Energy Savings in Electric Systems

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Schneider Electric Energy Solutions

Schneider Electric

Overview

- Understanding Your Electric Rate Structure
- Demand Response
- Power Quality
- Energy Efficient Transformers
- Metering
- Variable Frequency Drives
- Industrial Controls

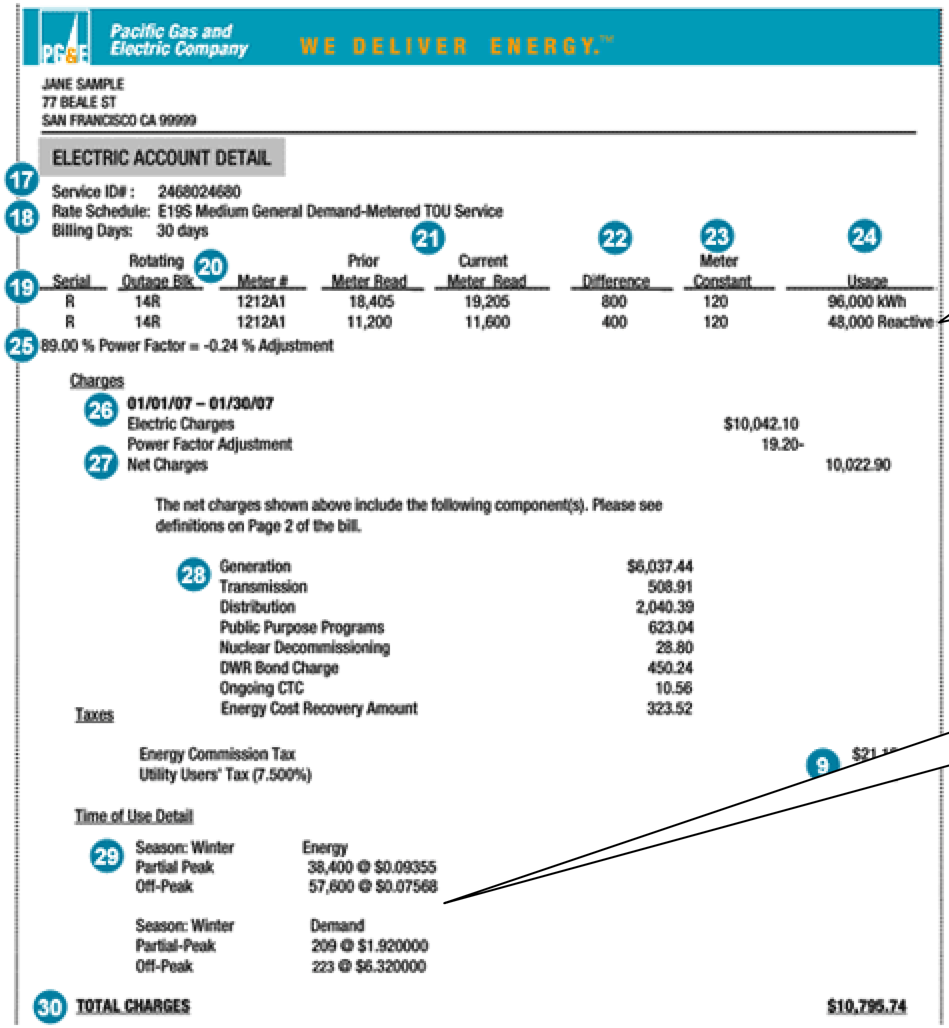
Understanding Your Electric Rate Structure

- Having a good grasp on your electric rate structure (also called a tariff) and your demand profile are of prime importance prior to looking for and/or implementing energy conservation measures.
- Things to look for in your rate structure:
  - Time of Use – time of day when power is more expensive
  - Demand Charges – what it costs to run concurrent loads
  - Power Factor – the impact of large capacitive or inductive loads

Electric Utility Charges – Beyond kWh

- Electric billing can be complex, but there are two major components of most bills that facilities can affect
  - Electric Usage, measured in kilowatt-hours (kWh)
  - Electric Demand, measured in kilowatts (kW)
- Electric Usage charges (kWh) are based on the actual energy used multiplied by a per-kWh rate
  - This rate may be different during peak and off-peak hours
  - Depending on the utility and agreement, this rate may fluctuate month-to-month
- Electric Demand (kW) charges are based on a peak usage period and represents to the utility your facility’s impact on their peak capacity

The Electric Utility Bill



Pacific Gas and Electric Company WE DELIVER ENERGY.™

JANE SAMPLE
77 BEALE ST
SAN FRANCISCO CA 99999

ELECTRIC ACCOUNT DETAIL

⑰ Service ID# : 2468024680
⑱ Rate Schedule: E19S Medium General Demand-Metered TOU Service
Billing Days: 30 days

⑲ Serial	Rotating Outage Blk ⑳	Meter #	Prior Meter Read ㉑	Current Meter Read	㉒ Difference	㉓ Meter Constant	㉔ Usage
R	14R	1212A1	18,405	19,205	800	120	96,000 kWh
R	14R	1212A1	11,200	11,600	400	120	48,000 Reactive

㉕ 89.00 % Power Factor = -0.24 % Adjustment

Charges

㉖ **01/01/07 – 01/30/07**		
Electric Charges	$10,042.10	
Power Factor Adjustment	19.20-	
㉗ Net Charges		10,022.90

The net charges shown above include the following component(s). Please see definitions on Page 2 of the bill.

㉘ Generation	$6,037.44
Transmission	508.91
Distribution	2,040.39
Public Purpose Programs	623.04
Nuclear Decommissioning	28.80
DWR Bond Charge	450.24
Ongoing CTC	10.56
Energy Cost Recovery Amount	323.52

Taxes

Energy Commission Tax
Utility Users' Tax (7.500%)

⑨ $21.1

Time of Use Detail

㉙ Season: Winter	Energy
Partial Peak	38,400 @ $0.09355
Off-Peak	57,600 @ $0.07568
Season: Winter	Demand
Partial-Peak	209 @ $1.920000
Off-Peak	223 @ $6.320000

㉚ **TOTAL CHARGES** **$10,795.74**

Reactive power is measured so that the utility can determine any power factor charges.

Usage and Demand are displayed during on-peak and off-peak hours with the corresponding charges.

On-peak, partial peak, and off-peak time periods can normally be found by contacting the utility or by looking on the utility's website.

Time of Use and Seasonal Rates

- Time of Use rates are electric rates that vary by the time of day. A utility may charge a higher rate during times of higher demand (called the peak rate) when power is more expensive to produce or purchase.
  - Some utilities may have a partial peak (also called mid-peak) in addition to the peak and off-peak rates.
  - Hours will vary based on local weather conditions and usage habits.
- Seasonal rates are rates that vary based on the time of year. A utility may charge a higher rate during the months of higher demand, normally the Summer months.
- Industrial customers with high peak loads may negotiate a flat rate, which will result in a lower on-peak and higher off-peak rate.

Demand Charges

- Demand charges can be based on a monthly, quarterly, seasonal, annual, or rolling 12 month peak
- Demand charges can represent up to 50% of a facility's monthly electric bill
- In effect, peak demand charges drive up your per-kWh cost
- An unnecessary 1kW load left on for an hour may not just cost you an extra 7¢ for an additional kWh. If it occurs during your coincident peak, it may cost you an extra $12!

Reducing Peak Demand Charges

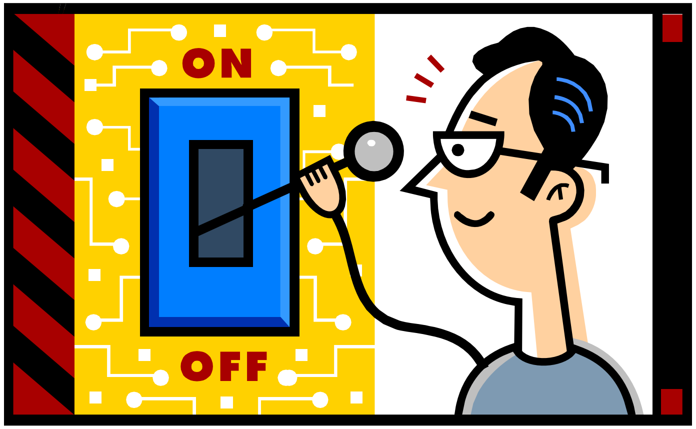
1. Understand your rate structure
   - What type of demand charge do you have (peak/off-peak, monthly, annual, seasonal, 12 month rolling)?
   - When is “peak time”?
   - Is space heating charged differently?
2. Understand your load profile
   - Where are the major loads?
   - Which loads are critical?
   - Which loads run constantly? intermittently?

Reducing Peak Demand Charges

3. Reduce waste
    - Find unnecessary loads running
        - over-lit areas
        - over-conditioned space
        - equipment running unnecessarily during breaks or off-hours
    - Fix compressed air leaks
    - Adjust temperatures to eliminate space heaters, especially in the Summer!

Reducing Peak Demand Charges

4. Try to stage large electric loads so they don't all run at the same time
    - Welders
    - Thermal Testing
    - Chillers
    - Paint Lines & Ovens
    - Air compressors



5. Demand Response & Peak Shaving
    - Certain non-critical loads (air conditioners, certain lights, space heaters, unattended bulk operation) can be shut off in response to a signal from the power company or a threshold signal from electric metering.
    - A generator can be cycled on to absorb some load
    - Requires transparency and cooperation from the plant

Reducing Peak Demand Charges

6. Install energy efficient equipment
    - Lighting
    - Motors
    - Drives
    - Pay careful attention to the payback achieved from cost savings (2 years or better where possible)
    - Specify energy efficient equipment when replacing failed or worn out equipment, as the incremental cost difference can many times pay back quickly
    - Eliminate electric space heaters where possible

Demand Response

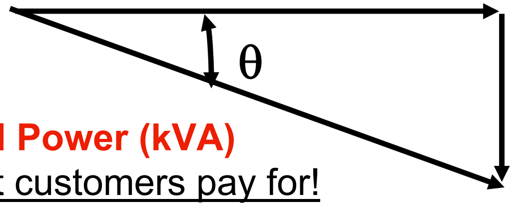
- As mentioned earlier, demand can be cut after a signal from the power company or a 3rd party demand aggregator
- The aggregator or utility will pay the facility to cut a pre-determined amount of demand, typically anywhere from 100-1000 kW in 4 hour blocks.
- The availability and economic payback of demand response programs depends on the territory where the facility is located
    - The Northeast, Texas, and California are the most active markets at this time, though programs do exist in other areas of the country
- The value of the curtailment will also depend on the agreed upon response time, which ranges from 30 minutes to several hours.

Power Factor

- A good portion of the total load in industrial power systems is inductive and has low operating power factor.
- Low power factor is caused by oversized or lightly loaded induction motors
- Low power factor results in:
  - Poor electrical efficiency!
  - Higher utility bills
  - Lower system capacity
- Typically, if a utility will charge a penalty for poor power factor, it will be below 90-95%

What is Power Factor?

- Let’s start with definitions:
  - Working Power: Normally measured in kilowatts (kW). It does the "work" for the system--providing the motion, heat, or whatever else is required.
  - Reactive Power: Normally measured in kilovolt-amperes-reactive (kVAR), doesn't do useful "work." It simply sustains the electromagnetic field.
  - Apparent Power: Normally measured in kilovolt-amperes (kVA). Working Power and Reactive Power together make up apparent power.
- The three types of power have a Pythagorean relationship:



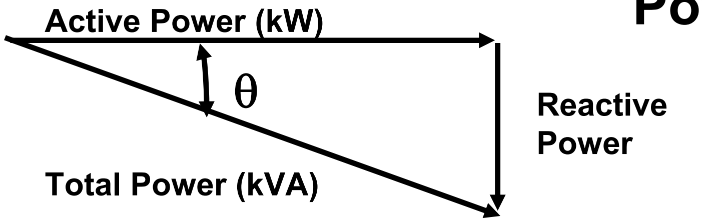
Active Power (kW):
Produces Useful Work

Reactive Power (kVAR)
Sets up Magnetic Fields
Produces no useful work

Total Power (kVA)
What customers pay for!

What is Power Factor?

Power Factor : A measure of efficiency. The ratio of Active Power (output) to Total Power (input)



Active Power (kW)

θ

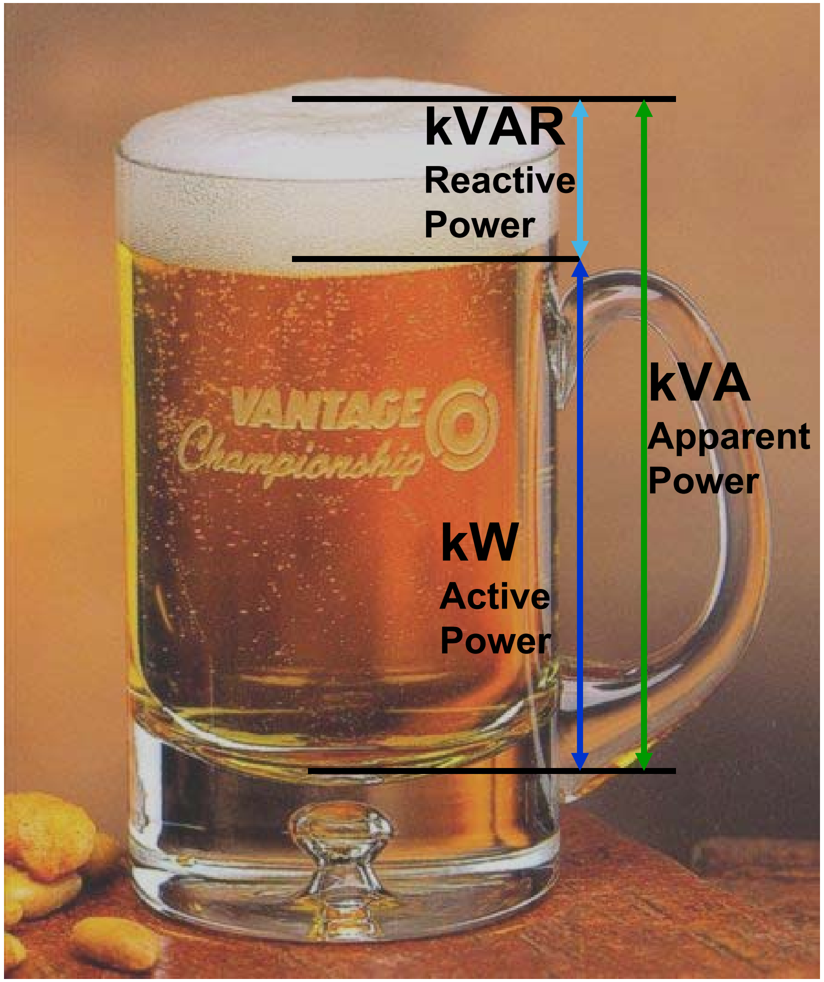
Reactive Power

Total Power (kVA)

$$\text{Power Factor} = \frac{\text{Active (Real) Power}}{\text{Total Power}} = \frac{\text{kW}}{\text{kVA}} = \text{Cosine}(\theta)$$

A power factor reading close to 1.0 means that electrical power is being utilized effectively, while a low power factor indicates poor utilization of electrical power.

Power Factor: The Beer Analogy



Mug Capacity = Apparent Power (KVA)

Foam = Reactive Power (KVAR)

Beer = Real Power (kW)

$$\text{Power Factor} = \frac{\text{Beer (kW)}}{\text{Mug Capacity (KVA)}}$$

Capacitors provide the Foam (KVAR), freeing up Mug Capacity so you don't have to buy a bigger mug and/or so you can pay less for your beer !

How do utilities charge for Power Factor?

- Utilities recoup the cost of providing reactive power in different ways…..
  - kVA billing: utility measures and bills every ampere of current including reactive current.
  - kW demand billing with Power factor adjustment: utility charges according to kW demand and adds a surcharge for power factor, typically in the form of a multiplier applied to kW demand.
  - kVAR Reactive Demand charge: A direct charge for use of magnetizing power. (example: 4.50/kVAR)

1 Two utilities recently introduced substantial Power Factor Penalties

  - ✍ TXU (Texas) $4.50 - $5.50 per kW Demand to 95% pf
  - ✍ TVA (Tennessee) $1.46 per kVAR lagging, $1.14 per kVAR leading (April 1, 2004)

Typical Uncorrected Power Factor

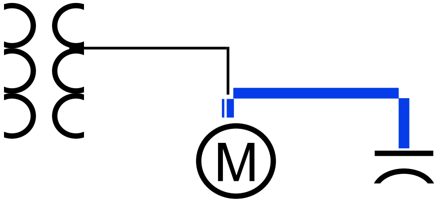
(Use only as a Guide)

By Industry	Power Factor	By Operation	Power Factor
Auto parts	75-80	Air compressor:	
Brewery	76-80	External motors	75-80
Cement	80-85	Hermetic motors	50-80
Chemical	65-75	Metal working:	
Coal mine	65-80	Arc welding	35-60
Clothing	35-60	Arc welding with standard capacitors	40-60
Electroplating	65-70	Resistance welding	40-60
Foundry	75-80	Machining	40-65
Forge	70-80	Melting:	
Hospital	75-80	Arc furnace	75-90
Machine manufacturing	60-65	Inductance furnace 60Hz	100
Metalworking	65-70	Stamping:	
Office building	80-90	Standard speed	60-70
Oil-field pumping	40-60	High speed	45-60
Paint manufacturing	55-65	Spraying	60-65
Plastic	75-80	Weaving:	
Stamping	60-70	Individual drive	60
Steelworks	65-80	Multiple drive	70
Textile	65-75	Brind	70-75
Tool, die, jig	60-65		

From IEEE Std 141-1993

What Can be Done to Improve Power Factor?

- The easiest solution is to add power factor correction capacitors to your electrical distribution system.

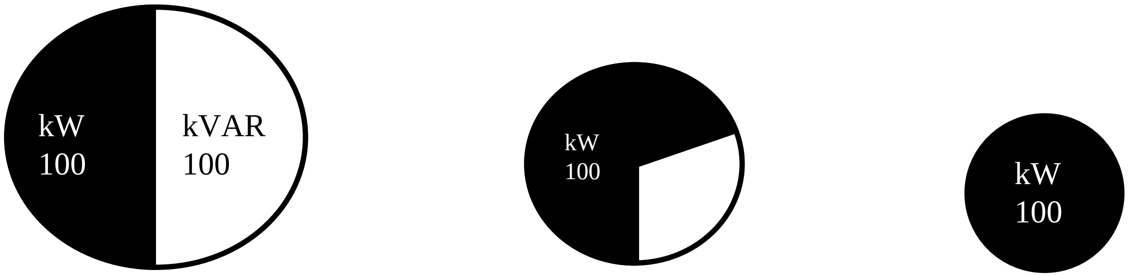


The Capacitor Supplies Reactive Current

- The utility supplies only the **ACTIVE**, or useful, power measured in kilowatts, and **not** the **REACTIVE** power.
  - – **Apparant** power the utility supplies is minimized
  - Efficiency/Power factor is increased
  - PF Penalty is reduced or eliminated
- Your bottom line is improved
  - The savings generated pay for the capacitors

What are the benefits of Power Factor Correction?

- Reduce Power Costs: lower utility bills since utility no longer supplies the reactive current.
- Released System Capacity
  - Capacitors off-load transformers and cables



kVA = 141
PF = 70%

kVA = 125
PF = 80%

kVA = 100
PF = 100%

- Improved Voltage
- Reduced losses

Other Benefits

- **Reduced Power Losses:**
  - As current flows through conductors, the conductors heat. This heating is power loss
  - Power loss is proportional to current squared ($P_{Loss}=I^2 R$)
  - Current is proportional to P.F.
  - Conductor loss can account for as much as 2-5% of total load
- **Capacitors can reduce losses by 1-2% of the total load**

$$\boxed{\%\ \text{Loss Reduction} = 100 \times 1 - \frac{(\text{Original P.F.})^2}{(\text{Desired P.F.})^2}}$$

Other Benefits

- **Voltage Improvement:**
  - When capacitors are added, voltage will increase
  - Typically only a few percent. Good if you have significant voltage drop near the load and want to raise the supply voltage locally.
    - Note: the voltage rises is limited.
  - Severe over-correction (P.F.>1) will cause a voltage rise that can damage insulation & equipment; or result in utility surcharges!
    - Usually a result of large fixed capacitors at mains

$$\boxed{\%\ \text{Voltage Rise} = \frac{\text{Capacitor kVAR} \times \text{XFMR}\ \%Z}{\text{XFMR kVA}}}$$

Fixed Capacitors - Low Voltage

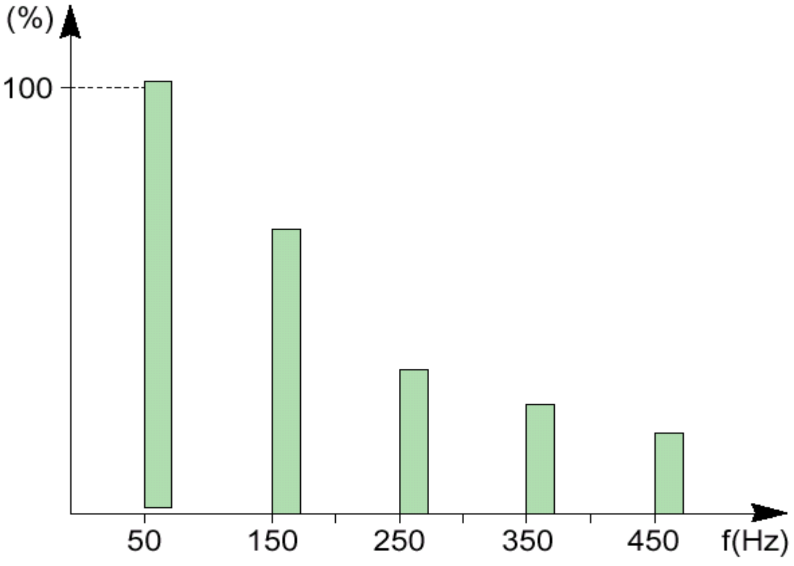
- Main Benefit
  - PF correction
- Side Benefit
  - voltage support
  - Small I^2R reduction
- Usage
  - Correcting pf on individual loads such as motors
- Disadvantages
  - Overcompensation (correct past unity)
  - Not to be used on non-linear loads
  - Unable to track minute by minute load changes occurring on non-compensated feeders

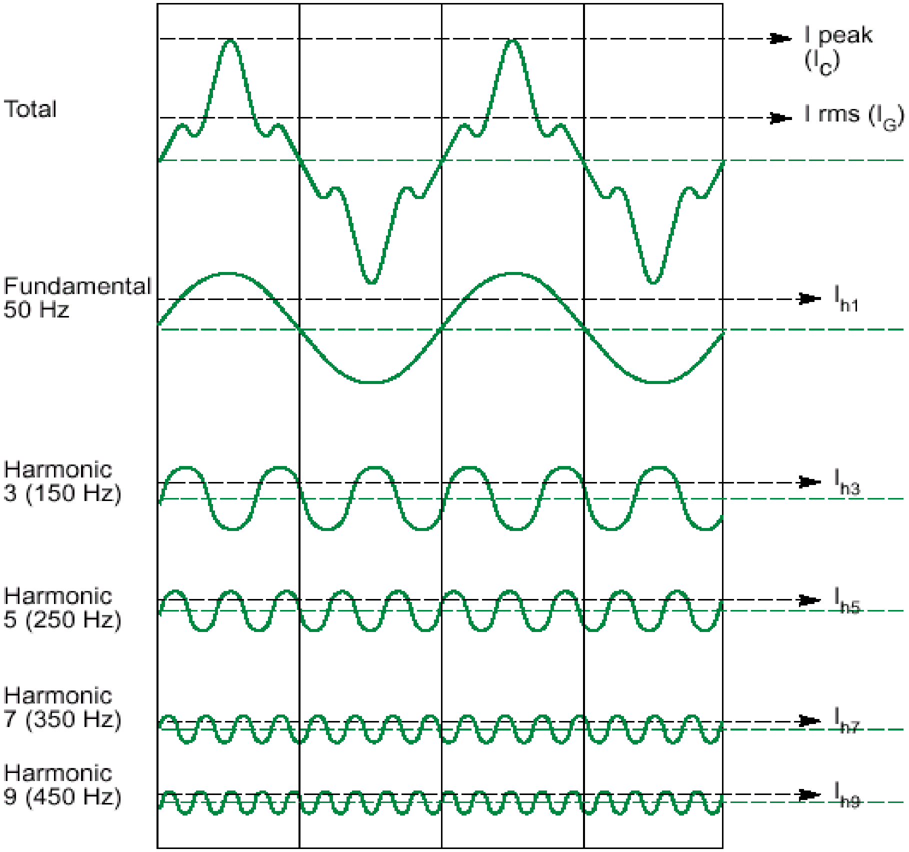
Standard Automatic Capacitor Systems

- Main Benefit
  - pf correction
  - Capacitor kicks in by stages to accommodate load changes
- Side Benefit
  - voltage support
  - Small I^2R reduction
- Usage
  - Correcting pf on entire MCC’s or substations
- Dangers
  - Not to be used on non-linear loads

What are Harmonics?

A harmonic is a component of a periodic wave having a frequency that is an integer multiple of the fundamental power line frequency

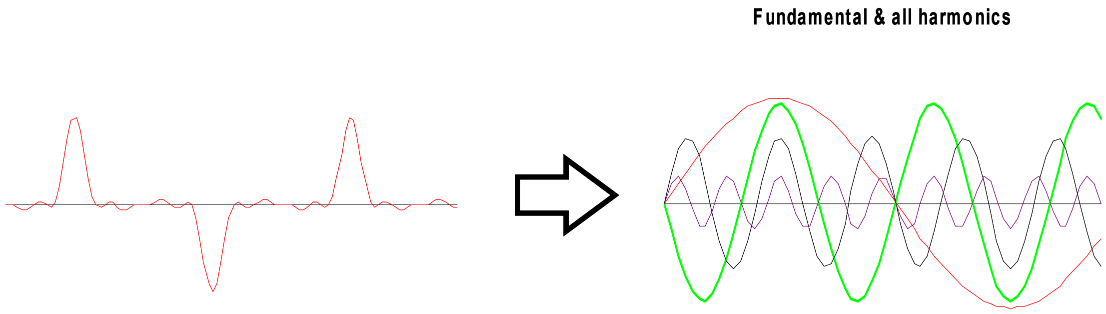




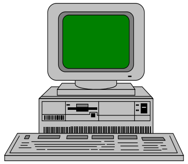
Composition of a Non-linear Waveform

- **The Cause of Harmonic Currents:**
  - The “Choppy”, non-linear current drawn by electronic loads is actually a “fundamental” (60hz) component plus many integer multiples of that fundamental frequency:

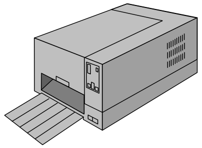
- These “*integer multiples of the fundamental frequency*” are just high frequency currents & they cause the problem



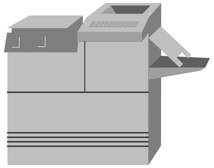
What equipment produces “Non-linear” Current?



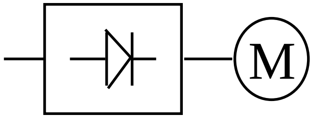
- Computers



- Fax Machines

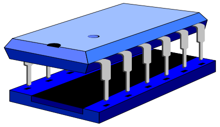


- Copiers



- Variable Frequency Drives

- Electronic Ballasts



- **Almost anything electronic**

Why are Harmonics a Problem?

Heating Effect:

Harmonics create heat in units proportional to the square of the harmonic order.

- 60Hz = 1heating unit (amp)
- 5th order = 25 heating units (amps)

Harmonics have a negative impact on a Facility by. . .

- Increasing operating costs
- Increasing process downtime
- Making traditional power factor correction difficult
- Lowering system efficiency

This impact is primarily due to the heating effect and produce many recognizable symptoms

How do you know if Harmonics are present in your system?

Common symptoms of harmonics include:

- Heating
  - Cable insulation breakdown
  - Random breaker thermal trips
  - Transformer failures
- Resonating power factor capacitors
  - Tuned to a frequency of load
- Thyristor (SCR) converter shorting
  - DC drives
  - Battery chargers
  - DC power supplies
- AC motor winding and bearing destruction
  - Path to ground for harmonics
  - Harmonic heating effects
- Random logic faults: CNC, PLCs, drives, UPSs, computers
- Power factor capacitor incompatibility
  - Harmonic heating effect
  - Trips on over-current
- Limits on capacity of generators & UPSs
  - Harmonic heating effect
- Generator faulting
  - Not able to regulate to frequency

Applying Power Factor Correction in the Presence of Harmonics

- Although capacitors do not cause harmonics, they can aggravate existing conditions. Problematic amplification becomes more likely as kVAR is increased.
- Harmonics will travel to the capacitors which try to soak it up but can resonate and become overloaded. Excessive resonance can destroy the capacitors. (See next 4 slides)
- Reactors in the capacitor bank protect it and “filter” *some* of the pollution
- Always consult a specialist in the field of Power Quality Correction when applying capacitors in the presence of non-linear loads.
- A PQC specialist will perform a series of measurements to determine the power factor and the harmonic distortion in your system

Energy Efficient Transformers

- Distribution transformers continue to draw power when connected, even when there is no load.
- Many facilities are under very low load conditions at night or on weekends, this includes single-shift industrial operations
- Newer transformers adhering to the NEMA TP-1 standard take this into account, as they are designed to run most efficiently at 35% load.
- Several online calculators (like this one at http://www.squaredleantools.com) exist for determining cost and energy savings. It’s important to evaluate cost savings under the specific load conditions of the site in order to select the most efficient transformer for the application.

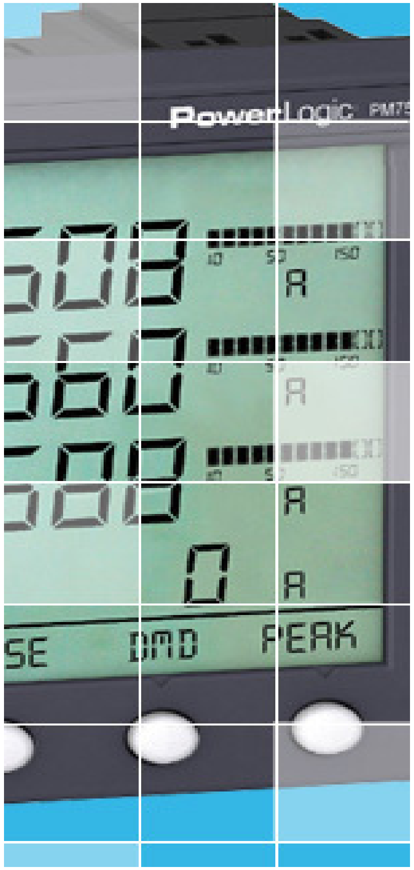
Energy Efficient Transformers

- Identifying potential opportunities
  - Older facilities will have undergone changes to their distribution system, and the transformers may be older and inefficient or may no longer be correctly sized for the load
  - Ask about any changes to the facility that have occurred since the transformers were installed
    - Were processes moved in or out?
    - Has the HVAC system been added to or made significantly more efficient?
    - Has the lighting load been cut by installing newer, more efficient lights?
    - Have processes changed to increase (additions of computers, automation, task lighting, etc) or decrease (reductions in hours, line sizes, etc. due to process improvement activities) power consumption?
- A transformer sales engineer can help you to evaluate these opportunities by metering loads and recommending upgrades, many times with very favorable payback.

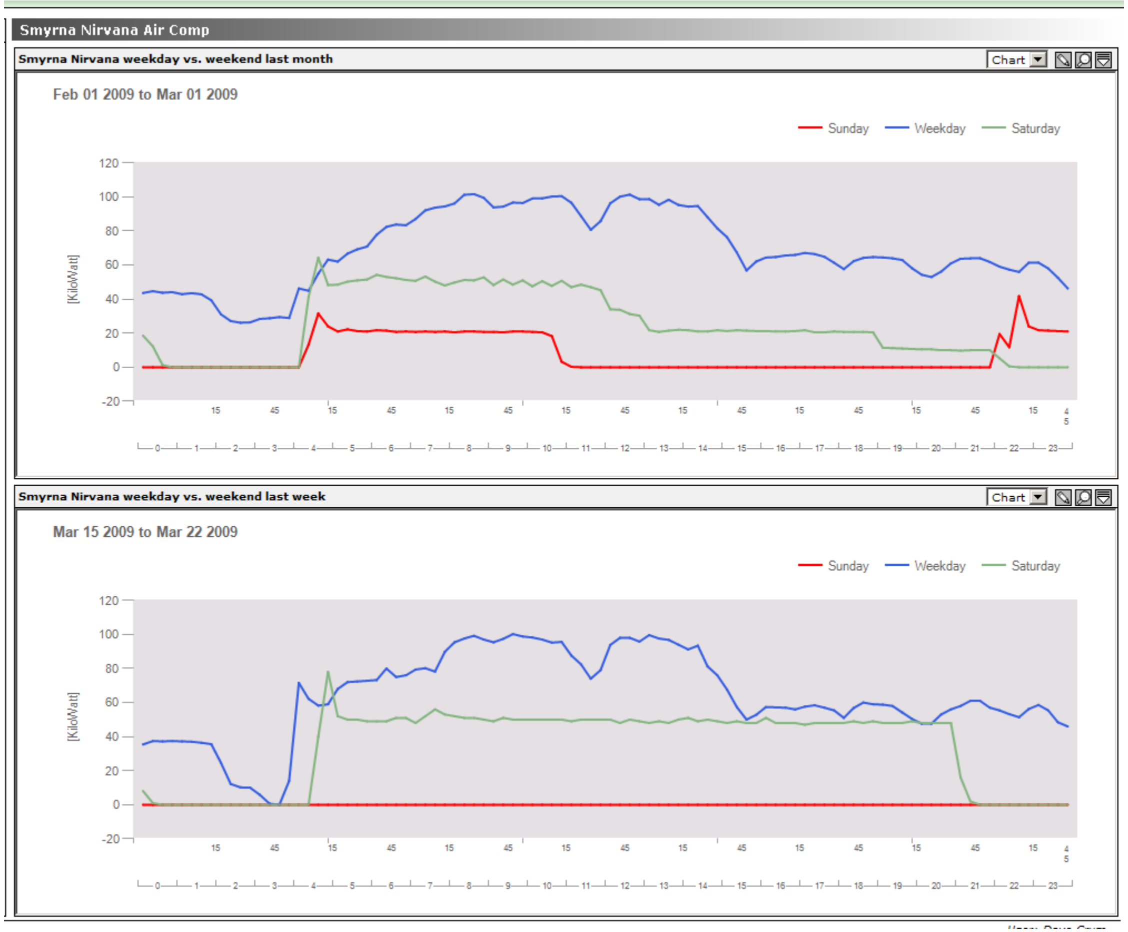
Metering and Monitoring

- Monitoring electric, gas, compressed air, and/or steam loads is essential for
  - understanding the usage profile of a facility
  - real-time power factor determination
  - verifying utility billing
  - monitoring for voltage sags and harmonic distortion

- For effective load profiling, meters should be located at
  - Utility Entry for whole facility load profiling and billing verification
  - Equipment, such as chillers, air compressors, cooling towers, boilers, and process heating equipment that have a large impact on the facility’s energy use and have variable loading profiles
  - Pieces of equipment sensitive to harmonic distortion and/or voltage sags

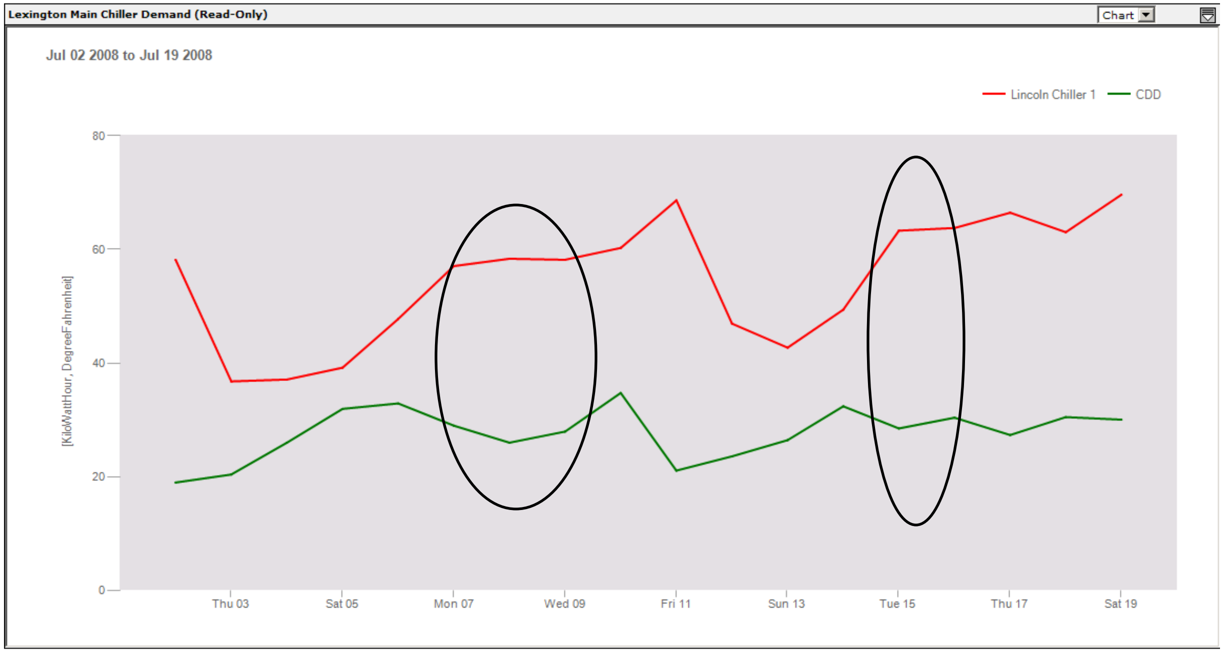


Uses for Metered Data



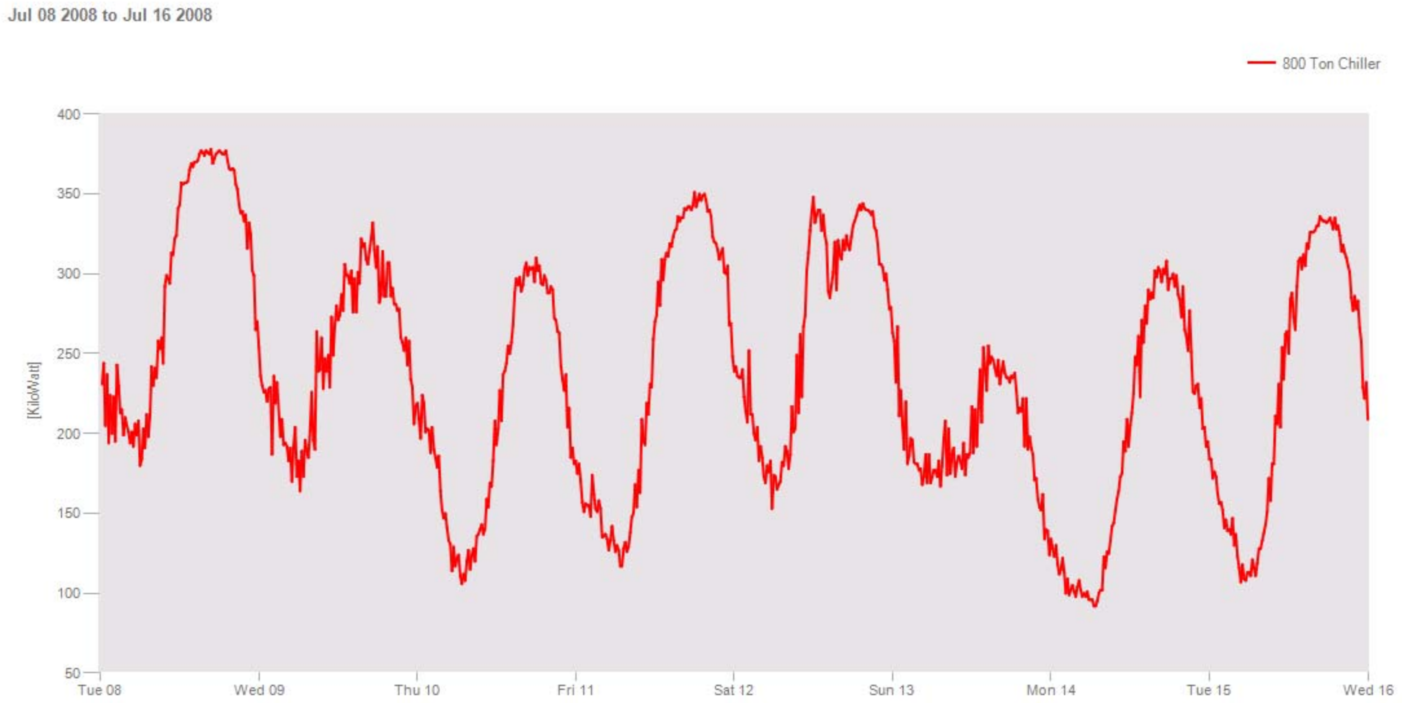
This graphic shows air compressor loading on weekdays and compares it to weekend loading. The upper graph shows average loading for the previous month, and the lower graph shows average loading for the previous week. This allows a facility manager to monitor whether the compressor is being shut down during periods of non-use.

Uses for Metered Data



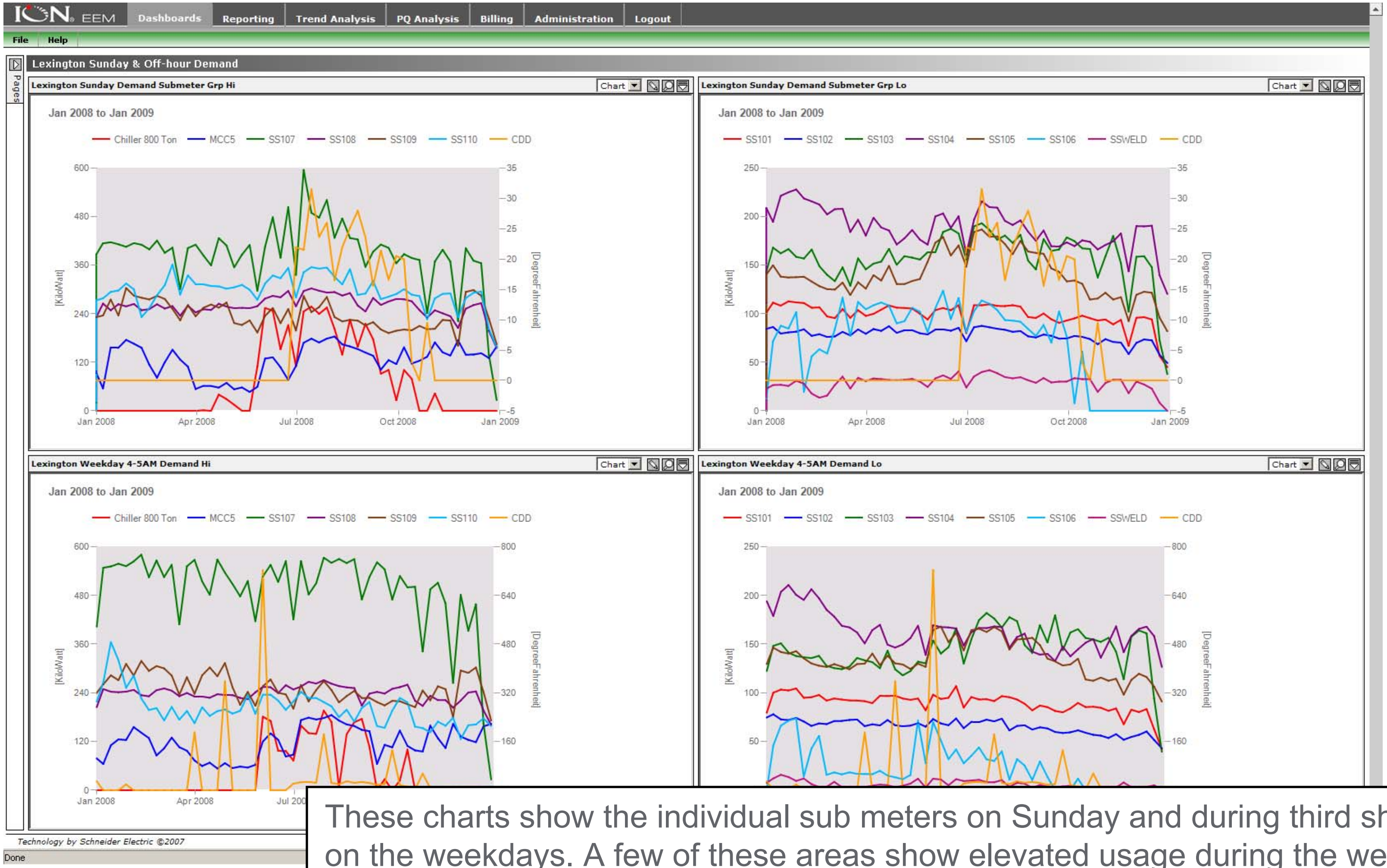
This graphic shows chiller loading and cooling degree days (CDD). This graphic shows that even though CDD were declining in some spots, usage remained high or climbed. This is a good opportunity to find out why.

Uses for Metered Data



Here, the chiller is showing reduced average demand at nights and on the weekends. This may be an opportunity to utilize a smaller unit to carry the load during these times.

Uses for Metered Data



These charts show the individual sub meters on Sunday and during third shift on the weekdays. A few of these areas show elevated usage during the week and may be areas where equipment is being left on. Also, the areas of highest use may be areas ripe for waste reduction.

Variable Frequency Drives - Background

- Purpose - Provides the ability to precisely match motor output to process requirements

- Potential benefits include
  - Improved product quality
  - Improved process throughput
  - Improved process control
  - Energy savings

- Most effective for applications with varying loads

- Common Applications: fans, blowers, and pumps

Affinity Laws

- In theory, the relationship between flow, pressure, speed, and pumping power in pumps (and fans, for that matter) can be explained by a simple set of rules called affinity laws:

$$\text{Flow} \; \alpha \; \text{Speed}$$

$$\text{Flow} \; \alpha \; \text{Head Pressure}^2$$

$$\text{Flow} \; \alpha \; \text{Power}^3$$

or

$$\frac{\text{Flow}_1}{\text{Flow}_2} = \frac{\text{Speed}_1}{\text{Speed}_2}$$

$$\frac{\text{Flow}_1}{\text{Flow}_2} = \frac{\text{Pressure}_1^{\;2}}{\text{Pressure}_2^{\;2}}$$

$$\frac{\text{Flow}_1}{\text{Flow}_2} = \frac{\text{Power}_1^{\;3}}{\text{Power}_2^{\;3}}$$

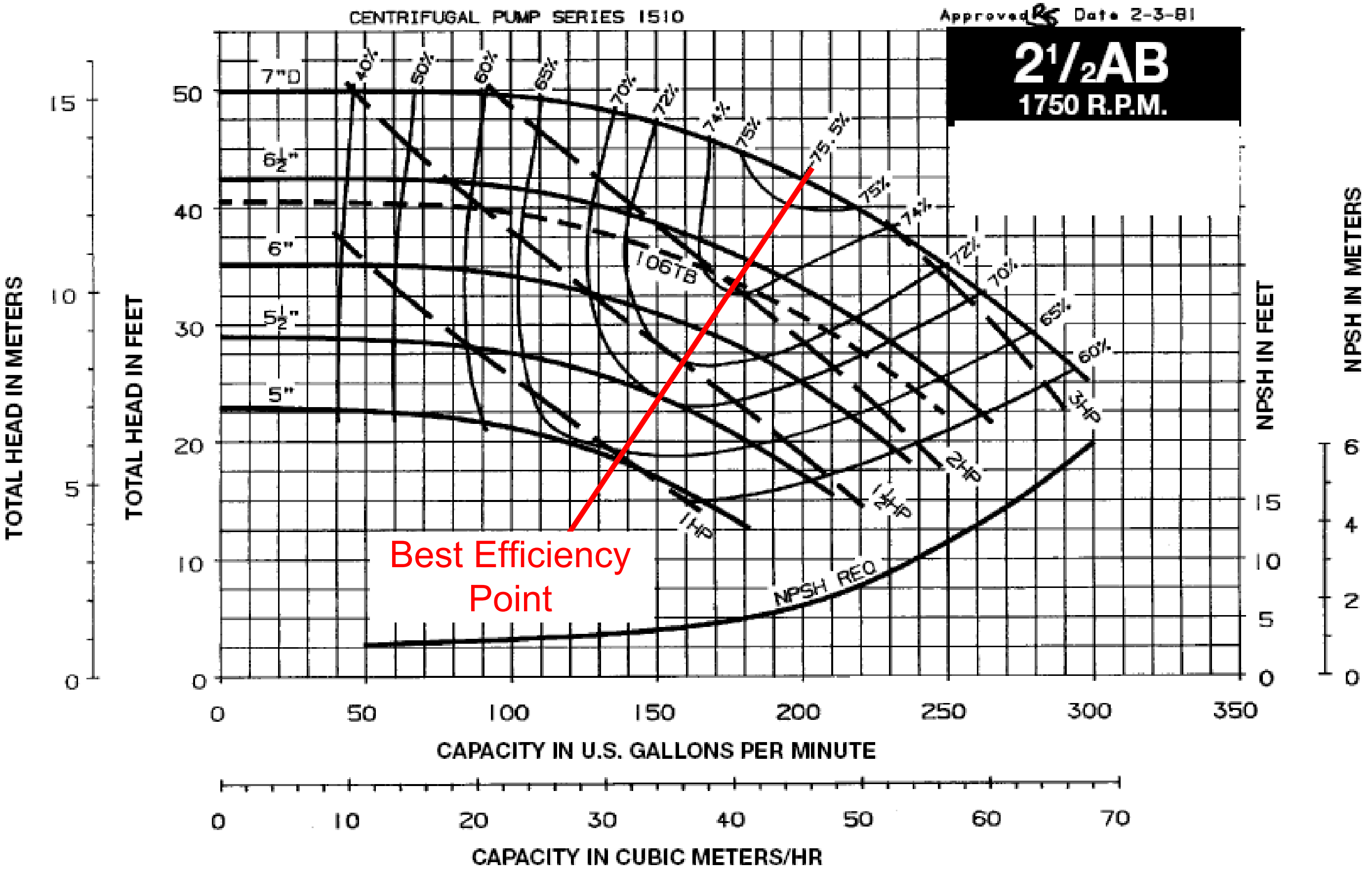
Affinity Laws

- The key words here are “in theory”. In practice, frictional losses and other inefficiencies alter the relationships a bit.
- What this means, however, is that there is a way to estimate the effect of a change in one variable on a change in another.
- In order to be more exact about changes in the effects of variables on each other, the pump curve must be referenced.

The Pump Curve

The best efficiency point (BEP) is specific to each pump and should be matched to the system's needs.

But how do we know what the system needs?

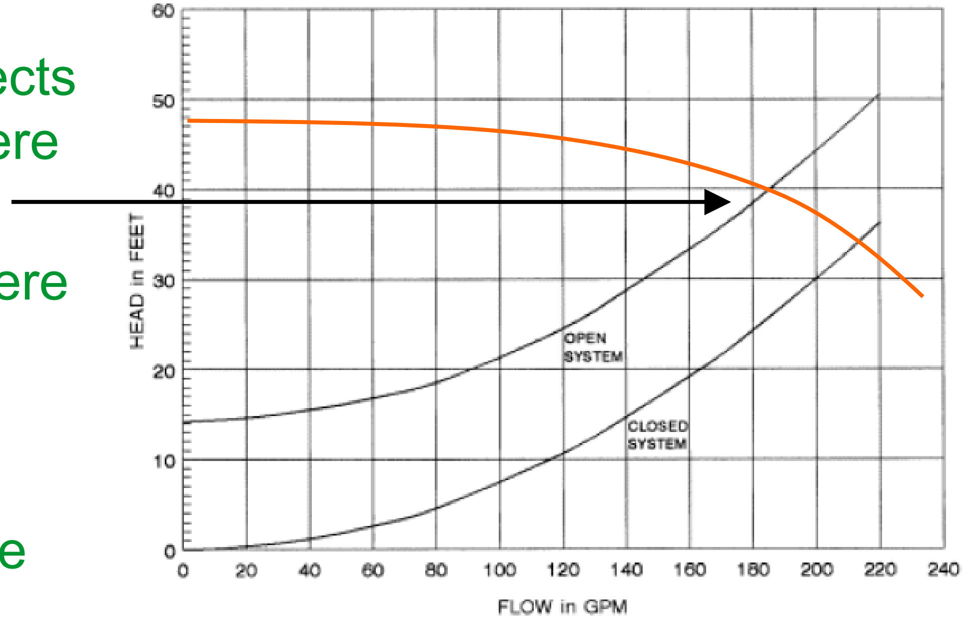


Best Efficiency Point

The System Curve

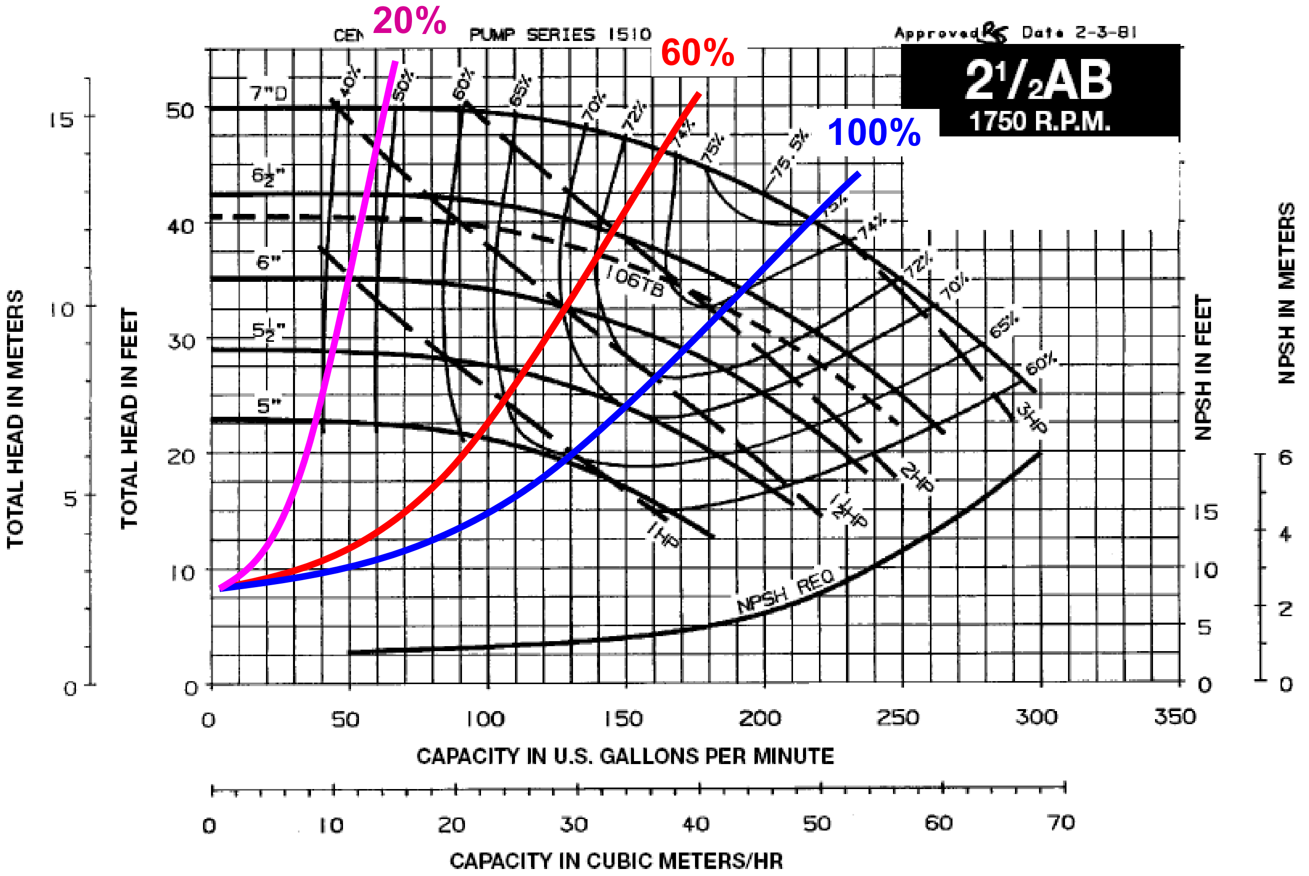
Because the Pump Curve alone is not enough

- The system curve combined with the pump curve is what really determines flow rates
- Where the system curve intersects the pump curve is the point where the system actually operates.
- **Closed system** – a system where the fluid travels through a continuous, closed loop (for instance, a chilled water loop)
- **Open system** – a system where the fluid leaves the system at some point (for instance, water pumping to a cooling tower



The System Curve

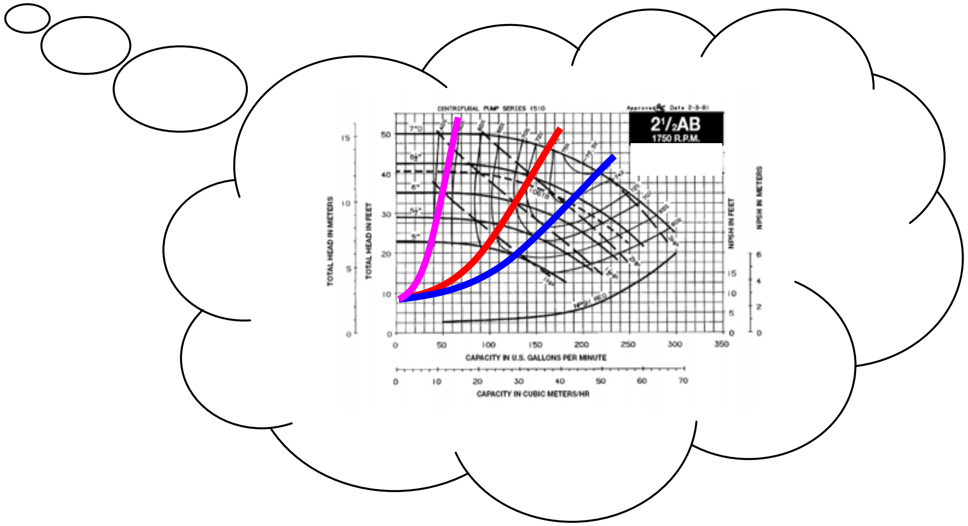
Effectively, opening and closing a valve changes the resistance in the system and creates a new system curve.



Reducing Pumping Energy

Use your head wisely…

- Several culprits exist that unnecessarily increase resistance in the system
  - partially closed valves
  - dirty/clogged pipes
  - unused equipment
- Removing any of these items will reduce the pumping power necessary, but what will happen when we reduce head in the system?



Reducing Pump Head

Use your head wisely…

- Since reducing head alone will merely allow us to ride the pump curve towards higher flow, we'll need to do something to allow us to reduce flow and maintain the head necessary in the system
- We have two options here (well, three, but we'll hit the third one later):
  - Reduce speed
  - Reduce impeller diameter
- Choosing the right option is a matter of understanding the application of the pump

Type of Duty	Reduce Speed	Trim Impeller
Constant flow, continuous or intermittent use	✓	✓
Variable flow or the possibility of changing flow requirements, constant or intermittent use	✓	

Variable Frequency Drives

- Reducing speed is the much more flexible option, but it may not always be the right one. Care must be taken with applying VFDs.
  - Resonant speeds must be avoided
  - Older motors are less tolerant to VFDs than newer, better insulated motors
  - Reducing speed may reduce pump efficiency
  - Speed should not be reduced to less than 25% of full speed to avoid overheating the motor
  - Avoid over driving the motor
- Though trimming an impeller (or purchasing a different sized one) may be the less expensive option, it will involve more downtime of the pump and is not easily reversible.

Variable Frequency Drives

- Because we know about affinity laws, we can deduce that decreases in speed will translate to decreases in pumping power.
- The table at the right represents a more conservative interpretation of the affinity laws, as shown below

$$\frac{Flow_1}{Flow_2} = \frac{Speed_1}{Speed_2}$$

$$\frac{Flow_1}{Flow_2} = \frac{Pressure_1^{\ 1.5}}{Pressure_2^{\ 1.5}}$$

$$\frac{Flow_1}{Flow_2} = \frac{Power_1^{\ 2}}{Power_2^{\ 2}}$$

Speed	Flow	Pressure	Power
5%	5%	1.1%	0.3%
10%	10%	3.2%	1.0%
15%	15%	5.8%	2.3%
20%	20%	8.9%	4.0%
25%	25%	12.5%	6.3%
30%	30%	16.4%	9.0%
35%	35%	20.7%	12.3%
40%	40%	25.3%	16.0%
45%	45%	30.2%	20.3%
50%	50%	35.4%	25.0%
55%	55%	40.8%	30.3%
60%	60%	46.5%	36.0%
65%	65%	52.4%	42.3%
70%	70%	58.6%	49.0%
75%	75%	65.0%	56.3%
80%	80%	71.6%	64.0%
85%	85%	78.4%	72.3%
90%	90%	85.4%	81.0%
95%	95%	92.6%	90.3%
100%	100%	100.0%	100.0%
105%	105%	107.6%	110.3%

Common Problems with VFDs

- VFDs create harmonics, which can upset sensitive equipment
  - load and/or line reactors can be used to mitigate this problem
- Do not always save energy - You must understand the system profile
  - Constant-speed loads may benefit from a smaller motor, rather than a VFD
- Motors will use 4-6% more than the full-load nameplate horsepower while at running at full load

VFD – Fan Power Consumption

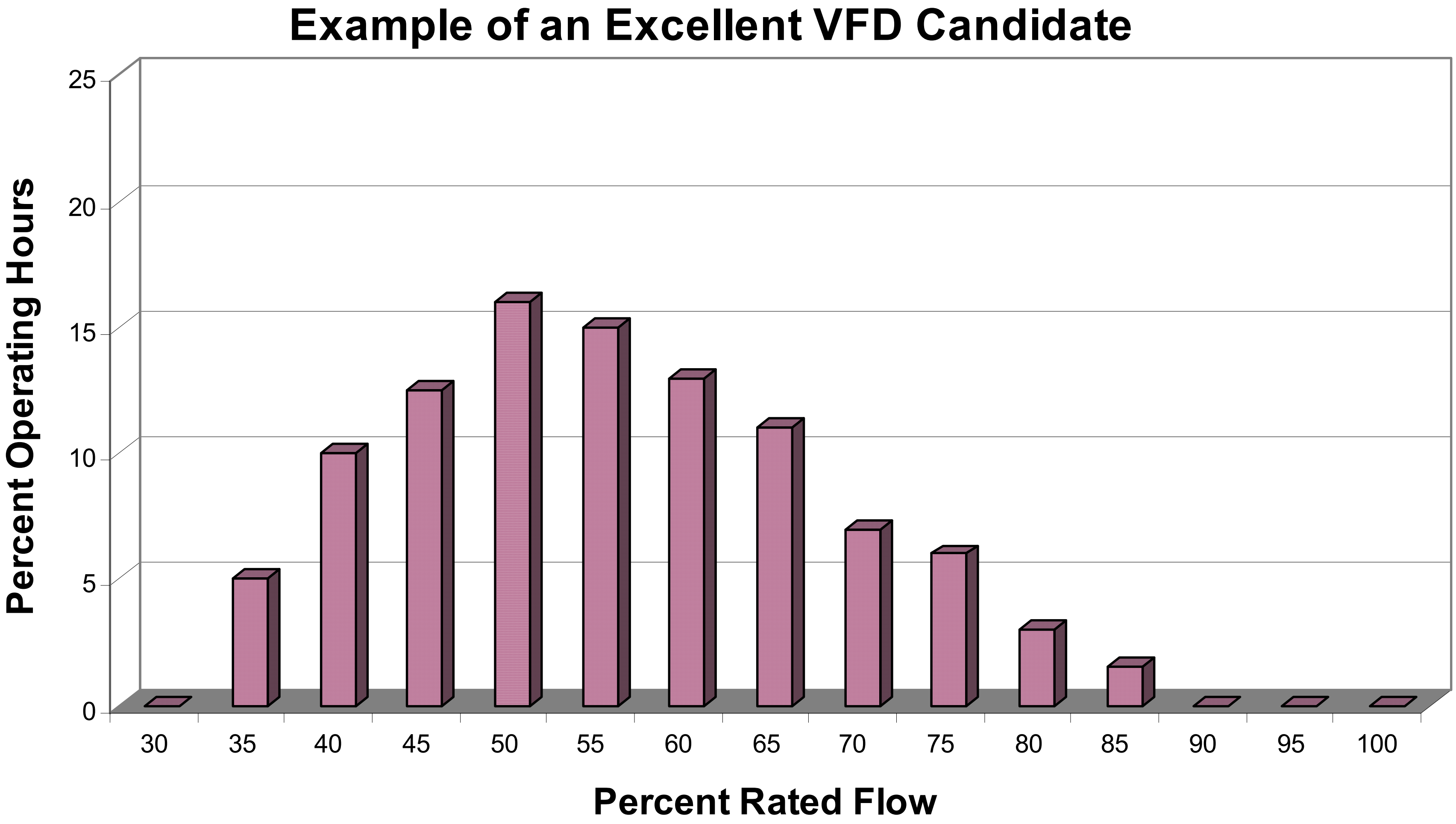
Flow Rate %	No Control %	VFD %
100	100	105
95	100	86
90	100	73
85	100	64
80	100	57
75	100	50
70	100	44
65	100	38
60	100	32
55	100	26
50	100	21
45	100	17
40	100	14
35	100	11
30	100	8
25	100	6
20	100	5

VFD Screening Methodology

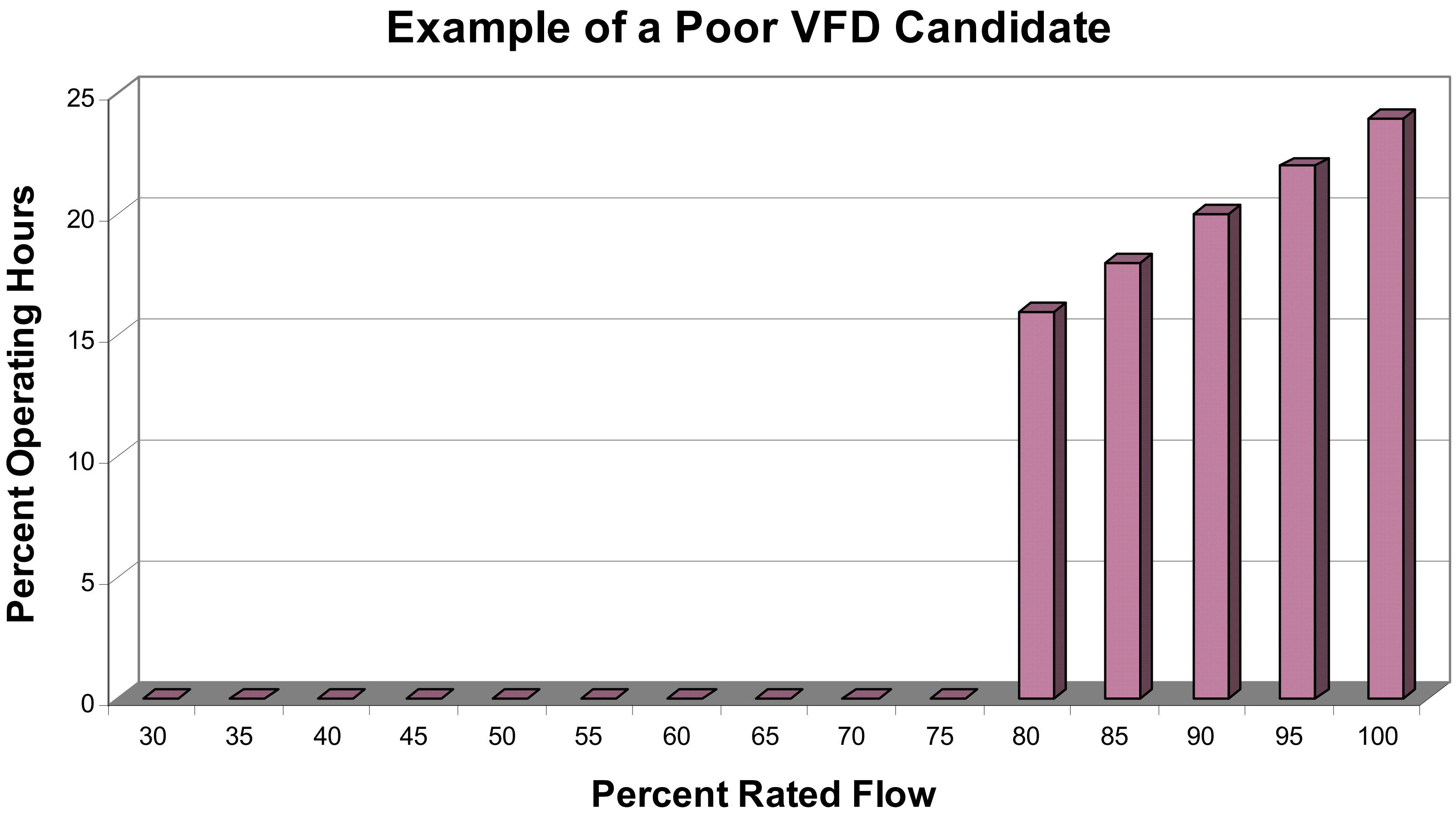
Good VFD applications (ie. ones that will pay back quickly) are loads with

- High annual operating hours
- Variable load characteristics
- Moderate to high horsepower rating

Load Duty Cycle



Load Duty Cycle



Controls

Controls Overview

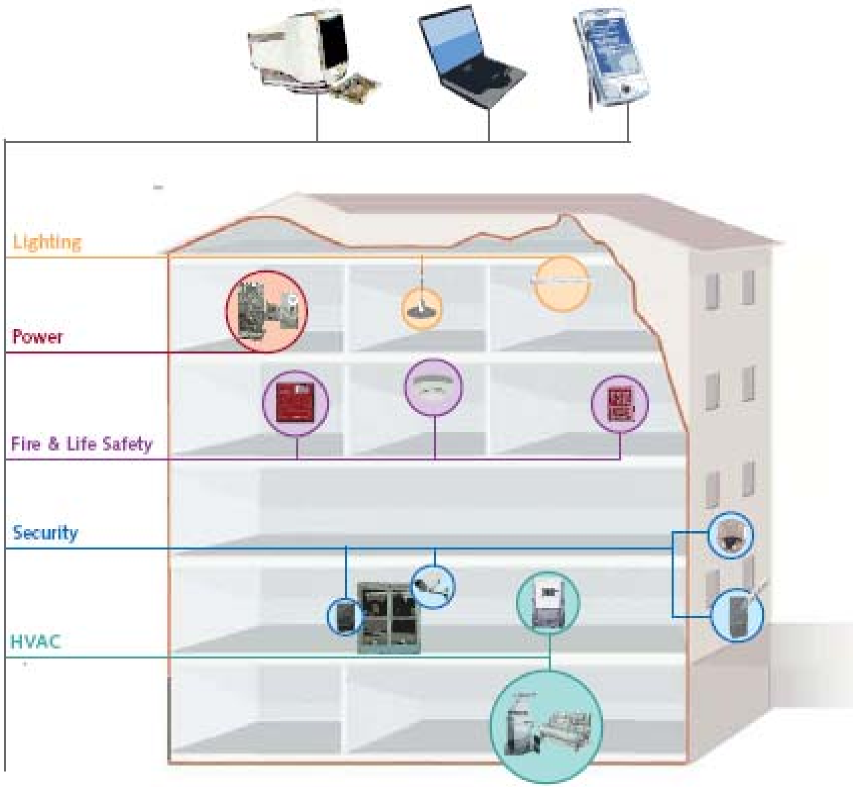
- Why Controls?
- Building Automation
- Occupancy Controls (sensors, etc.)
- Boiler Controls
- Compressed Air Controllers
- Timers, Automation

Why Controls?

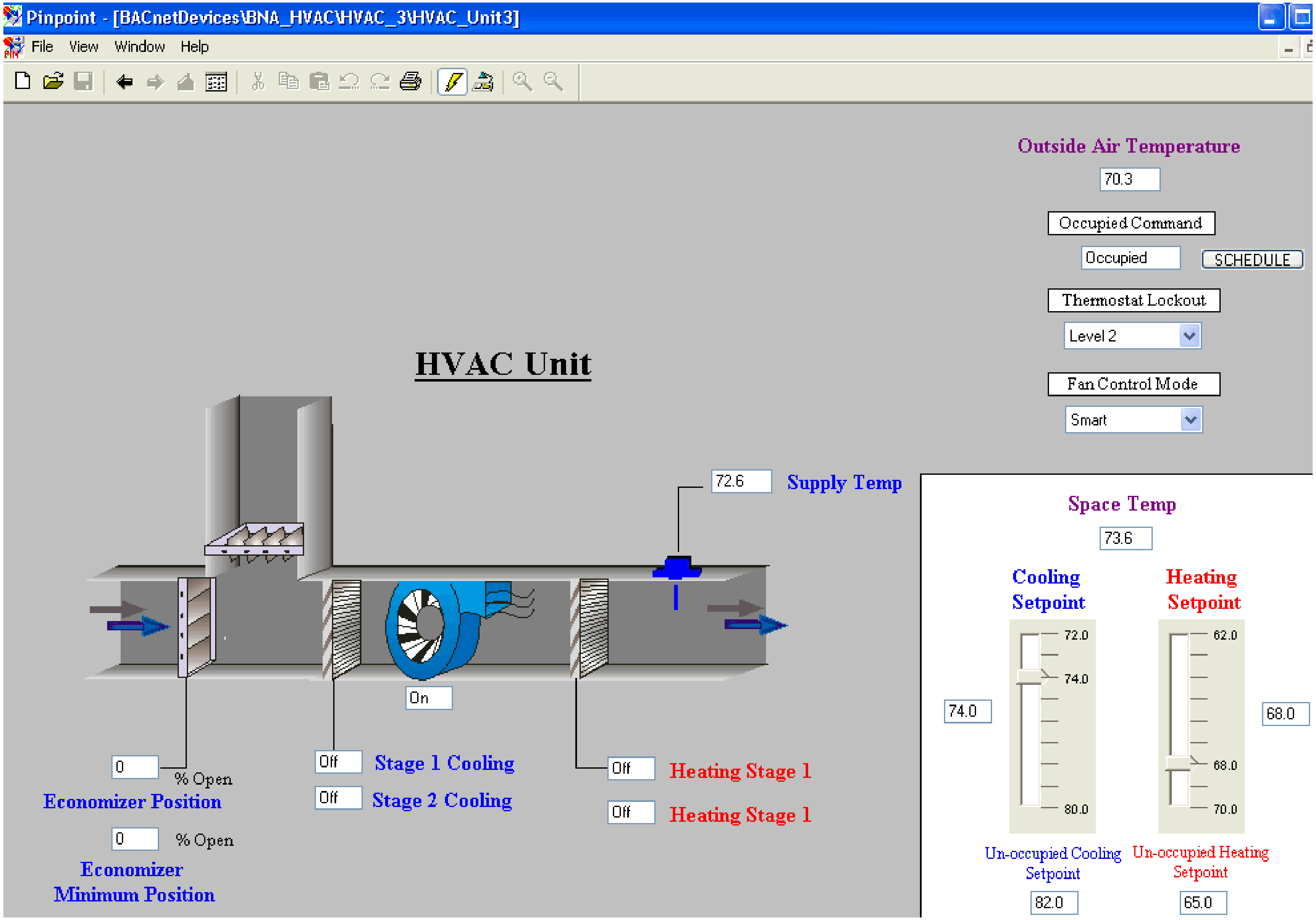
- Automated Control of building systems and equipment provide an active means of energy management
- After implementing energy conservation measures, controls help to maintain energy savings in the system.
- Controls, such as occupancy sensors, work to take the human element out of shutting down lighting and other equipment. No one has to remember to shut off the lights.

Building Automation

- Building Automation Systems (BAS) provide central control of most of the building's systems, including
  - HVAC
  - Lighting
  - Compressed Air
  - Steam
  - Chilled Water
  - Cooling Towers
  - Fire and Security Systems



Building Automation



Pinpoint - [BACnetDevices\BNA_HVAC\HVAC_3\HVAC_Unit3]

HVAC Unit

Outside Air Temperature: 70.3

Occupied Command: Occupied

Thermostat Lockout: Level 2

Fan Control Mode: Smart

Supply Temp: 72.6

On

Economizer Position: 0 % Open

Economizer Minimum Position: 0 % Open

Stage 1 Cooling: Off

Stage 2 Cooling: Off

Heating Stage 1: Off

Heating Stage 1: Off

Space Temp: 73.6

Cooling Setpoint: 74.0

Heating Setpoint: 68.0

Un-occupied Cooling Setpoint: 82.0

Un-occupied Heating Setpoint: 65.0

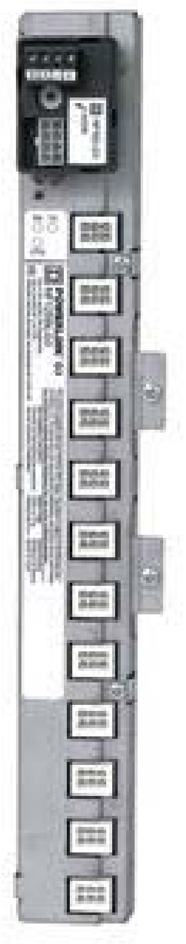
Building Automation

- Advantages for Energy Savings
  - A single terminal can monitor the conditions of the whole facility
  - Building Operators can drill down to the zone or even the air handler level to monitor the health of the system and verify proper operation
  - Centralized scheduling allows for zone temperature, supply air temperature, or chilled water setbacks on a schedule by time of day, day of week, or season
  - Additional sensors and actuators can be added to the system for advanced economizer, zone temperature, and lighting control
  - Variable Frequency Drives can be tied into the system for even more savings opportunities by throttling back ventilation fans, pumps, and cooling tower fans based on demand or temperature requirements
  - Can be used to stage equipment based on varying load conditions, such as boilers, chillers, and air compressors

Occupancy Controls

- Occupancy sensors switch lights or equipment on based on activity detected in the covered area and will shut lights or equipment off after a period of inactivity
- There are two types of occupancy sensors
  - Ultrasonic - detect sound
  - Passive Infrared Receiver (PIR) - detect heat and motion
- Some applications – lights, restroom exhaust fans, production equipment, or building automation systems (for demand ventilation)
- Can easily result in a 30-50% savings

Lighting Controls



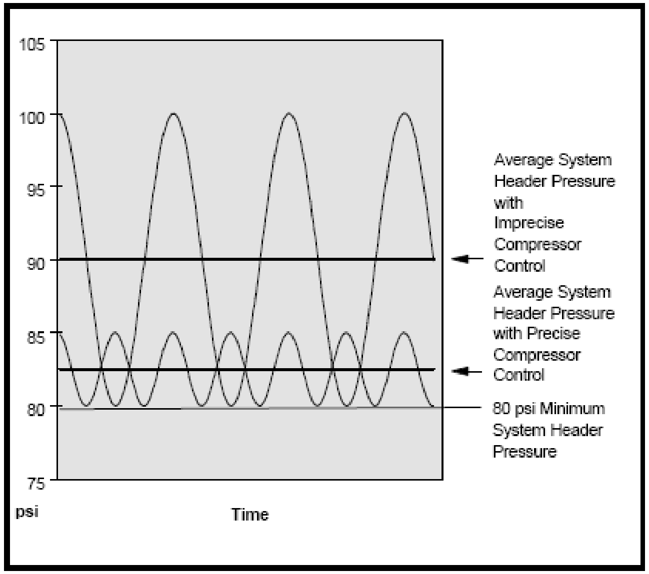
- Control lights on a schedule using an electronic controller and motorized circuit breakers.
- Can be used as a stand-alone device or in conjunction with a building automation system
- Are programmed to bring lights on prior to start of shift and shut them down on the off-shift
  - More advanced controllers can adjust for holidays and variable daily schedules
  - Normally include an override button for intermittent off-schedule use
- These controls not limited to lighting! They can also be used to control other devices for shifting loads off-peak or for bringing on and shutting down equipment on a schedule.

Boiler Combustion Controls

- Boiler combustion controls help to maintain the proper air-to-fuel ratio in a boiler by modulating fuel and airflow to match the load on the steam or hot water system.
- Mechanical controls
  - use mechanical linkages between the forced air damper and the fuel system to maintain proper air-to-fuel ratio
  - older technology
  - lower first cost
  - can fall out of calibration very soon after being tuned
- Electronic controls
  - using oxygen sensors in the flue gas to modulate the air
  - are 10-15% more efficient, on average, than mechanical controls
  - can be used in conjunction with variable frequency drives and tied in with a building automation system to save additional energy and allow for monitoring

Compressed Air Controls

- Simple and/or small compressed air systems can operate efficiently on machine-level controls, simply intended for controlling air pressure in the system
- Larger systems can get by on machine-level controls, but will likely not operate at peak efficiency
- Compressors are commonly staged by air pressure bands with imprecise pressure sensors, resulting in imprecise pressure control
- Newer Sequencing and Networked System controllers can more precisely match demand to compressor capacity



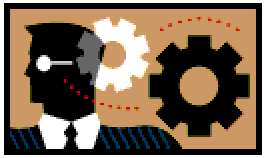
Impacts of Controls on System Pressure

Compressed Air Controls

- System Controls will bring air compressors on and shut them off to match fluctuations in system demand, and can do this more precisely than machine-level controllers
- Demand or Flow Controls can work with network controllers to maintain a higher pressure on the supply side than the demand side, resulting in more consistent air pressure control downstream and a reduction in short-cycling
- As in any system, it's important to consider the system as a whole. Controls will not be as effective without a properly configured and tuned system, including
  - proper storage
  - properly sized compressors
  - an air leak management program
  - a preventive maintenance program to keep components in peak condition

Industrial Control and Automation

- Industrial processes can easily drift out of control and become energy hogs
- Automation and industrial control helps to keep these processes within spec and to operate at peak efficiency, For example,
  - proximity sensors and solenoid controls can be used to switch equipment on and off
  - thermocouples and SCADA systems can be used to maintain precise process temperatures
  - variable speed drives and PLCs can be used to match conveyor speeds with cycle times



End of presentation