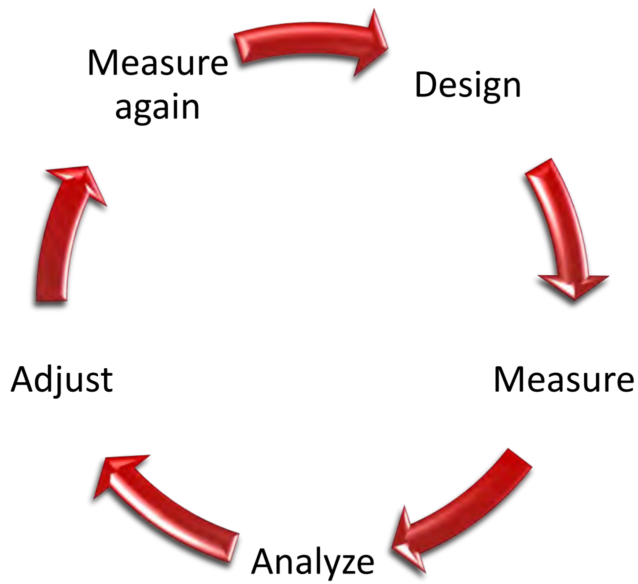
In Pursuit of Performance

A multifamily retrocommissioning case study

Presenter:
Kimberly Vermeer

BuildingEnergy Boston 2019
Friday, March 15, 2019
8:30 – 9:30 a.m.
Marina 4



URBAN HABITAT INITIATIVES

Session Agenda

- The “virtuous circle”
- Background Information
- Retrocommissioning & Response
- Evaluating Impact
- VRF Design Considerations
- Discussion

CEUs:

- AIA—1.0 LU/HSW
- BPI—1.0 hour
- GBCI 1.0 hour BD+C, ID+C, O+M, WELL
- MA CSL 1.0 hour Energy

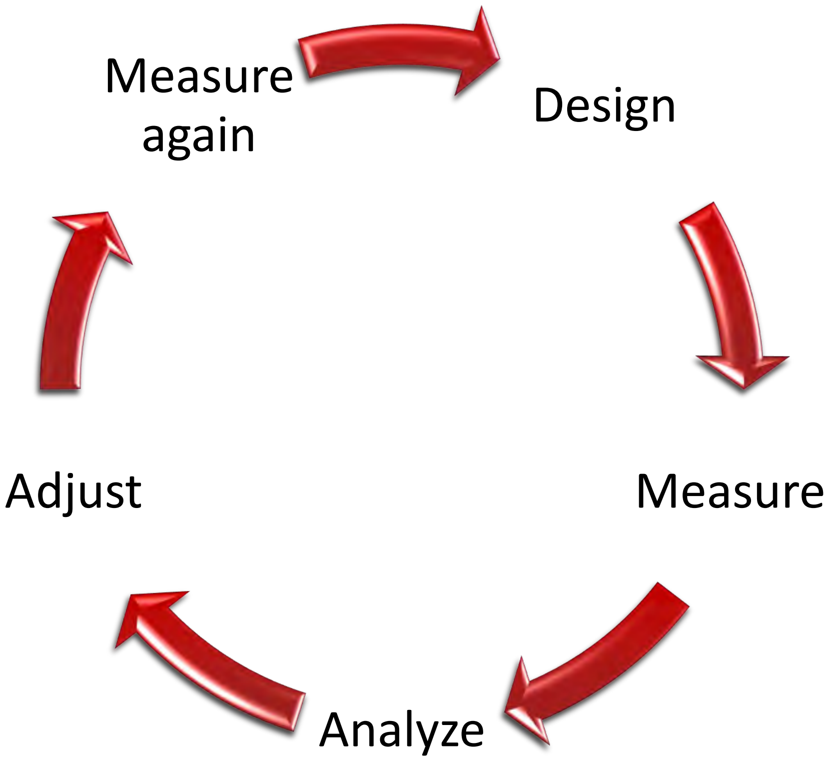
Learning Objectives

- Participants will review ***highlights of a retrocommissioning report*** for a multifamily building and explore how a retrocommissioning report can inform decision-making to improve a building's energy performance.

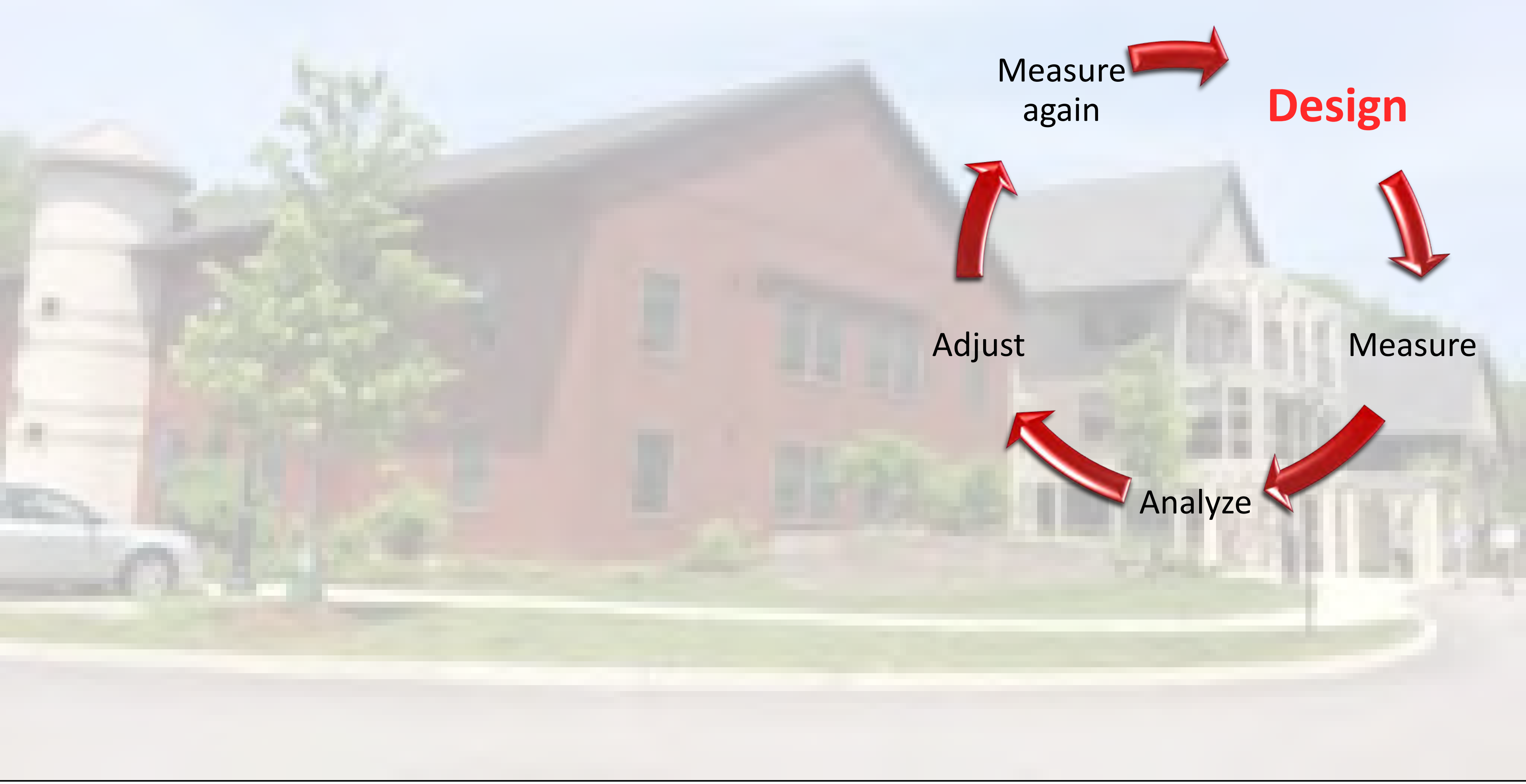
- Participants will gain an understanding of ***design considerations for using VRFs*** in a multifamily building.

- Participants will be able to ***evaluate*** how the measures taken by the owner's team affected ***building performance data*** from pre to post.

- Participants will ***participate in a discussion*** to identify strategies to employ during design and operations to achieve desired energy performance for a property.



The "Virtuous Circle"



Background

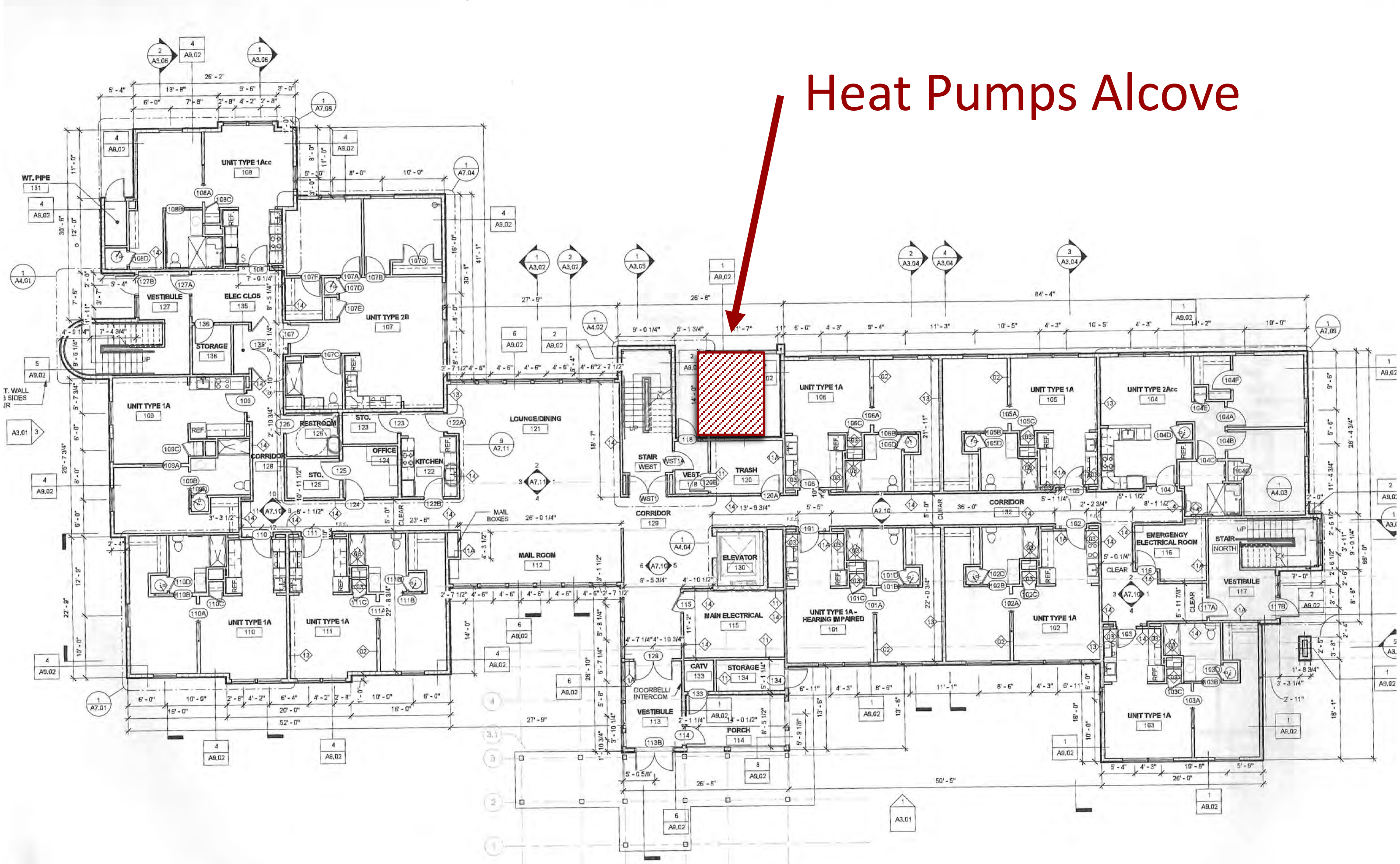
And Initial Design Features

Benfield Farms

- Metrowest location—rural, no natural gas service
- 26 units of senior rental housing, mostly affordable
- “Friendly 40B” but complicated, with opposition
- Operational early 2014

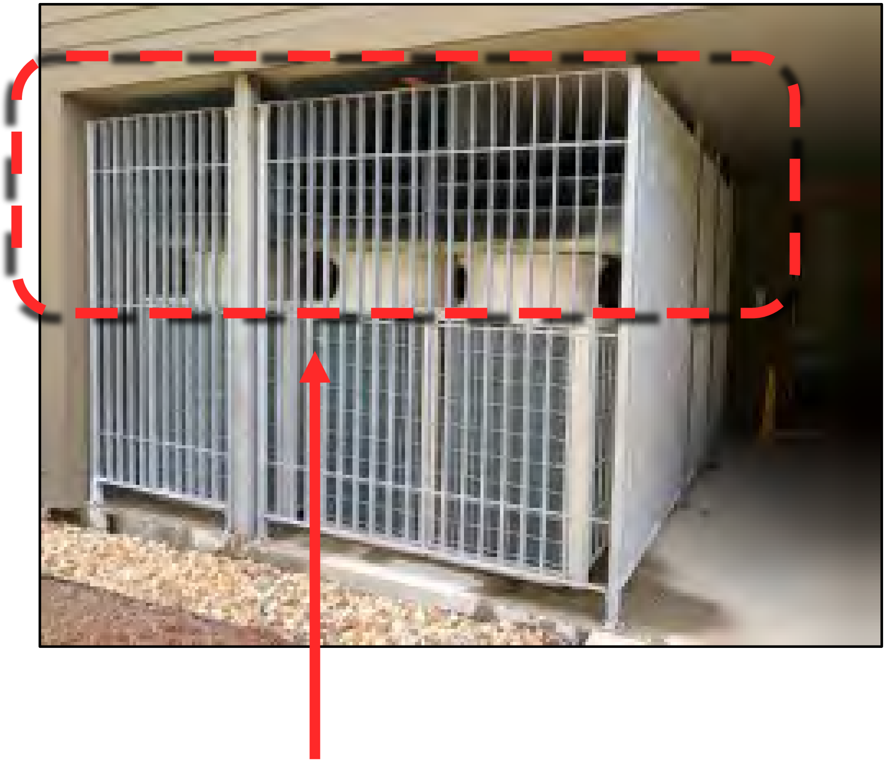
Going-in Design Considerations

- Aesthetics/Opposition
- Gas vs. Electric
- VRFs vs. Mini-splits
- Heat Pumps Location



Ground Floor Plan

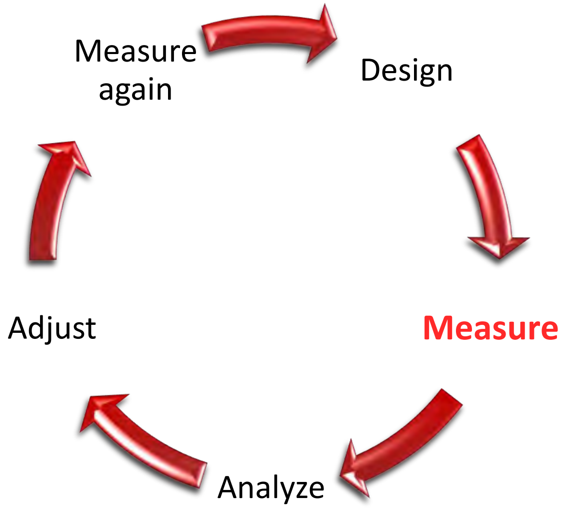
Initial Heat Pumps Location



Notice ductwork!

MEASURE: Initial Electricity Cost

- Terrible!
- Bills Very High!
- Demand Charges!

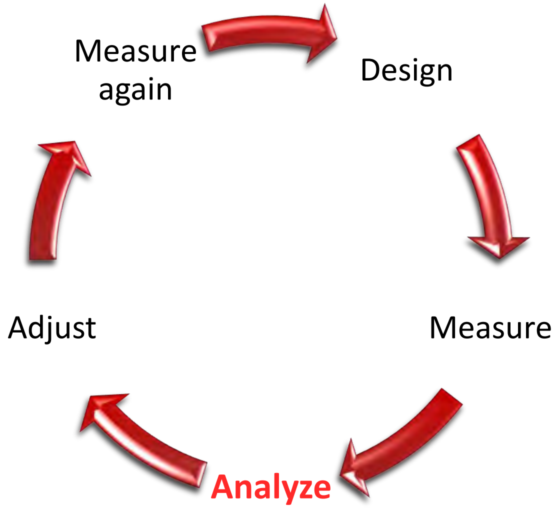


Initial Cost 2014 & 2015

YEAR	$/kWh	Total Use kWh	Gross Cost	PV kWh	PV Value	Meter Cost	SRECs	Net Cost
2014 (11 mo)	0.200	318,800	$63,661	0	0	$63,661	0	$63,661
2015	0.193	354,000	$68,381	0	0	$68,381	0	$68,381
2016								
2017								
2018								
2019 (2 mo)								

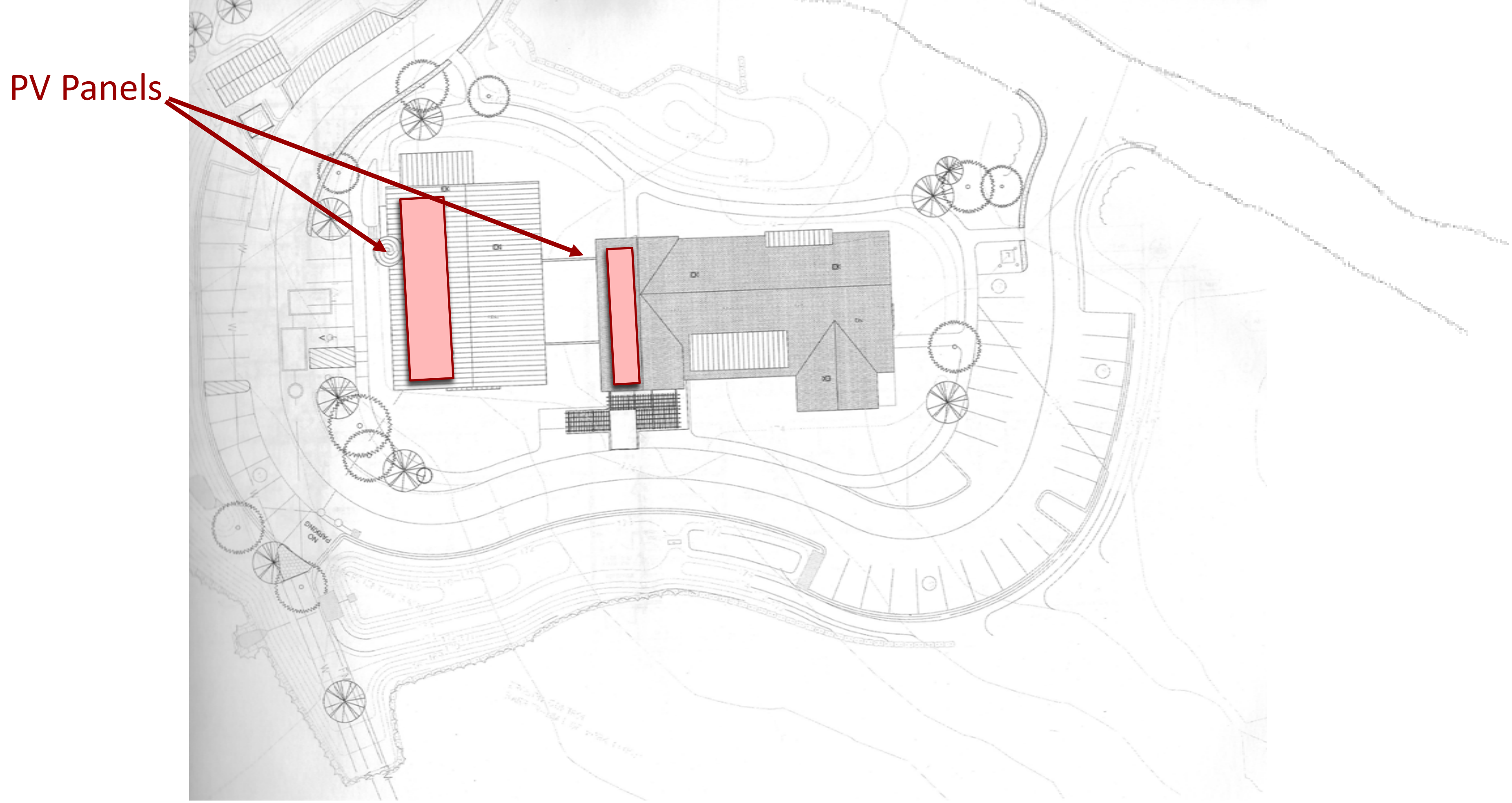
ANALYZE

- Grasp Demand Charges
- Consider alternate supply sources
- Evaluate Impact of on-site PV



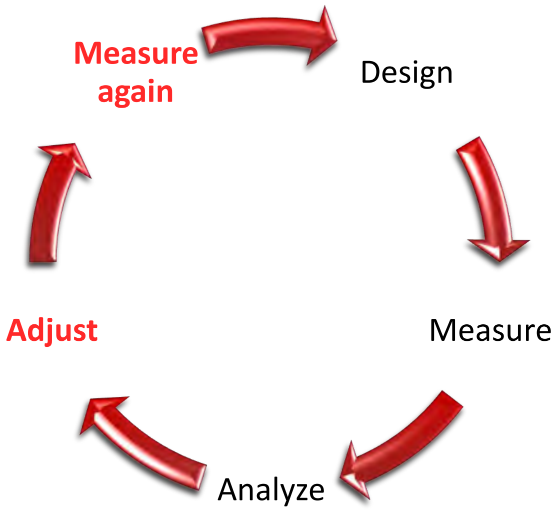
Initial Response: Add PV

- 44 kW system
- Completed late 2016
- Qualified for SRECs



Site with Roofs and PV locations

MEASURE AGAIN: Electricity Cost



Improvement:

- 2016 Meter Cost: $69,748
- 2017 Meter Cost: $57,857
- 2017 SRECs payments: $7,457
- Net reduction: $19,348

Costs 2014-2017

YEAR	$/kWh	Total Use kWh	Gross Cost	PV kWh	PV Value	Meter Cost	SRECs	Net Cost
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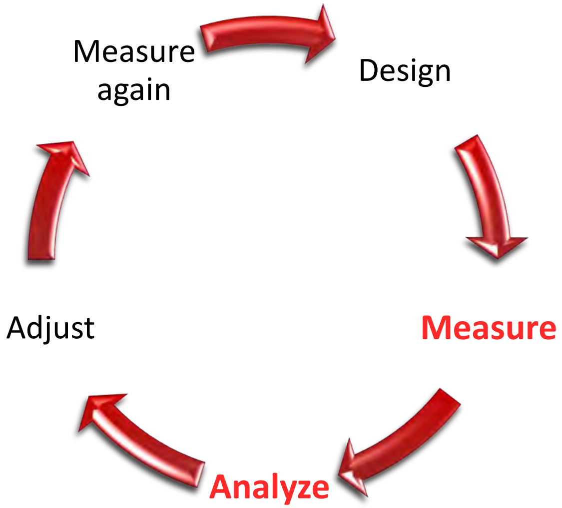
2015	0.193	354,000	$68,381	0	0	$68,381	0	$68,381
2016	0.202	352,743	$71,166	7029	$ (1,418)	$69,748	0	$69,748
2017	0.189	358,197	$67,550	51397	$ (9,693)	$57,857	$(7,457)	$50,401
2018								
2019 (2 mo)								

Costs still considered high: What next?



Retrocommissioning

Next Step:

Retrocommissioning Opportunity

- 2016: program funded through MassCEC, administered by Boston LISC
- Provided:
  - Site Inspection
  - Analysis
  - Report with Recommendations
- Work done by CLEAResult
- Report delivered early 2017

Retrocommissioning Report

Findings:

- Agreed: Costs very high
- VRFs work: They do meet the heating & cooling loads of the building
- VRFs are NOT working efficiently
- Other high energy-use concerns to follow up on

Report Components

- Plans and Information
- Engineering documentation
- Building Energy Use
- Utility cost analysis
- Recommendations

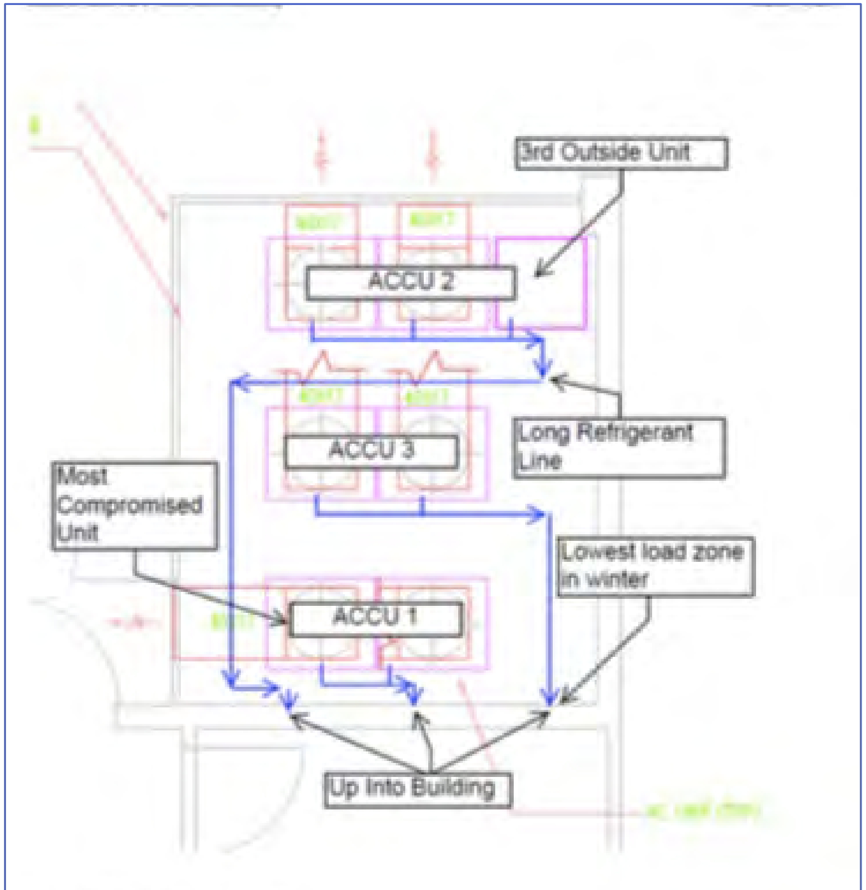


Diagram 1: Current outside unit layout

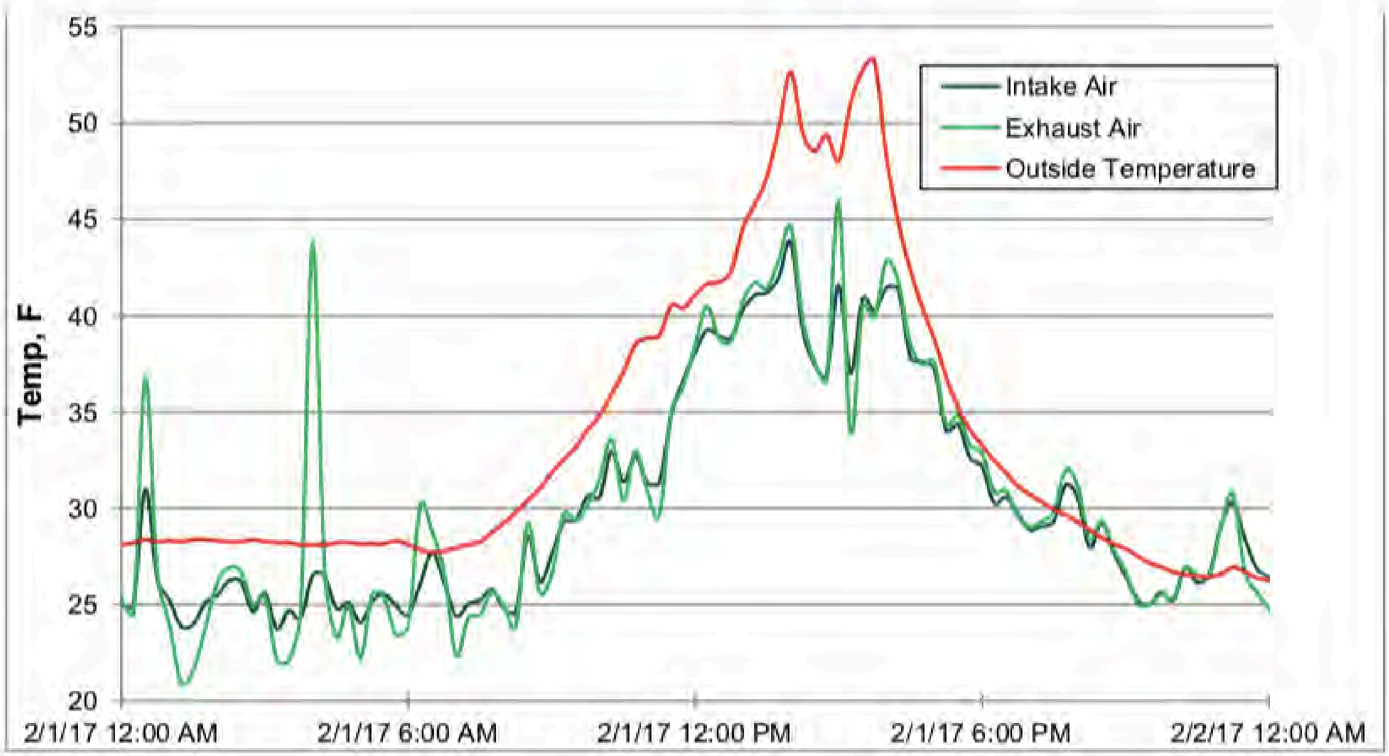
Other Energy Use Concerns:

- Baseboard heat
- Air sealing at attic
- General high use relative to benchmarks

Benfield Farms ASHP Retro Commissioning

Benfield Farms Common area electric break-out Usage components	Estimated annual kWh	
DHW heater for common areas	2,400	2%
Common area lights, interior	31,639	26%
Exterior lights, poles	5,475	4%
Exterior lights, wall packs	1,314	1%
Elevator	3,000	2%
Common area TV	1,000	1%
Exhaust fans	11,109	9%
ERV fans (2 ERV's)	31,536	26%
Tel-data, CATV, etc.	17,520	14%
Fan coil unit fans, common areas, halls etc	5,600	5%
Refrigerator	800	1%
Stove, electric	1,000	1%
Dishwasher	400	0%
Kitchen appliances inc microwave	1,000	1%
Office & comm room plug loads	250	0%
Exam room office plug loads	120	0%
Washing machines, 4 commercial	938	1%
Dryers, electric, 4 commercial	7,800	6%
Domestic water well pump, 2 @ 1.5 HP	Separate meter	
Dosing drip system pumps, 2 @ .5 HP	Separate meter	
Domestic water booster pump, 2 @ 7.5 HP	Separate meter	
Microfast blower, pump house, 1 HP	Separate meter	
Emergency generator block heater		0%
Elevator machine room AC unit	240	0%
Total non-HVAC, annual or per month	123,139 10,262	

Table 3. Common electric usage by component.



Graph 1: ACCU 1 - The ambient air around the outside units (Intake Air) is consistently cooler than the ambient air far away from the units (outside temperature). Heat pumps in heating mode work by making the outside air colder. The exhaust air is supposed to be colder than outside air. However, the intake air is supposed to be exactly equal in temperature to the outside air measured at a remote location. This demonstrates that colder rejection air is being re-entrained into the intakes of the outside units. The lack of delta between the Intake and Exhaust air also shows that the system is barely able to extract heat from the heat reservoir. A final note from this graph is that the system goes into defrost 5 times over the course of one day, which is often and is an energy efficiency penalty.

VRF Analysis Chart from Retrocommissioning Report

Report Recommendations

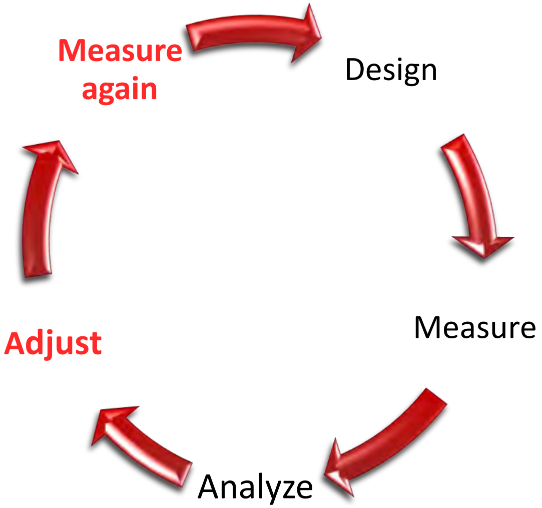
Recommendation	Priority	Who can do this?
Address air flow at heat pump outdoor units	1	Mechanical contractor
Address insulation and line set routing at heat pump outdoor units	2	Mechanical contractor
Reconfigure outside units relative to area served	3	Mechanical contractor
Reduce fraction of electric resistance heat	4	Owner
Air seal attic	5	Air sealing contractor
Implement demand limiting on heat pumps	6	Owner with manufacturer's representative
Reduce common area electrical baseload	7	Owner. May need assistance from electrical and/or energy contractors

Table 1. Summary of ECM recommendations

Options Costs & Benefits

OPTION	Cost	KWh Savings/yr	$$ Savings/yr
Move Heat Pumps to the outdoors	$100,000	72,000	$14,400
Make changes in existing HP location: ductwork, lines	$16,000	43,200	$8,640
Stop resistance heat use	$0	5,000	$1,000
Improve attic air barrier	$3,000	11,400	$2,300

What would you do?

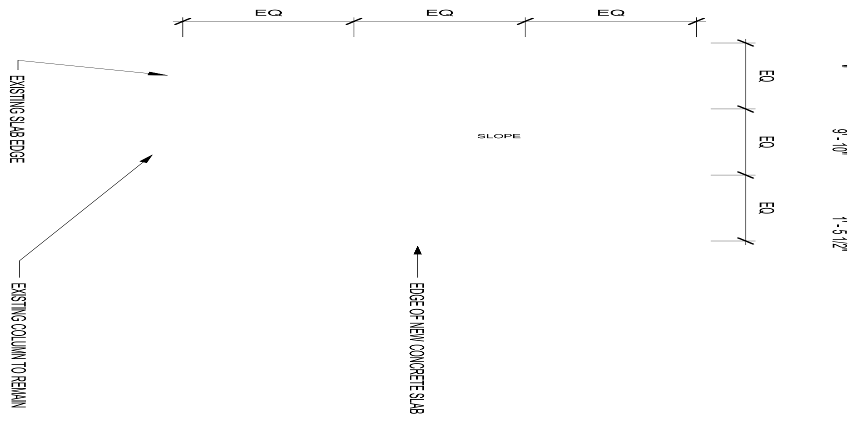


Response & Impact

Response: Relocate the heat pumps

BENFIELD FARMS Carlisle

MECHANICAL EQUIPMENT RELOCATION



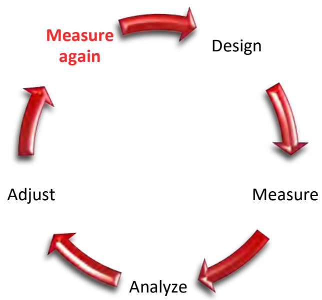
SKA

Prep & Installation

Slab Prep

Completed Relocation

Impact: Energy Use



Total Electricity Use (Meter + PV)

PV Online

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
2014	***	55,600	40,800	33,600	19,400	22,600	22,800	20,600	20,600	19,200	29,200	34,400	318,800
2015	48,000	51,200	37,600	27,400	19,200	22,600	22,400	24,800	22,200	22,000	27,800	28,800	354,000
2016	44,200	41,000	28,800	28,200	21,800	22,800	25,800	26,800	23,400	20,800	30,957	**38,186**	352,743
2017	41,582	42,833	38,895	28,218	24,345	25,696	25,626	24,042	22,662	19,118	26,247	38,932	358,197
2018	**48,332**	38,144	30,867	30,691	25,782	26,377	25,072	23,030	20,755	20,435	31,352	36,317	357,153
2019	42,325	38,050											

Heat Pump Move Complete

Costs through Feb 2019

YEAR	$/kWh	Total Use kWh	Gross Cost	PV kWh	PV Value	Meter Cost	SRECs	Net Cost
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2017	0.189	358,197	$67,550	51397	$ (9,693)	$57,857	$(7,457)	$50,401
2018	0.210	357,153	$75,091	46953	$ (9,872)	$65,220	$(13,685)	$51,535
2019 (2 mo)	*0.190*	*80,374*	*$15,271*	*4574*	*$ (869)*	*$14,402*	*$(4,674)*	*$9,728*

Impact: Project Costs & Benefits

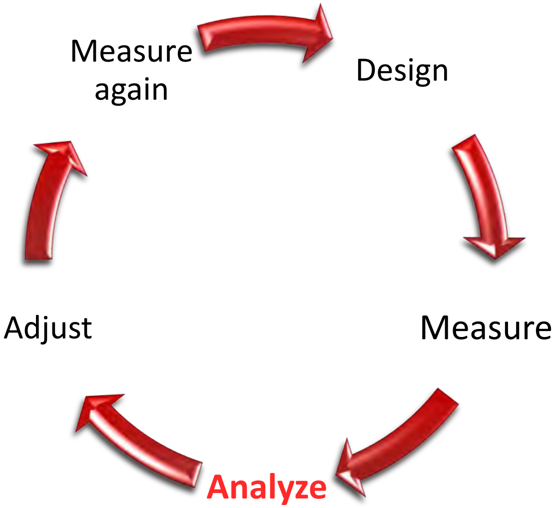
COSTS:

- $107,000
- Project components: Heat Pumps Move, Slab, New Fence Surround

BENEFITS

- Projected annual savings:
  - 72,000 kWh/yr
  - $14,400/yr
  - 7.5 yr payback
- Actual 2018 savings:
  - 1,044 kWh
  - $219
  - 498 yr payback

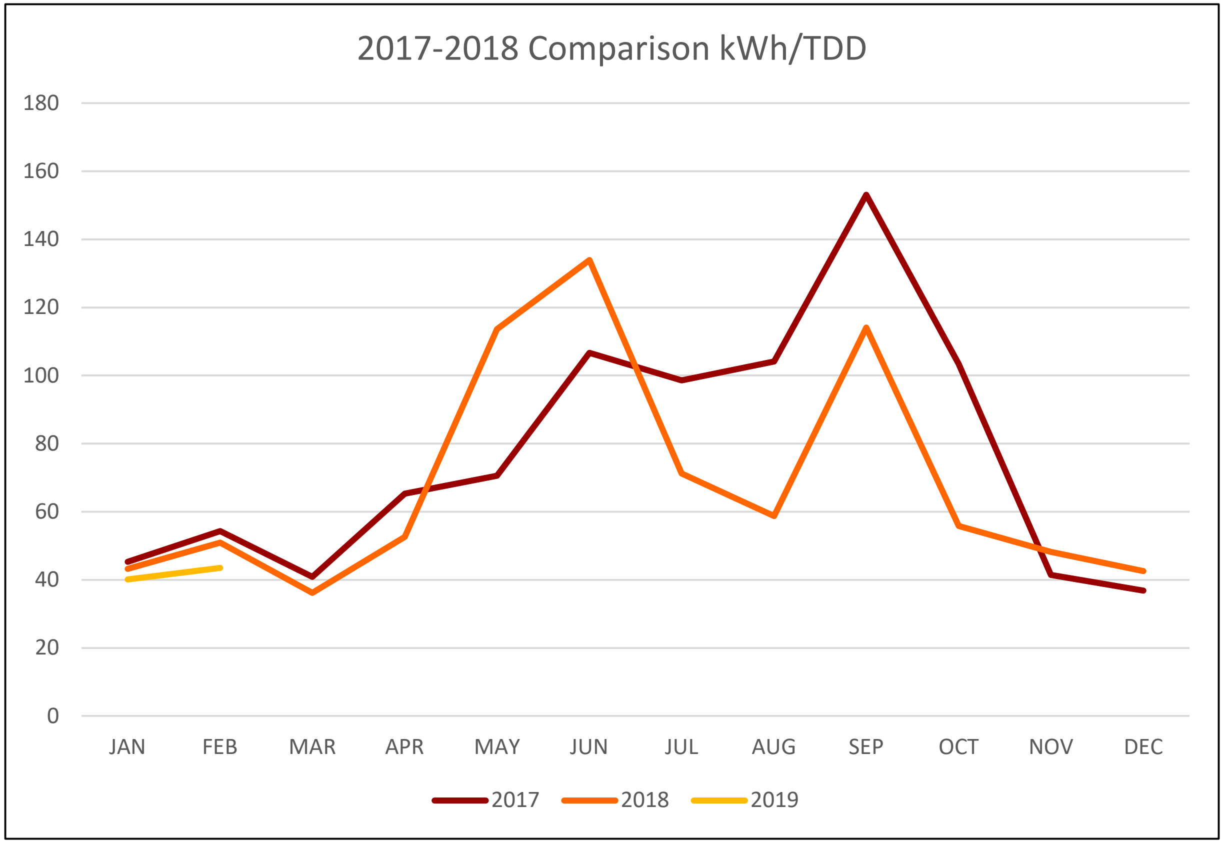
Heating & Cooling Degree Days



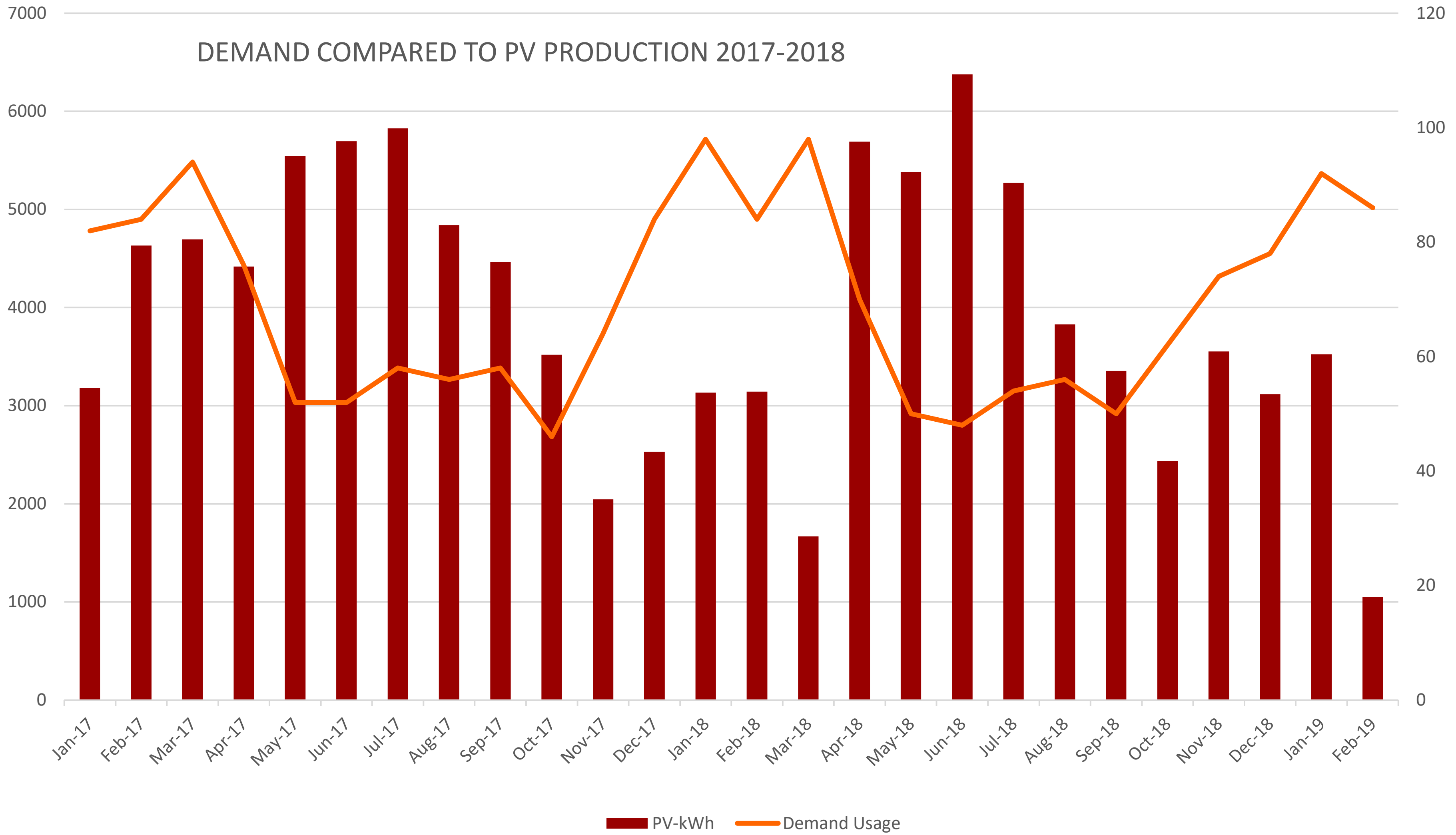
Year	HDD	CDD	TDD
2014	5704	769	**6473**
2015	5651	921	**6572**
2016	5177	1035	**6212**
2017	5310	881	**6191**
2018	5391	1133	**6524**

Weather Normalizing

Year	Total kWh/ TDD
2015	826
2016	863
2017	920
2018	821



Demand Charges



Revisiting VRF Design Considerations

Issues

- Gas vs. Electric
- VRFs vs Mini-splits
- Heat Pumps Locations
- **Demand Charges

Discussion

Your Questions

My Questions

- Who should be tracking performance? Why is it so hard?
- Why is it so hard to get good data?
- How can small organizations manage big efforts like this?
- How can we get the best information to decision-makers—during design and for operations?
- Would solar storage help?

Recap: Learning Objectives

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- Participants will gain an understanding of ***design considerations for using VRFs*** in a multifamily building.

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CONTACT INFORMATION:

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Thank-you!