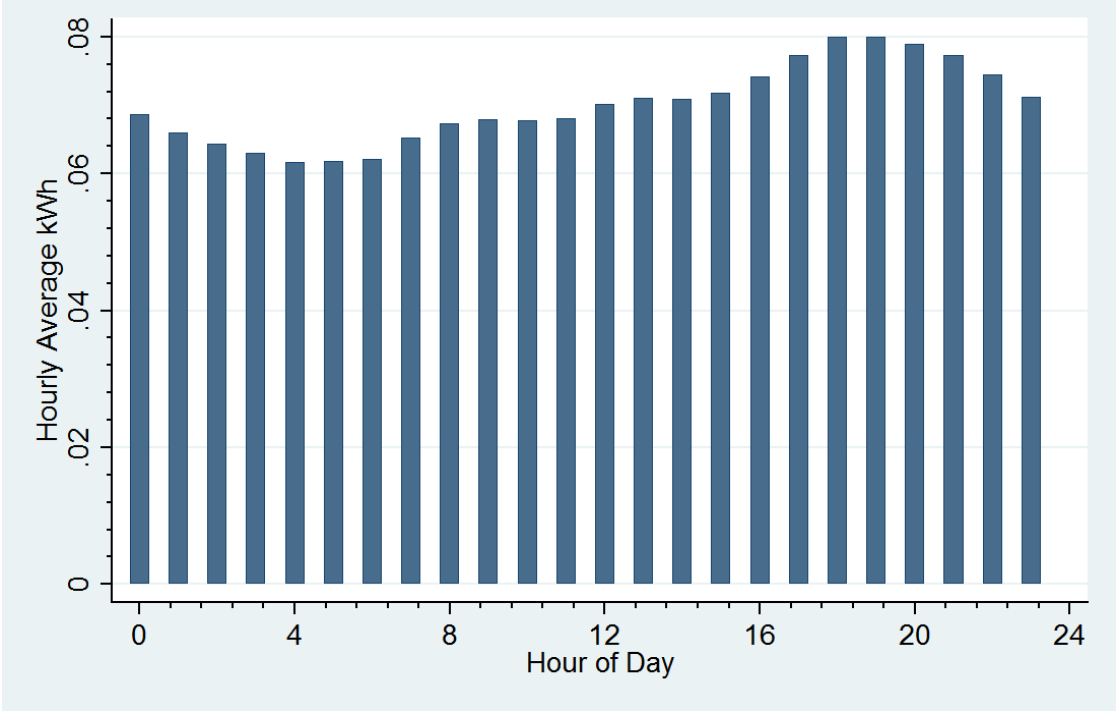


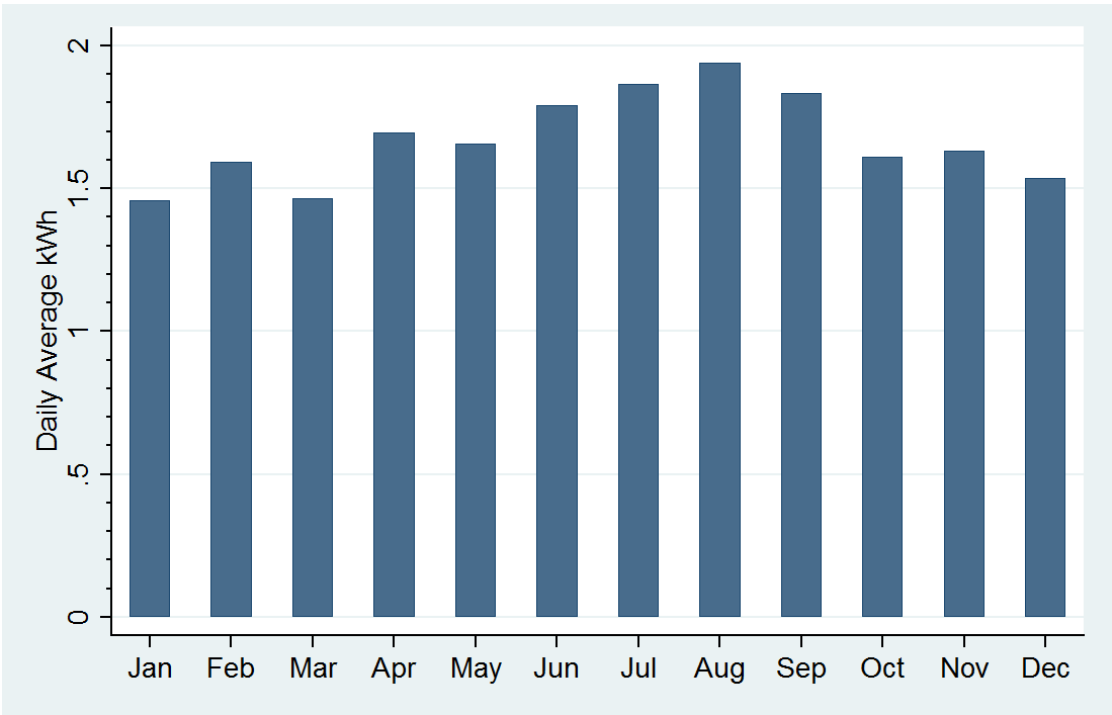
Refrigerator Annual kWh through the Years



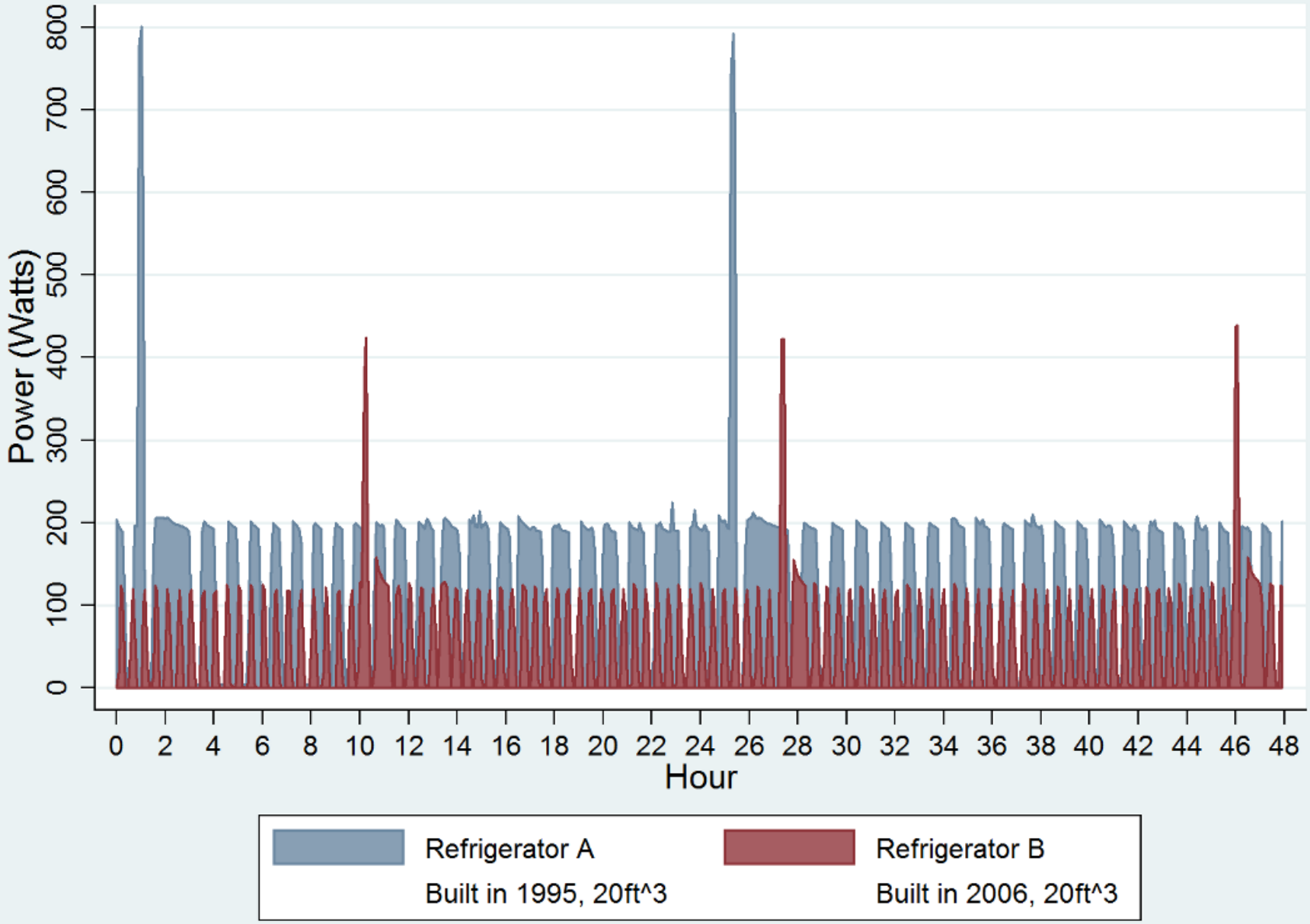
- Decline of 13.5 kWh/yr
- Fit conducted only on primary refrigerators

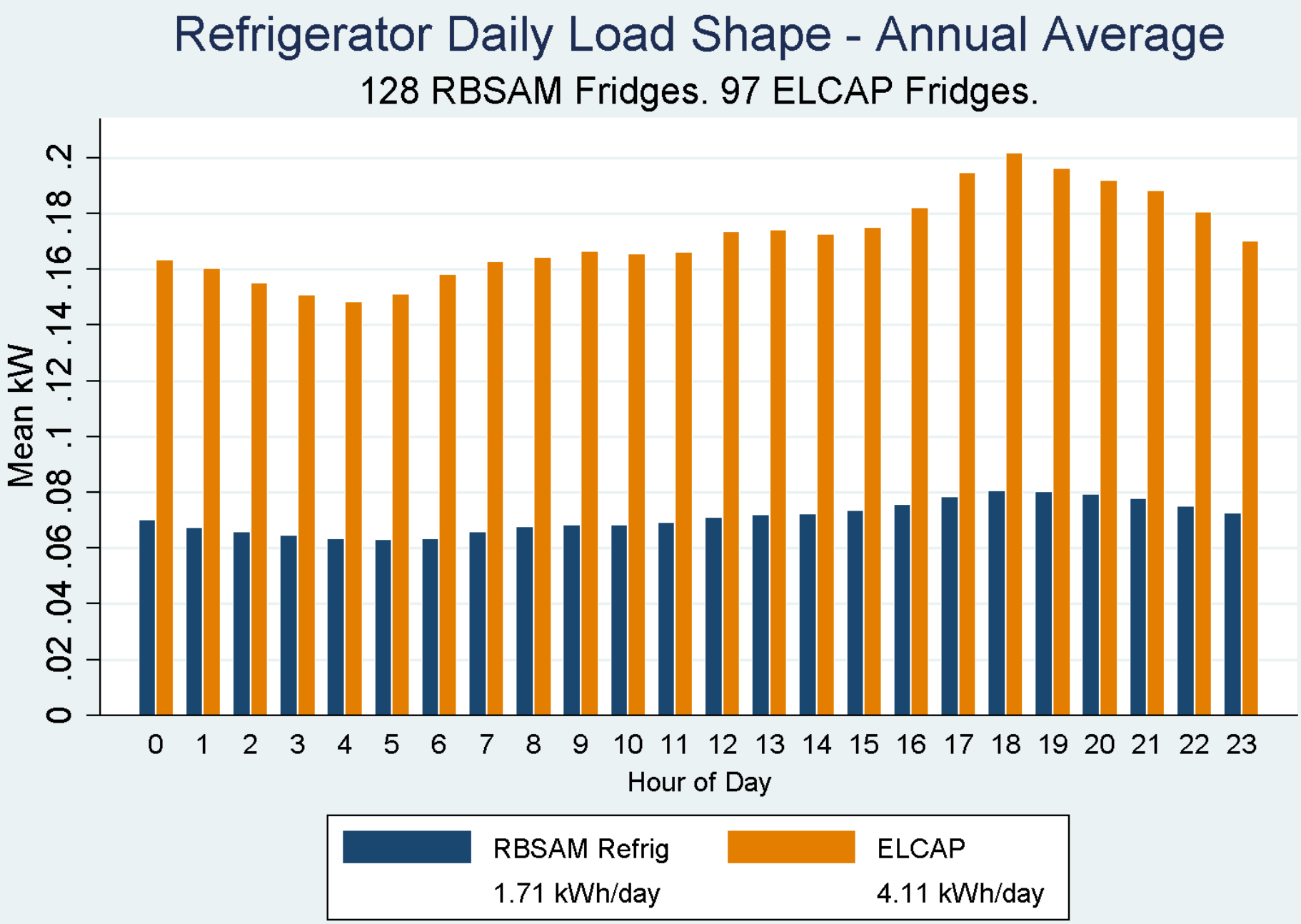
- Hourly and monthly load shapes for primary refrigerators



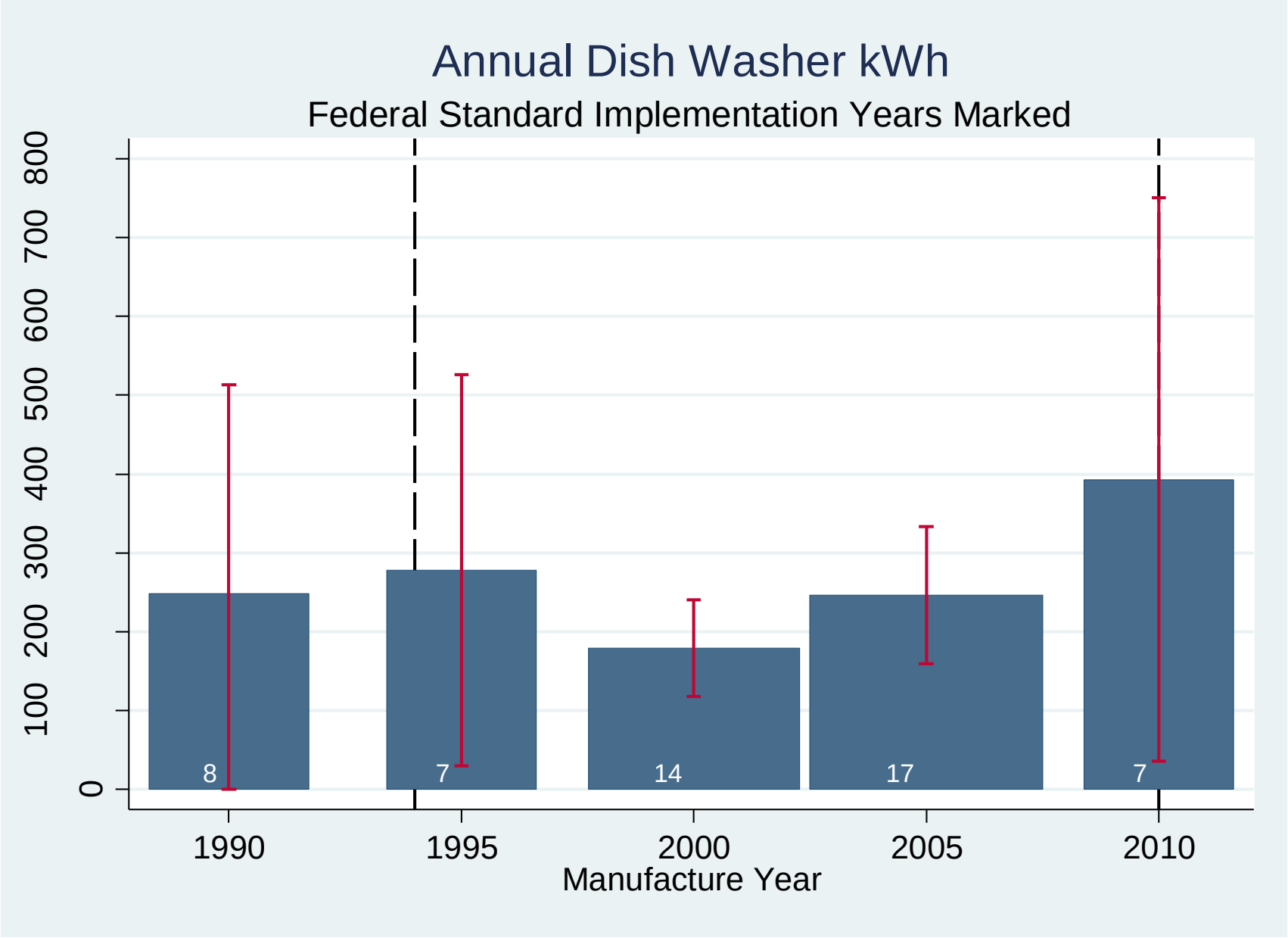


Refrigerator cycling over 2 days. 5-minute intervals

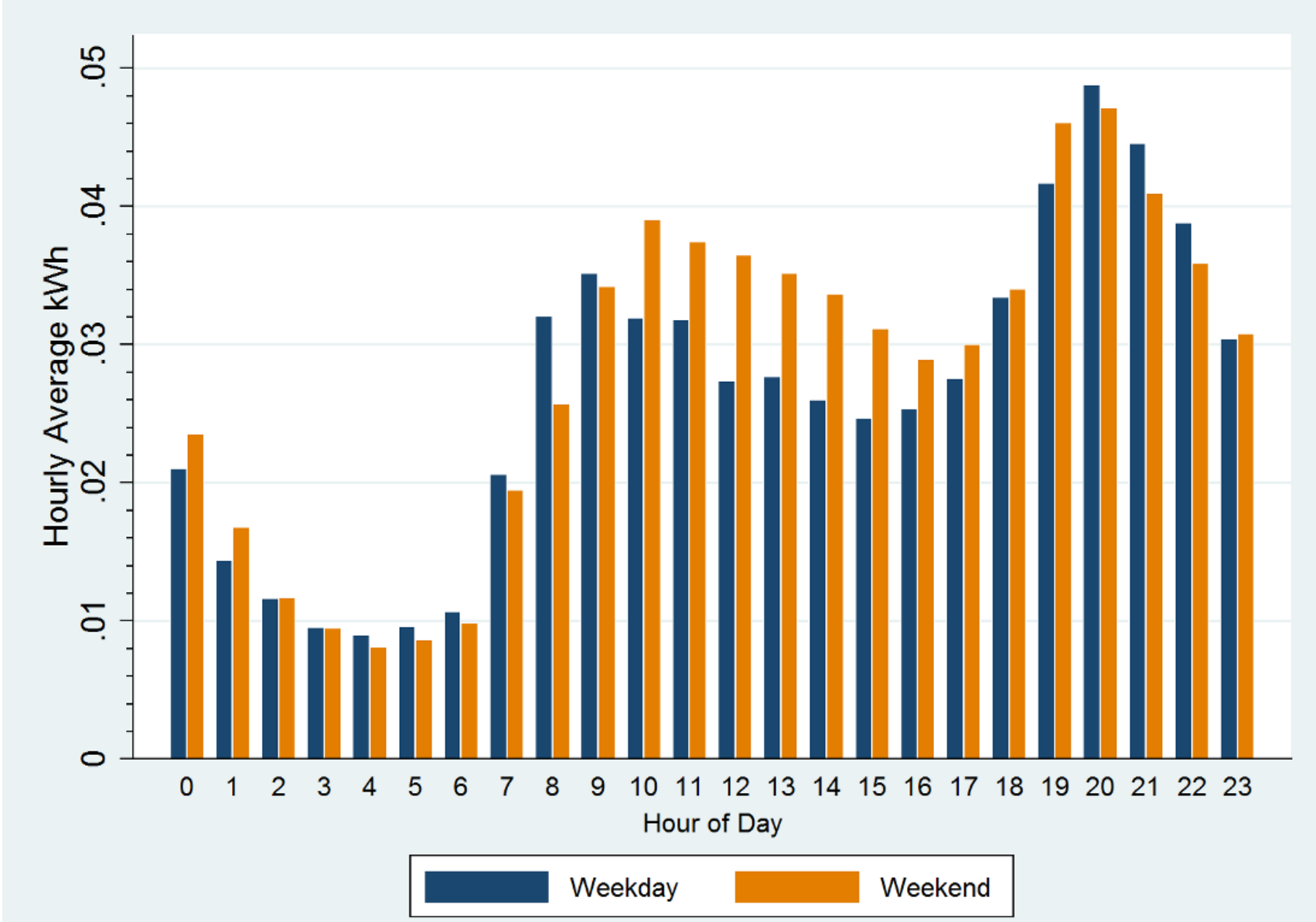



Refrigerator Daily Load Shape - Annual Average
128 RBSAM Fridges. 97 ELCAP Fridges.
Mean kW
0 .02 .04 .06 .08 .1 .12 .14 .16 .18 .2
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Hour of Day
RBSAM Refrig
1.71 kWh/day
ELCAP
4.11 kWh/day

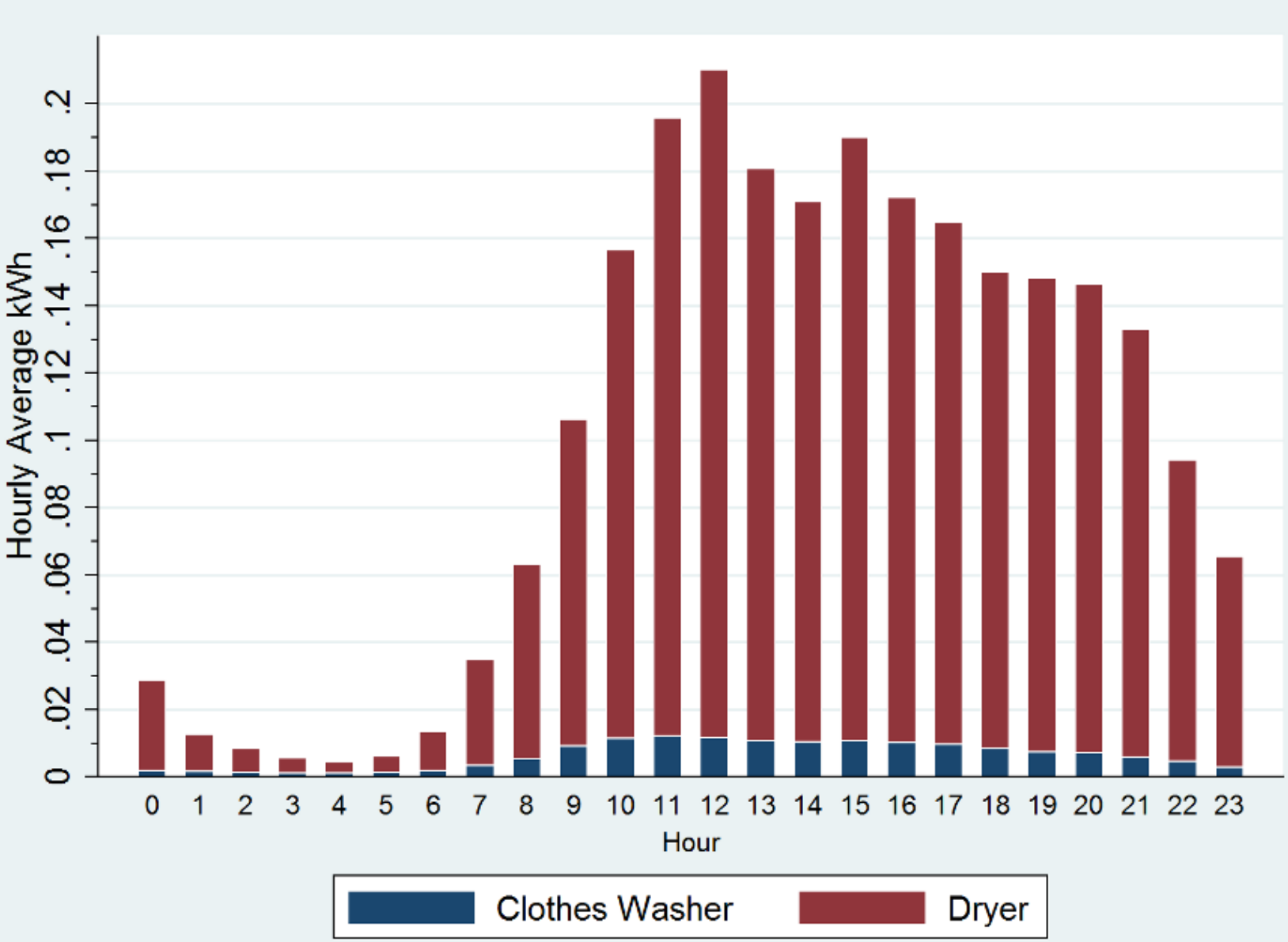
Dishwashers



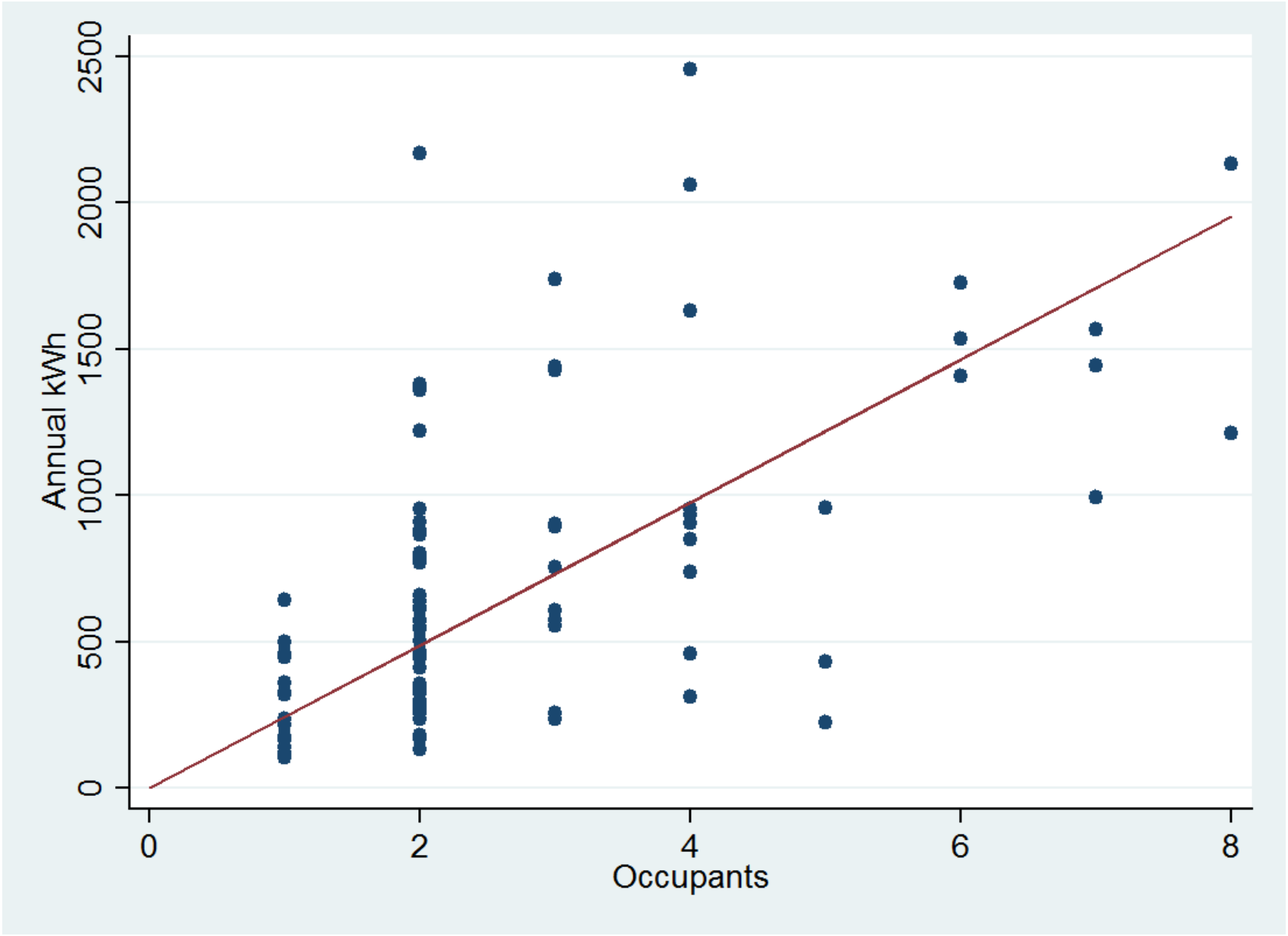
Dishwasher Hourly Load Shape



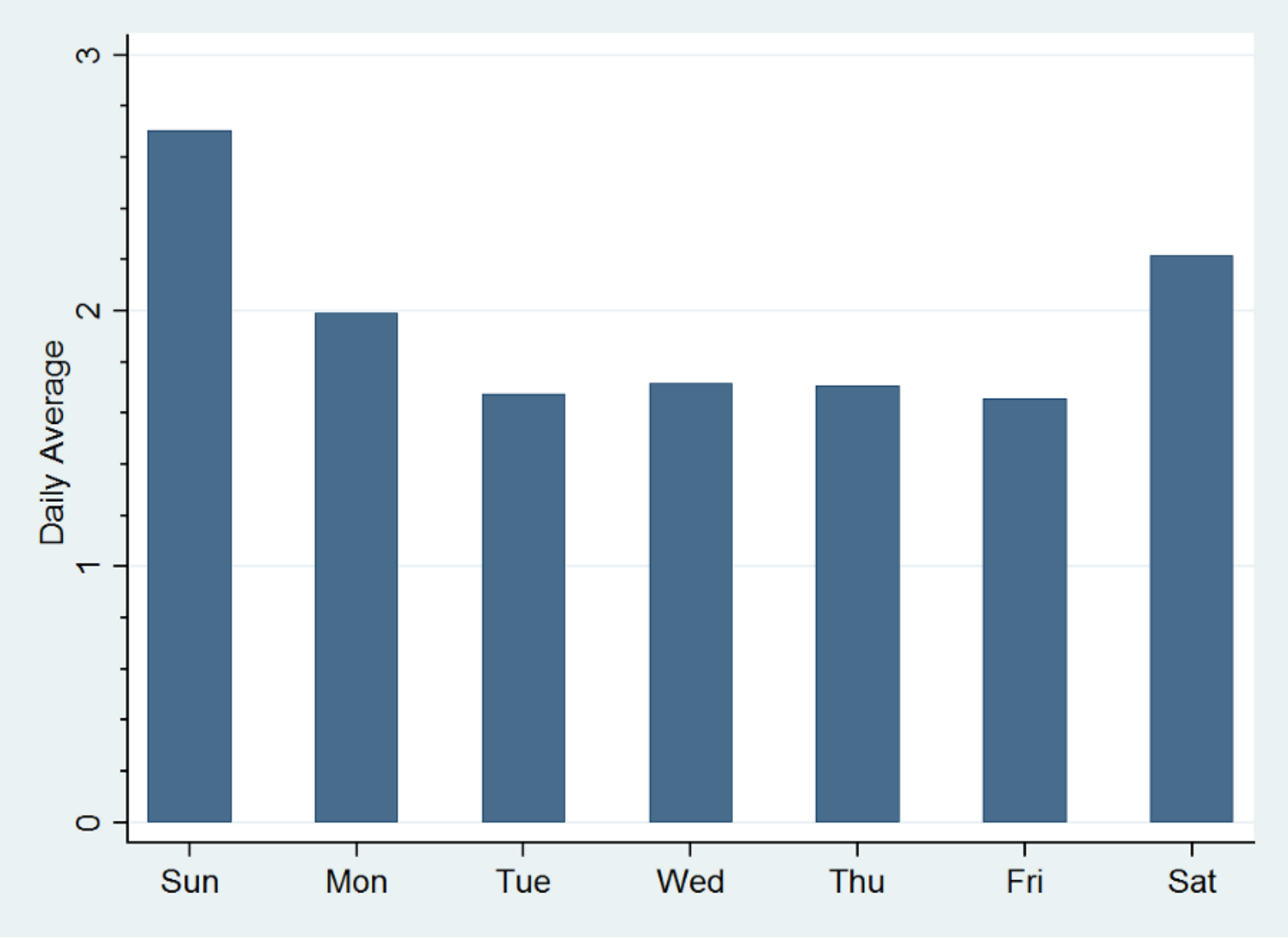
Laundry


Hourly Average kWh
0
.02
.04
.06
.08
.1
.12
.14
.16
.18
.2
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Hour
Clothes Washer
Dryer

Dryer energy use vs occupancy



More Laundry: Dryer Weekly Loadshape



All Done

- Travel Safely