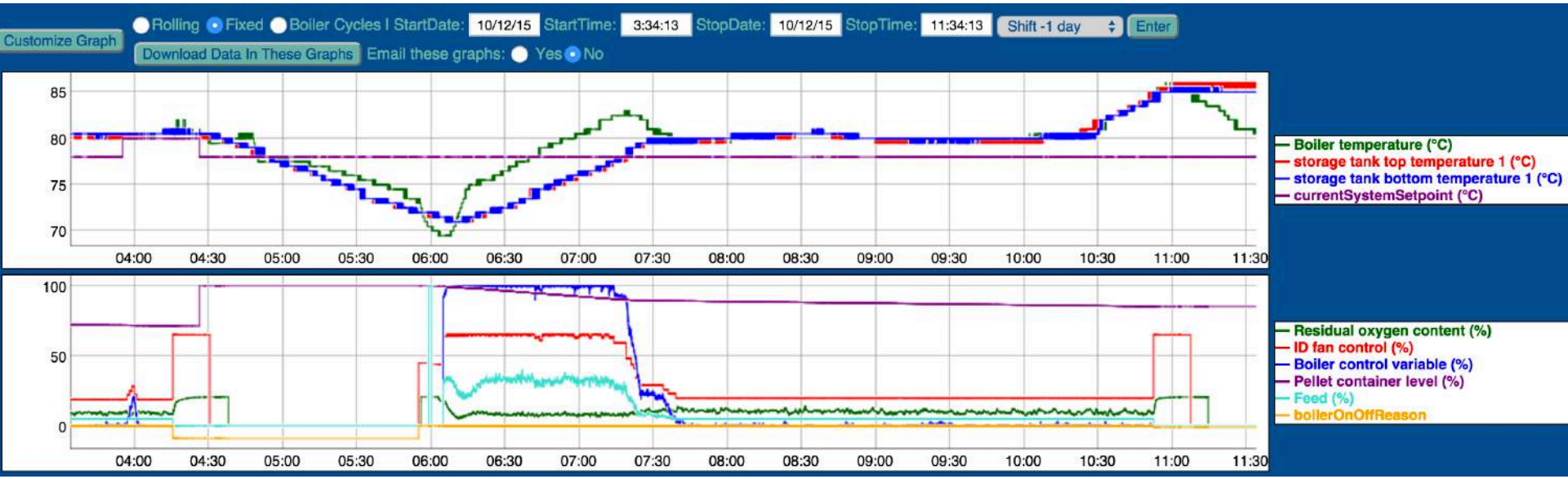
Comprehensive Monitoring and Boiler Performance



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info@dcmlogic.com

BoilerBrowser

Comprehensive Monitoring and Boiler Performance

- What is Comprehensive Monitoring?
  - What we mean by “Comprehensive Monitoring”
  - Other forms of remote monitoring
- What is Boiler Performance?
- How can Comprehensive Monitoring help you know and improve Boiler Performance?

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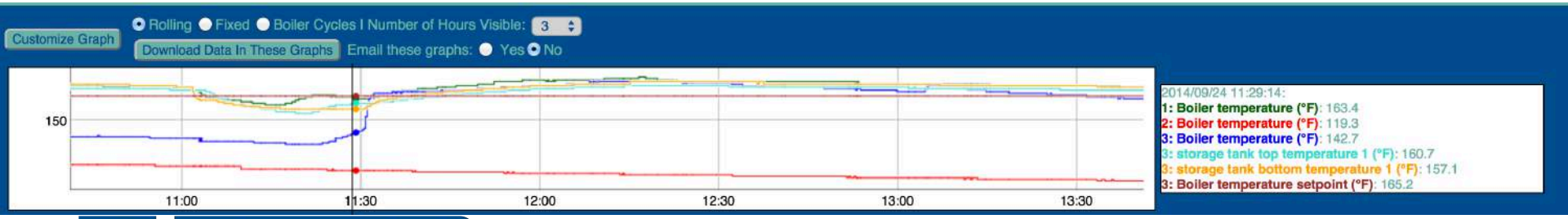
By "Comprehensive Monitoring," We Mean . . .

- Access to a comprehensive set of all parameters, variables, errors, states, I/O and all data points tracked by the boiler
  - Usually in the hundreds of points, sometimes over one thousand
- Access to this data from any time in its monitored history
- Graphical presentation of data
  - Tables deceive, graphs reveal
- Calculations of performance measures



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Other Monitoring Solutions

- Some manufacturers provide remote basic monitoring
  - Generally only 10-35 points (parameters, variables…)
  - Can monitor DHW, solar panels, heating zones
  - Can change parameters remotely
  - Limited data history; limited graphical representation tools
- Custom monitoring via BEMS of 10-20 data points

These are all useful tools, but are rarely helpful in understanding boiler performance

Comprehensive Monitoring and Boiler Performance

- What is Comprehensive Monitoring?
- What is Boiler Performance?
- How can Comprehensive Monitoring help you know and improve Boiler Performance?

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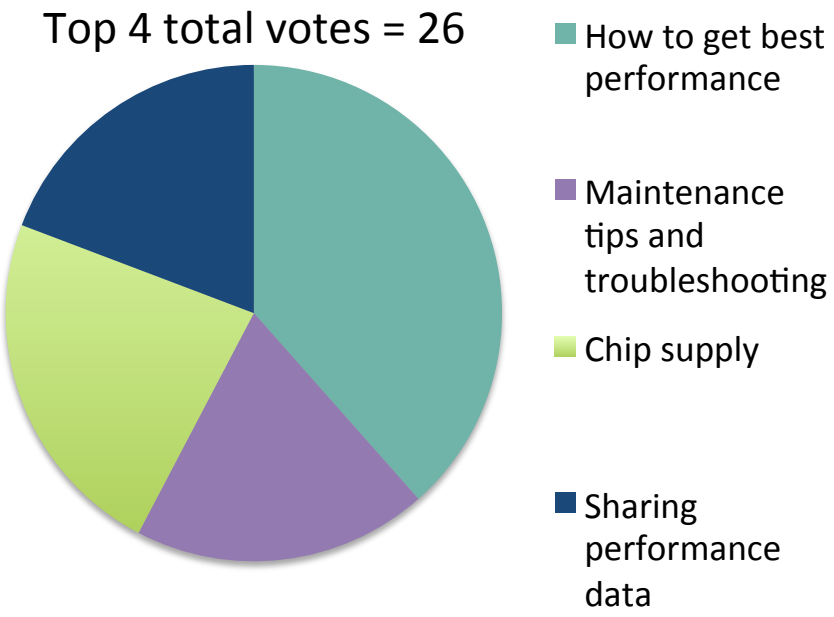
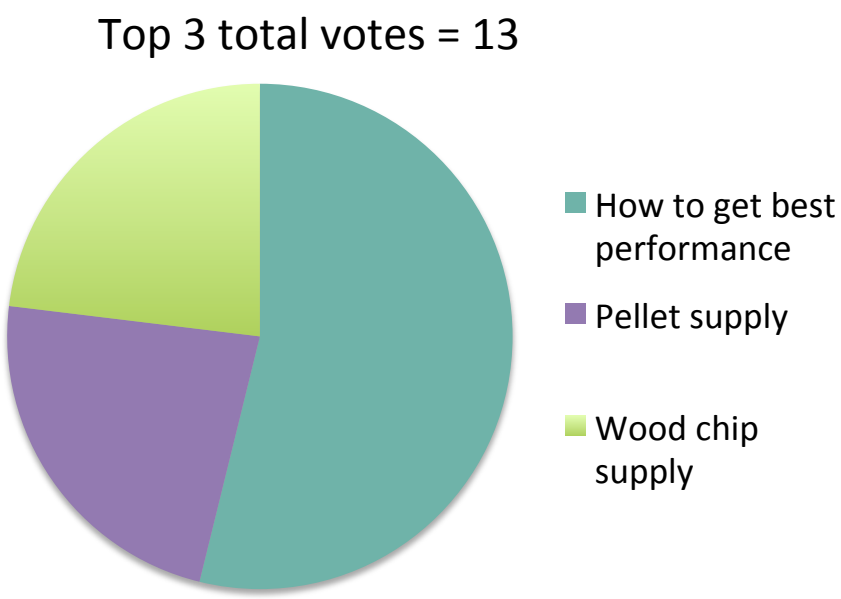
Performance is the #1 Concern of Boiler Owners/Operators

Spring 2014



Fall 2014



Source: NH Wood Energy Council post-workshop surveys of #1 choice for future panels; top 3-4 vote recipients

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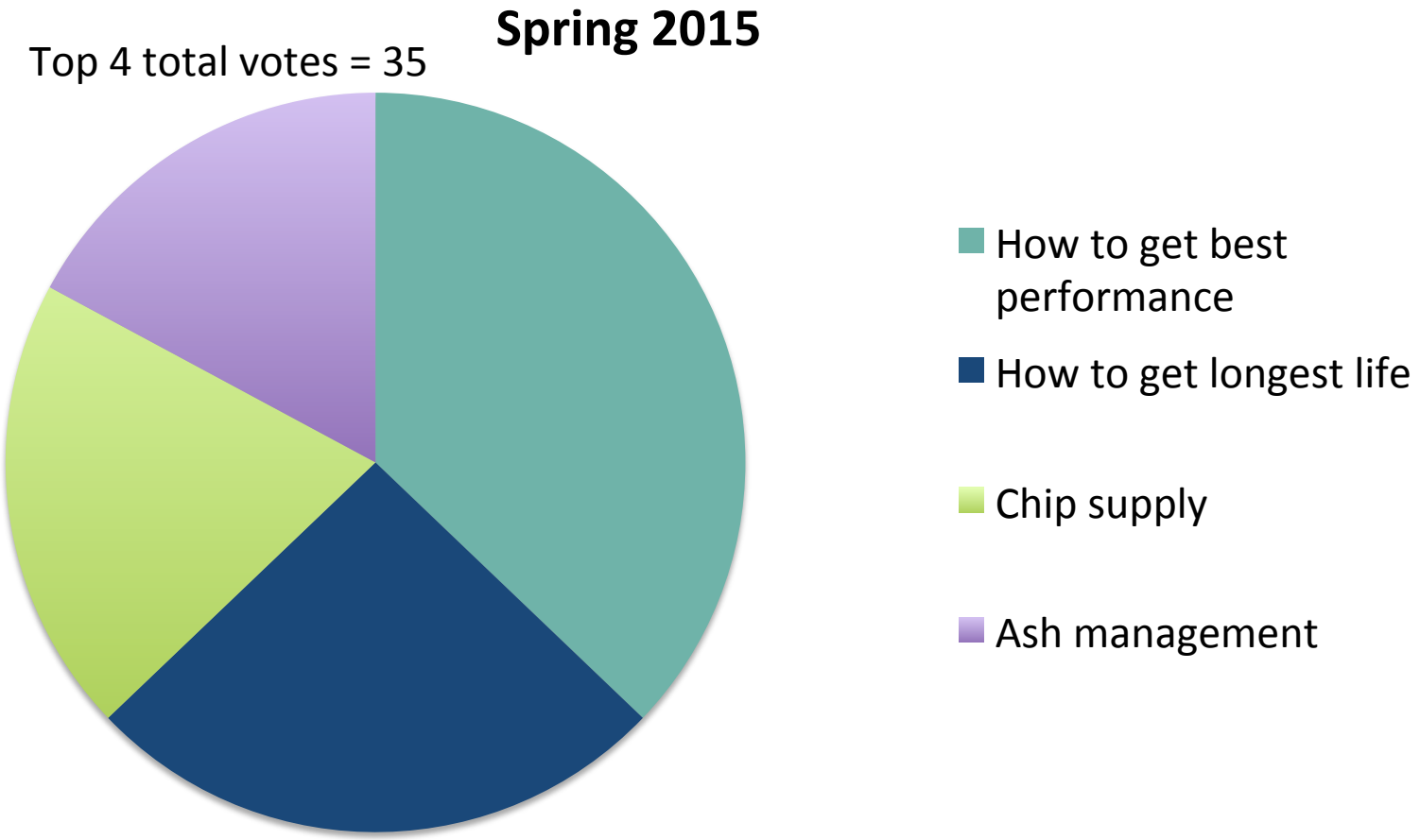
Performance is the #1 Concern of Boiler Owners/Operators



Source: NH Wood Energy Council post-workshop surveys of #1 choice for future panels; top 4 vote recipients

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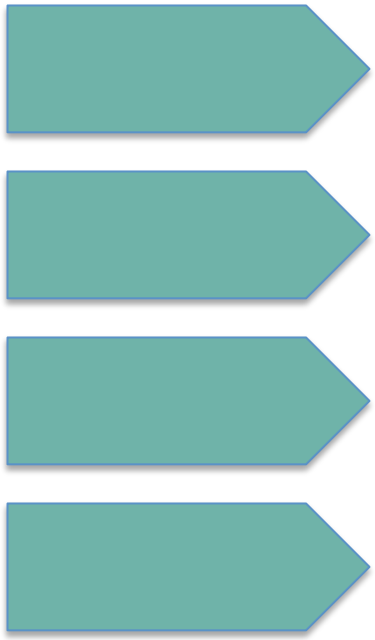
What do you mean by performance?



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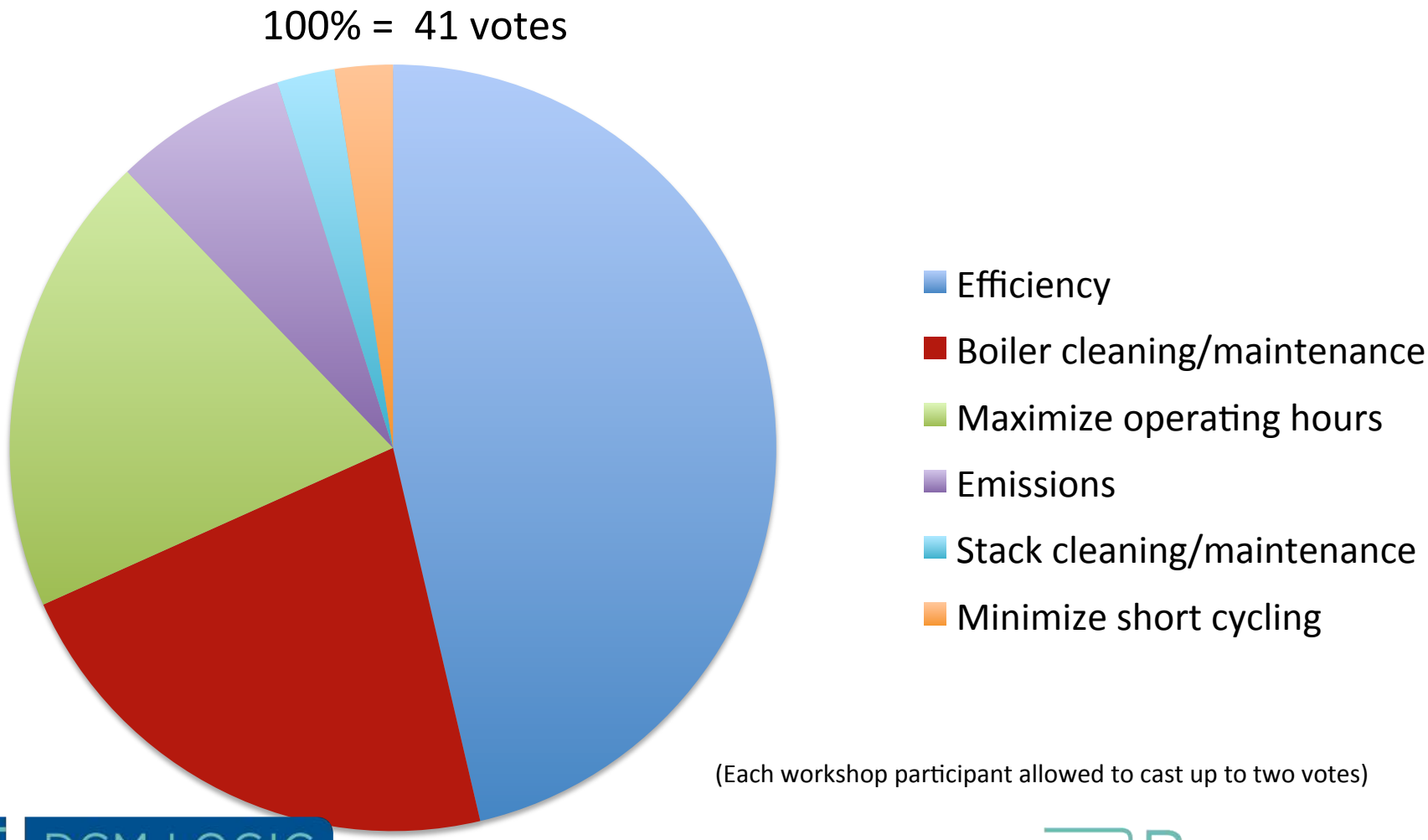
10/23/2015 NH Wood Energy Council Workshop Participants on Boiler Performance



(Each workshop participant allowed to cast up to two votes)

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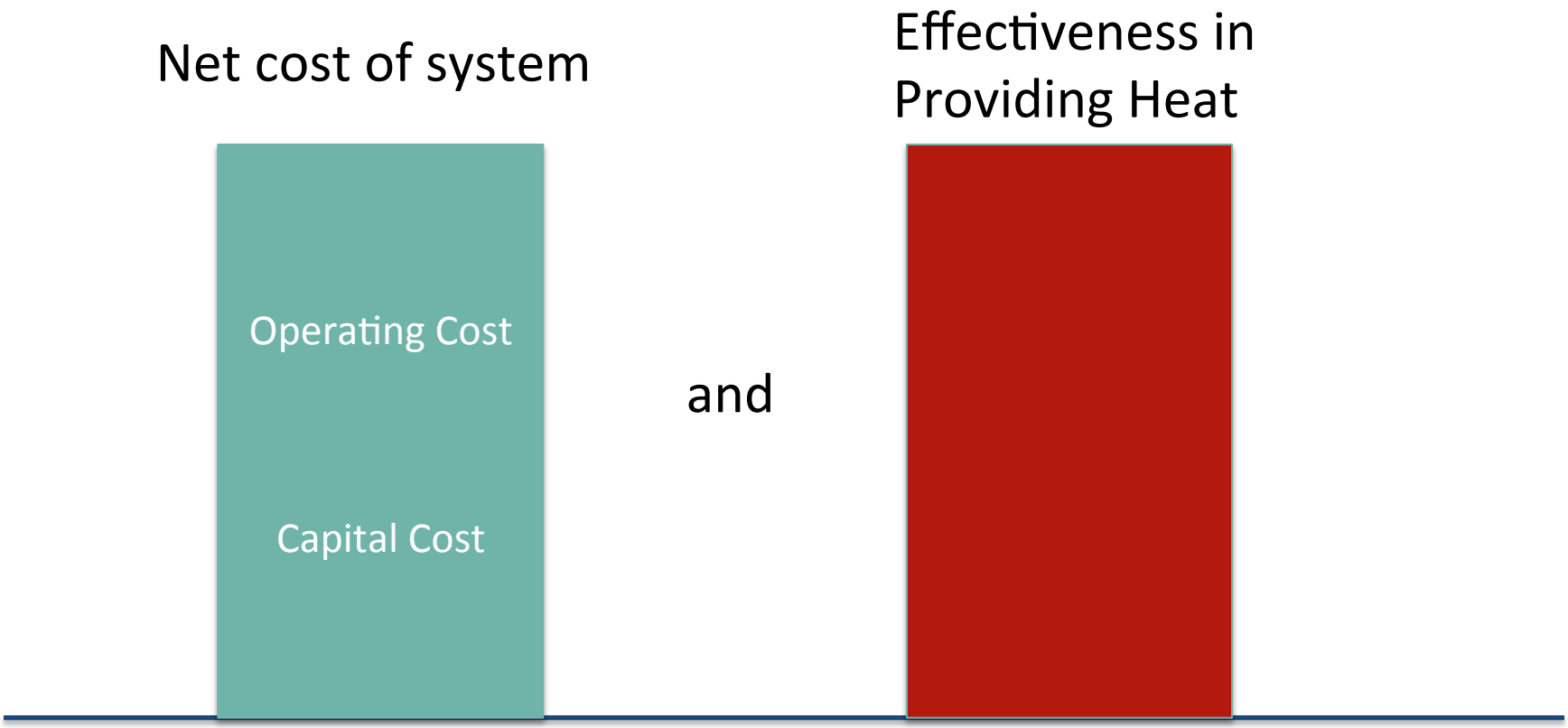
Our View: Performance is Cost and Effectiveness (Benefit)



We look at the performance of the entire boiler plant, not just individual boilers

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Cost Components: Capital Cost

Monitoring not so helpful in understanding this cost

Installed cost of biomass boiler plant

Installed cost of thermal storage (if any)

Grants + incentives

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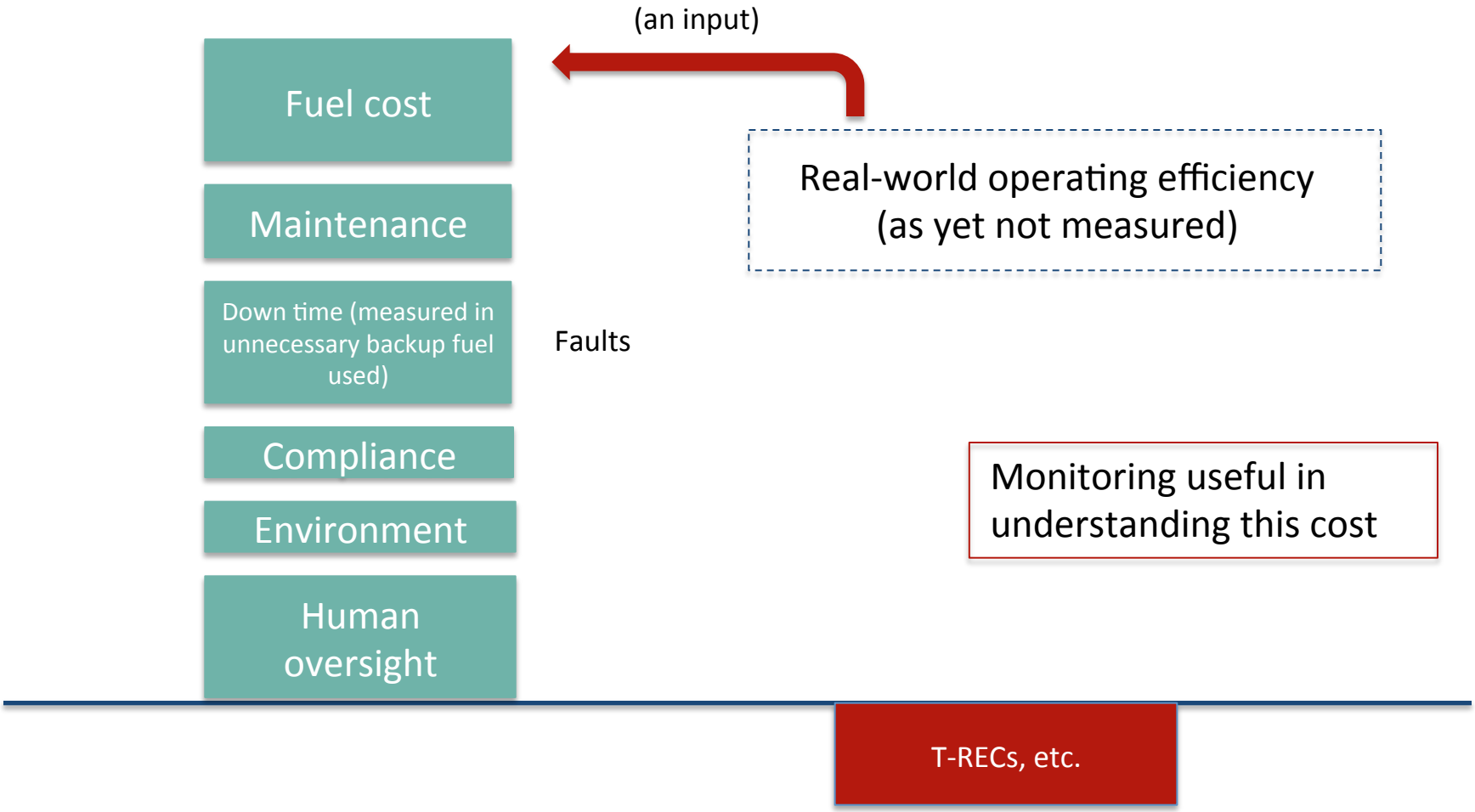
Cost Components: Operating Cost



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We Buy Commercial Boilers to Provide Steady Heat at a Certain Temperature

Heat Provided

Monitoring ESSENTIAL in understanding this benefit

Boiler Plant Effectiveness

Is water coming from the boiler plant at the right temperature?

- Duty Cycle
- Heating hrs./start
- Startup/shutdown time
- Cleaning time*
- Fuel fill time*

Foundations of Boiler Plant Effectiveness

*If heating, startup, or shutdown is interrupted

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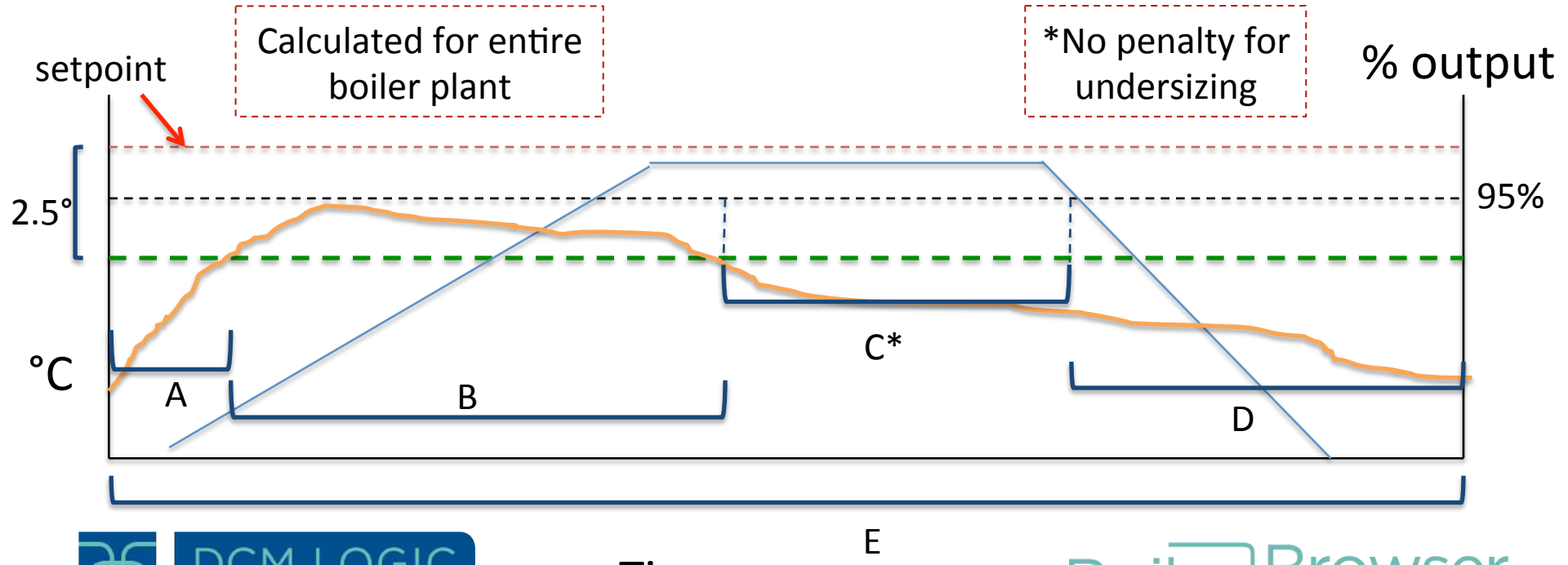
NOTE: Proper Water Temperature to the Building May be a Better Measure of Effectiveness

- But that's not the boiler plant's job
  - Responsibility of building control system
  - Temperature required by building always changing because of outdoor reset, etc.
  - Hard for a boiler to know/log
- Therefore, we just look at <u>temperature provided by boiler plant</u>

Boiler Plant Effectiveness

Boiler Plant Effectiveness = (B + C)/(E) = % of time when
Delivered Temperature ≥ (setpoint - 2.5°C)
OR
All boilers heating at > 95%



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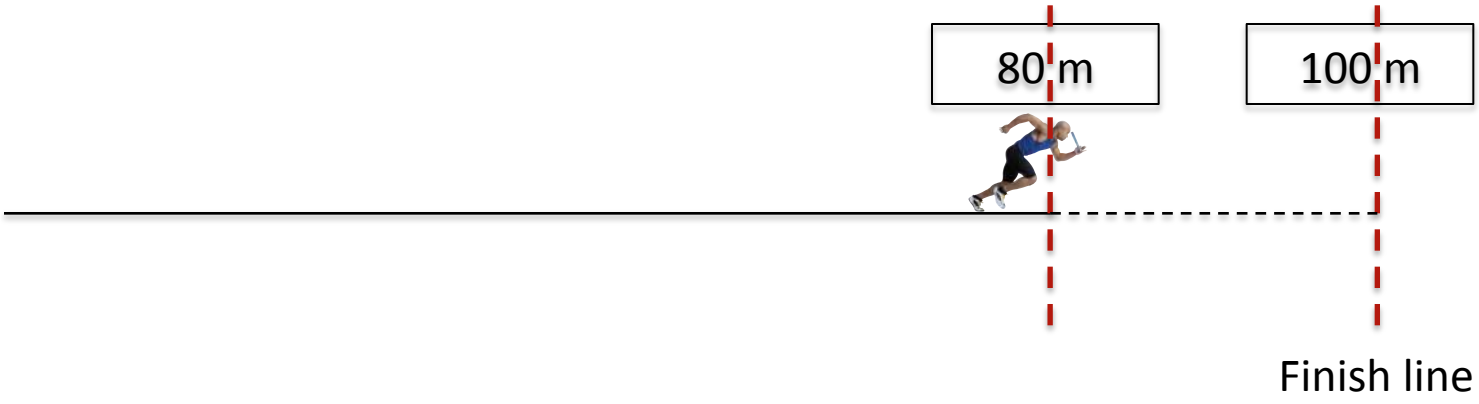
“Efficiency” is a Problematic Metric of Boiler Performance



- Results are more important than “efficiency”—if you run only 80 m of a 100 m event, it makes no sense to talk about efficiency over those 80 m
- The main purpose of a commercial boiler plant is to consistently provide water at a preset temperature
- How often you achieve this goal is more important than efficiency of operation
- Even if “efficiency” were a primary issue, current measures of thermal efficiency are steady-state figures that do not take into account real-world boiler operation

Comprehensive Monitoring and Boiler Performance

- What is Comprehensive Monitoring?
- What is Boiler Performance?
- How can Comprehensive Monitoring help you know and improve Boiler Performance?

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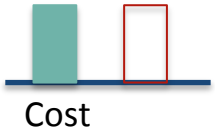
For Operating Costs, Comprehensive Monitoring Helps You . . .



	Know	Improve	
Fuel cost	✗	✓	
Maintenance	✓	✓*	*Especially cleaning
Down time (measured in backup fuel)	✓	✓	Respond to faults quickly
Compliance	✗	✗	
Environment	✓	✓	Minimize # of starts/stops
Human oversight	✓	✓	Helps onsite or offsite
T-RECs, etc.	✓	✓*	*Especially cleaning

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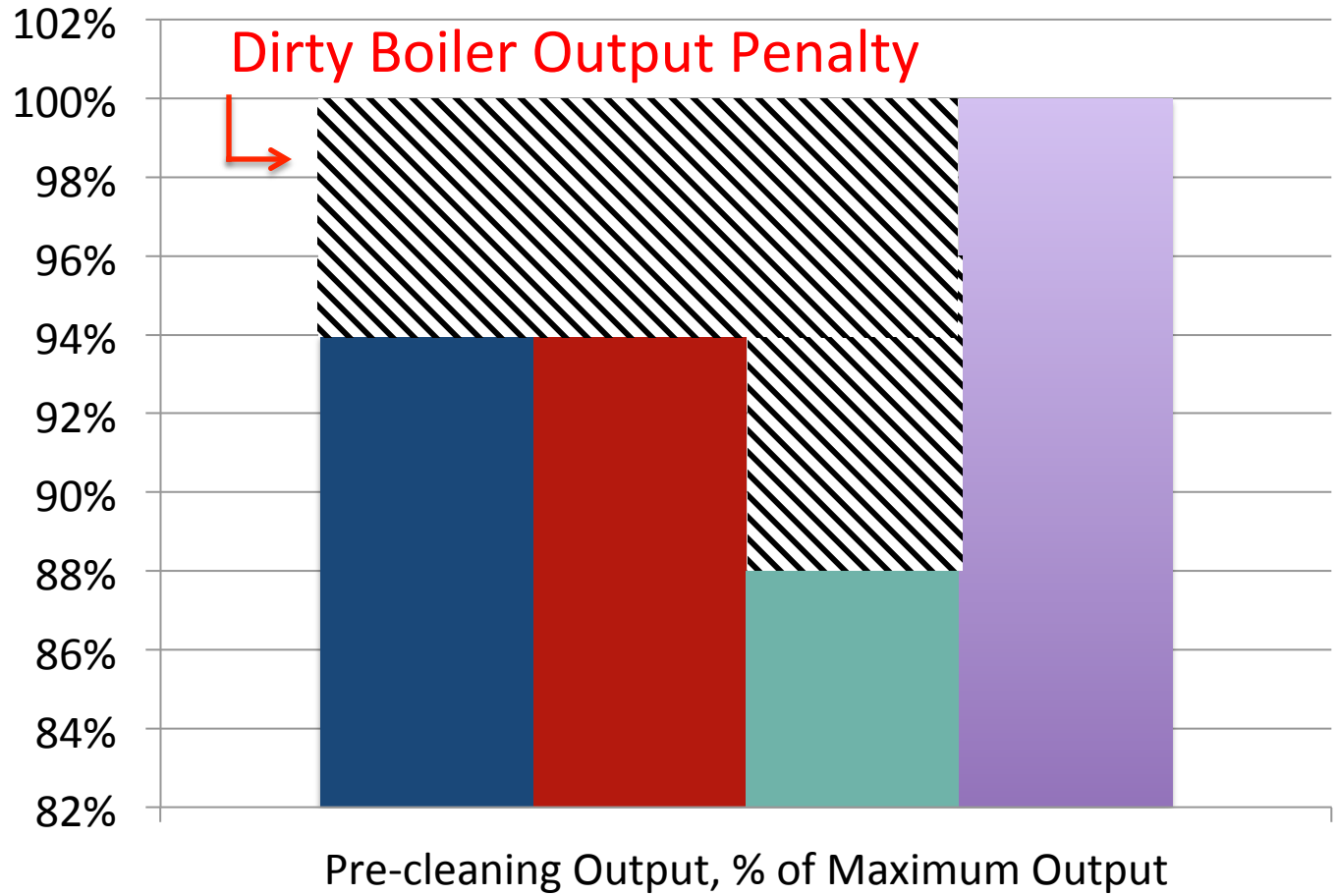
Clean Boilers Produce More Heat and More RECs



What's your dirty boiler output penalty?

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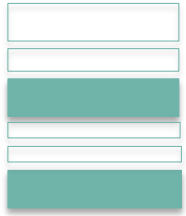
Monitoring Clearly Helps in Timely Fault Notification

Cost



Display Full Error History for Boiler: 1 for period selected above.

Boiler 1		
Code	**Name**	**Time**
1	Boiler temperature sensor faulty	2015-09-14 13:44:03 (GMT-5)
1	Boiler temperature sensor faulty	2015-09-14 13:42:45 (GMT-5)
1	Boiler temperature sensor faulty	2015-09-01 14:38:17 (GMT-5)
1	Boiler temperature sensor faulty	2015-03-25 11:03:05 (GMT-5)
1	Boiler temperature sensor faulty	2015-03-25 11:00:33 (GMT-5)
169	"Ash box full, please empty"	2015-03-16 09:24:26 (GMT-5)
1	Boiler temperature sensor faulty	2015-03-09 15:01:26 (GMT-5)
14	Boiler door open too long	2015-03-06 06:37:11 (GMT-5)
14	Boiler door open too long	2015-01-26 09:17:04 (GMT-5)
169	"Ash box full, please empty"	2015-01-20 16:01:06 (GMT-5)
14	Boiler door open too long	2015-01-05 14:37:54 (GMT-5)
125	Motor protection delivery screw	2014-12-03 23:23:54 (GMT-5)
169	"Ash box full, please empty"	2014-11-20 09:28:42 (GMT-5)
13	"Safety time expired, flue gas temperature too low for too long"	2014-09-04 07:59:26 (GMT-5)
14	Boiler door open too long	2014-07-23 07:10:31 (GMT-5)
0	Overheat Thermostat (STL) or EMERGENCY OFF activated	2014-07-03 10:35:18 (GMT-5)
58	Bus module faulty before power switched off	2014-05-05 12:24:54 (GMT-5)
58	Bus module faulty before power switched off	2014-05-05 12:20:05 (GMT-5)
169	"Ash box full, please empty"	2014-04-06 13:37:52 (GMT-5)
0	Overheat Thermostat (STL) or EMERGENCY OFF activated	2014-04-06 13:37:35 (GMT-5)
169	"Ash box full, please empty"	2014-04-05 18:06:17 (GMT-5)

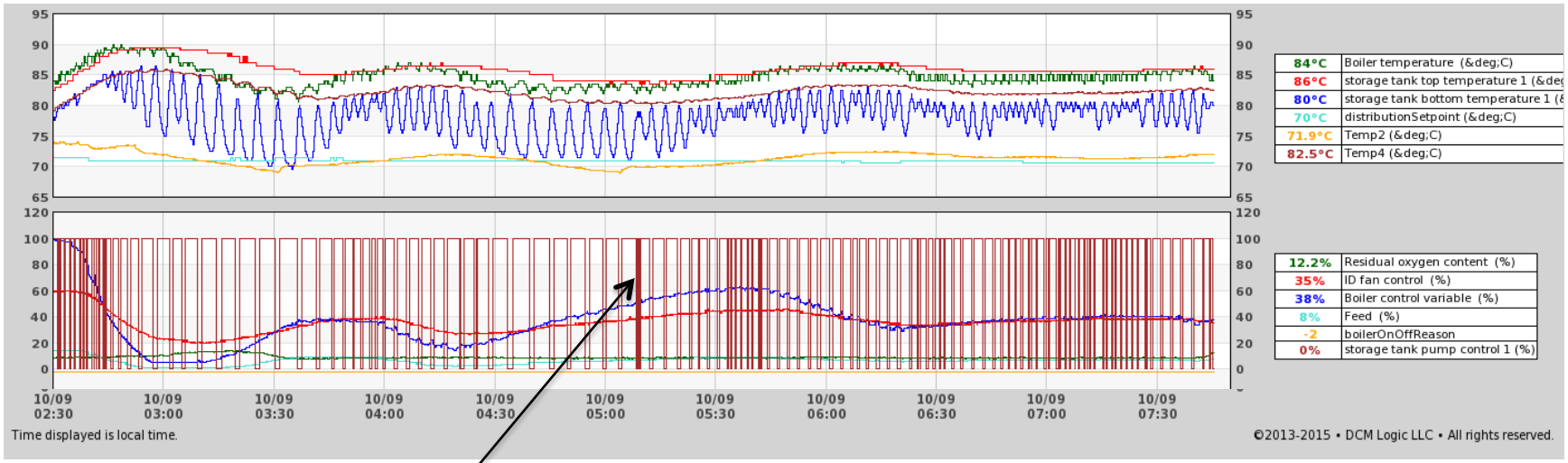
February 2015	**All boilers**
Boiler Count	52
Time in Fault	25d 9h
Avg Time in Fault	11h
Error Count	236
Error Count / Boiler	4.5
Top By Time	**ID** **Time** **Description** 16 6d 12h Check fuel outfeeder 5 2d 8h Test combustion chamber overpressure monitor 6 2d 8h Back-fire slide valve does not close 2 2d 2h Primary air flap blocked 11 1d 23h Ignition not successful

- Basic monitoring is just as fast with fault notification, BUT
- Comprehensive monitoring allows you to look up fault history and quantify boiler downtime

Not Sure How Long this Circulator Will Last . . .

Cost

Downtime



Circulator pump oscillating between 100% and near 0%

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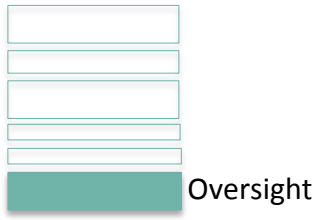
Frequency of Starts and Stops Provides Clues about Emissions

- Transitional operating states around startups/ shutdowns most likely to produce high particulate emissions

Performance Measure	Boiler 1	Boiler 2
Service Hours	6994	7065
Hours of Heating	5834	5834
Number of Burner Starts	2336	2420
Heating Hours per Start	2.50	2.41

Human Oversight Should Be An Important Cost of Boiler Operation



- For boiler plants with a boiler operator, it already is
- Facilities without dedicated operator may not see human oversight of boiler as important
- BUT: 5-15% of school plant operations and maintenance budgets go to heating fuel alone*

➢Boiler oversight SHOULD be an important part of facilities management

➢Comprehensive monitoring enables low-cost boiler oversight

*Keene NH, Williamstown VT, East Montpelier VT, Harwood Union HS (VT) budget data

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Boiler Plant Effectiveness is Dependent on Delivered Water Temperature

Effectiveness

Monitoring helps you . . .

	Know	Improve
Boiler Plant Effectiveness	✓	✓

Is water coming from the boiler plant at the right temperature?

Foundations of Effectiveness Score

	Duty Cycle	Heating hrs/start	Startup/shutdown time	Cleaning time*	Fuel fill time*
Know	✓	✓	✓	✓	✓
Improve	✓	✓	?	✗	✗

*If heating, startup, or shutdown is interrupted

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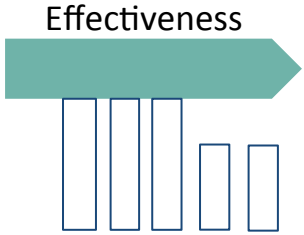
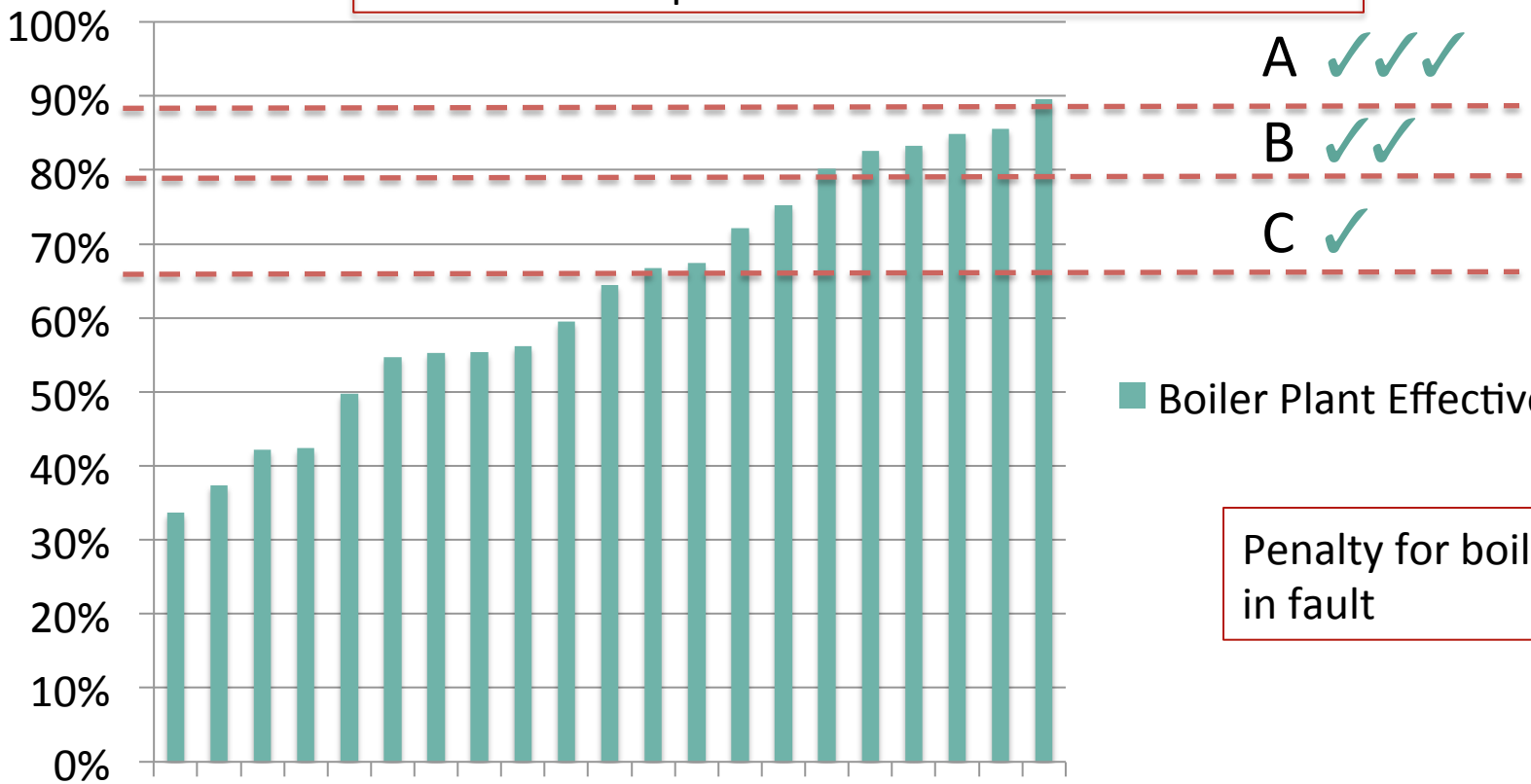
Boiler Plant Effectiveness Scores Vary Considerably



Boiler Plant Effectiveness =
% of time delivered temp ≥ (setpoint – 2.5°C)
OR
output of all boilers > 95%



Penalty for boiler off or in fault

Source: A selection of boilers plants monitored by DCM Logic; each bar represents one boiler plant

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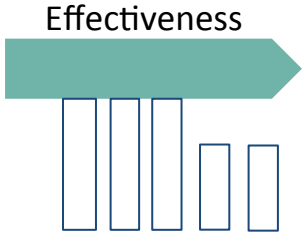
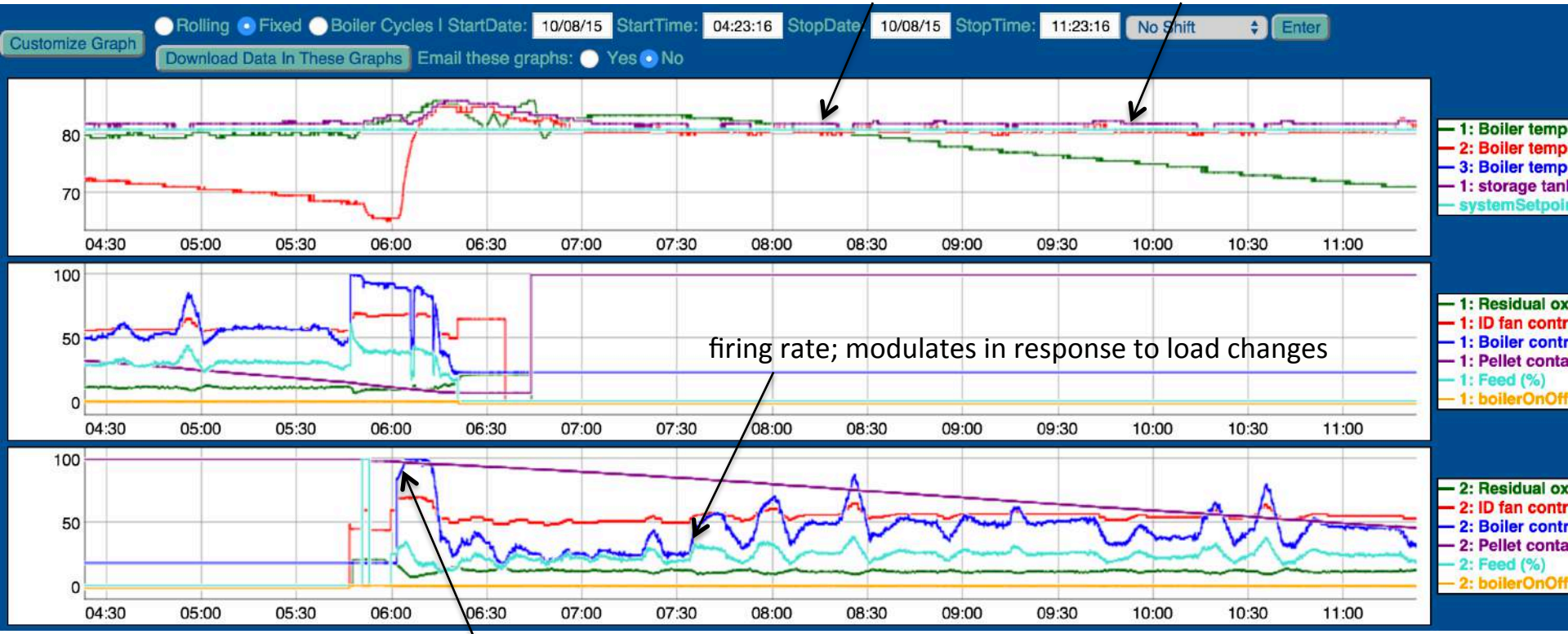
High Score: Graphs Can Also Help in Visually Assessing Effectiveness



setpoint

buffer tank top temperature



firing rate; modulates in response to load changes

firing rate ramps up quickly before reducing to a steady-state rate

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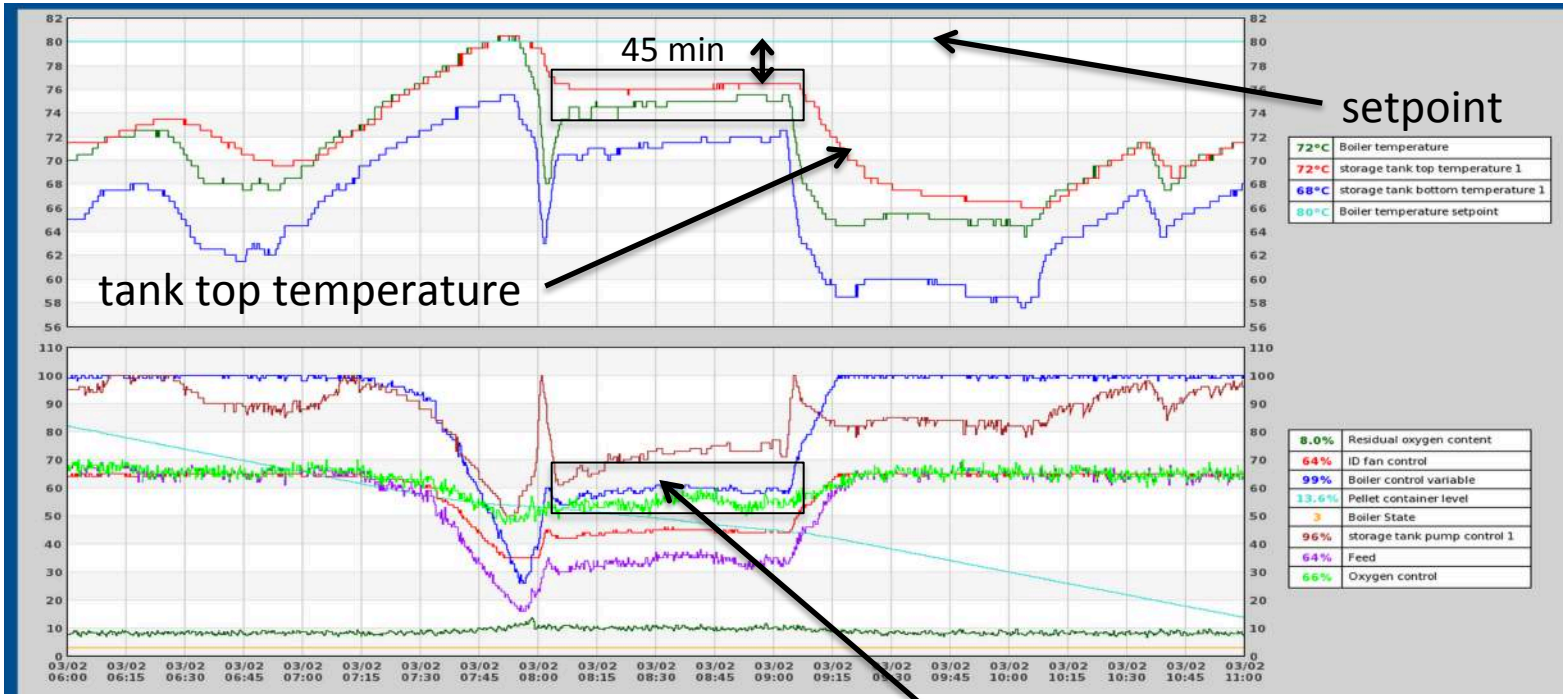
This Boiler Has a Lower Boiler Plant Effectiveness



Issue:

- Firing rate remains constant at ~60% even though a significant deviation from the setpoint has occurred for 45 minutes

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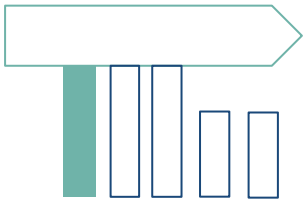
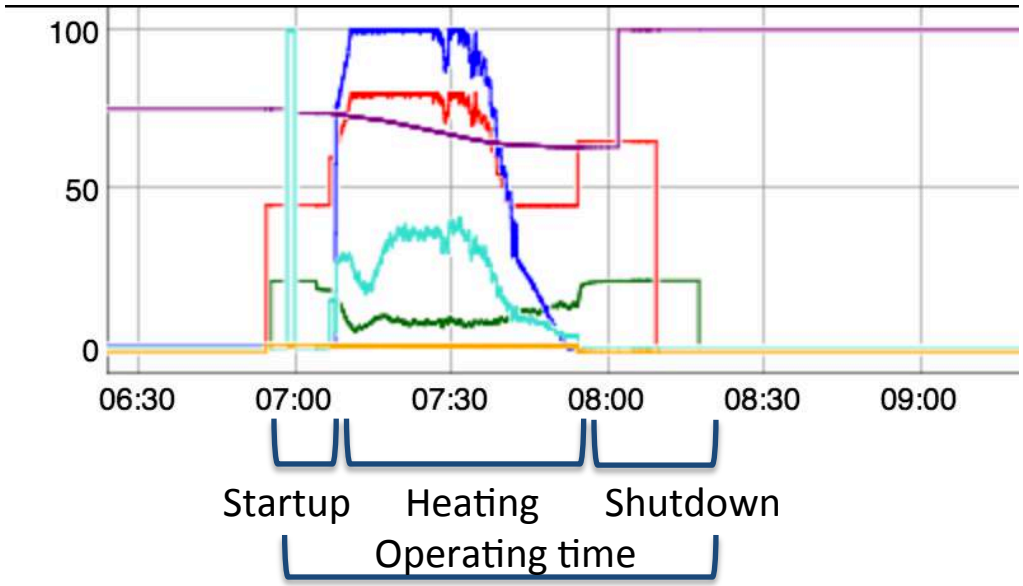
Know Your Duty Cycle Profile

Effectiveness



Duty cycle



- Duty Cycle = heating hours/operating hours (Measured Duty Cycle)

  Or, Duty Cycle = Heating time/(heating + startup + shutdown + cleaning*)

  *if it doesn't occur at the same time as another part of cycle

Higher duty cycle percentages mean that your boiler can provide useful heat for a higher percentage of the hours in a day (month)

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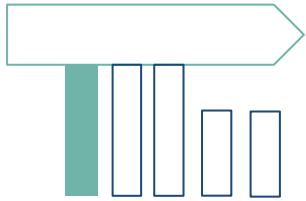
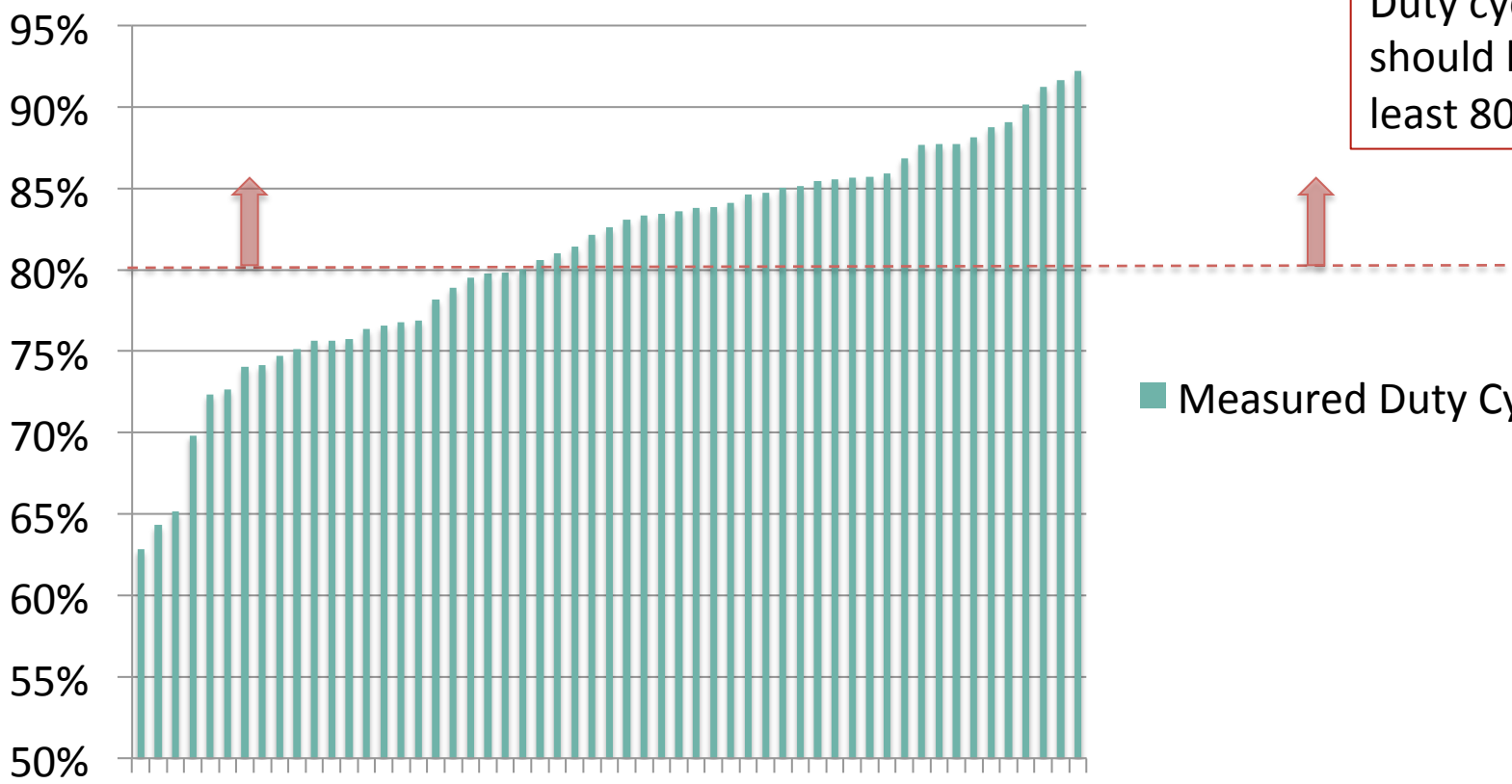
How Does Your Duty Cycle Stack Up?

Effectiveness



Duty cycle



Source: A selection of boilers monitored by DCM Logic; each bar represents one boiler

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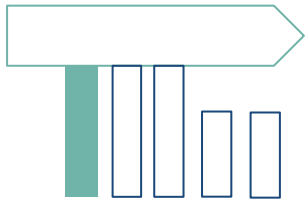
Why is Duty Cycle Important?

Effectiveness



Duty cycle

- It tells you how much of your boiler's rated capacity is actually available to you over time

  Duty Cycle x Rated Capacity = Effective Capacity

  ➛ "Rated Capacity" is overrated!

  ➛ Use Measured Duty Cycle to calculate Effective Capacity, not the Theoretical Duty Cycle

  ➛ When sizing, keep Effective Capacity in mind

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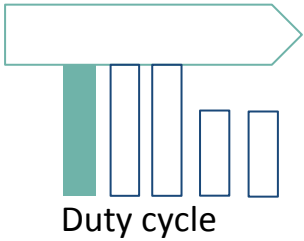
Theoretical Duty Cycle Different from Measured Duty Cycle



$$\frac{\text{Max runtime between cleanings}}{\text{(Max runtime + startup + shutdown + cleaning)}} = \text{Theoretical Duty Cycle}$$

$$\frac{\text{Heating Hours}}{\text{Operating Hours}} = \text{Measured Duty Cycle}$$

- Most boilers we monitor lag behind their Theoretical Duty Cycle by about 10% points
- Very highest performing boilers have Measured Duty Cycles within 1-2% points of Theoretical Duty Cycle

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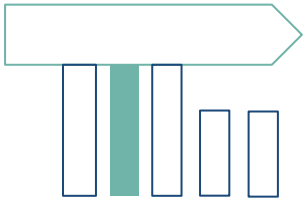
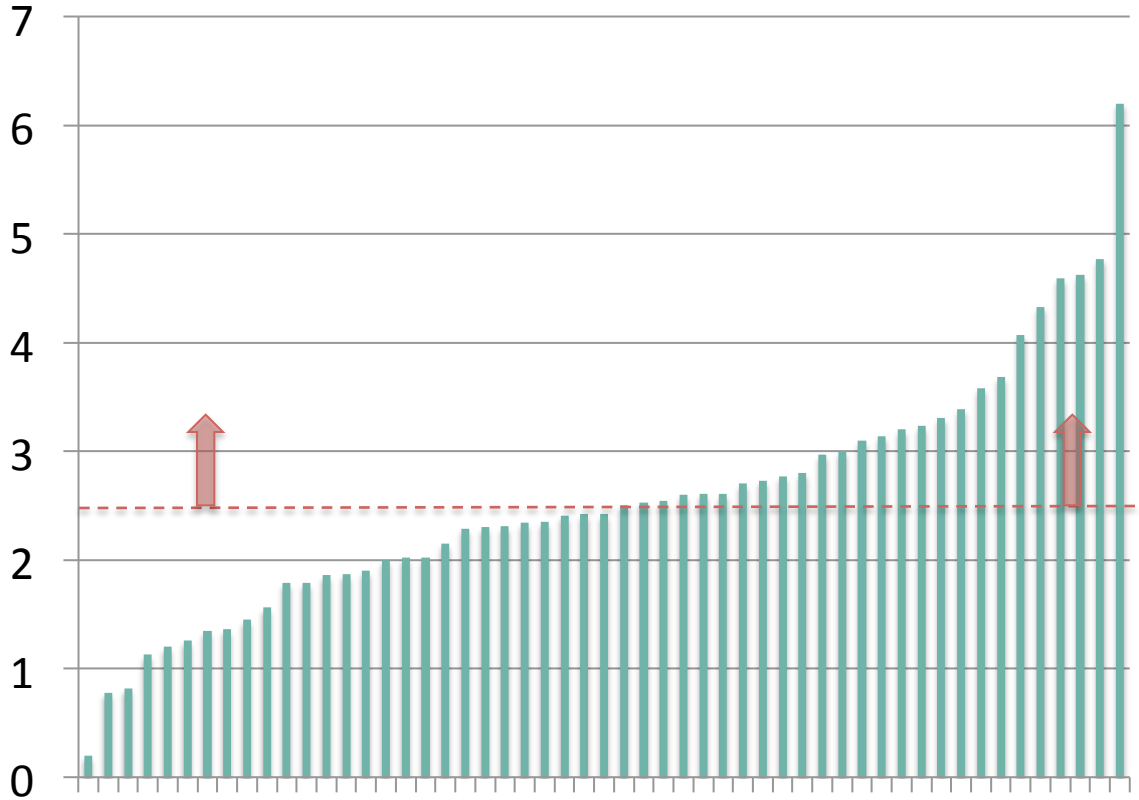
Heating Hours Per Start Vary Greatly

Effectiveness



Heating hours/ start



At least 2.5 heating hours/start is best

Source: A selection of boilers monitored by DCM Logic; each bar represents one boiler

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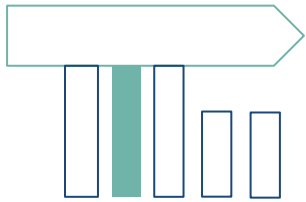
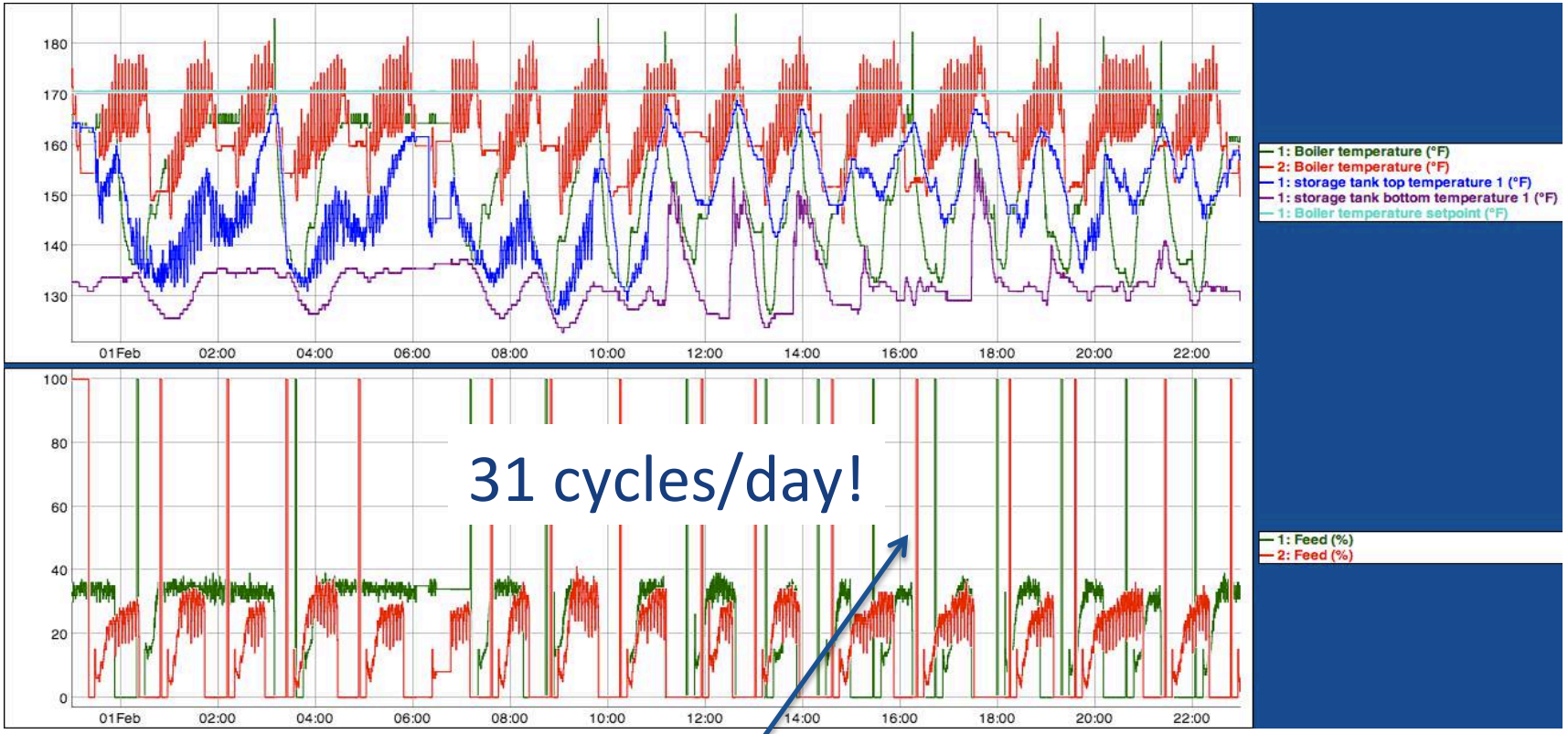
Graphs Also Show Short Cycling

Effectiveness



Heating hours

Boiler/Buffer Temps



Pellet Feed Rate

Each vertical line =
1 boiler startup

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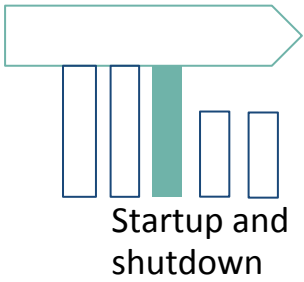
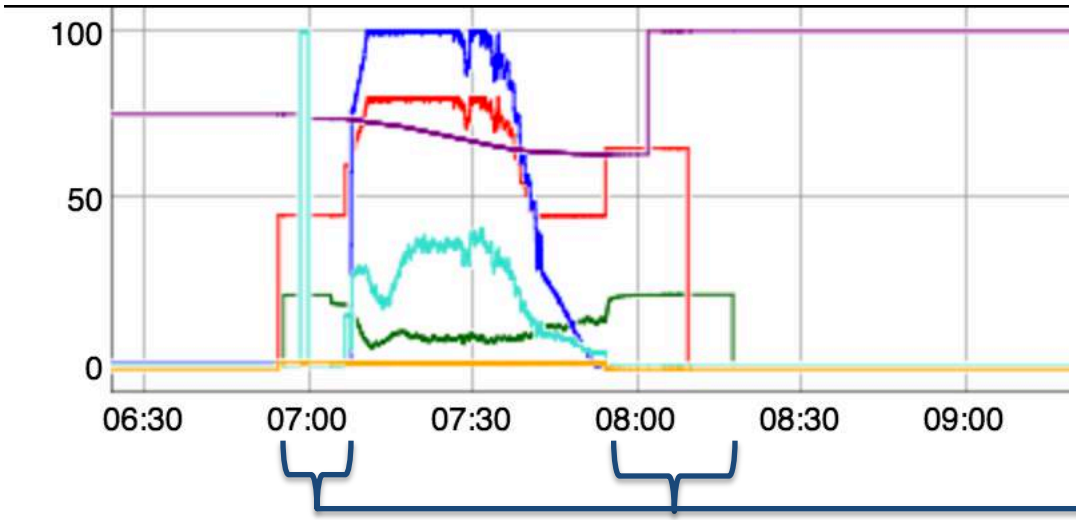
Know Your Startup and Shutdown Times





- 12 minute startup
- 24 minute shutdown

- Long startup/shutdown times make it difficult to maximize heating time
- All the more critical to minimize short cycling with long startup/shutdown times

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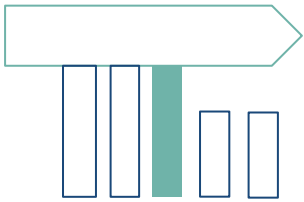
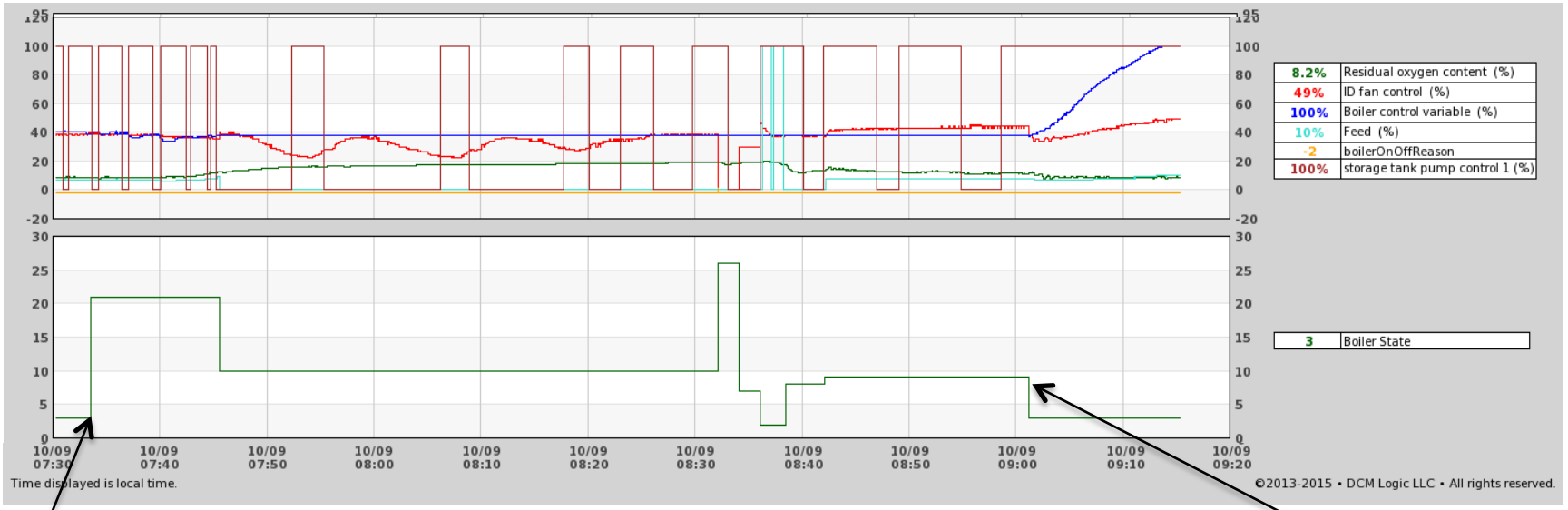
Very Long Shutdown

Effectiveness



Startup and shutdown



1.5 hours

Heating stops

This boiler takes 1.5 hours between shutting down and providing heat, regardless of the need for heat

Heating resumes

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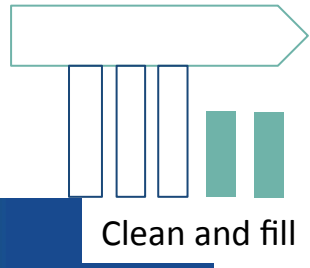
2 Boilers: Runtime Interrupted by Cleaning and Daybin Filling

Effectiveness



Clean and fill

Scheduled Time to Refill Green Boiler Bin

Scheduled Time to Refill Red Boiler Bin

Pellet Bin Levels

Stop to clean after running 8 hours

Green takes over

Red takes over

Green takes over

Pellet Feed Rate

100
90
80
70
60
50
40
30
20
10
0

11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00 01Apr 01:00

1: Feed (%)
2: Feed (%)
1: Pellet container level
2: Pellet container level

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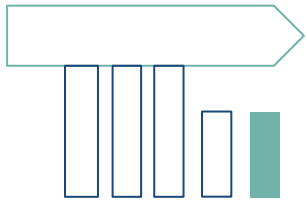
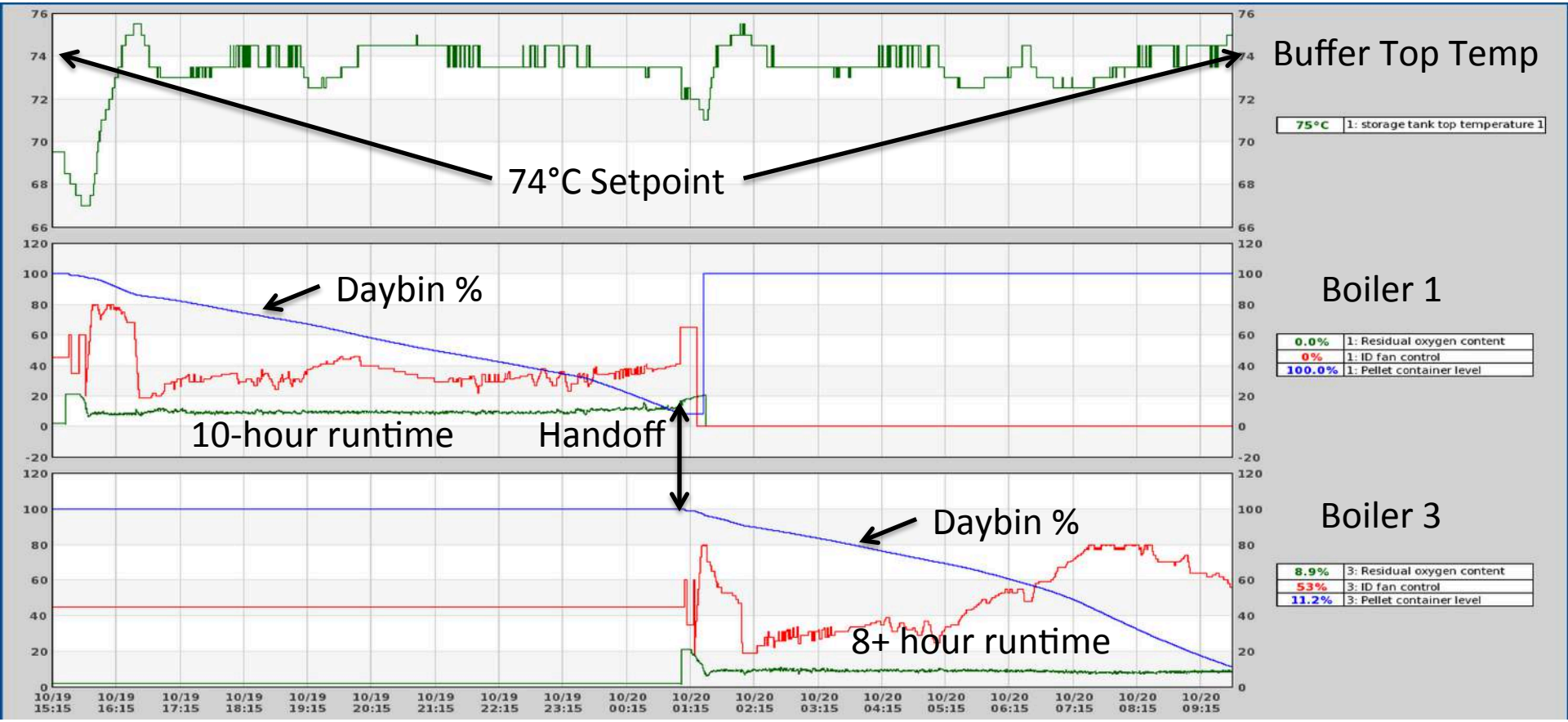
Uninterrupted Heating Cycles

Effectiveness



Fill



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This Seems Like a Lot of Work. Do I Really Need to Monitor My Boiler?

- 5-15% of school plant operations and maintenance budgets go to heating fuel alone
- Biomass boiler capital costs are high and often require an extensive and public approval process
- Your boiler is already collecting data, so additional monitoring costs are not high

➛You owe it to your organization and community to keep track of how your boiler is performing

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Yes—You Do Need to Look at Graphs and Boiler Performance Measures

- For most facilities managers or boiler operators, it makes sense to do this daily
- Your installer/manufacturer/distributor can help
- Know your boiler's startup/shutdown times and performance measures
- If you don't have comprehensive monitoring tools, ask your installer or manufacturer

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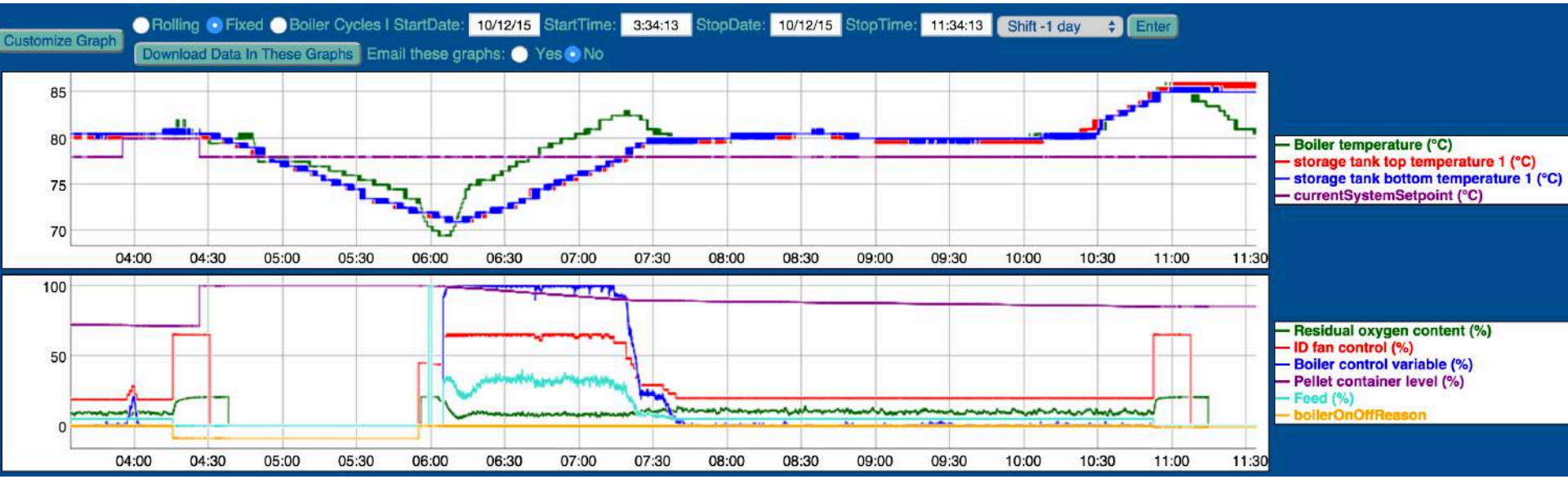
Comprehensive Monitoring and Boiler Performance



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