Temperature Monitoring & Analysis
New Metrics of Weatherization Success?

2014 RESNET Building Performance Conference

Presented by

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Southeast Energy Assistance

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RESNET Atlanta

Today's Presentation Agenda

- Introduce new concepts in thermal monitoring
- Illustrate SEA pilot test results to date
- Discuss broader implications with you:
  - Might this be a natural "pre-qualifier"?
  - How does this redefine/measure/confirm success?
  - Is there a need for a national database?
  - Does this redefine QA and Cost Effectiveness?
- What might be some logical next steps?

Precision Temperature Monitoring

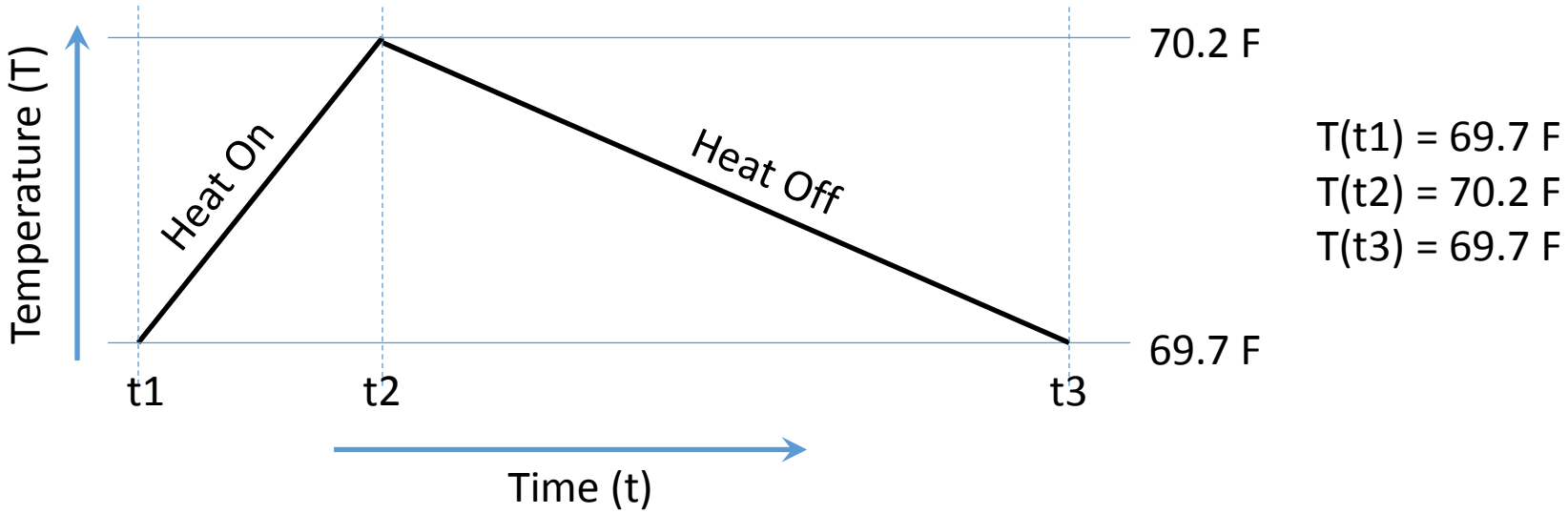
EKG monitoring defines heart health

Temperature monitoring defines home health

This is truly “The heartbeat of the home” SM

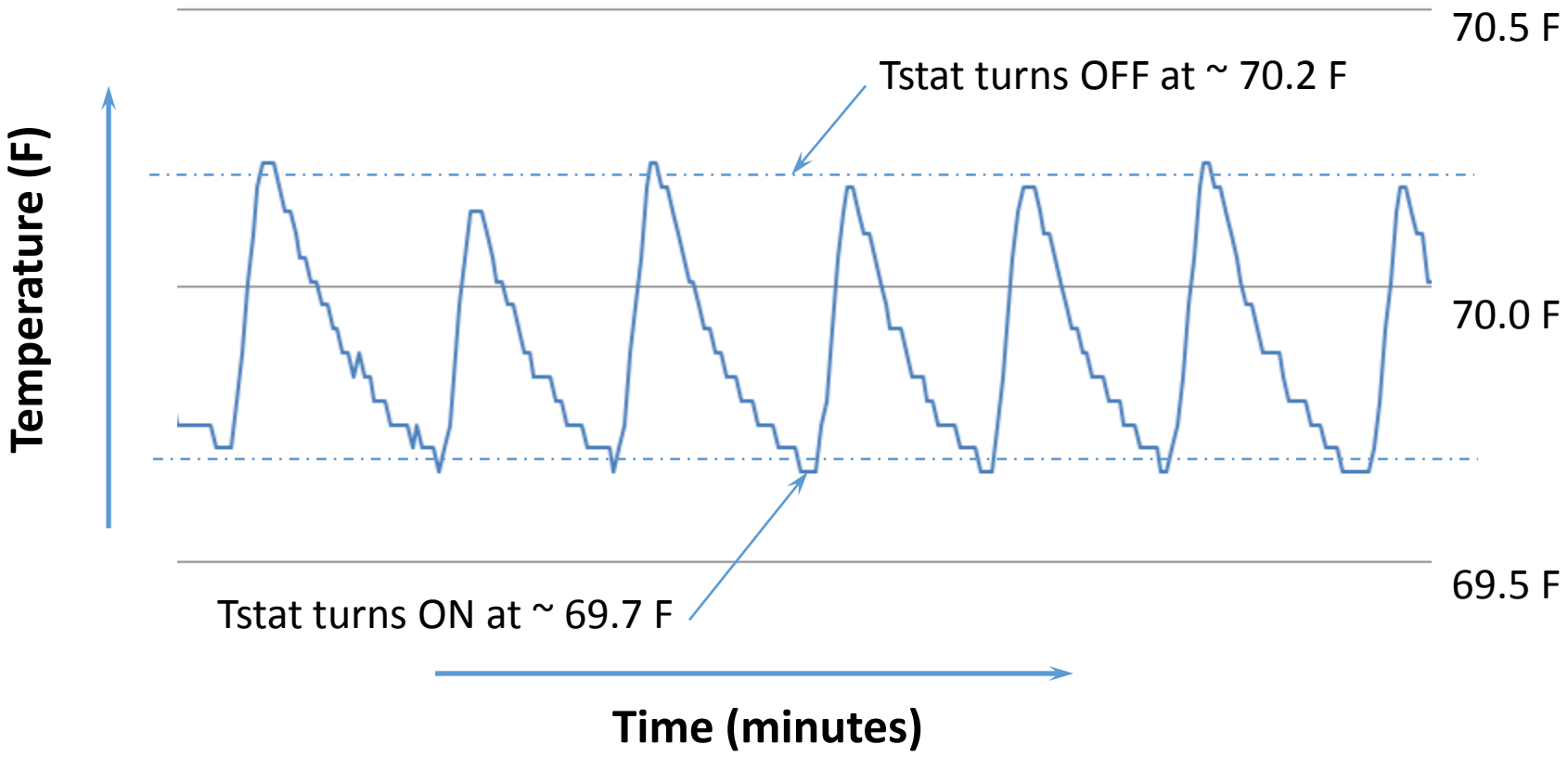
The Heat On Cycles tell you about the HVAC
Off Cycles tell you about the ENVELOPE

Think Temperature Rise and Fall **Rates**



Example of On/Off Cycle Tstat Heat Monitoring

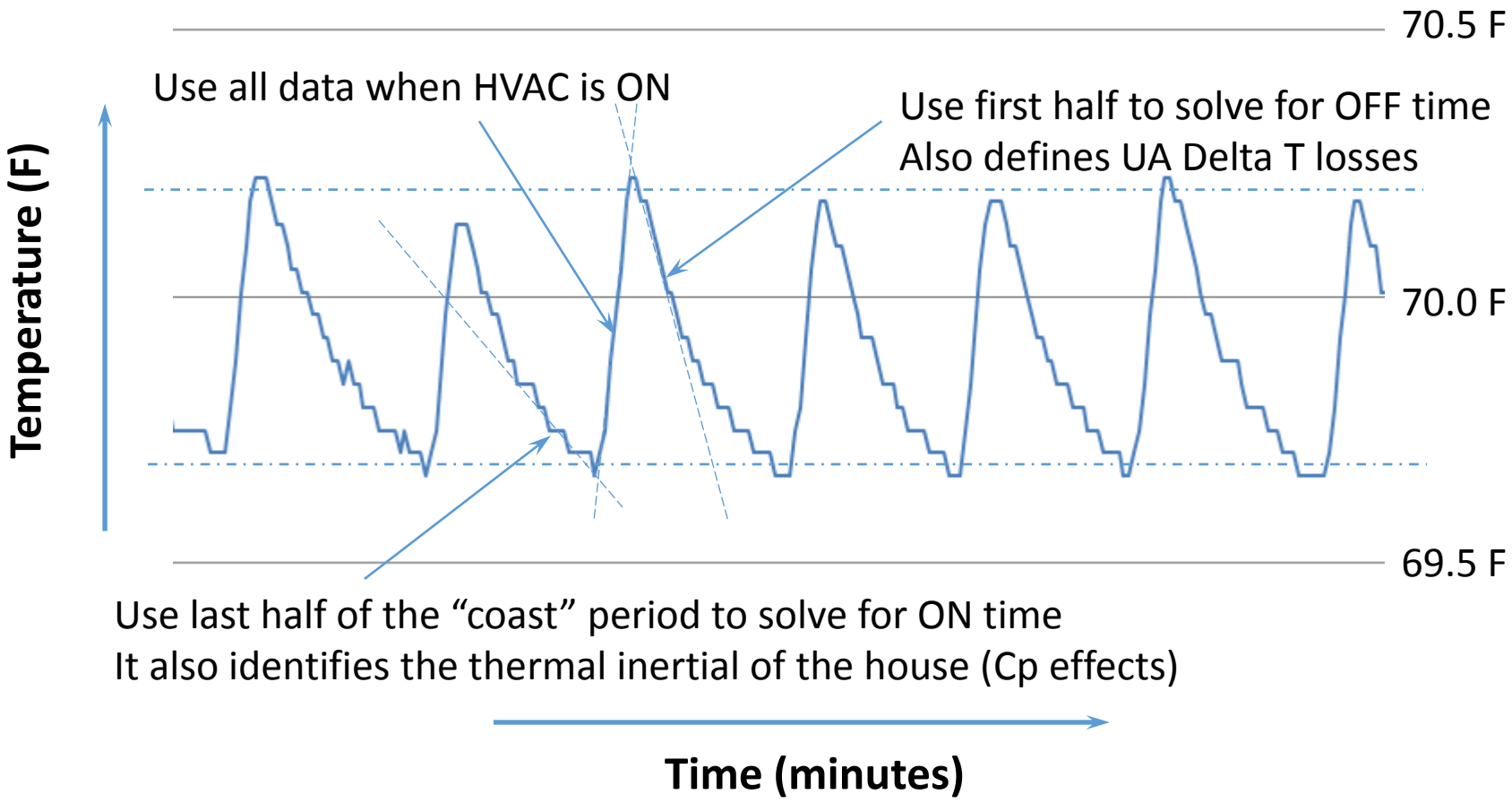
(Temperatures averaged over 1 minute with 0.04 Deg F resolution*)



* Onset Hobo Logger – 0.02 Deg F or better is also achievable

Example of On/Off Cycle Inferencing

Showing important choices about data into regression



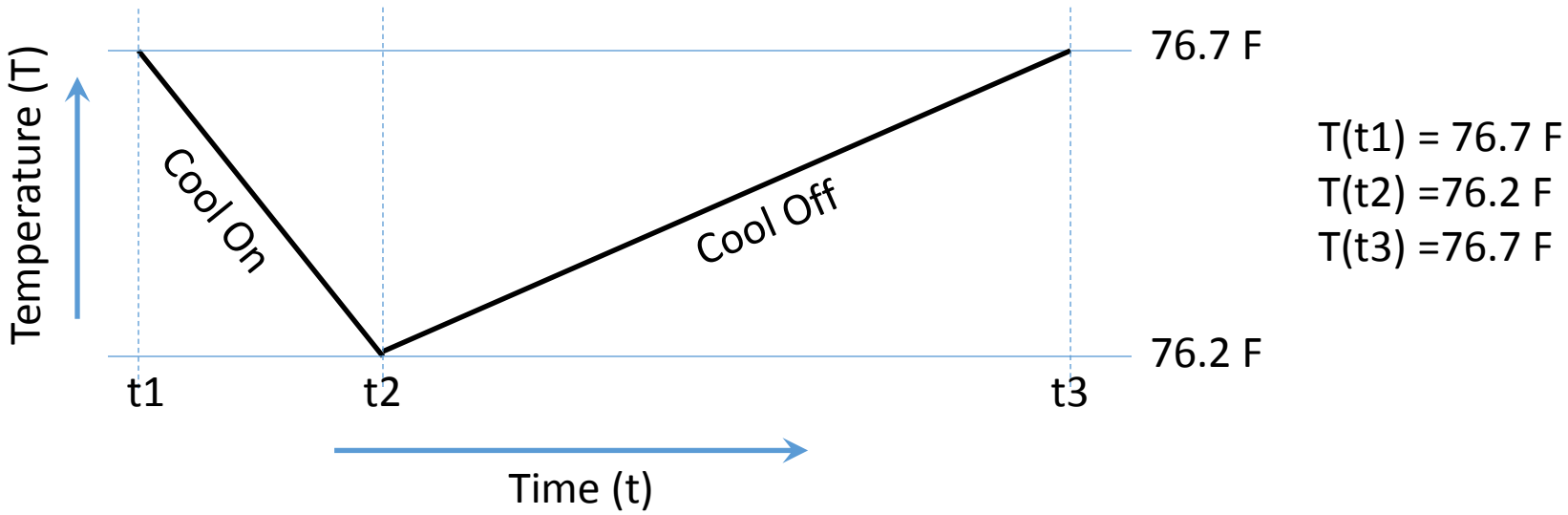
Many Device Builders & Partners

Example Providers

- Onset “Hobo”
- Lightstat
- JetLun

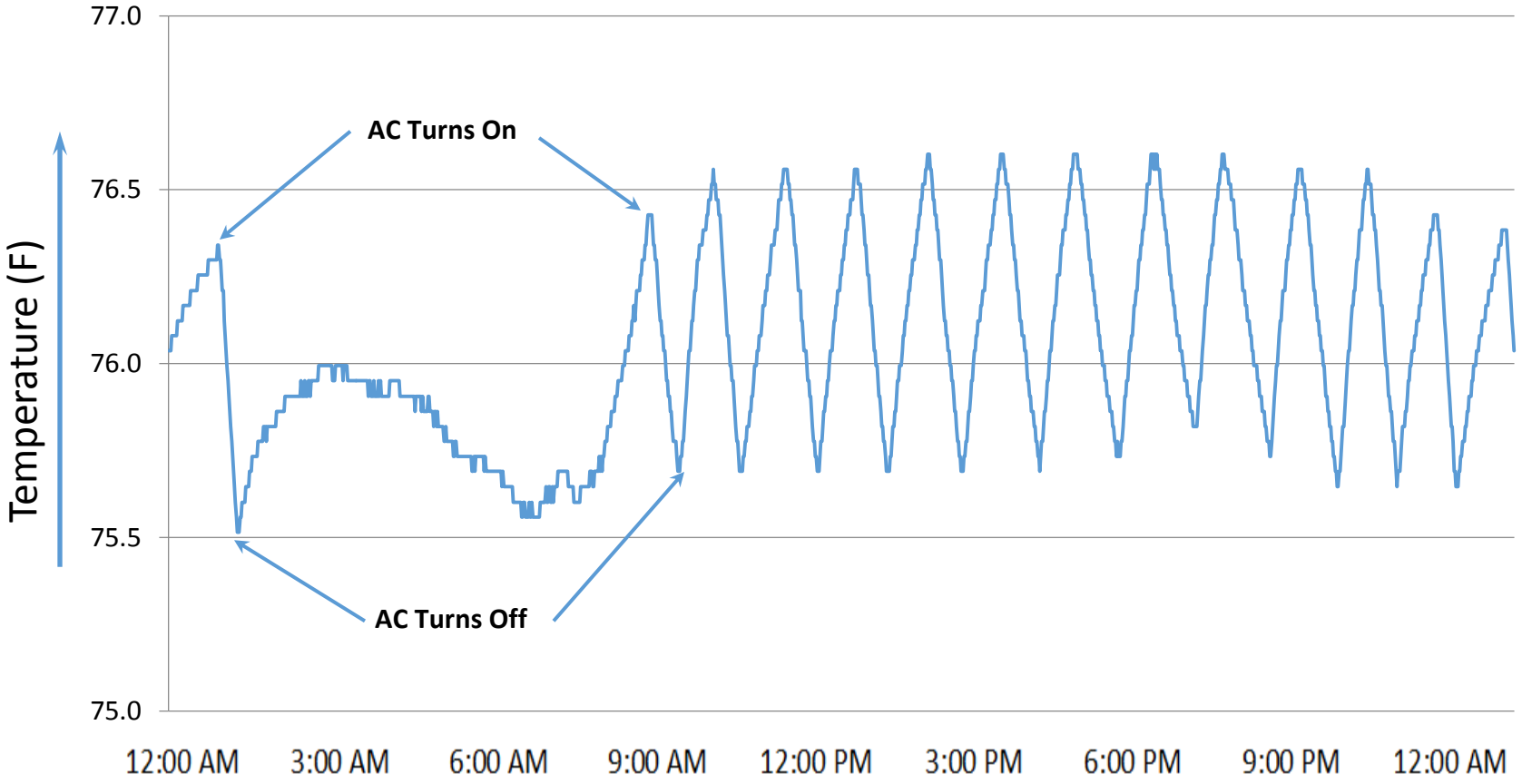
SEA used Hobo Loggers

Cooling Cycle Thermostat Example Setpoints

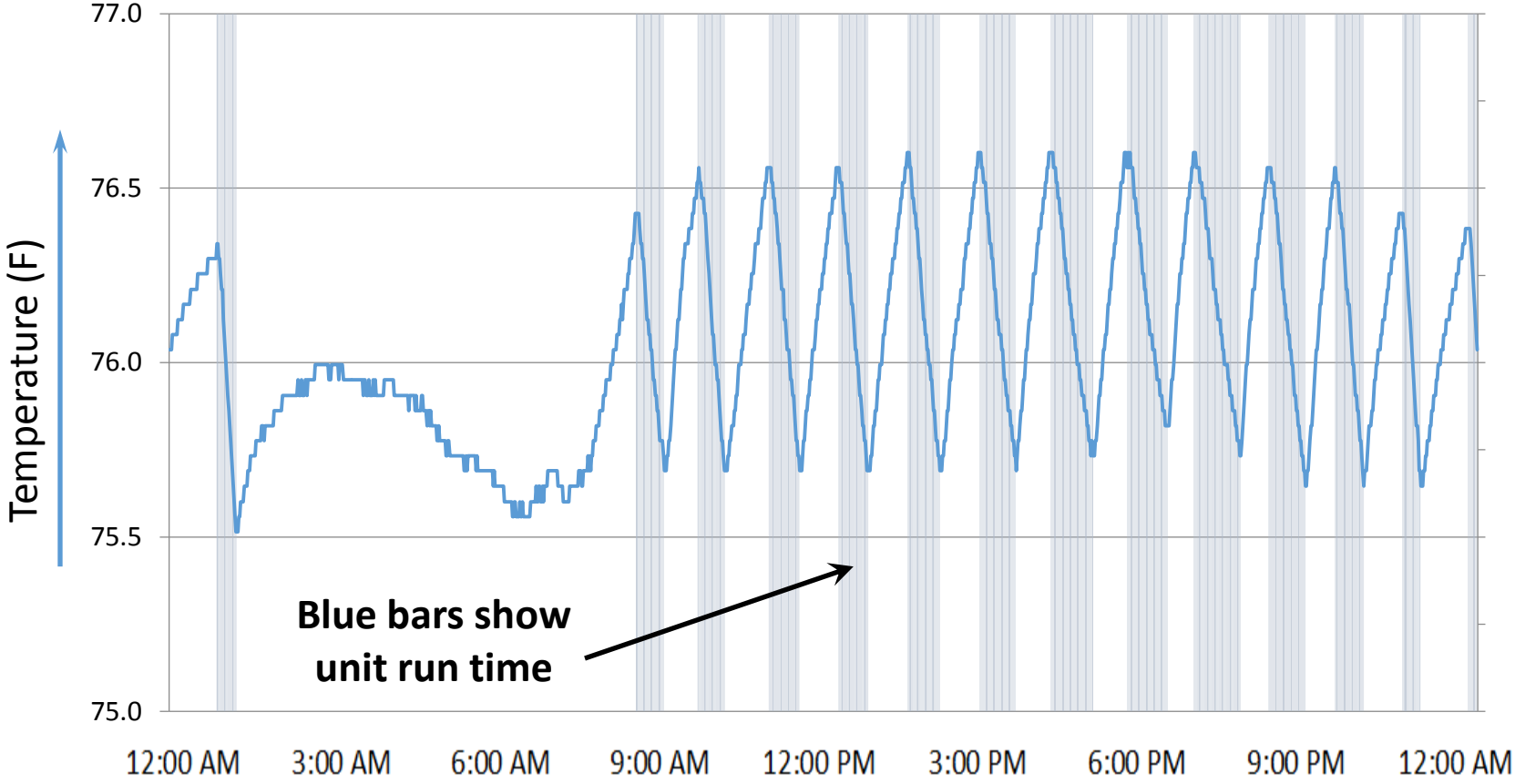


Raw 1 min Temps on a Typical Summer Day

You can clearly see the Air Conditioner Cycling



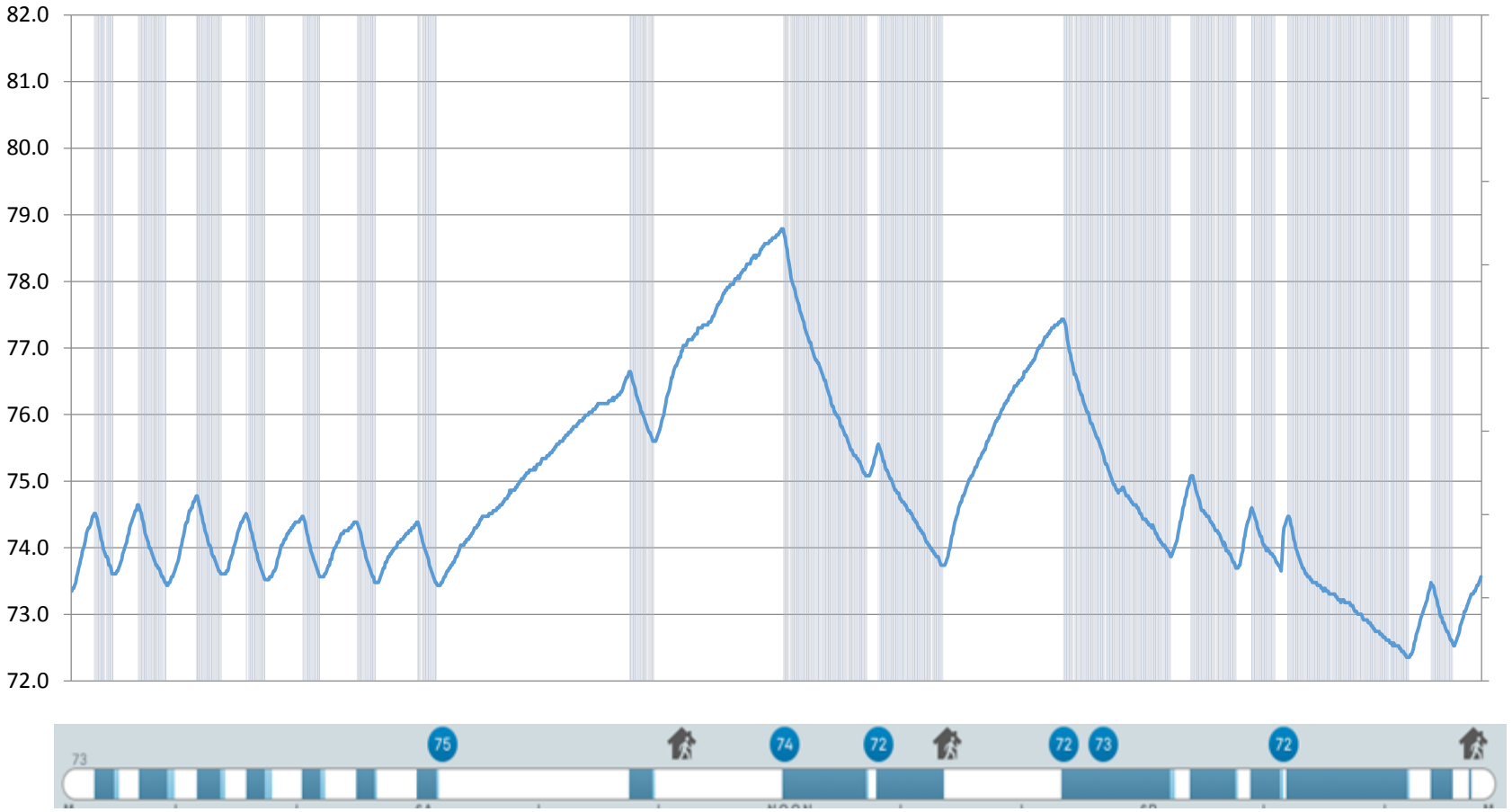
Apogee's Software Automatically calcs Run Time Automatically and precisely determines the TCRs*



AC ran 7 hours and 54 minutes - $4.75 for this day

*TCRs are Temperature Change Rates

NEST vs. Hobo Thermal Monitoring



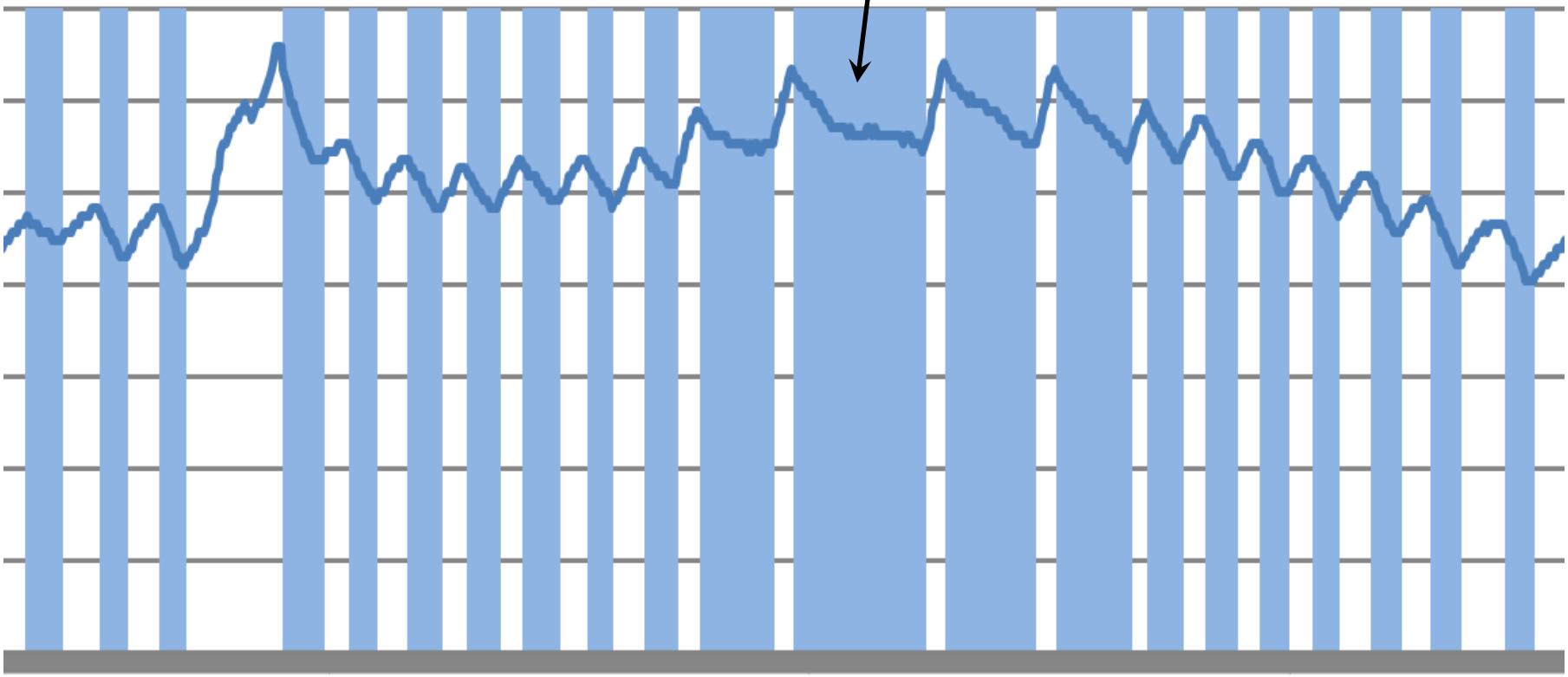
Apogee detects 11 Hrs 2 Min – The NEST said 15 Min

(Apogee called them they admitted a bug and said it was about 7 hours)

A Closer Look at a Problem AC Unit

Outdoor Air Temp was ~ 88 F

Unit maxed out – can't lower temp
It is a sizing/internal gain issue

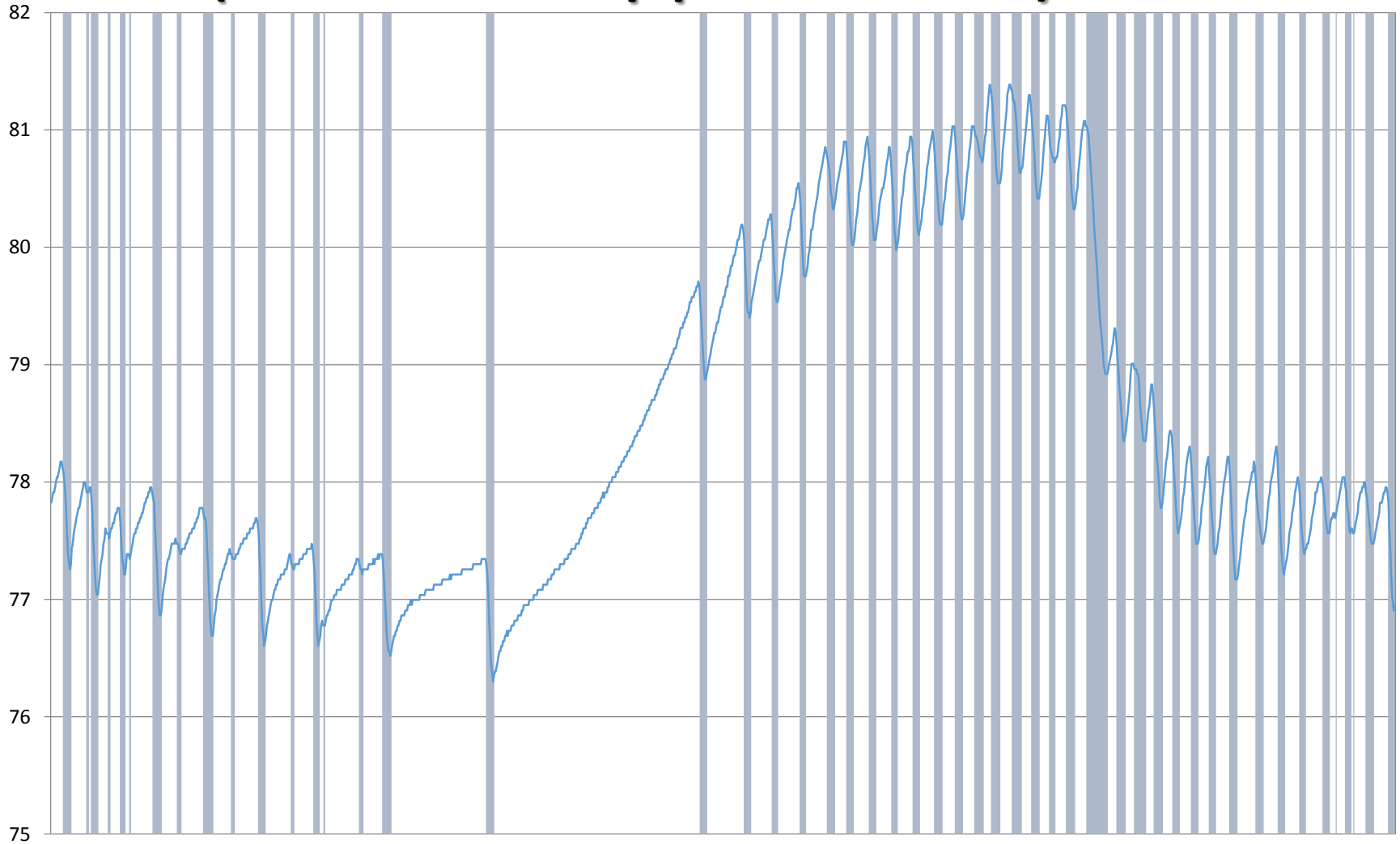


Unit working harder →

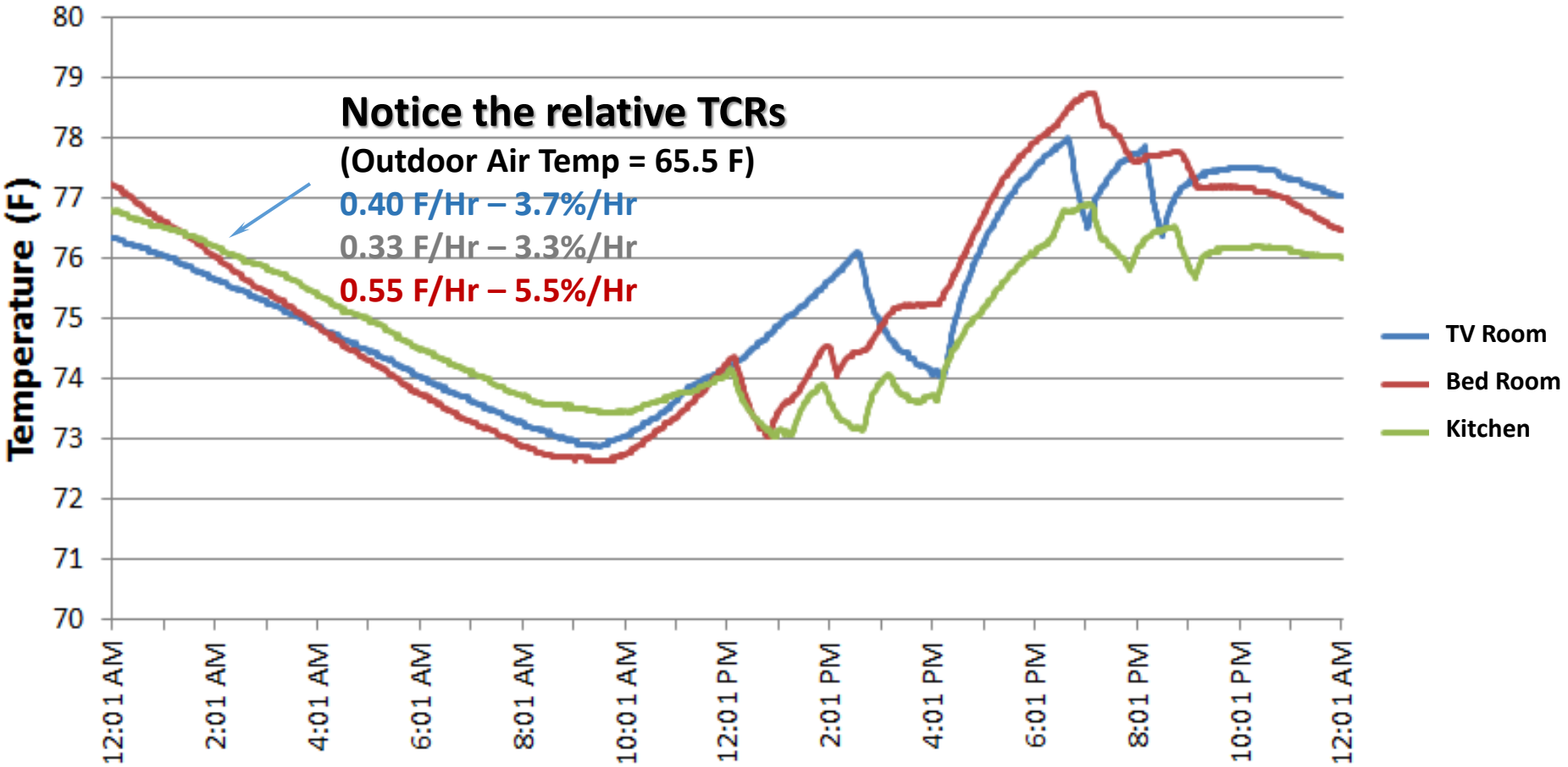
Unit working less and less →

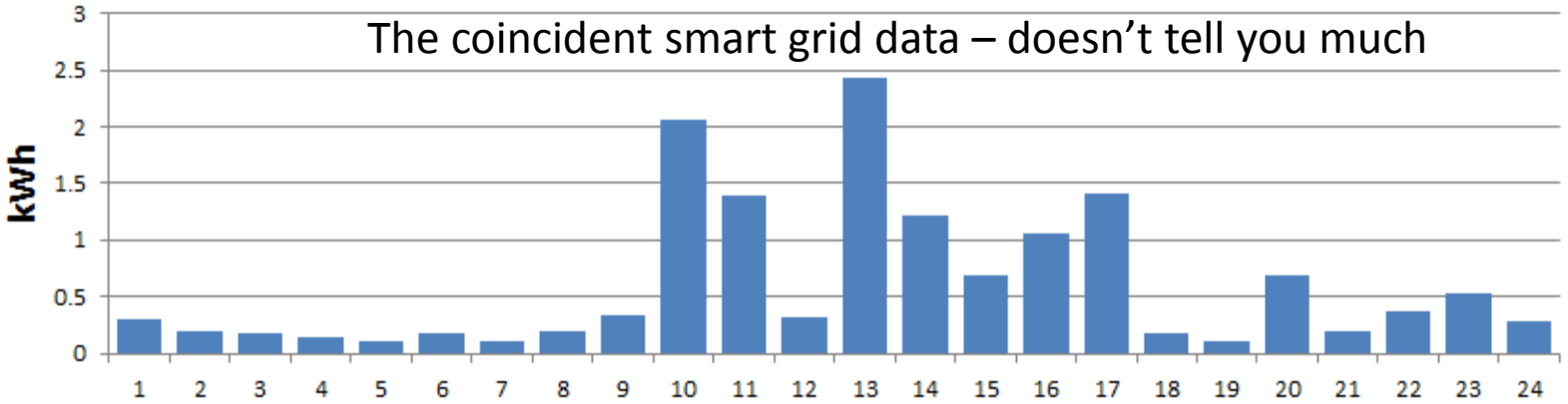
This AC Unit is Clearly Oversized

(outdoor air temp peaked at 95 F)

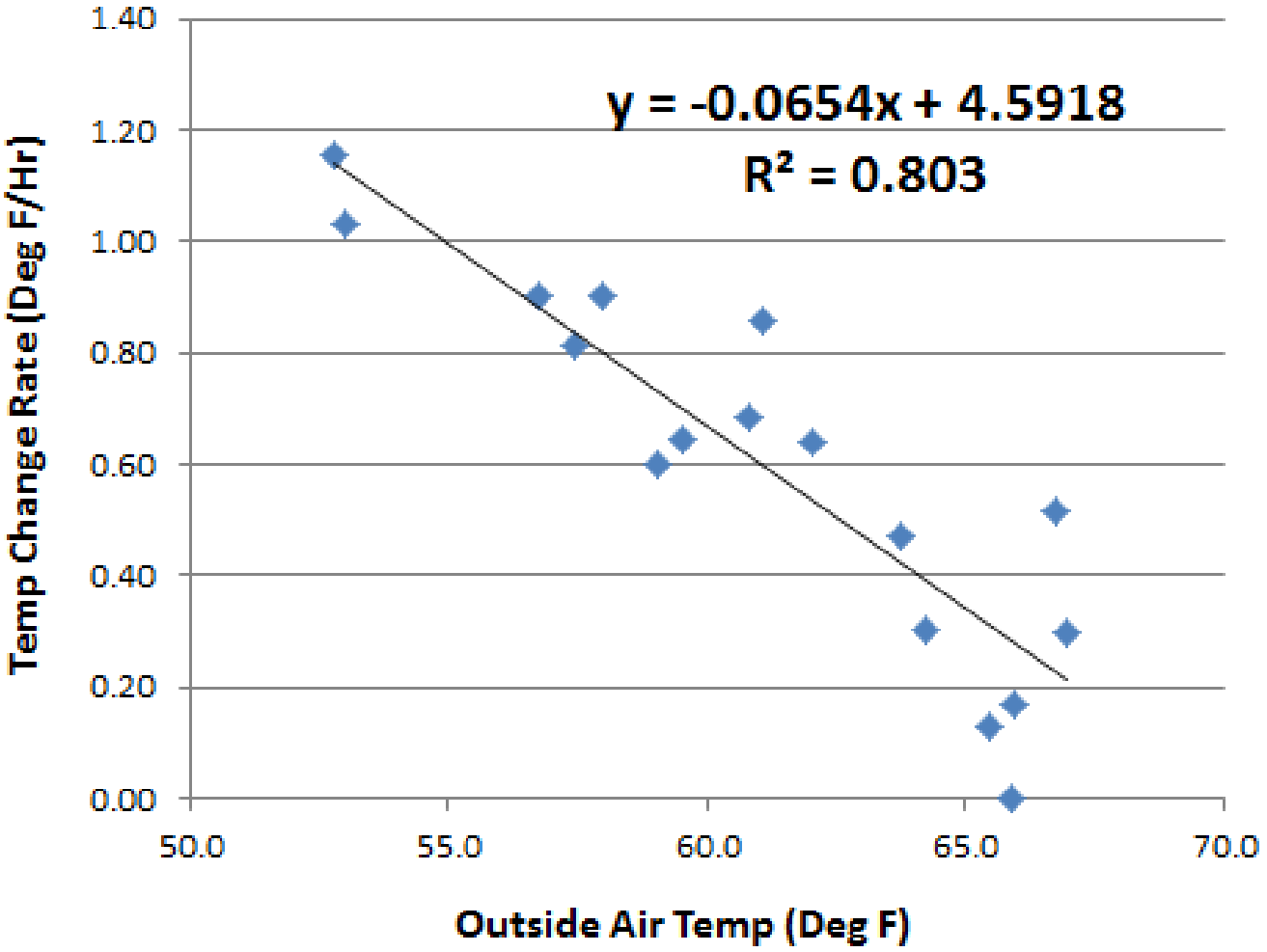


Temperature vs. Time of Day for Sunday 8/11/2013

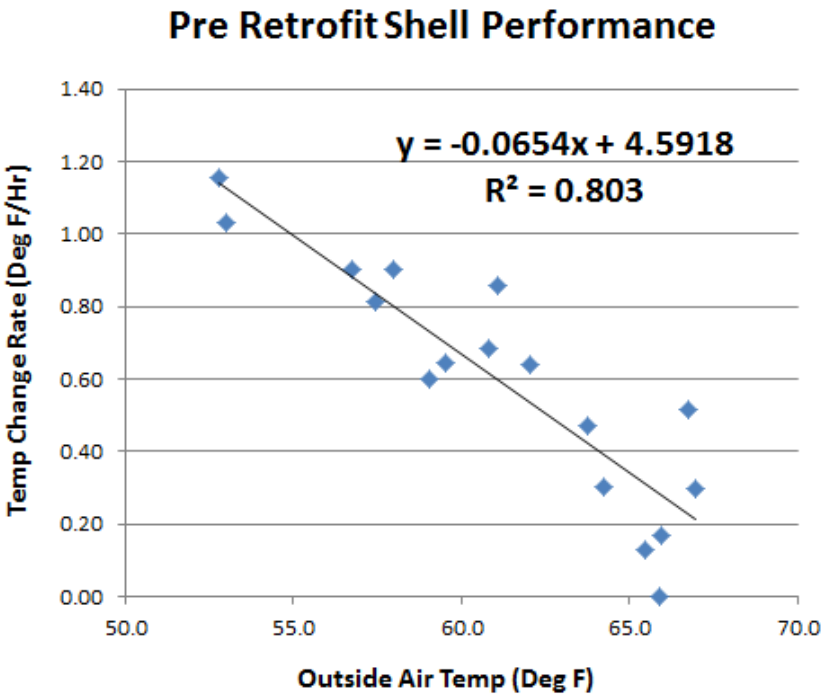




Measuring Temperature Change
(12 am – 6 am … Low Internal Gains)



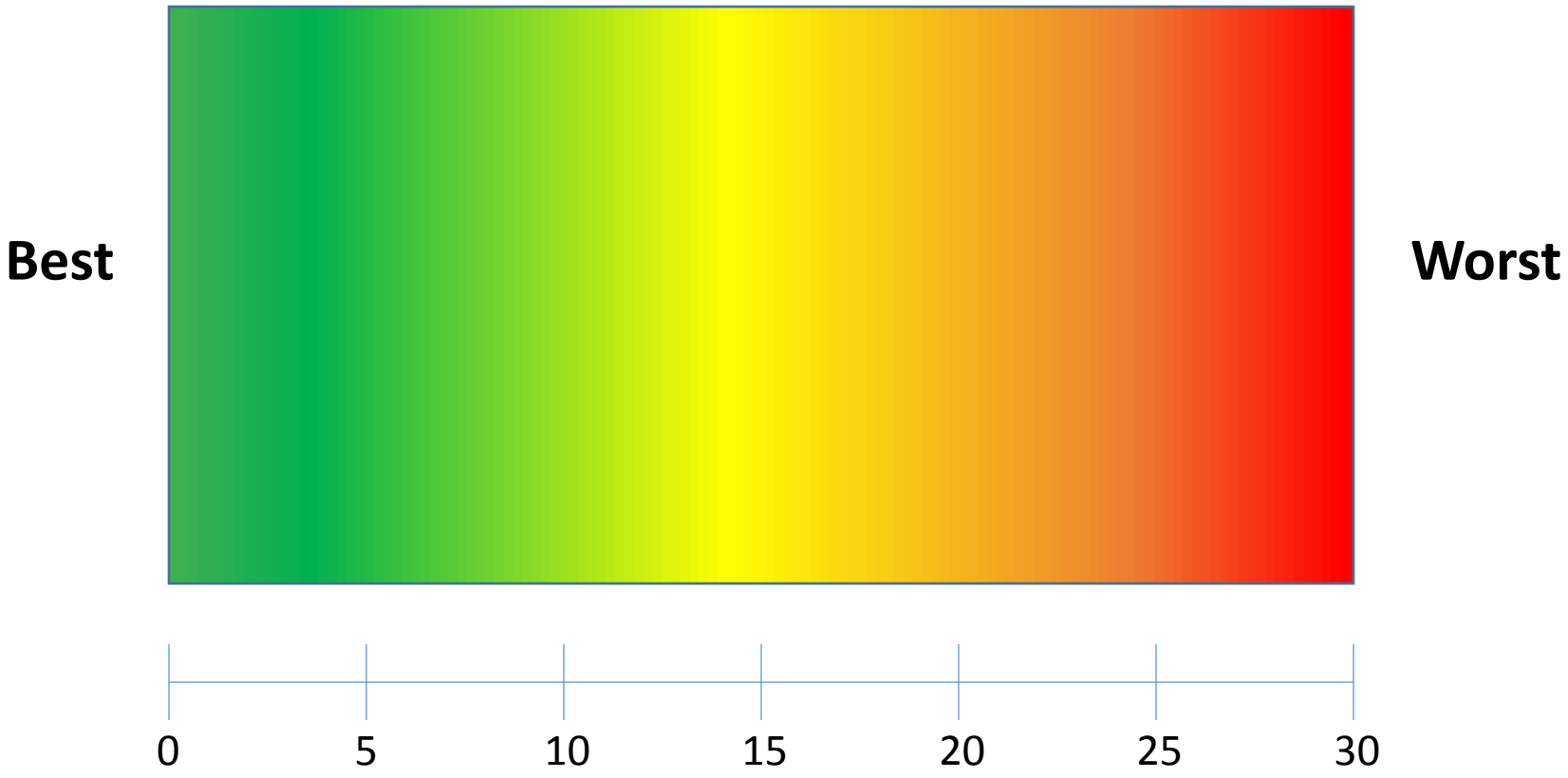
Convert to Performance Standard



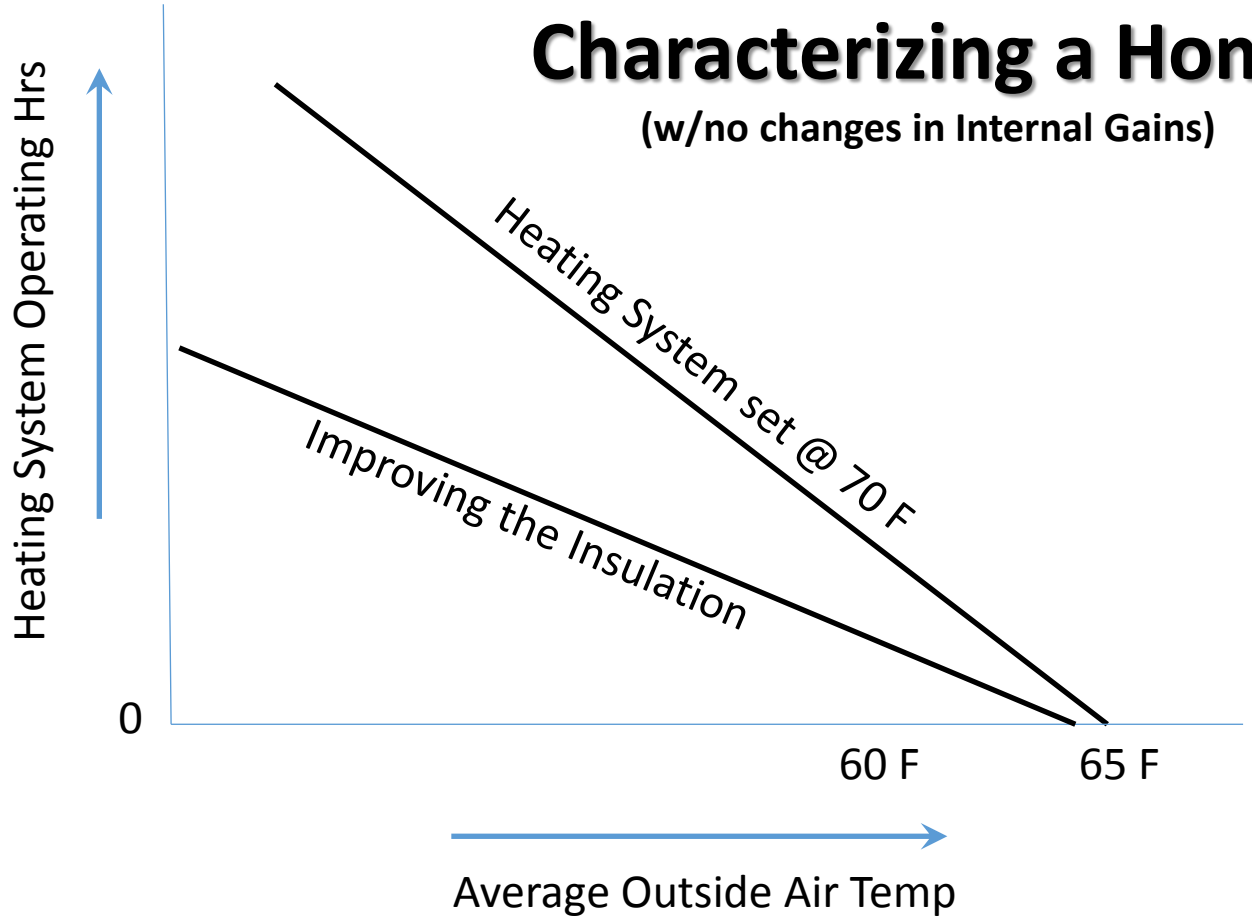
1.98 Deg/Hr at 40 F Outside

6.6% of the Temp Diff/Hour

Compare Thermal Performance



Compare run times from midnight to 6 AM



WAP Houses Used in during Pilot

House 1: 1948 1,663 sf

House 2: 1959 852 sf

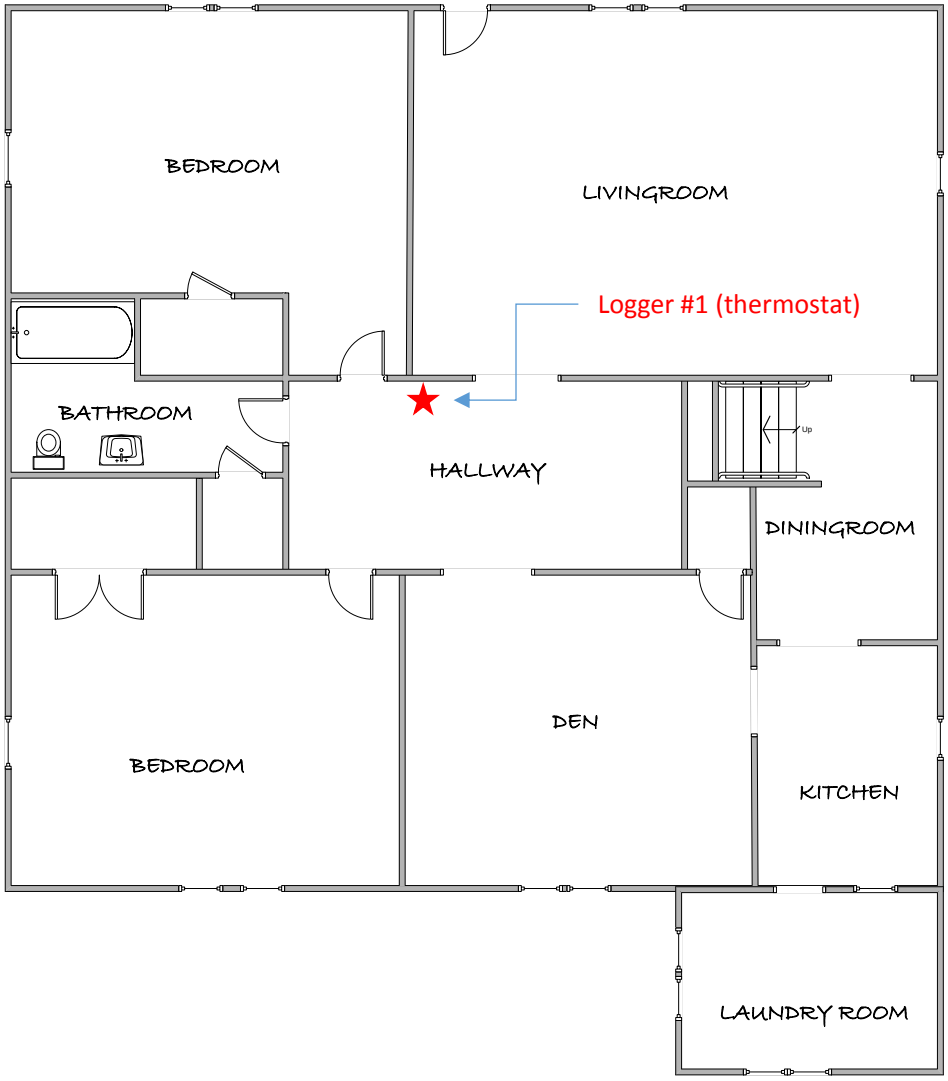
House 3: 1975 1,236 sf

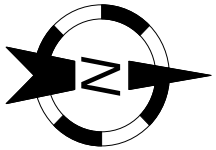
House 4: 1987 2,200 sf

3 Bedroom, 1 Bath, 1,663 sq ft, built in 1948

MAIN LEVEL

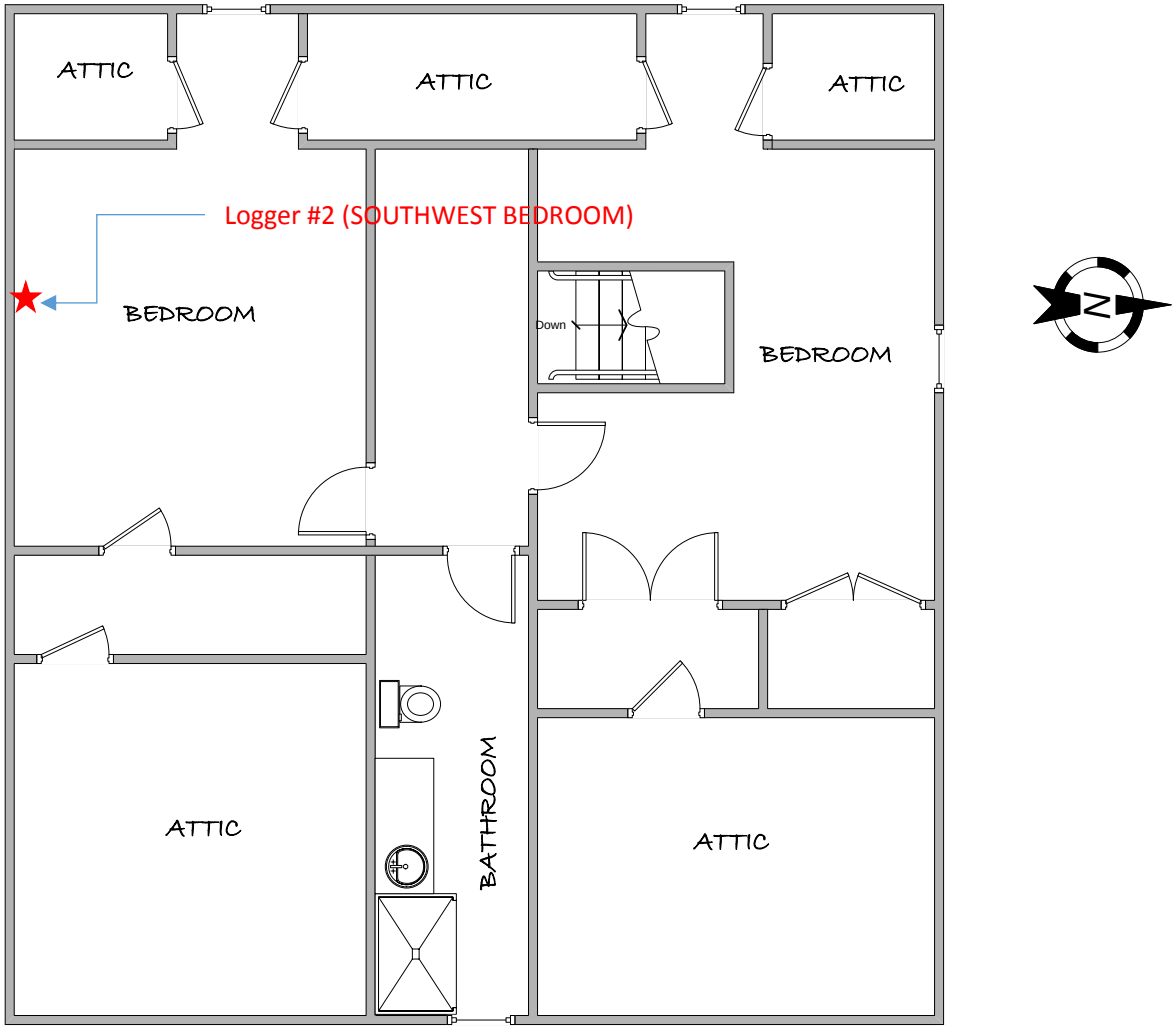
FRONT (WEST)

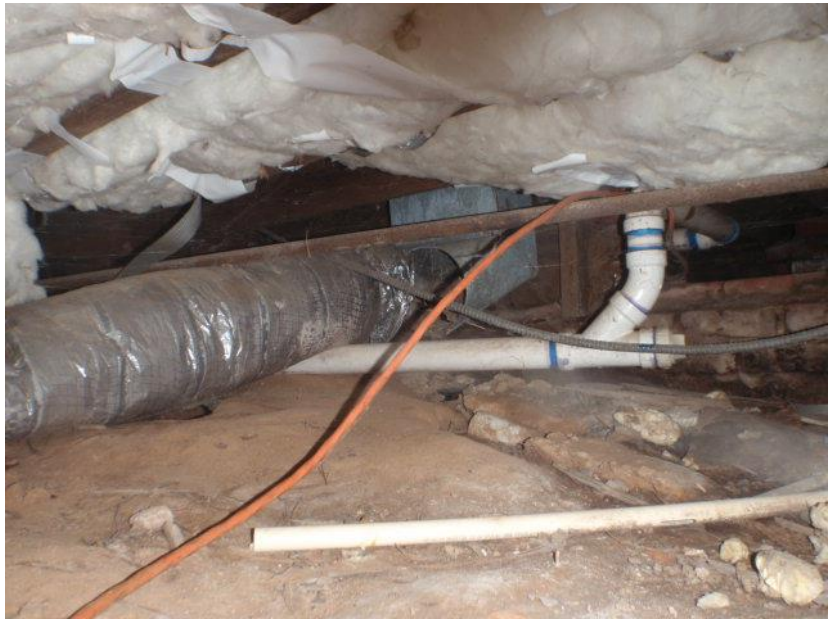




UPPER LEVEL

FRONT (WEST)





House 1

10409931

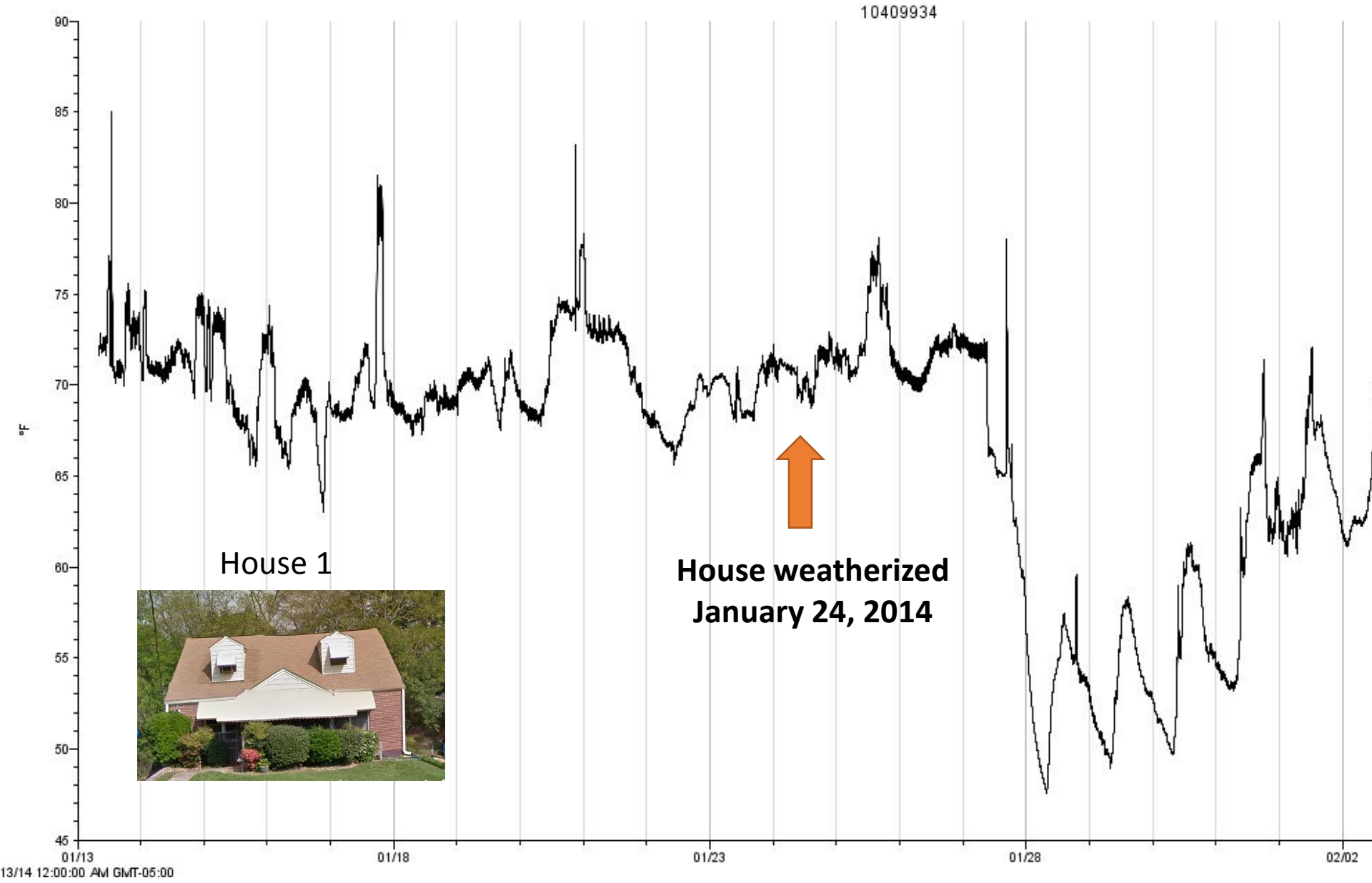
House weatherized
January 24, 2014

°F

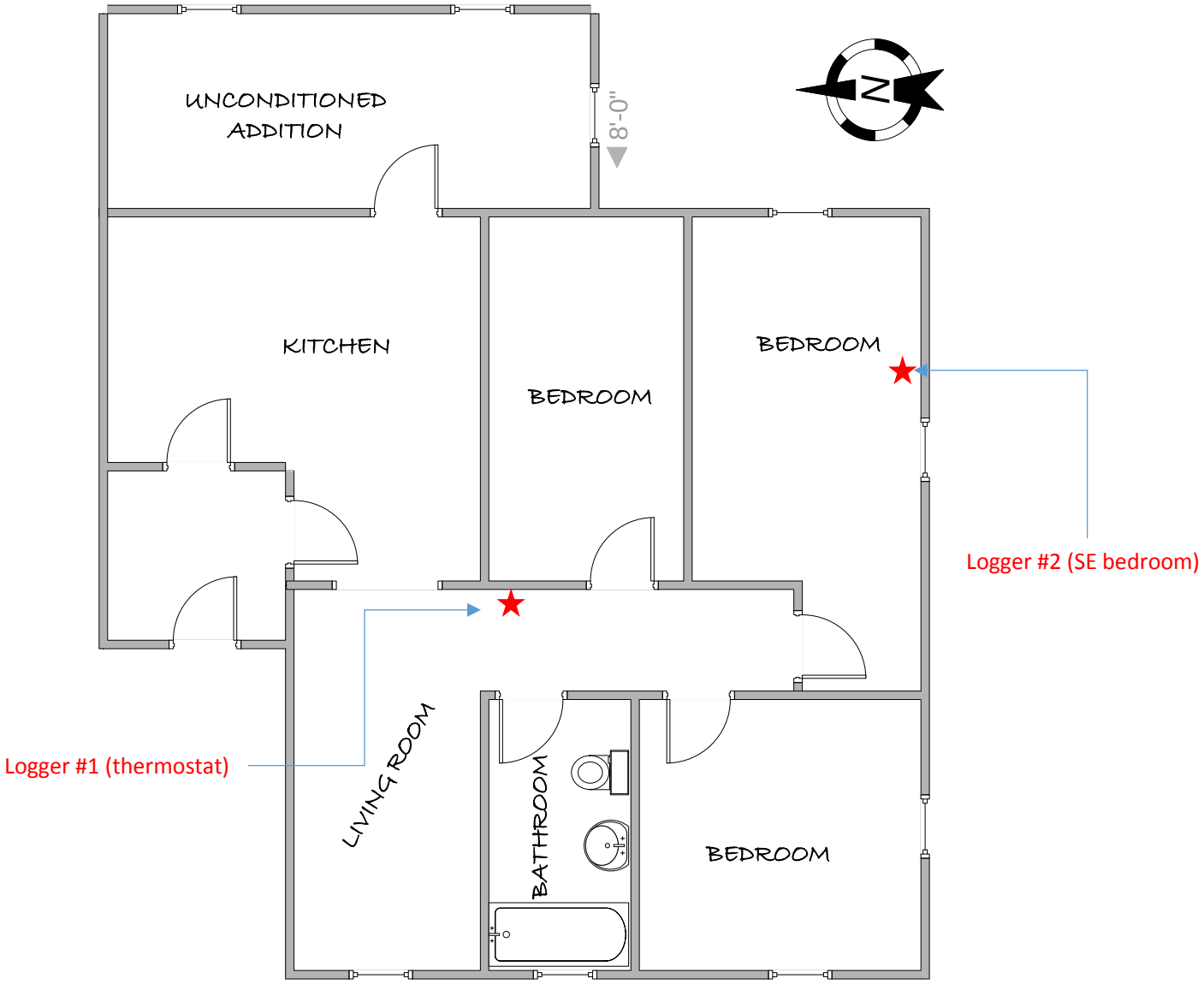
80
78
76
74
72
70
68
66
64
62
60

01/13
01/18
01/23
01/28
02/02

713/14 12:00:00 AM GMT-05:00


10409934
90
85
80
75
70
65
60
55
50
45
°F
01/13
01/18
01/23
01/28
02/02
13/14 12:00:00 AM GMT-05:00
House 1
House weatherized
January 24, 2014

2 Bedrooms, 1 Bath, 852 sq ft, built in 1959

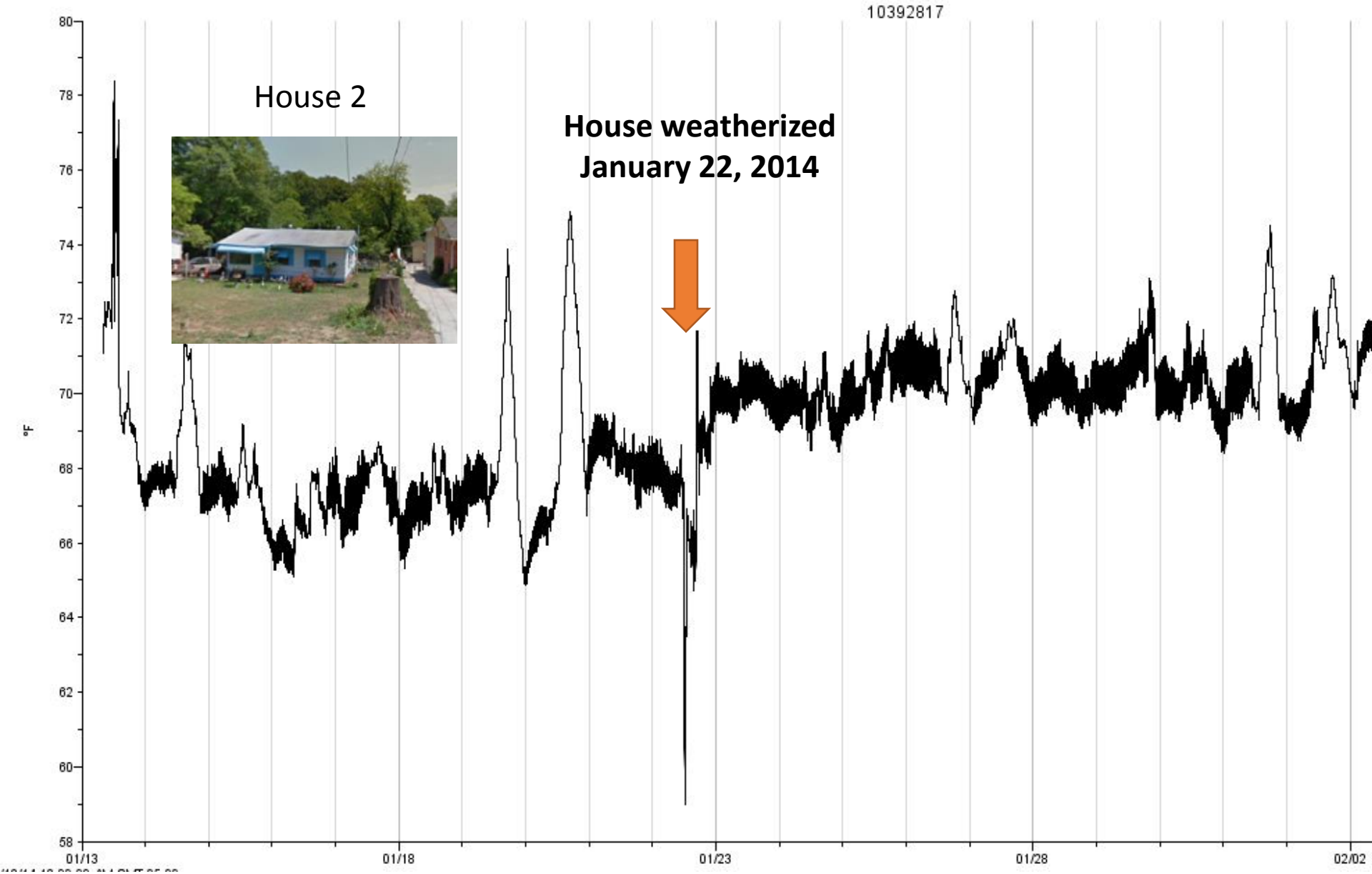


MAIN LEVEL

FRONT (WEST)

House 2

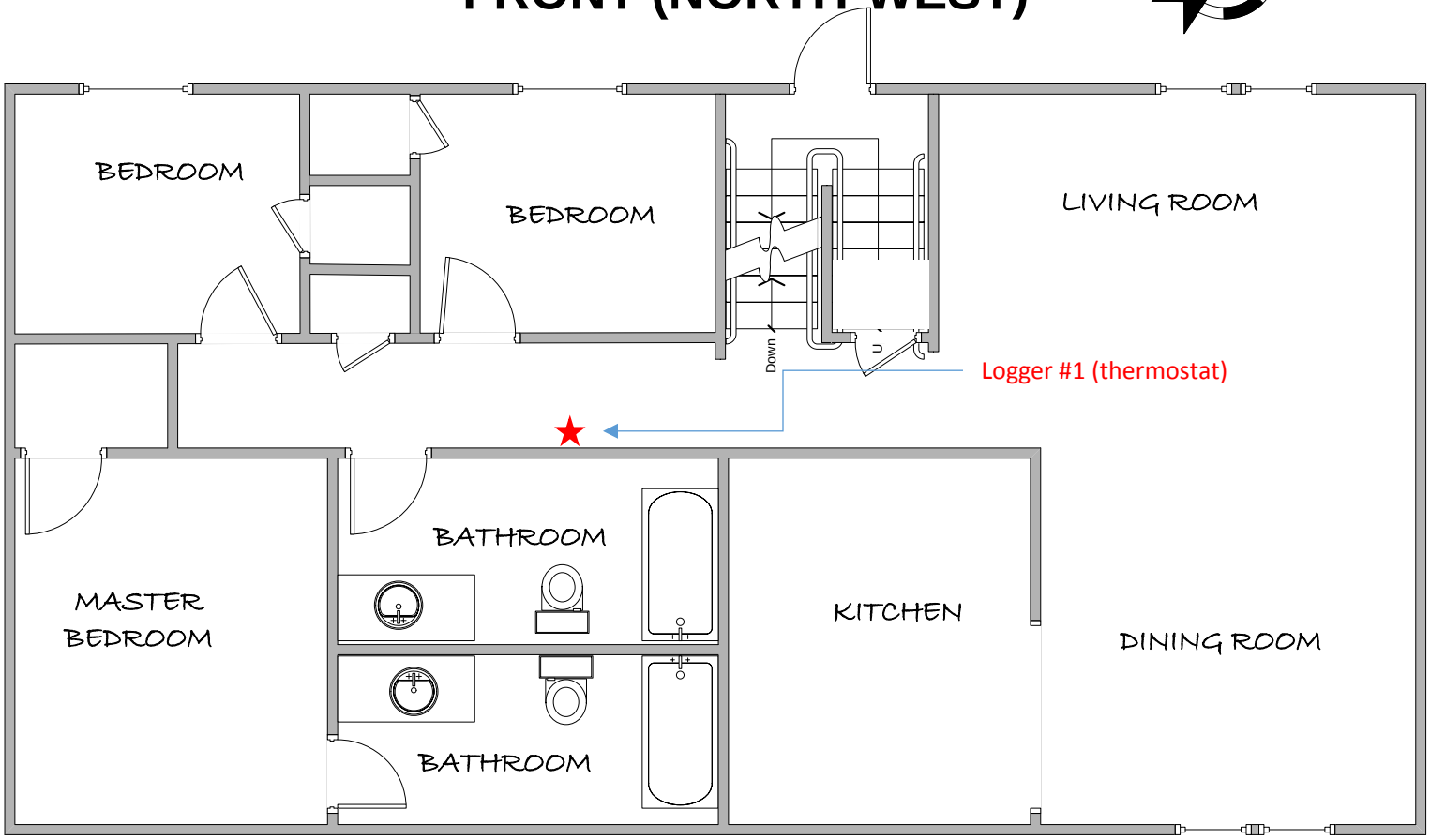
House weatherized January 22, 2014


10392817
House 2
House weatherized
January 22, 2014
°F
80
78
76
74
72
70
68
66
64
62
60
58
01/13
01/18
01/23
01/28
02/02

3 Bedroom, 3 baths, 1,236 sq ft, built in 1975

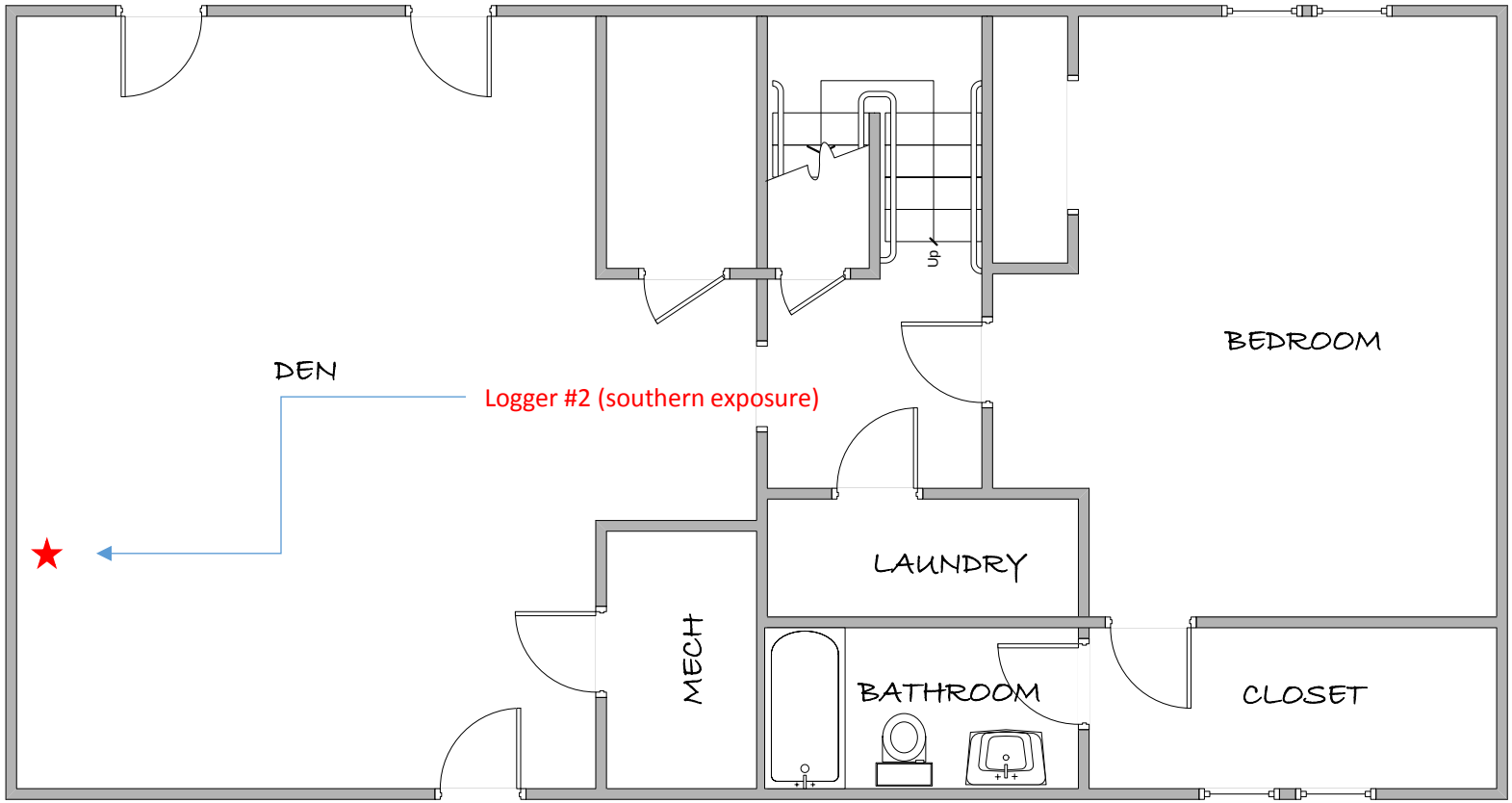
MAIN LEVEL

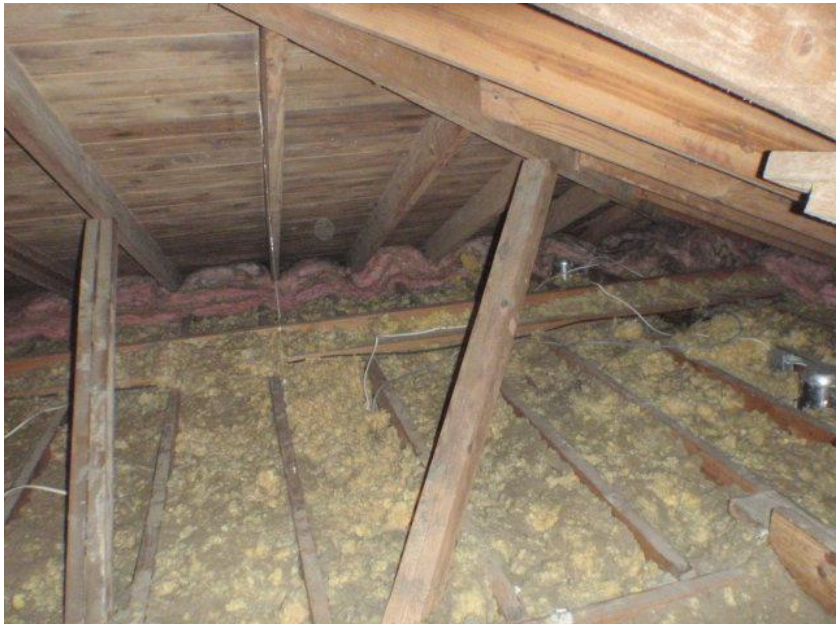
FRONT (NORTH-WEST)

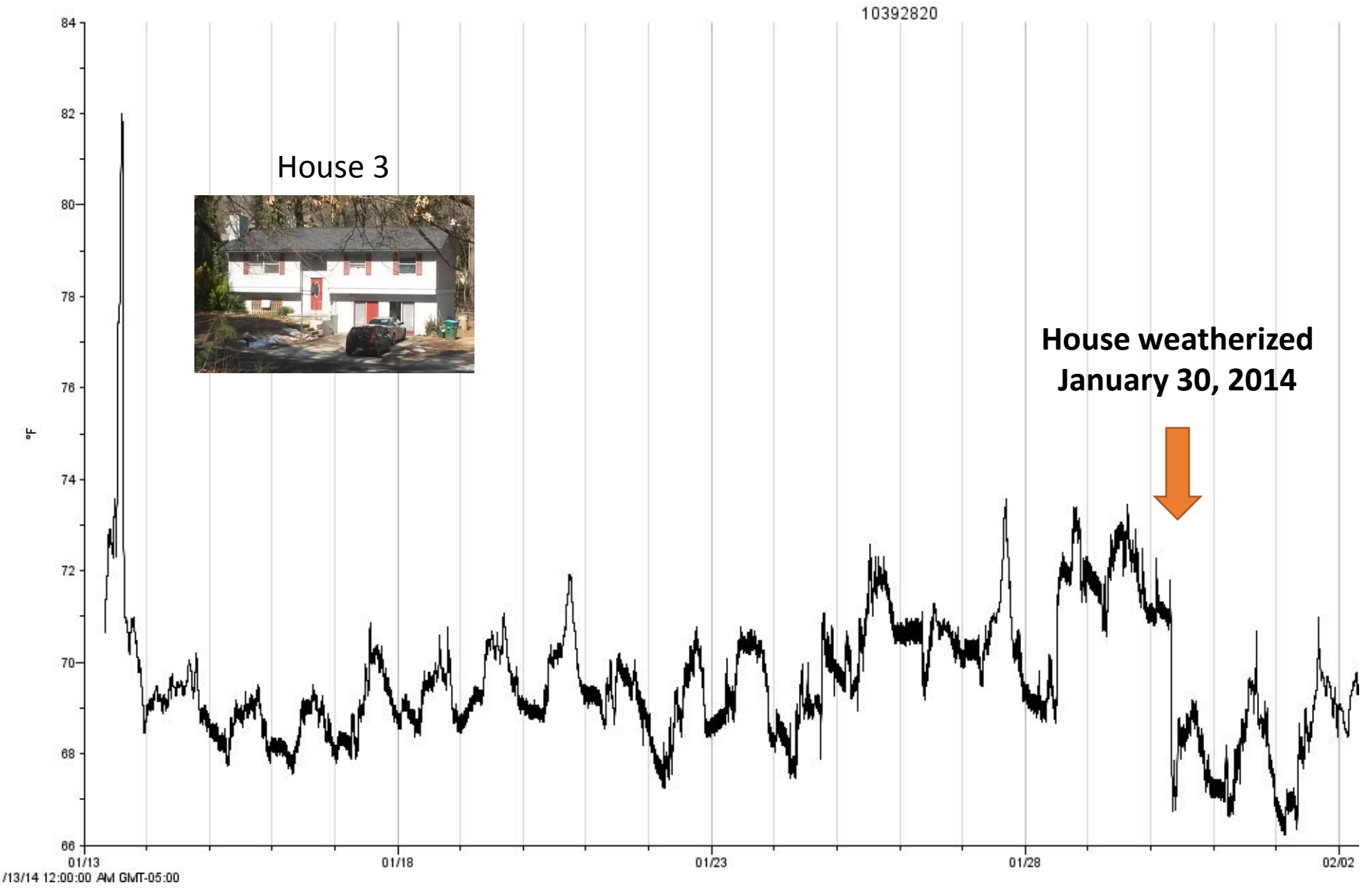


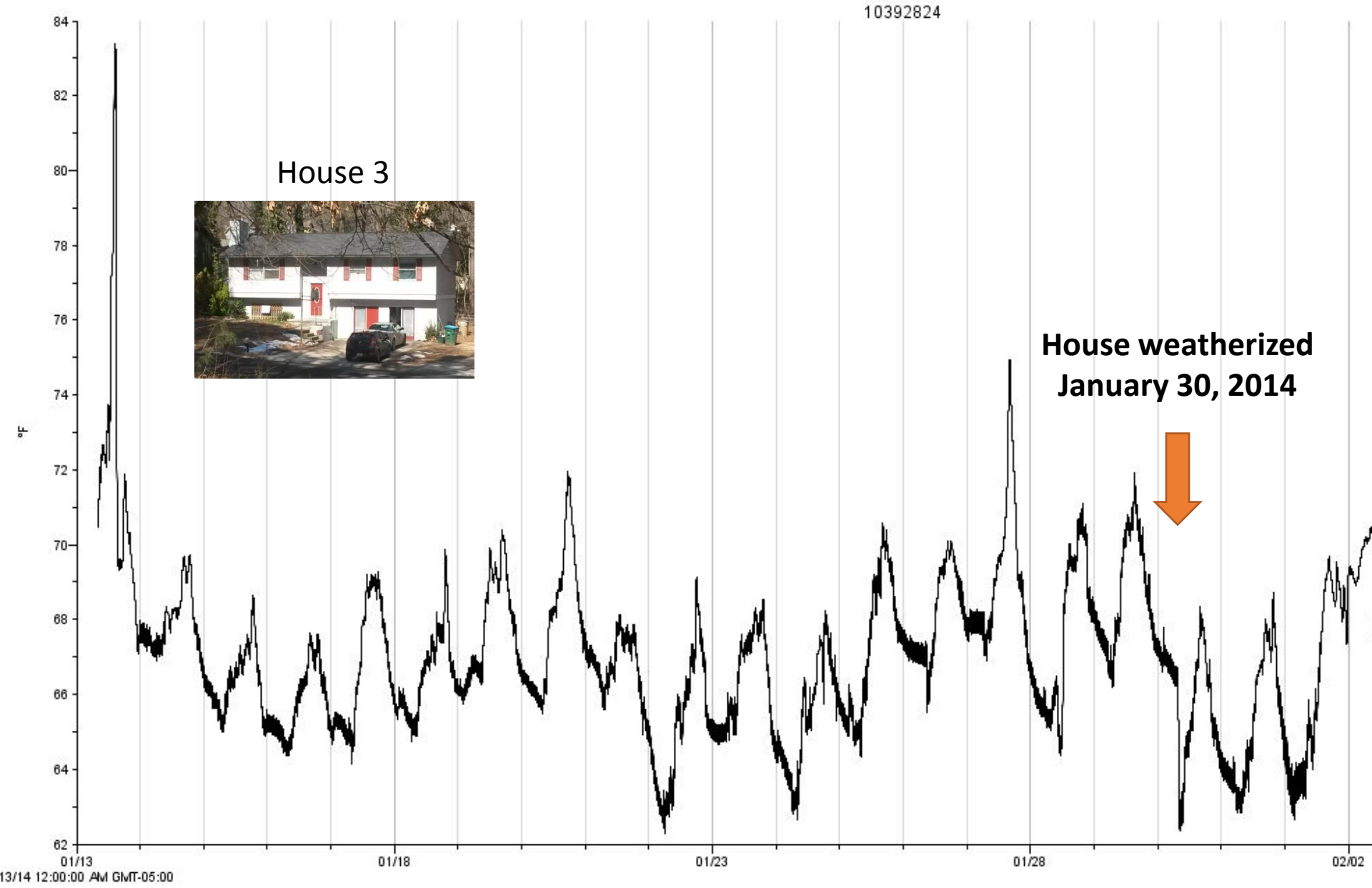
LOWER LEVEL

FRONT (NORTH-WEST)





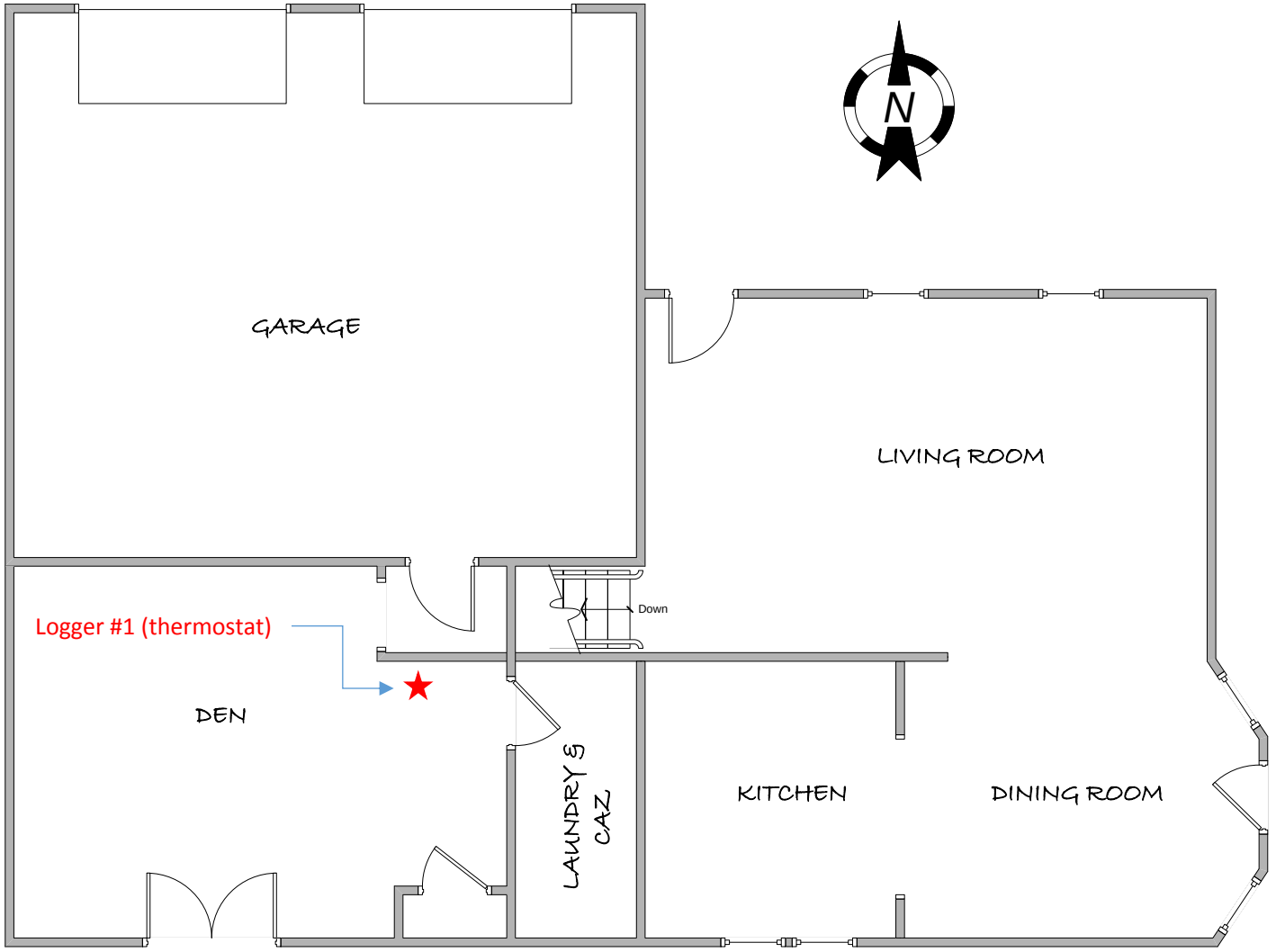

10392820
House 3
House weatherized
January 30, 2014
°F
84
82
80
78
76
74
72
70
68
66
01/13
01/18
01/23
01/28
02/02
/13/14 12:00:00 AM GMT-05:00


10392824
House 3
House weatherized
January 30, 2014
°F
84
82
80
78
76
74
72
70
68
66
64
62
01/13
01/18
01/23
01/28
02/02
13/14 12:00:00 AM GMT-05:00

4 Bedroom, 2.5 Bath, 2,200 sq ft, built in 1987

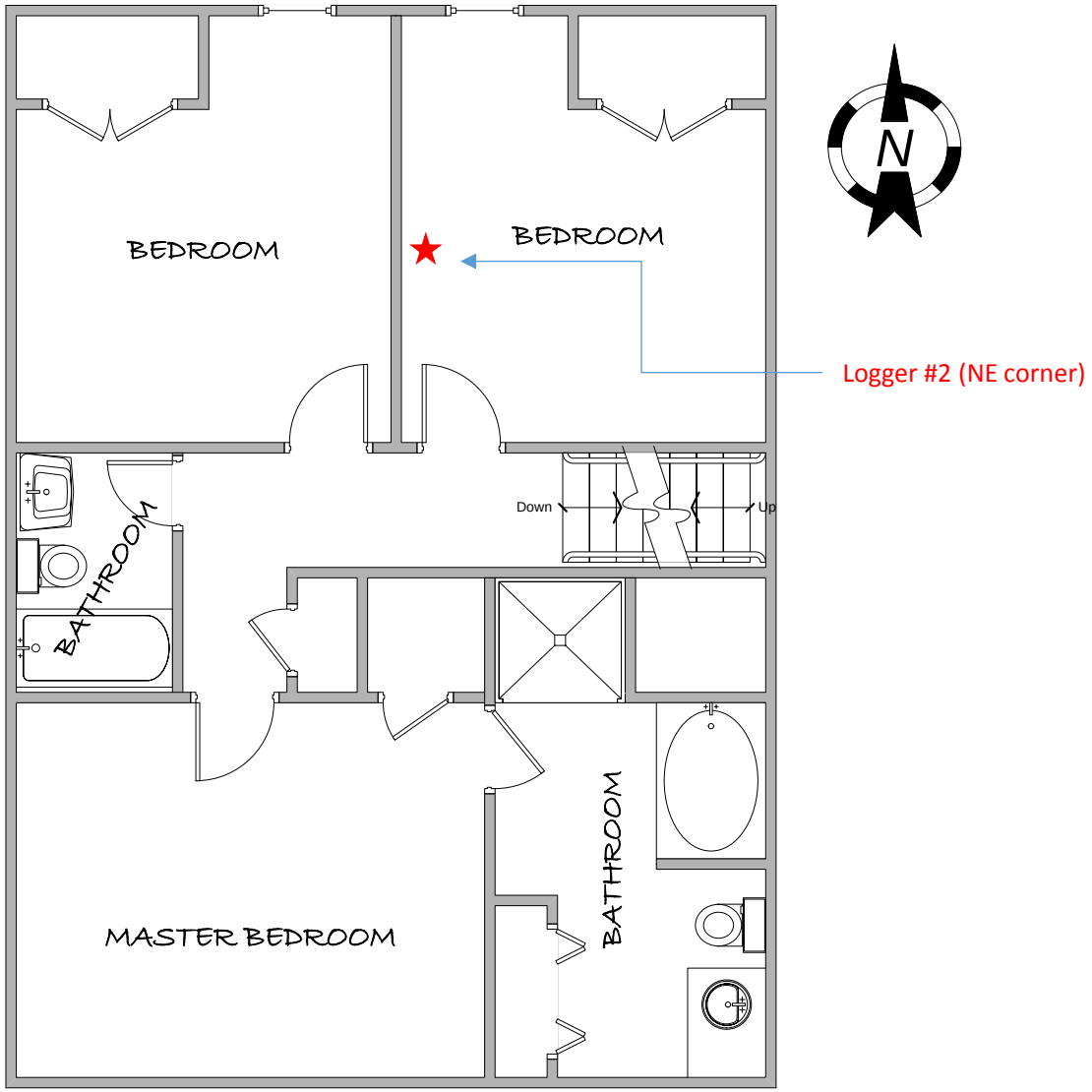
MAIN LEVEL

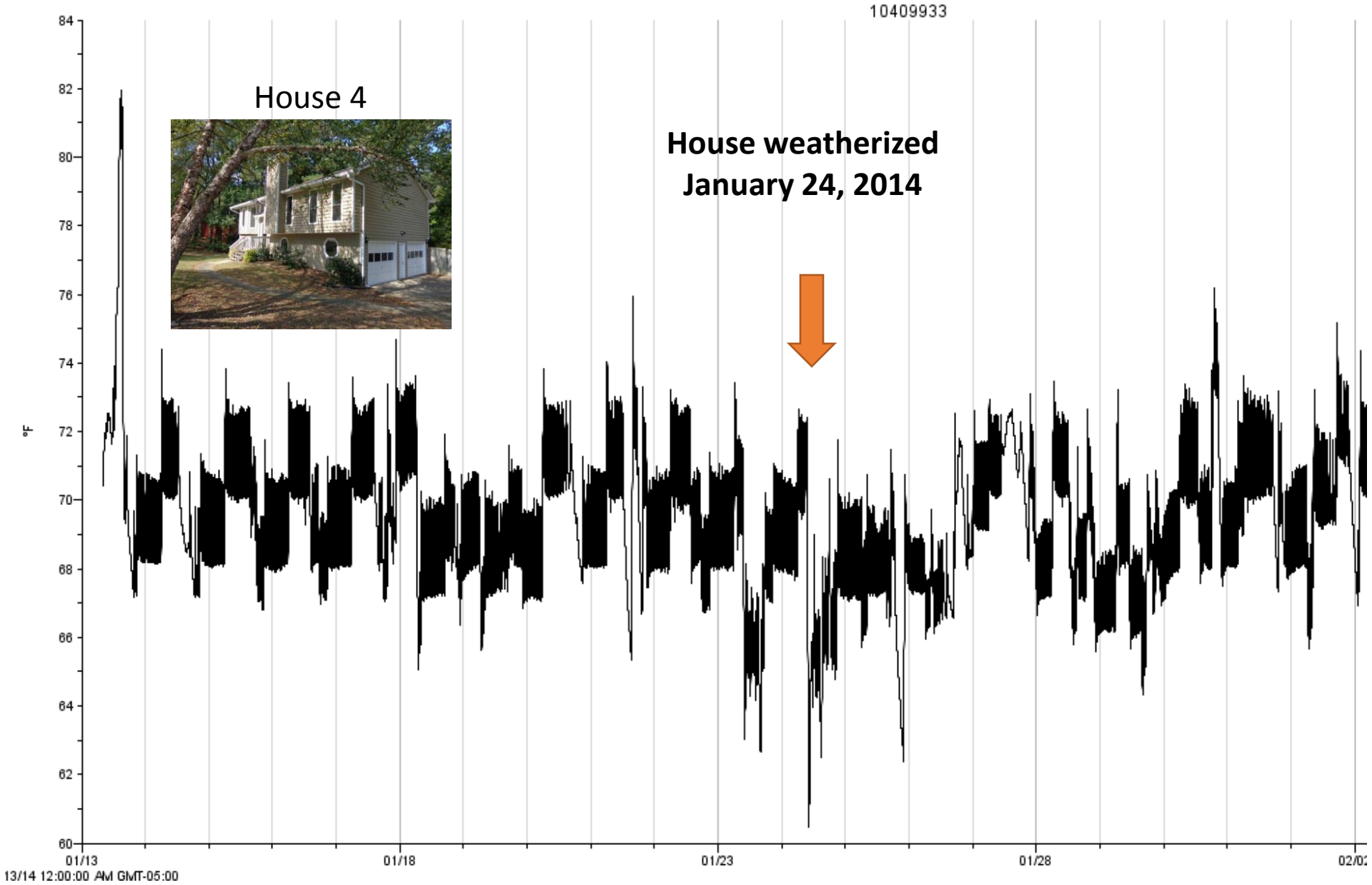
FRONT (NORTH)



UPPER LEVEL

FRONT (NORTH)




10409933
House 4
House weatherized
January 24, 2014
°F
84
82
80
78
76
74
72
70
68
66
64
62
60
01/13
01/18
01/23
01/28
13/14 12:00:00 AM GMT-05:00

House 4

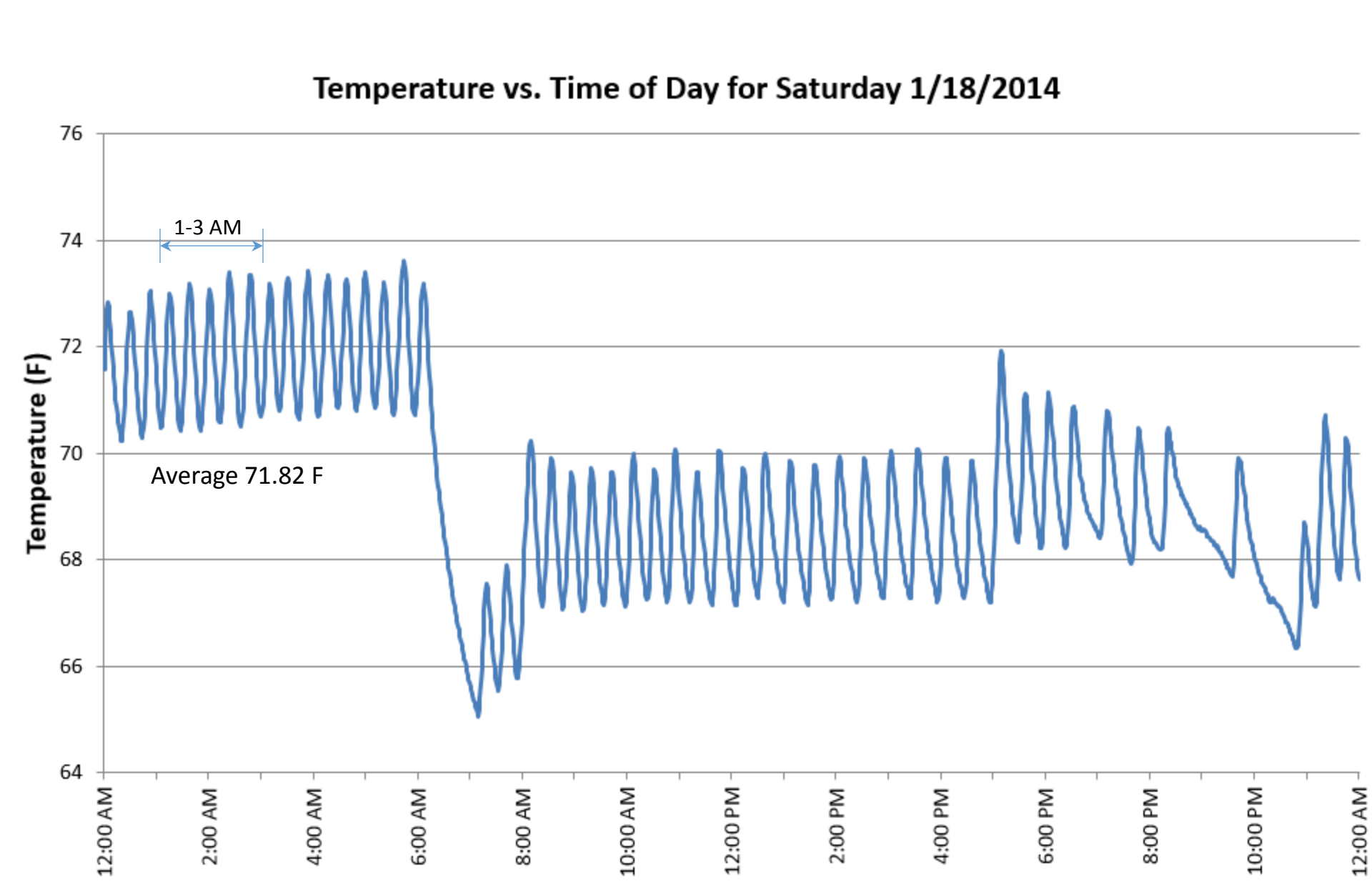
10409929

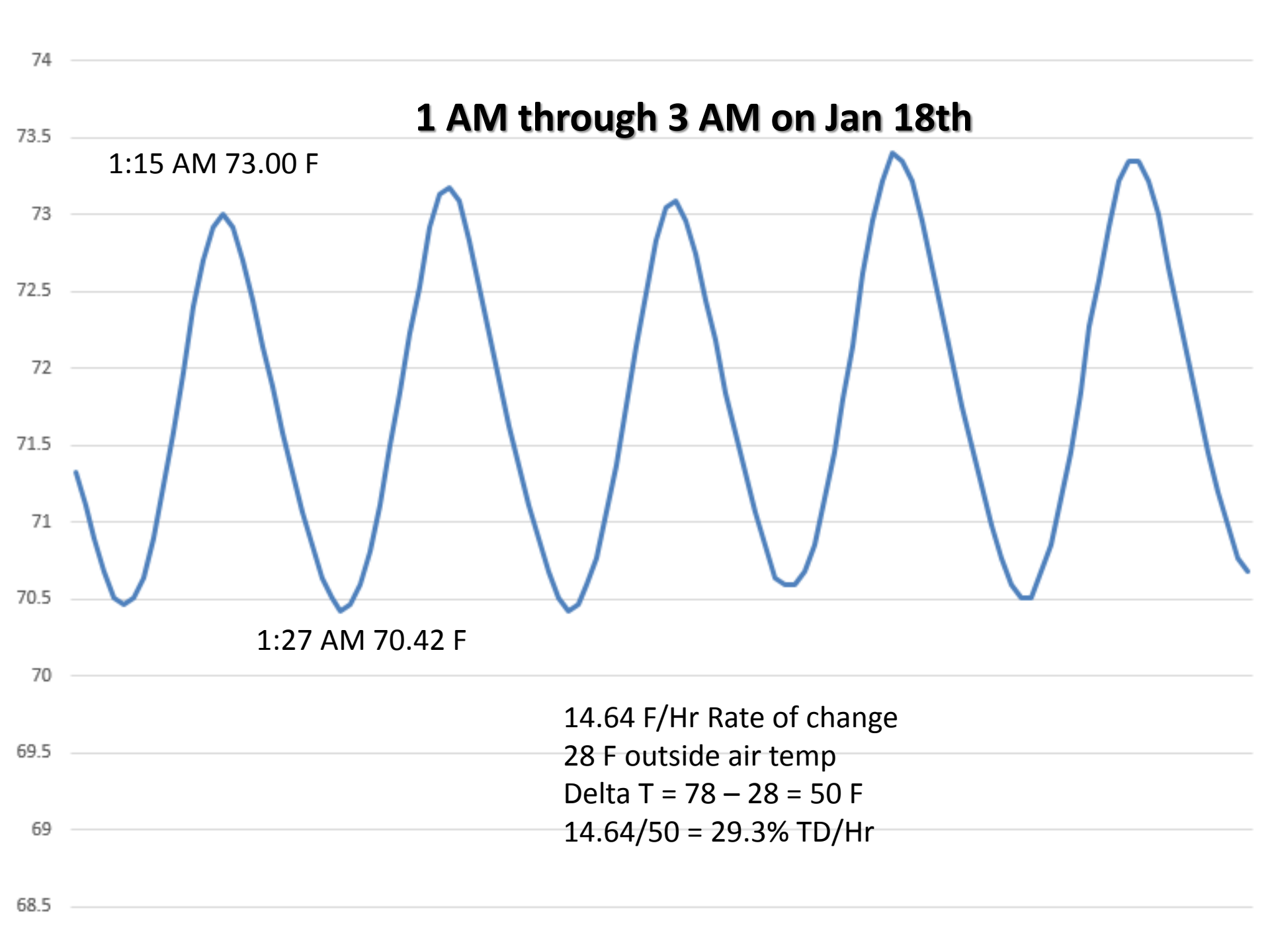
House weatherized
January 24, 2014

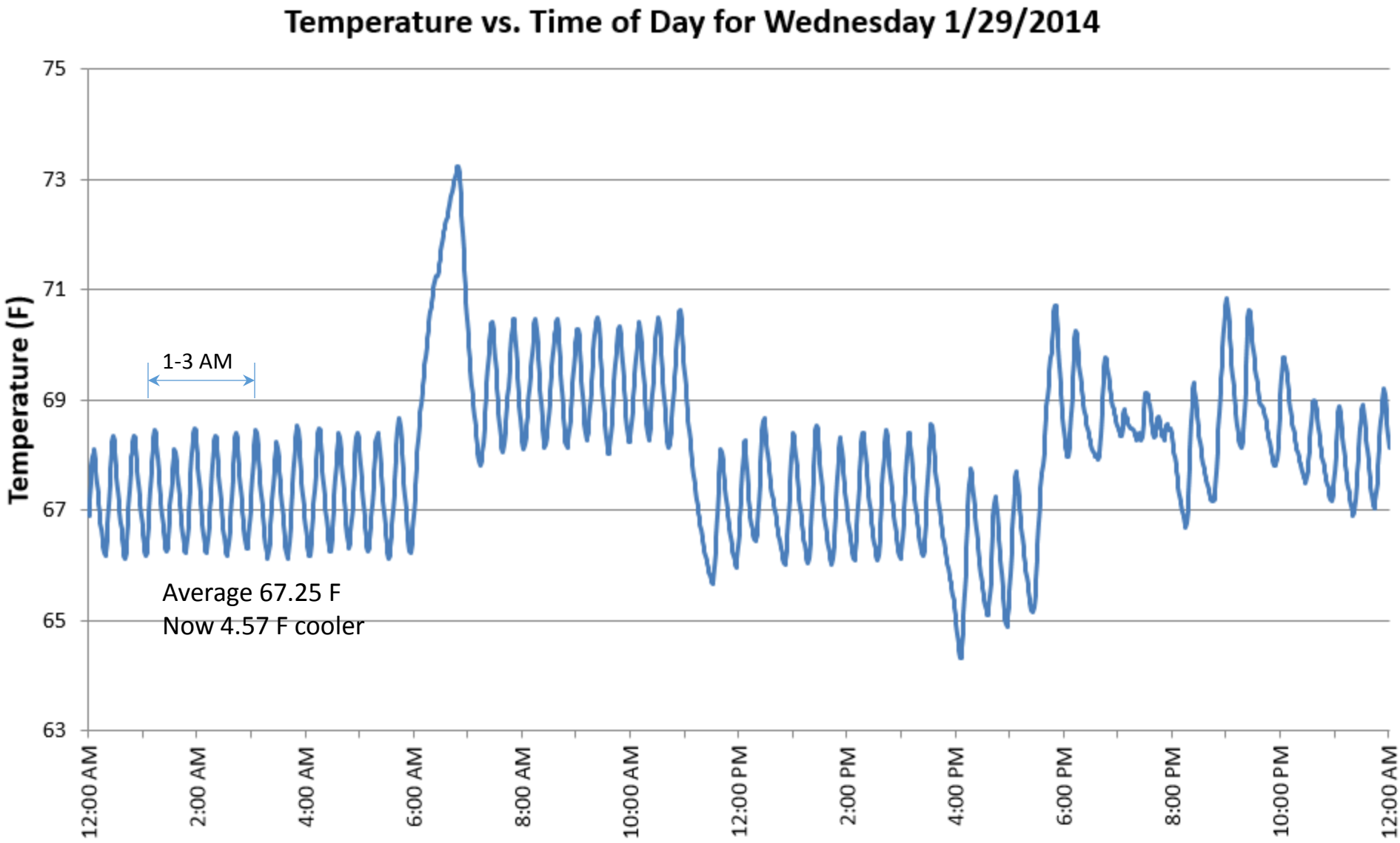
84
82
80
78
76
74
72
70
°F

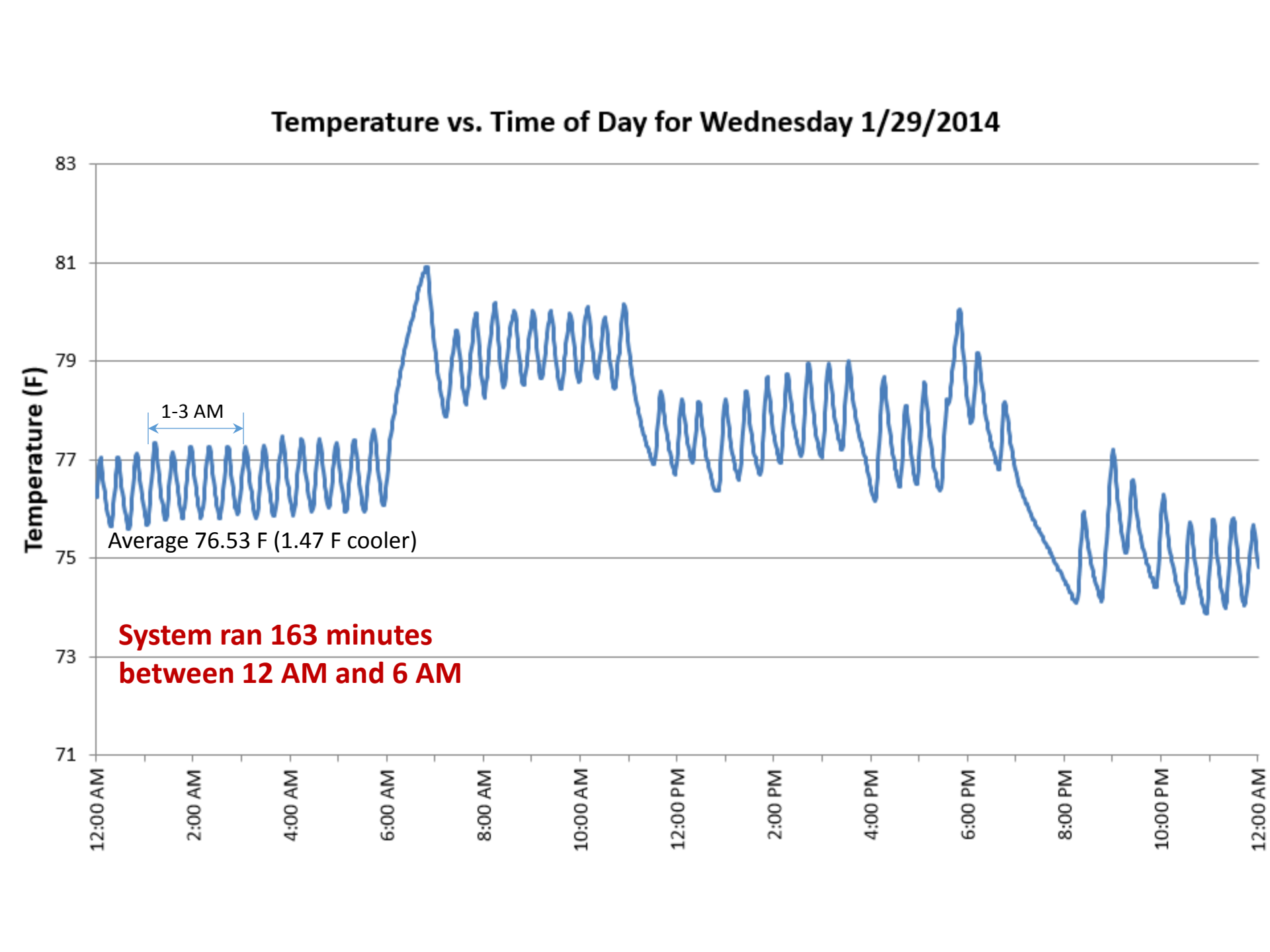
01/13
01/18
01/23
01/28
02/02

/13/14 12:00:00 AM GMT-05:00

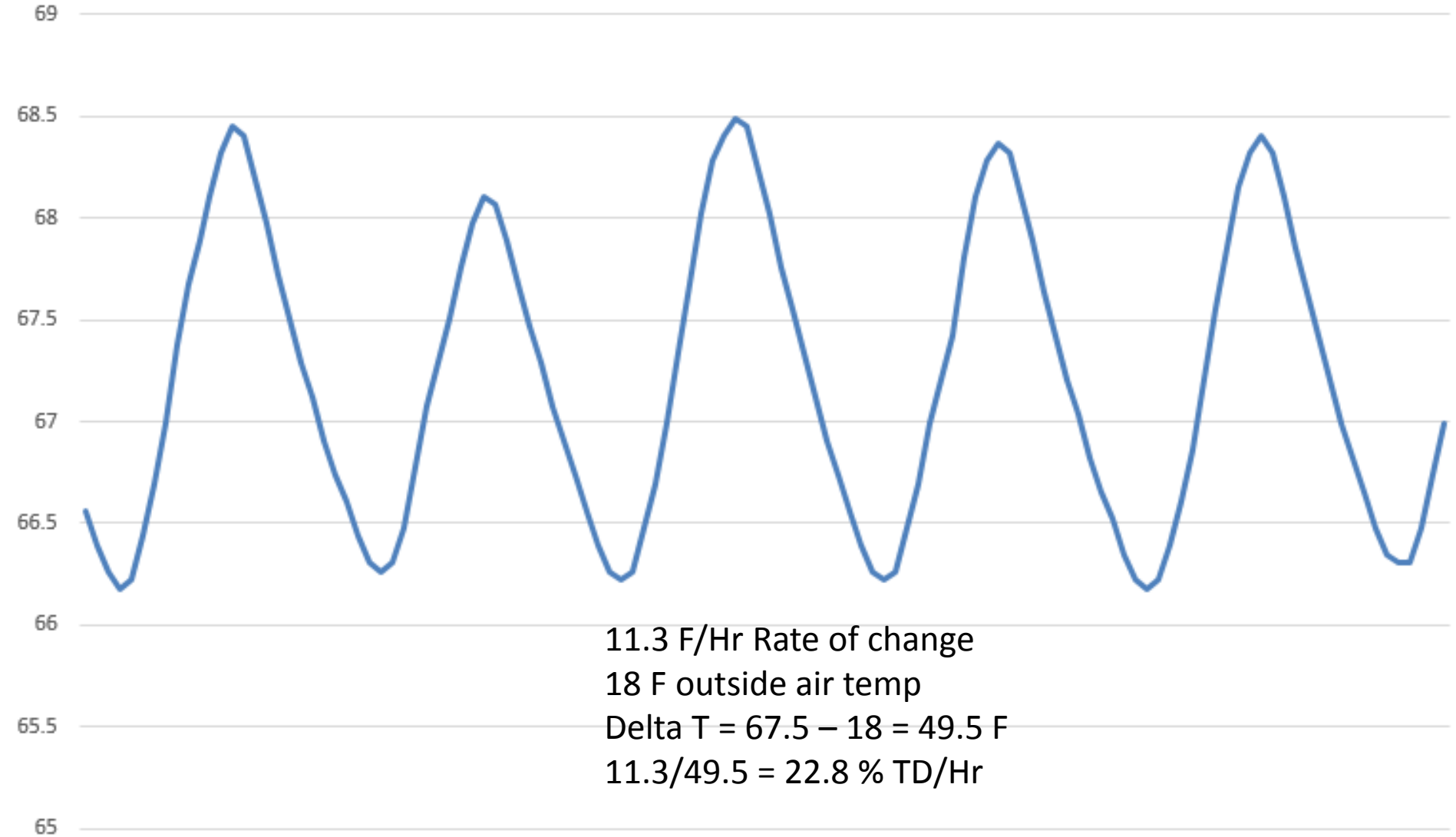

Temperature vs. Time of Day for Saturday 1/18/2014
Temperature (F)
76
74
72
70
68
66
64
1-3 AM
Average 71.82 F
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM


1 AM through 3 AM on Jan 18th
1:15 AM 73.00 F
1:27 AM 70.42 F
14.64 F/Hr Rate of change
28 F outside air temp
Delta T = 78 – 28 = 50 F
14.64/50 = 29.3% TD/Hr
74
73.5
73
72.5
72
71.5
71
70.5
70
69.5
69
68.5


Temperature vs. Time of Day for Wednesday 1/29/2014
Temperature (F)
75
73
71
69
67
65
63
1-3 AM
Average 67.25 F
Now 4.57 F cooler
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM

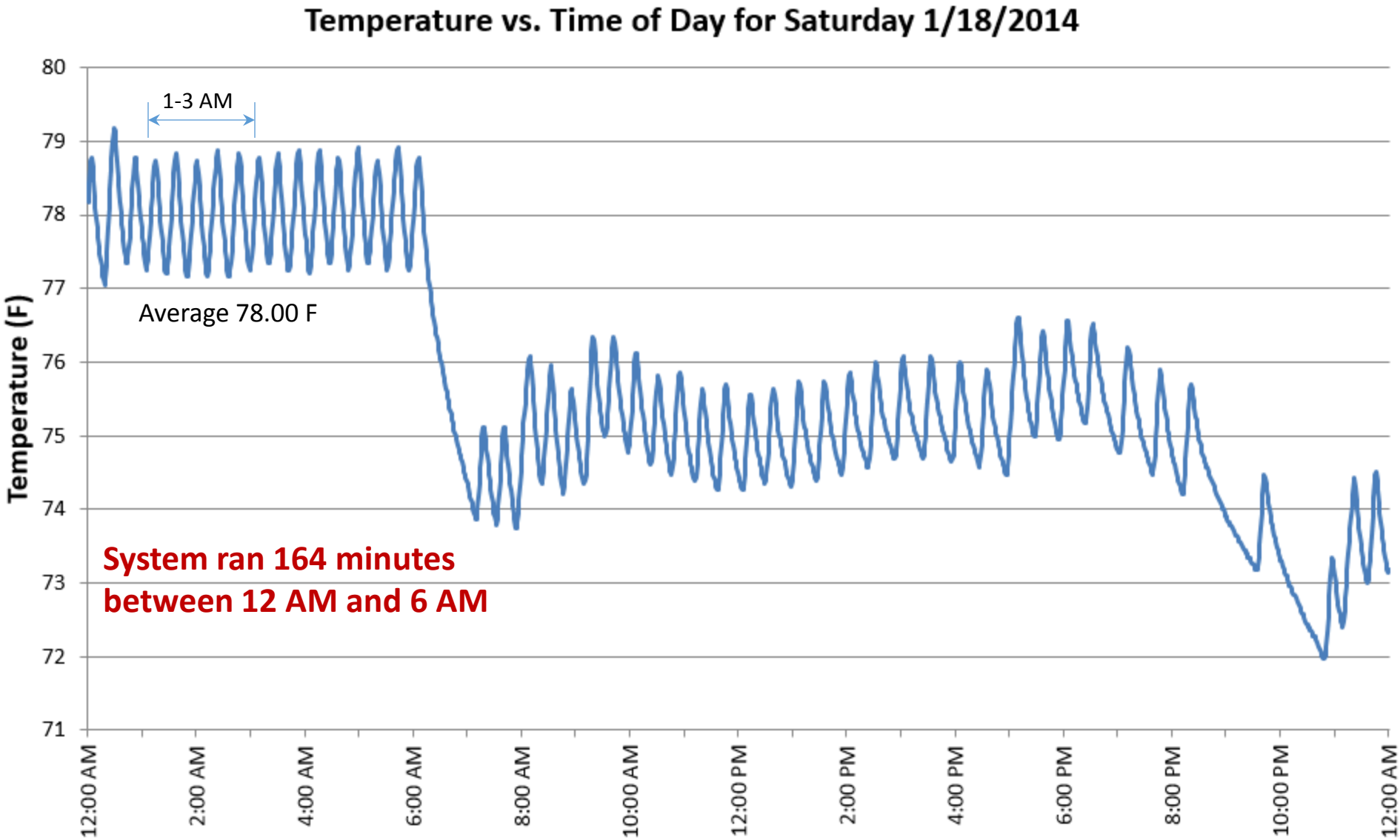

Temperature vs. Time of Day for Wednesday 1/29/2014
Temperature (F)
83
81
79
77
75
73
71
1-3 AM
Average 76.53 F (1.47 F cooler)
System ran 163 minutes
between 12 AM and 6 AM
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM

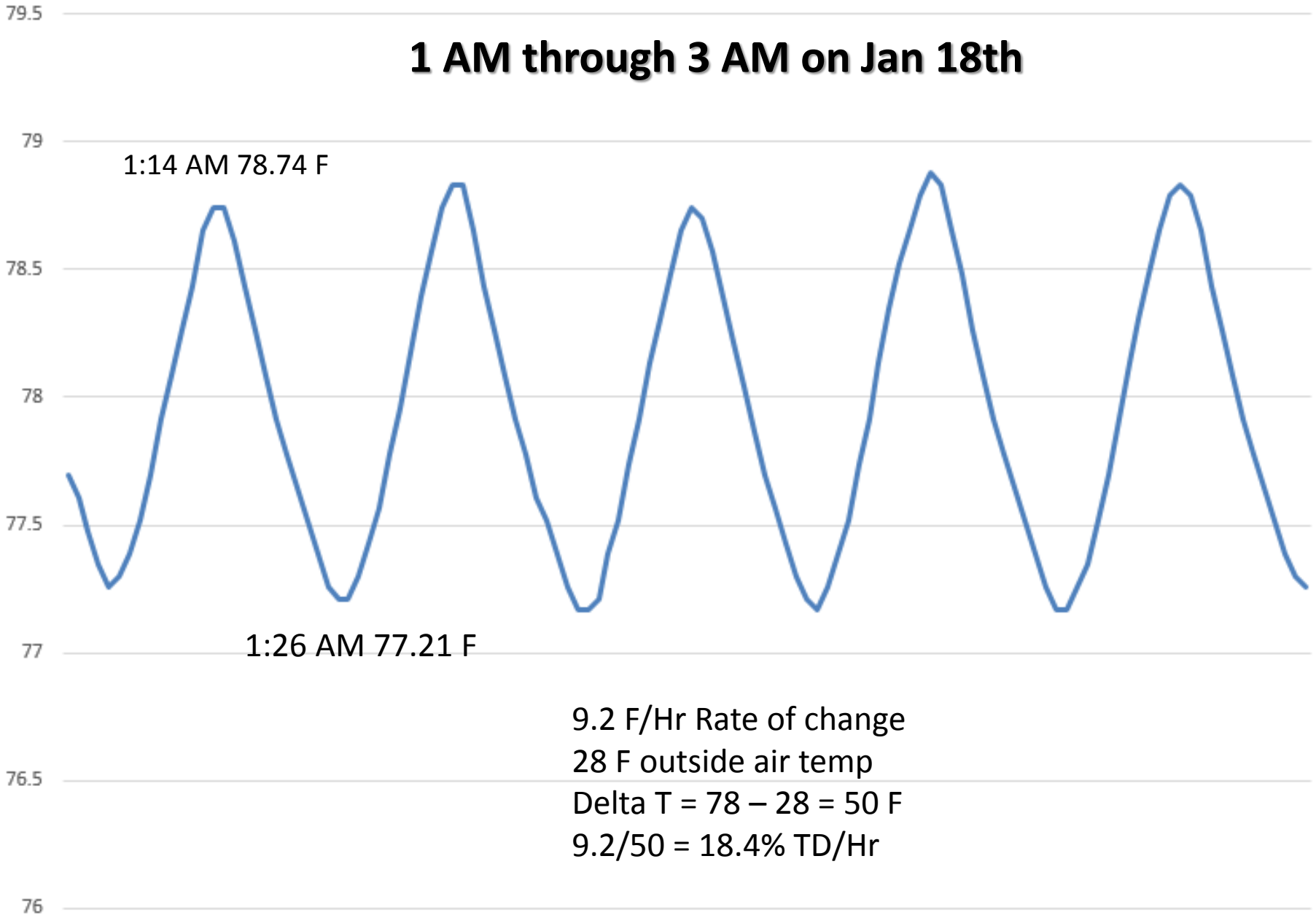
1 AM through 3 AM on Jan 29th

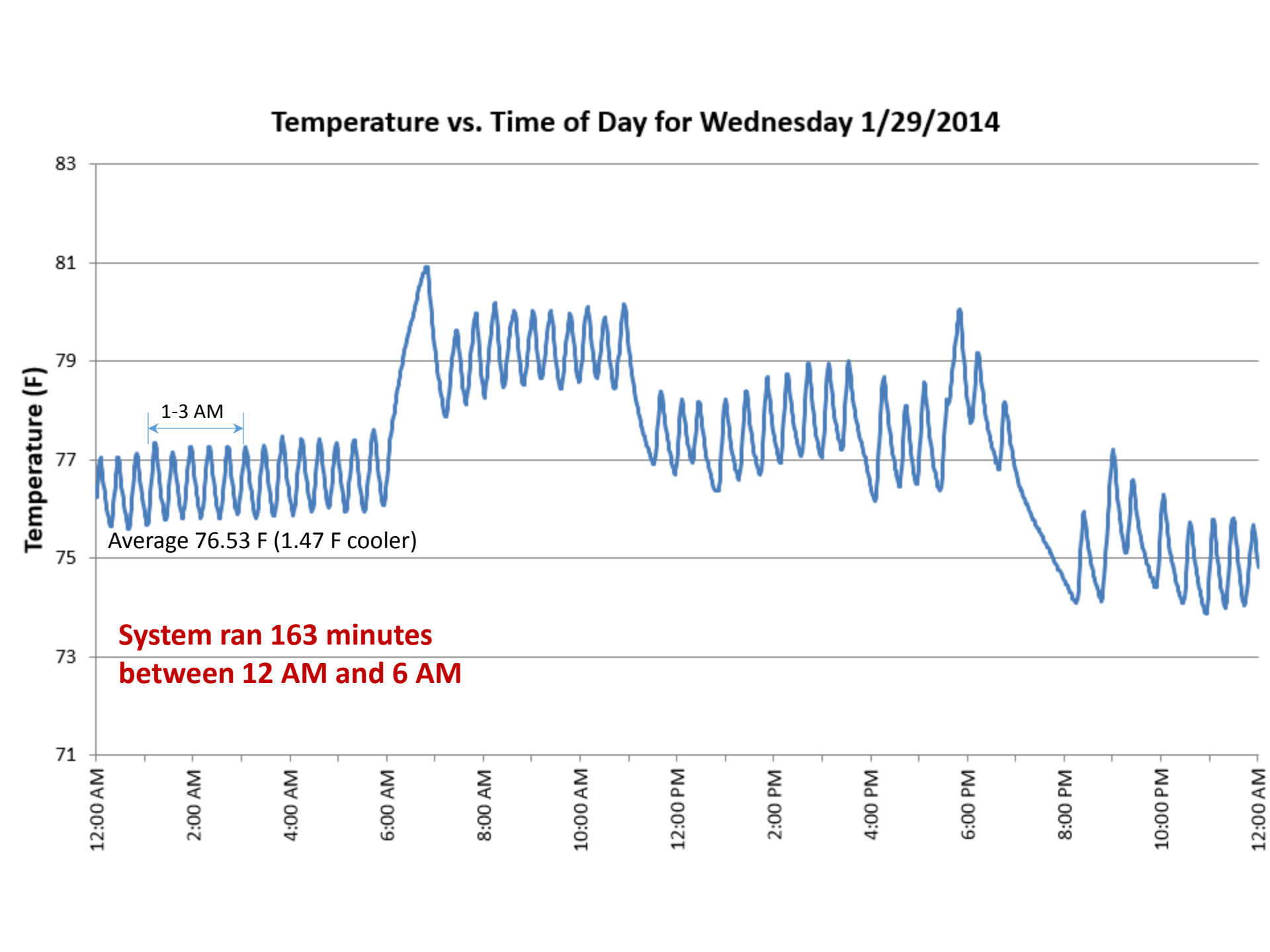


11.3 F/Hr Rate of change
18 F outside air temp
Delta T = 67.5 – 18 = 49.5 F
11.3/49.5 = 22.8 % TD/Hr

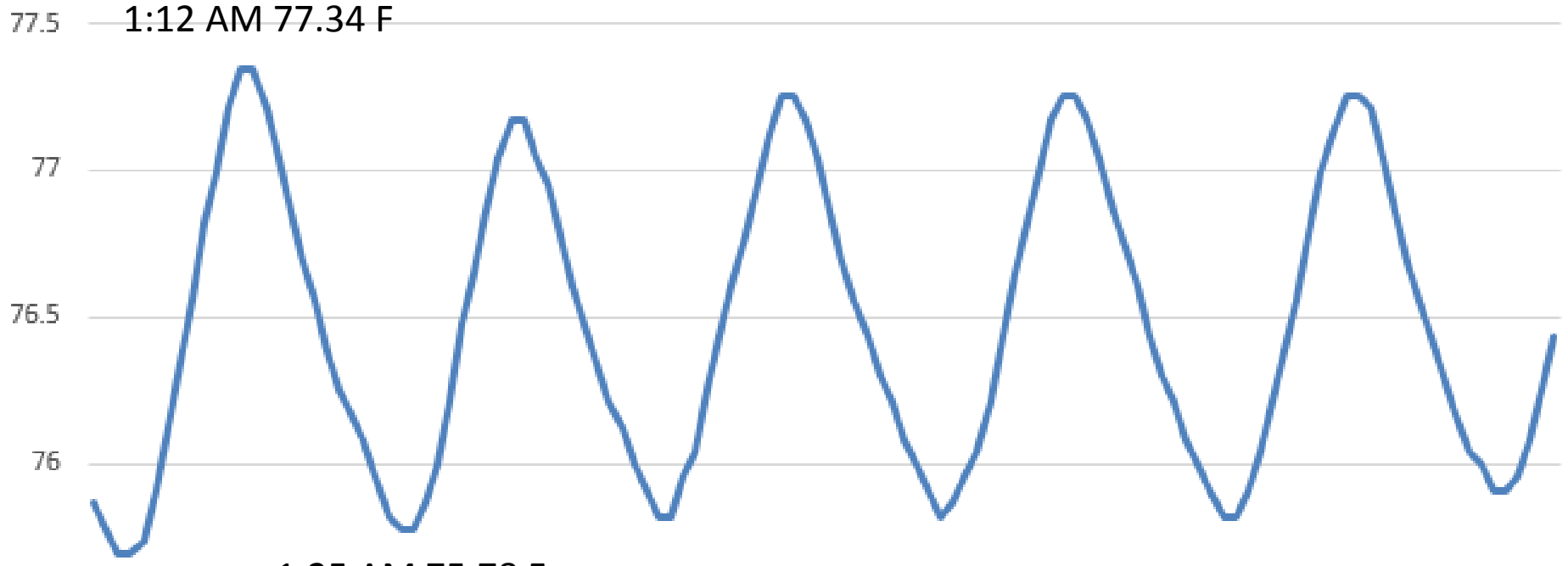
22% Thermal Upgrade


Temperature vs. Time of Day for Saturday 1/18/2014
Temperature (F)
80
79
78
77
76
75
74
73
72
71
1-3 AM
Average 78.00 F
System ran 164 minutes
between 12 AM and 6 AM
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM


1 AM through 3 AM on Jan 18th
79.5
79
78.5
78
77.5
77
76.5
76
1:14 AM 78.74 F
1:26 AM 77.21 F
9.2 F/Hr Rate of change
28 F outside air temp
Delta T = 78 – 28 = 50 F
9.2/50 = 18.4% TD/Hr


Temperature vs. Time of Day for Wednesday 1/29/2014
Temperature (F)
83
81
79
77
75
73
71
1-3 AM
Average 76.53 F (1.47 F cooler)
System ran 163 minutes
between 12 AM and 6 AM
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM

1 AM through 3 AM on Jan 29th



8.4 F/Hr Rate of change
18 F outside air temp
Delta T = 76.5 – 18 = 58.5 F
8.4/58.5 = 14.3 % TD/Hr

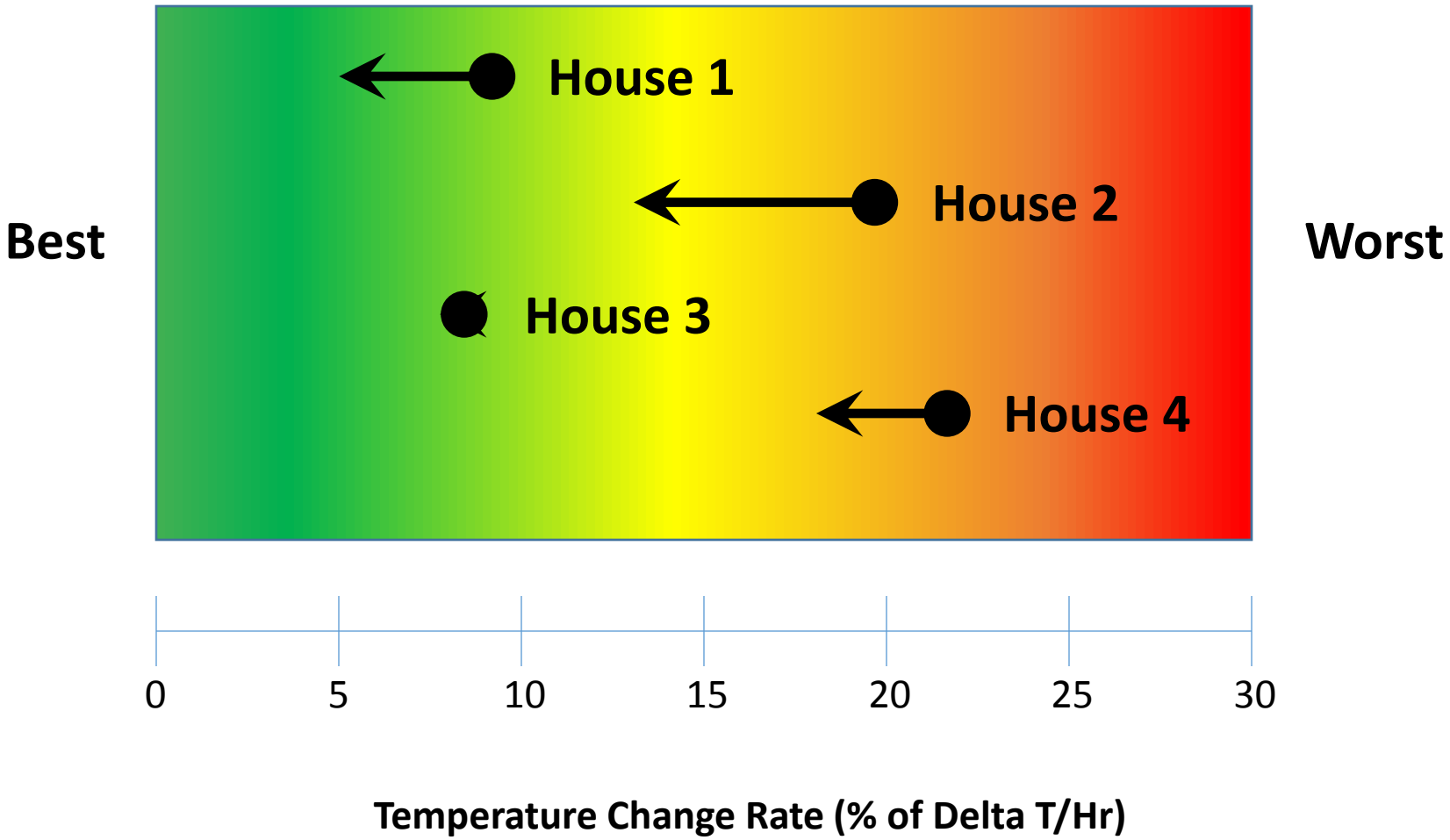
22% Thermal Upgrade

164 minutes at 50.0 F
163 minutes at 58.5 F
17% HVAC Run Time Impact

Thermal Monitoring Performance Results

	Improve Date	Logger	Before TCR %	After TCR %	TCR Impmnt	Run Time Impmnt
House 1	Jan 24th	931	10.6%	4.6%	56.6%	30%
		934	7.1%	7.1%	~ None	30%
House 2	Jan 22nd	815	18.8%	16.7%	11.2%	25%
		817	22.5%	9.2%	59.1%	25%
House 3	Jan 30th	820	6.2%	6.9%	~ None	~ None
		824	7.5%	7.8%	~ None	~ None
House 4	Jan 23rd	929	14.9%	13.5%	9.4%	17%
		933	29.3%	22.8%	22.2%	17%

Thermal Performance Standards



Blower Door Performance Results

	Blower Door Tests					
	Sq Ft	**Before**	**Before/SF**	**After**	**After/SF**	**Improvement**
House 1	1660	7002	4.22	4645	2.80	33.7%
House 2	852	6335	7.44	4725	5.55	25.4%
House 3	1236	5847	4.73	3883	3.14	33.6%
House 4	2200	4861	2.21	2905	1.32	40.2%

Insulation and Infiltration Upgrades

- One day later you can know if they
  - Changed the slope of the curve
  - The extent of the change made
  - You know if they disturbed the air balance
- Customers taking back the improvements
  - Can be informed about the impacts
  - Regulatory reporting is more robust

Benefits of Thermal Gain Analysis

- Identify problems with FROGs
- Identify problems with West facing glass
- Identify value of improvements with attic reflective materials (or verify they don't work)
- Solve other comfort issues
- Verify performance on retrofits to above
- And always separate out any takeback effects

This takes more data to perform

- Local logger for outside air temperature
- Local logger for attic air temperature
- Local logger for crawlspace temperature
- Requires weather service solar incidence data
- Probably requires interpretation/confirmation
- But, this is still really cheap to do!!!

Thank you for your participation

- We introduced the new monitoring concepts
- We illustrated the SEA pilot test results to date
- What are your thoughts about all this?
  - Might this be a natural “pre-qualifier”?
  - How does this redefine/measure/confirm success?
  - Is there a need for a national database?
  - Does this redefine QA and Cost Effectiveness?
- What might be some logical next steps?