Reactive Power and Harmonic Compensation

Guide to Power Factor

POWER QUALITY

Understanding Power Factor

There are many objectives to be pursued in planning an electrical system. In addition to safety and reliability, it is very important to ensure that electricity is properly used. Each circuit, each piece of equipment, must be designed so as to guarantee the maximum global efficiency in transforming the source of energy into work. Among the measures that enable electricity use to be optimized, improving the power factor of electrical systems is undoubtedly one of the most important.

To quantify this aspect from the utility company's point, it is a well-known fact that electricity users relying on alternating current – with the exception of heating elements – to absorb from the network not only the active energy they convert into mechanical work, light, heat, etc. but also an inductive-reactive energy whose main function is to activate the magnetic fields necessary for the functioning of electric machines.

Power factor is a term commonly used when considering the efficiency of an electrical power distribution system. Power factor or displacement power factor is a measurement between the current and voltage phase shift waveforms, based upon the (60hz) fundamental. Distortion power factor takes into account harmonics and is measured in root mean square (RMS) values. Typically, electrical loads are resistive, inductive, and include both linear and non-linear elements. Most commercial and industrial alternating current (AC) loads are inductive, due to the nature of the types of devices connected on the electrical system. Specific industries where power factor may be critical are steel/foundries, chemicals, textiles, pulp and paper, automotive, rubber and plastics. Several examples of equipment utilized, where power factor is a concern, may include; transformers, motors, lighting, arc welders, and induction furnaces, all which require reactive power to generate an electromagnetic field for operation. Such equipment can produce poor, or a low, power factor, measured in a decimal fashion, such as .70 (70% of value).

A unity power factor of 1.0 (100%), can be considered ideal. However, for most users of electricity, power factor is usually less than 100%, which means the electrical power is not effectively utilized. This inefficiency can increase the cost of the user's electricity, as the energy or electric utility company transfers its own excess operational costs on to the user. Billing of electricity is computed by various methods, which may also affect costs.

From the electric utility's view, raising the average operating power factor of the network from .70 to .90 means:

- reducing costs due to losses in the network
- increasing the potential of generation production and distribution of network operations

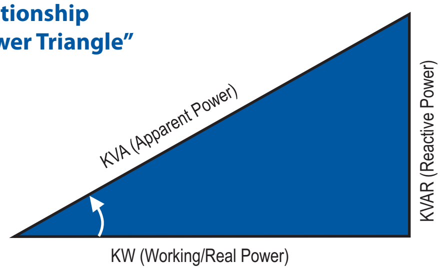
This means saving hundreds of thousands of tons of fuel (and emissions), hundreds of transformers becoming available, and not having to build power plants and their support systems. Thus in the case of low power factor, utility companies charge higher rates in order to cover the additional costs they must incur, due to the inefficiency of the system that taps energy.

Technically speaking, the sine wave for voltage and current to be in-phase occurs when both cross and peak simultaneously at the zero axis point. Alternating current (AC) power has two components leading and lagging, which make it difficult for zero crossing to take place. Voltage will "lead", while current will "lag", in most operating power systems. Power factor can also be considered to be leading or lagging. In a resistive-only load, there is no lag, therefore, power factor is 1.0, or unity PF. However, most loads are not strictly resistive and will include an ample amount of inductance. The increase of inductance creates an increase in current lag, causing the power factor to worsen. By applying capacitors, the power system becomes more efficient. Capacitors provide reactive power (VARS, or volt-ampere reactive), which replaces/returns the VAR's used by the inductive load.

It is possible to produce reactive energy, where necessary, by installing power capacitors or automatic power factor correction systems. Capacitors absorb a current that is 180% out of phase with the inductive-reactive current. The two currents are algebraically summed together so that circulating upstream from the point of installation of the capacitor is a reactive current that is equal to the difference between the inductive and capacitive currents.

In order to measure and size (rating) equipment, several values need to be obtained. Power factor consists of three components: kW (working or real power), kVA (apparent power), and KVAR (reactive power). kW "performs" the actual work, whereas KVAR does not "perform" any beneficial work, instead only maintaining magnetic fields. The relationship between kW and kVA is the kVAR. Where applicable, most equipment will have a nameplate rating, which includes current, voltage, kVA, plus kW and PF.

kW, kVA, kVAR (Reactive Power) Relationship "Power Triangle"



$$COS\ \theta = \frac{KW}{KVA} = PF$$

kW, kVA, kVAR (Reactive Power) Relationship

The power factor ratio determines the efficiency of electrical power being utilized within a power system.

$$\frac{\text{Working Power (kW)}}{\text{Apparent Power (kVA)}}$$

= Power Factor (PF)

Example ratio of poor power factor:

$$\frac{100\ (kW)}{125\ (kVA)}$$

=.80 (PF)

Example ratio with improved power factor, when installing capacitors:

$$\frac{100\ (kW)}{105\ (kVA)}$$

= .95 (PF)

Power Factor Improvement Example

Load of 100kVA

Existing PF .80
New PF (with capacitors) .95

Number of 100 watt light bulbs = 800
Number of 100 watt light bulbs = 950

Correction or improvement of poor power factor will:

- Lower electricity costs
- Increase kVA capability
- Increase kW for the same kVA demand
- Improve voltage regulation (drop),
- Allow for size reductions in cable, transformers & switchgear

This may reduce operational costs, by eliminating or deferring the need for new equipment expenditures, plus help to make future plant expansions less costly. Also, new equipment savings can be realized (potential to purchase at smaller ratings), existing equipment life may be extended, as well as an attractive return on investment and long term cost savings for installed capacitor systems.

Utility Billing Practices

Common energy and utility company billing practices include kWH or kVA with or without demand. Other characteristics may include a separate power factor penalty, or no specific penalty charge, or some type of adjustment for PF, or kVA with a reactive power component.
A demand charge can also be included, based on a certain peak time usage (30 minutes for example), which then reverts to a higher per kW fee. The difference here between the actual demand and the billed demand may include a variable for power factor of a predetermined value, which may be a penalty charge. The demand charge compensates the utility for capital investment required to serve peak load demands. Also, depending on the type of user, a contract with specific tariffs, interruptible rates, off peak rates, exportation of power and other creative rates may be in place. The type of meter used by the utility may support how power factor is determined. Electronic meters (which generally include more extensive data), or induction disc type meters are utilized.

As energy service and utility companies charge users of electric differently, it is recommended to request specific billing/contract information from the electric provider, to better establish and analyze electric cost components. Though unity power factor may be desirable, there are additional costs associated to achieve such a level. It is common practice to correct to at least .90 (.92-.95) or higher.

Power Factor Correction Capacitors

The capacitor function is to provide kilovar to a system at the point where connected. These devices mainly provide improved power factor, increased voltage level on the load, reduce lagging component of the circuit, reduce power losses, and reduce kVA load.

Unlike most electrical equipment, power factor correction capacitors, each time they are energized, continuously operate at full load or at loads which differ from this value only as a consequence of variations in voltage and frequency.

Overstressing and overheating shorten the life span of the capacitor. For this reason the operating conditions must be carefully controlled in order to obtain optimum results with respect to the lifespan of the capacitor. During the design and manufacturing process of a capacitor, both industry and quality standards are adhered to for rated voltage, overvoltage, rated power, rated capacitance, rated current, residual voltage, temperate, cooling air temperature, and ambient temperature.

For additional protection in low voltage capacitors, the capacitor elements making up the unit are individually fitted with an overpressure safety device. The function of this device is to interrupt a short circuit when the capacitor reaches the end of its useful life and is no longer able
to regenerate itself. This device breaks the connections of the terminal by exploiting the internal pressure that builds during the film's decom-position, which results from the overheating caused by the short circuit.

Capacitors for power factor were first used around 1915. Usage was limited due to high cost per KVAR, as well as the physical size and weight. In the 1930's, all capacitors used oil as the dielectric insulation. Oil impregnated paper was later used, with poly and metallized film now utilized. In the 1980's, PCB's were not allowed to be included as part of the dielectric media. Today, many capacitors are "dry type," with a resin composition or other type of non liquid material.

Individual power capacitors may consist of externally fused, internally fused, or fuseless types. Externally fused capacitors with current limiting or expulsion type fuses are the most common. Depending upon the application, capacitors may also be single phase or three phase, with one, two, three or four bushing arrangements. There are also other types of capacitors used for specialty applications, such as furnace and power electronics.

Types of Power Factor Correction Solutions

Requirements of the user (commercial, industrial, utility etc.), will vary widely. Low voltage class systems rated at 240-600 VAC generally have application needs and solutions, which may be met with off-the-shelf components, through highly unique, designed power systems. Simple, small, fixed "at-load" capacitors can be found at single motor locations. Larger fixed KVAR assemblies can be installed for correction of multiple equipment. Still larger, automatic (switched) capacitor banks can be found at the service entrance, to help correct a complete facility. Power factor correction may be integrated with MCC's and switchgear, as well as retrofitted or found as a match-and-line arrangement. Detuned capacitors with iron core reactors are used in harmonic environments. Please refer to Staco Energy's Guide to Harmonics for detailed information.

Theoretically speaking, when you must choose where to locate the capacitive power the most appropriate solution from a technical standpoint would be to assign each load its own power factor correction capacitor, to be switched on together with the machine. In practice, however, this entails excessive costs and technical problems in most cases, since it requires the installation of a larger number of low-power capacitors distributed in many different points, which cannot be effectively monitored over time; plus little benefit is to be derived from reducing losses in the cables, and they are negligible compared to those in the power transformer. Therefore, this solution is only feasible in large facilities or where there are very high power loads. The most appropriate power factor correction system thus consists in the installation of an automatic capacitor bank on the bus bars of the distribution panel (centralized power factor correction) and, if necessary, fixed capacitor banks for correcting the power factor of the transformer, asynchronous motors and any loads absorbing considerable quantities of reactive power. The automatic system of the capacitor bank has the task of switching in the necessary capacitance according to the load requirements at each given moment.

Medium voltage classifications of 2.4 kV and higher, will use power factor correction equipment installed indoors, such as in a large manufacturing operation, or, most often, outdoors. Configurations here can be either pole mounted, fixed or switched, or distribution substation located. When found in a substation rated at 2.4 to 34.5 kV, capacitors can be either open rack style (capacitors mounted on a fabricated structure and field installed), metal enclosed equipment (completely manufactured and testing from the factory), or an integrated hybrid version (metal enclosed protection and partial open-air capacitors). Mobile capacitors (self-contained trailer) rated from 15 kV-245 kV are used mainly by utilities for substation duty. Low and medium voltage solutions employ the use of shunt capacitors for power factor correction. Medium and high voltage series capacitors may be platform mounted and elevated, as well as located in a distribution or transmission substation. Such installations typically provide VAR support for transmission and distribution wires/lines.

Staco Energy Products Company designs and manufacturers low voltage fixed and automatic systems, which incorporate the use of a metal enclosure design including:

- Automatically switched capacitors
- Fixed capacitors
- Transient-free switched capacitors, with electronic switches
- Real time switched capacitor systems employing electronic switches and fast controller
- De-tuned capacitors, tuned filter systems
- Active harmonic filters

Further, to meet other power quality demands, Staco Energy Products Company can include surge protection, relay protection, controls, SCADA and communications, plus integration with other equipment, to make a full service energy management system.

Installed Benefits

Capacitor systems generally are the most economical means to improve facility power factor because of:

- Relatively low cost
- Ease of installation
- Minimal maintenance
- Efficient, with low losses

Correction or improvement of poor power factor will lower electricity costs, increase KVA capability, increase KW for the same KVA demand, improve voltage regulation (drop), and allow for size reductions in cable, transformers and switchgear. This may reduce operational costs, by eliminating or deferring the need for new equipment expenditures, plus help to make future plant expansions less costly.

Also, other new equipment savings can be realized (potential to purchase at smaller ratings); existing equipment life may be extended, as well as an attractive return on investment and long term cost savings for installed capacitor systems.

System Requirements

Loads vary, from 24/7 operation, to one eight hour shift, to numerous types of manufacturing processes. Selection of the different types of passive and active products should be considered to accommodate load fluctuations.

Application Checklist

To better facilitate application requirements and to assist with initial system design parameters, the following should be completed.

Low Voltage Class

Nominal System Voltage

240 VAC _________ 380 VAC _________ 415 VAC _________

480 VAC _________ 600 VAC _________ Other ___________

Wiring Connection

DELTA _______ Ungrounded WYE _______ Grounded WYE_______

Frequency

50 Hz______________ 60Hz_____________ Other______________

kVAR Requirements

Total Rating________________ Fixed kVAR: __________________

Number of Switched Steps________________________________

Size of Step: 1______ 2______ 3______ 4_______ 5______ 6_______

Capacitor Type

Heavy Duty STD ____

Harmonic Filter Application ______________________________

Special Type ____

Capacitor Switching

Three Phase Electro-Mechanical Contactor: __________________

Three Phase Electronic Switch ______________________________

(Note - 16ms PF controller and reactors required)

Type of Disconnect and Incoming

Lugs Only ____

Type of Circuit Breaker or Switch ____________________________

Existing Customer Disconnect _______________________________

Cable Entry: Bottom STD Top ___________ Other____________

Non-Standard Type of Fusing

Fusing: Main (Group)

Amps ______________ Type _____________ VAC ______________

Fusing: Capacitor: Step: STD

Type Enclosure

Indoor STD Outdoor_________ Special Environment __________

Paint Color Grey STD Other: ________________________________

Heater/Thermostat _________________ Fans _________________

Conditioned Air ____

Lighting (Internal/External) ___________ Receptacles __________

Power Factor Controller

StacoVAR STD Real Time:___________

Type of Controls

Neutral Unbalanced Protection _____________

Blown Fuse Alarm ___________________

Customer Specific Devices___________

PLC/Networking/SCADA __________

Other Devices or Integration

Surge/Lightning Arrestor or TVSS (Type) ________________

CT________ (split core or other type) Ratio___________

Lights___________ Other_______________________________

Harmonic Filtering Description_________________________

For additional information on harmonic filtering, including applications, reactor type, and active filters, please refer to our Guide to Harmonics.

Other Power Factor Considerations

Some general power factor determinations can be found simply based on a facility review and electric billing. Some electric utilities may offer analysis support. Contact Staco for a complete review of your power bill and application recommendations.

Some industries with poor power factor:

Automotive	.75 - .85	Forge	.75 - .85
Brewery	.75 - .80	Hospital	.75 - .90
Cement	.80 - .90	Mining	.70 - .80
Clothing-Textile	.60 - .80	Office Building	.80 - .90
Electroplating	.70 - .80	Oil Field	.60 - .70
Foundry	.75 - .85	Painting	.65 - .80

Industrial load types with poor power factor:

Induction motor	.70 - .80
Electric arc furnaces	.60 - .80
Welding	.40 - .70
Machining	.40 - .70
Stamping	.50 - .70
DC Drives, AC VFDs	.40 - .90
Fluorescent Lights *(magnetic ballasts)*	.70 - .80

Lighting and inductive loads represent most of today's facility loads. Non-linear loads continue to increase. The power factor can differ greatly between two users because it depends both on the type of equipment installed and how it is used. For example, asynchronous motors, by far the most widely used, though brushless motors actuated by static AC/DC or AC/AC converters are also popular, have a power factor that varies greatly according to the motor load and type of construction and can reach very low values in the absence of loads. Similar observations may be made with respect to transformers. It is always a good practice to ensure a power factor correction for medium voltage/low voltage transformers, because even when they are operating loadless (e.g., during the night) they absorb reactive power, which must be compensated.

Monitoring at the incoming service entrance or specific loads will also provide for further identification and a more detailed review of how best to treat power factor correction. Switchgear may include powermeters, which offer a wide range of values, and can offer additional information on the suspect load.

Location of Capacitors

Type Application	Cost	Benefit Cost	Flexibility
At Motor	Low	Acceptable	Minimal
At Feeders	Medium	Good	Better
At Service Entrance	Highest*	Best	Maximum

**May be lowest when compared to multiple, at motor load installations*

Without power factor correction, equipment draws more power than is actually needed to perform the work. With power factor correction, less total power is drawn. Payback justification of capacitors can be achieved by calculating the installed cost compared to the immediate monthly savings. In many cases, the initial cost will result in a short term payback of 12-18 months, with electric use savings continuing each month thereafter.

The addition of power factor correction is a combination of the engineer's sense of system operating efficiency and business management's sense of investment profitability.

Electrical Utility Billing and Sizing Power Factor Correction Equipment

As indicated earlier, electric utilities and energy companies bill consumers in various methods. The table on the following page provides information on sizing kvar requirements for power factor correction equipment installed at incoming (main load), or at feeder locations, the addition of capacitors will help to avoid any reactive demand charges from the utility.

When kW is the Primary Billing Component

To calculate the total kVAR needed, the kW, existing power factor and desired power factor must be known. For example:

kW demand is 590

Find present power factor, say .71

Find desired/corrected power factor, say .95

The table on the next page provides a multiplier that will indicate the amount of rated kVAR required.

Note: *kW present power factor and desired power factor examples above.*

KW Multipliers for Determining Capacitor Kilovars

How to use this table—find existing power factor (.71) in left column. On this same line, locate desired power factor (.95 noted in top column). The multiplier is .663, which is applied to the kW (590). Total kvar required is 391, which may be rounded to 400 kVAR.

Corrected Power Factor

Existing Power Factor	0.80	0.81	0.82	0.83	0.84	0.85	0.86	0.87	0.88	0.89	0.90	0.91	0.92	0.93	0.94	0.95	0.96	0.97	0.98	0.99	1.0
0.50	0.982	1.008	1.034	1.060	1.086	1.112	1.139	1.165	1.192	1.220	1.248	1.276	1.306	1.337	1.369	1.403	1.440	1.481	1.529	1.589	1.732
0.51	0.937	0.962	0.989	1.015	1.041	1.067	1.094	1.120	1.147	1.175	1.203	1.231	1.261	1.292	1.324	1.358	1.395	1.436	1.484	1.544	1.687
0.52	0.893	0.919	0.945	0.971	0.997	1.023	1.050	1.076	1.103	1.131	1.159	1.187	1.217	1.248	1.280	1.314	1.351	1.392	1.440	1.500	1.643
0.53	0.850	0.876	0.902	0.928	0.954	0.980	1.007	1.033	1.060	1.088	1.116	1.144	1.174	1.205	1.237	1.271	1.308	1.349	1.397	1.457	1.600
0.54	0.809	0.835	0.861	0.887	0.913	0.939	0.966	0.992	1.019	1.047	1.075	1.103	1.133	1.164	1.196	1.230	1.267	1.308	1.356	1.416	1.559
0.55	0.769	0.795	0.821	0.847	0.873	0.899	0.926	0.952	0.979	1.007	1.035	1.063	1.093	1.124	1.156	1.190	1.227	1.268	1.316	1.376	1.519
0.56	0.730	0.756	0.782	0.808	0.834	0.860	0.887	0.913	0.940	0.968	0.996	1.024	1.054	1.085	1.117	1.151	1.188	1.229	1.277	1.337	1.480
0.57	0.692	0.718	0.744	0.770	0.796	0.822	0.849	0.875	0.902	0.930	0.958	0.986	1.016	1.047	1.079	1.113	1.150	1.191	1.239	1.299	1.442
0.58	0.655	0.681	0.707	0.733	0.759	0.785	0.812	0.838	0.865	0.893	0.921	0.949	0.979	1.010	1.042	1.076	1.113	1.154	1.202	1.262	1.405
0.59	0.619	0.645	0.671	0.697	0.723	0.749	0.776	0.802	0.829	0.857	0.885	0.913	0.943	0.974	1.006	1.040	1.077	1.118	1.166	1.226	1.369
0.60	0.583	0.609	0.635	0.661	0.687	0.713	0.740	0.766	0.793	0.821	0.849	0.877	0.907	0.938	0.970	1.004	1.041	1.082	1.130	1.190	1.333
0.61	0.549	0.575	0.601	0.627	0.653	0.679	0.706	0.732	0.759	0.787	0.815	0.843	0.873	0.904	0.936	0.970	1.007	1.048	1.096	1.156	1.299
0.62	0.516	0.542	0.568	0.594	0.620	0.646	0.673	0.699	0.726	0.754	0.782	0.810	0.840	0.871	0.903	0.937	0.974	1.015	1.063	1.123	1.266
0.63	0.483	0.509	0.535	0.561	0.587	0.613	0.640	0.666	0.693	0.721	0.749	0.777	0.807	0.838	0.870	0.904	0.941	0.982	1.030	1.090	1.233
0.64	0.451	0.477	0.503	0.529	0.555	0.581	0.608	0.634	0.661	0.689	0.717	0.745	0.775	0.806	0.838	0.872	0.909	0.950	0.998	1.068	1.201
0.65	0.419	0.445	0.471	0.497	0.523	0.549	0.576	0.602	0.629	0.657	0.685	0.713	0.743	0.774	0.806	0.840	0.877	0.918	0.966	1.026	1.169
0.66	0.388	0.414	0.440	0.466	0.492	0.518	0.545	0.571	0.598	0.626	0.654	0.682	0.712	0.743	0.775	0.809	0.846	0.887	0.935	0.995	1.138
0.67	0.358	0.384	0.410	0.436	0.462	0.488	0.515	0.541	0.568	0.596	0.624	0.652	0.682	0.713	0.745	0.779	0.816	0.857	0.905	0.965	1.108
0.68	0.328	0.354	0.380	0.406	0.432	0.458	0.485	0.511	0.538	0.566	0.594	0.622	0.652	0.683	0.715	0.749	0.786	0.827	0.875	0.935	1.078
0.69	0.299	0.325	0.351	0.377	0.403	0.429	0.456	0.482	0.509	0.537	0.565	0.593	0.623	0.654	0.686	0.720	0.757	0.798	0.846	0.906	1.049
0.70	0.270	0.296	0.322	0.348	0.374	0.400	0.427	0.453	0.480	0.508	0.536	0.564	0.594	0.625	0.657	0.691	0.728	0.769	0.817	0.877	1.020
0.71	0.242	0.268	0.294	0.320	0.346	0.372	0.399	0.425	0.452	0.480	0.508	0.536	0.566	0.597	0.629	0.663	0.700	0.741	0.789	0.849	0.992
0.72	0.214	0.240	0.266	0.292	0.318	0.344	0.371	0.397	0.424	0.452	0.480	0.508	0.538	0.569	0.601	0.635	0.672	0.713	0.761	0.821	0.964
0.73	0.186	0.212	0.238	0.264	0.290	0.316	0.343	0.369	0.396	0.424	0.452	0.480	0.510	0.541	0.573	0.607	0.644	0.685	0.733	0.793	0.936
0.74	0.159	0.185	0.211	0.237	0.263	0.289	0.316	0.342	0.369	0.397	0.425	0.453	0.483	0.514	0.546	0.580	0.617	0.658	0.706	0.766	0.909
0.75	0.132	0.158	0.184	0.210	0.236	0.262	0.289	0.315	0.342	0.370	0.398	0.426	0.456	0.487	0.519	0.553	0.590	0.631	0.679	0.739	0.882
0.76	0.105	0.131	0.157	0.183	0.209	0.235	0.262	0.288	0.315	0.343	0.371	0.399	0.429	0.460	0.492	0.526	0.563	0.604	0.652	0.712	0.855
0.77	0.079	0.105	0.131	0.157	0.183	0.209	0.236	0.262	0.289	0.317	0.345	0.373	0.403	0.434	0.466	0.500	0.537	0.578	0.626	0.685	0.829
0.78	0.052	0.078	0.104	0.130	0.156	0.182	0.209	0.235	0.262	0.290	0.318	0.346	0.376	0.407	0.439	0.473	0.510	0.551	0.599	0.659	0.802
0.79	0.026	0.052	0.078	0.104	0.130	0.156	0.183	0.209	0.236	0.264	0.292	0.320	0.350	0.381	0.413	0.447	0.484	0.525	0.573	0.633	0.776
0.80	0.000	0.026	0.052	0.078	0.104	0.130	0.157	0.183	0.210	0.238	0.266	0.294	0.324	0.355	0.387	0.421	0.458	0.499	0.547	0.609	0.750
0.81		0.000	0.026	0.052	0.078	0.104	0.131	0.157	0.184	0.212	0.240	0.268	0.298	0.329	0.361	0.395	0.432	0.473	0.521	0.581	0.724
0.82			0.000	0.026	0.052	0.078	0.105	0.131	0.158	0.186	0.214	0.242	0.272	0.303	0.335	0.369	0.406	0.447	0.495	0.555	0.698
0.83				0.000	0.026	0.052	0.079	0.105	0.132	0.160	0.188	0.216	0.246	0.277	0.309	0.343	0.380	0.421	0.469	0.529	0.672
0.84					0.000	0.026	0.053	0.079	0.106	0.134	0.162	0.190	0.220	0.251	0.283	0.317	0.354	0.395	0.443	0.503	0.646
0.85						0.000	0.027	0.053	0.080	0.108	0.136	0.164	0.194	0.225	0.257	0.291	0.328	0.369	0.417	0.477	0.620
0.86							0.000	0.026	0.053	0.081	0.109	0.137	0.167	0.198	0.230	0.264	0.301	0.342	0.390	0.450	0.593
0.87								0.000	0.027	0.055	0.083	0.111	0.141	0.172	0.204	0.238	0.275	0.316	0.364	0.424	0.567
0.88									0.000	0.028	0.056	0.084	0.114	0.145	0.177	0.211	0.248	0.289	0.337	0.397	0.540
0.89										0.000	0.028	0.056	0.086	0.117	0.149	0.183	0.220	0.261	0.309	0.369	0.512
0.90											0.000	0.028	0.058	0.089	0.121	0.155	0.192	0.233	0.281	0.341	0.484
0.91												0.000	0.30	0.061	0.093	0.127	0.164	0.205	0.253	0.313	0.456
0.92													0.000	0.031	0.063	0.097	0.134	0.175	0.223	0.283	0.426
0.93														0.000	0.032	0.066	0.103	0.144	0.192	0.252	0.395
0.94															0.000	0.034	0.071	0.112	0.160	0.220	0.363
0.95																0.000	0.037	0.079	0.126	0.186	0.329
0.96																	0.000	0.041	0.089	0.149	0.292
0.97																		0.000	0.048	0.108	0.251
0.98																			0.000	0.060	0.203
0.99																				0.000	0.143
																					0.000

When kVA is the primary billing component

- kVA is 420, Power Factor is .75, then kW = 315 (kVA x Power Factor = kW)
- From the table earlier, find the known PF of .75 and desired PF of .95, indicating a multiplier of .553, or 315 kW x .553 = 174.19 kVAR, rounded to 175 kVAR equipment size
- 315 kW to desired PF of .95 = 332 kVA (kW divided by PF = kVA), which represents the corrected billing use

Electric utilities and energy companies may bill with varying methods. The above represents common billing practices. Billing structures can be based upon type of customer, usage, contract agreements, demand use, adjustments and surcharges/penalties.

Return of Investment and Payback

Using kVA as the primary billing component (shown above):

- kVA is 420, Power factor is .75, then kW = 315 (kVA x Power Factor = kW)
- From the table earlier, find the known PF of .75 and desired PF of .95, indicating a multiplier of .553, or 315kW x .553 = 174.19 kVAR, rounded to 175 kVAR equipment size
- 315 kW to desired PF of .95 = 332 kVA (kW divided by PF = kVA), which represents the corrected billing use

The existing kVA is 420, billed at $11.22 per kVA = $4712.

The new kVA is 332, billed at $11.22 per kVA = $3725

This represents a monthly savings of $987, or $11,844 annually. Assume an equipment cost of $5600 (not including installation), and this example shows an ROI of less than six months. After the payback period, there can be a 21% savings in the electric bill.

Purchase or lease?

Every business is different in how capital equipment is budgeted. Generally, leasing provides a fixed payment over a set term, which can help to preserve working capital and credit lines. The installation of a capacitor system typically allows for an improved cash flow (electric bill savings, little or no down payment and small monthly lease cost), and may offer tax advantages.
Both equipment and installation can be financed.

About Staco Energy Products Company

Since 1937, customers worldwide have been relying on Staco Energy Products Company to deliver voltage control and power quality solutions tailored to their needs.

As a leading power quality resource, we offer our customers world-class support; from our thorough applications assessment, to our ability to design and deliver a solution that is tailored to the specific needs of our customers; through delivery and commissioning.

Our professional, factory trained service team is in place to ensure that our customers' revenues are protected, and their investment provides them with many years of trouble free operation.

Staco develops total power solutions for OEM and end user applications.

In addition to the StacoVAR line of power factor correction and harmonic mitigation equipment, we offer a wide array of power quality products, including:

- ***Uninterruptible Power Supplies***
- ***Power Conditioners***
- ***Voltage Regulators***
- ***Power Factor Correction and Harmonic Mitigation***
- ***Active Harmonic Filters***
- ***Variable Transformers***
- ***Custom Engineered Test Sets***

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STACO ENERGY PRODUCTS CO.®
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Contact Us:
US Toll Free: 866-261-1191
Phone: 937-253-1191
E-mail: sales@stacoenergy.com
www.stacoenergy.com

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