Defining and Implementing Central Plant Optimization

Session 3 of 3 of the Series:

Optimizing Your Chiller Plant Room

Moderated by Laxmi Rao

Presented by Dave Klee and Ben Erpelding

Johnson Controls

Welcome

- **Webinar Duration:** 1 hour

- **Panelists:** Please silence /shut cell phones

- **Questions to Presenters:** Enter your **Questions** in the **Q&A box** at the lower right hand corner of screen **Questions will be answered after the end of the presentation**

- **Moderator** will handle **Questions to presenters** *Responses to unanswered questions will be provided by Jill Woltkamp after the webinar*

- If you are just listening to the webinar, send questions to jill.h.woltkamp@jci.com

- **Webinar (function) questions :** Please chat with Cheryl. Use the Chat box in the middle right hand section of the screen and choose - **"Chat privately to Cheryl"**

- **Survey:** Please complete the survey following the webinar

- **Webinar Download:** Recording and Presentation slides will be available at **www.districtenergy.org**

- **Note:** Session 3 will be more meaningful after viewing Sessions 1 & 2

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Agenda

Review the First Two Webinars

Discuss the CPO Myths

Summary

Q&A

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SELECT, DESIGN, OPTIMIZE

Optimizing Your Chiller Plant Room Webinar Program:

#1 Using Variable Speed Drives in Central Plants with Multiple Chillers

August 16, 2012

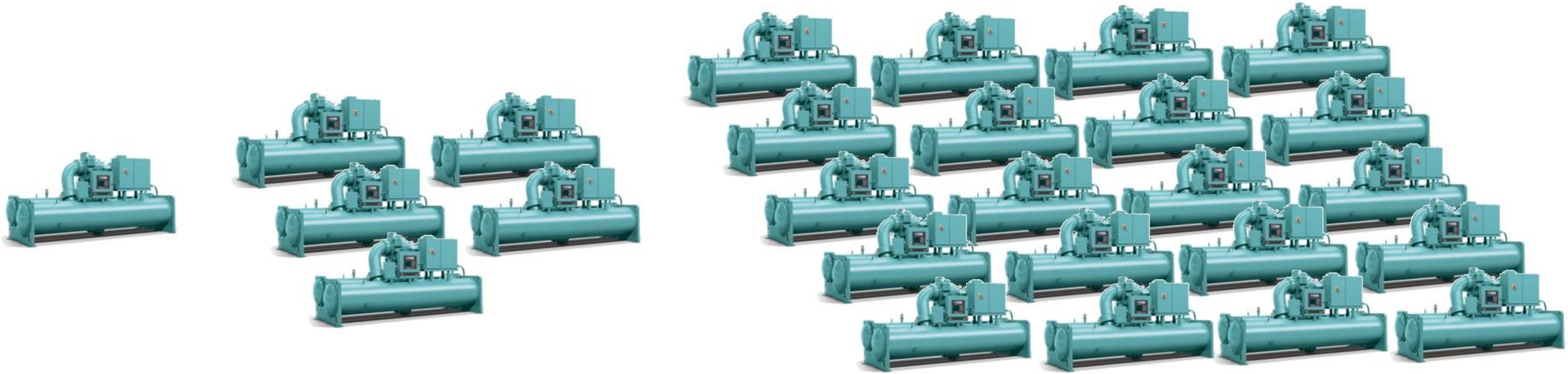**#2** Designing a Chiller Plant to be the Most Efficient

October 11, 2012

#3 Defining and Implementing Central Plant Optimization

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The Variable Speed Drive and Chiller Plant Design Myths

BUSTED

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Review
Using Variable Speed Drives in Central Plants with Multiple Chillers

- No matter the number of chillers....

- Applying VSD chillers in central plants saves energy over constant speed chillers, anywhere in the world

- The most efficient operating point for each chiller is at part load with a VSD

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Review
Designing a Chiller Plant to be the Most Efficient
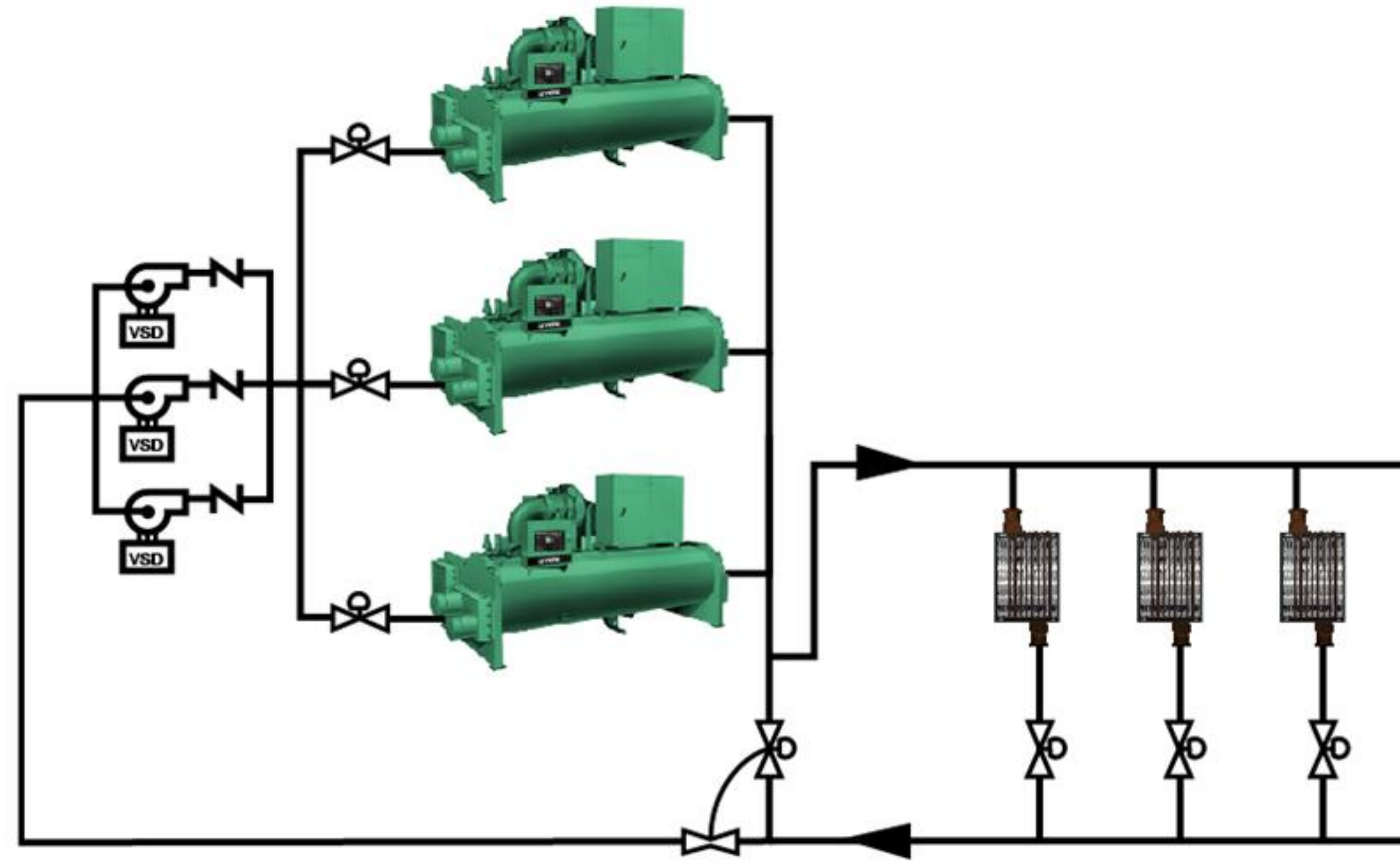
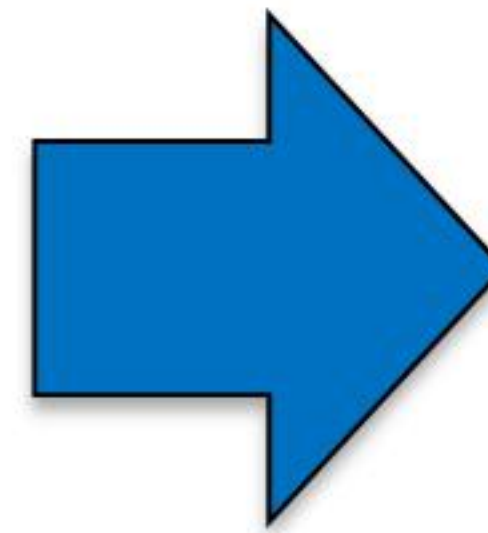- Speed does not track flow, and flow does not track load

- Reducing condenser flow and tower air flow saves net plant energy even though chiller energy increases as long as those reductions aren't too low (80% min typical)

- Headered VPF Plant mitigates low delta T impact

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Completed..

Up Next....

Review the Previous Myths

Central Plant Optimization Myths

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MYTH

#9

Automation = Optimization

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Automation is the data gateway for optimization

Optimization is data intensive

Automation

Variable Speed Drives

Chillers

Cooling Towers

Pumps & Motors

Johnson Controls

Automation is the data gateway for optimization

Optimization is data intensive

Automation

Variable Speed Drives

Chillers

Cooling Towers

Pumps & Motors

Johnson Controls

Comparing Automation versus Optimization

Automation	Optimization
Prerequisite	Opportunity
Sequences	Algorithms
The order of events	The optimal events
Executes	Advises
Holds setpoints	Calculates optimal states, speeds, setpoints
Meets the load	Meets the load with minimum power
Today's standard	Tomorrow's standard

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Automation ensures the load is met
Optimization ensures the load is met with minimum power

VFD

VFD

VFD

VFD

TON

TOTAL SYSTEM COOLING OUTPUT

COOLING TOWER FAN SPEED

CONDENSER PUMP SPEED

CHILLER VANE & SPEED

CHILLED WATER PUMP SPEED

POWER

TOTAL SYSTEM POWER INPUT

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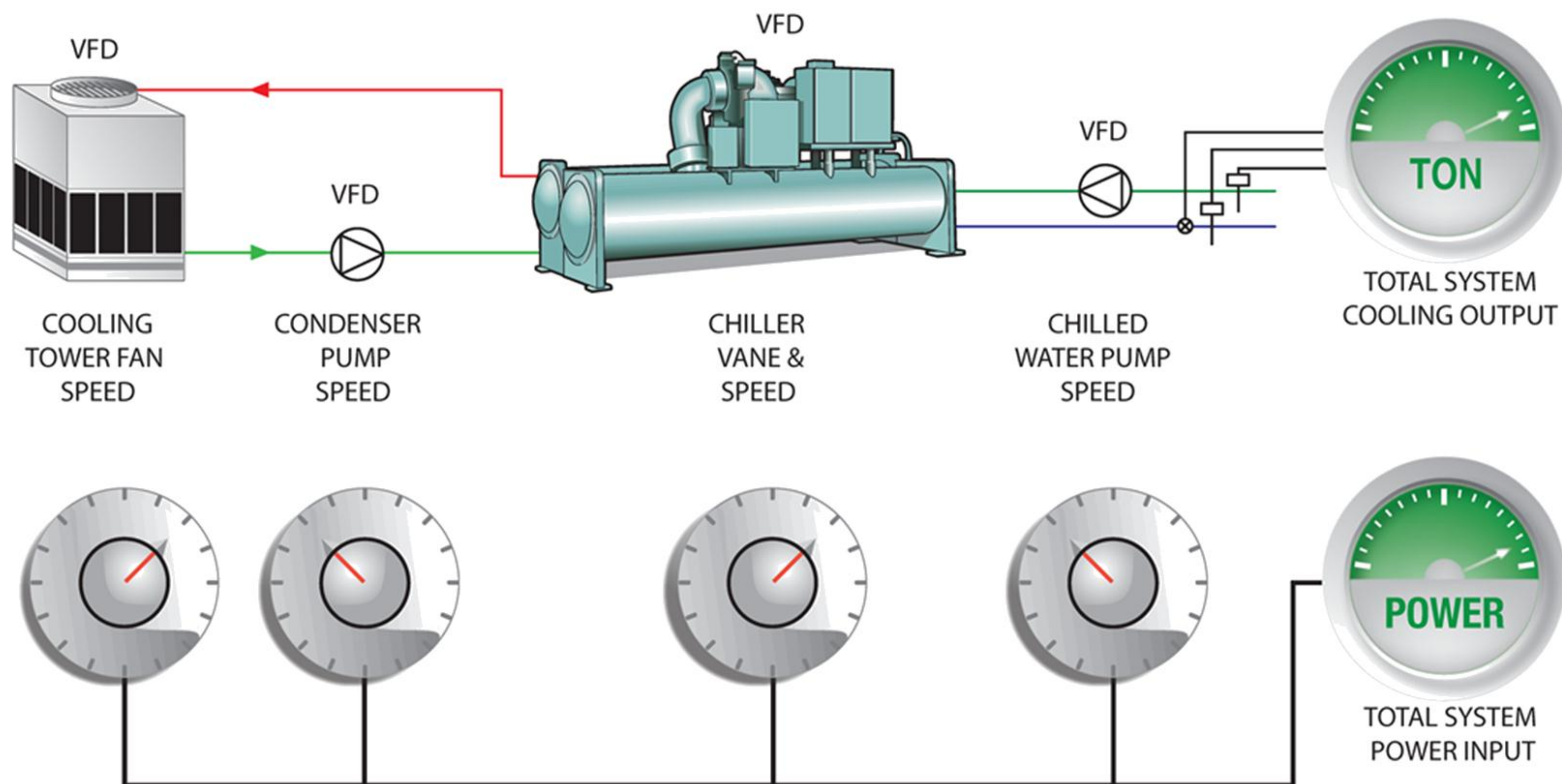
Decisions

The system has made **345** decisions since the beginning of this webinar

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MYTH #9

Automation = Optimization

BUSTED

Optimization <u>advises</u> automation on how to meet a load with the minimum possible power

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MYTH #10

A black box cannot run my plant better than our operators

Johnson Controls

What happens during operator visits to this black box?

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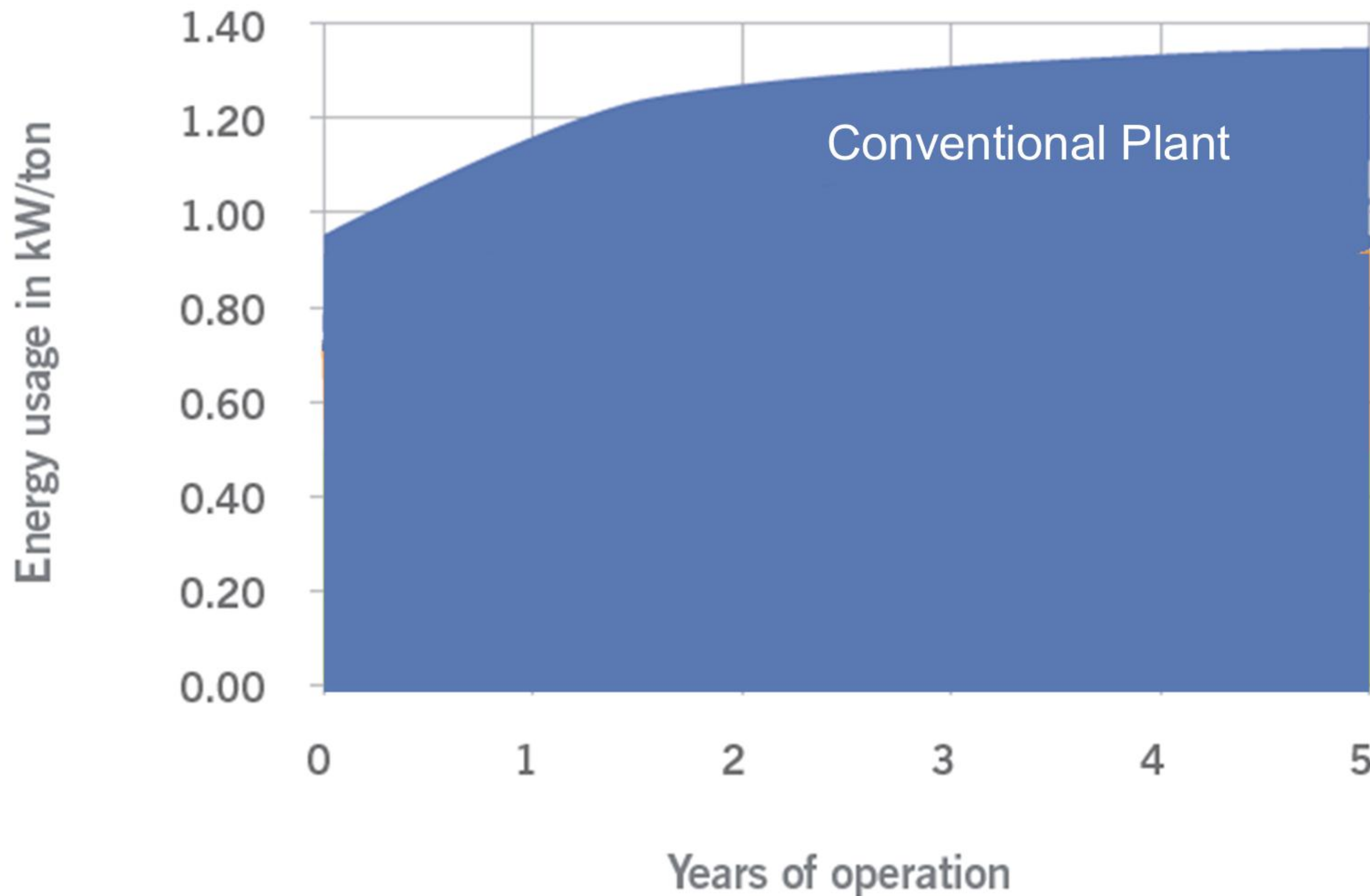
Performance Drift

Performance Drift

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Performance Drift

© Johnson Controls, Inc. 2012
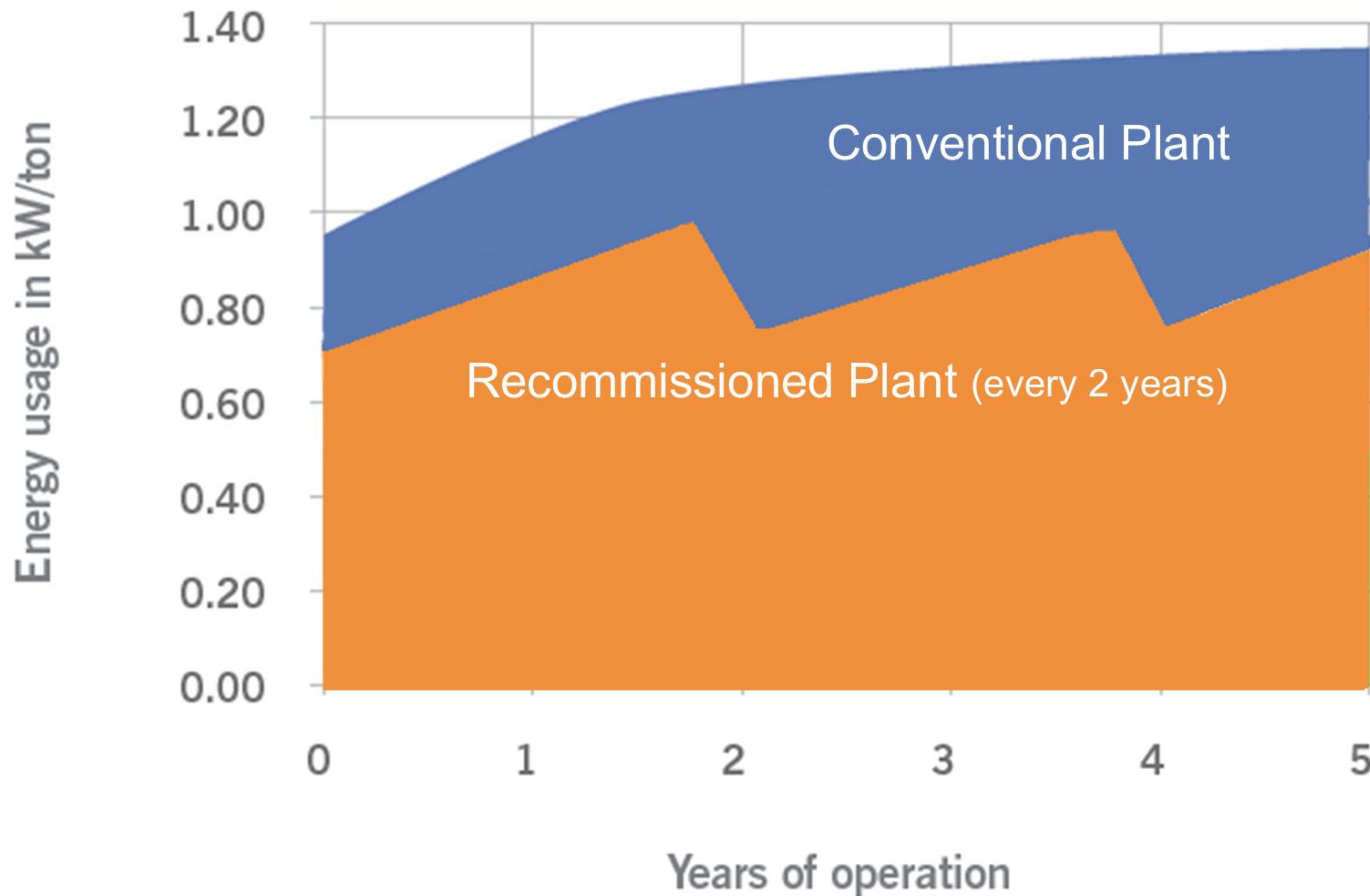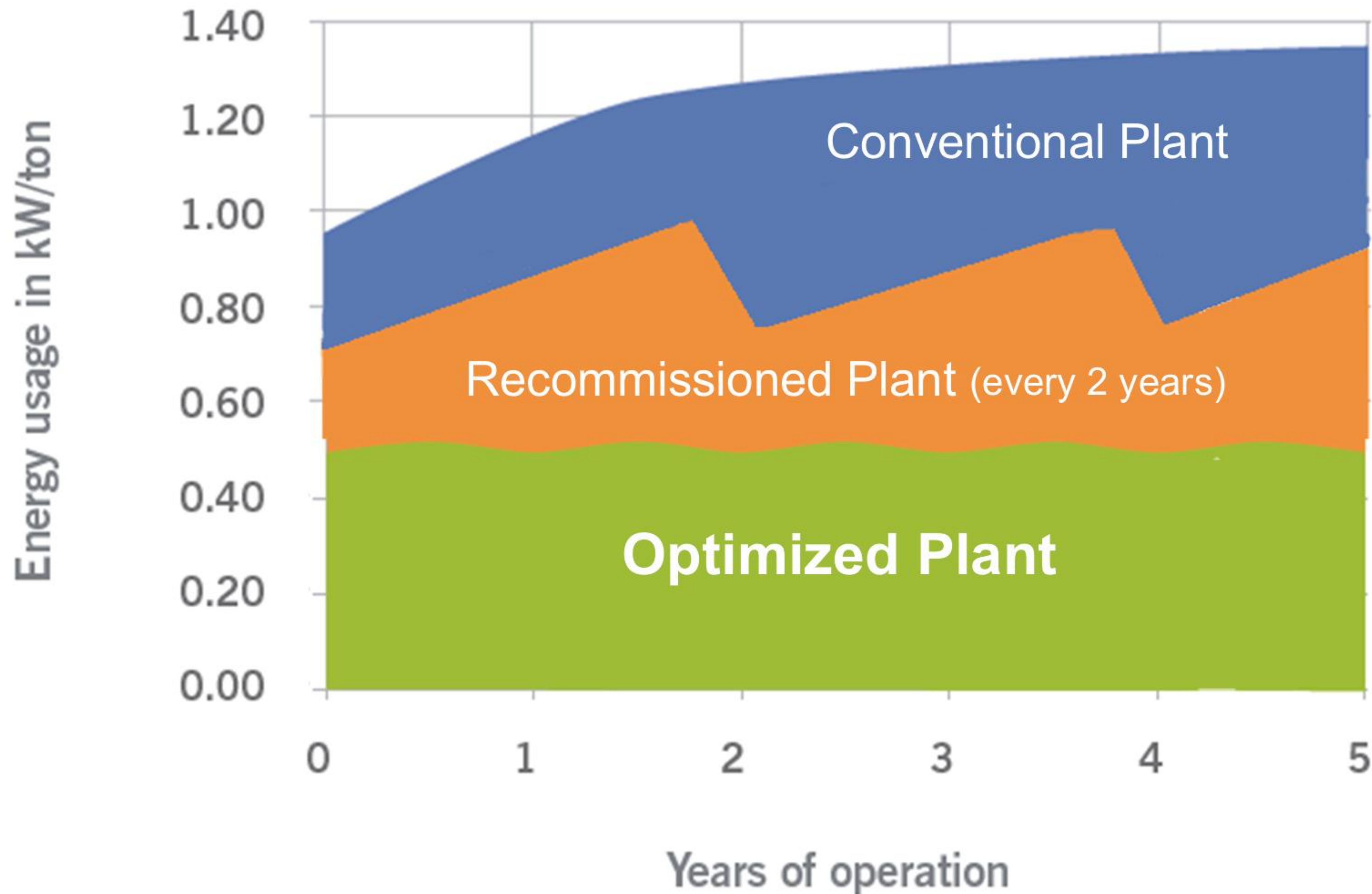
Efficiency Measurement, Verification and Management Cloud Services

Offering:

- Real-time operating analytics

- Comprehensive savings analysis reports

- Remote diagnostics
    - Email alerts
    - Proactive calls
    - 24/7 Call center
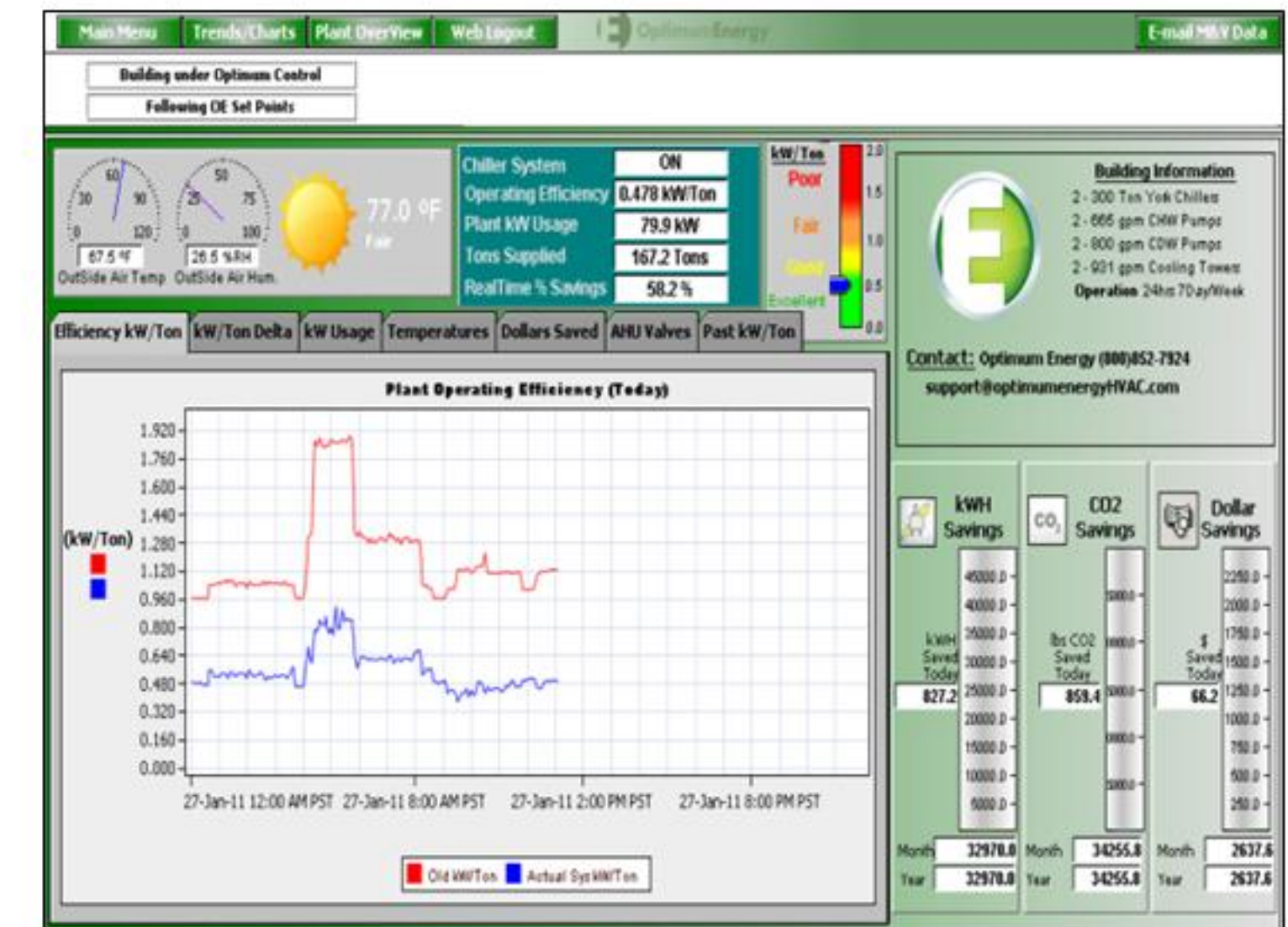
Outcome

- No operational drift

- On-going energy savings

- Peak energy efficiency regardless of climate and load variables

- Reduces operational costs

- Increased uptime

- Stream-lined plant operations

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Fighting Performance Drift

0.0 % CLOSED	0.0 % CLOSED	100.0 % CLOSED
OFF	OFF	ON
921.7 gal/min	988.5 gal/min	1629.6 gal/min

1

0.0 % CLOSED	100.0 % OPEN
OFF	ON
0.0 gal/min	1336.9 gal/min

2

0.0 % CLOSED	0.0 % CLOSED	0.0 % CLOSED
OFF	OFF	OFF
2.3 gal/min	3.1 gal/min	1.5 gal/min

3

53.5 °F

CTFAN1A
Enable	OFF
Speed	33.3 %
Alarm	OK
kW	0.0 kW

CTFAN1B
Enable	OFF
Speed	33.3 %
Alarm	OK
kW	0.0 kW

CTFAN2A
Enable	ON
Speed	99.5 %
Alarm	OK
kW	15.6 kW

CTFAN2B
Enable	OFF
Speed	33.3 %
Alarm	OK
kW	0.0 kW

CTFAN2C
Enable	ON
Speed	100.0 %
Alarm	OK
kW	38.7 kW

CTFAN3A
Enable	OFF

CTFAN3B
Enable	OFF

CTFAN3C
Enable	OFF

COMMS OFF KW/ton 0.218 KW 212.7 kW Ton 977.9

CDW Bypass Valve 25.0 %
CDWSP 25.9 psi
CDWRP 1.0 psi

47.3 °F

South Pump Room 1601.0 gal/min
CDWFLO 3547.0 gal/min

North Pump Room 1312.5 gal/min

CDWP1
Enable	Disabled
Speed	0.0 %
Alarm	Normal
kW	0.0 kW

OFF

CDWP2
Enable	Disabled
Speed	0.0 %
Alarm	Normal
kW	0.0 kW

OFF

CDWP3
Enable	Enabled
Speed	60.0 %
Alarm	Normal
kW	70.9 kW

ON

CDWP4
Enable	Disabled
Speed	0.0 %
Alarm	Normal
kW	0.0 kW

OFF

Chiller 1
CH1SS	Disable
CHSTSP	48.0 °F
kW	0.0 kW
CH1DMD	100.0 %

Chiller1DP: -0.1 psi
CH1CDWDP: 8.9 psi
CH1CHWDP: 1.5 psi

57.0 °F
56.5 °F
55.9 °F
55.4 °F

36.4 gal/min   0.0 %

Chiller 2
	Disable
CHS	48.0 °F

Chiller2DP: -0.2 psi
CH2CDWDP: 1.2 psi

99.7 %
99.7 %
100.0 %

HX-1

43.3 psi
49.5 psi
3.4 psi 56.0 °F
18.0 psi 46.6 °F
58.5 °F
46.8 psi

OPEN 0.7 gal/min
57.0 °F
59.5 °F

- Last year 100% fan speed was 52-55 kW
- The cooling towers are doing less work than before
- The pitch of the fan(s) is off
- The result = a decrease in the approach (efficiency) of the cooling tower and lost energy savings

Dashboard   Trends/Charts   Chilled Water System   AHU Valves   DeepThunder

MYTH #10
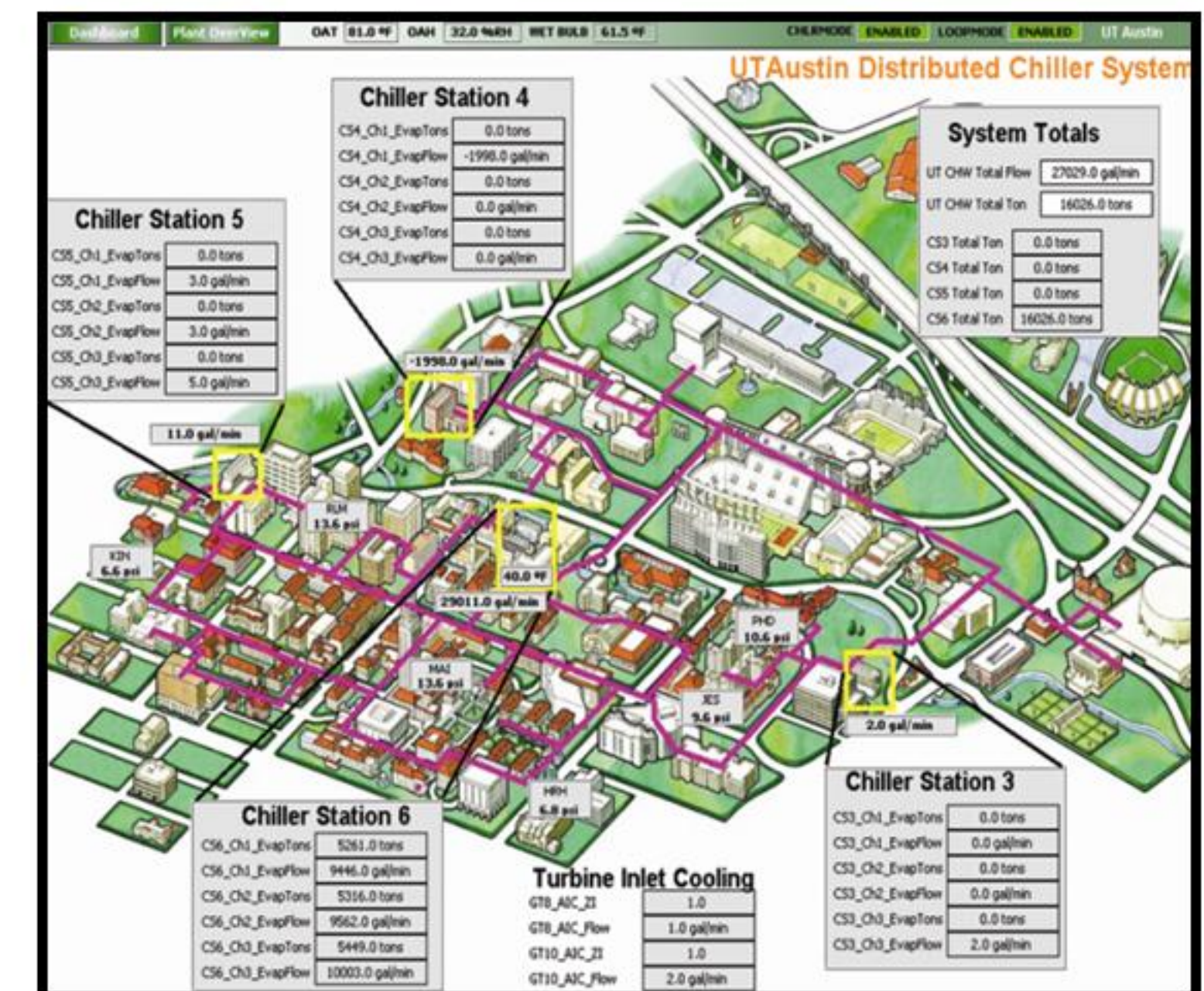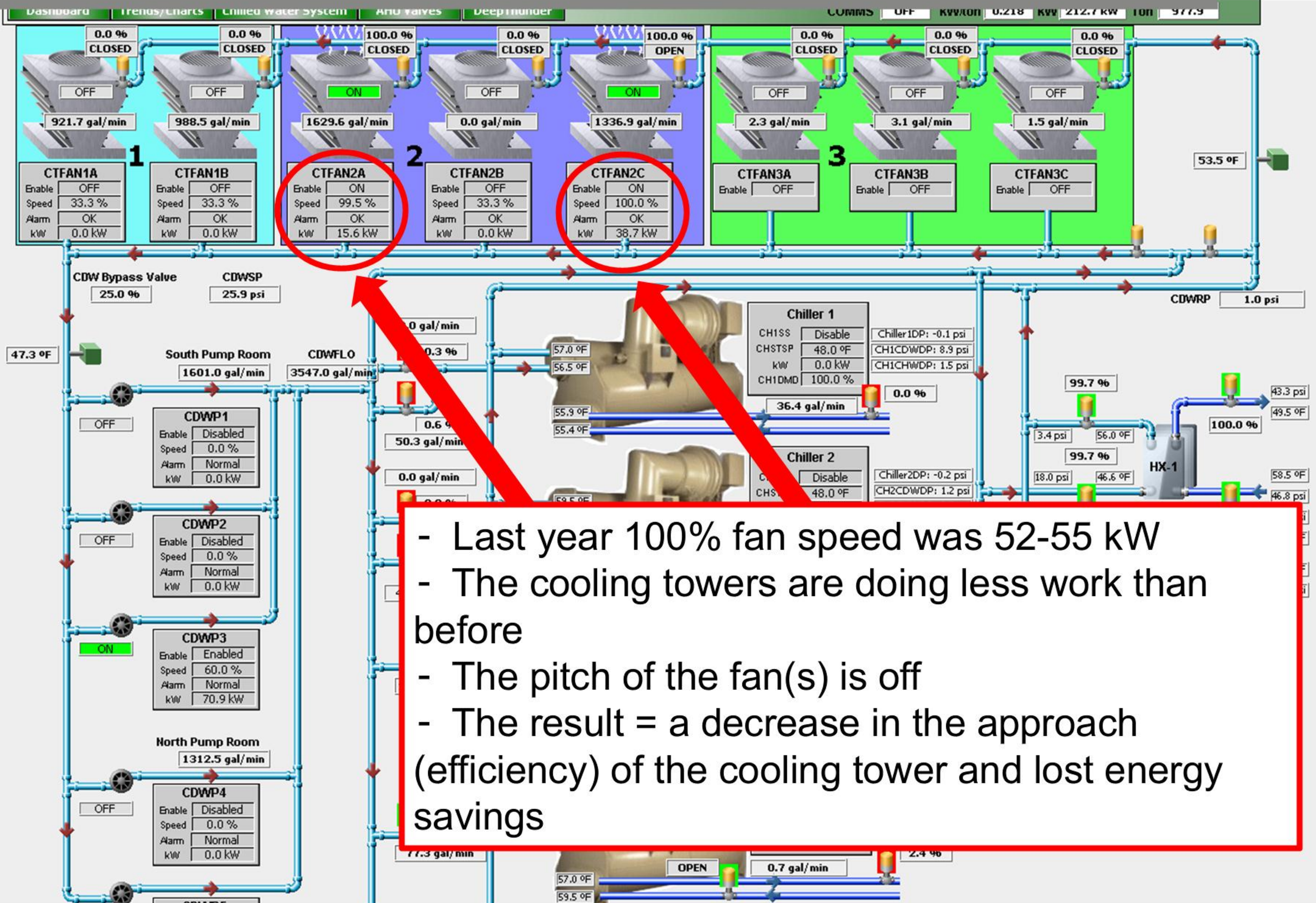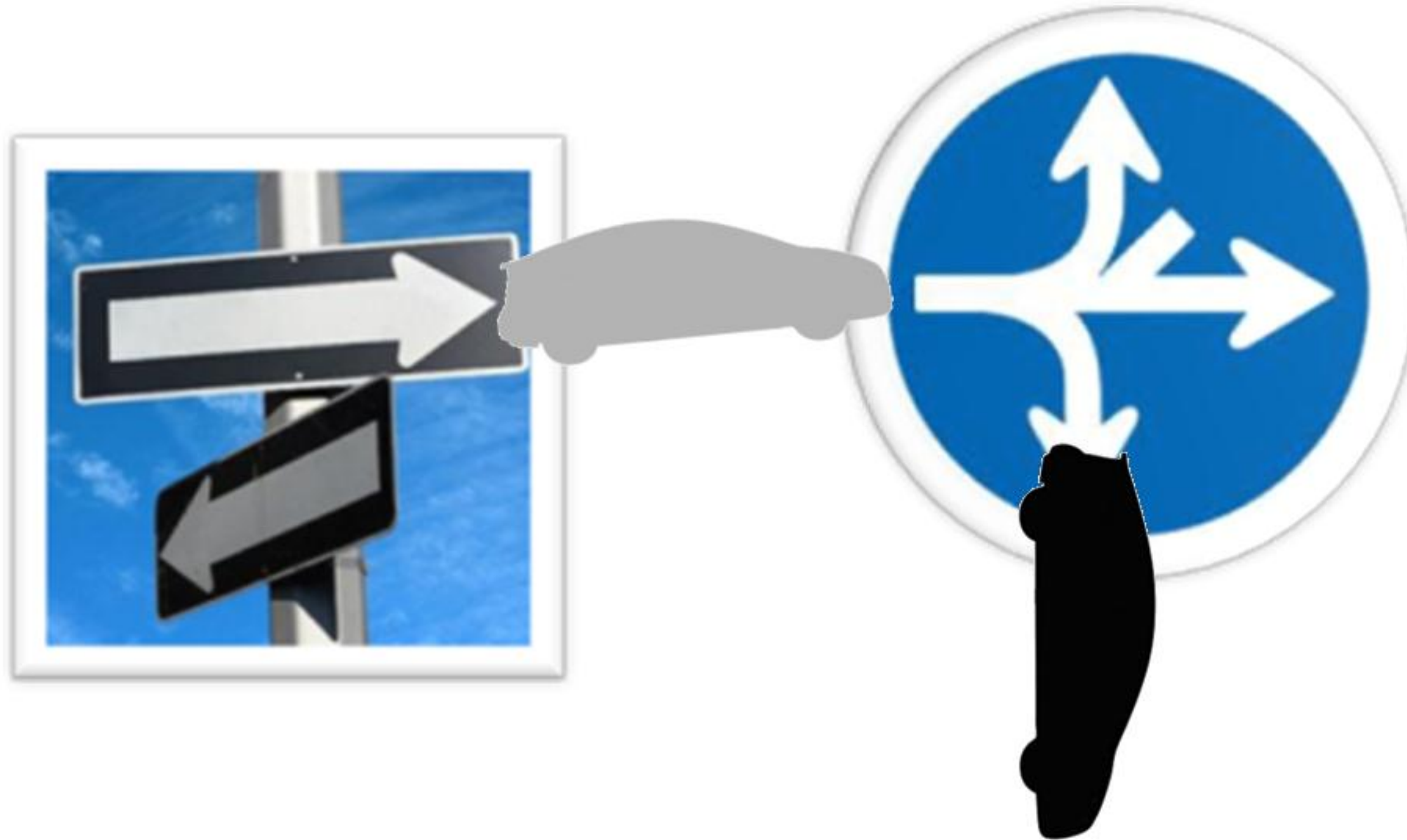
A black box cannot run my plant better than our operators

BUSTED

MVM and the black box helps ensure operator effectiveness

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Decisions, Decisions

The system has made **460** decisions since the beginning of this webinar

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MYTH #11

We already have algorithms in place, we don't need optimization

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Algorithms are <u>just a part</u> of an overall optimization solution
Performance modeling and Performance management are also critical

OUTCOME:

The plant performs at its peak, predicted efficiency, persistently over time

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Algorithms are <u>just a part</u> of an overall optimization solution

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Real-time, dynamic algorithms

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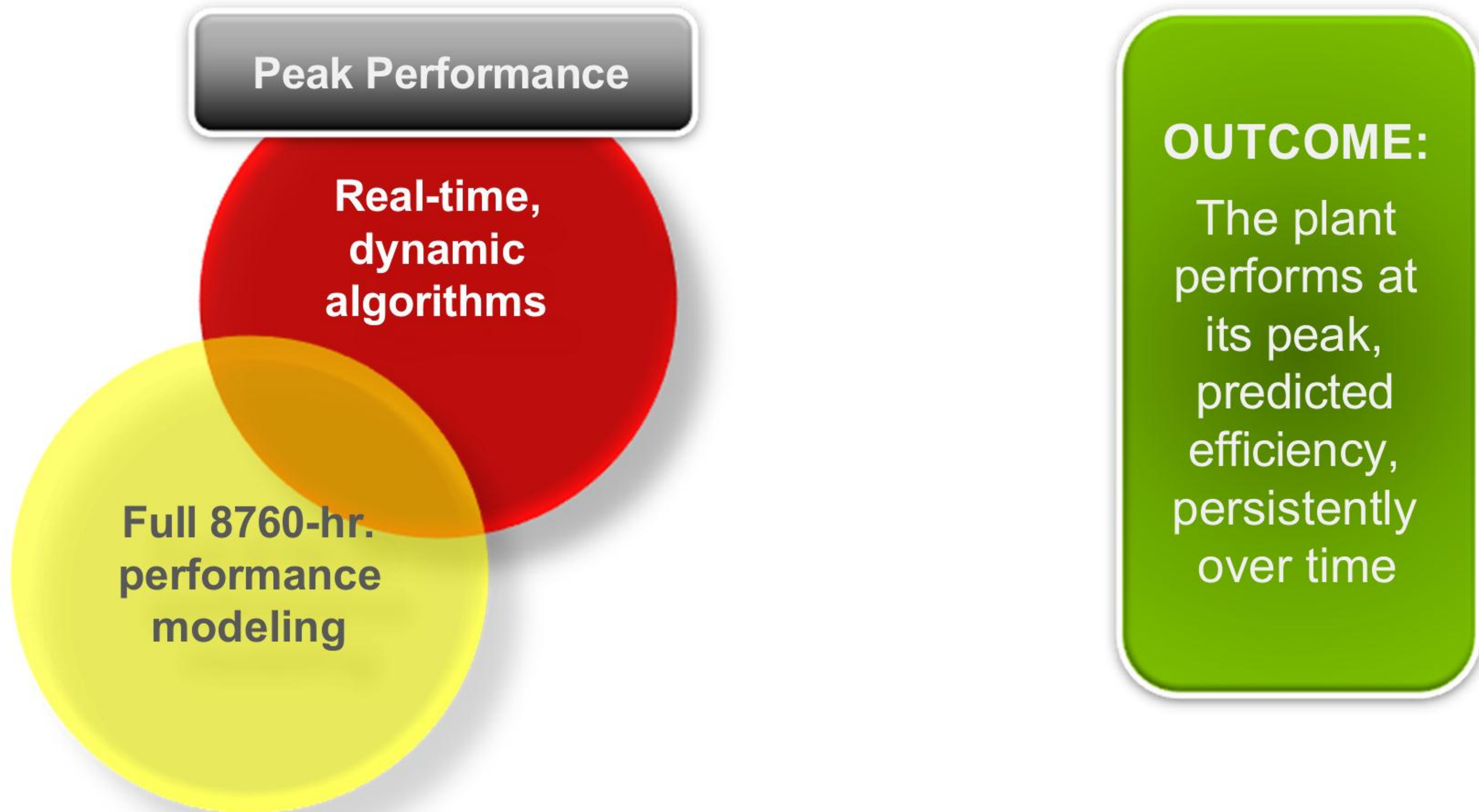## Performance modeling and Performance management are also critical

Peak Performance

Real-time, dynamic algorithms

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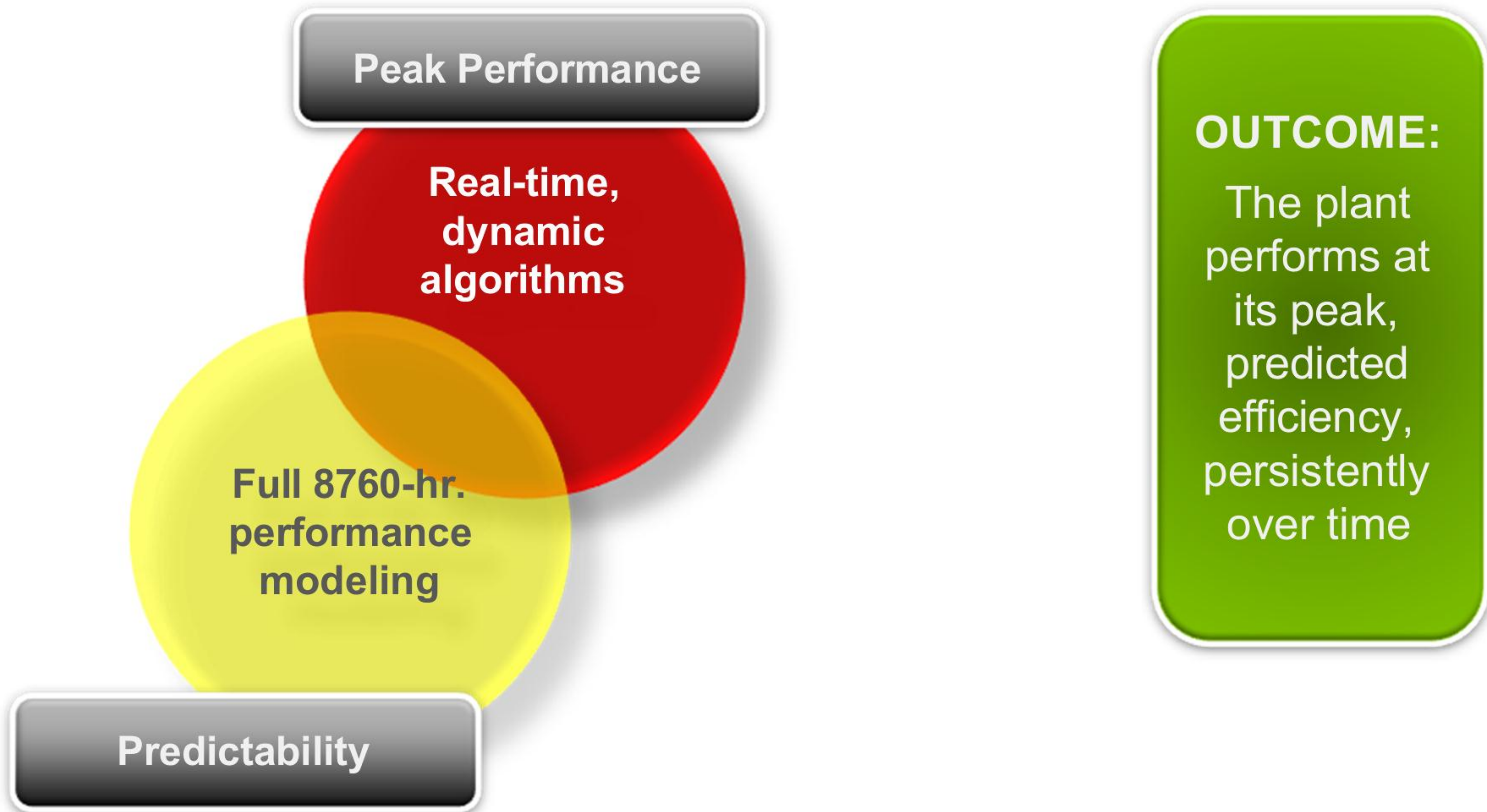
Peak Performance

Real-time, dynamic algorithms

Full 8760-hr. performance modeling

OUTCOME:

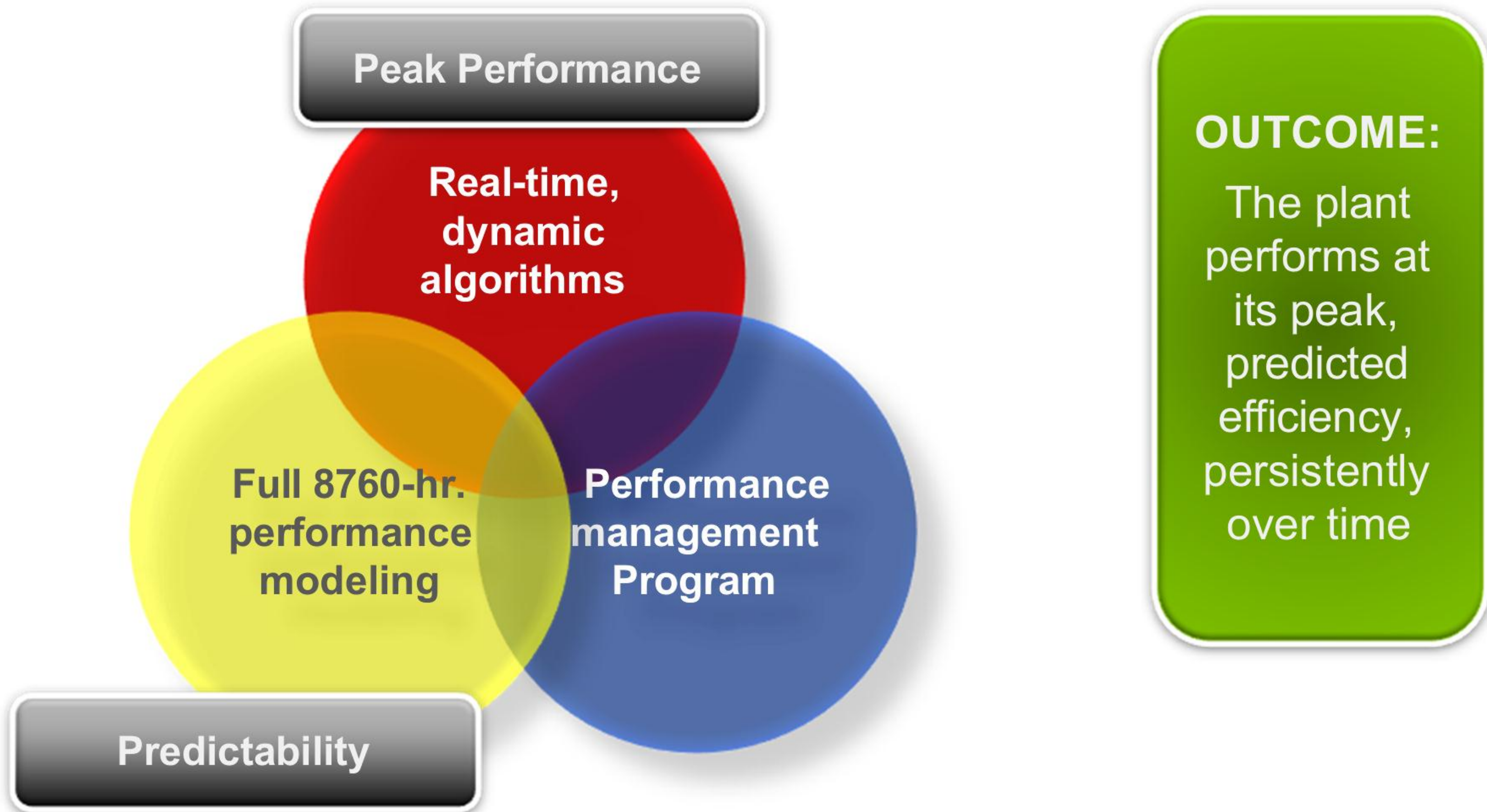The plant performs at its peak, predicted efficiency, persistently over time

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Predictability

OUTCOME:

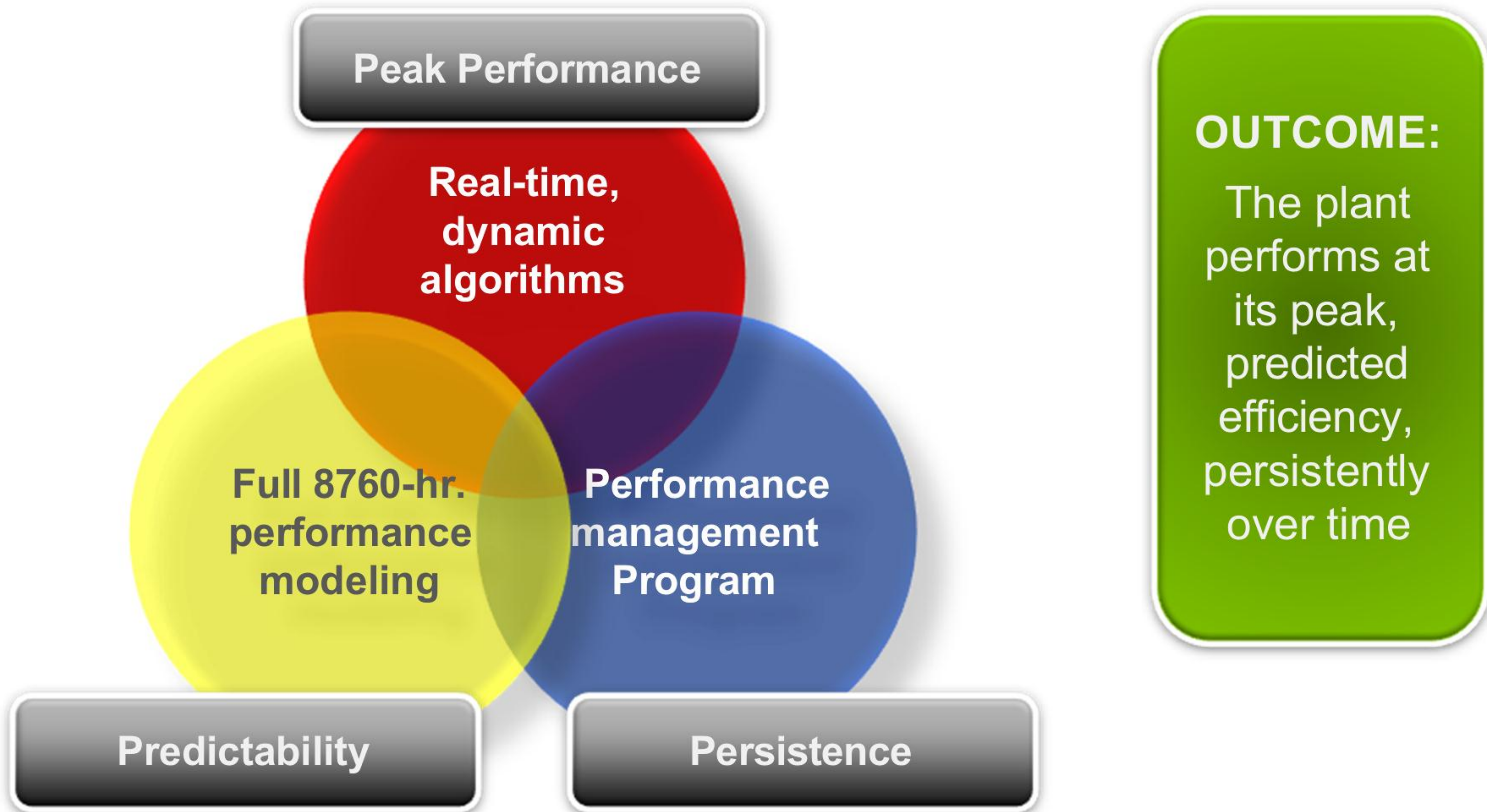The plant performs at its peak, predicted efficiency, persistently over time

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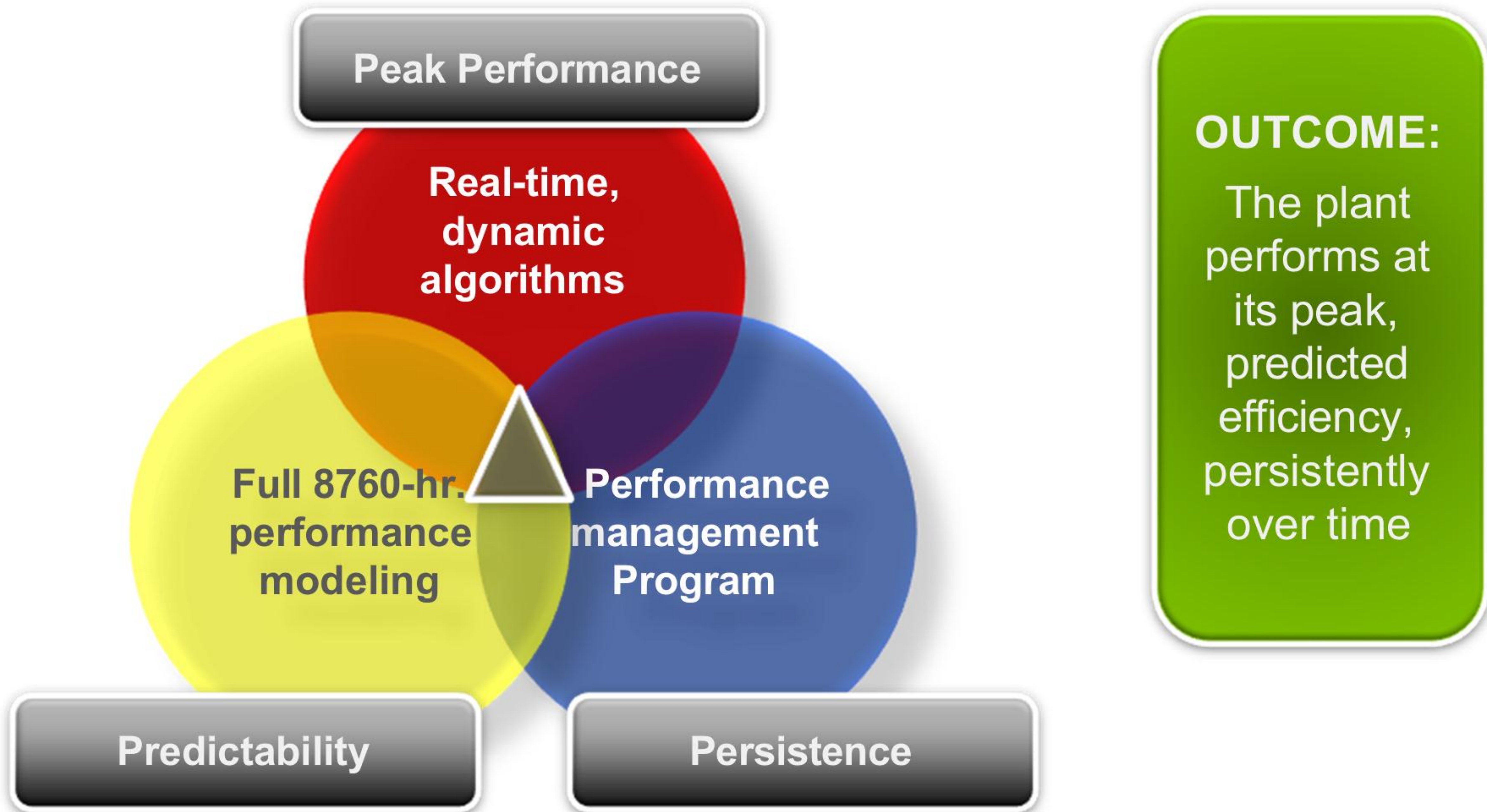**Peak Performance**

Real-time, dynamic algorithms

Full 8760-hr. performance modeling

Performance management Program

Predictability

Persistence

OUTCOME:

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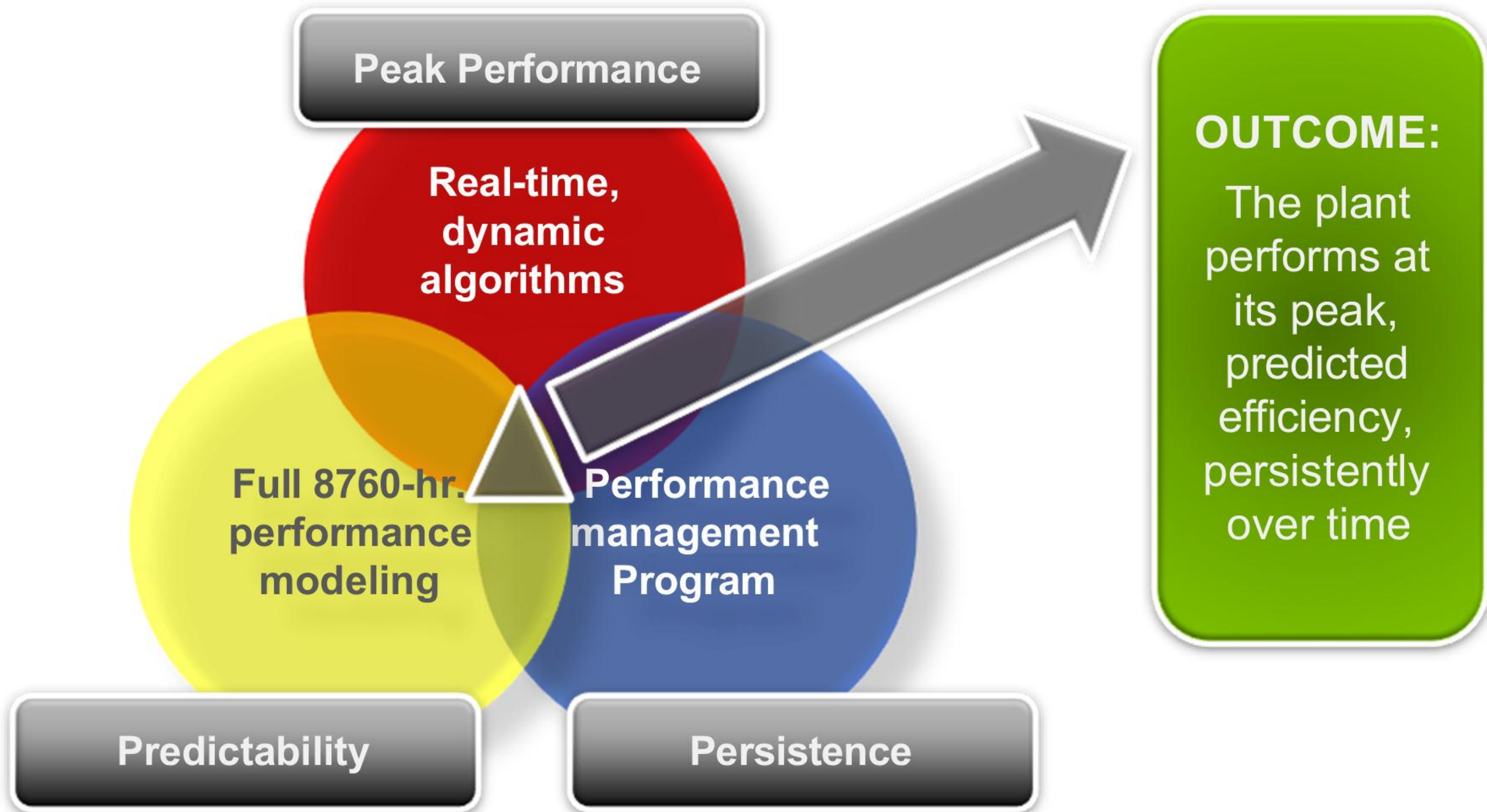**Peak Performance**

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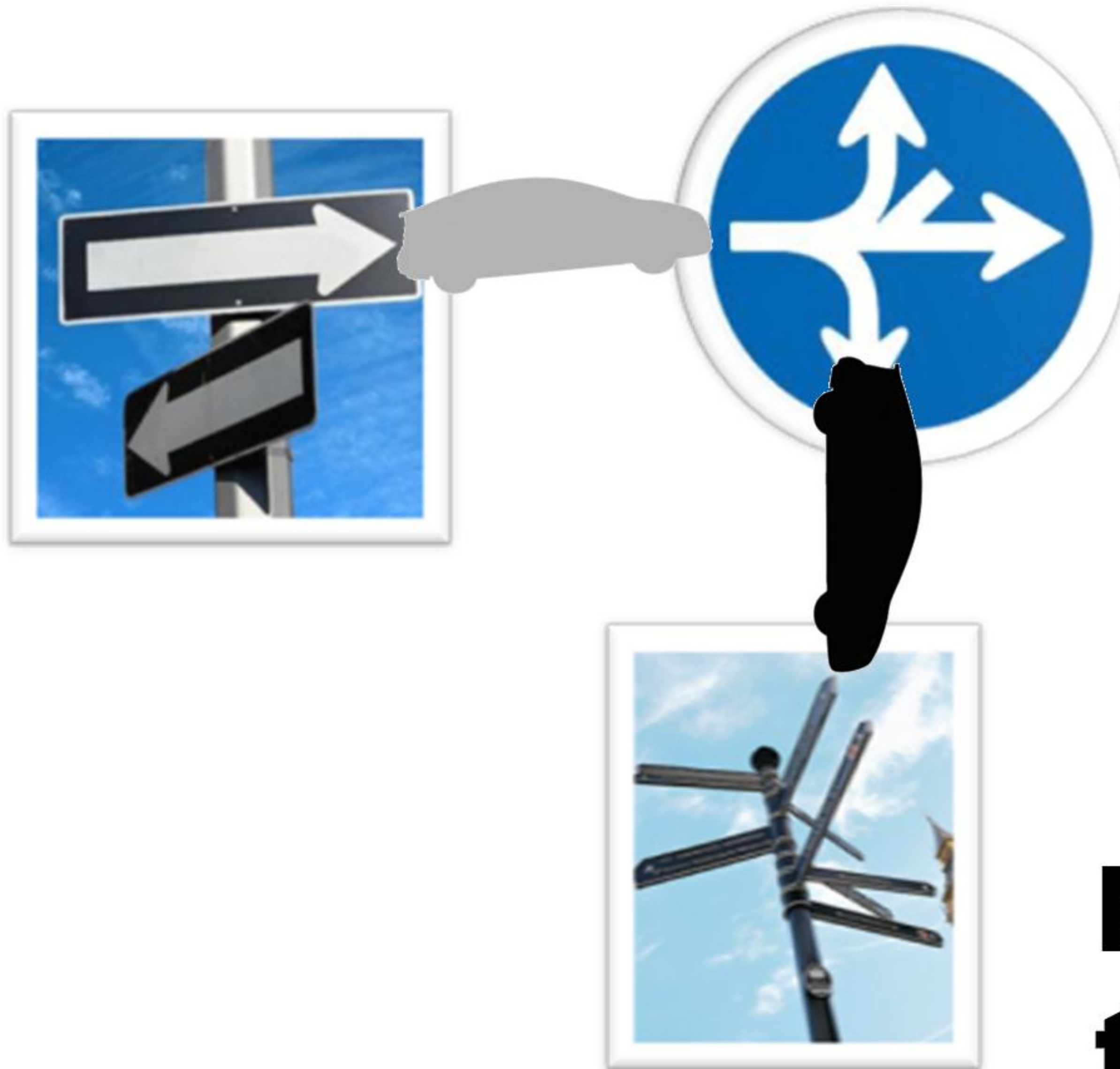## Performance modeling and Performance management are also critical

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Real-time, dynamic algorithms

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We already have algorithms in place, we don't need optimization

BUSTED

Optimization = Algorithms + Performance Modeling + Performance Management

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Decisions, Decisions, Decisions

The system has made **575** decisions since the beginning of this webinar

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MYTH #12 Our plant was designed at 0.7 kW/ton (5 COP), we don't need optimization
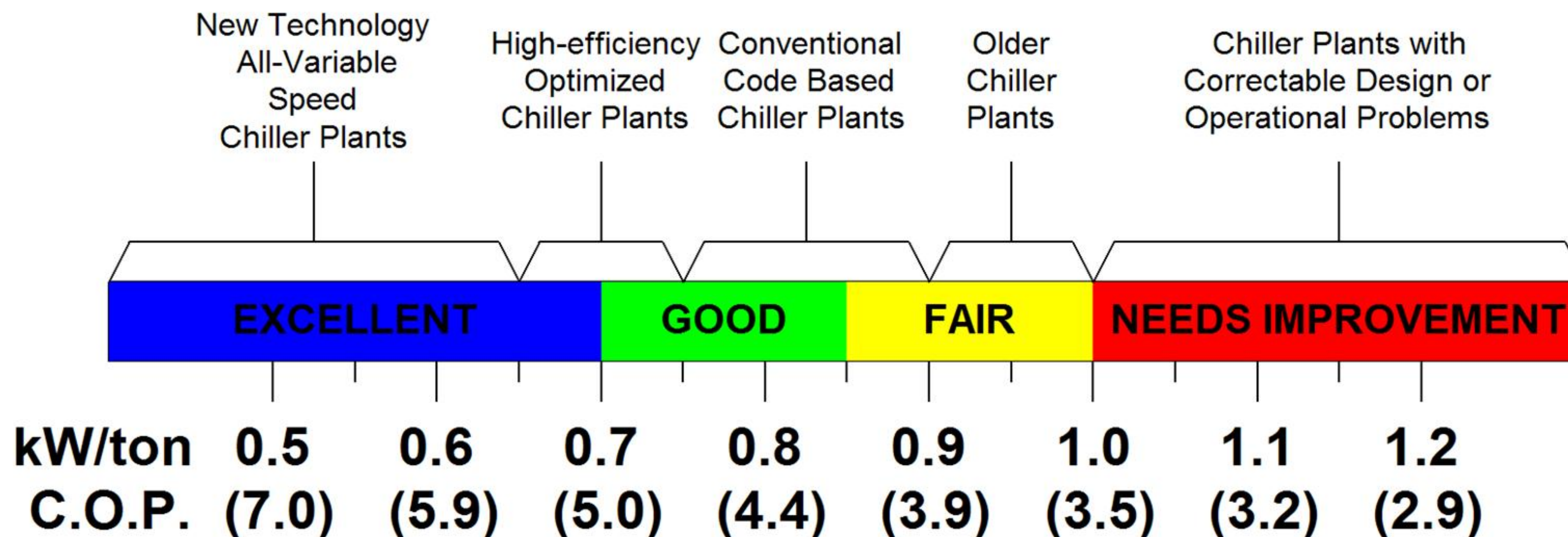
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Optimization Overview

THE 3 LAWS OF OPTIMIZATION

➡ You cannot optimize what you cannot measure

➡ Optimize systems, not components

➡ Optimization must be continuous and dynamic to maximize efficiency

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Measuring plant efficiency
How do plants measure up?

New Technology All-Variable Speed Chiller Plants

High-efficiency Optimized Chiller Plants

Conventional Code Based Chiller Plants

Older Chiller Plants

Chiller Plants with Correctable Design or Operational Problems

EXCELLENT	GOOD	FAIR	NEEDS IMPROVEMENT

kW/ton	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2
C.O.P.	(7.0)	(5.9)	(5.0)	(4.4)	(3.9)	(3.5)	(3.2)	(2.9)

AVERAGE ANNUAL CHILLER PLANT EFFICIENCY IN KW/TON (C.O.P.)
(Input energy includes chillers, tower fans, and condenser & chilled water pumping)

Based on electrically driven centrifugal chiller plants in comfort conditioning applications with 42F (5.6C) nominal chilled water supply temperature and open cooling towers sized for 85F (29.4C) maximum entering condenser water temperature.
Local Climate adjustment for North American climates is +/- 0.05 kW/ton

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Measuring plant efficiency
Example Savings Impact

Month	Load tons-hrs	Pre kW/ton
January	2,062,537	0.861
February	2,139,303	0.840
March	2,435,288	0.824
April	2,927,273	0.855
May	4,875,571	0.930
June	6,394,359	1.030
July	8,167,882	0.797
August	7,304,793	0.809
September	6,037,592	1.021
October	3,722,504	0.870
November	2,758,800	0.871
December	2,266,621	0.868
Totals	**51,092,523**	**0.888**
	COP	**3.96**

Plant Design:

0.7 kW/Ton

5 COP

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Measuring plant efficiency
Example Savings Impact

Month	Load tons-hrs	Pre kW/ton	Post kW/ton
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February	2,139,303	0.840	0.469
March	2,435,288	0.824	0.492
April	2,927,273	0.855	0.526
May	4,875,571	0.930	0.610
June	6,394,359	1.030	0.708
July	8,167,882	0.797	0.766
August	7,304,793	0.809	0.758
September	6,037,592	1.021	0.683
October	3,722,504	0.870	0.589
November	2,758,800	0.871	0.530
December	2,266,621	0.868	0.476
Totals	**51,092,523**	**0.888**	**0.643**
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Plant Design:

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Johnson Controls

Measuring plant efficiency
Example Savings Impact

Month	Load tons-hrs	Pre kW/ton	Post kW/ton	Savings kWhs	Savings $US
January	2,062,537	0.861	0.471	803,996	$64,320
February	2,139,303	0.840	0.469	793,057	$63,445
March	2,435,288	0.824	0.492	808,621	$64,690
April	2,927,273	0.855	0.526	963,087	$77,047
May	4,875,571	0.930	0.610	1,559,292	$124,743
June	6,394,359	1.030	0.708	2,058,893	$164,711
July	8,167,882	0.797	0.766	251,208	$20,097
August	7,304,793	0.809	0.758	372,424	$29,794
September	6,037,592	1.021	0.683	2,037,255	$162,980
October	3,722,504	0.870	0.589	1,048,373	$83,870
November	2,758,800	0.871	0.530	940,435	$75,235
December	2,266,621	0.868	0.476	890,356	$71,228
Totals	**51,092,523**	**0.888**	**0.643**	**12,526,996**	**$1,002,160**
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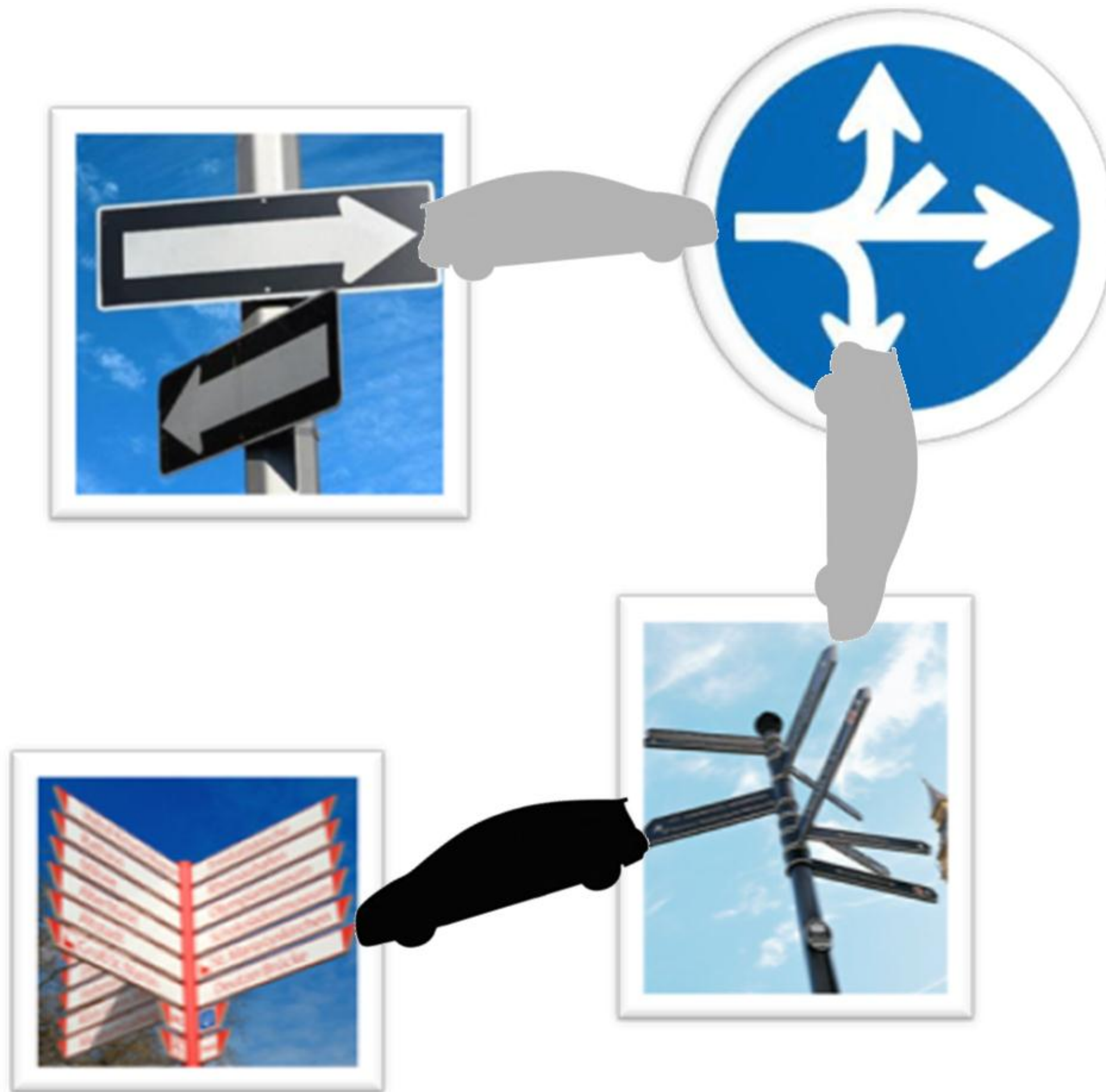**MYTH #12**

Our plant was designed at 0.7 kw/ton (5 COP), we don't need optimization

BUSTED

Plants rarely achieve or sustain design efficiency
Optimized plants exceed plant design, persistently

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Decisions, Decisions, Decisions, Decisions

The system has made **805** decisions since the beginning of this webinar

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MYTH #13

Partial VSD plants are not candidates for optimization

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Non-All VSD Plant
Showing Optimization Results

UT Austin Total System kW/Ton - 8/19/2011
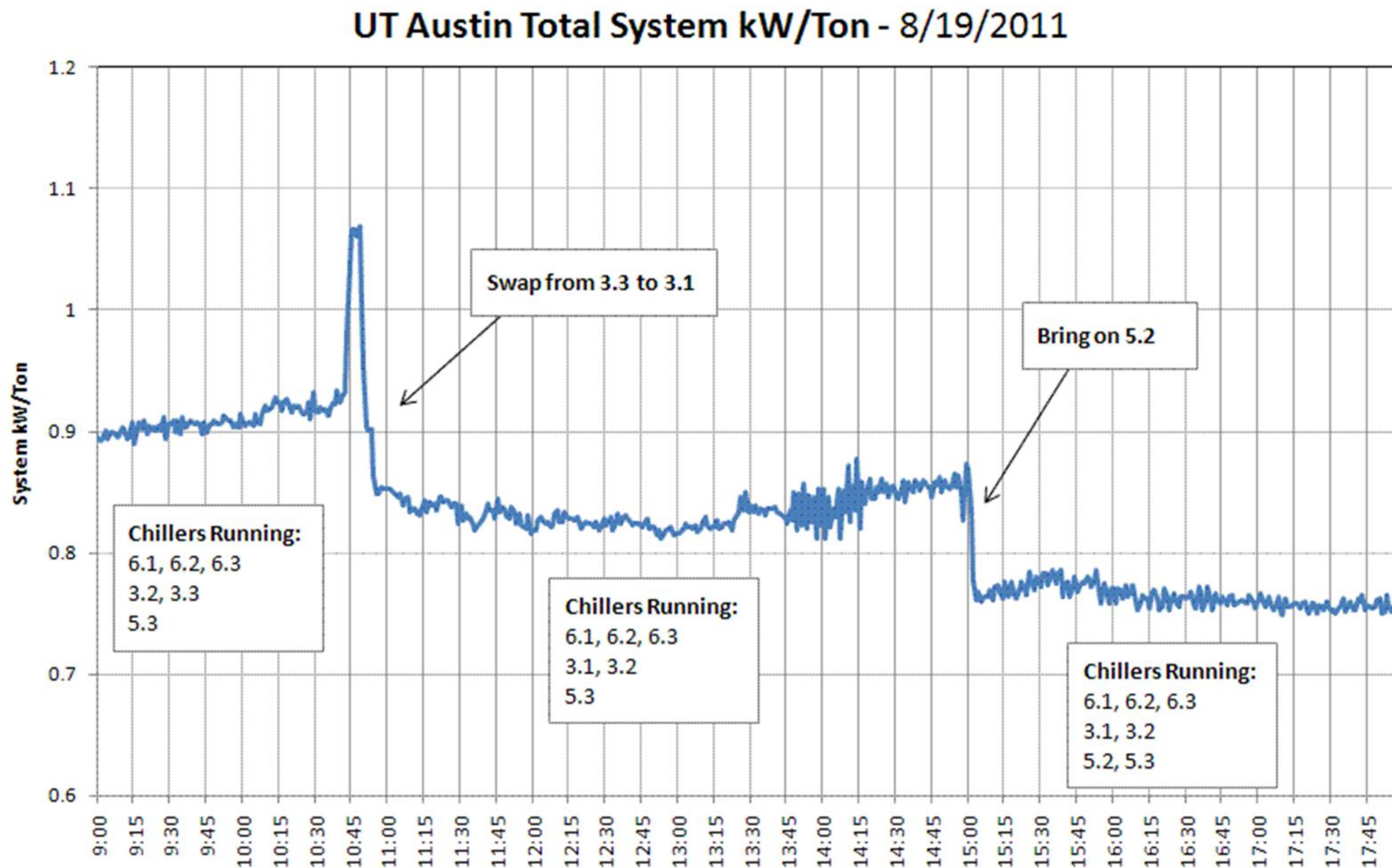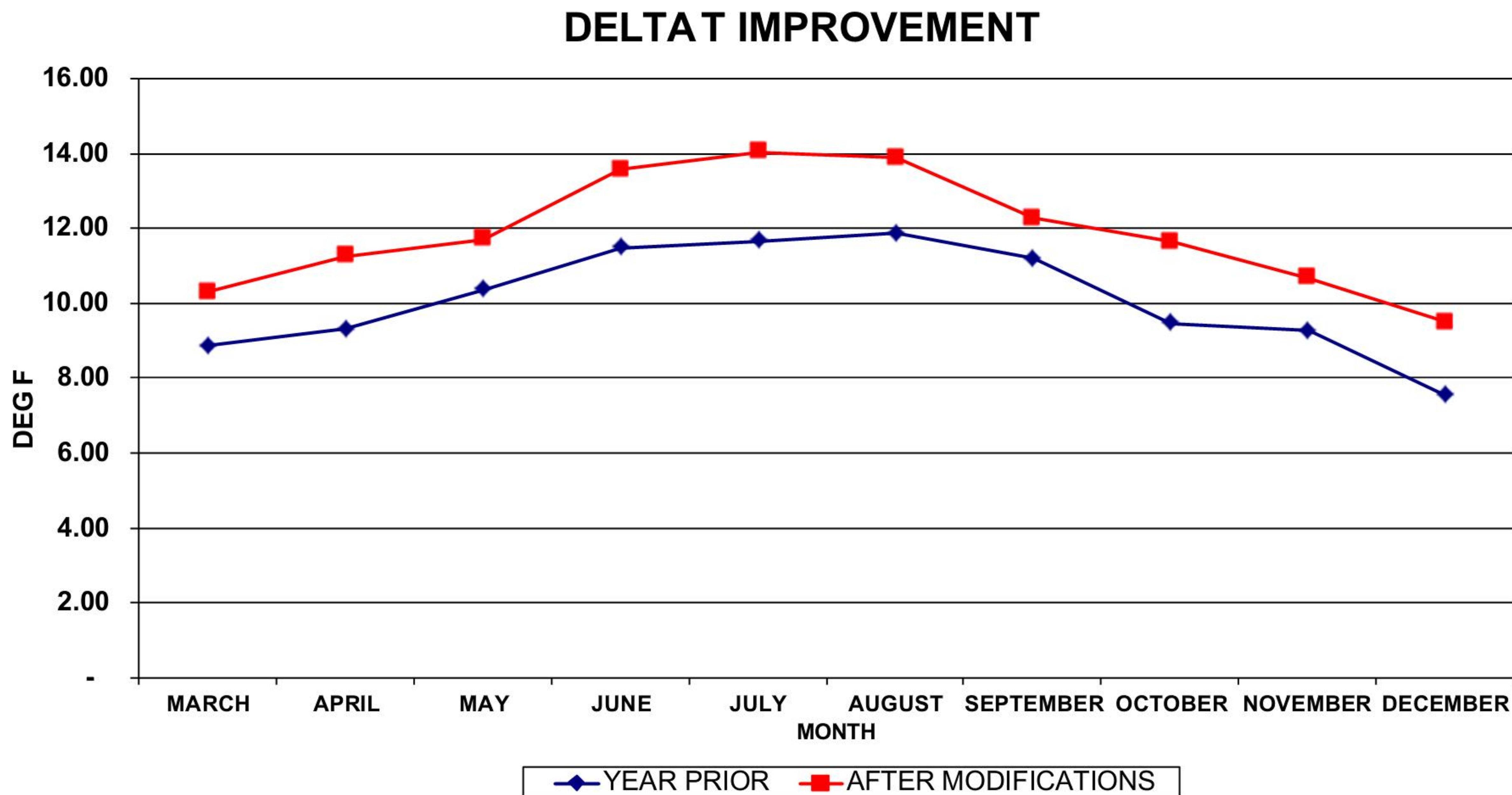
Non-All VSD Plant
Showing Optimization Results

REDUCTION IN CAMPUS STEAM USE
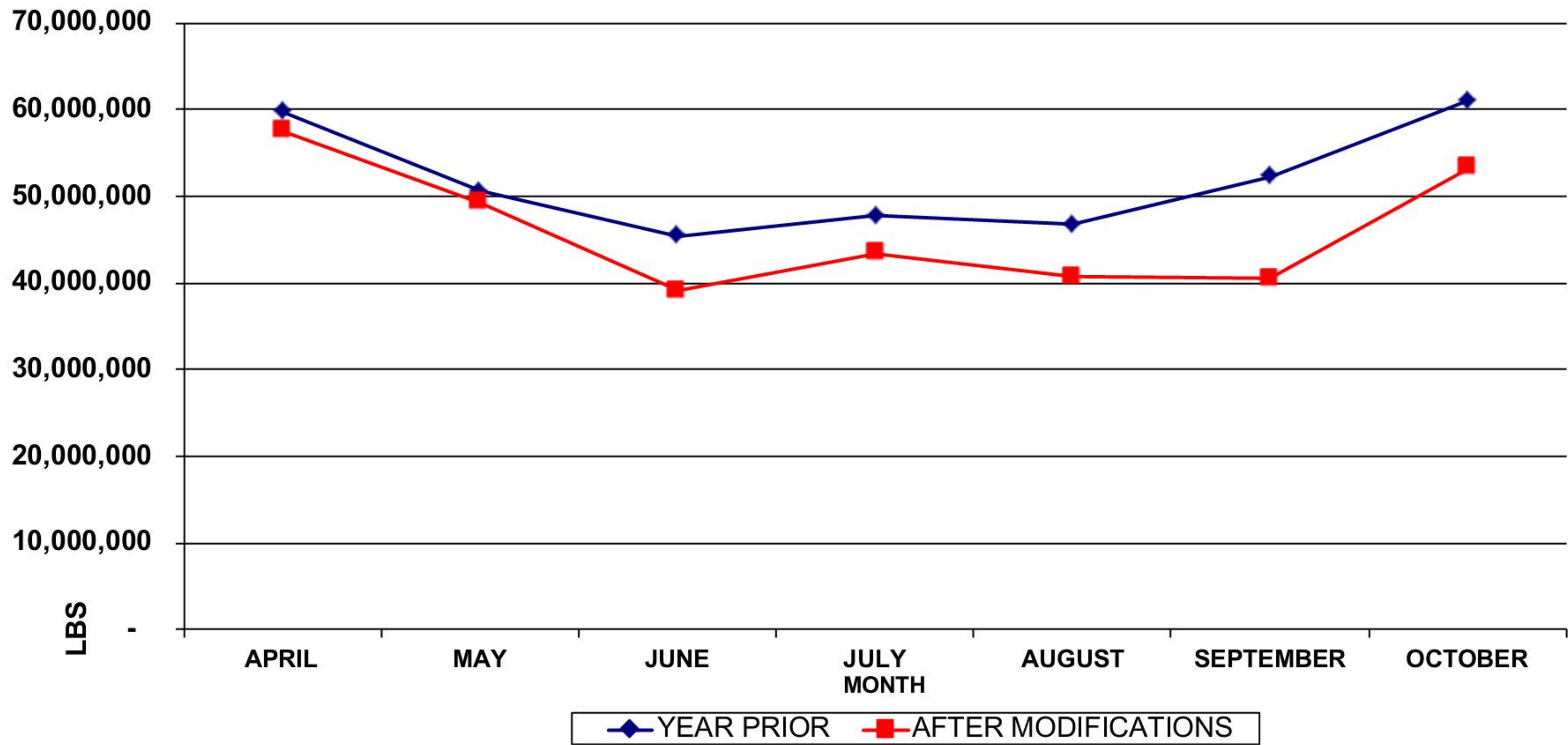
© Johnson Controls, Inc. 2012

MYTH #13

Partial VSD plants are **not** candidates for optimization

BUSTED

Choosing VSD systems is a technical and financial decision that is often justified

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The system has made 1035 decisions since the beginning of this webinar...

WRONG WAY

...with no wrong turns

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MYTH #9

Automation
=
Optimization

Johnson Controls

#9

MYTH

Automation

=

Optimization

BUSTED

Optimization _advises_ automation on how to meet a load with the minimum possible power

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Johnson Controls

Summary

1. The "black box," with a performance management program (including measurement & verification) helps ensure operator effectiveness.

2. To achieve and sustain maximum performance, Algorithms + Performance Modeling + Performance Management are all critical.

3. Plants rarely achieve or sustain design efficiency. Well-optimized plants exceed plant design efficiency persistently.

4. Choosing an all-VSD (or nearly-all-VSD) plant design (or upgrade) is a technical and financial decision that is often justified.

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Conclusion

- **Questions to Presenters:**

  - Enter your **Questions** in the **Q&A box** at the lower right hand corner of screen.

  - If you have joined just by phone, and have questions, please send them to jill.h.woltkamp@jci.com

- Please complete the **survey** following the webinar

- Webinar was recorded and will be available via download or streaming

- Presentation slides will be available in pdf format at www.districtenergy.org

Thank you for attending the webinar series!

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