

# UNDERSTANDING TIER 4 INTERIM AND TIER 4 FINAL EPA REGULATIONS FOR GENERATOR SET APPLICATIONS

While Tier 4 standards that begin to take effect in 2011 do not apply to generator sets used strictly for emergency standby power (with possible exceptions for California and non-attainment areas), power system specifiers and owners need to be aware of how the regulations will affect other genset applications.



The U.S. Environmental Protection Agency (EPA) began to enforce limits on diesel exhaust emissions from nonroad diesel engines in 1996 and stationary diesel-engine generator sets in 2006. Implemented in a series of steps called Tier levels, these regulations, over time, have introduced successively more stringent limitations on nitrogen oxides (NOx), carbon monoxide (CO), particulate matter (PM) and non-methane hydrocarbons (NMHC).

By  
**Christine Ueno**  
Regulatory Compliance Manager  
MTU Onsite Energy  
Mankato, Minnesota

In response to these regulations, engine manufacturers began introducing innovative design changes and sophisticated engine control systems that have successfully reduced the major pollutants in diesel exhaust to comply with each successive Tier level. Currently, all major generator set manufacturers offer products that comply with Tier 2, Tier 3 or Tier 4 Interim standards in various horsepower categories. This paper will explain the latest and near-term emissions requirements for generator set applications and discuss the technologies used to comply with the new standards.

## DRAMATIC EMISSIONS REDUCTIONS

Since the introduction of regulations in the mid-1990s, nonroad diesel emissions have been dramatically reduced. (See Figure 1.) By the time Tier 4 Final is introduced in 2014 and 2015, NOx and PM emissions from diesel exhaust will have been reduced by 99 percent.

It is important to remember that the EPA emissions regulations vary by the horsepower rating of the generator engine (or the metric

mechanical kW equivalent), not the kilowatt capacity listed on the generator nameplate. The Tier requirements have been written and implemented over an 18-year period that will culminate in 2015 with Tier 4 Final. The next big emissions reduction for medium to large generator sets begins in 2011 with Tier 4 Interim standards and concludes in 2014 and 2015 with Tier 4 Final standards. (See Figure 2.)

## Emergency standby power (ESP) exception

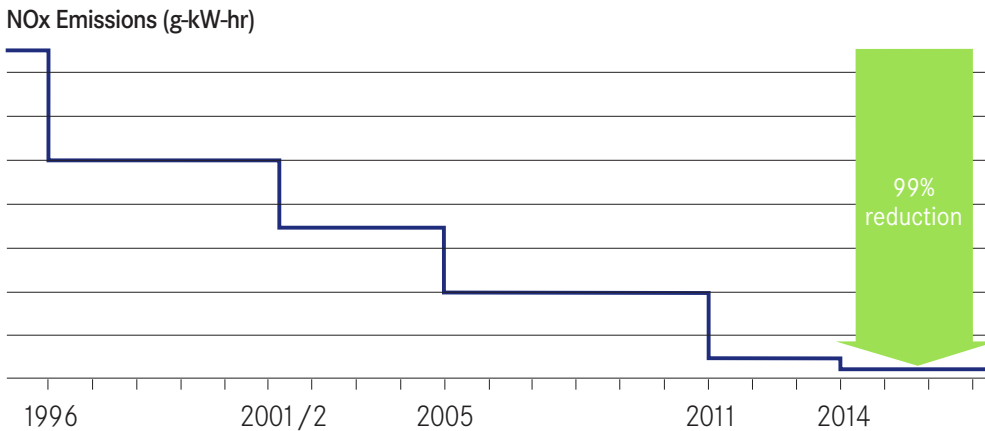
Throughout most of the United States, diesel-engine and gas-engine generator sets used strictly for emergency standby power (ESP) are exempt from EPA Tier 4 Interim and Tier 4 Final regulations. ESP installations have been exempted because Tier 2 and Tier 3 engine generators already exhibit emissions reductions of over 85 percent that have come about through in-engine design improvements. Additionally, because ESP units typically run fewer than 200 hours per year, their emissions have been judged to have an insignificant impact on local air quality. In fact, there are no time limits on running ESP generators in true emergency situations due to utility outages or equipment malfunctions. This means that all current Tier 2 and Tier 3 diesel generator sets in their applicable horsepower

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*All current Tier 2 and Tier 3 diesel generator sets in their applicable horsepower categories will be in EPA compliance through 2015 and beyond when used strictly for emergency standby power (ESP).*

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## EPA MOBILE OFF-HIGHWAY REGULATIONS (225KW TO 559KW)



**Figure 1.** By the time Tier 4 Final regulations are introduced in 2014 and 2015, NOx and PM emissions from off-highway diesel engines will have been reduced by 99 percent.

categories will be in EPA compliance through 2015 and beyond when used strictly for ESP. (See Figure 3.) ESP installations are also allowed up to 100 hours of running time per year for testing and maintenance.

However, while ESP generator sets are exempt from Tier 4 Interim and Tier 4 Final standards on a federal level, local authorities can enforce more stringent regulations. California, due to its persistent air quality problems and advanced regulatory initiatives, may require compliance with Tier 4 Interim standards in 2011 and Tier 4 Final standards in 2014–2015 for all generator set installations, including ESP. Engine manufacturers have argued that it would be in the best interest of customers and the environment for California to adopt the federal exemption for ESP. Manufacturers believe they will likely be successful in getting some regulatory relief for ESP in California before the new rules become effective.

Other parts of the country may also have more stringent regulations, especially in areas where municipalities have not attained current EPA air quality standards. These non-attainment areas are generally large population centers where due to either high local emissions or local weather conditions, ozone concentration exceeds EPA recommendations. Since NOx is a precursor to atmospheric ozone, non-attainment areas have sought to exercise greater control over point-sources of NOx. In order for municipalities to comply with emissions regulations in non-attainment areas, all diesel-engine and gas-engine generator sets may be required to comply with Tier 4 Interim in 2014 and eventually Tier 4 Final in 2015. (See Figure 4.)

#### Non-ESP applications

For applications other than ESP, Tier 4 regulations for generator sets will be phased in in two steps, beginning with Tier 4 Interim in 2011. Tier 4 Final will be required for small nonemergency generator sets beginning in 2013 and eventually all nonemergency generator sets by 2015. To achieve the level of emissions control required to meet Tier 4 Interim and Tier 4 Final standards, some form of exhaust aftertreatment will be required.

Generator set applications that will be required to comply with Tier 4 Interim in 2011 and Tier 4 Final in 2014 (<750 hp) and 2015 (>750 hp) include:

- // *Load management or peak shaving applications* – including any generator sets paralleled with the local utility and used in curtailment programs. While these generator sets may also be used for ESP, their secondary use for load management disqualifies them for exemption from Tier 4 Interim and Tier 4 Final.
- // *Prime power applications* – where the generator set is used as the primary source of electrical power due to the unavailability of normal utility power.
- // *Applications involving mobile rental power units* – including temporary power used at construction sites, seasonal utility peaking, special events or any other temporary power application.

### TIERS 1-4 NONROAD EMISSIONS STANDARDS

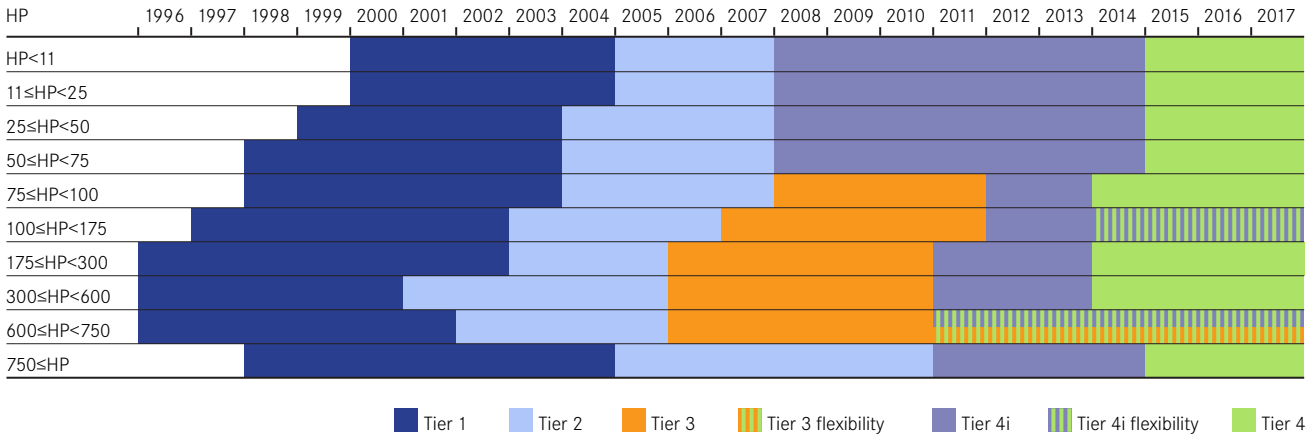


Figure 2. Nonroad diesel emissions standards vary by the horsepower rating of the engine and are being phased in over an 18-year period, culminating in 2015 with Tier 4 Final.

### EMERGENCY STATIONARY (ESP) RATINGS

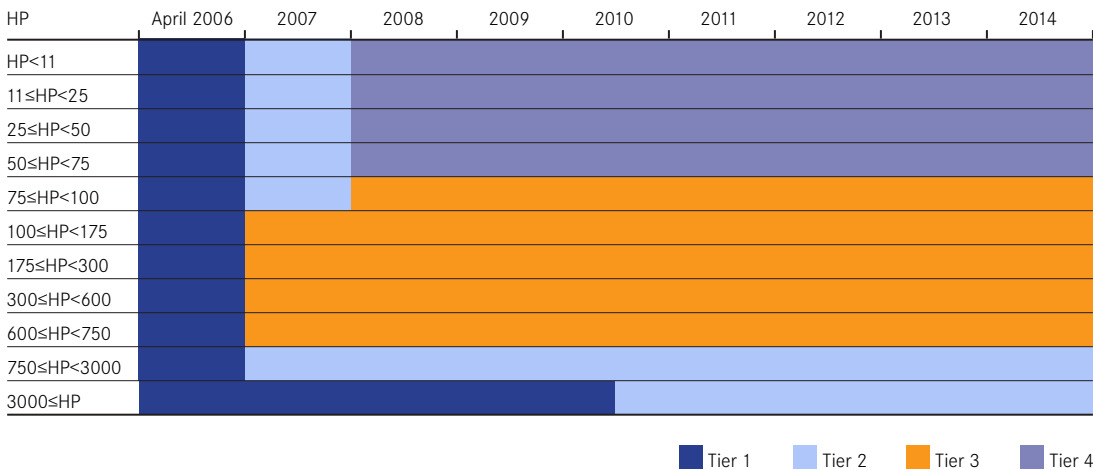


Figure 3. Generator sets used exclusively for emergency standby power are exempt from Tier 4 Final. Some smaller generator set engines are able to meet Tier 4 Interim without the need for aftertreatment.

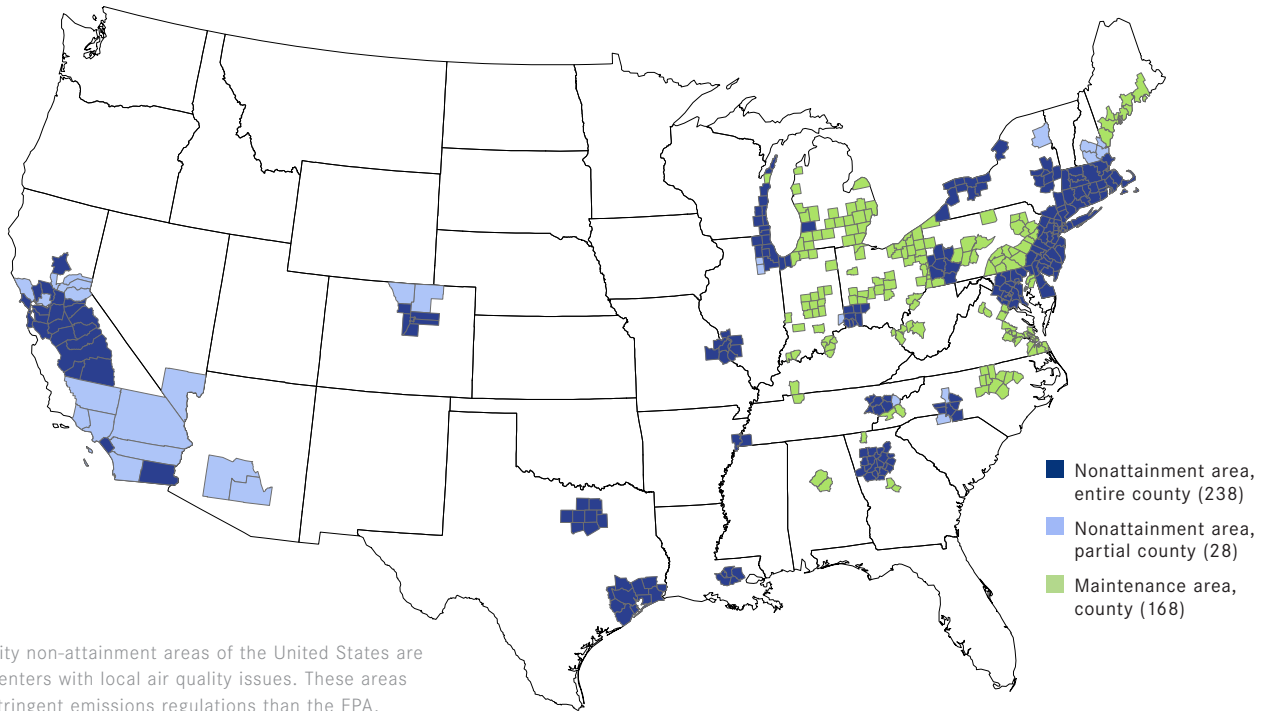
// Spark-ignited engine generators in non-ESP applications – including generator sets running on natural gas, LP, or methane collected from landfills, sewage treatment or coal seams. While these fuels are naturally clean-burning and compliant for PM, they do produce enough NOx to require exhaust aftertreatment for Tier 4 Interim and Tier 4 Final in non-ESP applications.

// Non-attainment area applications – generator set applications in California and other non-attainment areas of the country that have adopted stricter air-quality standards.

### IN-ENGINE DESIGN SUCCESSSES

While diesel engines have always been efficient and reliable, they have also had a history of producing exhaust with high levels of NOx and PM. However, in the past 15 years the modern diesel engine has been transformed into one of the cleanest prime movers available today. To date, the more than 85 percent reduction in NOx and PM in diesel exhaust has been achieved through changes to the combustion process. These advances involved changes to the geometry of the combustion chamber, valve timing, fuel injection and engine controls that distinguish today’s clean diesel engine.

## NONATTAINMENT AND MAINTENANCE AREAS 8-HOUR OZONE (1997 STANDARD)



**Figure 4.** Air quality non-attainment areas of the United States are large population centers with local air quality issues. These areas may enact more stringent emissions regulations than the EPA.

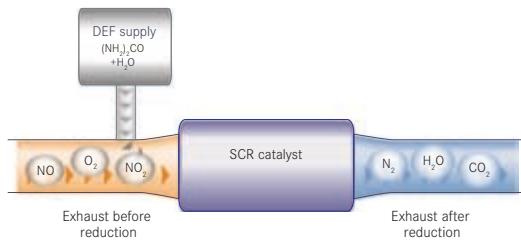
This in-engine improvement approach has resulted in the best performance, highest fuel efficiency and lowest heat rejection of any available technologies. In fact, the overall thermal efficiency of diesel engines now surpasses 40 percent in some applications, compared to about 27 percent for gasoline engines. Here are the in-engine design changes that have contributed to this major achievement:

- // *High-pressure common-rail fuel injection* – Operating at about 20,000 pounds per square inch, high-pressure common rail fuel injection helps improve combustion by more fully atomizing the fuel so it can burn faster and more completely.
- // *More precise injection timing* – The electronically controlled injector solenoids respond faster than old-style mechanical injectors, allowing more precise timing of the injection—a critical factor in emissions control. Up to three injections per power stroke are possible, depending on the engine application and operating conditions.

- // *Advanced electronic engine controls* – These sensors and controls monitor and manage dozens of operating and environmental conditions in order to optimize horsepower, torque and response to changes in load. These systems allow the engine to maintain combustion efficiency over a broad range of operating conditions and minimize emissions in the exhaust.

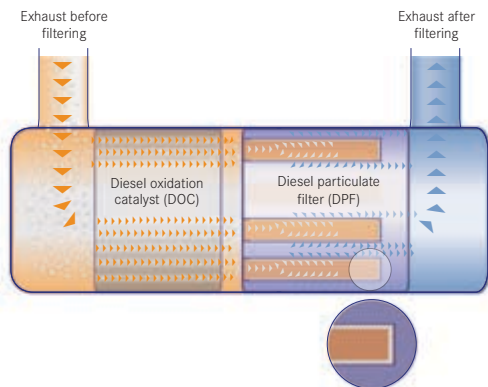
- // *Advanced turbocharging* – New variable-geometry turbochargers automatically compensate for changes in engine speed and power demand. Compound or staged turbocharging will also be used to meet Tier 4 Interim and Tier 4 Final. This technology achieves very high boost pressures by using a first turbocharger to moderately boost and intercool combustion air before this air is fed into a second turbocharger for final boosting and intercooling. This approach achieves much higher thermal efficiency than a single-stage turbocharger, and produces more power without increasing emissions.

## SELECTIVE CATALYTIC REDUCTION (SCR)



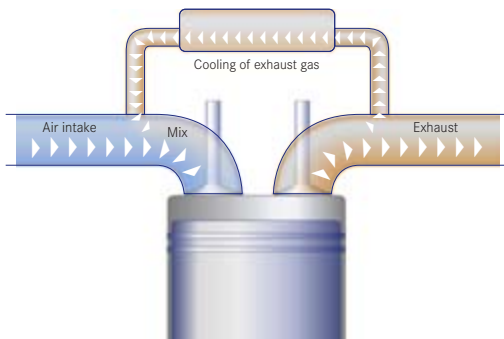
**Figure 5.** Selective Catalytic Reduction (SCR) will be the principal aftertreatment technology used to further reduce NOx in diesel exhaust.

## DIESEL PARTICULATE FILTERS (DPF)



**Figure 6.** A diesel particulate filter (DPF) traps the carbon particles in diesel exhaust and converts them to ash, which must be periodically removed.

## EXHAUST GAS RECIRCULATION (EGR)



**Figure 7.** Another emission control technology, exhaust gas recirculation (EGR), cuts NOx by reducing combustion temperatures using recirculated exhaust gases.

## EXHAUST AFTERTREATMENT

While in-engine refinements helped engine manufacturers achieve Tier 2 and Tier 3 standards, Tier 4 Interim and Tier 4 Final regulations will require exhaust aftertreatment to further reduce NOx and PM. The most effective and practical aftertreatment technologies include selective catalytic reduction (SCR) to control NOx and diesel particulate filters (DPF) to capture the remaining PM. While most diesel engines will require SCR to meet the NOx limits for both Tier 4 Interim and Tier 4 Final, some engine models will be able to meet the Tier 4 Final regulations for PM without a DPF. In addition, exhaust gas recirculation (EGR) combined with a DPF may be used in some engine platforms to reduce NOx in place of SCR to meet Tier 4 Final.

Here are the major technologies that will be used on diesel engine generators to meet Tier 4 Interim and Tier 4 Final:

// *Selective Catalytic Reduction (SCR)* – SCR will be used on some engine-generator applications to achieve Tier 4 Interim and Tier 4 Final regulations. SCR reduces the remaining NOx in diesel engine exhaust by up to 90 percent. It works by combining the exhaust gases with ammonia in the form of urea (or diesel emissions fluid, DEF) and passing the mixture over a catalyst. The result is exhaust that contains harmless elemental nitrogen, water vapor and carbon dioxide. Roughly one gallon of DEF is required for every 20 gallons of diesel fuel that is burned. SCR-equipped diesel generator sets will be available beginning in 2011 to meet Tier 4 Interim standards. In 2011, SCR will be used to meet Tier 4 Interim regulations in California and certain non-attainment areas for ESP, and all non-emergency applications regardless of location. (See Figure 5.)

// *Diesel Particulate Filter (DPF)* – This device traps and incinerates PM (soot particles) in diesel exhaust. The technology will not be required on most diesel engine generator sets to achieve Tier 4 Interim regulations, but it will be required in most power nodes in conjunction with SCR to achieve Tier 4 Final. A DPF uses a mechanical filter to trap soot particles after they have been partially oxidized by a catalyst. At certain intervals during operation, the trapped particles are incinerated. Periodically, inert ash will have to be removed from the DPF. (See Figure 6.) In 2014–2015, a combined DPF-SCR unit will be used to meet Tier 4 Final regulations for ESP in California and certain non-attainment areas, and for all non-emergency applications regardless of location.

// *Exhaust Gas Recirculation (EGR)* – EGR is another technology that may also be used on some engine-generator combinations to reduce NOx in diesel exhaust. EGR works by recirculating a small amount of cooled exhaust gas back into the combustion chamber. This reduces combustion temperatures and effectively reduces the production of NOx. EGR is very effective at reducing NOx, and EGR-equipped engines will not require SCR aftertreatment. However, EGR increases particulate emissions, so a DPF will be needed to meet both Tier 4 Interim and Tier 4 Final regulations. (See Figure 7.)



## CONCLUSIONS

Engine manufacturers have been working for nearly two decades to perfect emissions control technologies on diesel and spark-ignited engine-powered generators to make sure that compliant systems are in place as the EPA Tier levels become effective. Tier 4 Interim regulations will require SCR or EGR/DPF beginning in 2011 for applications such as prime power, peak shaving or load management. Current Tier 2 and Tier 3 generator sets are EPA-compliant for most ESP applications through 2015 and beyond, except in California and other non-attainment areas.

Tier 4 Final regulations will require technologies such as SCR and DPF beginning in 2014 for nonemergency applications of 750 hp and below; and in 2015 for nonemergency applications of 750 hp and above. Local regulations in California and certain non-attainment areas will require that all diesel generator sets meet Tier 4 Final beginning in the 2014–2015 time frame.

In order to make sure that your onsite power system will comply with all the latest EPA and local emissions regulations, consult your generator set manufacturer and local air-quality authorities.

MTU Onsite Energy Corporation  
 100 Power Drive  
 Mankato, MN 56001 USA  
 Phone: +1 800 325 5450  
       +1 507 625 7973  
 Fax: +1 507 625 2968  
 powergenregion3@mtu-online.com



*With over 50 years of experience, MTU Onsite Energy Corp. is a leading producer of diesel-powered generator sets from 30 kW to 3,250 kW and gas-powered generator sets from 30 kW to 400 kW for standby, prime power and cogeneration applications. MTU Onsite Energy Corp. is a Tognum Group company.*