

DOWNSTATE AIR SOURCE HEAT PUMP DEMONSTRATION

THE LEVY PARTNERSHIP

CENTSIBLE HOUSE

FRONTIER ENERGY

JANUARY 2022



The Levy Partnership



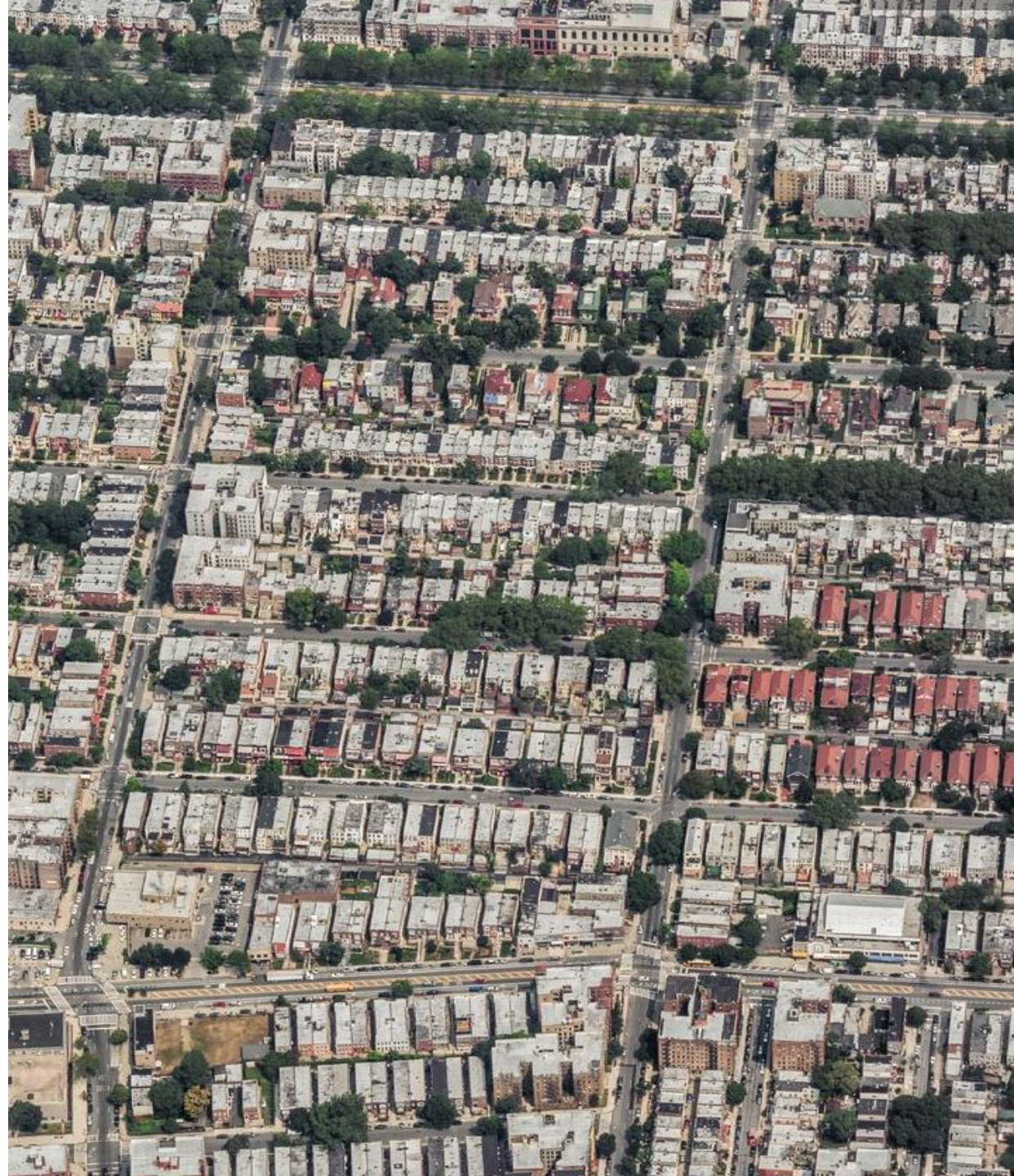
Centsible House

DOWNSTATE DEMO

- 20 Sites
- Brooklyn, Queens, Bronx, Yonkers, Long Island

Goals:

- Understand and demonstrate viability costs and savings
- Increase awareness, and confidence
- Market exposure
- Provide resources for NYSERDA to promote benefits



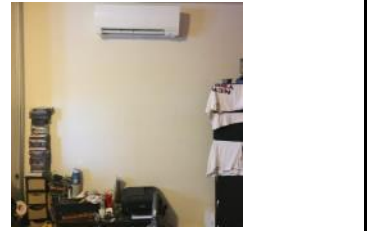
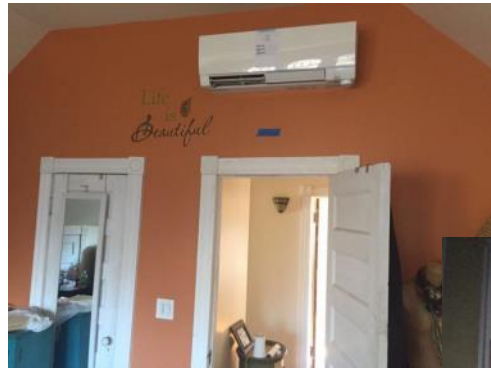
RETROFIT SCOPE

- Full boiler replacement
- Some weatherization
- Low-ambient equipment (NEEP cold climate air source heat pump listing)



HEAT PUMPS

- 3-4 condensing units
- 6-12 air handlers
- Wall mounted mini and multi-splits
- A few ducted units
- Mostly Mitsubishi/Fujitsu equipment



Mitsubishi	Fujitsu
Outdoor unit	Outdoor unit
MXZ3C24NAHZ	AOU12RLS3H
MXZ4C36NAHZ	AOU18RLXFZH
MXZ3C30NAHZ	AOU24RLXFZH
MXZ5C42NAHZ	AOU36RLXFZH
MXZ4C36NAHZ	AOU36RLAVM
Indoor units	Indoor units
MSZFH06NA	ASU7RLP1
MSZFH09NA	ASU9RLP1
MSZFH12NA	ASU12RLP1
MSZFH15NA	ASU18RLP1
MSZFH18NA	ASU24RLP1



ECONOMICS

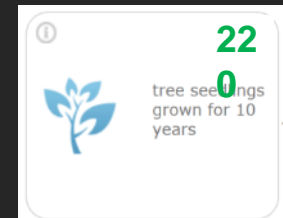
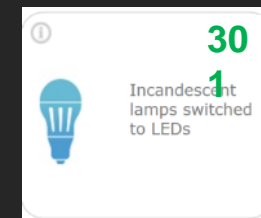
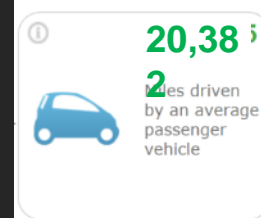
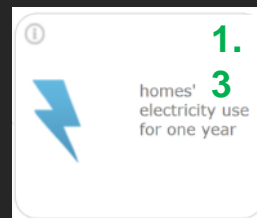
- \$10,000 to \$50,000 project value
- Up to \$8,000 in incentives/discounts/rebates special to demo
- Energy cost savings: **-\$939** to **\$1,597**
- Reason for purchase – increase home value, “central” cooling and solve poor heating distribution issues



INCREASED COMFORT

- A comprehensive approach to improve energy efficiency returns more sustainable benefits.
- Able to set room temperature individually.
- Homes with central AC and improved air sealing and insulation have attractive payback during resale, Benefits could range from high retention of investment value to increased equity.

PREMIUM VALUE



SITE RESULTS

- **Description of envelope improvements**
- **Costs by category**
- **Photo of building**
- **Equipment listing with capacity compared to load calculations**
- **Floor plan with equipment location**
- **Plots with before and after fuel use and utility bills**
- **Table summarizing pre and post costs and usage and implied COP**
- **Space temperatures**
- **Load lines**

SITE 10

Envelope Improvements

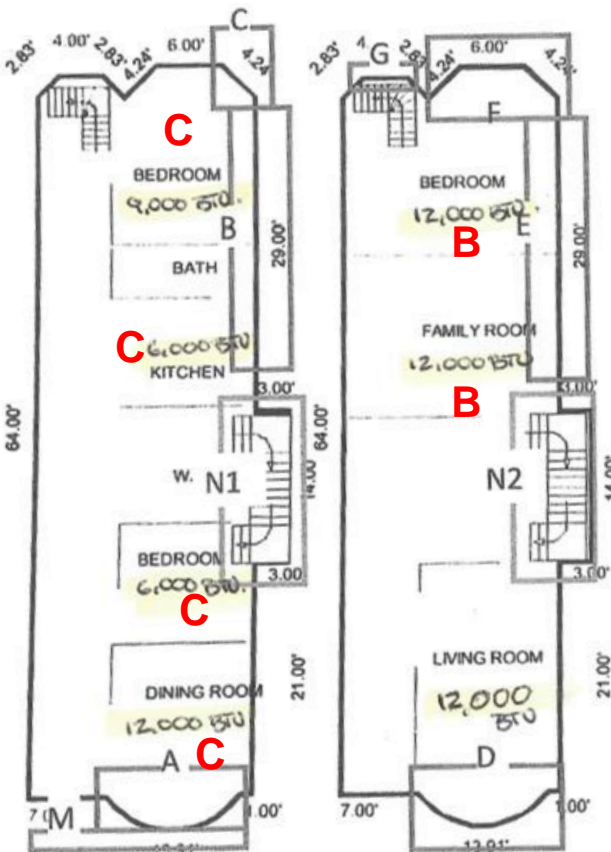
Envelope Improvement	Details
Air Sealing	Reduce overall air leakage of heated area from 1.75 ACH to 1.25ACH.
Rim Joist	Upgrade 180 square feet of existing rim joist to 2" High Density Foam, 1.5" Wood, 0.5" Wood Siding, R-15
Second floor attic insulation	Upgrade 320 square feet of existing ceiling to Gyp Bd, 2x6 16" OC, 6" cellulose, R-19

Costs

Item	Cost
Heat pump equipment (10 zones)	15,000
Heat pump labor	20,783
Total heat pump	35,783
Cost per ton	4,647
Cost per zone	3,578
Envelope materials + labor	10,736
Total job	46,519

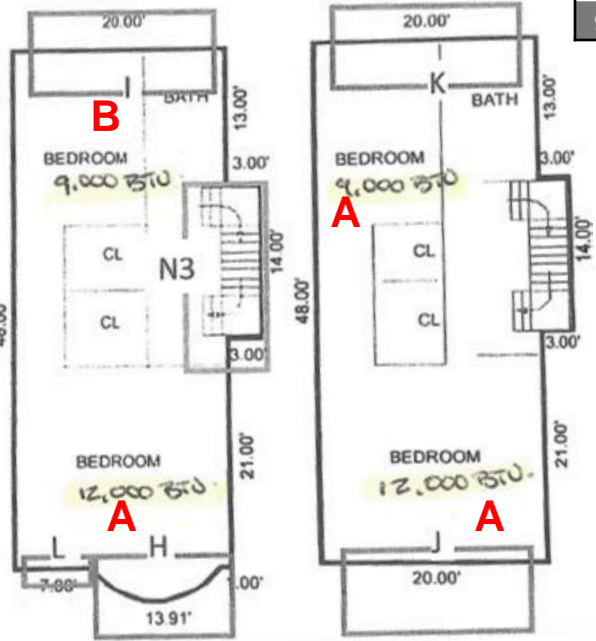


SITE 10

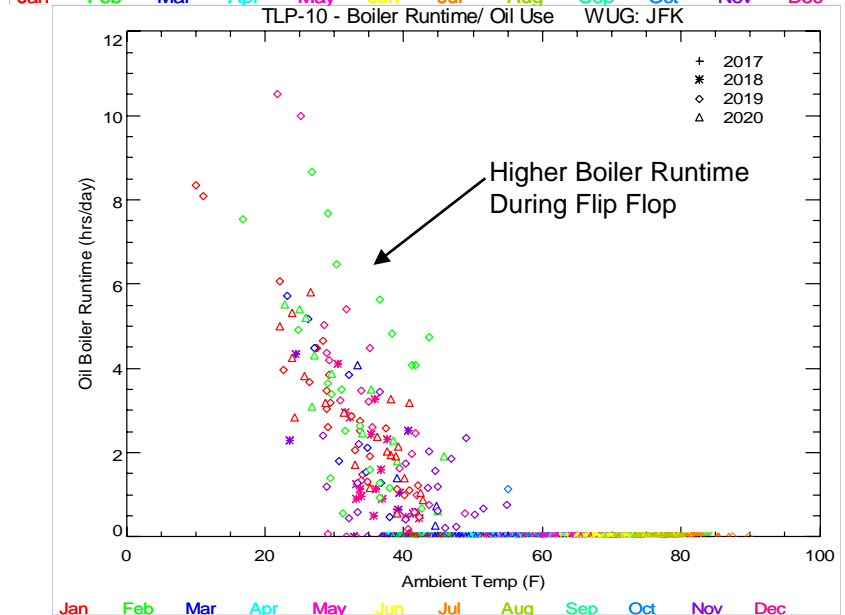
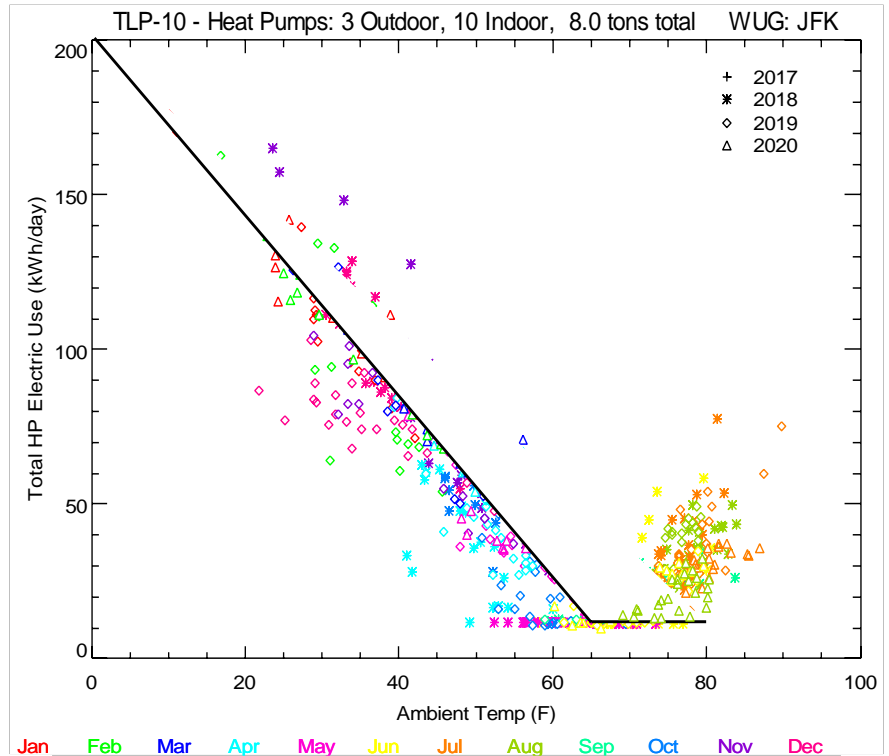
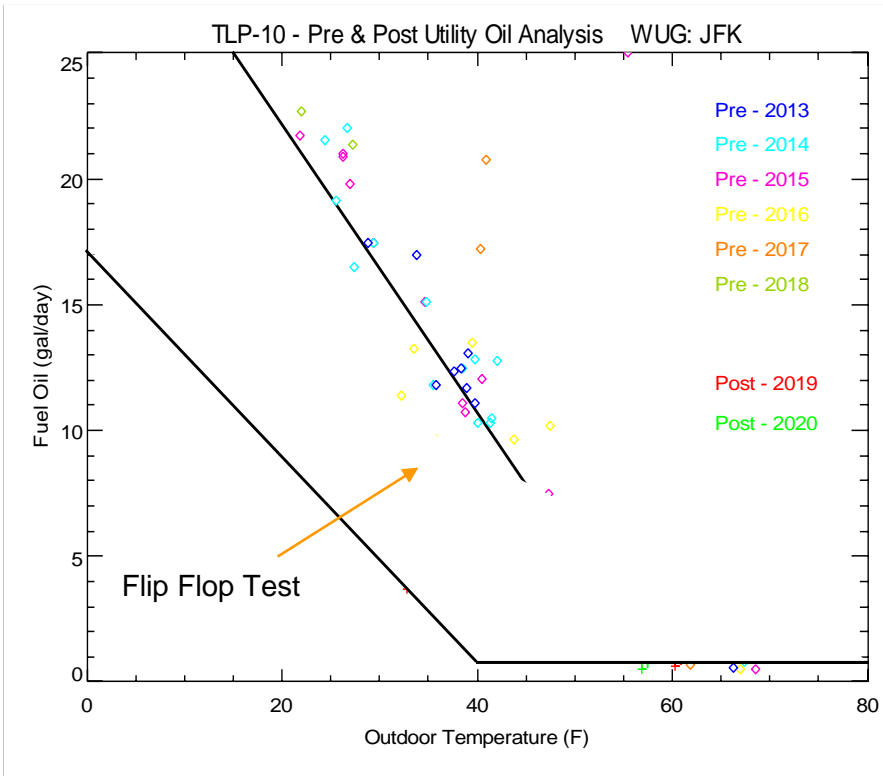


		Equipment Selection					
		Outdoor unit			Indoor units		
Floor	Room	Model	Cooling	Heating	Model	Cooling	Heating
1st floor	Living Room (C1)	MXZ-4C36NAHZ C			MSZ-FH12NA	12,000	10,900
	Bedroom (C2)		MSZ-FH06NA	6,000	8,700		
	Kitchen (C3)		MSZ-FH06NA	6,000	8,700		
	Back Bedroom (C4)		MSZ-FH09NA	9,000	10,900		
	Total		36,000	45,000	total	33,000	39,200
2nd floor	Dining/Kitchen (B1)	MXZ-3C30NAHZ			MSZ-FH15NA	15,000	12,900
	Back Bedroom (B2)		MSZ-FH12NA	9,000	7,900		
3rd Floor	Bedroom (B3)	B			MSZ-FH09NA	9,000	7,900
	Total		28,400	28,600	total	33,000	28,700
3rd Floor	Front Bedroom (A1)	MXZ-3C30NAHZ A			MSZ-FH12NA	12,000	13,600
4th floor	Front Bedroom (A2)		MSZ-FH12NA	12,000	13,600		
	Bedroom (A3)		MSZ-FH09NA	9,000	10,900		
Total			28,400	28,600	total	33,000	38,100
House Total	BTUH		92,800	102,200		99,000	106,000
	Tons		7.7	8.5		8.3	8.8

Loads	
93,273	110,633



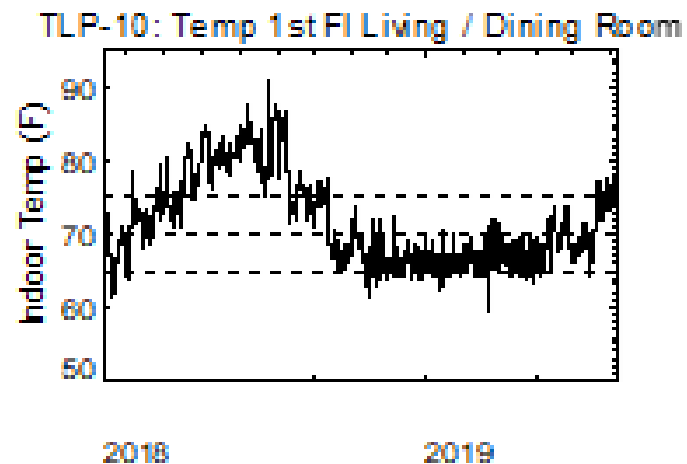
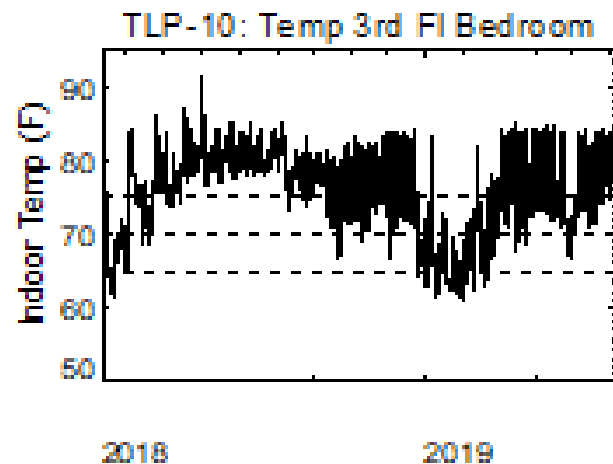
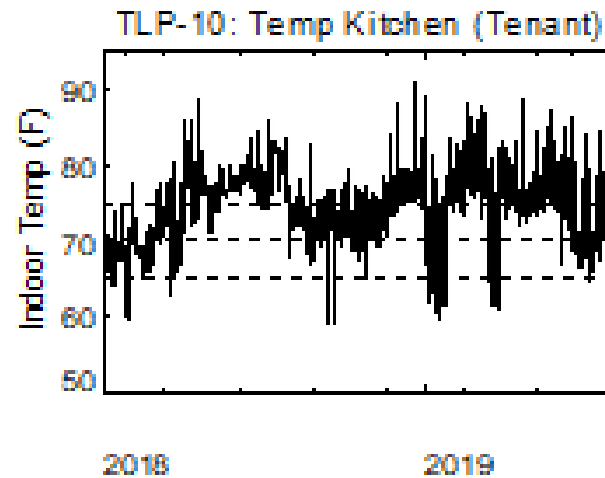
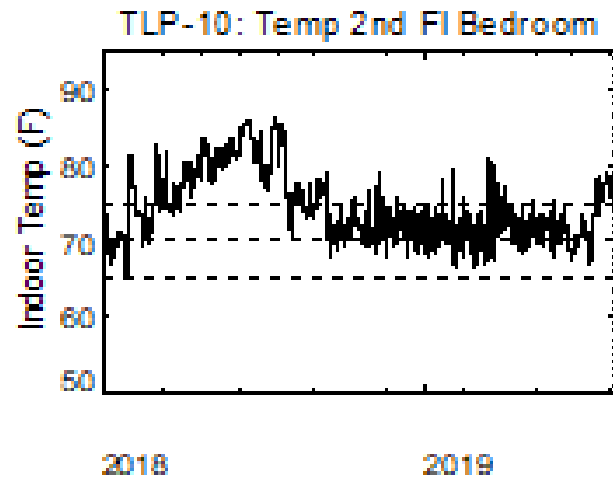
SITE 10



	PRE	POST	Savings
Costs	\$4,035	\$3,257	\$980
Oil (Gal/yr) \$2.45/gal	1,649	260	1,389
Electric (kWh/yr) \$0.20/kwh		13,110	(13,110)
Implied COP		2.2	

SITE 10

Indoor Space Temperatures



SITE 19

Envelope Improvements

Envelope Improvement	Details
Air sealing	Reduce overall air leakage of heated area from 4,742 CFM50 to 3,000 CFM50
Rim Joist Insulation	Rim joist upgrade, 122 sq ft, 2" high density foam, 1.5" wood, 0.5" wood, siding, R15

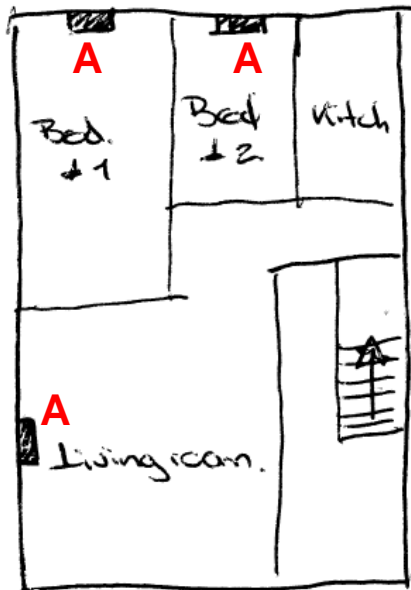
Costs

Item	Cost
Heat pump equipment (5 zones)	12,083
Heat pump labor	7,917
Total heat pump	20,000
Cost per ton	4,762
Cost per zone	4,000
Envelope materials + labor	0
Total job	20,000

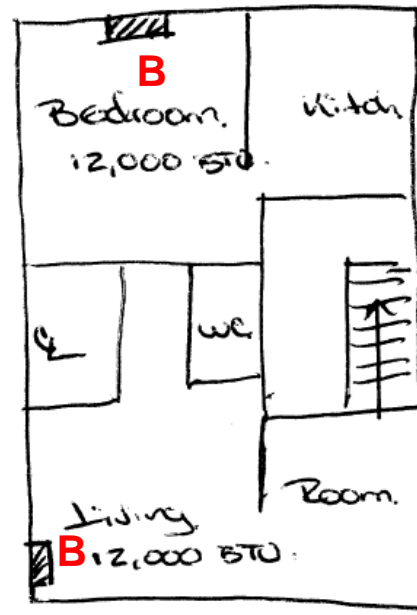


SITE 19

Floor	Room	RHVAC sizing calcs		Outdoor unit			Indoor units		
		Cooling	Heating	Model	Cooling	Heating	Model	Cooling	Heating
1st	Living Room			MXZ-3C24NAHZ			MSZ-FH06NA	6,000	8,700
	Back bedroom 1						MSZ-FH06NA	6,000	8,700
	Back bedroom 2						MSZ-FH06NA	6,000	8,700
	Total	15,367	23,415		22,000	25,000	indoor unit total	18,000	26,100
2nd	Front Bedrooms			MXZ-3C30NAHZ			MSZ-FH12NA	12,000	13,600
	Back Bedroom						MSZ-FH12NA	12,000	13,600
	Total	22,307	30,197		28,400	28,600	indoor unit total	24,000	27,200
Total	Btu	37,674	53,612		50,400	53,600		42,000	53,300
	Tons	3.1	4.5		4.2	4.5		3.5	4.4



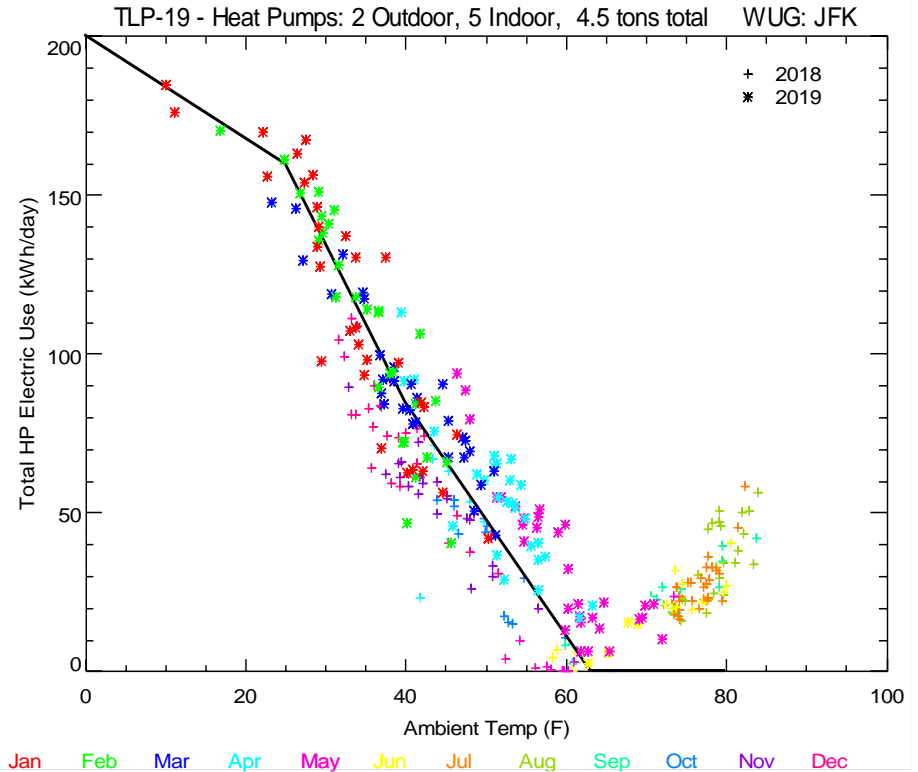
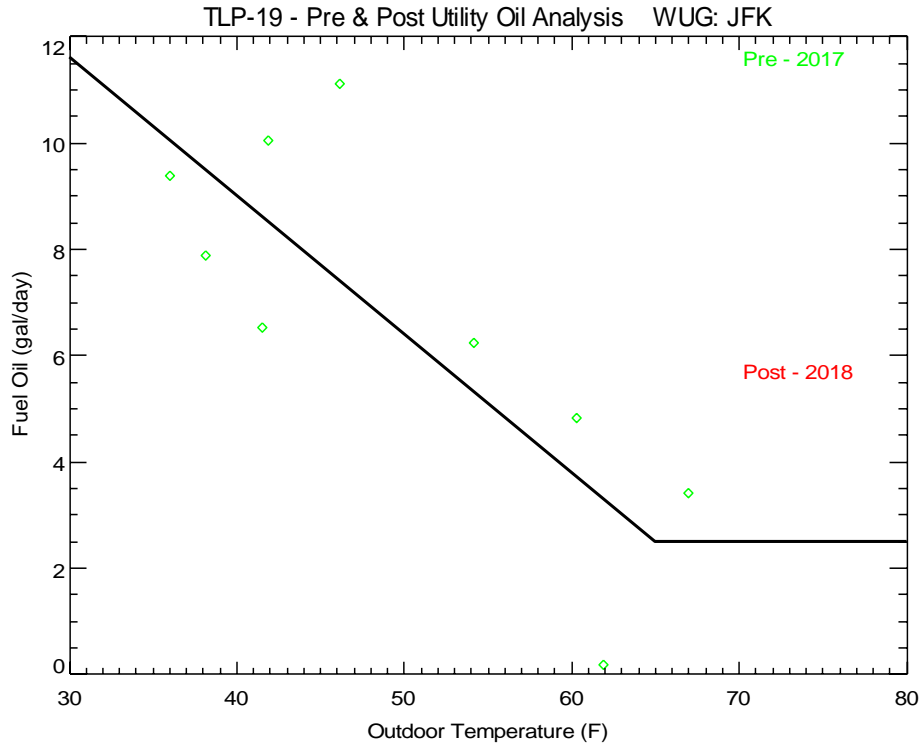
1st
Floor



2nd
Floor



SITE 19

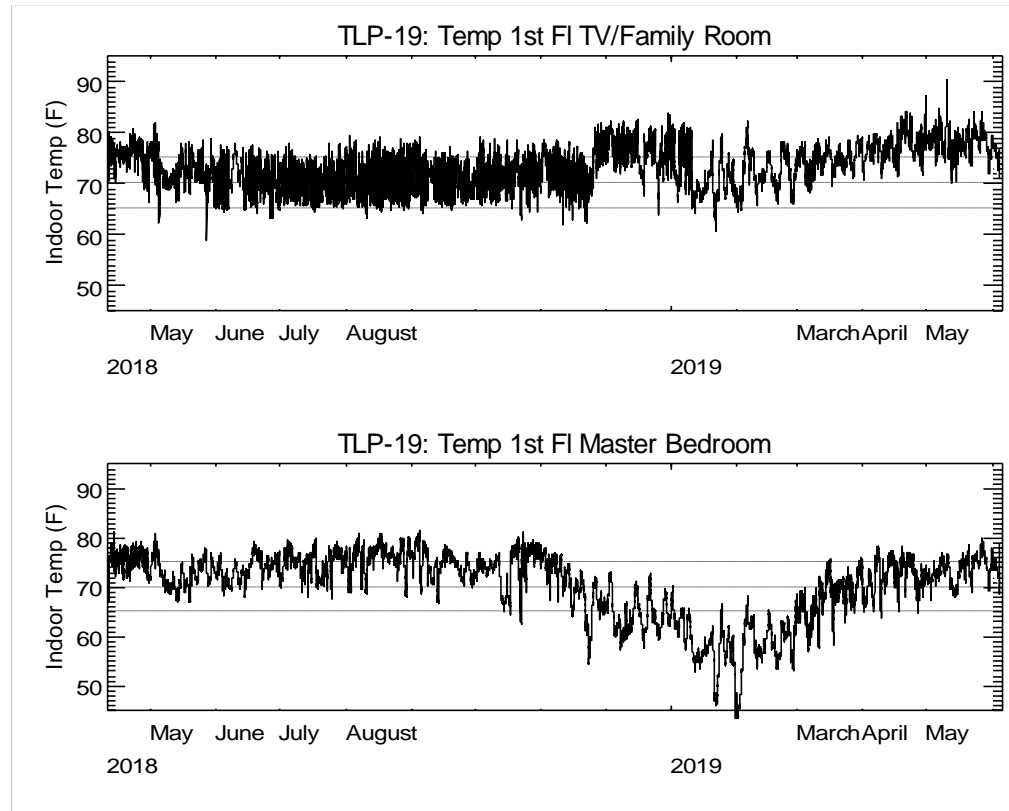


There was no post-retrofit oil use as indicated above. However, post-retrofit oil use was included in the analysis to account for DHW use. An electric DHW tank was installed at the time of the ASHP installation.

	PRE	POST	Savings
Costs	\$2,840	\$3,068	\$(228)
Oil (Gal/yr) \$2.45/gal	1,161	0	1,161
Electric (kWh/yr) \$0.20/kwh		15,339	(15,339)
Implied COP	2.4		

SITE 19

Indoor Space Temperatures



The second floor apartment was not accessible at the time of monitoring equipment installation or data retrieval.

SITE 23

Envelope Improvements

Envelope Improvement	Details
Air sealing	Reduce overall air leakage of heated area from 2,373 CFM50 to 1,750 CFM 50
Attic floor & knee wall	Upgrade 709 sqft of existing ceiling to Gyp Bd, 2x8 16" OC, 8" cellulose, R25
Exterior wall insulation	Upgrade 2,865 sqft of existing wall to Gyp Bd 2x4 16" OC cellulose, 1" wood, R12
3rd floor sloped ceiling	Upgrade 249 sqft of existing sloped roof to 2x6 16" OC, 5.5" cellulose, 0.5" wood, asphalt roofing R18

Costs

Item	Cost
Heat pump equipment (7 zones)	15,576
Heat pump labor	6,000
Total heat pump	21,576
Cost per ton	3,657
Cost per zone	3,082
Envelope materials + labor	13,596
Total job	38,540

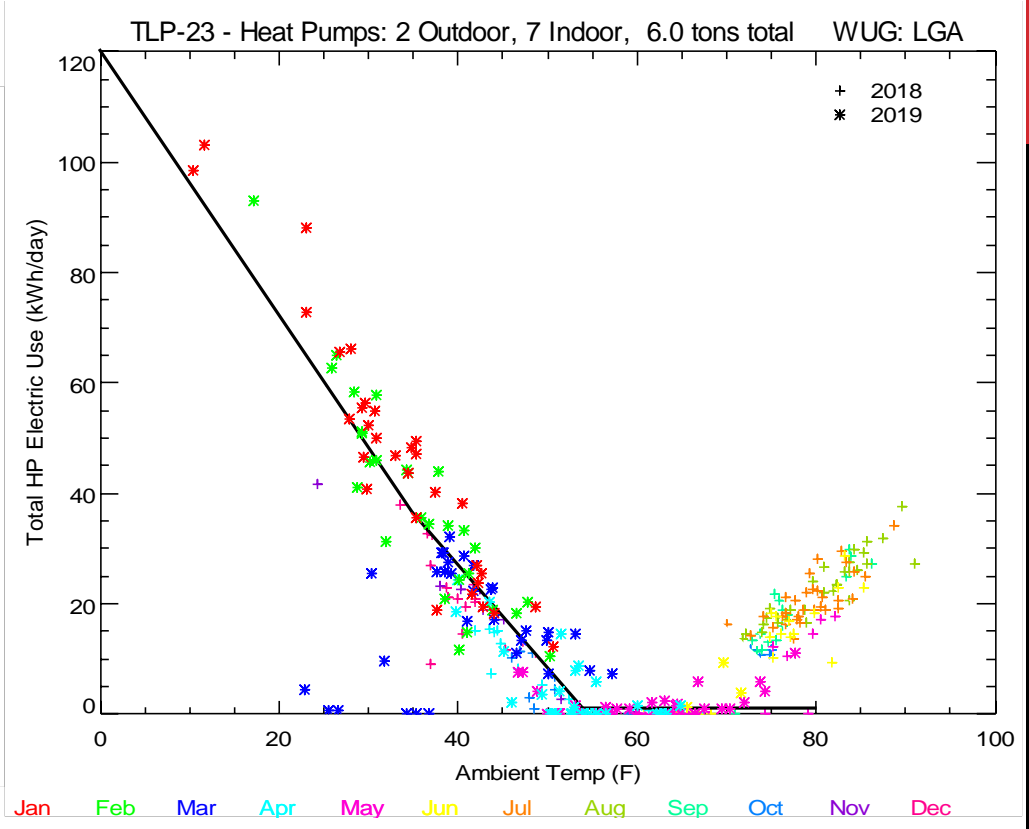
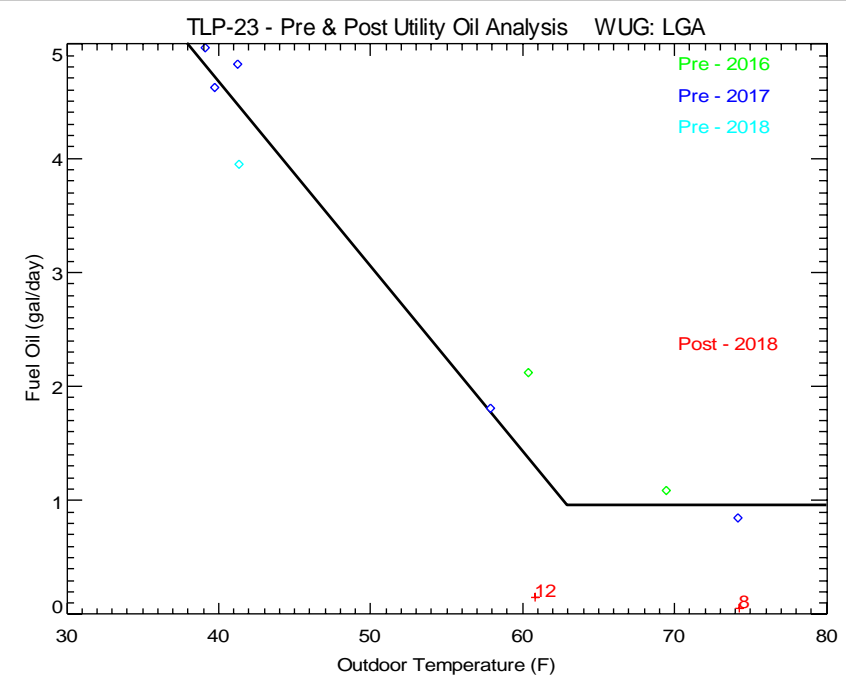


SITE 23

		Equipment Selection							
		Manual J sizing		Outdoor unit			Indoor units		
Floor	Room	Cooling	Heating	Model	Cooling	Heating	Model	Cooling	Heating
Basement	Basement			AOU36RLXFZ1H			ASU15RLF1	14,000	16,300
	Total	6,908	32,897						
1st floor	Living Room			AOU36RLXFZ1H			ASU7RLF1	7,000	8,100
	Kitchen				ASU7RLF1	7,000	8,100		
	Total	12,237	11,381		35,200	36,400	Indoor total	28,000	32,500
2nd floor	Master Bedroom			AOU36RLXFZ1H			ASU7RLF1	7,000	8,100
	Bedroom 1				ASU7RLF1	7,000	8,100		
	Bedroom 2				ASU7RLF1	7,000	8,100		
	Total	7,329	6,260						
Attic	Bedroom 3			AOU36RLXFZ1H			ASU7RLF1	7,000	8,100
	Total	3,248	3,873		35,200	36,400	Indoor total	28,000	32,400
House Total	BTUH	29,722	54,411		70,400	72,800		56,000	64,900
	Tons	2.5	4.5		5.9	6.1		4.7	5.4



SITE 23



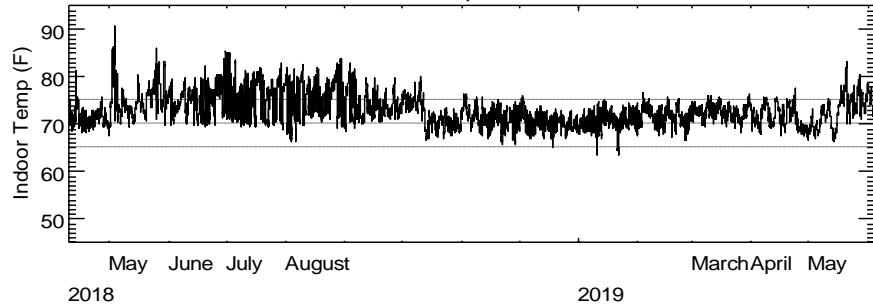
ASHP electric use goes to zero at 58°F. Pre-retrofit oil use was set to 0 when there was no HP operation (solid black line on the plot above).

	PRE	POST	Savings
Costs	\$1,582	\$937	\$645
Oil (Gal/yr) (\$2.45/gallon)	646	0	646
Electric (kWh/yr) (\$0.20/kWh)		4,685	(4,685)
Implied COP		1.8	

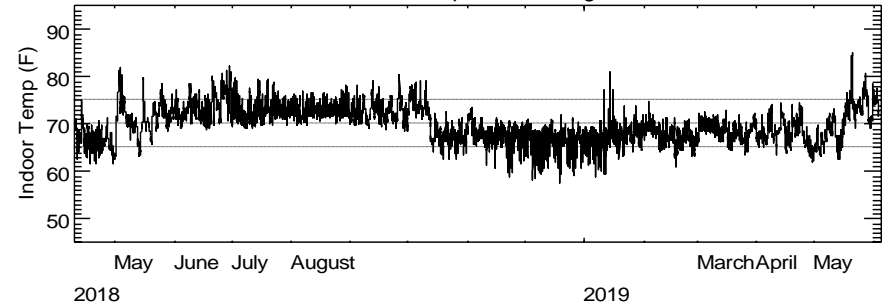
SITE 23

Indoor Space Temperatures

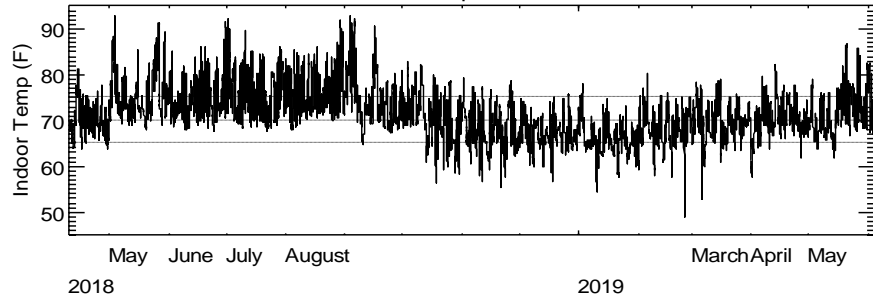
TLP-23: Temp 2nd Fl Bdrm



TLP-23: Temp 1st Fl Living Rm



TLP-23: Temp 3rd Fl Bedrm



SAVINGS SUMMARY

Site	old fuel	Site MMBTU savings	Savings lbs. CO2 emissions	Savings of HP only	Savings entire
1	Gas	51	5,946	\$ 52	\$ 171
3	Oil	209	34,022	\$ (355)	\$ 767
5	Gas	188	21,785	\$ (459)	\$ 520
10	Oil	190	30,949	\$ (202)	\$ 778
12 owner	Gas	22	2,489	\$ (158)	\$ 9
12 tenant	Gas	26	3,001	\$ (145)	\$ (62)
14	Oil	207	33,781	\$ 656	\$ 1,597
18	Oil	109	17,811	\$ 298	\$ 1,381
19	Oil	158	25,632	\$ (228)	\$ (228)
21	Gas	62	7,132	\$ (795)	\$ (624)
23	Oil	89	14,470	\$ (214)	\$ 645
25	Gas	86	9,898	\$ (387)	\$ (178)
31	Gas	42	4,807	\$ (448)	\$ (448)
32	Oil	75	12,288	\$ (14)	\$ 594
35	Oil	80	12,954	\$ 29	\$ 29
39	Oil	25	4,039	\$ (778)	\$ (778)
40	Gas	85	9,829	\$ (126)	\$ 277
41	Gas	-8	(1,010)	\$ (306)	\$ (306)
44	Gas	113	13,104	\$ 318	\$ 647
45	Oil	78	12,640	\$ (517)	\$ (151)
46	Gas	27	3,002	\$ (939)	\$ (939)
AVG		96	13,979	\$ (221)	\$ 200
AVG Oil (7)	Oil	122	19,859	\$ (132)	\$ 463
Avg Gas (6)	Gas	70	8,099	\$ (309)	\$ (63)

Savings are annual

COSTS SUMMARY

Site	Zones	Living Units	Heat pump equip. cost	Heat pump labor cost	Heat pump total cost	Weather-ization cost	Total cost	Heat pump total/zone	Heat pump total/ton
1	6	1	\$ 8,290	\$ 15,610	\$ 23,900	\$ -	\$ 23,900	\$ 3,983	\$ 4,686
3	7	1	\$ 11,156	\$ 20,992	\$ 32,148	\$ 5,500	\$ 37,648	\$ 4,593	\$ 5,358
5	10	1	\$ 18,024	\$ 34,166	\$ 52,190	\$ 5,500	\$ 57,690	\$ 5,219	\$ 8,698
10	10	2	\$ 15,000	\$ 20,783	\$ 35,783	\$ 10,736	\$ 46,519	\$ 3,578	\$ 4,647
12	8	2	\$ 12,687	\$ 24,443	\$ 37,130	\$ 10,000	\$ 47,130	\$ 4,641	\$ 5,626
14	7	1	\$ 13,530	\$ 9,500	\$ 23,030	\$ 28,431	\$ 51,461	\$ 3,290	\$ 3,715
19	5	2	\$ 12,083	\$ 7,917	\$ 20,000	\$ -	\$ 20,000	\$ 4,000	\$ 4,762
21	4	2	\$ 6,555	\$ 11,319	\$ 17,874	\$ 5,500	\$ 23,374	\$ 4,469	\$ 5,766
23	7	1	\$ 15,576	\$ 6,000	\$ 21,576	\$ 13,596	\$ 35,172	\$ 3,082	\$ 3,657
25	8	1	\$ 10,696	\$ 11,304	\$ 22,000	\$ 7,350	\$ 29,350	\$ 2,750	\$ 3,729
31	7	1	\$ 7,429	\$ 15,571	\$ 23,000	\$ -	\$ 23,000	\$ 3,286	\$ 4,792
32	4	1	\$ 5,682	\$ 6,318	\$ 12,000	\$ 3,500	\$ 15,500	\$ 3,000	\$ 4,138
35	6	1	\$ 10,200	\$ 14,800	\$ 25,000	\$ 1,000	\$ 26,000	\$ 4,167	\$ 6,250
39	4	1	\$ 4,903	\$ 7,097	\$ 12,000	\$ -	\$ 12,000	\$ 3,000	\$ 4,138
40	3	1	\$ 4,488	\$ 7,512	\$ 12,000	\$ 9,750	\$ 21,750	\$ 4,000	\$ 6,667
41	4	1	\$ 7,444	\$ 6,000	\$ 13,444	\$ 14,327	\$ 27,771	\$ 3,361	\$ 3,361
44	5	1	\$ 7,000	\$ 9,000	\$ 16,000	\$ -	\$ 16,000	\$ 3,200	\$ 4,324
45	11	3	\$ 14,000	\$ 10,000	\$ 24,000	\$ 10,000	\$ 34,000	\$ 2,182	\$ 3,000
46	8	1	\$ 19,100	\$ 8,900	\$ 28,000	\$ -	\$ 28,000	\$ 3,500	\$ 4,000
18	10	2	\$ 15,243	\$ 9,840	\$ 25,083	\$ 26,500	\$ 51,583	\$ 2,508	\$ 3,583
Avg	6.7	1.4	\$ 10,954	\$ 12,854	\$ 23,808	\$ 7,585	\$ 31,392	\$ 3,590	\$ 4,745

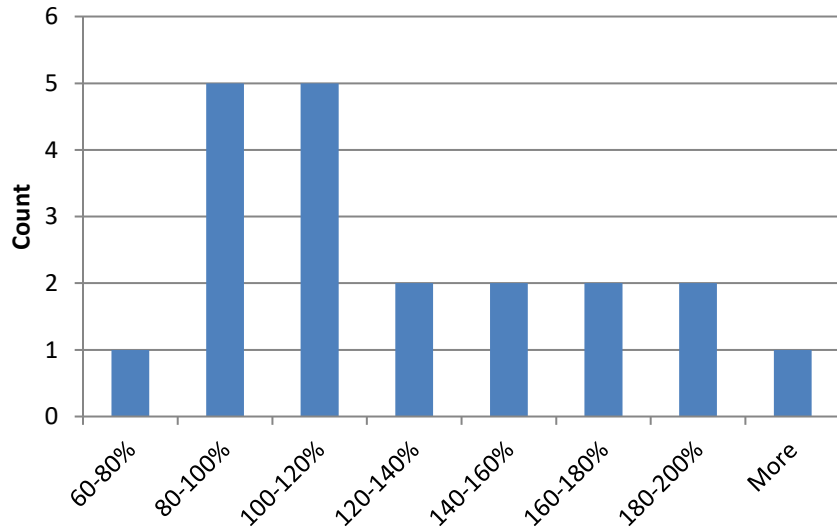
Costs before incentives and discounts

Installation Summary

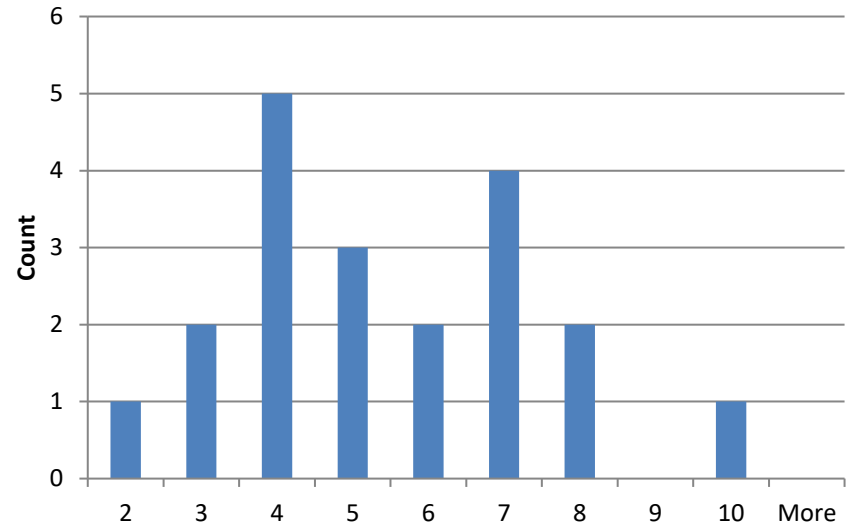
	Average
Zones per site	6.7
Living units per site	1.4
Zones per apt.	5.4
Heat pump equip. cost per site	\$10,954
Heat pump labor cost per site	\$12,854
Heat pump total cost per site	\$23,808
Weatherization cost per site	\$7,585
Total cost per site	\$31,392
Heat pump cost per zone	\$3,590
Heat pump cost per ton	\$4,745
Heating load (Btu/hr) per site	55,418
heating capacity (Btu/hr) @ 17 per site	68,322
heating capacity (Btu/hr) @ 47 per site	75,531
Capacity/Load avg. of all sites	129%

HISTOGRAMS - CAPACITY

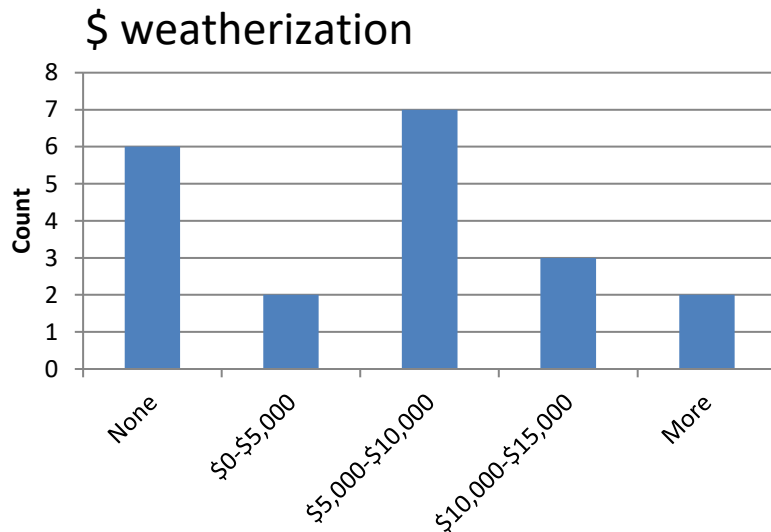
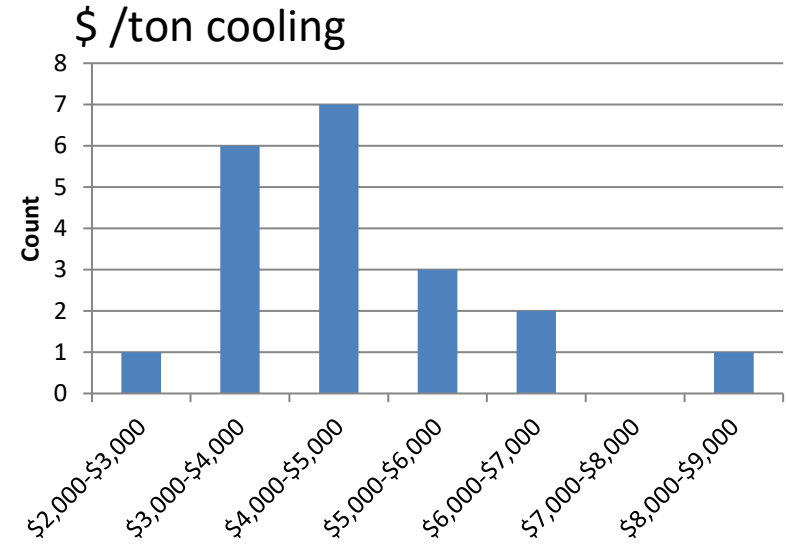
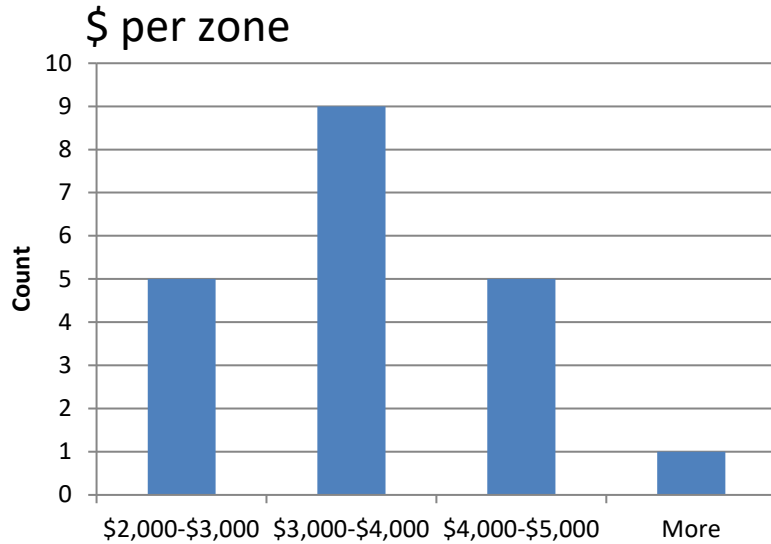
Capacity as % of Load



Zones per Apt



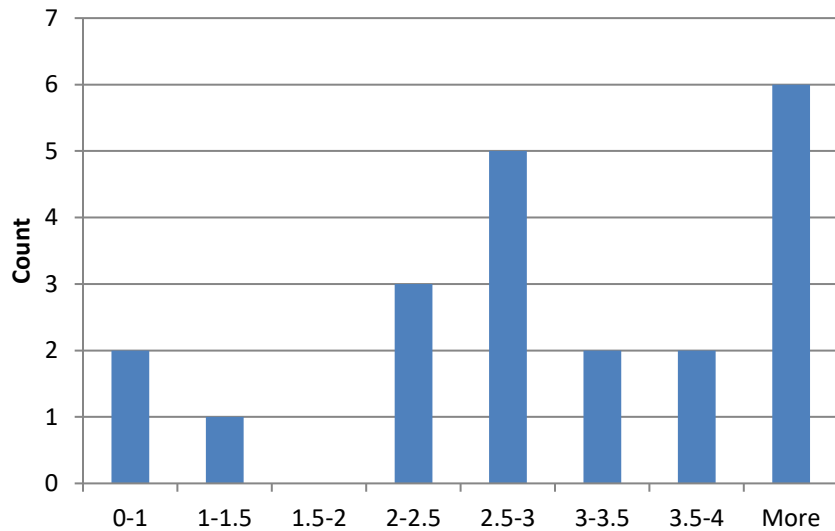
HISTOGRAMS - COST



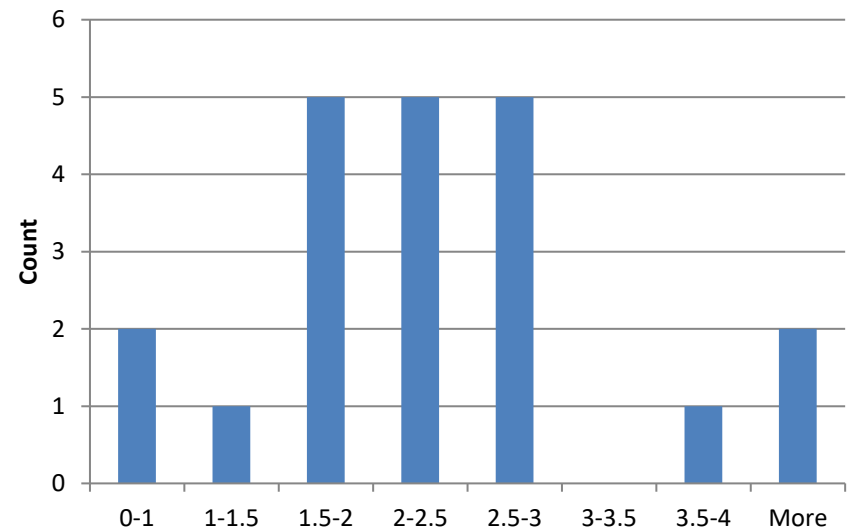
Costs are before incentives and discounts

HISTOGRAMS - COP

COP with envelope

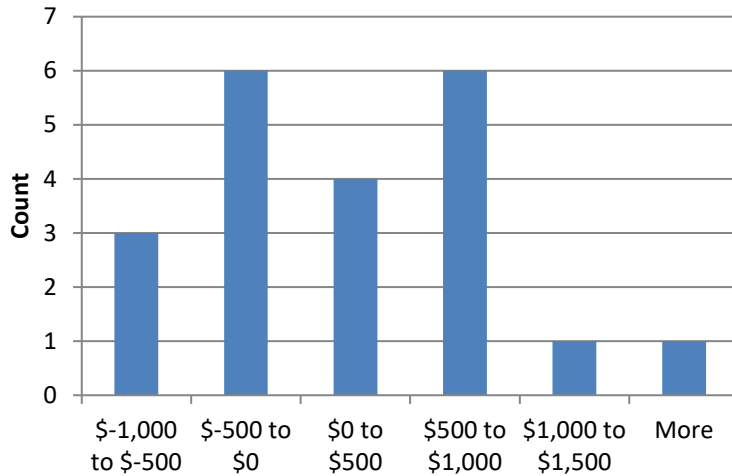


COP without envelope

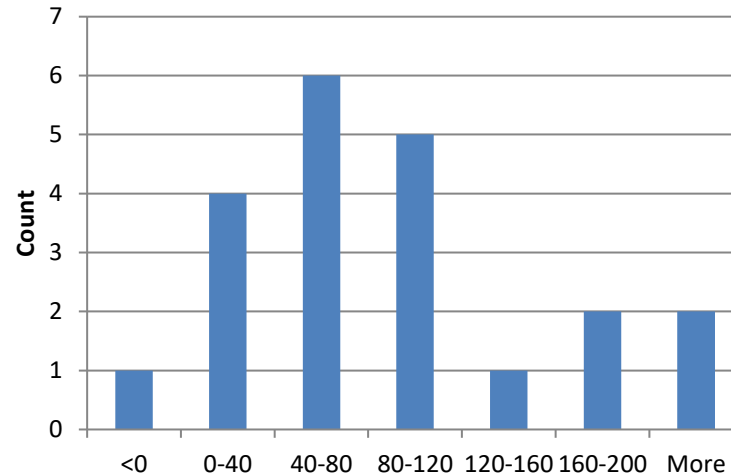


HISTOGRAMS - SAVINGS

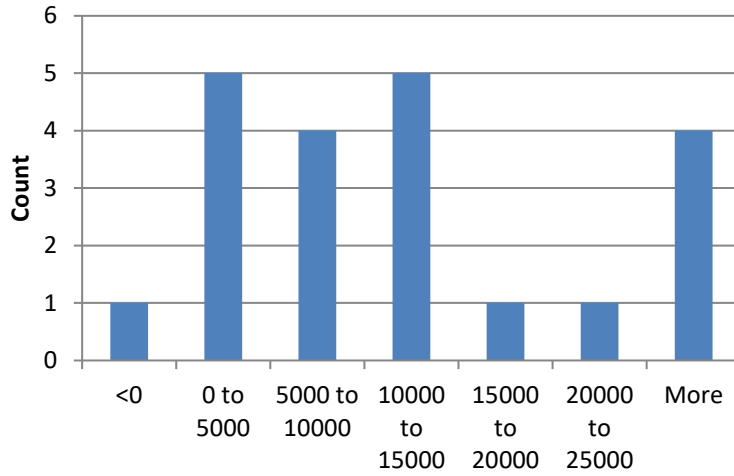
\$ savings/site



MMBTU savings/site



CO2 savings/site



Savings are annual

M&V Summary

	Avg	Avg Oil (7)	Avg Gas (6)
Old fuel	All	Oil	Gas
Site MMBTU savings	96	122	70
Savings lbs. CO2 emissions	13,979	19,859	8,099
\$avings of HP only	\$ (221)	\$ (132)	\$ (309)
\$avings entire	\$ 200	\$ 463	\$ (63)
COP accounting for envelope	3.5	3.7	3.3
COP raw	2.4	2.4	2.4

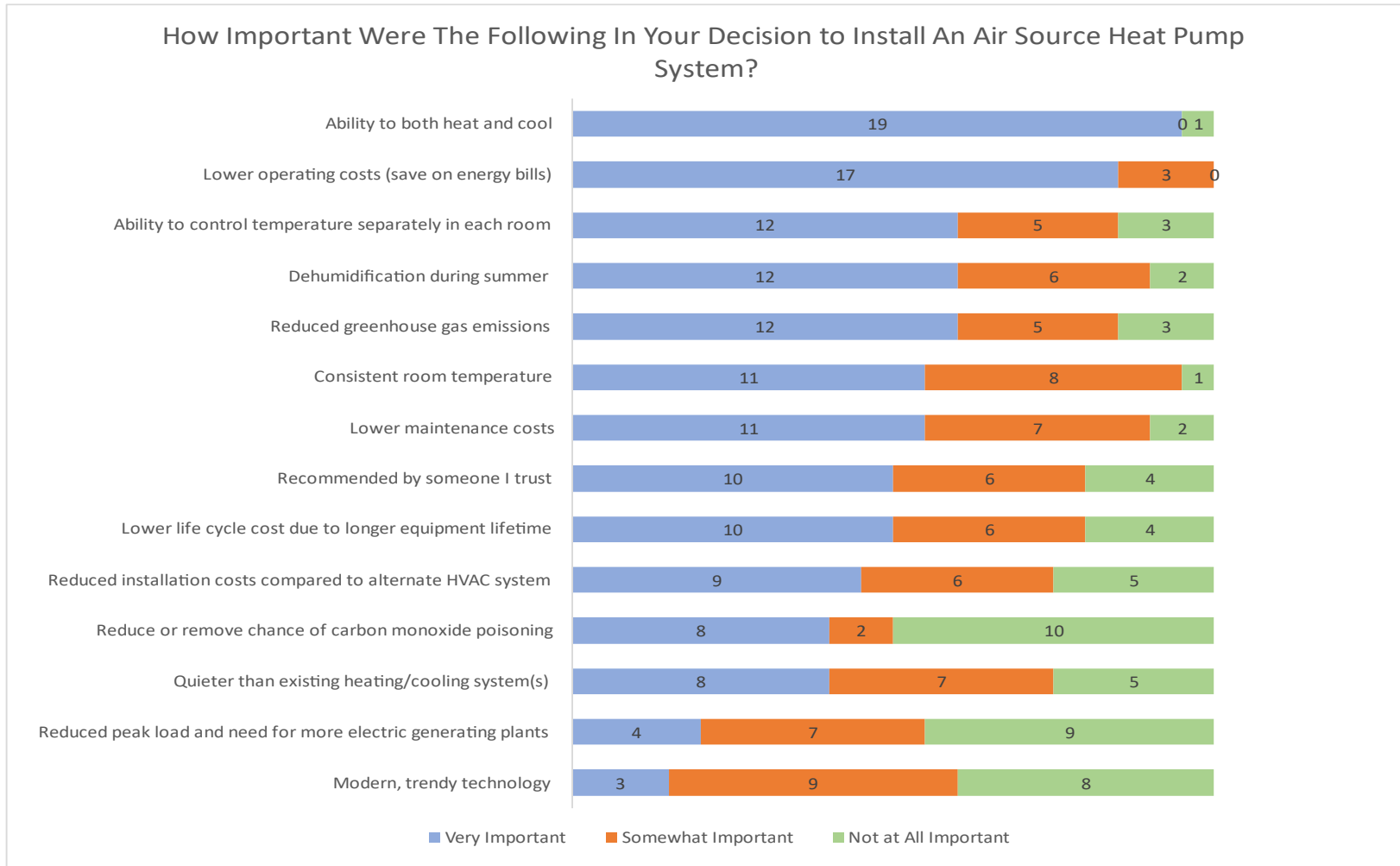
If you leave it they will use it

Site	Reduced existing system use by	Existing System Status
1	81%	In-Place
3	80%	In-Place
5	82%	In-Place
10	84%	In-Place
12 owner	74%	In-Place
12 tenant	84%	In-Place
14	100%	Removed
18	100%	Removed
19	100%	Removed
21	69%	In-Place
23	100%	In-Place
25	100%	Not Operational
31	68%	In-Place
32	100%	Removed
35	66%	In-Place
39	100%	In-Place
40	100%	Removed
41	-18%	In-Place
44	100%	Removed
45	100%	Removed
46	37%	In-Place

Could integrated controls have improved performance?

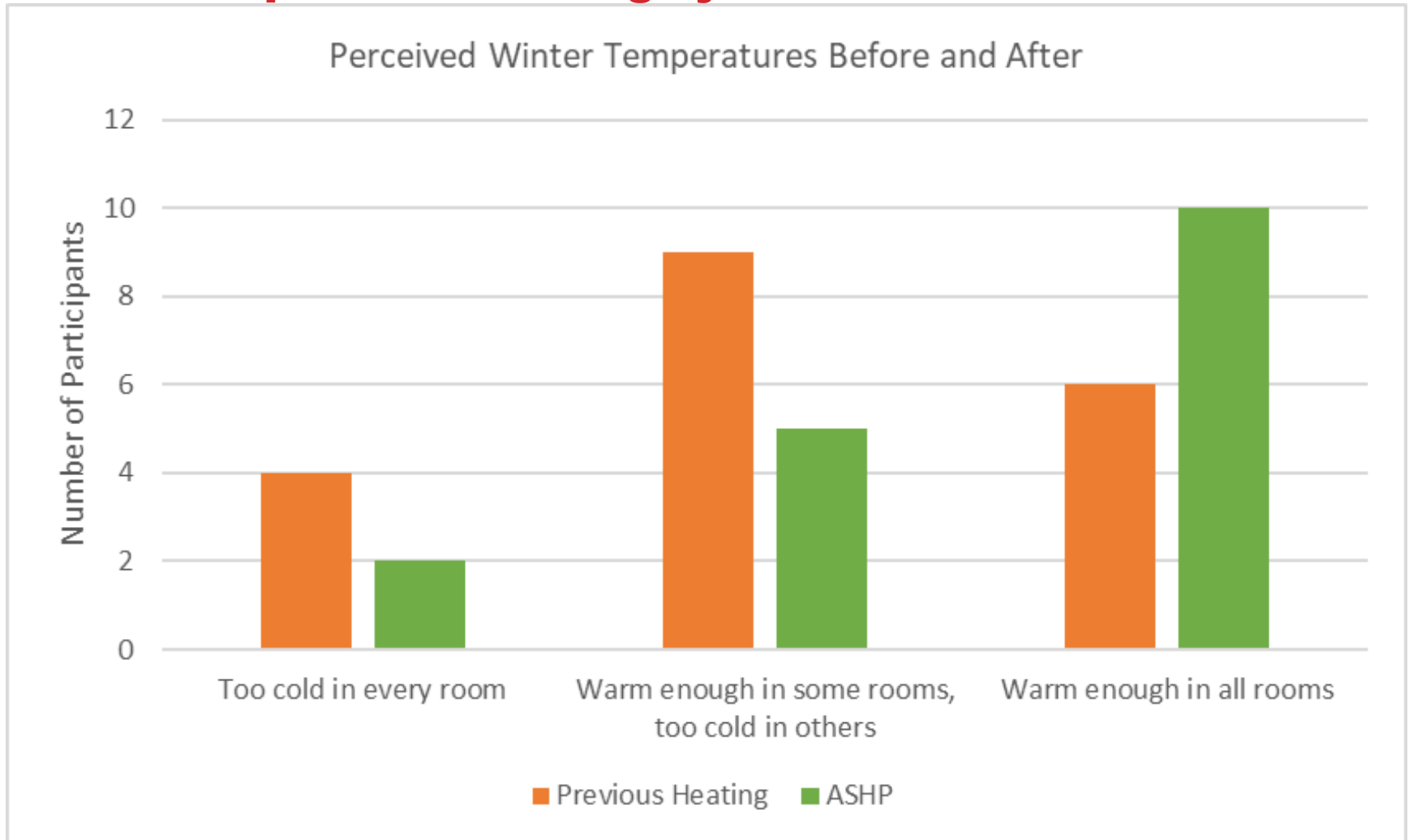
SURVEY

Q1- HOW IMPORTANT WERE THE FOLLOWING IN YOUR DECISION TO INSTALL AN AIR-SOURCE HEAT PUMP SYSTEM?



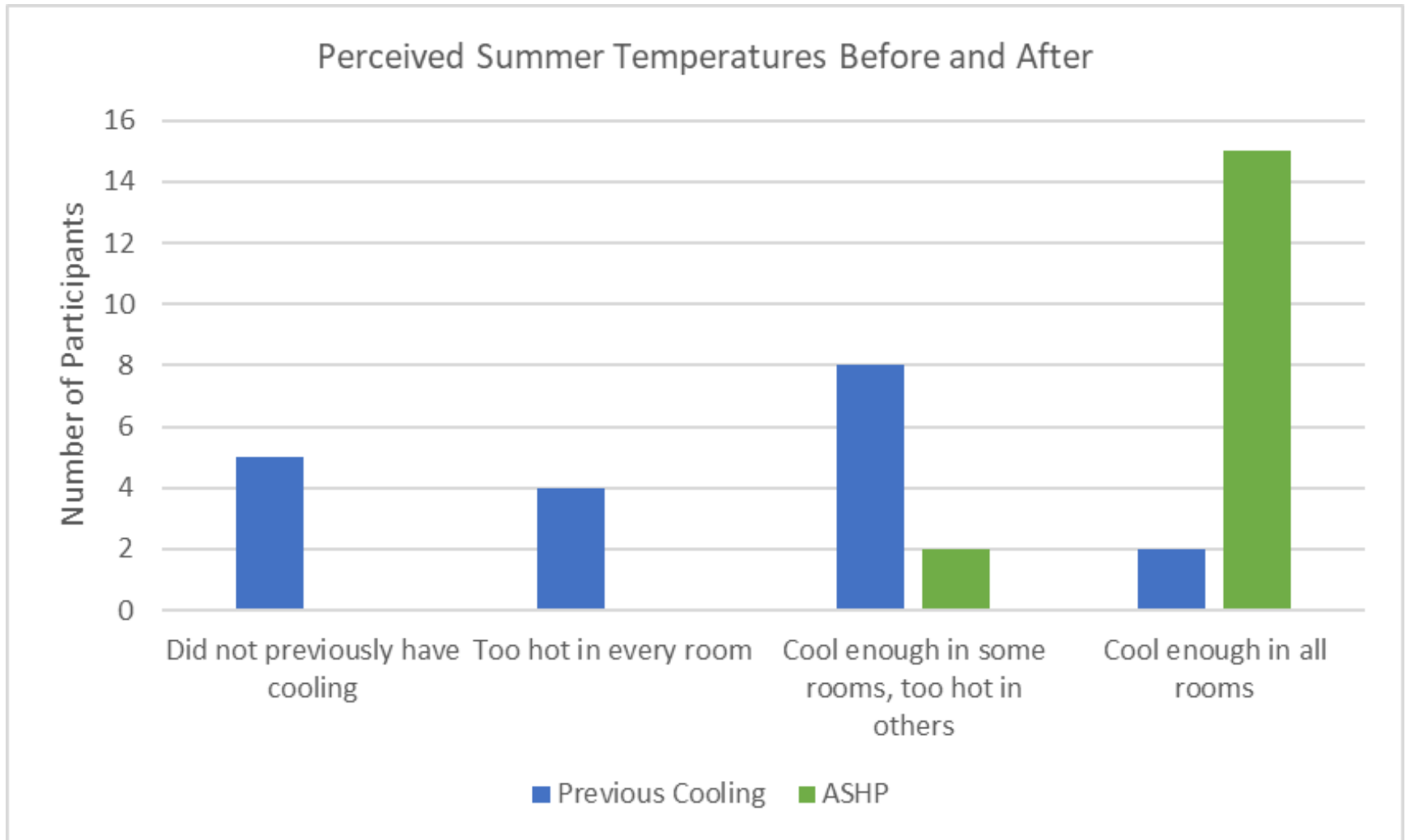
SURVEY

Perceived distribution of comfort throughout home during winter for previous heating system and ccASHP



SURVEY

Perceived distribution of comfort throughout home during summer for previous cooling system and ccASHP



MOTIVATIONS

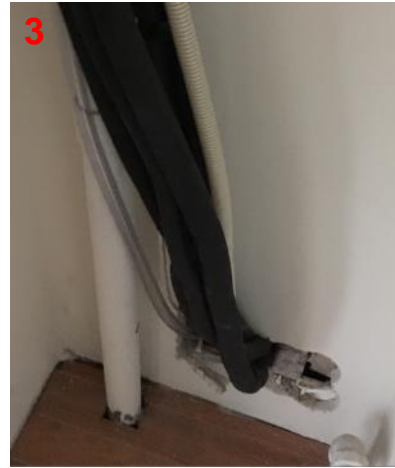
Owner or single decision maker

- Reduce operating costs
- Maximize return-on-investment of planned replacement
- Increase properties marketability

Tenants or other stakeholders

- Comfort
- Health
- Do not increase costs

Installation Problems



Installation Problems

Type of defect		Sites affected
Outdoor unit	Incorrect placement of condensers (stacking)	3
	Incorrect support/fastening of condensers (blocks, scrap wood)	3, 12, 21, 10
	Ground clearance of condensers	5, 21, 10
Condensate	Condensate tube drains to improper location	12, 10
	Condensate leak at evaporator	14, 10
	Condensate tubing – flex plastic instead of copper/PVC	3, 21, 10
Refrigerant Lines	Inadequate sealing of wall penetrations	5
	Line cover (or portion) missing	12
	Inadequate or missing refrigerant pipe insulation	5, 14
Other	Refrigerant leak	5, 3
	Damage to evaporator / lubricant leakage	12
	Noisy outdoor unit	10

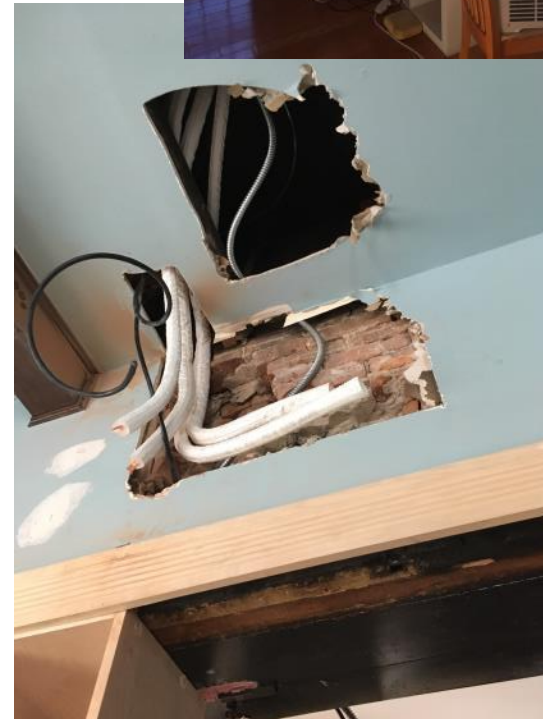
LESSONS

SALES

- Let homeowner talk about rooms and spots that cause discomfort.
- Pitch air handler locations and envelope measures to address biggest complaints.
- Clearly lay out how the work area will be restored to acceptable condition at the agreed budget . Will lines be surface mounted or recessed?

PLANNING

- Agree to equipment selection and placement locations. Mark locations on the walls.
- Under-promise and over-deliver on completion date.
- Agree on house rules regarding job site cleanliness.



LESSONS



IMPLEMENTATION

- Respect house rules.
- Assemble a multitalented team that is problem solving-focused.
- Offer solutions to solve roadblocks, not demands for more money.
- Finger-pointing diminishes client's confidence.

OPERATIONS

- Set-up operation modes for all zones.
- Provide tutorial for proper heating usage. Treat this no differently than boiler and furnace job sign-off.
- Emphasize the importance of maintenance. Call back seasonally to schedule service.

Successful implementation and healthy equipment generates loyalty and referrals.

Takeaways

- Comfort is major motivator
- Design details crucial (aesthetics of line sets) and impacts costs
- QA important
- Occupant education and expectations
- Weatherization underappreciated
- Right sizing possible, but small homes challenging
- Cooling and heating loads similar in attached homes
- If fossil fuel system left in place, good chance it will be used
- Use of multiple systems will increase energy consumption

Ongoing Questions

- What was the cause of low effective COPs?
- Did envelope improvements impact sizing?
- How would using single zone equipment impact costs, design, performance?
- Could integrated controls improve performance?

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