Final Report

ESTIMATES OF EMISSIONS FOR SMALL-SCALE, STATIONARY DIESEL GENERATOR ENGINES IN THE DALLAS-FORT WORTH AREA

TCEQ Project # 108, TERC Project H-10

Prepared for

Houston Advanced Research Center
4800 Research Forest Drive
The Woodlands, TX 77381

Prepared by

Michael Smylie
Lit-Mian Chan
Sandhya Rao

ENVIRON International Corporation
101 Rowland Way, Suite 220
Novato, CA 94945-5010

and

George Zirnhelt

Power Systems Research
1365 Corporate Center Curve, 2nd Floor
St. Paul, MN 55121-1298

January 17, 2005

ACKNOWLEDGMENTS

The work reported herein was performed under TCEQ Project #108, TERC Project H-10 by the Novato, California office of ENVIRON International Corporation. Mr. David Hitchcock with HARC was the project coordinator, and Mr. Bertie Fernando with TCEQ was the technical liaison for TCEQ. Michael Smylie of ENVIRON directed the overall effort. Lit-Mian Chan and Sandhya Rao of ENVIRON provided significant contributions. Power Systems Research provided the database for small-scale, stationary diesel generators in the Dallas-Fort Worth area, and conducted the focused survey work for the project.

TABLE OF CONTENTS

Page

APPENDICES

TABLES

1. INTRODUCTION

In January 2004, the Texas Commission of Environmental Quality (TCEQ) and Houston Advanced Research Center (HARC) retained ENVIRON International Corporation (ENVIRON) to estimate NOx emissions from small-scale, stationary diesel generators in the Dallas-Fort Worth (DFW) area and assess the regional impact from these emissions on the DFW area that includes the four non-attainment counties (Collin, Dallas, Denton and Tarrant Counties), and the surrounding eight near non-attainment counties (Ellis, Henderson, Hood, Hunt, Johnson, Kaufman, Parker and Rockwall Counties). This project is an extension of a recently completed ENVIRON project for HARC entitled "Estimates of Emissions from Small-Scale Diesel Engines" (ENVIRON, 2003), which studied the emissions from small-scale, stationary diesel generators in the Houston-Galveston Area (HGA), and the effects of these emissions on the HGA non-attainment area.[1,2,3]

This report is a final report for the project. A draft final report was submited to HARC and TCEQ in September 2004 (ENVIRON, 2004a), and an interim report documented the preliminary results of the project and was submitted to HARC and TCEQ in April 2004 (ENVIRON, 2004b).

This final report presents revised population and activity data and emission inventories for small-scale, stationary diesel generators in the DFW area based on results from a focused survey. In addition, comments from TCEQ and HARC on the interim and draft final reports are also included in this final report. Following this section, Section 2 of the report presents population and activity data of stationary diesel generators in the DFW area, as well as discussion and results of survey work to refine the population and activity data. Section 3 presents the estimated emission inventories for these generators using the population and activity data projected based on survey results, as well as discusses some potential NOx emission control technologies for these diesel generators. Finally, Section 4 provides references cited in the report.

---

[1] Funding for this study and the previous study estimating NOx emissions in the Houston-Galveston area were provided from separate sources. As such, several areas of this report, most particularly in regards to background information, are similar between the two study reports.

[2] The estimated population of small-scale, stationary diesel generators in the Houston-Galveston area study report and in the interim report for the Dallas-Ft. Worth area were based on national sales statistics. This "top-down" method for estimating population data has been used by a number of regulatory agencies, most notably the U.S. Environmental Protection Agency (EPA) and the California Air Resources Board (CARB). As discussed later in this report, the top-down estimate used in this study was refined through a focused survey.

[3] One of the conclusions in the Houston-Galveston area study report was to refine the "top-down" emission inventory using localized population and/or activity data when these data are available. However, modifying the Houston-Galveston area study report based on the activity data resulting from the focus survey work in this DFW study is beyond the scope of this DFW study. ENVIRON has recommended to HARC to provide funding to update the "top-down" emission inventory in the Houston-Galveston area study with the new activity data developed in the DFW study, as well as to combine both the Houston-Galveston area study report and the DFW study report into a single report.

BACKGROUND

Small-scale, stationary 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. Over the past several years the use of small-scale, stationary engine-powered electrical generators has grown among commercial, industrial and institutional users. Each year more than 100,000 commercial grade stationary generator sets powered by diesel or natural gas are sold in the U.S. (PSR, 2004). These products typically have lifetimes of 20 years or substantially more, and many operate only a few hours per year. As a result there are estimated to be over 1,000,000 small-scale, stationary engine-powered electrical generators in operation in the U.S. (PSR, 2004). Among these generators, it was estimated that there are about 350,000 diesel generator units with about 10% of these engines (or 35,000 units) estimated to be in the state of Texas (NESCAUM, 2003 & TexPIRG, 2002). However, the HARC generator study for HGA (referred later as the HGA study) indicated that there were about 29,000 stationary diesel generators in HGA alone (ENVIRON, 2003).

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. While the use of these stationary generators generally follows economic activity, some sectors tend to have greater need for standby and peak shaving power. Hospitals and airports, for example, are required by code to install and maintain standby generators, and energy intensive industry sectors and those who tend to have large demand for short periods of time tend to use peak shaving more frequently. In addition customers in regions where there are large seasonal variations in demand, such as in high summer air conditioning demand, tend to receive incentives from utilities for reducing their demand on the utilities during these periods.

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, Cummins, Detroit Diesel, Deutz, John Deere, Kubota, and Perkins engines. Typical NOx emissions from uncontrolled stationary diesel generators range from 10 to 14 grams per horsepower hour (g/hp-hr), depending on the horsepower rating. The NOx emissions from controlled stationary diesel generators are estimated to be about half of those for uncontrolled stationary diesel generators (AP 42, 1995). However, the exact percent of uncontrolled stationary diesel generators in the U.S. is unknown as different states have different requirements or regulations on small scale, stationary, back-up diesel generators.

Recognizing the potential significance of the emissions from these diesel generators, TCEQ adopted rules regulating new stationary internal combustion (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.

While there was no known estimates of emissions for small-scale stationary diesel generators in the DFW area, TCEQ estimated that the NOx emissions from these small-scale, stationary back-up diesel generators was about five tons per day (tpd) in the HGA. ENVIRON's HGA study, however, indicated that the NOx emissions from these stationary diesel generators in the HGA could range from 7 tpd to as high as 33 tpd, depending on the projected usage hours for these generators.

In order to better understand the impact of these diesel generators on the total NOx emission inventory in the DFW area, HARC and TCEQ retained ENVIRON to estimate the NOx emissions from small scale, stationary diesel generators in the DFW area, and to discuss potential control technologies to reduce NOx emissions from these diesel generators. In addition, ENVIRON was tasked with refining the population and activity data, including usage hours, of these generators through a focused survey.

SCOPE OF WORK

In general, this project consisted of three tasks, namely a data gathering and survey task, an emission quantification and impact assessment task, and a survey results and report development task. The scope of work for each task is defined below:

Task 1: Data Gathering and Survey Task

In this task, efforts were made to quantify the population, activity, and emission characteristics of stationary diesel generators nationwide with emphasis on the State of Texas. These efforts primarily involved literature searches and a review of available data and quantification methods, including those discussed and recommended in the HGA study. As information was obtained, diesel generators were categorized based on emissions (e.g., horsepower rating) and/or application (e.g., back-up, prime, or portable generators) characteristics. After the population, activity, and emission characteristics of stationary diesel generators were quantified, an assessment of the available data and methods was conducted to determine the applicability of these data to the DFW area. Finally, a recommended method for quantifying the population and activity data on small-scale, stationary diesel generators for the DFW area was made based on the assessment results.

Specific subtasks included the following:

- Reviewed the HGA study, and extracted pertinent information gained from the study;
- Assessed other available data and methods to determine the applicability of these data for the DFW area;
- Developed a methodology to estimate population and activity data of stationary generators found in the DFW area. The proposed methodology included, but was not limited to, the use of the following tools:
    - Existing dataset review (past relevant data, air permit applications etc.)
    - Diesel generator population and activity data via a market research company (Power Systems Associate or PSR)
    - Focused survey based on SIC codes on generator populations and usages

- Acquired a database with population and activity data for diesel generators in the DFW area from PSR, an engine market research company. The database included population, specifications, and operating data for stationary generators powered by diesel engines, broken down by emergency standby, peak shaving and baseload generators in the DFW area in 2003. The capacity for these generators ranged from less than 25 kW to 1,500 kW and more. For each generator type, the database included data for the following parameters:

  - Engine make
  - Engine model
  - Output rating [kW]
  - Year installed
  - Number of units
  - Average hours per year /unit
  - Load factor

- Compiled available relevant data on diesel generators from TCEQ's permitting department;

- Compiled, reviewed, and reduced available data, including existing datasets and newly acquired datasets, to determine the generator population and activity data by category in the DFW area;

- Developed and implemented a focused survey methodology based on SIC codes for small-scale, stationary diesel generators in the DFW area to gather population and activity data for verification and/or fine-tuning the database – PSR performed most of this sub-task with oversight from ENVIRON; and

- Summarized and presented the preliminary results of the population and activity data for stationary diesel generators in the DFW area as well as discuss the focus survey status in a preliminary report.

Task 2: Emission Quantification and Impact Assessment

In this task, available data, including existing and newly acquired datasets, were compiled, reviewed, and reduced to determine the generator population and activity data by category in the DFW area. Following this, a NOx emission inventory for stationary diesel generators in the DFW area was generated in a format consistent with the SIP and the improved and existing emission inventories were compared. In addition, potential NOx emission control technologies for small-scale, stationary diesel generators were reviewed and assessed as part of this task.

Specific subtasks included the following:

- Generated NOx emission inventory for generators in the DFW area in a format that was consistent with the SIP, and compared the improved and existing emission inventories. The emission factors used in developing these emission inventories were based on those provided in Volume I: Stationary Point and Area Sources of EPA's AP-42 Compilation of Air Pollutant Emission Factors (AP-42, 1995);

- Provided a summary of the potential NOx emission control technologies for small-scale, stationary diesel generators; and
- Summarized and presented the preliminary results of the emission inventory for diesel generators in the DFW area in the preliminary report.

Task 3: Survey Results and Report Development

In this task, a survey was conducted on all prospective generator set owners by two digit SIC codes using the list obtained in Task 1 of the baseline work. A survey team started with the highest probability owners and continually compared the results to the well-established norms that the team used to gauge ownership. The survey team interviewed prospective owners through phone calls until the success rate and the norms indicated that the team had exhausted at least 80% of all possible owners. At the end of the survey, the team had made about 7,000 contacts in order to identify the targeted number of generator sets.

The data from the survey was compiled and entered into a database that was designed to monitor quotas in each area. The results were tracked in terms of completed and incomplete contacts to the projected population for the area. When the survey team reached the 80% target quotas, the survey work was considered completed. At the same time the telephone contacts were being made, the team reviewed any documented information such as permit lists and other public record information that provided generator set locations. The team also contacted engine distributors to discuss survey estimates and to identify any areas that may have been missed.

Once the survey was completed, the results of the survey work were analyzed and summarized. Based on the results of the survey work, ENVIRON revised the population and activity data, as well as updated the emission inventory, for small-scale, stationary diesel generators in the DFW area. Finally, data gathering, methodology development and survey work, as well as study results, were summarized in a draft final report.

Specific subtasks included the following:

- Documented the results of the focused survey;
- Revised the population and activity data, as well as emission inventory results, for small-scale, stationary diesel generators in the DFW area based on the survey results; and
- Drafted a draft final report to summarize the focused survey results, as well as presented the revised population and activity data, and revised emission inventory for small-scale, stationary diesel generators in the DFW area.

QUALITY ASSURANCE AND QUALITY CONTROL

Quality assurance (QA) is a system of planning and structures set up beforehand to assure that the data and results presented in a report are accurate, analyses are properly performed, and assumptions are probably made and documented. On the other hand, quality control (QC) is the process of checking that these elements are actually true, usually after the fact.

QA procedures for this project emphasized proper data gathering and analyses, reporting and documentation control. For this project, ENVIRON first developed a workplan outlining, among others, the project approaches, assumptions and database used, and result reporting formats for TCEQ to review and comment, prior to performing the tasks. After receiving approval on the workplan from TCEQ and HARC, ENVIRON began the project according to the workplan. Throughout the project, ENVIRON provided monthly reports to TCEQ and HARC indicating the project status and issues encountered, as well as submitted an interim report and a draft final report presenting the preliminary and draft final results of the project to TCEQ and HARC for review and comment. In addition, ENVIRON ensured that:

- All data and information used in the data analyses were the best available to ENVIRON's knowledge, and were representative for or applicable to this project. Also, the sources and limitation or sensitivity of these data were also documented. These data were reviewed, outlined in the workplan, and approved by the project manager prior to being used for data analyses.

- Spreadsheet/data analysis results were reviewed and approved by the project manager prior to documenting them in reports or presenting them to TCEQ and HARC.

- All reports or documentation for the project were reviewed and critiqued internally by the key personnel prior to releasing to TCEQ and HARC for review, and public release of these reports or documentation were done or approved by TCEQ and HARC.

2. POPULATION AND ACTIVITY DATA

DATA SOURCES

In order to better estimate NOx emissions from small-scale, stationary diesel generators in the DFW area, the population and activity data for these generators must be quantified as accurately as possible, to the extent that data and information are available. In this project, ENVIRON reviewed the HGA study, and extracted relevant data from the study. In conducting the HGA study, a number of literature research sources were reviewed, and these sources were also reviewed to determine applicability for this study. These research sources include the following:

- Information contained in diesel generator permit records submitted to the TCEQ by industrial sources found in reference TEXPIRG[4] (see Appendix A, Source: TEXPIRG, 2002).

- A report on stationary compression-ignition engines prepared by the California Air Resources Board (CARB) (CARB, 2003).

- Information from the CARB statewide Portable Equipment Registration Program (PERP) & Distributed Generation (DG) Certification Program. The PERP establishes a uniform method for regulating engines and portable equipment throughout the state and provides a means for estimating the population and activity of this equipment. The DG Certification program requires electrical generation technologies that are exempt from district permit requirements to be certified by the CARB to specific emission standards before they can be sold in California. Data generated from the PERP and DG Certification program have been used to estimate emissions from diesel generators in California and elsewhere.

- Studies funded by the California Energy Commission (CEC) to develop an emission inventory and control technologies for backup generators in California. The results of these studies were published in CEC reports in December 2001 (CEC, 2001a & CEC 2001b).

- A study funded by the Northeast States for Coordinated Air Use Management (NESCAUM) to improve the emissions inventory for diesel generators in the Northeast State by estimating the population and activity data for these generators. Results of this study were published in a NESCAUM report in June 2003 (NESCAUM, 2003).

[4] As part of the literature research effort for the Houston-Galveston area study, ENVIRON contacted the TCEQ to inquire about data related to stationary diesel generators but was told that the State's permitting data does not break-out stationary emergency generators. In an Email date August 6, 2003, Kathy Pendleton with TCEQ stated that "I looked in the SCC listings and we (nor EPA) do not have a specific code for emergency generators. If a company reports generator information, it is under a general generator code, so it is very hard to impossible to distinguish them in the inventory".

- A study outlining the emission impacts of stationary diesel generators on public health in Texas conducted and published by an environmental group led by TexPIRG (TexPIRG, 2002).

Table 2-1 summarizes the relevant data/information found in the reference sources. While there were some relevant data found in these sources, ENVIRON determined that the best available and most complete data option to estimate emission inventories for small-scale, stationary diesel generators in the DFW area was the database from PSR, as concluded in the HGA area (ENVIRON, 2003), and outlined in the approved workplan to TCEQ and HARC for this project (ENVIRON, 2004c). As a result, ENVIRON procured a database from PSR, which contained predicted population and activity data for stationary diesel generators in the DFW area.

Table 2-1. Summary of relevant data/information found in the reference sources.

Data Sources/ Reports	Population	Activity Data	Emission Inventory	Control Technology
TEXPIRG	Population estimated using DFW capita population & diesel generator population data in California from the CARB study	Assumed 20% of generators operate 3 hours/day & 38% efficiency (or 0.72 load factor)	Estimated using DFW capita population and data from the CARB study	Brief discussion on alternative fuel engines, microturbines & Stirling engines
CARB's Stationary Engine Study	Population estimates for California based on PPER database, CEC study, and survey results in California	Usage hours: 953 hrs for prime or baseload generator & 30 hrs for backup generator; load Factor is 0.74	Emission estimates for California	Detailed discussions on control technologies (cleaner diesel engines, aftertreatment controls, cleaner diesel/alternative fuels, engine repowering & usage restrictions), and cost and demonstration programs
CARB's PPER/DG Certification Program	Information/data for the CARB stationary engine study	Information/data for the CARB stationary engine study	Information/data for the CARB stationary engine study	General reporting information on various control technologies, including microturbines and fuel cells
CEC Studies	Population estimates for backup generators (BUGs) over 350 kW by manufacturer & district in California	Activity data based on BUG air permits from different California districts	Emission estimates for BUGs over 350 kW by district in California	Detailed discussions on control technologies and costs for alternative fuels & aftertreatment devices

Data Sources/ Reports	Population	Activity Data	Emission Inventory	Control Technology
NESCAUM Study	Population estimates for stationary diesel engines in the Northeast states by capacity and state	Activity data from PSR database, partial permit data, and PSR survey data for	Emission estimates for station diesel engines in the Northeast states based on population from PSR survey results and AP-42 emission factors by capacity and state	Detailed discussions on control technologies and costs, and control technology case studies

The PSR database was developed based on national sales data of generators as of December 31, 2003, and maintained through the use of its continuing survey data, as well as selected economic factors from the Bureau of Census, County Business Patterns Survey. While ENVIRON used the population and activity data from the PSR's database to estimate the preliminary NOx emission inventory from diesel generators in the DFW area, it was recognized that information derived from the database were estimates and therefore were used only as a starting point for further refinement such as the use of results from the survey work of local small-scale, stationary diesel generator owners.[5,6]

The next three sections discuss the PSR database and its methodology in generating the database, and the focused survey and survey results.

PSR PARTSLINK™ METHODOLOGY AND DATABASE

PSR has maintained a database known as PartsLink™ over the past 27 years. PartsLink™ utilizes a mathematical model to estimate the number of engine powered products in service in the U.S. and the annual parts consumption associated with the operation of that equipment. This model is developed based on national engine sales data and maintained through the use of factual data including survey results developed and compiled by PSR on a continuing basis. Application populations are distributed geographically based upon selected economic factors from the Bureau of Census, County Business Patterns Survey.

Key elements of the data include:

- A continuing record of shipments from U.S. factories and imports from foreign suppliers;
- Exports of U.S. produced equipment; and

[5] Both CARB and EPA have used PSR's engine/equipment database for their non-road model development work and have refined or complemented the data with other data sources.

[6] As indicated in the Scope of Work, Task 3 of this project was to conduct a focused (localized) survey on owners/operators of stationary diesel generators in the DFW area. The information from the survey work was used to refine the PSR database, and thus, the emission inventories.

- An attrition model utilized to estimate retirement of engine powered products based upon:
  - Estimated engine life
  - Annual hours of utilization
  - Intensity of utilization – load factor
  - Reported parts consumption and replacement

These factors are used to calculate retirement rates and estimate the resulting number of products remaining in operation as well as to estimate the market for parts and components. While the database includes information on engines placed into service prior to 1973, this information is sometimes not complete. Moreover, PSR is aware that its data on some types of turbine installations is incomplete.

Estimated Engine Life

Because accurate data on actual engine life is not available, PSR has developed an estimating methodology that incorporates a wide variety of identifiable engine characteristics to predict the useful life of an engine at maximum continuous output. These factors include:

- Engine horsepower
- Rated speed
- Number of cylinders
- Displacement
- Aspiration
- Engine weight
- Configuration
- Bore
- Stroke

These variables, combined with constants developed by PSR through a comparison of project engine life to a few known benchmarks, have been used to calculate a projected engine life for every engine in the database.[7] Engine life is expressed as the average number of hours an engine will operate at the maximum continuous rated output for the engine. The product of horsepower and the number of hours of operation result in engine life described in horsepower hours.

Because normal engine operation does not necessarily involve operation at full output, PSR assumes that engine lifetime in actual hours is extended when the engine is operated at less than full output, but the number of horsepower hours always remains a constant. PSR further assumes that this lifetime will be a statistical mean and that a normal distribution can be used to describe all retirements.

[7] Typically PSR has found it necessary to establish these benchmarks through completion of 100 interviews with owners of each type of equipment in each market region.

Activity Levels

The hours per year experienced by an owner will vary considerably, but generally are similar for any given product application. In its survey, PSR asks for annual operating hours. In the model, PSR uses the mean hours per year for each application.

Fuel Consumption

The average output or load factor is typically similar within an application. Because users are usually not able to measure load factor (the average percentage of maximum output at which they are operating), a good indicator is the amount of fuel they consume. Fuel will vary almost directly with the amount of horsepower produced. In their survey, PSR asks for annual fuel consumption and then compares that response to fuel that would be consumed at maximum horsepower. This results in load factor.

In many cases, respondents are not able to easily estimate annual hours of operation or fuel consumed annually. In those cases, PSR asks respondents to estimate hours per week and fuel consumed per week. In addition, questions are asked to determine if use was seasonal, length of season, and use in off-season. The results of these questions are then projected over 52 weeks to obtain an annual result.

Survey Research

In order to develop reliable parameters for aftermarket indicators, PSR has developed an on-going survey of owners of engine-powered products. Using random sampling techniques to provide statistical reliability, PSR interviews more than 10,000 owners per year. The objectives of the survey include development of:

- Mean product lifetime
- Annual hours of operation
- Typical load factor
- Replacement frequency for key components

The survey is conducted among randomly selected owners of each type of engine-powered equipment in each market region, and asks users a rather simple set of questions which include:

- Type of equipment operated
- Equipment manufacturer
- Equipment model
- Age of the equipment
- Cumulative hours
- Hours operated during the past 12 months
- Fuel consumed during the past 12 months
- Engine installed, if available
- Year of manufacture, if known

- Maintenance, internal and external engine parts and components purchased during the past year

For generator sets, PSR categorizes installations by several factors indicated by a representative sample of owners:

- Engine type
- Fuel
- Owner SIC
- Duty cycle[8]
- Hours / year
- Grid connected

Over the years PSR has implemented a number of "rules" to facilitate data processing and storage rather than statistical reliability. Whenever possible, PSR benchmarks its data against widely accepted authoritative sources. PSR's effort is to establish credible, statistical reliability for the operating characteristics developed during the course of its survey.

Geographic Distribution

The geographic distribution of generator sets in service is accomplished by matching ownership and application norms to economic data provided by the Census Bureau County Business Patterns database. The ownership and application norms have been developed over the past 27 years through the development of a profile for owners of each type of equipment. PSR has augmented this information with a few other economic, demographic and meteorological factors to enable PSR to differentiate allocations for various types of products. Thus, these profiles consist of a correlation between any combination of up to 22 economic, geographic, demographic, and meteorological factors.

Over that same period of time PSR has interviewed more than 650,000 equipment owners. It has correlated the incidence of ownership by each of the 82 indicators as shown in Table 2-2. Most of these indicators are SIC codes at the two-digit level. PSR classifies each respondent by SIC, rolling the specific SIC up to the two-digit level. The ownership incidence is further allocated by number of employees, annual revenue, and annual payroll for each location, as well as by application for the specific type of equipment owned such as standby, baseload, peak shaving and other generators. Ownership incidence is further adjusted by other factors such as weather factors. The idea is that PSR can project X number of generators of a given type, size and application for every Y number of locations within a specific SIC code at the two-digit level.

This profile allows good comparative measurement of many economic parameters to the county level. For each county or combination of counties selected, the profile for owners of equipment in any application and power range is compiled based on Census (SIC and employee size) data and the strength of this profile is compared to the national profile for that same application. The proportionate allocation of equipment in that application and power range is then assigned to that

[8] PSR accepts the owner description of duty cycle, such as peak shaving, emergency standby or baseload, but it may adjust these descriptions based on annual hours of operation.

county. The association can be made for application, power rating, engine or equipment brand and model, and age distribution. With each level of specificity the statistical reliability deteriorates somewhat. The profile norms simply indicate the probability that a certain type of business entity or consumer will own a specific type of equipment. PSR then completes a normal distribution over the profile interval to determine what portion of the national population is located in any specific area.

Table 2-2. Indicators used in population allocation for the PSR database.

SIC	Descriptions	SIC	Descriptions
02	Agricultural Production-Livestock	51	Wholesale Trade-Nondurable
07	Agricultural Services	53	General Merchandise Stores
10	Metal Mining	54	Food Stores
12	Coal Mining	55	Automotive Dealers & Service
13	Oil And Gas Extraction	58	Eating And Drinking Places
14	Nonmetallic Minerals, Except	59	Miscellaneous Retail
16	Heavy Construction, Ex.	60	Depository Institutions
17	Special Trade Contractors	61	Non-depository Institutions
18	Horticultural Specialties	62	Security And Commodity Brokers
19	General Farms, Primarily Crop	63	Insurance Carriers
20	Food And Kindred Products	64	Insurance Agents, Brokers & Service
21	Livestock, Except Dairy And Poultry	65	Real Estate
22	Textile Mill Products	67	Holding & Other Investment Offices
23	Apparel & Other Textile Products	70	Hotels And Other Lodging Places
24	Dairy Farms	72	Personal Services
24	Lumber And Wood Products	73	Business Services
25	Poultry And Eggs	74	Veterinary Services
26	Paper And Allied Products	76	Farm Labor And Management Services
27	Printing And Publishing	76	Miscellaneous Repair Services
28	Chemicals And Allied Products	78	Landscape And Horticultural Services
29	General Farms, Primarily Livestock	78	Motion Pictures
29	Petroleum And Coal Products	79	Amusement & Recreation Services
30	Rubber & Misc. Plastics Products	80	Health Services
31	Leather And Leather Products	81	Legal Services
32	Stone, Clay, And Glass Products	82	Educational Services
33	Primary Metal Industries	83	Social Services
34	Fabricated Metal Products	84	Museums, Botanical, Zoological
35	Industrial Machinery & Equipment	85	Forestry Services
36	Electronic & Other Electric	86	Membership Organizations
37	Transportation Equipment	87	Engineering & Management Services
38	Instruments & Related Products	89	Services, NEC
39	Misc. Manufacturing Industries	91	Commercial Fishing
40	Railroad Transportation		
41	Local & Interurban Passenger		**Other non-SIC indicators**
42	Trucking And Warehousing		Miles of inland shoreline
44	Water Transportation		Miles of coastal shoreline
45	Transportation By Air		Average annual rainfall
46	Pipelines, Except Natural Gas		Average annual snowfall

SIC	Descriptions	SIC	Descriptions
47	Transportation Services		Annual degree days
48	Communications		Avg. annual hours of electric service interruption
49	Electric, Gas & Sanitary Services		Proportion of GDP
50	Wholesale Trade-Durable Goods		Proportion of Population

Components Replacement

As part of its ongoing survey, PSR asks respondents to report on the parts and components that they have purchased during the past year. For preventive maintenance parts, it asks for replacement rates for filters, belts, hoses, spark plugs, tune-up kits and other maintenance parts appropriate to the type of engine being discussed. PSR then asks about external components including water pumps, starters, alternators, turbochargers, injectors, nozzles and fuel pumps. Finally, PSR asks about overhaul and internal repair parts including valves, springs, retainers, guides and seals, gaskets, bearings, cylinder kits, and others. The result is a replacement rate based either on operating hours or calendar time as appropriate. The replacement rate is unique to each engine model and application. PSR has been collecting component and parts brand data since 1996.

Additional Notes On The Owner Survey

Each year, PSR's survey is directed to a random sample of businesses and consumers. In each case PSR identifies engine-powered products owned by the respondent. It then collects operating data for that respondent along with demographic and economic data. This information then becomes the basis for projecting the geographic allocation of engine-powered products. In the case of stationary generators, PSR looks at the distribution of generator sets among businesses by SIC and by employee size as well as location. From this information PSR is able to establish a correlation from which it can project the population across the entire nation. For example, PSR may find that metal fabricating companies (SIC 331) with between 400 and 600 employees own 14% of the generator sets between 200 and 300 kW. PSR knows from its sales records and attrition data that there are 150,000 units nationwide in this power range and thus 21,000 units are owned by companies of this size and SIC. PSR can find from Census data that there are 63,000 such companies nationwide; from this it can project that there will be one generator set in this power range for every three companies of this type. If there were sixty companies of this description in an area, PSR would then project that there were 20 generator sets of this size owned among them.

This methodology and the completion of more than 650,000 interviews over the past 27 years have allowed PSR to construct a matrix for SIC versus Product type. The data contained in this matrix is the nationwide incidence of ownership for each product type by companies within each SIC and employee size or by consumers. Further derivatives of this matrix, such as smaller geographic areas (e.g., down to the county level), more specific industrial codes, and/or more specific product specifications, can be compiled. The statistical reliability declines however as the information becomes more granular.

PREDICTED DIESEL GENERATOR POPULATION AND ACTIVITY DATA BASED ON NATIONAL INDICATORS

Introduction

Over the years, PSR has developed a method to estimate the population of small-scale, stationary generators in regional areas. The estimation of population requires several key factors relating to the operation of generators in order to reasonably determine where they are located and how long they are in service. For this study, PSR first used its PartsLink™ model, based on the national generator sales and survey data, as well as selected regional economy factors, to estimate the population and activity level for generators in the DFW area. This database was used as a baseline database to generate the preliminary results for the study. PSR then conducted an extensive survey to identify potential owners/operators in the region, to verify its model projections, and to refine estimates on hours of operation for installed small-scale, stationary diesel generators. The revised database resulting from the survey was used to generate the final results for the study. The baseline and revised databases are presented and compared in this section.

General and Economic Profiles of DFW Area

The DFW area evaluated for this study included Collin, Dallas, Denton, Ellis, Henderson, Hood, Hunt, Johnson, Kaufman, Parker, Rockwall, and Tarrant counties. This area represents about 25% of the total Texas population and about 30% of the total commerce in Texas. It also represents about 2% of the U.S. population. In addition, the DFW area represents about the same proportion of business and industry and, in general, characteristics about the DFW area do not seem to differ significantly with the norms used to determine generator incidence throughout the nation. These market indicators are based on data found in the U.S. Census Bureau County Business Patterns as seen in Table 2-3.

Table 2-3. Market area profile (Sources: US Census Bureau State & County QuickFacts)

People QuickFacts	USA	Texas	DFW
Population, 2001 Estimate	284,796,887	21,325,018	5,400,737
Population % change, April 2000 - July, 2001	1.2%	2.3%	3.5%
Population, 2000	281,421,906	20,851,820	5,221,801
Population, % change, 1990 to 2000	13.1%	22.8%	32.5%
Living in same house in 1995 & 2000, % age 5+, 2000	54.1%	49.6%	44.5%
Bachelor's degree or higher, % of age 25+, 2000	24.4%	23.2%	28.5%
Mean travel time to work, workers age 16+ mins, 2000	25.5	25.4	27.54
Housing units, 2000	115,904,641	8,157,575	2,031,348
Homeownership rate, 2000	66.2%	63.8%	60.6%
Housing units in multi-unit structures, percent, 2000	26.4%	24.2%	31.0%

People QuickFacts	USA	Texas	DFW
Median value of owner-occupied housing units, 2000	$119,600	$82,500	$122,660
Households, 2000	105,480,101	7,393,354	1,906,764
Persons per household, 2000	2.59	2.74	2.70
Median household money income, 1999	$41,994	$39,927	$48,347
Per capita money income, 1999	$21,587	$19,617	$23,699
Persons below poverty, percent, 1999	12.4%	15.4%	10.7%
Private nonfarm establishments, 1999	7,008,444	467,087	126,046
Private nonfarm employment, 1999	110,705,661	7,763,815	2,465,145
Private nonfarm employment, percent change 1990-99	18.4%	32.4%	47.3%
Nonemployer establishments, 1999	16,152,604	1,236,927	331,992
Manufacturers shipments, 1997 ($1000)	3,842,061,405	297,657,003	63,581,260
Retail sales, 1997 ($1000)	2,460,886,012	182,516,112	49,966,185
Retail sales per capita, 1997	$9,190	$9,430	$10,651
Minority-owned firms, percent of total, 1997	14.6%	23.9%	16.3%
Women-owned firms, percent of total, 1997	26.0%	25.0%	26.5%
Housing units authorized by building permits, 2000	1,592,267	141,231	44,743
Federal funds and grants, 2001 ($1000)	1,763,896,019	112,530,383	20,869,341
Local government employment - full-time equivalent, '97	10,227,429	850,380	184,225
Land area, 2000 (square miles)	3,537,438	261,797	9,105
Persons per square mile, 2000	79.6	79.6	1,626

The economic profile for the DFW area is shown in Table 2-4. This profile indicates that while slightly more prosperous than the state and country as a whole, the distribution of businesses is generally proportionate with slightly higher concentrations of public administration and industries related to mineral and resource extraction.

Table 2-4. Economic profile for the DFW area.

Category	Employees	Payroll [$ 000's]	# Firms	% of U.S.
Accommodation & food services	154772	2233636	6675	1.2%
Admin, support, waste mgt, remediation services	222843	6501453	5823	2.1%
Arts, entertainment & recreation	17418	582845	1042	1.1%
Auxiliaries including public administration, police and correctional facilities	21283	1201214	528	4.1%
Construction	107204	3987672	7282	1.1%
Educational services	20948	619959	958	2.3%
Finance & insurance	124415	6875838	6744	1.7%
Health care and social assistance	157821	5903597	8433	1.3%
Information	99626	6314463	2353	2.1%
Management of companies & enterprises	90773	7003729	1156	2.4%

Category	Employees	Payroll [$ 000's]	# Firms	% of U.S.
Manufacturing	230150	9827424	4599	1.3%
Mining & Extraction	7318	501953	595	2.4%
Other services (except public administration)	81717	1786744	8441	1.6%
Professional, scientific & technical services	139826	8519950	12157	2.0%
Real estate & rental & leasing	41025	1616684	4751	1.6%
Retail trade	210754	4932703	13311	1.2%
Transportation & warehousing	91757	3951514	2026	1.1%
Utilities	5969	360569	296	1.9%
Wholesale trade	136960	7063136	7473	1.6%
Grand Total	1964264	79,827,383	95561	1.5%

Nationwide Incidence of Generator Installation by Applications

Each year for the past 27 years, PSR have compiled data for generator sets delivered to customers in the U.S. based on manufacturers shipments. Over that same time period, PSR has interviewed more than 250,000 commercial and institutional establishments nationwide to identify the incidence of generator set installation and application. PSR has learned through that effort the frequency with which PSR can expect to find generator sets installed in places of business and in institutional settings including health care facilities, schools, government buildings and other types of facilities. Using the broad range of SIC codes, PSR can categorize incidence and installation by type of application including emergency standby, peak shaving, and baseload generators. PSR has continually refined this modeling effort and tested the model through 12 audits per year until it has become an accurate predictor of generator set populations based on relative low variances of 5% between the projected and nationwide audit survey data.

Table 2-5 presents the nationwide incidence of installation by applications developed by PSR. This data indicates that in the category for hotels and restaurants (Accommodation & Foodservices) for example, one will find 38 emergency generators for every 1,000 locations inspected.

Table 2-5 Nationwide incidence of generator set installation by applications.

SIC Category	Standby	Peak	Base
	(Incidence per 1000 locations)		
Accommodation & foodservices	38.48	7.43	9.95
Administrative & support & waste management &remediation services	222.26	12.95	10.77
Arts, entertainment, & recreation	272.16	28.27	36.05
Auxiliaries including public administration, police and correctional facilities	2433.53	132.40	292.35
Construction	28.53	1.54	3.02
Educational services	3339.26	136.91	206.87
Finance & insurance	261.60	8.86	3.85
Health care & social assistance	690.19	11.69	9.83

SIC Category	Standby	Peak	Base
	(Incidence per 1000 locations)		
Information	813.26	42.16	8.66
Management of companies & enterprises	569.98	23.03	43.35
Manufacturing	378.96	45.82	164.02
Mining	629.31	34.24	628.95
Other services (except public administration)	44.69	12.13	4.45
Professional, scientific, & technical services	50.66	6.52	4.47
Real estate & rental & leasing	145.54	9.72	2.50
Retail trade	10.05	0.83	1.18
Transportation & warehousing	25.25	14.43	1.11
Utilities	15115.97	3421.95	2473.61
Wholesale trade	33.04	8.93	1.46

Predicted Population, Capacity and Activity based on Nationwide Incidence Data

Based on the nationwide incidence generator installation data and the economic profile of the DFW area, PSR initially predicted a nationwide-based population and distribution of small-scale stationary diesel generators by commercial and institutional sectors in the DFW area. These population and distribution data are shown in Table 2-6.

The nationwide-based data were used as an input into the PSR PARTSLINK™ model to generate population data for diesel generators in the DFW area, broken down by county levels as well as by generator type (i.e., emergency, peak shaving or baseload) and by capacity in horsepower. As shown in Table 2-7, the model predicted there were approximately 30,000 diesel generator units in the DFW Area, with about 25,000 for emergency use, 2,000 for peak shaving use, and 3,000 for baseload use as estimated using the national indicators. In terms of electricity capacity, these diesel generators generated about 9,000 MW of electricity at full load, with about 6,400 MW from emergency generators, 2,000 MW from peak shaving generators, and 400 MW from baseload generators (see Table 2-8). However, with the exception of some baseload and peak shaving generators, most of these generators do not operate at full load conditions.

Table 2-6. Predicted distribution of small-scale, stationary diesel generators by sectors in the DFW area based on nationwide incidence of generator installation and DFW economic data.

Commercial / Institutional Sector	Base	Standby	Peak
Accommodation & foodservices	66	257	50
Administrative & support & waste management &remediation services	63	1,294	75
Arts, entertainment, & recreation	38	284	29
Auxiliaries including public administration, police and correctional facilities	154	1,285	70
Construction	22	208	11
Educational services	198	3,199	131
Finance & insurance	26	1,764	60
Health care & social assistance	83	5,820	99

Commercial / Institutional Sector	Base	Standby	Peak
Information	20	1,914	99
Management of companies & enterprises	50	659	27
Manufacturing	754	1,743	211
Mining	374	374	20
Other services (except public administration)	38	377	102
Professional, scientific, & technical services	54	616	79
Real estate & rental & leasing	12	691	46
Retail trade	16	134	11
Transportation & warehousing	2	51	29
Utilities	732	4,474	1,013
Wholesale trade	11	247	67
Total Generator Sets	2,713	25,391	2,229

Table 2-7. Predicted diesel generator population in the DFW Area based on national indicators.

County	Emergency	Peak	Baseload	Total
Tarrant	6,673	611	748	8,032
Rockwall	411	23	20	454
Parker	224	7	10	241
Kaufman	280	12	14	306
Johnson	329	12	16	357
Hunt	105	2	5	112
Hood	109	3	5	117
Henderson	137	3	8	148
Ellis	439	17	22	478
Denton	1,717	126	120	1,963
Dallas	11,872	1,158	1,478	14,508
Collin	3,095	255	267	3,617
Total	25,391	2,229	2,713	30,333

Table 2-8. Predicted total capacity of diesel generators in the DFW Area based on national indicators.

County	Emergency	Peak	Baseload	Total
	(MW)			
Tarrant	1,694	552	119	2,364
Rockwall	92	26	1	119
Parker	44	9	0	54
Kaufman	58	14	0	73
Johnson	71	14	1	86
Hunt	17	3	0	20
Hood	18	4	0	23
Henderson	24	4	0	29
Ellis	95	20	1	116
Denton	426	119	10	555
Dallas	3,036	1,000	249	4,285
Collin	791	235	38	1,063
Total	**6,367**	**2,000**	**419**	**8,786**

As part of its continuous nationwide survey effort, PSR also asks respondents about the operation of their generator sets to predict the life of the generator set. The life of the generator set is directly proportional to the number of hours it operates and the load factor proportional to the maximum horsepower output at which it operates. PSR obtains the hours of operation directly from respondents and calculates the load factor by comparing the reported fuel consumption to the fuel that would be consumed if the generator set were operated at 100% of its capacity. The combination of load factor and hours of operation provides an indication of what proportion of the mean expected lifetime is consumed each year. The expected lifetime is also a calculated result based on engine design characteristics and compared to experience over the years. The projected operating hours for generator sets based on PSR national surveys by power rating for the generator set are shown in Table 2-9.

Table 2-9. Estimated average hour usage for diesel generators in the DFW Area based on nationwide-incidence generator installation and DFW economic data.

Horsepower Range (kW)	Emergency	Peak Shaving	Baseload
	(Hours/year)		
0-150	50	350	2,880
150-300	80	420	4,240
300-500	120	460	4,460
500-700	120	460	4,460
700-1200	160	540	4,530
1200-2000	180	680	4,840
2000-5000	180	880	5,120
5000+	180	1,020	5,120

PROJECTED DIESEL GENERATOR POPULATION AND ACTIVITY DATA BASED ON SURVEY RESULTS

Focused Survey

In order to test the prediction for generator installation in the DFW area based on nationwide incidence of installation and DFW economic data, a focused survey was conducted on all prospective generator set owners by two-digit SIC from a list purchased from the American Business List. The source data included all non-residential facilities within the DFW area. The selection was at random and not biased to favor any specific SIC group or operational size. One out of every 14 or 7% of the commercial and institutional facilities within the DFW area was contacted during the survey. The contacts were designed to verify the type and location of the facility and to determine if there was an engine driven electrical generator set at that facility. If a generator set was located, the inquiry sought to determine the type of duty cycle and the number of hours per year the generator set was operated.

The focused survey was conducted by telephone using a computer assisted telephone interviewing system in which all sample selections were randomized from a master list using the questionnaire attached as Appendix B, which was programmed into the online system. The survey started with the highest probability owners and continually compared the results to the norms that were used to gauge ownership. The data from the survey were compiled and entered into a database that was designed to monitor quotas in each area. The results were tracked in terms of completed and incomplete contacts to the projected population for the area. When 80% target quotas was met, the survey work was completed.

At the same time that telephone contact were being made, information such as permit lists and other public record information that provided generator set locations were reviewed and documented. In addition, engine distributors were also contacted to discuss survey estimates and to identify any areas that may have been missed. At the end of the survey, 6,975 contacts were made in order to identify the targeted number of generators. The number of contacts by sectors is shown in Table 2-10.

Survey Results: Generator Population and Capacity

Among the 6,975 contacts, 2,244 generators installed by different applications were identified (see Table 2-11)[9]. Statistically, a randomly selected sample of this size among a large population (>10,000) would produce results with a sampling error of less than 5% for a confidence level of 95%. This means that if this process were repeated 20 times, the same results within ± 5% in at least 19 of those investigations would be found.

Table 2-10. Number of contacts by sectors for the focus survey.

Survey Contact Sector	# of Contacts
Accommodation & foodservices	492
Administrative & support & waste management &remediation services	429
Arts, entertainment, & recreation	77
Auxiliaries including public administration, police and correctional facilities	39
Construction	537
Educational services	71
Finance & insurance	497
Health care & social assistance	621
Information	173
Management of companies & enterprises	85
Manufacturing	339
Mining	44
Other services (except public administration)	622
Professional, scientific, & technical services	896
Real estate & rental & leasing	350
Retail trade	981
Transportation & warehousing	149
Utilities	22
Wholesale trade	551
Total	6975

9 Raw survey population, average operating hours, and load factors are provided in Appendix C, and detailed contact information for the survey respondents are provided in an electronic Excel file.

Table 2-11. Number of generators by applications for different sectors in the DFW area identified via focused survey.

Sector	Base	Standby	Peak
Accommodation & foodservices	3	17	6
Administrative, support, waste management & remediation services	7	119	9
Arts, entertainment, & recreation	2	33	6
Auxiliaries (public adm., police & correctional facilities)	5	68	8
Construction	1	11	0
Educational services	18	286	12
Finance & insurance	1	156	6
Health care & social assistance	8	492	5
Information	0	113	3
Management of companies & enterprises	6	59	0
Manufacturing	47	134	22
Mining	36	22	5
Other services (except public administration)	5	88	10
Professional, scientific, & technical services	2	105	4
Real estate & rental & leasing	0	81	3
Retail trade	1	6	0
Transportation & warehousing	0	2	2
Utilities	56	58	64
Wholesale trade	0	26	5
Total	198	1876	170

Table 2-12. Comparison of projected population based on survey results and predicted population based on nationwide indicators in the DFW area.

Generator Types	Projected Based on Survey Results	Predicted Based on National Indicators	Projected as a % of Predicted
Base	2584	2713	95%
Standby	24720	25391	97%
Peak Shaving	2297	2229	103%
Total	29,062	30,333	98%

As shown in Table 2-12, projecting these results against the economic data provided for the DFW region resulting in a projected total of 29,602 units of emergency, peak shaving and baseload generators or 97.5% of the predicted total of 30,333 based on national indicators. The projected population data were then fed into the PSR PARTSLINK™ model to generate population data by counties, generator types and capacities. The results are shown in Table 2-13[10].

These data are consistent with the population data estimated based on national indicators, indicating that there are about 25,000 generators emergency use, 2,300 for peak shaving use, and

[10] Detailed small-scale diesel generator population and activity data by counties in the DFW area projected using the focused survey results are provided in Appendix D.

2,600 for baseload use. As shown in this table, about 75% of these generators are located in the Dallas and Tarrant Counties.

As for electricity capacity, the diesel generators would generate about 8,000 MW of electricity at full load, with about 5,500 MW from emergency generators, 2,000 MW from peak shaving generators, and 400 MW from baseload generators (see Table 2-14). Again, other than some baseload and peak shaving generators, most of these generators do not operate at full load conditions.

Table 2-13. Projected diesel generator population in the DFW Area based on the focused survey results.

County	Emergency	Peak	Baseload	Total
Tarrant	6,482	611	704	7,797
Rockwall	411	23	20	454
Parker	205	7	10	222
Kaufman	280	12	14	306
Johnson	329	8	16	353
Hunt	103	2	6	111
Hood	109	3	5	117
Henderson	137	11	8	156
Ellis	439	17	22	478
Denton	1,686	136	116	1,938
Dallas	11,453	1,212	1,396	14,061
Collin	3,087	255	267	3,609
Total	24,721	2,297	2,584	29,602

Table 2-14. Projected total capacity of diesel generators in the DFW Area based on focused survey results.

County	Emergency	Peak	Baseload	Total
	(MW)			
Tarrant	1,455	552	115	2,122
Rockwall	92	26	1	119
Parker	32	9	0	41
Kaufman	58	14	0	73
Johnson	71	8	1	80
Hunt	21	3	4	28
Hood	18	4	0	23
Henderson	24	14	0	39
Ellis	95	20	1	116
Denton	393	139	9	541
Dallas	2,513	1,089	208	3,810
Collin	775	235	38	1,048
Total	5,548	2,113	378	8,039

Survey Results: Generator Operating Hours and Load Factors

Initially, the national norms compiled over a number of years were used to predict the number of units, average output and operating hours per year, as well as the average age of the units in operation. As part of the survey work, the output rating, operating hours per year, and year of installation of generators in the DFW area were also collected. Based on the survey results, the projected operation levels for these generators were drastically lower than was observed in the past. While the number of generators is consistent, Table 2-15 shows that the total electricity generated (kw-hr) by these sets is a fraction of what was predicted using the national indicators.

Table 2-15. Comparison of population, generated electricity, and age between data predicted using national indicators and projected based on focused survey results.

Category	Parameter	Predicted	Projected
Standby	# Units	25391	24720
	kw hrs [millions]	850.7	95.1
	Age [years]	11.1	12.9
Peak Shaving	# Units	2229	2297
	kw hrs [millions]	1229.7	35.5
	Age [years]	13.3	10.5
Baseload	# Units	2713	2584
	kw hrs [millions]	1733.5	115.3
	Age [years]	11.2	15.8

Table 2-16. Average hour usage for diesel generators in the DFW Area based on focused survey results.

Horsepower Range (kW)	Emergency	Peak Shaving	Baseload
	(Hours/Year)		
0-150	20	44	48
150-300	20	42	46
300-500	32	45	46
500-700	43	58	93
700-1200	52	93	115
1200-2000	52	118	250
2000-5000	52	118	250
5000+	52	118	250

During the course of the focused survey, the utilization of generators in the DFW area was found to be considerably less than what has been compiled over the past several years in nationwide surveys. The operating hours by different generator types based on the survey results are shown in Table 2-16. Comparing Table 2-9 and Table 2-16, this seems to be an acceleration of a downward trend in operating hours, especially true in the peak shaving and baseload applications where economics in 2003 were not favorable for operators. Many generators originally purchased as baseload generators are now being used for little more than standby and/or occasional peak shaving.

Table 2-17. Average load factors for diesel generators in the DFW Area based on focused survey results.

KW Rating	Standby	Base	Peak
100 – 150	0.72	0.48	0.44
150 – 300	0.75	0.46	0.42
300 – 500	0.76	0.47	0.45
500+	0.73	0.43	0.51

Load factors also tended to be lower than anticipated for peak shaving and baseload generators, although they did not tend to diverge quite as much from than what has compiled over the past several years in nationwide surveys. Average load factors for different generator types based on focused survey results are shown in Table 2-17.

These population data, average operating hours and load factors projected from the focused survey results were used to estimate the emissions from small-scale stationary generators in the DFW area.

3. NOx EMISSION INVENTORY AND CONTROL TECHNOLOGIES

In this section, information is presented on the methods for calculating NOx emissions inventory from small-scale stationary diesel generators in the DFW area. In addition to population and activity data (e.g., operating hours and load factors), NOx emissions factors are needed to estimate emissions from small-scale stationary diesel generators in the DFW area. The population and activity data from the focused survey results presented in Section 2 were used in estimating the emissions.

EMISSION FACTORS

To estimate the emission inventory from diesel generators in the DFW area for NOx emissions, AP-42 emission factors (AP-42, 1995) were used for all diesel engines. Emission factors used to estimate diesel generator emission inventories in the DFW area are shown in Table 3-1.

Table 3-1. NOx Emission factors for stationary diesel generators in the DFW Area.

Engine Size	NOx	
	g/hp-hr	lb/MWh
Diesel < 600hp	14.06	41.47
Diesel > 600hp	10.86	32.04

EMISSION INVENTORY

Using these emissions factors and the projected population, average operating hours, and load factors from the focused survey results, the emissions inventory broken down by counties are shown in Table 3-2[11]. As shown in this table, NOx emissions from emergency, peak shaving and baseload diesel generators in the DFW area were estimated to be approximately 7.0, 3.3, and 0.6 tons per day, respectively. For comparison, TCEQ estimated that the NOx emissions from the small-scale, stationary emergency diesel generators were about 5 tpd in the HGA; there was no known emission estimates for small-scale stationary diesel generators in the DFW area.

Table 3-2 shows that about 25% and 50% of the NOx emissions from small-scale stationary diesel generators were from the Tarrant and Dallas Counties, respectively; Denton and Collin Counties contributed about 7% and 13%, respectively, of the rest of the NOx emissions. Also, as seen in the table, most of the total NOx emissions were from emergency and peak shaving generators at approximately 50% and 40%, respectively.

[11] Detailed NOx emission inventories for small-scale, stationary diesel generators broken down by generator types, counties, and capacity ranges in the DFW area are provided in Appendix E.

Table 3-2. NOx Emissions estimates for small-scale stationary diesel generators in the DFW Area.

County	Emergency	Peak Shaving	Baseload	Total
	(tons per day)			
Tarrant	1.84	0.85	0.18	2.88
Rockwall	0.12	0.04	0.00	0.16
Parker	0.04	0.02	0.00	0.06
Kaufman	0.07	0.02	0.00	0.10
Johnson	0.09	0.01	0.00	0.10
Hunt	0.03	0.01	0.02	0.05
Hood	0.02	0.01	0.00	0.03
Henderson	0.03	0.02	0.00	0.06
Ellis	0.12	0.03	0.00	0.15
Denton	0.50	0.23	0.01	0.74
Dallas	3.16	1.74	0.31	5.21
Collin	1.01	0.36	0.06	1.44
Total	**7.04**	**3.34**	**0.60**	**10.98**

Table 3-3 shows the population and activity data, and emission estimates based on the PSR national indicators (preliminary results as reported in the interim report), and the refined population and activity data, and emission estimates projected based on the survey results. As shown in this table, the substantial differences in emission estimates mainly resulted from the major reductions in the usage hours for all generator types, especially the peak-shaving and baseload generators.

Table 3-3. Comparison of population, activity data, and NOx emission estimates for small-scale stationary diesel generators in the DFW Area based on national indicators and focus survey results.

	Emergency	Peak Shaving	Baseload	Total
Preliminary Data based on National Indicators				
Population	25,391	2,229	2,713	30,333
Usage Hours	50-180	350-1020	2880-5120	NA
Load Factor	0.74	0.74	0.74	NA
Emission Estimates (tpd)	29.55	40.85	63.67	134.06
Projected Data based on Survey Results				
Population	24,721	2,297	2,584	29,602
Usage Hours	20-52	42-118	46-250	NA
Load Factor	0.72-0.76	0.43-0.48	0.42-0.51	NA
Emission Estimates (tpd)	7.04	3.34	0.60	10.98

NOx CONTROL TECHNOLOGIES

The science of controlling exhaust emissions from diesel engines, including engines used in stationary diesel generators, is well understood and has been documented in a number of industry trade journals and technical literature. Both NESCAUM (NESCAUM, 2003) and the California Energy Commission (CEC) (CEC, 2001a) recently published reports that discuss in detail control technologies for stationary diesel generators. Key findings from these studies are summarized in this section.

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%. However, the timing adjustment strategy will substantially increase PM emissions; as a result, the use of a diesel particulate filter (DPF) is desired.

In its study (NESCAUM, 2003), NESCAUM reported that the capital cost for installing a SCR system on stationary diesel generators with a 1,000 to 3,000 hp (750 to 2,250 kW) range to be just under $180,000, with a cost-effectiveness value of $8,000 per ton of NOx reduction. According to the PSR database used in this study (see Appendix D), there are about 4,000 diesel generators in the 750 to 2,250 kW range in the DFW area, or about 12% of the total diesel generators in the DFW area. However, the NOx emissions contributed by these diesel generators is approximately 7.0 tons per day, or more than 60% of the total NOx emissions from the diesel generators in the DFW area. A conservative 80% NOx emission reduction through the use of SCR technology on these diesel generators would result in a reduction of 5.6 tons per day.

The NESCAUM report also indicated that the main issue for controlling emissions from diesel generators, especially in the case of smaller engines, is the cost and cost-effectiveness of control rather than the technical feasibility. Moreover, for some small emergency generators with limited hours of operation, emission reductions are relatively small as compared to central-station power plants for a given capital cost. It should be noted that substantial efforts are underway to develop and apply retrofit emission control technologies for existing on-road and off-road diesel engines, and many of these technologies are most likely to be applicable to existing stationary diesel generators, especially those with smaller diesel engines.

In the CEC study (CEC, 2001a), a number of fuel options and control technologies were investigated as potential candidates to reduce emissions from diesel generators in California. For NOx control technologies, the CEC report indicated that a14 to 22% reduction in NOx emissions could be achieved with water emulsion fuels[12], and a 70 to 95% reduction could be achieved with SCR technology.

[12] Lubrizol, one of the emulsion fuel providers, has verified with CARB a NOx reduction of 14% through the use of its PuriNOx emulsion fuel.

While the use of water emulsion fuels can provide modest NOx emissions reduction, it can pose a major issue for diesel generator operators because the use of these fuels will reduce the maximum power of the diesel generator by 5 to 15% due to the lower energy content of these fuels. According to the CEC report, the cost-effectiveness value for emulsion fuels range from $14,000 to $21,000 per ton of NOx reduction.

For the SCR technology, the CEC report indicated that there were five suppliers offering SCR systems for use on diesel engines and all suppliers offered systems that could achieve a 90 to 95% NOx reduction with maximum ammonia slip of 10 ppm. According to the CEC report, the capital cost to install a SCR system on a one MW diesel generator ranged from $45,000 to $160,000, and the cost-effectiveness value ranged from $11,000 to $38,000 per ton of NOx reduction.

4. REFERENCES

AP 42. 1995. "AP-42, Fifth Edition, Volume I: Chapter 3: Stationary Internal Combustion Sources - Table 3.3.1 and 3.4.1". Office of Transportation & Air Quality, Environmental Protection Agency, 1995. http://www.epa.gov/ttn/chief/ap42/ch03/final/c03s03.pdf.

CARB. 2003. "Staff Report: Initial Statement of Reasons for Proposed Rulemaking Airborne Toxic Control Measure for Stationary Compression-Ignition Engines". California Air Resources Board, Sacramento, CA. September.

CEC. 2001a. "Inventory of Backup Generators in the State of California". California Energy Commission, Sacramento, CA. December. P500-01-027.

CEC. 2001b. "Emission Reduction Technology Assessment for Diesel Backup Generators in California". California Energy Commission, Sacramento, CA. December. P500-01-028.

ENVIRON. 2003. "Estimates of Emissions for Small-Scale Diesel Engines". Final Report to Houston Advanced Research Center, ENVIRON International Corp., Novato, CA. December.

ENVIRON. 2004a. "Estimates of Emissions for Small-Scale, Stationary Diesel Generator Engines in the Dallas-Fort Worth Area". Draft Final Report to Houston Advanced Research Center and Texas Commission on Environmental Quality, ENVIRON International Corp., Novato, CA. September.

ENVIRON. 2004b. "Estimates of Emissions for Small-Scale Diesel Engines". Interim Report to Houston Advanced Research Center and Texas Commission on Environmental Quality, ENVIRON International Corp., Novato, CA. December.

ENVIRON. 2004c. "Estimate of Emissions from Small Scale Diesel Generators in the Dallas-Fort Worth Area". Workplan to Houston Advanced Research Center and Texas Commission on Environmental Quality, ENVIRON International Corp., Novato, CA. January 20, 2004.

NESCAUM. 2003. "Stationary Diesel Engines in the Northeast: An Initial Assessment of the Regional Population, Control Technology Options and Air Quality Policy Issues". Northeast States for Coordinated Air Use Management, Boston, MA. June.

PSR. 2004. "Engine Powered Products Populations and Activity Data - Dallas-Fort Worth". Summary Report to ENVIRON International Corp., Power Systems Research, St. Paul, MN. May 24.

TexPIRG. 2002. "Micropower at the Crossroads - Public Health and the Future of Distributed Generation". Public Citizen Environmental Defense, Austin, TX.

Appendix A

SMALL-SCALE, STATIONARY GENERATORS IN THE DALLAS-FORT WORTH AREA AS OBTAINED FROM RECORDS AVAILABLE AT THE TCEQ (Source: TEXPIRG, 2002)

Company	City	(kW)
Abbott Laboratories	Irving	477
Abbott Laboratories	Irving	619
Abbott Laboratories	Irving	354
Abbott Laboratories	Irving	477
Abbott Laboratories	Irving	619
City of Garland Water Utility Dept	Garland	na
City of Garland Water Utility Dept	Garland	na
City of Garland Water Utility Dept	Garland	na
DSC Corp	Plano	na
DSC Corp	Plano	na
DSC Corp	Plano	na
DSC Corp	Plano	na
Eagle Mountain Int'l Church	Neward	784
Eagle Mountain Int'l Church	Neward	784
Eagle Mountain Int'l Church	Neward	784
Eagle Mountain Int'l Church	Neward	784
GE Accessory Serv-Grand Prairie	Grand Prairie	321
GE Accessory Serv-Grand Prairie	Grand Prairie	321
Halliburton Energy Services	Fort Worth	485
Interactive Manufacturing	Garland	na
Interactive Manufacturing	Garland	na
Interactive Manufacturing	Garland	na
JPS Health Network		261
JPS Health Network		560
JPS Health Network		746
JPS Health Network		597
JPS Health Network		597
JPS Health Network		634
JPS Health Network		634
JPS Health Network		933
JPS Health Network		933
JPS Health Network		933
JPS Health Network		933
LH Lacy Company	Arlington	414
LH Lacy Company	Coppell	na
LH Lacy Company	Coppell	na
LH Lacy Company	Frisco	na
Lockheed Martin Tactical Aircraft	Fort Worth	na
Lone Star Acquisitions	Flower Mound	na
Lone Star Acquisitions	Flower Mound	na
Lone Star Pipeline Co	Ennis	na
Mattel Toys	Fort Worth	30
Mitchell Energy	Rhome	na
Mitchell Gas Services	Justin	na

Company	City	(kW)
MRS The Ink Co	Dallas	na
MRS The Ink Co	Dallas	na
Ratheon TI Systems	Richardson	na
Ratheon TI Systems	Richardson	na
Rosani Foods	Dallas	515
Solar Turbines	Desoto	na
Solar Turbines	Desoto	na
SPM Flow Control	Fort Worth	na
SPM Flow Control	Fort Worth	na
SPM Flow Control	Fort Worth	na
SPM Flow Control	Fort Worth	na
Stone Bennet Corp	Carrollton	597
Trinity Forge	Mansfield	234
TU Electric	Dallas	1,576
TOTAL		17,933

Appendix B

SURVEY QUESTIONNAIRE

DFW GENERATOR SET Owner Survey

Date ___/_____ Time Start: __:__ Interviewer ___________________

Respondent ____

Company ____

Telephone [___] ___ _____

Sample ID ________ SIC _______ Category [ ] _____

Introduction

Good morning / afternoon, I would like to speak with someone who would know whether your facility has an installed, engine powered electrical generator set either for full time power, emergency standby or for temporary power purposes.

Would you be able to tell me that or is there someone else in your organization I should speak with.

- ❑ I can tell you – we do not have a generator [terminate]
- ❑ I can tell you – we do have a generator [proceed to intro]
- ❑ You should speak with __________________ [contact this person and restart]
- ❑ Refused [terminate]

[Introduction]

Let me just quickly tell you what we are doing. My name is __________ and I am with Power Systems Research. We are strictly a market research company and we are not involved with sales of any product or service to you. We are working on a survey to try to determine the probability that different types of organizations own or operate engine powered generators. My questions are very brief and I am not asking for any confidential information. Moreover your responses are being combined with those of several hundred others and will not be released or published individually.

My first question is simply do you have a generator set at any of your facilities in ______ County?

Yes no [terminate] don't /know [terminate] refused [terminate]

Is the generator located at the facility where I am speaking to you?

Yes no

What other locations in ________ do you have where generators are located?

- ❑ None

Location 1 ____
Location 2 ____
Location 3 ____
Location 4 ____

Can you tell me what type of fuel is used in your generator(s)? [if more than one - check all that apply]

- ❑ Diesel
- ❑ Gasoline
- ❑ Natural gas
- ❑ Other [specify] --------------------------

What is the output rating of the generator? [if more than one note ratings for each]

______ kilowatts

For each of the generator sets we just listed could you please mention the engine make and model included.

	Make		***Models***	
❑	Caterpillar	________	__________	___________
❑	Cummins	________	__________	___________
❑	Deere	________	__________	___________
❑	Detroit Diesel	________	__________	___________
❑	Ford	________	__________	___________
❑	Waukesha	________	__________	___________
❑	Other [specify] ____________________________--			

Is the generator primarily for emergency backup or for some other purpose?

- ❑ Yes it is for standby

❑ Other

Which other purpose?

❑ Prime [full time] power
❑ Peak shaving
❑ Temporary power
❑ Other [specify] ______________________

How old would say the gen set is? [if more than one – note all that you can]

Years _____________

What would you say annual fuel consumption in the past year for each of your generator sets was? *[either value or volume]*

Unit 1 _______
Unit 2 _______
Unit 3 _______
Unit 4 _______

Finally, how many hours do you think the generator operated in the past 12 months? [if more than one – note all that you can]

Hours ________________________

That is the end of my questions. Thank you very much for your time and assistance.

Appendix C

DETAILED FOCUSED SURVEY RESULTS ON POPULATION, OPERATING HOURS, AND LOAD FACTORS FOR SMALL-SCALE STATIONARY DIESEL GENERATORS IN THE DFW AREA

&

DETAILED CONTACT INFORMATION (Electronic File: Survey Contacts.xls)

Respondent	Number of Generator Sets			Average Load Factors			Average Annual Hours		
SIC	Base	Peak	Standby	Base	Peak	Standby	Base	Peak	Standby
2	0	0	0						
3	1	0	0	69%			98.00		
7	1	0	0	38%			194.00		
8	2	0	0	57%			61.00		
13	0	0	0						
14	1	0	0	32%			110.00		
15	4	3	6	49%	60%	83%	97.00	113.33	35.67
16	6	0	3	48%		55%	109.33		14.67
17	17	0	14	54%		79%	99.65		32.29
18	4	0	6	47%		77%	124.00		28.00
20	3	0	5	50%		56%	144.67		17.60
21	0	0	1			88%			50.00
22	0	0	0						
23	2	0	0	52%			88.00		
24	0	0	3			75%			33.33
25	1	0	3	54%		95%	66.00		15.33
26	0	0	0						
27	0	0	8			77%			15.00
28	8	0	9	60%		72%	57.25		31.33
29	0	0	3			80%			21.33
30	0	0	0						
31	11	13	35	68%	66%	88%	115.82	104.00	21.03
32	2	2	7	55%	83%	80%	106.00	158.00	29.14
33	8	4	33	42%	56%	67%	87.00	114.00	32.42
34	8	4	31	70%	66%	73%	120.75	140.00	30.65
35	14	10	38	54%	60%	78%	97.43	102.40	24.47
36	11	11	44	51%	61%	68%	116.36	98.18	27.09
37	18	17	42	43%	63%	77%	92.11	125.53	29.05
38	2	4	23	79%	85%	81%	159.00	112.50	34.26
39	2	0	1	37%		93%	161.00		42.00
40	0	3	7		69%	69%		81.33	39.71
41	1	3	16	51%	71%	67%	134.00	135.33	32.75
42	0	1	8		72%	67%		164.00	27.50
44	0	0	0						
45	0	0	0						
46	0	0	0						
47	0	0	3			80%			44.67
48	0	2	0		63%			146.00	
49	0	0	3			73%			22.00
50	0	2	0		75%			128.00	
51	4	5	124	49%	66%	80%	84.50	126.40	24.76
52	0	2	43		56%	72%		101.00	24.79

Respondent	Number of Generator Sets			Average Load Factors			Average Annual Hours		
SIC	Base	Peak	Standby	Base	Peak	Standby	Base	Peak	Standby
53	1	4	32	46%	56%	74%	130.00	143.50	28.50
54	1	5	46	49%	58%	72%	202.00	107.20	30.22
55	2	3	21	33%	87%	75%	187.00	58.67	34.00
56	0	2	9			68%		23.00	42.00
57	1	2	32	54%	54%	73%	144.00	159.00	30.13
58	4	4	126	59%	67%	82%	181.00	127.50	25.37
59	0	0	10			70%			31.80
60	0	5	21		69%	73%		107.20	32.67
61	0	1	12		82%	72%		132.00	24.83
62	2	4	113	100%	54%	78%	91.00	88.00	29.12
63	0	1	48		84%	77%		102.00	28.08
64	6	6	243	58%	78%	73%	120.67	96.00	27.48
65	5	13	284	52%	77%	77%	112.80	107.69	25.73
66	0	0	10			83%			19.40
67	2	0	17	57%		81%	129.00		25.41
68	0	0	16			83%			23.75
70	1	1	177	53%	73%	69%	146.00	180.00	31.07
72	4	2	0	53%	61%		66.00	91.00	
73	4	4	14	40%	59%	67%	132.50	103.00	35.71
74	8	8	16	47%	66%	81%	87.00	116.00	26.50
75	3	3	9	49%	62%	72%	65.33	98.00	25.56
76	0	0	4			94%			22.50
77	0	0	2			65%			26.00
78	0	0	0						
79	2	0	0	69%			65.00		
80	9	1	30	51%	67%	82%	118.22	82.00	26.80
81	8	13	49	48%	67%	74%	90.00	96.77	32.04
82	0	0	0						
83	0	1	4		73%	53%		164.00	10.00
84	0	1	3		58%	62%		126.00	35.33
87	2	4	13	35%	72%	79%	131.00	92.50	24.31
90	0	0	0						
Grand Total	196	174	1880	53%	66%	75%	105.94	110.13	27.78

Appendix D

DETAILED POPULATION AND CAPACITY DATA FOR DIESEL GENERATORS IN THE DFW AREA

Population					Capacity				
Total for Dallas/Fort Worth Area (all 12 counties)									
KW Range	Emergency	Peak	Baseload	Total	KW Range	Emergency	Peak	Baseload	Total
0-25	3861	0	493	**4354**	0-25	76789	0	9844	**86633**
25-50	5900	0	791	**6691**	25-50	202822	0	26912	**229734**
50-100	3614	0	382	**3996**	50-100	243438	0	25174	**268612**
100-250	4783	116	549	**5448**	100-250	701718	20415	79763	**801896**
250-500	3303	535	174	**4012**	250-500	1118413	189604	52486	**1360503**
500-750	1338	325	59	**1722**	500-750	820714	202943	37208	**1060865**
750-1000	681	421	76	**1178**	750-1000	617491	386816	70499	**1074805**
1000-1500	962	670	55	**1687**	1000-1500	1222026	875455	62010	**2159491**
1500+	279	230	5	**514**	1500+	544749	437881	14187	**996817**
Total	**24721**	**2297**	**2584**	**29602**	**Total**	**5548160**	**2113114**	**378082**	**8039356**
Tarrant County									
KW Range	Emergency	Peak	Baseload	Total	KW Range	Emergency	Peak	Baseload	Total
0-25	1005	0	139	**1144**	0-25	19976	0	2812	**22788**
25-50	1502	0	169	**1671**	25-50	51840	0	5729	**57569**
50-100	955	0	112	**1067**	50-100	64550	0	7405	**71955**
100-250	1302	24	168	**1494**	100-250	192445	4176	24745	**221366**
250-500	866	149	54	**1069**	250-500	293579	53397	16330	**363306**
500-750	350	95	18	**463**	500-750	214424	59323	11636	**285383**
750-1000	177	116	29	**322**	750-1000	160382	106442	27048	**293872**
1000-1500	249	171	14	**434**	1000-1500	312406	222391	15634	**550431**
1500+	76	56	1	**133**	1500+	145604	105916	4128	**255648**
Total	**6482**	**611**	**704**	**7797**	**Total**	**1455206**	**551645**	**115467**	**2122318**
Rockwall County									
KW Range	Emergency	Peak	Baseload	Total	KW Range	Emergency	Peak	Baseload	Total
0-25	71	0	3	**74**	0-25	1439	0	61	**1500**
25-50	120	0	16	**136**	25-50	4019	0	539	**4558**
50-100	51	0	0	**51**	50-100	3348	0	0	**3348**
100-250	59	0	1	**60**	100-250	7979	0	100	**8079**
250-500	50	2	0	**52**	250-500	16973	635	0	**17608**
500-750	22	1	0	**23**	500-750	13536	600	0	**14136**
750-1000	16	5	0	**21**	750-1000	15222	4559	0	**19781**
1000-1500	19	13	0	**32**	1000-1500	23929	16592	0	**40521**
1500+	3	2	0	**5**	1500+	5600	3600	0	**9200**
Total	**411**	**23**	**20**	**454**	**Total**	**92045**	**25986**	**700**	**118731**
Parker County									
KW Range	Emergency	Peak	Baseload	Total	KW Range	Emergency	Peak	Baseload	Total
0-25	40	0	1	**41**	0-25	797	0	15	**811**
25-50	78	0	9	**87**	25-50	2611	0	296	**2906**
50-100	24	0	0	**24**	50-100	1561	0	0	**1561**

100-250	24	0	0	**24**	100-250	2876	0	0	**2876**
250-500	20	0	0	**20**	250-500	6430	0	0	**6430**
500-750	8	0	0	**8**	500-750	4850	0	0	**4850**
750-1000	2	2	0	**4**	750-1000	1700	1849	0	**3549**
1000-1500	9	4	0	**13**	1000-1500	10742	5425	0	**16167**
1500+	0	1	0	**1**	1500+	0	2000	0	**2000**
Total	**205**	**7**	**10**	**222**	**Total**	**31566**	**9274**	**310**	**41150**
Kaufman County									
KW Range	**Emergency**	**Peak**	**Baseload**	**Total**	**KW Range**	**Emergency**	**Peak**	**Baseload**	**Total**
0-25	50	0	2	**52**	0-25	999	0	39	**1038**
25-50	86	0	12	**98**	25-50	2879	0	401	**3279**
50-100	34	0	0	**34**	50-100	2150	0	0	**2150**
100-250	39	0	0	**39**	100-250	5183	0	0	**5183**
250-500	34	1	0	**35**	250-500	11605	300	0	**11905**
500-750	14	0	0	**14**	500-750	8665	0	0	**8665**
750-1000	9	3	0	**12**	750-1000	8406	2699	0	**11105**
1000-1500	13	7	0	**20**	1000-1500	16238	9050	0	**25288**
1500+	1	1	0	**2**	1500+	2000	2000	0	**4000**
Total	**280**	**12**	**14**	**306**	**Total**	**58125**	**14049**	**439**	**72613**
Johnson County									
KW Range	**Emergency**	**Peak**	**Baseload**	**Total**	**KW Range**	**Emergency**	**Peak**	**Baseload**	**Total**
0-25	55	0	3	**58**	0-25	1102	0	61	**1163**
25-50	103	0	12	**115**	25-50	3458	0	401	**3859**
50-100	39	0	0	**39**	50-100	2476	0	0	**2476**
100-250	47	0	1	**48**	100-250	6361	0	100	**6461**
250-500	39	1	0	**40**	250-500	13245	300	0	**13545**
500-750	19	0	0	**19**	500-750	11586	0	0	**11586**
750-1000	9	2	0	**11**	750-1000	8406	1700	0	**10106**
1000-1500	15	5	0	**20**	1000-1500	18713	6050	0	**24763**
1500+	3	0	0	**3**	1500+	5600	0	0	**5600**
Total	**329**	**8**	**16**	**353**	**Total**	**70948**	**8050**	**561**	**79559**
Hunt County									
KW Range	**Emergency**	**Peak**	**Baseload**	**Total**	**KW Range**	**Emergency**	**Peak**	**Baseload**	**Total**
0-25	21	0	0	**21**	0-25	415	0	0	**415**
25-50	43	0	5	**49**	25-50	1438	0	168	**1639**
50-100	11	0	0	**11**	50-100	672	0	0	**672**
100-250	10	0	0	**10**	100-250	1177	0	0	**1177**
250-500	7	0	0	**7**	250-500	2035	0	0	**2035**
500-750	3	0	0	**3**	500-750	1850	0	0	**1850**
750-1000	2	0	0	**2**	750-1000	1849	0	0	**1849**
1000-1500	4	2	0	**6**	1000-1500	5425	2925	0	**8350**
1500+	2	0	1	**3**	1500+	6000	0	4059	**10059**
Total	**103**	**2**	**6**	**112**	**Total**	**20861**	**2925**	**4227**	**28046**
Hood County									
KW Range	**Emergency**	**Peak**	**Baseload**	**Total**	**KW Range**	**Emergency**	**Peak**	**Baseload**	**Total**
0-25	22	0	0	**22**	0-25	429	0	0	**429**
25-50	43	0	5	**49**	25-50	1438	0	168	**1639**

50-100	11	0	0	**11**	50-100	672	0	0	**672**
100-250	14	0	0	**14**	100-250	1578	0	0	**1578**
250-500	8	0	0	**8**	250-500	2335	0	0	**2335**
500-750	4	0	0	**4**	500-750	2450	0	0	**2450**
750-1000	2	0	0	**2**	750-1000	1849	0	0	**1849**
1000-1500	4	3	0	**7**	1000-1500	5425	4350	0	**9775**
1500+	1	0	0	**1**	1500+	2000	0	0	**2000**
Total	**109**	**3**	**5**	**118**	**Total**	**18176**	**4350**	**168**	**22727**
Henderson County									
KW Range	**Emergency**	**Peak**	**Baseload**	**Total**	**KW Range**	**Emergency**	**Peak**	**Baseload**	**Total**
0-25	26	0	0	**26**	0-25	515	0	0	**515**
25-50	53	0	8	**62**	25-50	1769	0	268	**2070**
50-100	11	0	0	**11**	50-100	672	0	0	**672**
100-250	19	0	0	**19**	100-250	2335	0	0	**2335**
250-500	14	0	0	**14**	250-500	4285	0	0	**4285**
500-750	4	0	0	**4**	500-750	2450	0	0	**2450**
750-1000	3	5	0	**8**	750-1000	2699	4432	0	**7131**
1000-1500	6	3	0	**9**	1000-1500	7550	4350	0	**11900**
1500+	1	3	0	**4**	1500+	2000	5485	0	**7485**
Total	**137**	**11**	**8**	**157**	**Total**	**24275**	**14267**	**268**	**38843**
Ellis County									
KW Range	**Emergency**	**Peak**	**Baseload**	**Total**	**KW Range**	**Emergency**	**Peak**	**Baseload**	**Total**
0-25	75	0	3	**78**	0-25	1526	0	61	**1587**
25-50	125	0	17	**142**	25-50	4187	0	573	**4760**
50-100	61	0	0	**61**	50-100	4004	0	0	**4004**
100-250	66	0	1	**67**	100-250	9187	0	100	**9287**
250-500	50	1	1	**52**	250-500	16973	300	250	**17523**
500-750	24	1	0	**25**	500-750	14751	600	0	**15351**
750-1000	16	4	0	**20**	750-1000	15222	3659	0	**18881**
1000-1500	19	10	0	**29**	1000-1500	23929	13025	0	**36954**
1500+	3	1	0	**4**	1500+	5600	2000	0	**7600**
Total	**439**	**17**	**22**	**478**	**Total**	**95380**	**19584**	**983**	**115947**
Denton County									
KW Range	**Emergency**	**Peak**	**Baseload**	**Total**	**KW Range**	**Emergency**	**Peak**	**Baseload**	**Total**
0-25	267	0	26	**293**	0-25	5284	0	515	**5799**
25-50	403	0	53	**456**	25-50	13872	0	1769	**15641**
50-100	239	0	11	**250**	50-100	16015	0	672	**16687**
100-250	313	1	18	**332**	100-250	45570	188	2274	**48032**
250-500	228	28	5	**261**	250-500	77315	10045	1300	**88660**
500-750	90	18	0	**108**	500-750	54682	11521	0	**66203**
750-1000	55	30	2	**87**	750-1000	50392	27948	1849	**80189**
1000-1500	69	40	1	**110**	1000-1500	88665	52689	1075	**142429**
1500+	22	19	0	**41**	1500+	41140	36536	0	**77676**
Total	**1686**	**136**	**116**	**1938**	**Total**	**392935**	**138927**	**9454**	**541316**
Dallas County									
KW Range	**Emergency**	**Peak**	**Baseload**	**Total**	**KW Range**	**Emergency**	**Peak**	**Baseload**	**Total**
0-25	1768	0	263	**2031**	0-25	35099	0	5222	**40320**

25-50	2643	0	391	**3034**	25-50	91211	0	13459	**104670**
50-100	1732	0	221	**1953**	50-100	117169	0	14697	**131866**
100-250	2301	83	312	**2696**	100-250	340462	14701	45843	**401006**
250-500	1577	298	100	**1975**	250-500	535280	105569	30711	**671560**
500-750	633	166	38	**837**	500-750	388546	103410	23722	**515678**
750-1000	272	207	38	**517**	750-1000	243072	189918	35194	**468184**
1000-1500	401	335	31	**767**	1000-1500	512523	439480	34913	**986916**
1500+	126	123	2	**251**	1500+	249849	236404	4000	**490253**
Total	**11453**	**1212**	**1396**	**14061**	**Total**	**2513212**	**1089482**	**207760**	**3810454**
Collin County									
KW Range	**Emergency**	**Peak**	**Baseload**	**Total**	**KW Range**	**Emergency**	**Peak**	**Baseload**	**Total**
0-25	461	0	53	**514**	0-25	9207	0	1061	**10268**
25-50	701	0	94	**795**	25-50	24099	0	3145	**27244**
50-100	446	0	38	**484**	50-100	30149	0	2400	**32549**
100-250	589	8	48	**645**	100-250	86565	1350	6601	**94516**
250-500	410	55	14	**479**	250-500	138358	19058	3895	**161311**
500-750	167	44	3	**214**	500-750	102924	27489	1850	**132263**
750-1000	118	47	7	**172**	750-1000	108291	43610	6408	**158309**
1000-1500	154	77	9	**240**	1000-1500	196481	99128	10388	**305997**
1500+	41	24	1	**66**	1500+	79356	43940	2000	**125296**
Total	**3087**	**255**	**267**	**3609**	**Total**	**775431**	**234575**	**37747**	**1047753**

Appendix E

DETAILED EMISSION INVENTORIES FOR DIESEL GENERATORS IN THE DFW AREA

Total for DFW Area	NOx Emissions (tons/year)				NOx Emissions (tons/day)			
	Emergency	Peak	Baseload	Total	Emergency	Peak	Baseload	Total
0-25 kW	23.6	0.0	4.5	28.0	0.065	0.000	0.012	0.077
25-50 kW	62.2	0.0	12.2	74.4	0.171	0.000	0.033	0.204
50-100 kW	74.7	0.0	11.4	86.1	0.205	0.000	0.031	0.236
100-250 kW	215.3	8.2	35.1	258.6	0.590	0.022	0.096	0.709
250-500 kW	509.8	81.1	22.8	613.7	1.397	0.222	0.062	1.681
500-750 kW	321.5	71.3	14.7	407.5	0.881	0.195	0.040	1.116
750-1000 kW	314.8	165.3	47.8	527.9	0.862	0.453	0.131	1.446
1000-1500 kW	711.1	545.7	44.3	1301.1	1.948	1.495	0.121	3.565
1500+ kW	335.8	348.2	25.9	709.8	0.920	0.954	0.071	1.945
Total	2568.8	1219.8	218.6	4007.2	7.038	3.342	0.599	10.979
Tarrant County	**NOx Emissions (tons/year)**				**NOx Emissions (tons/day)**			
	Emergency	**Peak**	**Baseload**	**Total**	**Emergency**	**Peak**	**Baseload**	**Total**
0-25 kW	6.1	0.0	1.3	7.4	0.017	0.000	0.003	0.020
25-50 kW	15.9	0.0	2.6	18.5	0.044	0.000	0.007	0.051
50-100 kW	19.8	0.0	3.4	23.2	0.054	0.000	0.009	0.063
100-250 kW	59.1	1.7	10.9	71.6	0.162	0.005	0.030	0.196
250-500 kW	133.7	22.8	7.1	163.7	0.366	0.063	0.019	0.448
500-750 kW	83.9	20.9	5.1	109.9	0.230	0.057	0.014	0.301
750-1000 kW	81.8	45.5	18.3	145.6	0.224	0.125	0.050	0.399
1000-1500 kW	180.9	138.4	11.1	330.4	0.496	0.379	0.030	0.905
1500+ kW	89.8	82.6	7.5	179.9	0.246	0.226	0.021	0.493
Total	671.0	311.9	67.2	1050.2	1.838	0.855	0.184	2.877
Rockwall County	**NOx Emissions (tons/year)**				**NOx Emissions (tons/day)**			
	Emergency	**Peak**	**Baseload**	**Total**	**Emergency**	**Peak**	**Baseload**	**Total**
0-25 kW	0.4	0.0	0.0	0.5	0.001	0.000	0.000	0.001
25-50 kW	1.2	0.0	0.2	1.5	0.003	0.000	0.001	0.004
50-100 kW	1.0	0.0	0.0	1.0	0.003	0.000	0.000	0.003
100-250 kW	2.4	0.0	0.0	2.5	0.007	0.000	0.000	0.007
250-500 kW	7.8	0.3	0.0	8.1	0.021	0.001	0.000	0.022
500-750 kW	5.2	0.2	0.0	5.4	0.014	0.001	0.000	0.015
750-1000 kW	7.8	1.9	0.0	9.7	0.021	0.005	0.000	0.027
1000-1500 kW	13.7	9.7	0.0	23.5	0.038	0.027	0.000	0.064
1500+ kW	3.5	2.8	0.0	6.3	0.009	0.008	0.000	0.017
Total	43.1	15.0	0.3	58.4	0.118	0.041	0.001	0.160
Parker County	**NOx Emissions (tons/year)**				**NOx (tons/day)**			
	Emergency	**Peak**	**Baseload**	**Total**	**Emergency**	**Peak**	**Baseload**	**Total**
0-25 kW	0.2	0.0	0.0	0.3	0.001	0.000	0.000	0.001
25-50 kW	0.8	0.0	0.1	0.9	0.002	0.000	0.000	0.003
50-100 kW	0.5	0.0	0.0	0.5	0.001	0.000	0.000	0.001

100-250 kW	0.9	0.0	0.0	0.9	0.002	0.000	0.000	0.002
250-500 kW	2.9	0.0	0.0	2.9	0.008	0.000	0.000	0.008
500-750 kW	1.8	0.0	0.0	1.8	0.005	0.000	0.000	0.005
750-1000 kW	0.9	0.8	0.0	1.7	0.002	0.002	0.000	0.005
1000-1500 kW	5.9	3.4	0.0	9.4	0.016	0.009	0.000	0.026
1500+ kW	0.0	1.7	0.0	1.7	0.000	0.005	0.000	0.005
Total	14.0	6.0	0.1	20.1	0.038	0.016	0.000	0.055
Kaufman County	**NOx Emissions (tons/year)**				**NOx Emissions (tons/day)**			
	Emergency	**Peak**	**Baseload**	**Total**	**Emergency**	**Peak**	**Baseload**	**Total**
0-25 kW	0.3	0.0	0.0	0.3	0.001	0.000	0.000	0.001
25-50 kW	0.9	0.0	0.2	1.1	0.002	0.000	0.000	0.003
50-100 kW	0.7	0.0	0.0	0.7	0.002	0.000	0.000	0.002
100-250 kW	1.6	0.0	0.0	1.6	0.004	0.000	0.000	0.004
250-500 kW	5.4	0.1	0.0	5.5	0.015	0.000	0.000	0.015
500-750 kW	3.4	0.0	0.0	3.4	0.009	0.000	0.000	0.009
750-1000 kW	4.3	1.2	0.0	5.4	0.012	0.003	0.000	0.015
1000-1500 kW	9.2	5.4	0.0	14.6	0.025	0.015	0.000	0.040
1500+ kW	1.2	1.7	0.0	3.0	0.003	0.005	0.000	0.008
Total	26.9	8.4	0.2	35.5	0.074	0.023	0.001	0.097
Johnson County	**NOx Emissions (tons/year)**				**NOx Emissions (tons/day)**			
	Emergency	**Peak**	**Baseload**	**Total**	**Emergency**	**Peak**	**Baseload**	**Total**
0-25 kW	0.3	0.0	0.0	0.4	0.001	0.000	0.000	0.001
25-50 kW	1.1	0.0	0.2	1.2	0.003	0.000	0.000	0.003
50-100 kW	0.8	0.0	0.0	0.8	0.002	0.000	0.000	0.002
100-250 kW	2.0	0.0	0.0	2.0	0.005	0.000	0.000	0.005
250-500 kW	6.2	0.1	0.0	6.3	0.017	0.000	0.000	0.017
500-750 kW	4.5	0.0	0.0	4.5	0.012	0.000	0.000	0.012
750-1000 kW	4.3	0.7	0.0	5.0	0.012	0.002	0.000	0.014
1000-1500 kW	10.6	3.3	0.0	13.9	0.029	0.009	0.000	0.038
1500+ kW	3.5	0.0	0.0	3.5	0.009	0.000	0.000	0.009
Total	33.1	4.2	0.3	37.6	0.091	0.011	0.001	0.103
Hunt County	**NOx Emissions (tons/year)**				**NOx Emissions (tons/day)**			
	Emergency	**Peak**	**Baseload**	**Total**	**Emergency**	**Peak**	**Baseload**	**Total**
0-25 kW	0.1	0.0	0.0	0.1	0.000	0.000	0.000	0.000
25-50 kW	0.4	0.0	0.1	0.5	0.001	0.000	0.000	0.001
50-100 kW	0.2	0.0	0.0	0.2	0.001	0.000	0.000	0.001
100-250 kW	0.4	0.0	0.0	0.4	0.001	0.000	0.000	0.001
250-500 kW	0.9	0.0	0.0	0.9	0.002	0.000	0.000	0.002
500-750 kW	0.7	0.0	0.0	0.7	0.002	0.000	0.000	0.002
750-1000 kW	0.9	0.0	0.0	0.9	0.003	0.000	0.000	0.003
1000-1500 kW	3.2	2.0	0.0	5.2	0.009	0.005	0.000	0.014
1500+ kW	3.7	0.0	7.4	11.1	0.010	0.000	0.020	0.030
Total	10.6	2.0	7.5	20.0	0.029	0.005	0.020	0.055
Hood County	**NOx Emissions (tons/year)**				**NOx Emissions (tons/day)**			
	Emergency	**Peak**	**Baseload**	**Total**	**Emergency**	**Peak**	**Baseload**	**Total**
0-25 kW	0.1	0.0	0.0	0.1	0.000	0.000	0.000	0.000
25-50 kW	0.4	0.0	0.1	0.5	0.001	0.000	0.000	0.001

50-100 kW	0.2	0.0	0.0	0.2	0.001	0.000	0.000	0.001
100-250 kW	0.5	0.0	0.0	0.5	0.001	0.000	0.000	0.001
250-500 kW	1.0	0.0	0.0	1.0	0.003	0.000	0.000	0.003
500-750 kW	0.9	0.0	0.0	0.9	0.003	0.000	0.000	0.003
750-1000 kW	0.9	0.0	0.0	0.9	0.003	0.000	0.000	0.003
1000-1500 kW	3.2	3.0	0.0	6.2	0.009	0.008	0.000	0.017
1500+ kW	1.2	0.0	0.0	1.2	0.003	0.000	0.000	0.003
Total	8.6	3.0	0.1	11.7	0.024	0.008	0.000	0.032
Henderson County	**NOx Emissions(tons/year)**				**NOx Emissions (tons/day)**			
	Emergency	**Peak**	**Baseload**	**Total**	**Emergency**	**Peak**	**Baseload**	**Total**
0-25 kW	0.2	0.0	0.0	0.2	0.000	0.000	0.000	0.000
25-50 kW	0.5	0.0	0.1	0.7	0.001	0.000	0.000	0.002
50-100 kW	0.2	0.0	0.0	0.2	0.001	0.000	0.000	0.001
100-250 kW	0.7	0.0	0.0	0.7	0.002	0.000	0.000	0.002
250-500 kW	1.9	0.0	0.0	1.9	0.005	0.000	0.000	0.005
500-750 kW	0.9	0.0	0.0	0.9	0.003	0.000	0.000	0.003
750-1000 kW	1.4	1.9	0.0	3.3	0.004	0.005	0.000	0.009
1000-1500 kW	4.3	3.0	0.0	7.3	0.012	0.008	0.000	0.020
1500+ kW	1.2	4.1	0.0	5.4	0.003	0.011	0.000	0.015
Total	11.4	9.0	0.1	20.5	0.031	0.025	0.000	0.056
Ellis County	**NOx Emissions (tons/year)**				**NOx Emissions (tons/day)**			
	Emergency	**Peak**	**Baseload**	**Total**	**Emergency**	**Peak**	**Baseload**	**Total**
0-25 kW	0.5	0.0	0.0	0.5	0.001	0.000	0.000	0.001
25-50 kW	1.3	0.0	0.3	1.5	0.004	0.000	0.001	0.004
50-100 kW	1.2	0.0	0.0	1.2	0.003	0.000	0.000	0.003
100-250 kW	2.8	0.0	0.0	2.9	0.008	0.000	0.000	0.008
250-500 kW	7.8	0.1	0.1	8.0	0.021	0.000	0.000	0.022
500-750 kW	5.7	0.2	0.0	5.9	0.016	0.001	0.000	0.016
750-1000 kW	7.8	1.6	0.0	9.3	0.021	0.004	0.000	0.026
1000-1500 kW	13.7	7.8	0.0	21.6	0.038	0.021	0.000	0.059
1500+ kW	3.5	1.7	0.0	5.2	0.009	0.005	0.000	0.014
Total	44.2	11.5	0.4	56.1	0.121	0.031	0.001	0.154
Denton County	**NOx Emissions (tons/year)**				**NOx Emissions (tons/day)**			
	Emergency	**Peak**	**Baseload**	**Total**	**Emergency**	**Peak**	**Baseload**	**Total**
0-25 kW	1.6	0.0	0.2	1.9	0.004	0.000	0.001	0.005
25-50 kW	4.3	0.0	0.8	5.1	0.012	0.000	0.002	0.014
50-100 kW	4.9	0.0	0.3	5.2	0.013	0.000	0.001	0.014
100-250 kW	14.0	0.1	1.0	15.1	0.038	0.000	0.003	0.041
250-500 kW	35.3	4.3	0.6	40.2	0.097	0.012	0.002	0.110
500-750 kW	21.2	4.2	0.0	25.4	0.058	0.011	0.000	0.069
750-1000 kW	25.7	11.9	1.3	38.9	0.070	0.033	0.003	0.107
1000-1500 kW	51.9	32.8	0.7	85.5	0.142	0.090	0.002	0.234
1500+ kW	25.4	29.4	0.0	54.7	0.069	0.080	0.000	0.150
Total	184.3	82.7	4.9	271.8	0.505	0.227	0.013	0.745
Dallas County	**NOx Emissions (tons/year)**				**NOx Emissions (tons/day)**			
	Emergency	**Peak**	**Baseload**	**Total**	**Emergency**	**Peak**	**Baseload**	**Total**
0-25 kW	10.8	0.0	2.4	13.1	0.030	0.000	0.006	0.036

25-50 kW	28.0	0.0	6.1	34.1	0.077	0.000	0.017	0.093
50-100 kW	36.0	0.0	6.7	42.6	0.099	0.000	0.018	0.117
100-250 kW	104.5	5.9	20.2	130.6	0.286	0.016	0.055	0.358
250-500 kW	244.1	45.1	13.3	302.5	0.669	0.124	0.037	0.829
500-750 kW	152.5	36.3	8.9	197.7	0.418	0.100	0.024	0.542
750-1000 kW	123.9	81.2	23.9	228.9	0.339	0.222	0.065	0.627
1000-1500 kW	299.3	276.0	25.0	600.3	0.820	0.756	0.069	1.645
1500+ kW	154.0	189.5	7.3	350.8	0.422	0.519	0.020	0.961
Total	1153.0	634.0	113.7	1900.7	3.159	1.737	0.312	5.207

Collin County	**NOx Emissions (tons/year)**				**NOx Emissions (tons/day)**			
	Emergency	**Peak**	**Baseload**	**Total**	**Emergency**	**Peak**	**Baseload**	**Total**
0-25 kW	2.8	0.0	0.5	3.3	0.008	0.000	0.001	0.009
25-50 kW	7.4	0.0	1.4	8.8	0.020	0.000	0.004	0.024
50-100 kW	9.3	0.0	1.1	10.3	0.025	0.000	0.003	0.028
100-250 kW	26.6	0.5	2.9	30.0	0.073	0.001	0.008	0.082
250-500 kW	62.8	8.2	1.7	72.7	0.172	0.022	0.005	0.199
500-750 kW	40.7	9.5	0.6	50.8	0.112	0.026	0.002	0.139
750-1000 kW	55.2	18.6	4.3	78.2	0.151	0.051	0.012	0.214
1000-1500 kW	114.9	60.8	7.5	183.2	0.315	0.167	0.021	0.502
1500+ kW	48.9	34.5	3.6	87.1	0.134	0.095	0.010	0.239
Total	368.6	132.2	23.7	524.5	1.010	0.362	0.065	1.437