Getting a generator that can handle all your power generation needs is one of the most **critical aspects of the purchasing decision**. Whether you are interested in prime or standby power, if your new generator can't meet your specific requirements then it simply won't be doing anyone any good because it can put undue stress on the unit and even damage some of the devices connected to it. **Unfortunately, determining exactly what size of generator to get is often very difficult and involves a number of factors and considerations.**

While most sizing exercises are best done with sizing programs or with the help of a manufacturer's representative, it is still **important to understand the factors that affect the operation of your generator set so you can be confident you have the right equipment for your application.**

This information sheet details the factors that influence the sizing of a generator set and key load criteria a system designer should take into account. Correct loading of a generator is very important. Light loading can lead to wet stacking and significantly shortened engine life. Engine manufacturers recommend engines do not run below 30% of full load for extended periods. But using a generator too small for the load can result in unacceptable voltage drops and overheating.

The following criteria should be considered when sizing a generator set system:

Check Chart for Determining Tyoe of Load to be Applied to the Generator Set		
Load Criteria	**Load Category**	**Comments**
Application	Standby Power	No overload capacity available for temporary power supply
	Prime Power	Primary power with 10% overload capability
Ambient	Altitude	Check engine derations (turbocharger less than naturally aspired)
	Temperature	Check engine / alternator derations
	Humidity	Up to a maximum of 6% but depends on temperature
Voltage Dip	25% <	Standard AVR should maintain regulation for less than 25% dip
	25% >	Look at PMG for above 25% dip
Frequency	Governor Control	Verify maximumfrequency dip that systems will accept
Reactive Loading (Motors, etc.)	Single Large Motor	Check sizing engine to generator and starting aids
	Several Motors	Stage start with the largest motor first
Non-reactive Loading (Lights, Heaters, etc.)	Essential Loads	These are the loads a generator set has to be sized for
	Non Essential Loads	Some loads could be dropped from stanby circuit considering for standby applications
Electronic Loads	SCR Loads	Lareger size alternator may require for more than 25% SCR loading
UPS Systems	Leading Power Factor	Check with the manufacturer when UPS systems has leading power factors
Phase	Three Phase	Power factor will be 0.8 and requires a three phase generator
	Single Phase	See if single phase loads can be balanced on a 3ph system
Voltage	Configuration	Star, Parallel, Delta, Zig-Zag etc.

Project Parameters & Criteria

- **Minimum generator set load/capacity:** Running a generator set under light load can lead to engine damage, reducing reliability. Load banks should supplement the regular loads when loading falls below the recommended value.
- **Maximum allowable step voltage dip (starting and running):** Various pieces of electrical equipment have different tolerances for voltage dip. (Manufacturer's specification sheets should be consulted for the allowable drop in input voltage). The starting load of electric motors can be six times running load. Starting loads can affect the generator's voltage regulator system by reducing the voltage available. Generators must be sized large enough to ensure the maximum allowable voltage drop to the system is not exceeded.

- **Maximum allowable step frequency dip:** Generator sets produce a nominal frequency, which is 60Hz in North America. Excessive loads can overload an engine's governor system, reduce engine speed and hence generator frequency. The system designer has to take account of the maximum transient drop in speed and frequency the system will permit.
- **Ambient (Altitude and temperature):** An engine requires a certain quantity of air for combustion to achieve its rated power. Altitude, temperature and humidity will all affect the air density. An engine's power rating assumes an nominal altitude of less than 1000 feet, ambient temperature less than 85° F, and humidity less than 75%. Manufacturers detail the percentage reduction in available power for ambients conditions that exceed those assumed for the nominal rating.
- **Application:** Generator set size is also influenced by whether the application is for standby power, prime power or utility paralleling. Standby is an intermittent rating and assumes no overload capability. Standby ratings given by manufacturers can range 10% to 20% higher than prime ratings. Standby ratings assume the set will only have to run for a temporary period during main power interruption and are not for continuous operation or prime power.

Load Characteristics

The next and most important step in sizing a generator set is to identify every type and size of load the genera-tor set will power. In general, when non-linear loads are present, it may be necessary to oversize the alternator.

- **Power factor (PF):** Power Factor (PF) in an AC circuit is the ratio between apparent power measured in volt-amperes and real power measured in watts. This difference is expressed as a percentage. For example, 0.8 PF equals 80%. Real power is the actual capacity of the electrical power source to power the equipment it is connected to. Apparent power is the product of the current and voltage within a circuit. Reactive loads such as inductors and capacitors have energy storage within the load producing a time difference between the current and voltage wave forms. The stored energy returns to the source and is not available to power the load, hence apparent power. An electrical system with a low power factor (less than 0.8) will require higher currents to deliver to the connected load a required quantity of real power than a system with a high power factor. Its important to note the utility company supplies their customers with volt-amperes, but charges them for watts. Three-phase generator sets are rated for 0.8 PF loads and single-phase generator sets for 1.0 PF loads. Lower PFs require larger alternators or generator sets to properly serve the load. Caution should be used whenever applying generator sets to leading power factor loads. Only slightly leading power factor can cause generator sets to lose voltage control.

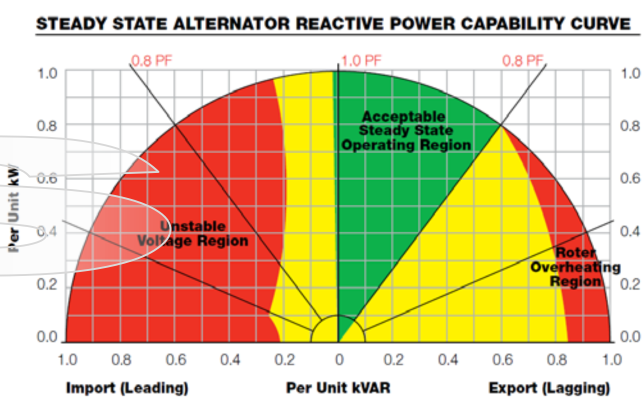

FIGURE 1 – A typical alternator curve of reactive power (kVAR) capability. A reasonable guideline is that a generator set can carry up to 10 percent of its rated kVAR capability in leading power factor loads without being damaged or losing control of output voltage. The most common sources of leading power factor are lightly loaded UPS systems with input filters and power factor correction devices for motors. Loading the generator set with lagging power factor loads prior to the leading power factor loads can improve stability.

- **Single-phase loads and load imbalance:** Single phase loads should be distributed as evenly as possible between the three phases of a three-phase generator set in order to fully utilize generator set capacity and limit voltage imbalance.
- **Peak loads:** Peak loads are caused by loads that cycle on and off—such as welding equipment, medical imaging equipment, or motors. Taking cyclic loads into account can significantly increase the size of the recommended generator set despite painstaking efforts to place loads in a step starting sequence.
- **Motor loads:** Calculating specific motor loads is best handled by sizing software which will convert types of motors into load starting and running requirements. For this discussion, however, it is sufficient to broadly characterize loads as high-inertia or as low-inertia loads for the purpose of determining engine power needed to start and accelerate motor loads.
- **Low-inertia loads** include fans and centrifugal blowers, rotary compressors, rotary and centrifugal pumps.
- **High-inertia loads** include elevators, single- and multi-cylinder pumps, single- and multi-cylinder compressors, rock crushers, and conveyors.
- **Motors over 50 HP:** A large motor startedacross the line with a generator set represents a low-impedance load while at locked rotor or initial stalled condition. The result is a high inrush current, typically six times the motor rated (running) current. The high inrush current causes generator voltage dip which can affect other systems. The manner in which generator voltage recovers from this dip isa function of the relative sizes of the generator, the motor, engine power (kW capacity) and generator excitation forcing capability. Depending on the severity of the load, the generator should be sized to recover to rated voltage within a few seconds, if not cycles. Various types of reduced-voltage motor starters are available to reduce the starting kVA of a motor in applications where reduced motor torque is acceptable. Reducing motor starting kVA can reduce the voltage dip, the size of the generator set, and provide a softer mechanical start. However, these starting methods should only be applied to low-inertia motor loads unless it can be determined that the motor will produce adequate accelerating torque during starting.
- **Variable frequency drive (VFD) motors:** Variable frequency drives (or variable speed) are non-linear loads, which are used to control the speed of induction motors, induce distortion in generator output voltage. Larger alternators are required to prevent overheating due to the harmonic currents induced by the VFD and to lower system voltage distortion by lowering alternator reactance. For example, VFD loads on a generator must be less than approximately 50 percent of generator capacity to limit total harmonic distortion to less than 15 percent.
- **Uninterruptible power supply (UPS) loads:** A UPS system uses silicon controlled rectifiers or other static devices to convert AC voltage to DC voltage for charging storage batteries and are another type of non-linear load. Larger alternators are required to prevent overheating due to the harmonic currents induced by the rectifiers and to limit system voltage distortion by lowering alternator reactance. Past problems of incompatibility between generator sets and static UPS devices lead to many misconceptions about sizing generator sets forthis type of load. Most UPS manufacturers have addressed these issues and it is now more cost effective to require UPS devices to be compatible with the generator set than to significantly oversize the generator for the UPS. Use the full nameplate rating of the UPS for determining load to allow sufficient capacity for generator set battery charging and accommodating full UPS load capacity.

- **Battery charger loads:** A battery charger is a non-linear load requiring an oversized alternator based on the number of rectifiers (pulses)—up to 2.5 times the steady-state running load for three-pulse; to 1.15 times the steady-state running load for 12-pulse. These loads are typically found in telecommunications systems.
- **Medical imaging loads:** These include CAT scan, MRI, and X-ray equipment. The generator set should be sized to limit the voltage dip to ten percent when the medical imaging equipment is operated with all other loads running in order to protect image quality.
- **Lighting loads:** In addition to lamp wattages, ballast wattages and starting and running power factors should be considered.
- **Regenerative loads:** For loads such as elevators, cranes and hoists, the power source is often relied upon for absorbing power during braking. That is usually not a problem when the utility is supplying power because it can be considered as an infinite power source with many loads. A generator set, in comparison, is able to absorb far less power, especially with no other loads connected. Generally, the regeneration problem can be solved by making sure there are other connected loads which can absorb the regenerative power. Excessive regenerative load can cause a generator set to over-speed and shut down.

Load Step Sequence

In many applications the generator set is sized to pick up all loads in one step. In some applications it is advantageous to start up the loads which cause the largest starting surge first and then the rest in multiple steps—the “largest motor first” rule. Codes may require sequenced load starting to start emergency and life safety loads within as little as ten seconds, while allowing other loads longer periods of time. In general, sequenced startup allows the smallest generator set in relation to the steady state load. When cycling motor loads exist, it will still be necessary to size the genera-tor set to start the largest cycling motor last, with all other loads connected.

Future Power Requirements

One last step in the sizing equation has to do with future needs. Power use is not fixed and tends to grow over time. Therefore, any generator set sizing exercise needs to take system expansion into consideration. Even with sophisticated software solutions, the final decision on generator set size needs to be tempered with judgment. And, the more you know about the parameters that affect sizing, the better that judgment will be.

Aksa Power Generation USA & LATAM offer sizing assistance for all applications.