Innovative Industrial Projects: Successful Approaches to Reducing Electricity Consumption

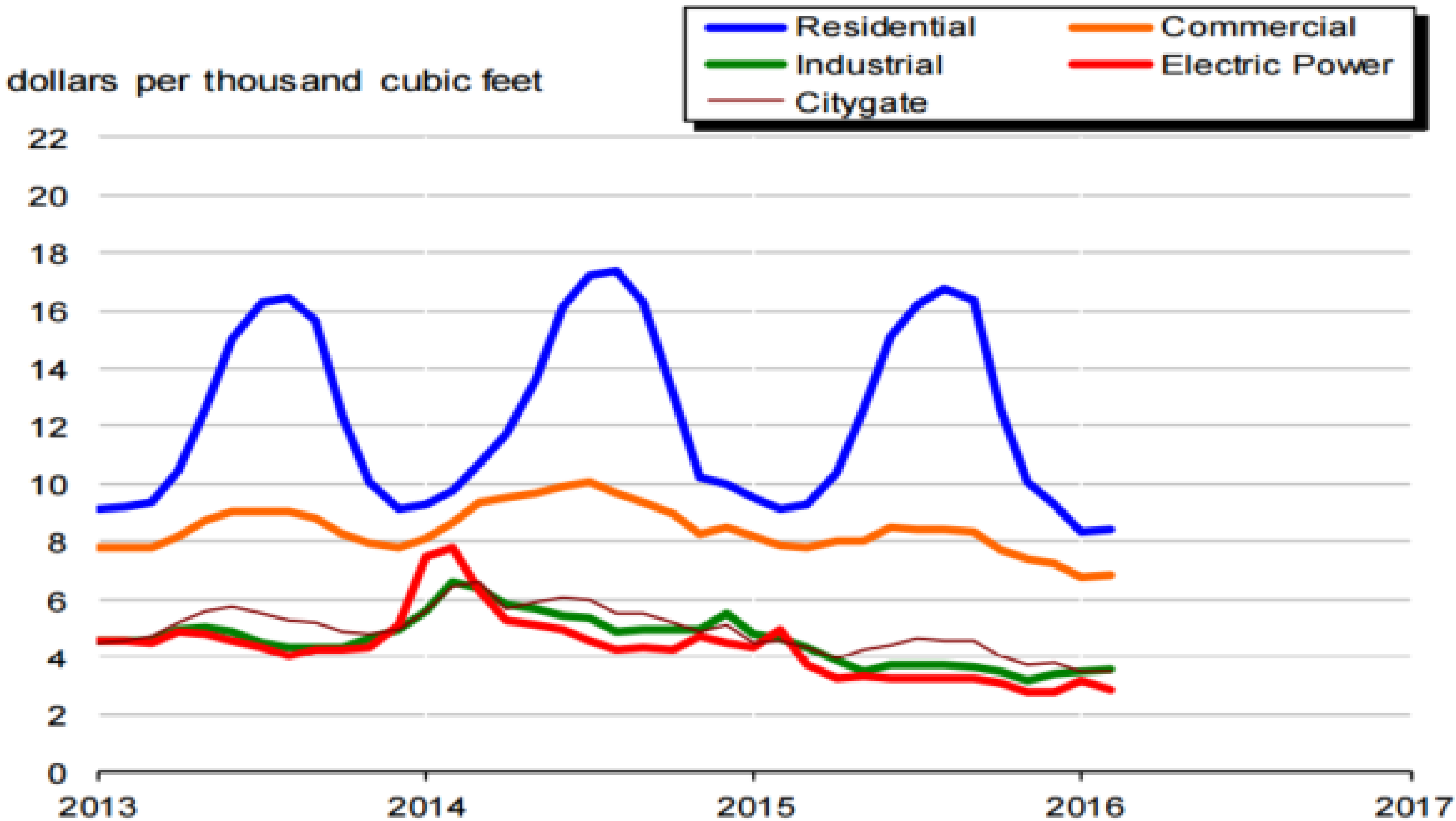
Tuesday, May 10

11:15 – 12:30 pm

Electricity-saving Projects Continue to Provide Reliable Savings

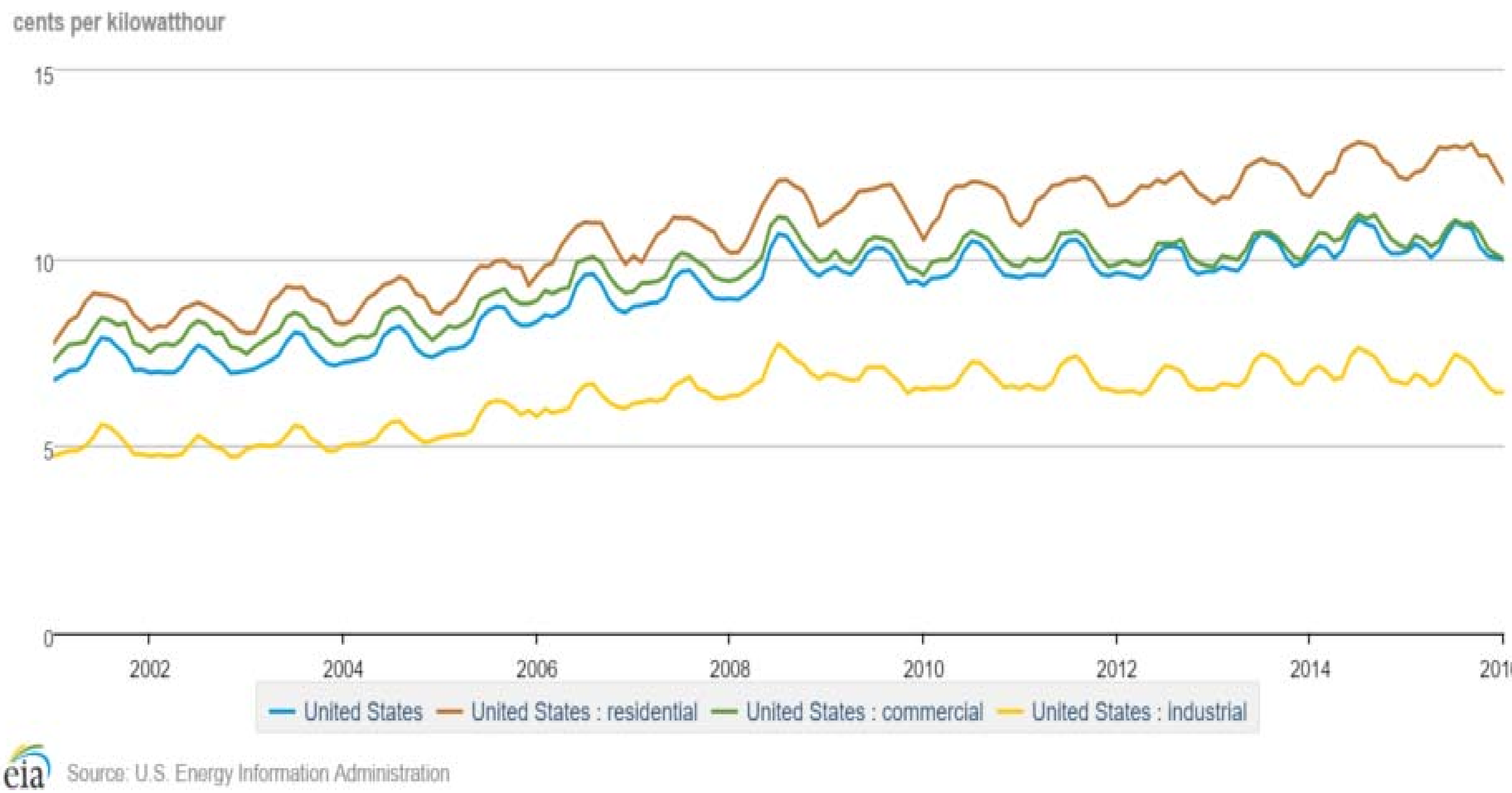
- We have seen upwards of 30% savings in industrial systems
- Today we will explore three successful projects undertaken by leading companies
- Let's keep this an open and interactive discussion

Average Consumer Price of Natural Gas



Reference – US Energy Information Administration

Average Retail Price of Electricity



Presentations From:

- Toyota – Dan Cooper
- CEMEX – Bhaskar Dusi
- Texas Instruments – Michael Braby

Using VFDs to Drive HVAC Energy

Dan Cooper
PE Facility Engineering, Toyota

Using VFDs to Drive HVAC Energy

May 10th 2016

Dan Cooper

Intro to Toyota North America

Camry
Camry Hybrid

Avalon
Avalon Hybrid

Corolla

Lexus RX 350/450h/ ES350

Highlander
Highlander Hybrid

Sequoia

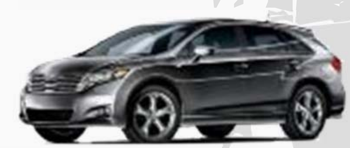
RAV4

Sienna

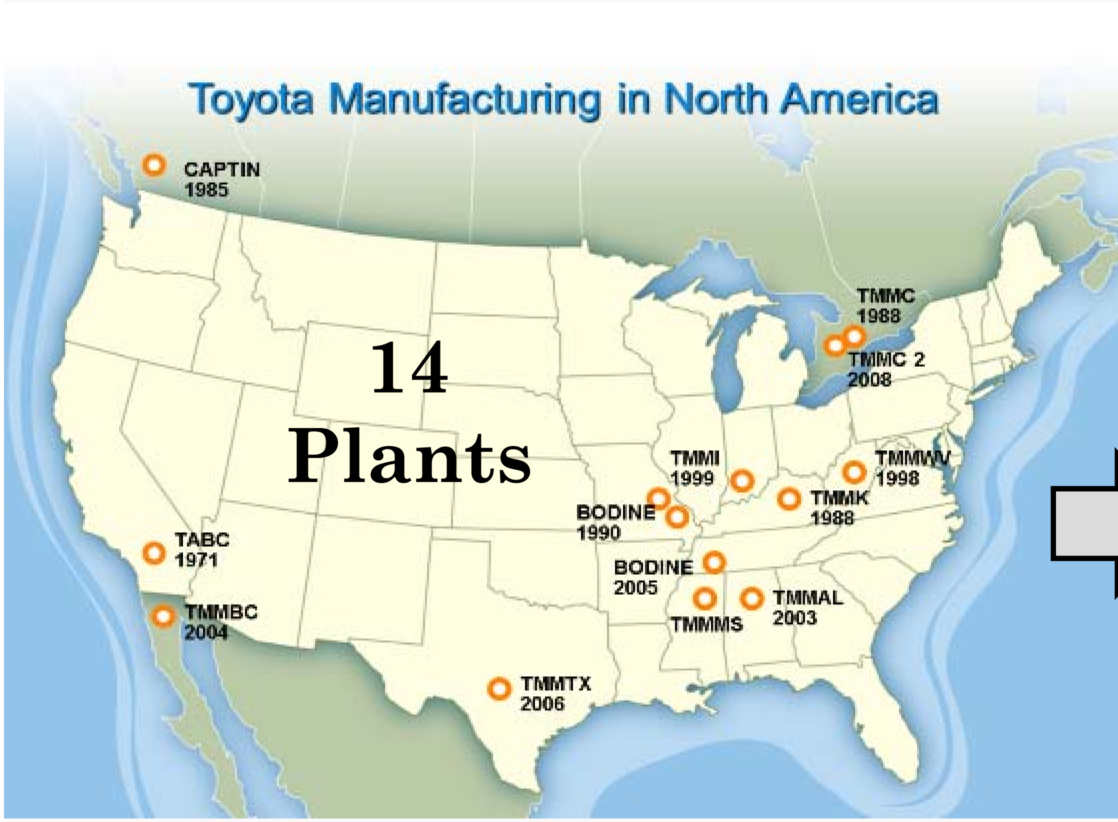
Tacoma

Tundra

Venza



HVAC Energy at Toyota

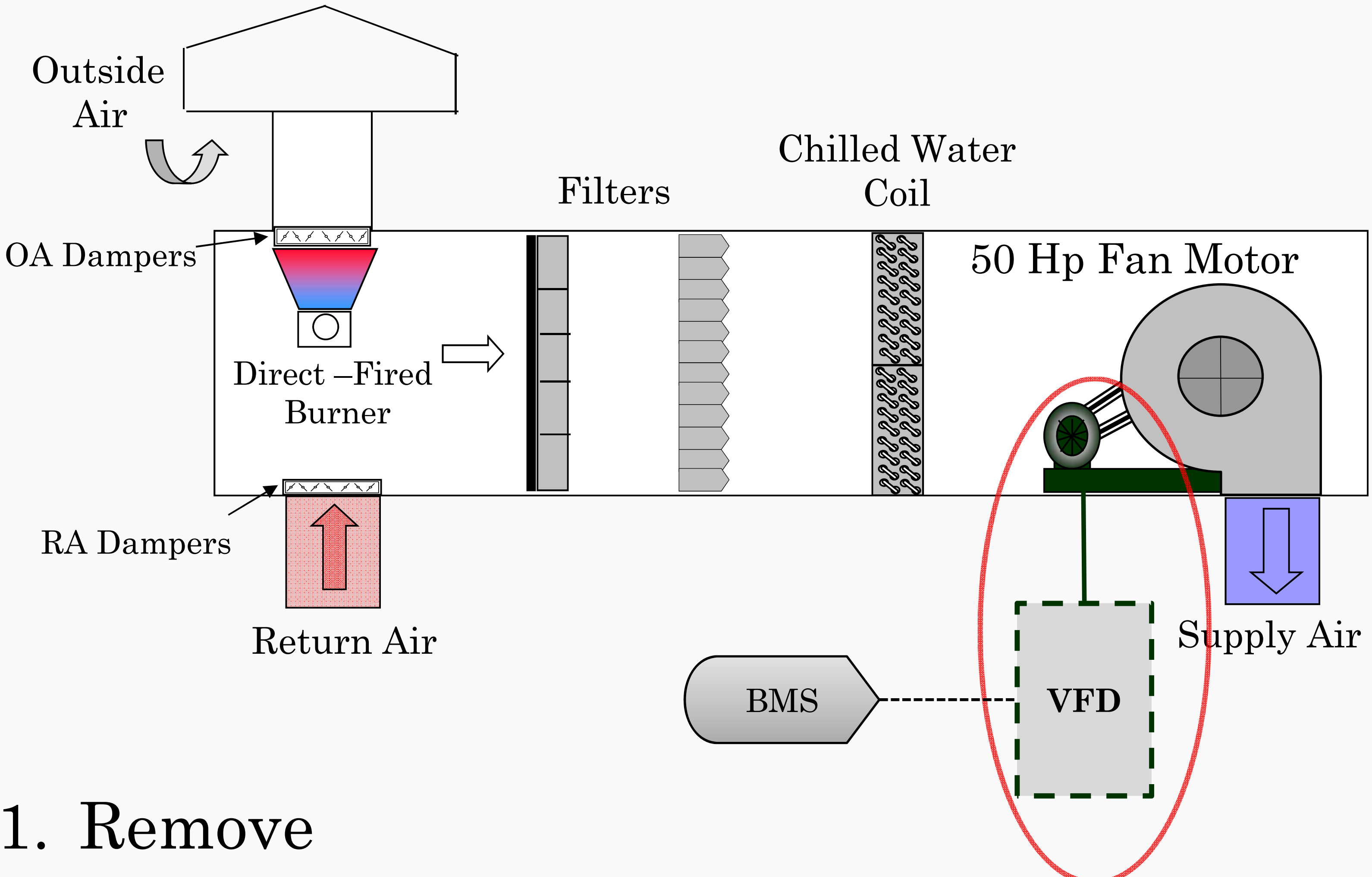


Approx. 40K HP (30 MW)

Target HVAC energy by:

1. Optimizing run time (non production)
2. Reducing air flow

Project Overview



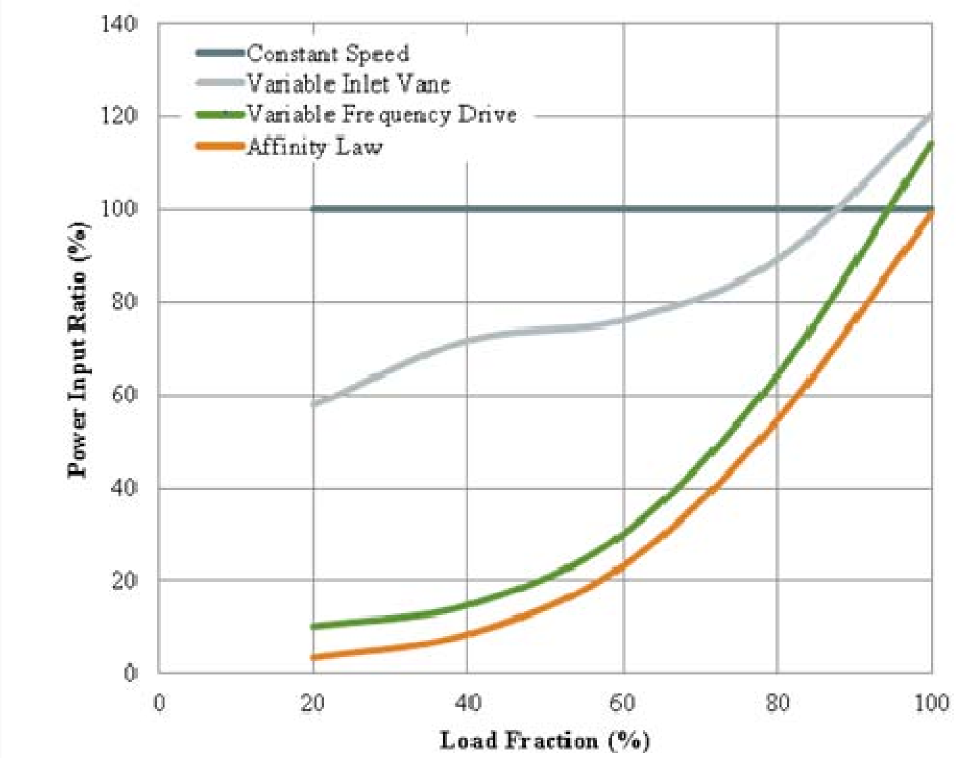
1. Remove
2. Install
3. Integrate

Install VFD to control fan motor

Fan Affinity Laws

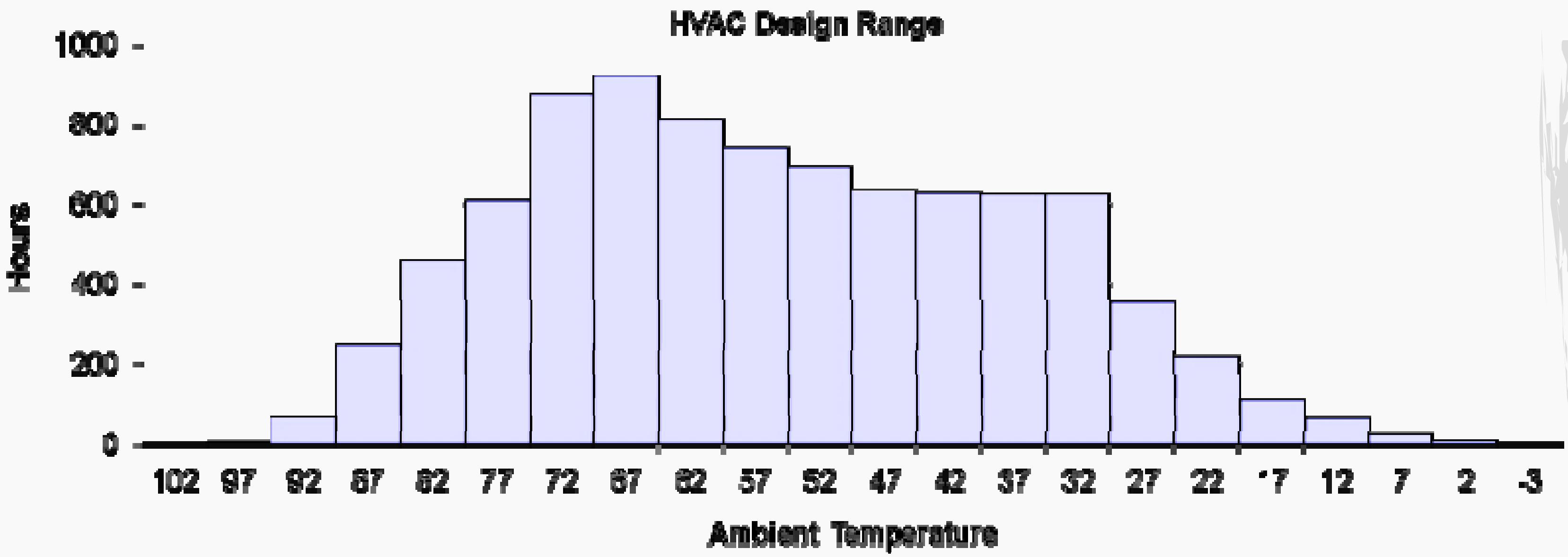
Basic fans laws:

1. Flow varies directly with fan speed
2. Pressure varies with square of fan speed
3. Power varies with cube of fan speed



2.5 Hz = 44 HP
4% reduction in fan speed results in reduced HP (50 HP)

Current Operation



1. Design temperatures
2. Building set points are 81º F summer and 65º F winter.
3. Units operate M-F, setback on weekends

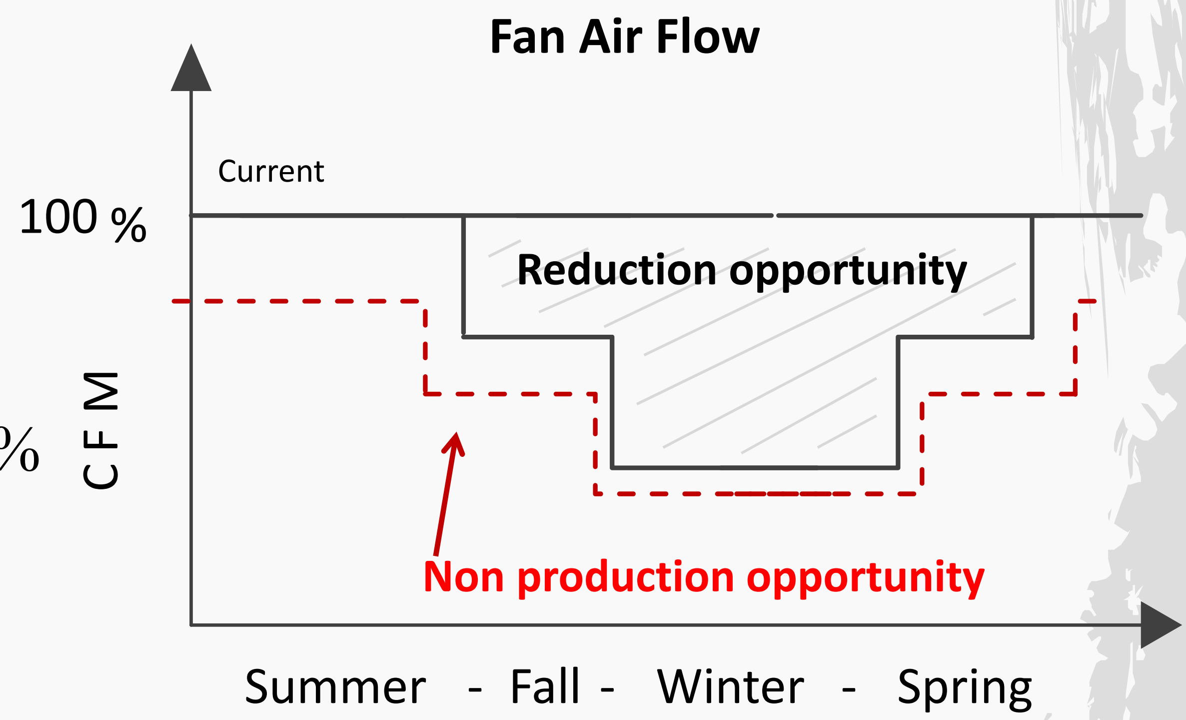
Savings Concept

Current condition –

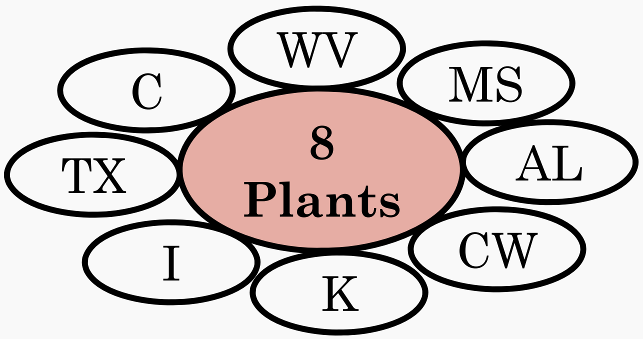
- Constant volume 100% cfm

Opportunity –

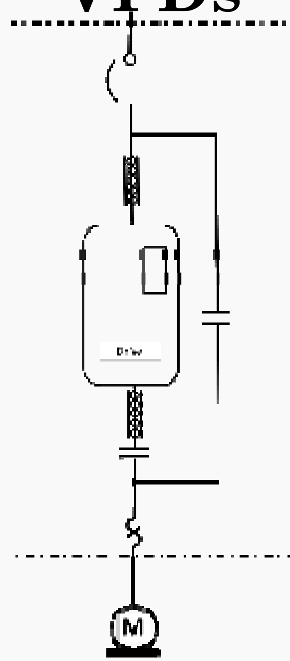
- Spring & Fall 40% cfm reduction
- Winter 50% cfm reduction
- Non production time 20%-60% cfm reduction



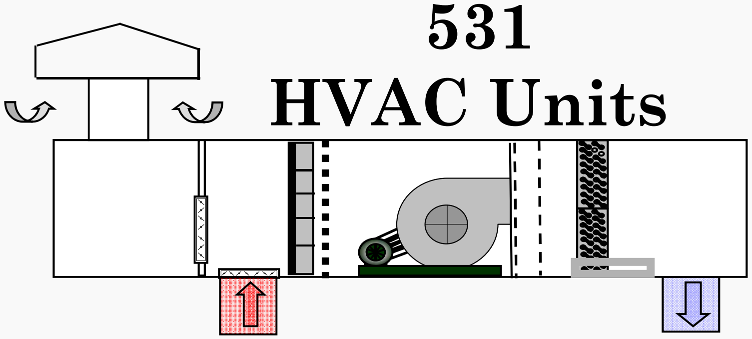
Project Summary

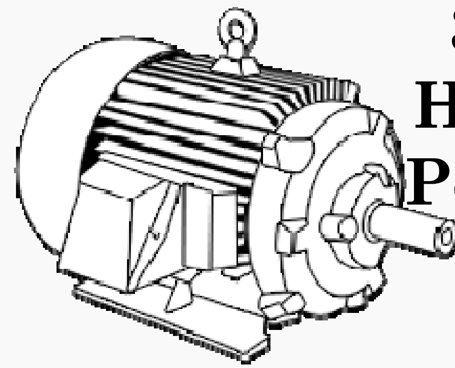


659
VFDs



531
HVAC Units





31K
Horse
Power

179,632 MMBTU Energy Reduction

BBBP Showcase Project

Showcase Project: Fan System Upgrade

TOYOTA

SECTOR TYPE
Industrial

LOCATION
Georgetown, Kentucky

PROJECT SIZE
7,300,000 Square Feet

FINANCIAL OVERVIEW
$1.25 Million

Plant Electricity | **HVAC**

Annual Plant Electricity Use

Baseline (2015)	450,000 MWh
Expected (2016)	438,300 MWh
Actual	Coming Soon

Electricity Savings:

2.6%

Annual Plant Electricity Cost

Baseline (2015)	$28,000,000
Expected (2016)	$27,300,000
Actual	Coming Soon

Cost Savings:

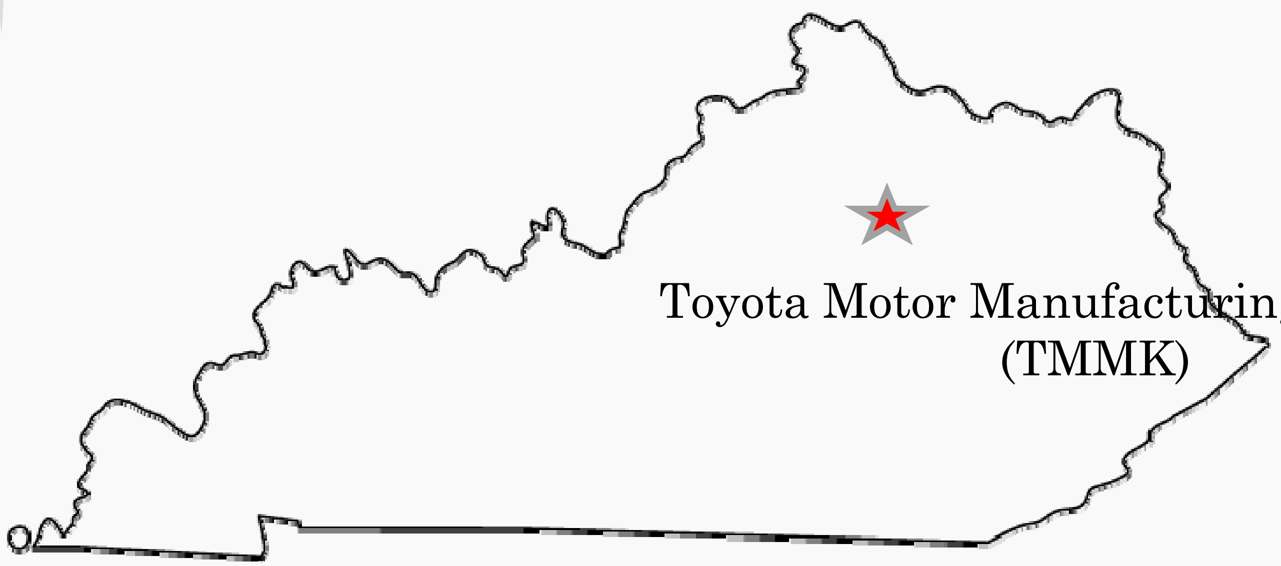
2.5%

TMMK VFD Project

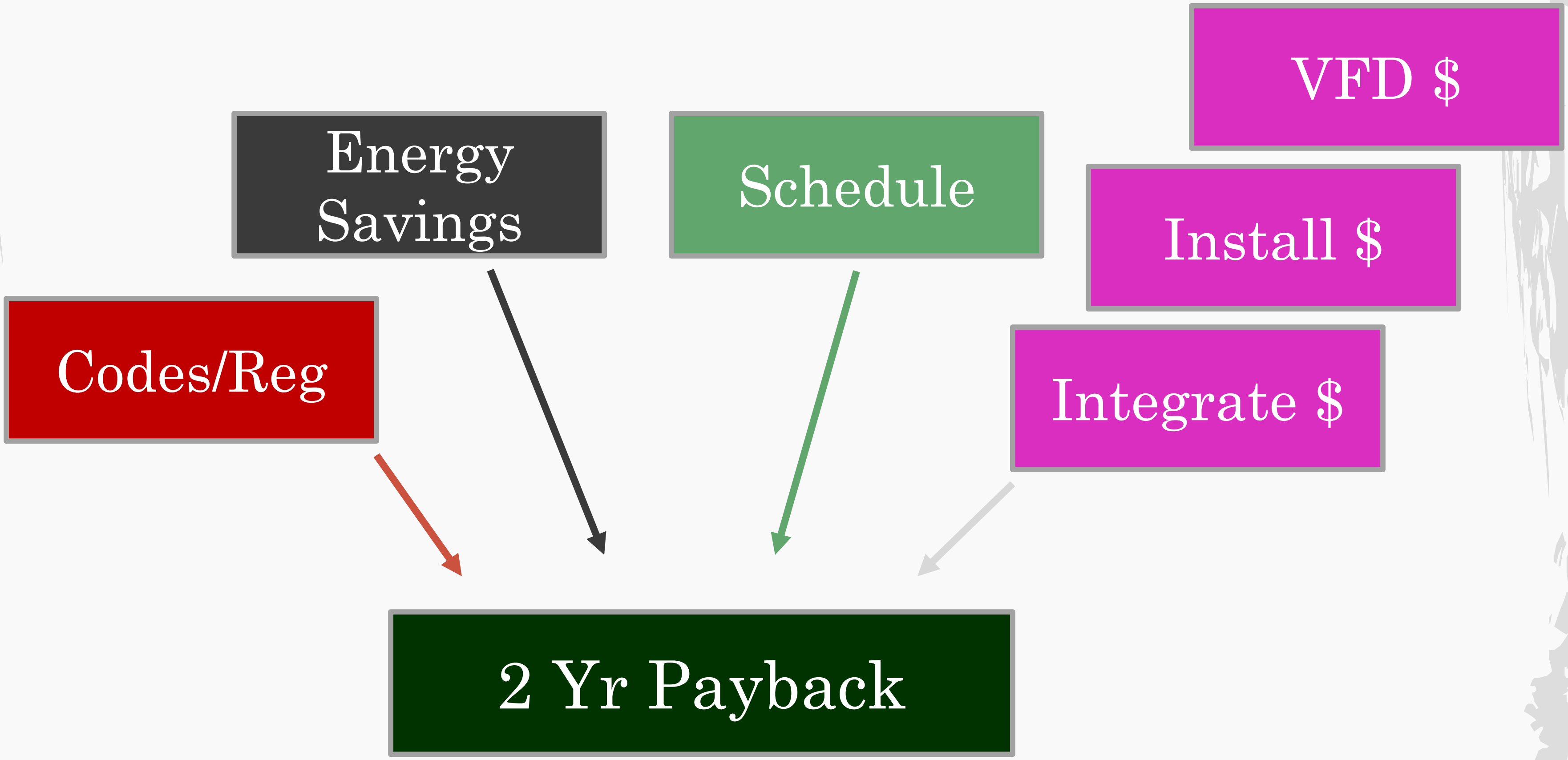
Objective: Reduce HVAC energy consumption

Scope: Install VFDs on 163 HVAC

Method: Seasonally adjust set points



Constraints

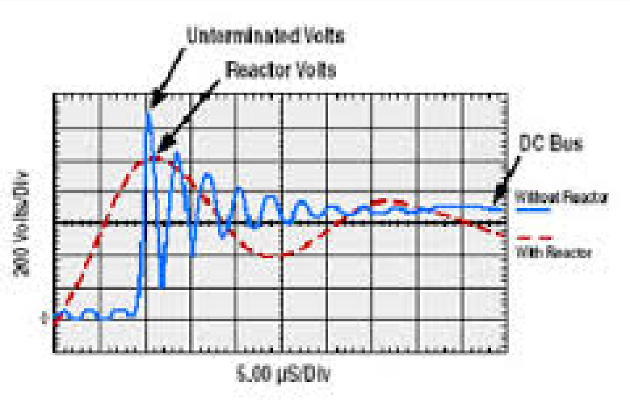


Issues / Challenges

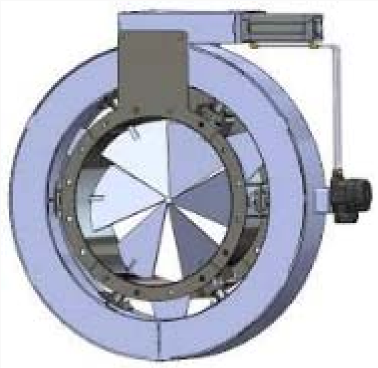
1. Age of units
2. Motor compatibility
3. Line/Load Reactors
4. Integration

Fan Motor

Reactors



Vortex Vanes



Building
Mgmt. System

Project Savings

Total kwh reduction: 11,715 MWh
Total savings: $702K

Project cost: $1.2M

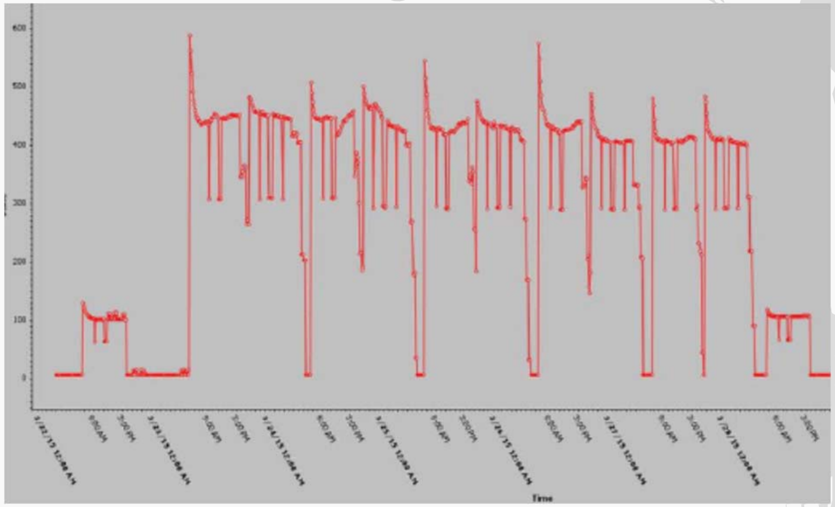
Simple payback: 1.8

Total HP: 8898

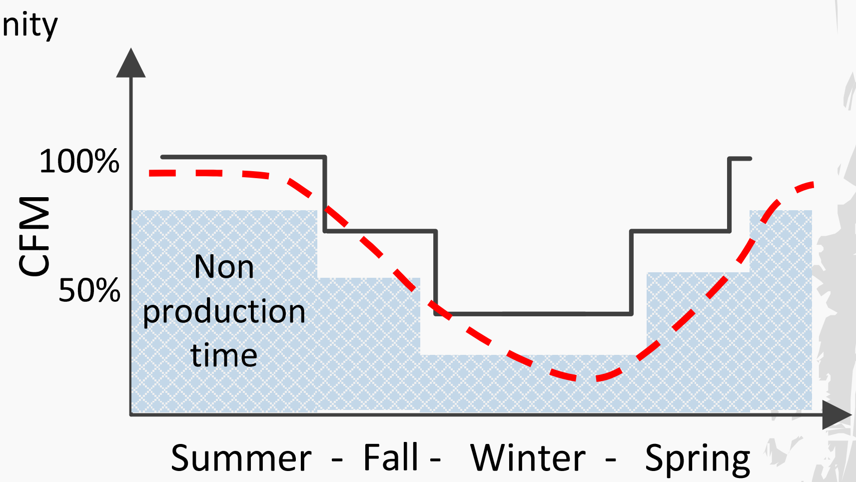
HVAC Units: 163

Future Opportunity

- Reduce speed during non production

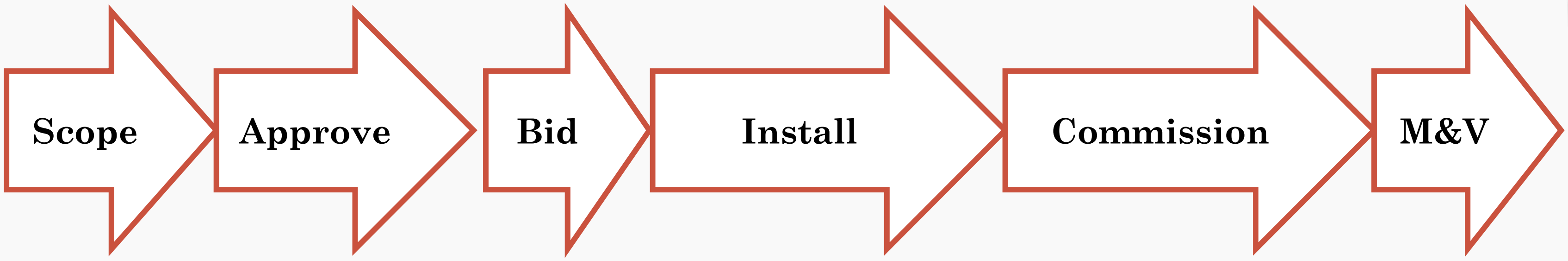


- BMS integration



Summary

1. Energy opportunity with <2 year payback
2. Started as a pilot , replicated to other plants
3. M&V – confirm energy savings



Additional benefits:

1. Reduced maintenance - belt replacement
2. Improve control of building balance
3. Ability to monitor and adjust system performance

Thank You

Questions / Comments ?

Compressed Air

U.S. DEPARTMENT OF ENERGY

"Air Over the Fence": A new concept for Optimization of Compressed Air Systems

Bhaskar Dusi, P. Eng.,C.E.M, C.E.A
Corporate Energy Manager, CEMEX, Inc.

"Air Over the Fence": A new concept for Optimization of Compressed Air Systems

Bhaskar Dusi
Corporate Energy Manager
CEMEX, Inc.

Tuesday, May 10, 2016

Better Buildings Summit
Washington D.C

Building the future™

A Global Building Materials Company

- Presence in 50 countries
  - >44,000 employees
- Annual production capacity of
  - 94.8 million metric tons of cement
  - 55 million cubic meters of ready-mix concrete
  - 159 million metric tons of aggregates
- Operate globally
  - 57 cement plants
  - 1,899 ready mix concrete facilities
  - 371 aggregate quarries
  - 221 land-based distribution centers
  - 69 marine terminals
- U.S. operations in 33 states
  - 13 cement manufacturing facilities
  - 355 ready-mix concrete plants
  - 77 aggregate quarries
  - 46 cement terminals

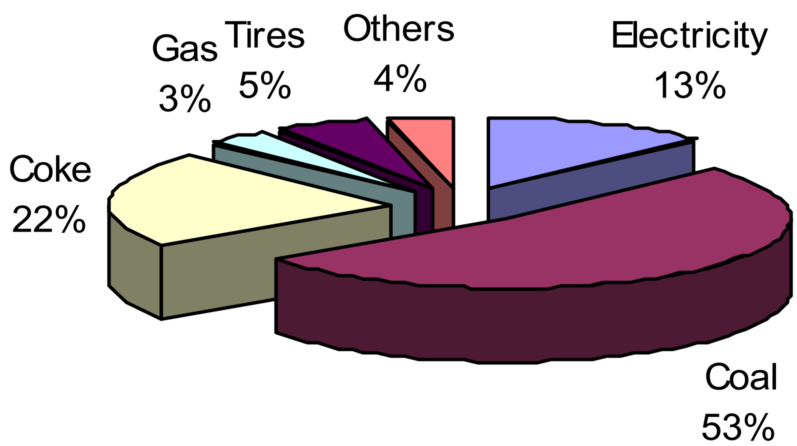
47%

38%

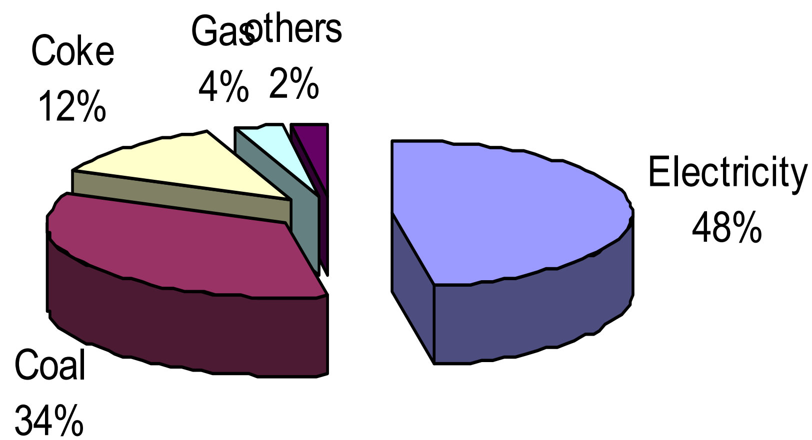
15%

% worldwide product sales 2012

Typical Cement Plant Energy Consumption



Energy Consumption (Equivalent MWh)



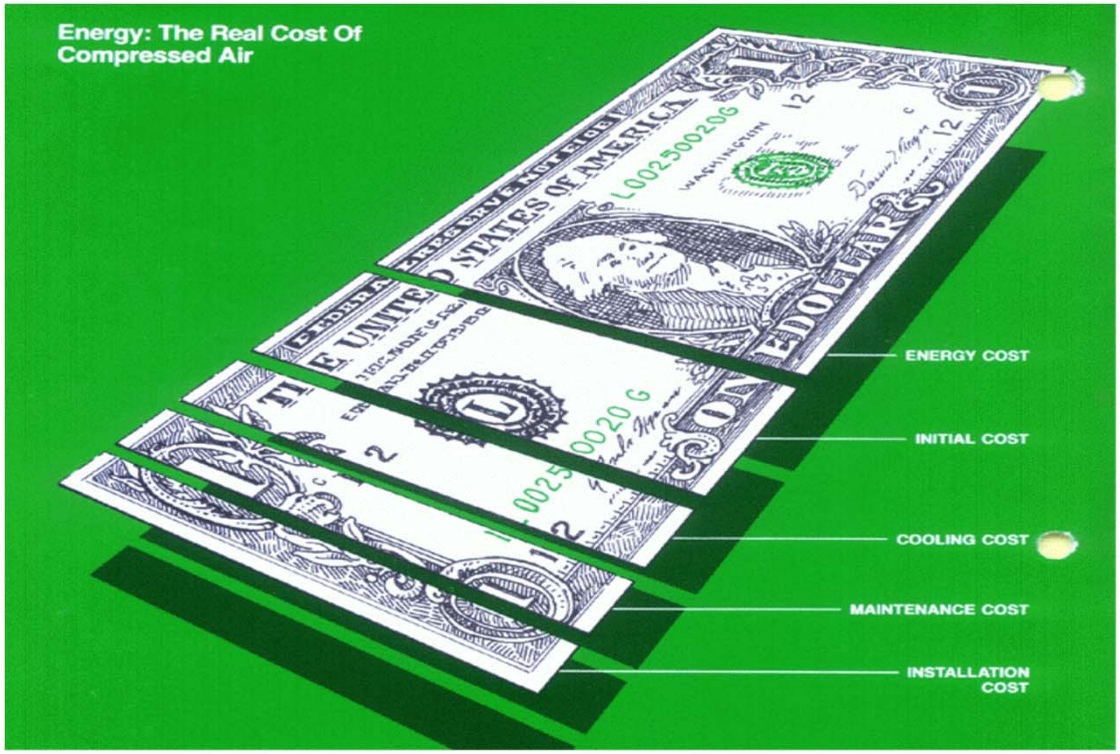
Energy Expenditure (US $)

CEMEX Experiences

- Structured approach for Energy Management" has helped us in
  - ✓ Formalizing our Energy Management Program
  - ✓ Organizing our energy teams
  - ✓ Maintaining focus
  - ✓ Sustaining momentum

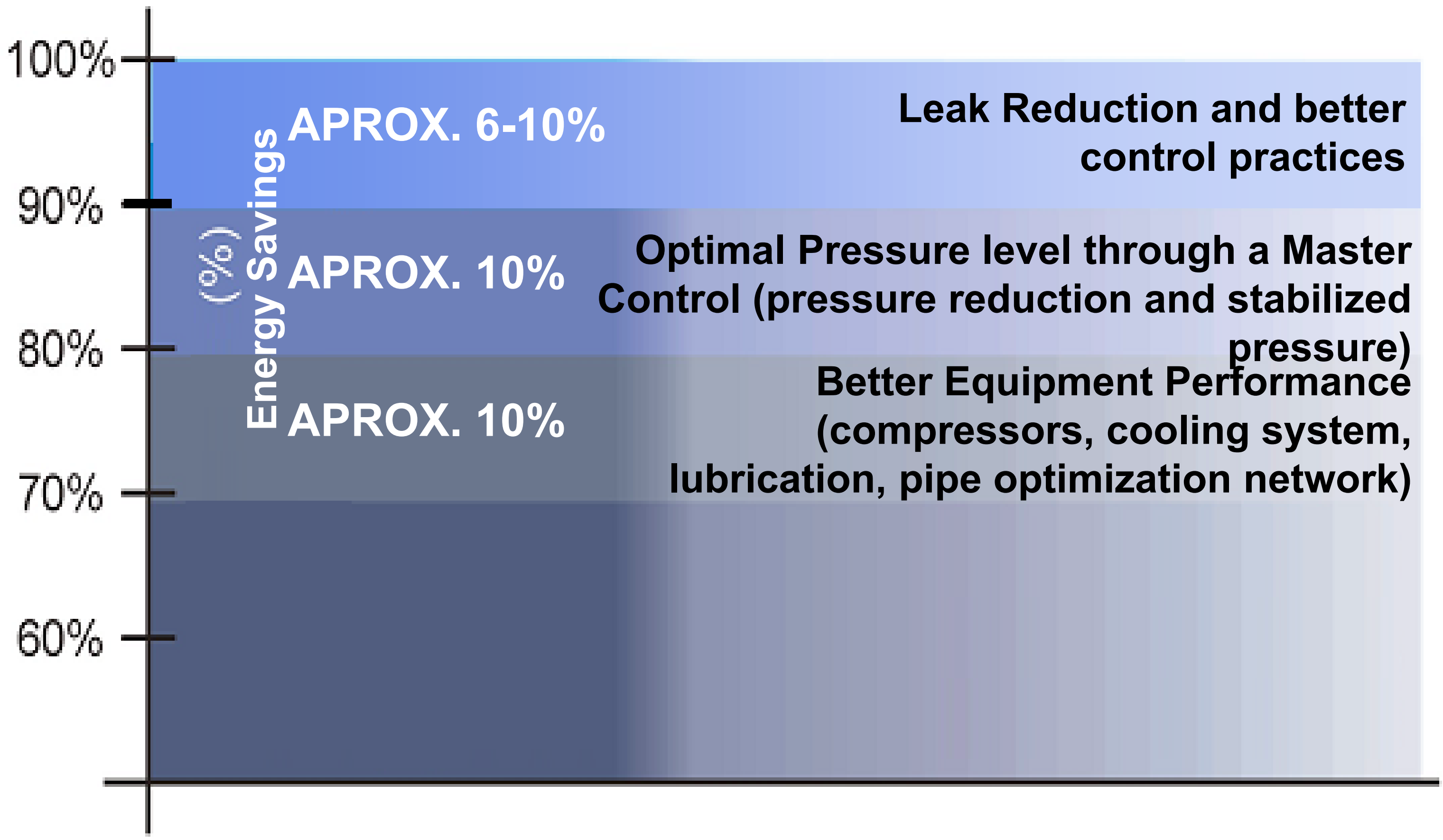
- What distinguishes CEMEX as an industry leader in energy efficiency?
  - ✓ Commitment to smart energy management
  - ✓ Ability to measure and track progress
  - ✓ Efforts to communicate the importance of energy efficiency to a wide audience
  - ✓ Recognize achievements

Real Cost of compressed Air



Energy Cost represents approximately 70% of Real Costs

Compressed Air Savings potential



Air Over the Fence : Background

- CEMEX started an initiative in 2005 to review the way in which CEMEX procured it's compressed air
- Traditionally just bought equipment and CEMEX to maintain
- CEMEX's Global Sourcing department along with Commodity
- Team reviewed the opportunity to change the focus to buying 'compressed air over the fence'
- In 2006 the first 'Air Over the Fence' contract was signed for the Hidalgo Plant in Mexico. Since then the program has been rolled out to new projects and other existing operations all over the globe

Strategy

- Air Over the Fence Strategy offers a good potential to reduce compressed air unit costs and supplier base. The strategy followed involve:

  ✓ To see Air Requirements as a Total System instead of an isolated solution.

  ✓ A reliable compressed air system in terms of quantity, quality and availability of air.

  ✓ To focus on minimizing the highest operational cost which is Energy, and to reduce the equipment maintenance costs, spare parts, inventories, etc.

  ✓ Air over the fence possibilities, as a main change to operate air compressed systems in CEMEX.

Objective and System Proposal

CEMEX

Objective

To reduce total compressed air costs in CEMEX through equipment improvement and outsourcing of compressed air through an "air utility" similar to paying for water or electricity.

Another important benefit is to avoid allocating / spending CAPEX in auxiliary equipment.

Structure of Outsourcing Model

Analysis

- Air Demand Analysis. Establish a baseline from current conditions
- RFP / Proposals. Proposal submission and evaluation

Installation

- Award mid/long term contract to supplier.
- Operation. Supplier installs and operates system
- Monthly fee payment

Follow up

- kWh savings guarantee follow up
- Periodic air leaks audits and repairs

Economic and Technological Improvements

Expected Savings

- **Energy Consumption Reduction**.
- **Zero Maintenance Cost**. Supplier is responsible for its own equipment. Spare parts inventory reduction.
- **CAPEX Avoidance**. Supplier owns equipment, CX possibly needs to invest in minor modifications

Expected Benefits

- **Air Quality and Quantity guarantee**
- **Reliability**. Air demand and energy consumption online monitoring
- **System improvement**. Air leak audits
- **Right to purchase equipment** at the end of the agreement at book or market value
- **CO_2 Tons Emissions.** Footprint reduction

Technology

- **Operation Efficiency:** systems designed to operate centrally controlled compressors, where possible, at full load to provide stable system pressure and air quality, while reducing energy consumption
- **Centralized Control (24/7):** Online & SMS monitoring ensuring prompt response when needed
- **Supply Guarantee:** Through a back-up compressor and adequate maintenance, supplier assures compressed air delivery. Supplier subject to penalty in case of failure to deliver air
- **Periodic Leak Audits:** Performed to the piping system for the plant to take corrective actions, and minimize costly air leaks

CEMEX “AOF” Installations in US

- 6 plants with 8 lines of production are in operation under AOF
  - ✓ 1 production line is new line started about 6 months back
  - ✓ 1 production line is green field start and in operation for about 7 years
  - ✓ 2 production lines are running for 6 years
  - ✓ 2 production line is running for 5.5 years
  - ✓ 2 production lines are running for 5 years
  - ✓ 2 plants are under review for possible AOF implementation

Savings Results

Air Over the Fence (AOF)							
Plant	Prior AOF		After AOF		Savings		
	Avg kWh/month	Avg CF/month	Avg kWh/month	Avg CF/month	%	Total kWh	Tons CO2
A	613,193	141,609,600	489,539	165,623,313	20%	7,542,909	5,374
B	617,043	109,663,996	327,018	108,676,695	47%	17,879,898	12,738
C	526,136	156,964,617	440,366	161,440,273	16%	6,604,272	4,134
D	1,152,752	309,492,655	900,383	320,161,503	22%	19,937,184	12,479
E	796,907	218,421,548	673,563	248,842,922	15%	8,510,718	3,306
F	1,438,655	198,000,000	840,921	284,426,989	42%	5,379,604	3,833

Compressed Air Energy Cost reduced from 18.5 kW/ 100 CFM to 17 kW/ 100 CFM

Savings Follow up and Review

CEMEX

CEMEX / KAESER Monthly Report

Plant Name:
Contract Start: 03/02/2015

Prior to SAU Installation

kWH*	CF minimum	CF maximum	CF average	CO2 Tons*
1,438,655	2,248,171,200		1,124,085,600	800,821
*kWH/month			CF/month	*not in contract

*kWH equivalent

Annually Contracted Amounts

kWH saved	CF min	CO2 Tons *
	2,376,000,000	

2,376,000,000 CF basic - 3,564,000,000 CF max per annum
198,000,000 CF/month basic, 5,000 CFM continuous

$5.75 per 100,000CF above 2,376,000 CF

12 month Rolling Profile

	kWH	kWH equivalent decrease (increase)	CF	CF decrease (increase)	CF excess above (below) contract basic
start 03/02/15					
Apr-15					
May-15					
Jun-15	680,316	758,339	228,241,216	(134,567,416)	**30,241,216**
Jul-15	659,806	778,849	223,592,776	(129,918,976)	**25,592,776**
Aug-15	806,957	631,698	254,361,669	(160,687,869)	**56,361,669**
Sep-15	871,701	566,954	298,747,257	(205,073,457)	**100,747,257**
Oct-15	893,060	545,595	306,531,505	(212,857,705)	**108,531,505**
Nov-15	1,007,660	430,995	344,231,546	(250,557,746)	**146,231,546**
Dec-15	893,993	544,662	303,827,257	(210,153,457)	**105,827,257**
Jan-16	839,694	598,961	284,270,033	(190,596,233)	**86,270,033**
Feb-16	915,100	523,555	316,039,642	(222,365,842)	**118,039,642**
Mar-16					
Apr-16					
May-16					
Year to date	**7,568,287**	**5,379,604**	**2,559,842,901**	**(1,716,778,701)**	**777,842,901**
Since startup	**7,568,287**	**5,379,604**	**2,559,842,901**	**(1,716,778,701)**	**777,842,901**

Total Reduction since start of Contract

KWH	5,379,604
CF (increase)	(1,716,778,701)
CO2 Tons	3833

Savings per month to date based on kWH decrease

	Electrical cost	0.55	kWH*
7,079.74	**$/month**	**$32,875.35**	* to be confirmed as of 03/13/15
17.7		**6441**	

Performance since Startup

Since startup May 30th the Kaeser SAU supply has averaged 6441 cfm at 17.7 kW/100cfm

Monthly Points of Interest

February consumption averaged 7080 cfm, this exceeds basic continuous supply of 5000 cfm and is a result of all compressors being available, including backup.

ENERGY STAR Partner Teaming profile

LEARN MORE AT energystar.gov

Industrial SPP / Partner Teaming Profile

Service/Product Provider

Kaeser Compressors, Inc
P.O. Box 946
Fredericksburg, VA 22404

Business: Air Compressor Wholesaler
Michael Camber
Marketing Services Manager
Phone: 540-834-4520
Email: michael.camber@kaeser.com

Industrial Partner

CEMEX
920 Memorial City Way, Suite 100
Houston, TX 77024

Business: Building Materials
Bhaskar Dusi
Corporate Technical Energy Manager
Phone: 713-722-2961
Email: bhaskar.dusi@cemex.com

Kaeser's Sigma Air Utility cuts compressed air energy by 28.5% for CEMEX in Louisville, KY

Project Scope
Kaeser provided a complete air system designed and built to meet CEMEX's needs. Kaeser operates and maintains the air system, and CEMEX pays a fixed monthly cost for compressed air as a utility.

Project Summary
In designing the Sigma Air Utility for CEMEX, Kaeser conducted an initial plant walkthrough, an Air Demand Analysis, and provided a compressed air system proposal that guarantees performance, supply, and energy savings for the contract period. The equipment supplied included high efficiency stationary rotary screw compressors (with EPAct compliant motors), clean air treatment equipment, and an air distribution network designed for low pressure drop. Compressors and dryers are controlled by Kaeser's Sigma Air Manager (SAM), which optimizes equipment efficiency.

- **Energy Savings**
  Estimated annual energy reduction of 28.5%
- **Investment**
  No capital investment required by CEMEX; company pays fixed monthly cost for compressed air supply for the length of its contract.
- **Financial Return**
  The yearly energy savings pays for at least 40% of the total annual compressed air supply cost. Furthermore, the customer assessed additional savings in maintenance and overhead costs.
- **Other Benefits**
  In addition to being the most energy efficient system possible, Sigma Air Utility guarantees air at the right pressure and quality for reliable plant operations and better product quality. It retains working capital for other projects, and the fixed monthly costs make for more accurate budgeting.

Monitoring & Verifying Energy Savings
Kaeser monitors compressors and system components through SAM. SAM features data storage hardware and analysis software to record operating trends and energy consumption, enabling verification of energy savings initially projected, and detection of new usage patterns that can be further optimized.

Distinguishing Value

EPA United States Environmental Protection Agency

AOF Installations

Before **After**

AOF Installations

Before

After

Recognition

HOME | XENIA DAILY GAZETTE | FAIRBORN DAILY HERALD | BEAVERCREEK NEWS CURRENT | SPORTS | OPINIONS | OBITUARIES | POLICE REPORTS | CLASSIFIEDS

Xenia Daily Gazette Electronic Edition click here

Fairborn Daily Herald Electronic Edition click here

The Wright Flyer Archived Editions

subscribe to our E-NEWSLETTER

Virtual Newsroom click here to submit news

Classifieds

Miami Valley HomeSeller Homes in and around Dayton

Fairborn Daily Herald

home · fairborn news · fairborn news Septembe

9/16/2011 11:00:00 PM Email this article · Print t

CEMEX recognized for saving electricity

FAIRBORN — The local CEMEX USA cement plant in decreased electric power consumption used for compressed air by more than half, earning the company a $226,000 rebate from Dayton Power & Light (DP&L).

The decrease in electricity consumption also reduces the amount of CO2 emitted into the atmosphere annually by more than 1,475 metric tons.

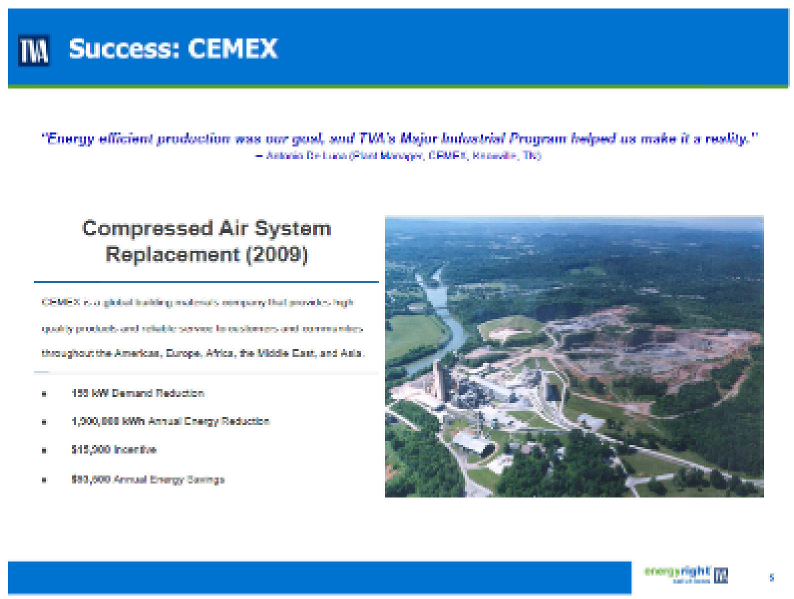
CEMEX USA's rebate is the largest that DP&L has paid to date as part of its energy efficiency programs offered to customers to meet Ohio's energy efficiency targets to reduce electricity consumption by 22 percent by the end of 2025.

Submitted photo

CEMEX Fairborn Plant Manager Alberto C from left and CEMEX Engineer Caleb Ru a rebate check from DP&L's Manager of E Efficiency Programs, Stefanie Campbell.

CEMEX's Fairborn plant replaced a compressed air system that consisted of five compresso varying horsepower operating 24 hours a day and consuming more than a projected 4.48 mi kilowatt hours (kWh) annually. Five new, more efficient 200 horsepower units now serve the compressed air needs on significantly less electricity (2.04 million kWh annually for an expect

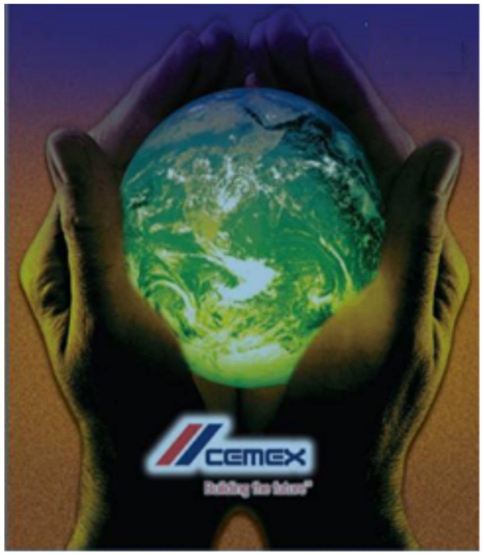
Fairborn



Knoxville

Questions & Answers

Thank you



Help Make a Difference.

Conserve energy wherever you can!

Cleanrooms

U.S. DEPARTMENT OF
ENERGY

Cleanroom Air System Efficiency: Reducing Energy Consumption at Texas Instrument's South Bldg.

Michael Braby
Energy Services Technical Lead, Texas Instruments

Cleanroom Air System Efficiency

Reducing Energy Consumption at Texas Instrument's South Bldg.

Presented By: Mike Braby

Based on work by project manager Alexander Vega & South Building facilities team.

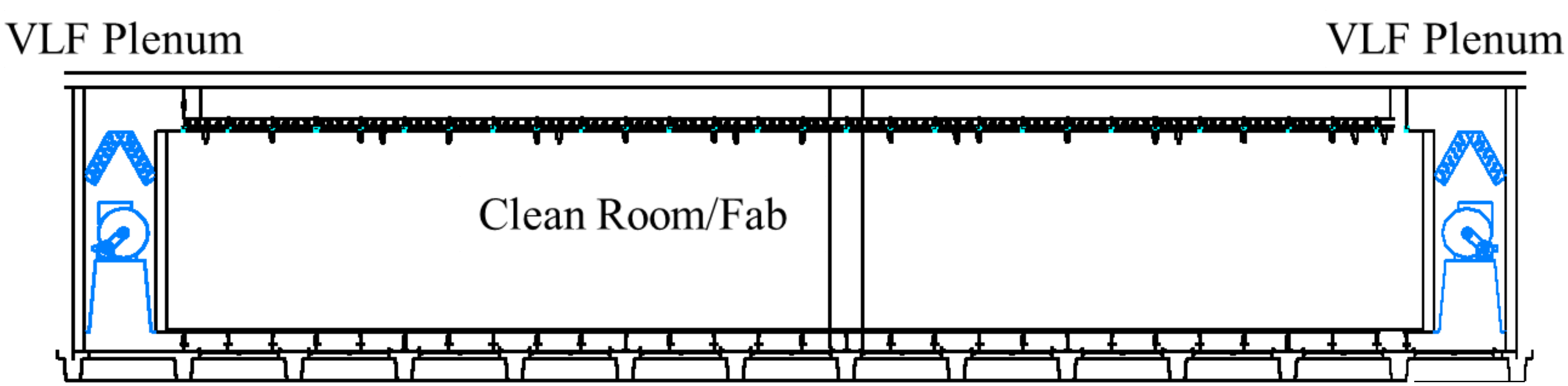
Cleanroom Air System Efficiency

- Background
  - Purpose of System
  - System Design
  - Efficiency Opportunities?
- Improvement Plan
  - Design
  - Potential Issues
- Results
  - Energy Saved
- Summary & Questions

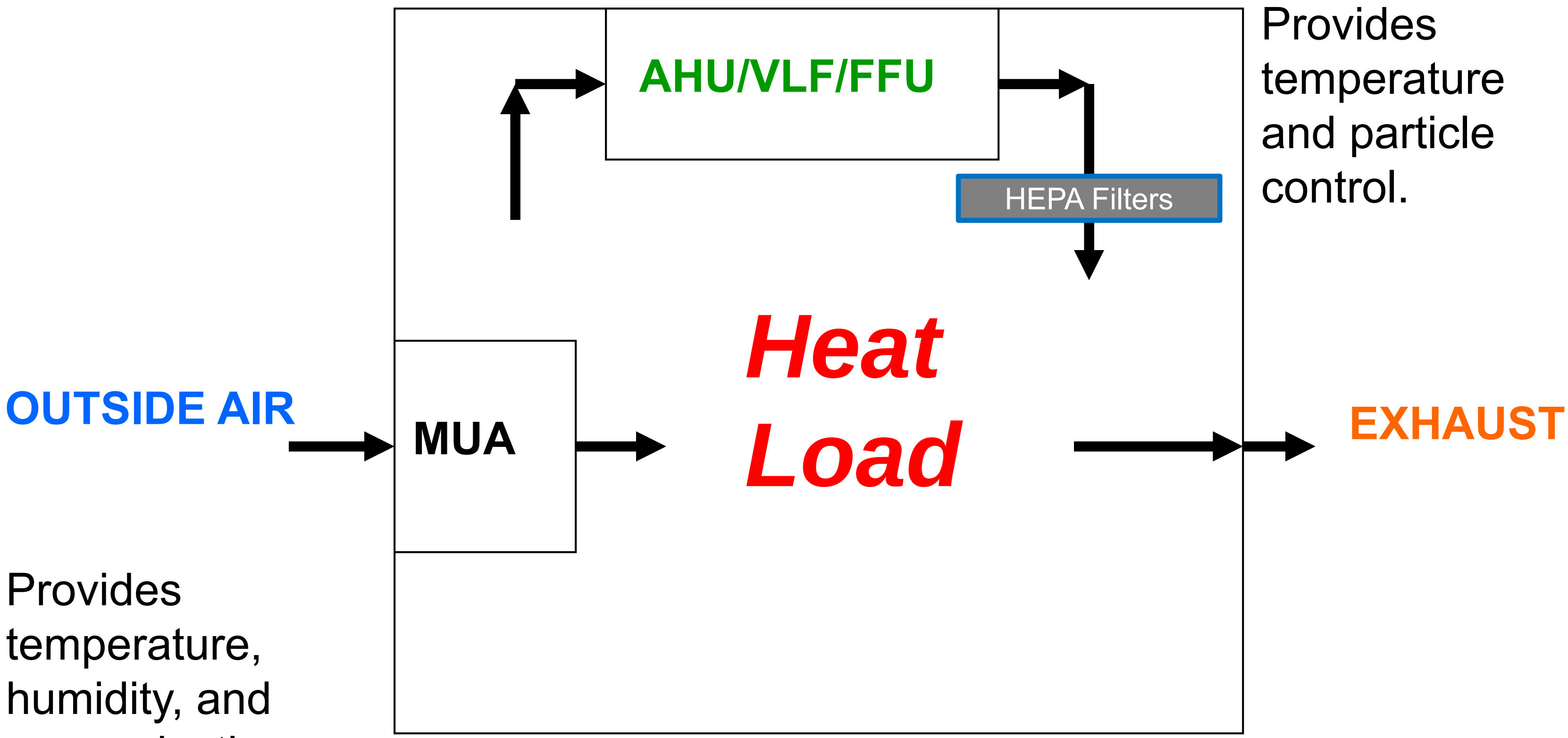
Clean Room HVAC Functions

- The central idea in clean room environment conditioning is to tightly control a number of variables: Temperature, Humidity, Pressure, as well as submicron airborne particles are all important.

- A clean room HVAC system accomplishes these functions using two primary components.
  - Make-up Air Handling Units
  - Recirculating Air Units



Fab Air Circulation Cycle

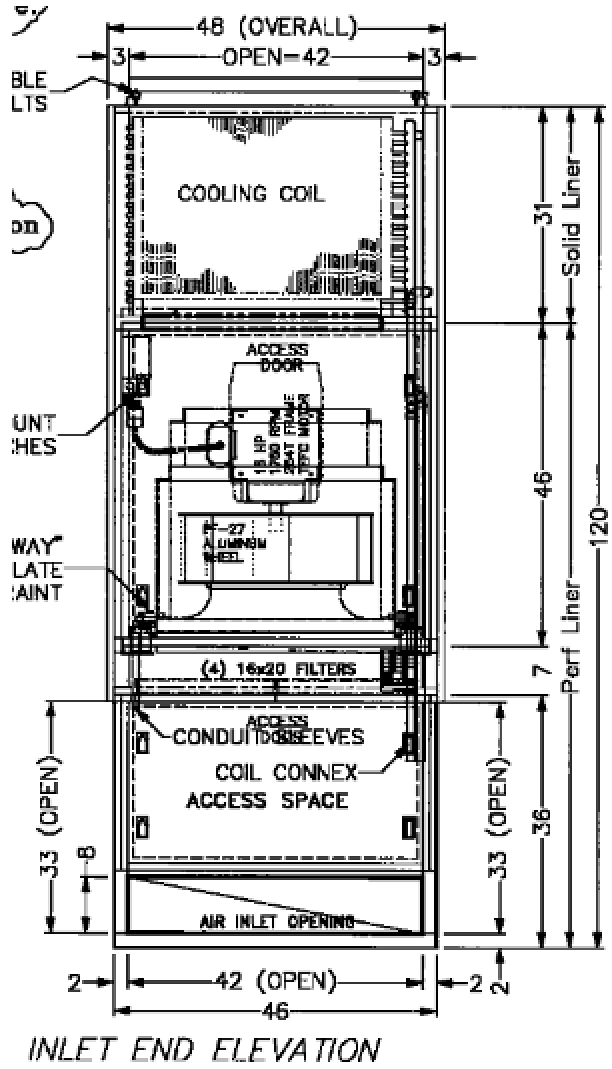


Provides temperature and particle control.

Provides temperature, humidity, and pressurization control.

South Building Air System Design

- Single level fab
- Modular VLF design.
- Direct Drive Fans.



Opportunity to Improve Efficiency

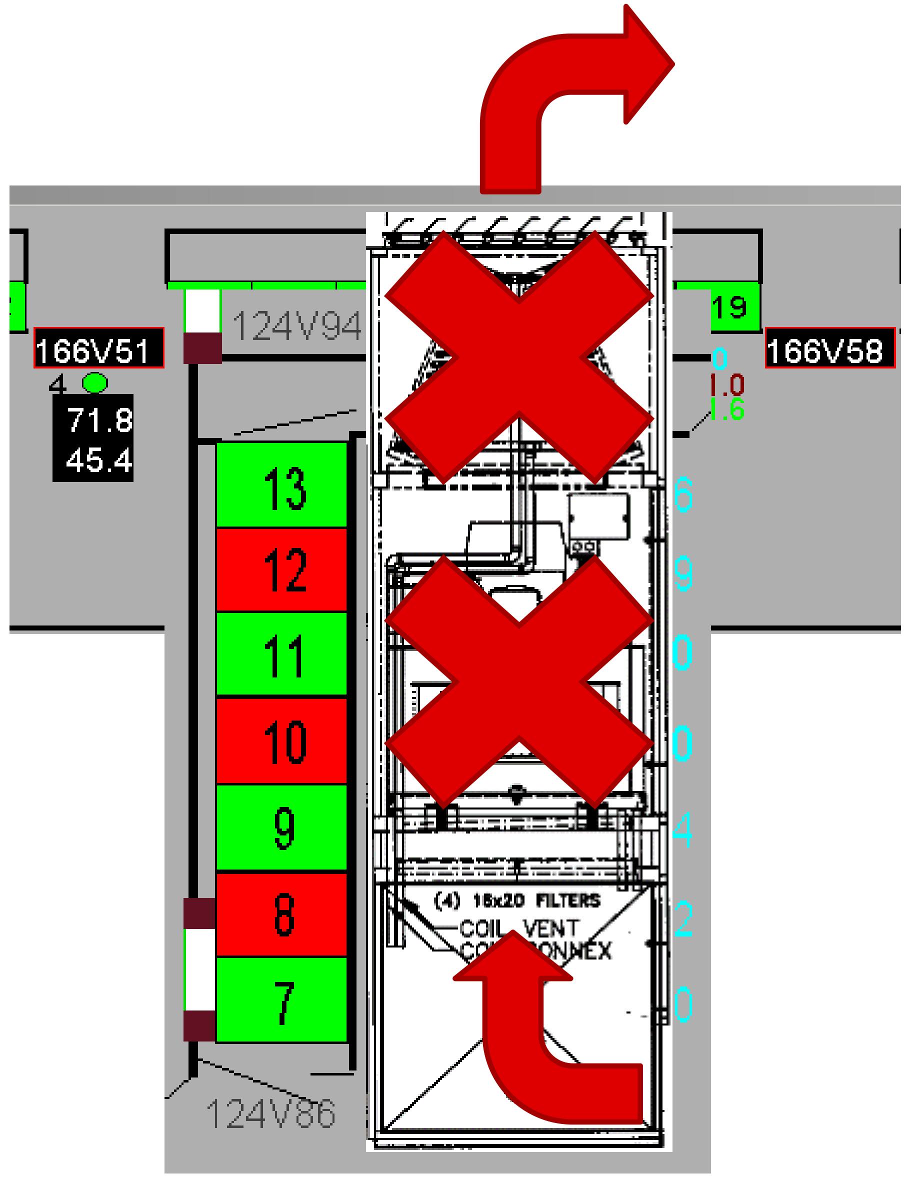
- Average HEPA face velocity at the start of the project was measured at 95 fpm.
- If air flow is used to control particle then more is better, right?
- Not necessarily, more air flow can lead to turbulence which can cause localized particle problems.
- Moving all that air costs $.
- Goal: Minimize the amount of a particle and temperature specif impact to worker comfort.
- Based on results from other loc achieve our goals.
- How to get there?

Air Flow Reduction Approach

- Before the project started, we had 19 of 52 VLFs in the two areas that were already off-line for energy savings.
- To achieve a lower flow of 50 fpm, it was estimated that an additional 9 VLFs could be turned off.
- Why not just go ahead and idle the remaining fans?

Problems

- Coil and Fan configuration eliminates cooling capacity when fan is turned off
  - **"NO FAN, NO COIL"**
- Turning off adjacent fans causes air flow balance issues
- Diminished cooling capacity and lack of balanced airflow ultimately affects fab temperature, tools, and people comfort
- Fan Rotation program is difficult to maintain, fans that remain off for extended periods of time develop flat bearings and shafts
- Turning off fans eliminates system redundancy
  - **Loss of N+1**



Proposed Solution

- Install Variable Frequency Drives to slow down the fans to desired speed.
- Expect power savings to be proportional to the cube of fan speed.
- ½ speed = 1/8 power.

$$\boldsymbol{CASE\ 1:\ N_{old} = N_{new}}$$

$$CFM_{new} = \left(\frac{RPM_{new}}{RPM_{old}}\right)^1 CFM_{old}$$

$$P_{new} = \left(\frac{RPM_{new}}{RPM_{old}}\right)^2 P_{old}$$

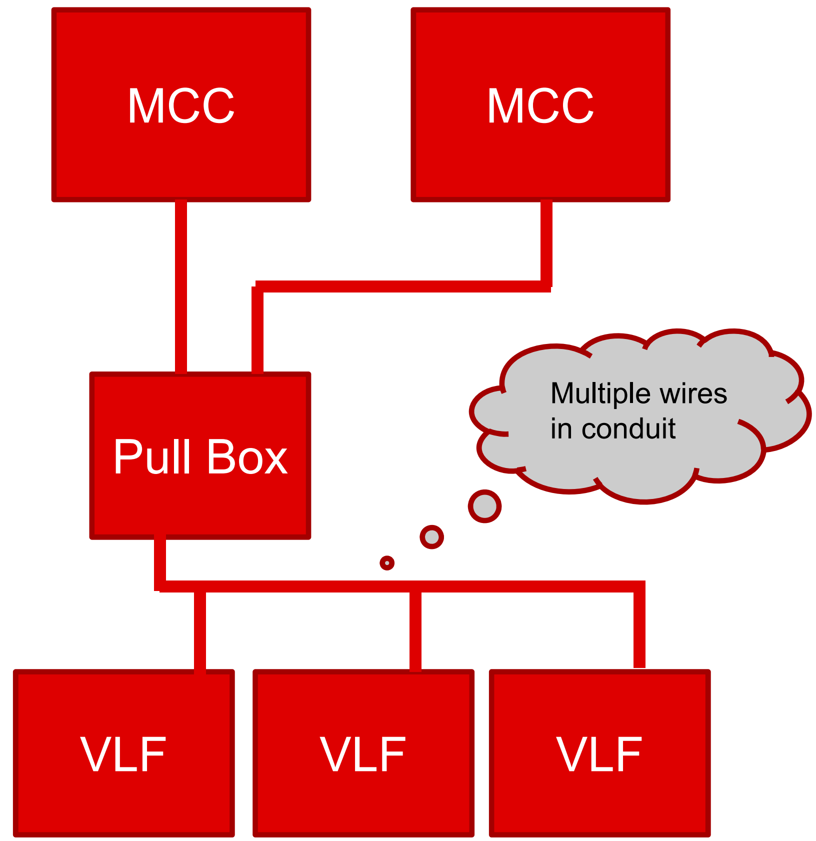
$$BHP_{new} = \left(\frac{RPM_{new}}{RPM_{old}}\right)^3 BHP_{old}$$

Scope of Work

- Retrofit existing MCC buckets to fusible disconnects
- Build unistrut racks and install 52 VACON 100 VFDs
- Install 4 Hirschman Network Switches and tie all VFDs into network for monitoring
- Evaluate, design, build, and install cabinets for 52 Sine Wave filters to support VFDs
- Modify SCADA screens to show new configuration, setup alarming and feedback
- Decrease average velocity to 50 fpm per procedure outlined in DFAB CCB

Why use Sine Wave Filters?

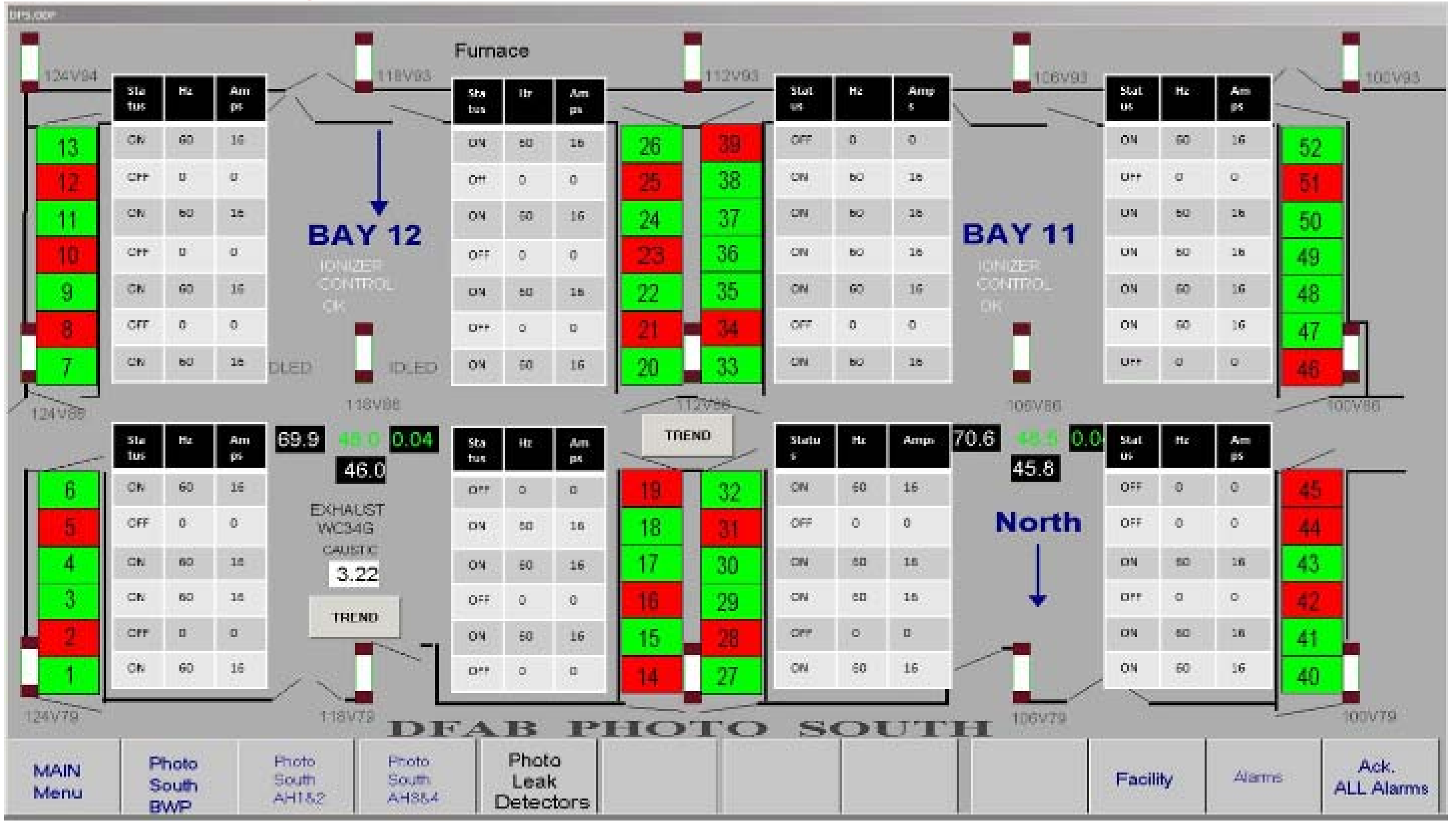
- Found Multiple electrical runs within one conduit from pipe space down to ground floor level
- Reduce risk of electrical induced bearing failure
  - Cleanroom wall removal required to access motors
- Cleans PWM waveforms generated by Variable Frequency Drives (VFDs).
- Eliminates high frequency content and voltage peaks
- Could easily not test power quality at motor



Project Results

- No major issues with VFD installations. Drives were installed and commissioned on a fan by fan basis over the course of two months.
- Other than testing operating range during commissioning, drives were left at 60 Hz after installation until all drives were installed.
- Once all drives were ready and individually commissioned, speed was reduced incrementally while monitoring particle counts.
- During the course of speed reduction, it was noted that some locations started having issues with air flow laminarity even though particle counts remained good.
- Further review determined that air flow issues were being caused by underfloor obstructions. Flow reductions halted before reaching targeted 50 fpm, but did still result in substantial savings.

Pre Project State



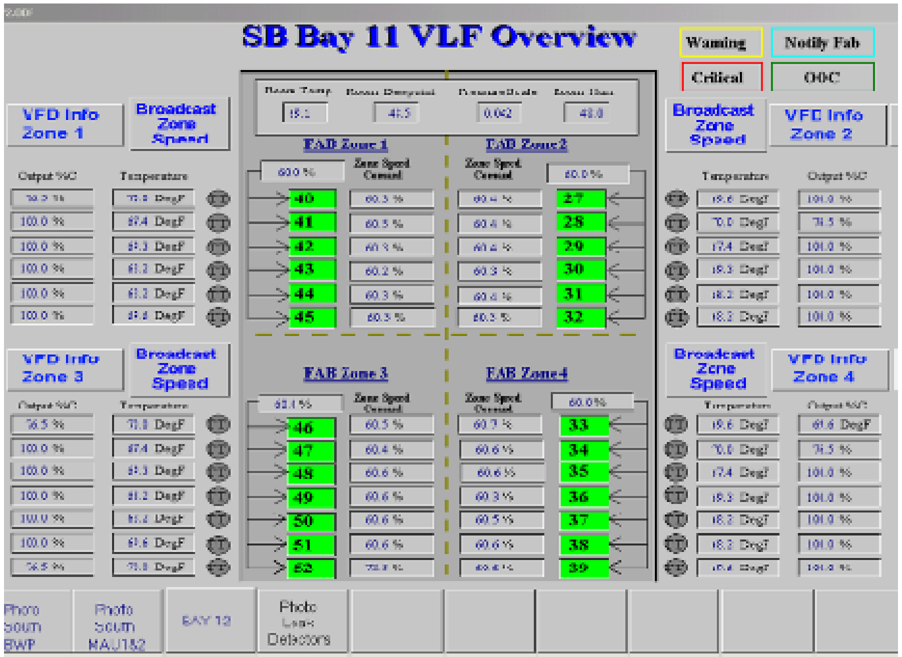
32 of 52 VLFs running

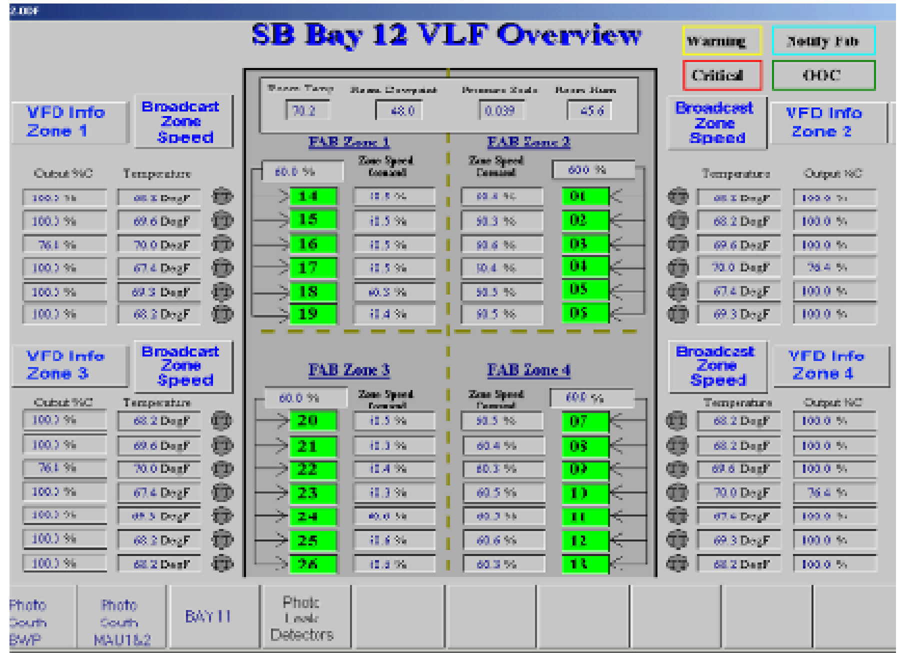
Drives running are at 60 Hz and drawing average of 16 Amps.

Average HEPA face velocity = 95 fpm.

Total Power = 383 kw.

Post Project State





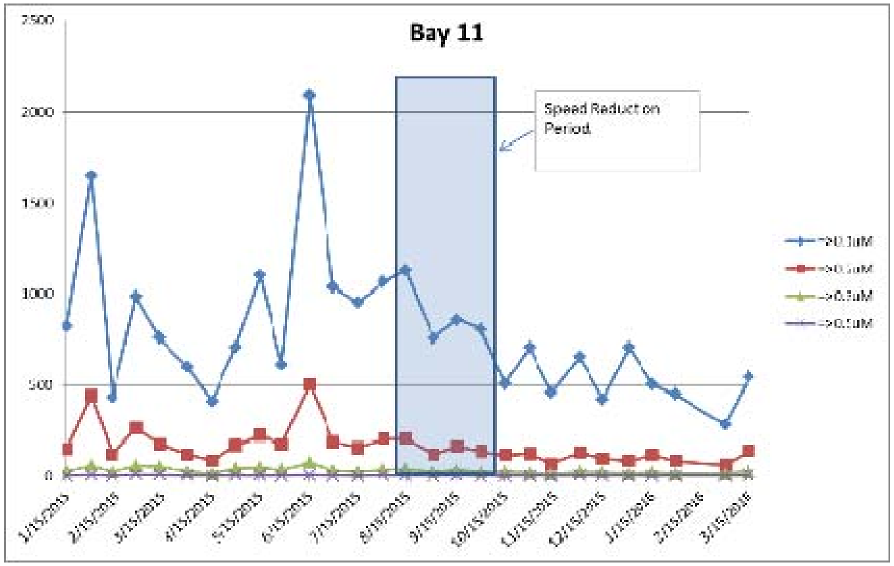
52 of 52 VLFs running @ 45 Hz

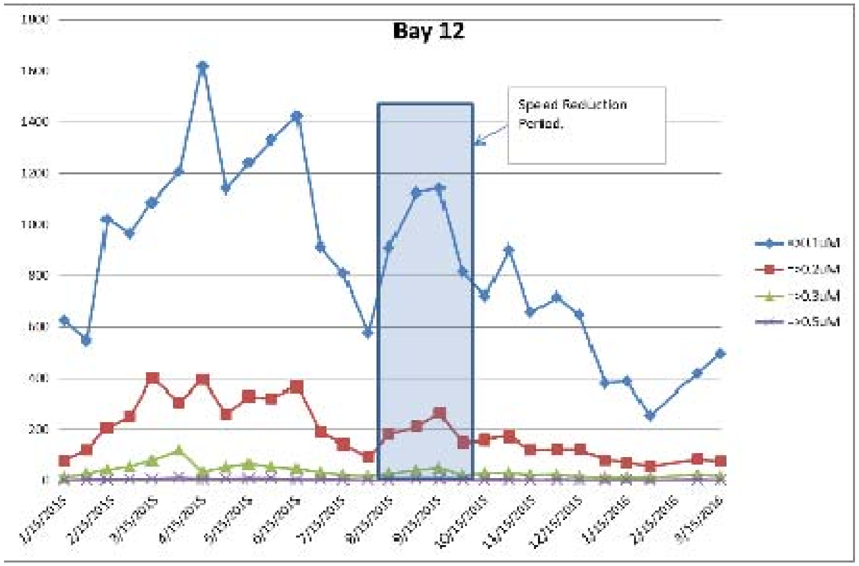
Drives running are drawing average of 7.9 Amps.

Average HEPA face velocity = 80 fpm.

Total Power = 307 kw. 76 kW reduction from original state.

Particle Counts & Room Impact





- Both bays remained in spec and actually showed an improvement in 0.1µ and 0.2µ counts.
- No impact on temperature and humidity.
- No worker complaints or concerns.

Project Summary

- Achieved 76 kw (20%) power reduction. Equal to 665,760 kwh per year.
- Did not achieve full goal of reducing air flow to 50 fpm, but the VFDs provide the flexibility to continue to optimize and reduce energy further in the future.
- Less time required by operations to manage rotation of equipment. Will equalize run time between fans.

Approximate Costs		
Description	Qty	Extended Price
Vacon 100 15 HP Drives	52	$52,000.00
Sine Wave Filters	53	$51,000.00
Mechanical & Electrical Installation	1	$73,000.00
Controls	1	$71,000.00
Commissioning	1	$10,000.00
Total		$257,000.00

Questions?

M-braby1@ti.com

Open Discussion - Questions

Thank you!

Enjoy the Remainder of the Summit!

U.S. DEPARTMENT OF ENERGY