Energy Efficiency Tips for Large Commercial and Industrial Facilities

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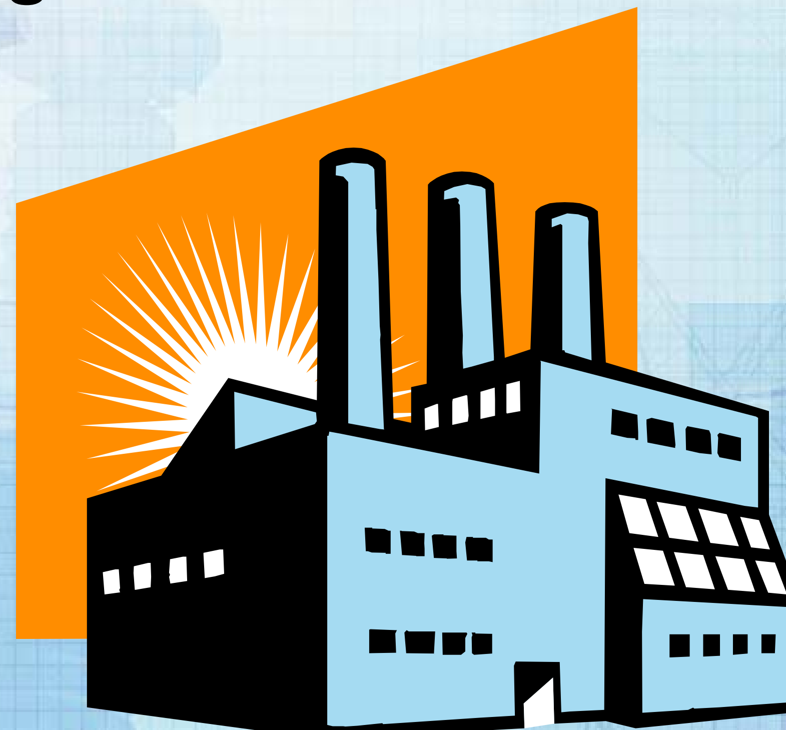

by Mark Zboran/Georgia Power

Georgia Power's Energy Seminar

Reducing Energy & Energy Costs

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- There are 4 basic steps to maximizing energy and cost savings:
  - Identify your goal
  - Identify your acceptable rate of return
  - Understand your utility rate structures
  - Identify your greatest areas for savings
    - Largest energy users
    - Largest areas of waste or inefficiencies
    - Areas that require little capital costs

Identify Your Goal

- What are you really trying to accomplish?
  - Saving money
  - Saving energy
  - Saving the environment

- How you answer this question will help determine what projects to evaluate.

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Identify Your Acceptable Rate of Return on Projects

How you answer this question will help determine what projects to actually commit budget dollars to.

- Payback
- IRR
- NPV

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Understand Your Utility Rates

GPC PLM-I

Month	Meter Read	Billing Days	Total kWh	Peak kW Demand	Electric Service Total
July '05	07/28/05	30	230,560	427	$14,548
August '05	08/30/05	33	252,800	410	$15,044
September '05	09/29/05	30	225,440	389	$14,054
October '05	10/28/05	29	189,600	363	$12,828
November '05	11/30/05	33	162,400	310	$11,898
December '05	12/30/05	30	127,200	277	$10,603
January '06	01/27/06	28	154,720	394	$11,616
February '06	02/28/06	32	189,920	394	$12,840
March '06	03/30/06	30	187,840	413	$12,769
April '06	05/01/06	32	250,880	461	$14,917
May '06	05/30/06	29	237,280	485	$14,460
June '06	06/28/06	29	279,200	512	$17,504
Total		365	2,487,840		$163,081
Peak		33	279,200	512	$17,504

Average cost per kWh – 7.13. ¢ **(accounts for recent fuel increases)**

Incremental cost per kWh - 4.01¢

Incremental cost per peak kW - $13.23/mo. Or $158.76/year

Incremental cost reflects the "actual" impact on your bill from reducing peak kW, or kWh

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Average ¢/kWh Calculation vs. Incremental ¢/kWh

Example: Installation of Occupancy Sensors

Original Peak Ltg. kW – 10
Original Annual Ltg. kWh – 60,000
New Peak Ltg. kW – 10
New Annual Ltg. kWh – 48,000
kWh Savings – 12,000
Avg. ¢/kWh Savings – 7.13¢/kWh x 12000 = $855.60/yr.
Increm. ¢/kWh Savings – 4.01¢/kWh x 12000 = $481.20/yr.

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Average ¢/kWh Calculation vs. Incremental ¢/kWh

Example: Lighting Retrofit

Original Peak Ltg. kW – 10

Original Annual Ltg. kWh – 60,000

New Peak Ltg. kW – 7

New Annual Ltg. kWh – 42,000

kW Savings - 3

kWh Savings – 18,000

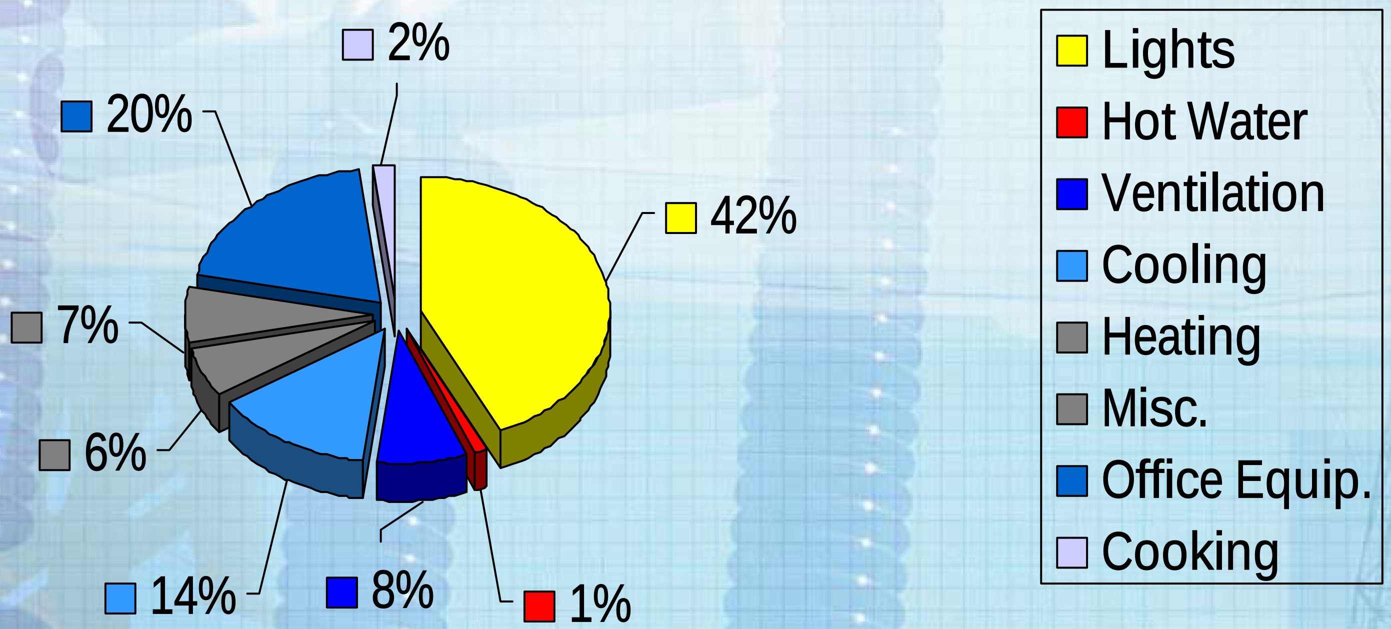
Avg. ¢/kWh Savings – 7.13¢/kWh x 18,000 = $1283.40/yr.

Increm. $/peak kW Savings - $158.76 x 3 kW = $476.28/yr.

Increm. ¢/kWh Savings – 4.01¢/kWh x 18,000 = $/721.80yr.

Total Increm. Savings - $1198.08 (7% less than avg.)

Identify Your Greatest Areas for Savings



Typical Office

Lighting Retrofits

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4-Foot Fluorescent Fixture Retrofits

Existing: 4 – T12, 34W, with high effic. magnetic ballasts (148 watts)

Retrofit: 4 – T8, 28W, with electronic ballast (96 watts)

Wattage Savings: 52 watts/Fixture

Retrofit Cost: $59/Fixture

Annual Savings @ $.713/kWh and 4000 Hours = $14.83 PB = 3.9

Annual Savings @ $.713/kWh and 6000 Hours = $22.24 PB = 2.7

Annual Savings @ $.713/kWh and 8000 Hours = $29.66 PB = 2.0

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8-Foot Fluorescent Fixture Retrofits

Existing: 2 – T12, 60W, with high effic. magnetic ballasts (133 watts)

Retrofit: 4 – T8, 28W, with electronic ballast (96 watts)

Wattage Savings: 37 watts/Fixture

Retrofit Cost: $60/Fixture

Annual Savings @ $.0713/kWh and 4000 Hours = $10.55 PB = 5.7

Annual Savings @ $.0713/kWh and 6000 Hours = $15.83 PB = 3.8

Annual Savings @ $.0713/kWh and 8000 Hours = $21.10 PB = 2.8

GE Screw-In Compact Fluorescent

Compared to Incandescent:

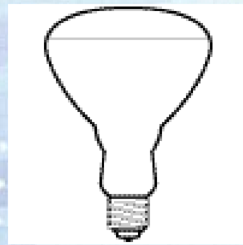
8-13X More life
Up to 13%
more light

7-20X More life
Up to 35%
more light

5-8X More life
Up to 150%
more light

3-13X More life
Up to 129%
more light

Compact Fluorescent now come as dimmable, daylight, and decorative options

	65R30/FL	FLE15/R30
		
Watts:	65	15
MOL:	5.37 in.	5.5 in.
Lumens:	725	720
Life:	2000	6000/10000
Savings (6000hrs, $.0713/kwh)		$21.39/Yr
Cost		$15
Payback		.7 Yr

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Retro-fit Incandescent EXIT Signs

to LED EXIT Signs

Existing: 2 – 20W incandescent lamps (40 watts)

Retrofit: LED lamps (3 watts)

Wattage Savings: 37 watts/Fixture

Retrofit Cost: $25/Fixture

Average Fixture & Lamp Life 25 years

Annual Savings @ $.0713/kWh and 8760 Hours = $23.11 PB = 1.1

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High Bay Lighting Retro-fits for 400W HPS or 400W MH

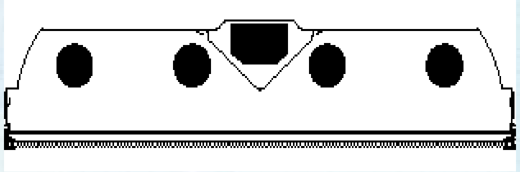
	Orion InteLite 6 lamp, 32W, T8	4 lamp, 54W, T5	400 Watt HPS	400 Watt MH	320 Watt Pulse Start w/Electronic Ballast
Annual Operating Hours	6000	6000	6000	6000	6000
Cost per kWh ($/kWh)	0.0713	0.0713	0.0713	0.0713	0.0713
Cost per Fixture (not including install.)	190	195	0	0	145
Watts/Fix	221	234	465	458	345
Initial Lamp Lumen Output	20358	20000	36000	36000	34000
Avg. % lumen output over life (CU * LLF)	88%	86%	52%	52%	54.00%
Avg. Lumen Output/Fixture	17822	17126	18720	18720	18360
Lumens/Watt	81	73	40	41	53
Life (hours)	20000	20000	24000	20000	20000
Annual Recycling Cost	$0.45	$0.30	$3.90	$4.68	$4.68
Annual Lamp Replacement Cost	$3.60	$4.80	$3.75	$4.50	$7.50
Annual Lamp Replacement Labor Cost	$21.60	$14.40	$6.25	$7.50	$7.50
Annual Energy Cost	$94.54	$100.11	$198.93	$195.93	$147.59
Total Annual Costs	$120.19	$119.61	$212.83	$212.61	$167.27
NPV w/o taxes (10%, 10 years)	-$928.53	-$929.91	-$1,307.72	-$1,306.40	-$1,172.80

320 watt CMH

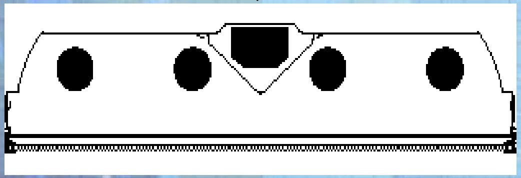
234 watt 4L, T5

222 watt 6L, T8

Instant Start or Program Start?



IS:
- Layouts and Application Are Generally Unchanged
- No Occupancy Sensor/Dimming Controls typically Used

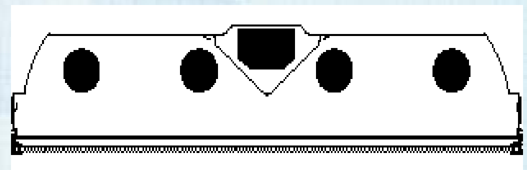


Program-Start:
- Occupancy Sensor/Dimming Controls will be used to maximize energy savings by managing light output

Note: New Retrofit Guidelines May Require Use of Controls

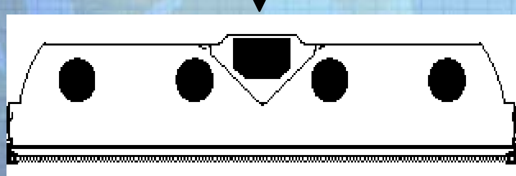
Planning to Convert HID to T5 or T8

Consider Glare/#Restarts?



T5

- T5 lamps produce more glare
- T5 lamps do not like to be cycled frequently



T8

T8 lamps produce less glare
T8 lamps can be cycled frequently

2005 Energy Policy Act

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Under the interim 2005 Energy Policy Act businesses may be eligible for a lighting retrofit tax deduction.

2005 Energy Policy Act

To qualify the following conditions must be met:

- The retrofit must be completed prior to 12/31/08.
- The retrofit must reduce the watts/sq. ft. by 25% to begin getting credit and by 40% to get the full credit of $.60/sq. ft. (warehouses must have a 50% reduction).
- The retrofit must include bi-level switching per ASHRAE 90.1 (2001).

Qualifying Lighting Reductions

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Space Type	Watts/sq. ft. required for partial & full deduction
Warehouse	.6 (100%)
Manufacturing	1.65 (50%) - 1.32 (100%)
Office	.98 (50%) - .78 (100%)

2005 Energy Policy Act

100,000 sq. ft. Manufacturing Example

Lighting level after retrofit - 1 watts/sq. ft. (1.32 required for 100%)

% of deduction credit – 100% or $.60/sq. ft.

Federal Tax Rate – 38%

Tax Savings = .38 x $.60/sq. ft. x 100,000 sq. ft. = $22,800

HVAC Opportunities

Chiller Plant Optimization

Energy In The Chiller Plant

– One of the highest energy users in most facilities
– High potential for inefficiency
– High potential for efficiency improvements

Chiller Plant Optimization

Phase I - Get it running right

– back to design conditions

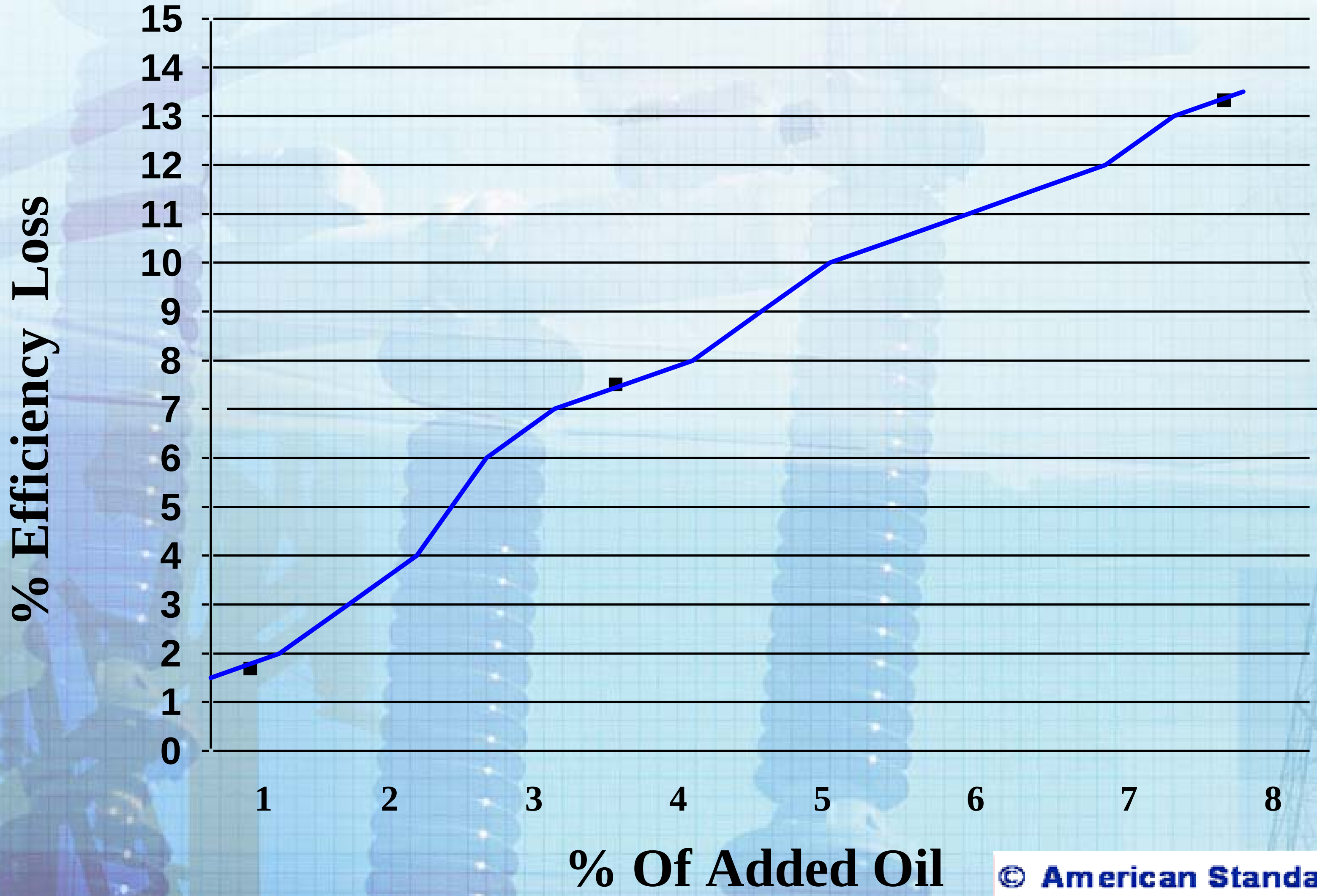
Common Condenser Inefficiencies

– Non-Condensable gases
– Fouled Condenser Tubes
– High Condenser Water Temp
– Low Condenser Water temp
– Low Condenser Water Flow
– High Condenser Water Flow

Common Evaporator Inefficiencies

- High Leaving Water Temp
- Low Evap. Temp.
- Low Evap. Press.
- Low Evaporator Water Flow
- High Evaporator Water Flow
- Contaminated Refrigerant
- Low on Charge

Efficiency Loss Versus Oil Content



An Example...

- **System Design Conditions**
  - Evap. 45 °F Sup, 55 °F Rtn — Actual 44 °F Sup, 54 °F Rtn
  - Cond. 85 °F LCWT, 95 °F ECWT — Actual 86 °F LCWT, 97 °F ECWT
- Chiller Specifications
  - 1000 Ton Chiller
  - 20 Years Old
  - 0.65 kW/Ton
- Utility Cost
  - $ 0.0401 / kWh
  - $ 158.76 /kW-yr
- Performance Impact
  - 1.5 % Efficiency Loss for 1 °F Increase in Lift

Let's Add It Up!

Condenser water 1 ^oF High	1.5 %
Condenser Δ T 1 ^oF High	1.5 %
Cond. approach 2 ^oF High	3.0 %
Evap. setpoint 1 ^oF Low	1.5 %
Evap. approach 1 ^oF High	1.5 %
Cond. pressure 2 psi High	6.0 %

Total losses	15 %

What's It Worth ?

- Using Equivalent Full Load Calculations:

  (Tons X kW/Ton) X ($/kW + $kWh X EQFL) = Annual Energy Cost

- Optimal Conditions:

  1000 X 0.65 X ($158.60 + $.0401 X 2500) = $ 168,253

- Our Conditions:

  1000 X (0.65 X 1.15) X ($158.60 + $.0401 X 2500) = $193,491

- The Excess Operating Expense = $25,238

Chiller Plant Optimization

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Phase II Get it running better

- design improvements

Chiller Efficiency Progress

Year	Efficiency kW/Ton Average	Good
1977	.84	.75
1980	.72	.68
1990	.65	.62
1991	.64	.61
1992	.63	.59
1993	.63	.55
1995	.61	.52
1997	.60	<.49

1977 -1997 ... over 50% improvement.

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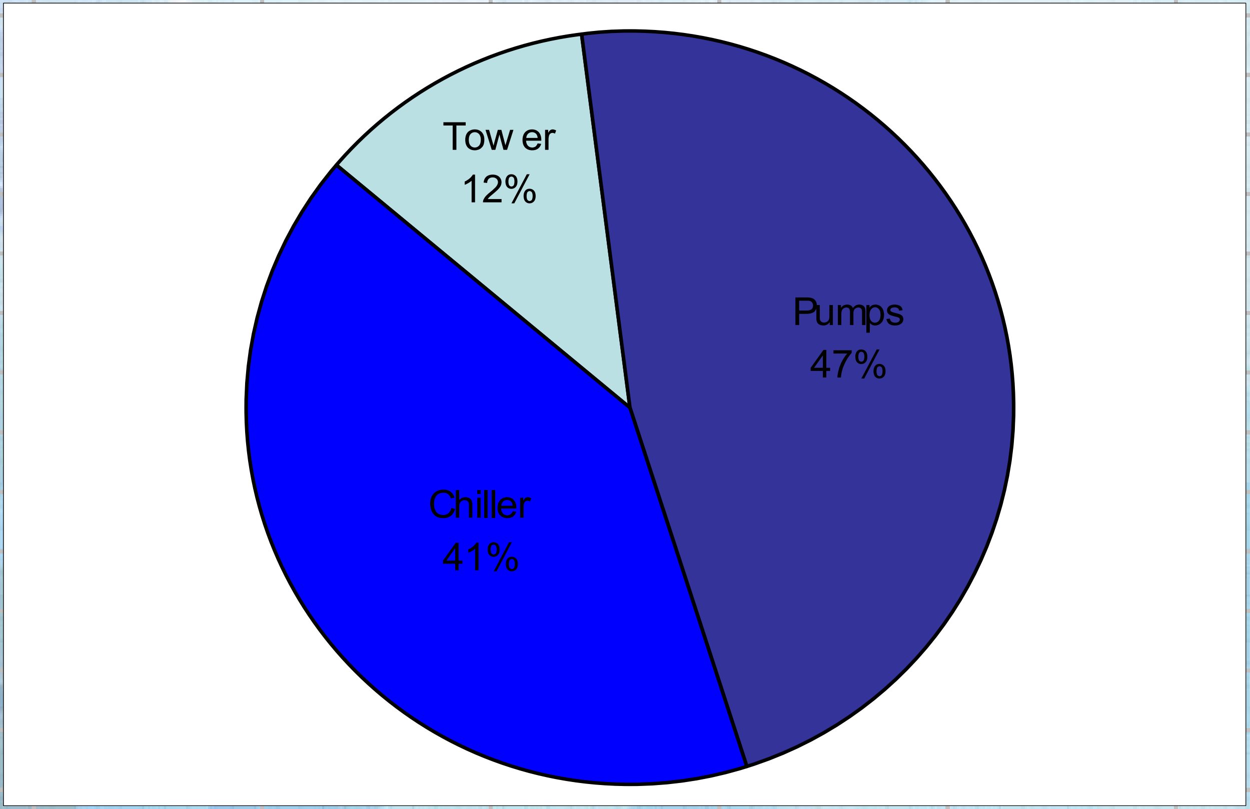
Chiller Plant Annual Energy Consumption

1995 - Current



Chiller Plant Optimization

Chilled Water Reset

Condenser Water Reset

Tower Fan Optimization

Chiller Load Matching

Condensing Pump Optimization

Chilled Water Pump Optimization

Free Cooling

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Chilled Water Reset

Typical Operation: Leaving water temperature is maintained at a constant 42 deg F

Strategy: Reset leaving water temperature based on space load and relative humidity – 48 degrees during cooler periods of year.

Savings: Each degree that the chilled water temperature is raised saves 1.5%

Condenser Water Reset

Typical Operation: Condenser water temperature is maintained at a constant 85 deg F

Strategy: Reset condenser water temperature based on outdoor wet bulb and system load – optimum is 80 deg F

Savings: Lowering the condenser water return temperature by 1 degree saves 1.5%.

Chiller Tower Control
What is Optimal ?

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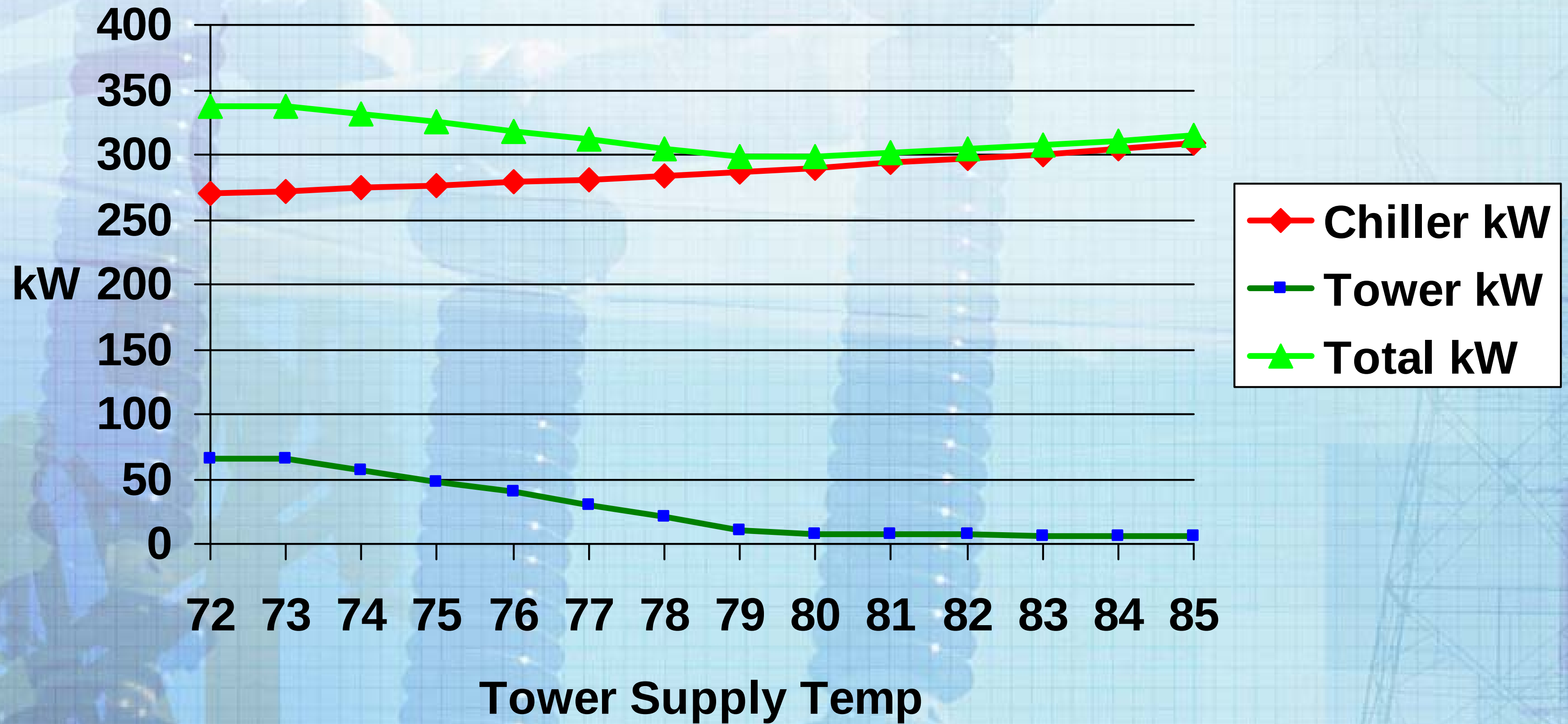


Install VSD's on Cooling Tower Fans

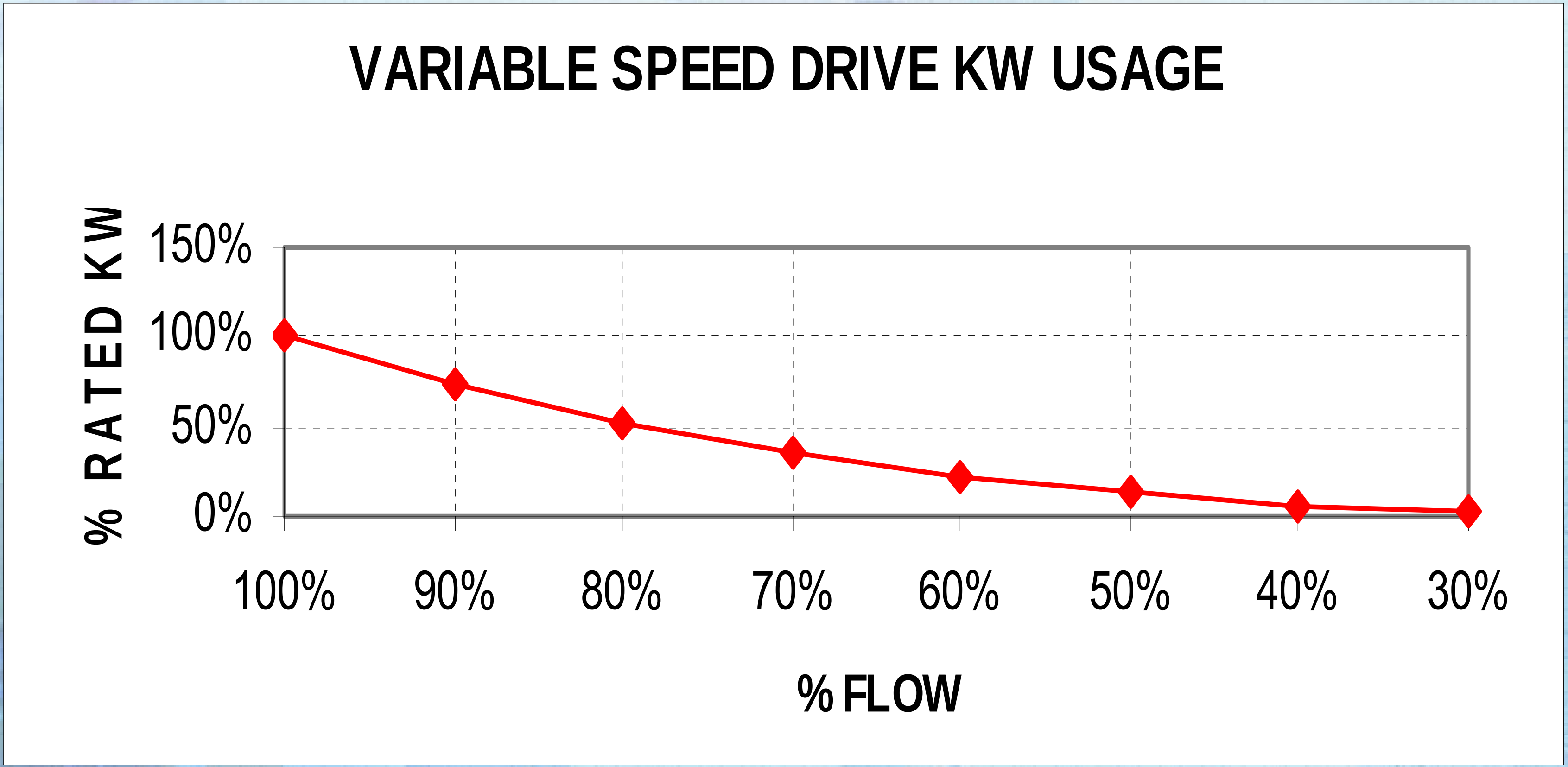
Typical Operation: Fans cycle to maintain desired setpoint

Strategy: Apply variable speed drives to more closely match tower capacity to system load and take advantage of the fact that:

$HP \approx CFM^{3}$,

A 20% CFM reduction results in a 50% HP reduction

Variable Frequency Drive Energy Savings



VFD Savings 1 Shift

Fan HP	20
Motor Efficiency	0.94
$kWh	0.08
# Shifts	1 shift
Hours of Operation (Clg. Twr.)	3120
1 Speed Fan EFLH	859.1
2 Speed Fan EFLH	390.8
VSD EFLH	160.5

Cooling Tower VSD Retrofit Cost Summary

	Annual kWh	Annual Cost	Annual VSD Savings	Payback for Changing to VSD
Single Speed Fan	13,636	$1,091	$881	4.5
Two Speed Fan	6,203	$496	$286	14.0
VSD Fan	2,625	$210	NA	NA

VFD Savings 2 Shifts

Fan HP	20
Motor Efficiency	0.94
$kWh	0.08
# Shifts	2 shift
Hours of Operation (Clg. Twr.)	6570
1 Speed Fan EFLH	1706.9
2 Speed Fan EFLH	678.3
VSD EFLH	304.4

Cooling Tower VSD Retrofit Cost Summary

	Annual kWh	Annual Cost	Annual VSD Savings	Payback for Changing to VSD
Single Speed Fan	27,092	$2,167	$1,769	2.3
Two Speed Fan	10,766	$861	$463	8.6
VSD Fan	4,976	$398	NA	NA

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Optimizing Chiller Loading

Typical Operation: Chillers are turned on to maintain a desired leaving chilled water temperature.

Strategy: Optimize operation by:

- using VSD’s
- base loading high efficiency machines
- matching chillers to load

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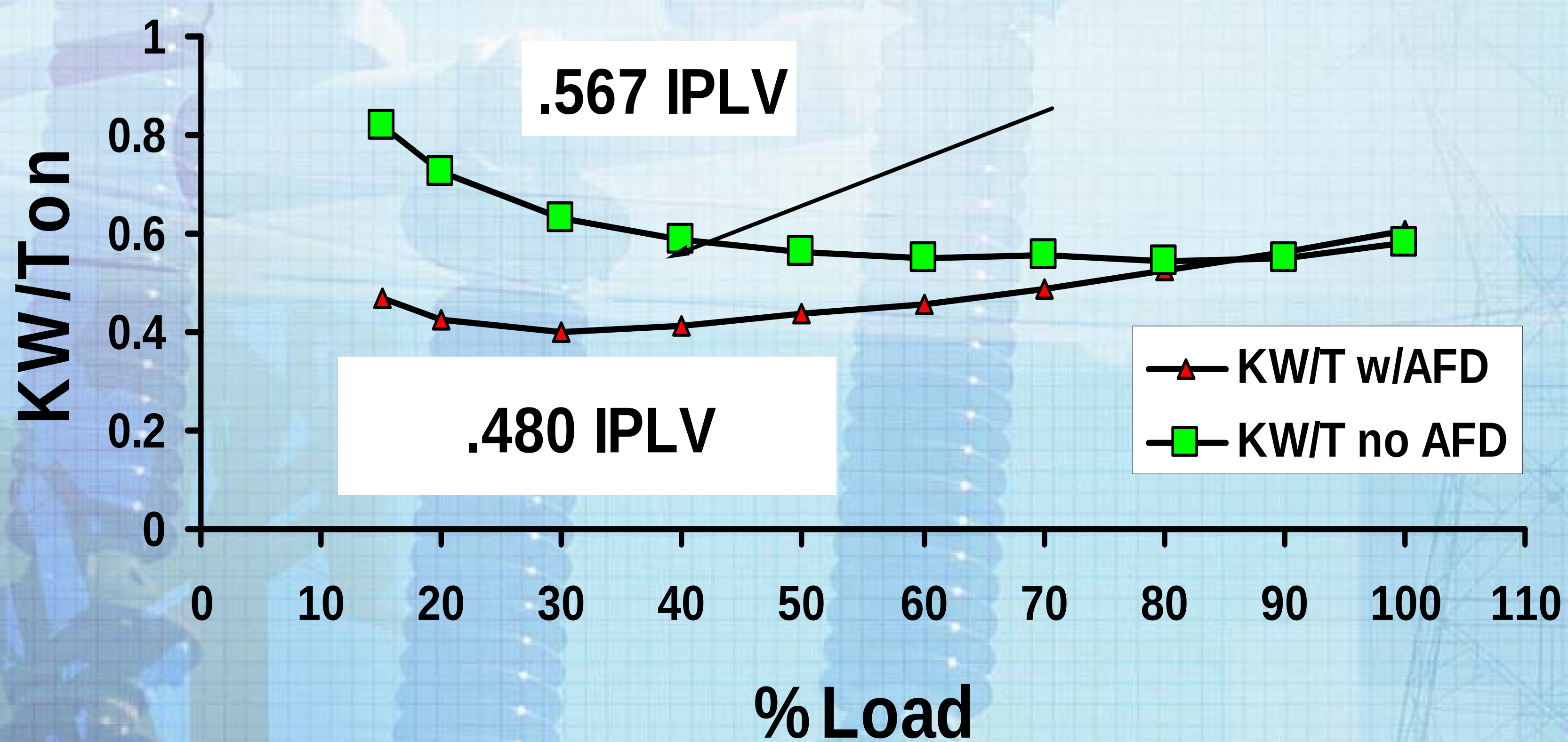
VSD Drives for Chillers



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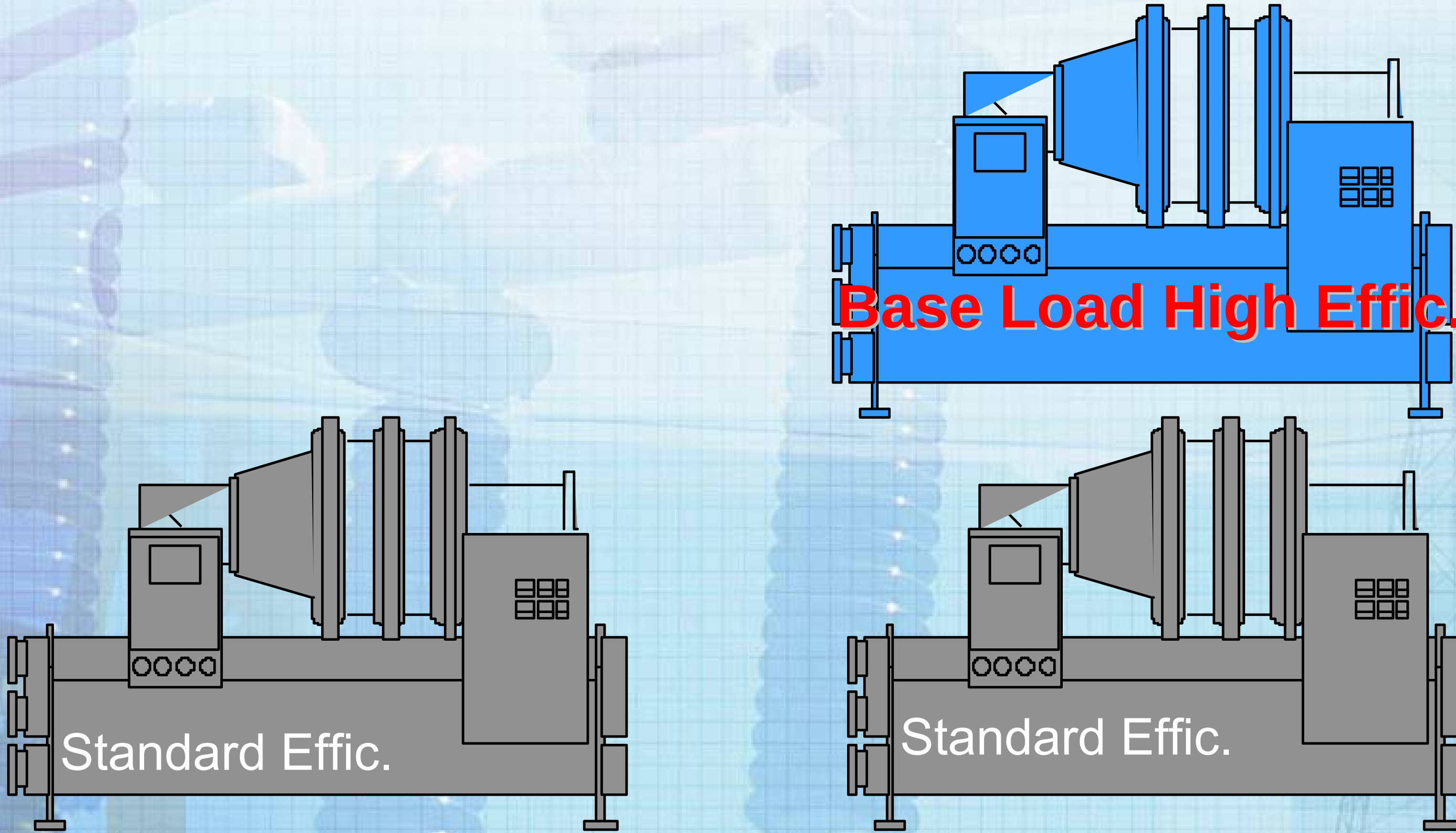
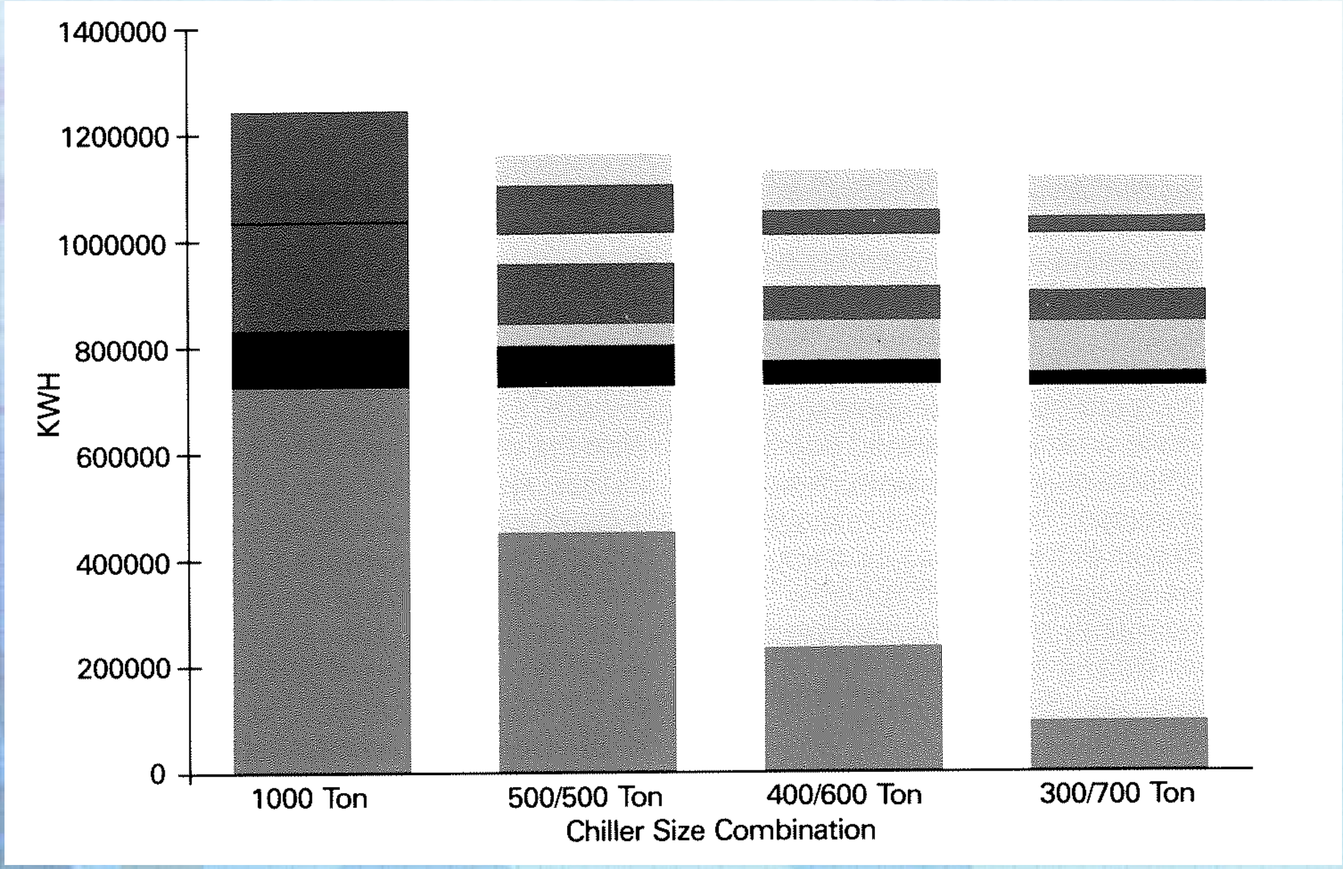
Base Load Most Efficient Chiller



Impact of Load Matching



Install VSD's on Condensing Water Pumps

Typical Operation: Pumps run at full flow when chillers are operational

Strategy: Install variable speed drives controlled from chiller refrigerant side differential pressure

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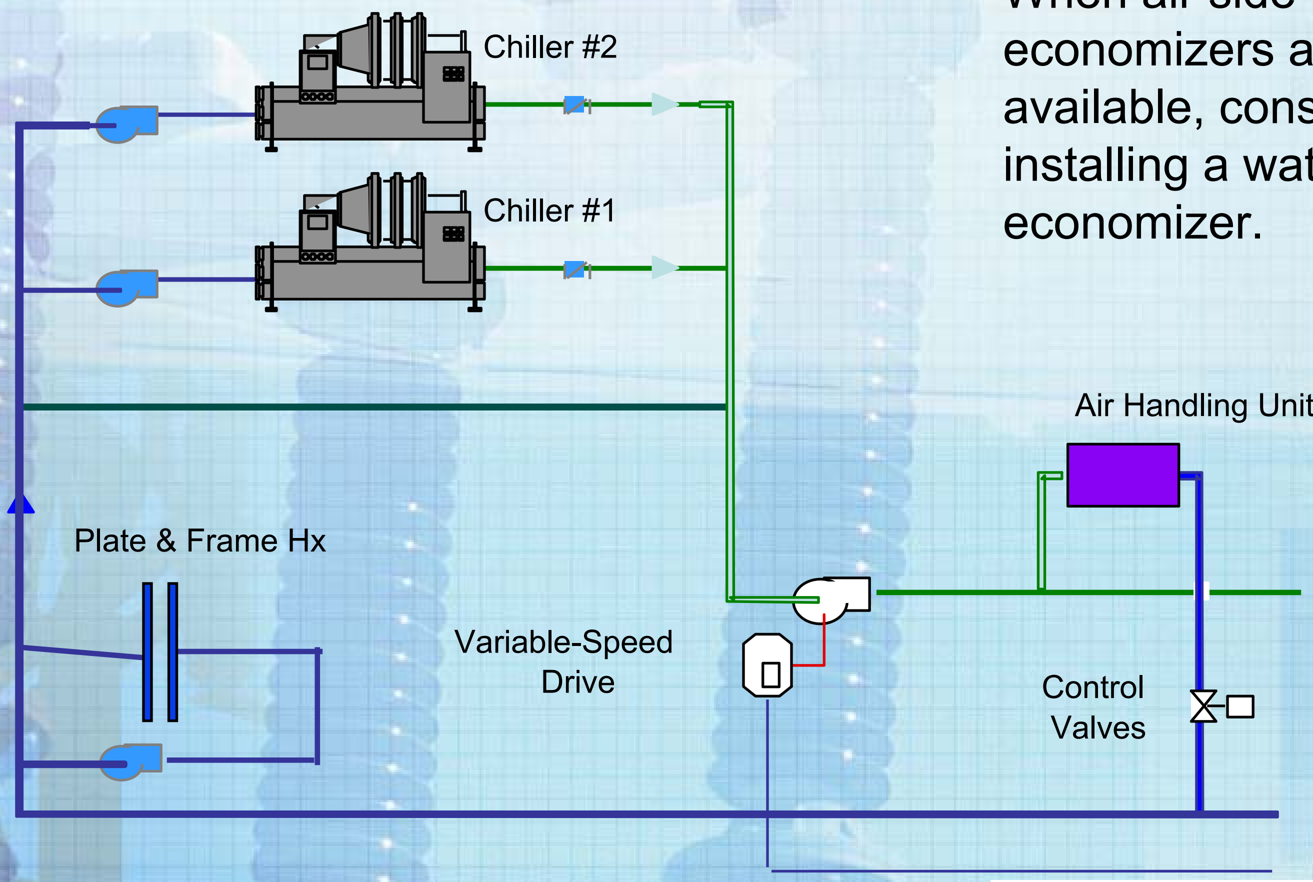
Condenser Water Pump VFD's
1 @ 75 HP

INSTALLED COST :	$ 12,000
SAVINGS :	$ 4,000
PAYBACK :	3 Years

Consider Winter Free Cooling



When air side economizers are not available, consider installing a water side economizer.

Optimize Air Handlers

Install VFD's on Central Air Handlers

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Installing VFDs can reduce air handler kWh consumption between 20%-40%/yr.

HP	20
Motor Efficiency	0.94
kW	15.87
Annual Operating Hours	2500
$/kWh	0.0401
Zone Type	Mixed
Existing Fan Control	Constant Speed
Proposed Fan Control	VSD
Annual kWh Savings	26,139
Annual Cost Savings	$1,048
Payback	3.8

Install VFD's on Central Air Handlers

Installing VFDs can reduce air handler kWh consumption between 20%-40%/yr.

HP	20
Motor Efficiency	0.94
kW	15.87
Annual Operating Hours	4000
$/kWh	0.0401
Zone Type	Mixed
Existing Fan Control	Constant Speed
Proposed Fan Control	VSD
Annual kWh Savings	41,822
Annual Cost Savings	$1,677
Payback	2.4

Reclaim Waste Heat From Exhaust Air

If large amounts of outside air are required and only a few exhaust points exist, consider installing air – air heat exchangers they can reclaim 70%-80% of the energy being exhausted.

Optimize HVAC Controls

Energy Management Strategies

Use EMCS to control HVAC equipment in ways that maximize comfort while minimizing energy consumption.

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Free Cooling or Economiser Mode

– Open outside air dampers when OAT < 60°

– Fan remains on to blow comfortable outdoor air throughout building

– Compressors can be turned off or run at reduced capacity

– Reduces annual cooling kWh by 20%

Reset Chilled Water System Values

– Each 1 ° F rise in chilled water temperature reduces chiller power consumption by 1.5%

  - During cooler periods can raise temp. to 48 ° F - 50 ° F

– Each 1 ° F rise in condenser water return temperature reduces chiller power consumption by 1.5%

  - Optimum condenser water temperature during cooler months is 80° F

Ventilation Control

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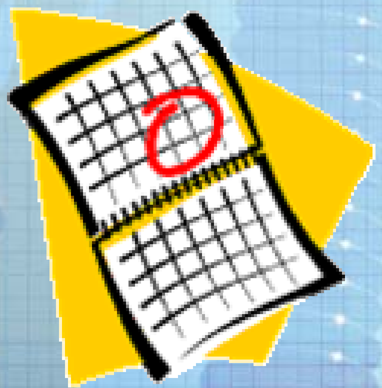
- Conditioning outside air requires high energy consumption
- Save energy by bringing in outside air as required by true occupancy rather than maximum theoretical occupancy by using CO_2 sensors
- Good applications: Theatres, Churches

Control Schedules

– Schedule equipment use based on occupancy

– Schedule set-up/set-back temperatures during unoccupied periods

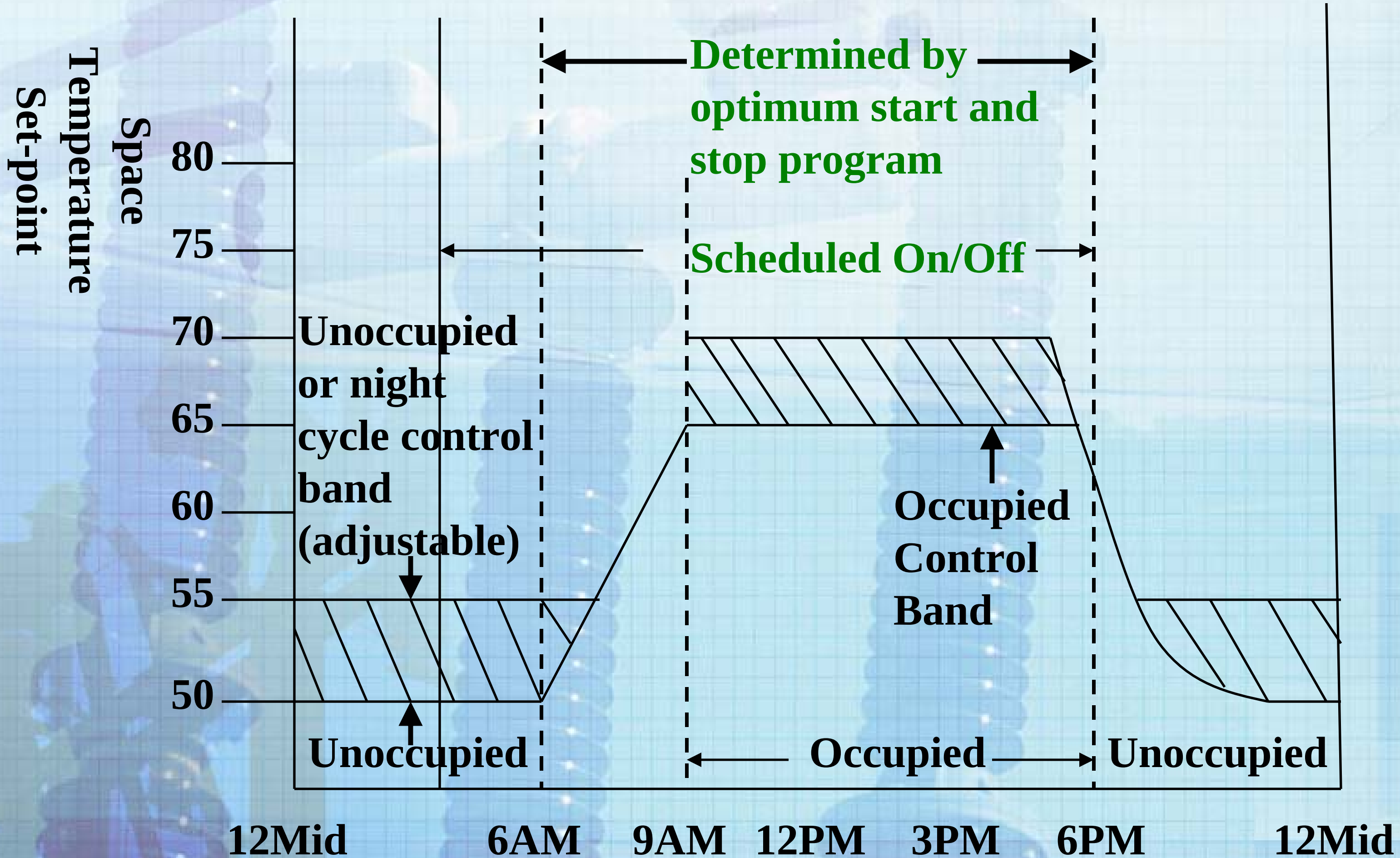
– Reduces HVAC kWh by 10%-20% vs. no control



Optimum Start/Stop

- Let EMCS determine when to start equipment
- System uses many variables to determine optimum start time:
  - Space temperature
  - Outdoor air temperature
  - Programmed space comfort conditions
  - Occupancy times
  - Heat loss/gain characteristics
- Maximizes energy savings without impacting comfort
- Can save an additional 5% - 10% kWh on top scheduling equipment on/off

Impact of Optimum Start/Stop



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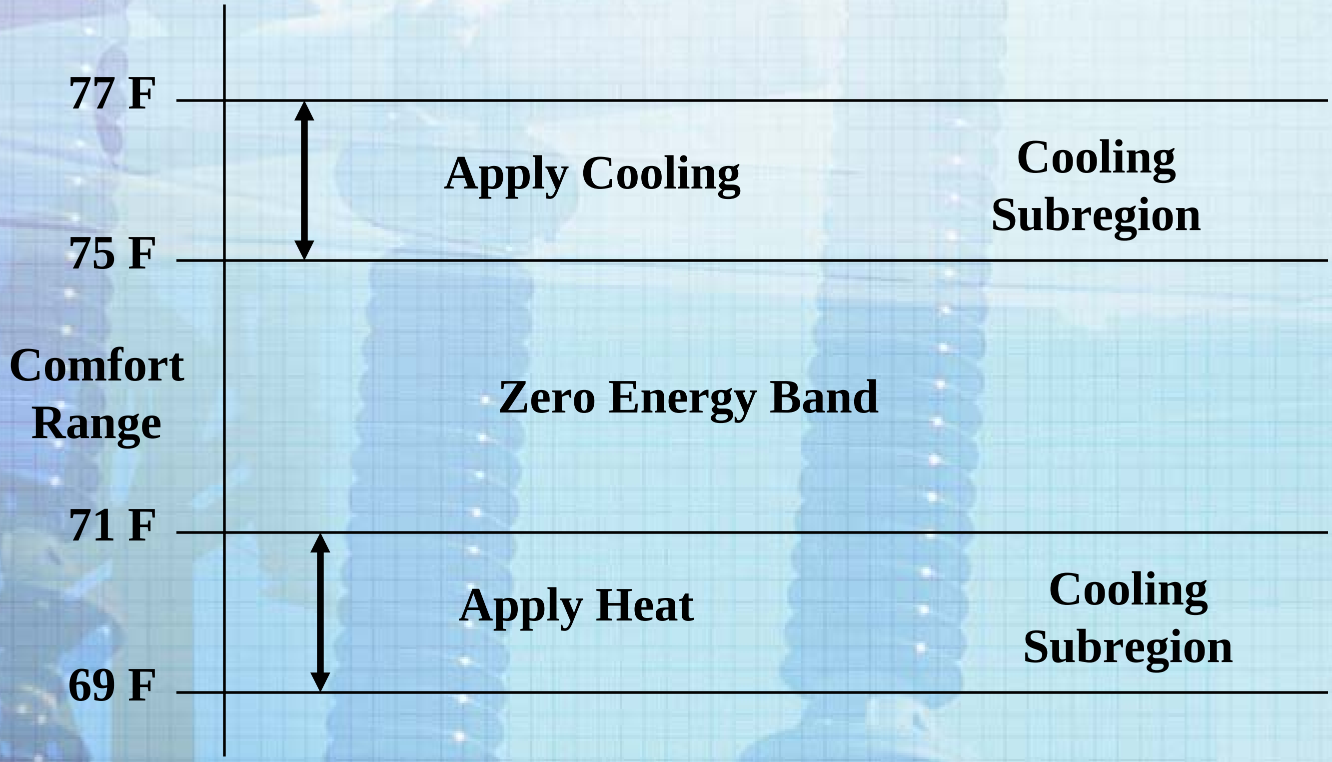
Increase Zero Energy Band

- Prevent simultaneous heating and cooling
- Establish dead band comfort range
- Reduces run time of equipment

Zero Energy Band Program



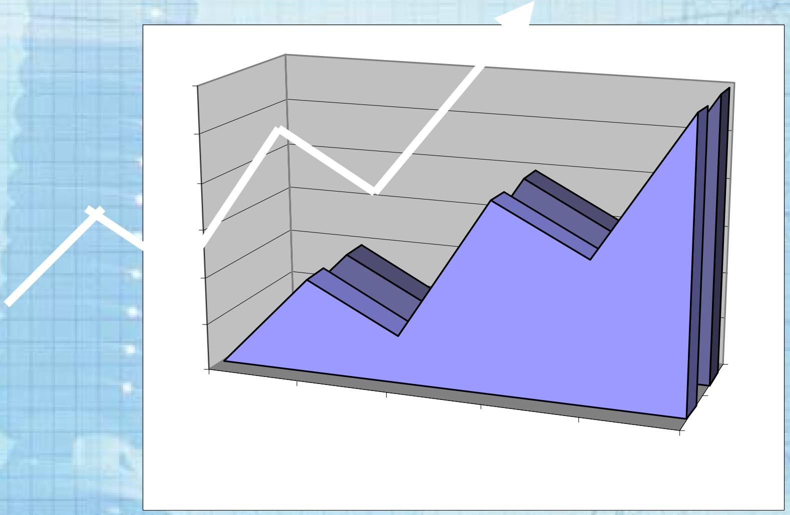
Demand Limiting

- Prioritize loads to shed
  - Water heating
  - Decorative fountain pumps
- Adjust space temperature set-points

Monitoring

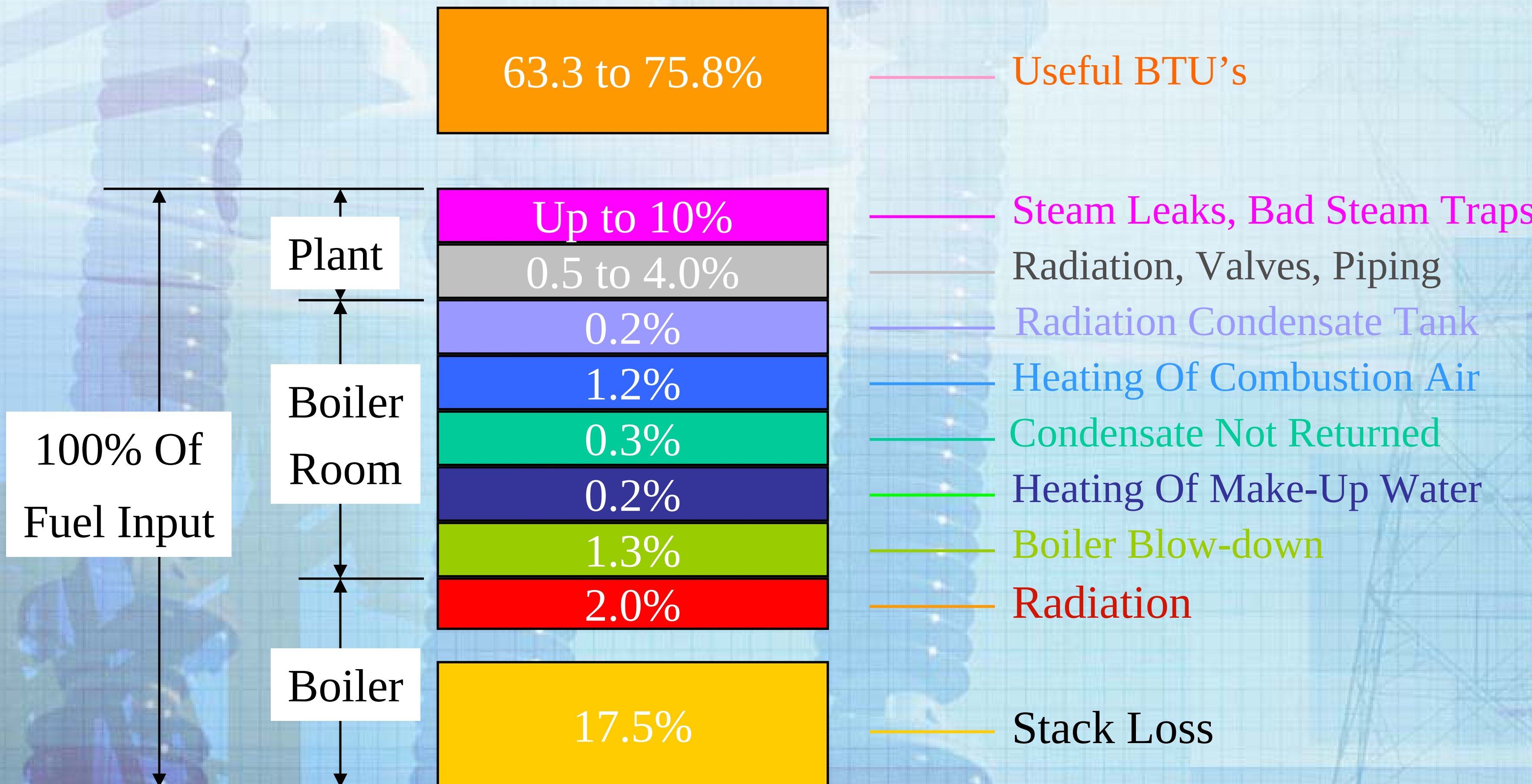
Monitoring energy use is key to controlling Costs

- Trending
- Alarming
- Reporting

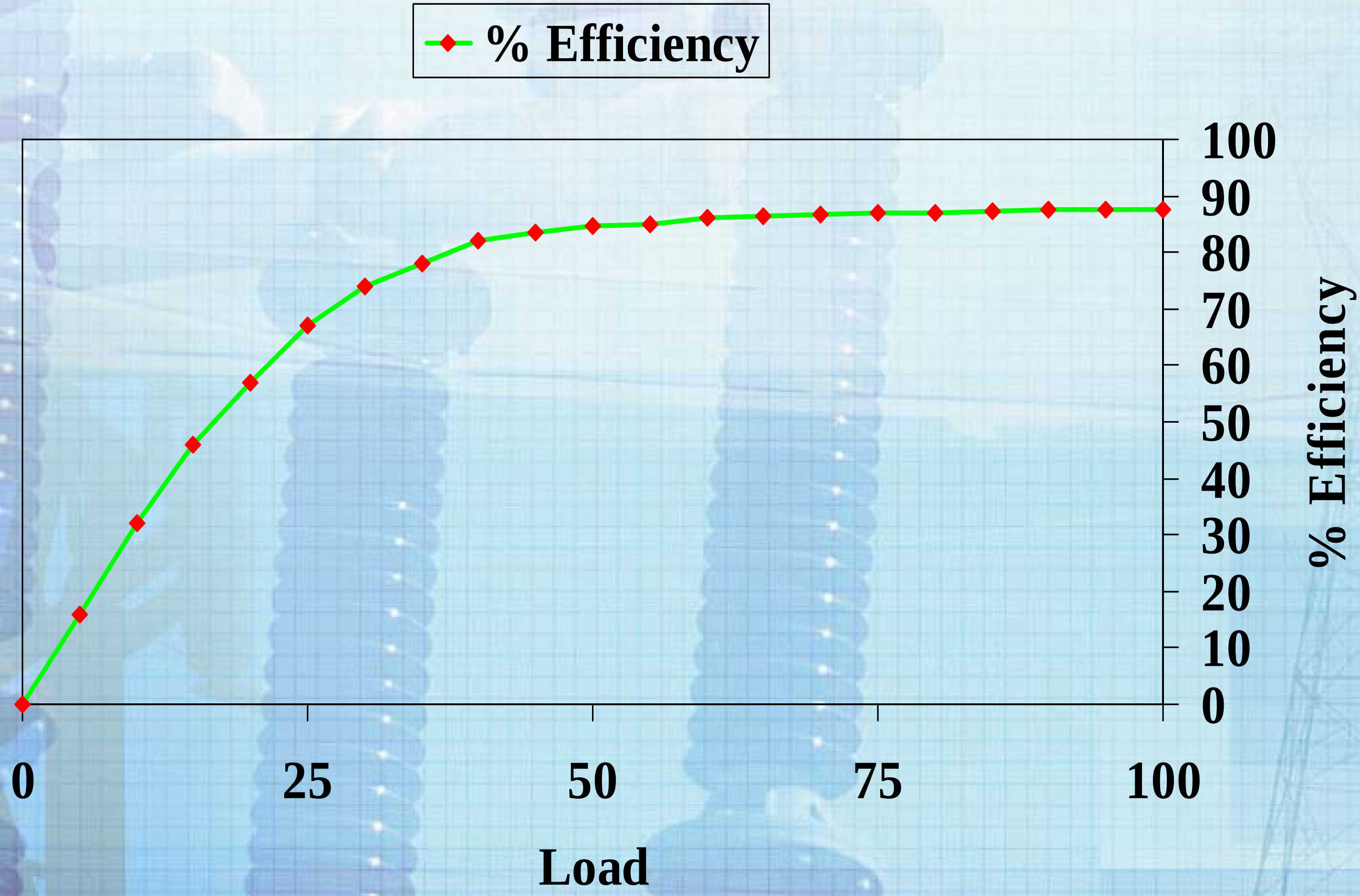


Optimize Gas Boiler Efficiency

Causes of Efficiency Loss



Minimize Partial Loading



Excess O_2 Losses

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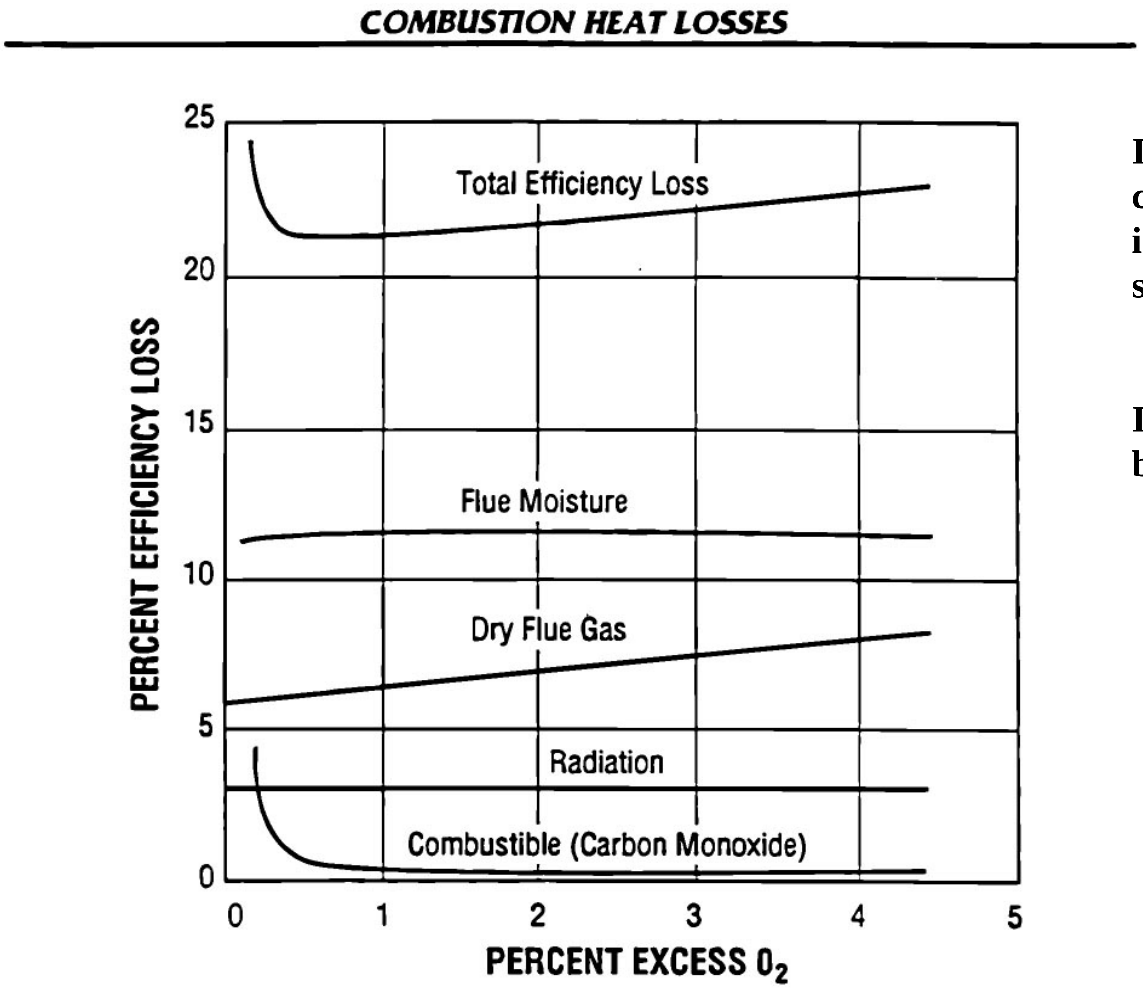

If a boiler is perfectly tuned and O2 trim controls are added, a minimum of 2% in annual gas consumption could be saved.

In reality most boilers could save between 4% - 10%.

Purchase an OXYGEN TRIMMING SYSTEM

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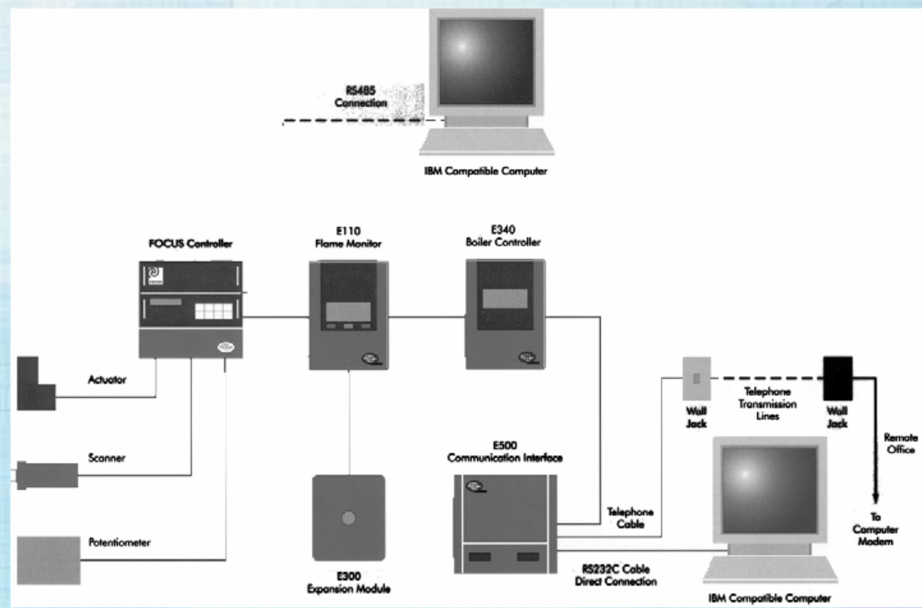
Installed Cost $9,000

Payback = 1.5 years

(150 bhp boiler operating 1.5 shifts for 5.5 days/week @ $.80/therm)



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Repair Steam Traps

Steam Traps

- A steam system that has not been maintained in 3 to 5 years can have between 15% to 30% of its installed steam traps leaking or failed. This equates to about 7.5% of the total steam produced.
- These failed traps are allowing live steam to escape into the condensate return system.
- A maintained steam system should have less than a 5% failed trap population or 1.7% loss of the steam produced.
- On average a single faulty trap will lose 12 lb/hr of steam or $1,156/yr.

Optimize Motors & Drives

Replace V Belts with Cog Belts

- Cog Belts can reduce energy costs by 2%
- Evaluate each application before applying. Not all applications will benefit.

Buy Premium Efficiency Motors

Upon failure, replace standard or high efficiency motors with premium efficiency motors (1%-2% energy reduction, payback < 2 years.

Table 1. Annual Savings from Specifying NEMA Premium Motors

Horsepower	Full-load Motor Efficiency (%)		Annual Savings from Use of a NEMA Premium Motor	
	Energy Efficient Motor	NEMA Premium Efficiency Motor	Annual Energy Savings, kWh	Dollar Savings $/year
10	89.5	91.7	1,200	$60
25	92.4	93.6	1,553	78
50	93.0	94.5	3,820	191
100	94.5	95.4	4,470	223
200	95.0	96.2	11,755	588

Note: Based on purchase of a 1,800 rpm totally enclosed fan-cooled motor with 8,000 hours per year of operation, 75% load, and an electrical rate of $0.05/kWh.

Optimize Environmental Controls

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Reduce Water Flow to Exhibits Where the Animals are Less Active at Night Using VSD's:

- Fresh & Salt Water Otters
- Sea Lions
- Belugas
- Penguins

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Pump Energy Saving Measures & Approx. Savings

Action	Est. Savings Potential
Valve throttling	5 - 20%
Impeller trim	5 - 30%
Reduce speed for fixed load	5 - 40%
Install parallel system for highly variable loads	10 - 30%
Replace throttling valves with speed controls	10 - 60%
Replace motor or pump with more efficient model	1 - 3%
Coatings inside pump	0.5 - 2%

Dave Flinton
ITT Industrial & BioPharm Group
September 20, 2006

Install VSD's on Larger Pumps

- Filters generally need to be cleaned every 3 days
- The first two days the filters are clean and the pressure drop across them are 10 feet
- The 3rd day the drop might be 35 feet.

Impact of Dirty Filters on Energy

Example:

1000 gpm pump,

Pump efficiency = .8

Motor efficiency = .95

System Head Loss = 35 feet (not including filters)

A Clean filter with 10’ of head requires 15.0 kW of pumping

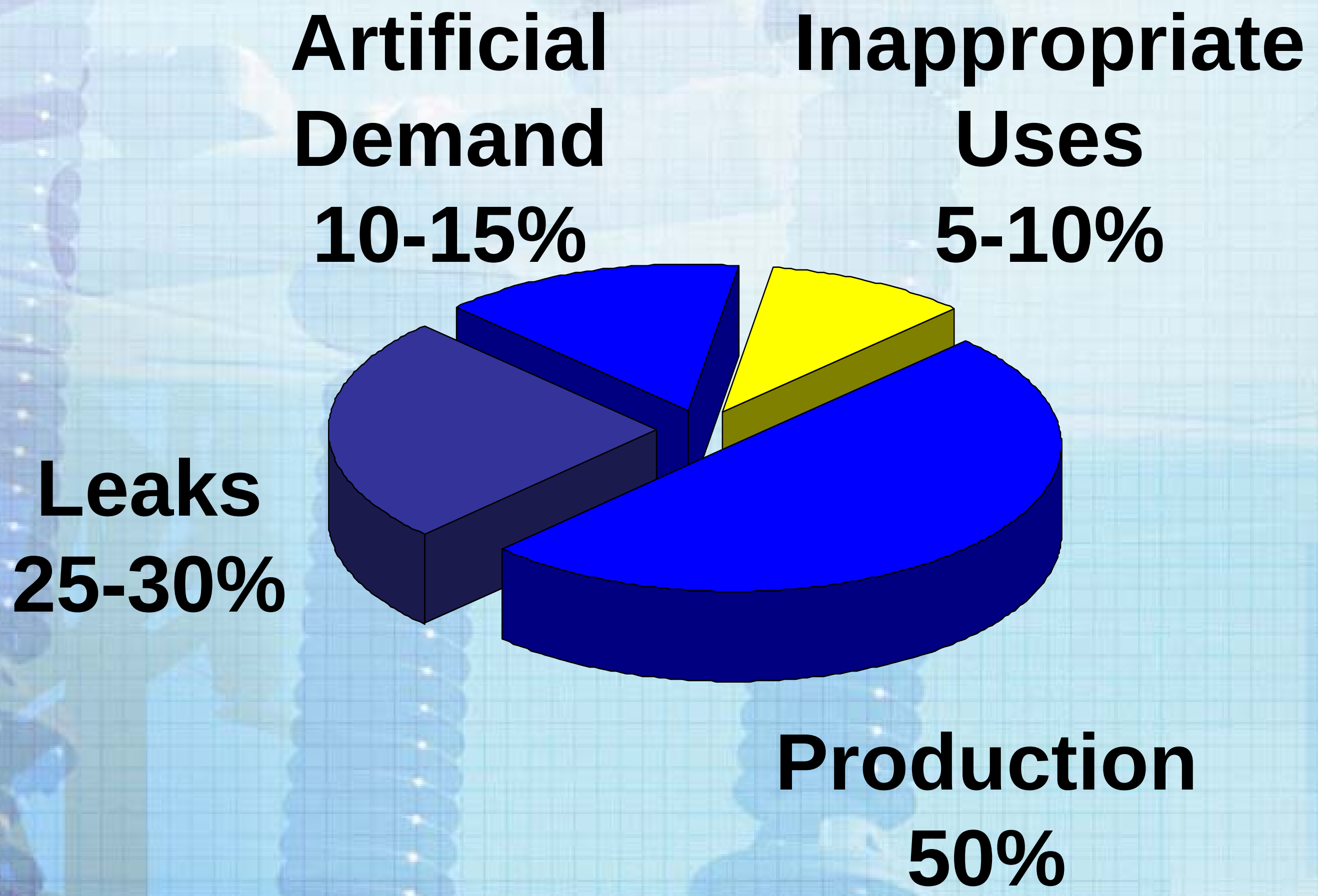
A Dirty filter with 35’ of head requires 23.3 kW of pumping

The Dirty Filter requires 35% more energy!

Optimize Compressed Air System

Slides courtesy of Dean Smith, Air Management

According to a Study by the DOE Only 50% of the Compressed Air Produced is Appropriately Utilized



Cost Reduction Opportunities

− Typically, only **25%-35% of the savings** opportunity is on the Supply side or **in the compressor room**

− Most opportunities are **out in the plant - 65%-75%**

Energy is only part of the story.
Total operating costs include:

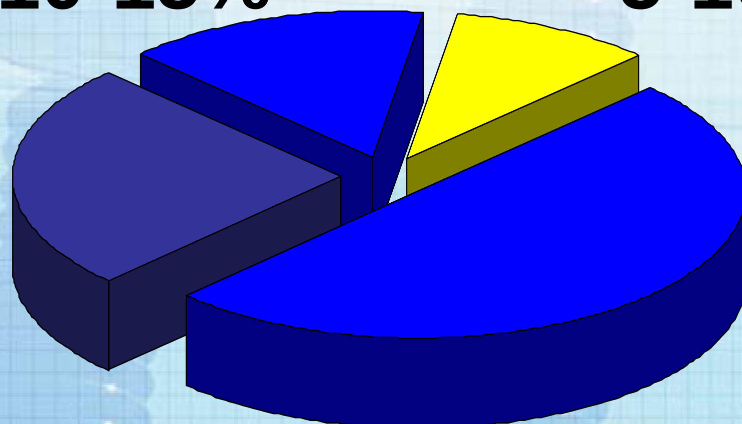
- Cooling costs, water, sewer, chemical treatment
- Maintenance, parts, inside labor, outside contractors.
- Major repairs and rebuilds
- Rentals costs as required
- Operating labor and supervision
- Depreciation and capital costs
- These costs are typically 30% of total costs; energy is 70%.
- Total annual operating costs represented = energy costs / .7 = $

When Trying to Reduce Costs Go For the Low Hanging Fruit First

3 Artificial Demand 10-15%

Inappropriate Uses 5-10% 2

1 Leaks 25-30%



Production 50%

- 1, 2, 3 are on the demand side
- 3 alone is on the supply side

Demand-Side Opportunities

Fix the Leaks!

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COMPRESSED AIR LEAK RATE											
STANDARD CUBIC FEET PER MINUTE											
Standard Conditions = 14.7 PSIA / 70 °F / 0% RH, 7.13¢/kWh, 8760 hours/yr.											
Air Pressure PSIG	**Size of Leak (in)**										
	1/64	**1/32**	**1/16**	**1/8**	**1/4**	**3/8**	**1/2**	**5/8**	**3/4**	**7/8**	**1**
	Leak rate in SCFM										
70	$37	$150	$598	$2,398	$9,581	$21,611	$38,350	$59,836	$86,193	$117,298	$153,274
80	$42	$167	$670	$2,673	$10,705	$24,109	$42,847	$66,956	$96,311	$131,163	$171,262
90	$46	$185	$740	$2,961	$11,842	$26,607	$47,344	$73,951	$106,555	$145,029	$189,375
100	$51	$202	$811	$3,248	$12,991	$29,231	$51,841	$81,072	$116,673	$158,895	$207,488
110	$55	$220	$881	$3,523	$14,116	$31,729	$56,463	$88,067	$126,916	$172,761	$225,601
120	$59	$239	$952	$3,810	$15,240	$34,227	$60,960	$95,187	$137,035	$186,627	$243,714
125	$62	$247	$987	$3,947	$15,740	$35,477	$63,208	$98,685	$142,156	$193,497	$252,708
150	$73	$296	$1,180	$4,684	$18,738	$42,222	$74,951	$113,675	$164,267	$223,478	$292,057

Eliminate Improper Uses of Compressed Air

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Any application that can be done more effectively or more efficiently by a method other than compressed air

Utilize blowers at 25 scfm/hp for :

- Open Blowing – drying, cooling,
- Sparging
- Personnel Cooling
- Atomizing
- Padding
- Vacuum Generation

Utilize Proper Equipment for :

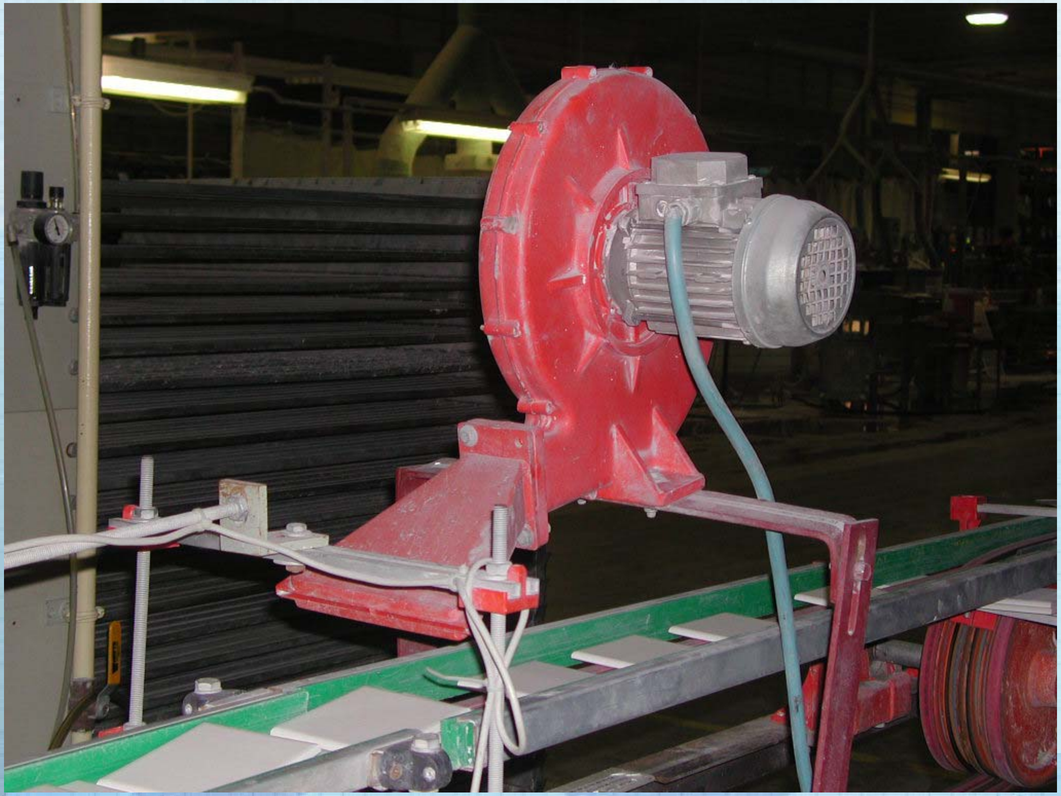
- Mixing or Agitation
- Cabinet Cooling

Utilize Storage to Eliminate Peak Demands for :

- Dilute Phase Transport
- Dense Phase Transport
- Open hand held blowguns or lances
- Diaphragm Pumps

Use Low Pressure Blowers When Possible

- Compressors deliver 4 cfm / hp
- Blowers deliver 15-25 cfm / hp but they must be properly applied



Use Vacuum Pumps Instead of Venturi Vacuums

Dedicated vacuum systems use 1/10th as much energy as venturi vacuum systems.

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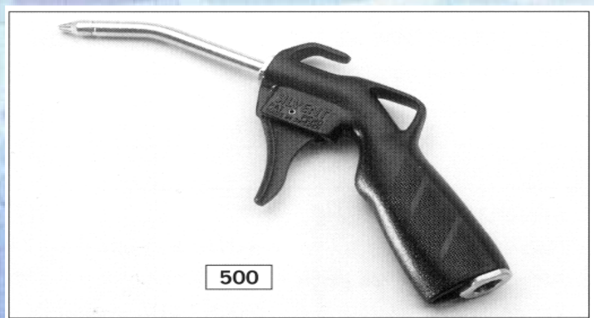
Use Electric Motors Whenever Possible

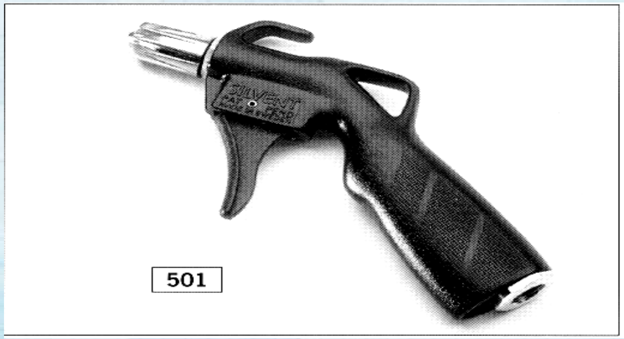
– In general, it takes 7-8 hp of electrical power to deliver 1 hp of compressed air to the plant floor.

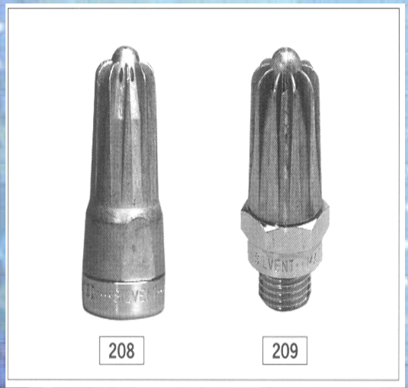
– Electric drive tools/motors use 1/7th – 1/8th as much energy as compressed air tools/motors.

Use High Efficiency Nozzles

- –Reduce consumption by 30%-70%
- –The supply air must be filtered to protect clearances







Reduce Artificial System Pressure

- The input power increases 1% for every 2 psi increase in compressor discharge pressure
- Unregulated consumption (leaks) increase ~ 1% for every psi increase in system pressure at 100 psig
- Net result is >1.5% - 2.0 % increase in operating costs for every 1 psi increase in pressure; and this does not include the cost of additional compressors

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Causes of Excessive System Pressure

– Excessive pressure drops due to improperly sized system components:

- Piping
- Filters
- Dryers
- Regulators

– Lack of proper storage – not enough storage is available to buffer high intermittent loads.

– Not understanding critical pressure applications.

Compressed Air System Pressure Profile

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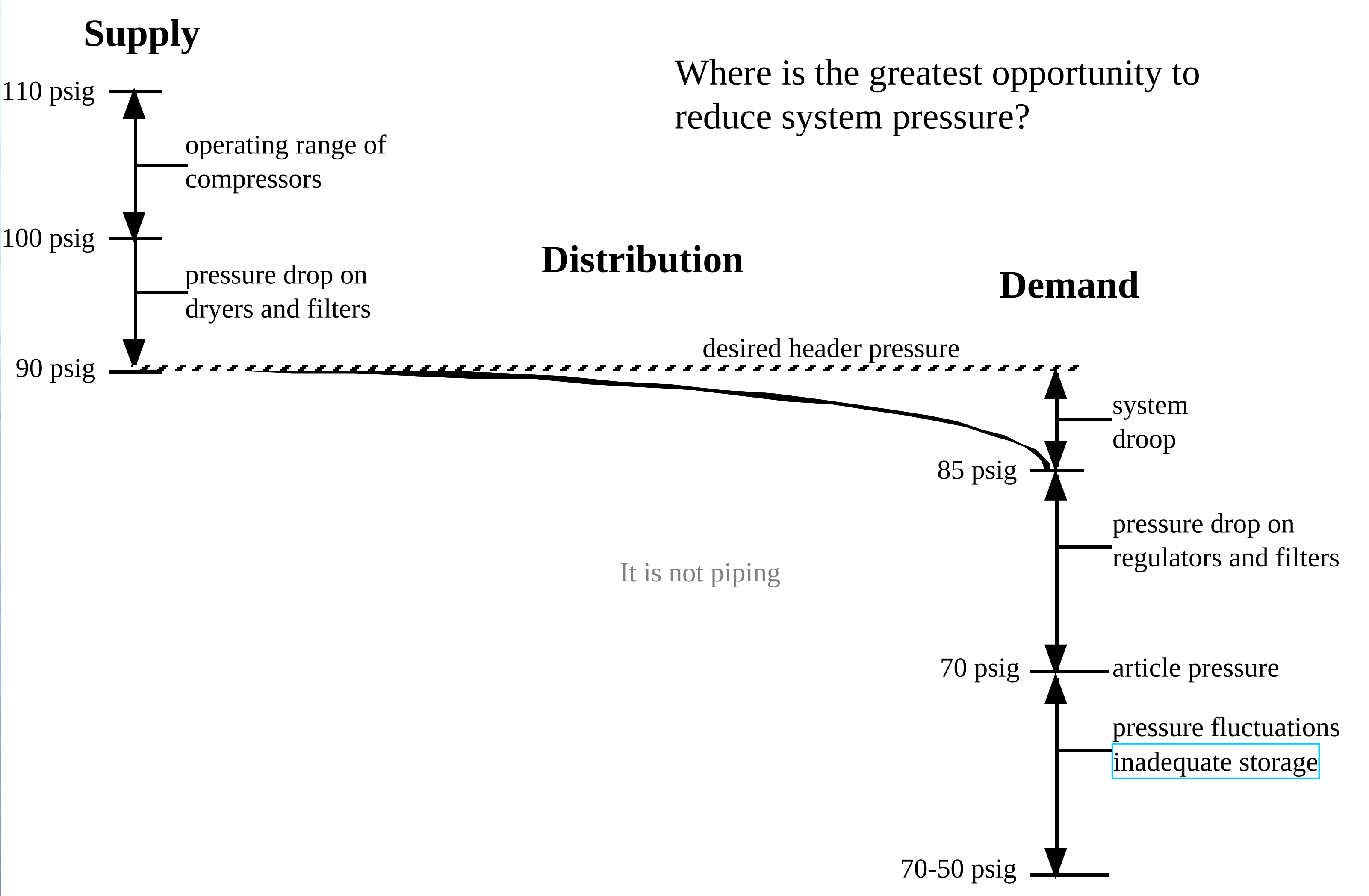

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Provide Adequate Central Plant Storage

- Plant storage must be after the filters and dryers to provide air on demand to the system without surging the cleanup equipment.
- Plant storage should be at a higher pressure than that required by the plant for it to be of any benefit.

- Compressor room storage must be sized based on the following considerations:

1. To support larger demand events when practical in order to minimize compressor power in the system.
2. To support the demand in the system during a compressor failure and backup compressor start. This must allow for the permissive time of the backup compressor(s) and must be calculated from the minimum control storage pressure which will normally be allowed.
3. To minimize cycling on the largest anticipated trim compressor. Cycles should be less than 20 per hour but preferably closer to 15 per hour.

Provide Adequate Local Storage

- Providing adequate local storage can reduce large pressure fluctuations throughout the compressed air system.
- Local storage requirements are often very small.

Local Storage Example

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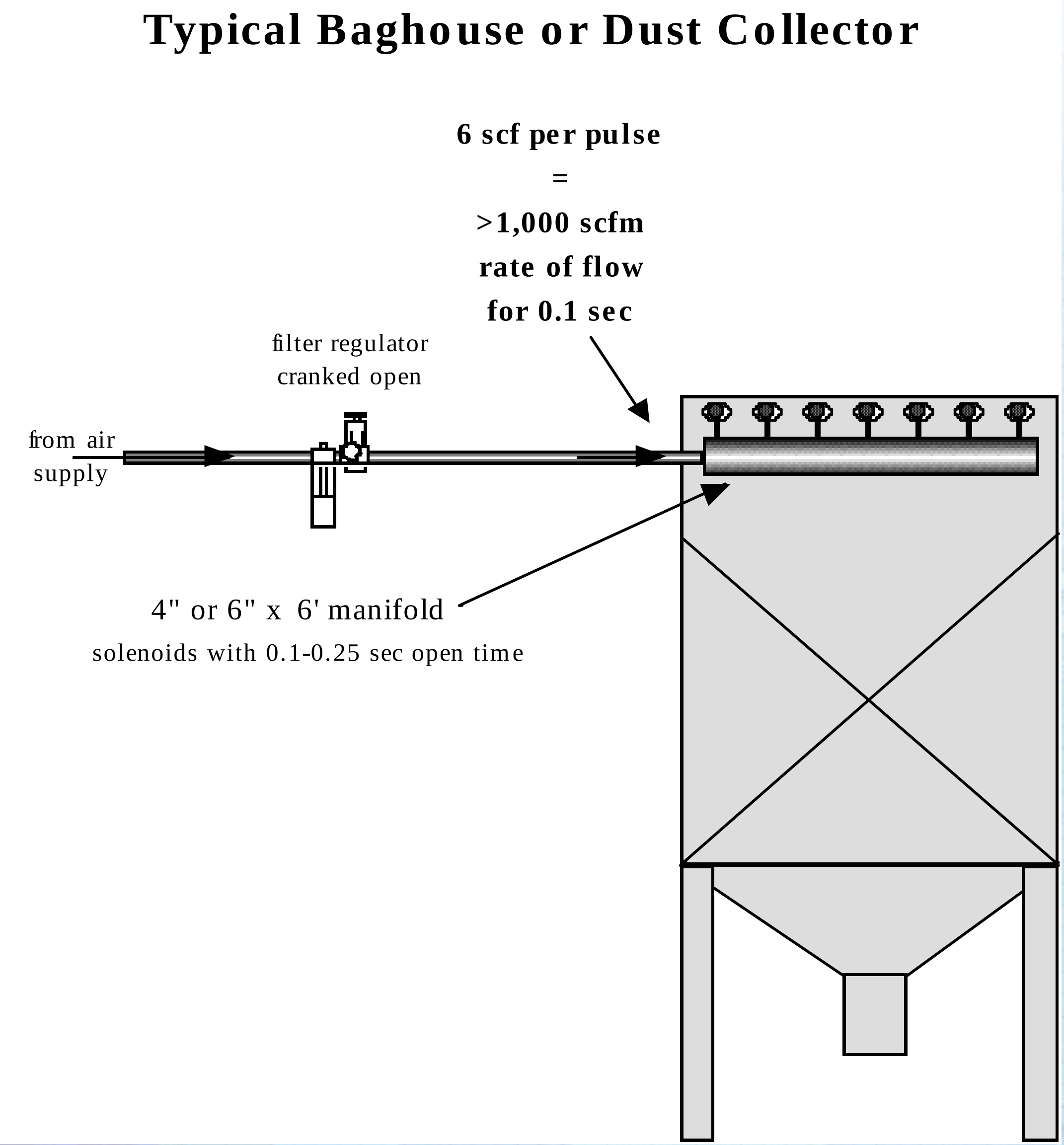
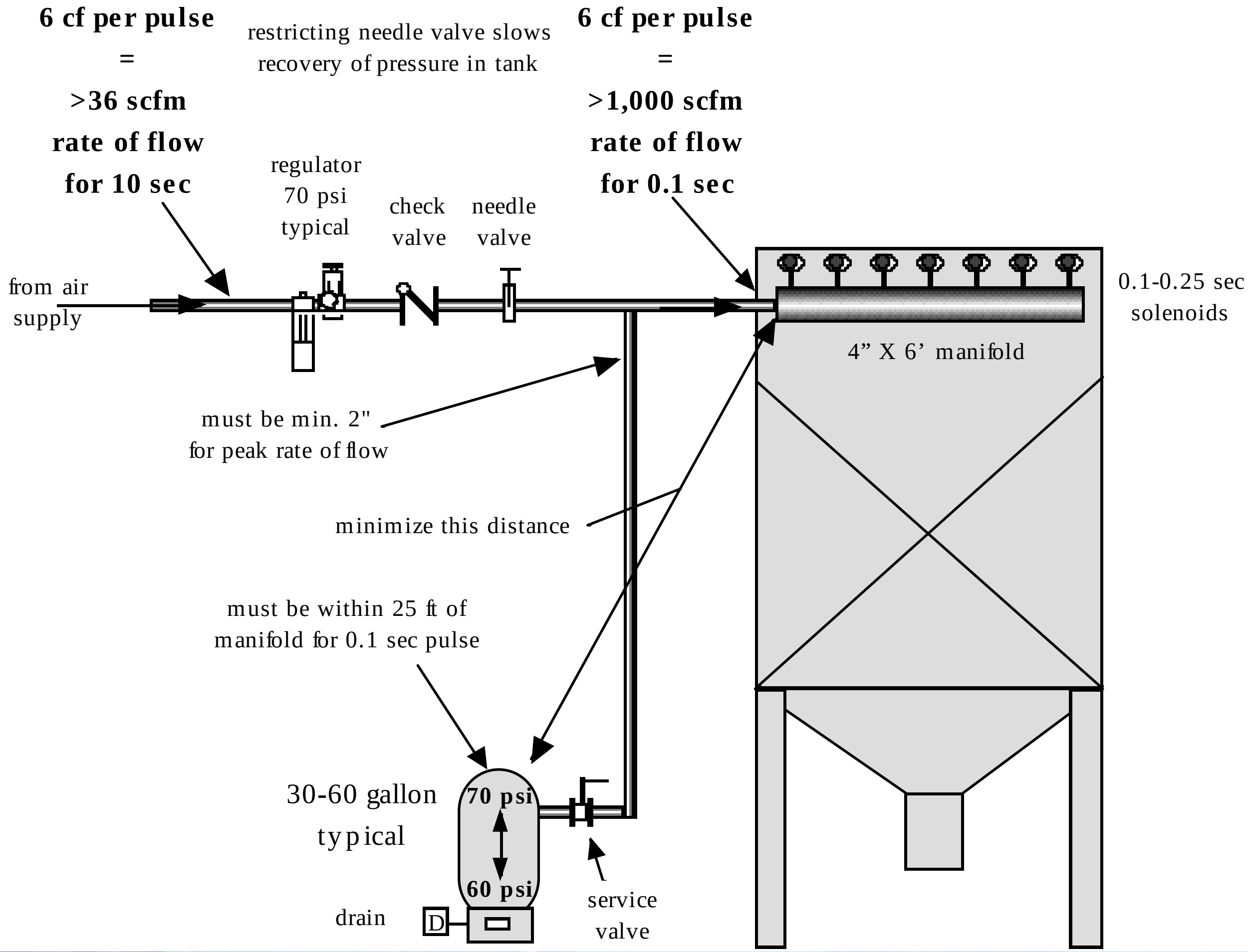
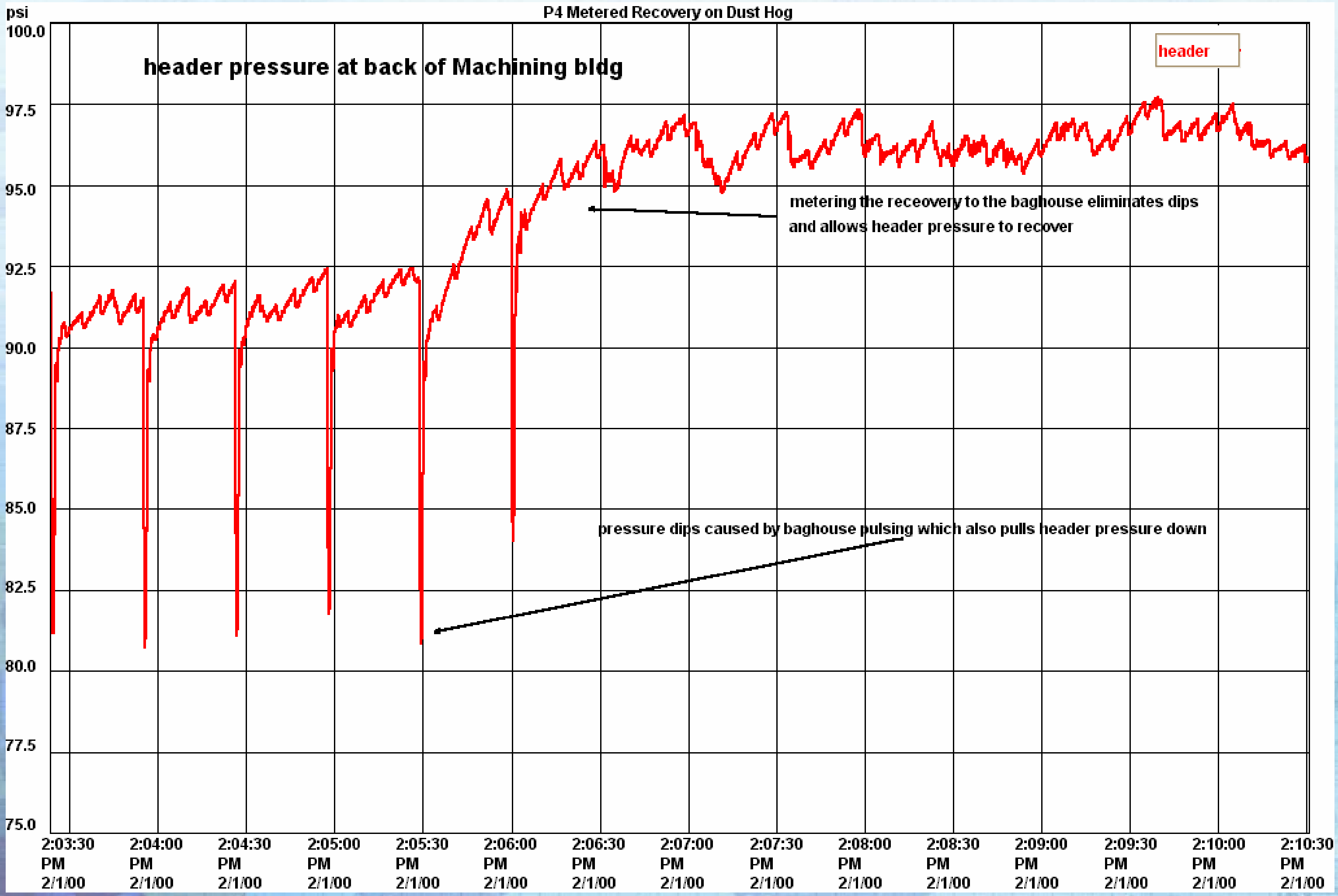


Proper Installation of Dedicated Storage for Baghouse or Dust Collector



Dedicated Storage for a Reverse Pulse Baghouse or Dust Collector

Inadequate storage at the point of use
The Positive Impact of Metered Recovery on the System



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Identifying Critical Pressure Applications

- Ask the following types of questions of the compressor operator and the production staff but take all answers with a very large grain of salt.
- Who calls? What specific piece of equipment is affected?
- Did it produce rejects or slow down at this pressure or is the alarm point and the actual requirement is lower?
- Does this loss of pressure occur on a regular basis? When was the last time pressure dropped to this level and what occurred?
- Where is the pressure level referenced; regulator gauge, header gauge, alarm?
- Are there more of this type of production equipment? Do they incur the same problem? When the pressure last dropped, did the same thing happen at all these production machines?
- What is the next production process affected if the pressure continues to drop?

Supply Side Opportunities

Compressor Equipment Efficiencies

Compressor types @ 100 psig	cfm / bhp	% efficiency
– Non-lubricated rotary screw	4.1	-11%
– Single stage lubricated rotary screw	4.5	0 %
– Two stage lubricated rotary screw	4.8	6 %
– Multi stage centrifugal	4.8	6-8 %
– Two stage reciprocating	5.2	16 %

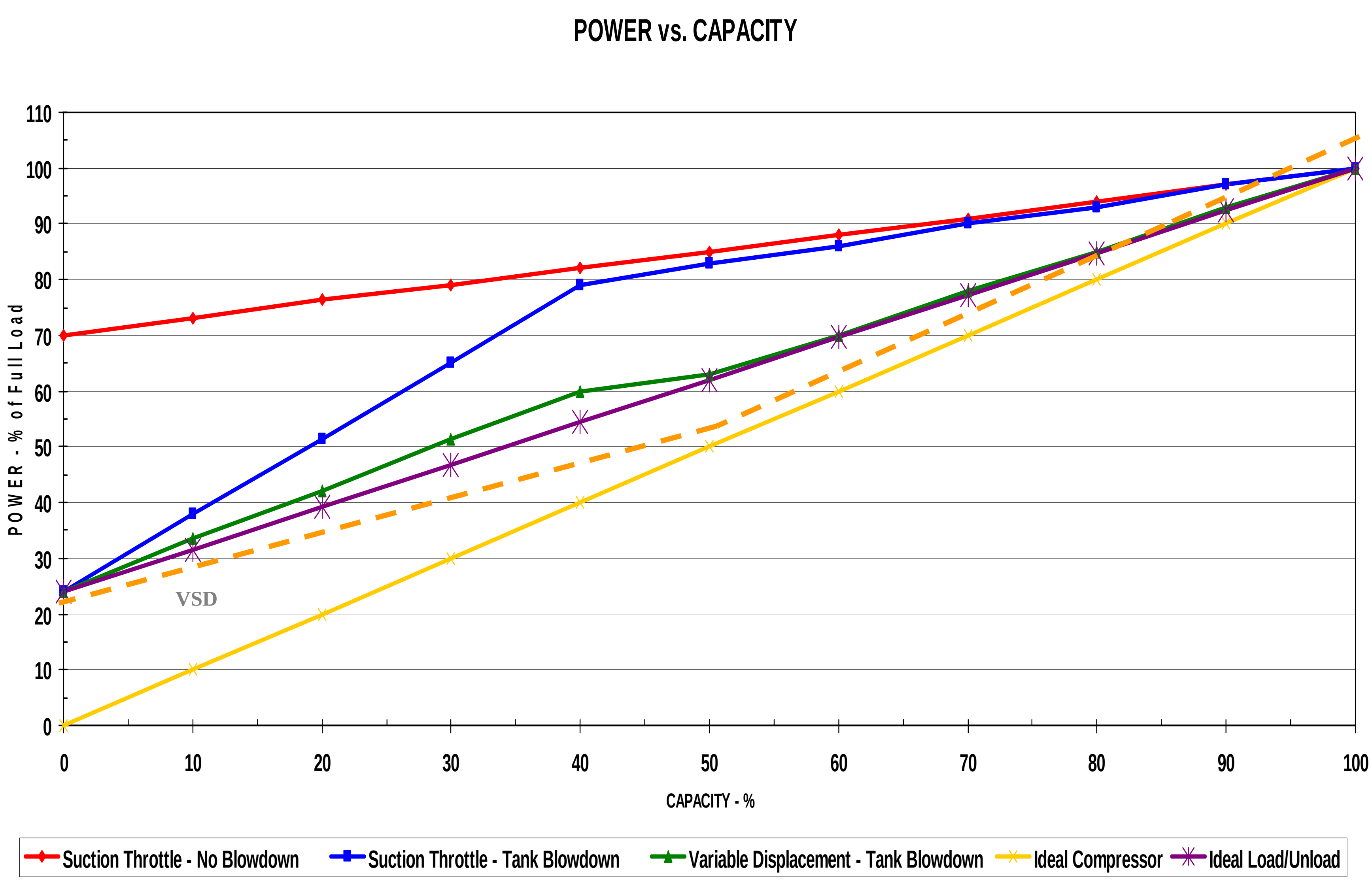
- **Practical energy savings based upon compressor type is only 6-8%**

The Impact of Controls on Efficiency

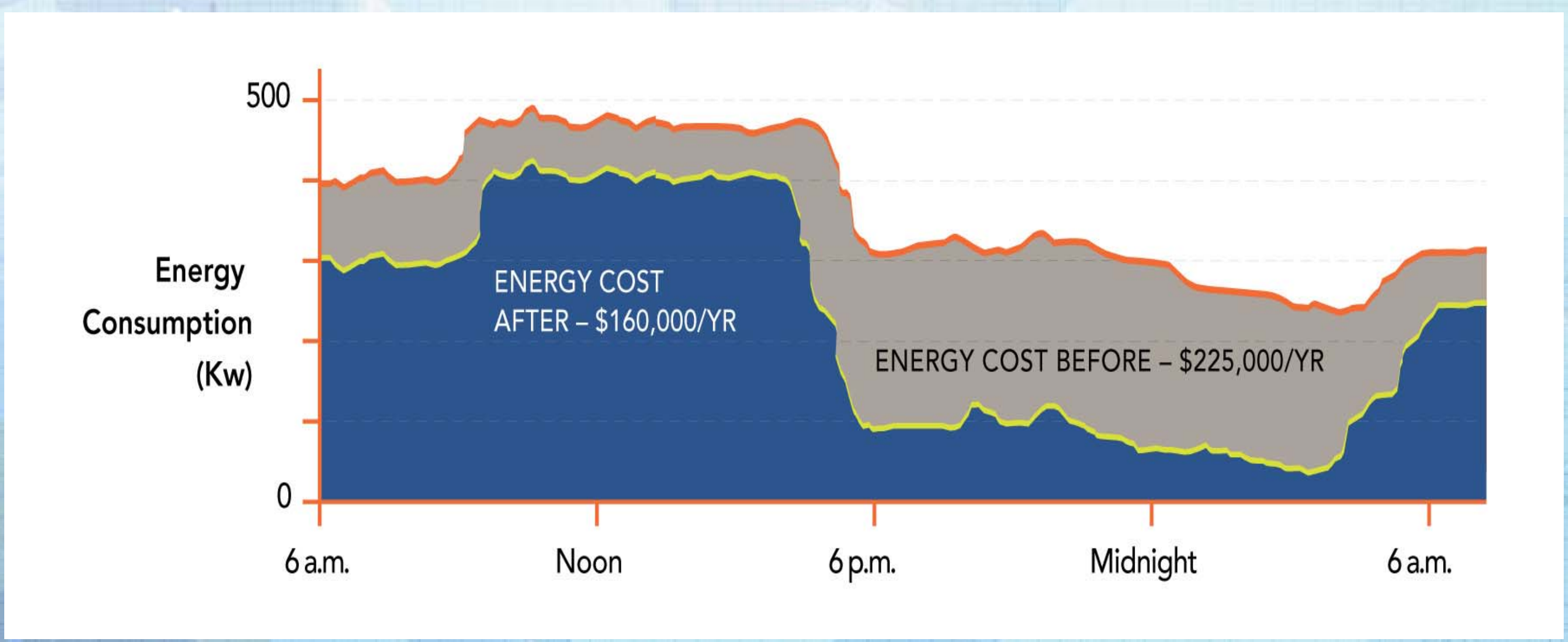
COMPRESSOR CONTROLS CREATE >90% OF THE SUPPLY SIDE OPPORTUNITY IN COMPRESSED AIR

- Part loaded compressors can be the result of control conflicts, or they may be intentional:
- Part loaded compressors allow higher pressures
- Part loaded compressors provide on line power for peaks
- Part loaded compressors provide backup for failures
- PART LOADED COMPRESSORS ARE VERY INEFFICIENT

Comparison of Rotary Screw Compressor Capacity Controls



Automation Case History
Plastic Bottle Blowing



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Compressed Air Savings Example

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Case Study, 400,000 sq. ft., Plastic Extrustion Facility

8 – 350 hp screw compressors

Measure	Cost to Implement	Annual Savings	Payback	NPV	IRR
Repair air leaks	$18,900	$89,370	0.21	$317,616	294%
Reactivate dryer heaters & controls for dryers 1-3	$0	$10,446	NA	$39,216	NA
Install dew-point controls on dryers 1-3	$5,250	$13,590	0.38	$47,400	167%
Reduce system pressure from 116 psig to 96 psig	?	$39,769	?	?	?
Install modulating valve & demand controller	$17,000	$14,203	1.2	$37,224	54%