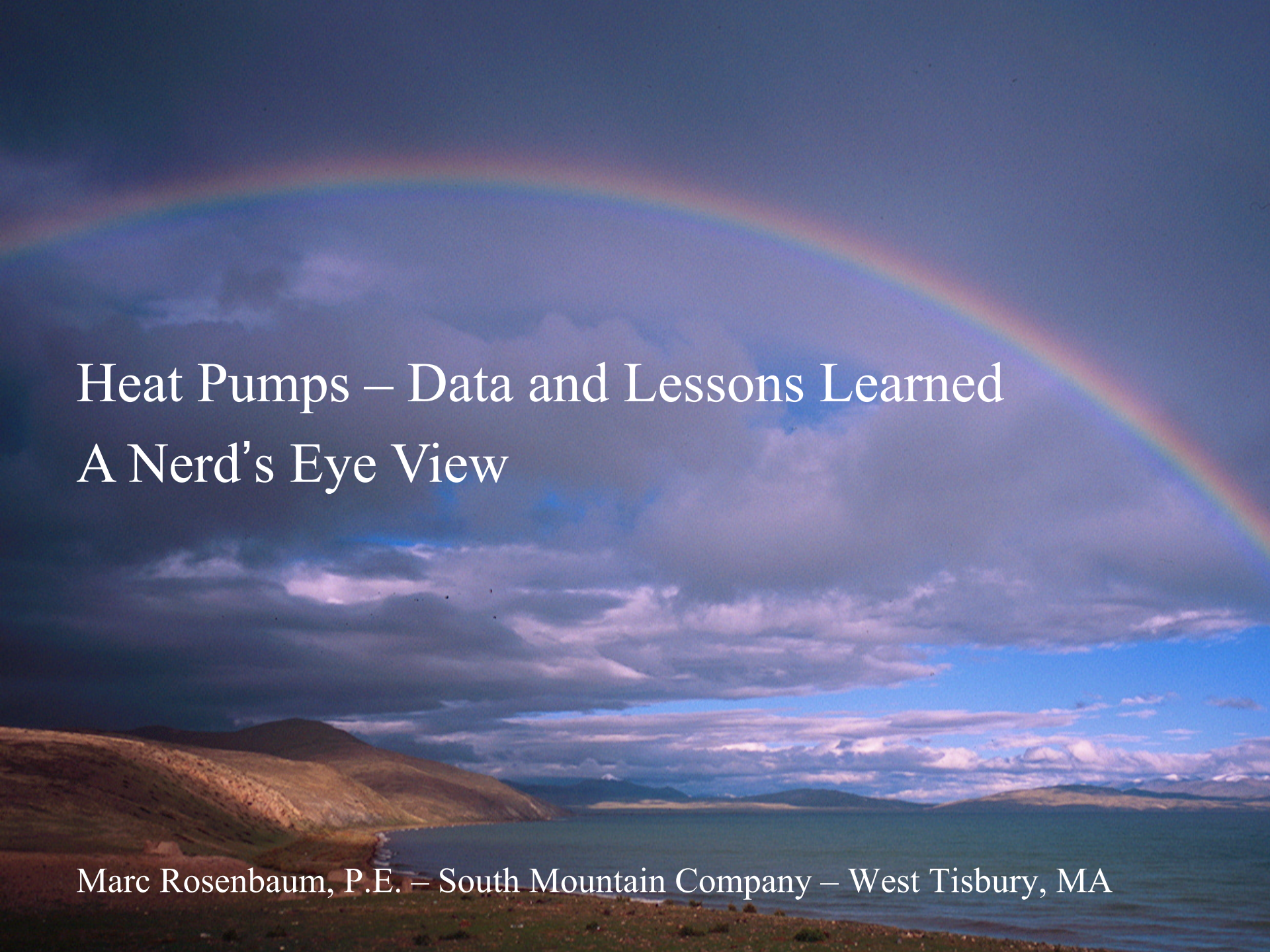


Heat Pumps – Data and Lessons Learned
A Nerd's Eye View

Marc Rosenbaum, P.E. – South Mountain Company – West Tisbury, MA

Why Heat Pumps?

- No onsite combustion
- No chimney or venting
- Provide heating and cooling (space conditioning)
- Cost-competitive in installation and operation
- Combines with renewable electricity to achieve Zero Net Energy

Space Conditioning with Minisplits

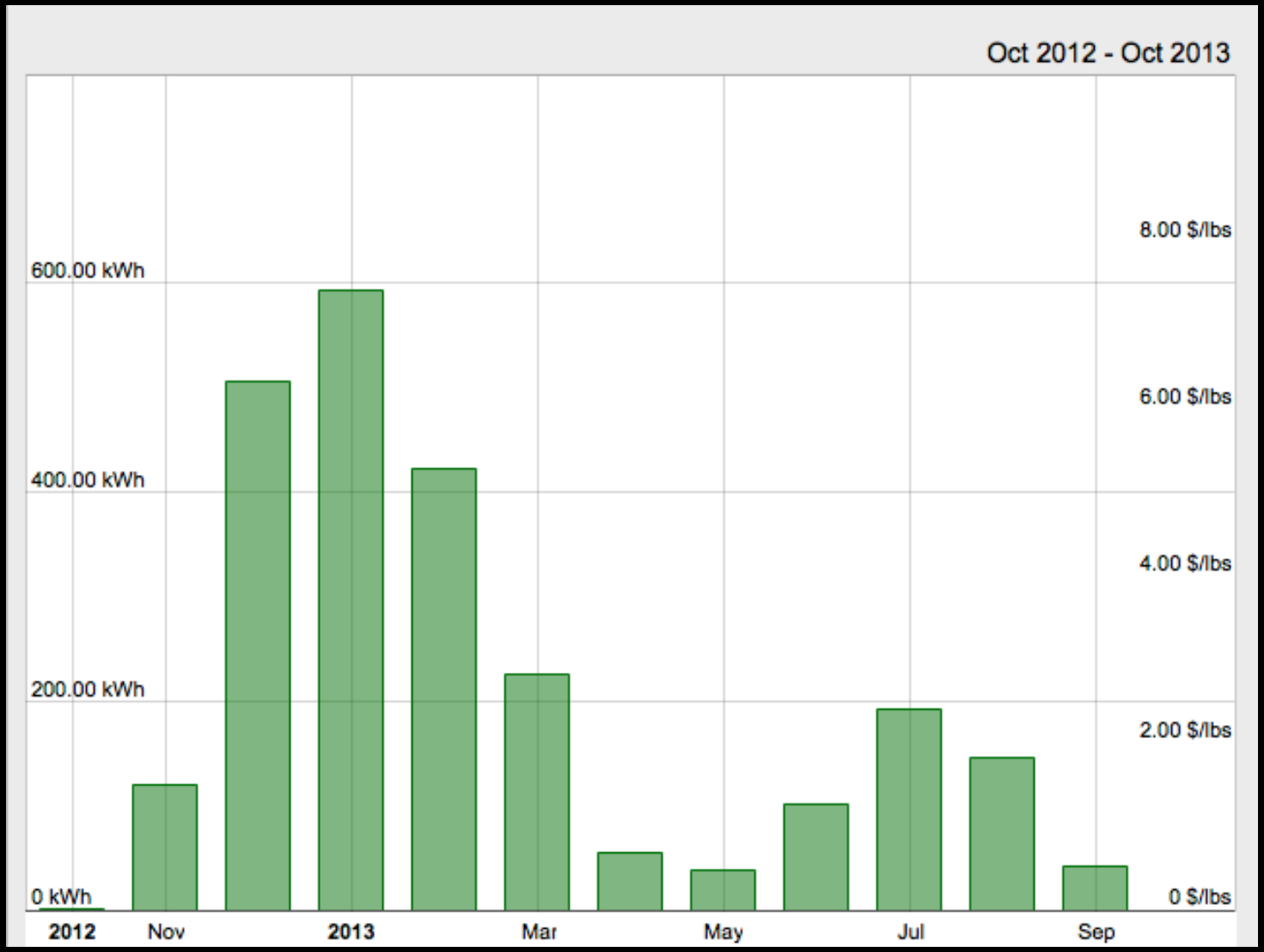
- Packaged technology
- Reliable
- Ducted and non-ducted solutions

Non-ducted Single Zone System

Non-ducted Single Zone System

- Single family PH in Brattleboro, VT
- 2,392 gsf, 1,766 sf TFA
- Mitsubishi Hyperheat FE12NA – HSPF 10.6
- PHPP predicted heating load is 4.23 kBTU/sf TFA/yr
- Predicted heating consumption 1.7 – 2.1 kBTU/sf TFA/yr, based on COP of 2.0 – 2.5
- Actual heating consumption 4.0 kBTU/sf TFA/yr
  - Setpoint?
  - COP?
  - Insolation?
  - PHPP?
  - Standby energy usage?
- Cool air doesn't rise

Non-ducted Single Zone System



Ducted Single Zone System

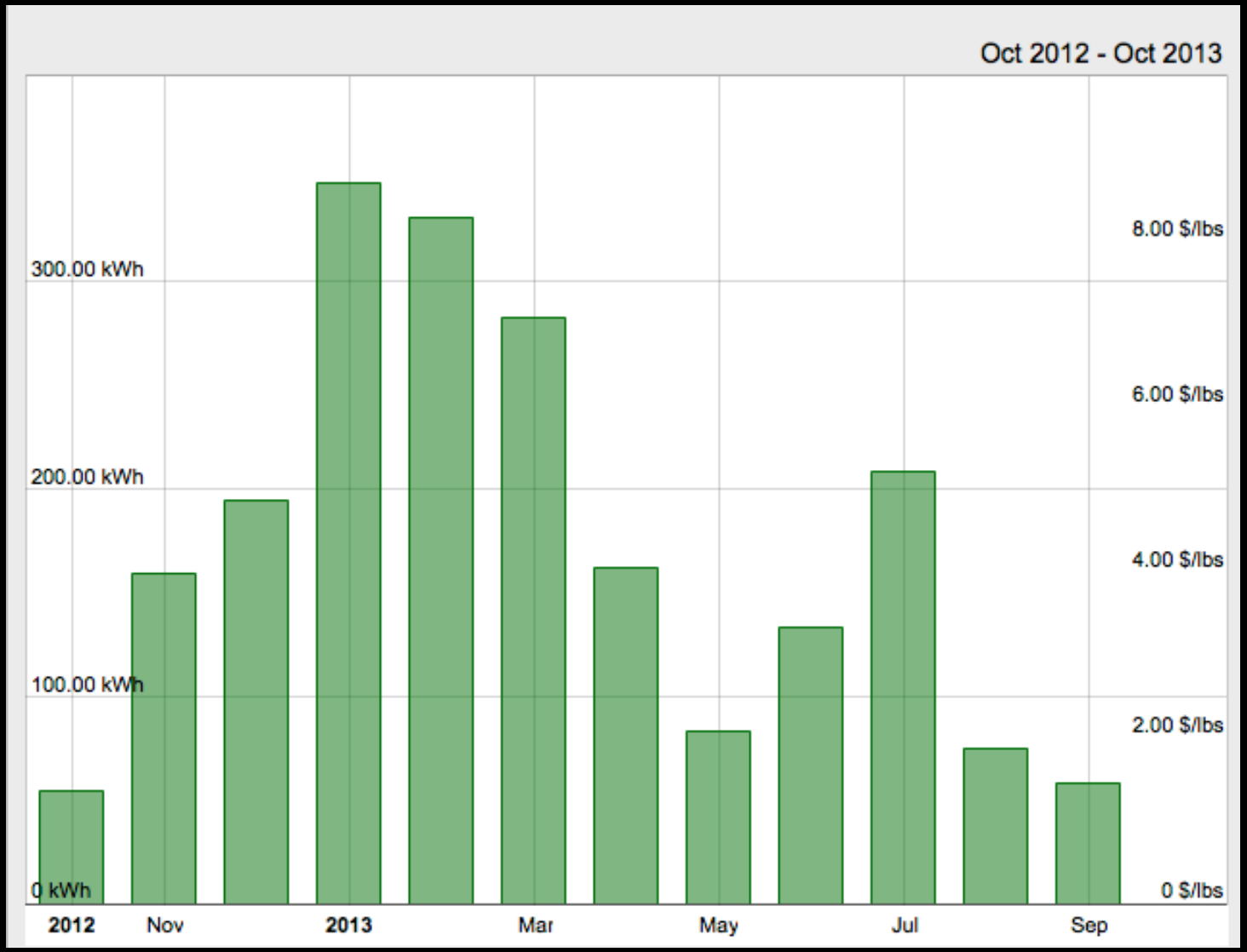
Caretaker Cottage – South Mountain Company

Ducted Single Zone System

- Single family DER in Chilmark, MA
- 1,258 gsf above basement
- Mitsubishi SUZ-KA18NA / SEZ-KD18NA – HSPF 10.0
- Simplified model predicted heating consumption of 1,649 – 2,061 kWh/yr based on COP of 2.0 – 2.5
- Actual heating consumption 1,749 kWh October 2012 – June 2013
- Additional electric heat on 2nd floor used 195 kWh


86.8
106.4
71.9
107.9
106
104
102
100
98
96
94
92
90
88
86
84
82
80
78
76
74
72
69.6
°F

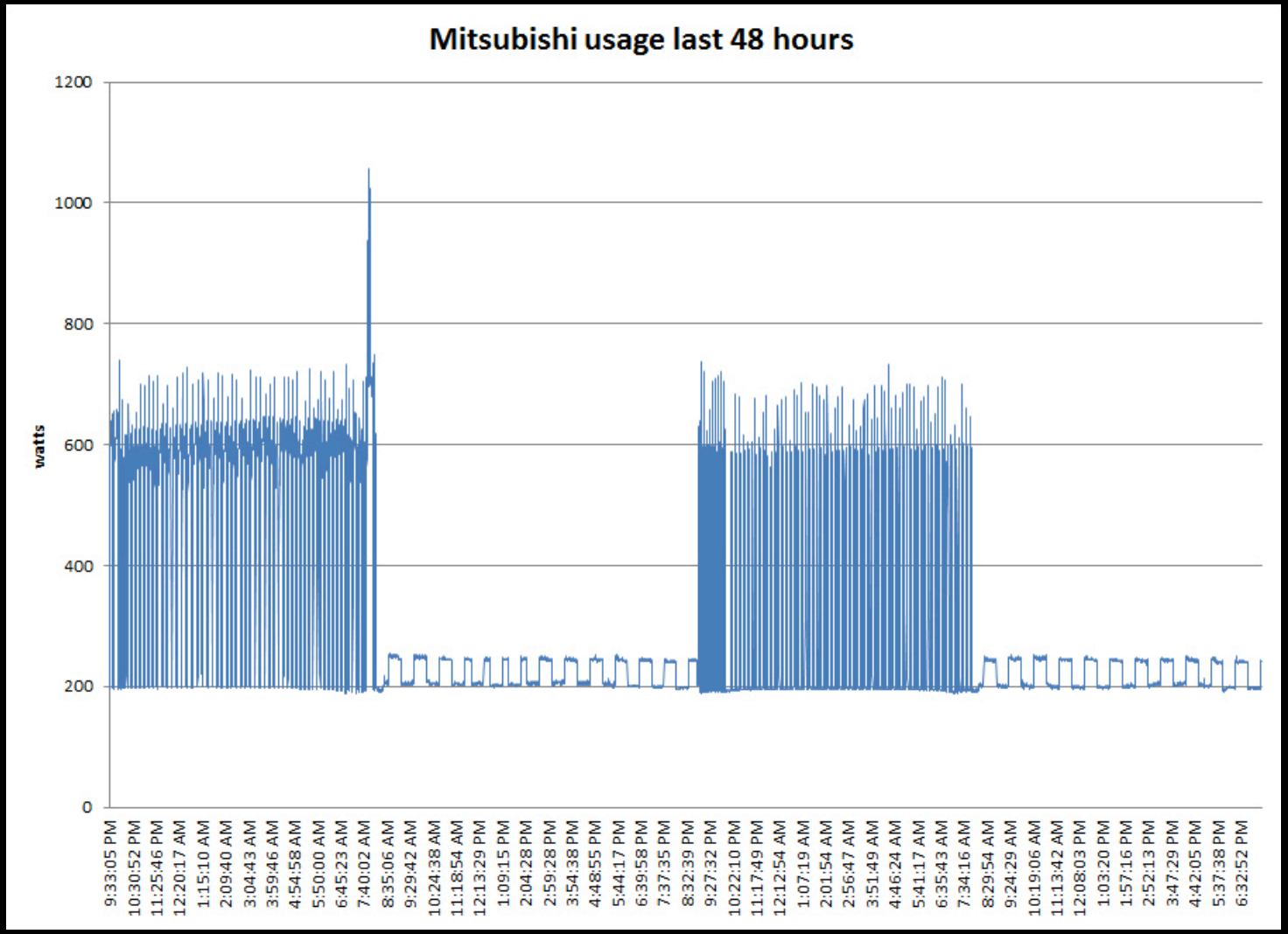
Ducted Single Zone System



Ducted Single Zone System

- Standby power is about 40W
- Duct Blaster result 21CFM25 after leaks sealed in AHU – about 3% of system flow
- Very quiet
- Low external static pressure increases duct sizing
- Duct insulation important in non-conditioned space
- Newer products such as Fujitsu RLFC series offer HSPF as high as 12.2, high outputs at low temperatures (9,000 BTU/hr unit rated at 15,400 BTU/hr at 5˚F), and lower system CFM – smaller ducts, higher supply air temperature

High System Baseline Power Use



Non-ducted Multi-zone VRF System

Bement School Dorms – Margo Jones Architect

Multi-zone VRF System

- Dormitory/faculty apartments Deerfield, MA
- 11,000 gsf, superinsulated construction
- (4) Mitsubishi 3 ton City Multi VRF condensers, 11 indoor units
- Simplified model predicted heating consumption of 12,545 kWh/yr based on COP of 2.5
- Actual heating consumption 13,200 kWh/yr first two years
- Cooling energy consumption first year was 10,231 kWh/yr – second year 8,367 kWh/yr – changed operating mode
- System has operated in below 0˚F conditions

Multi-zone Cold Climate VRF System

- Public school DER Plainfield, NH
- 8,000 gsf, superinsulated construction
- (1) Mitsubishi 8 ton City Multi Hyperheat VRF condenser, 11 indoor units
- Actual heating consumption 7,703 kWh/yr 9/15/10 – 6/11/11
- System has operated in -22˚F conditions
- System bid for $43K installed
- Most of the school has been retrofitted, and 32 tons of heat pumps added in total, and *electrical usage has not increased* while oil usage has dropped over 8,000 gallons/yr
- Total primary energy is 54 kBTU/sf/yr

Air-to-Water System

Installed by a f@*%#*^ messy French bastard

Chilmark Estate– South Mountain Company

Air-to-Water System

- Two houses totaling 7,500 sf in Chilmark, MA
- Removed Buderus oil boiler providing heat/DHW for both
- Installed (2) 4.5 ton Daikin Althermas and (1) 28 kW electric boiler in Main House, plus (1) 4.5 ton Altherma and (1) 20 kW electric boiler in Guest House
- Installed (2) 80 gallon Daikin DHW tanks as preheat to 120 gallon Viessmann electric DHW tank in Main House and (1) 80 gallon Daikin DHW tank as preheat to 80 gallon Buderus electric DHW tank in Guest House
- Installed Buderus gas boiler as emergency back-up for power outages
- At outdoor temperatures below ~25˚F, switchover to electric boilers
- Houses heated to 55˚F in winter

Air-to-Water System

- Previous energy usage was 3,187 gallons/yr of fuel oil, resulting in 71,389 lbs/yr of CO2
- Mid-May 2012 – mid-May 2013 energy usage was 10,740 kWh into the heat pumps, 7,651 kWh into the electric boilers, and 1,738 kWh into the electric DHW tanks – total of 19,859 kWh/yr. Using eGrid value of 728 lbs of CO2 per MWh for NEWE region, CO2 emissions were 14,457 lbs/yr, an 80% reduction. Fuel cost reduction was 70%.

Air-to-Water System

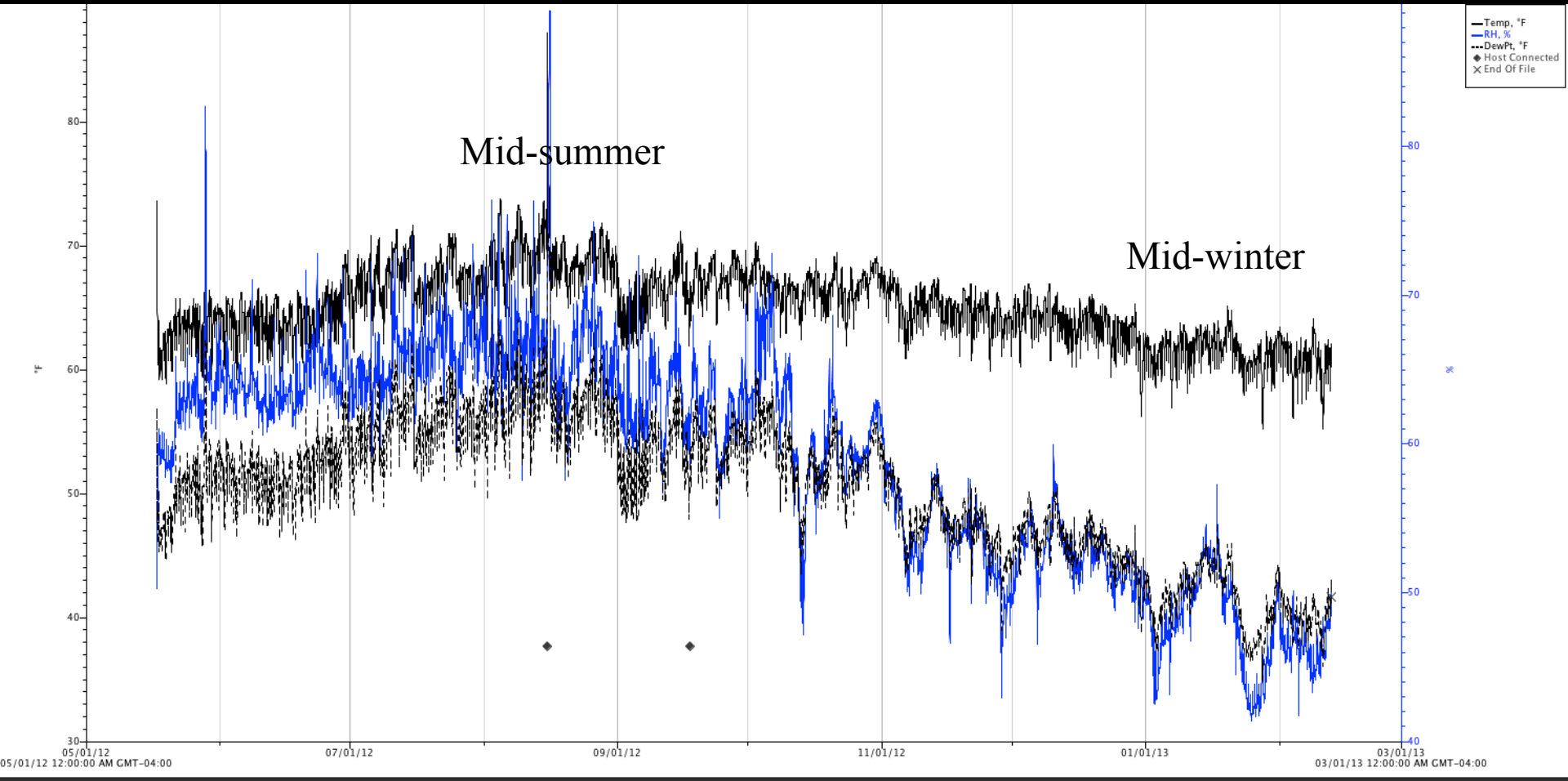
- Altherma heats DHW indirectly, sacrificing efficiency
- Guest House made DHW at 0.13 kWh/gallon (mixed value, hp plus electric resistance)
- Newer and smaller Althermas are rated at higher efficiencies and less reduction in output at low temperatures
- Best suited with radiant floors or any low temperature delivery system
- Expensive and much more complex than air-to-air minisplits

Heat Pump Water Heaters

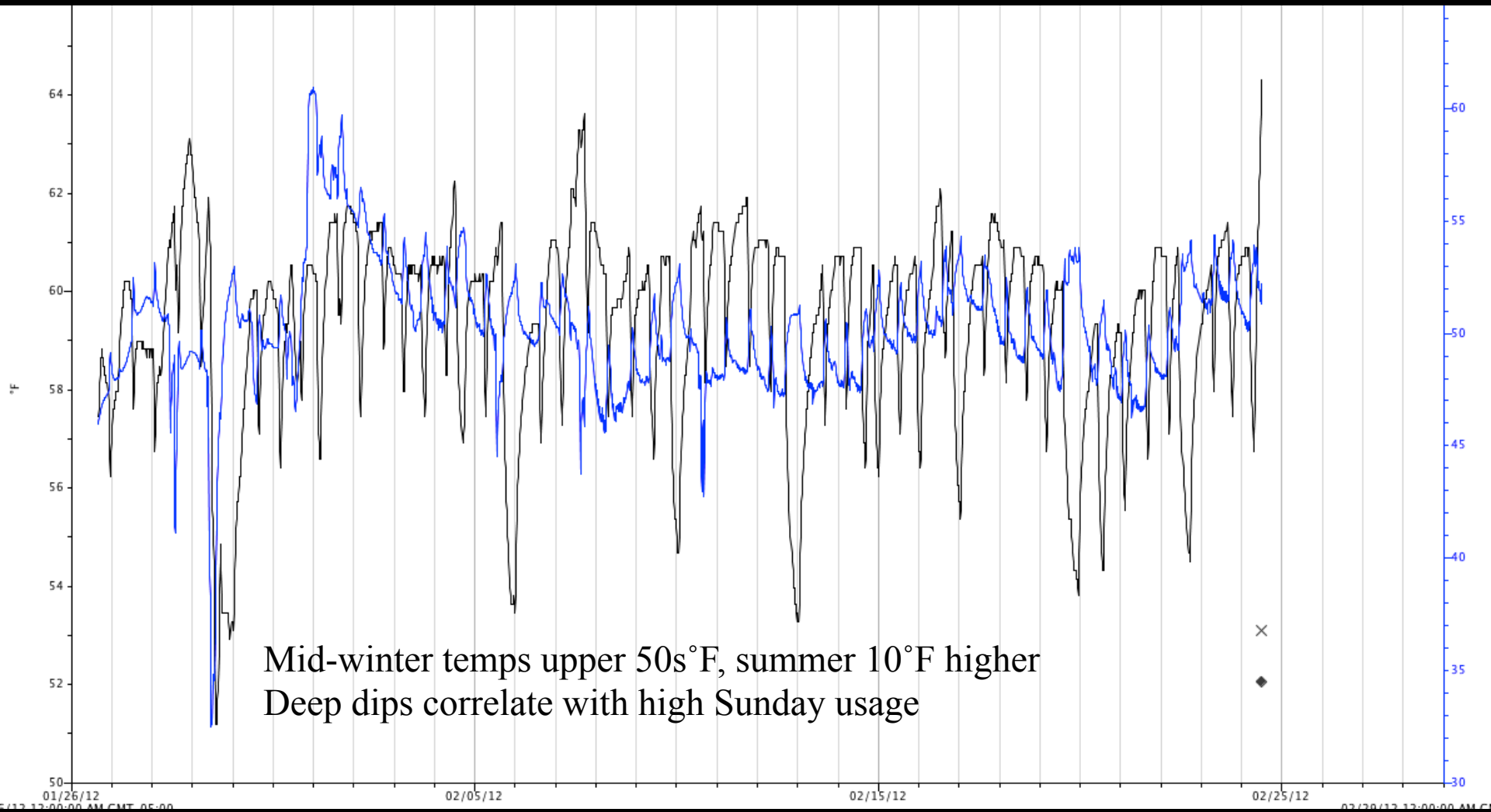
Heat Pump Water Heaters

- Two installations of Stiebel Eltron Accelera HPWHs
- 80 gallon tank, 5-600W HP, 1,700W electric resistance back-up
- Water meters on cold water inlets to tanks
- Case 1 in year-round DER with 42 gpd, Case 2 in seasonally occupied uninsulated basement with 49 gpd estimated
- Baseline is 50 gallon Marathon electric resistance water heater which uses 0.21 kWh/gallon
- In Case 1, HPWH consumed 0.062 kWh/gallon
- In Case 2, HPWH consumed 0.070 kWh/gallon

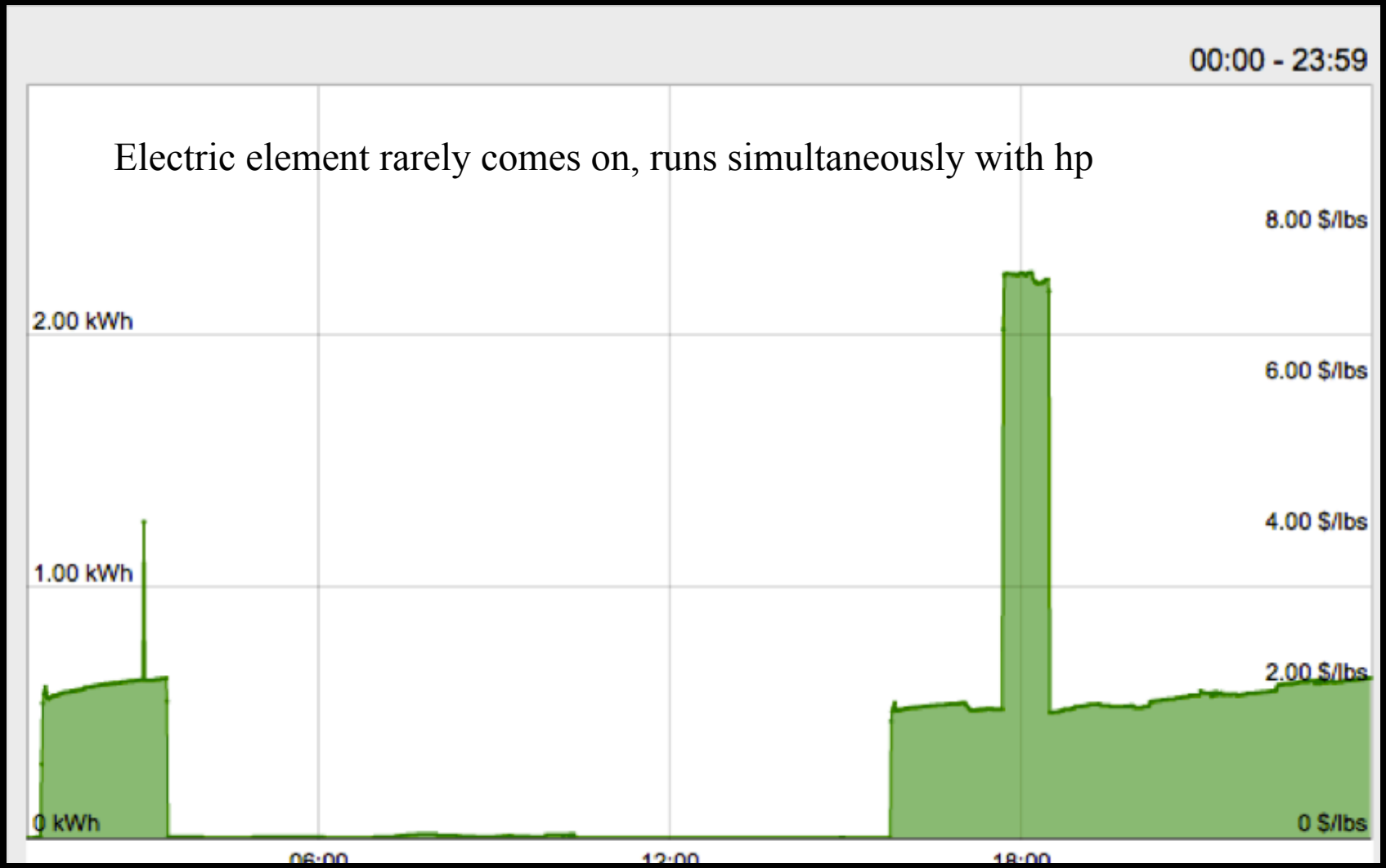
Heat Pump Water Heaters



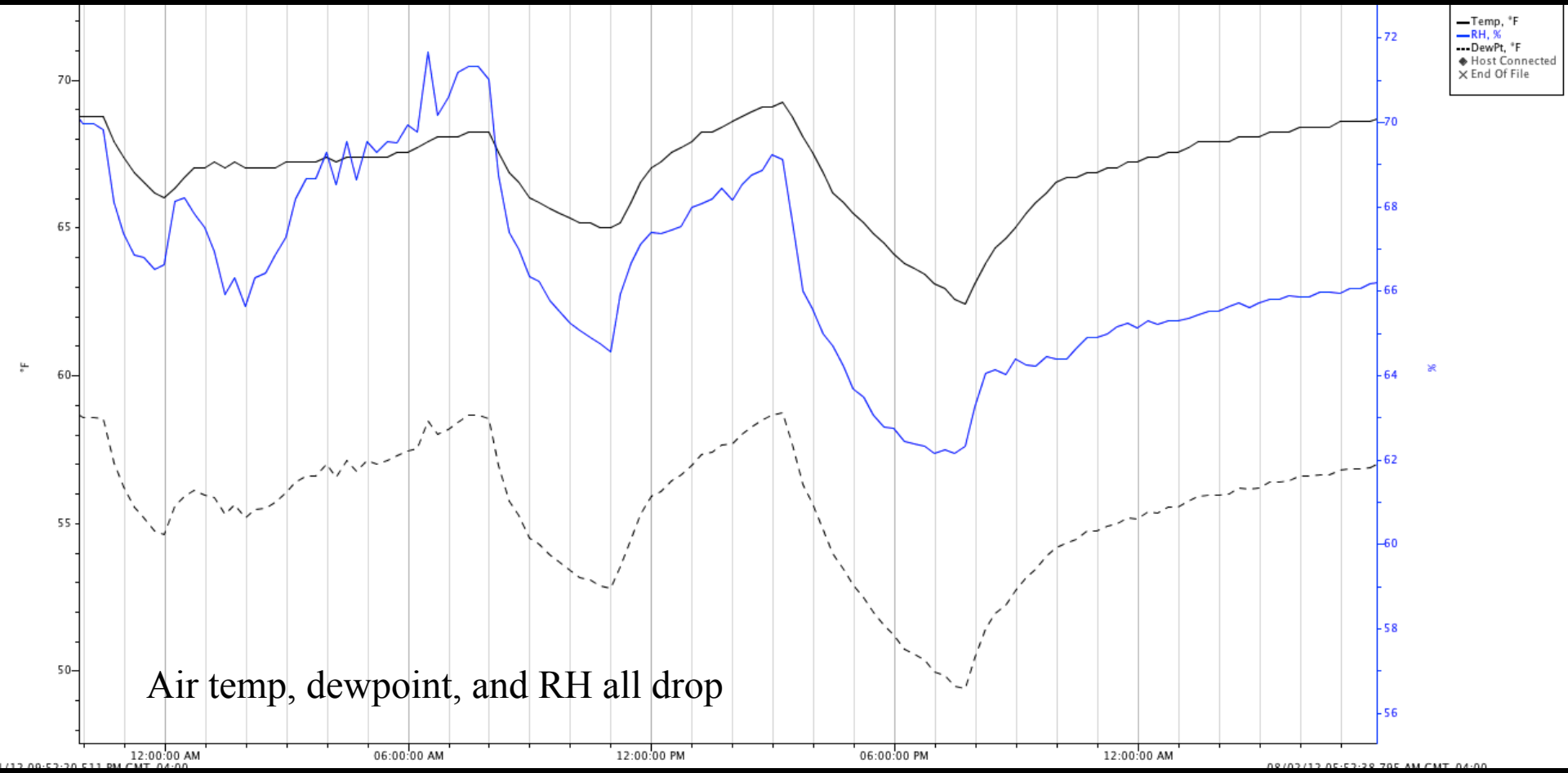
Heat Pump Water Heaters



Heat Pump Water Heaters



Heat Pump Water Heaters



Heat Pump Water Heaters

- In Case 2, the HPWH replaced an old oil boiler with a tankless coil and an 80 gallon DHW storage tank. Summer oil usage was approximately 1.05 gpd
- Estimated CO2 emission reduction was 89%

Heat Pump Pool Heaters

- Heat pump pool heaters operate at COPs of 4-5, saving emissions and cost vs. gas pool heaters
- Coupled with a solar electric system, they heat the pool on demand and power the pool pump, while exporting excess electricity during the rest of the year


Thank you
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http://thrivingonlowcarbon.typepad.com/
http://www.southmountain.com/