GENERAC®
INDUSTRIAL POWER

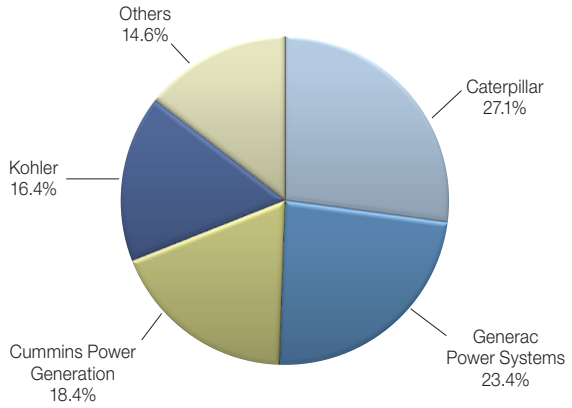
WHITE PAPER

Total Cost of Ownership
Diesel vs. Natural Gas Generators

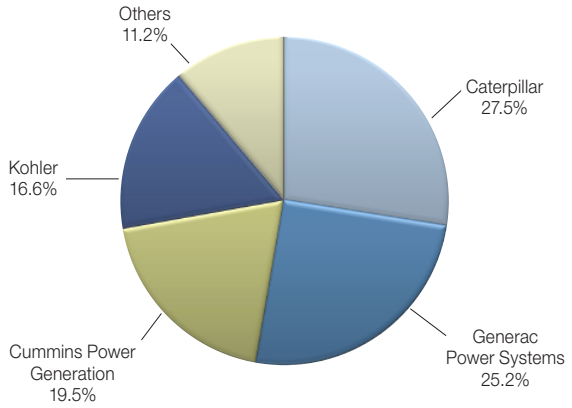
INTRODUCTION

The standby power market has historically been dominated by diesel generators, but this is changing. Frost & Sullivan North American market research data shows a rapid shift toward natural gas generators: 28 percent in 2013 and 38 percent in 2016. This growth is driven by many factors including a greater awareness of natural gas as a reliable fuel; increased concerns over diesel maintenance and refueling issues; expansion of utility demand response and interruptible rate programs; and the general desire to be more environmentally responsible. As the market continues to show greater interest in utilizing natural gas, there is an increasing dialogue taking place relative to total owning cost between these two options. This paper will focus on the key elements of that discussion.

Total Generator Set Market: Percent of Sales, North America, 2013



Total Generator Set Market: Percent of Sales, North America, 2016



*Others include companies such as Briggs and Stratton, MTU Onsite Energy, Multiquip Inc., and Winco Inc.

CAPITAL COST

From a capital cost standpoint, the generator market is split at 150 kW. Below 150 kW, generators use automotive-style engines with appealing cost points. In this market segment, natural gas generators are priced at or below diesel units. Above 150 kW, the generators use diesel-derivative engines that are more specialized and have a lower power density. In this market segment, natural gas units typically cost 60 to 100 percent over diesel. Though the generator cost increases dramatically, the associated transfer equipment and installation cost remains fairly constant. The net effect may be project cost increases in the 30 to 60 percent range. Since the generator cost is a significant component within a total owning cost analysis, your local distributor can capture current pricing for greatest accuracy.

One way to leverage the cost efficiencies of 150 kW or smaller natural gas generators is via on-generator paralleling technology, as with Generac's Modular Power System (MPS) products, for example. Since natural gas generators at 150 kW still use automotive-derivative engines, paralleling multiple 150 kW units can achieve very cost-effective solutions for midrange power applications. For large kW applications, paralleling four 500 kW generators provides significant operational and capital advantages over implementing a single natural gas 2000 kW generator. On-generator paralleling is also a great way to optimize an application for reliability and scalability.

DEMAND RESPONSE

Electric utilities and energy marketers often have times of physical and economic constraints in delivering electric power to their customers. Customers that wish to receive a discount on their electric rates may participate in demand reduction programs — demand response, interruptible rate, curtailment rate, etc. These programs provide a payback stream in opposition to the sunk cost of a standby generator system. Standby generators provide their normal value by deferring losses normally associated with power outages. Demand-response programs offer the potential to defer those sunk costs with a modest annual electric savings — $50/kW is not atypical in some markets. Consult your local utility or energy marketer for more details.

Participation in these programs requires the generator be U.S. Environmental Protection Agency (EPA) stationary nonemergency emission rated, which increases generator cost. Diesel generators must be EPA Tier 4-compliant, which incorporates expensive selective catalytic reduction (SCR) diesel engine exhaust aftertreatment. Tier 4 engine technology dramatically increases the generator cost, typically 40 to 50 percent, narrowing the capital cost difference to natural gas. SCR technology also adds an active control process that injects an ammonia derivative into the exhaust, which poses additional maintenance and reliability challenges.

Natural gas standby generators make the transition into demand-response applications with very little impact to cost or operational reliability. Natural gas generators greater than 85 kW are already equipped with a three-way catalytic converter used to reduce emissions. This is the same reliable, maintenance-free technology that is implemented on automobiles. Generator manufacturers simply need to validate the catalyst effectiveness to EPA stationary nonemergency standards and label the engine for nonemergency use. The cost adder for this increased functionality is typically only a few percent.

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INSTALLATION COST

Installation cost is very similar between diesel and natural gas generator options. For outdoor generators, installation costs are largely impacted by ampacity and distance. If you're carrying the same amps the same distance, the install cost between diesel and natural gas is largely the same. Specific project installation costs vary based on application configuration, cabling distance, copper and conduit cost, regional labor rates, etc. A reasonable initial estimate of $150/kW will typically cover cabling and the necessary transfer and distribution equipment. For detailed total owning cost calculations, an installing electrical contractor would need to bid the cost of installation for the specific site and configuration.

When installing natural gas generators, fuel must be piped to the generator. Normally this can be estimated in the $10 to $20/kW range to be inclusive of fuel pressure regulators, isolation valves and piping. Gas service capacity and available gas pressure need to be evaluated to ensure all gas infrastructure costs are identified.

FUEL RELIABILITY

Any discussion of diesel versus natural gas generators will quickly incorporate the perceived reliability of both diesel and natural gas as a reliable fuel source. If one fuel is perceived as being much more reliable than the other, the cost comparison would need to incorporate the economic impacts of a fuel failure. In many markets, natural gas is seen as an extremely reliable and well supported fuel choice:

- Infinite supply
- Not interdependent with electrical system
- Doesn't degrade
- Doesn't rely on human interaction to maintain reliability

Natural gas reliability and outage history information for a given location can often be gotten from the serving gas utility. The Gas Technology Institute (GTI) has also investigated the relative reliability of the two fuel sources (GTI Natural Gas Backup Power).

Diesel Maintenance

It is generally well understood that diesel must be maintained to be reliable (Standby Power Generation Fuel Security – Diesel vs. Natural Gas). Diesel fuel has multiple failure modes that need to be protected against with maintenance and contingency planning:

- Fuel depletion
- Moisture
- Biomass
- Gelling
- Fuel instability/varnishing
- Fuel transfer systems

Diesel fuel must be tested annually and maintained as necessary to be reliable. Fuel polishing is the process of removing the contaminants and restoring necessary fuel additives. This process must be done more frequently in high-humidity environments. As a general rule, fuel needs polishing every one to four years. The cost for this service varies, but $1.00/gal. is a reasonable initial estimate.

FUEL COST

Diesel and natural gas cost varies significantly over time, but certain trends are fairly consistent. Diesel is typically three to four times more expensive for the energy gained ($/BTU). Diesel also has the additional disadvantage of having to be prepaid. This initial prepay occurs at commissioning when the onsite diesel fuel tank is filled for the first time. Applications desiring extended runtimes — 72 or 96 hours of onsite diesel — have greater initial fuel costs and greater ongoing maintenance costs. Applications that use smaller tanks minimize fuel maintenance but run a much greater risk of running out of fuel.

Generators consume fuel based upon the fuel efficiency of the engine, run hours and the load level applied. Generators are usually programmed to run a weekly no-load exercise cycle for 20 min. Since this test normally is without facility load, fuel consumption is only about 5 percent of full-load-rated consumption. The majority of the generators fuel is consumed during power outages or demand-response operation. When performing a total cost of ownership calculation, estimates are needed for outage hours, demand-response hours, and expected load levels. Actual load levels will vary significantly between applications. Load levels of 50 to 75 percent are common. Assuming a conservatively higher generator load level of 75 percent illustrates the impact that fuel has on the generators total life cycle owning cost.

LOAD BANKING

Generators are periodically loaded to 100 percent capacity in a process called load bank testing. Diesel generators need this done more frequently, typically every 2 to 3 years, due to an effect known as wet stacking. Wet stacking is a buildup of unburnt fuel in the exhaust system. This can occur when a diesel generator is consistently operating at no load exercise or load levels less than 30 percent. Natural gas engines don't wet stack but still need periodic load bank testing to validate generator health and cooling system performance. Load banking cost can vary based on the physical constraints of the site and regional variations. An initial estimate of $1000 fixed cost and $1.50/kW can be used until detailed costing can be gathered from your local generator distributor.

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GENERATOR MAINTENANCE

Both diesel and natural gas generators will require routine maintenance. For standby generators with less than 250 hours of annual run time, this is typically an annual inspection and servicing. Generally speaking, filters and oil are changed annually. Cranking batteries are usually replaced every two to three years. Belts, hoses and coolant are inspected/tested annually and replaced as needed (typically every four to six years). Maintenance costs can be impacted by multiple factors. An initial estimate of $500 fixed cost and $1.00/kW can be used until detailed costing can be gathered.

ANALYSIS PERIOD

The largest portion of the North America generator market is standby power (greater than 90 percent). These are generators that are installed to meet code requirements or avoid the pain and economic losses associated with power outages. They are not normally installed based on short term economic cash flow/ROI calculation. When performing total owning cost comparisons between diesel and natural gas alternatives, the period for the comparison may be much longer than the traditional payback calculation. You may want to look at the cost comparisons over different time periods based on your objective. If the demands on capital are significant, you may wish to maintain a shorter five or seven-year analysis, which tends to favor diesel solutions. If natural gas is the preferred fuel choice and you wish to illustrate that it can pay for itself, use a longer 20 or 25 year analysis, period. Natural gas fuel savings and reduced maintenance with natural gas generators create benefits that accrue over time.

EMISSIONS

Emissions are typically not a hard cost within a total owning cost comparison but are often evaluated as a soft cost in line with corporate environmental policies. Natural gas generators that utilize catalytic converters produce less nitrogen oxides (NOx) and carbon monoxide (CO) as well as no measurable particulate matter (PM). Nitrogen oxides interact in the environment to create ground-level ozone, which is bad for anyone with respiratory issues like asthma. Carbon monoxide (CO) is a pollutant that replaces oxygen within the blood stream. Particulate matter (PM) is the smoke that is seen on diesel engines. Diesels have particulates but natural gas engines don't have measurable levels. The level is so low on natural gas engines that the EPA does not require it to be measured.

RUNNING THE NUMBERS

Using the Generac online total cost of ownership calculator (TCO Calculator), various configurations were compared to evaluate how diesel and natural gas generators compare in standby and demand-response applications. The following assumptions were utilized for these comparisons:

Period: 25 years

Inflation: 2.5 percent

Tank Size: 48 hr.

Diesel: $2.50/gal.

Natural Gas: $0.70/therm

Load Banking Natural Gas: Every six years

Load Banking Diesel: Every three years

Diesel Fuel Polishing: Every two years, $1.00/gal

Installation Cost: $150/kW

Run Hours (Standby Application): 20 hours no-load testing and 50 hours with load outage

Run Hours (Demand-Response Application): 20 hours no-load testing and 250 hours with load

Demand Response Electric Savings: $50/kW/year

Standby Application
Life Cycle Total Owning Cost (x1000)

Power Rating	Diesel	Natural Gas
150kW	$140 (1 x 150)	$110 (1 x 150)
500kW	$390 (1 x 500)	$385 (1 x 500)
1200kW	$925 (2 x 600)	$930 (4 x 300)
2000kW	$1,580 (1 x 2000)	$1,530 (4 x 500)

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Demand Response Application
Life Cycle Total Owning Cost (x1000)

Power Rating	Diesel	Natural Gas
150kW	$105 (1 x 150)	$(10) (1 x 150)
500kW	$278 (1 x 500)	$5 (1 x 500)
1200kW	$690 (2 x 600)	$30 (4 x 300)
2000kW	$1,580 (1 x 2000)	$10 (4 x 500)

Note: Negative number indicates a net positive cash flow resulting from electric savings

SUMMARY

Standby power has historically been dominated by diesel generators, but natural gas is rapidly become a preferred solution in many markets. Natural gas generators less than or equal to 150 kW are an easy choice for minimizing total owning cost and avoiding the hassles associated with onsite diesel. This advantage can be extended to larger kW projects using integrated paralleling technology and 150 kW generators.

As natural gas generators become larger than 150 kW, the generators' increased capital cost has tended to slow adoption in the standby market. More customers are taking a longer perspective as the concerns with onsite diesel continue to grow in the market. Natural gas generators provide a convenience and environmental impact that is extremely desirable. They also offer a cost-effective alternative to managing onsite diesel when evaluating across a 25-year life cycle.

Demand-response/interruptible electric rate programs exist in many markets. These programs offer an ongoing positive cash flow that can be used to help offset the cost of installing a standby generator system. Demand response requires EPA stationary nonemergency compliance, which is achieved with a minimal cost adder for natural gas generators. Diesel generators require expensive and complex Tier 4 aftertreatment, which adds 40 to 50 percent to the generator costs. It is not uncommon for these types of electric rate programs to allow natural gas generators to approach a cost-neutral position over the life cycle of the generator. The economics are not strong enough to justify installing demand-response generators for purely financial reasons. The economics do offer a compelling payback solution to defer the sunk cost of a standby generator system while avoiding the hassles of onsite diesel.

Generac has made a fully customizable total cost of ownership tool available at www.generatortco.com. Please utilize this tool to perform your own customized analysis for your unique situation.