White Gear – Green Mission

Buying Commercial Electric Power Generation for USMC Sustained Operations Ashore

Expeditionary Power Systems
Marine Corps Systems Command
www.marcorsyscom.usmc.mil/sites/pmeps

INTRODUCTION

U.S. Marine Corps units involved in the Global War on Terrorism, to include Operation Enduring Freedom, Operation Iraqi Freedom, and Horn of Africa, are buying Commercial Off-The-Shelf (COTS) electric power generators for several reasons including: (1) Supplement supply of military tactical generators and (2) increased power requirements for unanticipated infrastructure needs. Commands are purchasing these generators, often from the local economy and under an urgent needs basis. This creates a dilemma that manifests shortly after purchase and installation in the form of sustained support and/or replacement.

The purpose of this paper is to provide assistance to using units if they find themselves in need for additional electrical power and must pursue the COTS route. It is hoped this paper can be used as a primer for issues to consider prior to purchase. Wide distribution is encouraged; comments and recommendations for improvement are welcomed. Contact information is provided at the end.

BACKGROUND

Just as operational conditions or environments are extremely complex and varied, providing electrical power to meet these conditions is just as varied. Use of COTS generators in military environments is appropriate where:

1. A commercial generator is acquired for a limited duration (could be lease or purchase).
2. Commercial generators are used in garrison/training to save wear and tear on military standard generators.
3. Unit commanders employ commercial generators for non-mission-essential support of equipment.
4. A commercial generator is the only available option.

Marine Corps Systems Command at Quantico, Virginia, has the mission to field tactical electric power for combat capability. A key part of this responsibility is to procure and field equipment that is organically and logistically supportable. This includes provisioning for repair parts, supporting initial training of operators and maintainers, making available technical publications,

and facilitating the maintenance and supply processes. With a COTS item, the buying command now must assume management and fiscal responsibility for all operational, maintenance, and supply functions. The less expensive commercial generator is often not the most cost-effective or supportable generator available.

Using the comparison that a commercial pick-up truck is no replacement for a HMMWV, commercial generators are not built to the same rugged standard as military generators. Standard features that are on all military standard generators, but will probably not be found in commercial generators, include JP-8 fuel compatibility; strengthened housings and tie-down points for mobility and transportability; 24-volt DC electrical start systems (to allow jump start from a tactical vehicle); paralleling capability; NBC contamination and decontamination; electromagnetic pulse (EMP) shielding; reduced infrared, acoustic and electromagnetic interference emissions; and all-weather operation at rated power under high altitude and extreme temperatures. Out of the almost two dozen different types of Department of Defense mobile electric generators, the USMC buys only a subset of the family, based on the USMC mission of expeditionary maneuver warfare. A key element of the past and future decisions in selecting electric generators for the expeditionary mission of the Marine Corps has been transportability and mobility; this mandates lightweight solutions, and as such, the USMC does not field a mobile electric generator greater than 100 kW.

BUYING COMMERCIAL

So, you now find yourself in the situation where you have to buy, or help someone buy, some commercial generators to support a military mission. Most likely, time is not on your side. The following are issues and considerations to consider so that the equipment purchased can most fully meet the intended purpose.

Fixed or Mobile application: Many commercial primary power generators will do a better job of providing power in stationary applications. They can be lighter, more fuel efficient and quieter, and their engines can last longer between overhauls than tactical/mobile generators. A word of caution when ordering: One has know what you are ordering in the engine portion (primary power unit), which will require you to specify everything (muffler, fuel tank and fuel pumping system, etc.). Most commercial generators will not survive repeated movements on non-primary roads. Also, many engines on the commercial generators are not JP-8 compatible or they have de-ratings if run on JP-8 or JP-5 fuel. That is, they will not provide the same amount of power as they would with diesel fuel. Care must also be exercised to insure that the generator is compatible with Marine Corps trailers and trucks. The large-style fuel tanks sold with many generators can push the weight above the limits of the trailer when the tank is full. Also, many commercial units only have crane lift-rings and no fork-lift pockets and are damaged when tied down with straps thrown over them.

Electrical Load Analysis: Unfortunately, with electric power you will not know if you got it right until you buy it, install it, and turn it on. Even then, someone will always want to plug in more stuff than was planned for. Up-front planning and analysis is critical for getting the right amount and right type of electric power. Some questions that need to be asked and understood up front include the following:

- What is the continuous power need?
- What are peak power needs?
- Are the peak power needs affected by air conditioner or compressor startups (reactive or inductive loads) or by lights and heaters (resistive loads)?
- What is the criticality of electric power?
    - Is it critical, such as would be found in a tactical 24/7 situation where loss of power is life threatening (radar, communications, emergency medical facilities)?
    - Is it required, where extended loss of power is life threatening or would result in additional cost (water purification, fuel farms, chow hall, intermediate maintenance)?
    - Is it important, but non-tactical / non-life threatening (billeting; morale, welfare and recreation)?

Power Rating: Generator vendors and the military use different ways to rate their equipment. A commercial generator assembly will often be rated in KVA (kilo volts-amps). This is generally used when specifying a high-voltage output generator (5,000 volts to 15,000 volts). The vendor will also, or should, provide the effective kilowatt output (eKW). This is generally about 80 percent of the value of the KVA rating and is what should be used when doing an electrical load analysis. (KW = KVA x .80). The military uses a power factor when specifying power rating; military tactical generators are nominally specified for the kW output at a 0.8 power factor. Power factor and eKW are not the same. The eKW is the actual amount of output the generator can provide when a load is put on it. The military power factor is specified to handle reactive and inductive loads and their adverse impact on true available output power—power fluctuation caused by various loads turning on while the generator is running. Although it makes the military generator heavier, it is necessary. A lot of military tactical systems would not work properly (i.e., a user plugged a 10 kW load into a 10 kW generator) without this rating system.

Stand-by or Prime Power: Vendors also specify generators for Prime Power (continuous) or Stand-by Power load (intermittent). Stand-by Power is used for short durations of a few hours or days at a time. Preventive maintenance servicing is required after approximately 24 to 36 hours of operation. Stand-by power generators are less expensive than Prime Power generators. Standby Power generators are also not as tough as Prime Power generators and will not last as long. Prime Power is used for extended periods of time. They can provide up to six weeks' runtime before servicing is required.

(Note: Manufacturers maintenance servicing standards vary.)

You do not want to buy a stand-by generator and run it 24/7, unless you want to replace it frequently. For equal power output, a Continuous Prime Power generator will cost more than a stand-by generator.

Type of Power Distribution: When power generation is installed, there are several arrangements of the power distribution that should be considered. These definitions are used in military planning and carry over to commercial applications:

- Is the power source a dedicated system (i.e., not grid power, may need to be mobile, possibly used in a remote location)?
- Is the power source exclusive (i.e., special type of power such as high-**Y** or 400 Hz)?
- Is the power source part of, or supporting, a static grid?

Each of these type powers have layout implications and affect the selection of generators. In a dedicated or exclusive arrangement, the generator can be sized more closely and specified for the targeted power consumer. But this arrangement needs to provide its own back-up capability. In a grid arrangement, back-up power is more easily accomplished, but the primary generator now needs to be selected and installed with proper support systems (see Auxiliary Equipment below) to work properly with other power sources on the grid.

Host nation standards or U.S. standards for power output: A key issue to try to address up front is what the intended purpose of the power generation equipment is for the lifetime of the equipment being supported? Are you powering traditional U.S. equipment designed to operate on 120 Volts AC (VAC) at 60 Hz, or will the power be used to support equipment that needs 240 VAC at 50Hz, or something special, such as 440 VAC / 50Hz? Or is there an aviation or unique radar system that requires 400 HZ power? Although these specialty power outputs are not impossible to satisfy with commercial generators, they will require longer lead time to acquire. But a key issue to address is what will be the next power source for the equipment once this generator assembly needs to be replaced or when host nation power is brought on line to sustain the mission? If the equipment requiring power is 120 VAC/60 Hz and the power generators are 120 VAC/60 Hz, this is fine until host nation power is brought in at 240 VAC and 50 Hz. At this time, all the power-consuming devices need to be switched out, or power converters for both frequency and voltage conversion need to be installed between the incoming power lines and the target equipment. The system planner may want to consider installing generators with the output power configuration of host nation power, and then install the converters up front. This would allow for a cleaner installation and less confusion downstream when power is cut over.

Installation Guidelines: Buying the generator(s) is only one piece of the puzzle. To go along with the generator are several installation and facilities issues that must be addressed:

- ALL GENERATORS NEED TO BE PROPERLY GROUNDED.
- Will the generator be placed inside a building or sitting outside on a concrete pad? Fabrication of a building is highly subject to local building costs and contractor available services, but it may cost from $20 to $100 per square foot to erect (from scratch). Access for installation, servicing and maintenance, and replacement have to be considered early in the design.
- If installing on a concrete slab ($50 to $100 per cubic yard, plus labor), access again needs to be considered.

- If installed outside, an enclosed generator with sides and doors might be more desirable. If installed indoors, an open-frame, open sided generator may suffice.
- For very large generators, the strength of the concrete pad needs to be considered. For small generators, this is not as much of an issue.
- Vibration dampers or shock mounting should also be considered in case any delicate equipment is in close proximity to the generators.
- Fuel storage and routine refilling access need to be considered. For large power sites, the fuel consumption becomes a sizeable management issue. If fuel trucks are going to routinely service the site, road construction, upgrade, or maintenance might be needed.
- Fuel truck delivery routes need to be considered while making multiple fuel drops during the day. Do not place the fuel tank where it requires the truck driver to do sharp turns or a lot of backing up.
- Protection of the fuel tanks and generators from errant vehicles is always a wise idea.
- Protection of power lines (buried, covered, overhead) between generators and the end user needs to be considered.
- When it comes to a fuel site, military units in overseas locations are required to follow environmental guidelines just as if they were in the continental United States. Fuel spill containment, for both generators and fuel tanks, is necessary. If the generator placement is a long-term venture, a permanent arrangement might be worth considering, versus flexible catch pans.
- If the intent is to provide critical power on 24/7 basis in a remote or Third World situation, consider a three-generator configuration. Two generators would be on line and the third on stand by. The time it takes to get parts or a generator repaired can be measured in days or even weeks, and you don't want to have to operate without backup for that long.

Support Approach: As previously stated, generators run on air and fuel, but do not forget the other legs of the stool: operations, maintenance and support. Although generator assemblies have become very reliable due to many technical marvels, they still require routine maintenance plus site support for more in-depth servicing when the need arises. The procuring activity MUST budget for and procure contractor logistics support services to go with commercial generators. Marines with electrical technician training (MOSs 1141,1142) and diesel mechanic training (MOS 1341) are in short supply, and they will not have knowledge on the myriad of commercial generators available. At a minimum, the procuring activity should procure routine scheduled maintenance (in accordance with the original equipment manufacturer [OEM] guidelines) and should procure an operations/maintenance manual with a parts list break out. This material should reside with the generator or the person in charge of the purchase.

Equipment and Maintenance Cost: One vendor of large commercial power generation systems provides the following rules of thumb when it comes to costs for equipment purchasing

and maintenance. All prices are highly dependent on the location of installation, quality of service provider, whether new or used equipment is specified, and local economy dynamics:

- Equipment cost: $400-500 per eKW for small generators (100-300 kW)
- Equipment cost: $300-500 per eKW for larger generators (> 1 MW)
- Maintenance cost per service interval: $0.010 - $0.015 per eKW-hr (100-300 kW)
- Maintenance cost per service interval: $0.008 - $0.010 per eKW-hr (> 1MW)
- Service Interval: 10,000 - 15,000 hours (1-2 years at 24/7)

It should be noted, maintenance cost is highly dependent on load requirements, site conditions, fuel quality, and diligence in following routine preventive maintenance (changing filters, belts, fuses, etc.). It should also be noted that most generators less than 1 megawatt use automotive-based diesel engines (for weight savings), and these engines are only rated for 5,000 to 10,000 hours between major overhaul. A major overhaul requires the removal and complete tear down of the assembly, effectively taking it off line and out of service for a significant period of time. These service intervals also assume routine and preventative maintenance is being accomplished. Un-serviced equipment and harsh environments greatly degrade the life of a generator. Keep in mind, if running 24/7, one year's run time will rack up 8,760 hours.

Auxiliary Equipment: In addition to the generators installation and operation, there are multiple other pieces of equipment that might need to be considered and possibly procured. It is best that knowledgeable, trained individuals are consulted to decide when these items are appropriate:

- **High-voltage transformer / Low-voltage distribution –** To reduce copper cost, line size, line weight, and voltage drop, certain applications will work with high voltage (5000-15,000 volts). Step-down transformers are then trequired to get the voltage to consumer-level power. This is an added cost. It is also an added footprint on the ground in order to provide a safety buffer around these transformers. CAUTION: In the United States transformers used to be manufactured with carcinogenic PCBs, but this is now outlawed. It is possible that in some foreign countries these devices might still be in use and potentially sold to an unsuspecting buyer.
- **Switchgear network protection** – At both working voltages and high voltages, switchgear might be required if more than one generator is installed and the load is switched between them either for maintenance purposes or load sharing. This is also recommended to protect the generator from damage due problems on the load side. To include a feature like this requires selection of a compatible generator since it will require an integrated controller on the generator set itself. Then a stand-alone switchgear controller will be required. In addition to the upfront purchase costs (highly dependent on voltage and configuration), this capability also requires on-site setup by the OEM. Don't skimp on this—it is critical to buy this in order to make the system work properly.
- **Automatic Transfer Switch –** Similar to switchgear that allows the mechanics of load sharing and power output, the brains behind the scene to allow unattended operation and cut over to backup power, or to balance run time between multiple generators, is

performed by an automatic transfer switch. The other option is to pay for an operator on-site full time to manage load and generator cycling.

- **Remote monitoring** – More and more systems from the big vendor these days offer remote monitoring and other support features. This will require communication infrastructure at the site but can potentially save on manpower costs. Remember, a decision made up front for this capability (or several of the other capabilities) requires sustained support downstream to keep the contractor service in place and to take action once a warning or notice of required service is received.
- **Uninterruptible Power Supply (UPS)** – Depending on the application and criticality of type of power, a UPS may be warranted (similar in concept to what a homeowner or office worker might have hooked up to his/her personal computer). This is one area where detailed engineering and perception of logistic supportability need to be factored in. A key requirement for UPS sizing is the amount of "ride-through" time that the system has to provide between the main generator going down and a back-up generator coming on line. If the back-up generator is on site, this could be measured in seconds and full power might be sustained by the UPS during the course of a generator dropping off line. If a back-up generator has be rounded up and brought in from another site and hooked up, this "ride-through" time could be measured in hours. Again, criticality of power and logistics supportability drives this sizing exercise.
- **Paralleling** – This is a military term for an inherent capability in our tactical generators. This allows multiple generators to be interconnected and share a load so that if one generator goes off line, the load is not dropped. This functionality can be derived through use of many of the systems described above, but rarely is it inherent in a COTS generator in the way military operators come to expect it today. The COTS equivalent to paralleling is making a generator "grid-able," which means it can work with central power and place power back on the grid when not needed by its dedicated facility.
- **Lightning protection –** If the power is to be carried over poles or involves an outdoor switching yard, then lightning protection and network protection are a must.

Engineering support: Many of the features described above are available from multiple sources, but the buyer needs to be smart when specifying a system. Most large suppliers of power generators offer engineering support to design and layout a system to meet the customers need. Again, using a rule of thumb from one vendor, this service is generally provided at 5 percent to 7 percent of the cost of the equipment. The Marine Corps Systems Command, Program Manager for Expeditionary Power Systems (PM EPS) at Quantico can help with preliminary planning. However, the command has neither the resources nor sufficient personnel to perform detailed analysis.

Selecting and Buying Generators: For government contracting officers and project officers in need of a commercial generator solution, there are several recommended courses of action:

- **GSA federal buying schedule -** Acquisition regulations stipulate that federal buying schedules should be first consideration for goods and services. The General Services Administration has many schedules (contracts), to include power generation. The first

place for looking should start at www.gsa.gov. PM EPS has performed many of these data searches and can assist with this process.

- **Contingency Contracting -** Realizing the luxuries of continental United States buying strategies are not available when deployed, and local policies might dictate local economy support as first choice, provided below is assistance if it becomes necessary to specify and buy a generator locally.

- **Example of Commercial Specification -** In support of an urgent Operation Iraqi Freedom requirement for a HMMWV-towable, 20-kilowatt generator for the AN/TRC-170 communication suite, Marine Corps Systems Command procured commercial generators due to lack of a military tactical system in the right size and weight range. On the following page is the commercial based technical specification the Marine Corps used in procuring this system. Persons who need to develop a commercial specification are welcome to take and tailor this for their needs.

Point of Contact: This write up is provided as a service to the Fleet Marine Force by the Program Manager – Expeditionary Power Systems at Marine Corps Systems Command, Quantico, Virginia. It is not intended to be a mandate of how to do business but as information to assist in performing a difficult assignment. Comments and recommendations are welcome to improve the provided information. Any recommended changes and sources of additional information can be sent to pm_eps@nmci.usmc.mil. In addition, Power System Field Service Representatives are co-located at I, II, and III MEF, as well as deployed with II MEF to Iraq. They are available as technical experts to help in planning and are provided at no cost to using units. Names, email addresses, and physical locations of each of the FSRs can be obtained by contacting the above email address. The reader is also encouraged to visit the PM EPS web site at www.marcorsyscom.usmc.mil/sites/pmeps for technical discussion on this and many other topics related to Marine Corps power systems.

DESIRED ATTRIBUTES FOR COTS PURCHASED GENERATORS

A. It is desired that the generator shall operate at altitudes of 10,000 feet, at full load, for eight (8) hours unattended.

B. It is desired that the generator and all components shall be capable of operating in temperatures ranging from -25 degrees F to +135 degrees F (or IAW local requirements.)

C. It is desired that the generator shall have individual circuit breakers for each output.

D. It is desired that the generator be capable of resisting corrosion in salt air environment, with components resistant to surface blistering, material loss or breakdown, chalky residue, or loss of electrical conductivity.

E. It is desired that the generator shall incorporate an “anti-wet-stacking” feature to accommodate less than optimum power loads.

F. It is desired that the generator shall be painted with a water-reducible, Chemical Agent Resistive Coating (CARC) paint (ref MIL-P-64159).

G. It is desired that the generator shall provide a self-contained stowage of manuals, equipment, and any associated tools.

H. It is desired that the generator shall have a keyless starter switch.

I. It is desired that the generator shall be covered under an extended commercial warranty (terms to be provided by offeror).

J. It is desired that the generator shall not have a flow-through warranty for installed components, but address warranty issues directly.

K. It is desired that the generator shall be provided with a battery management system for de-sulfation.

L. It is desired that the generator shall be provided with a rapid oil change capability.

M. It is desired that the generator shall be provided with a grounding rod set and stowage.

N. It is desired that the generator be multi fuel capable to run on DL-1, DL-2, and JP8.

O. It is desired that the generator shall be provided with a fuel/water separator.

P. It is desired that the generator shall be provided with a low fuel shutdown with indicator.

Q. It is desired that the generator shall be provided with a sealed, maintenance free battery.

R. It is desired that the generator shall be provided with a battery compartment that can accommodate a military style 6T-form factor (standard MEP generator) battery.

S. It is desired that the generator shall be provided with an EPA compliant engine that remains unchanged for the anticipated duration of USMC procurement (2005-2009).

T. It is desired that the generator shall have no peculiar or special support equipment for operator and intermediate level maintenance.

U. It is desired the generator shall be third-party listed.

V. It is desired that the generator shall have a durable instruction data plates (or diagram plates), describing operating, servicing, schematics, safety measures and lubrication

procedures.

W. It is desired that a daily operator functional inspection should take no more than 10 minutes.

X. It is desired that preventive maintenance (PM) procedures associated with the operational intent of the generator shall not exceed 30 minutes.

Y. It is desired that the generator shall have a synchronizing capability to allow uninterrupted transfer of power between two like generators.

Z. It is desired that an ability to synchronize with another like generator be provided so that load can be transferred.

AA. It is desired that an ability to parallel with another like generator or external power source be provided so that load can be split or shared.

BB. It is desired that the generator shall provide a power distribution and control panel for imported external power.