Best Practices in Energy Efficiency

Tom Sherman C.E.M., C.E.A., C.D.S.M.
President
Sustainable Energy Services, Inc.

440.773.5044 Tom@sustainable-energy-services.com

How Do You Buy What You Can't Afford?

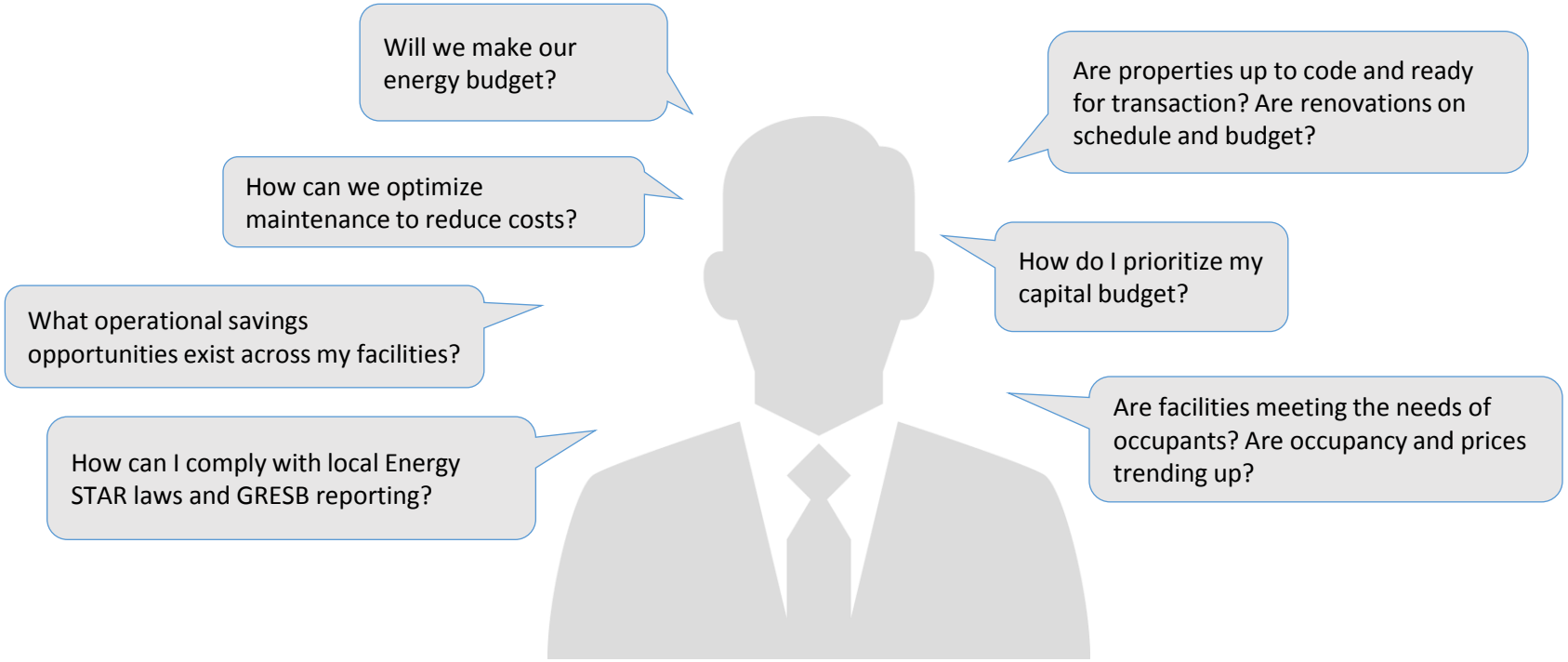
Pay Your Utility Less!

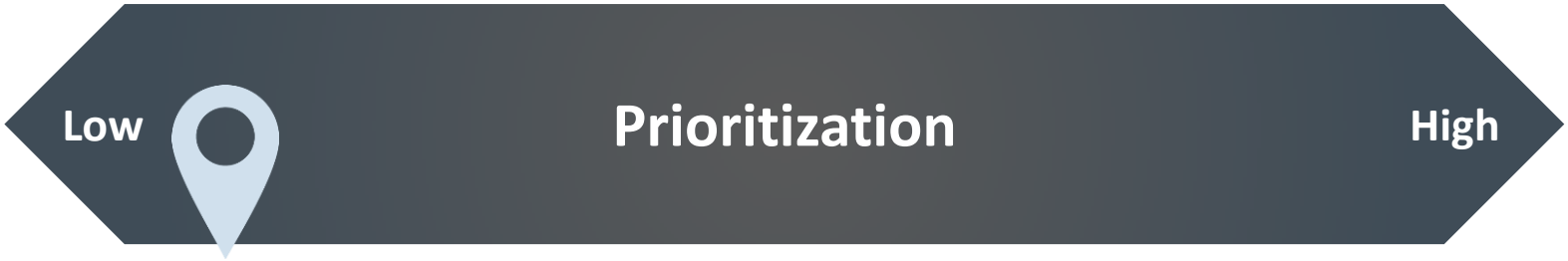
SUSTAINABLE Energy Services

What We Will Cover Today

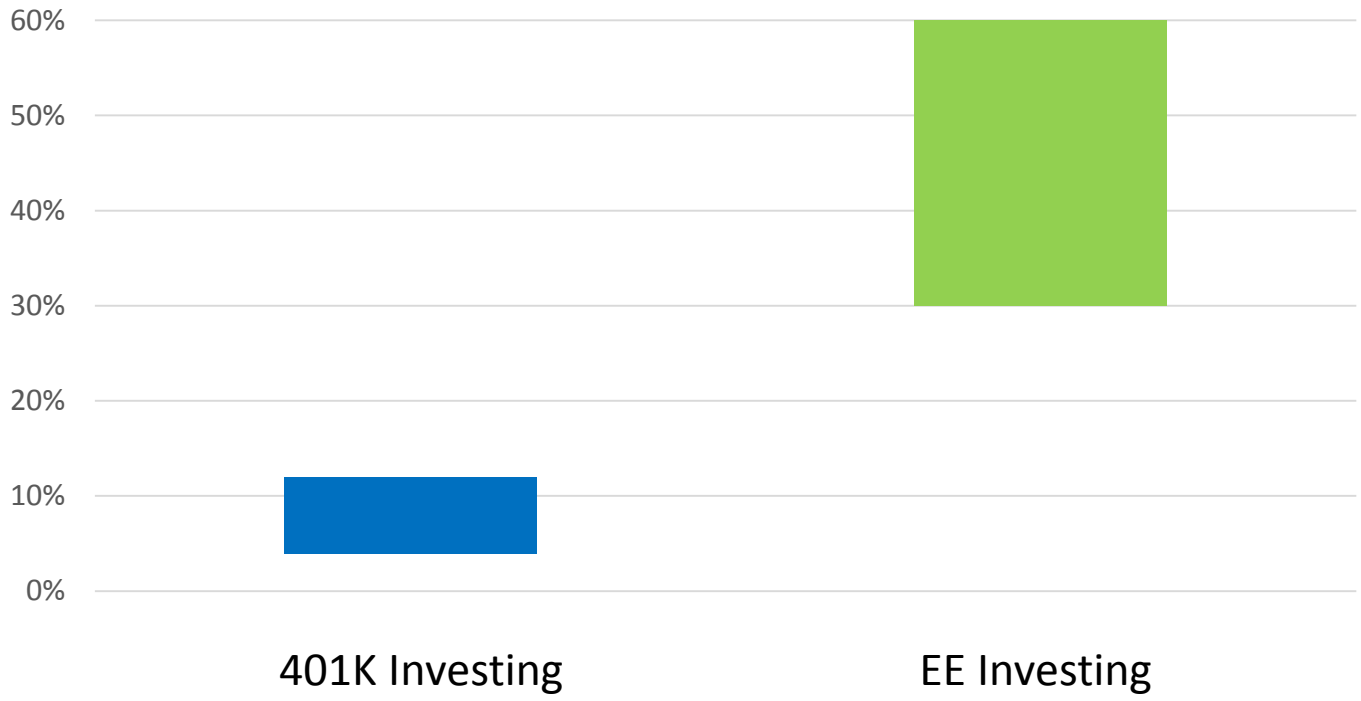
- Where to Start
- Lighting
- HVAC
- Building Envelope
- Motors and Pumps
- Motor Management
- Motor Preventive Maintenance
- Rebates
- Project Financing

Energy management competes with other priorities



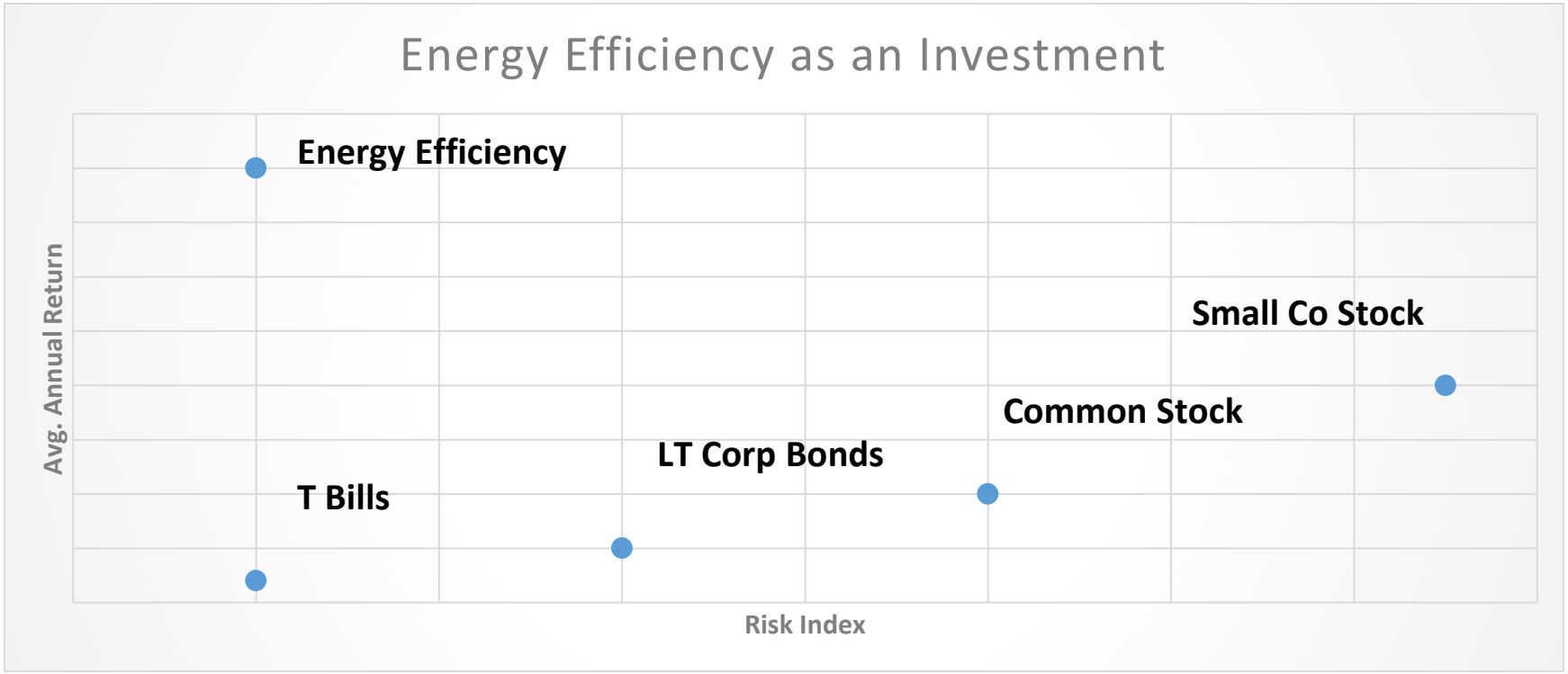


What Holds Decision Makers Back?



50% of Home Depot Shoppers Interviewed said a "Watt" is a Unit of Light!

How Energy Efficiency Stacks up



What 200 CFO's Said!

- Average required hurdle rate for core projects = 21%
- Average required hurdle rate for non-core projects = 27%

So why do core projects get favored treatment?

…because core projects generate additional benefits!

A Robust Energy Efficiency Program

Will…

- decrease energy costs 20% and more…
- reduce operating costs
- increase cash flow
- improve the environment
- improve facility sustainability
- provide a great marketing op
- Improve employee productivity
- improve employee morale

How will you get there?

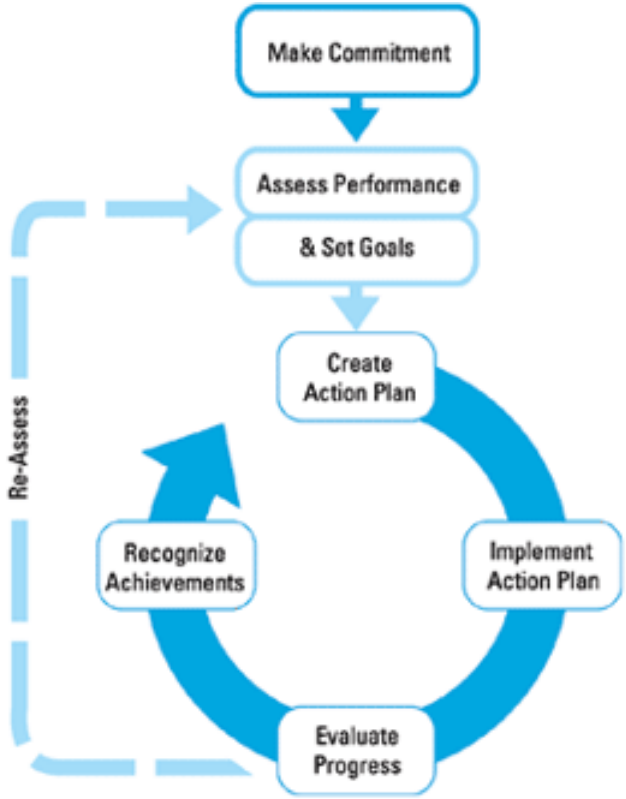
Do you have…

- a plan?
- the expertise?
- the tools?
- a road map?
- a champion?

Getting Started

- You need a Champion (senior level)
- Assess ‘Current State’
- Decide on ‘Future State’ – The Goal
- Assemble the Team
- Develop a Plan
- Implement
- Evaluate
- Correct as required

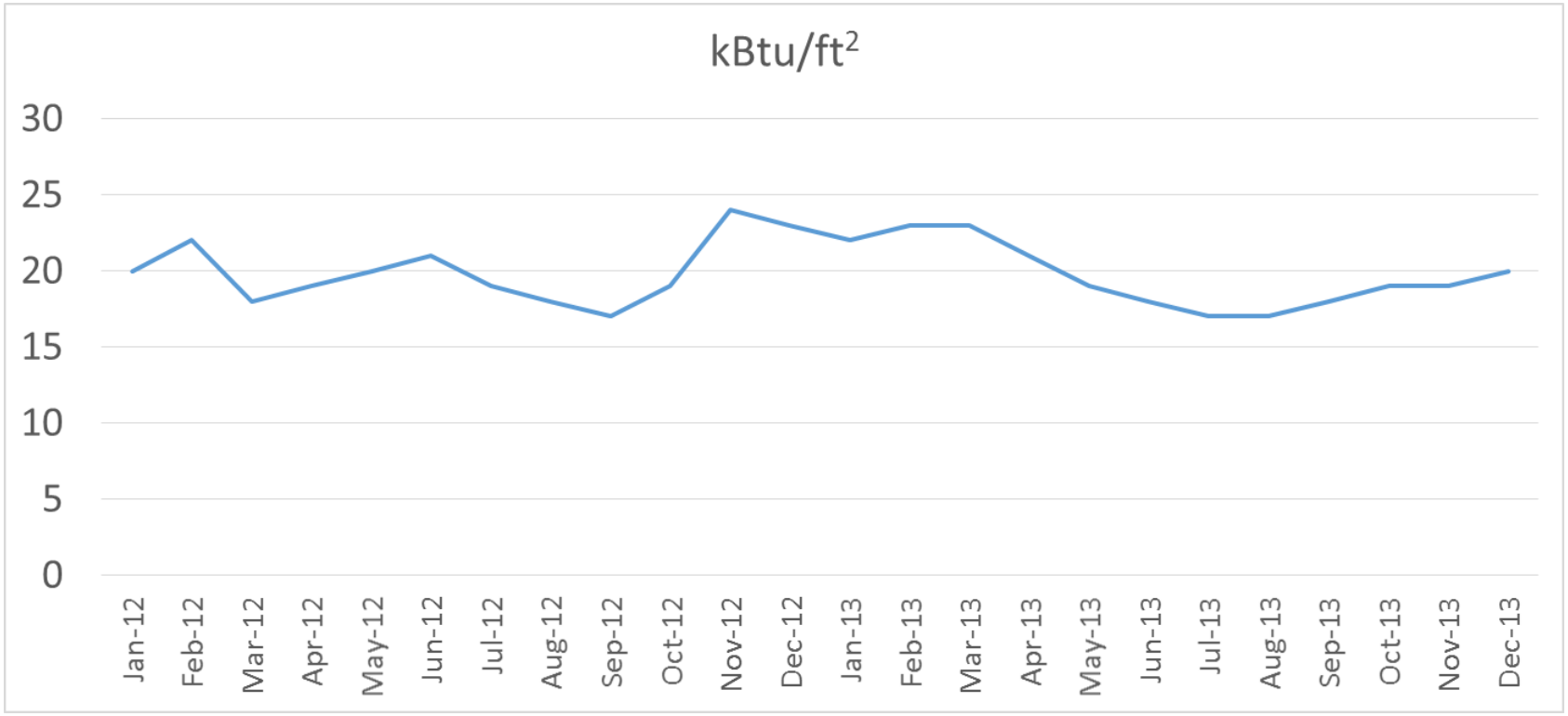
www.EnergyStar.gov



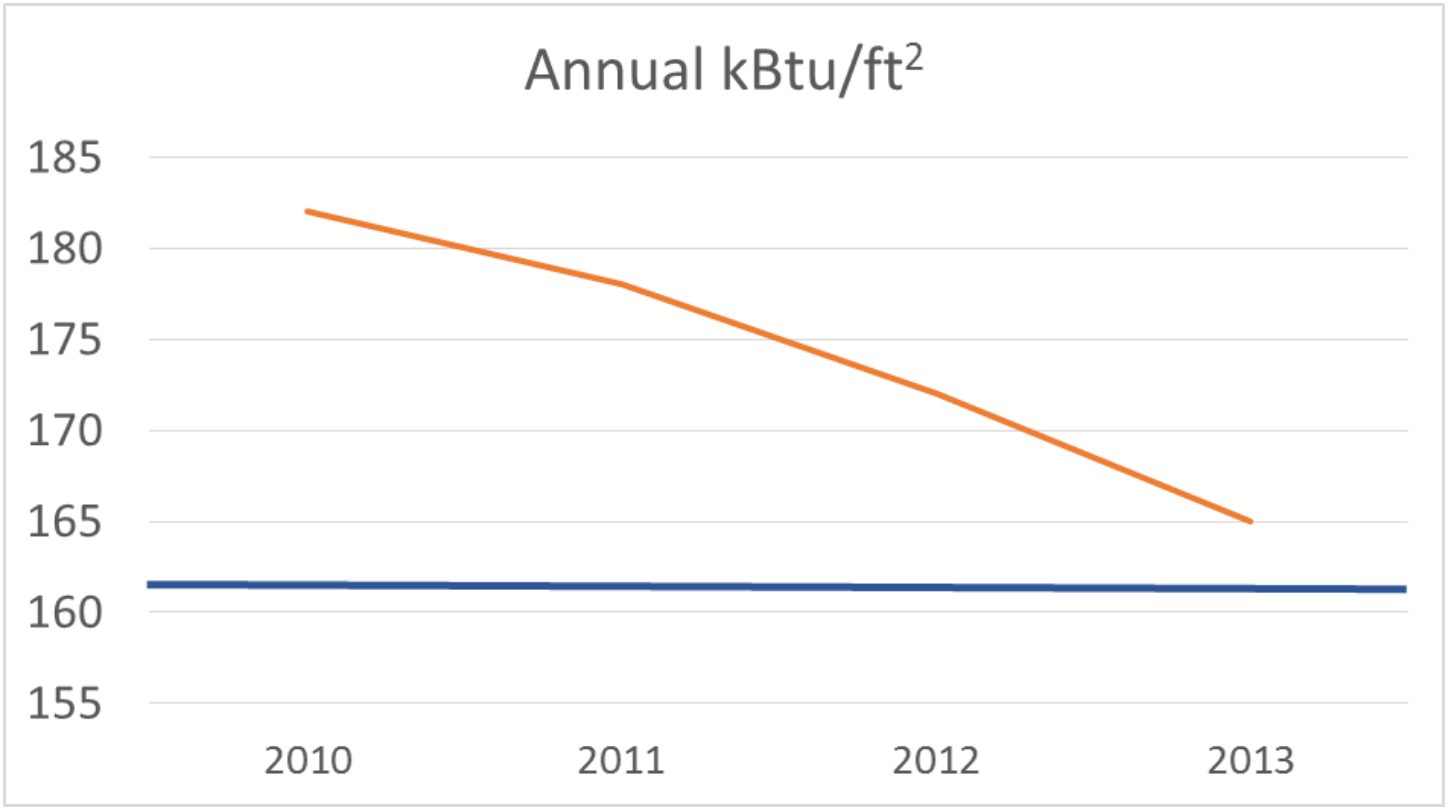
Use only qualified, independent energy auditor

- Encompass Whole Facility
  - Find all the savings possibilities
- Insist on ASHRAE Level 2 Energy Audit
  - American Society of Heating, Refrigeration and Air Conditioning Engineers
  - Level 2 ensures technical and financial analysis for decision making
- Use Independent Qualified Firm
  - Required for objectivity and utility incentives
  - Look for C.E.M. or C.E.A. certification
  - Independent: No tie to any equipment supplier or contractor
- Utilities Offer Energy Audit Incentives
  - Some utilities pay up to 50% of the energy audit fee

Start With A Baseline – 2 years of data min



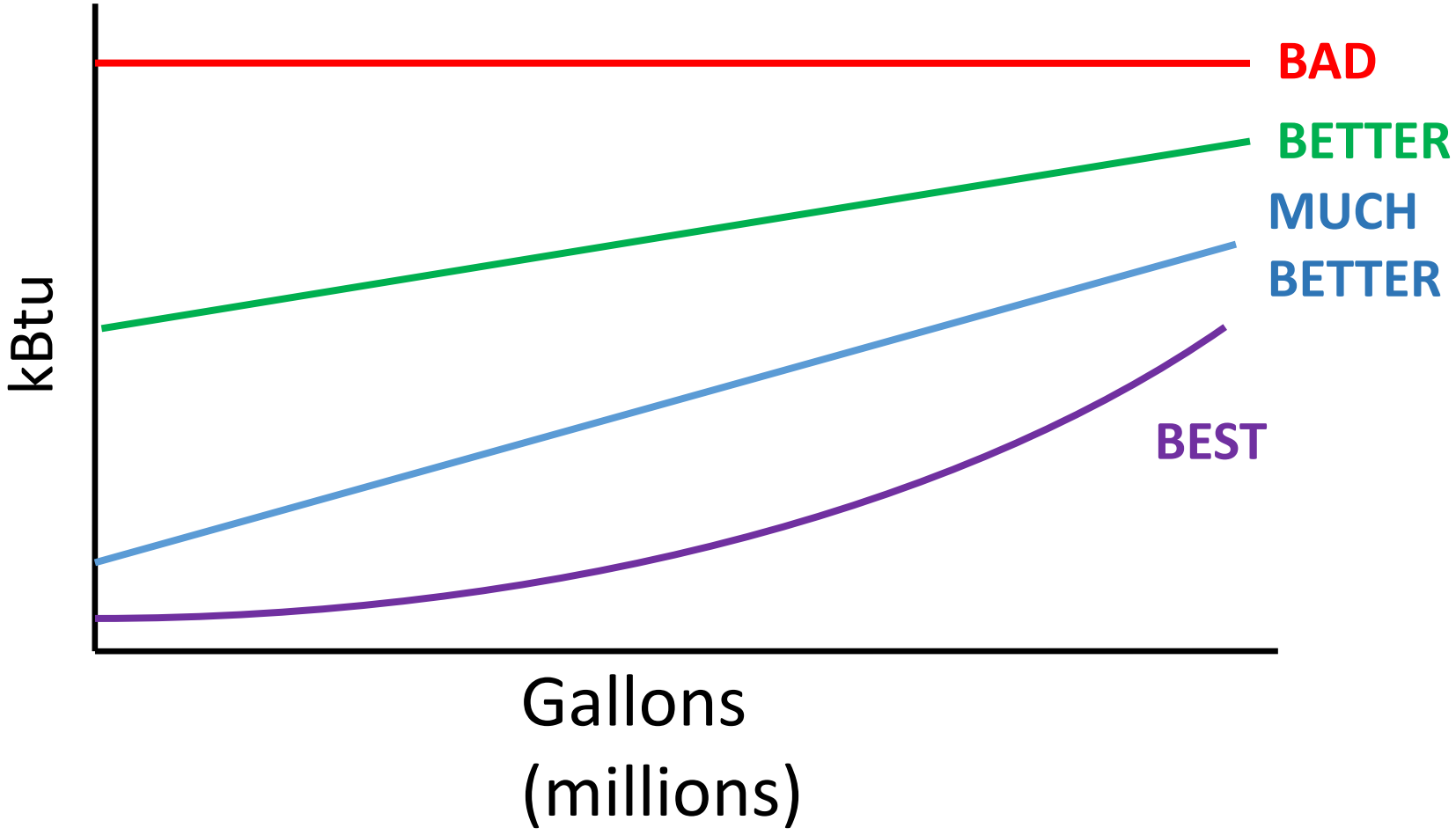
Goal is to improve vs benchmark



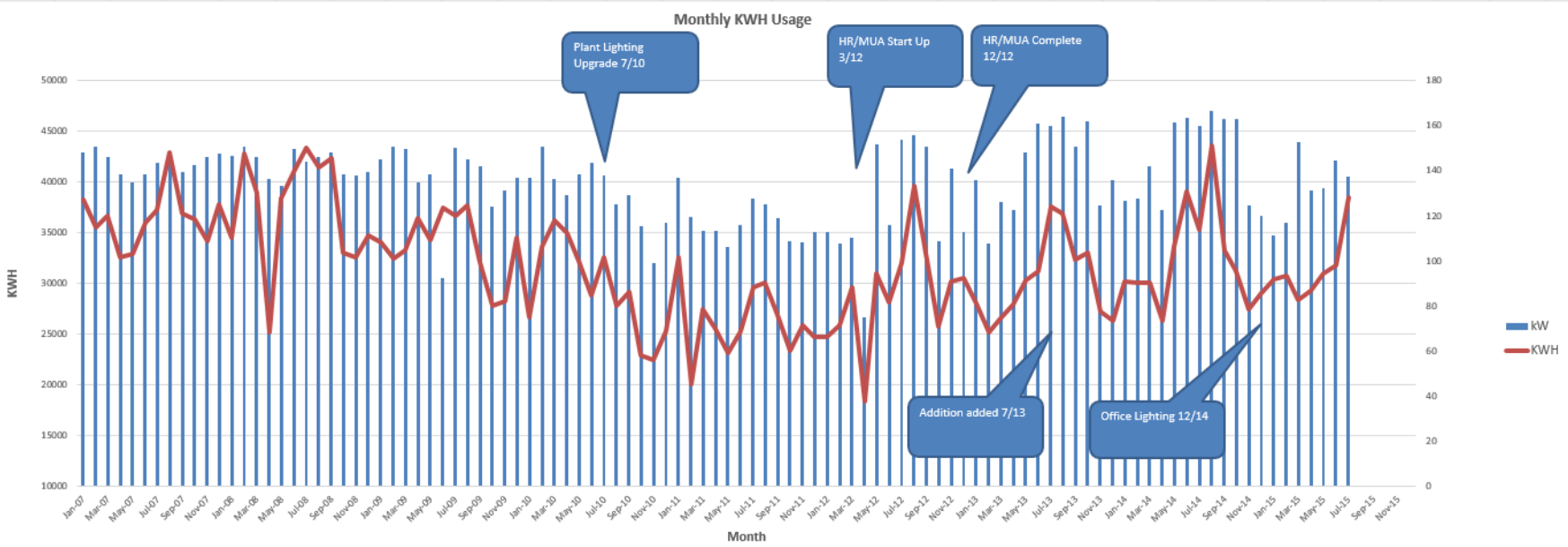
Energy Star: One Source for Benchmark Data
energystar.gov

Water Treatment Plants 2.89 kBtu / gallon per day

Track Energy to Flow



Insert project completion dates



	2007	2008	2009	2010	2011	2012	2013	2014
Total KWH	436,800	447,360	404,280	351,880	314,080	347,697	362,120	388,560
Percent Change		2%	-10%	-13%	-11%	11%	4%	7%

Isolate Major Contributors

- Understand the major contributors to your kBtu/gallon
- Year to year weather differences can affect data (CDD and HDD)
- If peak demand (kW, kVA, kVars) is part of your electric rate, know the major contributors and operating schedule

Be Careful How You Measure it

NFPA 70E Label – Required by OSHA, NEC

Sample arc flash label created using AFA v4.1 software

WARNING

Arc Flash and Shock Hazard
Appropriate PPE Required

Equipment type	600 V Switchgear
Grounding	Grounded
Working distance	18 inches
Available 3Ph bolted current	20 kA
Limited approach boundary	42 inches
Restricted approach boundary	12 inches
Prohibited approach boundary	1 inches
Incident energy at work distance	4.85 cal/cm2
Flash protection boundary	47 inches
Hazard Risk Category	2
Equipment name	PANEL ABC

Sample arc flash label created using AFA v4.1 software (alternate layout)

WARNING

Arc Flash Hazard
Appropriate PPE Required

Equipment Type	600V Switchgear
Grounding	Grounded
Work Distance	23 inches (600 mm)
Available 3-Ph Bolted Current	45 kA
Flash Protection Boundary	200 inches
Incident Energy at 23 inches	28.95 cal/cm2
PPE Level	4

Label created and printed from www.arcadvisor.com

Typical Energy Audit Findings

- Lighting
- HVAC
- Motors
- Pumps
- Equipment
- Building Envelope
  - Windows
  - Insulation
  - Infiltration

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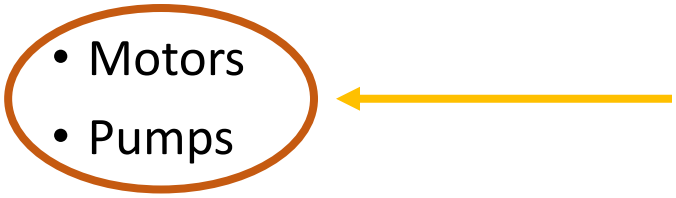


The Biggest Savings Opportunity

Do No Cost / Low Cost First

- Promote awareness
- Shop electric along with natural gas
- Consider ***Demand Response*** programs
- Adjust schedules – off peak power
- Add occupancy sensors
- Repair compressed air leaks
- Reduce compressed air pressure
- Seal openings to outside air

More Low Cost/No Cost Areas

- Implement Bi-level lighting
- Set back thermostats
- Shut off PC’s and other eqmt at night
- Shut off any unused equipment during day
- Cycle A/C units at different intervals

More Low Cost/No Cost Areas

- Change filters in air movers regularly
- Locate compressor air intakes in coolest area
- Add de-stratification fans
- Use V-notched belts for belt-drives
- Insulate furnaces, pipes, etc.
- Increase recycling efforts

LIGHTING

High Bay Lighting

Lighting

Example: Single High Bay Fixture; On 24 / 365

	HID	Fluorescent	LED	Induction
Fixture W	458	254	180	200
kWh/year	4030	1927	1577	1752
Cost/kWh	$0.12	$0.12	$0.12	$0.12
Cost/year	$484	$231	$189	$210
Life of bulb	15,000 hrs	35,000 hrs	70,000 hrs	100,000 hrs
Rebate	$0	$105	$122	$114

2 x 4 Office Ceiling Fixture

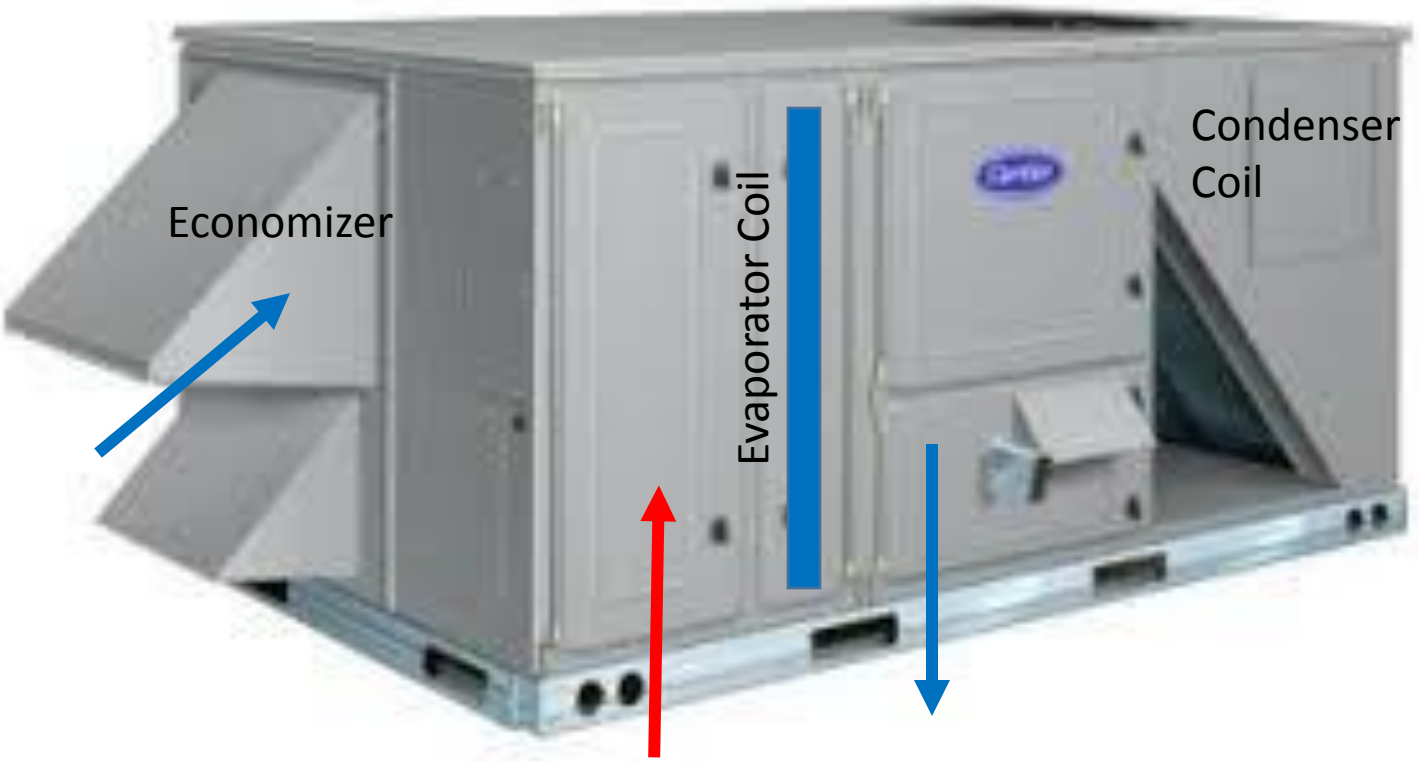
Lighting

Example: Single 2 x4 Office Ceiling Fixture; On 12 / 260

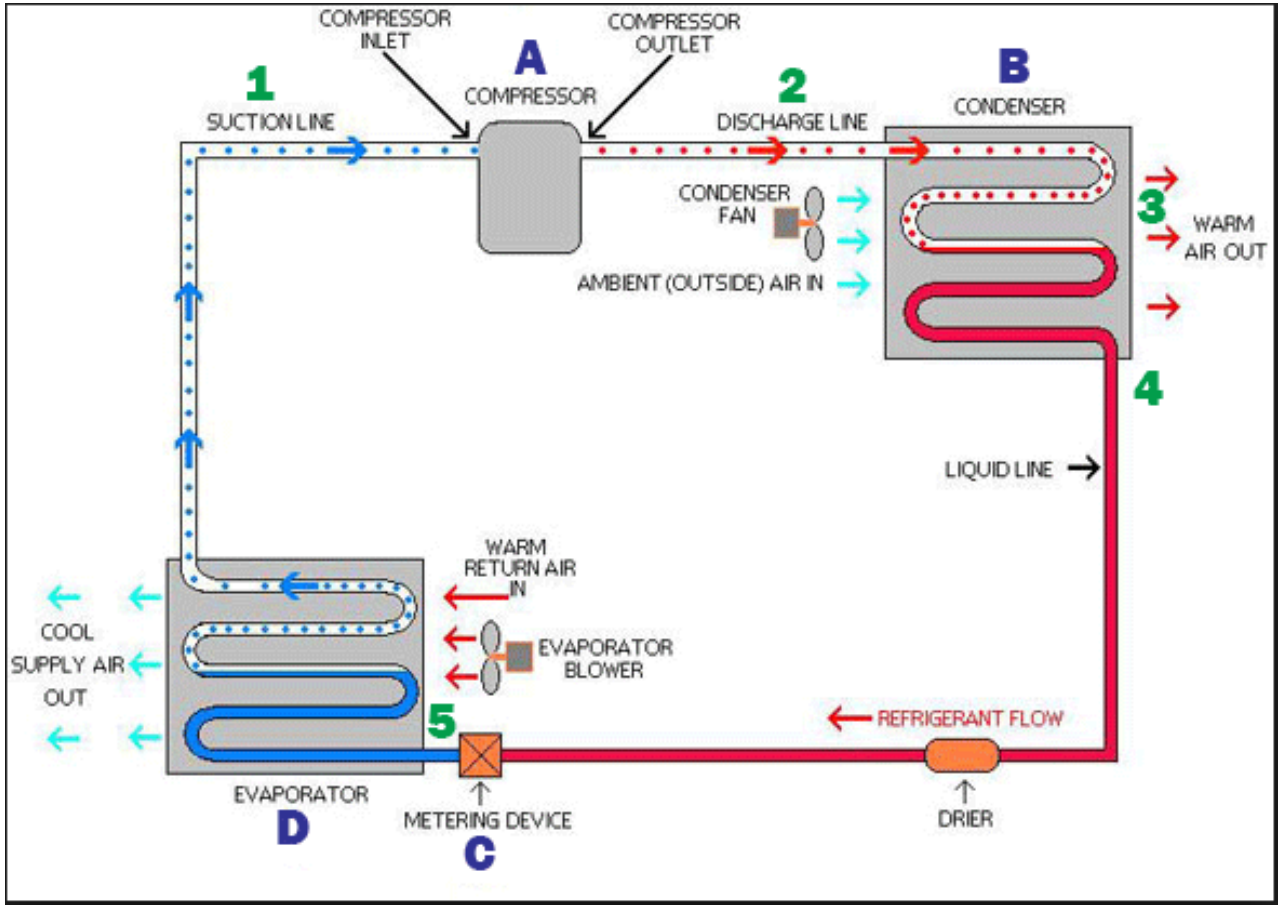
	T12 Fluorescent	T8 Fluorescent	LED
Fixture W	160	112	36
kWh/year	499	349	112
Cost/kWh	$0.12	$0.12	$0.12
Cost/year	$60	$42	$13
Life of bulb	15,000 hrs	35,000 hrs	70,000 hrs
Rebate	$0	$7.5	$19.35

HVAC

HVAC – Typical Roof Top Unit

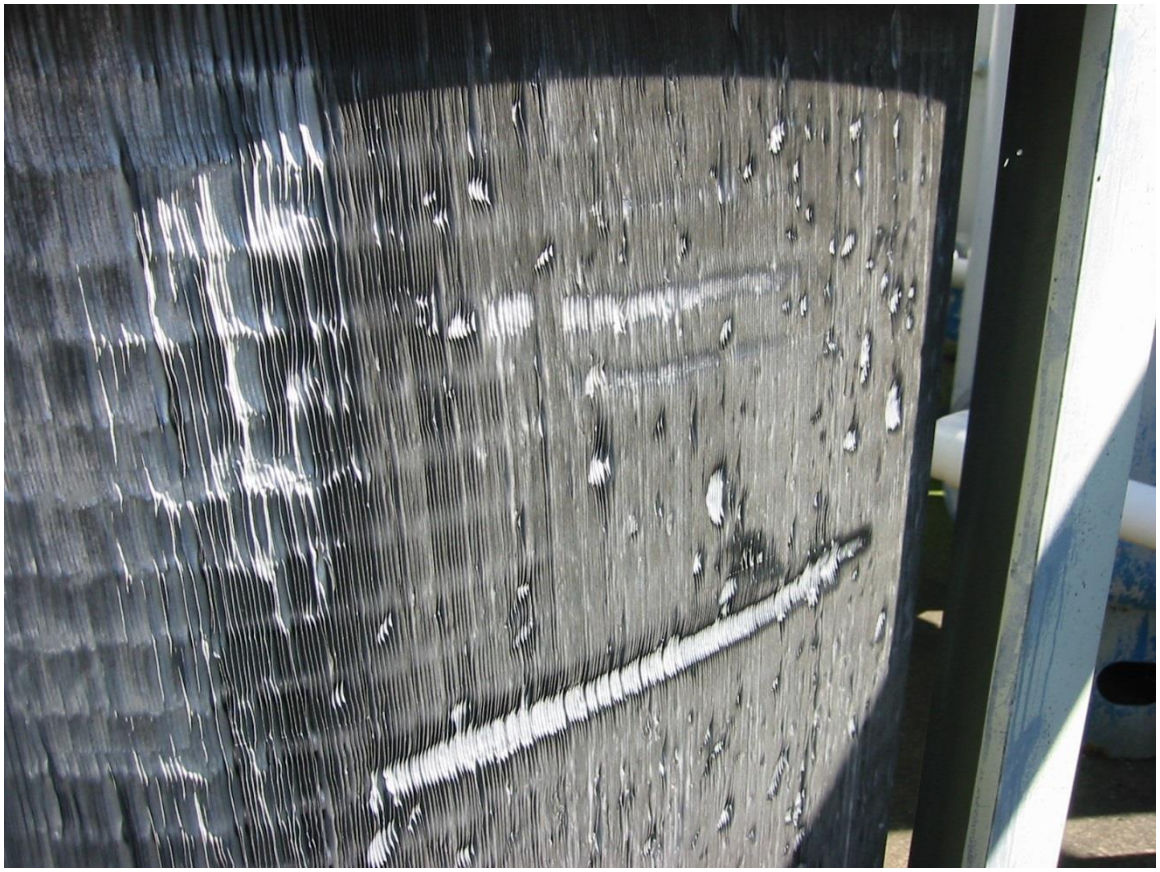


HVAC – Compression Cycle



HVAC – Condenser Coil Debris Accum.

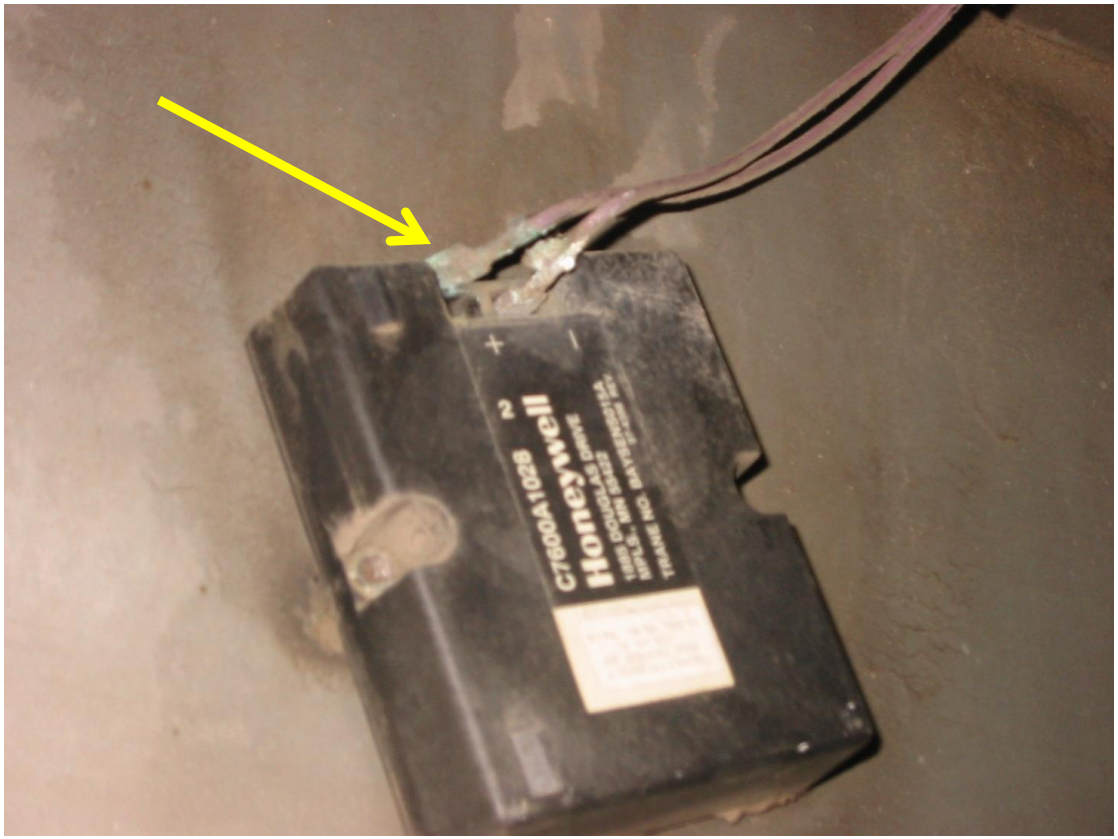
HVAC – Condenser Coil Hail Damage



HVAC – Economizer Screen

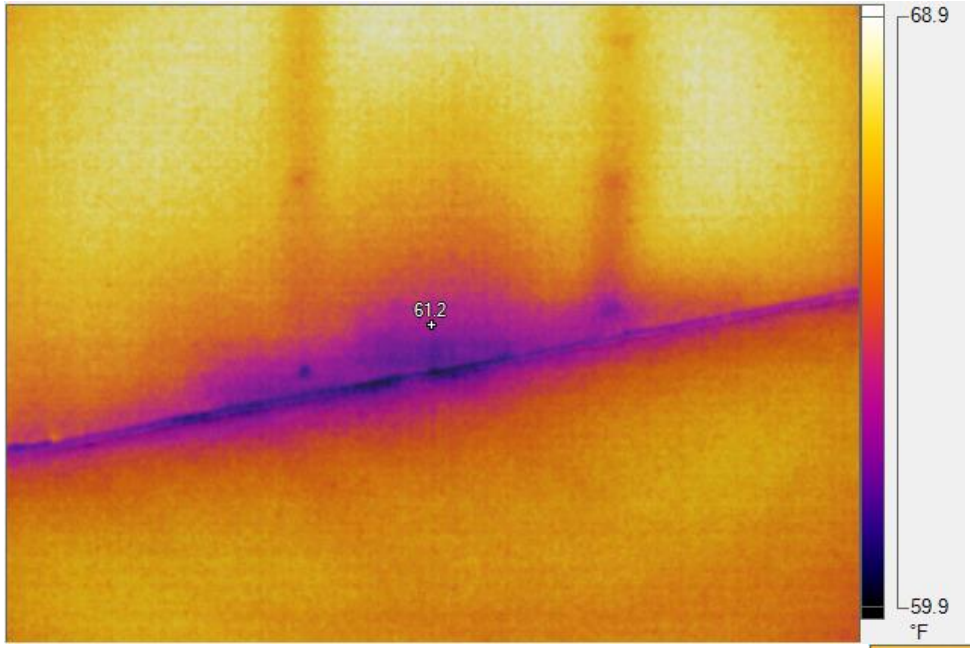
HVAC – Economizer Screen

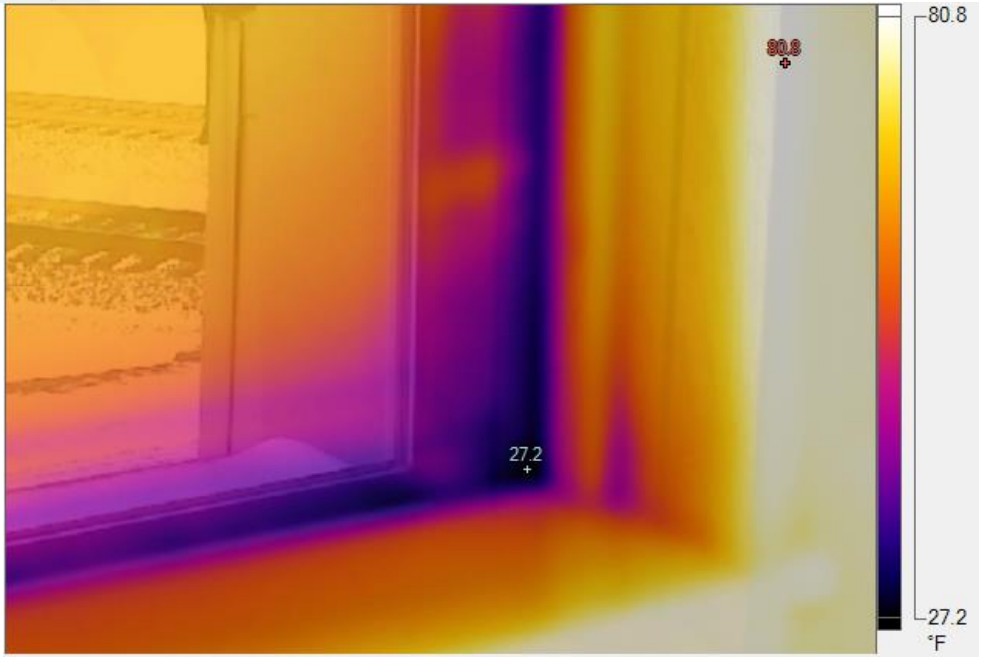
Hvac – Economizer Enthalpy Sensor



HVAC - Building Envelope

- Windows, doors, insulation, sealing


68.9
61.2
59.9
°F


80.8
80.8
27.2
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°F

Motors and Drives

Motors and Pumps

- Motors consume 90% of the energy in pumping stations
- Motors are the largest opportunity for savings money
- Running a motor costs more than 10 times its purchase price each year in energy costs alone
- Over life of motor, 98%+ of cost of ownership is operating cost

If owning a car was like owning a motor

- Purchase price = $30,000
- Annual operating cost = $500,000
- Operating cost over life of car = $4,000,000

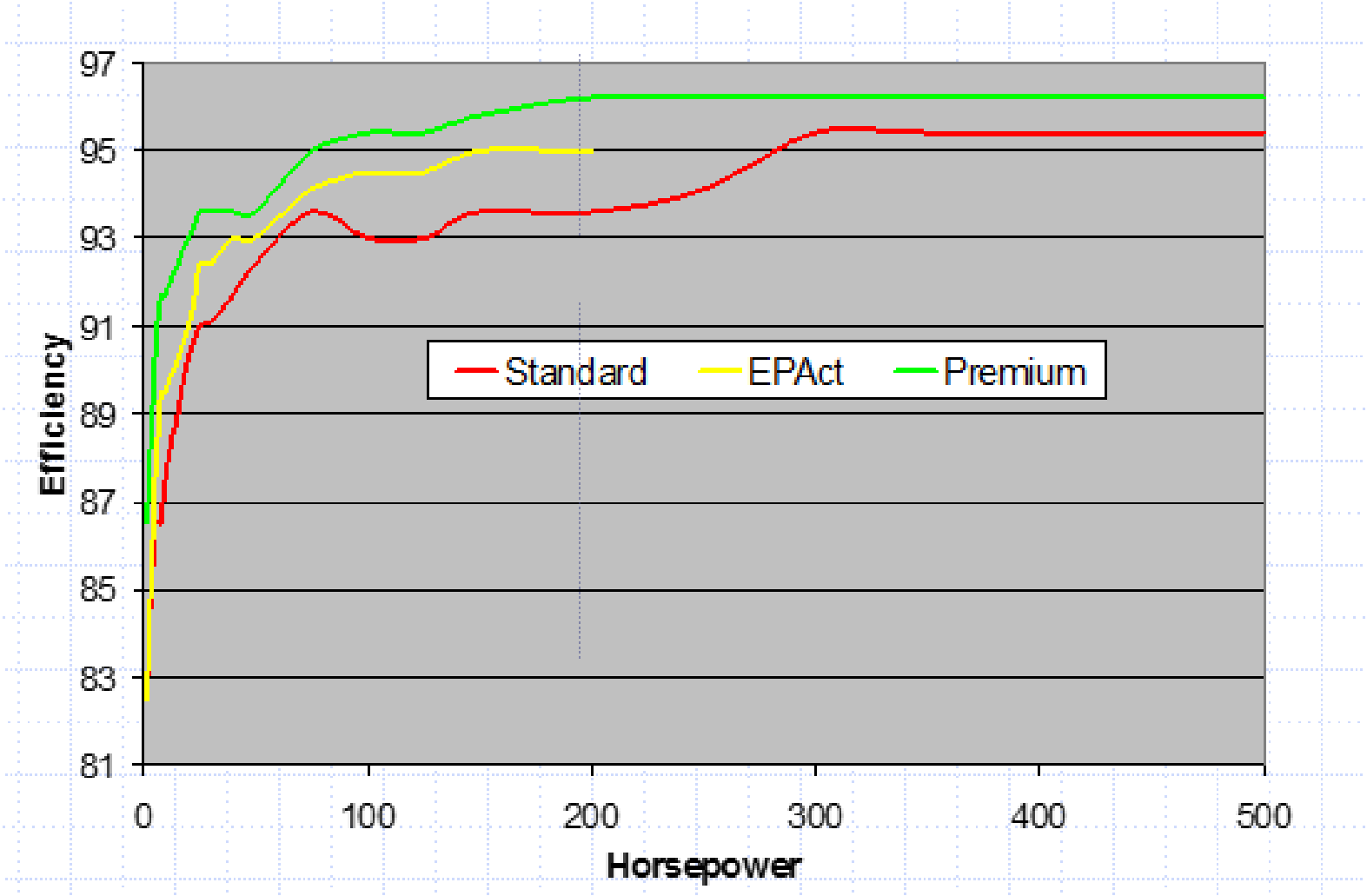
What would you be willing to do
to make your car run more efficiently?

How important is purchase price to you now?

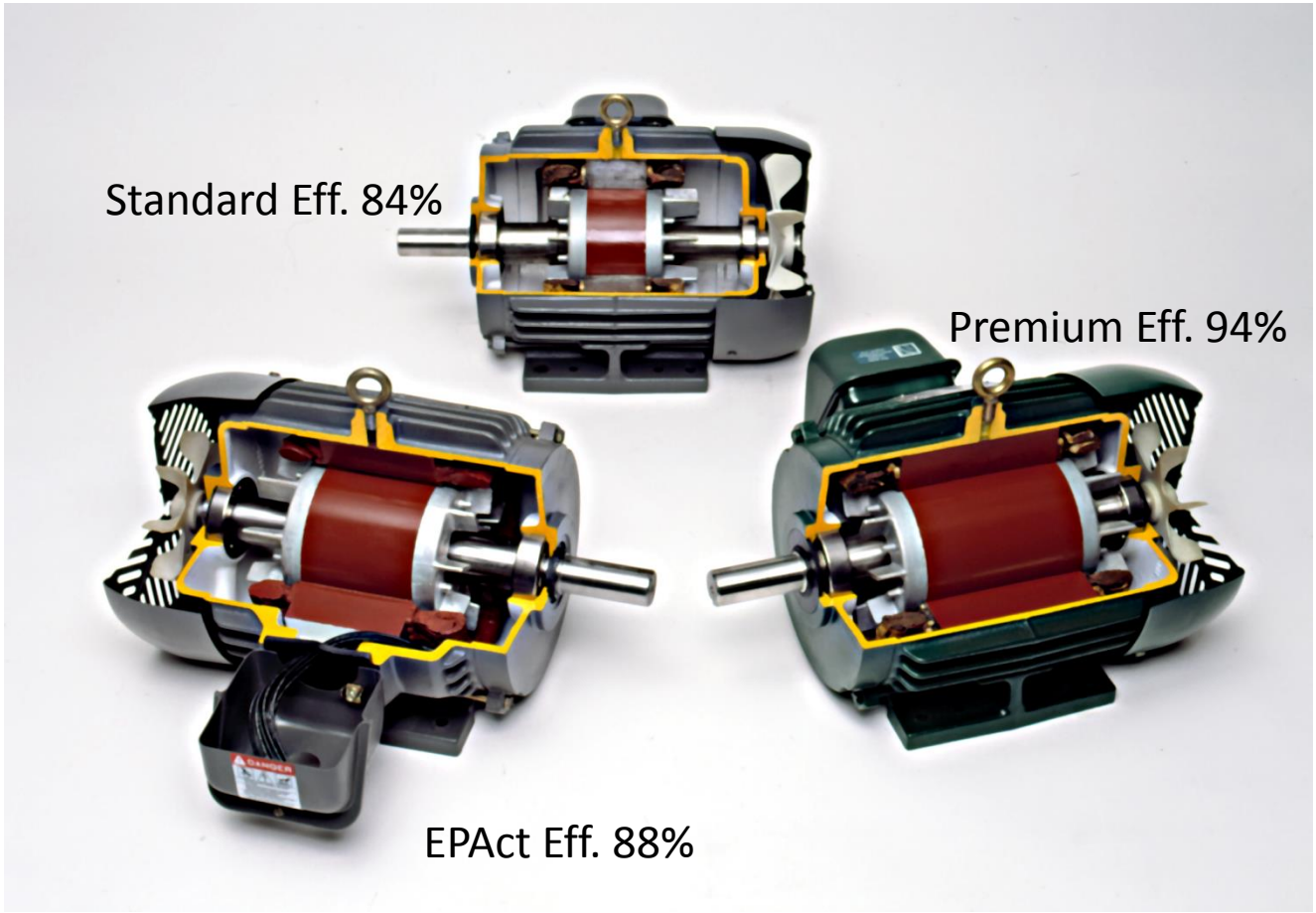
Motor Basics

- Standard Efficiency
  - Most motors today where installed before 1997
  - Typical efficiency is 83% to 90%
- EPAct Motors
  - Energy Policy Act of 1992
  - Effective October 1997
  - Typical efficiency is 87% to 92%
- NEMA Premium Motors
  - Energy Independence and Security Act 2007
  - Effective December 2010
  - Typical efficiency is 91% to 95%
- DOE Extending Range for Premium Efficiency Motors with Effectivity June 2016
  - New rule adds NEMA - A, B, C and IEC - N, H plus specials in 1HP to 500HP
  - Applies to 5 million units vs 1.6 – 2 million units currently
  - Current rule affects 18 million connected HP; ne rule affects 50 million HP

Motor Basics



Differences in Motor Construction
10 HP, 1200 RPM

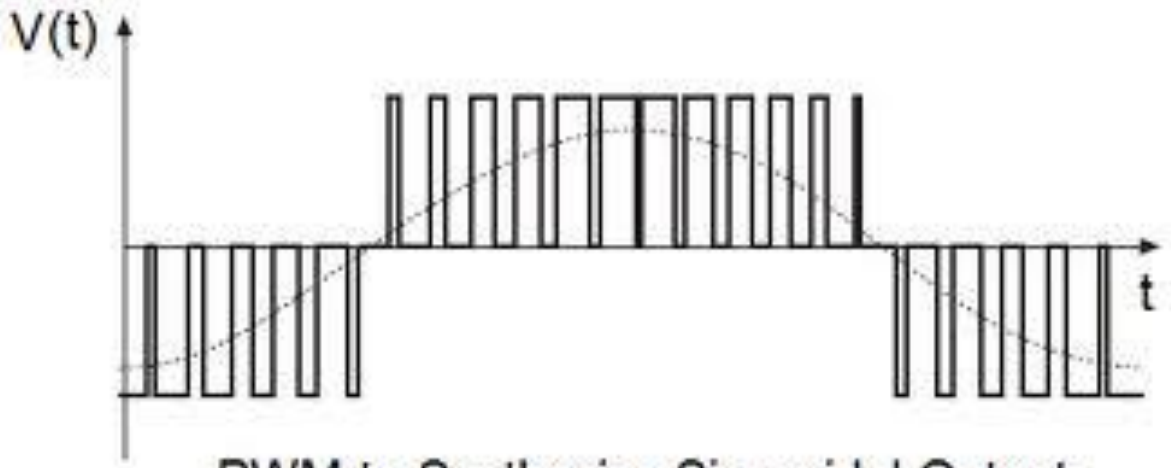


Inverter Grade Motors

- NEMA Premium Efficiency features plus
- Beginning and ending of windings are separated
- Extra insulation to protect against voltage spikes
- Wound with inverter grade magnet wire (for voltage spikes)
- Designed to handle higher frequency components
- Either rated for higher temperatures or constant speed cooling fan on auxiliary power for low speeds
- Will provide full-rated torque at zero speed and well past base speed

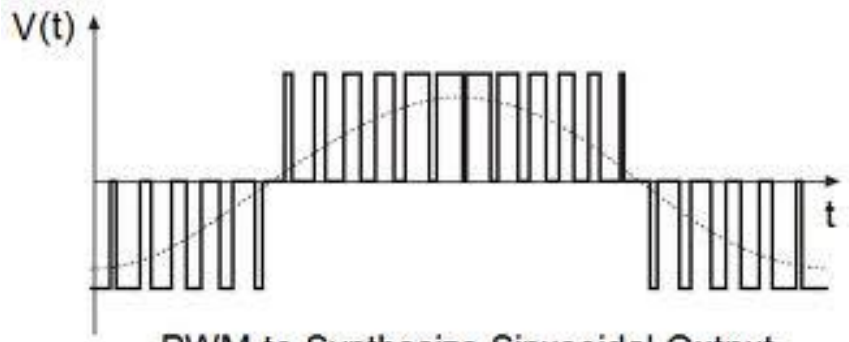
VFD Basics

VFD Output Voltage – PWM

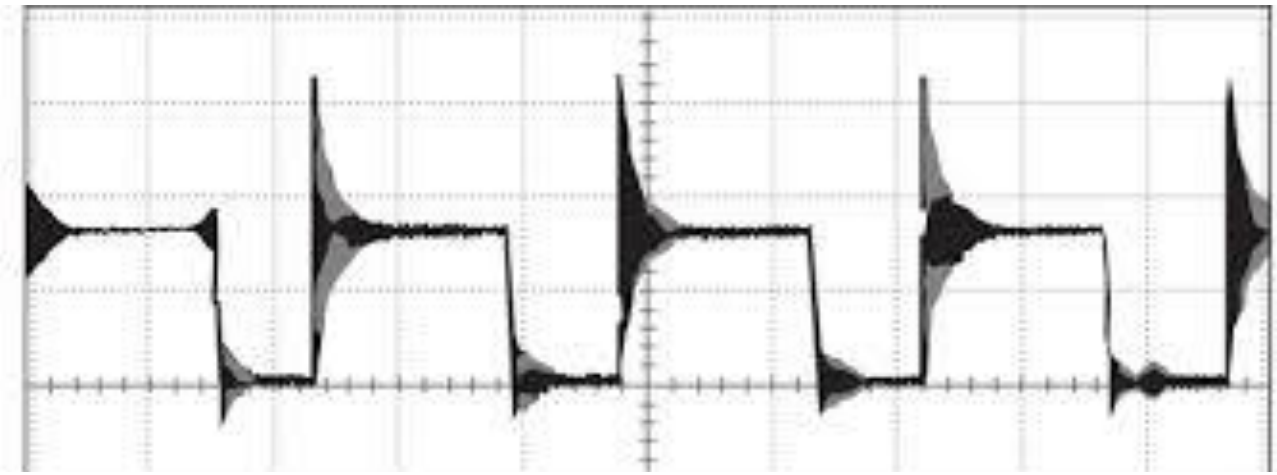


PWM to Synthesize Sinusoidal Output

VFD Output Voltage – Reflected Wave



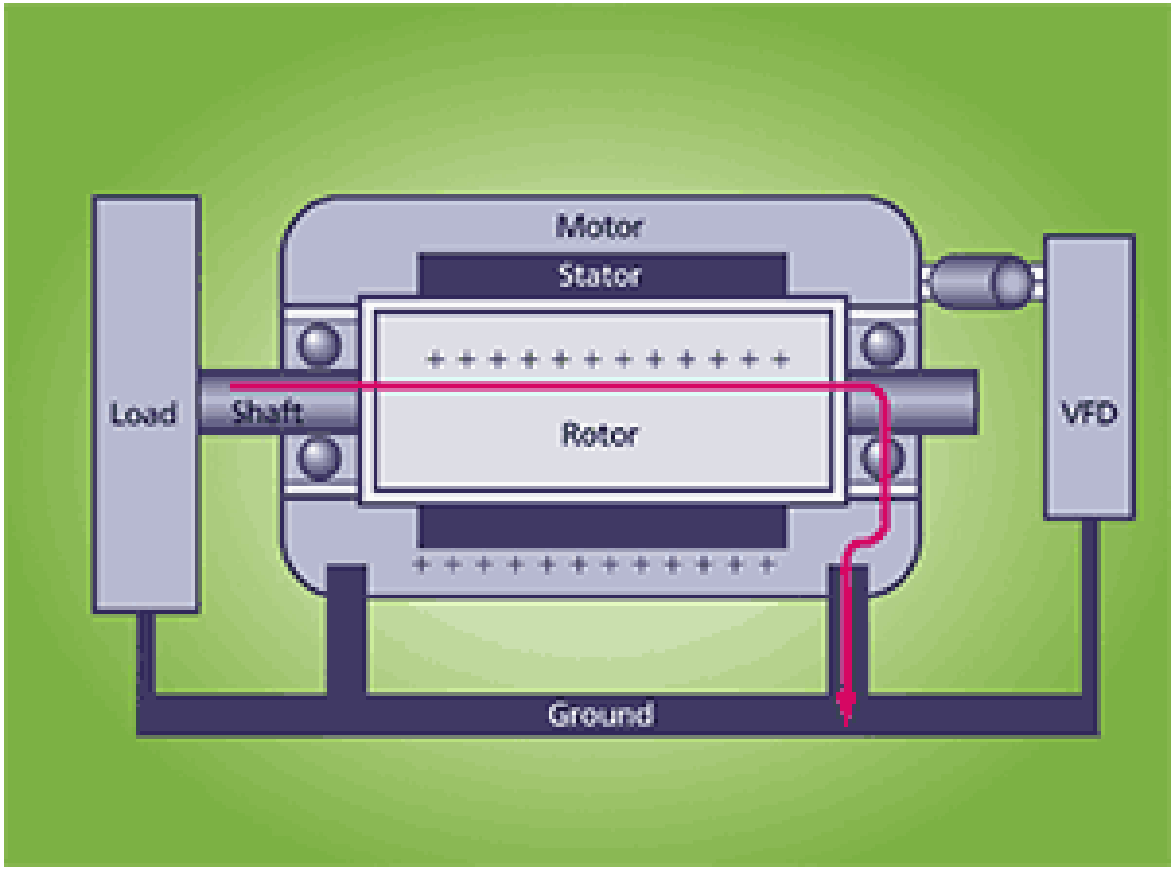
PWM to Synthesize Sinusoidal Output



Rapid dV/dT !!!

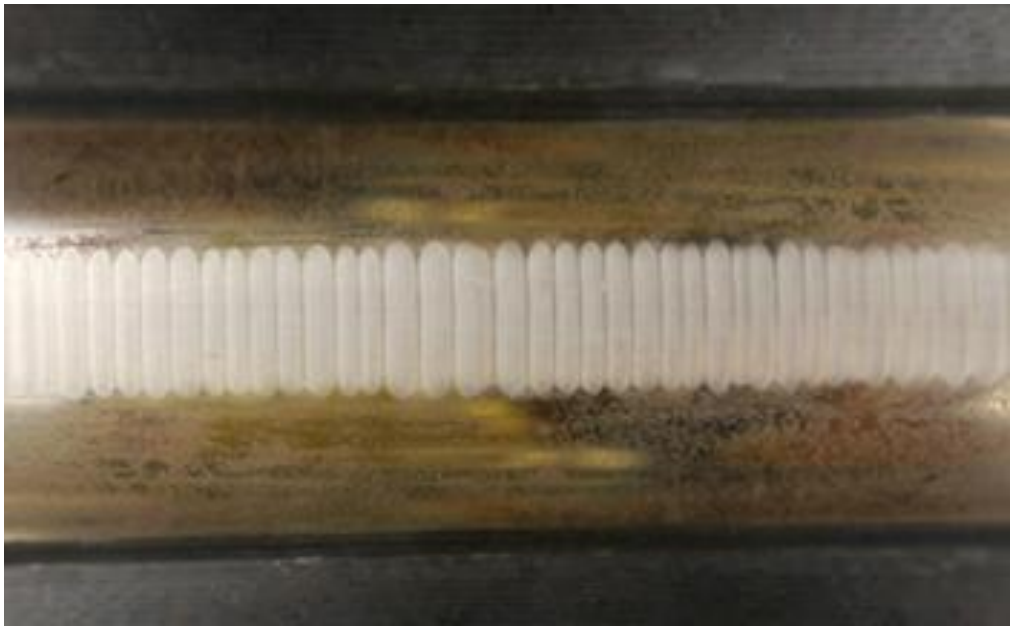
VFD Output Voltage – Insulation Failure

VFD Caused Bearing Wear

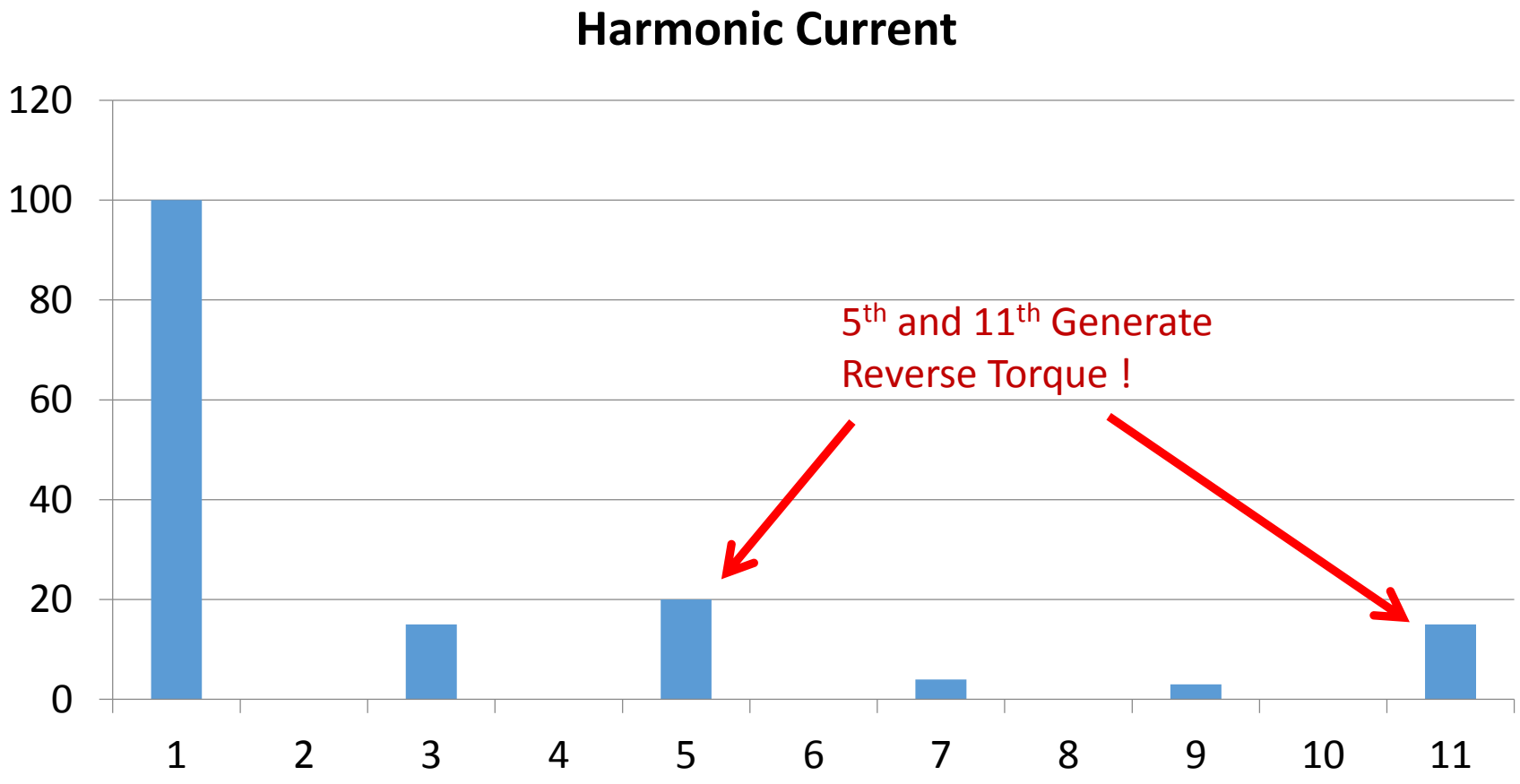


- Capacitive coupled leakage current
- Static electricity from load

Fluting in Bearing Chase Caused by Leakage Current



Negative Sequencing



Do VFD Drives Make Sense?

HP = 300 $/kWh = $0.09
Hours = 8760 $/kW = $ 7

Standard Motor	NEMA Prem Eff Motor	With VFD
$221,867	$203,378	$126,184

Save $18,489 annually with a more efficient motor

OR…save $95,683 annually by adding a VFD to the same more efficient motor

Investing in a 300HP Motor with VFD

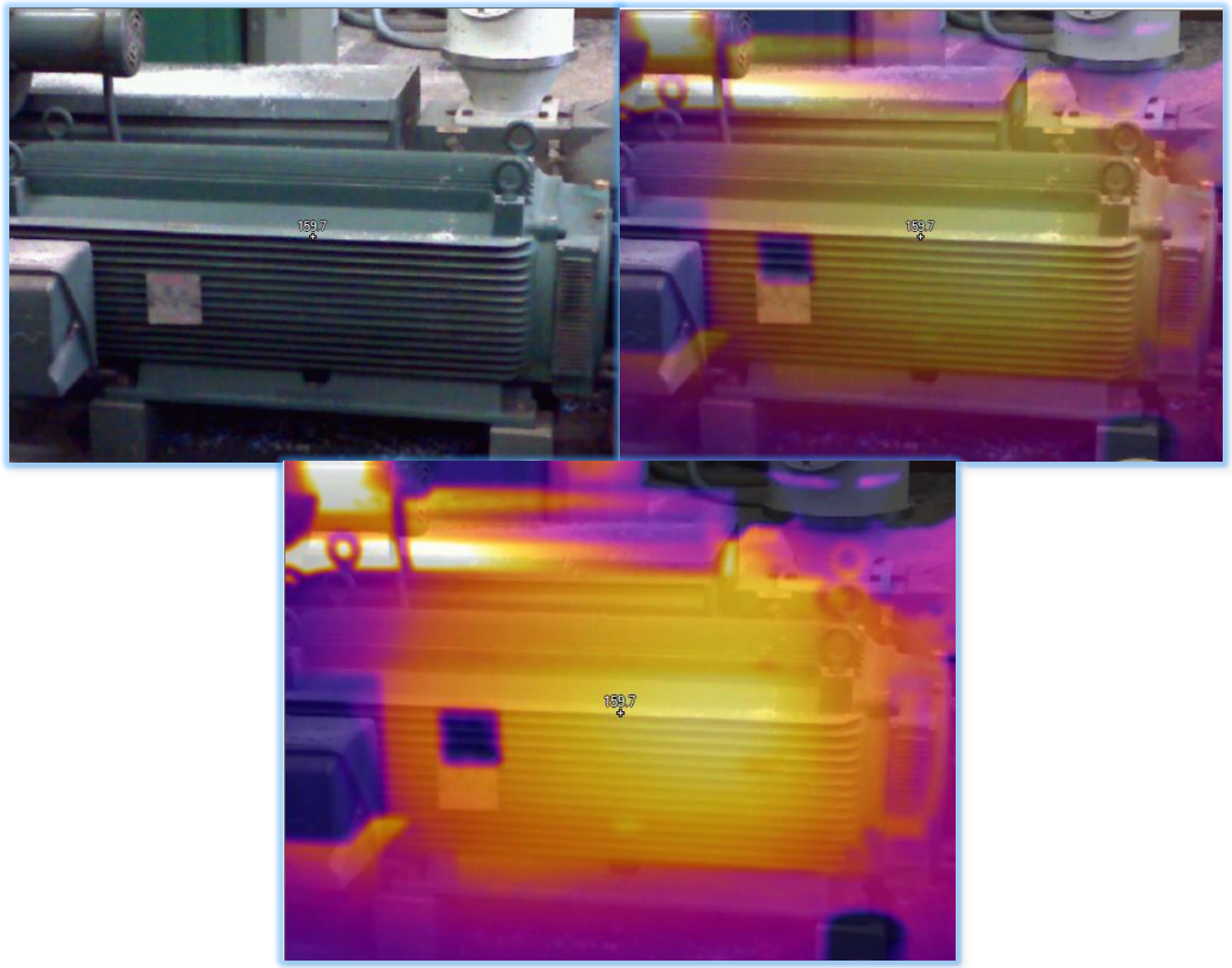
Item	Amount
Cost of Motor	$16,000
Cost of VFD	$18,000
Ship/Install cost	$16,000
Rebate	($18,000)
Total Investment	$34,000
Annual Energy Savings	$126,184
Simple Payback	0.3 Years
Return on Investment	370%

VFD Technical Considerations

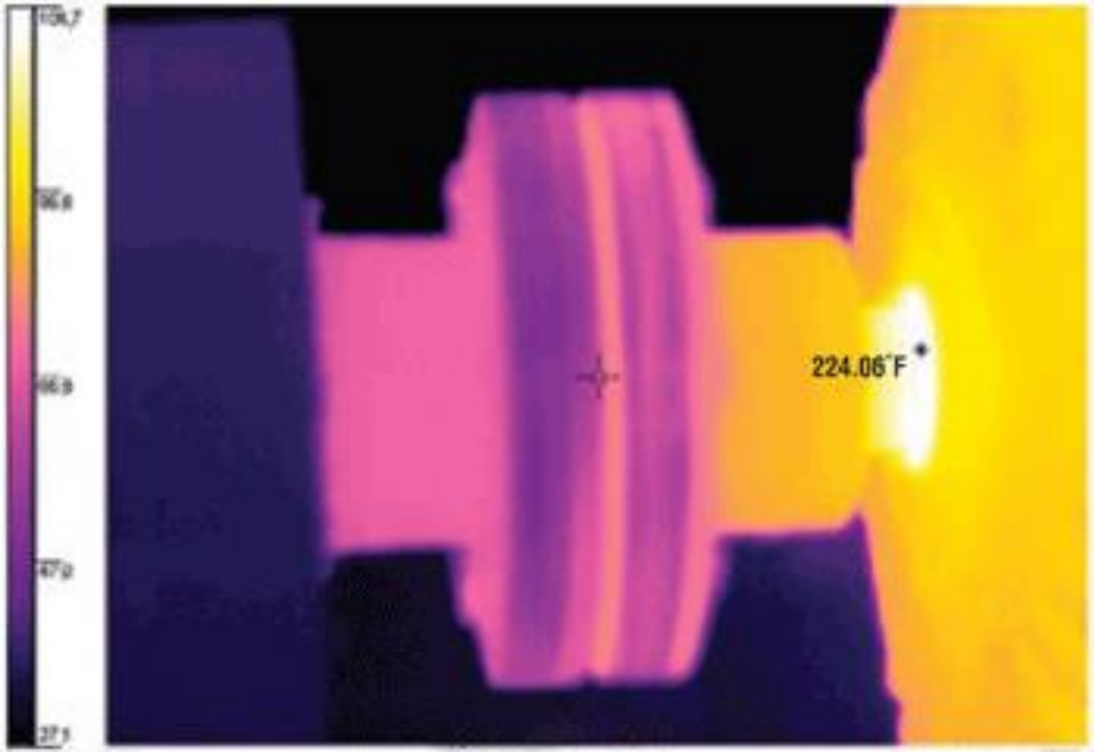
- Requires a varying load
- Requires inverter grade motor
- Limit VFD-Motor distance to 50 feet or less
- Preventive Maintenance critical for long term success
  - VFDs cause leakage current through bearings
  - 5^{th} and 11^{th} harmonic generate reverse torque
  - Current imbalance between phases < 10%
  - Voltage imbalance between phases < 3%
  - Watch for dV/dT exceeding CIV (corona inception voltage)
  - Thermal imaging should be compared every 3 to 6 months

Other Considerations

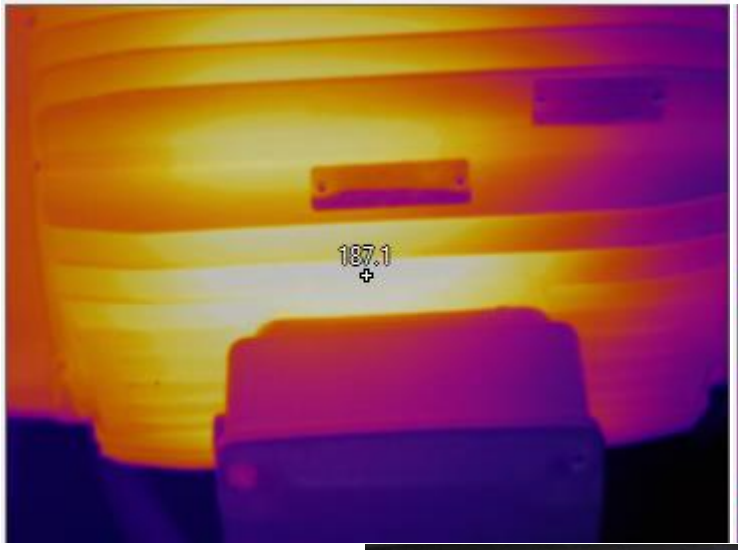
Infrared Imaging as a PM Tool

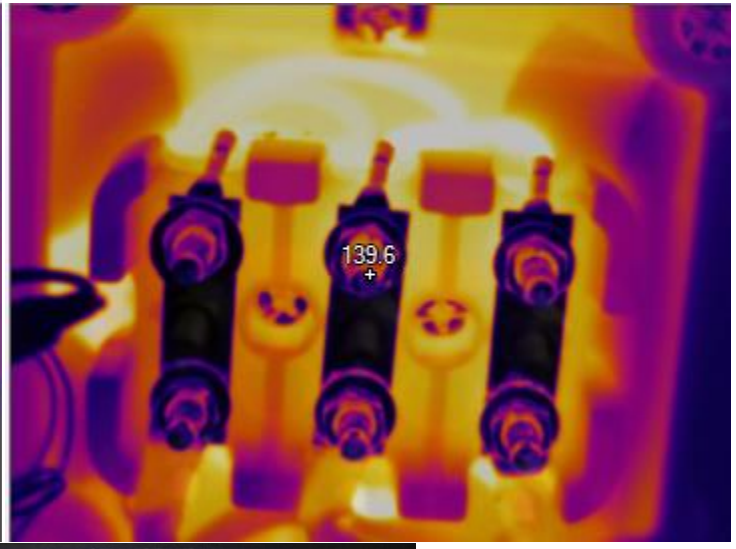


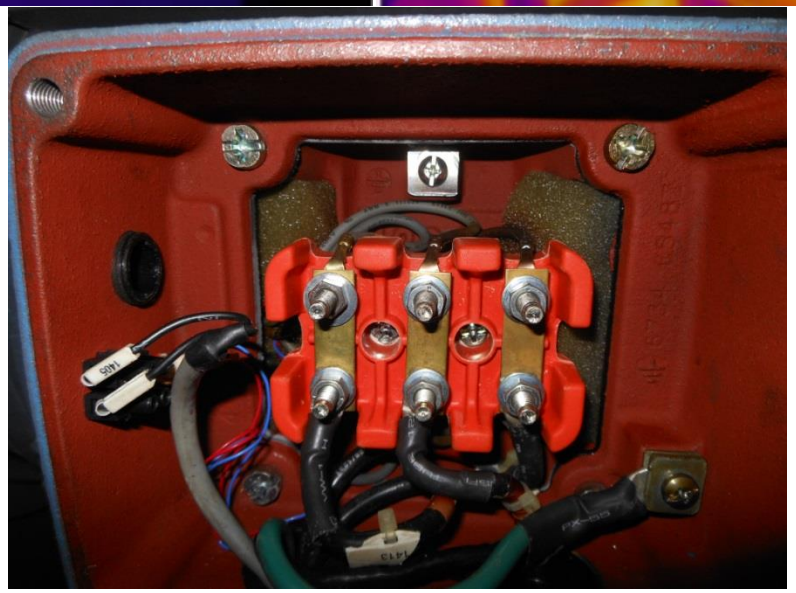
What Bearing Wear Looks Like



thermal Imaging - Extremely Helpful!







Motor Management, Preventive Maintenance (PM)

- Well planned PM is key to dependable, long-life operation of motors, pumps and generators
- Unscheduled stoppage and long repairs are intolerable
- Leadership often sees value of PM but resists investment for proper tools, resources and training
- PM often needs to be pitched as a business case
- Case studies of prior breakdowns and resulting costs will help
- Once budget approved, develop a plan for each motor category

Motor management Program

- Survey motors. Gather nameplate information (HP, RPM, enclosure, voltage, amps, etc.)
- Initially focus on motors that exceed minimum size and operating hours
  - 50 HP and above
  - 6,000 hours/year of operation minimum
- Collect info re Standard, EPAct and NEMA Prem. Eff.
- Constant load (not intermittent, cycle or fluctuating)
- Older or rewound motor

Areas to Cover for Good PM Program

- Thermal Imaging
  - Over-heating (insulation class, impact on life)
  - Overloads
  - Imbalances
- Vibration Analysis
  - Included load on shaft (pump bearing)
- Load Analysis
  - Tachometer and slip equations
- Power Analysis
  - Phase imbalance
  - Overload
  - Harmonics
  - Power Factor
  - Power Quality

Create a Record for Each Motor

M-13

Motors

General Information

Site Name	
Motor ID/ Tag	
Location/Service	
Year Built	2011

Motor Data	Nameplate
Manufacturer	Marathon
Model Number	EVD 256TFNA6001
Serial Number	AE R140
Motor Type	TEFC AC Prem Eff.
Motor Efficiency	92.4%
Full-Load HP	20
Frame Size	
Frame Style	256T
Full-Load RPM	~~3537~~ 3537
Synch RPM	3600
Volts	460
Phase	3
Full-Load Amps	23.4
Power Demand (kW)	18
Connection Type	

Design/Operating Conditions

	Design	Measured
Ambient Temp	129 F	136 F
Load on shaft	Blower	

Measurments

Voltage A	476.1
Voltage B	472.4
Voltage C	474.6
Current A	21.7
Current B	22.9
Current C	22.4
Shaft RPM	3541
Frame Temp Range	class H
Hotspot Temp	164.2 F

Motor Control

ON/OFF	Yes
VFD	NO
Soft-start	No
Multiple Speed Settings	No

Operating Schedule

Time of Day Scheduling	M-F 530A-10p Sat 7A-3p
Annual Oper. Hours	4654

Convert Collected Data into Database

ID	Location	Make and Model	HP	Photo	Vibration	IR	Power	Condition	Comments
M1	806 Erema Cutter/Compactor	WEG Lenze 06AG008	22.8	Yes	Yes	Yes	Yes		Excessive bearing wear, severe current unbalance
M2	806 Erema Extruder	WEG LENZE TEO1FOXOXOX000091180	22.8	Yes	Yes	Yes	Yes		Severe bearing wear, excessive heating at power connection, overloaded
M3	2 1/2 - Extruder	RELIANCE 01KL517389DFT1	150	Yes	Yes	Yes	Yes		Excessive bearing wear; severe 5th and 11th harmonic
M4	3 Layer 1 - Extruder C				No	No	No		Machine down
M5	3 Layer 1 - Extruder B				No	No	No		Machine down
M6	3 Layer 1 - Extruder A				No	No	No		Machine down
M7	5 Layer - Extruder D	CONTRAVES 2190B450B03	10	Yes	Yes	Yes	No		Moderate bearing wear; non-std
M8	5 Layer - Extruder E	CONTRAVES N058/0413-FN112	10	Yes	Yes	Yes	No		Excessive bearing wear
M9	5 Layer - Extruder C	BALDOR P28800450035000	25	Yes	Yes	Yes	No		Moderate bearing wear
M10	5 Layer - Extruder B	CONTRAVES 2190B450B02	10	Yes	Yes	Yes	No		Excessive bearing wear
M11	5 Layer - Extruder A	BALDOR 59084771-001001-JN	50	Yes	Yes	Yes	No		Moderate bearing wear; non-std
M12	2 1/2 - Grinder	LEESON M286TDB10B	30	Yes	Yes	Yes	No		
M13	9 Layer - IBC Exhaust Blower	MARATHON EVD 256TTFNA6001	20	Yes	Yes	Yes	No		
M14	3 Layer 2 - Air Ring Exhaust	MARATHON DUB 215TTFS6001GWR140	10	Yes	Yes	Yes	No		
M15	9 Layer - Air Ring Blower	MARATHON EVD286TSTFN6001BHR1401	30	Yes	Yes	Yes	No		
M16	9 Layer - IBC Supply	MARATHON EVD286TSTFN6001BHR1402	20	Yes	Yes	Yes	No		Slight looseness
M17	9 Layer - Extruder A	RELIANCE 73424318-00-DR-T1	60	Yes	Yes	Yes	No		
M18	9 Layer - Extruder B	RELIANCE 7350638-001-CK-T2	40	Yes	Yes	Yes	No		
M19	9 Layer - Extruder C	RELIANCE 7350638-001-CK-T3	40	Yes	Yes	Yes	No		
M20	9 Layer - Extruder D	RELIANCE 7350638-001-CK-T4	40	Yes	Yes	Yes	No		
M21	9 Layer - Extruder E	RELIANCE 7350638-001-CK-T5	40	Yes	Yes	Yes	No		
M22	9 Layer - Extruder F	RELIANCE 7350638-001-CK-T6	40	Yes	Yes	Yes	No		
M23	9 Layer - Extruder G	RELIANCE 7350638-001-CK-T7	40	Yes	Yes	Yes	No		
M24	9 Layer - Extruder H	RELIANCE 7350638-001-CK-T8	40	Yes	Yes	Yes	No		
M25	9 Layer - Extruder I	RELIANCE 7342431A-00-DKT1	60	Yes	Yes	Yes	No		
M26	3 Layer 2 - Extruder A	SAFTRONICS 5CD184TA096B017	60	Yes	Yes	Yes	No		
M27	3 Layer 2 - Extruder B	SAFTRONICS CD203PA097A151	50	Yes	Yes	Yes	No		
M28	3 Layer 2 - Extruder C	GE 5CD84TA096B032	60	Yes	Yes	Yes	No		
M29	605 Erema - Extruder	SIEMENS ILE10011DC434AB4Z	15	Yes	Yes	Yes	No		Moderate bearing looseness
M30	605 Erema - Cutter/Compactor	SIEMENS ILA91866	20	Yes	Yes	Yes	No		
M31	Macchi reclaim				No	No	No		motor not accessible
M32	3 Layer 1 - IBC Suply				No	No	No		Machine down
M33	2 /12 - Air Ring Supply	BALDOR M3314T	15	Yes	Yes	Yes	No		
M34	3 Layer 1 - IBC Exhaust				No	No	No		Machine down
M35	3 Layer 1 - Air Ring Supply				No	No	No		Machine down
M36	5 Layer - Air Ring Blower	TOSHIBA B0202OLF2UMH01	20	Yes	Yes	Yes	No		
M37	3 1/2 - Extruder	RELIANCE 7135052-001-DJT1	150	Yes	Yes	Yes	No		
M38	3 1/2 - IBC Suply Blower	MARATHON DVF 254TTFNA6001 AER1401	15	Yes	Yes	Yes	No		
M39	3 1/2 - IBC Exhaust	RELIANCE P21G3319H	10	Yes	Yes	Yes	No		Moderate bearing looseness
M40	6" Extruder	POWERTEC A32EYS1000100000	250	Yes	Yes	Yes	No		Bearings at both ends have moderate wear
M41	6" - Air Ring Supply	BALDOR M4107T	25	Yes	Yes	Yes	No		Moderate bearing wear and looseness
M42	2" Extruder	GE 5OD363NA001AO15	30	Yes	Yes	Yes	No		
M43	6" - Grinder	LEESON C324T17FB7D	30	Yes	Yes	Yes	No		
M44	6" - Grinder	DELCO 1V9716L1	40	Yes	Yes	Yes	No		
M45	3 1/2 - IBC Exhaust Blower	MARATHON DVA 215TTFS6001GWR1401	10	Yes	Yes	Yes	No		
M46	GD VS-40 Air Compressor	RELIANCE 89864009	54.4	Yes	Yes	Yes	No		
M47	3 Layer 2 - Air Ring Supply	MARATHON BVA254TTFNA6001AER140	15	Yes	Yes	Yes	No		Slight bearing wear

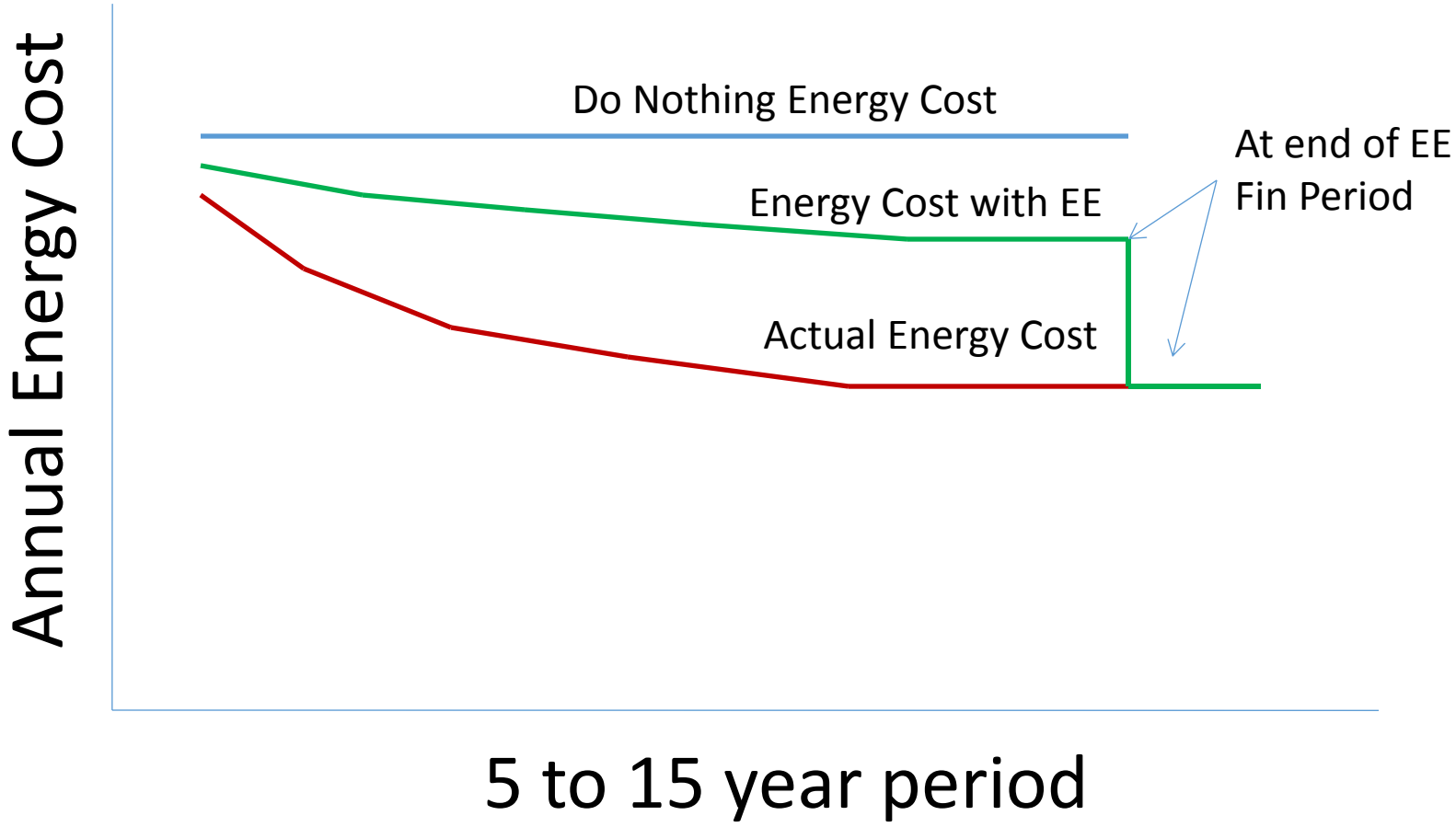
Utility Rebates

- Dayton Power, AEP and Duke have rebates for lighting, HVAC, motors & drives, compressed air and custom projects.
- FirstEnergy cash rebates are gone but DSE-2 Rider can be removed
  - PJM rebates available to FirstEnergy customers
- Efficiency Smart administers rebate programs for municipal utilities
- Rebates typically require pre-approval before purchasing – check the details with your utility
- Work with an independent energy efficiency firm if you need help

Financing Energy Efficiency

- Self-funding; no and low cost savings fund future ECM's
- Bank financing
- Utility rebates
- State funding thru grants and loans
- Pay for "fuel", not the equipment
- Performance contract
- Energy Efficiency Funding Specialists Firms

Energy efficiency financing



Energy efficiency project financing

Year	Energy Savings	Operational Savings	Total Savings	Contract Costs	Savings - Costs	Cumm Cash Flow
1	8,600	1,100	9,700	6,231	3,469	3,469
2	9,045	1,170	10,215	6,231	3,984	7,453
3	9,512	1,230	10,742	6,231	4,511	11,964
4	10,103	1,345	11,448	6,231	5,217	17,181
5	10,546	1,399	11,945	6,231	5,714	22,895
6	11,121	1,486	12,607	6,231	6,376	29,271
7	11,678	1,567	13,245	6,231	7,014	36,285
8	12,345	1,654	13,999	6,231	7,768	44,053
9	12,987	1,724	14,711	6,231	8,480	52,533
10	13,876	1,833	15,709	6,231	9,478	62,011
11	14,345	1,975	16,320	6,231	10,089	72,100
12	15,332	2,122	17,454	6,231	11,223	83,323
13	16,876	2,324	19,200	6,231	12,969	96,292
14	17,998	2,546	20,544	6,231	14,313	110,605
15	18,765	2,621	21,386	6,231	15,155	125,760

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Tom Sherman, C.E.M., C.E.A., C.D.S.M.

440-773-5044

Tom@sustainable-energy-services.com

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