HOUSINGVERMONT

ENSURING YOUR ENERGY REMAINS AFFORDABLE,

USING DATA FOR ENERGY OPTIMIZATION

Housing Vermont History

HV is a non-profit syndication and real estate development company created in 1988 by VHFA and endowed with a $2M investment

HV has raised $380 million in private equity for housing, which has leveraged an additional $487 million in private financing and public investment.

In the past 31+ years we have

- Created over 180 Projects through LIHTC Partnerships
- Developed over 6,000 units of affordable housing across the state of Vermont

Energy Totals

- 14 Solar PV systems serving 831 apartments.
- 22 Biomass systems serving 710 apartments.
- 31 Solar DHW systems serving 756 apartments.
- 111 Air source heat pumps serving 125 apartments.
- 1 Facility with all electric resistance heating 30 apartments

HV - Energy Services Division

2008	• Recognized the need to review mechanical efficiency in response to a spike in energy prices.
2011	• HVT started to collect small scale data on a real time basis.
2015	• HVT began to develop a "buildings" database and software.
2017	• Reduced costs of installed hardware coupled with cloud storage.
2020	• Data collection is becoming integral with every deployed project

Why Acquire Data?

- Data provides you with evidence on how your system is performing, not just running.

- How did you used to do it?

  Zero - No heat complaints!

  Zero - Hot water complaints!

  Zero - Comfort complaints!

  Given the lack of these complaints, we must believe that the….

System is Running !!

Why Analyze the Data?

- Data analysis provides you with insight if your systems are running as intended.
    - What does that mean?
    - Is it cycling properly?
    - Is it at the optimal capacity?
    - Does it Stage Properly?

Why Data Analysis?

Valid data helps prevent premature failure.

Helps to control operating costs.

Helps with scheduling maintenance.

Can detect emerging problems.

Develops design & replacement guidelines.

Construction feedback loop.

Data vs Information

1 0 1 0 0 1 0 0 1 0	1 1
0 1 0 1 0 1 0 1 0	1 0

Data

Data vs Information

1 2 3 4 5 6			
1 0 1 0 0 1	3	3	0
0 1 0 1 0	2	4	0

Data With Context

Data vs Information

	1	2	3	4	5	6	7					
	1	0	1	0	0	1				3	3	0
	0	1	0	1	0	1				3	5	0

Context to Information

Data vs Information

	1	2	3	4	5	6	7	8	9	R	H	E
RED SOX	1	0	1	0	0	1	0	0	1	4	6	1
YANKEES	0	1	0	1	0	1	0	1	1	5	8	0

Information

Internet of Things (IoT)

The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction[1].

Data from the IoT - (homeowner)

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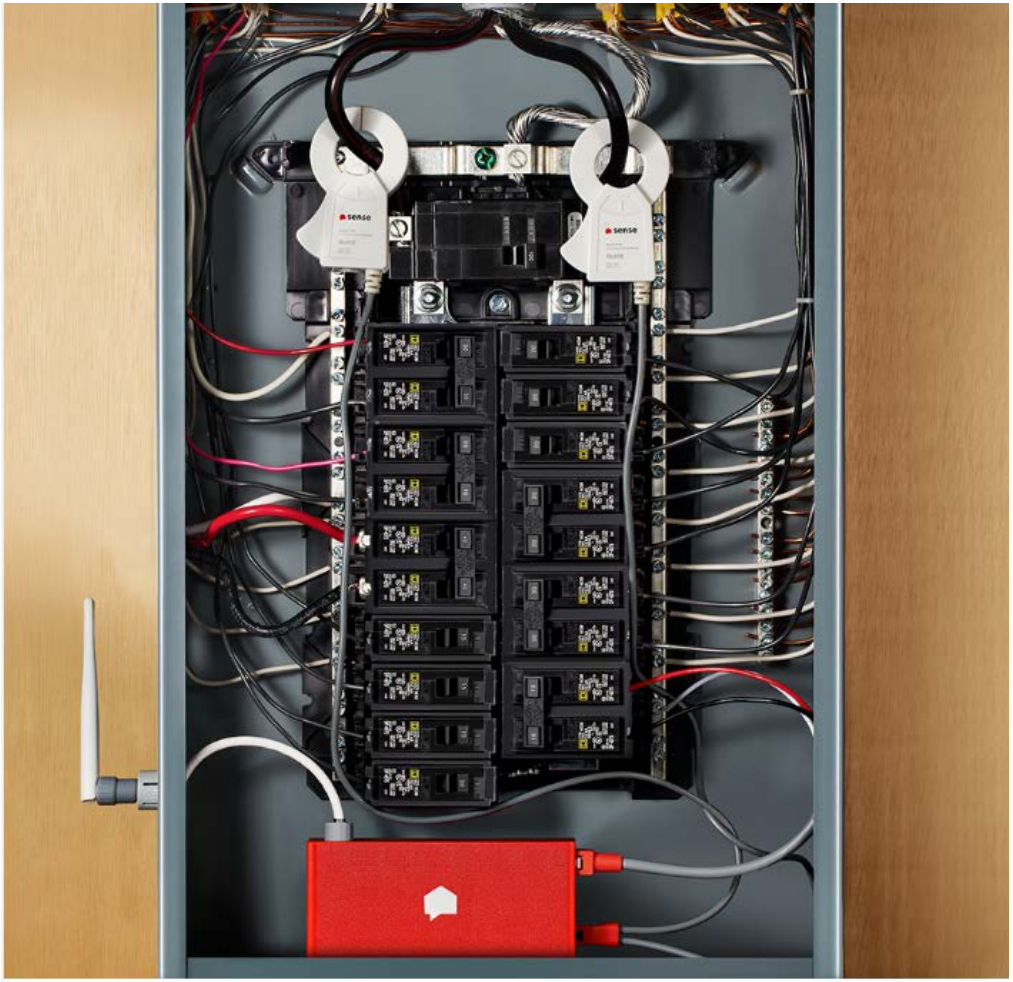

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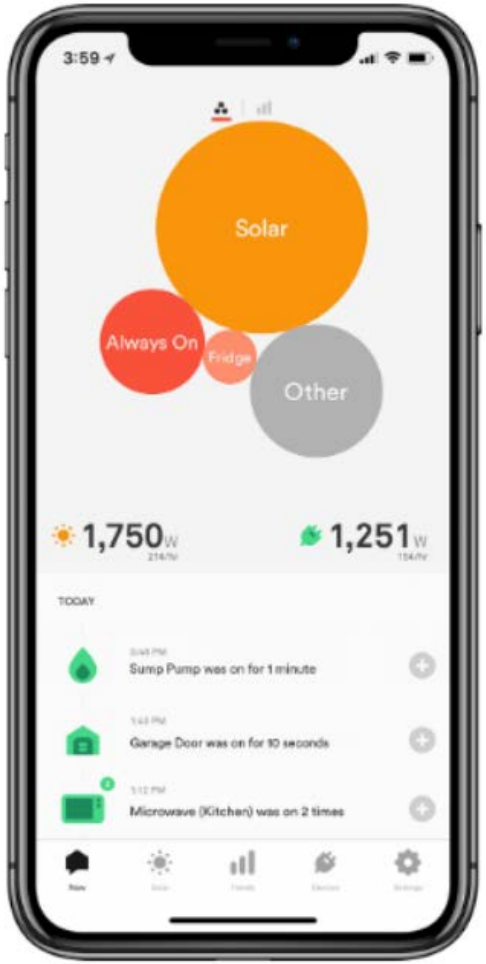

5:15pm
Garage door opened

5:20pm
Kitchen lights turned on

6:30pm
Iron was on for 8 minutes

7:45pm
Dryer turned off

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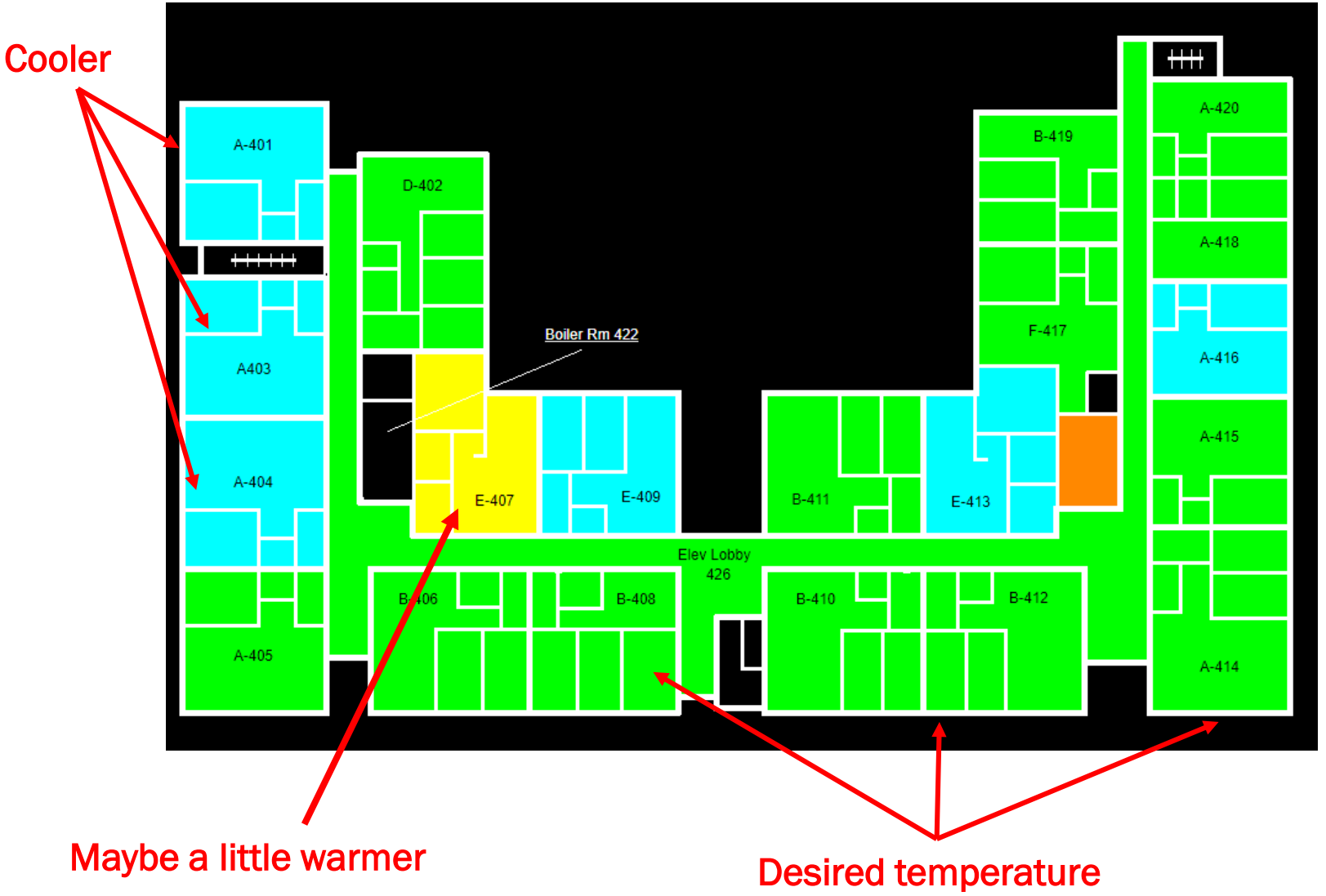
Data from the IoT

Manage our Data to Save $$

Data for the Property Manager

Data for the Property Manager

Data for the Property Manager



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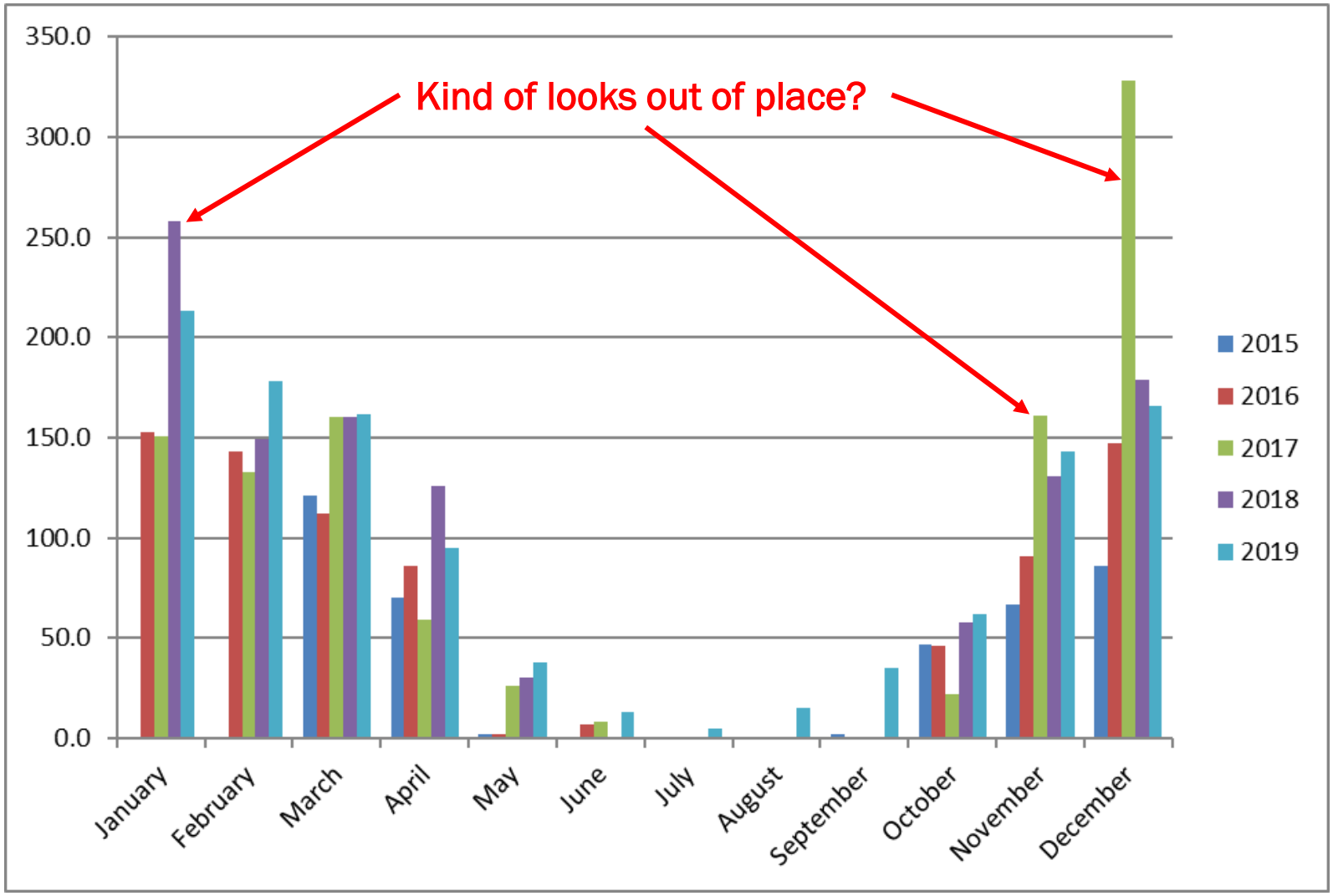
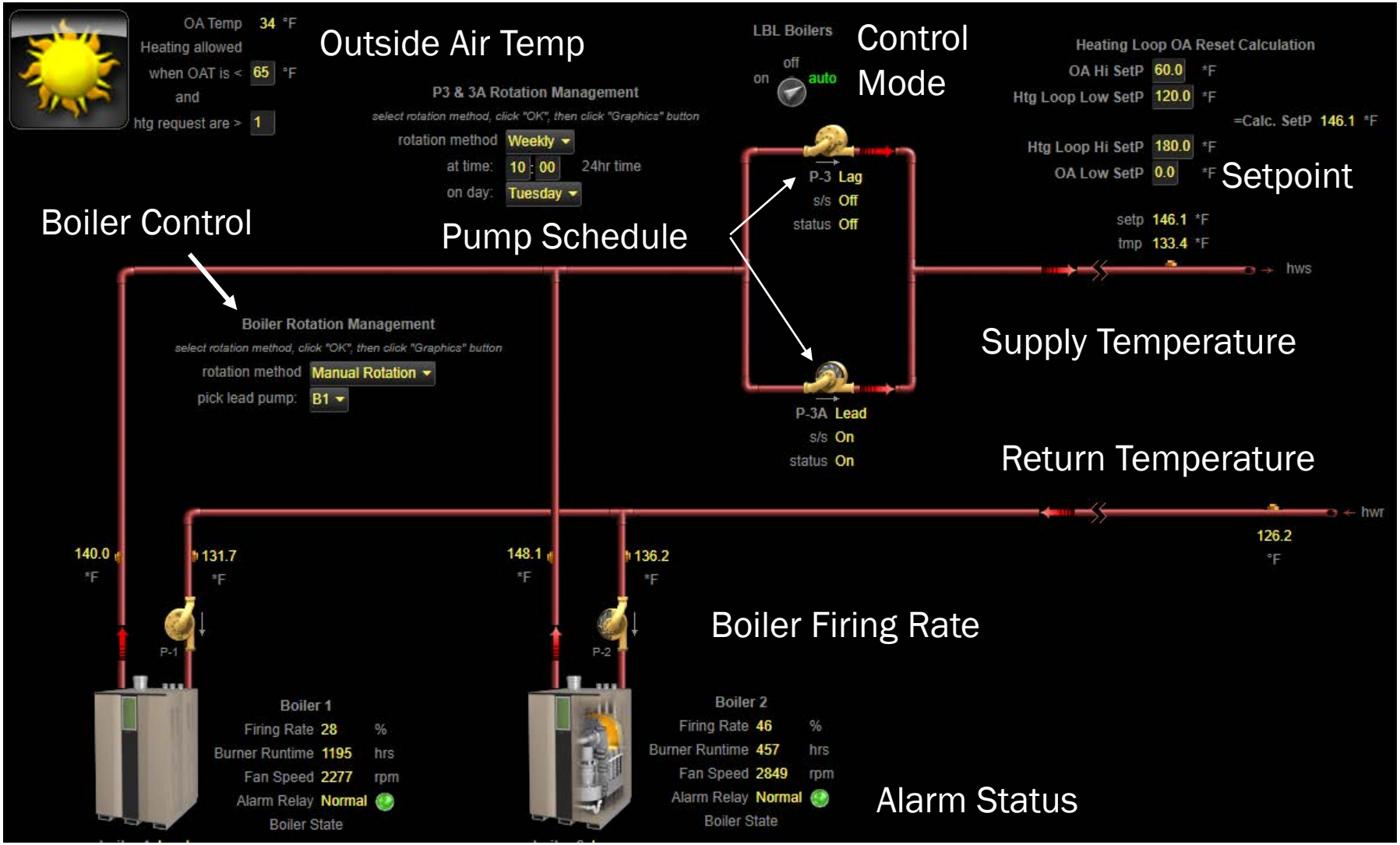
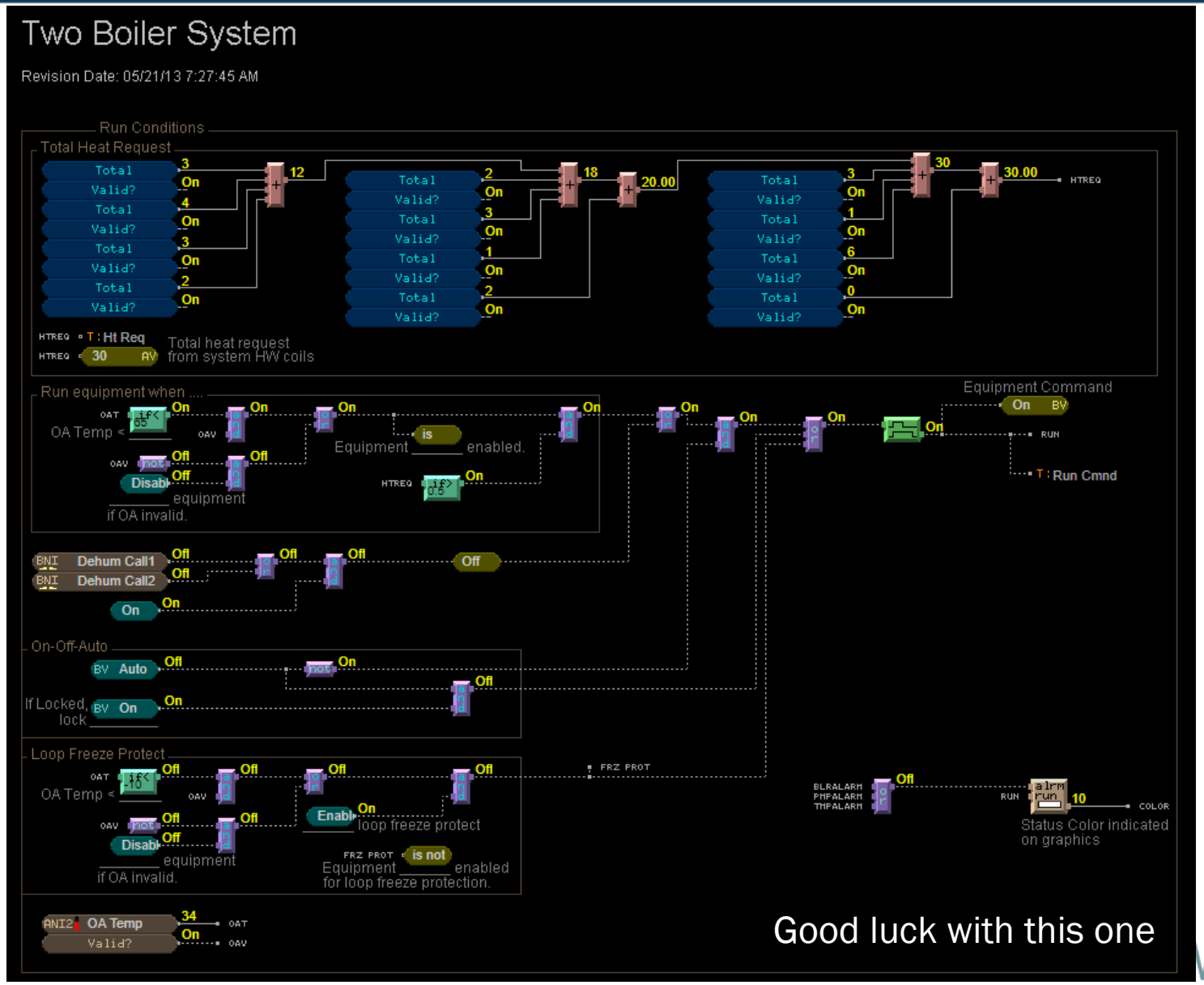
Data for the Property Manager



Data for the Property Superintendent



Data for the Property Engineer



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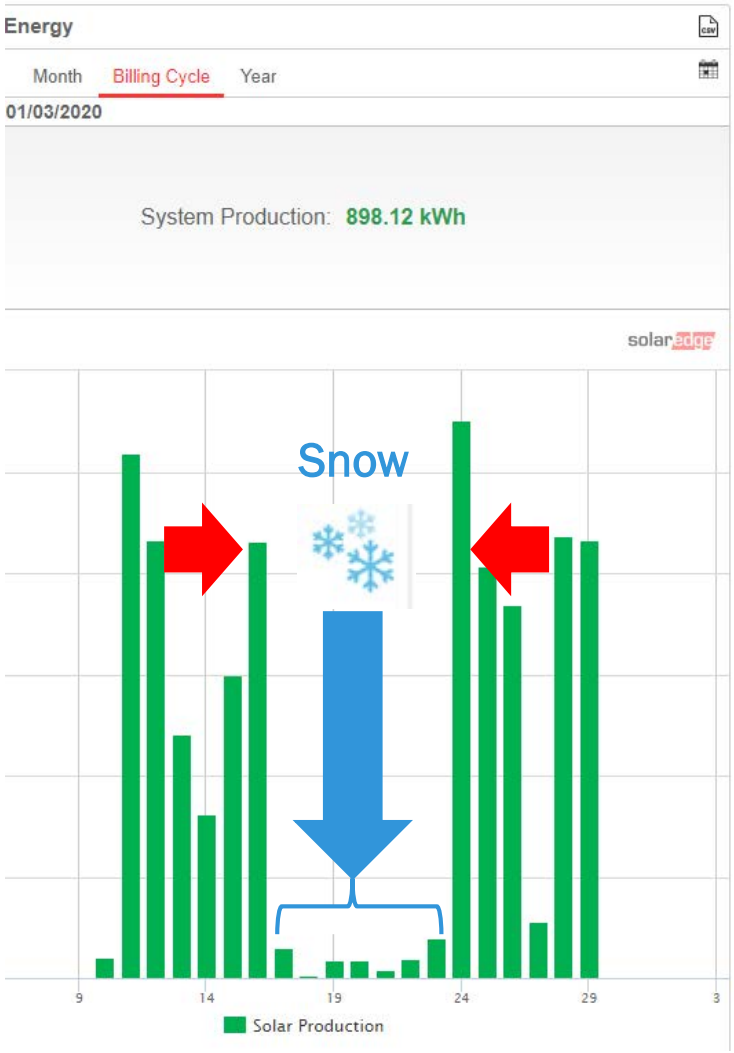
Data for the Finance Manager



Site Status	✓
ID	1173876
Name	HVT Taylor St.
Address	Taylor Street, Montpelier,Vermont,United St...
Installed	07/01/2019
Last Updated	01/14/2020 16:34
Peak Power	55.545 kWp

Partly Cloudy
31 °F
Feels like 31 °F
Wind N, 0 MPH
Humidity 85 %
Sunrise at 07:24
Sunset at 16:36

Tuesday	Wednesday	Thursday
34 - 34 °F	36 - 30 °F	30 - 3 °F
Partly Cloudy	Cloudy	70% Chance of Snow

Partly Cloudy
41 °F
Feels like 38 °F
Wind SSE, 5 MPH
Humidity 67 %
Sunrise at 07:19
Sunset at 16:40

Tuesday	Wednesday	Thursday
41 - 36 °F	45 - 28 °F	37 - 14 °F
Mostly Cloudy	Partly Cloudy	40% Chance Frozen Mix

Environmental Benefits

CO2 Emission Saved
97,037.6 lb

Equivalent Trees Planted
2,444.02

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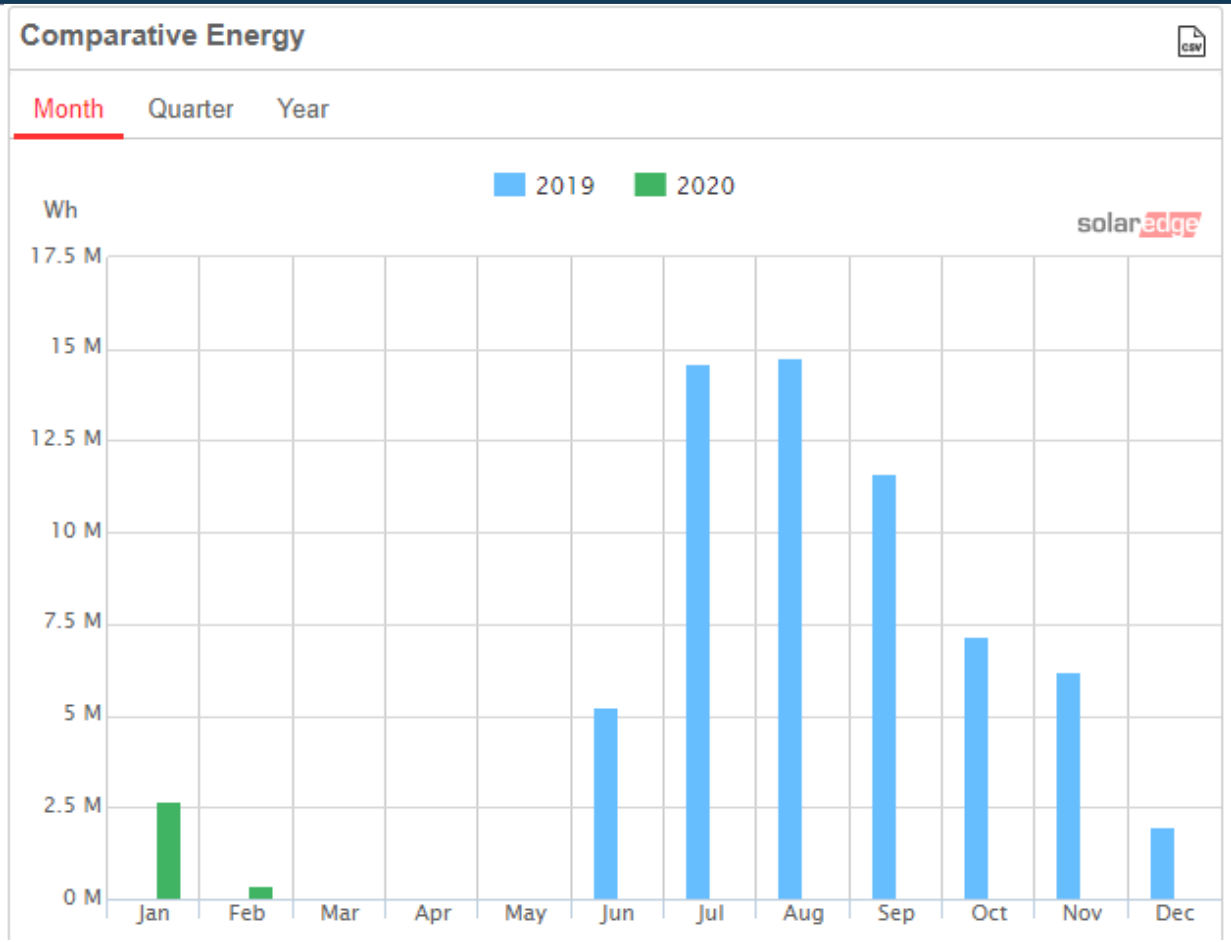
Data for the Finance Manager



Current Power	Energy today	Energy this month	Lifetime energy	Lifetime revenue
10.16 kW	94.38 kWh	385.1 kWh	64.65 MWh	$11,313.02

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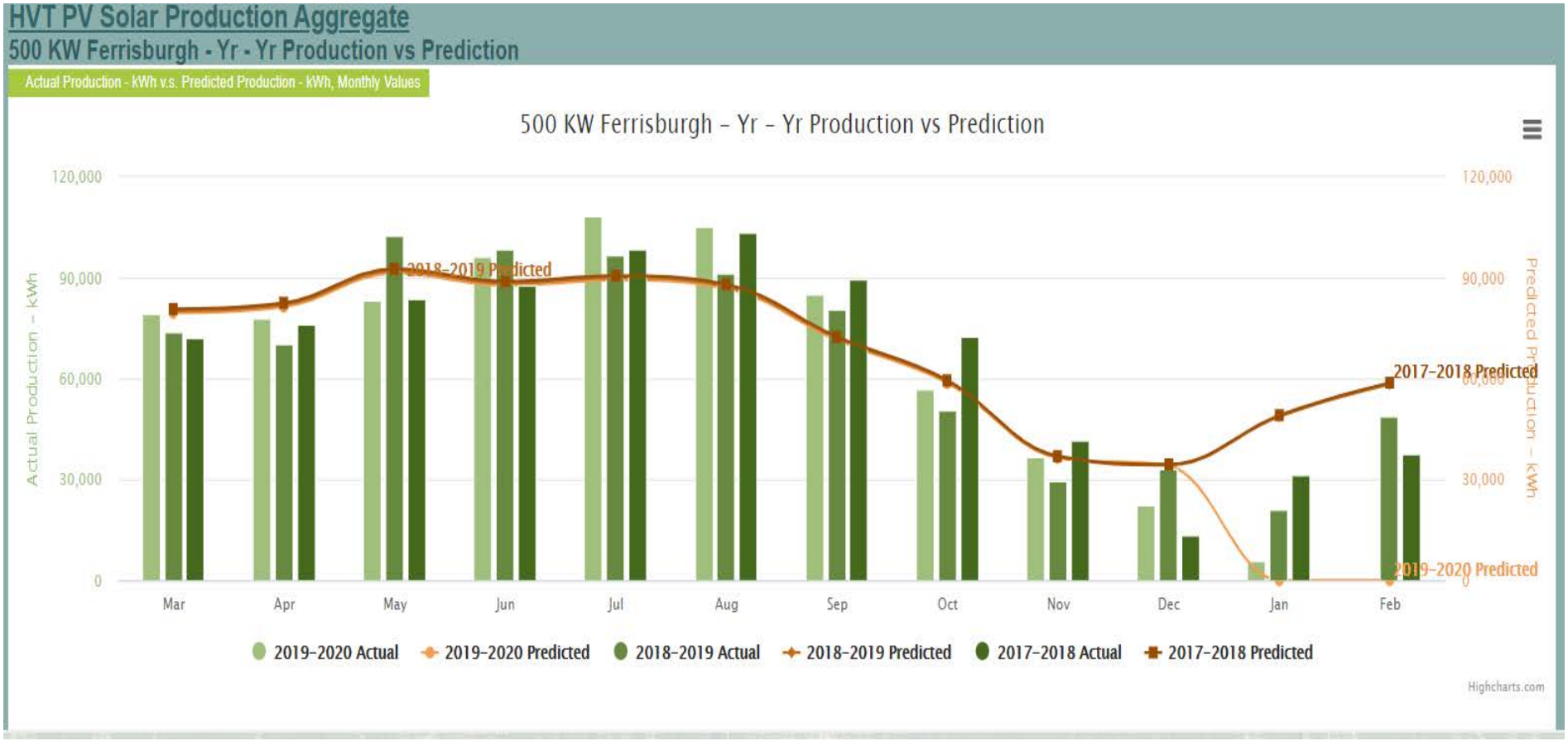
Data for the Finance Manager



Year over year comparison
Actual vs Predicted

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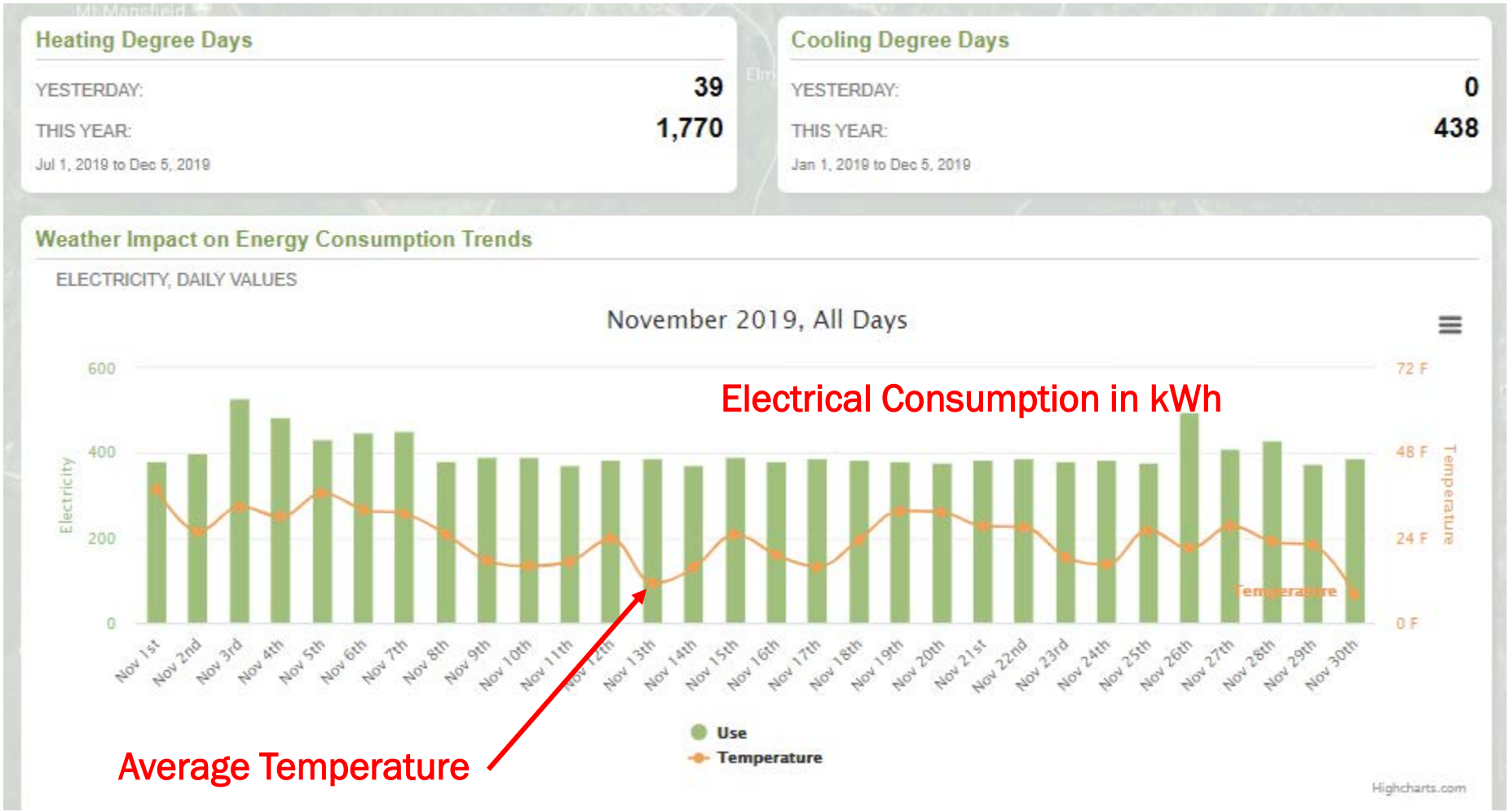
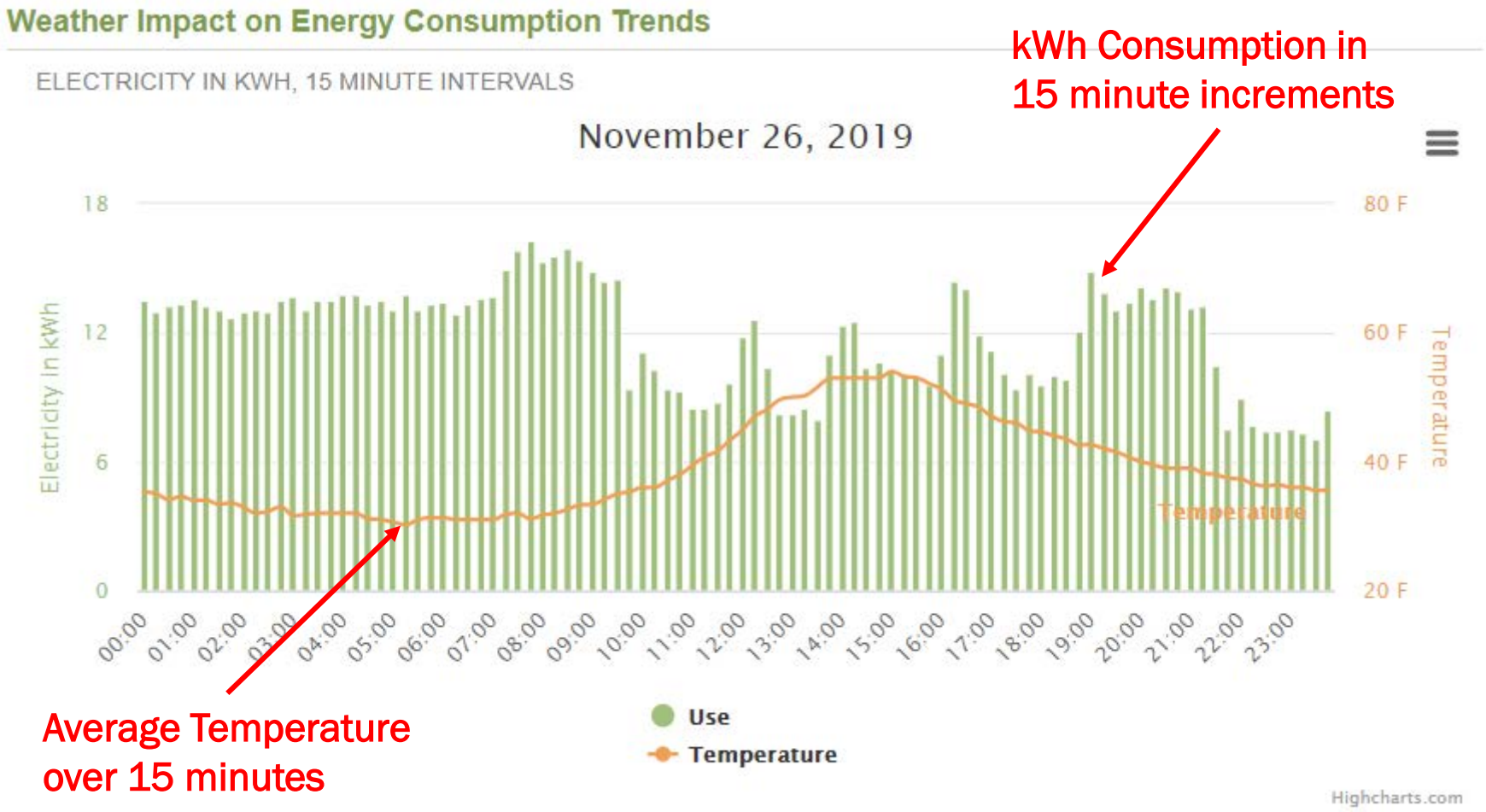
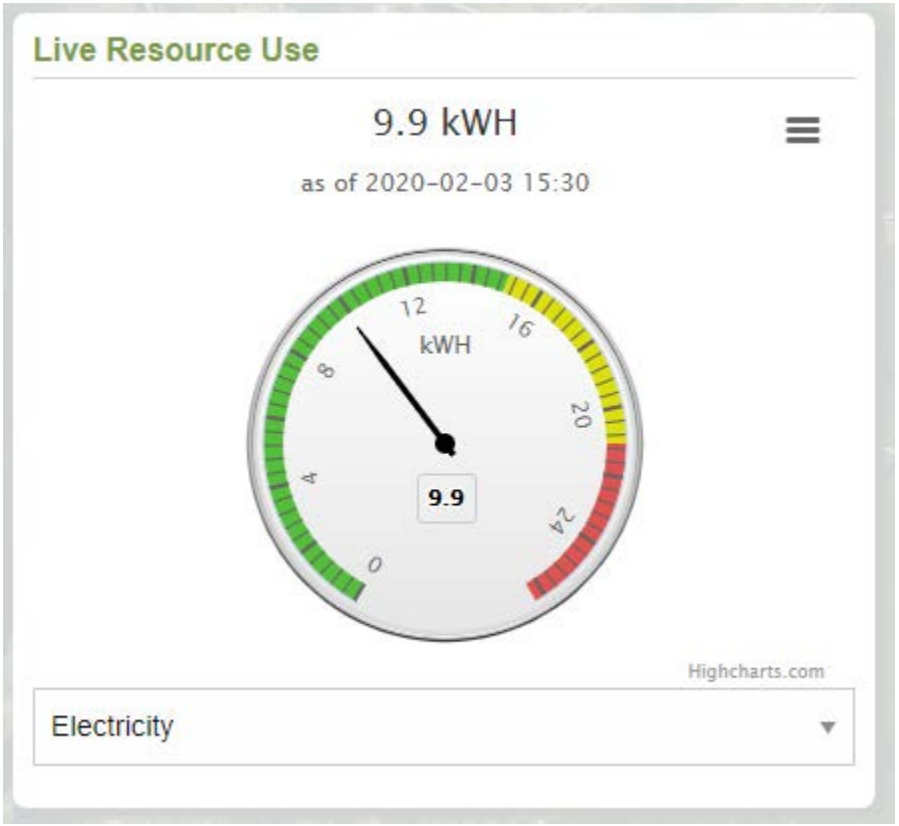
Data Visualization



Data Visualization



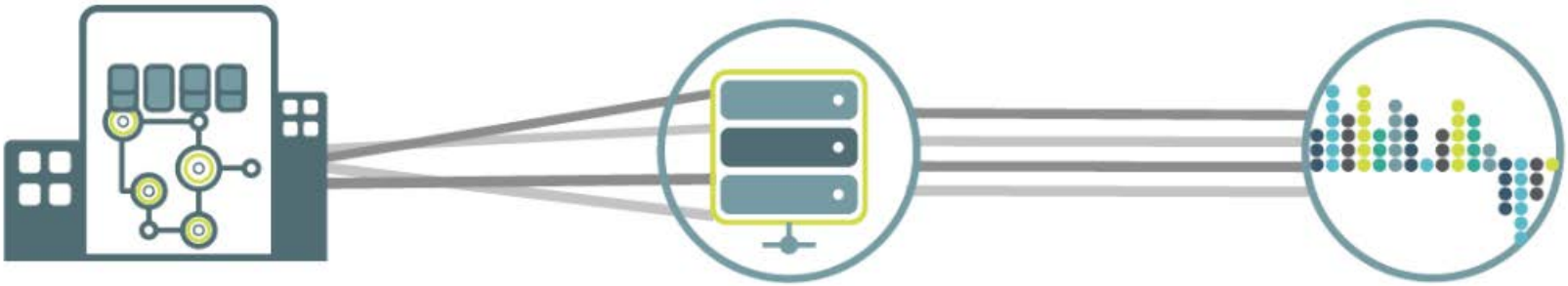
Data Visualization



System Performance At a Glance

- Building kWh Consumption
  - As of 3 February 2020
  - Dial Gauge presents consumption summary
- Green = Consumption to within AVG of the last 30 Days
- Yellow = Consumption within 125% of AVG of the last 30 days
- Red = Consumption within 150% of AVG of the last 30 days

Parsons Platform



Common Off The Shelf (COTS) hardware installed at the site acquires varying data types from:

- Boilers
- Pumps
- Electrical Panels
- Building Automation Systems
- Meters
- Solar Inverters

Data is collected in a cloud based, relational data base, tagged with a unique ID, and time stamped.

Data sets are displayed intuitively transforming the raw data into information. Data visualization helps with:

- System Commissioning
- Ongoing Operation
- Automated reporting
- Future designing

Effective Equipment Management

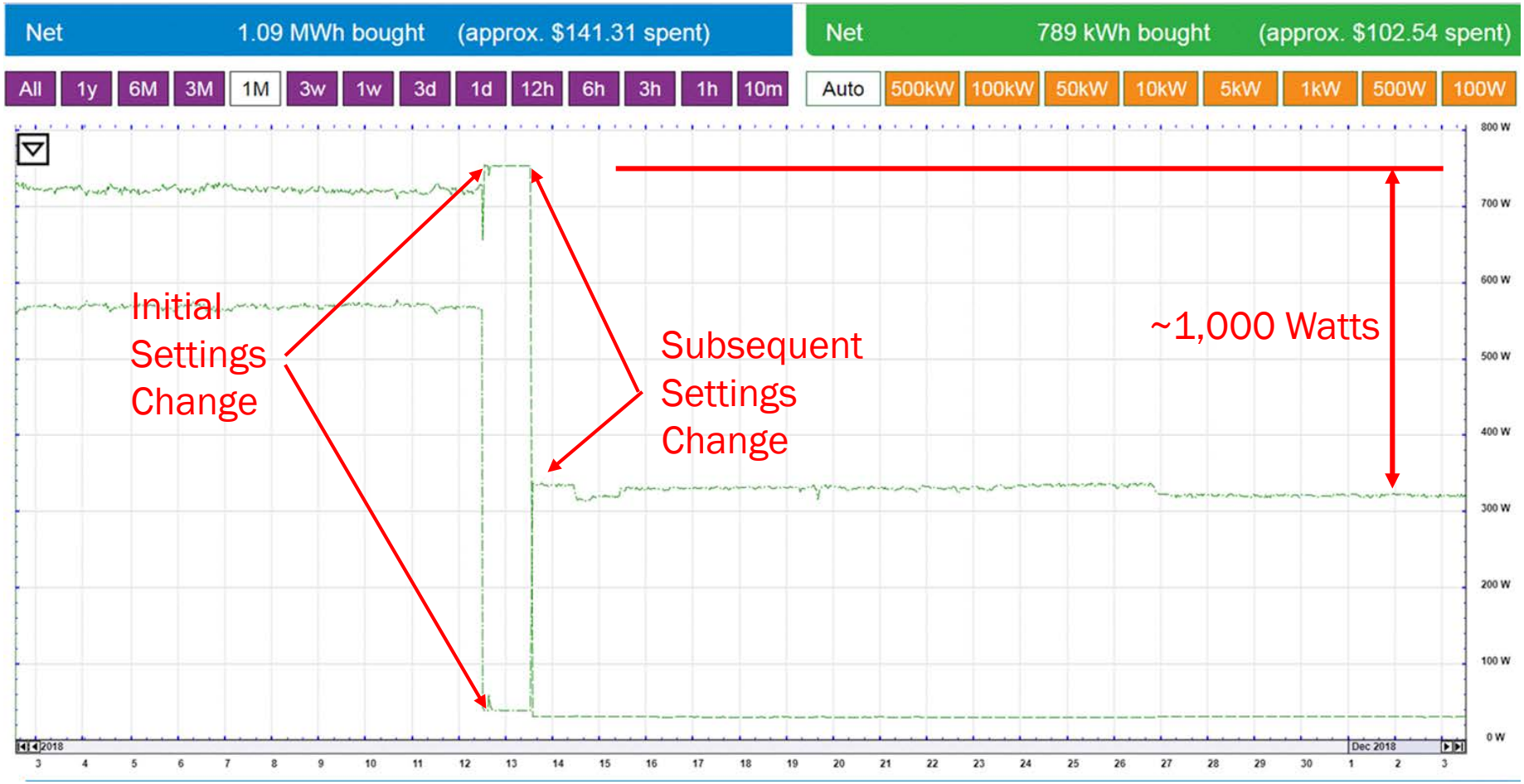
Case Study
North Pleasant Street
Middlebury, VT

- Combined Wood Pellet and Natural Gas fired hydronic heating system
- Main hot loop provided heating for warmth and indirect domestic hot water (DHW) heating for consumption.
- Residents reported problems with getting heat.
- Since the conversion to natural gas, pellet boilers were under-utilized
- HVT deployed data sensors and conducted an optimization study

Case Study

Category	Metric	Pre-Optimization Status	After Optimization Status	Change
Installed Boiler Capacity On-Line	BTU/SqFt/Hour	40.7	20	(51)%
Boiler Capatialization + Maintenance.	Units in Use	4	2	(50)%
Annual Fuel Cost	Dollars	$ 21,300	$ 12,000	(44)%
Annual House Electricity Costs	Dollars	$ 5,325	$ 3,762	(29)%
Total Annual Fuel and House Electricity Costs	Dollars	$ 26,625	$ 15,762	(41)%
Total Annual Fuel and House Electricity Costs	Dollars per Bedroom	$ 634	$ 375	(41)%
Annual Additional Free Cash Flow Provided to Partnership		$		10,863

Case Study



North Pleasant 2 – Middlebury VT Result of Grundfos pumps settings adjustment; initial situation was two main circulator pumps operating in constant pressure mode, Electrical Consumption on Pump #1 was ~ 725 Watts, Pump #2 ~ 575 Watts total electrical consumption ~ 1,300 watts. On November 12, 2018 pump #2 was placed into Auto Adapt mode, resulting in a kWh consumption of ~ 20 watts, on November 13, Pump #1 was also placed into Auto Adapt mode resulting in a revised cumulative consumption of approximately 330 watts; The pumps had been operating in constant flow mode for over four years.

Case Study

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Case Study

- Power consumption was constant 24/7; 365 days a year.
- Made setpoint adjustment on both pumps
- This simple change reduced electrical consumption by over 70%.

Over $1,500 Annually saved!

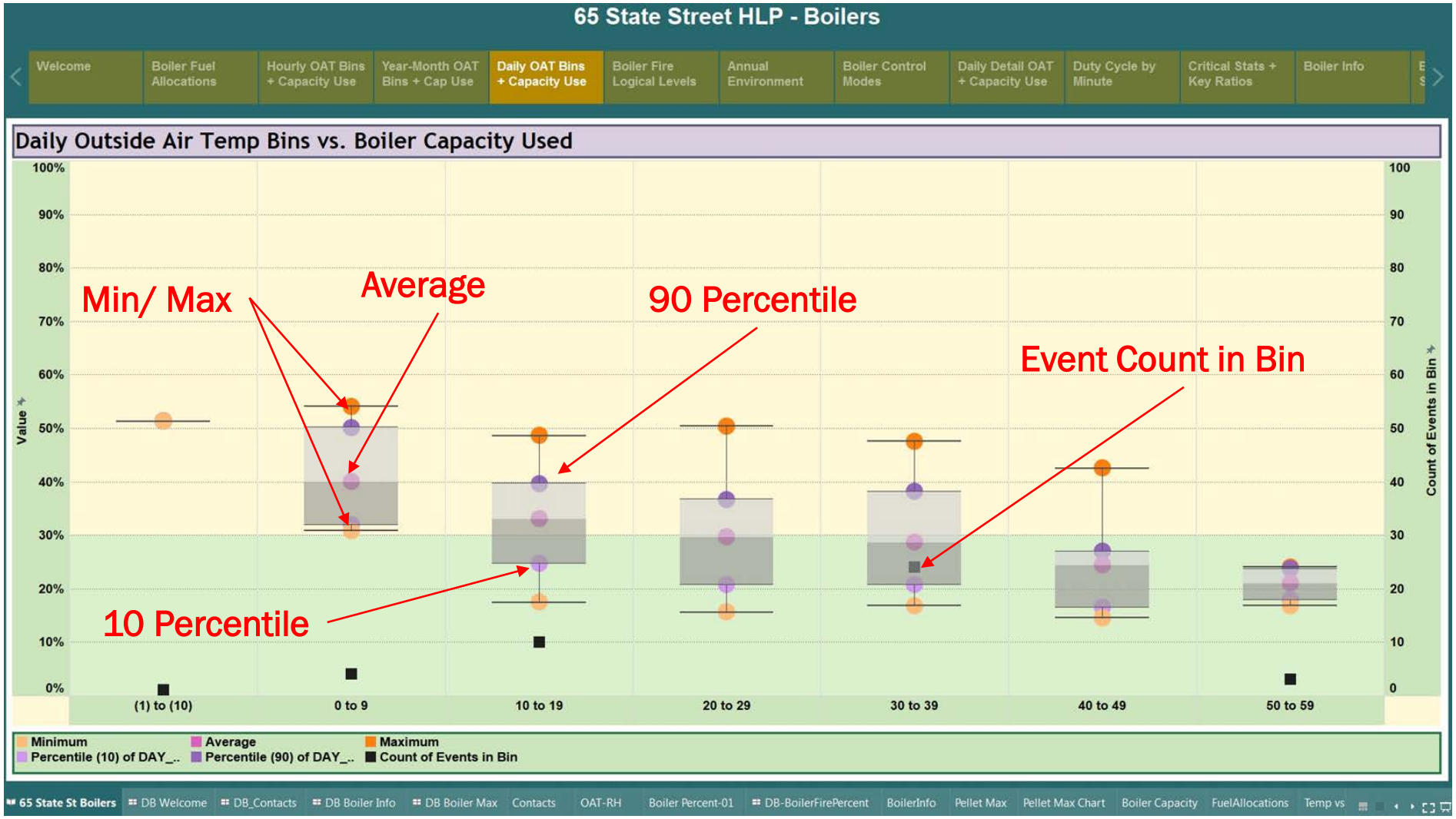
Case Study Applegate Apartments Bennington, VT

- One Site 104, 230 Sq Ft
- 104 Apartments
- 23 Buildings
- Converted 23 oil fired boilers to one central wood chip fired plant.
- Underground piping circulated hot water to all buildings.
- Retrofit helped to reduce average fuel cost from $165,000/ yr to $50,000 /yr

Applegate Apartments - Guiding Design

- Original retrofit design – central wood chip heating output 3.2 million BTU's
- Shared Data from an existing comparable sized building with the design team.

Applegate Apartments - Guiding Design



Applegate Apartments - Guiding Design

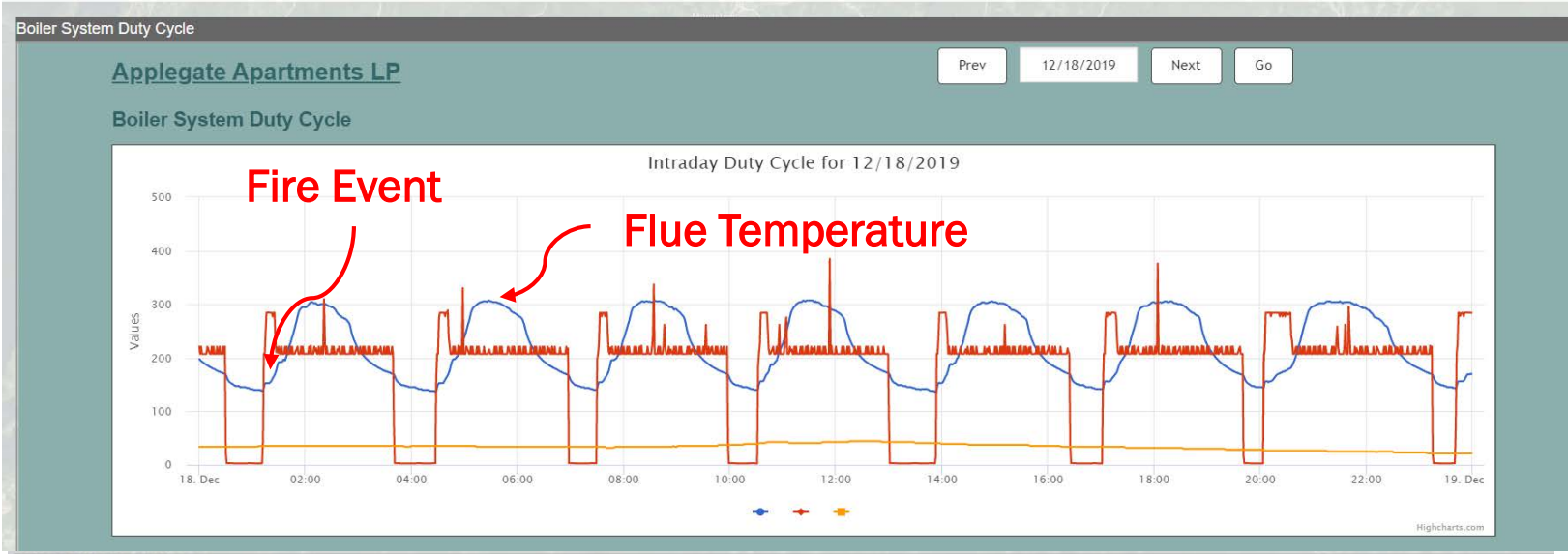
- Plans were revised to incorporate a 1.8 million-BTU plant instead.
- $200,000 in construction costs saved in the short term, and a more efficient boiler in the long term.
- Confirmed boiler used 75% capacity at temperatures at or below zero during the first year.

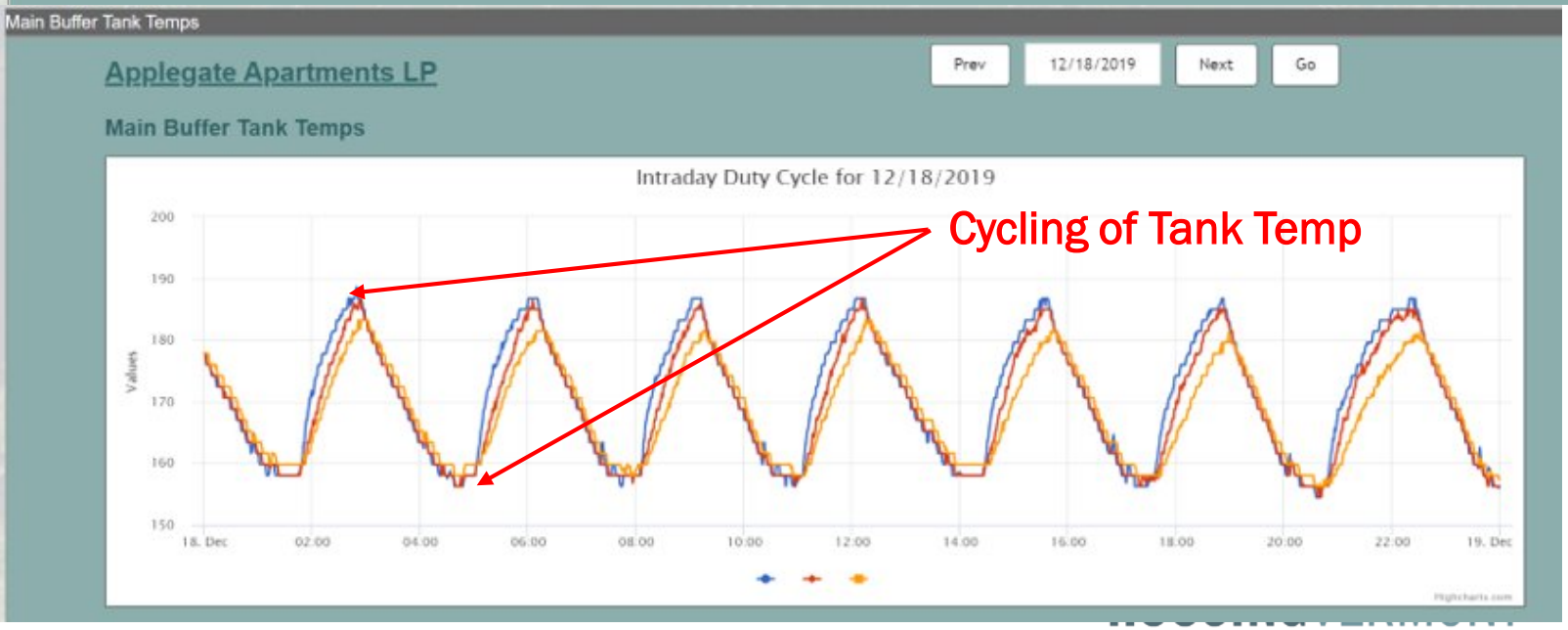
Case Study

Boiler System Duty Cycle

and

Buffer tank Temp's





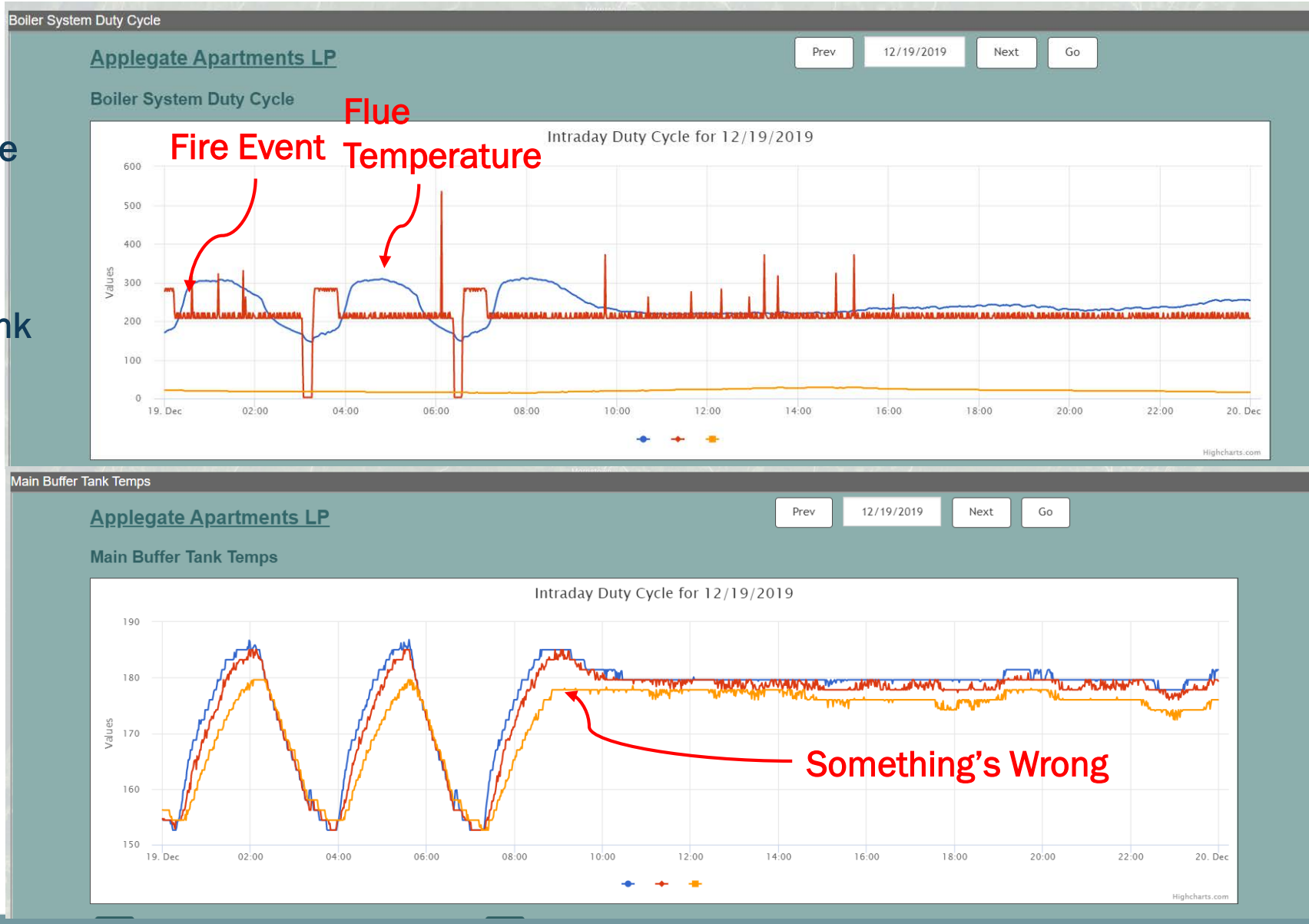
Case Study

Boiler System Duty Cycle

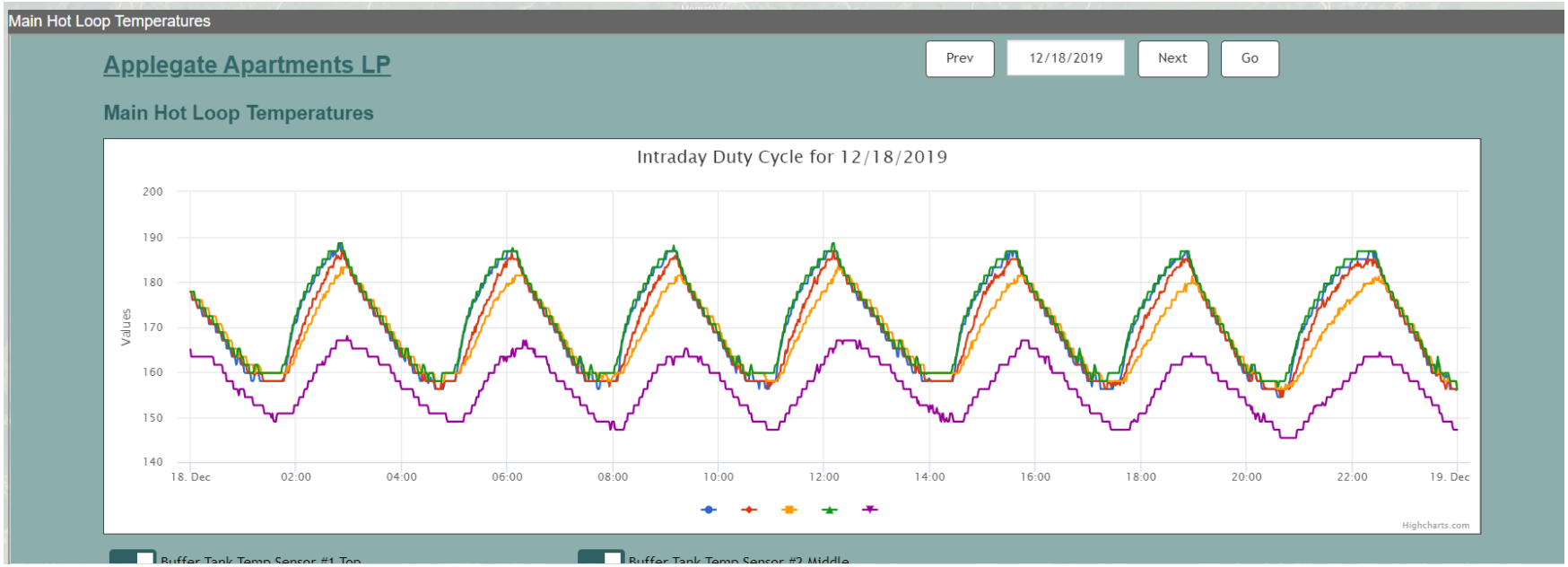
and

Buffer tank Temp's

Next Day



Case Study

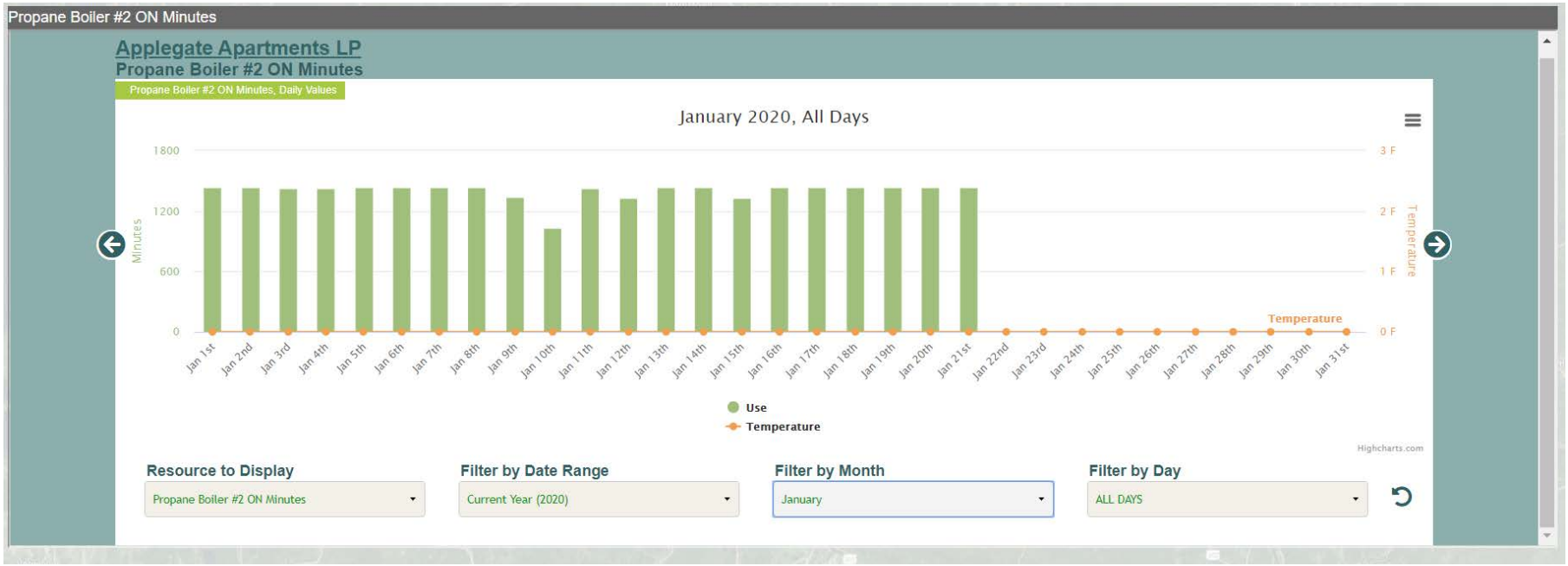


Hot Loop Temperature

Case Study

Nothing Appeared to be wrong

- Hot Loop Temperature was being maintained.
  - Zero - *No Heat Complaints!*
  - *But……*
  - *Heat source switched from Wood Chips to Propane*



- *Propane Boiler has been running **nonstop!***

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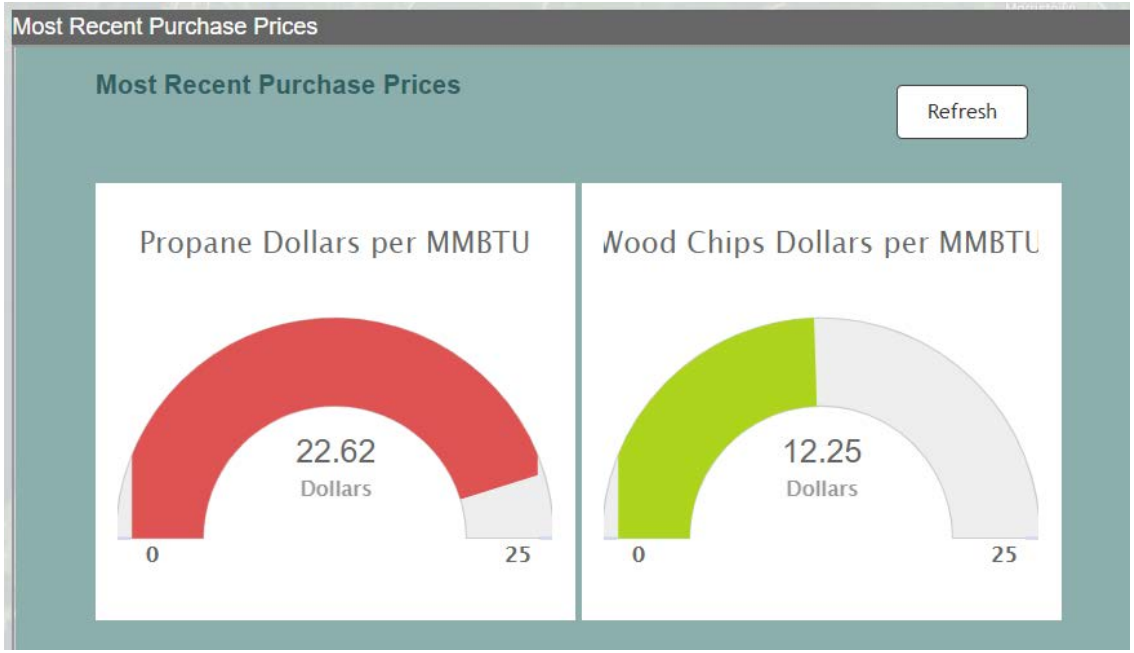
Case Study - Economics

- Estimated Annual kBTU's consumed for heat = 4,502,218, or 4,052.21 MMbtu



- *Propane Cost = $ 91,660; (4,052.1 x $22.6)*
- *Wood Chips = $49, 639; (4,052.1 x $12.25)*

$42,021 difference

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Empty the Ash Bin!

- Maintenance and management practices may have to evolve.
- You may need to do more of it.

Case Study
Canal Street Apartments
Winooski, VT

- Veterans Housing
- 25,260 Sq. Ft.
- 28 Apartments for Veterans and the public
- Heating and Cooling provided by Water Source Heat Pumps

Case study

First 4 years of operation

- Experienced high electrical costs
- Lost 5 heat pumps to compressor failure ($6,000 Each)
- Installed data telemetry showing the loop temperature was running abnormally high straining compressor's

Case study

We alerted our engineer

- Adjustments were made to the control logic
- The data collection system able to confirm the effectiveness of the settings change.
- The loop temperature is now running within the setpoints,

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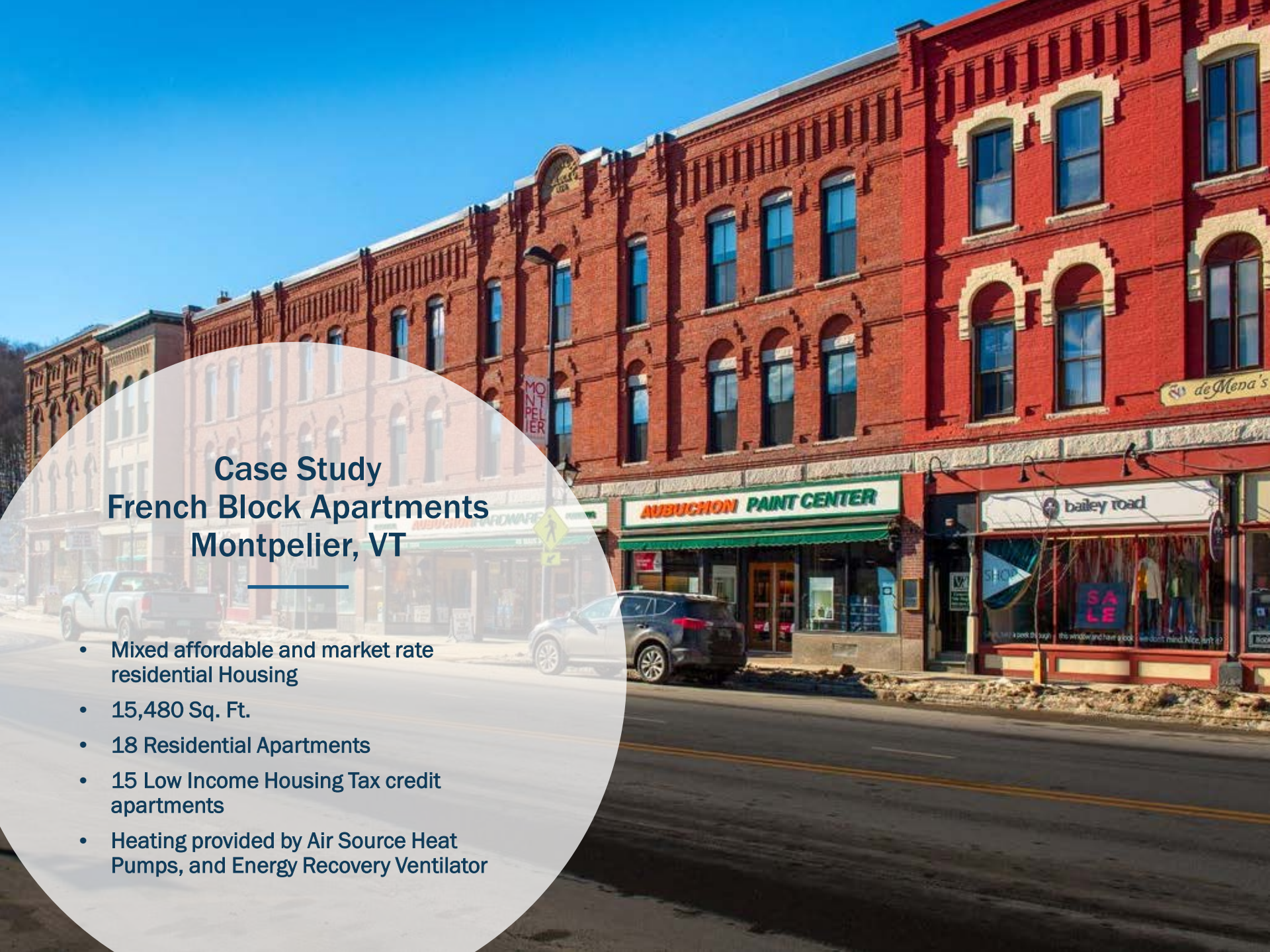
Case study

Benefits

- Less pressure on the compressors
- Reduced energy consumption
- Lower maintenance costs



Case Study
French Block Apartments
Montpelier, VT

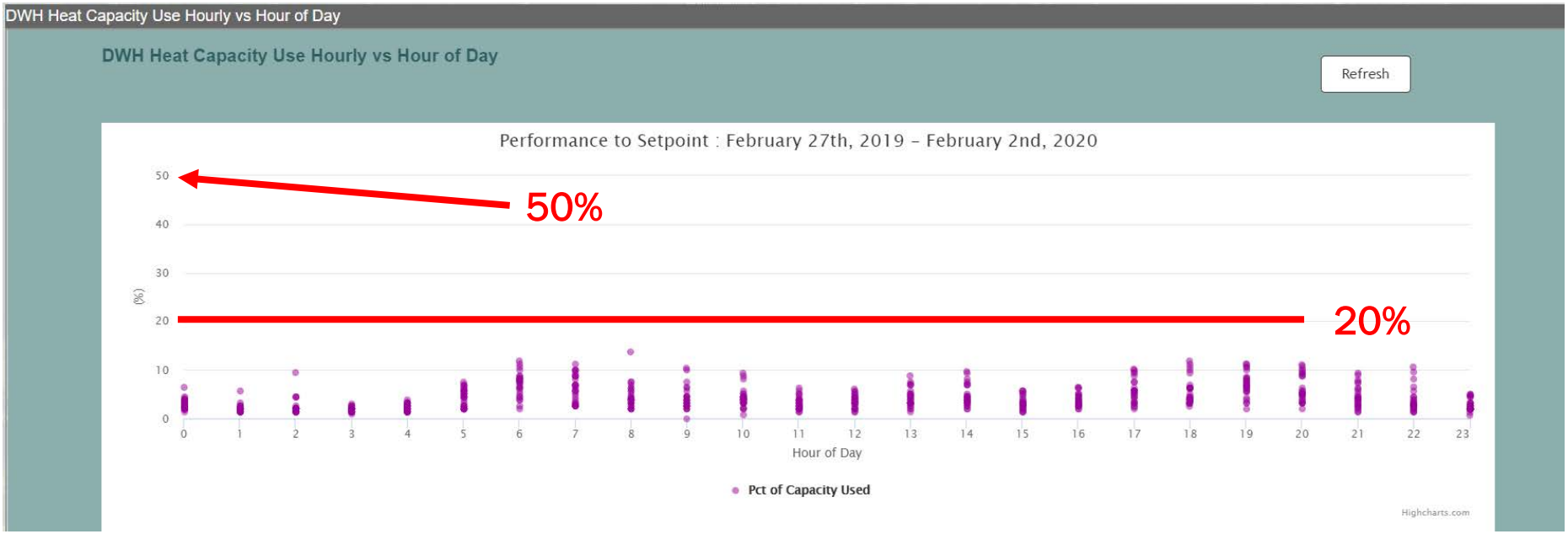
- Mixed affordable and market rate residential Housing
- 15,480 Sq. Ft.
- 18 Residential Apartments
- 15 Low Income Housing Tax credit apartments
- Heating provided by Air Source Heat Pumps, and Energy Recovery Ventilator

Case Study

Energy & Resource Use: Energy Use Intensity and Performance to Expectations

Resource	Unit	Annual Projected Usage	Annual Usage for 2019	Delta %
Electricity	kWh	99,678	94,275	5.4%
Propane	Gallons	500	1,140	128.0%
Water	Gallons	550,000	369,000	34.4%
All Energy	kBTU	385,852	426,000	10.5%
Energy Use Intensity	kBTU/SqFt	24.93	27.52	10.5%
Conditioned Space	Building	15,480		

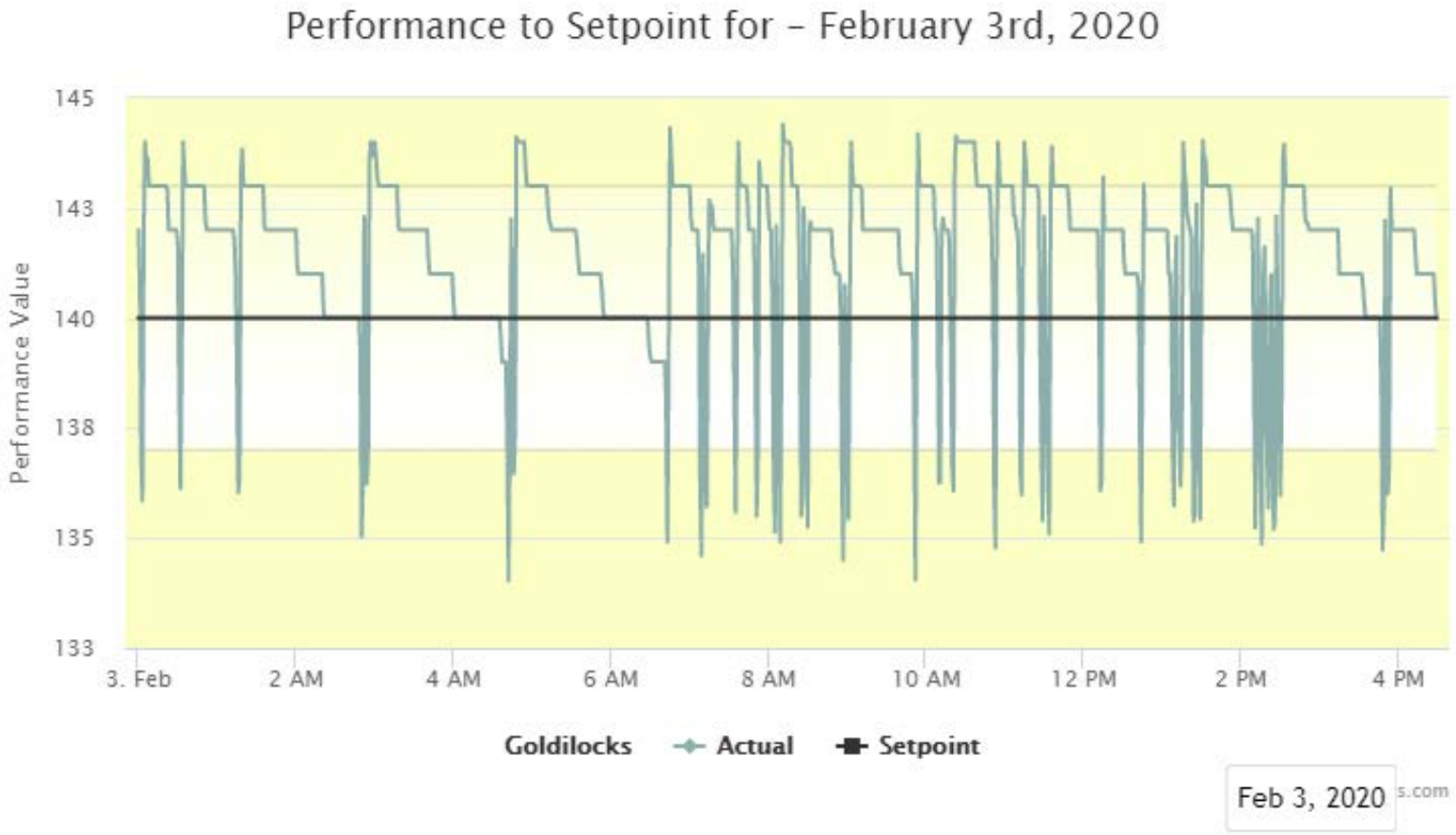
Case Study – DHW



The capacity utilization chart for the Domestic Hot Water (DHW) system

- For almost a year we have identified less than 20% of the DHW generating capacity is utilized.
- Design was code compliant, but installed in a single unit due to space constraints
- Ancillary impacts are increased propane consumption

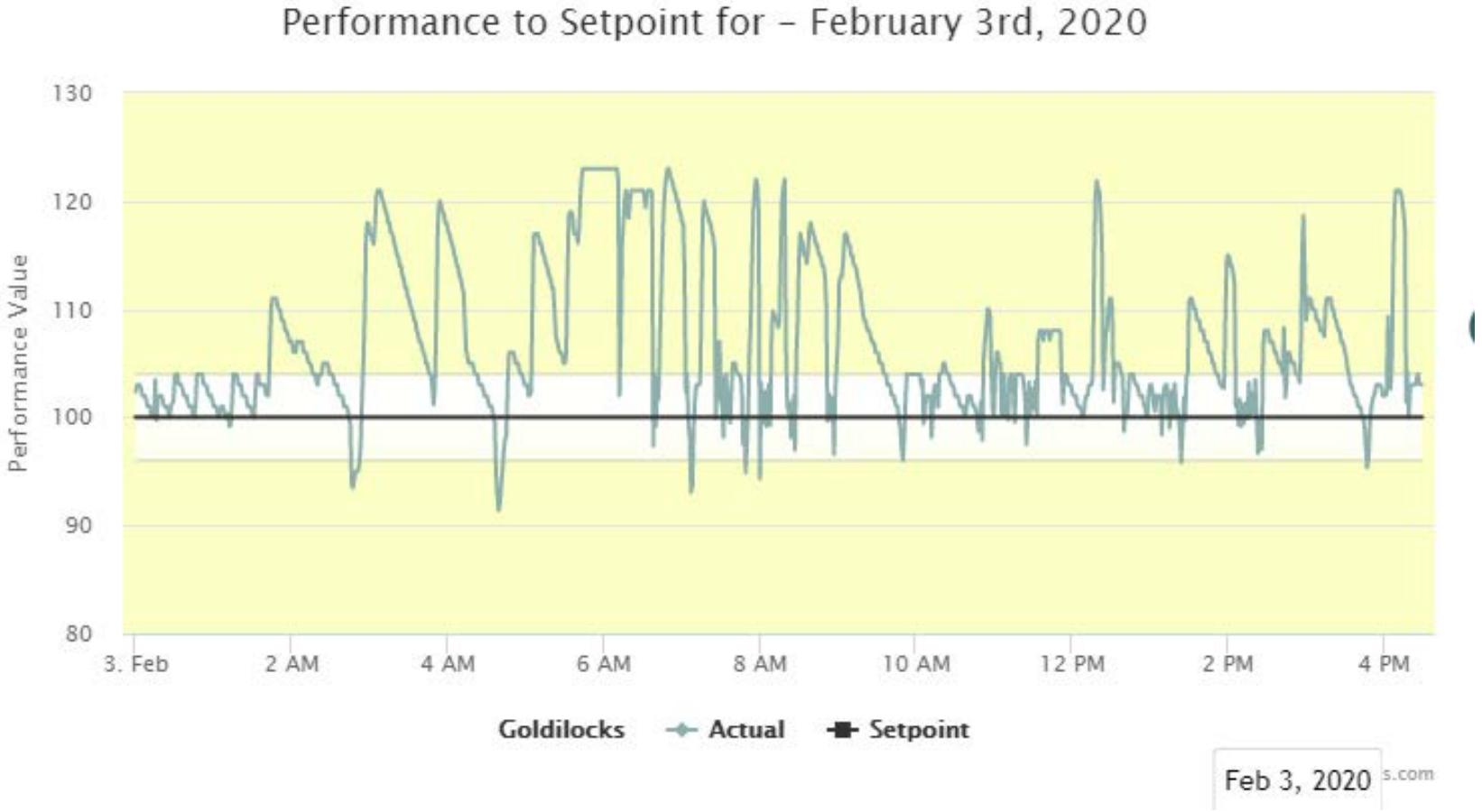
Case Study – DHW



The performance to setpoint chart for the Domestic Hot Water (DHW) system

- Indicated it is hard to keep that much water warm.

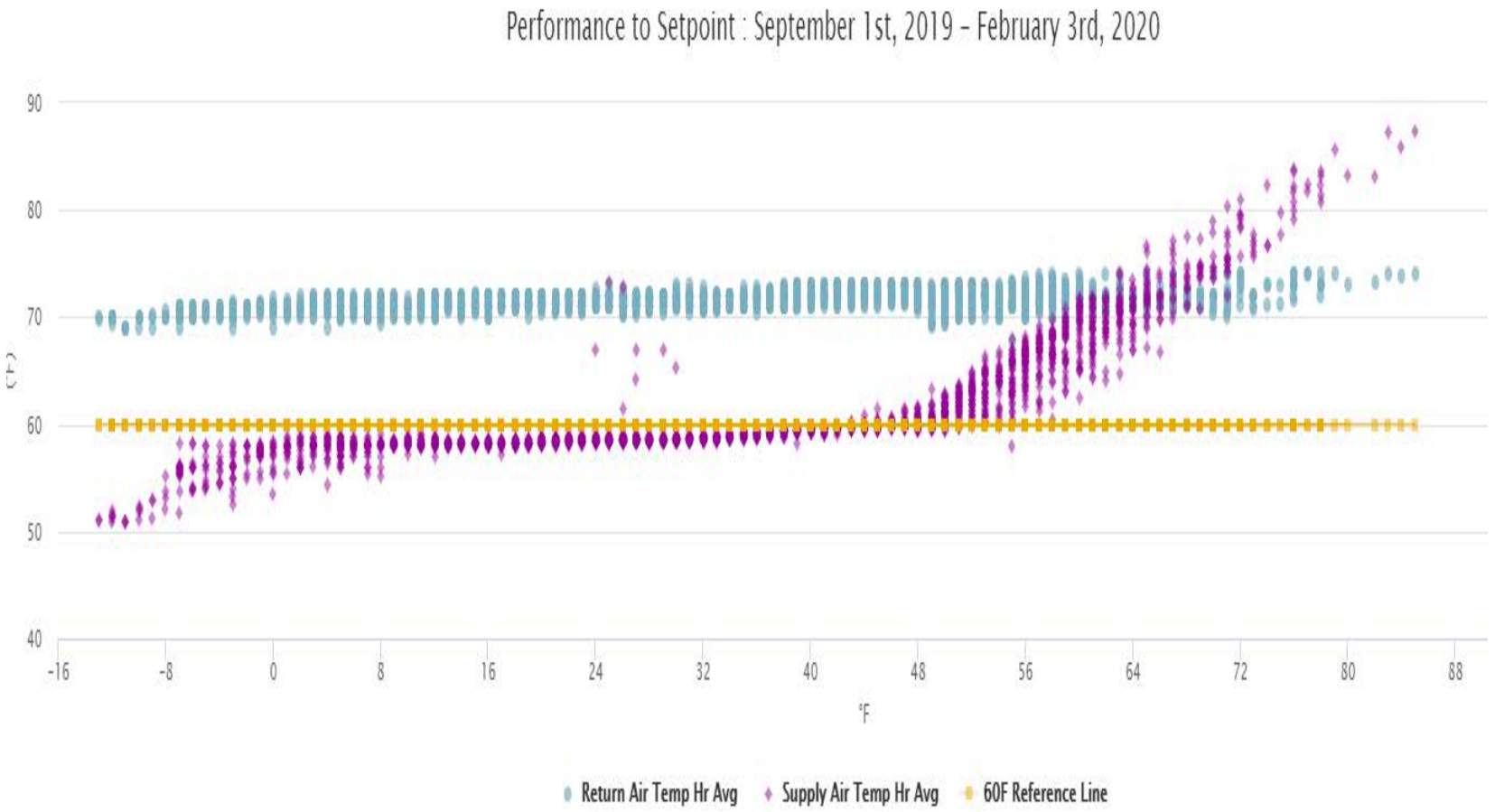
Case Study – DHW



The DHW temperatures downstream of the mixing valve

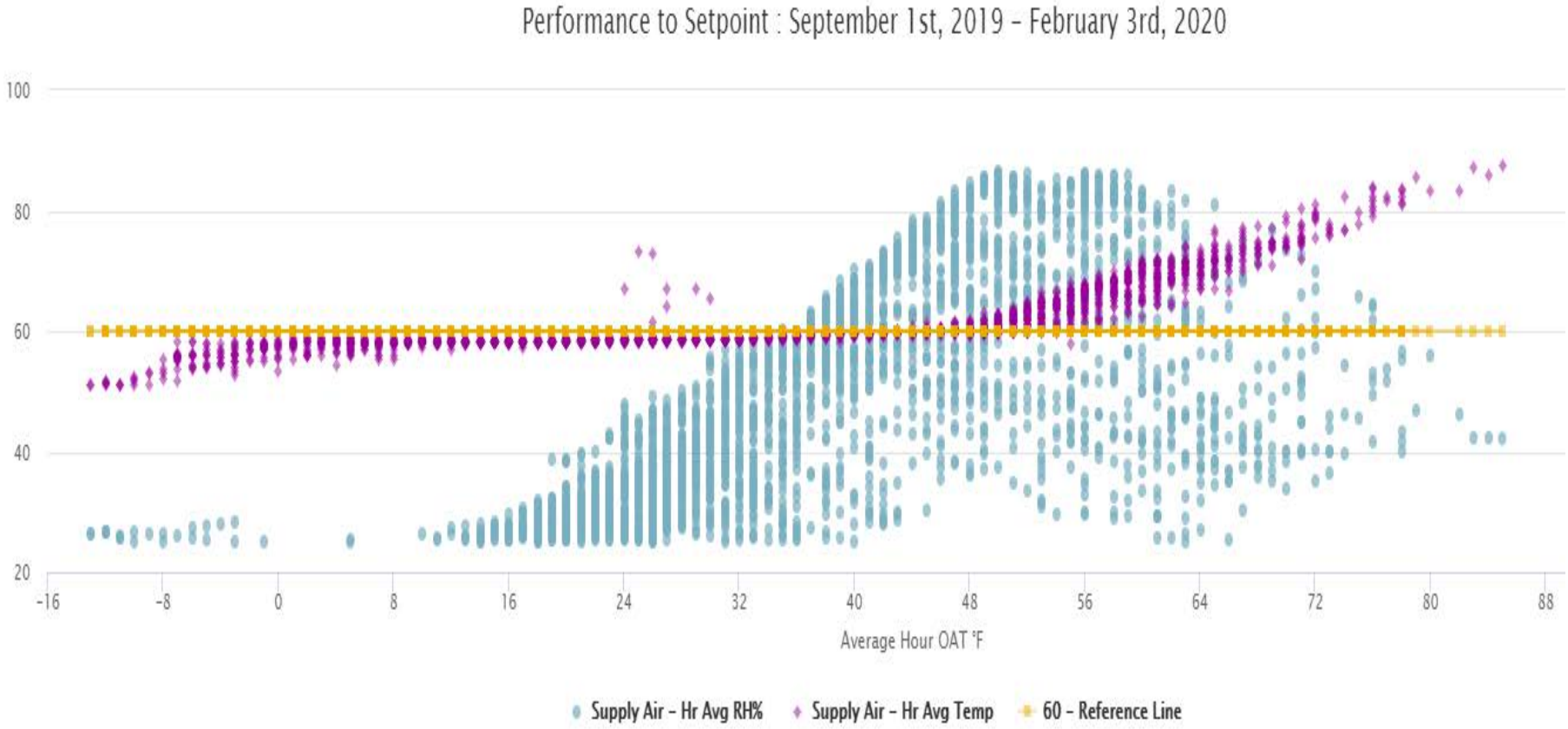
Case Study - ERV

French Block ERV: Supply Air Temperature vs Return Air Temperature



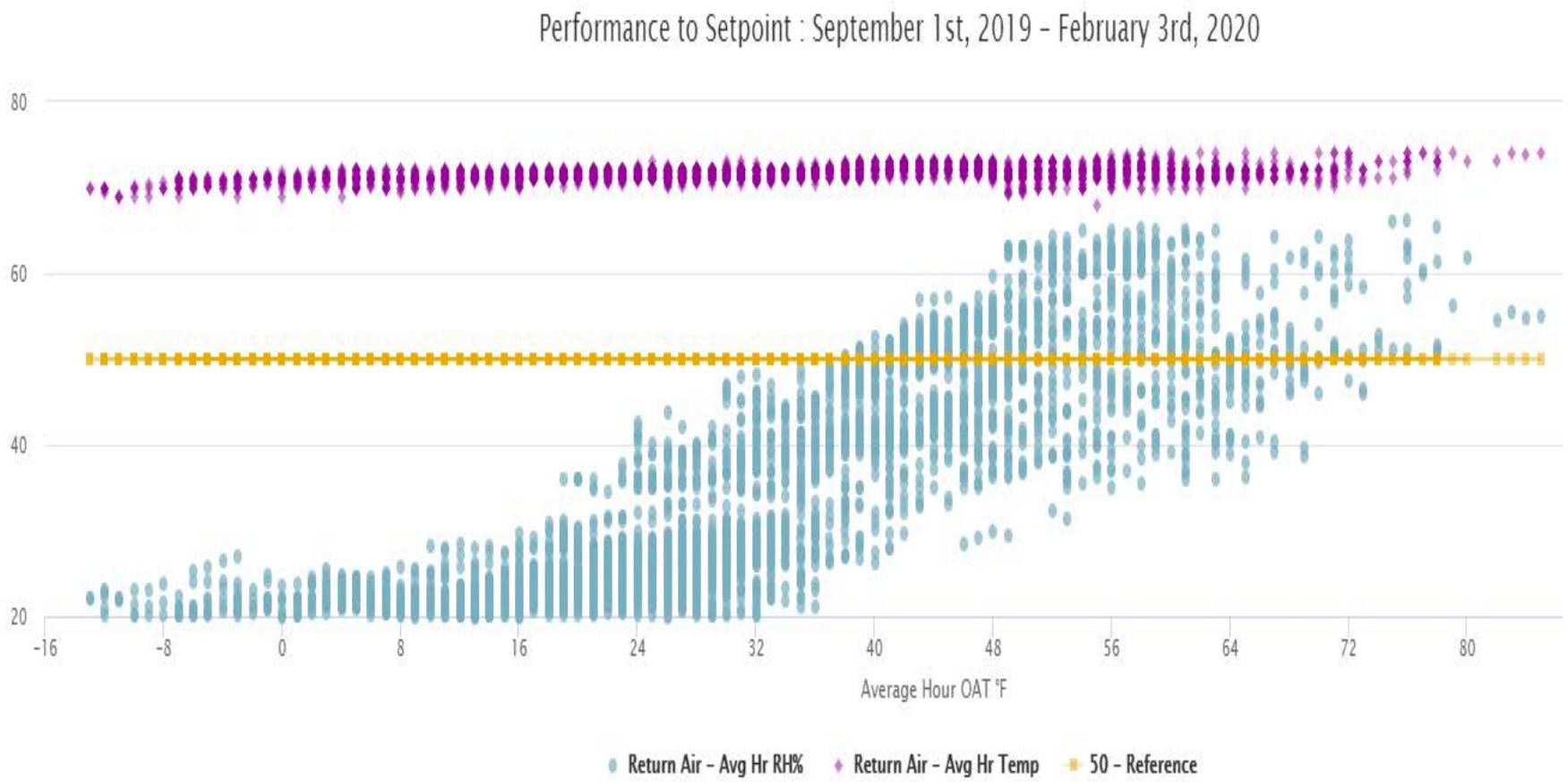
Case Study - ERV

French Block ERV: Supply Air Relative Humidity and Average Temperature



Case Study - ERV

French Block ERV: Return Air Relative Humidity and Average Temperature

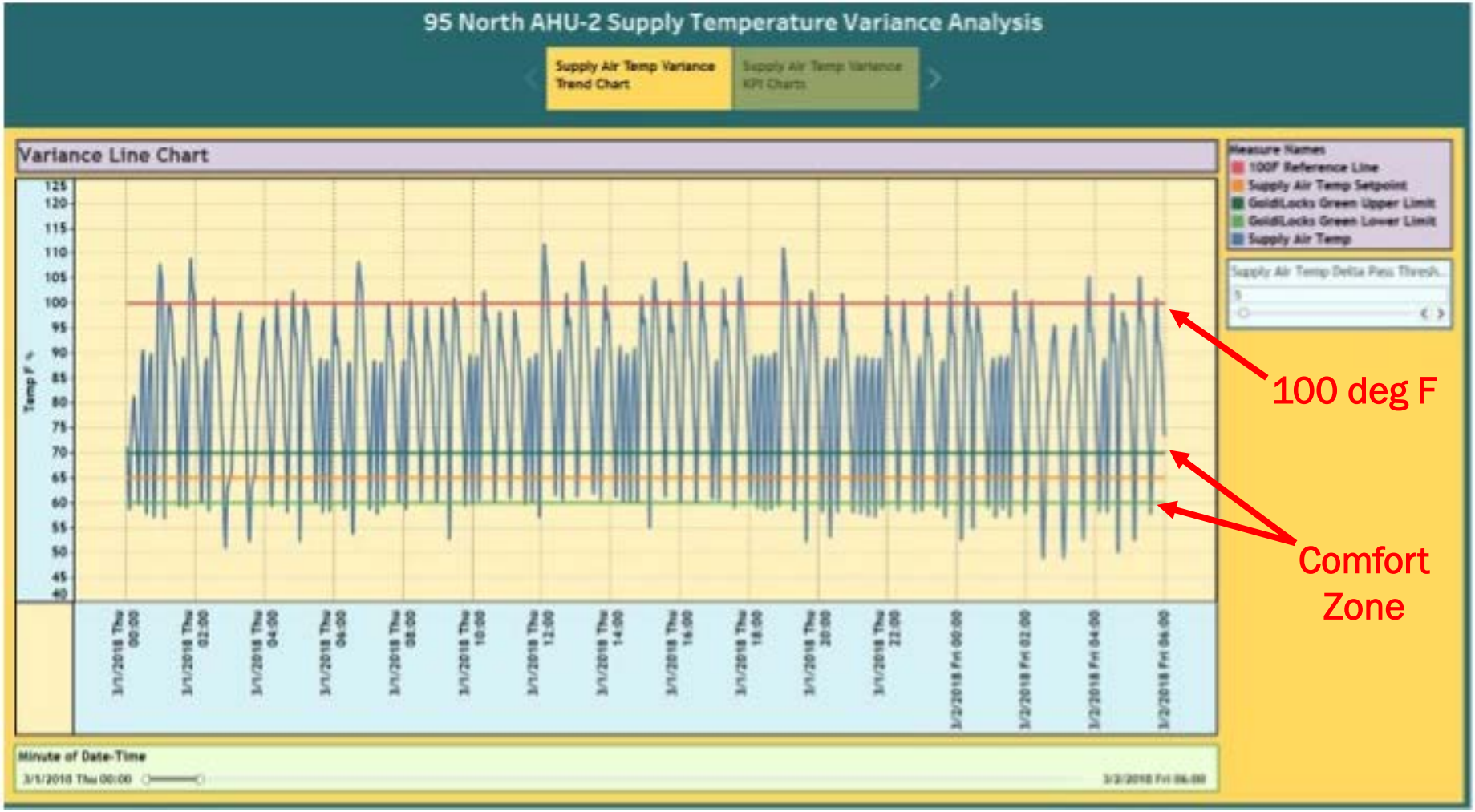


Case Study
95 North Avenue
Burlington, VT

- Committee on Temporary Shelter (COTS) offices
- 24,000 Sq. Ft.
- 14 Service Enriched Apartments for homeless
- Rooftop air handlers provide ventilation and fresh air.
- Boiler with hydronic Baseboard Providing heat.
- Mini split air source heat pumps for cooling.

Case study

Windows were always open, even during the coldest winter days?



AHU was supplying fresh air in extreme excess of setpoint!

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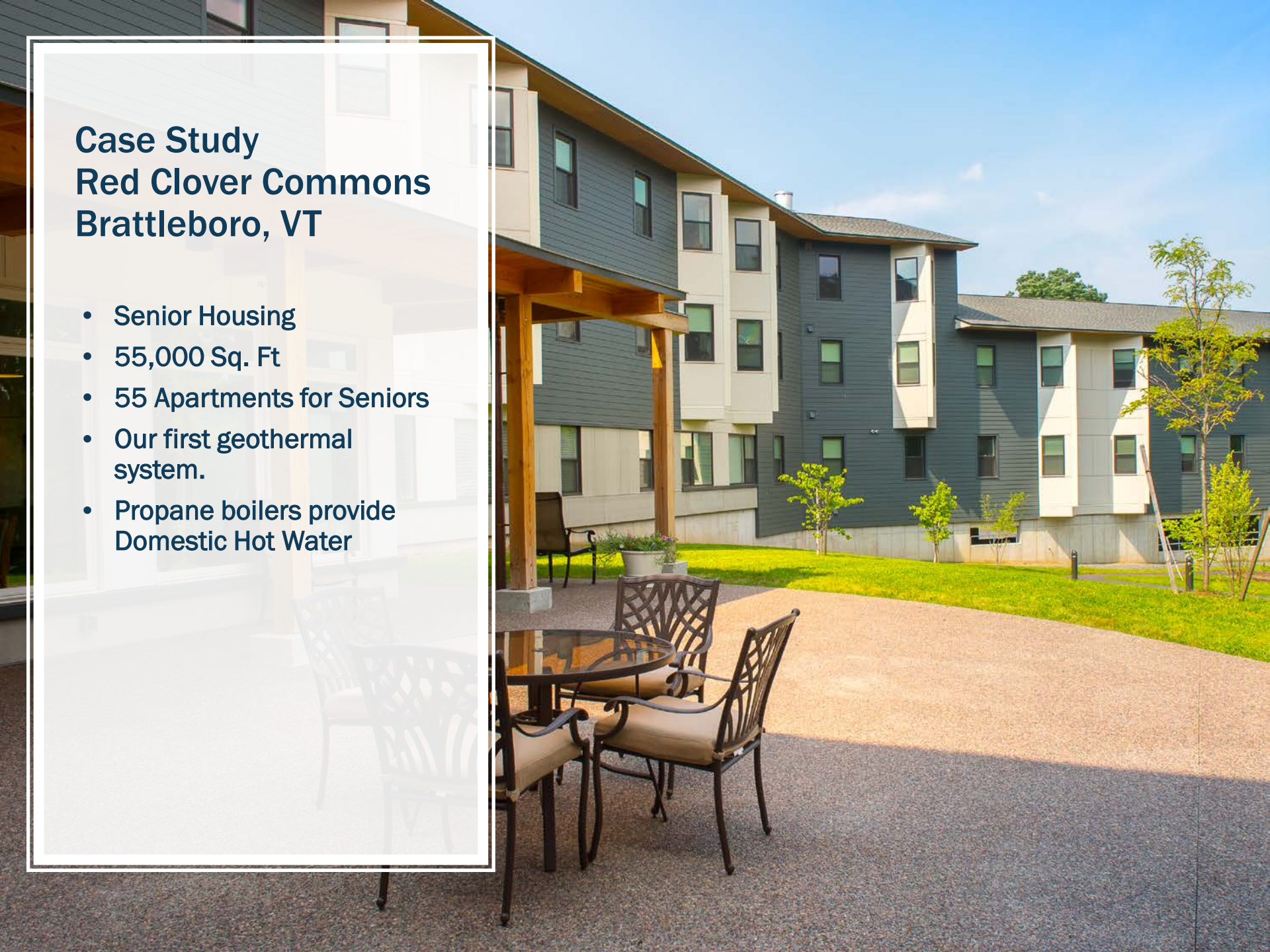
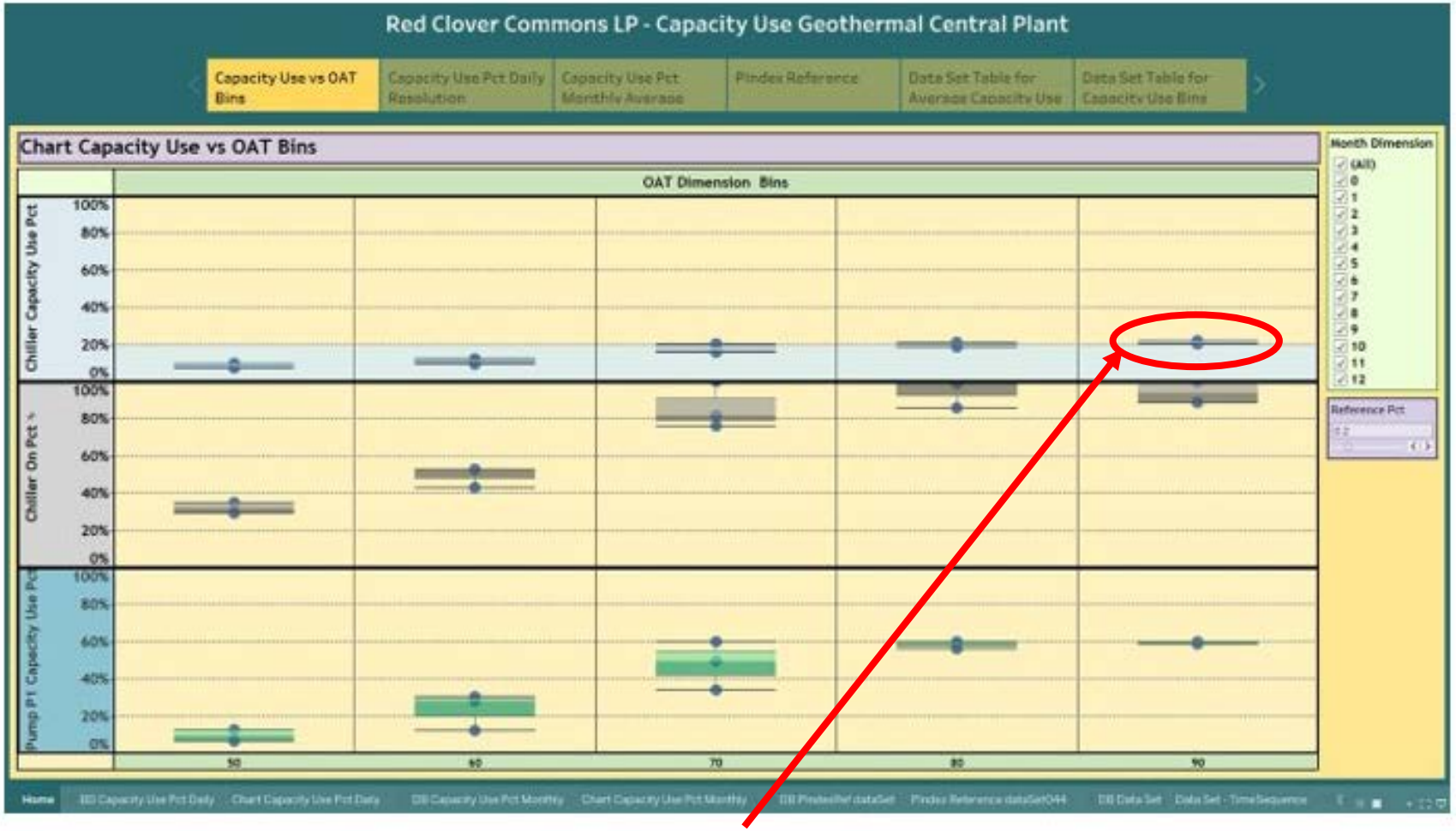


Case Study
Red Clover Commons
Brattleboro, VT

- Senior Housing
- 55,000 Sq. Ft
- 55 Apartments for Seniors
- Our first geothermal system.
- Propane boilers provide Domestic Hot Water

Case study



The data demonstrates that the chiller is using only 20% of its total capacity even under peak conditions of 90 degrees outside air temperature.

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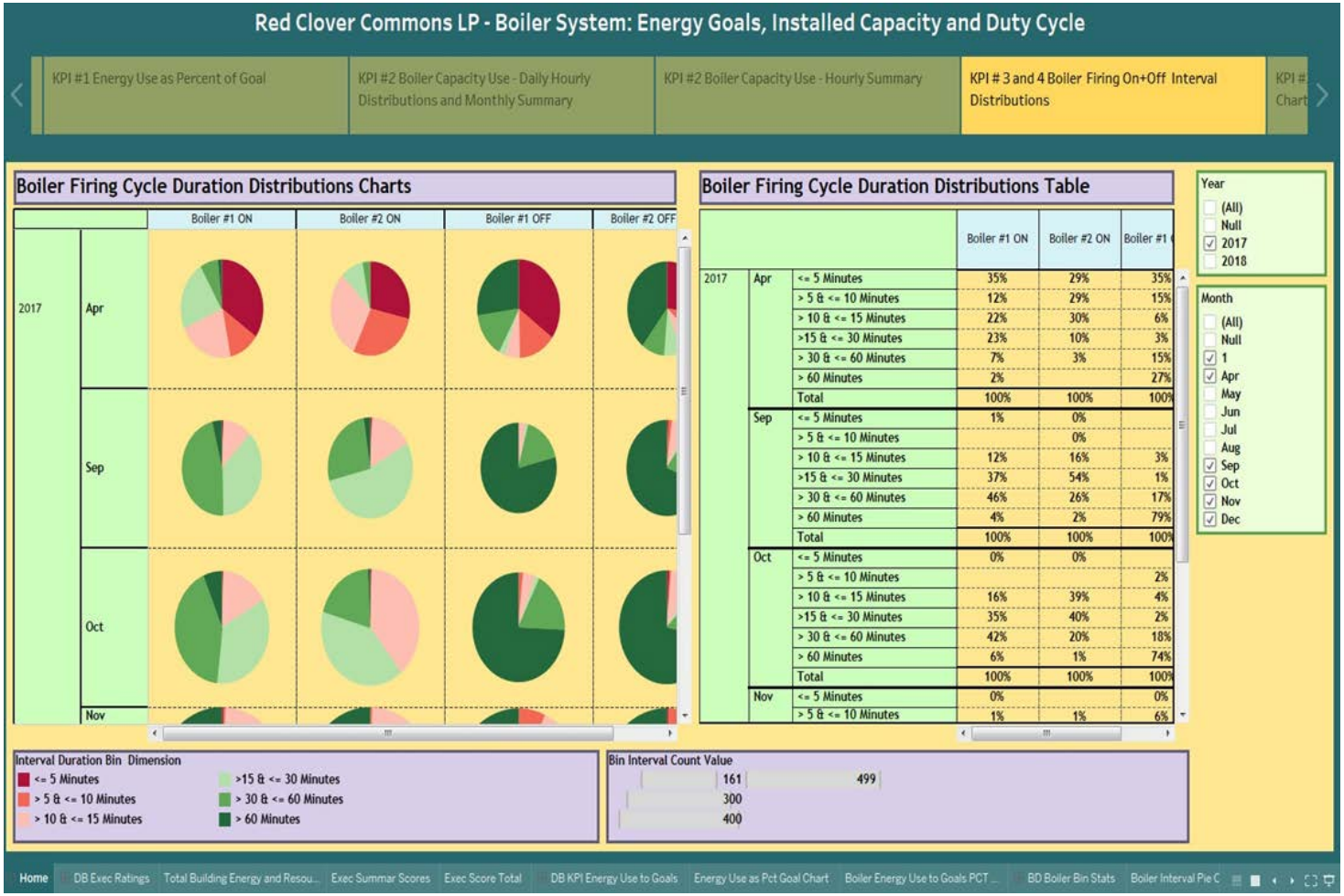
Case study



Domestic Hot Water boiler firings

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Final Thoughts

There are a lot of hands in these systems after construction is completed.

- Your systems seem to be working ok.
- How do you really know?
- Put context around your data
- Turn your data into information!

Final Thoughts

We went into this endeavor to save money on consumption

Our biggest savings turned out to be reduced capital costs by having the data to right size new installations and replacements

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THANK YOU

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