Final Report

ESTIMATES OF EMISSIONS FOR SMALL-SCALE DIESEL ENGINES

HARC Project H-10

Prepared for

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1. INTRODUCTION

In August 2003, the Houston Advanced Research Center (HARC) retained ENVIRON International Corporation (ENVIRON) to estimate NOx emissions from small-scale diesel generators in the Houston-Galveston area (HGA) and assess the regional impact from these emissions on the HGA. This report presents information on the methodology used by ENVIRON to estimate the population of small-scale diesel generators in the HGA and the emissions impact resulting from these generators. In addition, information is provided on emission control technologies for diesel generators and recommendations related to the use of study results.

BACKGROUND

Small-scale electrical generators are powered by a variety of engine types including natural gas or gasoline internal combustion (IC) engines, and diesel engines. Of these various engine types, the majority are diesel engines. It is estimated that there are about 350,000 diesel generator units in the United States with about 10% of these engines (or 35,000 units) estimated to be in the state of Texas. These generators are used for emergency stand-by or back-up electricity generation, for electricity grid stability and peak shaving, and in some cases, for powering construction and farm equipment and other applications where grid electricity is not available or hard to access.

Electricity capacities for these generators can range from 5-kilowatt (kW) residential back-up generators to large 7-megawatt (MW) power generators. These generators are predominately powered by Caterpillar engines, followed by Cummins, Detroit Diesel and John Deere engines. Typical NOx emissions from uncontrolled diesel generators range from 10 to 14 grams per horsepower hour (g/hp-hr), depending on the horsepower rating.

The Texas State Implementation Plan (SIP) estimates that NOx emissions contributed by diesel generators in the HGA is roughly five tons per day. However, this estimate is very crude and mainly accounts for traditional operation during distribution grid failure; it does not include those activities such as peak shaving and power applications where grid electricity is not available or hard to access. The additional emissions from these unaccounted activities could be substantial and undermine the investment to clean up large power plants. Recognizing the significance of the emissions from these diesel generators, the Texas Commission on Environmental Quality (TCEQ) adopted rules regulating new stationary IC generators in 2001. The adopted rule requires that owners of new stationary IC engines, including those for generators, apply for an operating permit prior to operating the equipment.

In order to better understand the impact of these diesel generators on the total NOx emission inventory in the HGA, the Houston Advanced Research Center (HARC) retained ENVIRON to estimate the NOx emissions from diesel generators in the HGA, as well as to discuss potential control technologies to reduce NOx emissions from these diesel generators.

4. SUMMARY AND RECOMMENDATIONS

This study provides a preliminary effort to quantify the emissions contribution from the stationary diesel generators, including emergency, peak shaving, and baseload generators, in the Houston-Galveston Area. The study concluded that soliciting and/or reviewing data from the fire department fuel storage registration, and city permit records provided very limited information on diesel generator population and activity data. Also, while there was some data available on diesel generators from TCEQ's air permit records for stationary engines, these data were insufficient to estimate the emission inventory from the diesel generators in the HGA.

Based on its diesel generator engine database, PSR estimates that there are about 24,000 emergency diesel generators, 3,000 peak shaving diesel generators, and 2,000 baseload diesel generators in the HGA. The electric capacities for these generators are estimated to be about 7,000 MW for emergency generators, 3,100 MW for peak shaving generators, and 400 MW for baseload generators in the HGA. Comparing PSR data with information or data published by other studies on diesel generators, this study concluded that there were some great uncertainties in the population, activity (usage hours) and electric capacity data from the PSR database.

While recognizing that there were some great uncertainties in the PSR database, the study attempted to estimate the emissions inventories from the diesel generators in the HGA using the PSR database, due to the unavailability of better data or information. Using the PSR database, the NOx emission inventories for emergency, peak shaving, and baseload diesel generators in the HGA were estimated to be approximately 33.0, 73.1, and 55.0 tons per day, respectively. For other diesel generators, mostly portable generators, the NOx emissions were estimated to be approximately 5.7 tons per day. Some of the emissions from the baseload generators should have been previously accounted for in the point source emission inventories, and most of the emissions from the other diesel generators should have been previously accounted for in the non-road mobile source emission inventories. Peak shaving generators contributed to 44% of the total NOx emissions in the HGA. Also, the emergency, peak shaving, and baseload generators in Harris County contributed about 45% of the total NOx emissions in the HGA. Portable diesel generators, which accounted for part of the non-road mobile source emissions, only contributed about 3% of the total NOx emissions.

Observing that the 33.0 tons per day of NOx emissions from emergency diesel generators estimated using the PSR data was substantially higher than the five tons per day estimated by TCEQ in 1997, this study attempted to assess the sensitivity of the activity data on the emission inventory. Using the 30 hours per year activity data for emergency generators based on a CARB study, the NOx emission inventory for emergency generators in the HGA was reduced from 33 tons per day to 7 tons per day – an 80% reduction in NOx emissions. It was clear from this sensitivity analysis that the operating hours assigned to each generator type has a major impact on the NOx emission inventory.

Also, PSR based their estimate for the diesel generator population and activity data in the HGA on 2003. During the last six years, the demand and utilization of electric power in the HGA has changed due to the deregulation of the electric power production industry and recent turmoil in

energy markets. More and more major electricity consumers (industries) are relying on other power sources, including stationary diesel generators, instead of the traditional central power plants, to meet their power demand, to avoid downtime resulting from central power plant down time, and to save energy costs. These power utilization changes and the increases in the power demand could contribute to the increases in the use of diesel generators, and thus, increases in the NOx emission inventory from this source as well.

In addition to estimating the emissions from diesel generators, this study also reviewed the emission control technologies for diesel generators. The study identified that the most effective method to reduce NOx emissions from large stationary diesel engines such as those used in stationary diesel generators is selective catalytic reduction (SCR) technology. SCR technology has been successfully applied to large diesel engines for many years with more than 80% reduction efficiency. For less costly NOx control strategies, injection timing adjustment and lean NOx catalyst technology can be considered, which generally provides more modest reductions of 10% to 30%. The cost for a SCR system for diesel generators ranges from $45,000 to $180,000, with cost-effectiveness values ranging from $8,000 to $38,000 per ton of NOx reduction.

RECOMMENDATIONS

Based on the results from this study, it is clear that the NOx emissions contributed by the stationary diesel generators can be substantially higher than the NOx emission inventory estimated by TCEQ in 1997. While the study attempted to estimate the emission inventory from the diesel generators in the HGA, these emission inventory results involved great uncertainties that were inherited from uncertainties in the PSR database.

Nonetheless, the emission inventory can be refined with some further effort in assessing the uncertainties of the PSR database, such as refining the population and activity data (e.g. usage hours and load factors) through focused survey and/or data-gathering work on targeted stationary diesel generator owners in the HGA. The survey and data-gathering work can be performed by way of phone, mailing, and field contacts. Diesel generator information or data extracted from the TCEQ's air permit records can be a good starting point for establishing a contact list for the survey effort. After acquiring new activity data from the survey effort, sensitivity analysis on the emission inventory should be performed using these new activity data. In addition to the focused survey effort, establishing local, regional or statewide data collection programs, such as those similar to the CARB's Portable Power Equipment Registration Program (http://www.arb.ca.gov/perp/factshe3.htm), would generate useful data for improving the emission inventory for diesel generators in the HGA.