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POWER DRIVE SYSTEMS FOR MOTOR-DRIVEN EQUIPMENT

A decarbonization tool

NEMA
National Electrical Manufacturers Association

cadeo

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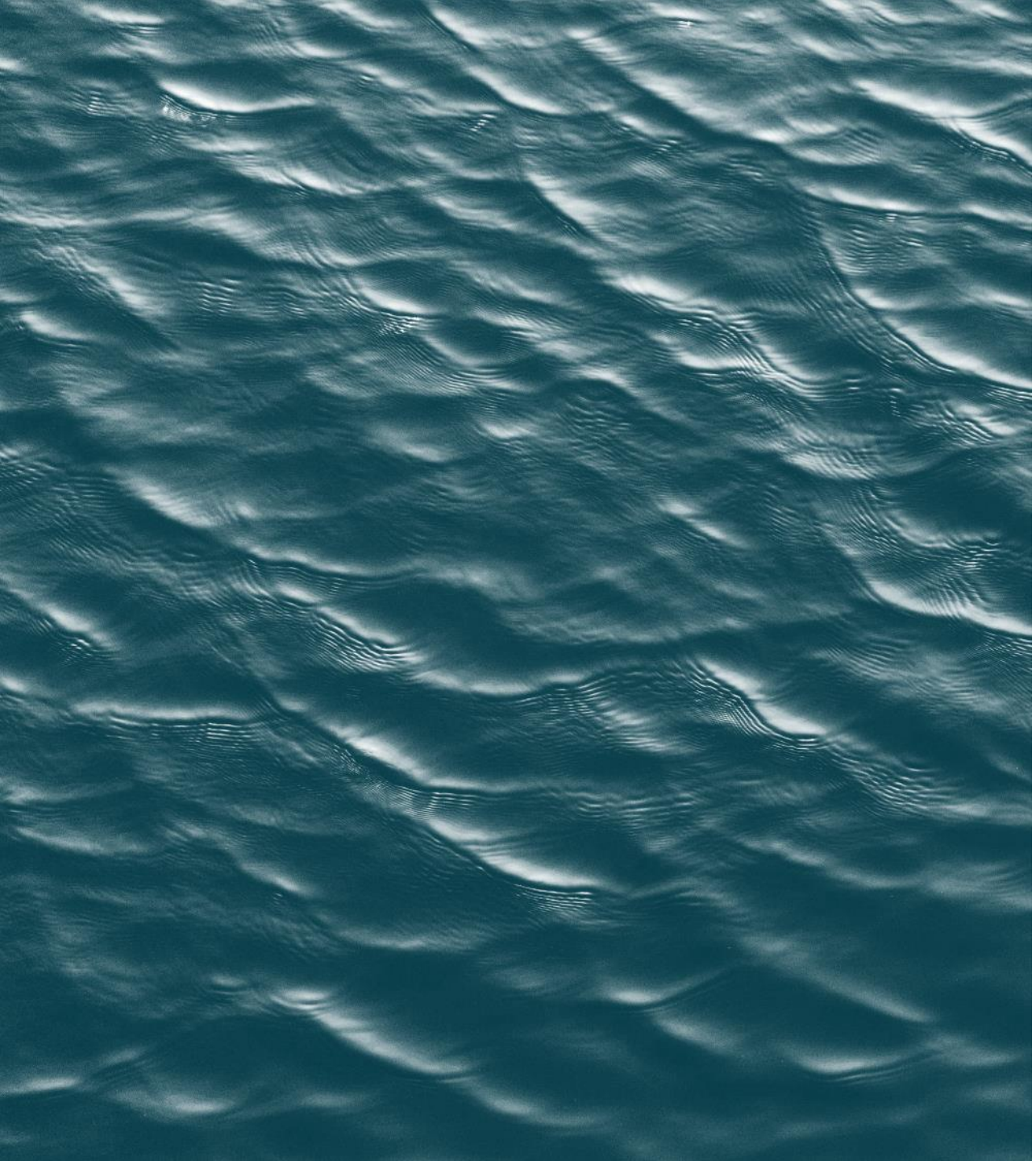

Overall Agenda

- Intro to PDS & PI
- PDS Research
- IAC Opportunity
- Applications & Next Steps

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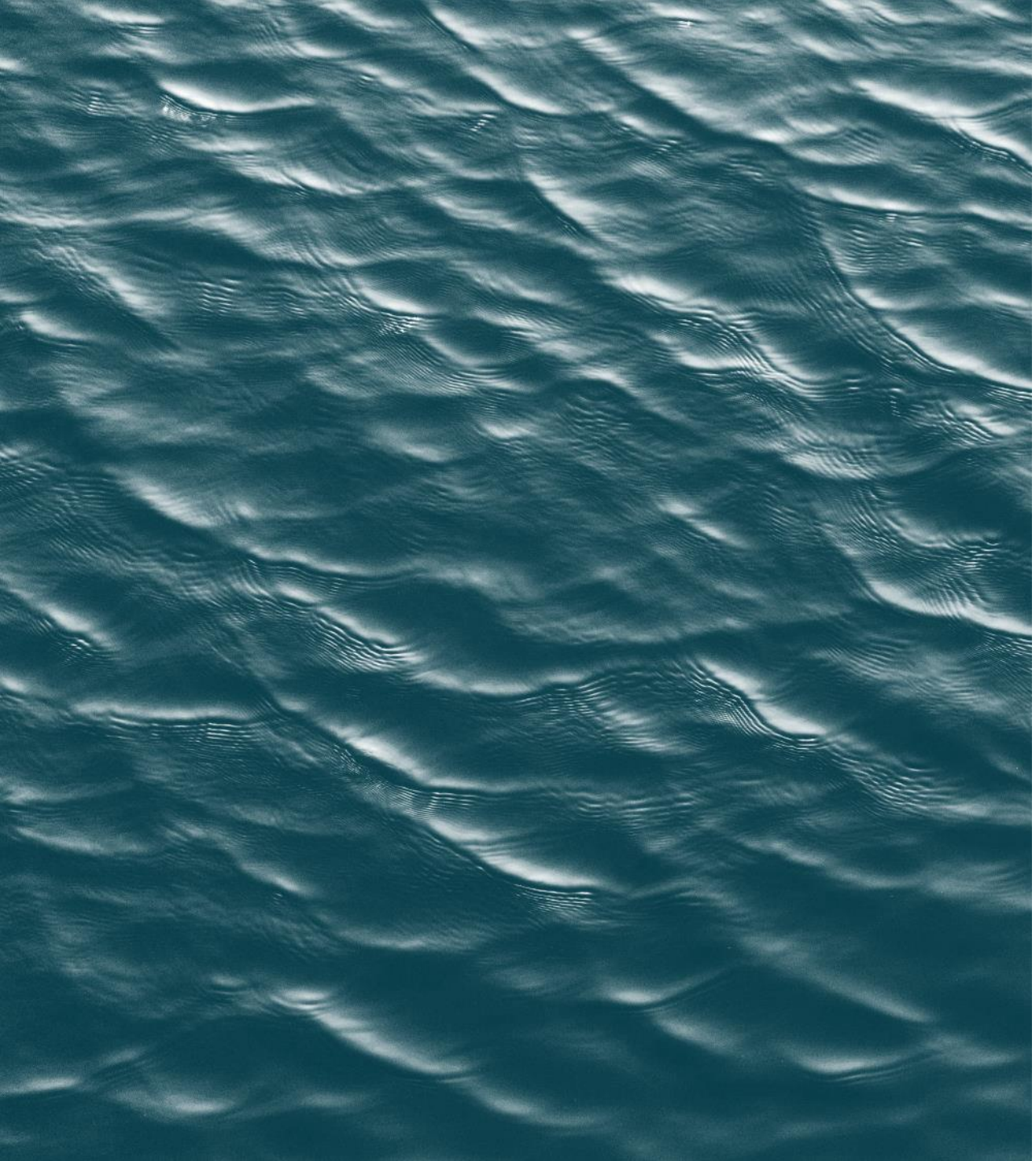

Introduction

- Intro to Power Drive Systems
- Evolution of measuring motor and drive energy use
- PI: a metric for PDS

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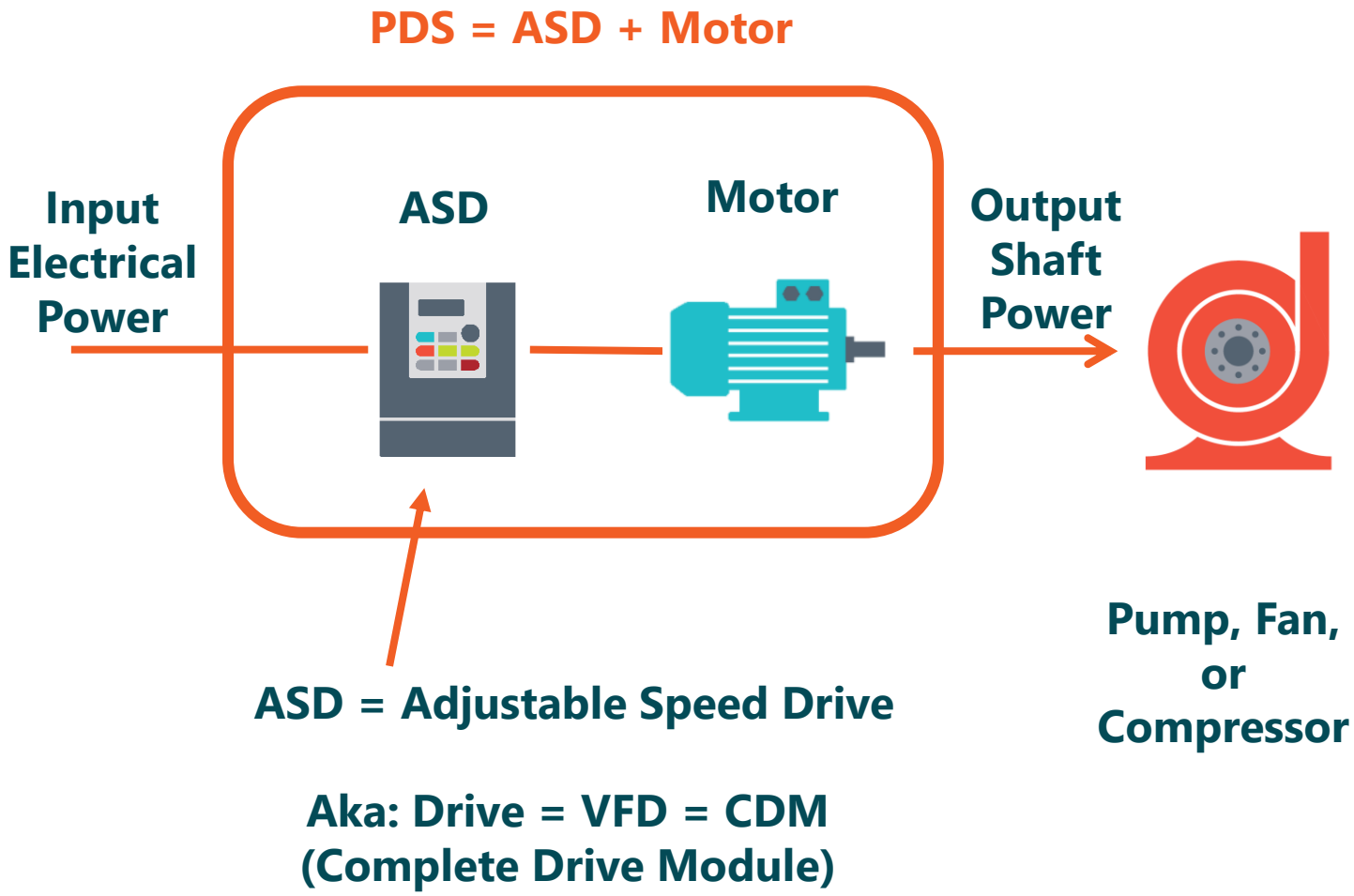
Power Drive System

- **PDS can be:**
  - **1-piece (e.g., ECM or other integrated motor and controls)**
  - **2-pieces (Drive on a wall)**
- PDS does **not** include end-use equipment



Evolution of motor & drive energy use

Existing legacy 1980's

- Motor efficiency [percent of losses]
- Power converter [VFD] [percent of losses]

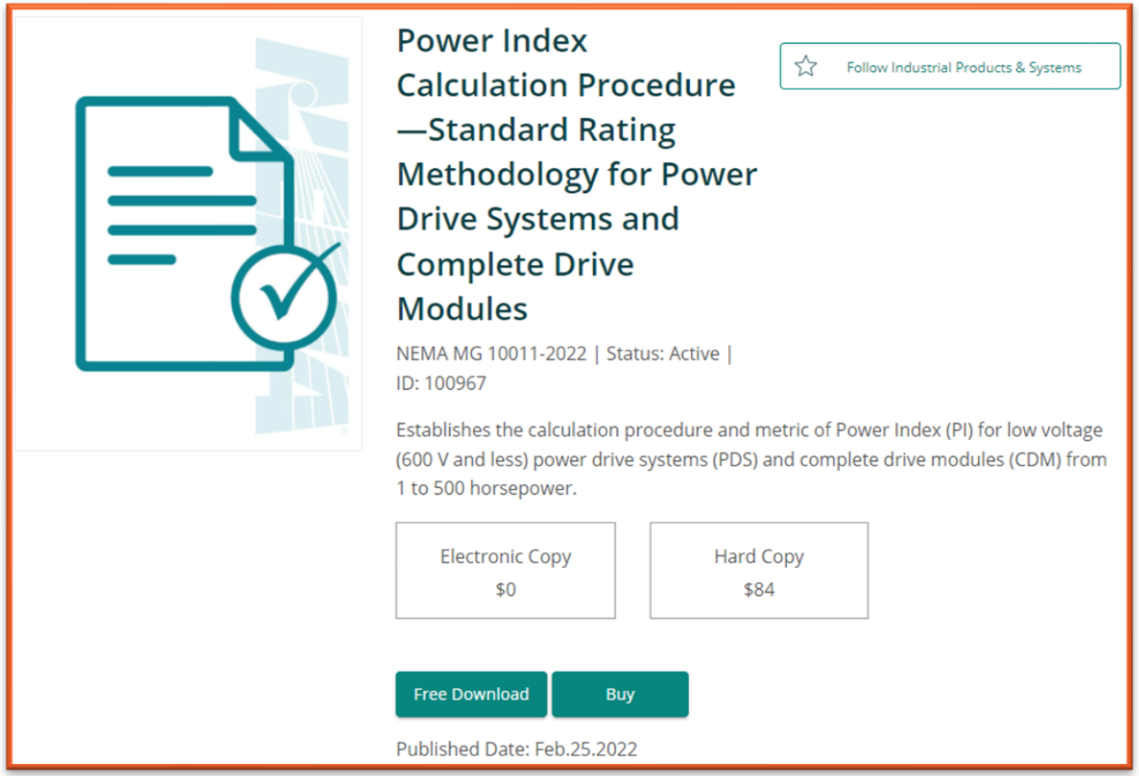
The new option 2020's

- Motor and power converter [Power Index PI- weighted average input power]

What's changed

- **Power electronics have advanced in performance**
- **Power electronics have become very cost effective**
- **Power prices per kWh have increased**
- New technologies have expanded performance options
- Connectivity to control systems [IOT] adds exponential energy savings

A Metric for Power Drive Systems



- Answers the question: how much will we save by adding a drive?
  - Estimates % savings over a baseline full-speed motor

PDS Research Results

Outline

- Collection of field data
- Analysis
- Load variability
- Potential uses
- Energy savings methods
- Non-energy benefits

Take- away: consider all fan & pump installations as possibilities

Field Data

Collected audit & operational data on over 400 pumps

Audit Data: Static data

Pump Manufacturer	Paco
Pump Model	Inline Type VL Model 4012
Motor Model Number	B085A/T07T145R034F
Pump Rated Flow	300
Motor Horsepower	15
Input Volts	480
Sector	Commercial
Application	Chilled Water Loop
Load Control	VSD

Operational Data: Run-time data

Variable	20:44	20:49
Outside Air Temp	85.80	85.60
Flow (gpm)	249	252
Input Power (kW)	1.85	1.90
Pump Speed (%)	68.1	68.1

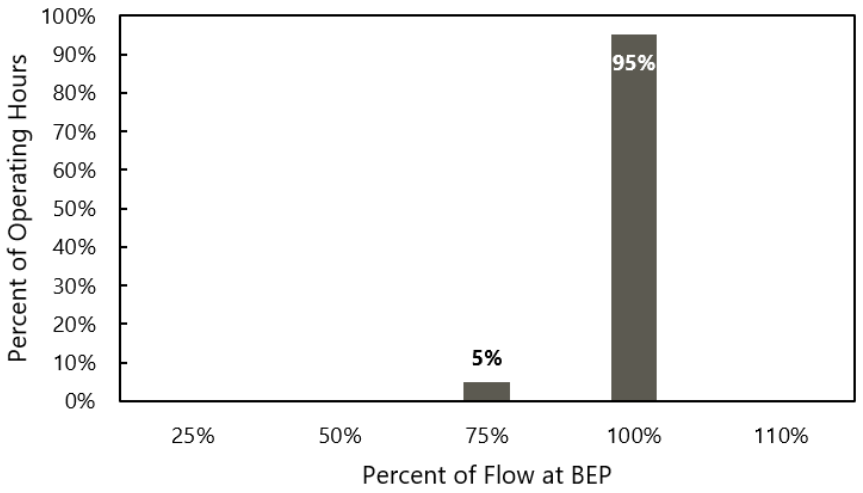
Load Variability

Systems were defined as variable or constant based on the load profile

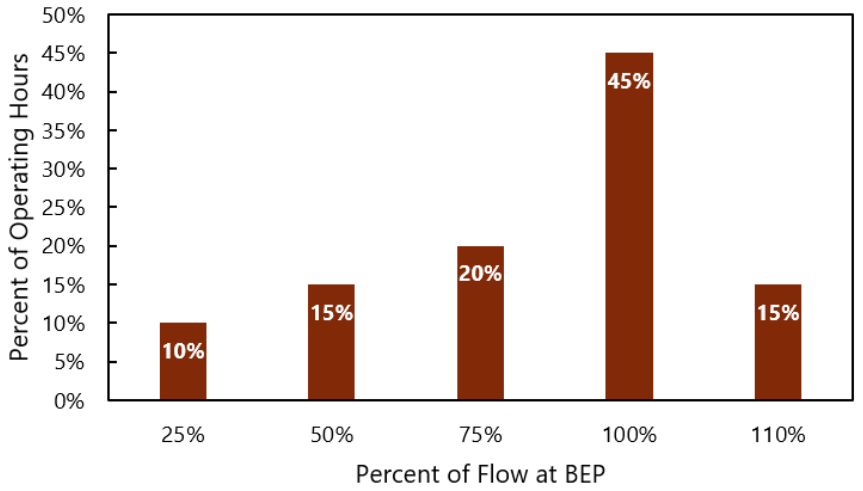
Pumps that had 90% or more of their operating time at one load point were classified as “Constant Load”

Pumps that had less than 90% of their operating time at one load point were classified as “Variable Load”

Load Profile – Constant Load

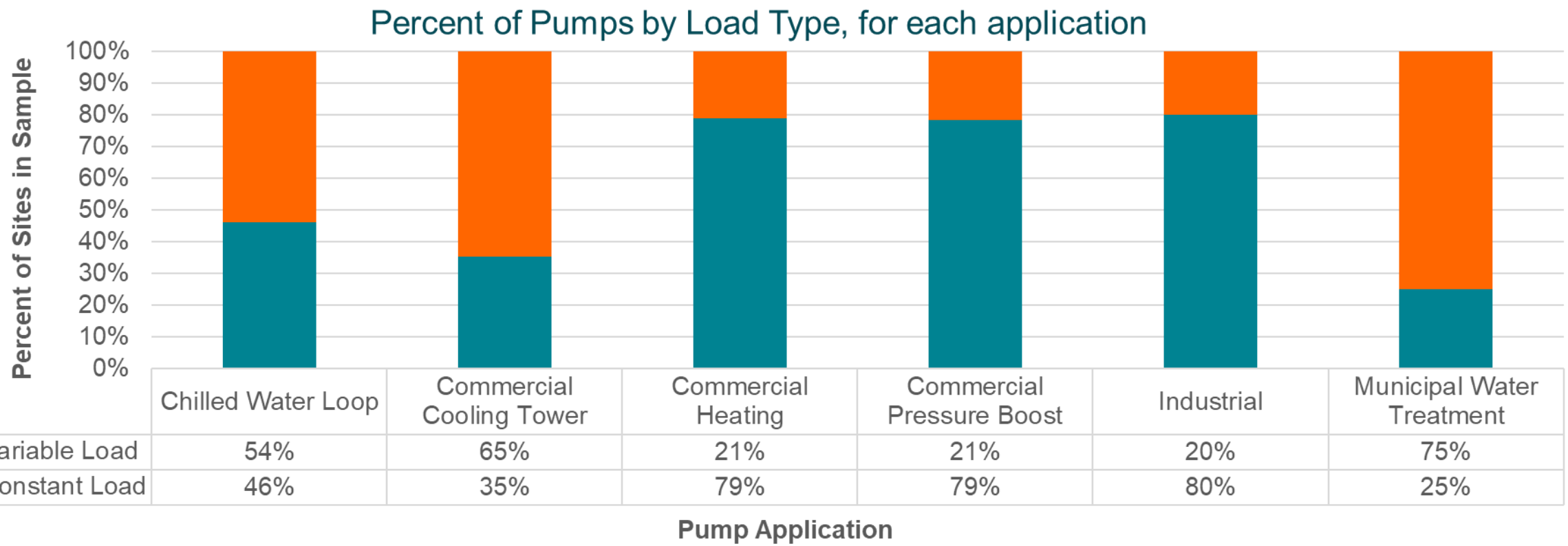


Load Profile – Variable Load



Load Variability

Every application was served by both constant and variable speed pumps

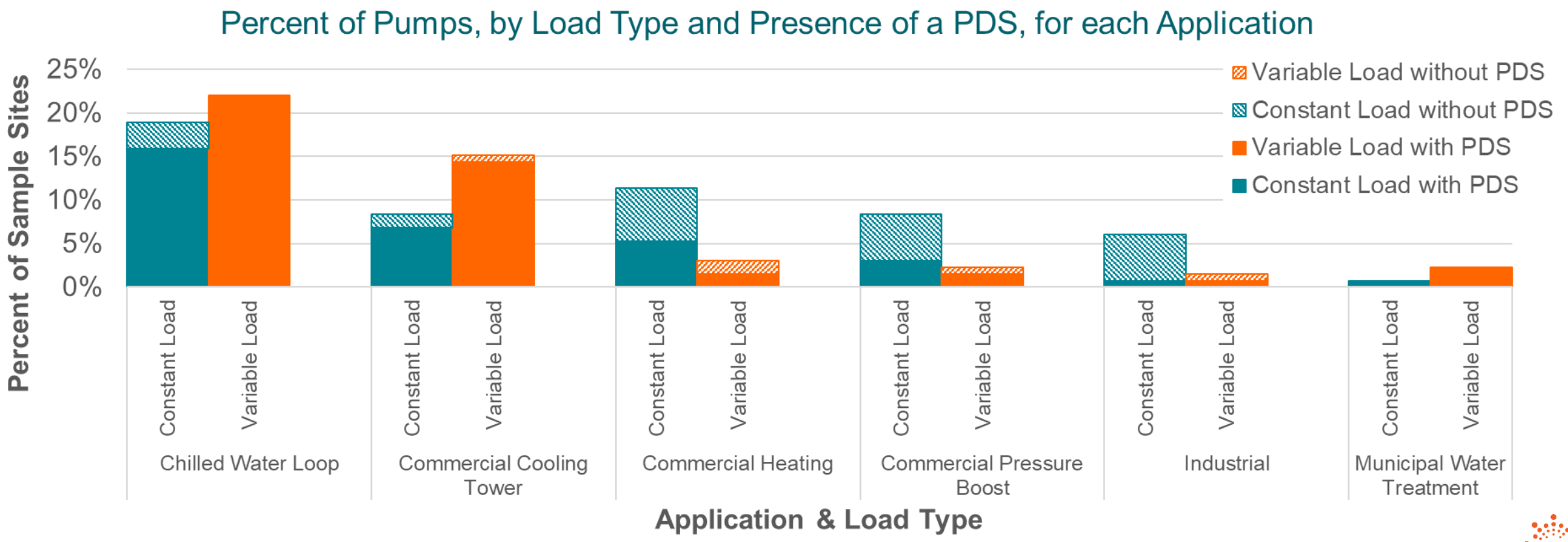


	Chilled Water Loop	Commercial Cooling Tower	Commercial Heating	Commercial Pressure Boost	Industrial	Municipal Water Treatment
Variable Load	54%	65%	21%	21%	20%	75%
Constant Load	46%	35%	79%	79%	80%	25%

There are applications that show more variability than others, but it is more dependent on the installation/operation of a system.

Current Application of PDS

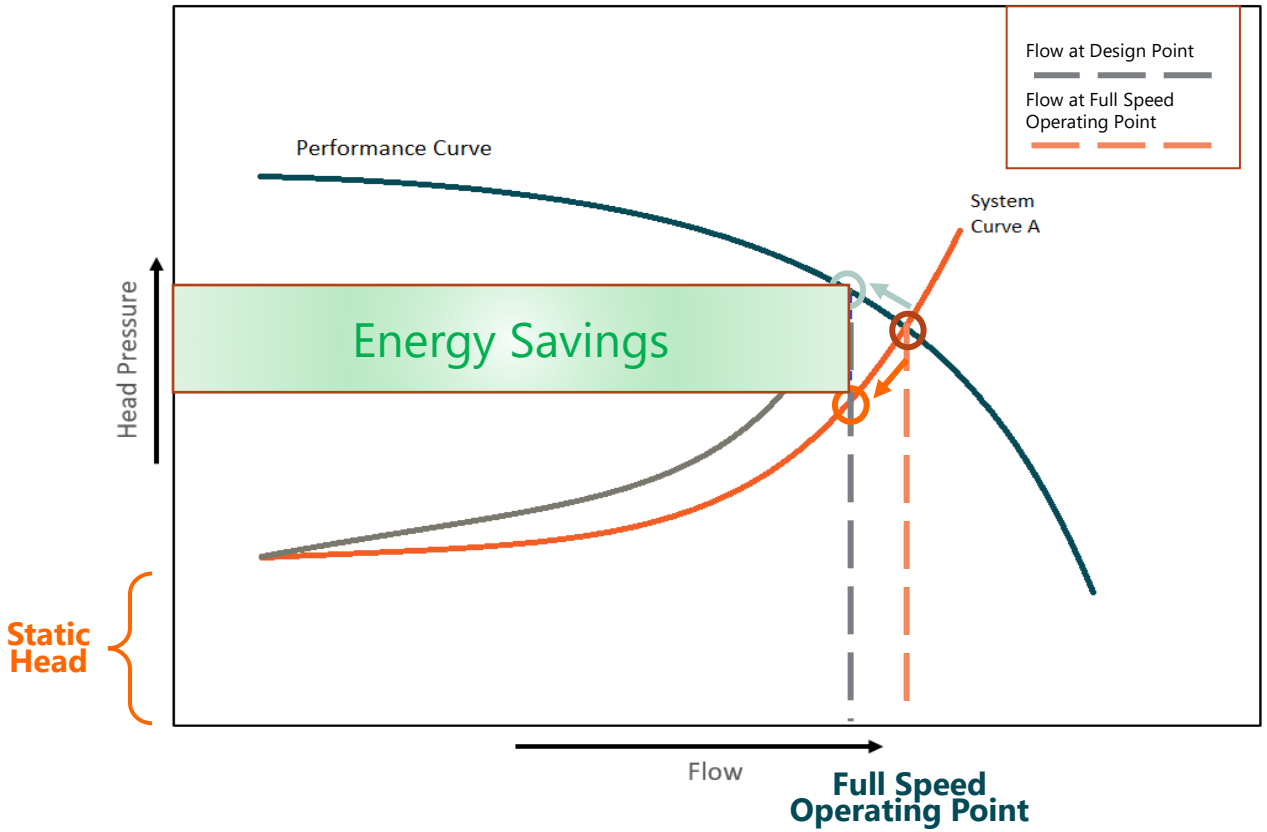
Users are already recognizing the benefits of PDSs on both constant and variable load systems



Energy Savings

Energy savings from being able to provide the required flow rate with less power

Analytical details



Constant Speed Pump Control ("Throttling")

- Increase pressure to achieve system flow
- Pump operates along pump curve

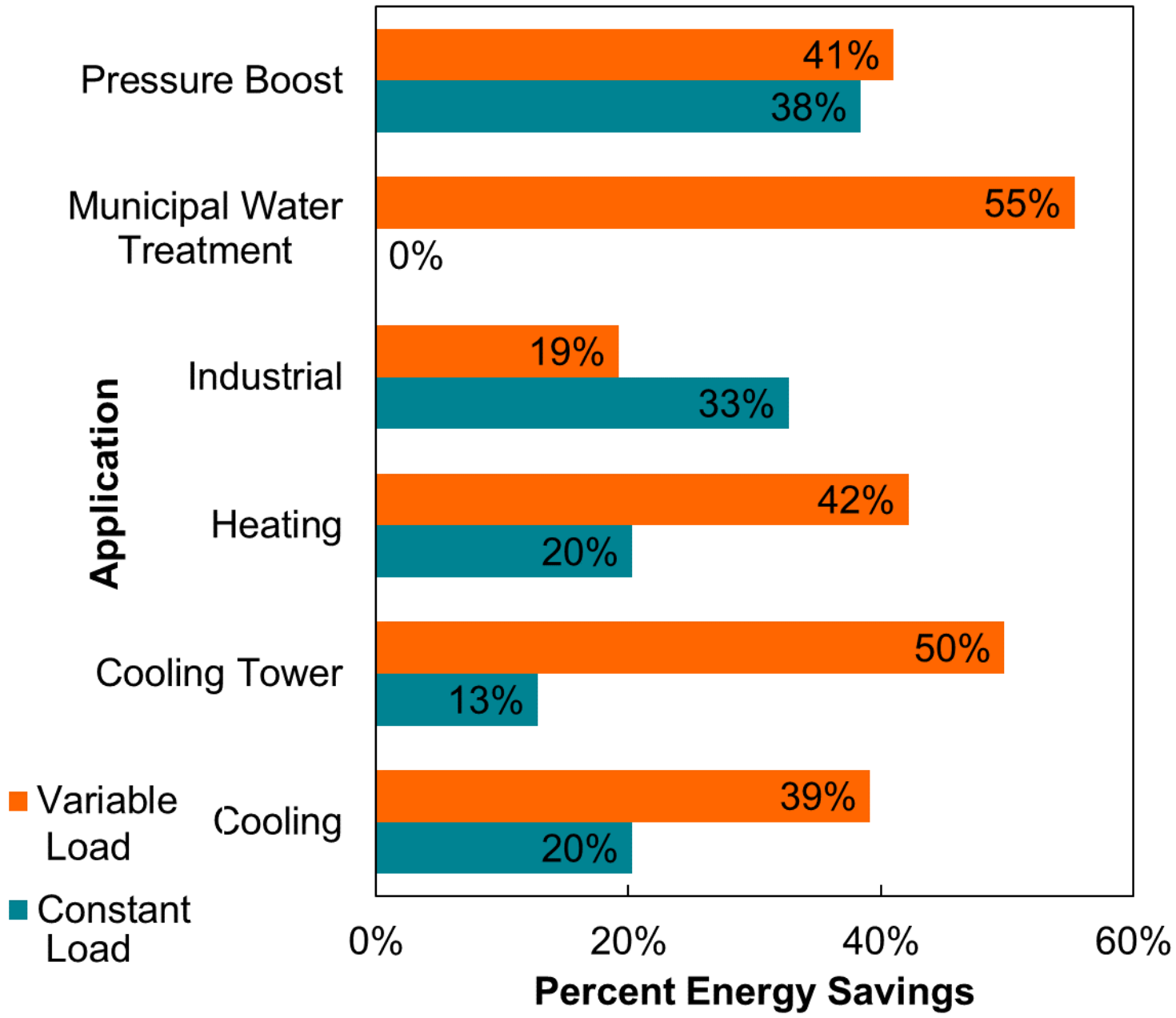
PDS Pump Control ("Variable Speed")

- Decrease speed to achieve system flow
- Pump operates along system curve

Energy Savings =
Annual Energy Consumption with Constant Speed Control –
Annual Energy Consumption with PDS Control

Energy Savings

Virtually all applications achieve energy savings



Energy Savings

The variable load systems showed higher energy savings potential, but constant load systems also have significant potential

Average power savings from transitioning from constant speed control to variable speed control

Load Type	Percent Energy Savings
Constant	23%
Variable	43%

Sensitivity analysis on static head and full load operating point showed that **static head had larger impact than full load operating point**, but did not change result that drives show potential for energy savings in both constant and variable load systems.

Variable Assessed	Percent Energy Savings			
	Constant Load		Variable Load	
	Low Limit	High Limit	Low Limit	High Limit
Static Head, Average	23%	31%	40%	55%
Full Speed Operating Point, Average	22%	23%	40%	45%

Non-Energy Benefits

More important to facility staff?

Decreased maintenance

Reduced wear and tear

Impacts overall system efficiency and productivity

Process improvements and improved control

System connectivity and visibility

Allows operators to better monitor and maintain system performance

Power Factor correction, regenerative drive applications, and voltage regulation

Grid benefits

IAC Opportunity

Outline

- IAC VFD Recommendations
- Pump opportunity: PDS for variable load
- Pump opportunity: PDS for constant load
- Fan opportunity: PDS for variable load
- Fan opportunity: PDS for constant load
- Overall expected PDS savings

Take- away: consider both constant load and variable load fan & pump installations

IAC VFD Recommendations:

Becoming more frequent with better payback

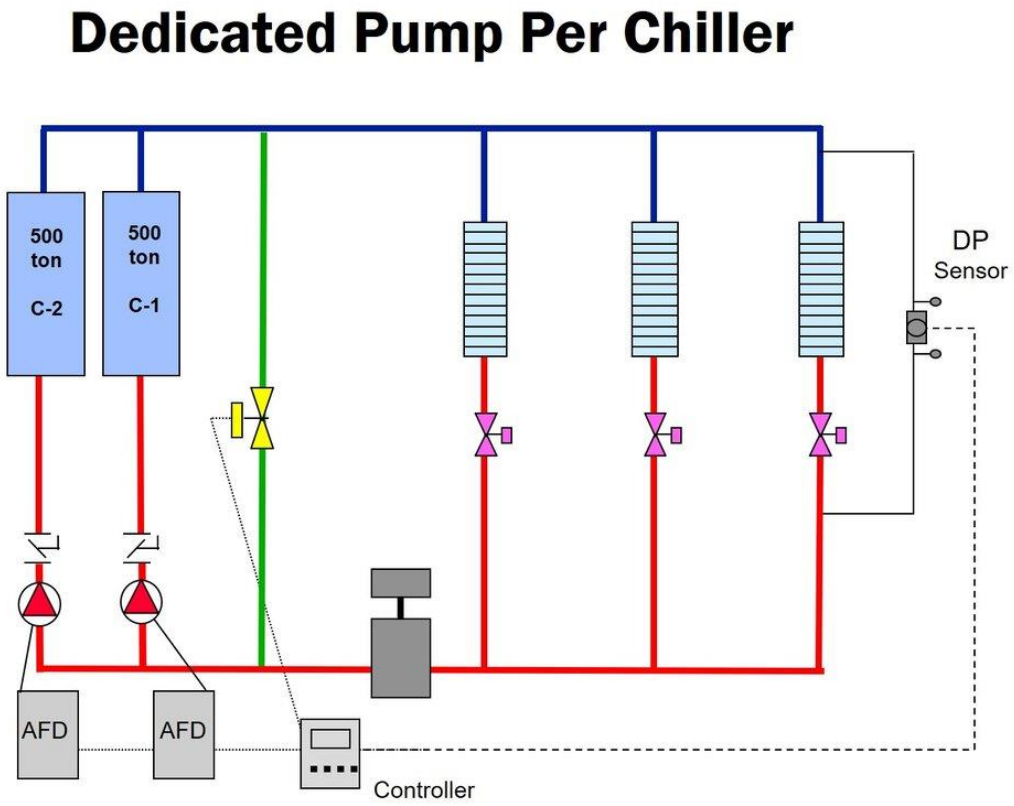
ARC 2.4146

USE ADJUSTABLE FREQUENCY DRIVE OR MULTIPLE SPEED MOTORS ON EXISTING SYSTEM

	Recommendations	% of all IAC recommendations	Average Payback	Implementation Rate
Since 1981	3978	2.6%	3.3	31.2%
Since 2012	1810	5.1%	1.9	33.0%

Pump Opportunity: PDS for variable load

Pump serving multiple zones or processes



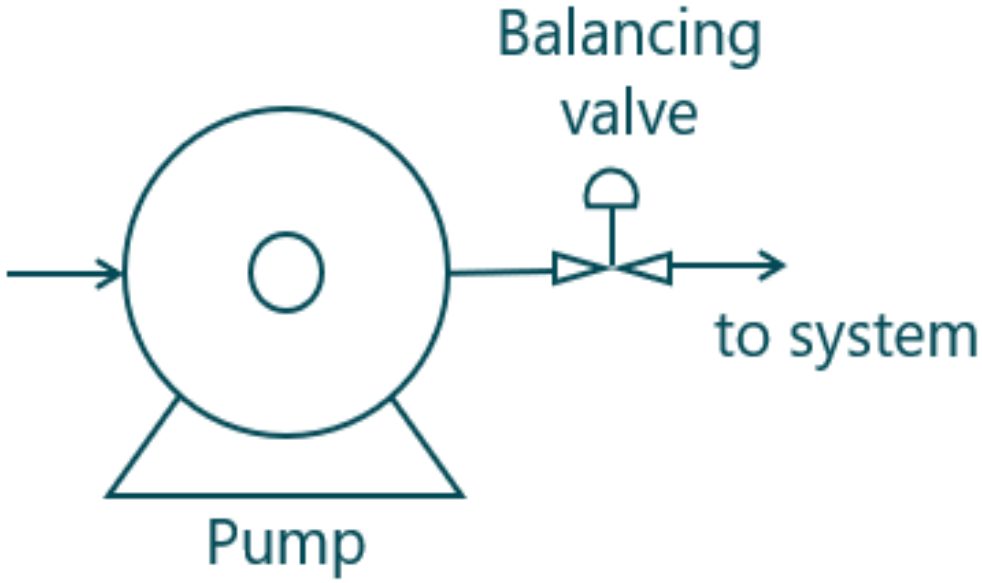
- 2-way control valves at each load
- Bypass line

Pump Opportunity: PDS for constant load

Balancing valve introduces losses

Considerations that indicate even bigger savings:

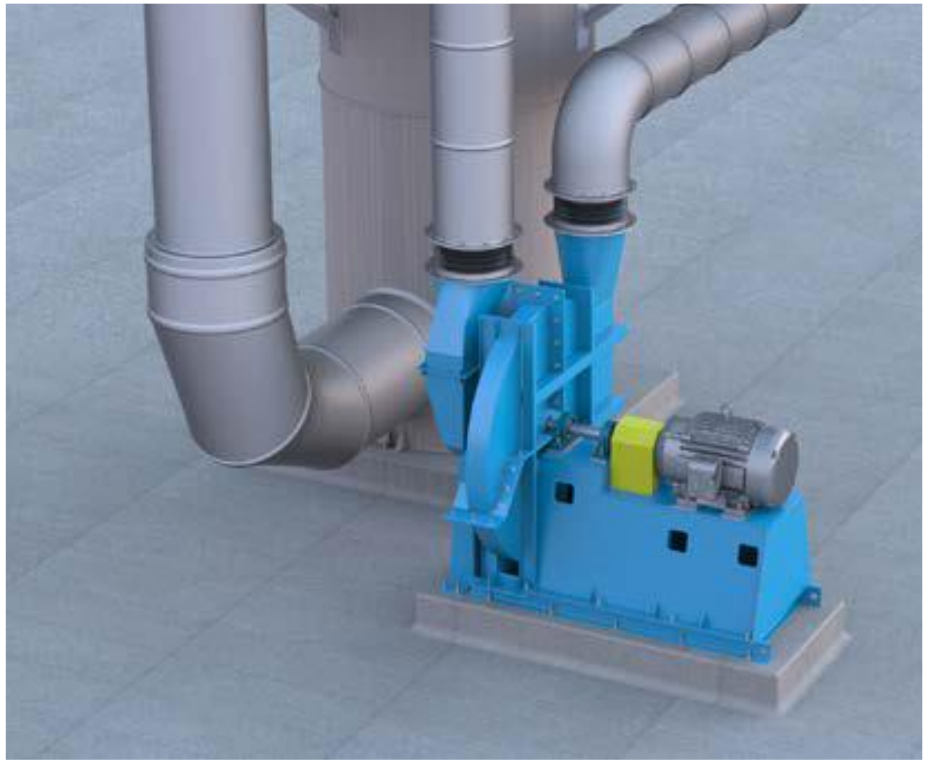
- Are valves closed down?
- Do pumps cycle on/off?



Fan Opportunity: PDS for variable load

Fan serving multiple zones or processes

Dust collection



Kiln fan

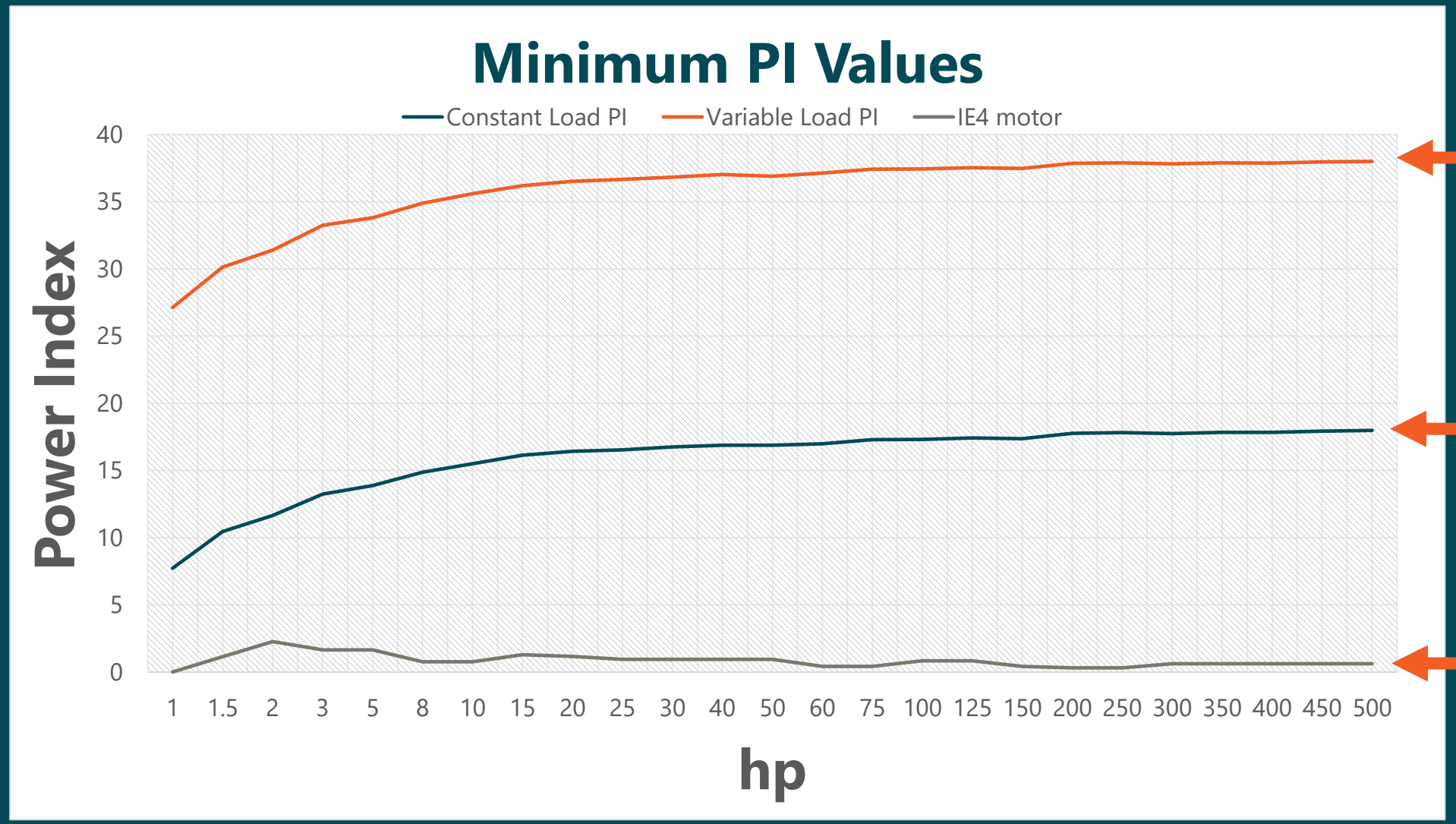
Fan Opportunity: PDS for constant load

- **Dampers introduce losses**
- **Sheaves are used to "resize" (aka "balance"")**

Considerations that indicate even bigger savings:

- Are dampers closed down?
- Do fans cycle on/off?

Expected PI Values (% Savings)



Add a drive to Variable Load System

Add a drive to Constant Load System

Motor efficient upgrade IE3->IE4

Applications

- Foundry Case Study: **variable load fan**
- Electrical Switchgear Case Study: **constant load pumps**
- Mechanical & Electrical Factors to Consider
- Summary
- Next steps

Foundry Cooling Tower

Automotive Parts Manufacturer
Brazil

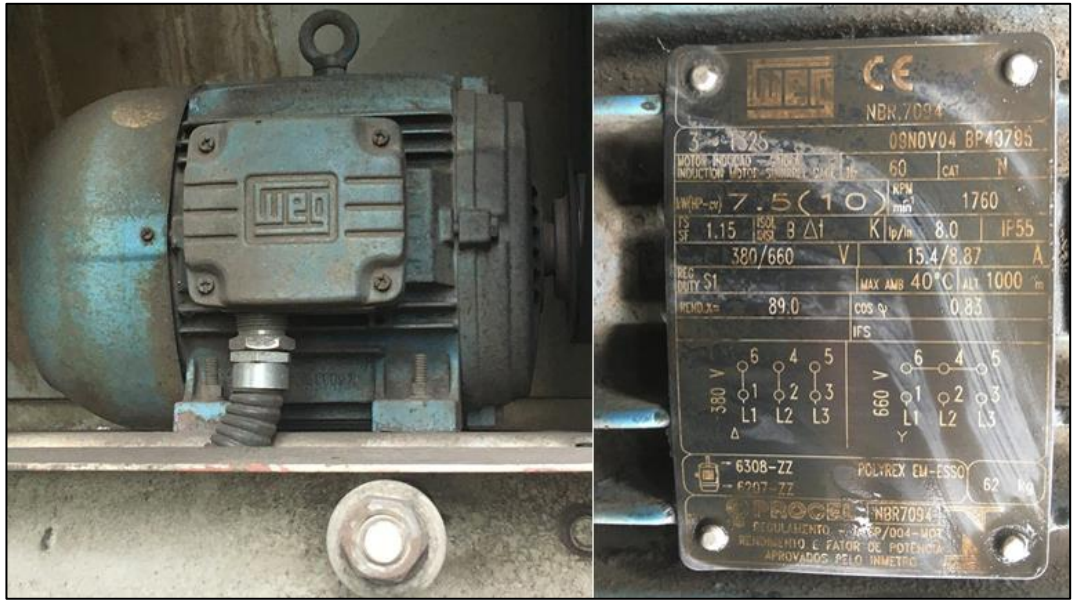
- Variable Load application
- Fan speed requirement changes with temperature conditions

Hübner

Before & After

No added PLC:
use VFD internal controls logic

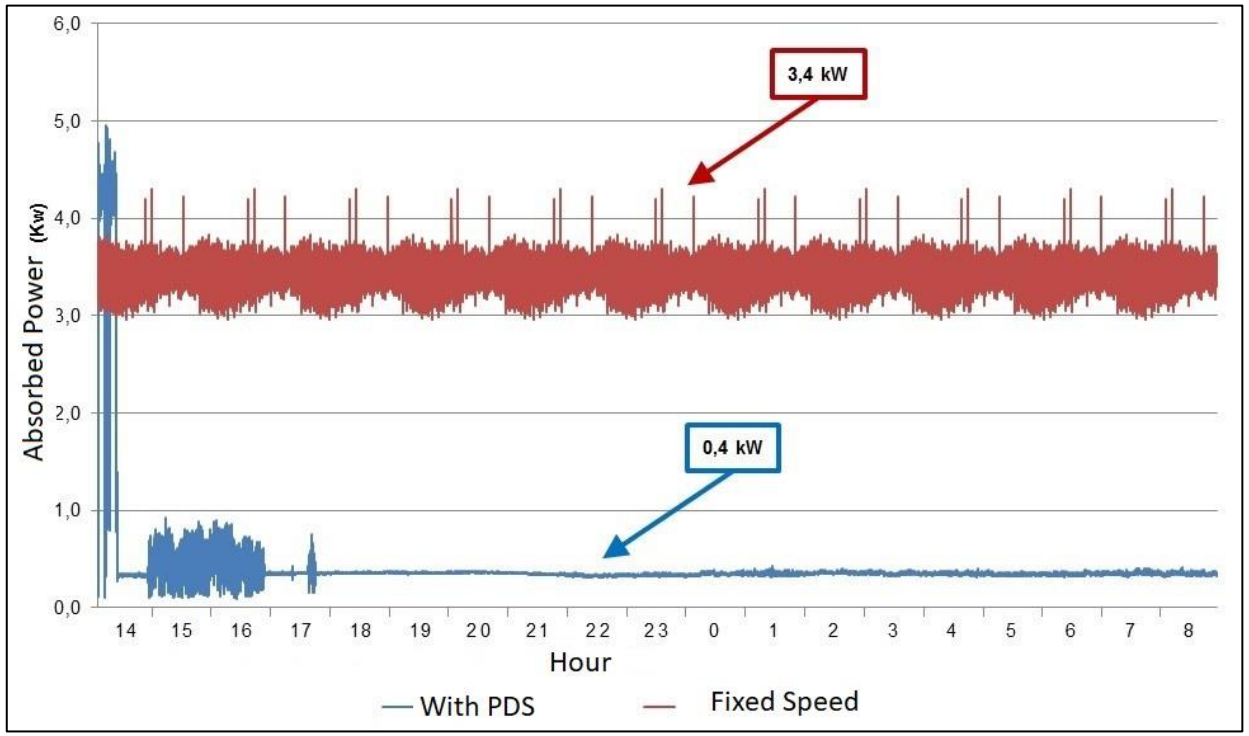
- 10 hp Standard efficiency fan motor
- Constant speed



- NEMA Premium + VFD
- Added temperature sensor in basin
- PID loop in VFD determines speed

Before & After

Verified 67% savings



- Estimated (predicted) savings 26.6%
- Validated (actual) savings 67.3%

Savings much higher that predicted because:

- Original motor sized to start DOL
- Estimated assumption load : 75%
- Measured load : 39%

Switchgear Manufacturer

IAC case study- Tennessee Technological University

Schneider Electric
Smyrna, TN

- Constant Load application
- Parts washer pumps
- Use drive to balance

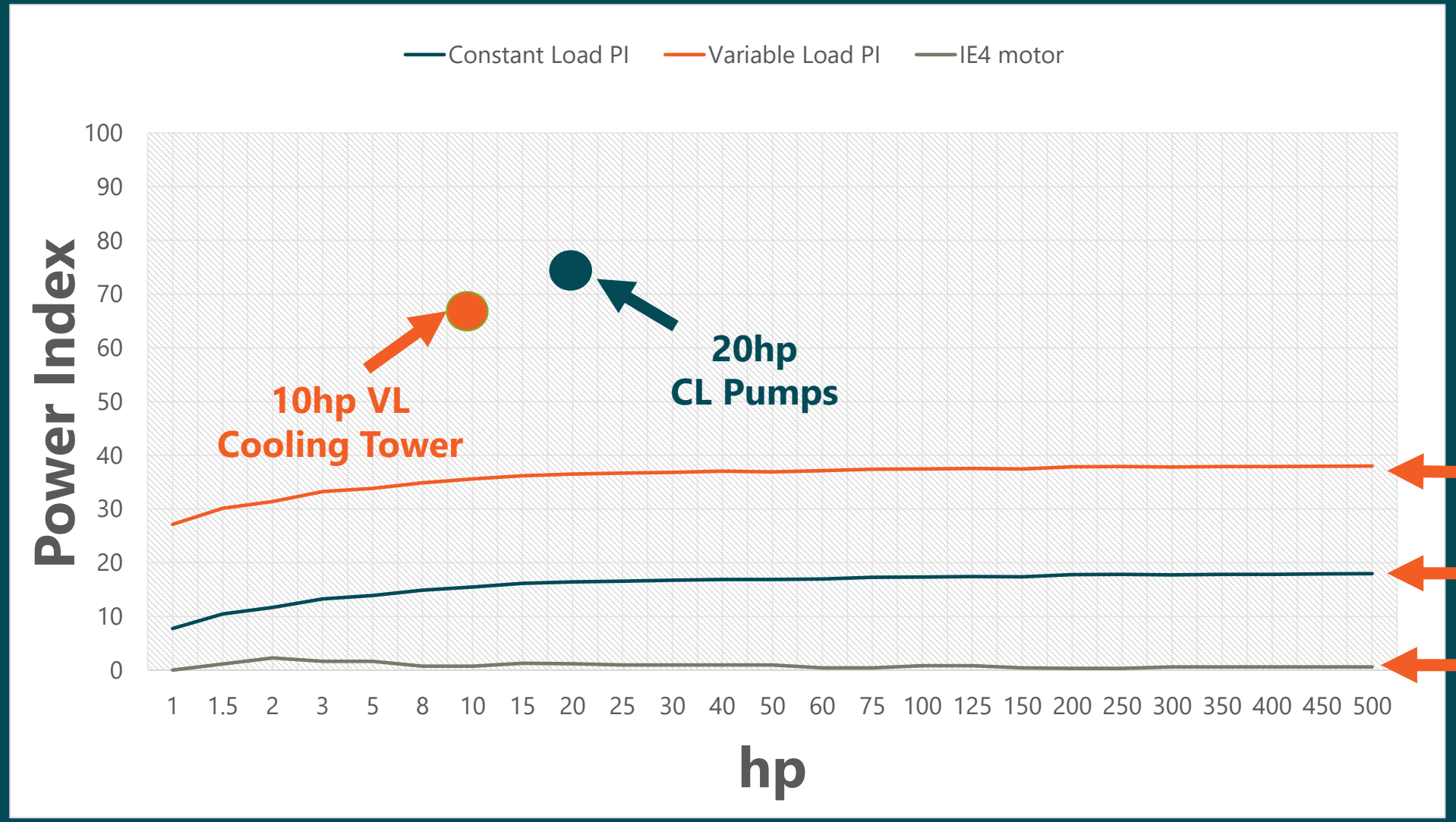
Before & After

Verified 72% savings

- 7 parts washer pumps
- 7.5-20 hp
- Butterfly valve on each pump discharge
- Closed 40-70%

- Added drive on each pump
- Measured Power draw went from 61kW -> 17kW
- Plant personnel decided to increase the system flow rates after drives installed
- Simple Payback: 11 months

Actual Case Study Savings vs Expected PI



Mechanical & Electrical Factors

PDS and VFDs

- Motor should be inverter-ready
  - Motors post 2000 are fine (typically)
  - PDS conversion should be reviewed by electrical staff
- Harmonics & Power Quality
  - Is starter/proposed drive far away from motor?
  - Add line/load reactors
- Some installations may need sensors/feedback/controls
- Commissioning & startup are important
- Other factors to consider
  - Some facility staff may be resistant
    - Drives have become much more reliable
    - Bypass switch allows full speed on failure

Summary

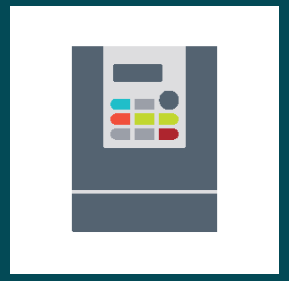
PDS and VFDs

Virtually any centrifugal equipment can benefit from PDS

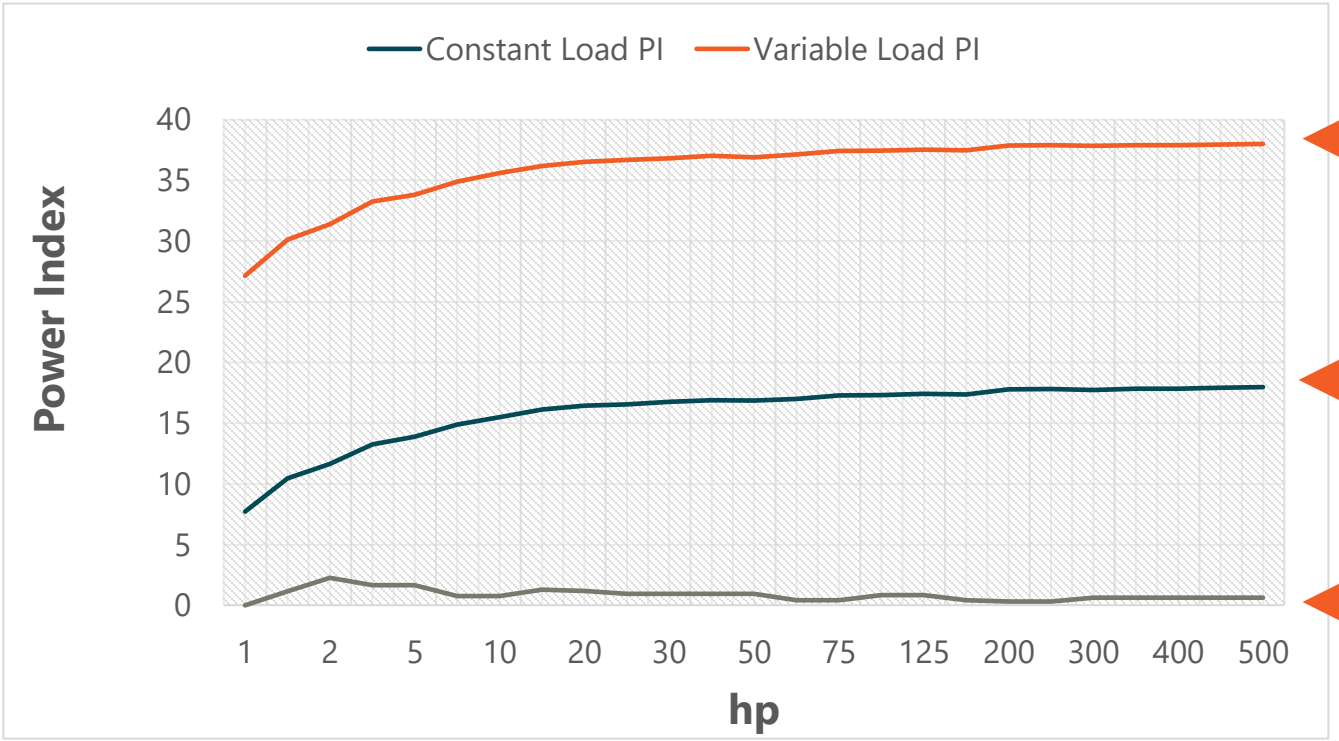
- **Average IAC Simple Payback 1.9 years**
  - Reliability has gone up
  - Costs have come down
- **Consider Non-energy benefits**
  - Decreased maintenance, process improvements, connectivity, grid benefits
- **Consider both constant and variable load applications**

Next Steps

PDS and VFDs



- What tools could help IAC adopt PDS across more applications?
- What tools could help end users increase the application rate?
  - Life Cycle Cost Calculators?
  - Information on available rebates?



Thank you!

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Reference Information

Press Release announcing PDS research & findings:
https://www.nema.org/news-trends/view/nema-neea-and-cadeo-group-publish-new-research-on-energy-savings-from-power-drive-systems

White Paper explaining research & findings:
https://www.nema.org/docs/default-source/motor-and-generator-guides-and-resources-library/power-drive-systems-energy-savings-and-non-energy-benefits-in-constant-and-variable-load-applications.pdf

15-minute video describing research & findings:
https://www.nema.org/motors-and-generators-toolkit/installer-and-designer-resources