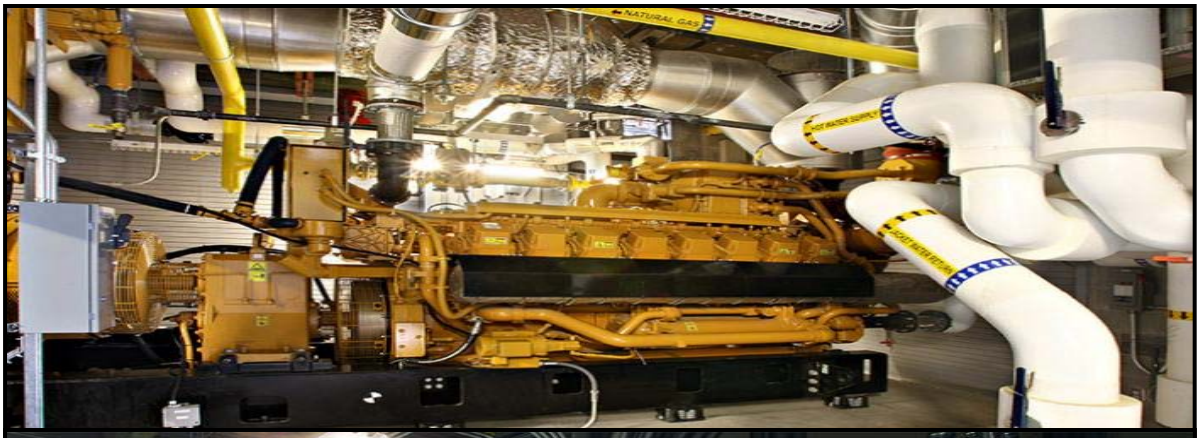
TMR ENGINEERING

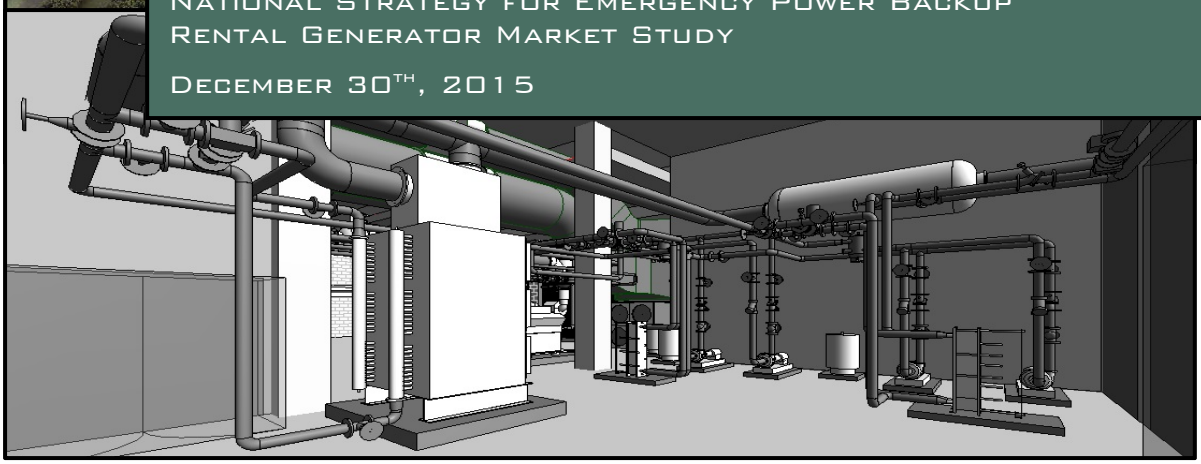


MECHANICAL | ELECTRICAL | PLUMBING

Electric Infrastructure Security Council

National Strategy for Emergency Power Backup
Rental Generator Market Study

December 30th, 2015



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Executive Summary

EISC contracted TMR Engineering to study the market availability of mobile standby power generation systems. The scope of the study includes systems that can operate in a long-duration outage (more than a week) and is confined to the 3 largest market share manufacturers. However, TMR did research other vendors to increase the validity of the study. This study details the types of mobile generators available, range of capacities and operating parameters, estimated costs to procure, and total market wide inventory of power generation assets.

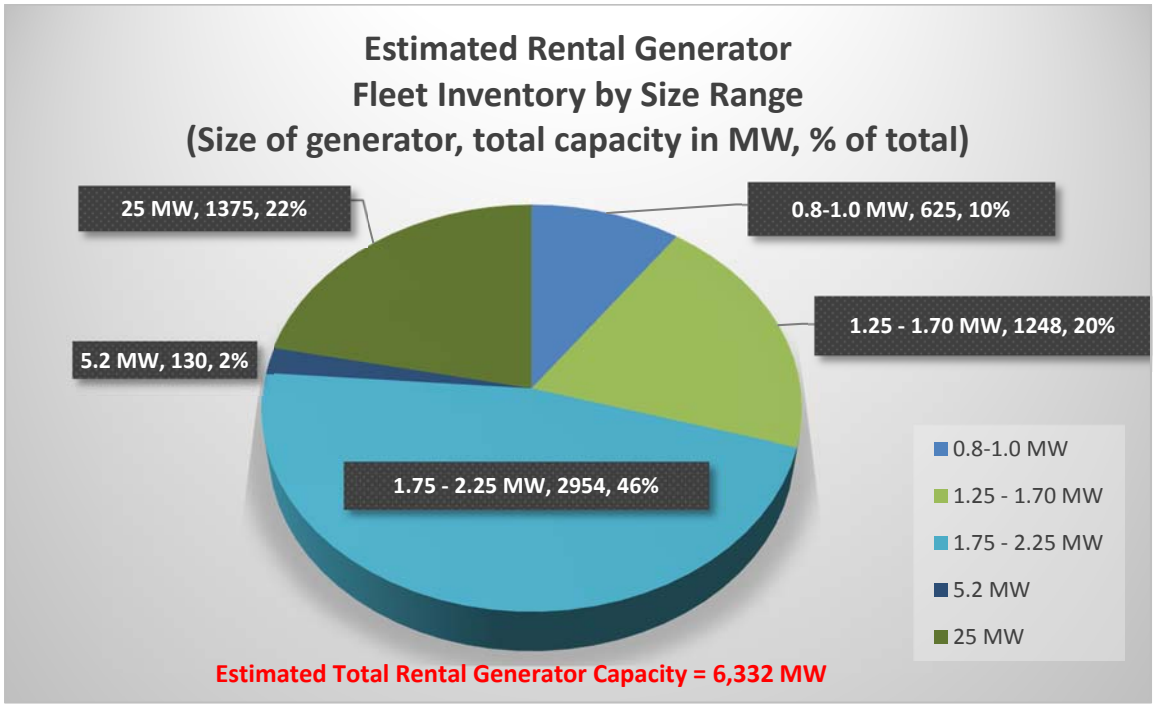
The power generation systems and equipment market is loosely divided into three major areas including the residential scale market ranging from 0.5 to 50 kW, the commercial scale market ranging in size from 25kW up to 4 megawatts, and the utility scale market includes turbine generator sets from 1200 KW up to 30 MW, capable of paralleling up to 200-400 MW or larger. Systems that are 2 MW and smaller can be transported in one container pulled by a semi tractor. Turbine based systems larger than 2 MW typically require two or three containers pulled by semi tractors.

Although purchase of new generators can require a 10-24 week lead time depending on size, rental generators 2 MW and smaller can typically be deployed in 2 to 8 hours assuming the generator is in the same area as the outage. Additional transport time is required if the generator must be transported from other regions. It is difficult to estimate the time required to tie-in these generators depending on whether the building has made provisions to connect a rental generator. Larger turbine based solutions can be transported in similar timeframes and setup in 1-10 days depending on the level of site preparation that has been completed.

Generator rental companies offer contracts to reserve generators for critical users so the generator can be delivered to the site during an emergency need. The cost of maintaining a 2MW diesel generator in a contingency arrangement may be estimated at $9,000 USD to $12,000 USD per month. The cost of renting a 2 MW generator is approximately $24,000-$30,000 USD per month for 24 hour backup operation. Fuel is not included in the base rental structure. An additional $9000 per day fuel charge is to be expected for the same generator. Additional costs for delivery, setup, oil changes every 250 hours of operation, and complicated installations can be expected.

In addition to the obvious shortages of generators and fuel that would occur during a black sky event, respondents actually reported that the two largest problems encountered during previous natural disasters was a shortage of cabling and of skilled labor to deliver and connect these generators. After all, connecting a rental generator to support a large building load can be complicated, requiring significant field engineering. Buildings that are well prepared for rental generator connections have a much higher success rate of actually procuring a generator and getting it connected properly. Some buildings are equipped with a pre-wired connection cabinet with quick connect compression lugs to facilitate rapid connection of an emergency power

generator. This is a cost effective best practice for buildings that cannot afford purchasing a permanent standby power generation system. This will also reduce the strain on installation labor and required cabling.



The chart above shows a total esetimated rental generator capacity of **6,332 MW inclusive of generators in the 1.0 MW size class and larger**. Using the utilization rates provided by each vendor, this equates to only about **2,652 MW of estimated capacity that is available for rent on any given day**. However, this assumes that any generator on this list is appropriate for any load that needs to be served. In reality, an estimated 1,475 MW of capacity (about 25%) is available in the form of large turbine generators ranging in size from 5 MW up to 25 MW. These generators will not be useful to support large single building loads because they are too large for this application. These units are more appropriate for substation level tie-in to support multi-building facilities. Applying the vendor provided utilization rates to these units and dropping these large scale generators out of the equation results in a **total estimated market availability of about 1,977 MW of capacity in the 0.8 MW to 2.25 MW generator size range**.

1.0 Process Summary

1.1 Scope

EISC contracted TMR Engineering to study the market availability of mobile standby power generation systems. The scope of the study includes systems that can operate in a long-duration outage defined as more than one week. Generators studied include only those large enough to support major infrastructure nodes such as water treatment plants, natural gas compression stations, and large food distribution facilities. This threshold was defined at 1.0 MW and larger.

The study is confined to the (3) largest market share manufacturers. These were initially believed to be Caterpillar, Cummins-Onan, and MTU. However, the rental generator market is comprised of generator manufacturers that also rent their product as well as 3rd party power generation rental companies that have no manufacturing capability. For this reason, TMR reached out to the top (3) in both categories.

1.2 Purpose

This study seeks to confirm the following:

- Types of mobile/transportable power sources available.
- Range of capacities/sizes/characteristics of equipment available.
- Estimated costs to procure a mobile/transportable power source and estimated costs for adjustments to the specs, including electromagnetic pulse (EMP) hardening
- Market wide inventory of power generation assets from the 3 largest market share manufacturers/distributors.

1.3 Methodology

TMR has established contact with not only the largest diesel fuel oil internal combustion engine manufacturers, but also with manufacturers of turbine driven generators and 3rd party rental generator companies. The following organizations were contacted.

Generator Manufacturers with Rental Generator Operations

- Caterpillar
- Generac

- Cummins/Onan
- MTU
- GE
- Mitsubishi Heavy Industries – Pratt Power Systems
- Kohler

Third Party Rental Generator Companies

- APR Energy
- Sunbelt Rentals
- United Rentals

Each respondent was interviewed and asked to describe the type of rental power generation systems they provide, their cost, lead time, installation logistics, best practices, and total inventory. Specific questions were targeted to understand how well equipped they were to respond to events like Hurricane Sandy and Hurricane Katrina.

In many cases, the data provided was incomplete or required additional interpolation. TMR processed this data to arrive at the most reliable conclusion possible. A summary of these assumptions is provided along with the total inventory summary.

2.0 Generator Market Overview

2.1 Market Breakdown

The power generation systems and equipment currently in the market place include electrical generators made for recreational use and home power back-up all the way up to power plant (utility) scale. This market is loosely divided into three major areas:

Residential Market

These smaller units are in the range of 500 to 50,000 watts (0.5 to 50 kW) and use gasoline, natural gas, propane and diesel oil as fuels. Portable units tend to be available with either gasoline or diesel oil as fuels. Stationary, permanently installed units are typically either natural gas or propane fueled. Residential scale systems typically are not equipped with paralleling capabilities to create banks of larger power supplies since this is not required by the load in this market.

Commercial Market

The commercial market demands are typically larger than home systems and the commercially available generators include many smaller units from 25kW up to 4

megawatts. These units are available in diesel, natural gas and a variety of other types of combustible gases such as landfill gas, biogas, and sewer gas. Some sizes are available in duel fuel capability as well. The majority of this market relies on internal combustion engines, but there are also manufacturers such as Capstone and Flex Energy that make micro turbine gas generators.

Mobile rental units are typically diesel powered internal combustion units and are only available up to 2 MW in capacity. However, onboard and external paralleling capabilities allow multiple generators to work in tandem to support much larger loads…typically in the 6-20 MW range.

Utility Scale Market

The utility scale market includes turbine generator sets from 1200 KW up to 30 MW. These use natural gas, diesel and liquid distillate fuels and are available with paralleling capabilities, typically in the 200-400 MW range, although theoretically even larger loads could be supported with this arrangement.

Several manufacturers make utility scale mobile rental turbine generators such as the 25 MW GE TM2500+ turbine, the 30 MW Pratt Power FT8, and the 5.2 MW Caterpillar XQ5200 based on the Solar® Centaur 60 model.

Utility Scale generators require utility scale tie-in locations on the medium and high voltage electric distribution grid, typically at either 35 kV or 15 kV grid nodes.

The units considered in this study are representative of the larger end of Commercial Market and Utility Scale market. The manufacturers of these power generators have a wide range of units and listed in this study are the several sizes considered most applicable to the events being considered. This discussion also lists some of the peripheral equipment necessary for operation. These include fuel oil storage tanks, power cabling, fuel oil pumps and urea systems. The individual scenarios are completed with a discussion of the placement of units.

2.2 Cogeneration (Combined Heat and Power)

Gas driven engines typically are not used for emergency life safety power backup due to the inability to quickly handle large load additions at startup as required by the National Electrical Code. However, there are exceptions to this, especially with units less than 500 KW.

Gas driven engines and micro turbines specifically designed for base loaded distributed power generation are growing in market acceptance. These systems are typically installed as part of a combined heat and power application which relies on waste heat from the prime mover to offset the building's heating loads, thereby providing a lower total cost of energy. Such systems are often deployed with black start capability to allow the system to run in island mode while utility power is unavailable.

Although combined heat and power systems have been deployed at campus level power plants for years, utility incentives and low cost natural gas have made building level systems an economically viable solution for many buildings with 24/7 baseline electric and thermal load such as hospitals, medical research facilities and industrial facilities. This type of system provides a meaningful power reliability upgrade to even robust buildings such as hospitals because natural gas operation

2.3 Generator Procurement Lead times

Permanently Installed Generators

To purchase a permanently installed generator above 1 MW in size, the lead time on production is typically 12-18 weeks. Smaller generators are typically available in 10-12 weeks. Custom units with EMP hardening, non-standard voltage output, or specialty switchgear/paralleling configurations can take greater than 24 weeks to procure. Large scale gas turbines can have lead times as long as a year.

These lead times only account for the time it would take to bring the generator to the site. Installation of a generator could take anywhere from 6 weeks to 24 weeks when considering all of the other site preparation related activities that must occur such as engineering, permitting, pouring a concrete pad, connecting electrical feeders to existing power distribution gear, etc.

Mobile Rental Generators

Mobile rental units 2 MW and smaller in capacity can be delivered via a single container tractor trailer. Typical response time from the time the phone call goes out to the time the generator arrives onsite is 2 to 8 hours under normal conditions. Since the primary mode of transport is by road, this delivery time is subject to traffic conditions and generator location. Generators are routinely driven across the country in the case of a large scale natural disaster, extending response time to 48 - 72 hours.

Mobile utility scale turbine generators in the 5-30 MW range can be delivered in either two or three trailers, depending on the vendor. In the case of Pratt Power's FT-8 Mobilpac

unit, the first trailer contains the gas turbine, electric generator, exhaust collector, diffuser and engine lube oil system. The second trailer carries the 15 kilovolts switchgear, control system, operation panel, protective relays, batteries and charger, motor control center and the hydraulic start package. At this scale and criticality of emergency power backup, these systems are routinely flown around the world on transport aircraft. Whereas road transport costs are in the range of $5-15k, costs for overseas air transport delivery can be upwards of $200,000 per unit. Websites advertise these systems can be installed in one day, but that scenario assumes site preparation has already been done. Many of these types of utility scale deployments involve multiple generators paralleled together to create larger power plants. In those cases, we understand 8-12 days is more reasonable for setup.

2.4 Generator Procurement Costs and Pricing Structure

Purchase of New Generators:

A new 2 MW diesel generator may have a price tag of $600,000.00 USD just for the generator set. However, a typical 2 MW generator installation with additional fuel tanks and electrical connections to the load can have an installed cost of $1.5 Mil to $2.5 Mil USD. Obviously price is highly dependent on a number of site specific factors.

Permanent natural gas generators are even more expensive. Typically natural gas generators cost roughly double what an equivalent diesel set costs. These systems in permanent installations are typically part of a larger combined heat and power system to reclaim the waste heat from the engine or turbine. These systems typically range in cost from $3.00 to $3.50 per watt of installed capacity.

Purchase of Used Generators:

Generators have life expectancies that are greatly affected by total run hours, schedule of overhaul procedures, regular maintenance and frequency of operation. A new 2 MW diesel generator may have a price tag of $600,000.00 USD. The same unit after 10,000 run hours would typically cost around $420,000.00 USD and if it is at 20,000 run hours past the last major overhaul, may only cost $180,000.00 USD.

Rental Generator Costs

Generator rental companies offer contracts to reserve generators for critical users so the generator can be delivered to the site during an emergency need. These units are thus committed and not available to anyone but the designated contractor. The cost of maintaining a 2MW diesel generator in a contingency arrangement may be estimated at

$9,000 USD to $12,000 USD per month. In the event of applying a unit held on contingency to the field, the cost will revert to the standard rental rates listed below.

The cost of renting a 2 MW generator that runs 8 hours a day is approximately $18,000-$20,000 per month. If that generator is used to support a 24 hour per day load, the same generator rental is estimated at $27,000-$30,000 USD per month. Fuel is not included in the base rental structure. An additional $9000 per day fuel charge is to be expected for the same generator. Further, after every 250 hours of operation the engine must have an oil change at a cost of $2500-$3000. Additional cabling and hardware for paralleling and connection is not included in these numbers.

Fuel Consumption:

Diesel Generators will consume #2 diesel oil at the approximate rate of 75 gallons per hour per megawatt. Therefore, a 2MW unit running at 100% load will require fuel as follows:

2 MW x 75 gal/MWHr x 24 Hr/day = 3,600 gallons per day
3,600 gallons per day x 7 days/week = 25,200 gallons per week
3,600 gallons per day x 30 days/month = 108,000 gallons per month

The price of oil has varied over the last year from over $3.00 USD to less than $2.00 USD per gallon. Using an average of $2.50 USD per gallon, the daily cost of oil would be $9,000 USD per day and $270,000 USD per month.

2.5 Generator Tie-In Logistics:

For facilities that do not have emergency power generators, one difficulty in procuring emergency power can be the physical electrical connection from the generator to the building's electrical distribution system. There are a number of ways to make this tie in:

Situation 1: No Provisions for Emergency Power Tie-Ins/ Full Load Backup

If the entire load must be backed up, typically a qualified electrician will remove panels on the main switchgear or switchboard to expose the main bus bars. These bars are effectively drilled through and lugs are attached while the gear is de-energized. The lugs are connected to conductors that are run to the exterior of the gear to a junction box where they can be connected to additional conductors running out to the generator. In this case, the generator must be equipped with an appropriate disconnecting means. This method of connection can take 24-48 hours to make since a significant amount of system modification is required.

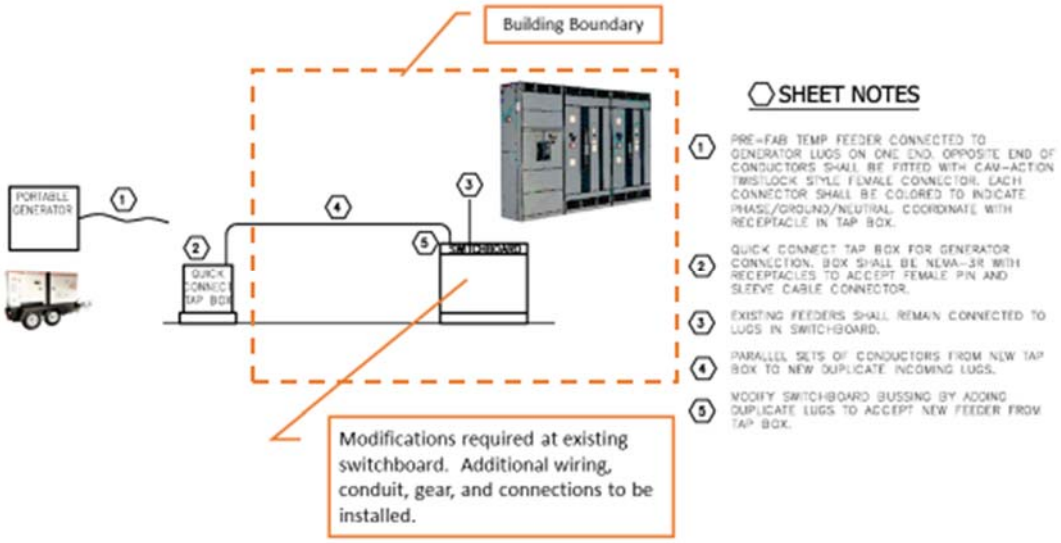


Figure 1 – Temporary Generator Tie-in Requiring Switchboard Modifications

Situation 2: No Provisions for Emergency Power Tie-Ins / Partial Load Backup

Most main electrical distribution gear has spare distribution breakers to accommodate future load expansion. These breakers can be used as tie-in points for smaller generators after a qualified person has verified the compatibility of the generator capacity and overcurrent protection size. This type of tie-in can be done in 4-16 hours.

Graphically this would look very similar to Figure 1 above, but would not require significant modification to the Switchboard itself.

Situation 3: Emergency Power Tie-In Cabinet Available

Some buildings are equipped with a pre-wired system to facilitate rapid connection of an emergency power generator. This typically involves a NEMA 3R cabinet on the exterior of the building with compression lugs, feeding back to the main switchgear or switchboard via some type of transfer switch. A rollup generator can be connected to the load in this scenario in an hour or less.

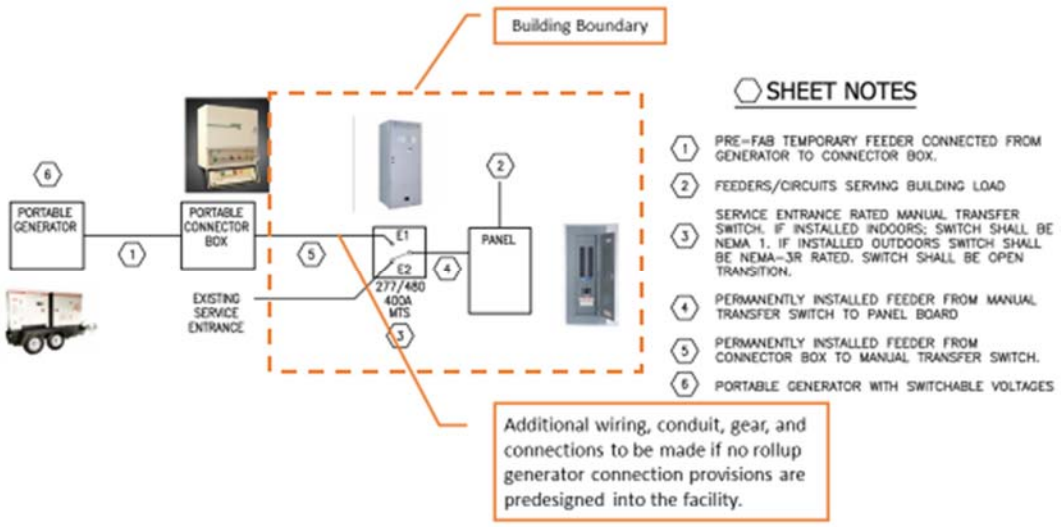


Figure 2 - Temporary Generator Tie-in with Pre-installed Tie-in Cabinet

2.6 Supply Chain Logistics Trends

Based on the responses from the interview process, TMR has developed the following list of weak links in the supply chain that emerged during previous disaster response events. Supply chain shortages occur in the following order:

1) Shortages of Cabling

If a 2 MW rental generator must be connected to a main switchboard serving a building load at 480V, this would require 6 sets (18 total cables) of 500 MCM SOOW cabling. Assuming the generator is located only 250 feet from the main switchboard, this connection would require 4500 feet of cabling. To help visualize this challenge, each cable would be 1.3" in outside diameter resulting in quite a large pile of cables.

2) Shortages of trained manpower to deliver and setup generators

During a black sky event, delivery of generator assets must rely on the available pool of truck drivers. These same truck drivers will be delivering all sorts of other critical assets, or responding to their own personal issues caused by widespread power outages. Assuming the generator was successfully delivered, connection of the generator requires trained electricians and varying degrees of field engineering to determine the best way to tie in. Depending on how prepared the facility is to accept a temporary rental generator this tie-in can involve anywhere from 4 hours of labor to 60 hours of labor or more. This manpower resource is usually the next weak link the supply chain.

3) Shortages of Generators

Evidenced by this study, the availability of rental generator assets is finite. History has proven this to be the case. Although comparing the exact generator demand to the inventory supply is outside the scope of this study, our respondents confirmed that large generator assets are quickly rented when there is a major pending power outage threat.

4) Shortages of Fuel

Assuming the generator has been successfully procured, delivered, and connected properly, fuel consumption for 1 MW and larger generators is tremendous. A 2 MW generator fully loaded will consume approximately one diesel fuel oil tanker truck of fuel every 2 days. Understanding the fuel supply chain complexities is another area that deserves further research.

3.0 Generator Inventory Findings

3.1 Generator Capacity

After compiling responses from all firms surveyed, the following generator assets have been identified.

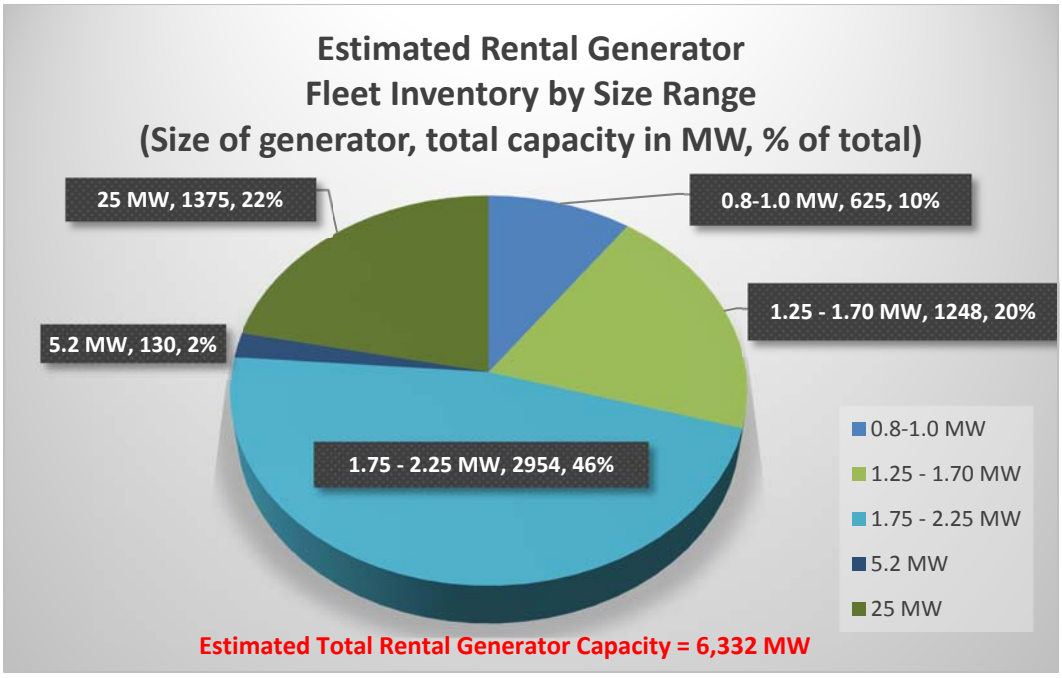


Figure 3 - Estimated Rental Generator Fleet Inventory by Size Range

The chart above shows a total estimated rental generator capacity of 6,332 MW inclusive of generators in the 1.0 MW size class and larger. Using the utilization rates provided by each vendor, **this equates to only about 2,652 MW of estimated capacity that is available for rent on any given day**. However, this assumes that any generator on this list is appropriate for any load that needs to be served. In reality, about 1,475 MW of estimated capacity (about 25%) is available in the form of large turbine generators ranging in size from 5 MW up to 25 MW. These generators will not be useful to support large single building loads because they are too large for this application. These units are more appropriate for substation level tie-in to support multi-building facilities. Applying the vendor provided utilization rates to these units and dropping these large scale generators out of the equation results in a **total estimated market availability of about 1,977 MW of capacity in the 0.8 MW to 2.25 MW generator size range.**

3.2 Study Assumptions and Disclaimers

1) Although Caterpillar provided strong data to indicate total rental generator fleet size in MW, they did not provide a detailed breakdown of generator capacity by generator size class. Data provided by other manufacturers was used to estimate the number of generators in each size class. Since Caterpillar represents a significant portion of the total market inventory, this assumption could skew the breakdown of capacity by size range if it is incorrect.

2) MTU was non responsive. Their size and asset allocation by size range was estimated based on best guesses by competitors.

3) United Rentals was non responsive. Their size and asset allocation by size range was estimated based on best guesses by TMR.

4) GE was non responsive. Their size and asset allocation by size range was estimated based on best guesses by competitors.

5) Kohler was still trying to compile the requested data as of the writing of this report. Their rental fleet is not believed to be large enough to significantly skew these results based on preliminary data received. Their size and asset allocation by size range was estimated based on best guesses by TMR.

6) Other rental generator companies not contacted as part of this study are estimated to comprise about 8% of the total market. These quantities were added to the analysis as a placeholder.

7) Utilization rates were very roughly estimated by the respondents. These number fluctuate greatly for each manufacturer. General consensus was that most respondents said that 60-70% of the available generator assets were rented at any time.