



ENCHANTED ROCK

The Power is On.

BACKUP GENERATOR EMISSIONS: FACT VS. FICTION

CUTTING-EDGE TECHNOLOGY PURPOSE-BUILT FOR LOWER EMISSIONS

At Enchanted Rock, our mission is to keep the power on for customers with cutting-edge electrical resiliency technology. Enchanted Rock continues to invest in ongoing innovation and development to advance the efforts to decarbonize the grid and provide local resiliency.



How much cleaner can gas generators be compared to diesel generators?

First, some history. In 2014, we decided to migrate from diesel technology to natural gas technology. We scoured the market to find a cleaner alternative that also met the stringent requirements for backup generation. Essential criteria were start times and transient response, power density, and cost. We learned the market did not offer such a solution, since diesel was so dominant and the only innovation was a new diesel emissions standard (i.e. EPA Tier 4 Final) that was still too dirty and much more expensive due to complex emissions control technology. We recognized this as a market opportunity.

Fast forward, our now patented gas reciprocating engines meet all performance requirements and are far cleaner than the traditional diesel backup systems currently being used - including Tier 4 diesel, also known as “clean diesel.” In fact, our emissions are low enough to run virtually unlimited hours during non-emergency conditions and can be authorized in non-attainment areas using standard air permits. This critical factor provides cost competitive alternatives to diesel generators by offering local resiliency and grid stabilization services to offset the cost of backup power.

We’re not stopping there either. We integrate load controls and behind-the-meter solar and use renewable natural gas to further decarbonize our Managed Power Resiliency offering.

SEPARATING FACT FROM FICTION

While evaluating your energy transition toward decarbonization, every facility must make an informed decision based on organizational goals and requirements. Unfortunately, there is conflicting information and confusion in the market today, so let's take a look at some of those statements to separate fact from fiction.

FACT: DIESEL PRODUCES HIGHER EMISSIONS THAN OTHER FUEL ALTERNATIVES



Emissions from new diesel engine generators are regulated by the EPA for NOx, VOCs, Particulate Matter (PM), and CO. When compared to these regulated emissions levels, Enchanted Rock's generators are significantly cleaner.

Enchanted Rock's natural gas microgrids offer cleaner local emissions than diesel by orders of magnitude with practically no run limitations - allowing facilities to support both resiliency and sustainable strategies. Our systems use natural gas, propane, and biogas to reduce or eliminate our carbon footprint.

On the topic of renewable natural gas, in a recent report from The Brattle Group, "Decarbonized Resilience: Assessing Alternatives to Diesel Backup Power," four scenarios are evaluated as alternatives to diesel. The report finds that "relative to diesel, these alternatives can virtually eliminate the emission of pollutants such as NOx, particulate matter, and volatile organic compounds, which contribute to local air quality problems."

The numbers speak for themselves. As you can see in Figure 1, the Enchanted Rock emissions are far less than that of a Tier 4 diesel engine output across the board.

RENEWABLE NATURAL GAS

What is RNG?

Renewable natural gas, or RNG, is pipeline-quality gas that is interchangeable with conventional natural gas. RNG is the product of the decomposition of organic matter (biogas) that is processed to purity standards.

Is RNG a Fossil Fuel?

No, RNG is an ultra-clean and ultra-lowcarbon natural gas alternative that is a mixture of carbon dioxide and hydrocarbons, primarily methane gas. It is captured when organic waste decomposes and releases biogas, which is collected and purified. Sources include landfills, livestock operations, wastewater treatment, and organic waste from industrial, institutional, and commercial entities.

How is RNG Carbon Negative?

RNG can be carbon negative depending on the source and its intended use. Instead of methane gas being released into the air, it is captured, processed, and then injected into a common carrier pipeline which then mixes the conventional NG molecules. Then through off-setting properties that match up with volumes that are combusted in an engine where the byproduct is carbon dioxide and electricity. Because the carbon intensity of methane gas is 25 times greater than the carbon intensity of carbon dioxide, displacing methane results in significantly lower greenhouse gas emissions.

Figure 1. Generator Emission Factor Comparison

Compound	ERock Rich-Burn		Tier 2 Diesel		Tier 4f Diesel		CARB DG-CERT Engine Emission Factor
	Engine Zero-Hour Emission Factor (lb/MWe-hr)	Emission Factor Source	Engine Zero-Hour Emission Factor (lb/MWe-hr)	Emission Factor Source	Engine Zero-Hour Emission Factor (lb/MWe-hr)	Emission Factor Source	
VOC	0.001	ERO Test Data	14.11	NSPS IIII	0.42	NSPS IIII	0.02
NOx	0.0035	ERO Test Data			1.48	NSPS IIII	0.07
CO	1.09	ERO Test Data	7.72	NSPS IIII	7.72	NSPS IIII	0.1
PM/PM10/PM2.5	0.003	ERO Test Data	0.44	NSPS IIII	0.066	NSPS IIII	-
SO2	0.007	AP-42 Table 3.2-3	0.016	AP-42 Table 3.4-1	0.016	AP-42 Table 3.4-1	-
CO2	1,395	ERO Test Data	1,555	AP-42 Table 3.4-1	1,555	AP-42 Table 3.4-1	-

Diesel Engine Emissions Compared to Enchanted Rock

Compound	Tier 2	Tier 4f
VOC	3136x	419x
NOx		422x
CO	7.1x	7.1x
PM/PM10/PM2.5	147x	22x
SO2	2.3x	2x
CO2	1.1x	1x

Enchanted Rock Emissions as a Percentage of other Engines and Regulation

Compound	Tier 2	Tier 4f	CARB DG-CERT
VOC	0%	0%	5%
NOx		0%	5%
CO	14%	14%	1090%
PM/PM10/PM2.5	1%	5%	-
SO2	43%	43%	-
CO2	90%	90%	-

Notes:

1. Enchanted Rock ISO 8178 D1 weighted test cycle emissions results from a single engine. Actual field test results may vary due to site conditions, installation, fuel specifications, test procedures, and engine to engine variability.
2. NMHCs/Nonmethane Hydrocarbons emissions found to be below the minimum detection level of the equipment.
3. NOx and CO emissions data are near-zero hour non-deteriorated emission rates which are not guaranteed emissions for purposes of air permitting. These rates are typical for lower run hours which will increase with catalyst age.
4. PM emissions not expected to change with catalyst age, although differences in fuel quality could impact actual emissions.
5. NSPS IIII emission limit for electric generator rated greater than 560kW.
6. California Code of Regulations Title 17, Division 3, Chapter 1, Subchapter 8, Article 3 - Distributed Generation Certification Program
7. NSPS JJJJ emission limits for stationary non-emergency natural gas engine greater than 500 hp, with an efficiency of 92%
8. AP-42 calculation assumes engine has a heat rate of approximately 12 MMBtu/MW

FACT: NATURAL GAS IS MORE RESILIENT AND RELIABLE THAN DIESEL AS A FUEL SOURCE



A recent study by the National Renewable Energy Laboratory (NREL), “A Comparison of Fuel Choice for Backup Generators,” analyzes the relative reliability of using natural gas compared to diesel as a backup fuel source. Their conclusion is: “We find that natural gas provides the largest additional reliability compared to diesel for regions that have high risks of long outages.”

Fuel availability and transportation also need to be considered. Natural gas is delivered through an incredibly robust underground infrastructure. During crisis situations, natural gas is readily available when diesel refueling is not always possible due to terminal supply shortages or over-the-road hazards. Enchanted Rock systems can run independently in island mode for days to weeks with no need for refueling logistics.

The reality is that constant conditioning and testing of engines leads to a higher level of reliability. Enchanted Rock natural gas-fueled microgrids run loaded while providing grid stability services, unlike diesel engines which are significantly limited in run hours.

MYTH: DIESEL BACKUP IS ALWAYS LESS EXPENSIVE THAN NATURAL GAS BACKUP



While diesel generators can be less expensive capital cost on a standalone basis, that is not the case for a dual purpose microgrid. By combining backup power with grid stability services, the net cost of natural gas services are lower than diesel. The NREL study concludes, “grid-connected generators can create positive economic value and have significantly lower failure rates than backup-only generators.”

Enchanted Rock’s Electrical Resiliency-as-a-Service offering allows customers to focus on their core business while we provide local resiliency, manage the assets and are responsible for maintenance and operations. When customers do not require backup power, Enchanted Rock aggregates the generator capacity and sells back to the grid to earn revenue. These periodic runs allow us substantially subsidize the cost to customers.

A dual-purpose microgrid offers significant economic advantages for our customers, including lowering initial cost to implement and ongoing maintenance and fuel costs. While diesel normally averages \$400-500/kw plus a lifetime of maintenance, natural gas microgrids run \$150-300/kw with no added cost for maintenance - a significant difference!



THE ENCHANTED ROCK SOLUTION

Founded in 2006, Enchanted Rock is a leader in electrical resiliency-as-a-service, powering companies, critical infrastructure, and communities to ensure operational continuity during unexpected power outages from extreme weather, infrastructure failures, cyberattacks and other grid disruptions. Enchanted Rock’s dual-purpose microgrids use natural gas and renewable natural gas (RNG) offsets to produce significantly lower carbon emissions and air pollutants than diesel generators, capable of achieving resiliency with net-zero emissions. Additionally, the company’s end-to-end microgrid software platform, GraniteEcosystem™, provides real-time 24/7/365 system monitoring and optimization, including forecasting of electricity market conditions to ensure worry-free reliable power to customers.

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