Power Quality and Energy Saving Solutions – What is Real?

Presented by:

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Powering Business Worldwide

New Trend in Selling PQ Solutions

- Selling PQ for the sake of PQ isn't good enough anymore
- Power Quality (PQ) and Energy Management (EM) linked by conservation activities (VFDs, fluorescent lights, etc.)
- Insurance (PQ) versus "real" (EM) savings
- Energy costs are rising
- Required payback periods are decreasing (<2 yrs)
- Significant confusion in sales methods and product literature
- Black-box "all-in-one" solutions are more common

Overview

- Need – Everyone wants to save energy!
- People want to believe that there is a simple solution
- Electric bills can be confusing
- Misleading sales methods by unknowing salespeople
- What claims are real?
- What claims are false?
- What should YOU do?

Understanding Your Utility Bill

Energy
(kWh)

Demand
(kW)

PF Charges

+

Taxes

EATON
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TVA

Snohomish County PUD
Public Utility District No. 1

PECO
An Exelon Company

Duquesne Light
Our Energy…Your Power

Reliant Energy

Alabama Power
A Southern Company

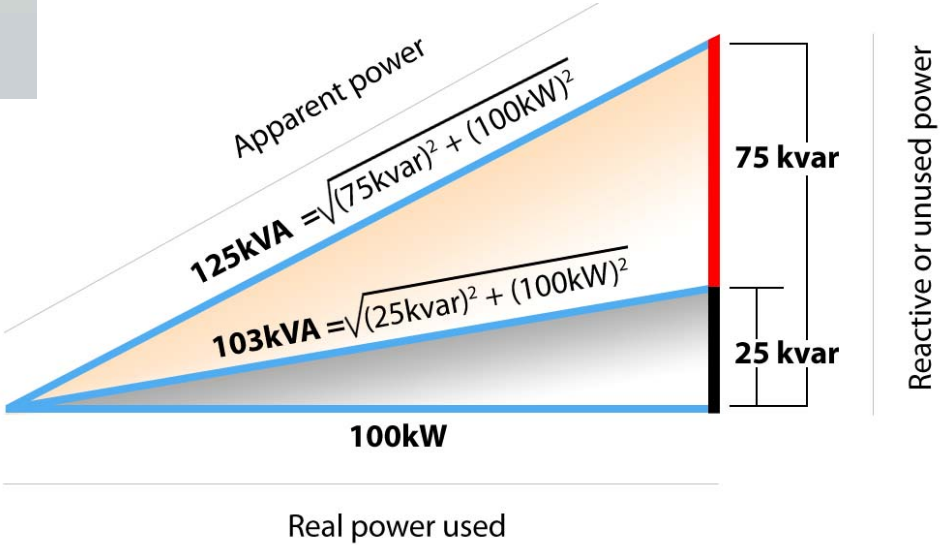
ONCOR

AEP

Is the Glass Half Empty or Half Full?

Wasted Capacity

Full Capacity



EPRI Said It Best….

You can only save energy that is wasted!!!

PQ Solutions that “Claim” to Save Energy

Category 1: PF correction equipment

- Black/green boxes with capacitors in them
- PF correction capacitors
- Harmonic filters

Category 2: Other PQ Solutions

- Negative sequence current reduction
- Neutral blocking filter
- Surge protection
- Soft starters
- Zig-zag reactors
- Harmonic mitigating transformers (HMT)
- Conservation voltage reduction (CVR) equipment
- Green plug

Energy Savers

A thought….don't you think the government would require these devices if they worked as well as claimed????

*Our units are **garaunteed** to save you money!*

(Maybe a "garauntee" is totally different from a "guarantee"….)

It Happens to the Best of Us….

- 2007 – Eaton Fluid Power Plant
- Applied Three (3) Energy Savers ($65k)
- Claimed 11-30%
- Actual Savings (Year/Year) – 15%?
  - What????? (Plant lighting was changed to energy efficient lighting three months prior to application of Energy Saver!)
- Actual Savings <1%!

It Happens to the Best of Us….

	kWh	kW	Excess rKVA	Cost	kW savings over previous year	Cost savings over previous year
N-07	346,811	664.3	198.5	$28,856.55	4.3%	4.1%
Oct-07	329,366	628.5	150.1	$27,351.46	3.9%	3.2%
S-07	297,597	571	106.5	$24,879.59	13.1%	11.5%
Aug-07	312,736	605.02	22.8	$26,120.39	15.9%	15.4%
J-07	331,227	637.56	64.1	$27,100.99	10.5%	10.4%
Jun-07	308,103	616.8	467.4	$26,607.99	12.2%	9.2%
M-07	319,200	630	529.7	$26,920.13	6.3%	5.6%
Apr-07	369,870	643	439.5	$28,231.73	16.6%	9.5%
M-07	354,678	664	510.1	$28,663.34	-4.5%	-4.5%
Feb-07	400,302	704.4	506.2	$30,757.42	16.2%	11.7%
J-07	395,049	708.7	533.6	$30,808.96	-18.0%	-21.5%
Dec-06	357,737	718.6	564.6	$30,444.10		
N-06	384,850	693.9	546.7	$30,099.75		
Oct-06	354,128	653.9	455.7	$28,255.68		
S-06	339,933	656.9	560	$28,109.33		
Aug-06	382,376	719.2	579.4	$30,869.79		
J-06	361,292	712.5	558.4	$30,259.63		
Jun-06	345,645	702.44	508.4	$29,315.43		
M-06	352,918	672	493.8	$28,505.66		
Apr-06	337,043	771.2	534.1	$31,194.23		
M-06	347,956	635.3	468.1	$27,432.08		
Feb-06	387,728	840.9	527.1	$34,813.36		
J-06	289,015	600.7	458.5	$25,364.67		

Year-over-year Data Should NOT be Used

- Year-over-year data can be very misleading
- Usually, only the good months are highlighted
- Residential data is especially difficult to track from year to year

PQ Solutions that “Save” Energy

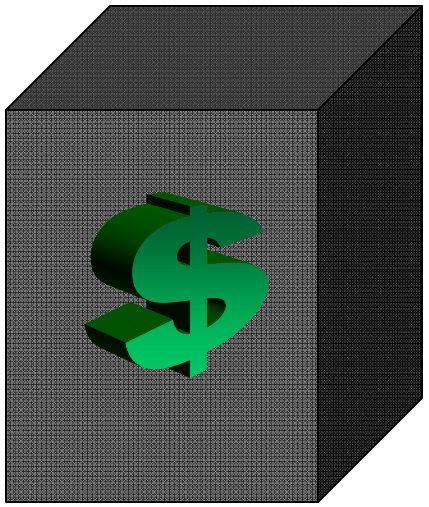
“Black Box” All-in-One Solutions

- **Description:** Magic boxes full of PF correction, harmonic correction, surge protection, etc.
- **Claim:** Up to 35%
- **Reality:** < 3% typical

But they showed me how it works…

Demo Cases – What's in that box?

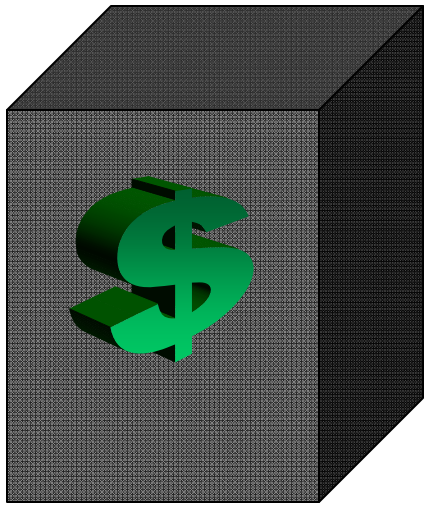
- Motor
- Capacitor
- Meter
- (….maybe a few tricks)



"Look…current reduced from 10 to 5 Amps, that results in 50% energy savings!"

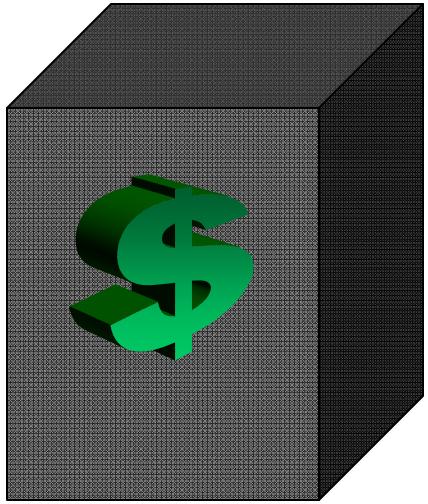
But they showed me how it works…

Electro-magnetic disk meter spins slower with the black box on. It takes 5 hours to make one rotation with the unit on vs. 4 hours with the unit off. Why?



But they showed me how it works…

They showed me a set of bills from a facility in Alaska and they saved money when the units were on. Why?



Typical Claims

- Correct PF
- Provide Surge Protection
- Save Energy
- Commercial, Institutional and Residential Targets

The Reality: Capacitors with MOV's
(i.e. PF correction with surge protection)

Authors' Viewpoint

- We have done the calculations
- We have done the measurements
- We have talked to the vendors
- We simply do not believe the excessive claims
- Can you save significant money with PF correction? Yes, IF there is a penalty

PQ Solutions that “Save” Energy

Harmonic Filters and PF Correction

- **Description:** Harmonic filters or PF correction equipment
- **Claim:** Reduce kW and eddy current losses
- **Reality:** Reduces I^2R depending on location – typical is less than 2%

PF Correction and Energy Savings

- Well known benefit: kW Loss Reduction (real savings)
- Problem: Overstated
- Claim: 11-30% savings
- Reality: 1-4% overall savings typical
- 500 “pieces of technology” installed…
- Open the “black box” – it’s full of capacitors… If it looks like a duck and swims like a duck and quacks like a duck….

PF Correction and Energy Savings

- Claim: Reduces harmonics
- Reality: Will ALWAYS increase harmonics by series or parallel resonance unless installed as a filter
- Is this a problem? Maybe, maybe not….
  - The caps can usually take it (for a while)
  - The system can take some additional current or voltage THD but should be watched

Capacitor Placement – Physical Location

Utility Penalty – If needed for PF penalty

- Typical savings is 5-30% of bill

Capacity Improvement – if needed to improve the capacity of a transformer or cable

- 1-2% of overall kW savings is typical

Loss Reduction – If needed for kVA or loss reduction

- 1-4% of overall kW is typical with distributed capacitor (some may *claim* more)

Power Factor Penalties

- Not possible to cover all penalties
  - Table 3 (Blooming/Carnovale paper) shows some typical methods
- User should determine which type of penalty (if any) the utility is using
  - Then investigate further
  - Sometimes utility uses multiple penalty methods

Power Factor Penalties

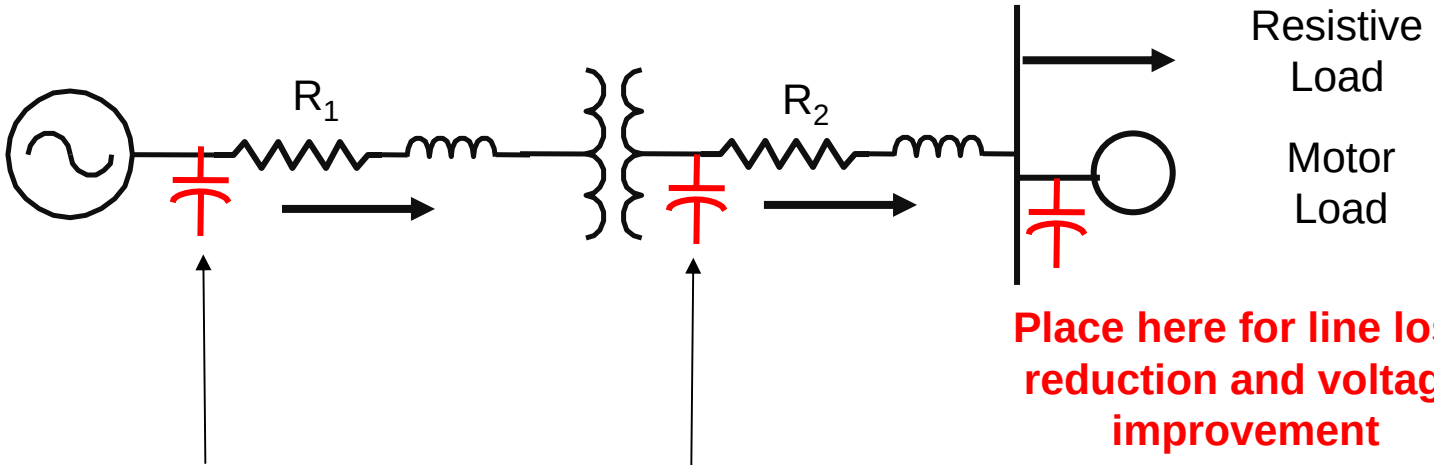
Table I (partial) from “Capacitor Application Issues” paper

http://www.eaton.com/EatonCom/Markets/Electrical/ServicesSupport/Experience/index.htm

POWER FACTOR PENALTIES

RATE TYPE	DESCRIPTION OF PF PENALTY	EXAMPLE
kVA (demand) rates	Penalty for < 1.0 pf; generally applied as a $/kVA	Demand = 800 kW; pf=80%; kVA=1000; demand charge = $10/kVA pf penalty = (1000 – 800)*$10 = $2000/month
PF (kVA) adjustment	When the pf is less than X%, the demand may be taken as X% of the measured kVA	When the pf is less than 90%, the demand may be taken as 90% of the measure pf=80%; kVA=1000; demand charge = $10/kVA Billed demand = 0.90*1000 = 900 kW pf penalty = (900 – 1000*0.80)*$10 = $1000/month
PF ratio (kW demand) adjustment	If the pf is < X%, the demand will be adjusted by the following: X%/actual pf * actual demand = adjusted demand.	If the pf is < 85%, the demand will be adjusted by the following: 85%/actual p demand = adjusted demand. Demand = 800 kW; pf=80%; demand charge = $10/kW Adjusted demand = (0.85/0.80)*800=850kW pf penalty = (850-800)*$10 = $500/month
PF magnitude (kW demand)	PF adjustment increases or decreases the net (kW) demand	Where the pf is < 85%, the net demand charges shall be increased 1% for each pf is < 90%; likewise, where the pf is higher than 95%, the demand charges wi

PF Correction – Loss Reduction



Place here for line loss reduction and voltage improvement

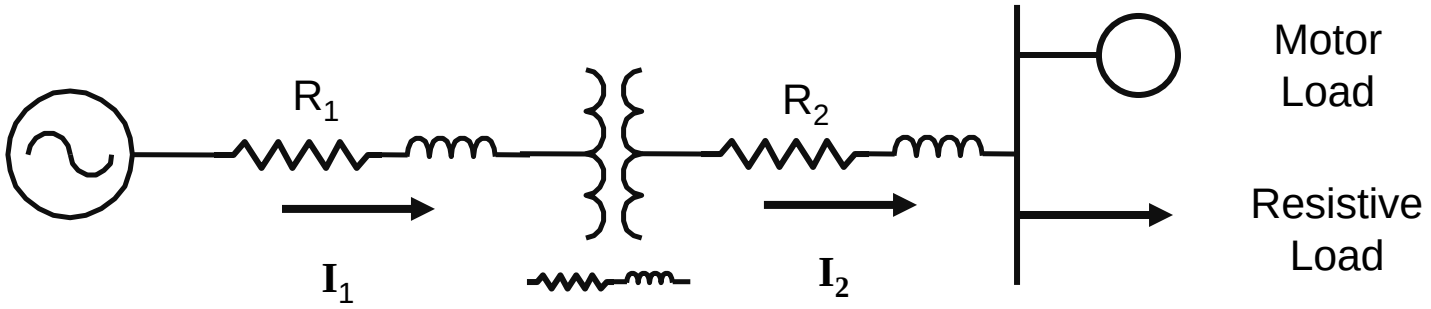
Place here for utility PF penalty

Place here for utility PF penalty (utility owned transformer)

or

Place here to reduce losses in transformer or free capacity

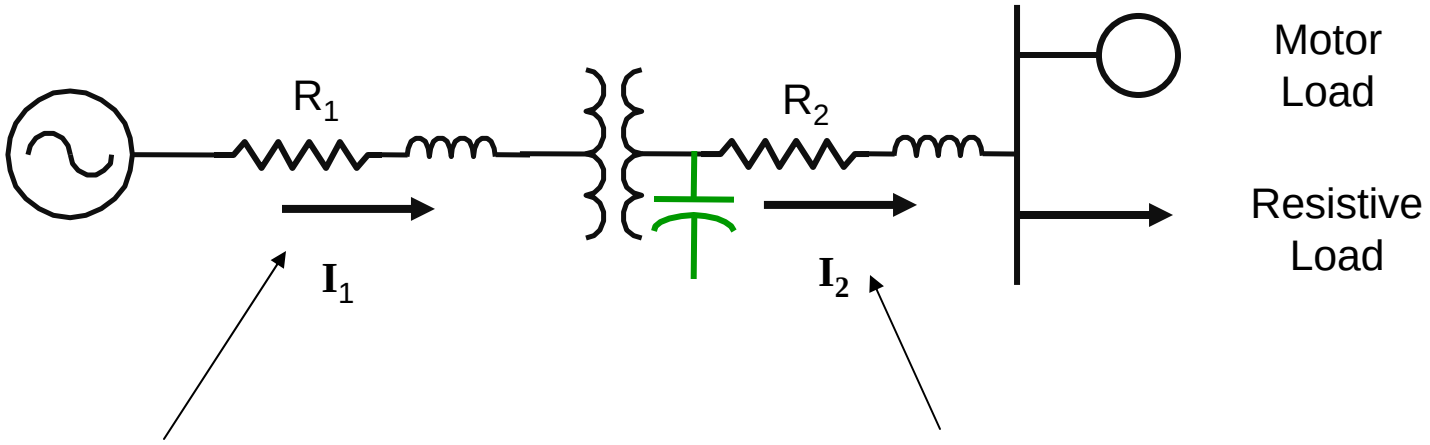
PF Correction – Loss Reduction



$$P_{LOSSES} = I_1^2 R_1 + I_2^2 R_2 + (\text{Transf Losses}) + (\text{Load Losses})$$

Delivery Losses

Savings Depends on Location



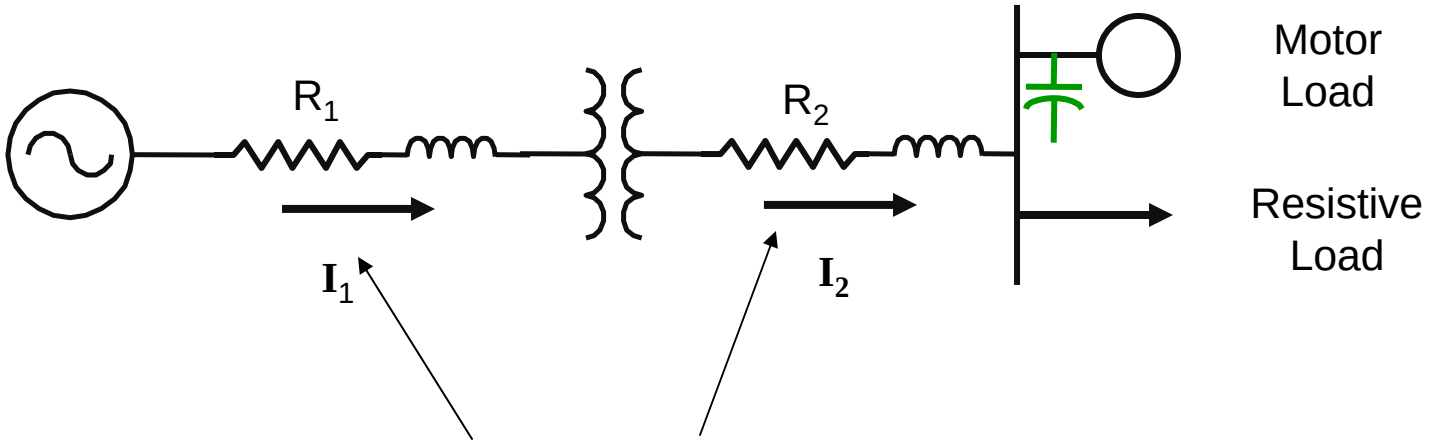
This current is reduced

This one is not

Many times, the "black box" vendors will say, "see, we don't reduce the current to your motor/loads."

Frequently convenient to locate capacitors at the main bus, but this reduces only part of the current and not the current that is likely to yield the greatest loss savings

Savings Depends on Location

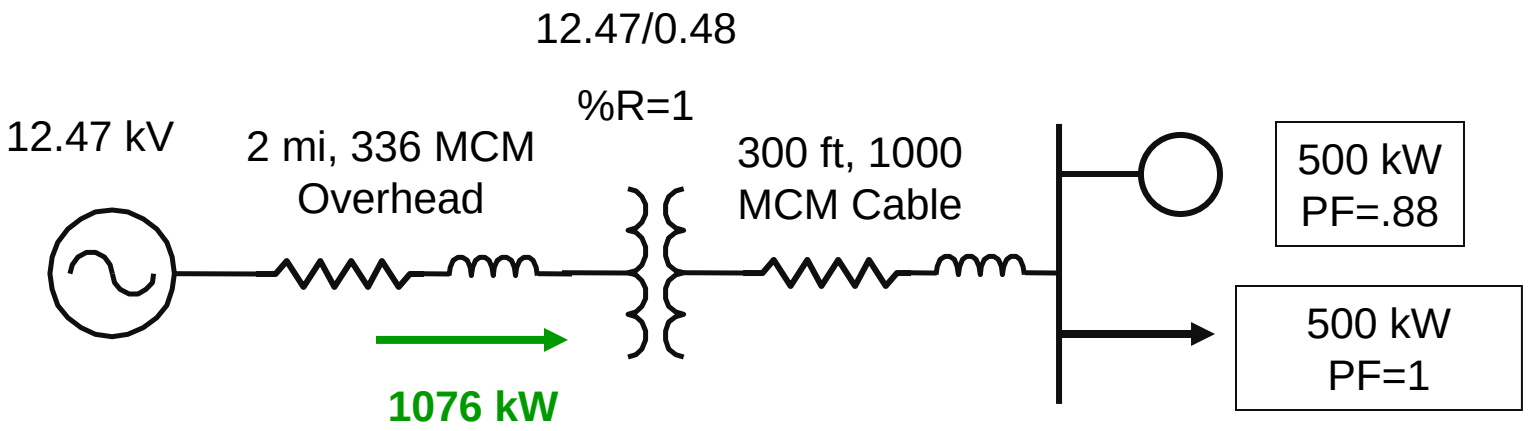


Both currents are reduced

Still, motor current is the same.

Placing the capacitor as close to the load as possible will generally yield the greatest power delivery loss savings but the application, in general, is more costly for multiple capacitors at the load(s).

Example – PF Correction Savings

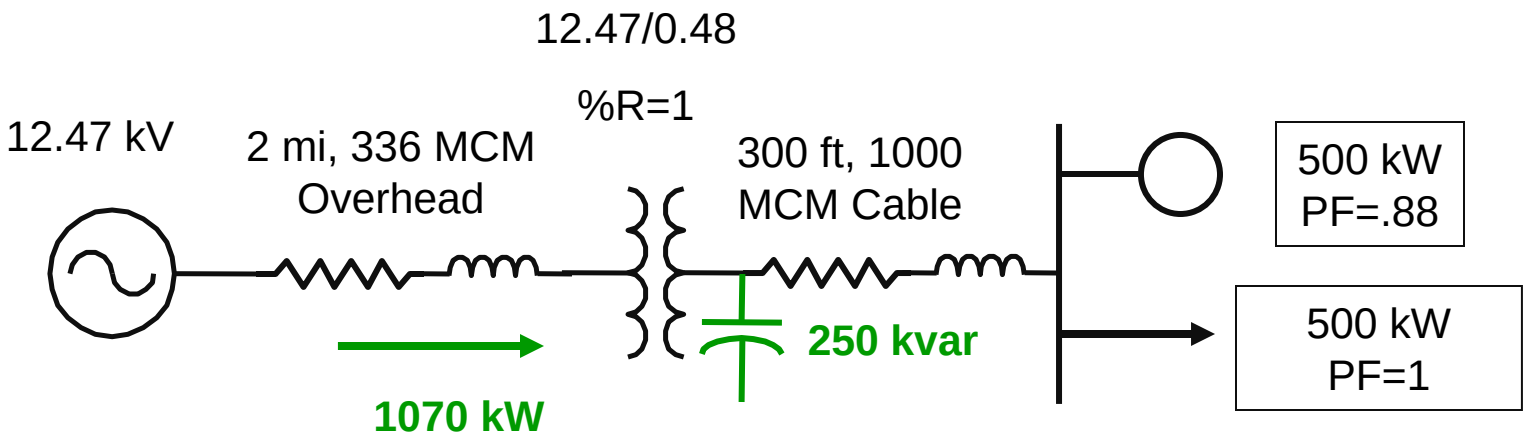


LOSSES: **4.73 kW** **0.44%** **5.1 kW** **0.47%** **71.2 kW** **6.65%**

Total Circuit Losses: 81 kW / 8.1%

Source: EPRI

Example, Capacitor at Main Incoming



LOSSES: **4.03 kW** **0.38%** **4.33 kW** **0.40%** **66.4 kW** **6.23%**

Saved a little here because voltage improved

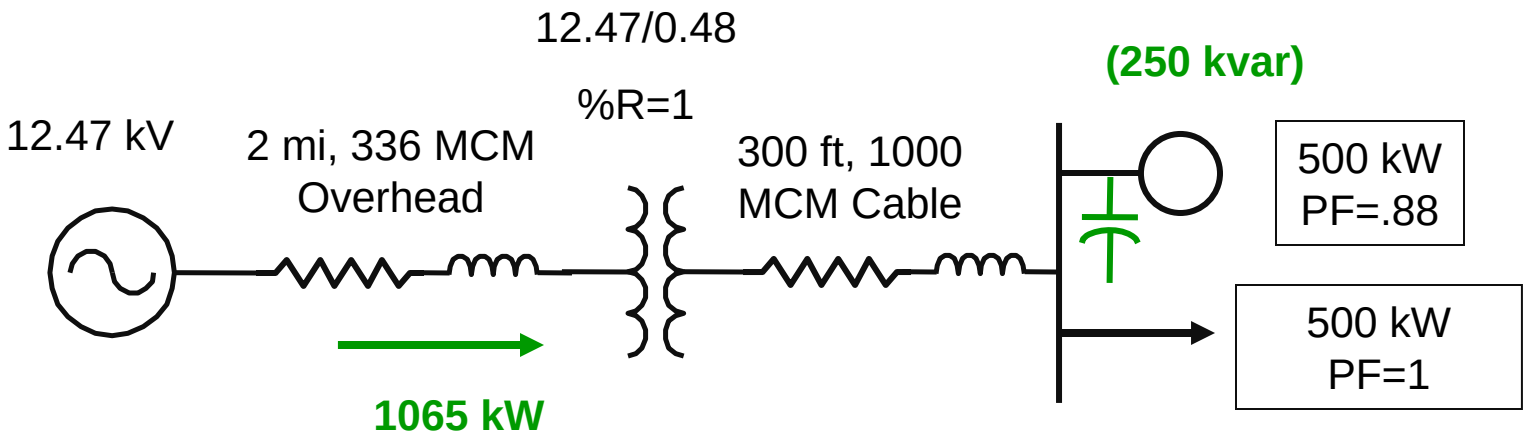
Total Circuit Losses: 74.8 kW / 7.48%

End User Loss Savings: 76 kW - 70 kW = 6 kW

This is 8% savings in losses, but net power into load decreases only 6 kW or 0.6% of load

Source: EPRI

Example, Capacitor at Load



LOSSES: **4.03 kW** **0.38%** **4.32 kW** **0.40%** **60.6 kW** **6.23%**

Total Circuit Losses: 68.9 kW / 6.89%

End User Loss Savings: 76 kW - 65 kW = 11 kW

This is nearly 15% savings in losses, but net power into load decreases only 11 kW or 1.1% of load

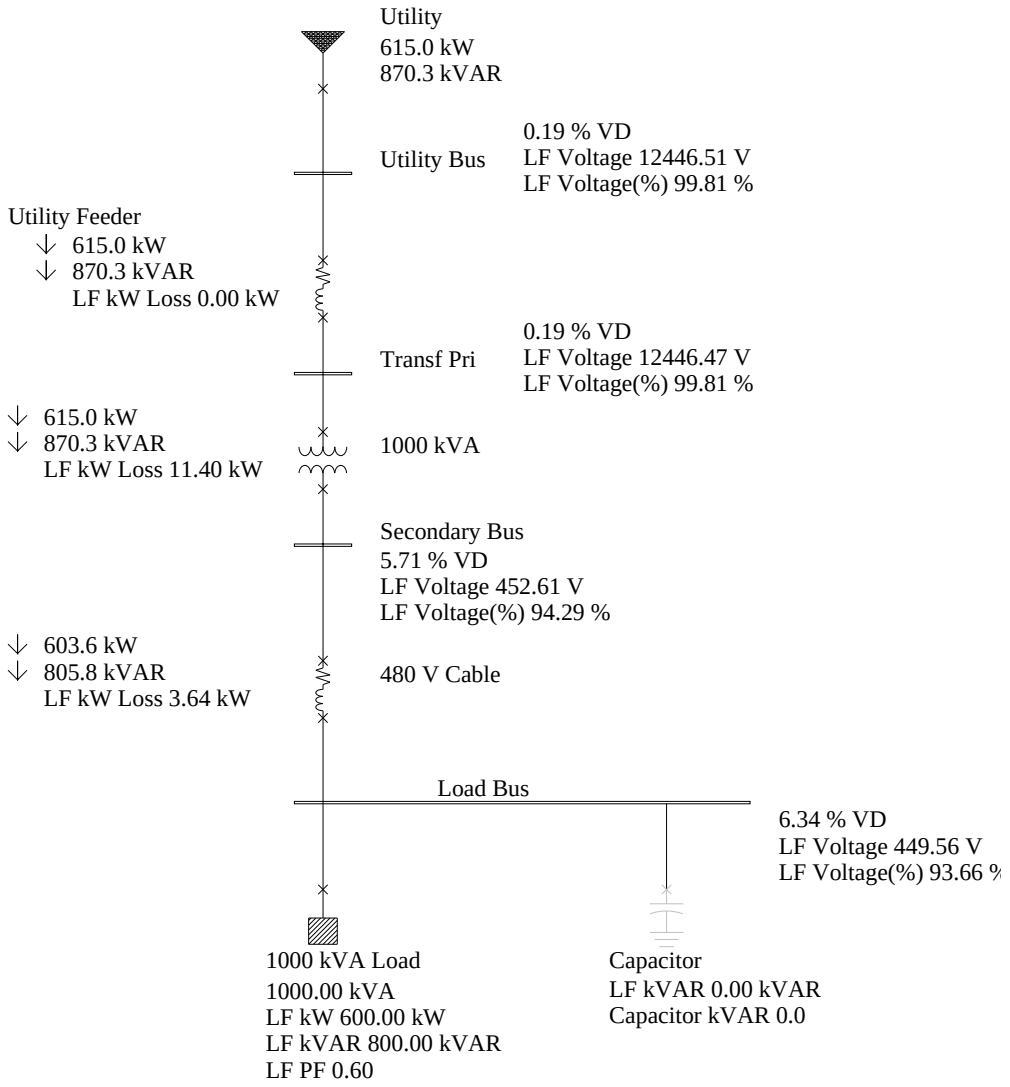
Source: EPRI

Computer Simulation – High Rise Building

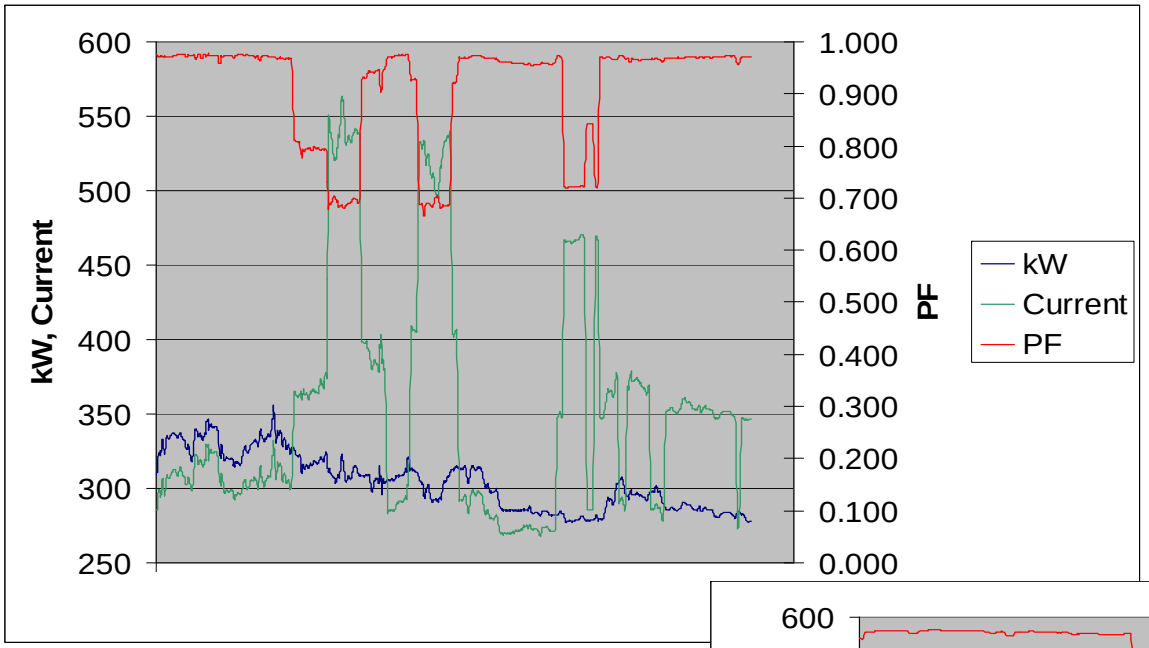
PF	kW	kvar	kvar added	% kW Savings
0.58	615	870	0	0.0%
0.62	612.8	771	100	0.4%
0.67	610.9	671	200	0.7%
0.73	609.2	568.8	300	0.9%
0.79	607.7	466	400	1.2%
0.86	606.6	361	500	1.4%
0.92	605.7	255	600	1.5%
0.97	605.1	147	700	1.6%
1.00	604.8	38	800	1.7%
0.99	604.9	-72	900	1.6%
0.96	605.3	-184	1000	1.6%

Computer Simulation – High Rise Building

1000 kVA @ 0.6 PF

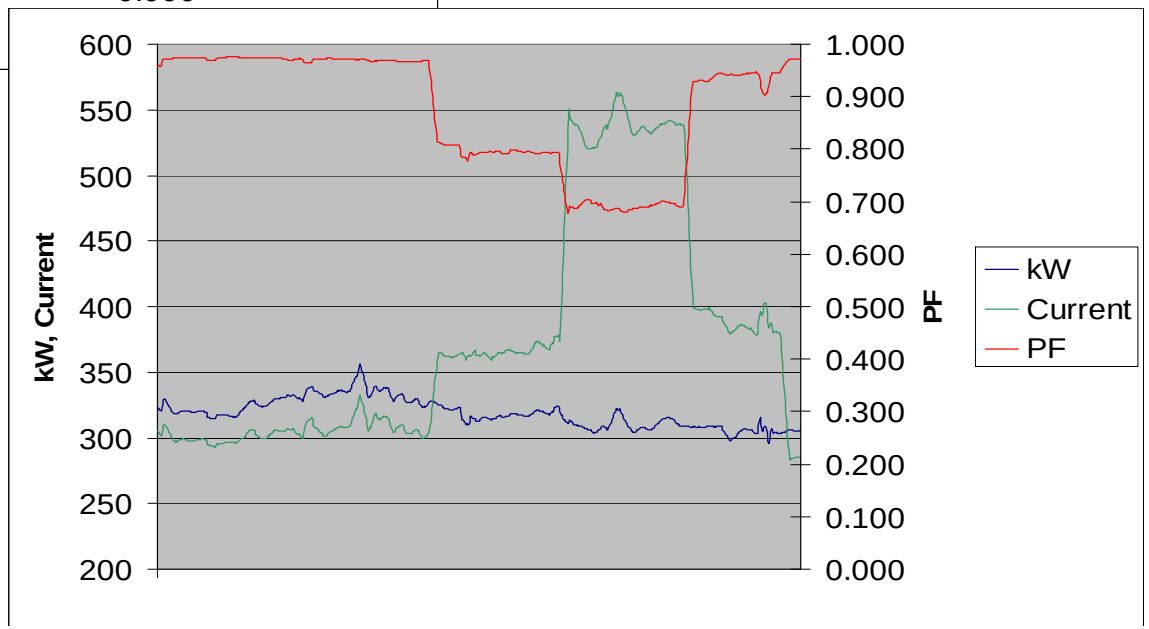


Field Tests



Trend Data During Test

Trend Data Zoom



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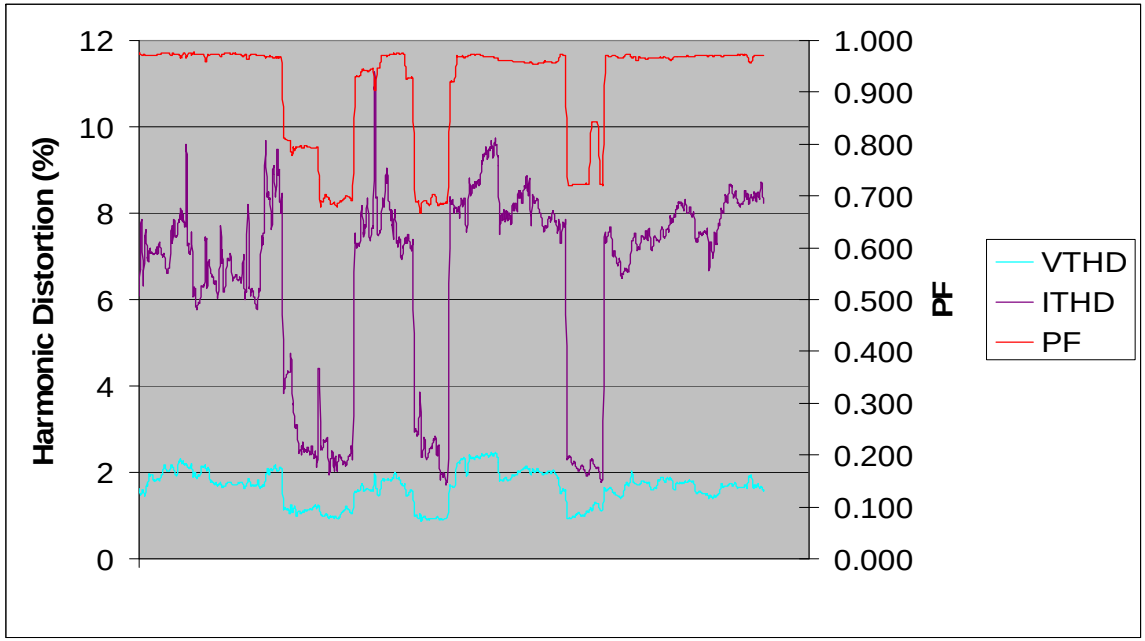
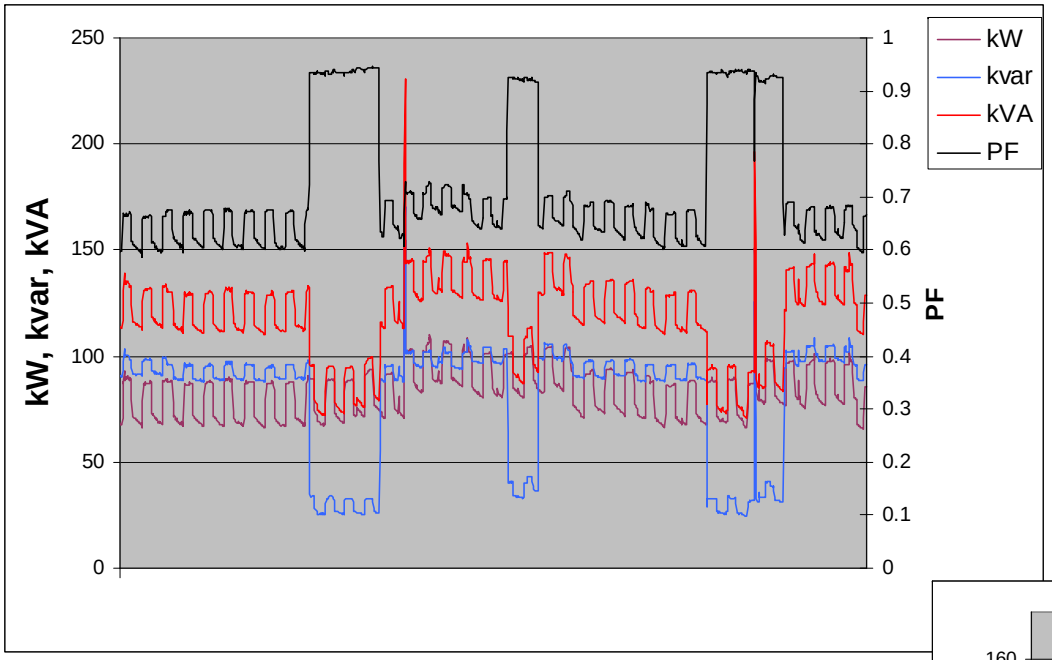
Field Tests



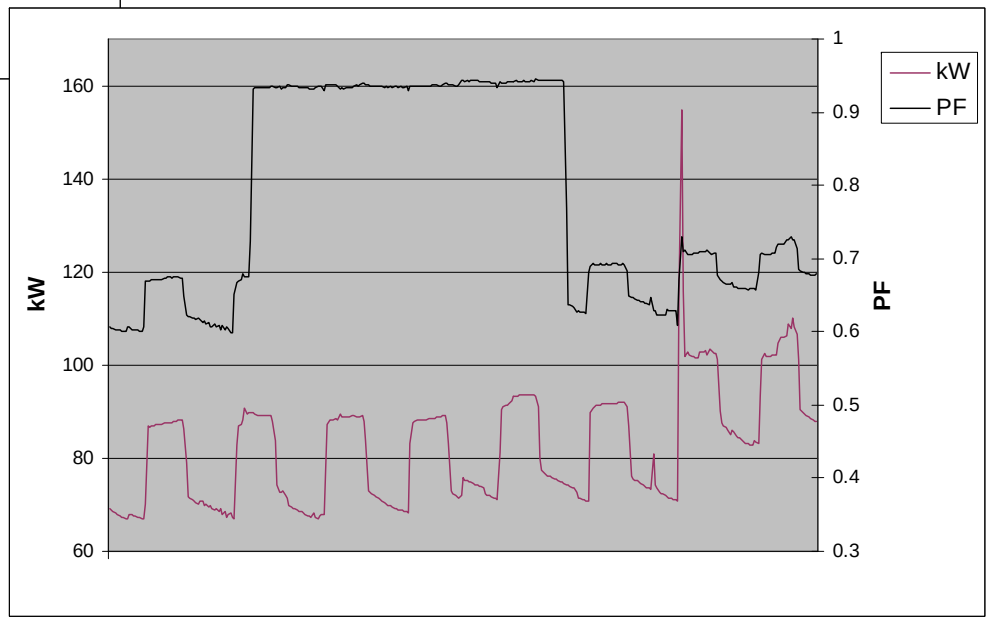
Harmonic Trend Data During Test

Field Tests



Load with Cycling Air Compressor

Zoom of Load with Cycling Air Compressor



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Confusion Created by Sales

Hard Savings	Soft Savings
Reduced kWh	Lengthens equipment life
Reduced kW	Protects sensitive electronic equipment
Improved PF	Reduces maintenance
Reduction in equipment losses (cables, transformers, motors, etc.)	Protects environment
Reduced taxes	Less HVAC required
	Space savings
	Improves safety
	Reduces greenhouse gases

Confusion Created by Sales

- Expert/Third party testimonials and/or “Technical sign-off” (usually engineer signs off then the sales person goes to the controller or finance person with the paper)
- Unknowing/Non-technical or passionate salesmen (he believes and so should you!)
- Patented technology
- Only the inventor truly understands the “technology”
- Hard to prove/disprove guarantees (buy our stuff and then show us you didn’t save…)
- Sell to unknowing residential and commercial customers with little or no knowledge of kW vs. kVA (current is reduced so “power is reduced”)

Confusion Created by Sales

Confusing Percentages

- Transformer 97% Efficient
- New Transformer 97.8% Efficient
- Either 0.8% Improvement or 27% Reduction in Losses

Faulty/Questionable M&V

- Inferences/overgeneralizations from “similar” measurements
- Comparison to customer with PF penalty
- Revenue grade metering
- CT inaccuracies/phase shifts
- Lack of practical demonstration method
- Too long/short measurement length

Interesting Quotes

What genuinely makes this product different and thus sets it apart from most other devices on the market is built in line noise filtering, “LNF”. This LNF circuit helps to balance out the distortion in the wave cycle which causes KVAR’s in the harmonic balance associate with inductive loads.

(Interpretation: Can you say “flux capacitor”?)

Achieved savings derived from using both MOV, TVSS and line filter capacitance together in one unit maximizes the energy savings feature in real time operations, with results showing anywhere from 5% - 20% or more in monthly electrical savings possible.

(Interpretation: I can almost guarantee it might work....)

Highly sophisticated band-pass filter....blocks out harmonics, power spikes and surges....clean up your power...increase your power factor, reduces KVAR, amp draw and most importantly kWH usage...remember, you are billed for kWH....reducing your kWH reduces your electric bills.

(Interpretation: Does everything but wash your car)

Interesting Quotes

Utility companies hate our product because it takes money out of their pockets. They don't like when customers save money on their bills.

(Actually: yes, they do and they would love to pay you to save them from building new gen plants)

How do you get 30% savings on a typical power system – well, if you save 2% on every motor and you have 15 motors, there you go....

(Must be that "new math" – I guess I really don't understand per unit math after all....)

The inventor will call you to talk to you about the product

(I'm still waiting by the phone....)

Interesting Quotes

"Power Factor" improvement is recognized by the US Department of Energy and all Electric Power Companies as a method to reduce kWH on your electric bill.

(Actually: yes, PF correction is recognized but not, generally speaking to reduce kWH)

Our product is certified by ANSI/UL STD 810 FOLDER which means it is a POWER FACTOR improver.

(Regarding surge protection) – Every time you type on your keyboard, you create micro-transients. These transients travel through the power system and waste energy. Installing our surge protection will clean up your system and save you XXX% on your energy bill.

Interesting Quotes

You have to install our product – it works over time. You can't just turn it on and off and expect it to show a difference.

These capacitors are "different" – they aren't just regular capacitors.... (opened the box and what do you know....)

Q: How does 18 AWG wire in a demo box translate up to 500 MCM in a plant?

A: It just does....

Interesting Reference Quotes

Our KWH was reduced by approximately 15-18%….Amperage was reduced by 22% and the KWH was reduced by about the same....I'm not an electrician, so cannot explain exactly how they work, but testing has shown us they do.

This also gave (us) the opportunity to participate in something that is positive for the environment and good for the country we live in.

My Favorite HELP Line Calls

"I just started working for a company that makes energy saving devices...sometimes our product saves energy and sometimes it doesn't – can you help me explain to our customers why that is the case????"

I want to sell some black box energy savings devices and I want to be conscientious about what I'm selling. I've set up a W-H meter and did some testing. Why would my meter spin slower with the unit on if it doesn't save real kW?

(Finally, a valid question!)

My Favorite Personal Slams (on me)

You are thinking too much like an engineer – you will probably never understand this product.

OK smart guy, how many classes did you talk about PF correction in college – 2, maybe 3 and does that make you an expert on this stuff?

Eaton doesn't like us because we have a patent on the "technology" and you can't sell it.

....what doesn't kill you makes you stronger!

My Favorite Redemption Line

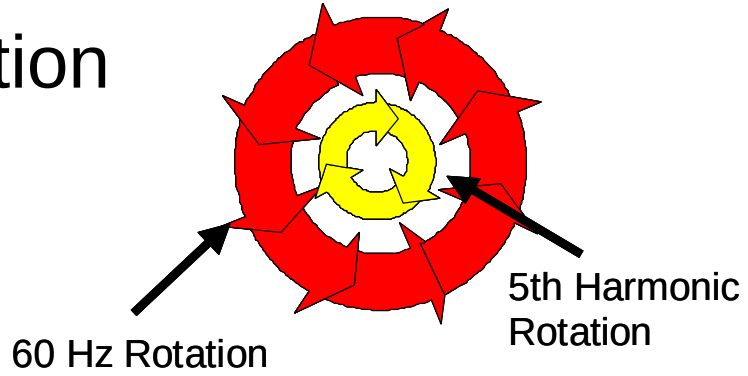
...salesman that sold the product but came to understand the truth....

“I can’t believe we sold you this bucket of $%#*^!

Other PQ Solutions that “Save” Energy

Products that Reduce Negative Sequence Currents in Motors

- **Description:** Voltage unbalance or negative sequence voltage harmonics make motor resist 60 Hz rotation
- **Claim:** > 10% savings?
- **Reality:** MG-1 describes voltage/current unbalance but losses are typically < 2%



Other PQ Solutions that “Save” Energy

(Balancing) Zig-Zag Reactors

- **Description:** Balance voltages, cancel harmonics, improve PF
- **Claim:** > Up to 20% savings?
- **Reality:** I^2R savings, possible harmonic savings, possible PF savings, possible voltage unbalance savings – total less than 3% typically

Other PQ Solutions that "Save" Energy

Surge Suppressors

- **Description:** TVSS/SPD typical equipment
- **Claim:** Transients waste energy and surge protection equipment removes transients
- **Reality:** Impossible and unbelievable! FTC warning = 0.00000%
- From EPRI = typical load may yield 0.044 Wh/yr from many severe transients/year
  "….you can only save energy that is wasted…"

Other PQ Solutions that “Save” Energy

Harmonic Mitigating Transformers

- **Description:** Phase shifting transformers
- **Claim:** Up to 20%
- **Reality:** Actual savings is from energy efficient transformer changes (2-4%) plus < 4% from harmonic reduction is typical

Other PQ Solutions that “Save” Energy

Neutral Blocking Filter

- **Description:** 3rd harmonic blocking filter
- **Claim:** Up to 8%
- **Reality:** Possible to get up to 8% but more typical is 1-4% depending on load mix

Other PQ Solutions that “Save” Energy

Soft Starter

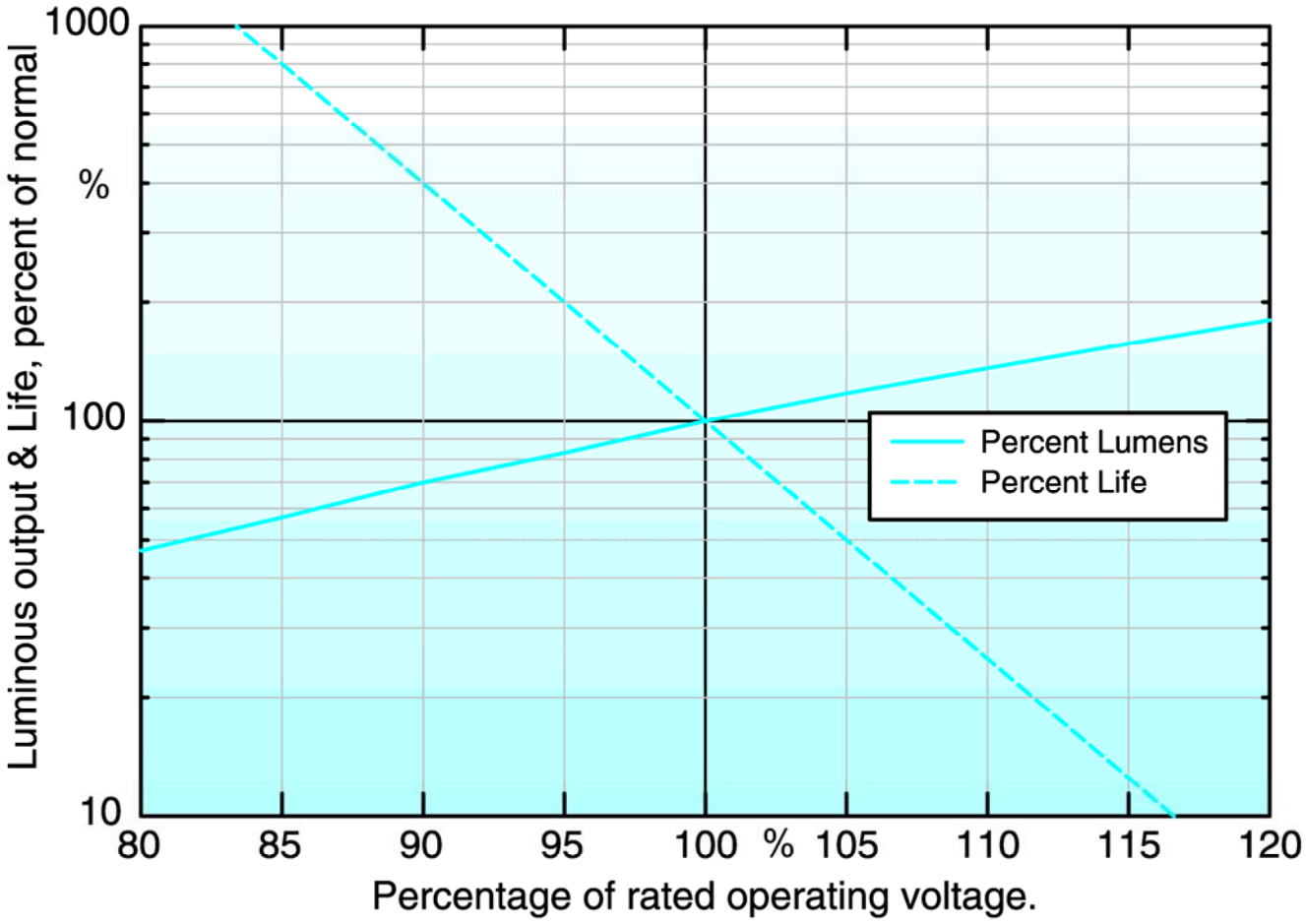
- **Description:** Power electronic motor starter
- **Claim:** Reduce kW demand
- **Reality:** 2-10 seconds of starting current will not significantly reduce 15 min billing demand. In addition, inrush current is primarily reactive (kvar, not kW). Savings = 0%.

Other PQ Solutions that “Save” Energy

Conservation Voltage Reduction (CVR)

- **Description:** Reduce voltage to loads by 5-10%
- **Claim:** Reduce kW demand, usage up to 13%
- **Reality:** Depends on load mix – constant impedance loads will reduce kW but could increase load cycles (heating loads, for example). Constant HP (motor) loads could increase current and increase I^2R losses. Typical <2% for aggregate systems could be more for specific individual loads.

Voltage Reduction and Incandescent Light Bulbs



Source: Light Measurement Handbook; http://www.intl-light.com

You save energy but you get less light: why not change to a more efficient lighting technology instead?

Other PQ Solutions that “Save” Energy

Energy Saver (green) Plug

- **Description:** “The Green Plug was invented by my thesis adviser…it’s really a Modulated Switched Dynamic Filter Capacitor Compensator (did he mean to say “flux capacitor?”), a device designed to make existing power systems more powerful and energy efficient by reducing the amount of reactive energy and harmonic currents that are generated by electrical residential and commercial loads”
- **Claim:** “…the actual savings available through the green plug are difficult to measure…but he estimated that power producers could expect to experience a drop of 10-20% in power if the green plug is used extensively”
- **Reality:** No comment ☺

Table 2 – Summary Table

Description

Primary PQ Benefit

Stated EM Savings or Other Benefit(s)

Realistic EM Savings

Reasons for Discrepancies

Conclusion: Buyer Beware!!!

Energy Management Cost Saving Solutions

Supply Side Management

Save money through rate structure optimization, penalty avoidance and utility bill accuracy verification

- Energy management audits and assessments
- Power factor correction
- Meters

Enterprise Monitoring

Manage the facility's energy usage through meters and software to identify savings opportunities

- Meters
- Enterprise software
- Billing and trending applications
- Data integration with BMS

Demand Side Management

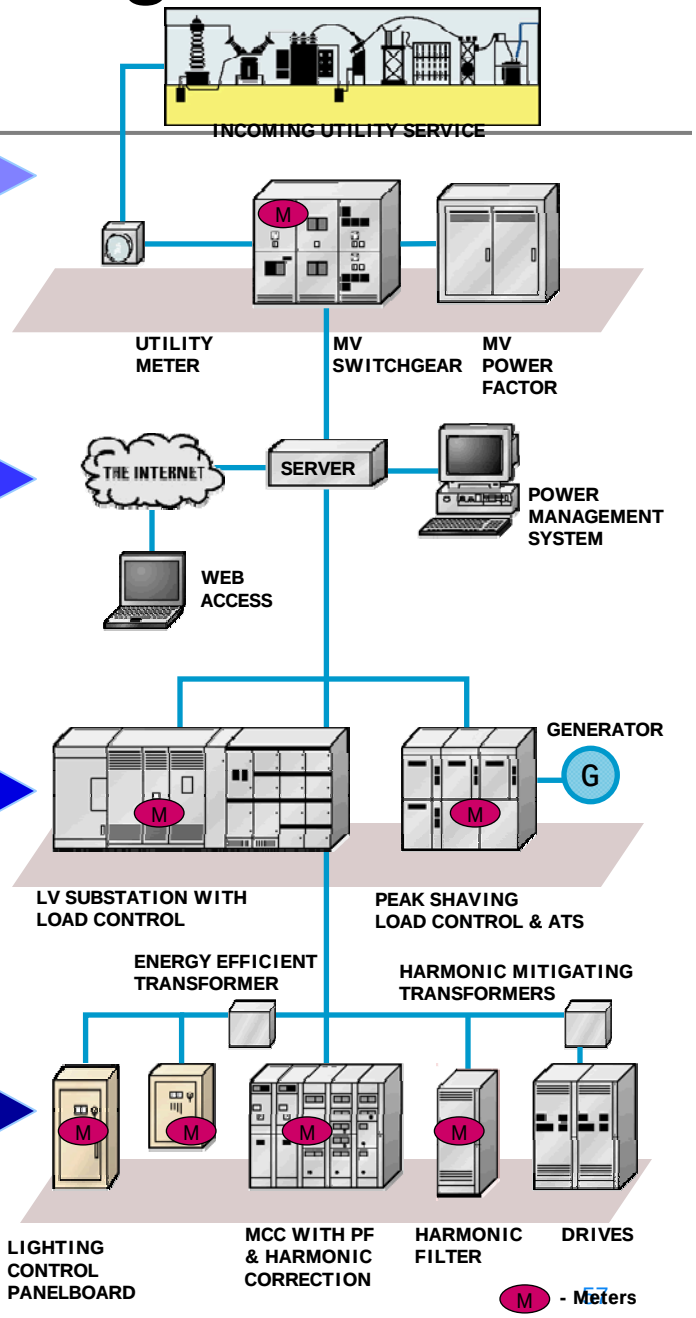
Reduce energy consumption and save money by controlling loads

- Peak shaving
- Load control
- Meters
- Distributed generation
- Time-of-use programs
- Operational savings

Energy Efficient Devices

Conserve energy through installation of energy-efficient devices

- Drives
- Transformers
- Lighting control
- Power factor correction
- Harmonic Solutions



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Potential Savings of Solutions

Table 2 (partial) from “Power Quality and Energy Management Solutions” paper

http://www.eaton.com/experience

ɾiption	**Primary PQ Benefit**	**Stated EM Savings and Other Benefits**	**Realistic EM Savings**	**Reason for**
ıcts to address **ive sequence nts**	Negative Sequence Current reduction	• Eliminates “reverse” rotation action on motors yielding higher efficiency • kW and kWh savings (usually > 10%) • Reduces heating • Prevents premature damage	• kW and kWh savings (usually < 2 %)	• Hard to stated cl • Easier tc “some”
ıcts to address **lanced voltages** ding **zig-zag ɒrs**)	Negative Sequence Current reduction	• Eliminates “reverse” rotation action on motors yielding higher efficiency • kW and kWh savings (usually > 10%) • Reduces heating • Prevents premature damage	• kW and kWh savings (usually < 2 %)	• Hard to stated cl • Easier tc “some”
ɛ protection	Elimination of voltage transients	• kW and kWh savings (usually > 20%) • Prevents damage • Reduces need for maintenance • Improves performance of equipment	• 0.000 %	• Uneduca
ɒrrection	Reduce kvar flows on power system	• kW and kWh savings (usually > 20%) • Prevents damage • Reduces need for maintenance • Improves performance of equipment	• 0.5-2% typical (excluding harmonics) • If electric utility charges PF penalty, PF charges may actually save up to 10% or so (not kW or kWh savings)	• Easy to based or may pur and kvar • NOTE: as kW o though a

Summary

Is it a good idea to buy PQ solutions?

- Yes – for PQ and reliability reasons

Do PQ solutions save energy?

- Sometimes but not as much as many will claim

Does PF Correction equipment save significant money on the utility bill?

- Yes, if there is a penalty

Wrap-up and Questions

Reference Papers and Presentations:

1. Carnovale/Mueller, “Power Quality Solutions and Energy Savings” (PQ Conference – 2005)
2. Blooming/Carnovale – “Capacitor Application Issues” (IEEE IAS – 2006)
3. EPRI – “Energy Savings: You Can Only Save Energy That Is Wasted”
4. EPRI – “Strategies for Evaluating Black Box Technologies”

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http://www.eaton.com/experience

Questions?


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