Noise & Emission Control

Whitepapper
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Innovate, Integrate, Operate: Cutting Data Center Noise & Emissions Costs

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Innovate, Integrate, Operate: Cutting Data Center Noise & Emissions Costs

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To ensure an uninterrupted power supply to the data center, even in the event of a severe power outage, the facilities are equipped with standby diesel or natural gas generator sets. These generators operate infrequently throughout the year, primarily for testing or in rare instances of power loss. When in use, they must comply with regulatory emissions and noise standards.

Unless otherwise required, most applications are needed to meet the emissions standards for these pollutants as per the table below:

Tier 4 Standards for Engines Above 560 kW, in g/kWh (g/bhp-hr)

Category	NOx (g/kWh)	NOx (g/kWh)	CO (g/kWh)	HC (g/kWh)
Generator sets	0.67 (0.50)	0.03 (0.022)	3.5 (2.6)	0.19 (0.14)

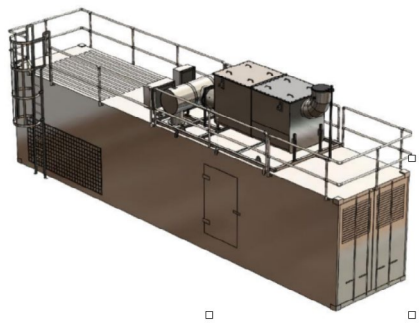
Besides, it is not surprising to see the trends in noise level requirement as stringent as 65dBA at 1m for some data centers are that are operating close by sensitive receptors such as the hospitals, schools, daycare, and senior citizens homes.

This article explores key strategies for reducing costs by integrating smarter, cleaner, and quieter technologies, optimizing both compliance and operational efficiency while achieving the applicable emissions and noise levels.

1. Innovative Systems

Airless versus Air-Assisted SCR systems

For both diesel and natural gas applications, Selective Catalytic Reduction (SCR) technology can significantly reduce the total cost of ownership when manufacturers provide airless systems. Unlike conventional air-assisted SCRs, which require compressors to deliver compressed air for Diesel Exhaust Fluid (DEF) injection, airless systems eliminate this need, reducing complexity and operational costs. By choosing an airless SCR technology, operators benefit from fewer components, lower maintenance requirements, and reduced installation costs, all while maintaining comparable NOx (Nitrogen Oxide) reduction efficiency. The images below showcase an example of an airless SCR installation on a 76.3L, 1840kW diesel generator, featuring a roof-mounted framework with safety rails and an access ladder (courtesy of IMS-EI Williams Industries).



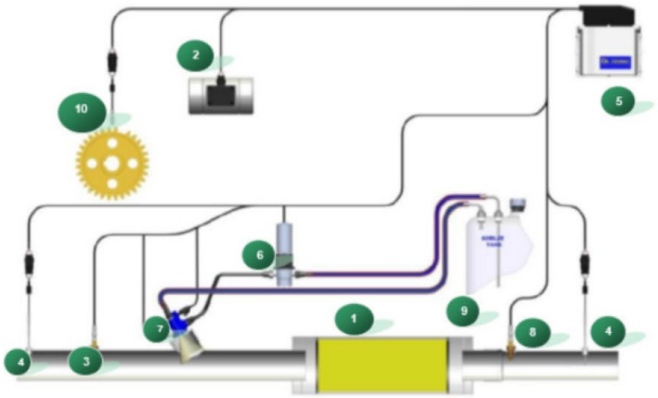
Closed Loop versus Open-Loop SCR systems

A closed-loop SCR system offers lower DEF consumption compared to an open-loop system. This is achieved through continuous monitoring of NOx levels using both “Engine Out” and “Tailpipe” NOx sensors, ensuring precise emissions control across the SCR catalysts.

In contrast, an open-loop system relies on a single outlet NOx sensor, prioritizing simplicity but compromising accuracy and efficiency. The closed-loop system’s real-time feedback mechanism allows for more precise DEF injection, preventing over-injection, reducing waste, and minimizing wear and tear on the injection system. By optimizing DEF usage, closed-loop SCR technology enhances operational efficiency while ensuring compliance with emissions regulations.

An example of airless closed-loop system is illustrated in this image. (courtesy of IMS-EI Williams Industries)

1. SCR Catalysts
2. MAP Sensor (Air Intake Pressure) or CanBus Signal
3. Exhaust Temperature Sensor
4. NOx sensors (Engine Out and Tailpipe)
5. ECU
6. DEF Pump
7. DEF Injector
8. Backpressure Sensor
9. DEF Buffer Tank
10. Speed Sensor (RPM) or CanBus Signal



2. Integrated System

Integrated silencer

Effective noise reduction can be strategically managed alongside emissions control, regardless of engine type or fuel source. This is best achieved through one or a combination of the following approaches:

1. **Targeting Engine Noise Peak Frequencies:** Most engines have available exhaust noise sound pressure level data, which should be shared with exhaust system suppliers to optimize exhaust component run lengths. Properly tuning the system to address peak noise frequencies prevents unnecessary system oversizing. Suppliers offering turnkey exhaust solutions, including emissions control components and accessories, have an advantage in incorporating noise reduction techniques through elbows, WYEs, collector tubes, SCR mixing chambers, stacks, and tailpipes. In some cases, primary or secondary silencers are added to meet stringent 65 dBA at 1m noise level requirements by attenuating dominant frequencies.

2. **Optimizing Total Exhaust System Backpressure**: All engines have a maximum allowable backpressure threshold that must not be exceeded. However, as long as the total exhaust system remains within this limit, cost-effective noise reduction can be achieved by leveraging baffling, bends, exhaust diverters, and emissions control components such as Diesel Oxidation Catalysts (DOCs) and Diesel Particulate Filters (DPFs). A precise backpressure calculation, incorporating a factor of safety, ensures optimal balance and reducing noise while maintaining system backpressure below the engine’s maximum allowable limit.

3. **Optimized Installation Layout:** The layout of an exhaust system, including its proximity to other potential structures, reflective surfaces, and open spaces, plays a crucial role in noise mitigation. Leading exhaust manufacturers collaborate with acoustical engineering firms to develop cost-effective solutions that maximize noise reduction. Proven techniques include noise barriers, cladding, and insulation around exhaust and emissions systems to shield surrounding areas, especially residential neighborhoods, from generator breakout and airborne noise. The installation example shown here demonstrates a cladded SCR system with a fine-tuned mixing chamber and noise barrier, ensuring both efficient emissions control and superior noise attenuation (courtesy of IMS-El Williams Industries).

3. Creative Operation

Optimized DEF Tanks and DEF delivery line

Knowing the operating details (engine duty cycles) and annual run-times can help with futher cost reductions particularly with an optimized DEF tank size. In most cases the generators are running less than 150 hours per year and as a result, the DEF tanks needed for the SCR can be right-sized such that refilling can take place at the same time as engine fuel refilling. The following strategies have been used effectively by a number of data centers around the globe:

1. **Main tanks in tandom with 24-hour tanks**: A main tank can serve 3 to 4 generator SCRs in a typical site whereby individualized dedicated 24-hour tanks are installed for each generator SCR. In some cases, by having the main tanks close to the SCR injectors, no additional transfer pump may be needed and if there is a need for one, then a smaller size pump can be exploited.

2. **Customized DEF tanks**: While some prefer plastic tanks, others prefer customized stainless steel tanks that are low profile and can be installed inside the enclosure, within the diesel tank available spaces, or in an cavity that may exist for canopied engines.

3. **DEF Tank storage**: DEF should be stored in a well-ventilated area, and employees should use protective equipment for eyes and hands when working with DEF. DEF tanks are best installed where the temperature is between 12°F and 77°F. One needs to ensure for heated tanks and/or cooling technologies if the ambient temperature may be outside that range.

Thermal Management

Exhaust temperature is a critical factor in the catalytic performance of Selective Catalytic Reduction (SCR) systems. For SCR units utilizing base-metal oxide catalysts, the optimal operating temperature ranges between 600°F and 750°F. Deviations above or below this range can significantly reduce SCR efficiency. To ensure optimal performance, the following strategies are implemented:

1. **Cold Applications: In cold environments**, SCR units should be positioned as close as possible to the engine's exhaust discharge to retain heat. If exhaust temperatures are insufficient, supplemental heating sources, such as heating elements, can be introduced to elevate the exhaust stream temperature and maintain the required operating window for efficient SCR activity.

2. **Hot Applications**: For high-temperature applications, excess heat must be safely dissipated before reaching the SCR catalyst. To prevent thermal degradation, the SCR may be positioned farther from the engine exhaust discharge, and cooling mechanisms may be integrated into the exhaust stream to regulate temperatures within the optimal range.

3. **High Vapor Content Applications**: In applications with high water vapor content, excessive moisture can negatively impact SCR efficiency. To mitigate this, dilution chambers may be implemented to reduce vapor concentration and minimize its adverse effects on catalyst performance.

4. **System Optimization**: One other cost reduction technique is through the system layout optimization.

The individual exhaust and emissions compoenenet can be placed to create the best temperature exposure to the catalyst:

- **Diesel Applications**: When incorporating Diesel Oxidation Catalysts (DOCs) and Diesel Particulate Filters (DPFs), emissions specialists strategically position them within the exhaust system. DPFs benefit from passive regeneration using heat from upstream components while simultaneously acting as a heat sink for downstream SCR units, ensuring optimized exhaust temperature.

- **Natural Gas Applications**: Thermal management is achieved by optimizing pipe diameter, exhaust routing, wind exposure, and radiated heat within the engine compartment, ensuring stable temperatures for SCR operation. The use of primary and secondary silencers also would allow for thermal management and further noise control as well.

An example of a thermally managed emissions system is shown for a 95.4L, 2.5MW diesel application.

By implementing these technologies and preferably leverging the turn-key solution providers, data centers can effectively address noise and emission concerns while supporting their growth and operational need at reduced total cost of ownership.