MF Opportunities, Challenges

- Flat roofs
- Storage location
- Piping runs!

Brooklyn System

- 24 40-ft^2, flat-plate collectors
- 1,500-gallon storage tank
- Initial Cost: ~$105,000 ($109/ft^2)

Solar O&M

- Smooth, reliable operation of SDHW is the **exception** (in my experience).
- **Drainback** systems may alleviate reliability concerns, but high pumping energy ($50-$100/y for SF system)
- O&M needs/costs hard to estimate (poor documentation – just anecdotes).

Reliable Solar Systems

Recommendations:

- Good **design** and **installation**
- **Monitor** SDHW performance
- Clear **O&M** manual/instructions
- Perhaps explore service contracts, PPAs.

Solar DHW

Advantages

- Direct use of renewable energy
- No fuel costs
- $ more attractive on MF scale

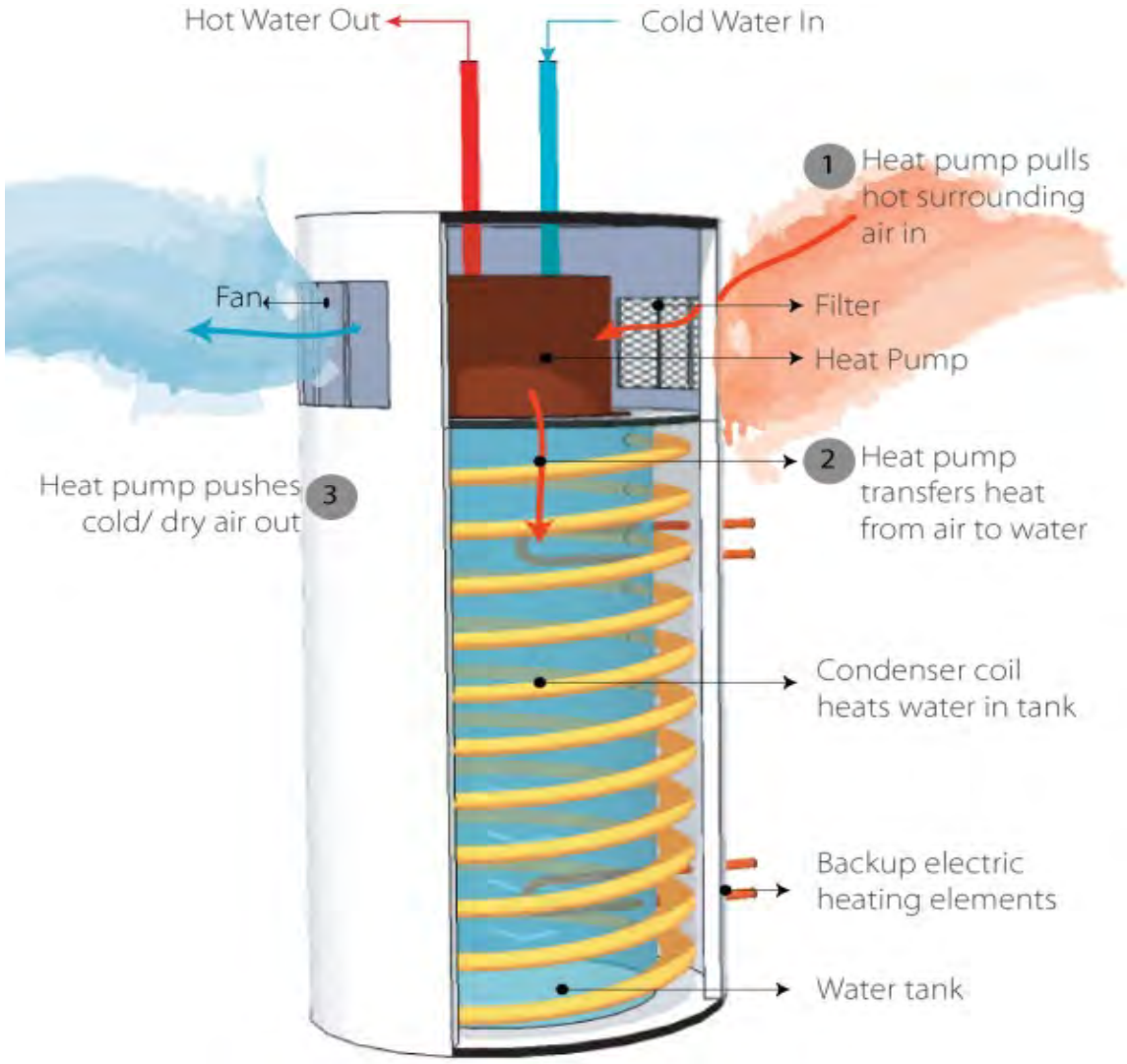
- **Aesthetics**

Disadvantages

- High first cost*
- Reliability and O&M requirements vary

- **Aesthetics**

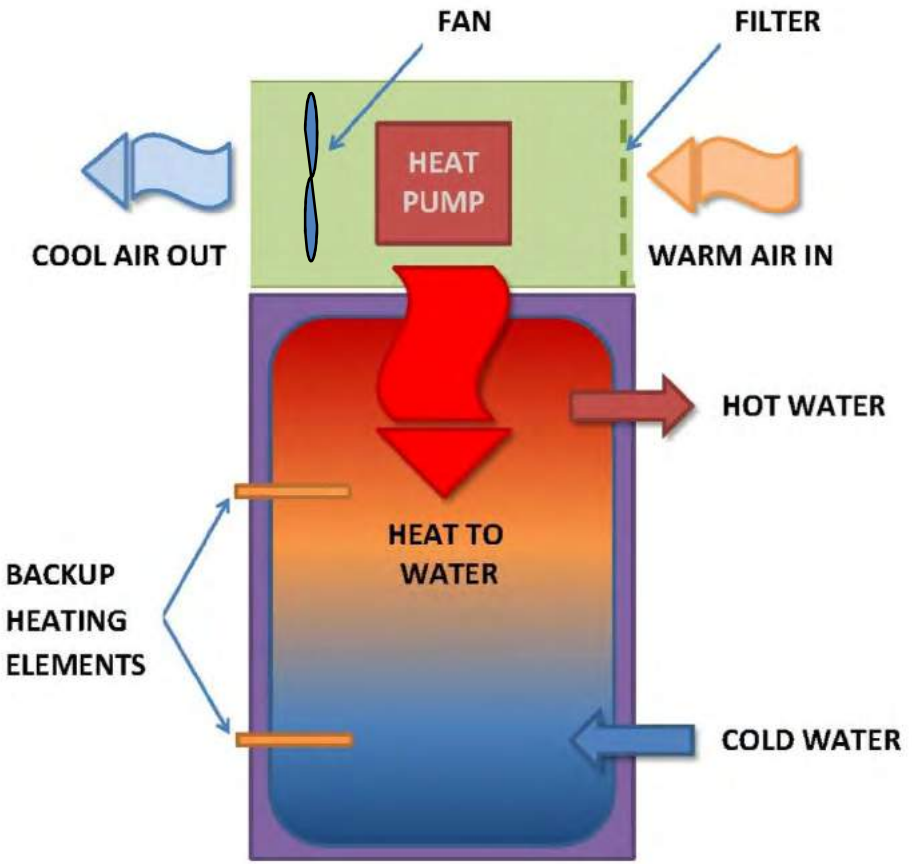
Heat Pump Water Heaters



How do they Work?

- Moves heat from surrounding air into water.

- Cools & dehumidifies the surrounding air.



HPWH Monitoring

- Monitored 14 HPWHs at sites in MA and RI for over 1 year (2010-11)

- Seasonal COPs ranged from 1.0* to 2.6

HPWH model	No. Monitored	Capacity (gal)	Energy Factor	Avg. COP	% Electric Resistance
GE	10	50	2.35	1.82*/ 1.64	33%*/ 41%
AO Smith	2	60/80	2.33	2.13	5%
Stiebel Eltron	2	80	2.51	2.35	6%

Where can HPWHs Work Well?

- Basements of NE homes
- Down south

Where may HPWHs NOT work well?

- Closets
- Finished or occupied basements (noise, cold)
- Apartments (space, noise, comfort)

HPWH Costs (MA,RI Study)

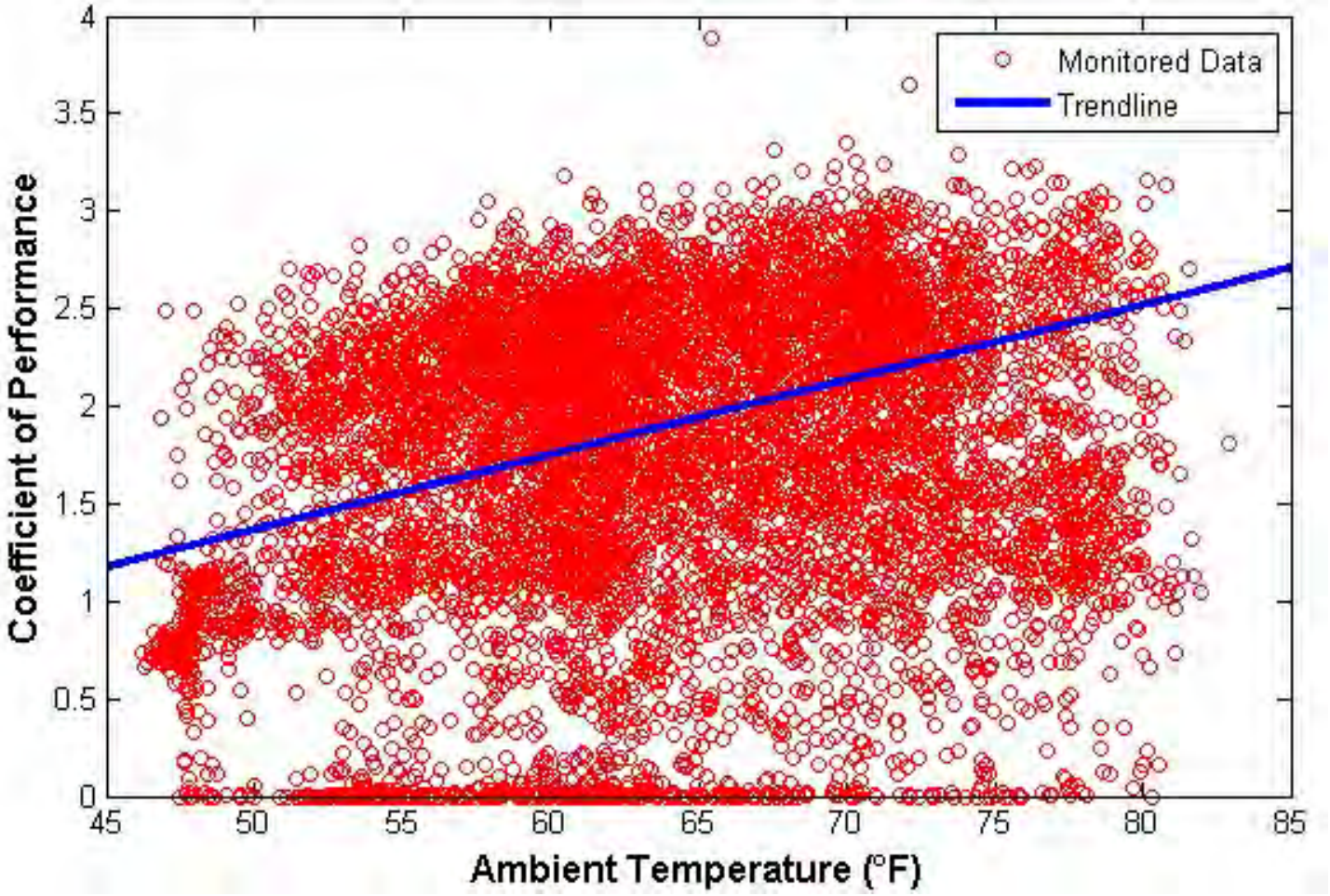
- Average savings: ~**$300-350**/yr compared to electric resistance ($0.17/kWh)
- **$1,400-$2,700** incremental installed cost (over std. elec. tank)
- Some costs have come down over past few years, some incentives available.

HPWH Performance Factors

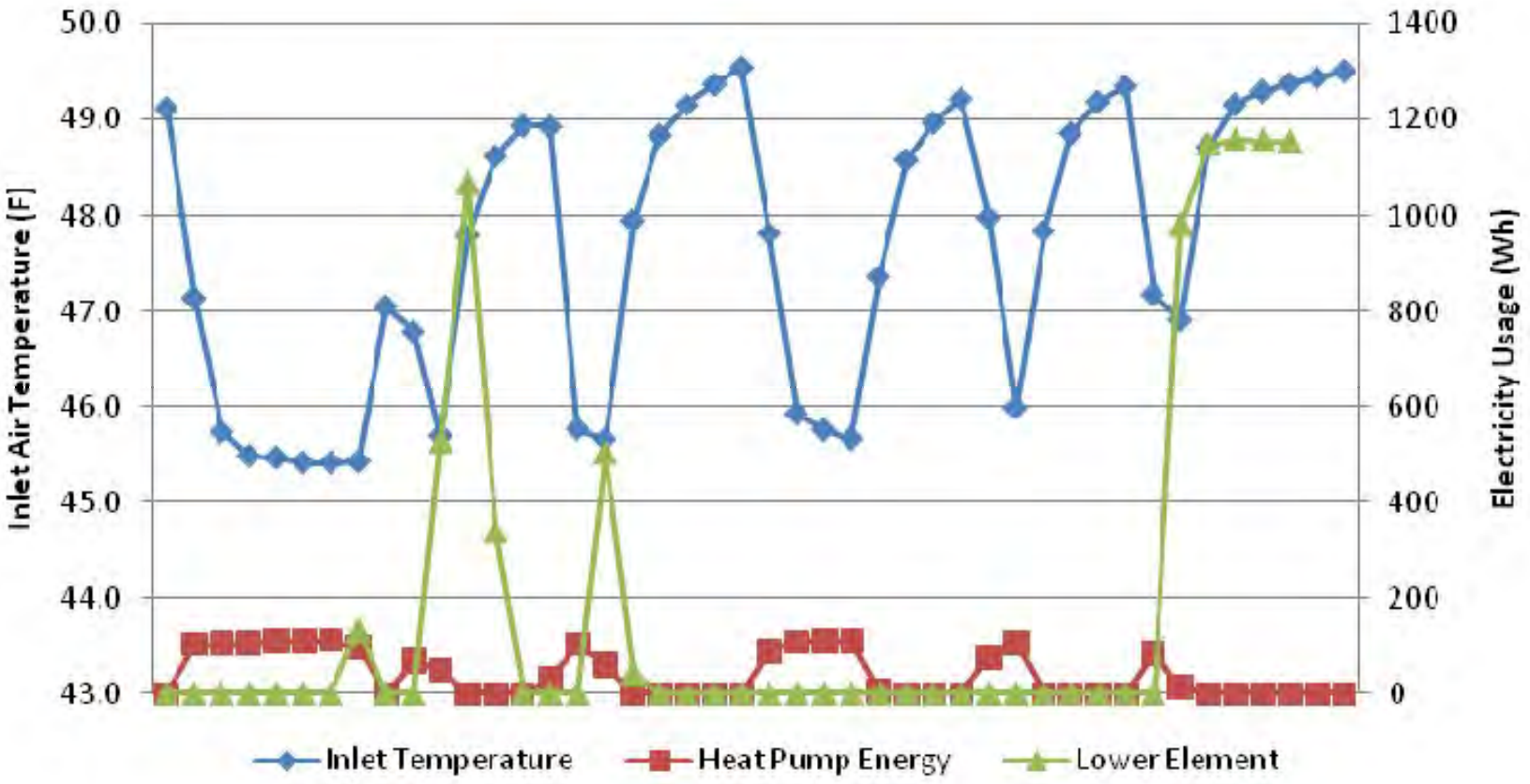
For a given HPWH, COP varies with:

- Surrounding air temp
- Total water consumption
- Water draw profile

Air Temperature Dependence

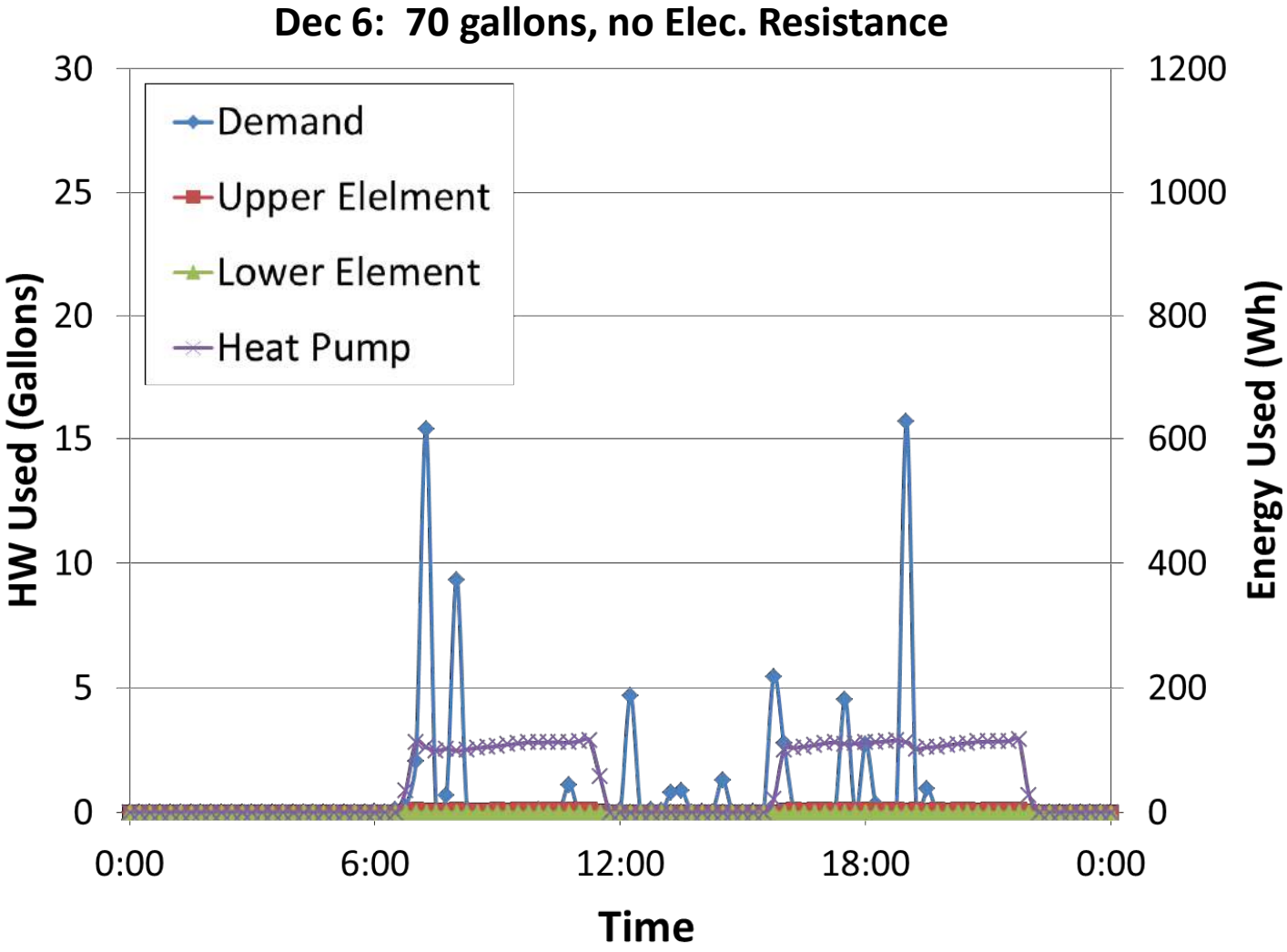


Site 5: Low Ambient Temps

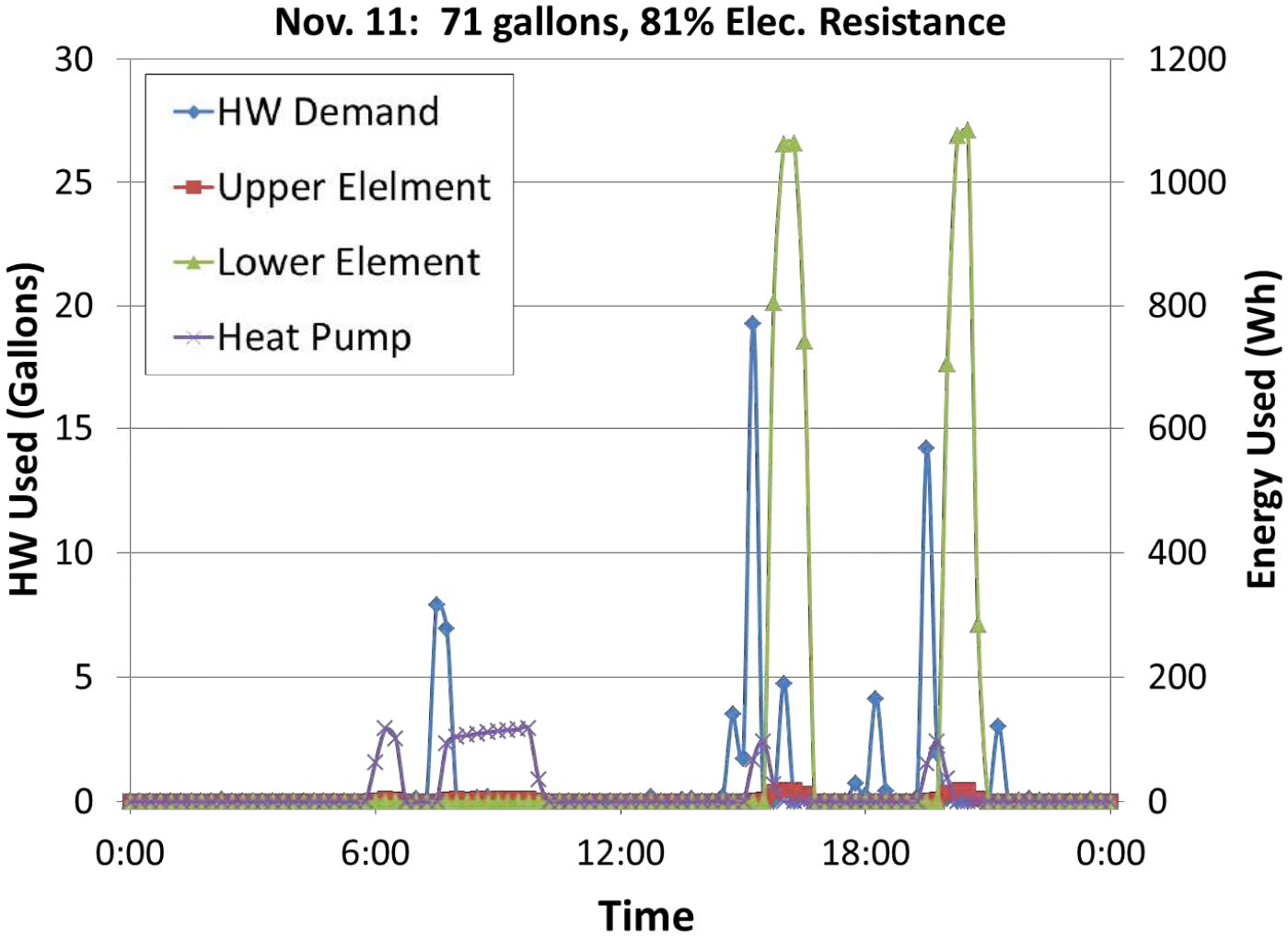


Site 5: COP = 0.77; Average Ambient Temperature = 48°F

Site 3: Concentrated Draws



Site 3: Concentrated Draws



To Minimize Resistance Heat:

BIGGER IS BETTER

HOTTER IS BETTER

Monitoring Summary

HPWH model	No. Monitored	Capacity (gal)	Energy Factor	Avg. COP	% Electric Resistance
GE	10	50	2.35	1.82*/ 1.64	33%*/ 41%
AO Smith	2	60/80	2.33	2.13	5%
Stiebel Eltron	2	80	2.51	2.35	6%

Mixing Valves and Temperature

- Unlike most water heaters, increasing the setpoint of HPWHs can increase efficiency
- Tempering (anti-scald) valves are good practice

Managing Condensate

- Install condensate pump, if needed
- Place on blocks
- Install drain pan

HPWH Sitting in Water

Proper Installation

Maintenance

- Some filters in HPWHs should be regularly cleaned.
- Educated homeowners.

HPWHs in Multifamily

Proper HPWH Application?

Space Conditioning Impacts

Latest Study

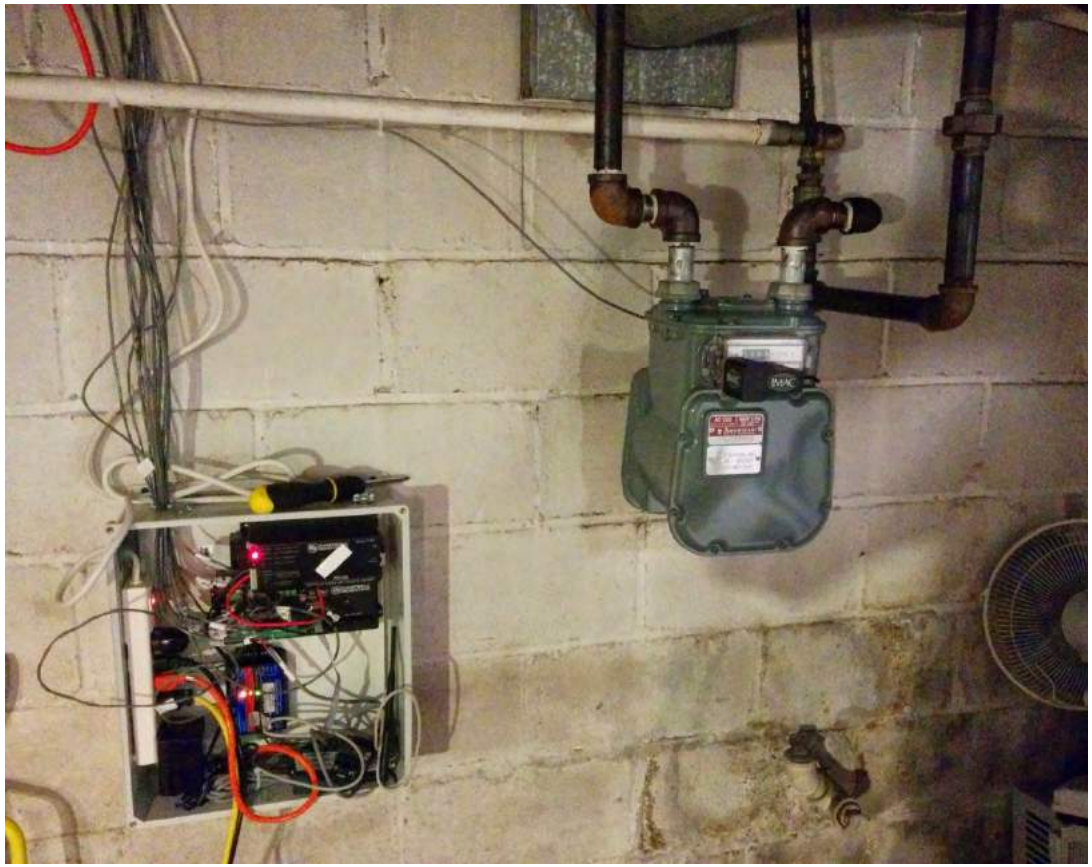
- 3 HPWHs
- in 3 CT basements

Switched between **Hybrid** (HP) mode and Resistance (**ER**) mode to see if any more heating fuel was used.

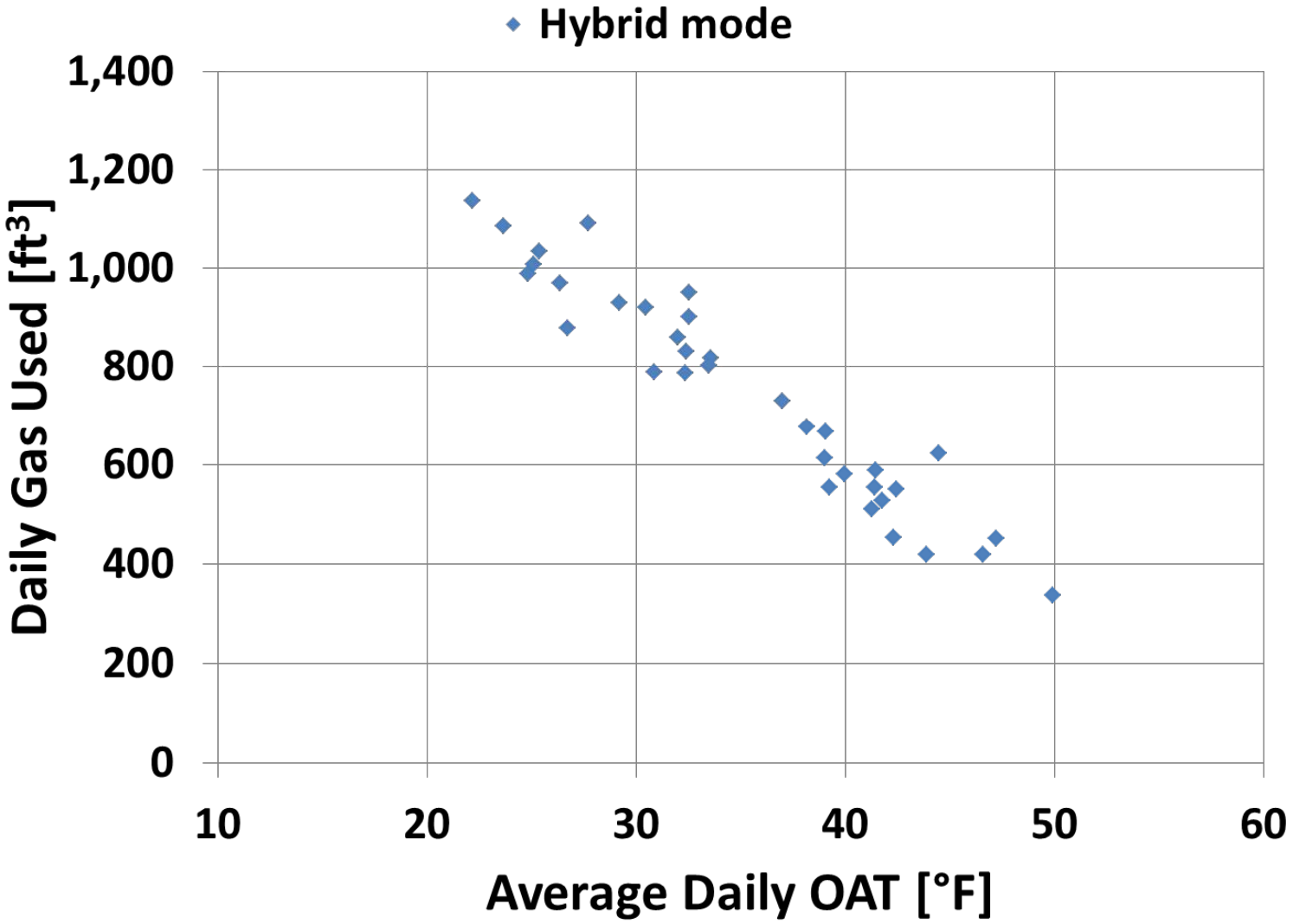
Monitoring Heating Fuel

Cycle between:

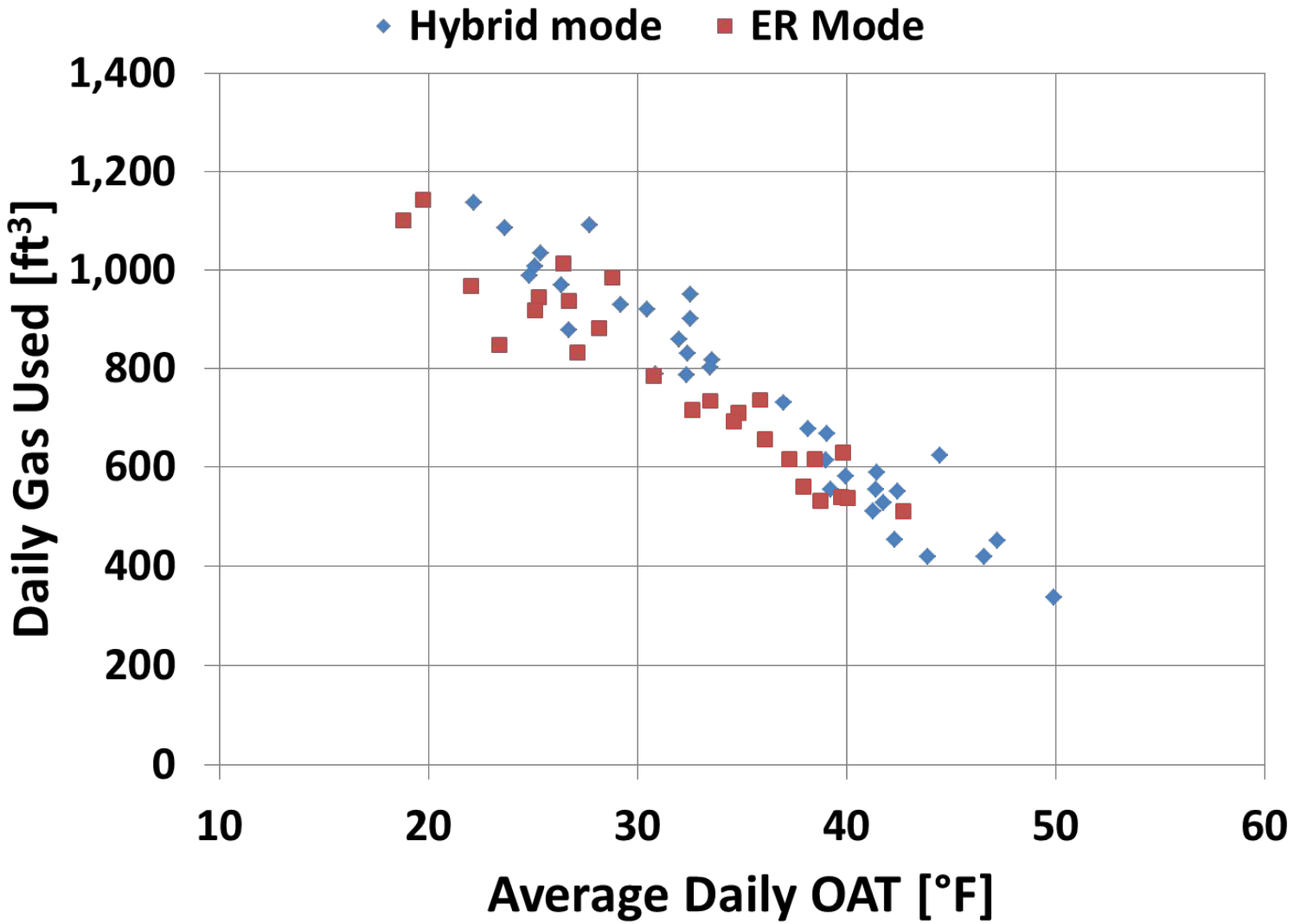
- HP (hybrid) mode
- Resistance mode

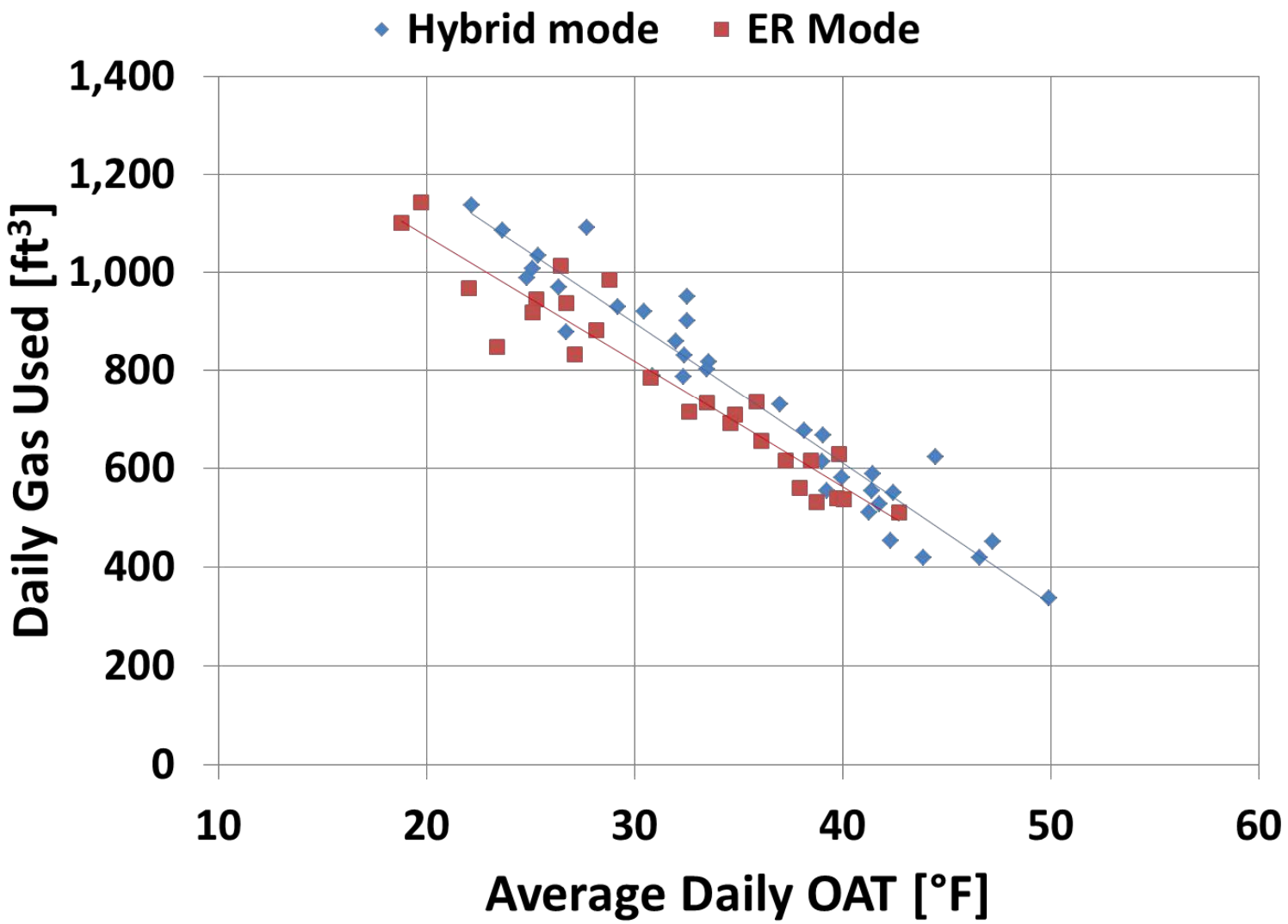


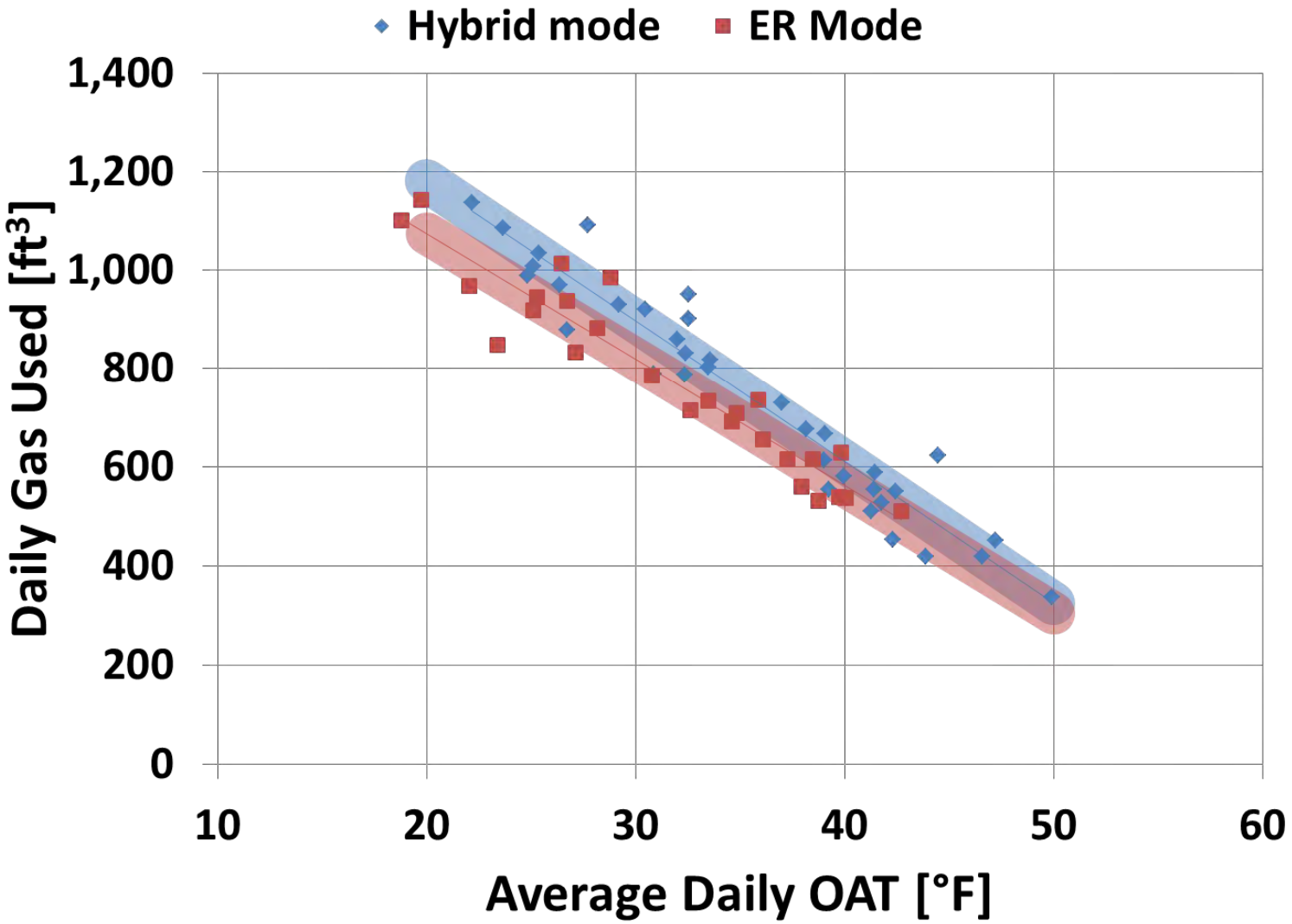
Furnace Gas in **Heat Pump** Mode



Furnace Gas in **Resistance** Mode




Hybrid mode
ER Mode
1,400
1,200
1,000
800
600
400
200
0
Daily Gas Used [ft3]
10
20
30
40
50
60
Average Daily OAT [°F]


Hybrid mode
ER Mode
1,400
1,200
1,000
800
600
400
200
0
Daily Gas Used [ft³]
10
20
30
40
50
60
Average Daily OAT [°F]

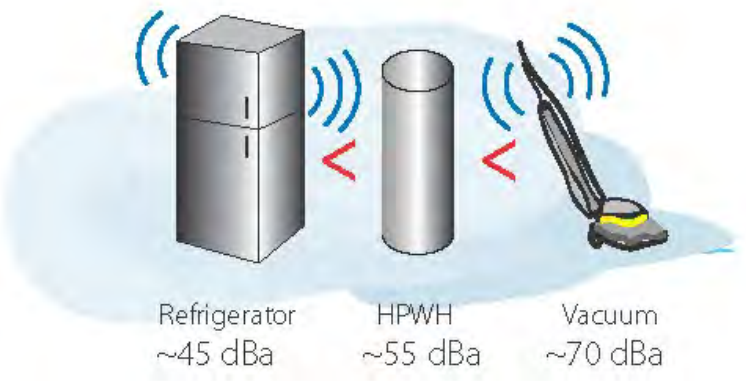
HPWHs

Advantages

- With COP ~2, uses half the electricity of resistance

Limitations:

- Needs volume (~1,000 ft^3)
- Cools surrounding space
- Surroundings >45°F
- Condensate draining
- Noise



Solar Option: PV + HPWH?

PV needed to power HPWH in efficient home:

1-1.5 kW_{STC}

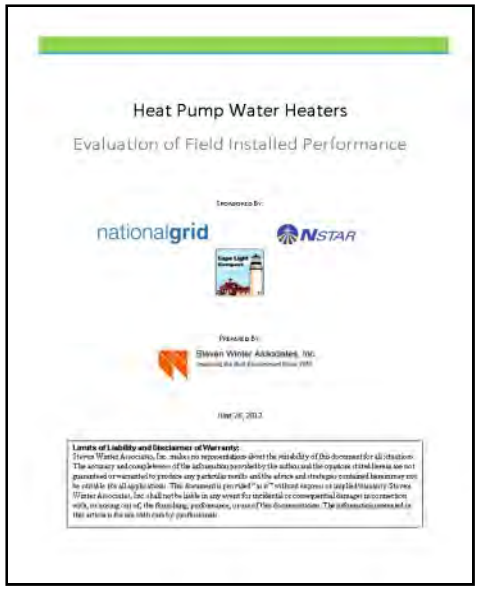
Cost @ $4/Watt:

$4,000 - $6,000

*All HPWH caveats still apply.

HPWH Resources

http://www.masssave.com/~/media/Files/Residential/Information-and-Edu-Docs/HPWH_QI_Guide.pdf



http://ma-eeac.org/wordpress/wp-content/uploads/Heat-Pump-Water-heaters-Evaluation-of-Field-INstalled-Performance.pdf

Systems Discussed

1. Resistance Tanks
2. Tankless Resistance
3. Solar Thermal
4. Heat Pump Water Heaters

SF Cost Summary

	Resist. Tank	Resist. Tankless	Solar Therm.	HPWH
Approx. Cost	$1,000	$1,000	$10,000*	$2,400*
Ann. DHW Cost	$530	$500	$160	$250

Assumptions

- 40 gal/day
- 70°F temp rise
- $0.20/kWh
- 70% solar fraction

MF Cost Summary

	Resist. Tank	Resist. Tankless	Solar Therm.	HPWH
Approx. Cost	$800	$800	$3,000* +$800	Not Likely
Ann. DHW Cost	$400	$375	$160	

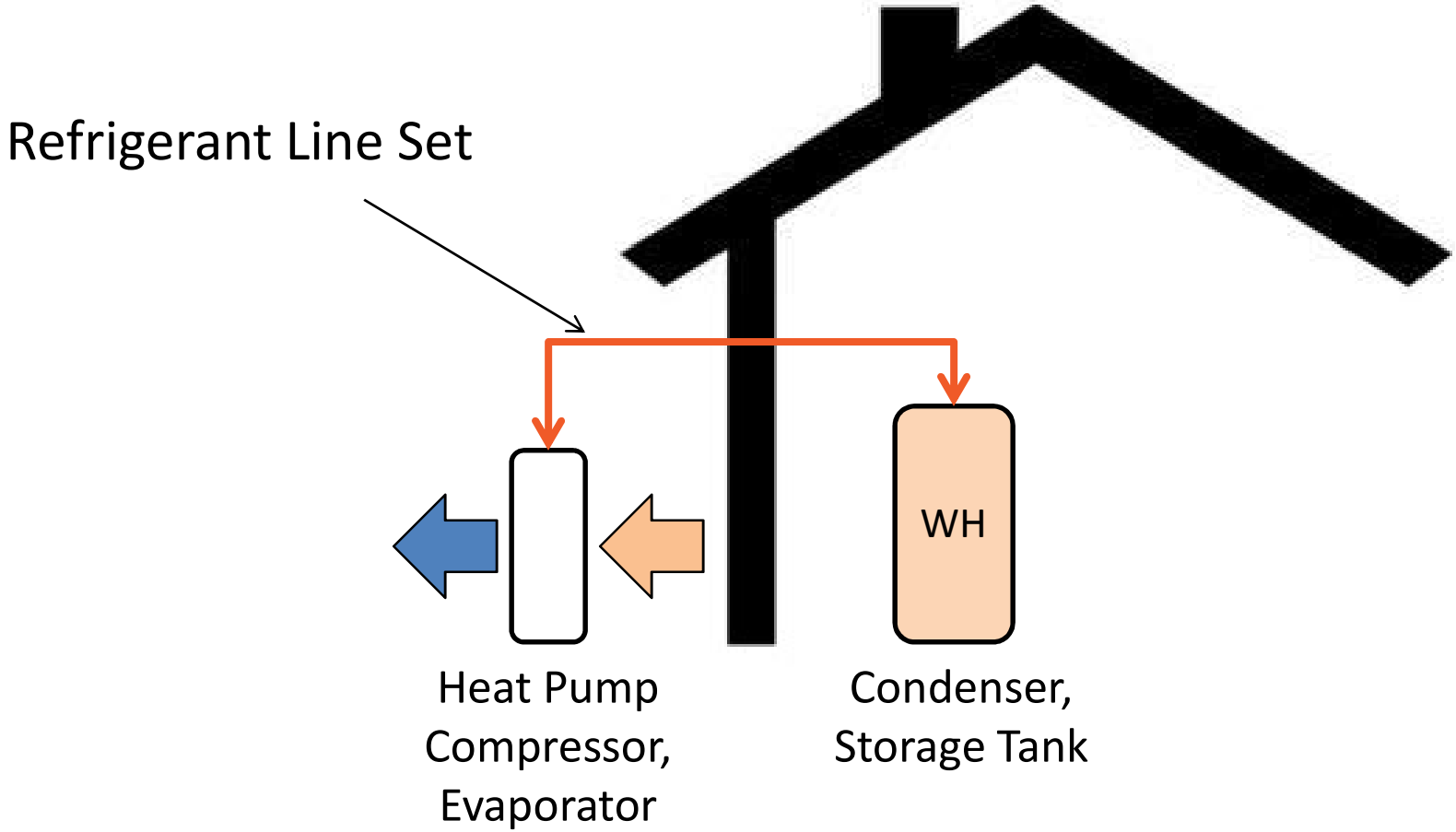
Assumptions

- 30 gal/day
- 70°F temp rise
- $0.20/kWh
- 55% solar fraction

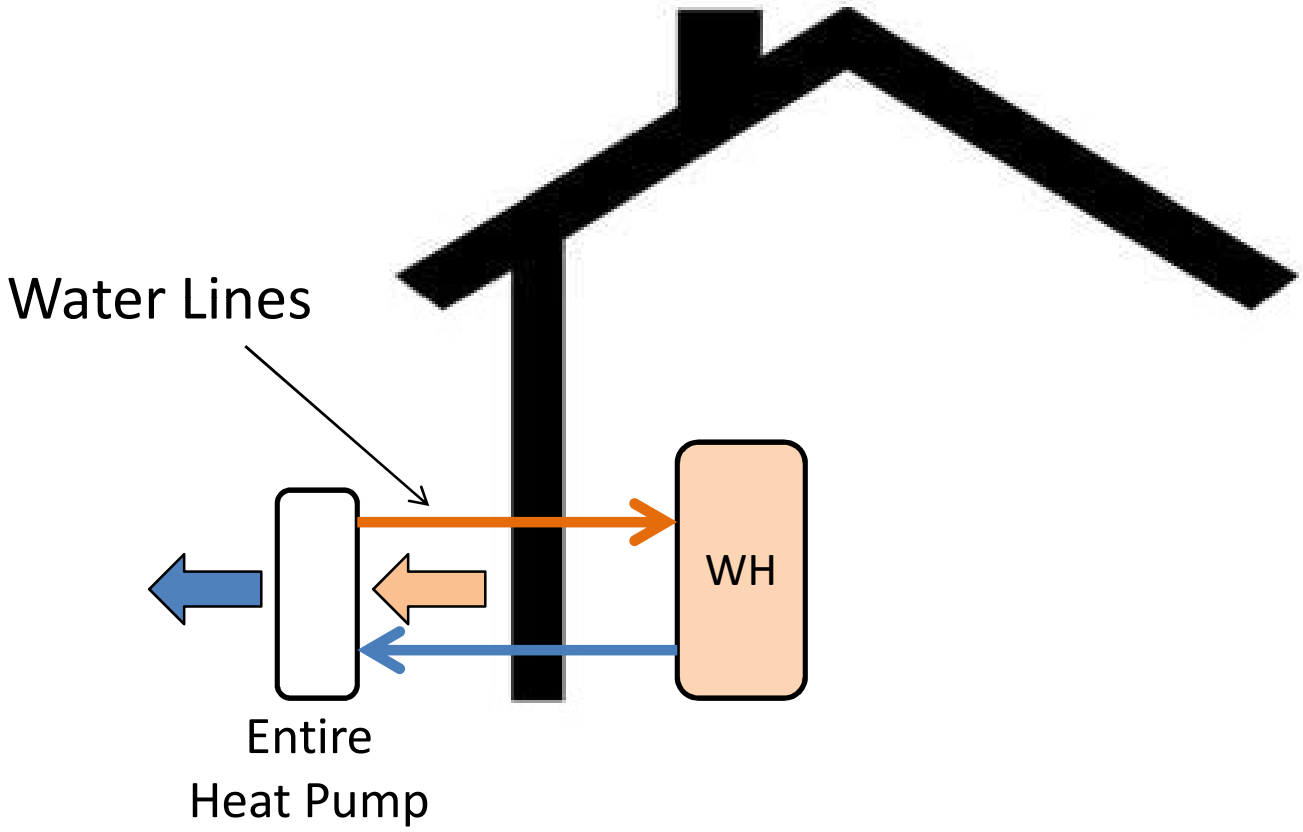
New Systems to Watch For:

1. Split HPWHs
2. Packaged outdoor HPWHs
3. Commercial/MF HPWHs for cold climates

Split HPWHs


Refrigerant Line Set
WH
Heat Pump
Compressor,
Evaporator
Condenser,
Storage Tank

Packaged Outdoor HPWH (CO_2)



Commercial/ MF HPWHs

- Available now
- Not for cold climates (below 50°F)
- Cold-climate CO_2 systems DO exist overseas…

Other Options

- Ground-source heat pumps (expensive, generally used for all heating and cooling)

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- Homeowners participating in the studies
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Evaluation report:
http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/inverter-driven-heat-pumps-cold.pdf

NEEP database:
http://www.neep.org/initiatives/high-efficiency-products/emerging-technologies/ashp/cold-climate-air-source-heat-pump

SWA Blog (search for "heat pumps"):
http://blog.swinter.com/

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