

PowerwoRx e³

PowerwoRx e³ (patent applied for) provides a Whole House Energy Management System for the best possible energy savings and Total Home Protection based upon a unique technology that provides three key benefits:

- Equipment Protection
- Electrical Noise Filtration
- Energy Savings

Equipment Protection

PowerwoRx e³ is like having an **ELECTRONIC BODYGUARD** for your home or business! **PowerwoRx** technology provides Surge and Spike Suppression, a feature that will help protect and extend the useful life of your electrical equipment.

Voltage surges and spikes come from many different internal and external sources such utility grid changes, damaged transformers or electrical lines due to accidents or acts of God, old or out dated utility transformers that supply electrical power to your home, lightning and turning on and off major motor loads in your home.

Typical homes in the United States are bombarded with literally hundreds of surges and spikes a day that damage sensitive electrical equipment over time. A combination of the **PowerwoRx e³** harmonic resistant capacitors and metal oxide varistors (MOV's) give the home owner the maximum protection available on the market today. The external lights on the **PowerwoRx e³** system provide an easy visual indicator that the system is protecting your home.

Electrical Noise Filtration

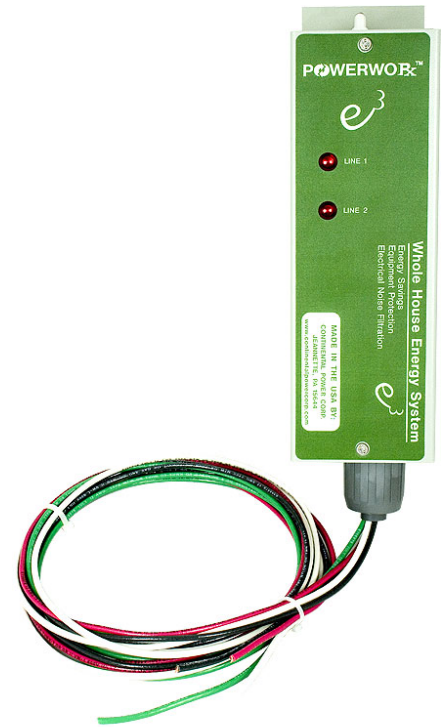
PowerwoRx e³ technology provides Harmonic Filtration which has become more important since the 1980's and almost mandatory going into the 21st Century due to the proliferation of computers, fax and copy machines and variable frequency drives which are known as "nonlinear loads". "Nonlinear loads ask for and use electric current in "pulses" unlike traditional electrical equipment. This pulse use of electrical current creates damaging noise, interference and heat on today's electrical systems causing interference within sensitive electrical equipment or worse causing them to overheat and fail. The use of computerized electronics within the American home has been growing at exponential rates and the need for filtering out the interference, noise and heat created by nonlinear loads has never been greater.

Installing the **PowerwoRx e³** system in your home will reduce the need to produce electrical energy reducing the amount of coal and oil being burned to generate the electric energy resulting in the reduction of environmentally harmful emissions of carbon dioxide, nitrous oxide and sulfur dioxide.

It is **EcoTrust Energy's** mission to install **PowerwoRx e³** systems in 500,000 homes across this county which will annually reduce the need to generate 17 megawatts of electricity saving 42,250 tons of coal or 231,500 barrels of oil and reducing by 98,250 tons of carbon dioxide, 42,000 pounds of nitrous oxide and 221,500 pounds of sulfur dioxide of annual greenhouse emissions.

Energy Savings

PowerwoRx e³ provides energy savings by reducing the amount of power drawn from your utility with the use of specially designed harmonic resistant capacitors. **PowerwoRx e³** systems optimize your homes power factor thus reducing the amount of energy your homes motor loads use such as air conditioners, refrigerators, freezers, washers, dryers, dishwashers, pool pumps, vacuum cleaners, furnace blower motors, fans etc. Motor loads (inductive loads) inherently require more energy to do their work compared to other electrical equipment in your home. The **PowerwoRx e³'s**



“power factor optimization” significantly increases the efficiency of your motor load and stores waste energy resulting in decreased demand and usage of electricity from your utility company. This can equate to cost savings for you the home owner.

Power factor is the measurement of how efficient your electrical system is using the energy delivered to your home from your utility company. For example, your stove and dryer heating coils and incandescent light bulbs have a “power factor rating” of unity or 1. This equipment converts electric energy to heat and light. Motor loads as described above can have “power factor ratings” as low as 0.2. This combination of electric loads in American homes results in an average “power factor rating” of .77 or less. The .77 indicates that your home is using more energy than it should to operate your electrical equipment. The **PowerwoRx e³** technology has a proven track record of increasing a home’s “power factor rating” to .95 or better.

So what does this mean as far as real savings? The answer is “it depends”. Typical savings are in the 8%-15% range based upon customer feedback but actual results will vary depending on inductive loads. EcoTrust Energy does not guaranty any specific energy savings. The value of **PowerwoRx e³** is all three features: Equipment Protection, Electrical Noise Filtration, and Energy Savings. Just the first two features provide more than enough benefits to justify installation of the unit.

PowerwoRxTM E3 “Clean Power System” Specifications

Unit Model	CPS-1C-240-V1
Power Line Voltage (VAC)	120/240
Nominal Voltage (VAC)	150
Rated Voltage (VAC)	240 +/- 10%
Phase Configuration	single Φ res.
Frequency (Hz)	50 -60
Power Dissipation (J) – From MOV’s <small>(2ms current wave)</small>	550J
Peak Pulse Current (A) <small>(8/20 microsecond current wave)</small>	40,000
Surge Current (A)	6,500
Maximum Clamping (V) <small>(@ 200A, 8/20 microsecond current wave)</small>	340/690
Total Capacitance (μF)	30
Operating Temperature ($^{\circ}$C)	-40 to +70
Line Wires (AWG)	12
Wire Rating	UL THHN 90C
Circuit Breaker Required (A)	20 or 30
Dimensions (WxHxD)	3.06”x11.1”x5.0”
Weight (lbs.)	3
Warranty	10 Year product Plus\$25,000 home appliance and electronics warranty

Note: Comes in both a NEMA 1 enclosure (US40718) for dry mounting locations and a NEMA 3 enclosure (P/N US40771) for external installations.

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[What meter can be used to verify Power Factor and the other parameters required to evaluate my electrical system?](#)

[Some customers using other “Energy Savings Devices” or basic capacitors in a box of which there are a dozen products like this, have not experienced any energy savings. Does this mean we will not see any energy savings with the PowerwoRx e³?](#)

[Does PowerwoRx e³ protect me from all Surges and Spikes?](#)

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[What happens if a lightning spike comes into a building through a window air conditioner or some path other than the electrical line?](#)

[When a Demo Case is being used in a home with PowerwoRx Installed, why does the meter still show the same as before the PowerwoRx was installed in the home?](#)

Electrical Terms - Definitions:

Alternating Current (AC)
Voltage (Volts)
KVA (Kilovolt Amperes)
Harmonic Interference
Phase
Resistive Load
Transformer (Voltage Type)
Electro Magnetic Field (EMF)

Amperes (Amps)
Watt, Kilowatts, Kilowatt Hours
KVA(R)
Circuit
Inductive Load
Power Factor
Capacitance
Metal Oxide Varistor (M.O.V.)

Does the PowerwoRx e³ work in any home?

Yes it does! The PowerwoRx is designed to go into any home with a single-phase circuit breaker panel with breaker switches. For homes with the old screw in type fuses, the unit will work but additional hardware will be required. The "energy savings" from PowerwoRx comes from how it deals with inductive loads or to put it in more common terms, how it deals with motor driven appliances. If you say "yes" to only **two or more** of the following then you could be saving money on your electric bill right now!

- Is your central air conditioner / heat pump unit 3 years or older?
- Is your forced air furnace 3 years or older?
- Do you have a pool?
- Do you have a well?
- Do you use an air conditioner?
- Is your refrigerator / freezer not EnergyStar rated?
- Do you have more than one refrigerator / freezer?
- Is your washer / dryer not EnergyStar rated?
- Do you have a hot tub or a Jacuzzi?
- Is your dishwasher not EnergyStar rated?
- Is your home over 2500 Square feet?

Installation Considerations?

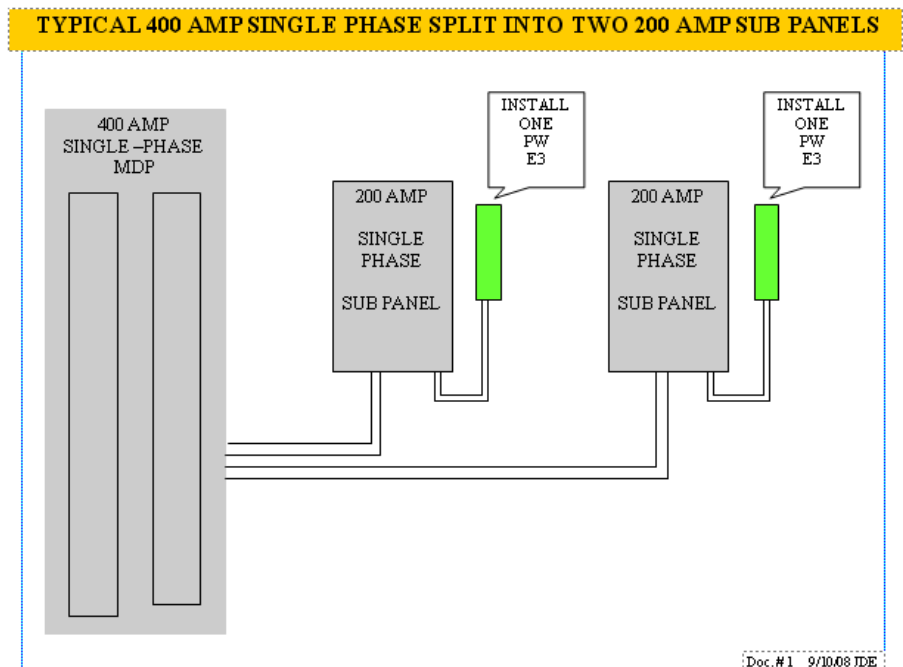
PowerwoRx e³ must be installed by a licensed electrician (or equivalent in areas which do not issue licenses) or the 10-year Warranty is void. The PowerwoRx e³ mounts next to a standard 100A or 200A single phase power panel. The unit's two supply wires (L1 and L2) are connected into a dedicated 220V, 20A or 30A breaker, ideally located at the top of the panel but can be installed anywhere an opening exists. The neutral and ground are connected to their respective busses. Questions regarding proper attachment and wiring should be directed to the electrician who can verify local and state codes are being complied with. The Installation Guide which accompanies the product can be found at the end of this document.

Some specific questions from Electricians.....

1. A standard 200 Amp service has 1-Panel with a 200 Amp main breaker, usually located 3-5' from the meter. Should the PowerwoRx e³ be tied in on the line-side of the main breaker or can a separate branch breaker be installed and hook it up there? Could it even be installed to an existing 240 Volt breaker? **ANSWER: The PowerwoRx e³ is always installed on the switched side of the MAIN 200A breaker through a dedicated 20A or 30A double-pole breaker. If the panel is full or there is not a double space available to add a double-pole breaker, space can be made available by using two split or "piggyback" breakers.**
2. Does the 20A or 30A dedicated double pole breaker need to be at the top of the panel – there have been some manufacturers who say it must? **ANSWER: The dedicated double pole breaker can be installed in any open slot that will accommodate a 240V breaker, regardless of whether it is at the top or bottom. The reason some have suggested the breaker MUST be installed at the top of the panel is the assumption that a surge or spike will only be stopped if it reaches the PowerwoRx e³ first. This is not true. The PowerwoRx Surge and Spike protection will activate as soon as the line voltage exceeds the rated voltage +20%. Yes, it does take more time for the voltage to travel to the bottom of the panel and then out to the PowerwoRx e³ then if it were connected to the top slot in the panel. Regardless of location, the Surge or Spike will be stopped or arrested long before it can travel out from the panel on branch circuits to appliances and electronics in the building.**
3. Some areas require a 200A disconnect be mounted at the meter and from the disconnect run a line to a 200A Main Lug Only panel inside the home. In that application, should the PowerwoRx e³ be located at the exterior disconnect. **ANSWER: In all cases, the PowerwoRx e³ is always installed on the switched side of the MAIN 200A breaker through a dedicated 20A or 30A double-pole breaker, not on an exterior disconnect.**
4. Many times the panel in the home is in a bedroom or other "living area" where people may not want to look at this "green box" on the wall. Can it be located elsewhere, like in a closet in the attic, and if so how far from the panel is this permitted? **ANSWER: The PowerwoRx e³ can be remotely located in a closet or some other less-conspicuous location. Distance from the panel should be minimized. Keep in mind that the two indicator lights are the only indication that the PowerwoRx e³ is operating properly. Consequently the unit should be located in an area where the lights can be checked. An inaccessible attic would not be the ideal location.**

5. If there were enough room in the panel could the PowerwoRx e³ be placed inside the panel box? **ANSWER:** Because the two indicator lights are the only indication that the PowerwoRx e³ is operating properly and code does not permit the cover of the power panel to be modified, locating the unit inside the panel would not be the ideal location.
6. Can the wires coming from the PowerwoRx e3 be shortened or lengthened and if so do they need to be the same length? **ANSWER:** Yes the wires can be shortened to whatever length is necessary and no the wires do not need to be the same length. **UPDATE:** Continental Power has approved lengthening of the wires to accommodate mounting the unit further away from the panel than the current wiring allows. As a general rule, the length of the wires should be kept as short as possible and electricians should follow standard electrical code regarding adding wire to the unit.
7. Can PowerwoRx e3 be mounted horizontally rather than just vertically and why does it have to be mounted at least 12" from the main panel? **ANSWER:** Due to the way the PowerwoRx is assembled internally, the ideal mounting orientation is vertically (as instructed in the Installation Instructions) with the wires coming out the bottom. **UPDATE:** Continental Power has approved a horizontal mounting orientation with the cover on the top side and the wires coming out on the right. In addition, the 12" requirement is being removed from the installation instructions.

8. Many "Custom" homes have one 400A meter and run from there with a line to each of (2) 200A panels in the home with main breakers. If we locate one PowerwoRx e³ in just one of the panels are both panels protected? **ANSWER:** One PowerwoRx e³ per 200A panel is required. If only one PowerwoRx e³ is installed, only one panel is protected. In this case installing two PowerwoRx e3's is recommended, one per 200A sub panel per the following diagram:



9. If a home or small business has two 200-amp main panels, does a PowerwoRx e3 need to be installed on both panels? **ANSWER:** Typically one unit is recommended for each 200A panel. One reason you may want to only install one unit is if the boxes are located next to each other, and the total current draw with all appliances turned on (maximum current draw) is less than 200A. If the current draw is over 200A and the panels are not side by side, the only way to protect the panels and attached appliances and electronics is to have a unit on each panel. In addition, the PowerwoRx provides adequate treatment for only up to 200A so if the total current draw is over 200A the PowerwoRx will not provide the expected results.
10. If a home or small business has a 200 amp service and a 100 amp sub panel either next to, or in a remote location, does a PowerwoRx e3 need to be installed on both panels, or one of the panels, & if so which panel? **ANSWER:** If the 100A sub panel is located close by, one PowerwoRx is adequate. If the 100A sub panel is 100 yards away in another building, a second PowerwoRx on the sub panel is suggested to insure the sub panel has adequate surge & spike protection, harmonic filtration, and PF reduction. Of course it is also dependent on what reactive loads are tied to the sub panel. If there are little or no reactive loads, and there are few appliances or electronics to protect, a unit on the sub panel would not be warranted.

How long will the PowerwoRx e³ last?

It has a predicted lifespan of over 20 years. This claim is based upon the synergy between the three components which protect each other and lessen the derating of components which is typical in "capacitor in a box" type products.

What is the PowerwoRx e³ Warranty?

The warranty on PowerwoRx e³ is the best in the industry – a full 10 year! The patent pending design and the quality of the components used in the PowerwoRx e³ Whole House Energy Management System lets us offer this industry leading warranty. No other manufacturer comes close. Even if the PowerwoRx e³ performs as it should in the event of a lightning strike nearby, and the Industrial rated MOV's which absorb the energy sacrifice themselves, EcoQuest will repair or replace the unit.

In addition, a \$25,000 warranty on the homeowners appliances AND electronics is included! For more details on this warranty see the policy at the end of this document. It should be noted that the PowerwoRx only protects against surges on the electrical lines, not on the Telephone or TV Cable. For 100% protection Telephone and Cable surge protectors are needed.

Note: The \$25,000 warranty on the homeowners appliances AND electronics applies to the residential PowerwoRx e3. A PowerwoRx e3 installed in a commercial facility is not covered. The commercial 3-phase PowerwoRx have the same industry leading 10-year warranty but do not have the appliance/electronics warranty.

How much current will the PowerwoRx e³ handle?

The PowerwoRx e³ is designed for 240V and 200A which is typical for residential applications. For larger "Commercial" applications, a line of 3-Phase Commercial PowerwoRx e³ units will be available through EcoTrust Energy. EcoTrust Energy has established a Certification program and units are available for certified distributors.

Will the PowerwoRx e³ affect any of my appliances and their normal use?

No, if anything, your motors will run about 10% cooler, which is good because heat is the enemy of a motor. PowerwoRx e3 reduces I²R line losses which improves voltage stability, improving motor performance.

Is the PowerwoRx e³ tested and approved by independent labs?

Yes, the PowerwoRx e³ is UL listed and tested (PowerwoRx UL certificate is under the UL 508 "Industrial Control Equipment" category, UL Certificate # E320259, dated 3/27/08). To see the UL listing on the internet go to: http://database.ul.com/cgi-bin/XYV/template/LISEXT/1FRAME/showpage.html?name=NMTR.E320259&ccnshorttitle=Power+Circuit+and+Motor-mounted+Apparatus&objid=1079441548&cfgid=1073741824&version=versionless&parent_id=1073990288&sequence=1

The 200A Single Phase residential product is: CPS-1C-240-V1

The technology is also recognized by the U.S. Department of Energy.

Update on 8/24/08: The PowerwoRx e3 is UL approved and has been manufactured at Continental Power's manufacturing facility near Nashville, TN. In March 2008 EcoQuest exercised our option to manufacture and anticipated manufacturing 90 days later. Continental proceeded to file the appropriate paperwork with UL. Although this effort only involves paperwork and an inspection of EcoQuest's facility, and typically the process takes a short period of time, for several reasons outside of EcoQuest's control the process has been delayed. The latest communication from UL assured EcoQuest and Continental that the paperwork was in process and would be completed shortly. Considering EcoQuest was ready to begin manufacturing in mid June, and considering the backlog of orders, and considering the application of PowerwoRx in homes does not typically required UL approval, it was decided to begin manufacturing at EcoQuest. The product being manufactured uses the UL approved design and UL approved components but with the UL mark removed. Once the UL paperwork is complete and the EcoQuest facility has been inspected, we will resume using the UL mark on the product.

In order to make PowerwoRx available for our Canadian Independent Business Owners, additional certification was required. EcoQuest has for several years now chosen to use QPS Evaluation Services located in Toronto, Canada as our "International" certification agency. The QPS mark currently appears on many of our existing products (DuctwoRx and in-Duct product lines, Gemini, AP3000, etc). Also, as an interim step to the UL process outlined above and while the PowerwoRx was under evaluation by QPS for Canadian certification, Ecoquest requested that the agency certify the PowerwoRx for the US market as well.

In order to certify a product for Electrical Safety in the US, the certification agency must be accredited by OSHA. These accredited labs are known as Nationally Recognized Test Labs or NRTL's. NRTL's are qualified organizations that are recognized under the Agency's NRTL Program as meeting the requirements to perform independent (i.e., third-party) product safety testing and certification. **When first adopted, OSHA regulations gave two examples of approval organizations: Underwriters Laboratories (UL) and Factory Mutual Research Corporation (FMRC). In 1983, as a result of a successful lawsuit brought by a private lab, OSHA was ordered by a court to remove the specific references to UL and FRMC and in 1988 it complied with the court's ruling removing the references and established the current NRTL Program to recognize other qualified independent labs and organizations as NRTLs.** An OSHA accredited lab is an OSHA accredited lab and are all considered equal provided the certification being sought appears in a lab's scope of recognition. Each NRTL is approved for a scope of recognition which identifies: (1) The types of products the NRTL may approve, (2) the NRTL's "recognized sites" which are the NRTL's wholly-owned sites that can perform the full range of product testing and certification activities necessary in approving those products, and (3) "supplemental programs" through which the NRTL can use **other resources** in performing activities necessary for product testing and certification. Currently, only 15 labs worldwide are recognized by OSHA as NRTL's, one of which is SGS US Testing Company (SGSUS).

SGS, established in 1858, is the world's largest inspection, verification, testing and certification organization. SGS operates more than 1000 offices and laboratories and employs over 50,000 people worldwide. SGS has been recognized as an NRTL since 1998, and has partnered with QPS Evaluation Services to be one of their affiliate test labs. Under OSHA's

supplemental program, QPS, under the supervision of SGS, can perform US Electrical Safety Certification Testing, thus making a certified product eligible to bear an NRTL mark (in this case SGS US).

EcoQuest began placing the Certification marks of both QPS (for Canada) and SGS (for US) on the PowerwoRx (will appear on each units serial number) on August 12, 2008. The mark appears as follows:



This is equivalent to any other certification mark issued by both the US and Canada.

How much can I expect to save per month by using the PowerwoRx e³?

That depends on many factors. The size of your home, the amount of inductive motor load, and the amount you are paying per kilowatt-hour for electricity etc. Based upon customer feedback average savings is somewhere in the 8% to 15% range but some users have seen no energy savings.

How long will it take for the PowerwoRx e³ to pay for itself?

Looking strictly at Energy Savings the product can pay for itself within 2-3 years. This of course depends on individual circumstances, number of appliances and age, electrical costs and usage patterns, the homes power factor as well as other criteria. The other benefits can turn out to be the biggest benefit of all! Consider Surge & Spike Protection, as well as the harmful effects of harmonic distortion. These invisible but very real threats to all electrical appliances and electronics in the home can and will cause premature failure. Considering the significant investment in these appliances and electronics, often totaling in the 10's of thousands of dollars, the protection provided by PowerwoRx e³ could be the biggest money-savings benefit of the product.

Is the PowerwoRx e³ easy to install and who is qualified to perform the installation?

Yes, but the PowerwoRx e³ must be installed by a licensed electrician or qualified electrical installer in areas where electricians are not required to be licensed. Qualified installers can be HVAC contractors. It is ultimately the responsibility of the EcoTrust Energy distributor to insure the installer is qualified. EcoTrust Energy does not evaluate installers as to their qualifications and only in the event of a warranty claim will the qualifications of the installer be questioned. If the installer is determined to not be qualified based upon local standards, and the product failure is attributable to improper installation, the product warranty will be void.

Installation requires opening up of the electrical panel, exposing potentially dangerous high voltage wires. The unit comes with complete installation instructions and installs in about 15-30 minutes as long as there is space to add a 20A or 30A double pole breaker.

Why haven't I heard of these products until now?

That's easy; two words "cost effectiveness". Up until recently, electric rates throughout America were cheap, costing us 2, 3 or 4 cents per kilowatt-hour. Now, electric rates are 8, 10, 12, 14, and 19 and in some cases New York City is 22 cents per Kwh, and Hawaii is 33.5 cents per Kwh. At the cheaper rates the PowerwoRx e³ didn't make sense, but at the current rates, it makes all the sense in the world.

What about PowerwoRx e³ for Surge Protection?

One of the most important features of the PowerwoRx e³ is the ability to protect the entire home against power surges. No longer is there a need for so many individual surge protectors in the home. The PowerwoRx e³ provides a broad range of protection for hardwired appliances and most home electronics such as appliances, televisions, satellite equipment, entertainment systems, etc. The unit protects from power line surges as well as spikes caused by internal wiring problems, loose connections and fluctuating demand from large motors such as vacuum cleaners, heating and cooling equipment, etc.

Is the PowerwoRx e³ Energy Star rated?

PowerwoRx e³ is not Energy Star rated because this type of product does not fit into the Energy Star rating system. Our Technology partner Continental Power is addressing this with Energy Star requesting the addition of an appropriate certification category. It should be noted that Continental Power is an Energy Star partner.

Does the PowerwoRx e³ save any energy on Resistive (non-motor) loads?

Resistive loads are equipment like incandescent lighting, electric resistant heating, electric hot water heaters and electric ovens and ranges. These devices require no "magnetic power" or "reactive power" to operate; consequently they have no negative impact on Power Factor. The energy savings capability of PowerwoRx e³ is achieved by storing the reactive power which is typically wasted, and making it available for reactive loads as required. There is no energy savings from PowerwoRx e³ being attached to a purely resistive load.

Can the PowerwoRx e³ cause my electric bill to go up and does it use electricity when there is little or no power demand?

A Demonstration Kit using a typical electric meter is being designed and will be available from EcoQuest. It will be a great interactive tool to show the PowerwoRx e³ will not cause the electric meter to turn on its own. This "Living Proof" for energy, which includes a home Electric Meter, will not turn when just the PowerwoRx e³ is applied.

Is the PowerwoRx e³ available for sale in Canada or other Countries?

PowerwoRx Is UL certified and has also been certified by SGS/QPS for sale in Canada. For the PowerwoRx e³ to be approved for sale in Europe, the product requires a ROHS compliance certificate and CE Certification. These steps are underway but at this point no completion date is available.

Mounting Considerations – what if the Residential Power Panel is flush-mounted in an exposed area?

The PowerwoRx e³ is designed to be SURFACE MOUNTED only due to its size (5" deep) and the surface mount mounting flange. Even if the 200A Power Panel is recessed and therefore flush mounted, the PowerwoRx e³ must still be surface mounted. With several feet of wire to tie into the power panel, the PowerwoRx e³ can be mounted in a less obvious location.

What is the difference between PowerwoRx e³ and other "Energy Saving" devices in the market?

There are over a dozen manufacturers of products that "look" similar and make similar claims as PowerwoRx e³ regarding energy savings. These products are in many cases less expensive so what is the difference?

The numerous "Power Savings Devices" on the market today consist of two electrolytic capacitors in a box. The PowerwoRx e³ contains:

- 2 Electrolytic Capacitors
- 2 Harmonic Filters
- 2 MOV's for Surge/Spike protection
- Additional electronics

A comparison of the two products is like comparing a golf cart and a sports car. They are both considered transportation, but the sports car has a lot more capability. As far as the literature goes, we all know that companies make all kinds of claims. The PowerwoRx e³ has:

1. The best warranty in the business (10 years)
2. A patent pending product developed by a team of MIT PhD's with no other product like it in the market
3. True Harmonic and Noise Filtration
4. True Surge & Spike Protection thanks to Industrial MOV's
5. \$25,000 warranty on connected appliances & electronics (see the end of this document).

PowerwoRx e³ is a premium product that has premium features. Consequently there is no comparable product on the market today that combines all these features together.

There are several products on the market which provide individual features much like the PowerwoRx e³:

- Leviton 51120-1 Whole House Surge Suppressor, 1-Phase - single feature only for a home: \$190
- Panamax MAX In-Wall Powerkit-Pro electronic Noise reduction unit, single feature only- but not a whole-house unit: \$299
- Facility Management Solutions Inc. Power factor correction device, single feature only for a home: \$349.

Total cost of all 3 units: \$838 and does not have many of the features and benefits of the PowerwoRx e³ PowerwoRx e³ by EcoQuest International - One unit, One installation and One low price!

Does the PowerwoRx e³ consume energy on its own?

No. The PowerwoRx e³ stores and supplies energy to the electrical appliances in the home, it does not directly consume electricity. Consequently, if an amperage meter (current probe) is placed on the electrical lines leading to the PowerwoRx e³, a reading of 3-4 amps will typically be shown. Even when no appliances are on, and therefore no electricity is being consumed, there will still be current flow showing on the current probe. Most assume this translates into 400W of energy being "used" which on an annualized basis will cost the homeowner well over \$100 per year at current electric rates. The truth is the PowerwoRx e³ "uses" no energy. This is easily proven by turning off all electrical loads and going to the Electric Meter and reading the consumption – the meter will not be turning.

Another interesting test is to power a typical motor load like a bench grinder. Use a current meter to measure the inrush current at start-up as well as the steady-state current draw with and without the PowerwoRx e³ in the circuit. With PowerwoRx e³ activated the current draw at start-up and steady-state is typically reduced by over 30% thanks to the storing of the reactive energy by the PowerwoRx e³.

Is Continental Power also selling the PowerwoRx e³?

EcoQuest International, activTek Environmental and EcoTrust Energy have been granted exclusive distribution rights of the PowerwoRx e³ Total Home Energy Management System, and EcoTrust Energy has been granted non-exclusive distribution rights to the remainder of Continental Power Corporations commercial product line. Our agreement with Continental Power does not allow for them to sell the PowerwoRx e³ directly, so any calls or e-mails to Continental Power to obtain the product would be unproductive. In addition, Continental Power does not sell on their web site nor do they solicit for or accept independent distributors. They are a solutions provider and have been for 15 years.

Out of respect for Continental Power's management team please do not contact them directly, either by phone or e-mail. They have been asked not to respond to any inquiries so when they do not respond you will understand why. All questions regarding the energy products should be directed to either askecoquest@ecoquestintl.net or commercialsupport@activtek.net

Why is PowerwoRx e³ still shown on the Continental Power website?

Information on PowerwoRx e³ can be found on the Continental Power website (<http://www.continentalpowercorp.com/>). As the inventor, manufacturer and marketer of this Energy Management Technology for over 15 years having the product on their web site lends credibility. Even if a customer were to go to the site, they will not be able to purchase the unit directly from Continental Power. In the near future, the "residential" link on their site will be redirected to EcoQuest and EcoTrust Energy.

Some Power Company Representatives have said Power Factor Correcting devices do not result in savings on the customer's electric bill – why?

The following response was provided by Ed Kimmel, President of Continental Power:

I have fifteen years worth of data that I have shared with many engineers that have made the same statement as above. I can tell you with 100% confidence that our systems do reduce kWh and kW usage as well as reduce or eliminate power factor penalties and reduce harmonic distortion.

As you know, no two electrical systems are the same, and no two utility companies bill their customers exactly the same. There are electric utility companies that charge more for kW and kWh usage than others. There are electric utility companies that penalize a customer for poor power factor. We see much larger reductions in usage in less efficient electrical system. This is to be expected. We also see shorter payback periods and larger ROI's on electric utilities with higher rates than others.

Power factor is just one third of the technology incorporated in the PowerwoRx Systems. We also install PowerwoRx for noise reduction and protection, using MOV's for surge and spike protection and harmonic filtration for noise reduction.

In my fifteen years of installing our equipment I have never had a dissatisfied customer. This I have done by being honest and upfront with every customer I have had. We do reduce kW and kWh usage!

*Ed Kimmel, President
Continental Power Corporation*

Most Power Companies do not charge a penalty for poor power factor. States currently charging a residential Power Factor penalty include California and Texas with several others adding this provision in 2008. Regardless of power factor penalties, PowerwoRx can and does save energy, but is important to understand that the amount of saved energy is dependent upon an almost infinite number of factors so being able to predict what the savings will be is impossible. EcoQuest and EcoTrust Energy state that savings are typically 8-15%, and this is based upon feedback from customers who have installed PowerwoRx e³.

Are there any tax incentives for buying the PowerwoRx e³ unit?

The PowerwoRx e³ could potentially qualify for a tax credit under the Energy Policy Act of 2005. As of December 31, 2007, most of the residential tax credits (windows, doors, roofs, insulation, HVAC, and non-solar water heaters) expired. On February 27, 2008, the House passed \$18.1 billion in renewable energy tax incentives (H.R. 5351), including an extension of the tax credit for energy-efficient home improvements. The bill is similar to the one passed last year, which was ultimately removed from the 2007 Energy Bill, signed into law in December 2007. This bill must still pass in the Senate, and be signed by the President to become law.

See [IRS form 5695](http://www.irs.gov/pub/irs-pdf/f5695.pdf) <http://www.irs.gov/pub/irs-pdf/f5695.pdf>. Taxpayers should consult their tax professional or accountant for how the PowerwoRx e³ can qualify for the Tax Credit and how much of the purchase price and installation costs apply. Neither EcoQuest nor EcoTrust Energy make any claims regarding an individual's ability to receive a tax credit.

For an update on the legislation click <http://blog.b-e-f.org/2008/06/10/senate-says-no-to-the-renewable-energy-and-job-creation-act-of-2008/>.

Are Commercial versions of the PowerwoRx e³ available?

Continental Power has a comprehensive line of commercial and industrial units sized for various voltage and phase configurations. These will be available through EcoTrust Energy. Prior to being able to purchase these products, a training and certification must be completed. This training will be separate from the current activTek Commercial Certification program and will be broken down into three levels:

1. Tier 1: For non-custom installations (such as 480V, 600A, 3-Phase power panels), the implementation is simple and requires basic technical skills. Typical customers are convenience stores, office buildings, strip malls, gas stations, and light manufacturing to name just a few. These units require no special instrumentation or evaluation.
2. Tier 2: For small to medium installations require an electrician to make measurements and
3. Tier 3: For large custom installations the number of units required is determined by a multi-step process including a technical on-site evaluation, review of the previous 12 months electric bills, and inputting information into a proprietary software program developed by EcoTrust Energy to determine the appropriate hardware. The level of expertise is significantly greater and will require specialized hands-on training.

Training was conducted the week of July 7 for Tier 1 & 2 certifications. Conference calls and on-line training is planned and schedules will be announced shortly.

Please note that commercial versions of the PowerwoRx e³ are available to EcoTrust Energy on a non-exclusive basis. Continental Power Corporation is a small company focused on a few very large industrial applications but will continue to sell and install systems.

Can PowerwoRx e³ be mounted on the outside of the building?

The standard PowerwoRx e³ case is a NEMA 1 and therefore cannot be mounted outdoors or where exposed to moisture.

For exterior mounting order the PowerwoRx mounted in a NEMA 3 enclosure, P/N US40771

Will PowerwoRx e³ affect X10 lighting control systems, or Telephone or TV signals that are sent over the AC line?

Considering the Harmonic and Noise Filtration technology used in the e3, this is a good question. Continental Power Corporation has found that the harmonic filtration capability of the e3 WILL cancel out the X10 and other control signals generated to communicate over the AC line. Consequently PowerwoRx e3 should not be used in buildings where the AC line is being used to transmit lighting control, telephone, TV or any other signal. A special PowerwoRx may be available in the future which has the harmonic filtration removed.

How can the PowerwoRx e³ provide the exact amount of capacitance to correct the Power Factor in every home?

Understanding that the ideal power factor is 1, and that poor power factor makes for an inefficient electrical distribution system which translates into higher kVA as well as higher KWh. A common question is "how can this device work in every home"? Some companies promote having an electrician come out to a home, measure power factor and then create a custom unit designed for that home. There are several reasons such a process is not recommended:

1. The power factor will vary depending upon what appliances are running at any given time. If the goal is to measure power factor, what appliances should be turned on?
2. Years of experience has shown that the configuration of PowerwoRx provides the optimum solution for the majority of homes. To produce a custom solution adds significant cost and provides little if any payback.
3. Some are concerned that adding too much capacitance will put the home into a lead condition (where the current waveform will lead the voltage waveform). Again, this will be dependent upon what appliances are running at any given time.

What meter can be used to verify Power Factor and the other parameters required to evaluate my electrical system?

There are dozens of meters on the market. At the high end are meters like the Fluke model 435 that sells for \$7000+. EcoTrust Energy recommends a simple and basic Power Clamp Meter manufactured by Extech that includes the ability to measure Power Factor. This meter is available from EcoTrust Energy for \$225, part number US40765.

Some customers using other “Energy Savings Devices” or basic capacitors in a box of which there are a dozen products like this, have not experienced any energy savings. Does this mean we will not see any energy savings with the PowerwoRx e³?

Typical “Energy Savings Devices” on the market contain capacitors which place 30 micro farads on the system, potentially over correcting the system in many cases. The PowerwoRx e³ only has 10 micro farads, so overcorrecting will be rare with the PowerwoRx e³. The advantage of the PowerwoRx e³ is the “synergy” of the 3 elements; surge and spike protection, harmonic filtering, and energy savings. These synergies, not unlike the EcoQuest air purification systems, are vital together. What is the biggest difference and the large savings with the PowerwoRx e³ is line conditioning. By cleaning up the power the motors are more efficient and not as wasteful. Competitor’s products overcorrect and in some cases no savings are realized. In these cases installing a PowerwoRx resolved the problem. In no cases have we experienced a customer’s electric bill going up due to the addition of capacitance. There have been instances where a customer was saving energy and then added a swimming pool and another unit was added to compensate, but never the other way around. Here is an excerpt from a university about using capacitors to increase power factor:

“Adding too much capacitance can push the system from “lagging” to “leading”; for example, adding too much capacitance may change the power factor from 95% to 105%. Although leading power factor does not harm equipment, purchasing excess capacitors is expensive and serves no useful purpose. In addition, some meters may read a leading 105% power factor as 95%. If so, you would not get credit for the power factor correction from 95% to 100%. (Other utility meters would read a power factor of 105% as 100%). Because of these reasons, we recommend a conservative approach to power factor correction in which we never overcorrect the power factor past 100%”.

Does PowerwoRx e³ protect me from all Surges and Spikes?

PowerwoRx e³ provides protection from Surges and Spikes coming in on the main power line, as well as internal threats such as those originating on a branch circuit. Although electrical appliances and electronics in the branch circuit where the surge or spike originated are exposed, once it reaches the main power panel where the PowerwoRx e³ is connected the surge or spike will be arrested. Considering there are typically 15-20 branch circuits in a typical home, the risk exposure is minimal.

It should be understood there are two additional paths which a surge or spike can enter the home from which are NOT protected by the PowerwoRx e³. These two paths are your cable service and your phone service. The only way to protect a “surge back feed” through cable and phone wiring is to provide surge protection on all three sources of entry that includes your electrical system, cable system and phone system. Cable and Phone surge suppressors are available from most electrical suppliers.

What causes powerline surges?

Surges can be classified as external and internal. External surges are generally more severe than internal surges while internal surges generally occur more frequently (about 80% of all surges are internal). External surges are frequently caused by storms and normal power company switching operations. Internal surges occur when equipment within the building is cycling on and off.

How often do surges occur?

Very large surges occur infrequently (from a few times a year in medium exposure areas to 40 times a year in high exposure areas) since they are mainly storm induced (lightning and temporary interruptions due to storm damage), but surges over 1000 volts may occur many times a day since they are caused by normal equipment operation.

Can PowerwoRx e³ help resolve issues with interruptions in electricity?

PowerwoRx is not a solution for brownouts or power interruptions which last more than a few milliseconds. Many customers complain of these types of power issues and the only solution for insuring an uninterrupted supply of electricity is a UPS, or uninterruptible power supply. These devices are much like what is used to power computers, just much bigger. The PowerwoRx would be able to help resolve issues with harmonics, noise, surges or spikes, but the PowerwoRx cannot help with power dropouts that last more than 2 cycles or 1/30th of a second.

It should be noted that the major risk in a power dropout or brownout condition is when the power comes back on. At the point at which power is restored, all inductive loads come on at the same time, creating damaging power spikes and distortion (noise and harmonics). The PowerwoRx provides protection for this damaging condition.

How can PowerwoRx e³ help reduce surges and spikes if it is merely connected to the panel?

The surge & spike protection is accomplished by a device called an MOV (Metal Oxide Varistor). When the voltage rises significantly above the rated voltage (+20%), the MOV turns on and the voltage is shunted to ground, insuring the system doesn’t see the spike or surge. By definition this is considered a spike arrester. The other components in the PowerwoRx, the harmonic filters and electrolytic capacitors act as suppressors by capturing the small surges and spikes that come down the line.

Confusion often occurs because logic would say that the unit should be connected in serial like a fuse or breaker, so when there is a surge or spike the PowerwoRx would open the line. This line of thinking is logical but that is not how this device or others like it operate.

Can PowerwoRx e3 be used with a back-up power generator?

Back-up power generators are becoming more and more common in home applications as well as commercial, often run off propane or natural gas as a protection for power outages. PowerwoRx is an excellent addition to a system which incorporates a back-up generator for several reasons:

- In the switchover process which is typically automatic, as the generator comes on line and the relay which connects the generator to the main panel is closed, typically a spike in power is induced. The PowerwoRx e3 will clamp this spike, thereby protecting appliances and electronics.
- Power supplied by back-up generators is typically not clean – meaning the noise and harmonic content is high. The PowerwoRx e3 will reduce the overall noise and harmonics.
- Back-up generators are typically not sized to run all appliances. In some instances loads will exceed the rated output. PowerwoRx reduces KVA demand from the generator by supplying the reactive power to inductive loads. This means that a customer can realize additional capacity from their generator they would not have had without PowerwoRx e3.
- PowerwoRx will help to reduce I^2R losses when powering inductive loads.

One note of caution: Most back-up generators are connected to a sub panel which powers a select group of circuits so as to not overload the generator. The installing electrician must take this into account. If the PowerwoRx e3 is placed on the main panel and a contactor to isolate a sub panel for back-up power loads is used, the PowerwoRx e3 will not be connected when the generator is engaged.

In no way will there be any detrimental effects to either the PowerwoRx e3 or the generator. We highly recommend the PowerwoRx e3 for emergency backup generator applications.

Can PowerwoRx e3 be used with Solar Panel installations?

PowerwoRx e3 is an excellent addition to any solar panel installation regardless of the configuration. Some common configurations are:

- Solar is used to supplement the systems energy needs
- Solar is connected to the grid via a bi-directional electric meter
- The system is off grid and relies on 100% solar energy for all the energy needs

All three of the PowerwoRx technologies benefit a system which incorporates solar:

- Surges & spikes are more frequently internally generated than external. Solar Power Center protection is accomplished by a device called an MOV (Metal Oxide Varistor). When the voltage rises the PowerwoRx prevents the spike from potentially damaging the expensive electronics including the Inverter.
- Harmonics are more prevalent in a solar generated power system due to the nature of how the AC waveform is created by the Inverter. These Harmonics waste electricity, are damaging to appliances and electronics. PowerwoRx significantly reduces Harmonics and Noise in the system
- Improved Power Factor translates into reduced I^2R losses, increasing system capacity and reducing energy use.

If the PowerwoRx is hit with such a large spike that it sacrifices itself, will the electricity still be on? Is the home still protected?

The PowerwoRx is connected in parallel (not like a fuse which is in series) so in no case will the supply of electricity to the home be affected. If the home is hit with a surge & spike of great magnitude like what would occur from a lightning strike in the area, and the PowerwoRx e3 sacrifices itself, the result is the PowerwoRx will no longer be operational. This is indicated by:

1. One or both lights will no longer be lit.
2. There is typically a strong smell of a damaged electrical device. This is normal and indicates the unit has sacrificed itself in order to protect your homes electronics and appliances.

In either case it is just as if the PowerwoRx had been disconnected from the panel, meaning the home will no longer be completely protected and a replacement unit should be ordered immediately. Remember, PowerwoRx carries a 10-year warranty, and the only limitation is the product must be installed by a licensed qualified electrician.

What happens if a lightning spike comes into a building through a window air conditioner or some path other than the electrical line?

Surges and spikes often come through paths other than the main incoming electrical line. The PowerwoRx is effective at arresting these surges and spikes but the owner must realize that the surge or spike must reach the PowerwoRx. This means that any electrical appliances or devices on the branch circuit where the surge or spike originates will potentially be damaged since they are located before the PowerwoRx. For this reason point-of-use surge suppressors should be incorporated on very costly or sensitive electronics.

When a Demo Case is being used in a home with PowerwoRx Installed, why does the meter still show the same as before the PowerwoRx was installed in the home?

The PowerwoRx Demonstration Case is an excellent way to show exactly what the PowerwoRx is doing with regards to a motor load. When first turning on the demo case we see that the current coming to the case (what we call the SUPPLY side) is the same as what is going to the motor (LOAD side). Once the PowerwoRx in the case is turned on, the current coming into the case (supply side) drops, yet the current going to the motor (load side) is the same. This is because on every cycle of the AC waveform, literally 60 times per second, the PowerwoRx is storing reactive current and supplying it to the motor when it needs it. In essence the PowerwoRx is recycling energy which otherwise would have been wasted. When then the PowerwoRx in the demo case was turned off, the PowerwoRx in the home was storing this reactive energy and supplying it back to the motor. Since the motor always received the current necessary to run, approximately 1.2A, the meters don't show any signs of a PowerwoRx in the home. A person would have to go back to the 200A electric panel and take an inductive current meter around the incoming power line at the top of the panel to see the effects of the PowerwoRx mounted in the home. This is a typical method to show that the PowerwoRx is not only working, but is having a very positive effect. But when the PowerwoRx is turned on in the demo case, now the PowerwoRx **closest to the load** takes over the responsibility to store and supply (recycle) the otherwise wasted reactive current, which is why we see a drop in the current in the demo case. Even if a home 5 PowerwoRx installed it would be the same, because the PowerwoRx in the case will always be the closest and therefore it will always be the device to recycle the current.

Electrical Terms - Definitions

Alternating Current (AC)

The flow of electrons in a conductor measured in amperes. Alternating current reverses its direction of flow in a cyclical manner; i.e. 60 cycles per second. Conversely, direct current always flows in the same direction at 0 cycles per second.

Amperes (Amps)

The unit measure for the flow of current in a conductor (analogous to gallons per minute in a piping system).

Voltage (Volts)

The measurement of the electromotive force or potential which will make electrons flow in a conductor or circuit.

Watt, Kilowatts, Kilowatt Hours

Electrical power consumption is measured in watts.

A Kilowatt is 1000 watts. A Kilowatt Hour is 1000 watts used for one hour.

We are concerned with true power which is the measure of power actually used by the load as measured by the utility watt meter and our T.I.F. meter.

In pure resistive A/C circuit, power could be calculated by measuring the voltage across the phase conductors and multiplying by the current flowing through the circuit conductors with an amp meter. To measure true power in inductive circuits power factor must be considered.

KVA (Kilovolt Amperes)

KVA is the non power measure of the voltage multiplied by the amperes.

KVA is not a measure of true power it is a measure of the level of apparent power a generator or transformer could deliver to a circuit with a power factor of one.

To convert from apparent power to true power, you must take the KVA and multiply it by the power factor. For example, 100 KVA of measured apparent power serving an inductive load with a power factor of .9 would result in a real power of 90 KW.

If Kilowatts (KW) are the measure of true or real power available for work then KVA is a measure of apparent power needed to get the true power to the work.

From a utility's point of view they are generating power with a power factor of one.

In other words the KW and KVA at the outlet of the power plant is the same value.

As the power factor is degraded by load and transmission factors it takes proportionally more KVA per KW used to create and deliver to the consumer true or USABLE power.

The effect that a lagging power factor has on the utility is then to force it to generate more apparent power to satisfy our clients' needs for true or USABLE power.

In other words, if we measure a power factor of 1.0, then each KVA is being turned into a KW and the real and apparent power are equal.

If the power factor is .5 then each KVA supplied to the transformer by the utility results in one half of one KW of real power being consumed and measured. This means the utility has to absorb the difference in real vs. apparent power.

The affect on the utility supplying power to a network of customers with lagging or poor power factor is that its generating and distribution efficiency is reduced.

Because the current being generated by the utility has to increase as the demand for KVA increases and in a poor power factor network the current increases disproportionately faster than in a network with unity power factor, then the losses due to the resistive heating in the power distribution network of conductors increases.

The term most frequently used to express this problem is $W=I^2 R$ meaning that conductor, transformer and motor heating increase at the rate of the amperes squared time the resistive component of the circuit. Some customers are penalized for low power factor by being charged for the difference between KVA and KW. Power factor e^3 reduces the $I^2 R$ losses by improving power factor and reducing KW.

KVA(R)

The measure of the amount of reactive KVA that is necessary to raise a lagging power factor toward unity.

Harmonic Interference

AC power is delivered throughout the distribution system at a fundamental frequency of 60 Hz. (50 Hz in Europe.) Harmonics are defined as, "integral multiples of the fundamental frequency." For instance, the 3rd harmonic frequency is 180 Hz, the 5th is 300 Hz, etc. In the US, the standard distribution system in commercial facilities is 208/120 wye. There are three phase wires and a neutral wire. The voltage between any two phase wires is 208, and the voltage between any single phase wire and the neutral wire is 120. All 120 volt loads are connected between a phase and neutral. When the loads on all three phases are balanced (the same fundamental current is flowing in each phase) the fundamental currents in the neutral cancel and the neutral wire carries no current. When computer loads and other loads using switched mode power supplies are connected, however, the situation changes.

Switch mode power supplies draw current in spikes, which requires the AC supply to provide harmonic currents. The largest harmonic current generated by the SMPS is the 3rd. The magnitude of this harmonic current can be as large or larger than the fundamental current. Also generated, in smaller amounts, are the 5th, 7th, and all other odd harmonic currents.

Like the fundamental current, most harmonic currents cancel out on the neutral wire. However, the 3rd harmonic current, instead of canceling, is additive in the neutral. Thus if each phase wire were carrying, in addition to fundamental current, 100 amps of 3rd harmonic current, the neutral wire could be carrying 300 amps of 3rd harmonic current. In many cases, neutral-wire current can exceed phase wire currents. This extra current provides no useful power to the loads. It simply reduces the capacity of the system to power more loads, and produces waste heat in all the wiring and switchgear. When the 3rd harmonic current returns to the transformer it is reflected into the transformer primary where it circulates in the delta winding until it is dissipated as heat. The result is overheated neutral wires, switchgear, and transformers. This can lead to failure of some part of the distribution system and, in the worst case, fires. In addition, waste heat in all parts of the system increases energy losses and results in higher electrical bills. 3rd harmonic currents can increase electrical costs by as much as 8%

Circuit

A closed loop consisting of conductors (wires) from a source of voltage (a transformer in our case) to a load (motors, fluorescent lamp ballasts or resistive loads) that provides the path for the flow of current through the load.

Phase

Phase is a trigonometric measure of the angle between the 60-cycle wave current form and the 60-cycle voltage wave form. In a perfect world, the current wave form and the voltage wave form leaving a generator would start at the same time.

In reality, the inductive characteristics of the electrical distribution system and the inductive loads imposed on it retard the current wave form and cause it to lag the voltage wave form (If a circuit had more capacitance, then inductance the current wave form) would lead to the voltage wave form.

Inductive Load

In general loads that operate by the passing of alternating currents through a coil of wire wound around an iron core. The resulting magnetic field is used to:

a - cause a motor shaft to rotate, or

b - induce a similar current in another coil of wire wound around the same piece of iron core as in a transformer (There are inductive heaters that are coils of wire wound around the media to be heated.)

Resistive Load

A load that turns all energy (current and voltage) applied to it into heat. Includes incandescent lamps, space heaters, immersion heaters, etc. These loads are not inductive.

Power Factor

When current and voltage wave forms start at the same time they are in phase and power factor is 1. As circuit inductance retards the current wave form it falls out of phase or lags the voltage wave form.

The measure of a lagging current wave form is expressed as a percentage; i.e., if the current lags the voltage by 10%, the power factor is 100% less 10% or 90% or 0.90.

Effects of low power factor:

It is sometimes considered that the wattless component of a current at low power factor is circulated without an increase of mechanical input over that necessary for actual power requirements. This is inaccurate because internal work or losses due to this extra current produced and must be supplied by the utility. Since these extra losses manifest themselves in heat, the capacity of the distribution network is reduced. Moreover, wattless components of current heat the line conductors, just as do energy components, and cause losses in them.

The loss in any conductor is always

$$W=I^2R$$

where W = the loss in watts, I = the current in amperes in the conductor, and R = the resistance in ohms. It requires much larger equipment and conductors to deliver a certain amount of power at a low power factor than at a power factor close to 1.

An excellent document is available from the Department of Energy describing the importance of Power Factor and how improving power factor can reduce electrical costs. See

<http://www1.eere.energy.gov/industry/bestpractices/pdfs/mc60405.pdf>

Transformer (Voltage Type)

Inductive devices used to isolate the flow of current in one circuit from another while allowing magnetic coupling of the two circuits to create a voltage in the second circuit. Transformers may be used to step down a voltage from a higher level to a lower level or to step up a voltage from a lower level to a higher level or to maintain the same voltage on both sides (primary and secondary) while isolating the circuits from one another. Fluorescent lamp ballasts are transformers.

Capacitance

A measure of a circuit or device's ability to store electrical energy. Applied primarily to A/C circuits where the alternating nature of the current charges and discharges the capacitor as the current reverses its direction of flow in the circuit.

Capacitors ability to store electricity is measured in "Farads" or increments thereof as in microfarads. Capacitors are used to improve the performance of certain inductive circuits as discussed under power factor.

Electro Magnetic Field (EMF)

Technically, the term "electromagnetic field" (EMF) refers to all fields throughout the electromagnetic spectrum. In common usage, however, the term usually refers to so-called extremely low-frequency nonionizing radiation fields—those fields below 300 Hertz (Hz)—and often only to those fields in the 50 to 60 Hz range, which are also known as power-frequency EMFs. As a type of nonionizing radiation, EMFs in this range do not have sufficient energy to remove an electron from an atom or molecule, but generally transfer thermal energy to other particles. Power-frequency EMFs are those generated by electric power delivery systems—those for which there has been the greatest public concern and research about possible adverse human health effects.

Power-frequency EMFs have two components: electric fields and magnetic fields. The electric fields are generated from potential energy, or the presence of voltage on a power line. The magnetic fields, on the other hand, are generated from the actual electrical current, or the flow of electricity. Thus, when a standard household electric light is plugged into a live electrical socket, but turned off, it generates only an electric field. Once turned on, it generates both electric and magnetic fields, since the voltage is still present but current is now flowing. The size of a magnetic field increases as the amount of current flow increases, as the size of the source increases, and as one gets nearer to the source.

Metal Oxide Varistor (M.O.V.)

A discrete electronic component that is commonly used to divert excessive current to the ground and/or neutral lines. Acting like a pressure relief valve, an MOV is comprised of zinc oxide with small quantities of bismuth, cobalt, manganese and other metal oxides.

Mathematics of electric power In circuits

Electric power, like mechanical power, is represented by the letter P in electrical equations. The term *wattage* is used colloquially to mean 'electric power in watts.'

In direct current [resistive](#) circuits, instantaneous electrical power is calculated using [Joule's Law](#), which is named after the British [physicist James Joule](#), who first showed that heat and mechanical energy were interchangeable.

$$P = VI$$

Where P is the power ([watt](#) or W) and V is the potential difference ([volt](#) or V) and I is the current ([ampere](#) or A)

For example:

$$2 \text{ A} \cdot 12 \text{ V} = 24 \text{ W}$$

Joule's law can be combined with [Ohm's law](#) to produce two more equations:

$$P = I^2 R = \frac{V^2}{R}$$

Where R is the [resistance](#) ([Ohm](#) or Ω).

For example:

$$(2 \text{ A})^2 \cdot 6 \Omega = 24 \text{ W}$$

and

$$\frac{(12 \text{ V})^2}{6 \Omega} = 24 \text{ W}$$

In [alternating current](#) circuits, energy storage elements such as [inductance](#) and [capacitance](#) may result in periodic reversals of the direction of energy flow. The portion of power flow that, averaged over a complete cycle of the AC waveform, results in net transfer of energy in one direction is known as [real power](#) (also referred to as active power). That portion of power flow due to stored energy, that returns to the source in each cycle, is known as [reactive power](#).

Power triangle - The components of AC power

The relationship between real power, reactive power and apparent power can be expressed by representing the quantities as vectors. Real power is represented as a horizontal vector and reactive power is represented as a vertical vector. The apparent power vector is the hypotenuse of a right triangle formed by connecting the real and reactive power vectors. This representation is often called the *power triangle*. Using the [Pythagorean Theorem](#), the relationship among real, reactive and apparent power is:

$$(\text{apparent power})^2 = (\text{real power})^2 + (\text{reactive power})^2$$

The ratio of real power to apparent power is called [power factor](#) and is a number always between 0 and 1.

