DATE: January 14, 2019

TO: Council Sustainability Committee

FROM: Director of Utilities & Environmental Services

SUBJECT Diesel Backup Generators: Environmental Impacts and Feasibility of Alternatives

RECOMMENDATION

That the Committee reviews and comments on this report.

SUMMARY

Diesel generators are widely regarded as the obvious choice in emergency backup power because diesel is more reliable, powerful, and cost effective than alternatives like natural gas and battery-stored energy. It also allows for continuous operation in extended emergencies, which is why all 38 of the City's stationary emergency backup generators are diesel-powered. While the reliability and cost-effectiveness of alternatives have improved dramatically in recent years, diesel remains the superior option for emergency backup generators. Additionally, due to the Environmental Protection Agency's (EPA) regulatory stringency of diesel technology over the past two decades, today's standard diesel fueled engines produce far fewer emissions than they once did. This report provides an overview of the landscape of today's emergency power technology and assesses potential opportunities to improve the sustainability of our generator fleet without compromising power or reliability.

BACKGROUND

Clean Air Act – In 1990, the Clean Air Act was amended to focus more heavily on several specific threats, including toxic pollutants and precursors to acid rain. The amended Act promoted the use of alternative clean fuels including low sulfur diesel fuel and natural gas in on- and off-road diesel engines. The amendment also called for the establishment of a national permitting program to ensure compliance with the Act.

EPA Tiered Regulations for Nonroad Engines – In response to the Clean Air Act, the Environmental Protection Agency (EPA) established a national regulatory program in the

mid-90s for nonroad diesel engines.[1] The regulations included three tiers of increasingly stringent emissions standards that were phased in from 1996 to 2008. In 2005, the fourth and most stringent tier was established with a phase-in period from 2008 to 2015.[2] Compliance with Tiers 1 through 3 required manufacturers to improve the design of their engines. Tier 4 compliance required even further emission control design improvements. Compliance with these emissions standards affects only new or modified facilities. Existing standby powered generators are exempt or grandfathered in and are not required to upgrade until the facilities are upgraded or replaced.

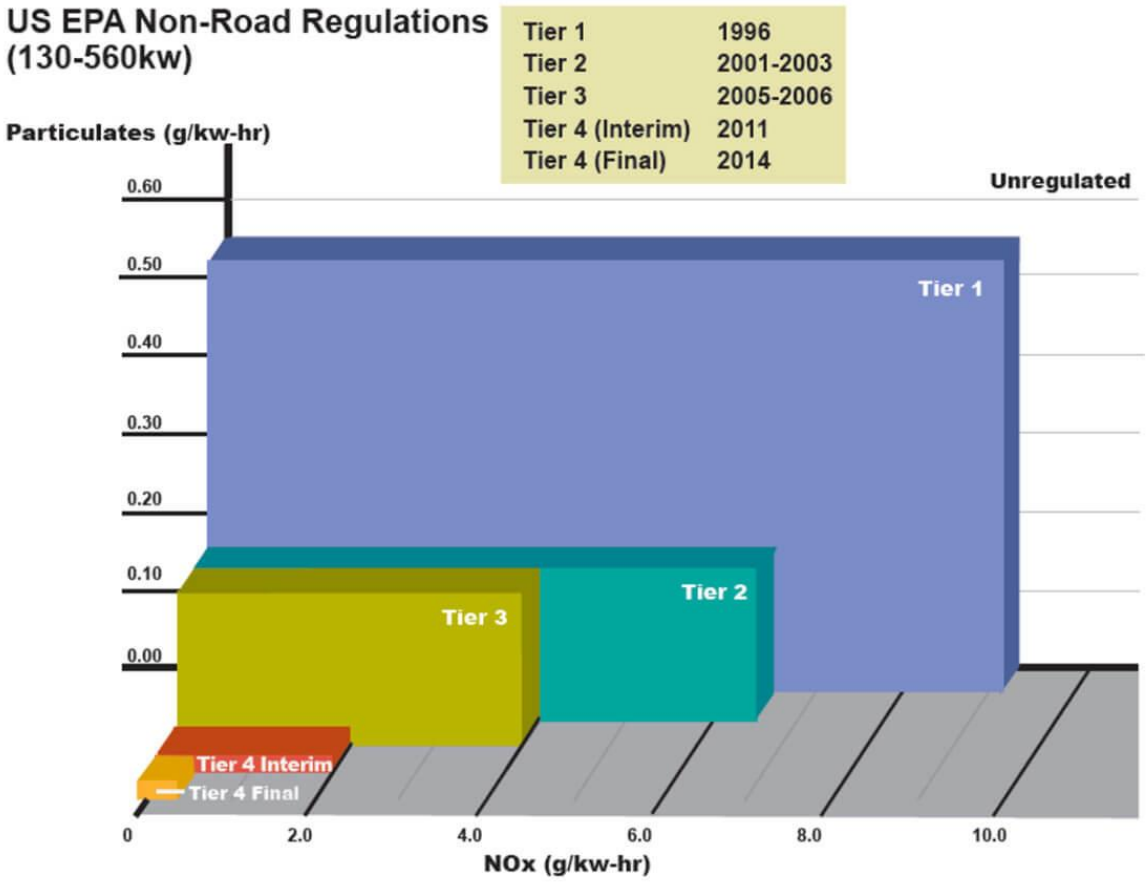
EPA Requirement Regarding Fuel for Stationary Generators – Per EPA regulations, after 2014, all non-road engines and equipment must use ultra-low sulfur diesel (ULSD), which has 99% less sulfur than conventional diesel fuel.[3,4]

DISCUSSION

Diesel Generators – Diesel backup generators must be operated periodically in order to ensure that they remain operational in emergencies. Air Quality Management Districts across the country, including the Bay Area Air Quality Management District (BAAQMD), strictly regulate this testing and other non-emergency usage to ensure minimal diesel emissions (typically less than 50 hours allowed per year). As such, the City only exercises its generators for the bare minimum amount of time to ensure readiness in the event of an emergency (typically 12 hours per year). Per EPA regulations, the City also uses ULSD in all its diesel engines. ULSD fuel contains 99% less sulfur and has been found to significantly reduce certain emissions, particularly nitrogen oxides and particulate matter.

Locally-enforced usage limitations and cleaner diesel are not the only measures in place today to reduce emissions associated with diesel technology. The EPA's regulatory stringency over the entire industry has resulted in the development of inherently cleaner engines. Tier 4 diesel engines, which began their phase-in as the required standard for all new engines in 2008, are equipped with the latest in emission control technology. This technology, when paired with ULSD, has been proven to reduce particulate matter (PM) and nitrogen oxides (NOx) emissions to near zero levels. The graph below provides a visual representation of the NOx and PM emission limits across the various Tiers.

[1] https://www.epa.gov/regulations-emissions-vehicles-and-engines/regulations-emissions-heavy-equipment-compression
[2] https://www.dieselnet.com/standards/us/nonroad.php#tier3
[3] https://www.epa.gov/regulations-emissions-vehicles-and-engines/regulations-emissions-heavy-equipment-compression
[4] https://www.epa.gov/fuels-registration-reporting-and-compliance-help/overview-diesel-fuel-testing-and-reporting



However, most Tier 4 diesel engines, especially in the larger horsepower ranges, did not begin to enter the market until around 2011. As such, it could still be decades before all older models of non-road engines are replaced throughout the country due to the fact that Tier 4 regulations only apply to new generators. Because the City's generator fleet was phased in at various times, many lower-Tier generators are still in use. Table 1 presents the estimated Tier breakdown of the City's inventory of generators.

Table 1. Estimated Tier Distribution of City's Stationary Generators

Tier	Total Stationary Generators*	Percentage of Stationary Fleet	Avg. Model Year**	Total kW
Tier 0 (Unregulated)	4	11%	1994	2,600
Tier 1	9	24%	1999	2,967
Tier 2	10	27%	2006	7,386
Tier 3	4	11%	2008	396
Tier 4	10	27%	2013	1,167

*Does not include 125 kW Airport Terminal generator due to lack of information at this time
**Based on estimations of model year for each generator

As indicated in Table 1, 62% of the City's generators are currently estimated to be between Tier 0 and Tier 2. This means that they could be producing roughly 40% to 90% more NOx and particulate matter pollutants than the current technological standard.[5] Due to the limited amount of time that these generators run per year, however, these higher emission rates are negligible. Based on the preliminary analysis provided in Table 2, the cost associated with replacing Tier 0 – 2 generators with modern technology would cost approximately $9 million.

Table 2. Estimated Replacement Costs of Tier 0 – Tier 2 Generators

Tier*	Site Name	Size	Est. Replacement Cost
0	City Hall	1,250 kW	$1,092,000
0	Police Department	350 kW	$210,000
0	Well B	500 kW	$280,000
0	Well E	500 kW	$280,000
1	Eden Shores Lift Station	122 kW	$140,000
1	Fire Station #1	125 kW	$224,000
1	Fire Station #9	40 kW	$42,000
1	Tennyson Lift Station	130 kW	$140,000
1	Utility Corp Yard	350 kW	$210,000
1	Valle Vista Lift Station	600 kW	$350,000
1	Walpert Pump Station	750 kW	$420,000
1	Well C	450 kW	$280,000
1	Well D	400 kW	$245,000
2	1285' Pump Station	400 kW	$245,000
2	250' Pump Station	350 kW	$210,000
2	500' Pump Station	500 kW	$280,000
2	750' Pump Station	500 kW	$280,000
2	Centex Lift Station	60 kW	$56,000
2	Hesperian Pump Station	2,000 kW	$1,400,000
2	Marathon Lift Station	60 kW	$56,000
2	Skywest Pump Station	1,500 kW	$1,120,000
2	WPCF	2,000 kW	$1,400,000
2	WPCF	16 kW	$14,000

*This identifies the Tier at which each generator is required to perform based on estimated model year and size. It is possible that some generators actually perform at a higher Tier standard than required, though staff does not believe that any of the generators in this table perform beyond Tier 2.

Total: $8,974,000

Biodiesel and Renewable Diesel – Biodiesel and renewable diesel are two additional fuel options proving to cost-effectively reduce emissions from diesel engines. *Biodiesel*, made from vegetable oils and animal fats, is typically blended at levels of 2% to 20% with petroleum-based diesel in order to be compatible with diesel engines. These blends are typically referred

[5] See Emissions Regulations Chart on page 8, https://www.npsdiesel.com/wp-content/uploads/Brochure-Emissions-Technology-John-Deere.pdf

to as B2, B5, or B20, depending on the blend percentage. Pure biodiesel is referred to as B100. Studies have shown that while biodiesel is often associated with decreases in carbon monoxide, hydrocarbon, and particulate matter emissions, it is also linked to increases in NOx and slight engine performance reduction. Additionally, the use of biodiesel blends may require engine modifications to ensure the fuel is compatible with the technology. For this reason, use of biodiesel can affect engine warranties.

Renewable diesel is also made from vegetable oils and fats, but its refining process is similar to that of petroleum-based diesel. Unlike biodiesel, 100% renewable diesel (RD100) matches the chemical composition of conventional diesel and is considered a "drop-in" solution because it can be utilized in any existing diesel technology without threatening engine performance.[6] Neste, one of the largest global suppliers of renewable diesel and key supplier in northern California, reports that their 100% renewable diesel can reduce greenhouse gas emissions by 50 – 90% over the lifecycle of the fuel when compared to conventional diesel, and fine particulate emissions alone are reported to be reduced by 33% when compared to low-sulfur diesel.[7] Relatedly, California Air Resources Board data reports that the total emission intensity of renewable diesel, in general, can be up to 80% lower than ultra-low sulfur diesel depending on the source.[8] More details regarding the total emission intensity of renewable diesel when compared to ultra-low sulfur diesel is shown in Table 3.

Table 3. Total Emission Intensity Across Fuel Type and Source

Fuel Type and Source	Total Emission Intensity (Direct and Indirect Emissions) (gCO2e/MJ*)
Ultra-Low Sulfur Diesel	98.03
Renewable Diesel	19.65 – 82.16
Sourced from tallow, high energy rendering	39.33
Sourced from tallow, low energy rendering	19.65
Sourced from Midwest soybeans	82.16

*Grams of carbon dioxide equivalent emissions per megajoule

The Cities of Oakland, San Francisco, and San Leandro recently converted their entire public vehicle fleet to renewable diesel, boasting emission reductions of more than 80% virtually overnight.[9,10,11] In most areas of the country, the availability and price of renewable diesel when compared to biodiesel blends and ultra-low sulfur diesel makes its adoption

[6] https://www.pscleanair.org/469/4-Things-To-Know-About-Renewable-Diesel
[7] https://www.neste.com/companies/products/renewable-fuels/neste-my-renewable-diesel/reduced-emissions
[8] https://www.arb.ca.gov/fuels/lcfs/lu_tables_11282012.pdf
[9] https://ngtnews.com/oakland-and-renewable-diesel-not-a-single-downside
[10] https://www.dieselforum.org/policyinsider/diesel-sulfur-limits-worldwide-and-the-need-for-ulsd
[11] https://www.prnewswire.com/news-releases/city-of-san-leandro-switches-its-municipal-vehicles-to-run-on-neste-my-renewable-diesel-300652157.html

impractical. In California, however, renewable diesel is both readily available and cost-competitive due to California Low Carbon Fuel Standards. [12]

While both biodiesel and renewable diesel have been successfully implemented in transportation fleet applications, they have shortcomings that render them not suitable for use in standby backup emergency generators. Because they are derived from vegetable oils and animal fats instead of petroleum, these fuels can increase water and biological contaminants in fuel supplies which can cause corrosion and other problems in the engines and fuel storage tanks. Another significant difference between using bio- or renewable diesel in a fleet versus in a backup generator system is that the fuel in a vehicle is used in a relatively short time. On the other hand, fuel which is stored for use in a backup generator can remain unused for a very long period of time. This, combined with the fact that these alternative diesels are naturally biodegradable, makes the fuel impractical for use in critical application backup generator systems. Staff is not aware of any water or utility districts using renewable diesel in emergency backup generators. Staff will continue to monitor future developments and technologies affecting the viability of using these clean diesel options in standby generators.

Natural Gas Generators – Emissions from natural gas generators have historically been regarded as cleaner than diesel generators. However, with today's cleaner diesel technologies, this is no longer necessarily the case.

Furthermore, natural gas generators also have significant reliability concerns that cannot be ignored, particularly in our seismically sensitive region. Natural gas generators are typically connected directly to a gas line, which can offer a seemingly endless fuel source. However, gas lines are susceptible to breakage in seismic events. They are also sometimes shut off as a precaution immediately following seismic events or major fires, thus rendering natural gas generators useless during such occurrences. As such, natural gas generators would not be a reliable source of emergency power for water or sewer systems, or for municipal facilities in Hayward. Furthermore, natural gas generators are known to be less responsive to changes in load demand, which is often necessary with utility infrastructure facilities, further diminishing reliability for our purposes.

Microgrids – Microgrids are the newest and cleanest alternative backup power option, though this power source also poses significant reliability concerns. Microgrids are localized grids that require an energy source for charging, either via the power grid or an onsite renewable energy source, such as solar panels. They require large batteries to store excess energy for later use. When connected to the grid during normal operations, microgrids are capable of both drawing from and contributing to the grid. During emergencies and outages, they can operate completely independently of the grid, also known as "islanding." The system can function so long as there is sunlight. When there is no sunlight, however, the system can only meet a facility's energy demand from hours to days at a time depending on the size of the battery. In the event of an emergency in which just one overcast day occurs, the power supply to a facility could be dramatically affected.

[12] https://www.gladstein.org/the-potential-and-challenges-of-renewable-diesel-fuel-for-heavy-duty-vehicles/

Reliability concerns aside, microgrids are extremely expensive. While there are a number of systems currently in use across the country, they have been primarily funded through multimillion-dollar state and federal grant awards. The City of Fremont, for instance, currently has microgrids in place at three of its fire stations. Each microgrid is comprised of a 40kW solar photovoltaic carport canopy paired with a 95kWh batter energy storage system.[13] These microgrids were installed in 2016 via a $1.8 million-dollar California Energy Commission (CEC) grant and a $700,000 match from the local technology developer, Gridscape Solutions, for a total project cost of $2.5 million. The lifetime of these technologies must also be considered. In the case of the solar microgrid, it is important to note that while some solar panels can last in the 25 – 30-year range, batteries typically last closer to 15 years, meaning that significant replacement costs will be required in order to keep the system running over long periods of time.[14] There may also be some challenges related to recycling a microgrid system after its useful life.

Locating microgrids is also physically infeasible at most of the City's facilities. The demands associated with most pump stations and lift stations would require a very large solar array and a very large battery system and space tends to be limited at these sites.

Conclusion – The technological landscape of power generation has changed dramatically over the past twenty years and a national push to reduce emissions is the driving force behind these changes. Diesel engines, in particular, have become far less harmful to the environment and continue to be more reliable than natural gas-powered engines or solar-battery options. While diesel generators and fuels on the market today have become significantly cleaner, the majority of the City's generators still rely on Tier 0, 1, and 2 engines. Upgrading all of these engines to the current Tier 4 standard is cost prohibitive. Switching our ultra-low sulfur diesel fuel source to renewable diesel could be a low-cost way to further reduce the emissions of these generators without sacrificing reliability or requiring any technological upgrades. However, given the limitations of renewable diesel use in backup generators, staff cannot recommend its use at this time.

ECONOMIC IMPACT

Periodically assessing the environmental impacts of the City's diesel backup generators and the feasibility of alternatives ensures the continued reduction of our municipal carbon footprint and positively impacts public health, which ultimately leads to a more sustainable and resilient community, with fewer health-related costs.

FISCAL IMPACT

Staff estimates that replacing all the City's older generators would cost approximately $9 million. Routine replacements will continue to occur as engines reach the end of their useful

[13] https://s3-us-west-2.amazonaws.com/memberresource/ICLEI+Member+Case+Study+Fremont+CA+Microgrid.pdf
[14] https://www.energysage.com/solar/solar-energy-storage/what-are-the-best-batteries-for-solar-panels/

life. New engines are required to meet Tier 4 standards and such replacement costs are therefore phased in over time.

STRATEGIC INITIATIVES

This item supports the City's Complete Communities Strategic Initiative. The purpose of the Complete Communities Strategic Initiative is to create and support services and amenities that provide inclusive and equitable access with the goal of becoming a thriving and promising place to live, work and play for all. Evaluating opportunities to reduce the emissions of our backup generators allows the City to continue reducing its carbon footprint and improve the resiliency of our community, thus supporting the following goal and objective.

Goal 1: Improve quality of life for residents, business owners, and community members in all Hayward neighborhoods.

Objective 4: Create resilient and sustainable neighborhoods.

SUSTAINABILITY FEATURES

Continuously evaluating the sustainability of various backup power technologies and fuel sources has the potential to cut emissions associated with the City's emergency backup generator fleet and overall carbon footprint.

NEXT STEPS

Staff will continue to explore alternatives and seek the cleanest, most reliable technology available for replacements as each emergency backup generator nears the end of its useful life.

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