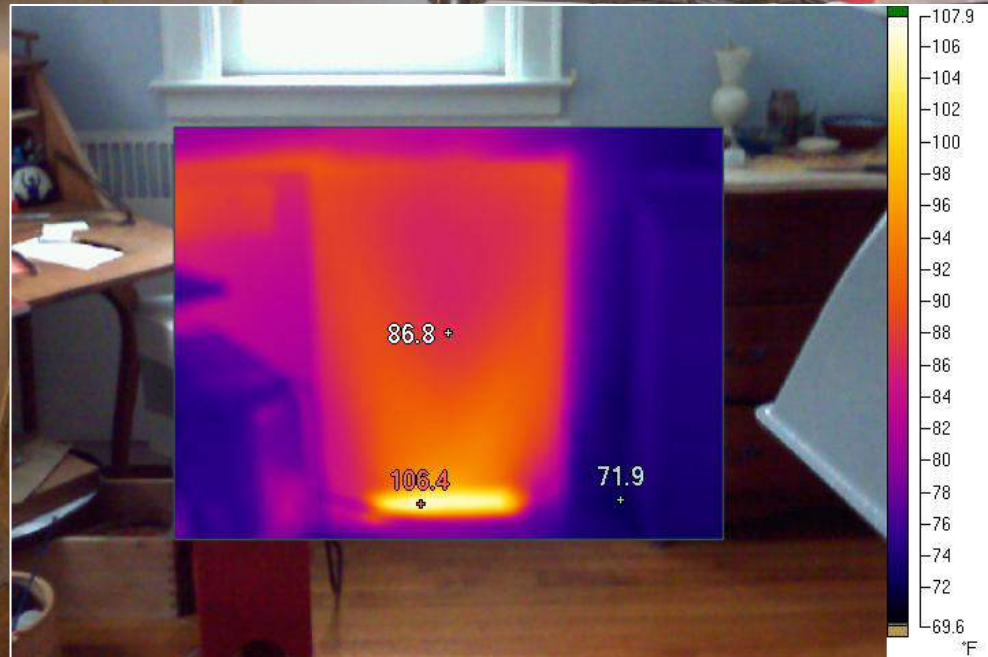
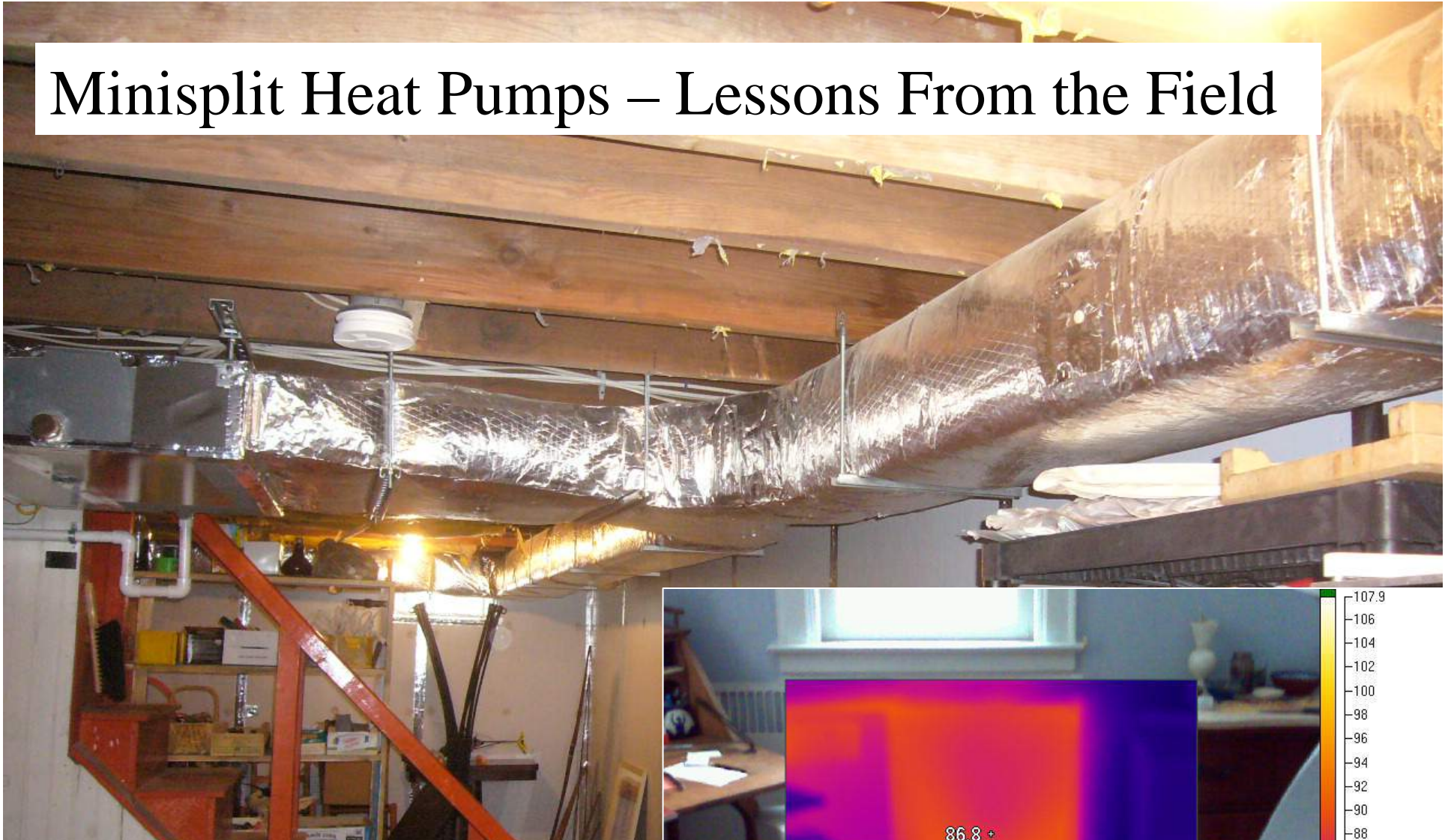


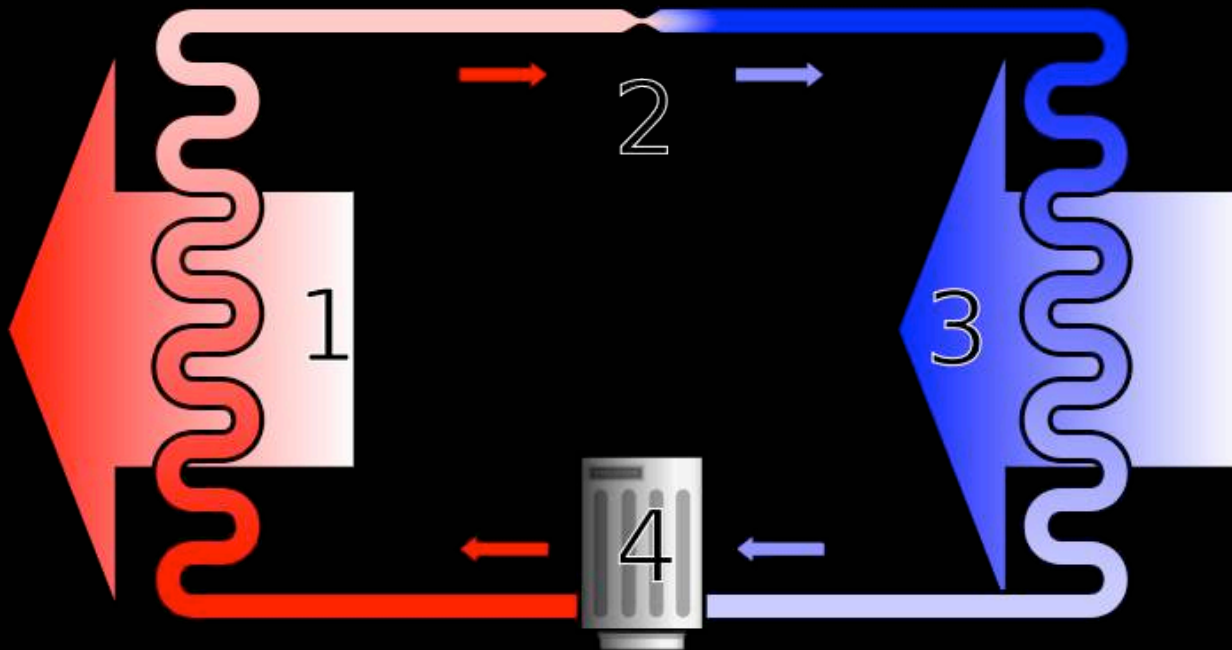
Minisplit Heat Pumps – Lessons From the Field



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

What's A Heat Pump?

A device that consists of a compressor, an expansion valve, a refrigerant, and two heat exchangers, that uses electricity to move heat from a colder location to a warmer one.



The advantage is in the concept of COP...

What's COP?

In an electric heat pump, Coefficient of Performance (COP) is the ratio of how much energy is moved by a heat pump divided by how much electrical energy is put into the system. More efficient heat pumps have higher COPs.

$$\text{COP} = \frac{\text{energy supplied to the space}}{\text{energy input to the heat pump}}$$

What's a Minisplit Heat Pump?

- A minisplit is an electrically-driven heat pump that uses the outdoor air (air source) as the source from which it extracts heat
- Developed by Japanese manufacturers, minisplits use variable speed, inverter-driven compressors, and variable speed fans, to achieve high efficiency
- Traditionally, air source heat pumps weren't used in predominantly heating climates because their capacity dropped off too quickly at cold temperatures, requiring expensive electric resistance as back-up heating
- Minisplits don't need back-up heat
- *Cold climate* minisplit heat pumps are available with rated outputs at temperatures as low as **-15°F**

Space Conditioning with Minisplits

- Outdoor air is the source/sink for heating/cooling
- Packaged technology includes controls
- Reliable
- Ducted and non-ducted solutions
- Single and multizone systems
- Inverter-driven, highly variable systems

Space Conditioning with Minisplits

Indoor Equipment



Ceiling-recessed



Floor-mounted



Horizontal-ducted



Wall-mounted

Outdoor Equipment



M-Series OD Units

- Residential systems rated outputs 9,000 to 48,000 BTU/hour
- Single and multizone (up to 8) systems
- Several types of indoor terminal units

Space Conditioning with Minisplits



Products

SINGLE ZONE



Wall Mounted



Universal Floor / Ceiling



Large Ceiling



Slim Duct



Compact Cassette



Cassette

MULTI ZONE




Multi Zone Systems (2 to 4 Zones)



Flex Zone Systems (2 to 8 Zones)

COP vs. Temperature

COP is dependent on source (outdoor air) temperature. The colder the outdoor air, the lower the COP is.

MXZ-4C36NAHZ Heating capacity without any float 

| Temp | | Rated freq. (Non-ducted) | | | Rated freq. (Ducted) | | |
|------------|-----------|--------------------------|-------------|--------------|----------------------|-------------|--------------|
| Outdoor(F) | Indoor(F) | Capacity KBtu/h | Input kW | COP (W/W) | Capacity KBtu/h | Input kW | COP (W/W) |
| -13 | 70 | 33.8 | 4.68 | 2.12 | 33.8 | 5.95 | 1.66 |
| -4 | 70 | 39.4 | 5.07 | 2.28 | 39.4 | 6.45 | 1.79 |
| 5 | 70 | 45.0 | 5.46 | 2.42 | 45.0 | 6.95 | 1.90 |
| 14 | 70 | 45.0 | 4.81 | 2.74 | 45.0 | 6.12 | 2.16 |
| 23 | 70 | 45.0 | 4.15 | 3.17 | 45.0 | 5.29 | 2.49 |
| 32 | 70 | 45.0 | 3.71 | 3.56 | 45.0 | 4.72 | 2.80 |
| 41 | 70 | 45.0 | 3.41 | 3.87 | 45.0 | 4.34 | 3.04 |
| 50 | 70 | 45.0 | 2.81 | 4.70 | 45.0 | 3.57 | 3.69 |
| 59 | 70 | 45.0 | 2.34 | 5.64 | 45.0 | 2.98 | 4.43 |

Capacity vs. Temperature

As with COP, heating capacity drops with decreasing outdoor temperature.

6-2. HEATING CAPACITY

■ MODEL: ASU9RLS2

| | |
|-----|-----|
| AFR | 500 |
|-----|-----|

| | | Indoor temperature | | | | | | | |
|--------------------------|------|--------------------|------|------|------|------|------|------|--|
| | | °FDB | | 60 | | 65 | | 70 | |
| Outdoor temperature ↑ | °FDB | °FWB | TC | IP | TC | IP | TC | IP | |
| | -5 | -7 | 14.7 | 1.97 | 14.3 | 2.01 | 14.0 | 2.05 | |
| | 5 | 3 | 16.1 | 1.98 | 15.7 | 2.02 | 15.4 | 2.06 | |
| | 14 | 12 | 16.8 | 1.91 | 16.4 | 1.95 | 16.0 | 1.99 | |
| | 23 | 19 | 18.3 | 1.84 | 17.9 | 1.88 | 17.5 | 1.92 | |
| | 32 | 28 | 18.8 | 1.78 | 18.4 | 1.82 | 17.9 | 1.85 | |
| | 41 | 37 | 21.3 | 1.85 | 20.8 | 1.89 | 20.3 | 1.93 | |
| | 47 | 43 | 23.1 | 1.91 | 22.6 | 1.95 | 22.0 | 1.99 | |
| | 50 | 47 | 25.5 | 1.94 | 24.9 | 1.98 | 24.3 | 2.02 | |
| 59 | 50 | 26.5 | 1.95 | 25.8 | 1.99 | 25.2 | 2.03 | | |

AFR : Air Flow Rate (CFM)
TC : Total Capacity (kBtu/h)
IP : Input Power (kW)

Cold Climate Minisplits

The fundamental question is:

How do I select a minisplit that will heat my project at the design temperature of the location?



Cold Climate ASHP Spec

Scope

- Air-to-air, split system heat pumps
- Both single-zone and multi-zone systems
- <65k Btu/hour at 47°F (dry bulb)
- Ducted and ductless systems
- Does NOT include ground-source or air-to-water heat pump systems

Performance Requirements

- Compressor must be variable capacity
- Indoor and outdoor units must be part of an AHRI matched system
- ENERGY STAR Certified
- COP @5° F >1.75 (at maximum capacity operation)
- HSPF >10 for Single-zone systems or HSPF >9 for Multi-zone systems
- Engineering data for each system must be reported through the attached “Cold Climate Air-Source Heat Pump Performance Information Tables”. Incomplete tables will not be considered.

Cold Climate ASHP Spec

Provide engineering data for the conditions shown below. "Minimum" and "Maximum" refer to the steady-state heating capacities at each condition that equipment can deliver during normal operation. Capacities in the "Rated" column should correspond to those listed on the AHRI certificate at 47°F and 17°F ODB. In some cases these may be equal to the "Maximum" capacity values. Btu/hour is total heat output, and kW is power input. Do not include the power required for defrost cycling or drain pan heater operation in the table.

| Outdoor Dry Bulb (°F) | Indoor Dry Bulb (°F) | | Capacity Level | | |
|-----------------------|----------------------|-------|----------------|-------|---------|
| | | | Minimum | Rated | Maximum |
| 47°F | 70°F | Btu/h | | | |
| | | kW | | | |
| | | COP | | | |
| 17°F | 70°F | Btu/h | | | |
| | | kW | | | |
| | | COP | | | |
| 5°F | 70°F | Btu/h | | | |
| | | kW | | | |
| | | COP | | | |

OPTIONAL- If engineering data are available for operation at lower temperatures (below 5°F), provide this information below.

What Is The Selection Process?

- ✓ Determine the design heating temperature for the location
- ✓ Determine the building heating load at design temperature
- ✓ Determine how many heating zones
- ✓ Decide what format(s) of indoor unit is desired (ducted or non-ducted)?

Example: Non-ducted Single Zone System

- Design temperature 8°F
- Design heating load 13,000 BTU/hr
- Wall cassette, single zone

Find a unit that has at least 13,000 BTU/hr at 5°F

Example: Non-ducted Single Zone System

WALL MOUNTED TYPE
ASU9-15RRLS2

Fujitsu

6-2. HEATING CAPACITY

■ MODEL: ASU9RSL2

| | |
|-----|-----|
| AFR | 500 |
|-----|-----|

| | | Indoor temperature | | | | | | | | |
|---------------------|------|--------------------|------|------|------|------|------|------|------|------|
| | | °FDB | | 60 | | 65 | | 70 | | 75 |
| Outdoor temperature | °FDB | °FWB | TC | IP | TC | IP | TC | IP | TC | IP |
| | -5 | -7 | 14.7 | 1.97 | 14.3 | 2.01 | 14.0 | 2.05 | 13.3 | 2.13 |
| | 5 | 3 | 16.1 | 1.98 | 15.7 | 2.02 | 15.4 | 2.06 | 14.6 | 2.15 |
| | 14 | 12 | 16.8 | 1.91 | 16.4 | 1.95 | 16.0 | 1.99 | 15.2 | 2.07 |
| | 23 | 19 | 18.3 | 1.84 | 17.9 | 1.88 | 17.5 | 1.92 | 16.6 | 2.00 |
| | 32 | 28 | 18.8 | 1.78 | 18.4 | 1.82 | 17.9 | 1.85 | 17.0 | 1.93 |
| | 41 | 37 | 21.3 | 1.85 | 20.8 | 1.89 | 20.3 | 1.93 | 19.3 | 2.00 |
| | 47 | 43 | 23.1 | 1.91 | 22.6 | 1.95 | 22.0 | 1.99 | 20.9 | 2.07 |
| | 50 | 47 | 25.5 | 1.94 | 24.9 | 1.98 | 24.3 | 2.02 | 23.1 | 2.10 |
| 59 | 50 | 26.5 | 1.95 | 25.8 | 1.99 | 25.2 | 2.03 | 23.9 | 2.11 | |

AFR : Air Flow Rate (CFM)
TC : Total Capacity (kBtu/h)
IP : Input Power (kW)

Fujitsu also makes a single zone ducted unit with similar specs

Example: Non-ducted Single Zone System

Daikin

Temp: Fahrenheit **FTXS24LVJU + RXS24LVJU**

TC: kBtu/h

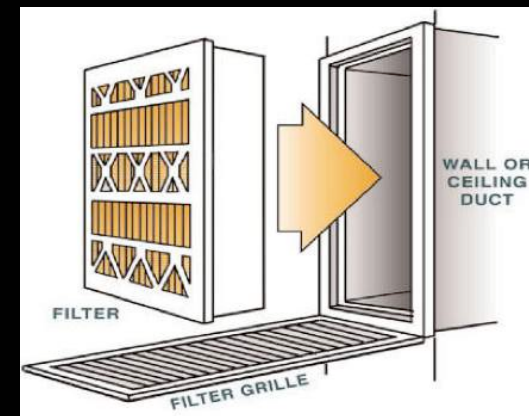
PI: kW

| INDOOR | OUTDOOR TEMPERATURE (°FWB) | | | | | | | | | | | |
|--------|----------------------------|------|-------|------|-------|------|-------|------|-------|------|-------|------|
| | 5 | | 14 | | 23 | | 32 | | 43 | | 50 | |
| EDB | TC | PI | TC | PI | TC | PI | TC | PI | TC | PI | TC | PI |
| °F | | | | | | | | | | | | |
| 59.0 | 12.09 | 1.42 | 14.53 | 1.50 | 16.96 | 1.57 | 22.82 | 2.05 | 26.26 | 2.16 | 28.55 | 2.23 |
| 70.0 | 11.34 | 1.46 | 13.78 | 1.54 | 16.22 | 1.61 | 21.95 | 2.10 | 25.40 | 2.21 | 27.68 | 2.28 |
| 71.6 | 11.05 | 1.48 | 13.48 | 1.55 | 15.92 | 1.62 | 21.60 | 2.12 | 25.03 | 2.23 | 27.33 | 2.30 |
| 75.2 | 10.75 | 1.49 | 13.18 | 1.57 | 15.62 | 1.64 | 21.24 | 2.14 | 24.68 | 2.25 | 26.98 | 2.32 |
| 77.0 | 10.60 | 1.50 | 13.04 | 1.57 | 15.47 | 1.65 | 21.07 | 2.15 | 24.51 | 2.26 | 26.80 | 2.33 |
| 80.6 | 10.30 | 1.52 | 12.74 | 1.59 | 15.17 | 1.66 | 20.72 | 2.17 | 24.16 | 2.28 | 26.45 | 2.35 |

Although this is nominally a 24,000 BTU/hr unit, its capacity at 5°F is lower than the previous nominal 9,000 and 12,000 BTU/hr units, and it can't meet our design heating load

Observations about Ducted Systems

- In small single zone houses we estimate a cost premium of \$2,500 – 5,000 vs. a single wall cassette system, depending on if additional electric heaters are provided and what they cost
- Advantages over point source include:
 - Quieter
 - Very even temperature distribution
 - Cooling throughout the house
 - Possible integration with ventilation
 - Filtration upgrades possible



Observations about Ducted Systems

- Low external static pressure increases duct sizing
- Beware short return lengths and fan noise (duh Marc)
- Traditional concepts such as throw become challenging
- Cold climate products such as Fujitsu RLFC series offer HSPF as high as 12.2, high outputs at low temperatures, and lower system CFM – smaller ducts, higher supply air temperature



This Fujitsu RLFC is 9,000 BTU/hr in cooling and 15,400 BTU/hr at 5°F using 353 CFM.

The air handler can be mounted vertically or horizontally.

Note access space required.

Observations about Ducted Systems

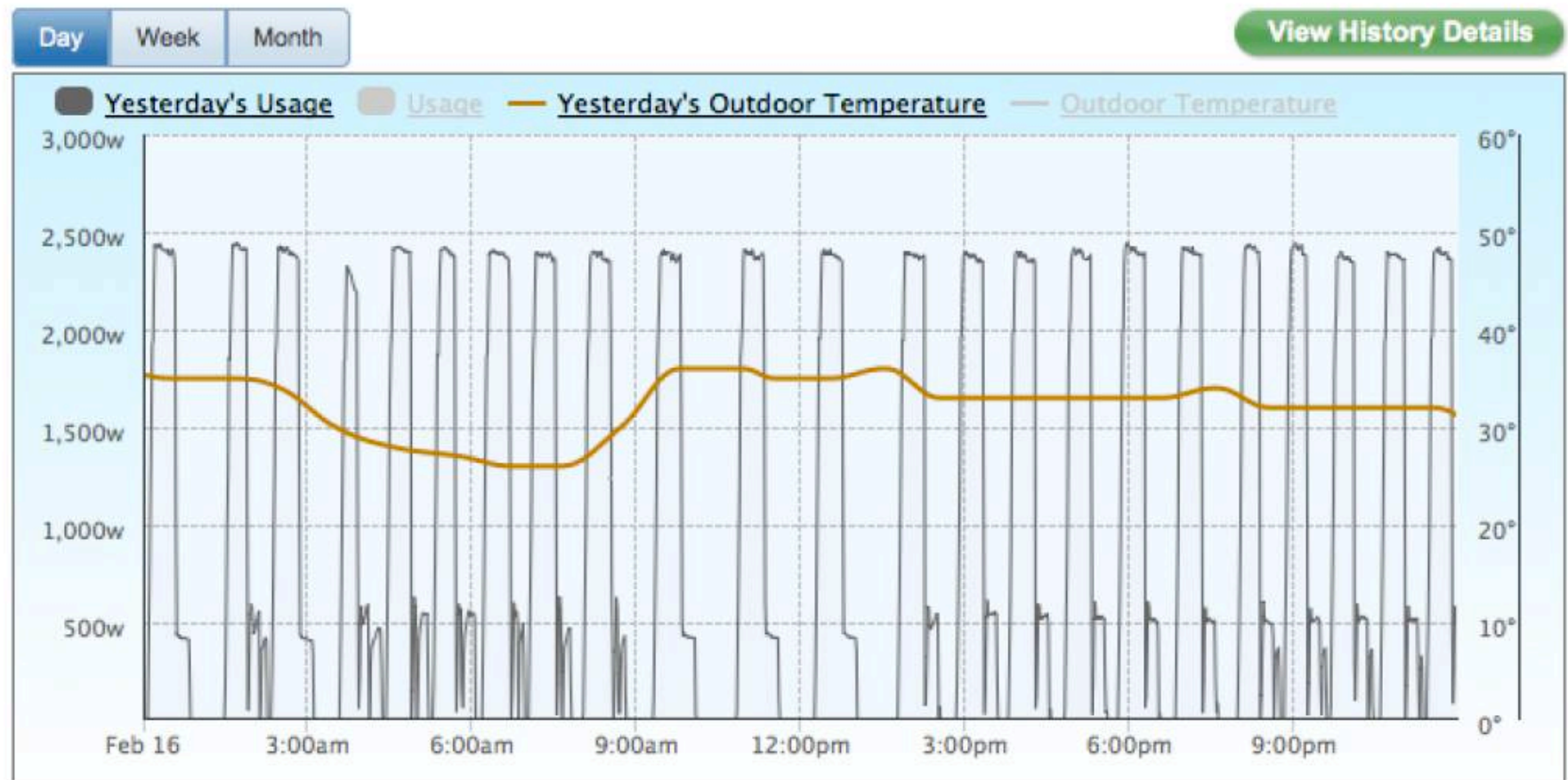


An Interesting Phenomenon



Ducted Fujitsu ARU9RLF/AOU9RLFC

Minisplit heat pump, Minute by Minute View for Today



Ducted Fujitsu ARU9RLF/AOU9RLFC

Minisplit heat pump, Minute by Minute View for Today

Day Week Month

[View History Details](#)

