CLIFFORD Power Systems, Inc.

GENERATOR SALES, SERVICE, RENTAL AND PARTS
INDUSTRIAL / COMMERCIAL

GENERAC INDUSTRIAL POWER

Planning Electrical System Reliability

A New Way to Think About Large KW Standby Generator Applications

- *One large standby generator set (traditional).*
- *Or, two or more generators paralleled to achieve the same output.*

MEMBER EGSA Electrical Generating Systems Association

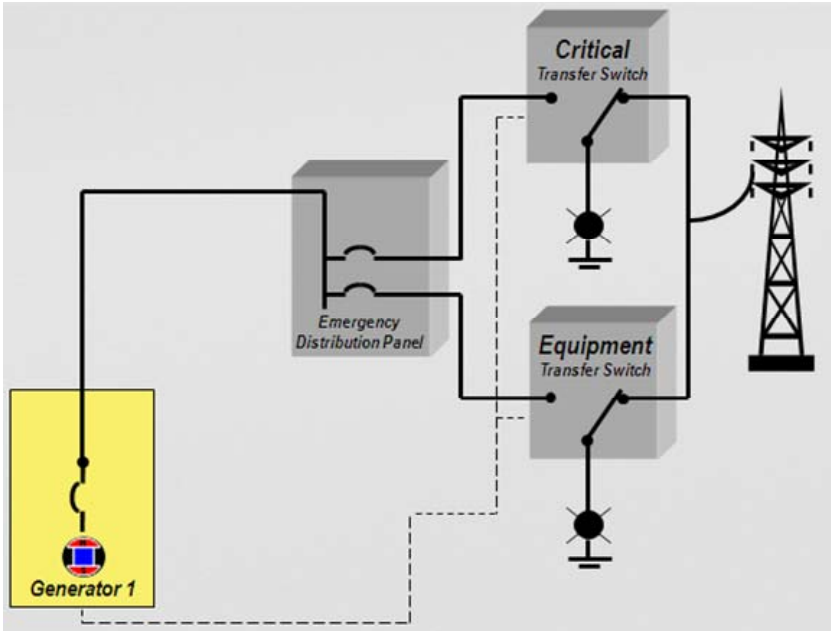
Advantages of a single large KW Standby Generator Set:

- Proven design, many installations in existence.
- Relatively simple system design.
- One generator to set, connect and troubleshoot service issues.

Disadvantages of a single large KW Standby Generator Set:

- **Single point of failure can render the entire system useless**. No redundancy for critical loads.
- Expensive to purchase and usually long lead times.
- Large natural gas fueled engines are very expensive and are usually not considered because of budgets.
- Potential for costly engine or alternator repairs.
- Load Bank Testing and planned maintenance usually requires the entire system to be taken off line.
    - In critical applications, planned maintenance and load bank testing can result in higher costs if performed in maintenance windows that usually entail overtime charges.
    - Sometimes an end user will require that a backup (rental generator) is connected and operational before maintenance and load bank testing can be performed on their permanently installed generator. Utilization of this backup power source still:
        - Requires a switchover time allowance.
        - And, it will increase the cost to perform the service. The additional cost will include labor to connect and then disconnect the temporary unit, rental costs and transportation.

Traditional Single Standby Generator Installation



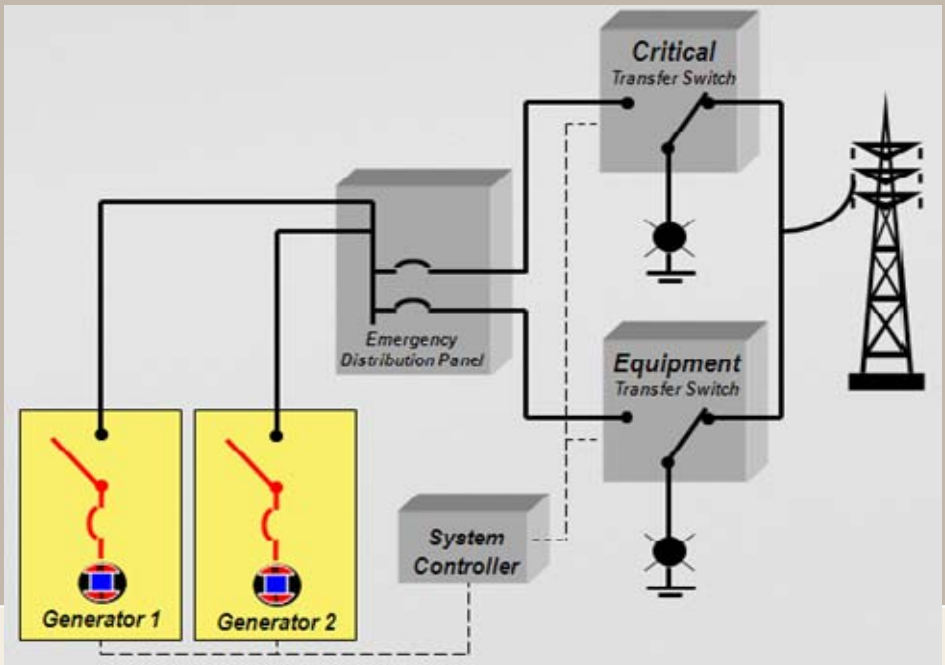
- In installations that are lightly loaded but have been sized for future capacity, engine “wet stacking” issues can arise.
- Less installation location options because of weight, size and airflow requirements.
- Heavier capacity material handling equipment needed to install the generator.
- Higher freight charge potential for oversized loads.
- Heavy weight capacity concrete mounting pads and vibration isolation considerations required.
- Potential for a significant amount of on-site generator assembly (Fuel Tank, Enclosure, Vibration Isolation, Exhaust System including welding). This on-site assembly is usually performed by the installing contractors. Many times this is an unexpected cost to installing contractors.

Powering Innovation

Utilizing Generac MPS Paralleled Generators for a Standby Generator Installation

Please note the Generac MPS system does not utilize expensive electrical switch-gear to parallel generators as traditionally used in the past.

The cost of purchasing these complete systems is comparable to or less than an equivalently sized single generator solution.



Advantages *of* ***multiple*** *generators paralleled to achieve a large KW Standby Generator Set requirement:*

- **YES!** Proven design, many installations in existence.
- System Redundancy for Reliability
  - In a properly designed system there is a high degree of reliability to critical system loads.
  - Individual units can be taken off line for maintenance and testing while maintaining backup for critical loads.
- **Scalability.**
  - Only install or operate the number of kilowatts needed at the time of initial installation. This results in lower initial capital costs and operating engines more efficiently to prevent "wet stacking". Additional capacity can be added as needed.
- Large Natural Gas Fueled generator installations can be assembled for a fraction of the cost of a single engine natural gas system. Or, if desired, diesel fueled and natural gas fueled generators can be combined to form the overall KW output requirements.
- **Flexibility.**
  - Generator sets are small enough to fit into spaces that can't accommodate large units. Also, generators are light enough for rooftop applications and many are small enough for parking garage consideration. Since modules don't have to be physically located together, you can better utilize available space.
- **Serviceability.**
  - Individual generators can be taken off line for routine maintenance while others remain on line for potential backup to critical loads.
  - Overall cost to maintain more, smaller engines will be comparable to one large engine.
  - A smaller engine can be serviced quicker than a large one. Some large engines can be out of service for as long as a full day.
  - Collectively, smaller engines will consume less oil and coolant than a large engine. This lower usage of fluids is environmentally friendly.
  - Higher volume production engines will typically have better local parts availability.
- In most cases generator assemblies arrive at a job site fully assembled.
- Lighter, smaller generator packages are easier and less costly to install.
- Less weight generators do not require as substantial a concrete mounting pad as a larger system.

Disadvantages of multiple generators paralleled to achieve a large KW Standby Generator Set requirement:

- In a system that does not shed less critical loads reliability can go down if a single unit fails.
  - This scenario can be eliminated and turned into an advantage with a well designed system.
- Depending on the number of units it can take up additional real estate.
- Requires technicians specifically trained on the paralleling system for troubleshooting and repair of paralleling issues. (Clifford Power Systems, Inc. has the knowledge and expertise.)

To illustrate how reliability increases by utilizing multiple generators, please examine the table below.

Generator System Reliability

Number of Generators in the System	Level of Redundancy for Critical Loads			
	None	N+1	N+2	N+3
1	98.0%			
2	96.0%	99.96%		
3	94.1%	99.92%	99.999%	
4	92.2%	99.88%	99.998%	99.99998%

First, the reliability for a single generator solution is set to 98%. This is a number utilized within the nuclear industry for reliability studies. An assumption is made that the generator is being well maintained and tested regularly.

If we examine a three generator system, we see that the most critical loads in the system, illustrated by the N+2 column, will benefit from five nines of reliability. The priority two loads in the system also benefit from an increased reliability of 99.92%.

In a paralleled generator system critical load reliability always increases provided the system incorporates load prioritization and a load shedding scheme. This can also be achieved by adding extra generation capacity. Load prioritization, load shedding and extra generator capacity will avoid system operation in the first column. The load prioritization and shedding plan can best be accomplished during the design stage of the system.

To prioritize loads during the design phase, the following steps can be followed.

1. Determine the number of priority loading steps (up to three in a Generac MPS system).
   A. Additional steps can also be achieved by utilizing internal transfer switch timers.
2. Determine the highest priority loads that need to be backed up.
   A. These loads should be grouped together if possible so that they are being fed by one or more distribution panels.
3. Determine the second highest priority loads that need to be backed up.
   A. Again, these loads should be grouped together if possible so that they are being fed by one or more distribution panels.
4. If three steps are desired, determine all other lower priority loads that need to be backed up. Group these loads into one or more distribution panels.
5. Determine a load prioritization/shedding scheme utilizing transfer switches, shunt trip breakers or a building power management system as shown below and add the necessary transfer switches and/or control wiring to achieve the desired outcome.

Load prioritization can be accomplished via:

- Transfer switches:
  The Generac Power Manager-System Controller (PM-SC) will allow up to three permissive steps.
  This will insure that up to three different steps of priority loading can be obtained based on available power.
  As a transfer switch option, load can be shed by transferring lower priority transfer switch loads into a neutral position in the event of a partial system failure.
- Utilizing the Generac PM-SC load shed signals to trip downstream shunt trip breakers (requiring manual reset).
- Utilizing the Generac PM-SC load shed signals to building management systems or directly to specific equipment.

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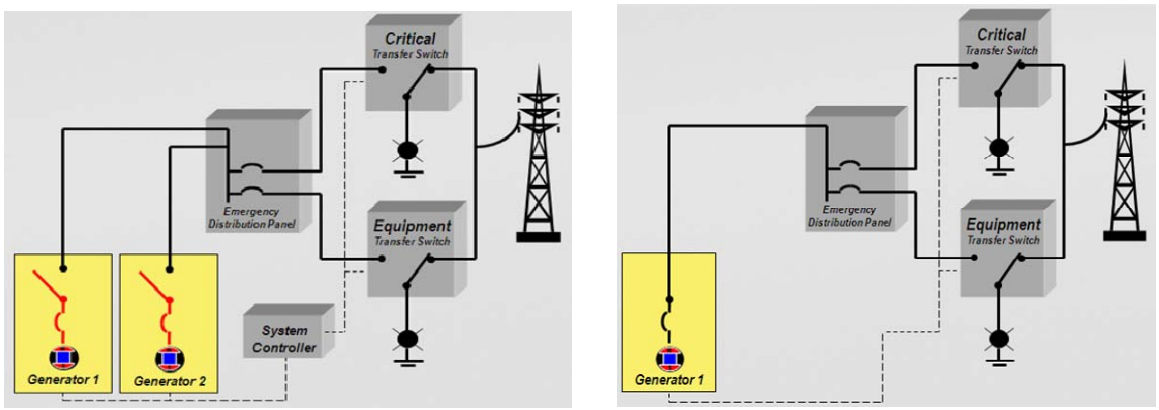
Large Standby Generator Systems, A final word:

The reliability and expense of installing a large generator system entails careful consideration. The use of a large, single generator backup power solution is a viable and usually safe option but there are some significant drawbacks. A paralleled solution provides a compelling argument for an end user because of critical system reliability and maintaining end user uptime during routine maintenance. In almost all large KW requirement applications the multiple paralleled solution makes good, logical sense.

Side-by-Side, the advantages are clear:



Multiple vs. Single

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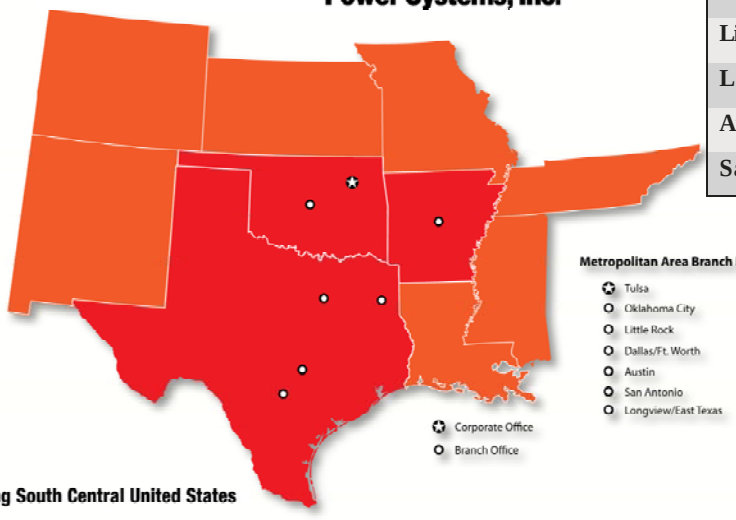

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