IEPEC International Energy Program Evaluation Conference

Measuring up -- how does my baseline compare?

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2017 IEPEC Conference — Baltimore, Maryland

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Spring, 2016

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The Massachusetts Program Administrators (PAs) decided to undertake this study for several reasons…

- For potential studies in support of their 2019 to 2021 three-year plan goals.
- Launching demand pilots and anticipate that demand will be a greater focus of energy efficiency programs going forward.
  - Ambitious goal of quantifying the load shape for all major current and future electric end uses in addition to obtaining their current saturations.
  - Having accurate load shapes is an important component of accurately estimating those demand savings.

Planning a Phased Approach

- NILM looks cheap, but the accuracy is uncertain.
- Onsite metering looks expensive, but the accuracy is excellent.
- A combined approach looked good, but we couldn't tell how well the NILM would correlate with the onsite metering.

Timing

- Phase I (June 2016 – October 2016)
  - tests and verifies the data collection and analysis approach on about 5% of the overall sample of sites in one county
- Intermediate Analysis and Planning for Phase II (October, 2016 – February, 2017)
- Phase II (March, 2017 – March, 2018)
  - a full-scale implementation of the study across the entire state

Phase 1 Objectives

- Figure out as many of the places as possible where NILM wouldn't work well. We were hoping it would work well everywhere, but in the event it worked just OK for some end uses, we could refine our sample for phase 2.
- Refine estimates of CV and frequency of each end use
- Sample was not chosen randomly – it was chosen to try to get at least 5 sample points for each significant end use on our list.

Fall, 2016

A Residential Load Disaggregation, So Close But Yet So Far Away

- THURSDAY, AUGUST 10 - 8:30 – 10:00 - 8A Maryland
- Duckhunt! Benefits and Risks of Load Disaggregation and End-Use Metering for Determining End-Use Loadshapes - Terese Decker, Navigant
- A Snapshot of NILM: Techniques and Tests of Non-Intrusive Load Monitoring for Load Shape Development - Justin Elszasz, Navigant

Key Findings from Test Phase

	Whole Home Energy Monitor	Full End Use Metering
Equipment Cost*	$100-200/ site	$1000-$1500 / site
Installation Qualifications	None	Electrician
Installation time	0.5 hours / site for one person	3 hours / site for two people
Maintenance time	2.5 hours / site	0.5 hours / site
Data Frequency	32-second	1-minute
Data Quality	Poor	Excellent
Analysis Required	Third party load disaggregation	In-house
Within-home Communication	Home internet bridge	Powerline carrier

*Equipment cost includes shipping, installation training, data access, and technical support

December, 2016

Planning for Phase 2: CVs

End Use Category	Target End Use	Frequency of Occurrence in MA Households	Target Precision	CV - Energy	CV - Utility Peak	CV - ISO Peak	Oversample Driver
Heating and Cooling	Central AC / Heat Pump	29.0%	15.0%	0.56	0.60	0.56	CV - Utility Peak
	Room AC	64.0%	30.0%	1.33	1.70	2.36	CV - Utility Peak
	Ground Source Heat Pump	1.0%	100.0%	0.56	0.60	0.56	CV - Utility Peak
	Other Electric Heat	5.0%	20.0%	0.50	2.00	1.88	CV - Energy
	Space Heaters / Plug-in Fireplaces	15.0%	15.0%	1.00	2.45	2.45	CV - Energy
	Boiler Circulator Pump	51.0%	15.0%	0.50	0.77	0.43	CV - Energy
	Other Fuel Furnace Fan	53.0%	10.0%	0.50	0.15	0.13	CV - Energy
Kitchen Appliances	Dishwasher	71.0%	30.0%	0.79	1.93	2.66	CV - Utility Peak
	Freezer	13.0%	20.0%	0.42	0.32	0.38	CV - Utility Peak
	Refrigerator	100.0%	20.0%	0.31	0.32	0.28	CV - Utility Peak
	Second Refrigerator	28.0%	20.0%	0.59	0.54	0.53	CV - Utility Peak
DHW	Hot Water Heater	15.0%	15.0%	0.42	0.65	0.93	CV - ISO Peak
	Tankless Hot Water Heater	0.6%	100.0%	0.42	0.65	0.93	CV - Utility Peak
	Heat Pump Water Heater	2.0%	20.0%	0.42	0.65	0.93	CV - Utility Peak
Laundry	Washer	86.0%	30.0%	0.68	2.17	2.47	CV - Utility Peak
	Electric Dryer	68.1%	20.0%	0.46	3.81	1.52	CV - ISO Peak
Miscellaneous	Dehumidifier	50.0%	15.0%	0.83	0.83	0.76	CV - Utility Peak
	Aquarium	2.0%	100.0%	0.50	0.50	0.50	CV - Utility Peak
	Golf Cart/Large Battery Charger	5.0%	100.0%	1.00	1.00	1.00	CV - Utility Peak
	Well Pump	12.0%	100.0%	1.72	1.84	1.62	CV - ISO Peak
	Sump Pump	30.0%	30.0%	1.44	1.48	1.46	CV - Energy
	Booster Pump	5.0%	100.0%	0.80	0.06	0.87	CV - Energy
	Pool Pump	10.0%	20.0%	0.72	0.75	0.79	CV - ISO Peak
	EV Charger	0.4%	100.0%	0.70	1.00	1.00	CV - Utility Peak

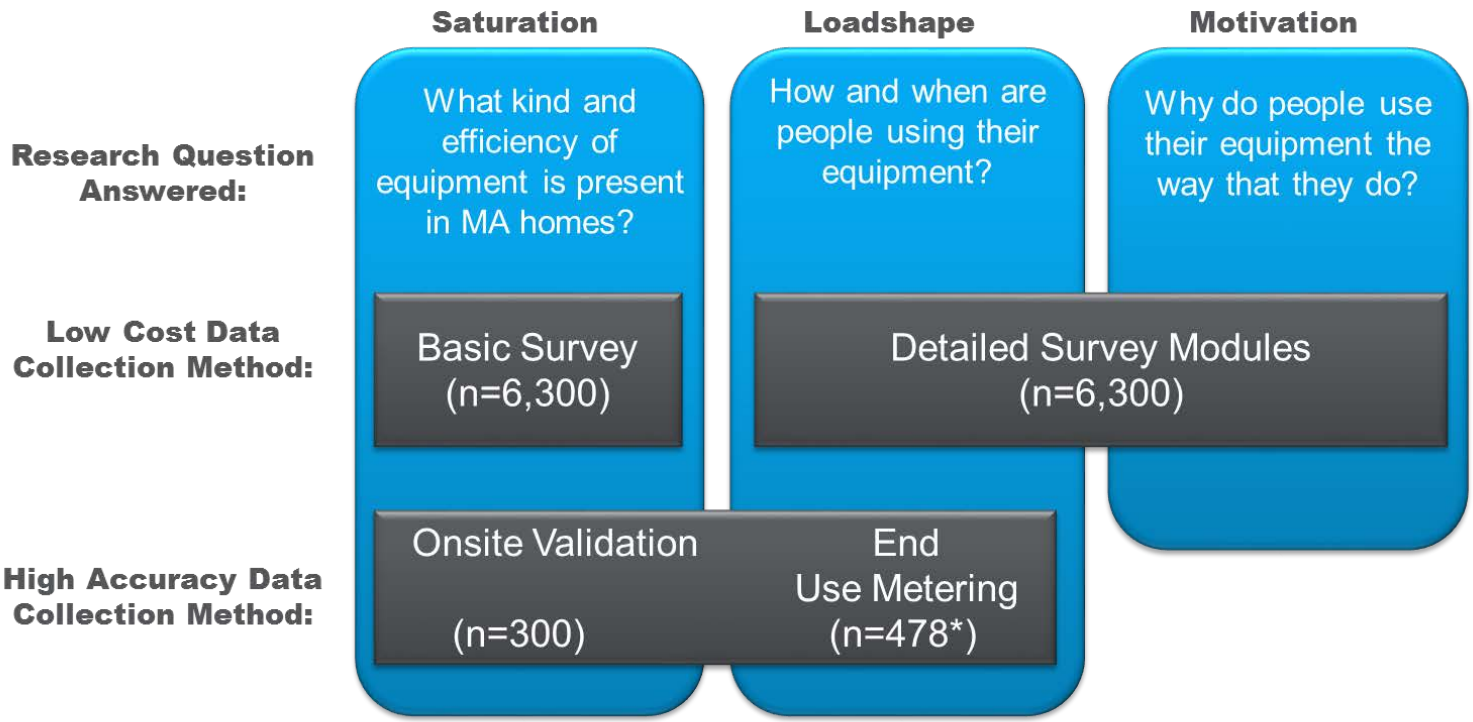
Planning for Phase 2: Sample Sizes

End use	Estimated Frequency	Targeted End Use Precision - Energy	Targeted End Use Precision – Utility Peak	Targeted End Use Precision – ISO-NE Peak	Oversample	Number of Core Sample Sites*	Number of Oversample Sites	Total Number of Sites Expected
Central AC / Heat Pump	29.0%	10.1%	10.6%	9.9%	No	87	0	87
Room AC	64.0%	15.8%	20.3%	28.2%	No	192	0	192
Ground Source Heat Pump	1.0%	84.3%	100.6%	93.6%	No	3	0	3
Other Electric Heat	5.0%	20.5%	82.0%	77.2%	Yes	15	3	18
Space Heaters / Plug-in Fireplaces	15.0%	15.0%	36.8%	36.8%	Yes	45	77	122
Boiler Circulator Pump	51.0%	6.7%	10.3%	5.8%	No	153	0	153
Other Fuel Furnace Fan	53.0%	6.6%	1.9%	1.7%	No	159	0	159
Dishwasher	71.0%	9.0%	21.8%	30.1%	No	213	0	213
Freezer	13.0%	11.2%	8.7%	10.4%	No	39	0	39
Refrigerator	100.0%	3.0%	3.1%	2.7%	No	300	0	300
Second Refrigerator	28.0%	10.7%	9.9%	9.6%	No	84	0	84
Hot Water Heater	15.0%	6.7%	10.5%	15.0%	Yes	45	61	106
Tankless Hot Water Heater	0.6%	186.1%	289.8%	415.6%	No	2	0	2
Heat Pump Water Heater	2.0%	13.0%	20.3%	29.1%	Yes	6	24	30
Washer	86.0%	7.0%	22.3%	25.4%	No	258	0	258
Electric Dryer	68.1%	5.4%	44.1%	17.6%	No	204	0	204
Dehumidifier	50.0%	11.2%	11.3%	10.3%	No	150	0	150
Aquarium	2.0%	41.1%	41.1%	41.1%	No	6	0	6
Golf Cart/Large Battery Charger	5.0%	45.5%	45.5%	45.5%	No	15	0	15
Well Pump	12.0%	48.6%	51.8%	45.6%	No	36	0	36
Sump Pump	30.0%	25.3%	25.9%	25.6%	No	90	0	90
Booster Pump	5.0%	36.3%	2.9%	39.6%	No	15	0	15
Pool Pump	10.0%	18.2%	19.1%	20.2%	Yes	30	14	44
EV Charger	0.4%	N/A	N/A	N/A	No	1	0	1
Total						300	178	478

Oversamples

End Use	Number of Oversamples	Meter Type	Onsite Scope
Hardwired electric heat	3	Hardwired	Meter all hardwired electric heat onsite, collect characterization data about each, meter whole home energy consumption
Plug-in space heater/fireplace	77	Plug-in	Meter all plug-in space heaters onsite, collect characterization data about each
Electric hot water heaters	61	Hardwired	Meter all electric hot water heaters onsite, collect characterization data about each, meter whole home energy consumption
Heat pump water heaters	24	Hardwired	Meter all hardwired electric heat onsite, collect characterization data about each, meter whole home energy consumption
Pool pumps	14	Some hardwired, some plug-in	Meter all pool pumps onsite, collect characterization data about each, meter whole home energy consumption if pool pump is hardwired in whole home panel

Final Study Design



*Includes end use oversample

Spring, 2017

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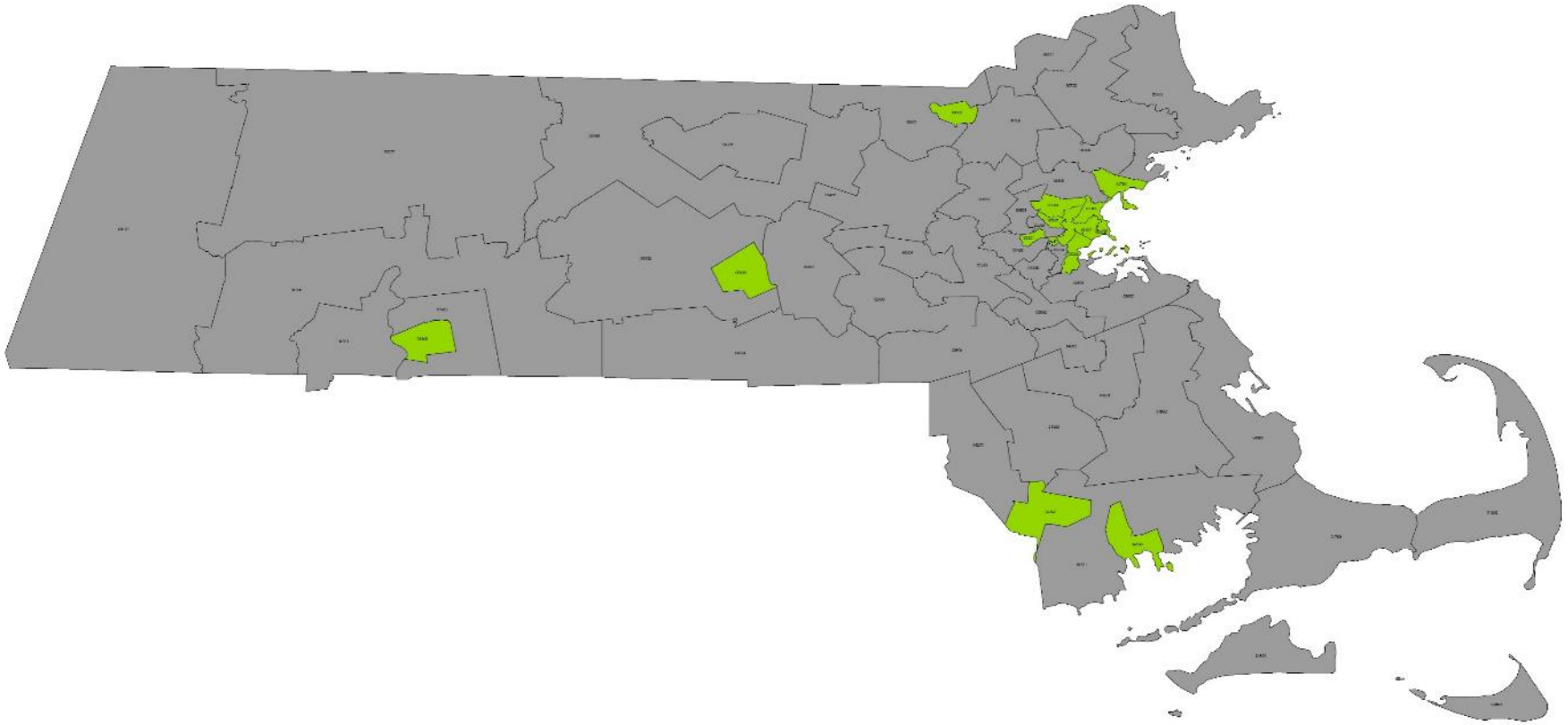
How we tried to reduce response bias: Geographic targeting of survey recruitment



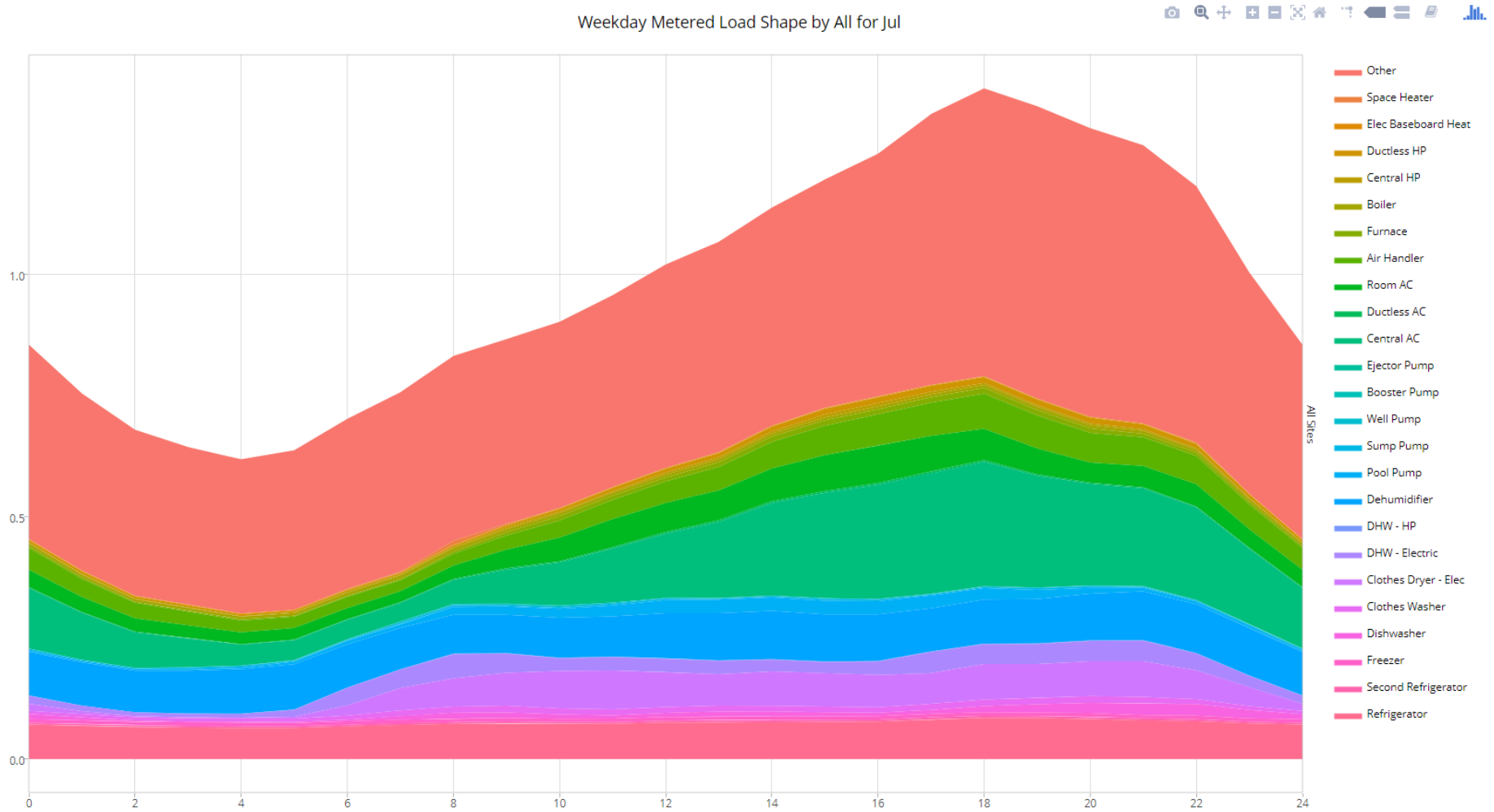
How we tried to reduce response bias: Set representativeness quotas for onsites for housing type, owner/renter, PA, income level, English speakers, etc.

August, 2017

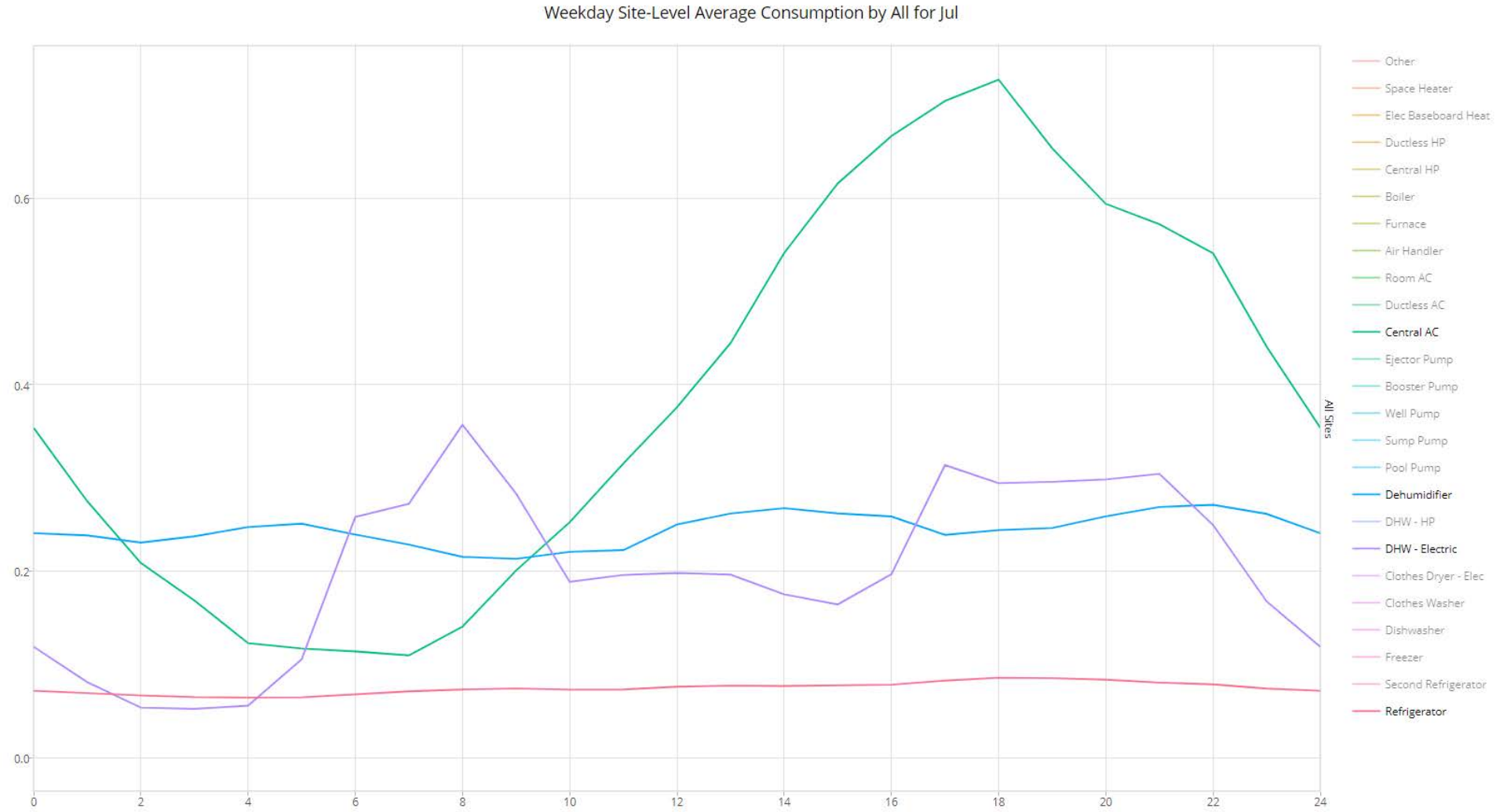
Saturation Key Findings

- Oil saturation is declining steadily
- Heat pumps are not common, but increasing
- Central AC saturation is increasing
- PAs are starting to use the saturation data to plan for 19-21 cycle.

Loadshape results are on the way



Loadshape results are on the way



We are working to extend the length of the study, turning this into a panel study.

- Primary expense comes in installing equipment.
- Additional visits to check on equipment are relatively inexpensive.
- Observe increasing saturation of high impact end uses (EVs, heat pumps, heat pump water heaters)
- Catch more extreme weather and peak behavior
- Use panelists for additional experiments (e.g. install new equipment or push behavior change, etc.)

Key takeaways

- Doing hard stuff can be risky for everyone involved.
- Phasing complex studies dramatically reduces the risk of study failure.
- You always learn something by piloting your data collection and analysis and criticizing what you did. The more extensive and real the pilot is, the better.

Questions?

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