
Commission 1-1

Request:

On page 14 of Exhibit GLB-1, Mr. Booth states, "I believe that the sophisticated programs that are being tried by some utilities have proven not to show cost benefit, whereas the conventional power factor optimization programs show a significant cost benefits. Many of the industry leaders, including vendors of sophisticated equipment in the marketplace, have admitted that there is little economic benefit associated with the more sophisticated Volt/Var optimization equipment applications."

a) Please provide support for the belief stated in the first sentence, quoted above.
b) Please provide support for the second sentence for the statement of admission by industry leaders and vendors.

Response:

a) Mr. Booth has, in his career, prepared numerous Distribution System Power Loss Management Manuals, including in early 1980s for the North Carolina Alternative Energy Corporation and The American Public Power Association, and in the late 1980s for the Tennessee Valley Public Power Association and three manuals for the National Rural Electric Cooperative Association Cooperative Research Network (NRECA CRN). The power factor correction portions of the second edition of the NRECA CRN Power Loss Management Manual which Mr. Booth wrote is attached as Attachment No. GLB DR 1-1A (Chapter 4, pages 40, 41, and 42 and Chapter 10). Mr. Booth has prepared hundreds of studies for hundreds of electric utilities, which have included the implementation of power factor correction and voltage reduction and optimization. These studies have shown on average for every one percent (1%) voltage reduction there is between an eight-tenths to one percent (0.8 to 1.0%) demand reduction. Power factor optimization through the application of capacitors and capacitor controls has shown energy savings and demand reduction through power loss reduction, which offset the capital investment in a range of six (6) to eighteen (18) months. These projects, in every case, have documented the energy and demand savings associated with the program implementations. Utility modeling software allows for an accurate system analysis and implementation plan and cost-benefit analysis to be completed. The issue I raised is that the Company has provided no detail for a proposed program or financial analyses that support the Company's position that spending money to simply evaluate voltage and volt-ampere reactive (VAR) optimization, or VVO equipment, is of benefit, while the Company has already long proven utility solutions at its disposal. In a December 2012 Department of Energy (DOE) report on the initial findings of the VVO projects funded under the Smart Grid Investment Grant (SGIG) program under the American Recovery and Reinvestment Act of 2009, the DOE states:

"Generally speaking, utilities applying VVO technologies expect to see 1% reductions in electricity consumption for every 1% reduction in voltage levels."[1]

This statement of finding from the 99 DOE funded SGIG projects is consistent with system improvements that were derived, in my experience, through planned voltage and power factor correction improvements. The issue becomes an engineering economics exercise regarding whether the additional VVO control systems, communication systems, and electric system improvements are recoverable through measurable savings, and whether these improvements were directly needed for VVO implementation or simply deferred upgrades already needed for efficient electric system operation.

b) In recent meetings, including one with ABB at its North Carolina State University Centennial Campus facility, ABB stated that its Volt/Var optimization project implementation programs show a marginal improvement over the conventional application of voltage regulators and control of voltage and capacitor additions to achieve optimum power factor correction on individual feeders. This statement is also supported by the overall findings in the DOE report, which I referenced earlier in this response, that the overall performance of VVO systems may not yield financial justification beyond the engineering methods that the Company could deploy to condition feeder voltage and power factor such as: balance system load, optimize transformer taps, install additional phase wires to limit line losses, and optimize capacitor and regulator placements. Also, presentations and workshops provided at the IEEE Power & Engineering Society General Meeting held July 26 and 27, 2010, including Volt Var Control Workshop (IVVC) Issues for the future, to include subsection What Duke is doing today?; Volt/Var Control at Progress Energy Carolinas Past, Present and Future; and EPRI Volt-Var Control Workshop; provide further support for my statements.

Prepared by or under the supervision of: Gregory L. Booth, PE

[1] United States Department of Energy, Application of Automated Controls for Voltage and Reactive Power Management- Initial Results, December 2012, page ii.

Commission 1-2

Request:

Can Volt/Var management be considered an effective energy efficiency measure? If so, how? If not, why not?

Response:

Volt/Var management is an effective energy measure with its foundation in traditional utility voltage and Var control solutions. The Volt component of a program allows optimization of feeder voltages which reduces the I2R power losses, and can be combined with a voltage reduction program which will reduce demand during the short duration control periods. The Var management component involves the addition of line capacitors for power factor correction, creating a lagging power factor particularly at peak load periods of not less than 98 percent. This reduces the line current, thus the I2R power line losses. Power factor optimization not only reduces power losses, it also allows for enhanced utilization of transformer capacity. The closer to unity power factor, the closer kVA is to being equal to kW, which means more of the available transformer kVA can be used to meet the kW demand requirements of the customer's electric load and, in some cases, without installing larger transformers or increasing power line capacity. This freed up system capacity and its associated capital value is one possible benefit, and second is reduction in electric system demand and energy derived from the reduction in energy lost through power losses. Again, the Company has not indicated what measurable technical and financial benefits that it expects by any possible VVO system, and whether these benefits would be greater than those derived through other engineered methods.

Prepared by or under the supervision of: Gregory L. Booth, PE

DISTRIBUTION OPERATIONS

NRECA CRN

COOPERATIVE RESEARCH NETWORK

PROJECT 01-28

Power Loss Management

For the Restructured Utility Environment

second edition

Attachment NO. GLB DR 1-1A

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PROJECT 01-28

Power Loss Management
For the Restructured Utility Environment
second edition

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Attachment NO. GLB DR 1-1A

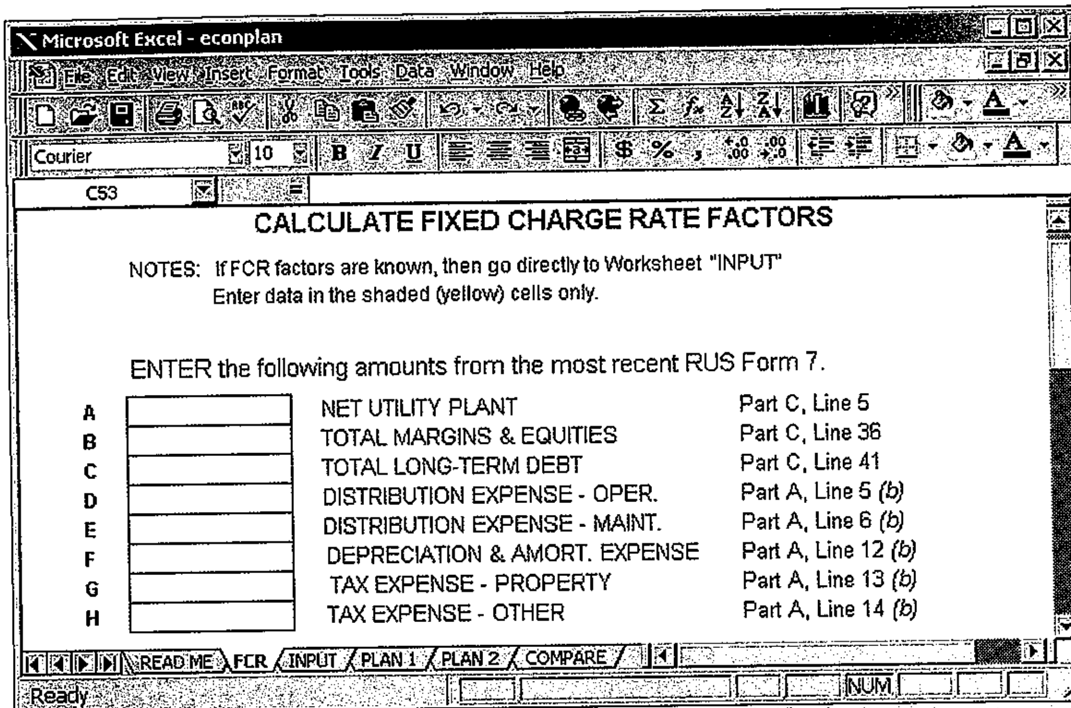

FIGURE 4.4: Excel Spreadsheet Input Data Used to Calculate Fixed Charge Rate

Power Factor

The kVA load carried by a single-phase line or transformer is the product of the voltage in kV and the current in amperes.

Example 4.6 calculates apparent power.

EXAMPLE 4.6: Apparent Power

A single-phase 7.2-kV primary line is carrying 50 A. Determine the apparent power in kVA.

Solution: The kVA loading is (7.2 kV) × (50 A) = 360 kVA. For the line described, the kW load (real power) normally will be a lower value, perhaps 300 kW in this case.

REACTIVE POWER

kW values are lower than kVA values. The reason is that apparent power (kVA) consists of two components: useful power (kW) and reactive power (kVAR). The phasor sum of kW and kVAR equals kVA. When kVAR are drawn, user loads, lines and transformers must carry more amperage than they would if only kW were required by the loads. Since losses equal I^2R, the need to provide kVAR to load causes an increase in system losses. See Figure 4.5 for kVA, kW and kVAR relationships.

DETERMINING POWER FACTOR

Power Factor, the ratio of the useful power in kW to the apparent power in kVA, is expressed by the following formula:

$$\text{Power Factor} = \frac{\text{kW}}{\text{kVA}}$$

There are other mathematically equivalent formulas for power factor that may be more useful for some types of analyses:

$$\text{Power Factor} = \frac{\text{kW}}{\sqrt{(\text{kW})^2 + (\text{kVAR})^2}}$$

$$\text{Power Factor} = \cos Ø$$

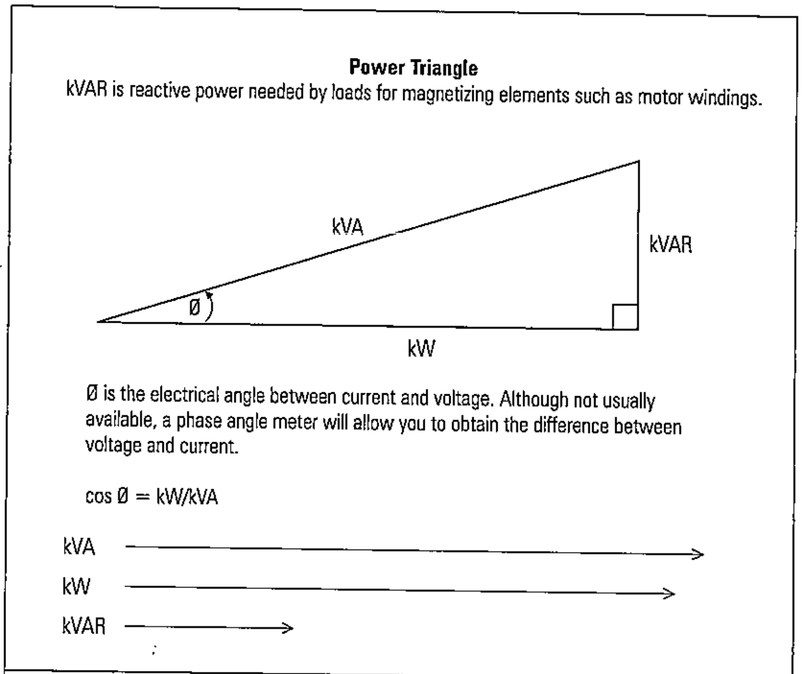

FIGURE 4.5: kV, kW and kVAR Relationships

Here Ø is the electrical angle between the current and the voltage. Load power factors are said to be lagging because of the direction of this electrical angle. Capacitor power factors are leading because the angle lies in the opposite direction.

The power factor of the load carried by the line in Example 4.6 above can be calculated as follows:

$$\text{Power Factor} = \frac{\text{kW}}{\text{kVA}} = \frac{300\text{ kW}}{360\text{ kVA}} = 0.833$$

Power factor is often expressed as a percentage, so the above power factor is 83.3 %.

The relationships among power factor, kW, kVA, and kVAR can be determined graphically by using the curves in Figure 4.6.

Example 4.7 shows the effect of power factor on losses.

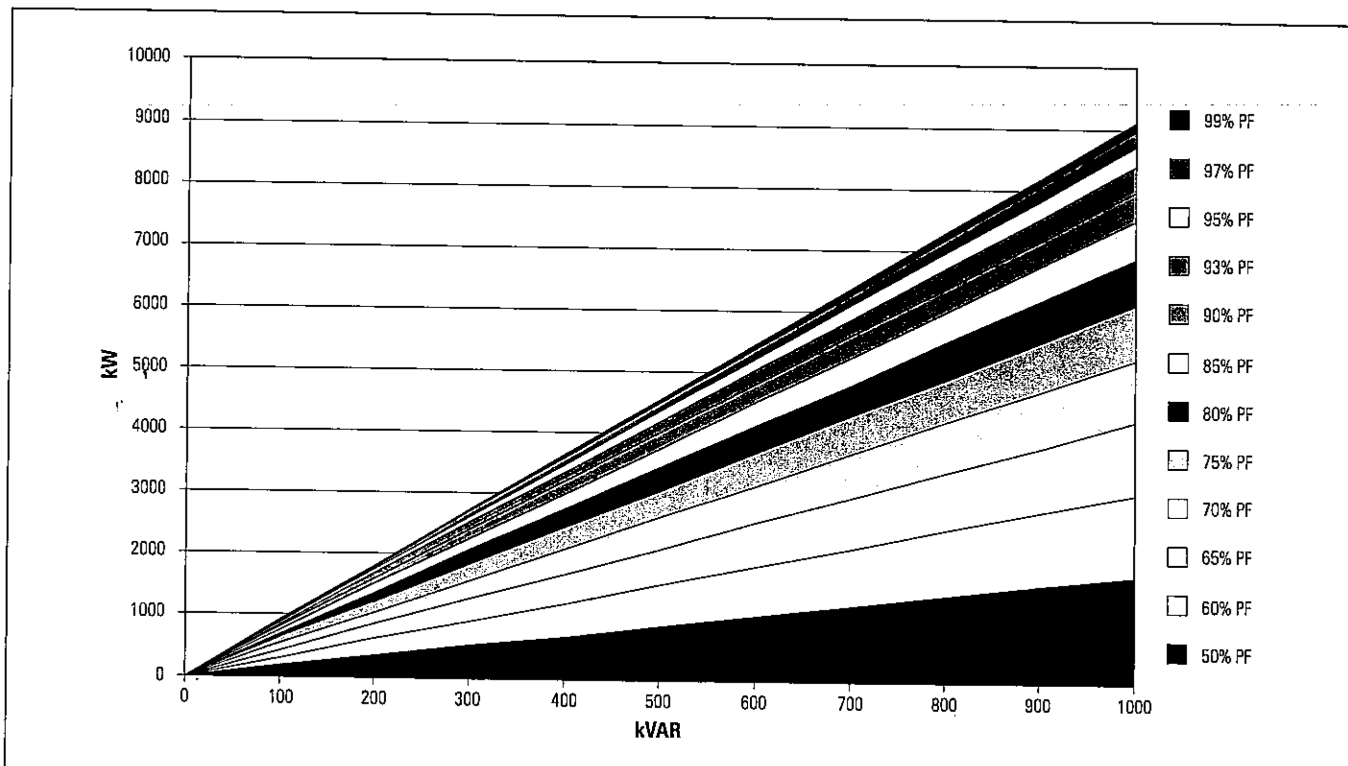

FIGURE 4.6: kW, kVAR, and Power Factor Curves

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Example 4.7 illustrates the effect of power factor on system component losses. Improving the power factor from 83.3% to 100% reduced the losses from 7,500 W to 5,209 W, saving over 2 kW of previously-lost power. Power factor can be improved by installing capacitors on primary lines that have a low, lagging power factor. Capacitors are discussed in Section 10 of this manual.

Exercise 4.1 illustrates the use of concepts covered in this section.

EXAMPLE 4.7: Effect of Power Factor on Losses

If the losses on the line described in Example 4.6 are 7,500 W, what losses will occur if the load power factor is 100 % instead of 83.3 %?

Solution: Since the line loss equals I^2R and I equals 50 A, the total primary line resistance, R, including the return circuit, must be 3 ohms to create 7,500 W of losses. At a load power factor of 100 %, the kVA would equal the kW, so the kVA load would be 300 kVA. Thus, the new primary amperes are:

$$\text{Amperes at 100\% Power Factor} = \frac{300\ \text{kVA}}{7.2\ \text{kV}} = 41.67\,A$$

The new losses are:

$$\text{Losses at 100\% Power Factor} = (41.67\ \text{A})^2 \times 3\ \text{ohms} = 5{,}209\ \text{W}$$

EXERCISE 4.1: Load and Loss Analysis Factors

For the month of July, Watts County EMC experienced a system peak demand of 4,100 kW, and the peak coincident with the wholesale power supplier was 3,940 kW. At the time of the Watts County system peak, kVAR metering at the point of delivery recorded a peak reactive demand of 2,213 kVAR. Metered wholesale kWh for July was 1,433,688 kWh. Determine the following factors for Watts County for July:

- Load factor
- Power factor
- Estimated loss factor
- Peak load responsibility factor
- Peak loss responsibility factor

The solution to this exercise can be found in Appendix F.

10 Capacitors

In This Section: Effect of capacitors; types of capacitor installations; capacitor operation and maintenance; calculating capacitor loss-reduction; capacitor placement

Installation of capacitors on distribution systems improves efficiency by causing the overall power factor (as viewed from all points between each capacitor installation and the supply point) to move closer to 100%. Capacitors also improve line voltage, which results in lower losses on lines and transformers on the system. The power factor attained with capacitors results in greater loss reduction than that achieved by raising voltage.

For a description and definition of power factor see Section 4 of this manual. Example 4.7 in that section illustrates reduction of line loss through improved power factor.

Effect of Capacitors

The power factor of most consumer loads falls short of 100% because the loads draw reactive power (kVAR) as well as useful power (kW). Virtually all loads draw lagging kVAR because of the lagging inductive load offered by components such as motor windings. Unless capacitors are installed on the system, the entire kVAR load must be supplied from substations and delivery points, and will flow through lines and transformers to reach users. This kVAR flow increases line and transformer currents and increases losses according to the I^2R law.

Capacitors can reduce line currents.

Capacitors draw leading kVAR, and can satisfy the lagging kVAR requirements of inductive loads (See Figure 10.1). The power factor for facilities supplying power in the vicinity of the capacitors is improved, and line currents are reduced, as are system losses.

Example 10.1 illustrates the use of a primary line capacitor bank to improve power factor and reduce line currents. Example 10.2 calculates what dollar savings might be achieved by installing a number of capacitor banks over an entire feeder.

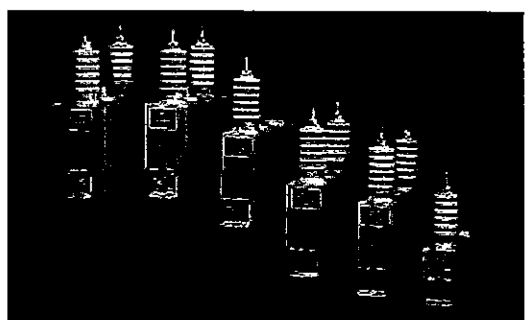

FIGURE 10.1: Capacitors are Excellent Tools for Reducing System Losses.

Attachment NO. GLB DR 1-1A

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EXAMPLE 10.1: Effect of Capacitor on Line Current

A three-phase tap line off a main 12.47/7.2 kV feeder carries 40 balanced amperes at 85% power factor. Assuming line voltage is 100% of nominal voltage, what size capacitor bank should be installed on the tap to correct the power factor to 100%? What amount of line amperes will flow with the capacitor bank in service?

Solution: To correct power factor to 100%, the capacitor bank kVAR should equal the load kVAR. Load kVAR is found as follows:

$$\text{Load kVA} = 40\text{ A} \times 12.47 \times \sqrt{3} = 864\text{ kVA}$$
$$\text{Load kW} = \text{Power Factor} \times \text{kVA} = 0.85 \times 864\text{ kVA} = 734.4\text{ kW}$$
$$\text{Load kVAR} = \sqrt{(\text{kVA})^2 - (\text{kW})^2} = \sqrt{(864)^2 - (734.4)^2} = \sqrt{746{,}496 - 539{,}343} = \sqrt{207{,}153} = 455\text{ kVAR}$$

The nearest standard capacitor-bank size meeting this requirement is 450 kVAR.

After correction to 100% power factor, the new kVA will equal the load kW. Therefore, the line amperes with the capacitor bank in service can be found as follows:

$$\text{Circuit Amperes} = \frac{\text{New kVA}}{12.47\text{ kV} \times \sqrt{3}} = \frac{734.4\text{ kVA}}{12.47\text{ kV} \times \sqrt{3}} = 34\text{ amperes}$$

This example shows that a significant reduction in line amperes can result from installing a capacitor bank.

EXAMPLE 10.2: Loss Savings Achieved by Capacitors

Readings taken at peak load on a substation feeder that has no installed capacitors show 4,400 kW and 2,700 kVAR (85% power factor). The cooperative estimates there is 132 kW of primary line loss on this 12.47/7.2 kV feeder at peak load. An economic analysis reveals that the equivalent first cost of primary line losses is $1,300 per kW.

If fixed and switched capacitors are installed throughout the feeder to correct the peak load power factor to 100%, what is the approximate relationship between the cost of the capacitor installations and the equivalent first cost of the savings in line losses?

Solution: Since the objective here is to find only an approximate estimate of the savings in line losses, a simplified method can be used. If the load is distributed fairly evenly throughout the feeder and the entire load has about the same power factor, the feeder can be modeled by an equivalent circuit.

The solution begins with a calculation of the feeder amperes at the substation.

$$\text{Feeder kVA} = \sqrt{(4{,}400\text{ kW})^2 + (2{,}700\text{ kVAR})^2} = 5{,}162\text{ kVA}$$
$$\text{Feeder Amperes} = \frac{5{,}162\text{ kVA}}{12.47\text{ kV} \times \sqrt{3}} = 239\text{ amperes}$$

Since the stated line loss is 132 kW, the next step is to find the equivalent line resistance that will result in this amount of loss. The following formula can be used to find the equivalent line resistance:

$$\text{Equivalent R} = \frac{3I^2R}{3I^2} = \frac{\text{Total Losses}}{3I^2}$$

For this example:

$$R = \frac{132{,}00\text{ watts}}{3 \times (239\text{ amperes})^2} = 0.77\text{ ohms}$$

Peak power factor can be improved to 100% by installing 2,700 kVAR of capacitors throughout the feeder. At 100% power factor, the feeder amperes will be reduced as follows:

$$\text{Feeder Amperes} = \text{Feeder kW} = 4{,}400\text{ kW}$$
$$\text{Feeder Amperes} = \frac{4{,}400\text{ kVA}}{12.47\text{ kV} \times \sqrt{3}} = 204\text{ amperes}$$

Losses at 100% power factor can be calculated using the equivalent R previously found for the feeder.

$$\text{Losses at 100\% Power Factor} = 3\,I^2R = 3 \times (204\text{ A})^2 \times 0.77\text{ ohms} = 96{,}133\text{ watts} = 96\text{ kW}$$

Therefore, the savings in peak losses are 132 kW - 96 kW = 36 kW.

The total equivalent first cost of these losses is:

$$\text{Equivalent First Cost of Loss Savings} = 36\text{ kW} \times \$1{,}300\text{ kW} = \$46{,}800$$

10

Since it is impossible to place and switch capacitors so perfectly that the feeder power factor is kept at exactly 100% at all times and locations, the actual dollar savings will be somewhat less than the Equivalent First Cost of Savings calculated in Example 10.2. Nevertheless, the cost of 2,700 kVAR in capacitor installations, some switched and some unswitched, may be substantially less than the equivalent first cost of loss savings.

Example 10.2 illustrates that, based on primary line loss savings alone, capacitors can pay for themselves and produce net savings for the cooperative in typical situations.

IMPACT OF CAPACITORS ON WHOLESALE POWER COSTS

For some cooperatives, the savings in primary line losses are only part of the savings that capacitors can produce. Many cooperatives are billed by their wholesale power suppliers for kVAR demand as well as kW demand. Rate structures that charge for kVAR demand may include a power factor penalty or a demand billing based on kVA rather than kW. In either case the net result is the same: direct cost for kVAR to the purchasing cooperative. Wholesale kVAR charges might be as much as several dollars per kVAR per month. Enormous savings can be produced by installing capacitors because they provide kVAR that would otherwise have to be drawn from the bulk power supplier.

CAPACITOR DIELECTRIC LOSSES

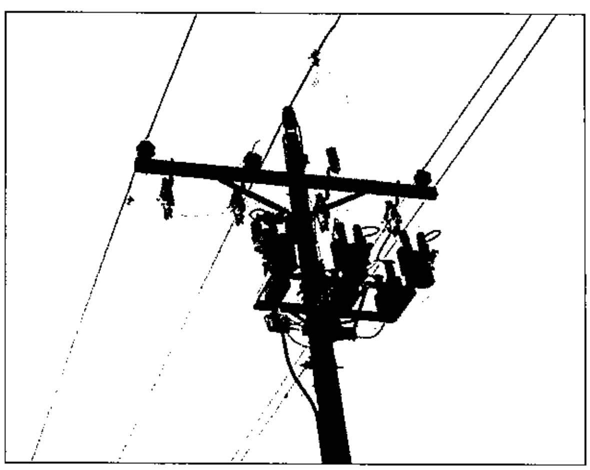
Losses occur on capacitors themselves. However, compared to losses on lines and transformers, capacitor loss is small. For example, a typical all-film 300 kVAR capacitor dissipates about 50 W. That is a negligible factor in most studies and evaluations, except for purchase evaluations used to select the best capacitor vendor.

Types of Capacitor Installations

Capacitors are relatively easy to install and are among the most trouble-free of electrical devices. Line capacitor installations are protected with conventional cut-out fused switches. Capacitor failure is rare if the appropriate fuse element is used. Fuse rating should be closely coordinated with capacitor size. Figure 10.2 illustrates some capacitor types.

BALANCING LOAD REACTIVE POWER

The most difficult aspect of capacitor application is maintenance of proper balance between total



Switched Capacitors

Fixed Capacitors

FIGURE 10.2: Types of Capacitors

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kVAR of capacitors connected at any particular time and load kVAR present at that time. Like load kW, load kVAR changes over time. Some provision must be made to vary total connected capacitive kVAR to roughly match load kVAR. It is inadvisable to install capacitors based on peak load kVAR and then leave all these capacitors connected at off-peak times. The reason is that excessive capacitive kVAR would exist on the system during light load periods. This would result in an overall leading power factor for the feeder. A leading power factor increases line amperes as much as they will be increased by a lagging power factor. A leading power factor can also cause other problems such as excessive line voltage and harmonics.

The following example of failure to remove capacitors that were too large for the load kVAR was observed at a cooperative.

> A 600 kVAR capacitor was installed near the location of an industrial consumer, and the capacitor was not removed after the consumer went out of business. Losses at the wholesale metering point increased from 7% to 23%. The cause was not immediately identified because the cooperative did not identify whether the indicated power-factor at the supply point (85 percent) was leading or lagging. It turned out that the power factor was leading, and the cause was excessive capacitive kVAR on the feeder.

SWITCHED AND FIXED CAPACITORS

The total kVAR of connected capacitors can be controlled by installing automatic switching on some of the installed capacitors. Capacitor units equipped with switches (switched capacitors) are switched off-line so that, during light load periods, the amount of connected capacitive kVAR will be close to the inductive load kVAR. Some capacitors can be permanently connected to the line, since there will always be a base amount of load kVAR even at minimum load, Capacitors that remain connected on line at all times are called fixed capacitors.

Many methods of automatic control are used with switched capacitors. For example, On/Off switching controls may be activated by:

- **VAR-sensing devices** that require voltage and current inputs
- **Auto Adaptive controls** that look at daily cycles and are able, within a few weeks, to provide continuous adjustment
- **Line current-sensing devices**
- **Line voltage-sensing devices**
- **Time clocks**
- **Ambient temperature sensors.** These are inexpensive devices
- **Remote control** provided by SCADA systems.

Different types of capacitor controls can be used for various installations on the same feeder, and combination control schemes can be used, even on a single installation.

Capacitor installations on a distribution feeder will produce greater benefits if an engineering study is performed to determine the size and location of the individual units. The study should include recommendations on the units to be switched and the type of switching controls to be used. Manufacturers' standard capacitor sizes and the availability of poles with space for the installations should be addressed in such a study.

Capacitor Operation and Maintenance

Capacitors on distribution lines must be kept operational if their benefits are to be retained. Lightning surges or other disturbances occasionally cause capacitor fused-cutouts to open. Cooperatives should promptly check and re-fuse such units to keep all capacitors operational. Care should always be taken in re-fusing capacitor units, since energizing units that have been damaged internally often results in capacitor case failure.

Since no consumer complains when a capacitor cut-out opens, some cooperatives may delay returning the capacitor to service. However, such delays are costly because of increased line losses.

Switched capacitors need to be checked periodically to ensure proper operation of switches and controls.

Attachment NO. GLB DR 1-1A

10

Calculating Capacitor Loss Reduction

Tables 10.1 and 10.2 show results of capacitor loss-reduction calculations for a typical system.

In assessing the viability of installing substation capacitors for loss-reduction, it is important to look carefully at each individual substation. In Table 10.1, note that payback within as little as three years can be realized for some substations in the system, while other will require 20 years for payback.

Table 10.2 shows the calculated savings for one month, at substations, from capacity that is released by installed capacitors.

TABLE 10.1: Typical Peak Loss Reduction and Cost of Capacitors

Substation	Peak Loss Savings kW	First Year Loss Savings $	kVAR Added	Cost of kVAR	Total First Year Cost	Payback Years
# 1	91.03	$11,606	2100	$37,800	$26,194	3
# 2	69.21	$8,824	1800	$32,400	$23,576	4
# 3	5.63	$718	600	$10,800	$10,082	15
# 4	9.74	$1,242	300	$5,400	$4,158	4
# 5	200.28	$25,536	4400	$79,200	$53,664	3
# 6	13.26	$1,691	600	$10,800	$9,109	6
# 7	4.15	$529	600	$10,800	$10,271	20
# 8	82.65	$10,538	2200	$39,600	$29,062	4
# 9	26.84	$3,422	1500	$27,000	$23,578	8
# 10	9.50	$1,211	900	$16,200	$14,989	13
# 11	12.54	$1,599	1200	$21,600	$20,001	14
Total	524.83	$66,916	16,200	$291,600	$224,684	4

The data are based on Peak kW Loss Savings of $15/kW, Demand Annualization Factor 8.5, and cost of kVAR of $18/kVAR.

TABLE 10.2: Typical System Capacity Release

Substation	Actual August 2001					Corrected to 98% PF			
	Transf. 3Ø MVA (Base Rating)	Peak kW	PF	Peak kVA	Transf. % Load	Peak kVA	Transf. % Load	Released Capacity kVA	$18/kVA Released Capacity
# 1	7.50	6,414	89.0%	7,207	96.1%	6,545	87.3%	662	$11,913
# 2	7.50	5,800	88.0%	6,591	87.9%	5,918	78.9%	673	$12,106
# 3	2.50	2,337	93.2%	2,508	100.3%	2,385	95.4%	123	$2,211
# 4	2.50	2,378	95.7%	2,485	99.4%	2,427	97.1%	58	$1,050
# 5	10.00	12,208	89.4%	13,655	136.6%	12,457	124.6%	1,198	$21,570
# 6	3.75	3,526	93.5%	3,771	100.6%	3,598	95.9%	173	$3,117
# 7	3.75	2,224	88.1%	2,524	67.3%	2,269	60.5%	255	$4,590
# 8	10.00	8,836	92.7%	9,532	95.3%	9,016	90.2%	515	$9,279
# 9	10.00	7,781	93.5%	8,322	83.2%	7,940	79.4%	382	$6,879
# 10	15.00	1,833	87.3%	2,100	14.0%	1,870	12.5%	229	$4,126
# 11	10.00	5,663	92.4%	6,129	61.3%	5,779	57.8%	350	$6,304
Total	82.50	59,000	91.2%	64,823	85.6%	60,204	80.0%	4,619	$83,144

10

Capacitor Placement

Capacitors may be installed to reduce or eliminate bulk power charges for kVAR, or for other reasons, such as contractual requirements, associated with wholesale purchased power, They can be installed in substations to supplement distribution line installations. Installed equipment cost for substation capacitors may be less than that for the same amount of line kVAR, because many kVAR in a substation can be switched with a single three-phase device and control unit. However, when capacitors are installed at substations, the cooperative does not get the benefit of reduced distribution line losses. Substation installations should be made only after the maximum practical amount of line capacitors has been installed.

UTILIZATION VOLTAGE CAPACITORS

Another possible location for capacitors that should not be overlooked is at the utilization voltage level of member equipment supply buses. This location may be practical for some commercial and industrial members. Since these capacitor locations lie beyond the meter, the members themselves would purchase and install these capacitors. The cooperative's role is to design commercial and industrial retail rates that provide incentive for member installation of capacitors. Such rates might include power factor penalty provisions or demand charges based on kVA demand readings instead of kW demand readings.

COORDINATION WITH MEMBERS

Capacitors installed at utilization voltage levels offer the added advantage of reducing currents in distribution transformers and secondary lines. To facilitate reduction of these currents and their associated losses, cooperatives should design rates that encourage members to install capacitors. Cooperatives might also consider a program to provide technical assistance and advice to members who wish to purchase and install capacitors.

Exercise 10.1 illustrates the use of concepts covered in this section.

EXERCISE 10.1: Application of Capacitors

One of the 12.47/7.2 kV distribution feeders on the electric system of Voltage County EMC extends for 2.6 miles, at which point commercial loads and taps are encountered that amount to 1,250 kW of peak load at 86% power factor. The line construction is three-phase, 1/0 ACSR conductor (0.888 ohms per mile).

The EMC has calculated that line losses represent an equivalent first cost of $2,200 per peak kW, so there is a genuine concern about the amount of loss on this feeder. Assuming the load is balanced among the three phases and ignoring any loads which might be tapped off the feeder before the end of the 2.6 miles mentioned above, calculate the peak kW of line loss from the information given.

When the Voltage County EMC Manager heard about the extent of line loss on the feeder, an order was issued to engineering to take steps to reduce the losses to a more acceptable amount. Replacing line conductors was considered, but rejected as impractical at the present time because of other demands on construction crews. Then someone suggested that the low power factor of the load might make capacitor installations effective in reducing losses.

Calculate the total kVAR of capacitors which need to be installed in the load area to improve the peak power factor to 100%. After these capacitors are installed, what will be the new value for peak line losses and what dollar savings will result on an equivalent-first-cost basis?

The solution to the exercise can be found in Appendix F.