# Controlling Building Harmonics and Other Things to Enhance Energy Savings

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*“It may seem small, but the sum of small parts can equate to something large.”*

**1840:** Maximum Power Transfer Theorem = ***Jacobi's Law.***

**1890:** Passive Filters introduced for transmission systems.

**1910:** Electrolytic Capacitor is patented for AC motors.

**1956:** Bell Labs introduces solid-state MOSFETS to market.

**1959:** Variable Speed Drives introduced (adding to harmonics)

**1962:** LED's Introduced (lowers PF by about 5%)

**1971:** Active Filters widely used to mitigate harmonics.

**1992: DOE EER for Electric Motors/Power Monitoring.**

**2001: MPTS Discovered (Solved Jacobi's Law).**

**2013:** Trans Power's MPTS SYSTEM V1 receives UL Certification.

**2017:** Trans Power's MPTS SYSTEM V2 commercially available.

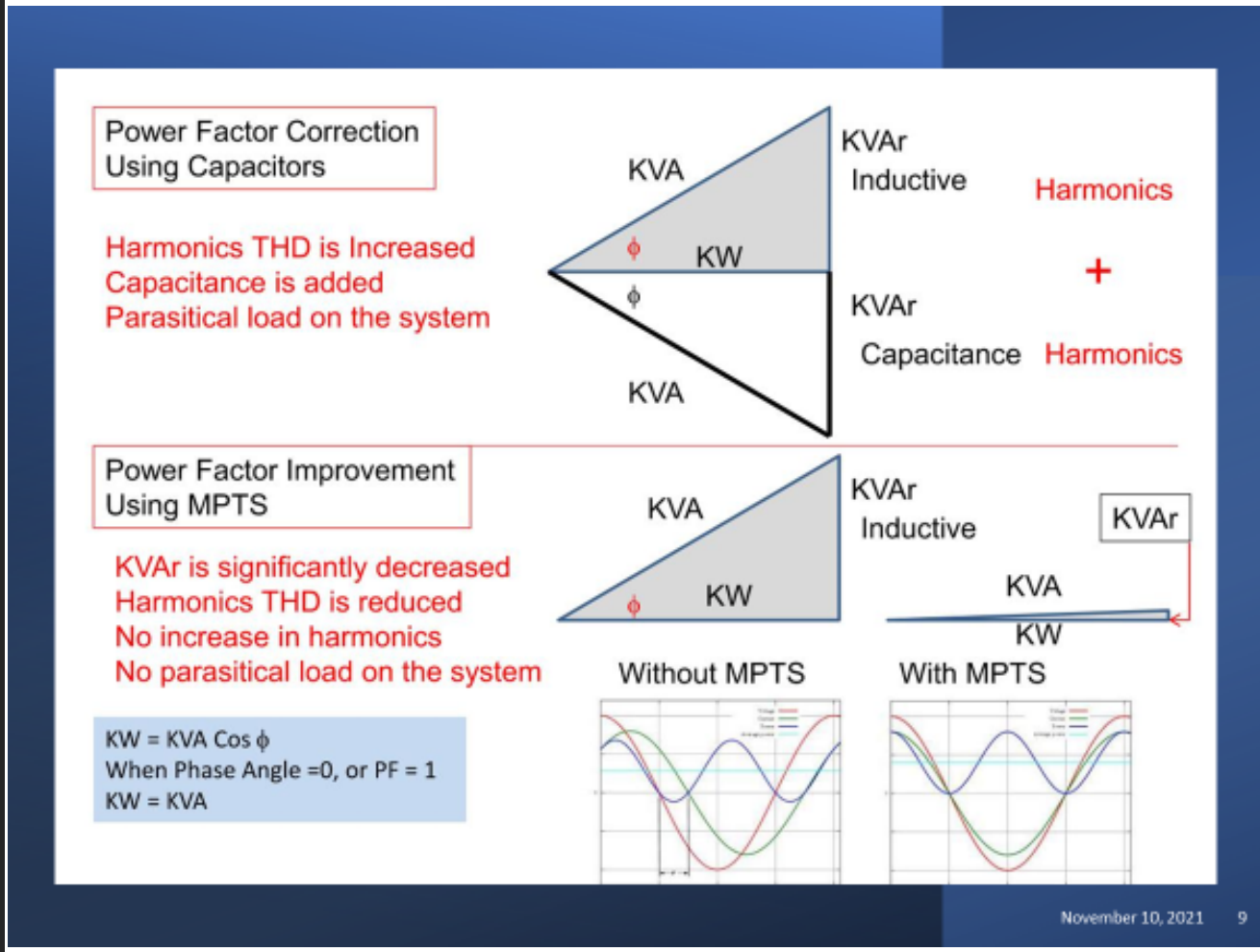
# The Power Quality Story

**POWER QUALITY = Synchronization of Voltage, Current, Frequency and Phase.**

1. Harmonics is one of the most overlooked issues in Engineering
2. Harmonics is a 4 semester masters' specialty and most folks do not really understand the impact on a system
3. Harmonic waves head towards the lowest impedance part of the electrical network
4. High impedance networks have the lowest THD
5. Without some way to control impedance, harmonics running throughout system and causing damage
6. Effects system uptime/downtime
7. Increases maintenance costs
8. Increases landfill waste as equipment fails and requires replacement
9. Reliability, Resilience, Reducing carbon footprint

# Why Do Environmenalists Care about PQ?

# How to Properly Correct Power Factor Problems



## Watts Per Square Feet

### Power Factor impacts Watts per Square Feet of the building

Watts per Square Feet = (√3 x KV x A) / Square feet

*for three phase application*

*= Gross Power / Square feet*

**Example:**

**This example illustrates the change in watts per square feet with different power factor values at the Mains Power Panel in buildings**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Assume PF at Mains average value=** | **0.50** | **PF** | **0.75** | **PF** | **0.85** | **PF** | **0.96** | **PF** |
| **√3** | For Three Phase Power Supply multiply by= | 1.732 | | 1.732 | | 1.732 | | 1.732 | √3 |
| **V** | Supply Voltage = | 480 | Volts | 480 | Volts | 480 | Volts | 480 | Volts |
| **A** | Total Connected Load Current= | 1,000 | Amps | 750 | Amps | 675 | Amps | 601 | Amps |
| **Watts** | Total connected Watts= | 831,360 | Watts | 623,520 | Watts | 561,168 | Watts | 499,440 | Watts |
| **Square feet** | Total building Square Feet= | 200,000 | SFT | 200,000 | SFT | 200,000 | SFT | 200,000 | SFT |
| | Watts per SFT= | **4.16** | Watts | **3.12** | Watts | **2.81** | Watts | **2.50** | Watts |

Installing proper power quality equipment actually reduces energy consumption by about 20% unlike current solutions that only mask the problem.

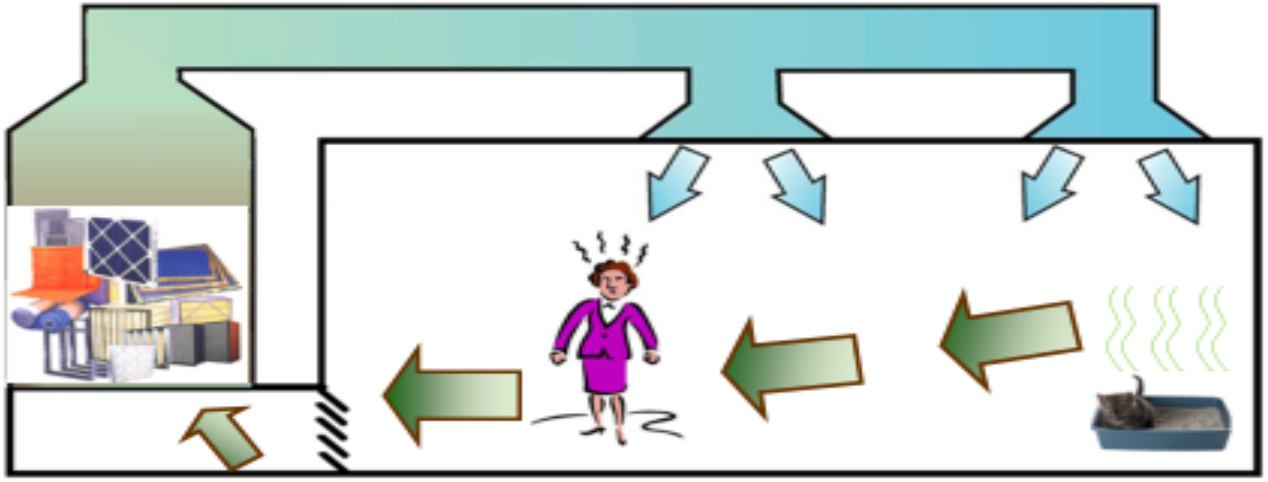
# Superfecta of Energy Savings

21st century approach for energy savings

- Electrical Power Quality
- Air Quality
- Water Conservation
- Renewable Energy

# Technologies to Address Pathogens
# Passive Air Purification

## UV Lights & Filters



**You have to bring all the pollutants to the device!**

**No protection in the conditioned space**

**Can't eliminate ongoing odor problems**

# Comparing Bi-Polar to UVC?

| | Bi-Polar Ionization | UVC Light |
|---|---|---|
| Replacement Interval | None | Annually |
| Produces Ozone? | No | No |
| Kills Mold, Bacteria, Virus? | Yes | Yes |
| Kills Pathogens in the Space? | Yes | No |
| Controls Odors? | Yes | No |
| Reduces Particulate? | Yes | No |
| Contains Mercury? | No | Yes |
| Electrodes Fragile? | No | Yes |
| Shock Resistant? | Yes | No |
| Hazardous Disposal Required? | No | Yes |

# Water is the Next Gold?

GPF Toilets: 1.28

GPF Urinals: 0.5 gpf

Sink Aerators: 0.5 gpm

Cooling Towers: nlt 5 cycles

Boilers: Conductivity controller, heat recovery

Vacuum and Process systems: Must recycle water

Sterilizers: Must recycle water

Kitchens:  Garbage disposers bad news! Compost food waste!

Washing Machines: Energy star saves 30-60%/load (required by code)

Pools are a huge waster if you do not have a cover to protect from evaporation

Sprinkler Systems:  Extensive standards on metering, and design

Ref:  SECO:  State Energy Conservation Design Standards 2017

# Renewable Energy


While renewable energy is great, in a power loss situation Renewables disconnect from the grid.  Installing stand-alone systems in a building or campus setting important for safety and reliability.

Generators still have a place in resiliency!

# Why Exceed Code when Purchasing Air Handling Units

What are the numbers really? (2015 Energy conservation code C403.2.3, only requires Seer 13 for small units and 11 on large units)

12/(kW/ton)=EER

EER=(.875*SEER)

Let's take a 5-ton 16 SEER Rheem Split system $4025.93

EER = 14  12/14=.857kW/ton  4.28 kW  Run 3000 hours 12,857 kW  1414/yr. @$.11/kw

Let's take a 5-ton 20 SEER Goodman Split system $5373.00

So EER= 17.5  12/17.5=.685 kW/ton 3.42 kW  Run 3000 hours 10,275 kW  1130/yr.@$.11/kw

It costs $1348 more, you save $284/yr. = 4.74-year payback but remember unit will last 20 years and utility cost will increase, if not the $/kw/ the transportation will for sure. (with energy efficiency thermostats savings are greater)

Available equipment significantly exceeds code requirements!

# Why Use Heat Recovery Ventilation

Let's say you exhaust 100 CFM from a restroom, the Broan heat recovery ventilator costs $1025.00

How much does it cost to condition 100 CFM of outside air?

Rule of thumb about $4.00/cfm = $400 per year to condition. Studies have shown HRV saves about 75% of the ventilation loss. So savings could be about $375/100 cfm.

100 cfm equates to roughly .973 tons on a peak day. As we discussed before @.685 kW/ton = 1.14 kW running 8760 hours, = 9986 kWh @.11 = $1098. Assuming that peak is only 30% of the time it reduces the savings say to $330. We have less than a 3-year payback.

Benefits: Downsize HVAC and increased comfort from OA ventilation

(there is always more than one way to estimate savings)

# Energy Efficient Lighting

Often missed is to reduce the number of lights when retrofitting with LED's.  Now why is that?

Say your average fluorescent fixture has 3-32-watt bulbs, this is 96 watts.  Say a Phillips 32 W bulb is 81 lumens per watt.  Result, we have 7776 lumens.

So, you purchase a 55-watt led fixture it is 135 lumens per watt.  7425 lumens.  You can also purchase an LED fixture at 165 lumens per watt so the same fixture could be 9075 lumens.

In the first example, you have fewer lumens, but it could also be more lumens.  If you had 4-bulb fixtures the lumens would be 10,368 and the new fixture would have 30% fewer lumens.  If you had 2-bulb fixtures the lumens would be 5184 so the new fixtures would be about 40% brighter.

The point here is to ensure the ending lumens in the space meets IES standards.  You may need fewer fixtures, you may need more. LED FIXTURES VARY SIGNIFICANTLY IN LUMENS PER WATT AND QUALITY! Also remember LED's reduce the power quality in a building.

# Energy Efficiency and VFD's

VFD's create harmonics in a system. This can increase maintenance throughout the system. It is critical all VFD's are specified with harmonic filters.

If you can reduce CFM and resheave a fan so that each space is properly ventilated, you will save more energy than using VFD's and setting up harmonics in a system.

With built up systems, after air balance, the air balance company should resheave the fan to reduce static pressure to only that which is needed in the system as most systems are specified oversized. This will save a lot of energy.

Based on fan laws we know a 10% increase in fan speed increases the hp by 33%. We want to balance at the maximum load and lower the fan rpm if possible.

# Energy Efficient Boilers

- The new boilers now adays are as much as 96% efficient, where many of the old boilers are about 80%.
- 1,000,000 BTUH you can save 16% on your heating bills.
- Modular packaged staged systems are much more efficient than replacing a large boiler with another large boiler.
- Remember all equipment runs most efficient when fully loaded.

# Air Loss and Other Thoughts

Remember air loss can be significant in older buildings.  If you are not replacing windows, consider resealing all windows and sealing other areas of infiltration in your building.

Vestibules can save energy in buildings that high traffic flow. (IEC 2015 402.5.7 Building entrances shall be protected with enclosed vestibule) Air curtains are an option as well, but many people find them annoying so carefully consider placement, docks are a good application for air curtains.

If you are not replacing ductwork, may wish to consider sealing ductwork.  You could be leaking significantly above the ceilings and losing a lot of energy.

# Skylights

We all love the looks of skylights, right?

Our Roof has an R value of 25-38. (if replacing the roof why not go for the max?)

Energy Code only requires a U value of 0.75 = R 1.33 (International Energy Code 2015 C402.4.3.2)

If you can get your light through your vertical windows, it is much better from an energy efficiency standpoint than getting your light through the roof.

# Summary

Energy and Maintenance Savings: Power quality technology is far and above the most important step  building owners can take.

Employee Health and Wellness and Equipment Protection: Indoor air quality technology protects the health and well being of employees, enhances productivity, reduces absenteeism, and enhances employee satisfaction.

Water Quality and Conservation:  We cannot live without water, almost any facility can reduce water consumption by at least 30%

Renewable Energy:  Mixing stand-alone equipment with standard technologies can enhance building reliability. Back-up generation for resiliency.

Always purchase the most efficient equipment on the market, the payback makes up for the higher initial costs.

# Questions??

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