ENERGY FUTURES GROUP

"Solar Access Program"

ACHIEVING ENERGY & COST SAVINGS FOR MIDDLE INCOME HOMEOWNERS* IN CENTRAL & WESTERN MASSACHUSETTS

Gabrielle Stebbins & Richard Faesy, Energy Futures Group;
Bruce Harley, Bruce Harley Energy Consulting;
and many, many others

October 17, 2022

*60% - 80% state median income (SMI)

Agenda

1. Solar Access Origin
2. Solar Access Design
3. Solar Access Results
4. Q&A

Energy Futures Group

Vermont-based clean energy consulting firm established in 2010

Areas of Expertise

- Energy efficiency & renewable energy
- Program design
- Integrated resource planning
- Policy development
- Expert witness testimony
- Building codes
- Evaluation
- Cost-effectiveness

Range of Clients

- Government agencies
- Advocates
- Regulators
- Utilities

Clients in 45 states and provinces plus regional, national and international organizations.

October 17, 2022

Solar Access Origin

Response to 2017 "Affordable Clean Residential Energy Program" Request for Proposals

"To help low- and moderate- income MA residents access cost-saving, clean and efficient technologies (focusing on coordinating state agencies), and to:

1. Stimulate innovative, replicable solutions
2. Deliver the highest, long-term cost savings
3. Demonstrate the potential of combining solar (PV) and cold climate air source heat pumps (ccASHPs) for reducing energy burden
4. Collect data

THANK YOU, PROJECT FUNDERS!

MASSACHUSETTS CLEAN ENERGY CENTER

DOER Massachusetts Department of Energy Resources

Solar Access Program Goal:

To optimize project costs with projected savings to achieve neutral annual cashflow in 100 homes serving ≤80% SMI (**goal was partial offset of heating**)

Solar Access Design: Key Elements

- Solar (PV) plus ductless Heat Pumps (ccASHPs) with home energy audit (WX not mandatory)
- **<u>MANY</u>** Project Partners: Four entities interacting with customers
- 3rd party, neutral "Energy Coach" via CET
- Solar Access 6-month Payment Subsidy
- Customer Recruitment: Social Media, Paid Print, Earned Media, Direct Mail, Coordinated with Partnering Organizations, Attended Local & Community Events
- Savings Guarantee: Refund cost difference between actual consumption & projected savings
- Evaluation, Measurement and Verification
  - QA/QC: 15% of installations (generally very good)
  - eGauge energy monitoring: 15% of sites
  - At program start, no $$ evaluation;
  - At program end, used remaining budget to collect billing data for analysis

Solar Access Design: Financials

Bundled all available incentives, credits, mark-downs and added more!	
ccASHP rebates	$1,100: ($800 from MassCEC* + $300 from utility)
Federal Investment Tax Credit	30%
State Solar Tax Credit	15% up to $1,000
SRECs then SMART	Varied
SAP “6-month” Payment Subsidy	Up to $5,500 per project to fund loan payments until credits and incentives “kicked in”
SunBug pre-negotiated discount (e.g. Solarize)	20% off avg. statewide price for homeowner-owned PV
Mitsubishi pre-negotiated discount (e.g. HeatSmart)	Reduced cost by $200/ton (or 12,000 Btu/hour)

Solar Access Loan Product
A single (PV plus ccASHP loans combined), 10-year fixed rate loan
Loan financed 100% of the project cost
Loan Loss Reserve: sliding scale default lender guaranty based on borrower’s creditworthiness
Deferred payment: no loan payment for 3 months
PV financing: 35% upon project acceptance; 65% upon project connectivity
ccASHP financing: 100% upon project completion

Goal:
Revenue Neutral from Project Start

Solar Access Design: Implementation

Multiple program steps & partners = Many handoffs

1. Intake process of leads from CET
2. Evaluation and education
3. Site assessment
4. PV System Design
5. Proposal Presentation & Adoption
6. Permits, Interconnection, SREC/SMART
7. System Installation Schedule
8. Photovoltaic System QA

https://www.istockphoto.com/photo/baton-handoff-gm183306560-1565056

https://www.istockphoto.com/photo/woman-athlete-runs-hurdles-for-track-and-field-gm993744768-269171126?utm_source=unsplash&utm_medium=affiliate&utm_campaign=srp_photos_top&utm_content=https%3A%2F%2Funsplash.com%2Fs%2Fphotos%2Fhurdle&utm_term=hurdle%3A%3A%3A

Changes outside SAP control

10/2018: First loan approved
11/2018: Solar credits shift from SREC to SMART
1/2019: Monthly cashflow ≤ -$25; annually neutral
3/2019: MassCEC Heat Pump Rebate Ends
No Natural Gas Customers
Solar Loan Ending
Lag time for (1) Solar Permission to Operate, (2) Local Inspection, (3) ccASHP Rebate
Pandemic
Passing Time → Need for Implementation Changes

Solar Access Results:

Budget Category	% of Budget
Contractor Liaison & Team Coordination	26%
Customer Acquisition	24%
SAP 6-month Payment Subsidy	16%
Program Administration	14%
Quality Assurance, Energy Monitoring, Reporting	11%
Loan Loss Reserve, Savings Guarantee	9% (really, 0%)

Massive effort to address "hand-offs" and external policy changes

Massive effort to find/secure/convince participant

Every participant needed SAP 6-month subsidy

NOT ONE Savings Guarantee claim
NOT ONE claim by UMassFive from the Loan Loss Reserve (yet) (*1/2 of all loans are paid out)

Tax credit uptake: 26 Federal (all Year 1) & 33 State ($94-$1000)

1,105 Leads. Leads transferred:

- 25 sent to low-income programs
- 225 sent to SunBug (17 jobs)
- 223 to Girard (4 jobs)
- Widening the "60%-80% SMI" range would have retained ~50% of leads that were screened out.
- Other reasons for dropping out:
  - Required SAP 6-month subsidy was >$5,500.
  - Insufficient solar / poor home layout for heat pumps
  - Customer not interested

Solar Access Results: Customer Recruitment

- **Built Upon Existing Relationships and Trust**
  - Role of CET as a non-profit
  - Partnered with other organizations (Town of Lee, UMassFive, utilities, DoER)
  - Co-branded events
  - Leveraged local and community efforts (100/year)
- **Outreach Approaches**
  - Direct mail:
    - Not very effective. 6 leads out of 11,240 letters
    - Partners sending out notices on CET's behalf *did* work
      - E.g. Town of Lee, UMassFive, utilities, DoER
  - Social Media:
    - Very effective @ $20/day.
    - Frequent, small changes = surges in leads
  - Customer Testimonials:
    - Very effective (website & social media)
  - Local print:
    - Paid print not very effective.
    - Earned media showing a local customer was effective

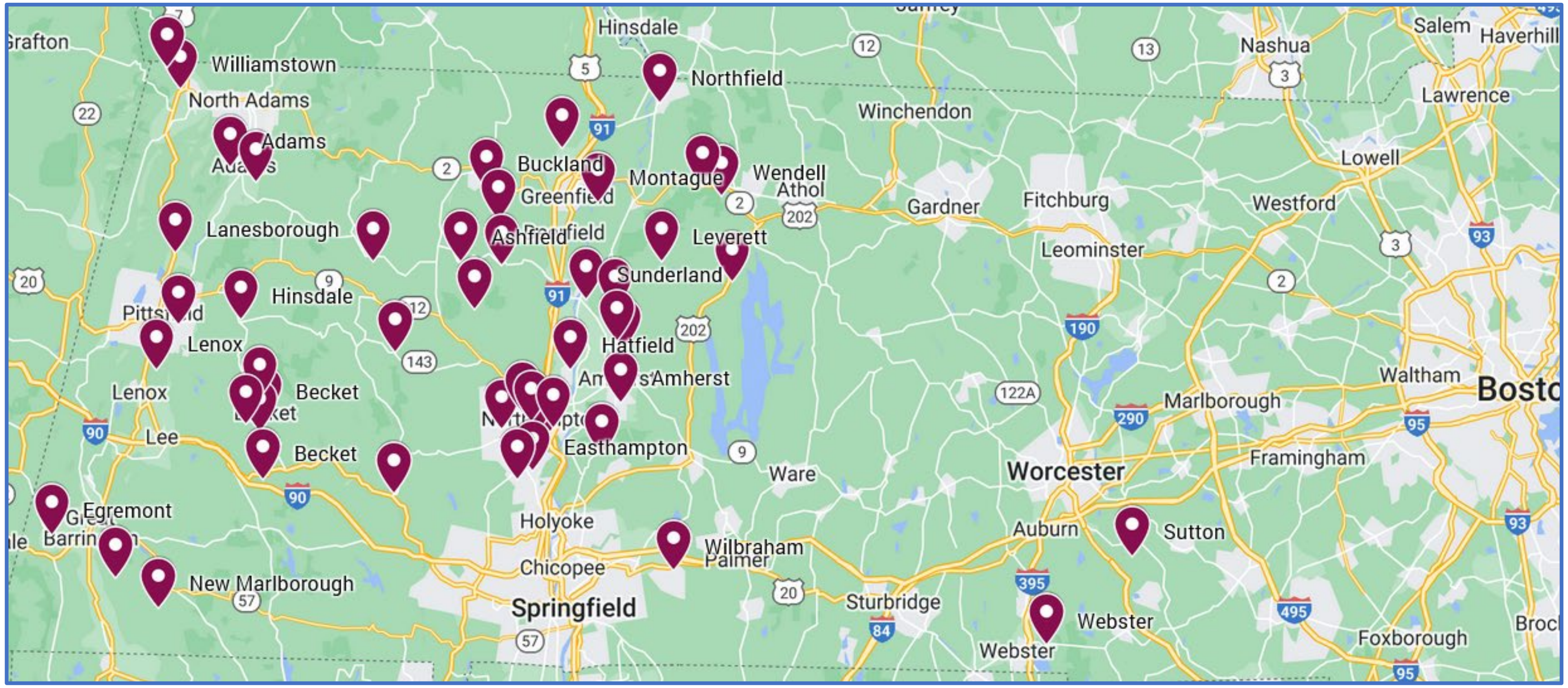
"Needle in a Haystack Program" - Ian Finlayson

Photo credit: https://securityintelligence.com/forecasting-a-breach-is-like-finding-a-needle-in-a-haystack-not-that-tough/

Solar Access Results: Installations

49 sites in western MA

- 1,100 leads = 0.04% lead rate
- Installations completed Aug 2018 – July 2020 (majority: Feb 2019 – June 2020)
- Medians…
  - 6-month subsidy: $4,200
  - Solar: $31,040
  - Heat Pump: $6,660
  - Loan: $39,500



Solar Access Design: Customer Recruitment

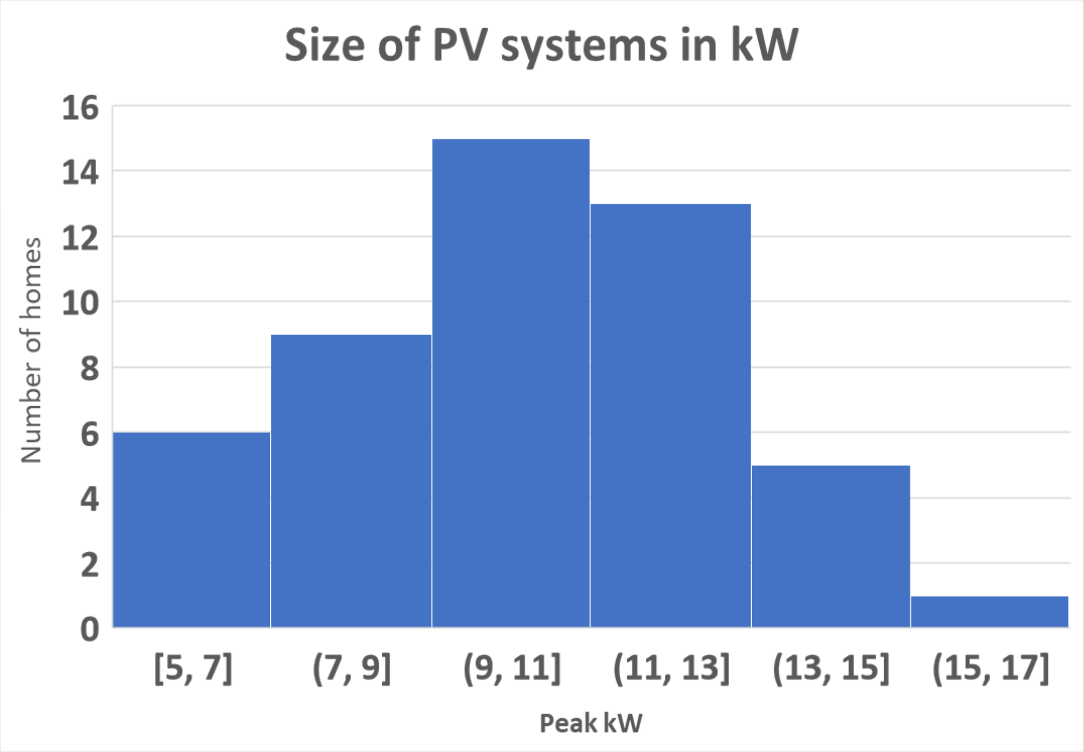
- **Challenges**
  - Crowded solar marketplace – people assumed SAP was “too good to be true”
  - People didn’t know what a heat pump was
  - Reaching 60%-80% SMI:
    - Direct mail not effective, but could identify the population focus
    - Social media did allow targeted demographic data initially – then removed the feature
    - Targeting geographic areas with the 60%-80% SMI population was helpful

- **Ad Messaging – What Worked**
  - Leaning on non-profit status & state funding/support
    - To differentiate from for-profit solar / heat pump offers
  - Comfort performed much better than any other focus
    - “Beat the heat this summer with Solar Access, a state-funded program”
  - Social media allowed for dynamic creative
    - Uploaded multiple photos/messages to test various combinations to find what worked
  - Customer Testimonials
    - Used on web, social media, PR opportunities

PV Systems: Average/house = 10 kW

- **Median price/system of $31,04** ($3,220/kW)
- Some projects required structural or roof work. This was incorporated into PV costs.
- Initiatives that serve lower-income populations can expect increased costs due to deferred maintenance (roof, electrical panels). **THIS NEEDS TO BE FACTORED INTO INITIATIVE DESIGN**

n=49

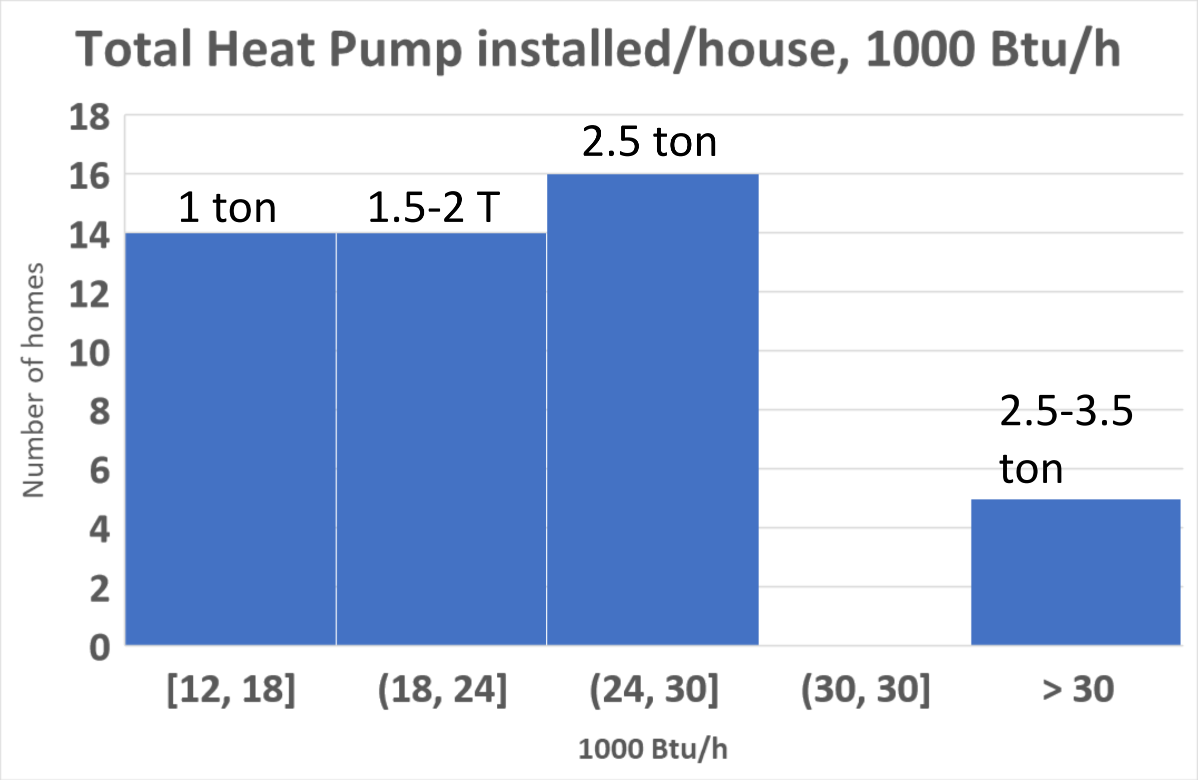


Note: There is very little correlation between PV system size and pre- or projected kWh/house

ASHP Installations: Average/house = 22,000 Btu/h

- **Median price/house of $6,660** (= $4,900/ton; $5770 per zone or head)
- Average price/house is $8,810, driven by a few larger systems
- Typical existing home design heating load of around 40,000 – so these can supply roughly half
- 8 homes had multi-zone (all only 2 - 3 zones)

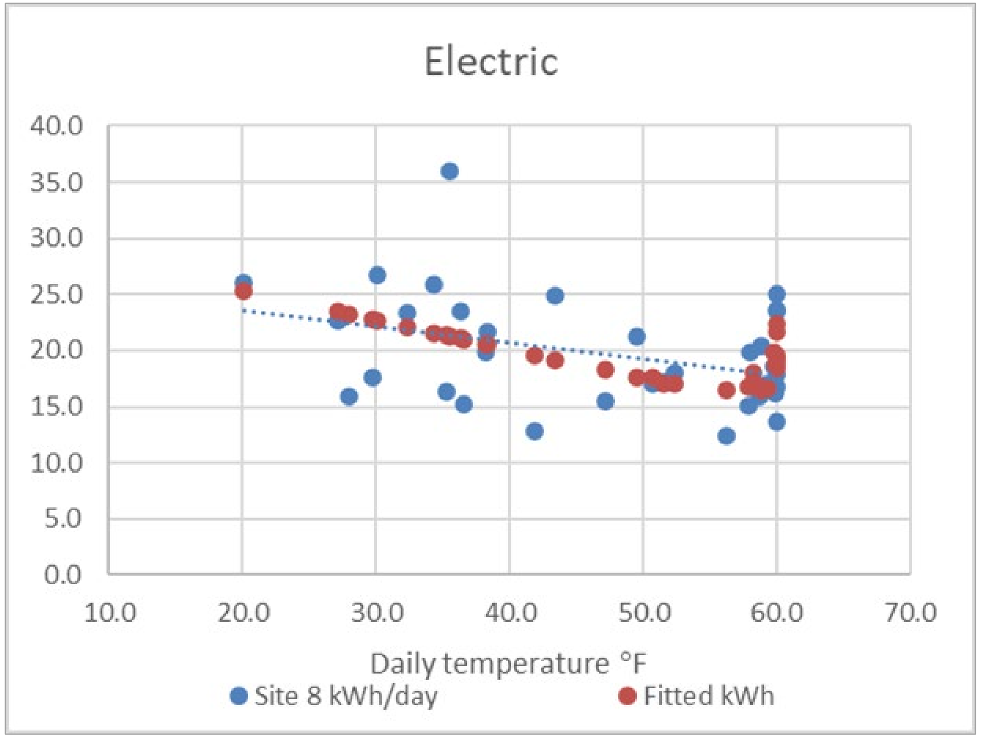
n=49

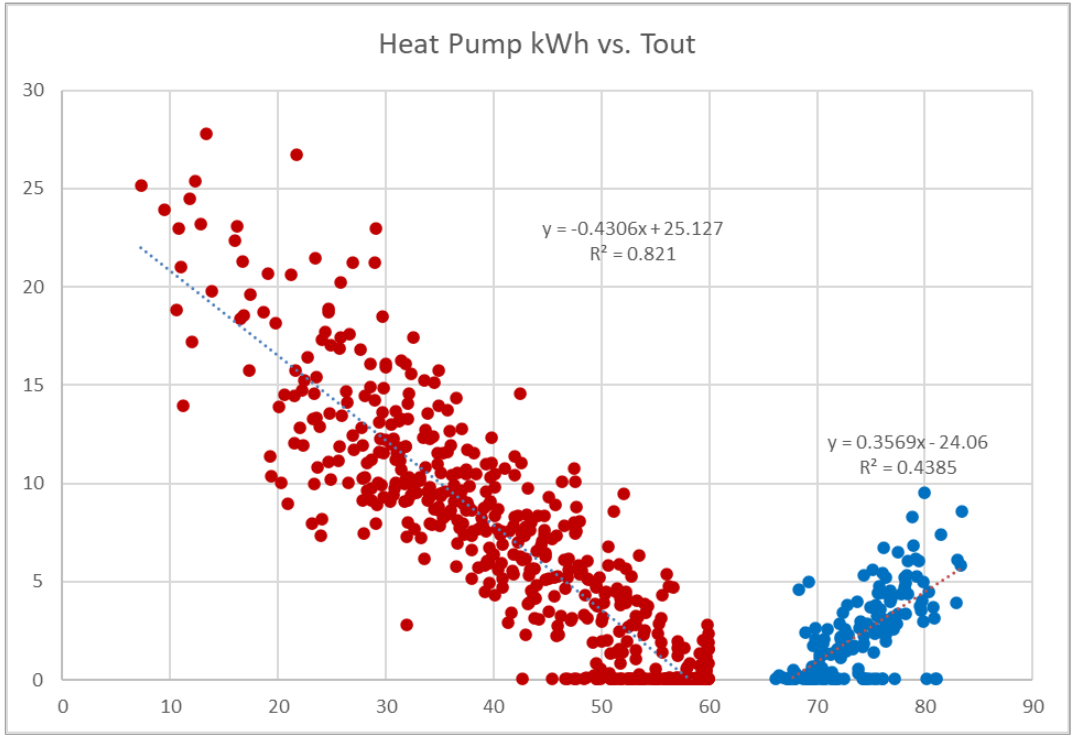


Energy Analysis

- Analysis completed on 38 homes
  - Remainder: insufficient data, other barriers (non-responsive, moved, etc.)
- **HVAC system analysis (ASHP and fossil fuel): 28 homes**
  - 8 had significant solid fuel use (wood/pellet/coal stoves): non-quantified
  - 2 had unanalyzable data
- 10 had eGauge monitors installed and operating
  - Data logging of heat pump, PV, whole house electricity consumption
  - Higher confidence in heating and cooling HVAC consumption
  - Still depends on electric and fuel billing analysis for pre, and fuel for post
- 18 required energy bill analysis for pre- and post-work energy use

Egauge analysis example (site 8)





Pre kWh:	Heat season	**1362**	Post kWh:	Heat season	**2245**
R^2: 0.19	Cool season	**296**	*R^2: 0.82*	Cool season	**142**
	Base	**5412**		Base	**5451**

Energy Analysis – HVAC performance

- Statistical analysis: energy consumption/interval vs. degree days/interval
- **Normalized to standard weather** (degree day base: heat 60, cool 74)
  - Electric: base + (heating) + (cooling)
  - Fuel: (base) + heating

- Heat pump efficiency: COP = energy out / energy in (COP of 1 = 100% efficient)

Estimated COP = (fuel saved * fuel eff) / (ASHP input energy)

PV system performance

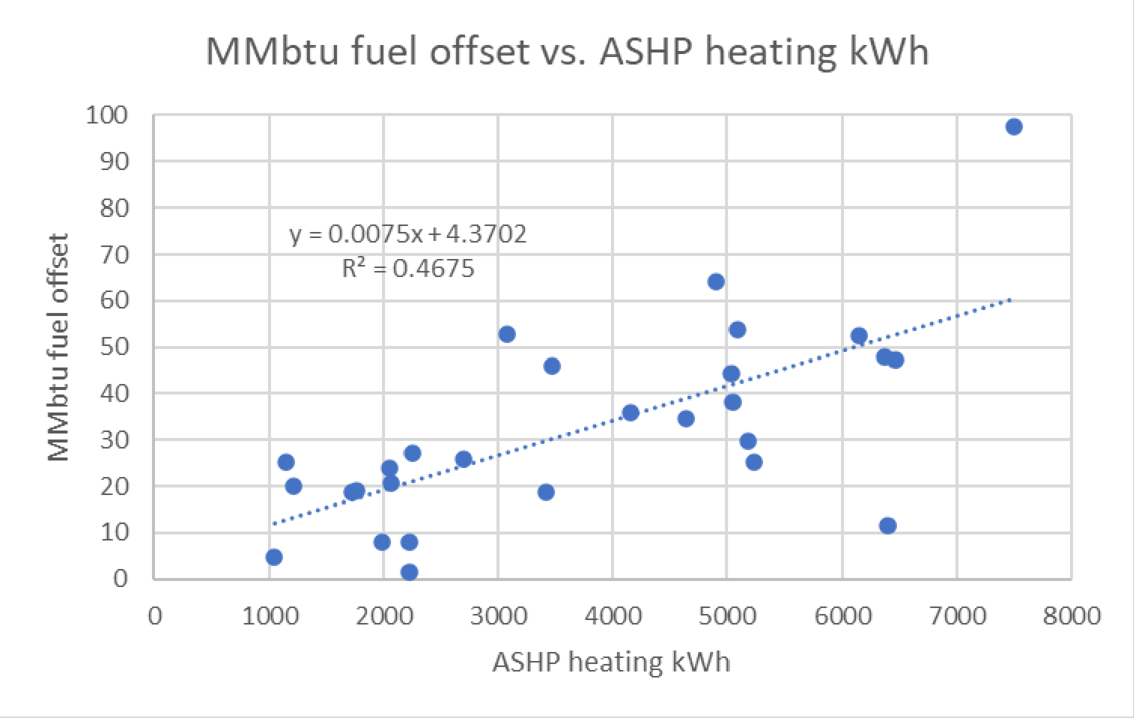
- Sunbug provided direct datalogged monitoring results
- Most systems had 2-3 years of data: robust kWh production record
- 2 systems of 28 missing, got PV from electric bill records

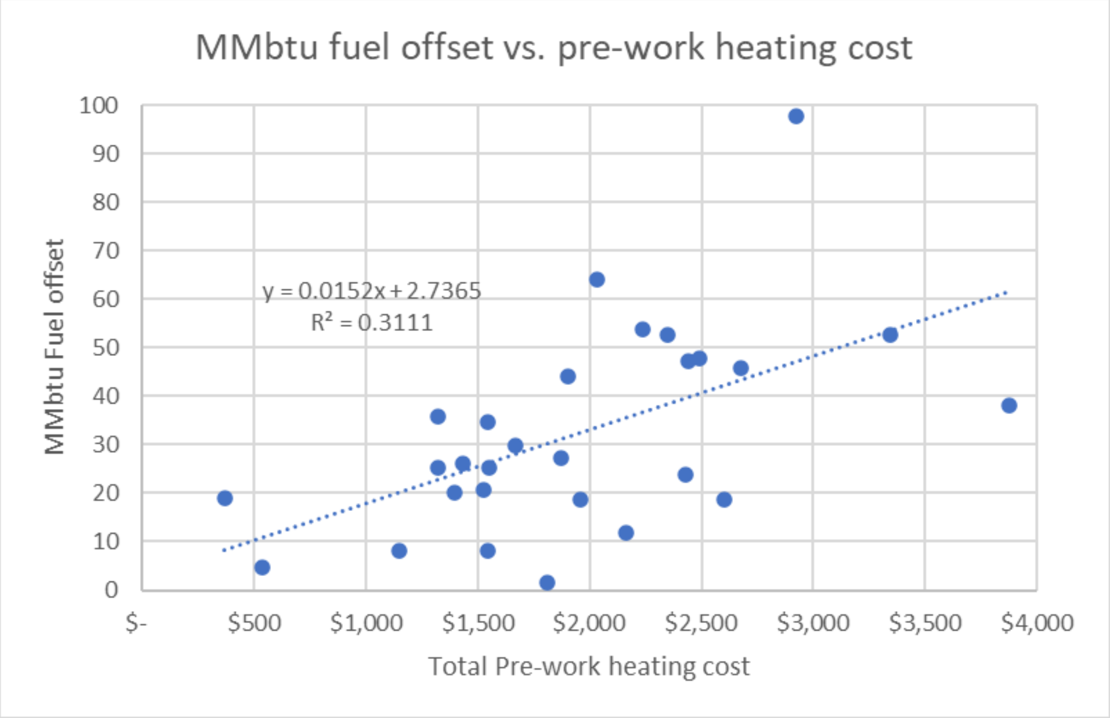
Key HVAC results

	Results (n=28)	% of projected	Notes
Mmbtu fuel savings/house	32.3	68%	19 homes with "consistent" heat pump use saved 40.6 Mmbtu / 65% of fuel
Fuel % saved	46%		
ASHP heating consumption kWh	3,735	86%	19 with "consistent use": 4,659 kWh
Estimated (implied) heating COP	2.3	N/A	Virtually the same for multi- and single-zone; consistent with other studies
COP as a % of HSPF rating	66%	N/A	Consistent with other studies; was higher for multi-zone (78%) than single (63%)

More heat pump use = more fuel saved/offset

- Driven partly by heat pump size but more by behavior/installation
- Also fairly strongly related to pre-install heating cost = motivation





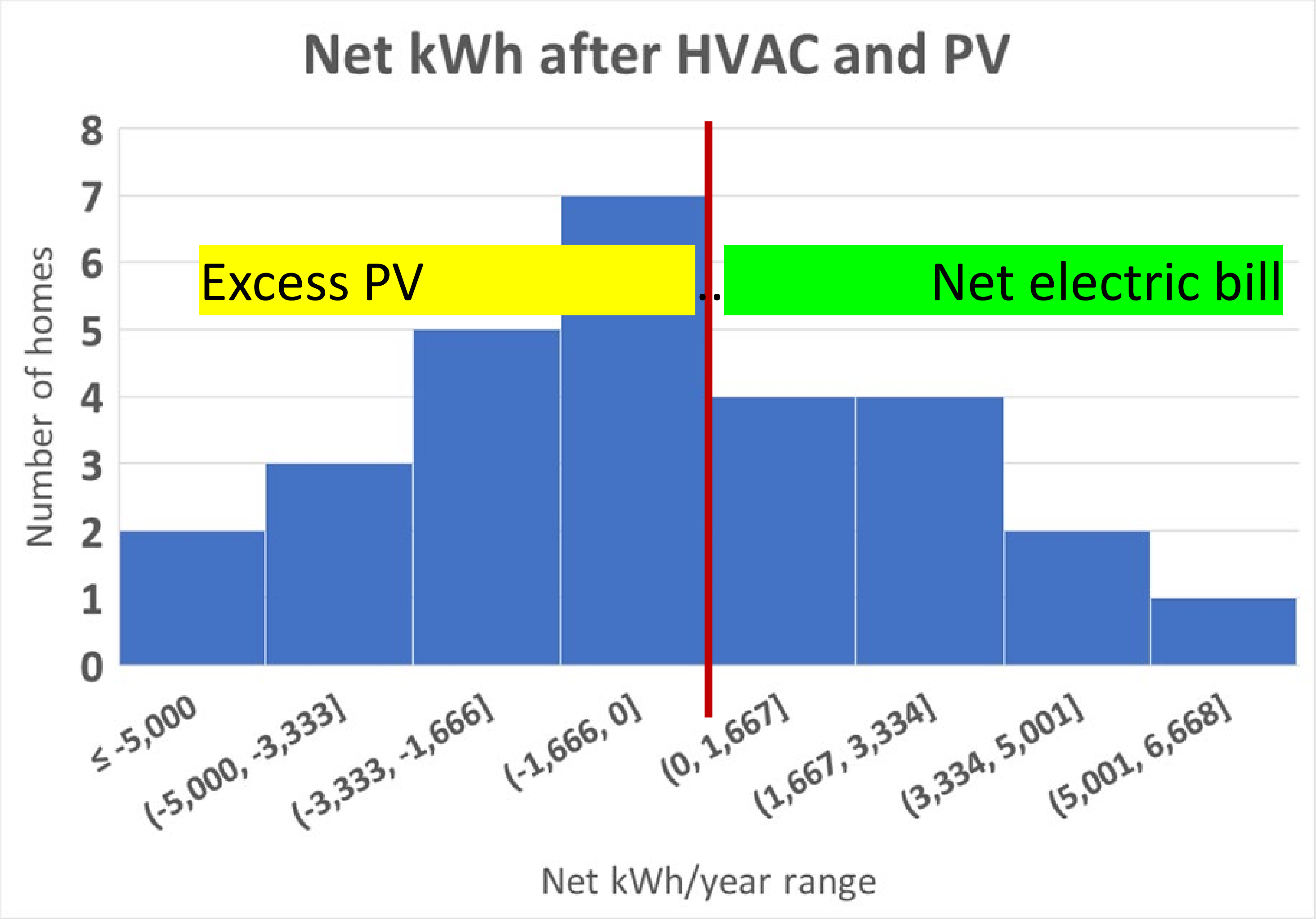
Key PV results

	Results (n=28)	% of projected	Notes
Annual PV produced kWh	10,347	105%	PV generation is predictable: 1000 kWh / kW in New England
PV as % of house electricity consumption	115%	N/A	(based on normalized consumption)
Excess PV generated (kWh/year)	625	N/A	Very wide range: -5,300 to +7,660

- Excess PV production could be utilized by increasing heat pump use
- In some cases, additional heat pump(s) may be needed for more effective use while maintaining comfort throughout
- Adding an EV charger is another option

Most homes had excess PV production

n=28



Key savings results

	Results (n=28)	% of projected	Notes
GHG annual savings lb. CO2e	**10,305**	**96%**	Calculated with the **same factors as original projections, for comparison**
Fuel annual cost savings	**$881**	**109%**	Calculated at **the same fuel/electric prices used in original projections**
Electricity annual savings	**$1672***		
Cost savings, HVAC only	**$213**	N/A	Net of fuel savings + ASHP heating cost
Savings at today's fuel/electric prices	**$3,787**	N/A	**48% increase** > original of $2,553

*Does not account for unrealized savings due to excess PV production

GHG savings insights

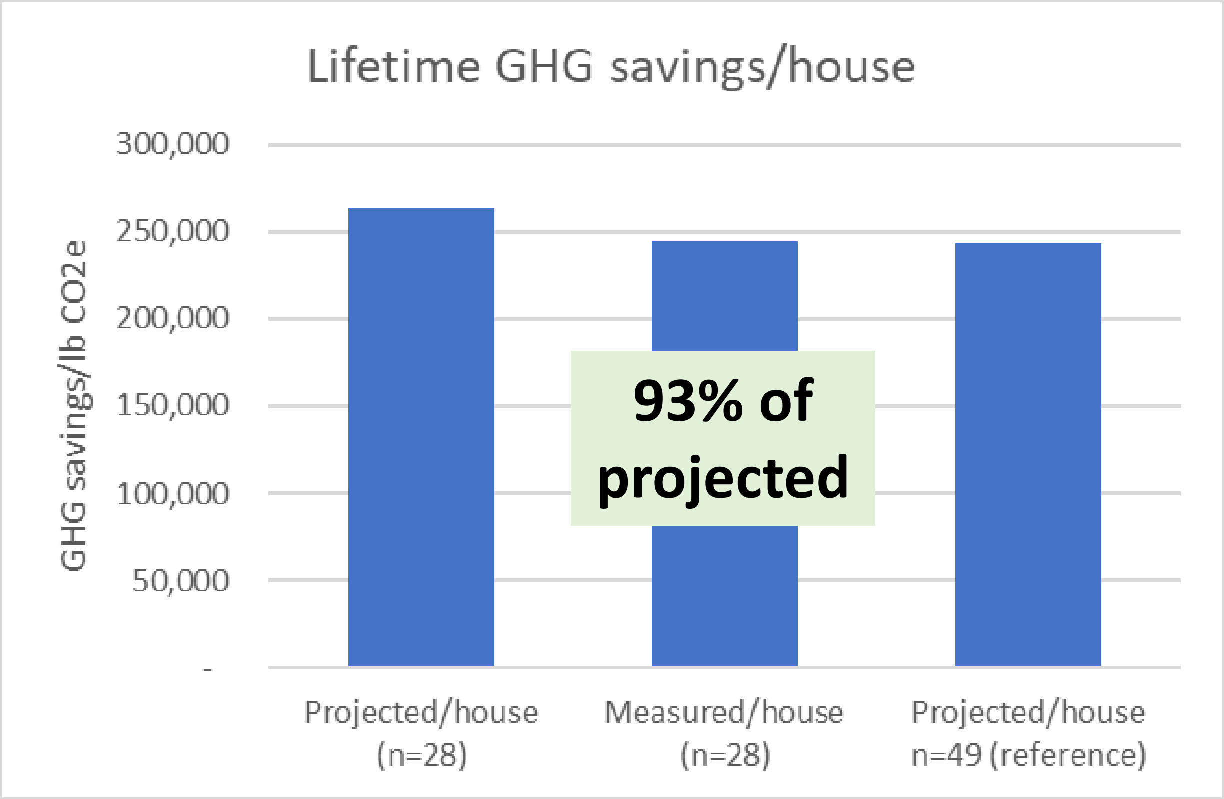
- PV accounts for 75% of GHG savings, 92% of $ savings
- Increasing heat pump use increases both GHG and $ savings

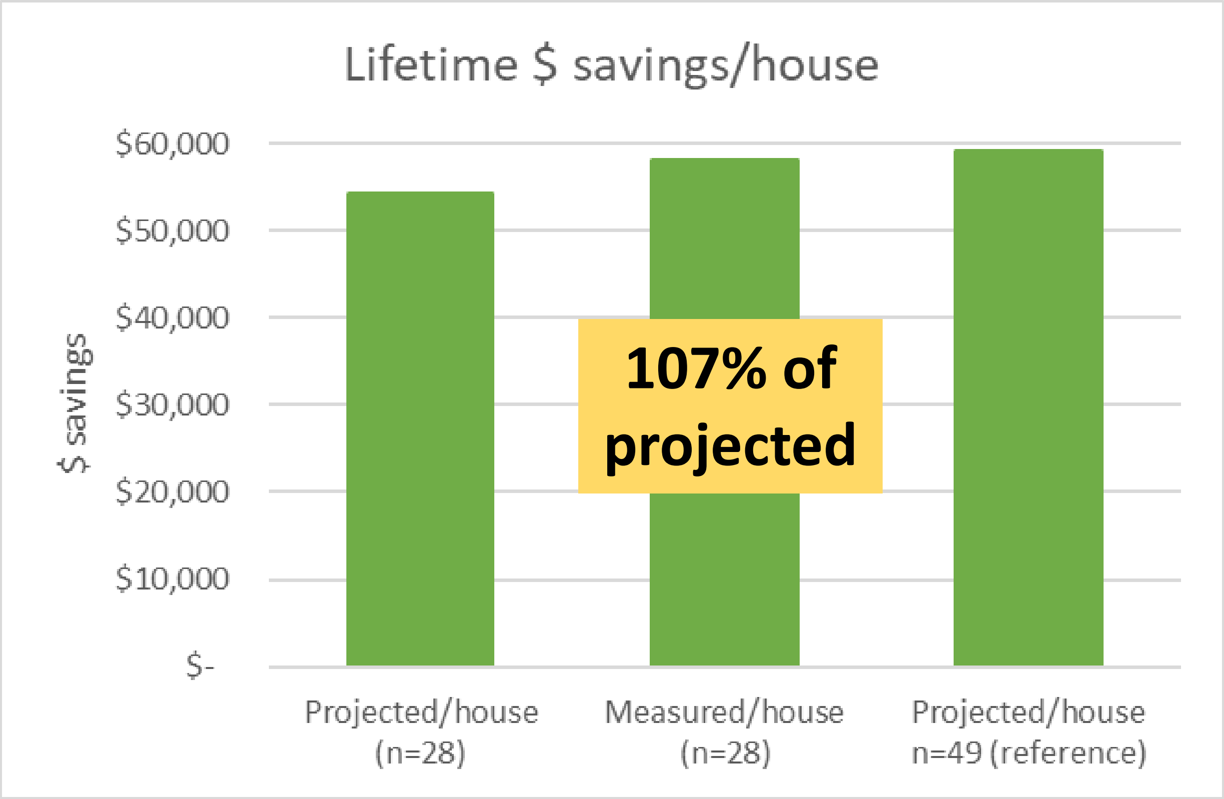
Unsubsidized cost of ASHP and PV installation/lb CO2e *annual savings*:

- Heat pumps: **$3.38** (not counting near-neutral cooling impact)
- PV systems: **$4.06**

Subsidy cost/lb CO2e: $0.45 (applied to ASHP+PV total)

Lifetime savings/house (based on 28 houses)





All GHG and $ savings shown (except the "today's prices" row on the previous slide) are calculated using the *same* GHG factors and prices from the original proposal, as were the reported projections.

Note: % achieved vary from the annual values because HVAC life = 20, PV = 25 years

Takeaways: Energy & Money

- Lifetime $ projections were exceeded and GHG nearly achieved
  - If the heat pumps were utilized more, both of these would increase
  - $ savings are conservative based on fixed lifetime pricing
- Electric savings vs. fuel savings:
  - Large majority of $, GHG savings from PV installation (75% of GHG, 92% of $)
  - Increasing heat pump use increases $ and GHG savings (and share from HVAC)
- There is a limit on $ savings if PV is oversized on an annual basis
  - Many participants have excess annual PV generation
  - Could be eliminated by running their heat pump more, and/or adding heat pump capacity to better utilize the heat pump while providing comfort
  - Could be no/low cost for these owners with $10/15k whole-house incentive

Takeaways: Programmatic

What Worked with Solar Access	Ideas for Improvement
Customers like (neutral) Energy Coach	…but Energy Coach needs technical training • Opportunity to ratchet training for MassSave Heat Pump Installer Network? • Note: Dept of Energy currently supporting a national certificate
Combining technologies	…but all ccASHP installs should have WX, too • And all technologies should be mentioned (e.g. Even if PV isn’t included within a program, if it’s a good site, have the service provider mention the possibility of PV)
Savings Guarantee assuages homeowner fear/risk	No Savings Guarantee claims were made, so • Why not offer it regularly?
Loan Loss Reserve (LLR) assuages lender fear/risk	No LLR claims were made, and they are costly, so • Is it needed? Would a larger subsidy be a less expensive approach to lessening risk of loan default?

Takeaways: Programmatic

What Worked with Solar Access Initiative	Ideas for Improvement
6-month subsidy made investment cash neutral	…but 6-month subsidy of $5,500 no longer available - neither is Solar Loan middle income subsidy • How can this gap be filled if future initiatives are offered?
Reasonable fuel savings (50%) for "partial" system	…but so much more is possible with customer follow up: "Use your heat pumps more!" • Most most incentive programs do not go back after install • Incentives like MassSave whole home might want to consider incorporating post-install check-ups winter after install.

To enact these takeaways…

policy makers, utilities, regulators, administrators, providers must coordinate…

CONSISTENTLY

Takeaways: Programmatic

SERVING THESE HARD-TO-REACH POPULATIONS & CREATING A *WORTHWHILE* BUSINESS OPPORTUNITY FOR SERVICE PROVIDERS REQUIRES:

- Streamlining (& combining) offerings
- Reducing time & complexity in approvals and hand-offs
- Leveraging the "trust" factor associated with state, non-profit partners, & customer testimonials
- Partnering with local, community-embedded organizations
- Increasing affordability & cashflow outcome
- Minimizing policy changes & increase consistency of offerings
- Selling comfort!
- Allowing for program flexibility – listen to customer & service provider feedback
  - Serving middle to lower income homeowners means addressing other issues (panel, roof)

If they say it's not working, it won't!

Homes & Quotes

"The Solar Access Program allowed someone on a **limited income** to be a part of the **renewable energy world** and **upgrade a home heating/cooling** system at the same time."

"I have saved money on electricity, **improved comfort**, cooling+heating, and **increased the value of my property**."

"**Super easy financing**, we're still enjoying tax credits spread out over several years, and we are grateful for the 0% interest loan."

"Amazing program that the state would do well to replicate or replace with something comparable in the future."

"This program made it **affordable** for us to transform our fossil-fuel-heavy dependent house to one that **generates clean energy** and uses it much more **efficiently**."

ENERGY FUTURES GROUP

Gabrielle Stebbins

Managing Consultant, EFG

gstebbins@energyfuturesgroup.com

(802) 825-9515

energyfuturesgroup.com

Bruce Harley Energy Consulting, LLC

Bruce Harley

Principal, Bruce Harley Energy Consulting

bruce@bruceharleyenergy.com

(802) 694-1719

Extras

Slides with explanation of savings calculation and more detailed breakdowns of results, etc.

ASHP: single vs. multizone systems

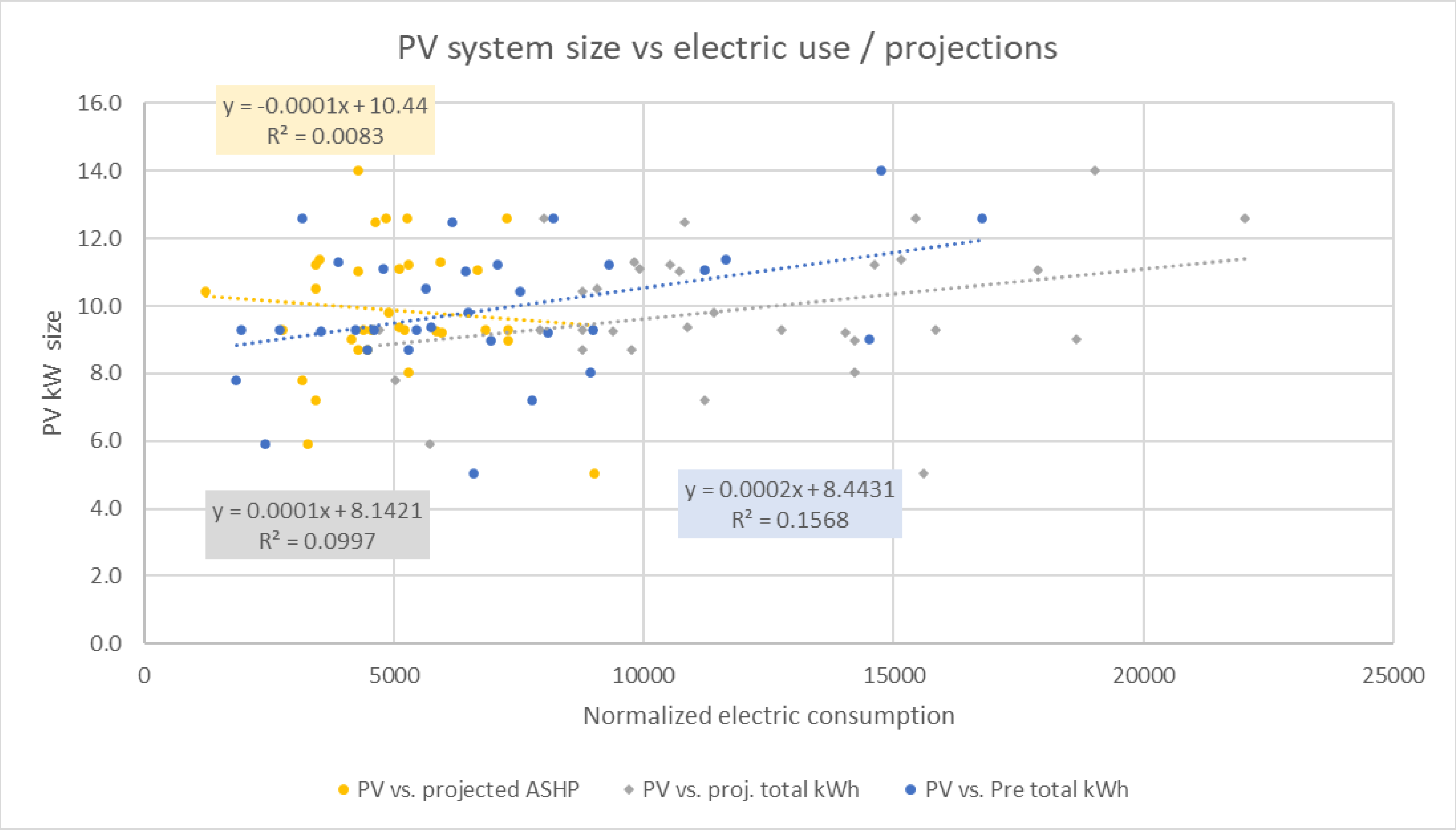
n=49

	Number of homes	
	sys 1	sys 2
Single head ductless	40	13*
Multi-head ductless	9	0
Of the multi-head:		
2 zones	8	0
3 zones	1	0

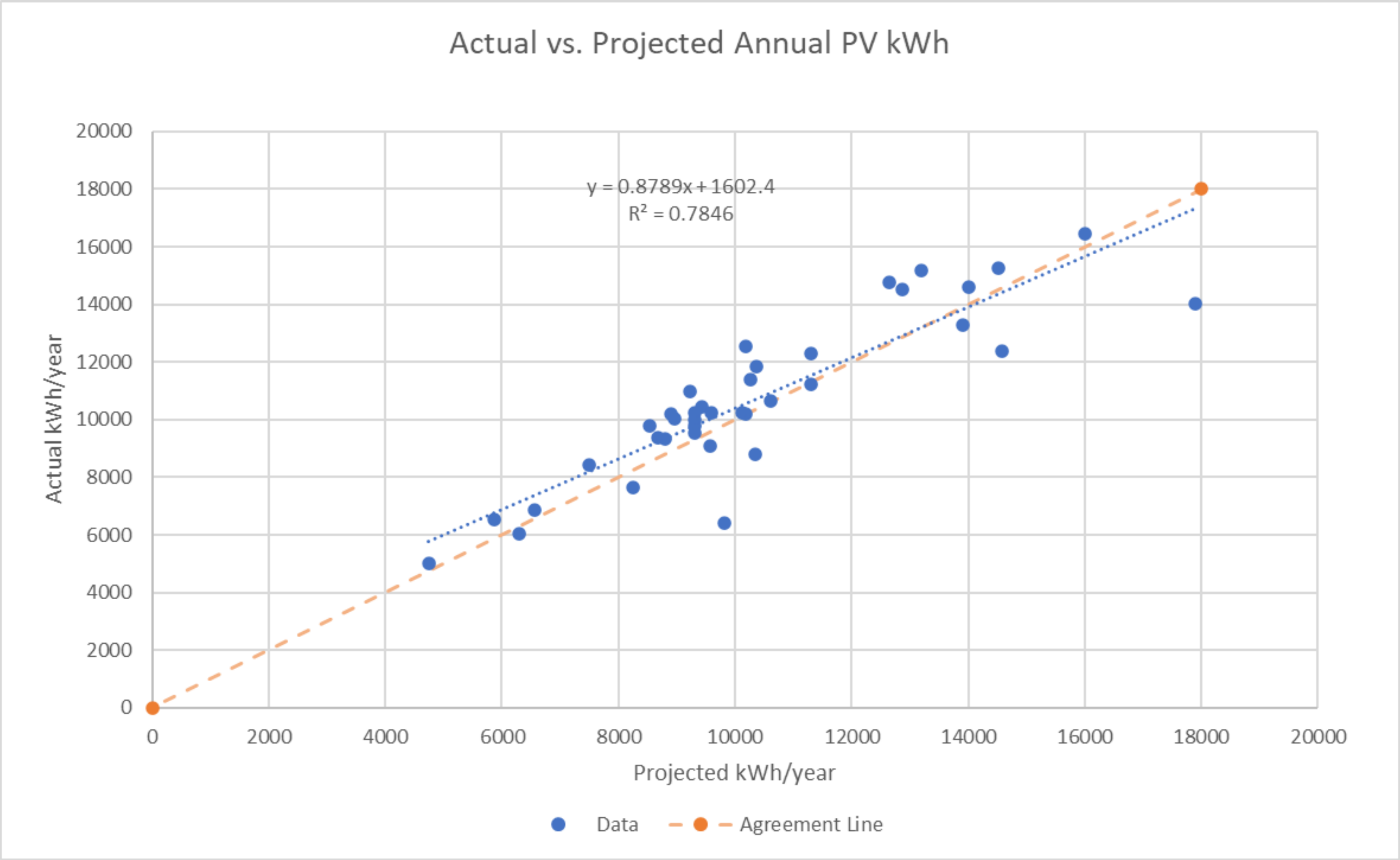
* 1 had total of 3 single-head systems

Total heads/house	# of houses
1	27
2	19
3	3
4	0

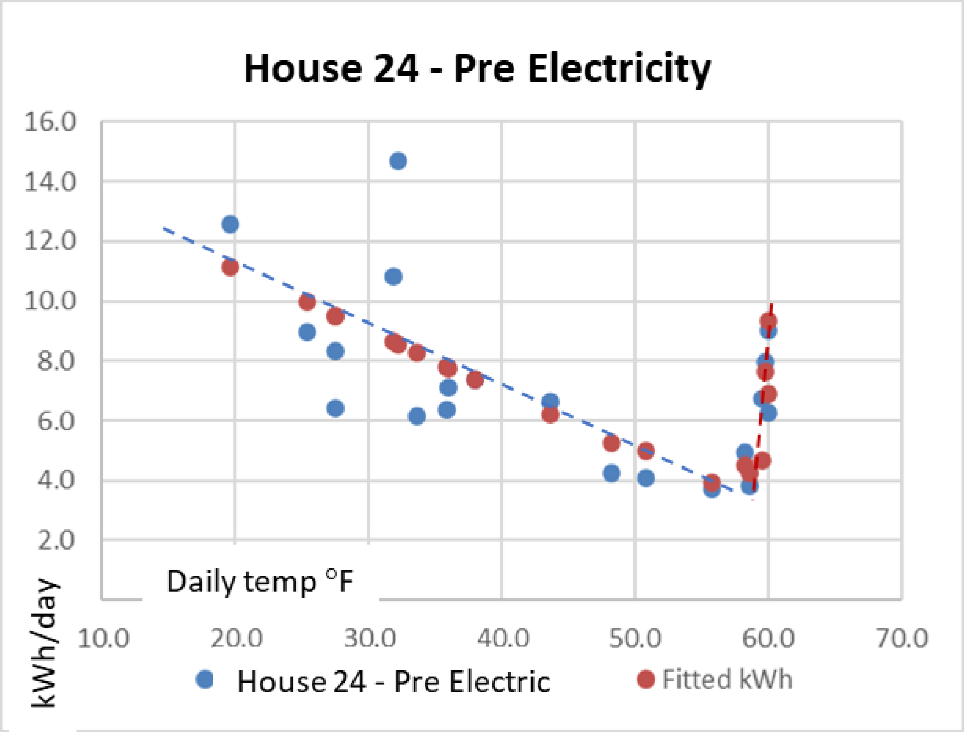
PV size vs. kWh projections

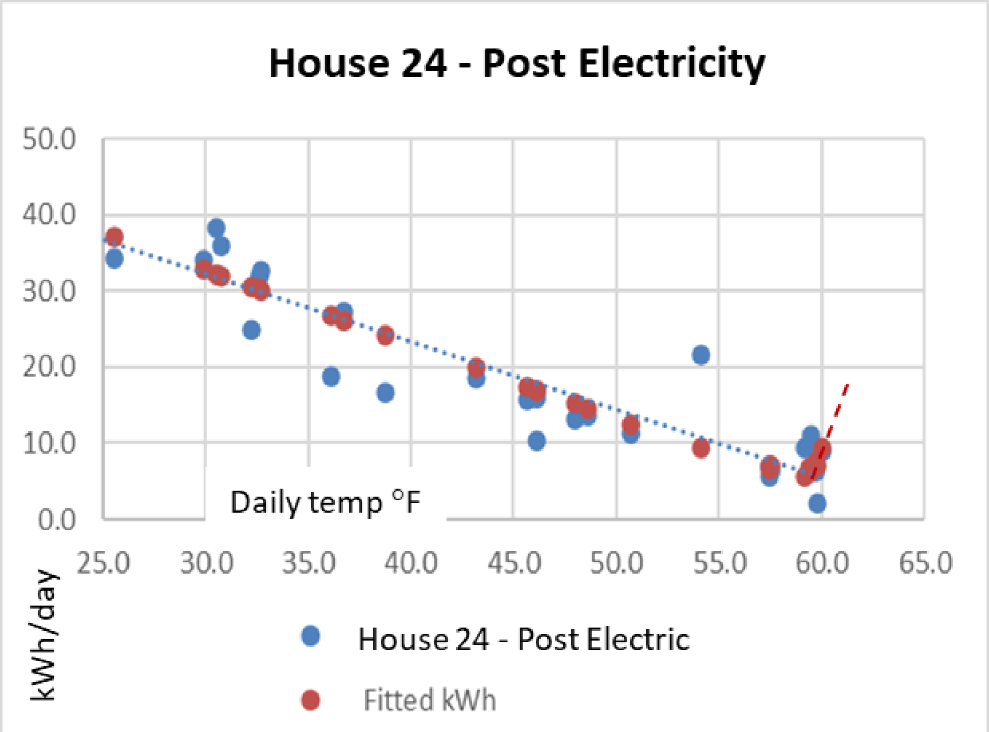


PV production is reliable to predict



Electric bill analysis example (site 24)

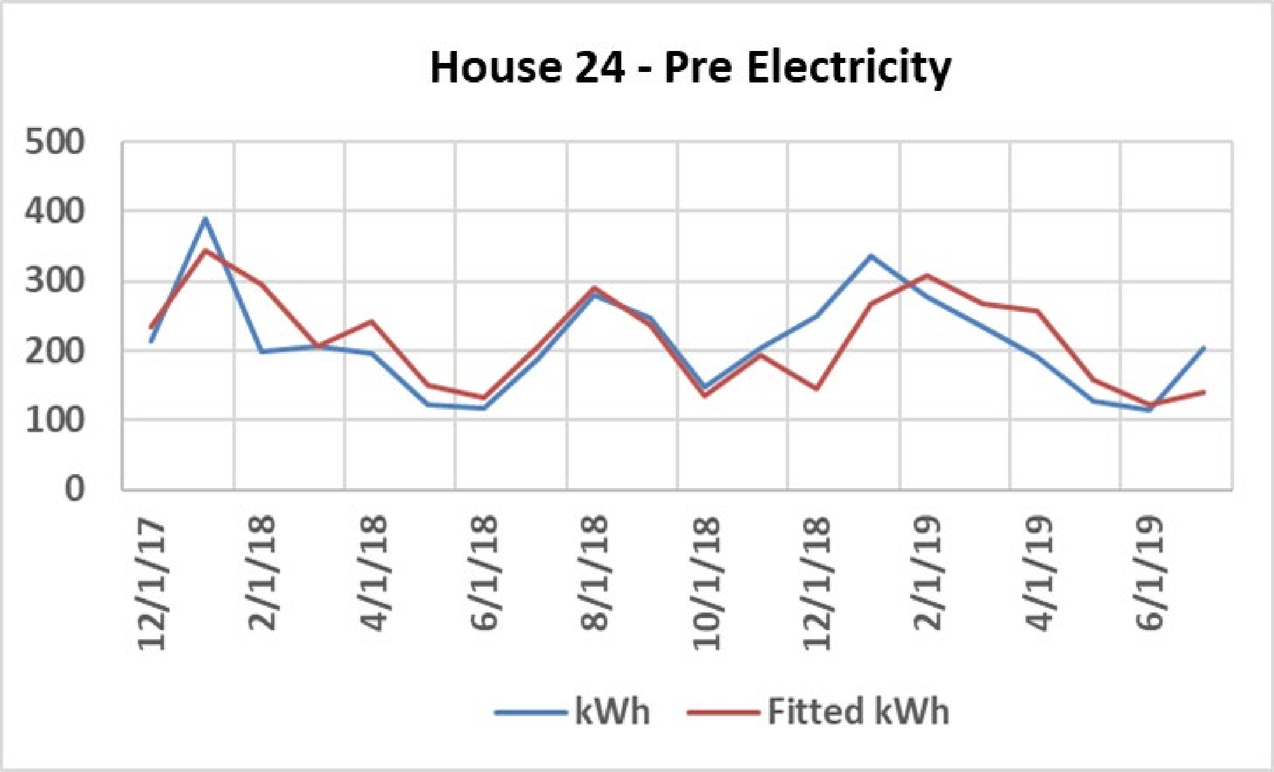




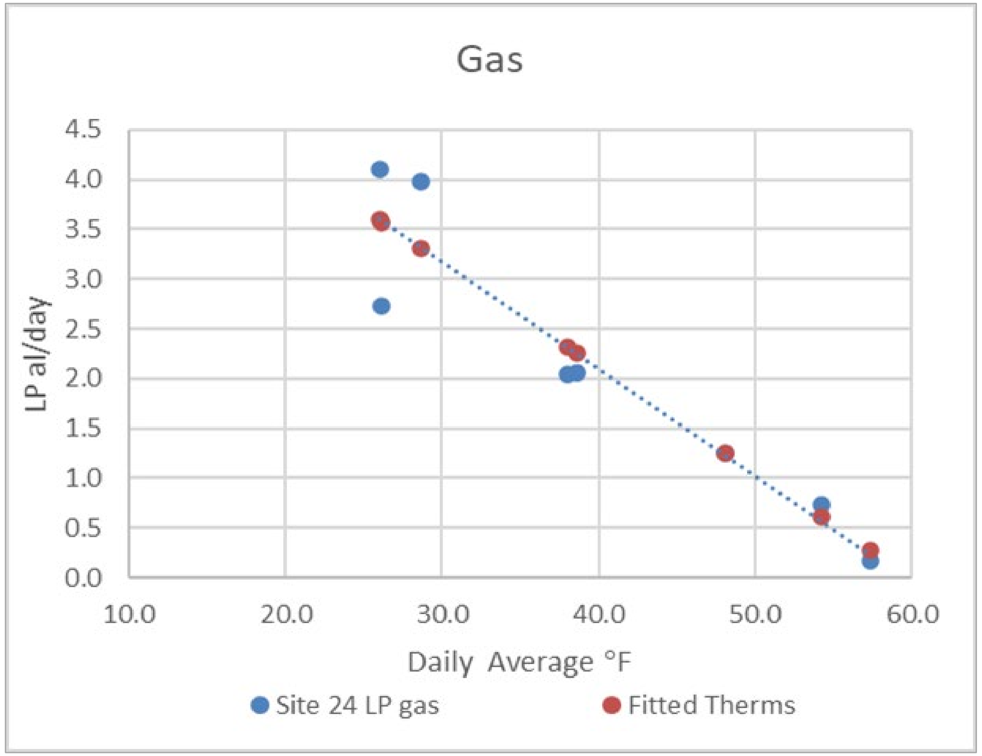
Pre kWh:	Heat season	1058
R^2: 0.50	Cool season	316
	Base	1045

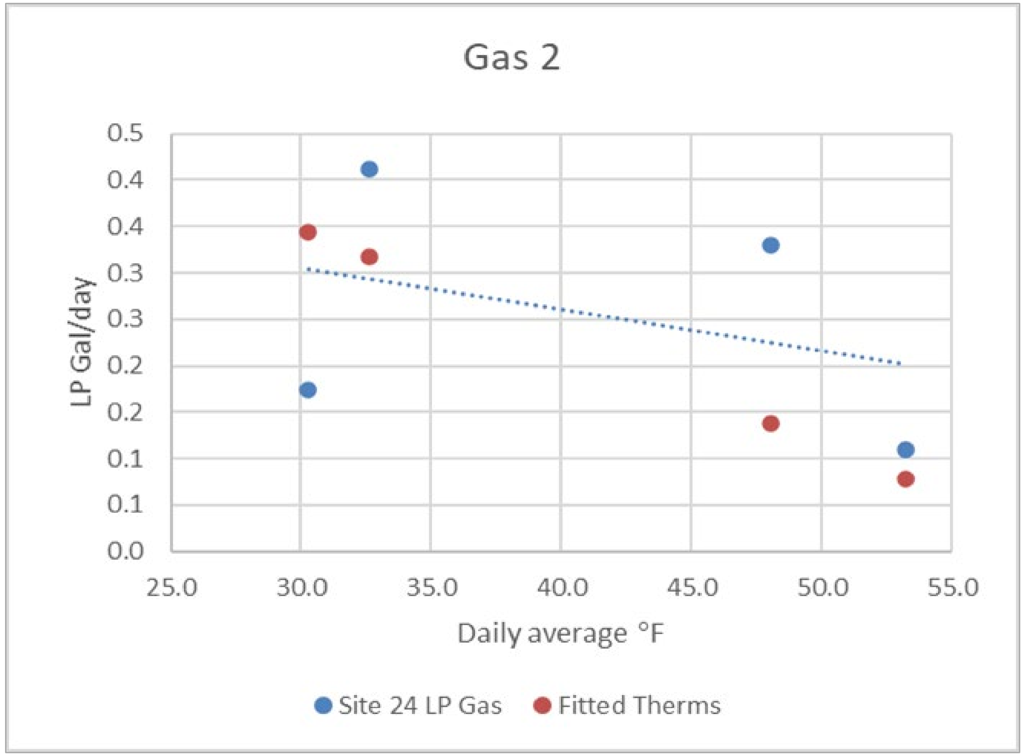
Post kWh:	Heat season	5040
R^2: 0.84	Cool season	255
	Base	1267

Example of fitted to actual monthly bills



LP gas (Propane) analysis example (site 24)



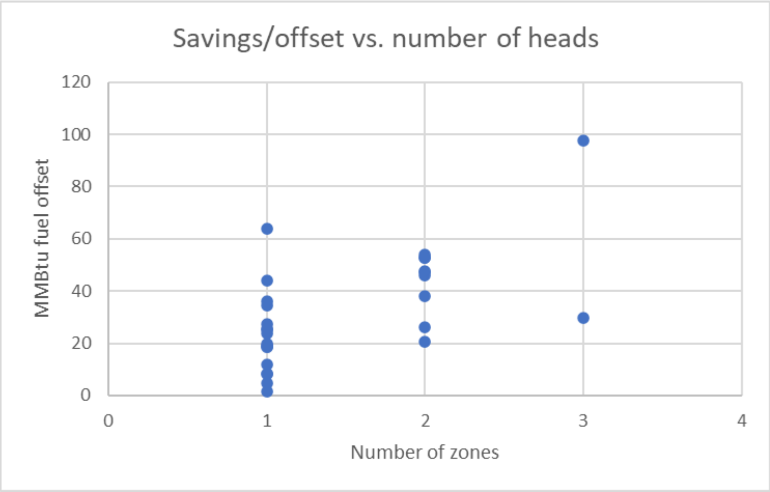


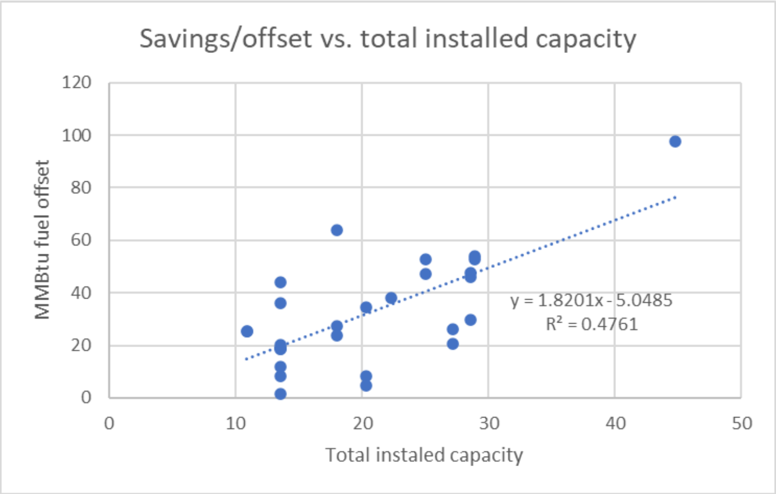
Pre LP gas:	Heat	546
R^2: 0.96	Base	0

Post LP gas:	Heat	60
R^2: 0.65	Base	0

Fuel offset by installed heat pumps

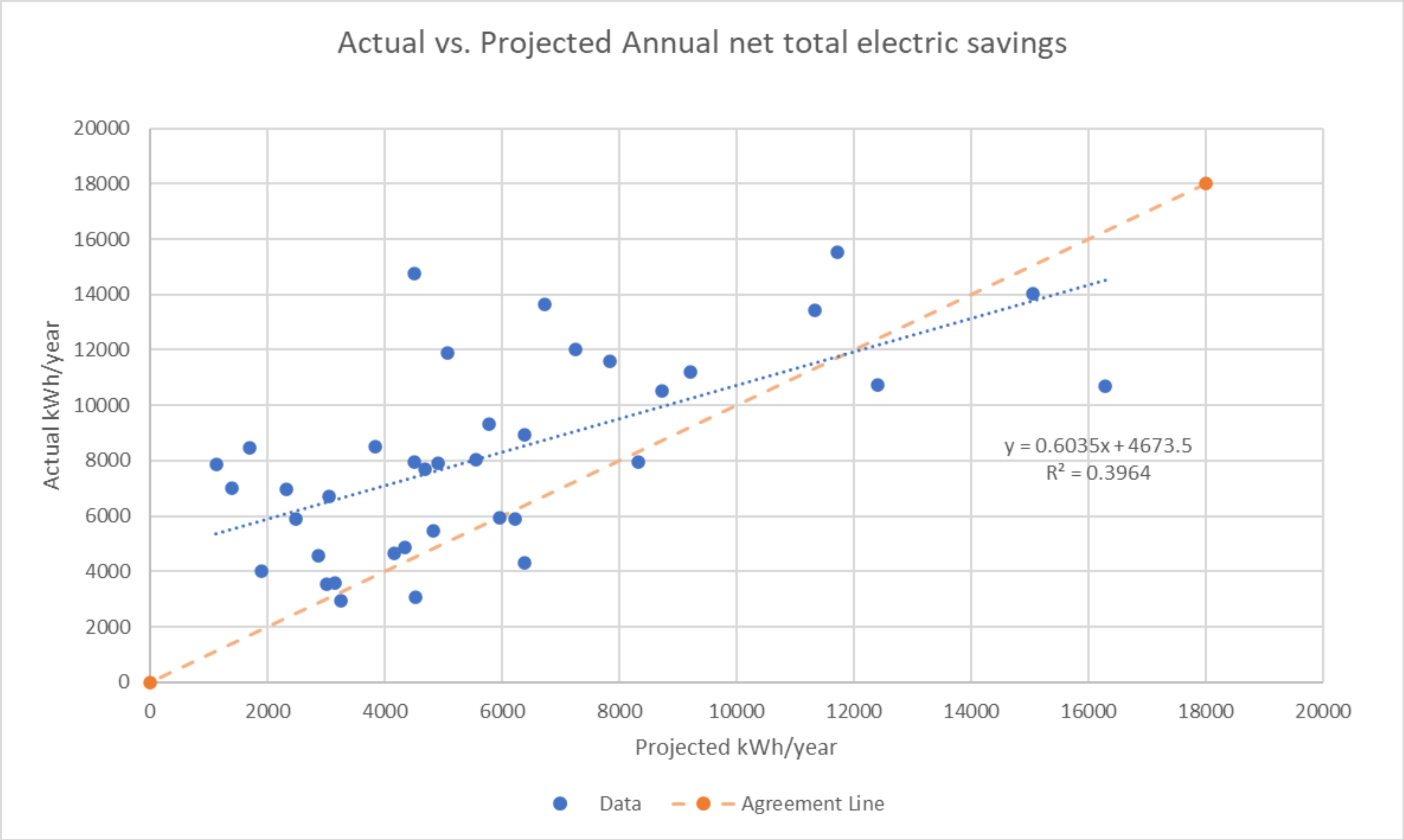
- More heating capacity definitely led to more fuel offset
    - But with pretty wide scatter – behavior, coverage still significant factors





Predictions underestimated total kWh saved

- Those with lower predictions underestimated the kWh savings partly because the heat pumps weren't used as much



Key HVAC results

	n	Fuel heat savings	Mmbtu savings	Fuel % saved	Estimated (implied) heating COP
All systems (averages)	**28**	**-**	**32.3**	**46%**	**2.3**
Oil systems	11	275	38.0	40%	2.4
LP systems	12	397	34.7	59%	2.2
Electric systems*	2	2414	8.2	39%	2.0
Gas systems	3	176	17.6	18%	2.6
Highest >33% fuel offset	17	-	42.5	61%	2.4
<=33% fuel offset	11		16.5	23%	2.2
Multi-head homes	5		44.7	51%	2.4
Single-head homes	23		29.6	44%	2.3

Key HVAC results

	n	Actual vs. proj. ASHP kWh	Actual vs. proj. fuel savings	Estimated COP as % of "HSPF"
All systems (averages)	**28**	**86%**	**68%**	**66%**
Oil systems	11	86%	65%	69%
LP systems	12	98%	77%	63%
Electric systems	2	87%	-	57%
Gas systems	3	39%	40%	69%
Highest >33% fuel offset	17	99%	82%	69%
<=33% fuel offset	11	65%	44%	61%
Multi-head homes	5	78%	73%	78%
Single-head homes	23	63%	66%	63%

Key PV/net results

* Negative = excess PV production

	n	Annual PV production kWh	Actual vs. proj. PV production	Net annual kWh* (PV - normalized whole house)
All systems (averages)	**28**	**10347**	**105%**	**-625**
All incl. those w/o HVAC	38	10674	104%	x
Oil systems	11	10682	106%	-335
LP systems	12	10183	104%	-1384
Electric systems	2	10020	89%	1252
Gas systems	3	9992	112%	99
Highest >33% fuel offset	17	10390	104%	-532
<=33% fuel offset	11	10281	106%	-768
Multi-head homes	5	10617	100%	1276
Single-head homes	23	10288	106%	-1038

GHG reduction per house

	n	GHG savings annual lb CO2e	% GHG achieved (vs. proj)
All systems (averages)	**28**	**10,305**	**96%**
Oil systems	11	11,582	87%
LP systems	12	9,799	95%
Electric systems	2	9,053	144%
Gas systems	3	8,481	100%
Highest >33% fuel offset	17	11,247	104%*
<=33% fuel offset	11	8,848	84%
Multi-head homes	5	10,305	79%
Single-head homes	23	11,952	100%

*Note: at >50% offset, this goes to 119% (n=10)

ENERGY FUTURES GROUP

Key $ savings per house

	n	Fuel cost savings- annual	Electric cost savings- annual	% of proj. cost savings achieved	Annual net HVAC only cost savings
All systems (averages)	**28**	**$881**	**$1,672**	**109%**	**$213**
Oil systems	11	$796	$1,596	105%	$41
LP systems	12	$1,120	$1,516	98%	$396
Electric systems	2		$2,681	144%	$476
Gas systems	3	$238	$1,899	142%	$ (62)
Highest >33% fuel offset	17	$1,221	$1,432	111%*	$295
<=33% fuel offset	11	$337	$2,042	106%	$87
Multi-head homes	5	$1,191	$1,288	86%	$142
Single-head homes	23	$807	$1,755	114%	$229

*Note: at >50% offset, this goes to 122% (n=10), or 160% at today's fuel prices

Key $ savings per house

	n	Fuel cost savings-annual	Electric cost savings-annual	Fuel cost savings-current $	Electric cost savings - current $
All systems (averages)	**28**	**$881**	**$1,672**	**$1,196**	**$2,591**
				+36%	***+24%***
Oil systems	11	$796	$1,596	$1,239	$2,474
LP systems	12	$1,120	$1,516	$1,376	$2,350
Electric systems	2		$2,681		$4,155
Gas systems	3	$238	$1,899	$317	$2,943
Highest >33% fuel offset	17	$1,221	$1,432	$1,656	$2,219
<=33% fuel offset	11	$337	$2,042	$459	$3,166
Multi-head homes	5	$1,191	$1,288	$1,632	$1,996
Single-head homes	23	$807	$1,755	$1,092	$2,720