Northeast Power Systems, Inc.

Benefits of Operating Your Generator at a Higher Power Factor

Introduction

Many large industrials and municipals that own and operate generation may be able to produce more power from their generators by operating them at a higher power factor, rather than at a power factor determined by their load. The additional power released by their generator can be either sold back to the supplying utility for revenue, or can be used locally for reduced utility power consumption. To operate a generator at a higher power factor usually requires that the industrial or municipal have a load power factor (power factor of load when generation is not considered) of near unity. This is most economically achieved with a large inexpensive medium voltage metal enclosed capacitor bank. The capacitor bank relieves the generator from having to produce the vars, and enables it to produce more power. Var production with the capacitor bank is far less expensive than the cost to produce vars with a generator, when the generator can be operated at a higher power factor.

Electric utility customers and municipals that meet some of the following conditions should consider and pursue the information contained in this document.

- Generators are utilized on a continuous basis and are operated at a power factor less than their rating

- Pay for poor power factor and own generation

- The generators' prime mover (i.e. gas, steam or hydro turbine) has a power rating that can operate the generator at a higher power factor and thereby a higher power output.

- Pay a KVA demand charge and operate their generators at a low power factor.

Background

Synchronous generators when purchased have a nameplate rating which defines the power factor rating of the machine and the corresponding power output of the machine, i.e. 10MW, 0.85PF machine. Synchronous generators are often operated at their rated power factor and power rating or at a lesser MW rating to meet var requirements (or system power factor or KVA requirements). The power factor rating of most synchronous generators is typically between 0.8 lagging to 0.95 lagging. By convention, a synchronous generator operating with a lagging power factor is producing vars, while one operating with a leading power factor is consuming vars. From a reactive power viewpoint, a generator with a lagging power factor is much like a shunt capacitor bank (shunt capacitor banks put out vars as does a generator). The primary difference is that a generator will put out real power in addition to the reactive power by merely changing the field voltage.

Operating a synchronous generator with a lagging power factor does not require additional power from the prime mover. It does, however, reduce the amount of real power that the generator can produce by increasing the stator winding current. In many cases, a generator operating with a lagging power factor can have its control settings changed or type so that it will put out more KW and less vars. The additional kW output of the machine can be utilized to offset power consumption or sold back to the power provider for revenue. The reduction in kvar due to operating the machine at or near unity power factor can be provided with an automatic metal-enclosed shunt capacitor bank.

As an example, system "A" in Figure 1 shows a typical power system with on-site generation. The on-site generator is rated 25MVA at 0.8 Power Factor (PF) and supplies roughly 53% of the industrial systems load. The industrial systems load has an aggregate sum of 45 MVA at 0.84 Power Factor and is a 24/7 - 365 day operation. This equates to a reactive power flow of 24.4 MVAR and real power flow of 37.8 MW. The utility supplies the remaining amount of power as shown (17.8 MW, 9.4 MVARS, 20.1 MVA @ 0.88PF).

The plant owners wish to reduce their overall cost for power. One method as provided here is to improve their overall plant power factor to 0.90 lagging and increase their generator MW output by improving power factor. System "B" in Figure 1 shows how a capacitor bank was utilized to accomplish this goal. System "B" shows that the addition of an 18.25 MVAR capacitor bank enabled their generator to output an additional 5 MW while improving the plant power factor to 0.9 Lagging.

System "B" offers the following benefits:

- Reduced Electric Utility Bill due to an improvement of Plant Power Factor.
- Reduced Electric Utility Bill due to lower amount of purchased power from power provider.

In today's de-regulated market place, 5 MWATTS of power can equate to millions of dollars a year in savings. Payback periods for the capacitor bank can be less than one month.

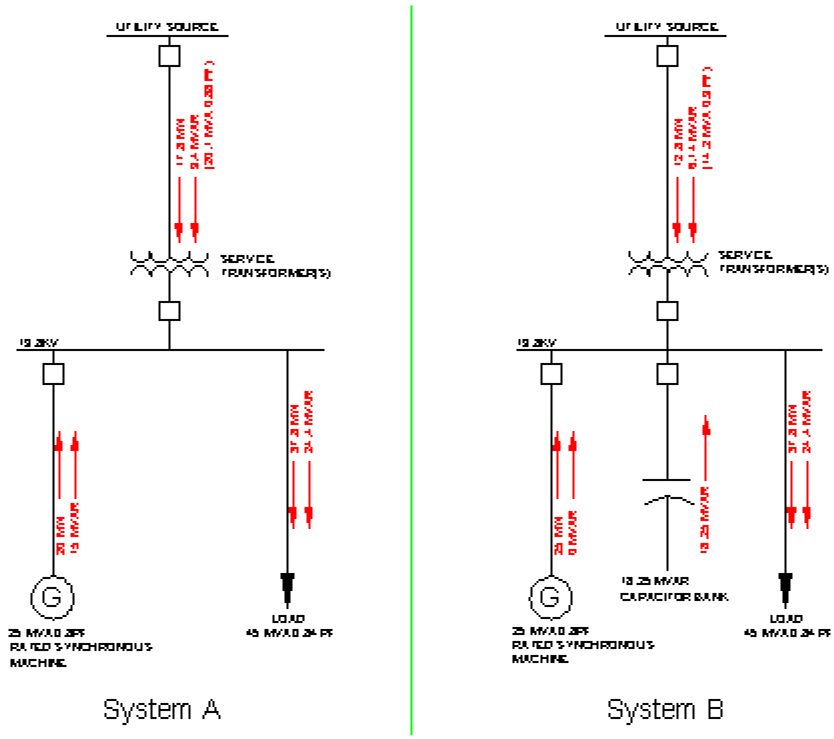

Figure 1 - Typical Power System with On-site Generation. The Figure Shows How The Realand Reactive Power Flow Can be Changed For The Addition of a Capacitor Bank

Generator Capability

Every generator has its own capability curve and this information should be available with the machine documentation or from the manufacturer. The capability curves define the operating characteristics of the generator in terms of kW and KVar. A typical synchronous generator reactive-capability curve, as shown in Figure 2, can be utilized to determine the capability of a generator and whether additional KW can be obtained from the generator. For example, the machine represented by the curve in Figure 2, when operated at a lagging power factor of 0.8, will have a kW output of 0.8 per unit and a kVAr output of 0.6 per unit.

Operating the same machine at unity power factor will result in a machine KW output of 1.0 Per Unit KVA and a kVAr output of 0.0 per unit. The required vars to offset the generators reduction in var output (or rating of Medium Voltage Capacitor Bank) can be calculated by simply subtracting the initial generator var output at the initial operating point from the generators var output at the final or desired operating point.

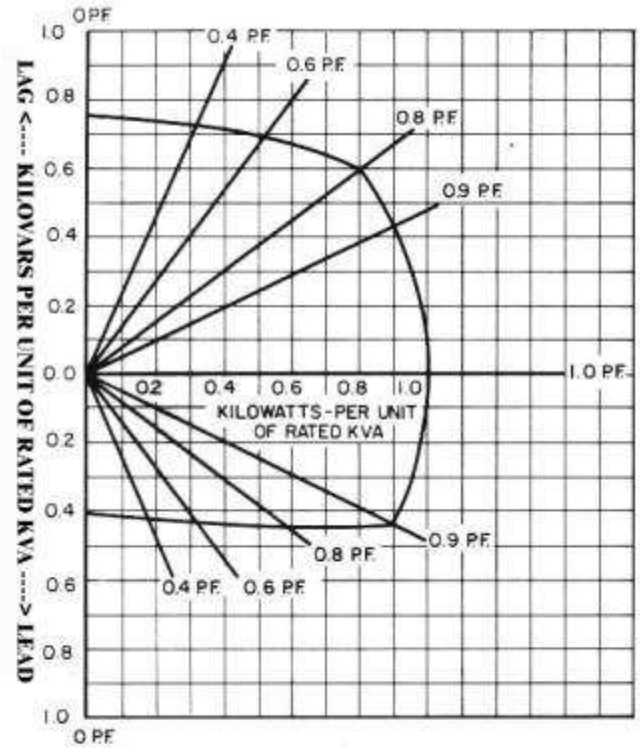

Figure 2 –Typical Synchronous Generator Reactive-Capability Curve

Conclusion

Power consumers that own synchronous generators can increase their revenue or save on their electric power consumption by purchasing a shunt capacitor bank and changing their generators' control settings. The ratings of the generators prime mover should be checked against the generators capability curve to ensure it can operate at or near unity power factor. If it is determined that the generator can operate at a higher power factor, a financial justification for the capacitor bank that considers the following should be conducted:

- The increased kW outputs of the synchronous generator will either reduce the amount of power purchased from your electric power provider or it will increase the revenue obtained for power that is sold to the power provider.

- The capacitor bank can reduce utility bills by alleviating power factor penalties associated with the purchase of power from the power provider.

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