Noise & Emission Control

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Cleaner Power for AI Age: Yearly NOx Compliance Trends & Solutions

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As data centers expand globally to support AI-driven workloads, the demand for reliable backup power continues to surge. Diesel and Natural Gas generators remain the industry go-to-choices for backup power systems, offering fast response and high energy density. However, these generators also emit nitrogen oxides (NOx), which are tightly regulated due to their role in smog formation and respiratory health issues. Year-over-year, NOx emission compliance has grown more stringent, necessitating the adoption of advanced emissions control technologies — particularly aftertreatment systems such as SCR (Selective Catalytic Reduction), DPF (Diesel Particulate Filter), and 3WCs (Three Way Catalysts) — tailored to both diesel and natural gas generator types.

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 Yearly NOx Compliance Trends & Solutions, and it gives typical installation examples of smarter, cleaner, and quieter technologies, optimizing both compliance and operational efficiency while achieving the applicable emissions and noise levels.

The Rise of AI and Its Impact on Power Infrastructure

Artificial Intelligence (AI) applications — from real-time inference to training large language models — are compute-intensive and energy-demanding. Hyperscale data centers, edge computing hubs, and colocation providers are scaling their infrastructure to meet this demand. With AI pushing uptime requirements to near-perfect levels, backup generators have become more critical than ever. As their operational hours increase (especially during grid stress or in areas with unreliable power), emissions from these generators come under sharper scrutiny by regulatory boards such as EPA (Enciromental Protection Agency) and CARB (California Air Resource Board). It is not abnormal to also imagine that in near future many of these underutilized backup generator assets will be used in non-emergency peak shaving to support the grid structure or to reduce the reliance of the hosting facility on the city grid.

Regulatory Overview: Annual NOx Compliance Landscape

Across the U.S. and globally, emissions regulations such as the U.S. EPA Tier 4 Final standards, the European Stage V standards, and local air district rules (e.g., CARB) enforce strict limits on NOx emissions. These standards typically limit NOx emissions to 0.5 g/kWh or lower for stationary engines — with the most stringent rules affecting high-population and non-attainment areas.

Here is a general breakdown of how compliance expectations have evolved in recent years and what is coming in the years to come:

Year	NOx Compliance Trend	Implication for Generators
2018-2020	Early Tier 4 Final adoption	Some diesel gensets transitioned to SCR/DPF systems
2021-2022	Increased enforcement & local rules (e.g., NYC, Bay Area)	Retrofit requirements for existing fleets
2023	More stringent monitoring/reporting	Digital emissions tracking becomes standard
2024	Pressure to align with net-zero goals	Natural gas gensets gain relative popularity
2025+	Push toward zero-NOx zones & carbon-free reliability and Beyond Tier 4 Final	Aftertreatment optimization + hybridization

Aftertreatment Systems for Diesel Backup Generators

Diesel generators are known for their durability and load-following capabilities. At the same time, they are also high emitters of NOx and PM (particulate matter). To meet modern standards, two primary aftertreatment systems are typically employed:

1. Selective Catalytic Reduction (SCR)

- **Purpose:** Reduces NOx by injecting urea (DEF: Diesel Exhaust Fluid) into the exhaust stream, converting NOx into harmless nitrogen and water.
- **Effectiveness:** Up to 98% NOx reduction has been achieved with ElWilliams/IMS Airless SCR system. An example of installation is shown here.
- **Challenge:** Space restrictions prevent the use of standard SCR units and in most cases the customized solutions are being implemented for the stacked container applications.
- **2025 Trends:** Modular SCR units are now being integrated into containerized genset designs, with sensors and dosing control optimized for low-hour standby operation (typically less than 150 hours per year). In the colder climates, heated DEF tanks and heated urea lines are also being implemented.

2. Diesel Particulate Filters (DPF)

- **Purpose:** A DPF Traps and oxidizes particulate matter (soot). This is an aftertreatment solution for Diesel Applications

- **Effectiveness:** Up to 99% PM reduction has been achieved with ElWilliams/IMS Airless SCR system. An example of data-center installation is shown here.

- **Challenge:** Low duty cycles in standby gensets may not generate enough heat for passive regeneration (combustion of trapped soot); hence, active regeneration or hybrid strategies are at times needed.

- **2025 Trends:** The DPFs are installed as close as possible to the engine discharge to leverage the most of exhaust temperature. Most of these DPF applications benefit from passive regeneration of the soot. If the exhaust heat is not enough during weekly exercise cycles, it is recommended for the generator to run for a period of time (typically 1 – 2 hours) at a load that produces an exhaust temperature above 650F to adequately combust the trapped soot.

Aftertreatment for Natural Gas Generators

Natural gas gensets are increasingly used in urban and emissions-sensitive areas due to their cleaner combustion. However, they still produce NOx depending on the combustion strategy:

1. Lean-Burn Natural Gas Engines + SCR

- **Why Lean-Burn?:** Higher efficiency, lower CO and HC emissions, but elevated NOx levels.
- **Aftertreatment Need:** SCR systems are needed to reduce NOx to acceptable levels.
- **2025 Focus:** Deployment of low-temperature SCR catalysts to accommodate cooler exhaust from lean-burn engines during standby use. An example of ElWilliams/IMS airless SCR system is shown in this image.

2. Rich-Burn Engines + Three-Way Catalysts (3WC)

- **Why Rich-Burn?:** Operates with excess fuel to reduce NOx, easier to control with precise stoichiometry.
- **3WC Benefits:** Simultaneous reduction of NOx, CO, and hydrocarbons — no need for urea or Diesel Exhaust Fluid (DEF) and as a result a more economical option.
- **Limitation:** Not as efficient as lean-burn for large-scale, continuous power applications.

Applications Consideration

- **Urban Data Centers:** Historically favored rich-burn + 3WC setups due to space, simplicity, and regulatory alignment.
- **Large Hyperscale Sites:** Generally preferred Lean-burn + SCR configurations for its higher efficiency and better scalability.

AI Demand Requires More Than Just Capacity — It Requires Compliance

AI infrastructure growth is leading to:

- Increased generator runtime (e.g., for training sessions requiring continuous power assurance).
- Tighter tolerances for generator emissions, especially where grid integration or local offsets are required.
- Regulatory interest in lifecycle emissions, encouraging data centers to invest in permanent aftertreatment or hybrid microgrid strategies.

Some of the past Proactive Measures Include

- Retrofit programs for legacy diesel fleets with SCR/DPF kits similar to what took place for the on-road heavy duty diesel applications (Trucks, Busses,) from 2007 to 2010
- Switching to natural gas gensets with integrated aftertreatment that either came from the OEM or supplementary emissions aftertreatment by emissions solution provider.
- Coordinated compliance monitoring via emissions control software tied to generator control systems.

Final Thought: A Decarbonized but Reliable Future

As it was briefly discussed, the rapid expansion of data centers, driven by AI age, presents a dual challenge: ensuring reliable backup power while complying with increasingly strict NOx emission standards. Aftertreatment systems such as SCR, DPF, and 3WCs are not optional; they are essential enablers for generator viability in a compliance-driven landscape. As annual NOx standards tighten and digital emissions monitoring becomes ubiquitous, operators who integrate smart, compliant aftertreatment strategies into their genset designs will be best positioned to balance uptime with environmental responsibility.