Final Report

ESTIMATES OF EMISSIONS FOR SMALL-SCALE DIESEL ENGINES

HARC Project H-10

Prepared for

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1. INTRODUCTION

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

BACKGROUND

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

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

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

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

SCOPE OF WORK

This project consisted of four tasks, which included:

- Data and method assessment task;
- Method development and data-gathering task;
- Emission quantification and impact assessment task; and
- Report development task.

The scope of work for each task is defined below.

- **Task 1: Data and Method Assessment** – In this task, efforts were made to quantify the population, activity, and emission characteristics of 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. 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 diesel generators were quantified, an assessment of the available data and methods was conducted to determine the applicability of these data to the HGA. Finally, a recommended method for quantifying the population and activity data on small-scale diesel generators for the HGA was made based on the assessment results.

- **Task 2: Method Development and Data-Gathering** – In Task 2, a methodology was developed to estimate the population and activity data for generators found in the HGA. The proposed methodology included, but was not necessarily limited to, the following estimation tools:

  - existing dataset review;
  - diesel generator sale data via market research companies and/or trade organizations;
  - fire department registration on diesel fuel storage requirements;
  - building and air permit applications; and
  - surveys based on SIC with emphasis on major users such as hospitals, office buildings, shopping complexes, and factories.

  In addition, some effort was made to obtain information to confirm the estimated population of small-scale diesel generators by contacting market research companies, trade organizations and fire departments located within the HGA, the Texas Commission on Environmental Quality's (TCEQ) permitting department, and county governments. Moreover, a list of generator owners was developed so that follow-up telephone surveys could be performed as necessary to complement and/or confirm population datasets.

- **Task 3: Emission Quantification and Impact Assessment** – In this task, available data, including existing datasets and newly acquired datasets, were compiled, reviewed, and reduced to determine the generator population and activity data by category in the HGA. Following this, a NOx emission inventory for generators in the HGA 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 diesel generators were reviewed and assessed as part of this task.

- **Task 4: Report Development** – Data gathering and method development work conducted as part of this study as well as study results were summarized in a draft technical memorandum and final report.

2. PROJECT APPROACH

In this section of the report, the various approaches that were followed to quantify the population and activity data of small-scale diesel generators are presented. In addition, the methodology used to estimate NOx emissions is presented.

DEVELOPMENT OF POPULATION AND ACTIVITY DATA

Literature Review

In order to better estimate NOx emissions from small-scale diesel generators in the HGA, 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 first performed a literature search and reviewed population and activity data on diesel generators to compile available data and quantification methods used in Texas and other states.

In conducting this study, a number of literature research sources were reviewed. These research sources include the following:

- Information contained in diesel generator permit records submitted to the TCEQ by industrial sources (see Appendix A).
- A report on stationary compression-ignition engines prepared by the California Air Resources Board (CARB) (CARB, 2003).
- Information from the CARB statewide Portable Power Equipment Registration (PPER) program. This program 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. Data generated from the PPER has been used to estimate emissions from diesel generators in California and elsewhere.
- A study funded by the California Energy Commission (CEC) to develop an inventory of backup generators in California. The results of this study were published in a CEC report in December 2001 (CEC, 2001a)
- 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).
- 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).

In addition to these research sources, ENVIRON contacted several fire departments in the HGA to seek registration information on diesel fuel storage requirements, and building and air permit applications. ENVIRON also procured a database that contained estimated engine populations and activity data for diesel generator engines in the HGA from a market research company called Power Systems Research (PSR)[1]. Based on the findings from the literature search and review task, ENVIRON developed a methodology to estimate an emission inventory for diesel generators in the HGA using emission factors and other relevant data found in the literature search, as well as the population and activity data in the PSR database.

Finally, ENVIRON reviewed a number of NOx emission control technologies for diesel generators as part of our effort to compile and categorize available data. This review of emission control technologies was used to assess emission benefits resulting from the application of emission control technologies on these small-scale diesel generators. Some of the evaluated control technologies include engine technology such as exhaust gas recirculation (EGR) and aftertreatment devices such as selective catalyst reduction (SCR) and lean NOx catalyst.

Fire Department Registration, and Air and Building Permits

As part of the population and activity data gathering effort, ENVIRON contacted various fire departments in the HGA to determine if any diesel generator population information could be obtained from diesel fuel storage requirements in the county. Through this effort, ENVIRON found that most of the fire departments in the area are voluntary departments and thus do not fall under mandatory state commission regulations. Of the non-volunteer fire departments contacted, most only had records for storage facilities with large liquid fuel tanks (i.e., tanks with greater than 500 gallons of liquid fuels). In addition, the policies and records of the non-volunteer fire departments varied from city to city and between counties -- some departments had very detailed records, while others had no information at all.[2] It was also determined from these contacts that farm and residential underground storage tanks (USTs) with a capacity of 1,100 gallons or less and aboveground storage tanks (ASTs) with a capacity below 1,100 gallons are excluded from TCEQ regulations and permitting.

In addition to fire departments, ENVIRON also contacted various county/city building engineering and permit offices to determine if diesel generator information was included in building permit records.[3] Through this effort, ENVIRON found that in general no records of installed diesel generators (or generators of any type) are included in building permit records. ENVIRON also researched air permitting documentation as a further method for obtaining information on generators in the HGA. A list of approximately 240 generators registered with TCEQ as part of the 2001 permitting requirement rule implementation is attached (Appendix A). In summary, data gathering efforts through fire departments, and building and air permitting

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[1] CARB and EPA also use PSR's engine databases for their off-road equipment models development work.

[2] One fire department in Harris County indicated that Humble City had about 30 diesel generators based on building permits, electrical permits and fire inspection data in the city.

[3] County/city offices contacted included Montgomery County, Chambers County, City of Galveston, and Brazoria County.

records did not yield the population and activity data necessary to estimate the NOx emission inventory in the HGA.

PSR PARTSLINK™ Methodology and Database[4]

Over the past 23 years, Power Systems Research (PSR) has maintained a database known as PartsLink^{TM}. PartsLink^{TM} utilizes a mathematical model to estimate the number of engine powered products in service in the United States and the annual parts consumption associated with the operation of that equipment. This model is developed 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.[5]

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
- 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

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[4] George Zirnhelt of Power Systems Research provided some information in this section.

[5] While ENVIRON used the population and activity data from the PSR's database to estimate the NOx emission inventory from diesel generators in the HGA, it was recognized that information derived from the database are estimates and therefore were used only as a starting point for future refinement if no other better data were available. 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.

- 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.[6] 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.

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.

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[6] 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.

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[7]
- 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.

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[7] 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.

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 20 years through the development of a profile for owners of each type of equipment. These profiles consist of a correlation between any combination of up to 22 economic, geographic, demographic, and meteorological factors. 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 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.

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 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 are 20 generator sets of this size owned among them.

This methodology and the completion of more than 200,000 interviews over the past 20 years has 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.

DIESEL GENERATOR POPULATION AND CAPACITY

The database provided by PSR included the population and activity data for diesel generators in the HGA, broken down by county levels, as well as by generator types (i.e., emergency, peaking, baseload, and other or portable) and by capacity in horsepower. As shown in Table 2-1, PSR estimates that there are approximately 31,000 diesel generators units in the HGA, with about 24,000 for emergency generators, 3,000 for peak shaving generators, and about 2,000 each for baseload and other generators.[8]

Table 2-1. Estimated diesel generator population in the HGA.

Diesel Generator Population (Totals by County)					
	Emergency	**Peak**	**Baseload**	**Other**	**Total**
Brazoria	3696	546	319	349	4910
Chambers	2218	320	140	170	2848
Fort Bend	2610	346	200	208	3364
Galveston	2258	279	155	170	2862
Harris	9423	1298	1043	1159	12923
Liberty	386	25	20	10	441
Montgomery	2317	292	161	176	2946
Waller	779	62	37	35	913
Total	23687	3168	2075	2277	31207

During our review of the PSR data, the estimates derived from the database were perceived to be somewhat high as compared to data found in the literature review. For example, among stationary ignition engines, CARB estimates that the state of California has about 20,000 units for emergency stand-by generators, and about 7,000 units of stationary prime engines (CARB, 2003). However, the CEC study reported that there were about 4,100 back-up generators in the state with a total capacity of 3.2 MW based on air permit data provided by the California Air Quality Management Districts (with the notable exclusion of the Bay Area Air Quality

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[8] “Other generators” are mostly portable generators that fall under the off-road equipment source instead of stationary source in the EPA definition.

Management District), a few utility companies and state agencies, and one private company (CEC, 2001b).[9]

In the NESCAUM study (NESCAUM, 2003), PSR estimated that there were 33,000 units of stationary diesel generators in the Northeast States, with about 27,000 emergency generators, 6,000 peak shaving generators, and 400 baseload generators. The total capacity for these generators was about 12,000 MW, with about 9,000 MW from the emergency generators, 2,800 MW from the peak shaving generators, and 200 MW from the baseload generators. Moreover, using the total number of diesel generators, including portable generators, and per capita data in California and Texas, the TexPIRG study (TexPIRG, 2002) estimated the total number of diesel generators in Texas to be about 33,000 units, with about 7,000 emergency generators, 2,000 prime generators, and 24,000 portable generators.

In terms of electricity capacity, PSR estimated that the diesel generators in the HGA generated about 11,000 MW of electricity, with about 7,000 MW from emergency generators, 3,100 MW from peak shaving generators, about 400 MW from baseload generators, and 500 MW from other (portable) generators as shown in Table 2-2.

Table 2-2. Estimated total capacity of diesel generators in the HGA.

	Diesel Generator Capacity (MW)				
	Emergency	**Peak**	**Baseload**	**Other**	**Total**
Brazoria	1085	531	53	65	1734
Chambers	637	314	22	30	1004
Fort Bend	757	341	30	31	1159
Galveston	648	285	22	25	979
Harris	2853	1206	206	268	4533
Liberty	98	28	1	0	127
Montgomery	663	294	24	26	1006
Waller	210	75	2	4	291
Total	6951	3072	359	450	10832

Comparing the total capacity of 12,000 MW for the Northeast States to that derived from the PSR database, the 11,000 MW electricity generation from the diesel generators in the HGA seemed to be high on a per capita basis; in 2001, the population in the Northeast States was approximately 42 million with approximately 5 million people residing in the HGA. A review of industry types in the Northeast States and the HGA did not provide a clear indication of differences in industry types that result in a greater demand for electricity utilization in the HGA.

Also, based on data obtained from the Energy Information System that showed 76,000 MW peak generating capacity in Texas in 1999[10], the capacity of 10,000 MW for emergency and peak shaving generators obtained from the PSR database was equal to about 13% of the projected 2003 peak generating capacity of 80,000 MW assuming on an average growth of 1% (average growth value from 1990 to 1999). This 13% value was higher than the 10% value that the

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[9] As a note, the report indicated that a couple of the air districts acknowledged that data provided to the study were incomplete.

Electric Power Research Institute estimated for installed capacity of backup generators to the total peak demand in the U.S (TexRIPG, 2002).

The detailed population and capacity data obtained from the PSR database broken down by generator capacity ranges and by county are provided in Appendix B.

DIESEL GENERATOR ACTIVITY DATA AND EMISSION FACTORS

In addition to population data, emission factors and activity data (e.g., operating hours and load factors) are needed to estimate NOx emissions from diesel generators in the HGA. PSR's database estimated the activity data in operating hours per year based on its survey effort. The operating hours for different generator types and capacity ranges provided in the PSR's database are tabulated in Table 2-3.

Table 2-3. Estimated average hour usage for diesel generators in the HGA.

Hours per Year				
Range (kw)	**Emergency**	**Peak**	**Baseload**	**Other**
0-150	50	350	2880	200
150-300	80	420	4240	400
300-700	120	460	4460	600
700-1200	160	540	4530	800
1200+	180	880	5120	800

In its 2003 study report, CARB estimated the operating hours for back-up generators to be 30 hours per year based on its survey work (CARB, 2003). This value is substantially lower than PSR's estimate of 50 to 180 hours per year, depending on the capacity range. Since PSR did not provide the load factor in their database, a load factor of 0.74 obtained from the CARB study was used for the all generator types, except the "other" (portable) type where a load factor of 0.48 was used.

To estimate the emission inventory from diesel generators in the HGA for particulate matter (PM), NOx, and volatile organic compounds (VOC), AP-42 emission factors were used for all diesel engines with the exception of those over 600 horsepower. For these engines, VOC emission factors from the Sacramento Air Quality Management District (SMAQMD)'s September 2002 "Internal Combustion Engine Manual were used.[11] Emission factors used to estimate the HGA diesel generator emission inventory are shown in Table 2-4.

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[10] http://www.eia.doe.gov/cneaf/electricity/st_profiles/texas/tx.html#t1

[11] The SMAQMD manual uses AP-42 emission factors, except where emission tests conducted by California for purposes of Best Available Control Technology (BACT) determinations revealed higher emission factors (NESCAUM, 2003).

Table 2-4. Emission factors for diesel generators in the HGA.

Emission Factors for Diesel Generator NOx, PM10, and VOC emissions						
	NOx		PM_{10}		VOC	
	g/hp-hr	lb/MWh	g/hp-hr	lb/MWh	g/hp-hr	lb/MWh
Diesel < 600hp	14.06	41.54	1	2.95	1.14	3.36
Diesel > 600hp	10.86	32.16	0.32	0.94	1*	2.95*
					*from SMQAMD Manua	

DIESEL GENERATOR EMISSION INVENTORIES

The inventories for PM, NOx and VOC emissions from emergency diesel generators in the HGA were estimated to be approximately 1.3, 33.0, and 3.0 tons per day, respectively. For peak-shaving generators, the PM, NOx and VOC emissions were estimated to be approximately 2.3, 73.1, and 6.7 tons per day, respectively. For baseload generators, the PM, NOx and VOC emissions were estimated to be approximately 2.8, 55.0, and 5.8 tons per day, respectively. For other diesel generators, mostly portable generators, the PM, NOx and VOC emissions were estimated to be approximately 0.3, 5.7 and 0.5 tons per day, respectively. Some of the emissions from the baseload generators should have been previously accounted for in the point source emission inventories, and most of the emissions from the other diesel generators should have been previously accounted for in the non-road mobile source emission inventories. The emission inventories broken down by counties are shown in Table 2-5. Detailed emission inventories broken down by generator types, counties, and capacity ranges are shown in Appendix C.

Table 2-5. Emission inventories for diesel generators in the HGA.

County	Pollutants (tpd)											
	PM10				NOx				VOC			
	Emergency	Peak	Baseload	Other	Emergency	Peak	Baseload	Other	Emergency	Peak	Baseload	Other
Brazoria	0.20	0.41	0.41	0.04	5.17	12.66	8.02	0.78	0.46	1.16	0.69	0.07
Chambers	0.12	0.24	0.16	0.02	3.01	7.43	3.37	0.38	0.27	0.68	0.29	0.03
Fort Bend	0.14	0.26	0.23	0.02	3.59	8.06	4.51	0.36	0.32	0.74	0.39	0.03
Galveston	0.12	0.21	0.18	0.02	3.06	6.76	3.35	0.28	0.27	0.62	0.29	0.02
Harris	0.54	0.94	1.57	0.17	13.68	28.75	31.83	3.55	1.22	2.62	2.76	0.31
Liberty	0.02	0.02	0.01	0.00	0.45	0.65	0.09	0.00	0.04	0.06	0.01	0.00
Montgomery	0.12	0.22	0.19	0.02	3.13	6.96	3.60	0.29	0.28	0.64	0.31	0.02
Waller	0.04	0.05	0.02	0.00	0.98	1.80	0.24	0.05	0.09	0.17	0.02	0.00
Total	1.31	2.34	2.76	0.29	33.08	73.07	55.00	5.68	2.96	6.68	4.76	0.49

As seen in the table, NOx emissions from peak shaving generators contributed approximately 44% of the total NOx emissions with about 45% of the total NOx emissions contributed by the emergency, peak shaving, and baseload generators in Harris County. Portable diesel generators, which accounted for part of the non-road mobile source emissions, only contributed about 3% of the total NOx emissions.

In Chapter 117 of the TCEQ NOx Rule concerning control of air pollution from nitrogen compounds, TCEQ estimated that NOx emissions from total point sources were about 670 tons per day in 1997. TCEQ further estimated that in 1997, approximately 5 tons per day of NOx emissions from point sources were contributed by stationary emergency generators (TCEQ, 2002). This estimate is substantially lower than the 33 tons per day of NOx emissions from the emergency generators estimated using the PSR's database[12].

Sensitivity of Activity Data on Emission Inventories

To assess the sensitivity of the activity data, the CARB activity data of 30 hours of operation for emergency generators was used to generate a NOx emission inventory for emergency generators. Using the 30 hours per year activity data, the NOx emission inventory was reduced from 33 tons per day to 7 tons per day – an 80% reduction in NOx emissions. It is clear from this sensitivity analysis that the operating hours assigned to each generator type will have a major impact on the NOx emission inventory. It is recommended that the NOx emission inventory be revised if there is better available activity data.

As noted above, PSR based their estimate for the diesel generator population and activity data in the HGA on 2003. During the last six years, the demand and utilization of electric power in the HGA has changed due to the deregulation of the electric power production industry and recent turmoil in energy markets. More and more major electricity consumers (industries) are relying on other power sources, including stationary diesel generators, instead of the traditional central power plants, to meet their power demand, to avoid downtime resulting from central power plant down time, and to save energy costs. These power utilization changes and the increases in the power demand could contribute to the increases in the use of diesel generators, and thus, increases in the NOx emission inventory from this source as well.

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[12] It should be noted that PSR based their estimate for the diesel generator population and activity data for diesel generators in the HGA on 2003.

3. EMISSION CONTROL TECHNOLOGIES FOR DIESEL GENERATORS

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 below.

NOx CONTROL TECHNOLOGIES

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 B), there are about 5,100 diesel generators in the 750 to 2,250 kW range in the HGA, or about 16% of the total diesel generators in the HGA. However, the NOx emissions contributed by these diesel generators is approximately 110 tons per day, or about 67% of the total NOx emissions from the diesel generators in the HGA. A conservative 80% NOx emission reduction through the use of SCR technology on these diesel generators would result in a reduction of about 90 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[13], and a 70 to 95% reduction could be achieved with SCR technology.

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.

PM AND VOC CONTROL TECHNOLOGIES

While it was not the focus of this study, reducing PM and VOC emissions should also be considered when dealing with emissions from diesel generators. For PM control options, diesel particulate filters (DPF) can provide 80% to 90% emission reduction, while oxidation catalysts can provide about 20% reduction but at a lower cost. Both diesel particulate filters (with catalyst) and oxidation catalysts can provide 80% to 90% reduction in VOC emissions including toxic air HC emissions and CO emissions.

The NESCAUM study indicated that the capital cost of a DPF system installed on stationary diesel generators ranged from about $45,000 to $120,000, and the capital cost of an oxidation catalyst system installed on a generator application was about $25,000. The NESCAUM study estimated that the cost-effectiveness of DPF and oxidation catalyst installations ranged from $2,000 to $90,000, and from $1,000 to $23,000 per combined ton of PM, VOC, and CO emissions for diesel generators with 500 hours and 2,000 hours of operations, respectively.

The CEC report indicated that there were two suppliers offering DPFs that could provide substantial (85% to 90%) PM reductions; both suppliers have verified their DPFs with CARB at 85% PM reduction for on-road applications with the use of ultra low sulfur fuel. The costs for the DPF systems as reported in the CEC report were about $60,000, with a cost-effectiveness value range from $180,000 to $260,000 per ton of PM reduction. The CEC report indicated that the cost of an oxidation catalyst system for a one MW diesel generator ranged from $16,000 to $45,000 with a cost-effectiveness value range from $150,000 to $500,000 per ton of PM reduction (VOC emission reductions were not investigated in the CEC study).

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

4. SUMMARY AND RECOMMENDATIONS

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

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

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

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

Also, PSR based their estimate for the diesel generator population and activity data in the HGA on 2003. During the last six years, the demand and utilization of electric power in the HGA has changed due to the deregulation of the electric power production industry and recent turmoil in energy markets. More and more major electricity consumers (industries) are relying on other power sources, including stationary diesel generators, instead of the traditional central power plants, to meet their power demand, to avoid downtime resulting from central power plant down time, and to save energy costs. These power utilization changes and the increases in the power demand could contribute to the increases in the use of diesel generators, and thus, increases in the NOx emission inventory from this source as well.

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

RECOMMENDATIONS

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

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

5. REFERENCES

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NESCAUM. 2003. “Stationary Diesel Engines in the Northeast: An Initial Assessment of the Regional Population, Control Technology Options and Air Quality Policy Issues”. June.

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Appendix A

Small-scale generators in the Houston Metropolitan Area as obtained from records available at the TCEQ (TexPIRG, 2002)

Company	City	Capacity (kw)
3 Tec Energy	Huffman	Na
Acacia Natural Gas	Brookshire	Na
Acacia Natural Gas	Magnolia	596
Acacia Natural Gas	Magnolia	895
Acacia Natural Gas	Magnolia	895
Acacia Natural Gas	Magnolia	91
Acacia Natural Gas	Magnolia	545
Acacia Natural Gas	Magnolia	546
Acacia Natural Gas	Magnolia	546
Acacia Natural Gas	Magnolia	582
Amercian Nat'l Power	Houston	na
Amercian Nat'l Power	Houston	na
American Exploration Co	Labelle	198
Amoco Gas Co	Texas City	na
Anadarko Petroleum	Beaumont	na
Apache Corp	High Island	na
Apache Corp	Houston	596
Aubrey S. Labuff & Assoc Constr	Houston	na
Ausimont USA	Orange	na
Ausimont USA	Orange	na
Bledsoe Petro Corp	Dallas	298
Cherry Crushed Concrete	Houston	na
Chocolate Bayou Water Co	Alvin	na
Chocolate Bayou Water Co	Alvin	na
Chocolate Bayou Water Co	Alvin	na
Coastal Markets	Missouri City	na
Compressor Systems	Votaw	246
Cross Timbers Operating	Friendswood	na
Dow Chemical	Freeport	na
Dow Chemical	Freeport	na
Duke Energy Field Services	Beaumont	na
Duke Energy Field Services	Beaumont	na
Duke Energy Field Services	Nederland	na
Duke Energy Field Services	Nederland	na
Duke Energy Field Services	Nederland	na
Duke Energy Field Services	Nederland	na
Dynegy Mid Stream Services	Mont Belvieu	160
Dynegy Mid Stream Services	Mont Belvieu	160
Eastex Gas Storage & Exchange Spring		91
El Du Pont de Nemours La Porte		112
Engineered Asphalt Products	Houston	na
Enron Oil & Gas	Houston	763
Enterprise Products Operating	Mont Belvieu	na
Equilon Pipeline Co	Mont Belvieu	na
Exxon Chemical Co	Baytown	na
Exxon Chemical Co	Baytown	na
Exxon Chemical Co	Baytown	na

Company	City	Capacity (kw)
Exxon Chemical Co	Baytown	na
Exxon Chemical Co	Baytown	na
Exxon Chemical Co	Baytown	na
Exxon Chemical Co	Baytown	na
Exxon Chemical Co	Baytown	na
Exxon Co	Katy	2,461
Exxon Mobil	Pasadena	na
Exxon Mobil	Pasadena	809
Exxon Mobil	Pasadena	809
Friede-Goldman Offshore	Orange	na
Friede-Goldman Offshore	Orange	na
Friede-Goldman Offshore	Sabine Pass	na
GB Biosciences	Houston	na
GB Biosciences	Houston	na
GB Biosciences	Houston	na
GB Biosciences	Houston	na
GB Biosciences	Houston	470
GB Biosciences	Houston	470
GB Biosciences	Houston	470
GB Biosciences	Houston	470
General Electric Packaged Pwr	Houston	557
General Electric Packaged Pwr	Houston	557
General Electric Packaged Pwr	Houston	1,507
General Electric Packaged Pwr	Houston	1,507
Goldking Production Co	Baytown	45
Goldking Production Co	Baytown	47
Goldking Production Co	Baytown	334
Hampshire Chemical	Deer Park	na
Hanover Company	Pearland	na
Hardy Oil & Gas USA	Beaumont	na
Hilcorp Energy	Beaumont	na
Hilcorp Energy	Beaumont	492
Hilcorp Energy	Houston	298
Hilcorp Energy	Sweeney	na
Hilcorp Energy	Sweeney	944
Hilcorp Energy	Sweeney	298
Hilcorp Energy	Sweeney	298
Hilcorp Energy	Sweeney	298
Hilcorp Energy	Sweeney	944
Hilcorp Energy	Sweeny	944
Hilcorp Energy	Sweeny	944
Hilcorp Energy	Sweeny	944
Hilcorp Energy	Sweeny	944
Hilcorp Energy	Sweeny	944
Hilcorp Energy	Sweeny	944
Hilcorp Energy	Sweeny	52
Hilcorp Energy	Sweeny	52
Hilcorp Energy	Sweeny	522
Hilcorp Energy	Sweeny	522
Hilcorp Energy	Sweeny	74
Hilcorp Energy	Sweeny	74
Hilcorp Energy	Sweeny	74
Hilcorp Energy	Sweeny	74

Company	City	Capacity (kw)
Hilcorp Energy	Sweeny	74
Hilcorp Energy	Sweeny	74
Hilcorp Energy	Sweeny	74
Hilcorp Energy	Sweeny	74
Hilcorp Energy	Sweeny	91
Hilcorp Energy	Sweeny	91
Hiicorp Energy	Sweeny	522
Hilcorp Energy	Sweeny	596
Hilcorp Energy	Sweeny	522
Hilcorp Energy	Sweeny	596
Houston Pipe Line Hydrocarbons	Silsbee	na
Houston Pipe Line Hydrocarbons	Silsbee	na
Hunt Oil Co	Sour Lake	na
Huntsman Chemical	Pasadena	na
Hydrocarbon Training & Dev	Houston	30
ISK Biosciences	Houston	na
ISK Biosciences	Houston	na
ISK Biosciences	Houston	na
KCS Resources	Cypress	na
Lone Star Pipeline Co	Katy	na
Mariner Energy	Beaumont	74
Mariner Energy	Beaumont	74
Market Hub Partners	Liberty	na
Market Hub Partners	Liberty	na
M-I Drilling Fluids	Galveston	172
M-I Drilling Fluids	Galveston	172
M-I Drilling Fluids	Galveston	172
M-I Drilling Fluids	Galveston	172
Mitchell Energy	Galveston	198
Moss Bluff Gas Storage Systems	Liberty	110
Motiva Enterprises	Port Arthur	na
National Oil Well	Galena Park	na
National Oil Well	Houston	na
National Oil Well	Houston	na
New Park Shipbuilding & Repair	Houston	na
Nicolas K. Barco Co	Port Arthur	492
Nicolas K. Barco Co	Port Arthur	492
North Central Oil	Manvel	74
Oasis Pipeline Co	Katy	466
Oasis Pipeline Co	Katy	310
Oasis Pipeline Co	Katy	310
Occidental Chemical	La Porte	na
Ocean Energy	Clear Lake	168
Ocean Energy	Seabrook	na
On Fiber Houston	Houston	205
Oryx Energy	Stowell	492
Oryx Energy	Stowell	596
Pennzoil Petroleum	Hankamer	654
Petro Hunt Corp	Winnie	na
Petrolite Corp	Pasadena	na
PG&E Gas Transmission	Katy	na
PG&E Gas Transmission	Katy	na
Phillips Petroleum	Wallis	307
Phillips Pipe Line	Pasadena	na

Company	**City**	**Capacity (kw)**
Phillips Pipe Line	Pasadena	na
Pioneer South Central	Brookshire	400
Pioneer South Central	Brookshire	400
Pioneer South Central	Brookshire	400
Quantum Chemical	La Porte	186
Quintana Petroleum	Rosenberg	na
Reliant Energy Field Services	Houston	242
Rohm & Haas Texas	Deer Park	na
Rohm & Haas Texas	Deer Park	na
Rollings Environmental Services		932
Rollings Environmental Services		932
Rollings Environmental Services		932
Rollings Environmental Services		932
S&S Energy Products	Channelview	na
Sabine Pipe Line Co	Port Neches	na
Safety Kleen Deer Park	Deer Park	932
Safety Kleen Deer Park	Deer Park	932
Safety Kleen Deer Park	Deer Park	932
Safety Kleen Deer Park	Deer Park	932
Safety Kleen Deer Park	Deer Park	932
Safety Kleen Deer Park	Deer Park	932
Safety Kleen Deer Park	Deer Park	932
Santa Fe Energy Resources	Deckers Prairie	67
Seagull Energy E&P	Seabrook	168
Shell Oil	Deer Park	354
Smith International	Houston	na
Smith International	Houston	na
Smith International	Houston	na
Smith International	Houston	na
Smith International	Houston	na
Smith International	Houston	447
Smith Production	Kountze	298
Smith Production	Kountze	246
Smith Production	Raywood	22
Smith Production	Raywood	332
Smith Production	Raywood	447
Smith Production	Raywood	447
Sonat Texas Gathering Co	Sabine Pass	na
Southwestern Gas Pipeline	Magnolia	91
Teco	Houston	na
Teco	Houston	na
Tejas Gas Pipeline Co	Port Neches	91
Tejas Gas Pipeline Co	Port Neches	91
Texaco Exploration & Production	Humble	74
Texaco Exploration & Production	Humble	na
Texaco Exploration & Production	Humble	na
Texaco Exploration & Production	Jersey Village	596
Texaco Exploration & Production	Jersey Village	522
Texaco Exploration & Production	Jersey Village	na
Texaco Exploration & Production	Jersey Village	na
Texaco Exploration & Production	Port Neches	205
Texas Instruments	Stafford	na
Texas Instruments	Stafford	na

Company	City	Capacity (kw)
Texas Instruments	Stafford	na
Texas Instruments	Stafford	na
Texas Meridian Resources Exploration	Liverpool	60
Thermal Energy Cooperative	Houston	1,678
Thermal Energy Cooperative	Houston	1,678
Thermal Energy Cooperative	Houston	1,678
Torch Operating Co	Dayton	168
Torch Operating Co	Dayton	246
Tri-Union Development	Alvin	na
Tri-Union Development	Alvin	124
Tri-Union Development	Alvin	124
Trunkline Gas Co	Houston	242
TU Electric	Dallas	157
United States Gypsum	Galena Park	na
United States Gypsum	Galena Park	na
US Department of Energy	Winnie	na
US Department of Energy	Winnie	na
US Department of Energy	Winnie	60
US Department of Energy	Winnie	60
US Department of Energy	Winnie	671
US Department of Energy	Winnie	671
Vastar Resources	High Island	na
Vastar Resources	Vidor	291
Vintage Petroleum	Baytown	86
Vintage Petroleum	Pasadena	38
Vintage Petroleum	Pasadena	51
Wagner Oil	Orange	384
Wagner Oil	Orange	139
Weeks Exploration Co	High Island	545
Winnie Pipeline Co	Magnolia	895

Appendix B

Detailed Population and Capacity Data for Diesel Generators in the HGA

Total for Houston/Galveston Area											
Number Estimates	Emergency	Peak	Baseload	Other	**Total**	Capacity Totals (KW)	Emergency	Peak	Baseload	Other	**Total**
0-25 kW	3127	0	332	263	**3722**	0-25 kW	63736	0	7010	5534	**76280**
25-50 kW	4110	0	492	376	**4978**	25-50 kW	144867	0	16853	12979	**174699**
50-100 kW	3424	0	326	199	**3949**	50-100 kW	242435	0	23227	13800	**279463**
100-250 kW	5892	219	598	947	**7656**	100-250 kW	874763	38965	88719	154898	**1157345**
250-500 kW	2976	593	148	328	**4045**	250-500 kW	977665	204969	41255	96551	**1320440**
500-750 kW	1193	420	42	74	**1729**	500-750 kW	744322	268008	27037	45675	**1085042**
750-1000 kW	1006	591	73	21	**1691**	750-1000 kW	941714	556675	70659	20219	**1589267**
1000-1500 kW	1306	928	52	59	**2345**	1000-1500 kW	1697771	1220333	60567	82569	**3061240**
1500+ kW	653	417	12	10	**1092**	1500+ kW	1263540	783526	24000	17300	**2088366**
Total	**23687**	**3168**	**2075**	**2277**	**31207**	**Total**	**6950813**	**3072476**	**359327**	**449525**	**10832142**

County	**Brazoria**										
Number Estimates	Emergency	Peak	Baseload	Other	**Total**	Capacity Totals (KW)	Emergency	Peak	Baseload	Other	**Total**
0-25 kW	482	0	55	37	**574**	0-25 kW	9861	0	1151	816	**11827**
25-50 kW	639	0	73	54	**766**	25-50 kW	22561	0	2486	1827	**26874**
50-100 kW	525	0	48	33	**606**	50-100 kW	37252	0	3535	2335	**43122**
100-250 kW	940	28	100	159	**1227**	100-250 kW	138011	4919	15018	26010	**183958**
250-500 kW	458	117	18	41	**634**	250-500 kW	150795	40406	4700	11265	**207166**
500-750 kW	187	72	3	16	**278**	500-750 kW	116765	45836	2142	9950	**174693**
750-1000 kW	156	99	15	2	**272**	750-1000 kW	145788	93377	14641	1959	**255764**
1000-1500 kW	208	154	6	6	**374**	1000-1500 kW	270882	202168	6859	8850	**488759**
1500+ kW	101	76	1	1	**179**	1500+ kW	193566	144520	2000	2000	**342086**
Total	**3696**	**546**	**319**	**349**	**4910**	**Total**	**1085481**	**531226**	**52532**	**65011**	**1734250**

County	**Chambers**										
Number Estimates	Emergency	Peak	Baseload	Other	**Total**	Capacity Totals (KW)	Emergency	Peak	Baseload	Other	**Total**
0-25 kW	285	0	23	16	**324**	0-25 kW	5846	0	487	350	**6682**
25-50 kW	391	0	43	36	**470**	25-50 kW	13847	0	1441	1207	**16495**
50-100 kW	331	0	20	8	**359**	50-100 kW	23452	0	1388	548	**25388**
100-250 kW	551	16	38	74	**679**	100-250 kW	81851	2749	5420	12180	**102200**
250-500 kW	279	56	5	29	**369**	250-500 kW	90654	19512	1350	8465	**119981**
500-750 kW	109	49	1	3	**162**	500-750 kW	68029	31101	700	1815	**101645**
750-1000 kW	95	65	5	0	**165**	750-1000 kW	89122	61246	4857	0	**155225**
1000-1500 kW	118	95	4	4	**221**	1000-1500 kW	153108	125681	4692	5925	**289406**
1500+ kW	59	39	1	0	**99**	1500+ kW	111196	73850	2000	0	**187046**
Total	**2218**	**320**	**140**	**170**	**2848**	**Total**	**637105**	**314139**	**22335**	**30489**	**1004068**

County	**Fort Bend**										
Number Estimates	Emergency	Peak	Baseload	Other	**Total**	Capacity Totals (KW)	Emergency	Peak	Baseload	Other	**Total**
0-25 kW	338	0	31	25	**394**	0-25 kW	6923	0	676	551	**8149**
25-50 kW	462	0	52	37	**551**	25-50 kW	16344	0	1764	1254	**19362**
50-100 kW	386	0	39	17	**442**	50-100 kW	27455	0	2892	1152	**31499**
100-250 kW	643	17	53	105	**818**	100-250 kW	95736	3017	7459	16711	**122923**
250-500 kW	333	60	13	19	**425**	250-500 kW	108938	20750	3450	4950	**138088**
500-750 kW	128	51	0	0	**179**	500-750 kW	79976	32511	0	0	**112487**
750-1000 kW	111	68	6	1	**186**	750-1000 kW	104473	64044	5955	999	**175471**
1000-1500 kW	137	104	5	4	**250**	1000-1500 kW	178149	136820	5784	5850	**326603**
1500+ kW	72	46	1	0	**119**	1500+ kW	138546	83400	2000	0	**223946**
Total	**2610**	**346**	**200**	**208**	**3364**	**Total**	**756539**	**340542**	**29980**	**31467**	**1158528**

County	**Galveston**										
Number Estimates	Emergency	Peak	Baseload	Other	**Total**	Capacity Totals (KW)	Emergency	Peak	Baseload	Other	**Total**
0-25 kW	292	0	26	19	**337**	0-25 kW	5954	0	571	416	**6940**
25-50 kW	396	0	44	34	**474**	25-50 kW	14023	0	1490	1154	**16667**
50-100 kW	335	0	23	13	**371**	50-100 kW	23686	0	1604	888	**26178**
100-250 kW	563	13	46	83	**705**	100-250 kW	83500	2244	6554	13193	**105491**
250-500 kW	285	39	8	18	**350**	250-500 kW	92854	13335	2150	4700	**113039**
500-750 kW	111	43	0	0	**154**	500-750 kW	69207	27502	0	0	**96709**
750-1000 kW	97	57	3	0	**157**	750-1000 kW	91081	54016	2997	0	**148094**
1000-1500 kW	119	87	4	3	**213**	1000-1500 kW	154179	113699	4713	4425	**277016**
1500+ kW	60	40	1	0	**101**	1500+ kW	113196	73800	2000	0	**188996**
Total	**2258**	**279**	**155**	**170**	**2862**	**Total**	**647680**	**284596**	**22078**	**24775**	**979129**

County	**Harris**										
Number Estimates	Emergency	Peak	Baseload	Other	**Total**	Capacity Totals (KW)	Emergency	Peak	Baseload	Other	**Total**
0-25 kW	1234	0	157	139	**1530**	0-25 kW	25038	0	3233	2803	**31074**
25-50 kW	1599	0	209	160	**1968**	25-50 kW	56180	0	7251	5657	**69088**
50-100 kW	1335	0	164	110	**1609**	50-100 kW	94144	0	11648	7693	**113486**
100-250 kW	2335	130	305	427	**3197**	100-250 kW	348724	23372	46714	71142	**489952**
250-500 kW	1224	270	94	203	**1791**	250-500 kW	406845	93851	26955	62471	**590122**
500-750 kW	478	156	38	55	**727**	500-750 kW	297908	99485	24195	33910	**455498**
750-1000 kW	399	218	40	18	**675**	750-1000 kW	371285	203603	38213	17261	**630362**
1000-1500 kW	542	360	29	38	**969**	1000-1500 kW	705193	473675	33806	51594	**1264268**
1500+ kW	277	164	7	9	**457**	1500+ kW	547590	311906	14000	15300	**888796**
Total	**9423**	**1298**	**1043**	**1159**	**12923**	**Total**	**2852908**	**1205892**	**206015**	**267832**	**4532646**

County	**Liberty**										
Number Estimates	Emergency	Peak	Baseload	Other	**Total**	Capacity Totals (KW)	Emergency	Peak	Baseload	Other	**Total**
0-25 kW	66	0	6	2	**74**	0-25 kW	1393	0	138	46	**1577**
25-50 kW	72	0	10	7	**89**	25-50 kW	2446	0	349	244	**3038**
50-100 kW	60	0	3	0	**63**	50-100 kW	4394	0	184	0	**4578**
100-250 kW	93	0	1	1	**95**	100-250 kW	13146	0	100	100	**13346**
250-500 kW	27	4	0	0	**31**	250-500 kW	7630	1200	0	0	**8830**
500-750 kW	24	0	0	0	**24**	500-750 kW	15356	0	0	0	**15356**
750-1000 kW	20	7	0	0	**27**	750-1000 kW	19121	6915	0	0	**26036**
1000-1500 kW	19	13	0	0	**32**	1000-1500 kW	25009	17409	0	0	**42418**
1500+ kW	5	1	0	0	**6**	1500+ kW	10000	2000	0	0	**12000**
Total	**386**	**25**	**20**	**10**	**441**	**Total**	**98495**	**27524**	**771**	**390**	**127179**

County	**Montgomery**										
Number Estimates	Emergency	Peak	Baseload	Other	**Total**	Capacity Totals (KW)	Emergency	Peak	Baseload	Other	**Total**
0-25 kW	300	0	27	19	**346**	0-25 kW	6097	0	595	416	**7107**
25-50 kW	406	0	46	35	**487**	25-50 kW	14382	0	1557	1187	**17126**
50-100 kW	354	0	23	14	**391**	50-100 kW	25144	0	1604	944	**27692**
100-250 kW	572	15	46	87	**720**	100-250 kW	84803	2664	6554	13958	**107979**
250-500 kW	287	43	10	18	**358**	250-500 kW	93434	14715	2650	4700	**115499**
500-750 kW	116	45	0	0	**161**	500-750 kW	72240	28717	0	0	**100957**
750-1000 kW	99	59	4	0	**162**	750-1000 kW	93039	55915	3996	0	**152950**
1000-1500 kW	122	90	4	3	**219**	1000-1500 kW	158389	117912	4713	4425	**285439**
1500+ kW	61	40	1	0	**102**	1500+ kW	115196	73800	2000	0	**190996**
Total	**2317**	**292**	**161**	**176**	**2946**	**Total**	**662724**	**293723**	**23669**	**25630**	**1005745**

County	**Waller**										
Number Estimates	Emergency	Peak	Baseload		**Total**	Capacity Totals (KW)	Emergency	Peak	Baseload	Other	**Total**
0-25 kW	130	0	7	6	**143**	0-25 kW	2625	0	160	138	**2923**
25-50 kW	145	0	15	13	**173**	25-50 kW	5084	0	516	449	**6049**
50-100 kW	98	0	6	4	**108**	50-100 kW	6909	0	372	240	**7521**
100-250 kW	195	0	9	11	**215**	100-250 kW	28992	0	900	1604	**31496**
250-500 kW	83	4	0	0	**87**	250-500 kW	26515	1200	0	0	**27715**
500-750 kW	40	4	0	0	**44**	500-750 kW	24841	2856	0	0	**27697**
750-1000 kW	29	18	0	0	**47**	750-1000 kW	27805	17560	0	0	**45365**
1000-1500 kW	41	25	0	1	**67**	1000-1500 kW	52862	32969	0	1500	**87331**
1500+ kW	18	11	0	0	**29**	1500+ kW	34250	20250	0	0	**54500**
Total	**779**	**62**	**37**	**35**	**913**	**Total**	**209884**	**74835**	**1948**	**3931**	**290598**

Appendix C

Detailed Emission Inventories for Diesel Generators in the HGA

Total for HGA	**PM10**					**NOx**					**VOC**			
Emissions (tons/yr)	Emergency	Peak	Baseload	Other	**Total**	Emergency	Peak	Baseload	Other	**Total**	Emergency	Peak	Baseload	Other
0-25 kW	3.5	0.0	22.0	0.8	**26.3**	49.0	0.0	310.3	11.0	**370.3**	4.0	0.0	25.1	0.9
25-50 kW	7.9	0.0	53.0	1.8	**62.7**	111.3	0.0	746.0	25.9	**883.2**	9.0	0.0	60.3	2.1
50-100 kW	13.2	0.0	73.0	2.0	**88.2**	186.3	0.0	1028.1	27.5	**1242.0**	15.1	0.0	83.2	2.2
100-250 kW	66.3	17.9	368.1	40.9	**493.2**	933.7	251.5	5183.7	575.9	**6944.9**	75.5	20.3	419.3	46.6
250-500 kW	118.2	102.4	194.7	34.1	**449.3**	1663.8	1442.3	2741.3	479.9	**6327.3**	134.6	116.7	221.7	38.8
500-750 kW	33.0	45.2	42.2	6.3	**126.7**	1124.0	1542.1	1437.7	215.1	**4319.0**	103.5	142.0	132.4	19.8
750-1000 kW	52.4	104.6	111.3	3.6	**271.9**	1786.2	3563.6	3794.5	124.4	**9268.7**	164.5	328.1	349.4	11.5
1000-1500 kW	103.3	343.2	99.1	14.9	**560.6**	3522.3	11698.4	3378.0	507.9	**19106.6**	324.3	1077.1	311.0	46.8
1500+ kW	79.1	239.8	42.7	3.1	**364.8**	2696.2	8173.9	1456.7	106.4	**12433.3**	248.2	752.6	134.1	9.8
Total	**476.9**	**853.1**	**1006.2**	**107.5**	**2443.7**	**12072.9**	**26671.9**	**20076.4**	**2074.1**	**60895.3**	**1078.6**	**2436.8**	**1736.5**	**178.4**

County	**Brazoria**	**PM10**	tons/yr			**Brazoria**	**NOx**	tons/yr			**Brazoria**	**VOC**	tons/yr	
Emissions (tons/yr)	Emergency	Peak	Baseload	Other	**Total**	Emergency	Peak	Baseload	Other	**Total**	Emergency	Peak	Baseload	Other
0-25 kW	0.5	0.0	3.6	0.1	**4.3**	7.6	0.0	50.9	1.6	**60.1**	0.6	0.0	4.1	0.1
25-50 kW	1.2	0.0	7.8	0.3	**9.3**	17.3	0.0	110.0	3.6	**131.0**	1.4	0.0	8.9	0.3
50-100 kW	2.0	0.0	11.1	0.3	**13.5**	28.6	0.0	156.5	4.7	**189.8**	2.3	0.0	12.7	0.4
100-250 kW	10.4	2.3	63.7	6.8	**83.2**	146.4	31.8	896.5	96.3	**1170.9**	11.8	2.6	72.5	7.8
250-500 kW	18.2	20.2	22.0	3.7	**64.2**	256.8	284.3	310.3	52.3	**903.8**	20.8	23.0	25.1	4.2
500-750 kW	5.2	7.7	3.4	1.3	**17.6**	176.5	263.4	115.0	45.9	**600.8**	16.3	24.3	10.6	4.2
750-1000 kW	8.1	17.5	23.1	0.4	**49.1**	276.5	597.8	786.3	12.1	**1672.6**	25.5	55.0	72.4	1.1
1000-1500 kW	16.5	56.9	11.1	1.6	**86.1**	562.7	1937.8	378.8	54.4	**2933.7**	51.8	178.4	34.9	5.0
1500+ kW	12.1	44.2	3.6	0.4	**60.3**	413.0	1507.7	121.4	12.3	**2054.4**	38.0	138.8	11.2	1.1
Total	**74.4**	**148.8**	**149.4**	**14.9**	**387.4**	**1885.4**	**4622.6**	**2925.8**	**283.3**	**9717.2**	**168.5**	**422.1**	**252.3**	**24.3**

County	**Chambers**	**PM10**	tons/yr			**Chambers**	**NOx**	tons/yr			**Chambers**	**VOC**	tons/yr	
Emissions (tons/yr)	Emergency	Peak	Baseload	Other	**Total**	Emergency	Peak	Baseload	Other	**Total**	Emergency	Peak	Baseload	Other
0-25 kW	0.3	0.0	1.5	0.0	**1.9**	4.5	0.0	21.6	0.7	**26.7**	0.4	0.0	1.7	0.1
25-50 kW	0.8	0.0	4.5	0.2	**5.5**	10.6	0.0	63.8	2.4	**76.8**	0.9	0.0	5.2	0.2
50-100 kW	1.3	0.0	4.4	0.1	**5.7**	18.0	0.0	61.4	1.1	**80.6**	1.5	0.0	5.0	0.1
100-250 kW	6.2	1.3	22.0	3.3	**32.8**	87.3	17.7	310.4	46.6	**461.9**	7.1	1.4	25.1	3.8
250-500 kW	10.9	9.8	6.4	3.0	**30.0**	153.3	137.6	90.0	42.0	**423.0**	12.4	11.1	7.3	3.4
500-750 kW	3.0	5.2	1.1	0.2	**9.6**	102.5	177.6	37.6	8.4	**326.1**	9.4	16.4	3.5	0.8
750-1000 kW	5.0	11.5	7.7	0.0	**24.1**	169.0	392.1	260.8	0.0	**821.9**	15.6	36.1	24.0	0.0
1000-1500 kW	9.3	35.7	7.7	1.1	**53.8**	317.1	1217.0	262.5	36.4	**1833.0**	29.2	112.0	24.2	3.4
1500+ kW	7.0	22.6	3.6	0.0	**33.1**	237.3	770.4	121.4	0.0	**1129.1**	21.8	70.9	11.2	0.0
Total	**43.7**	**86.1**	**58.9**	**7.9**	**196.5**	**1099.7**	**2712.5**	**1229.4**	**137.6**	**5179.2**	**98.2**	**248.0**	**107.1**	**11.6**

County	**Fort Bend**	**PM10**	tons/yr			**Fort Bend**	**NOx**	tons/yr			**Fort Bend**	**VOC**	tons/yr	
Emissions (tons/yr)	Emergency	Peak	Baseload	Other	**Total**	Emergency	Peak	Baseload	Other	**Total**	Emergency	Peak	Baseload	Other
0-25 kW	0.4	0.0	2.1	0.1	**2.6**	5.3	0.0	29.9	1.1	**36.3**	0.4	0.0	2.4	0.1
25-50 kW	0.9	0.0	5.5	0.2	**6.6**	12.6	0.0	78.1	2.5	**93.2**	1.0	0.0	6.3	0.2
50-100 kW	1.5	0.0	9.1	0.2	**10.8**	21.1	0.0	128.0	2.3	**151.4**	1.7	0.0	10.4	0.2
100-250 kW	7.3	1.4	29.8	4.4	**42.8**	102.3	19.5	419.2	61.6	**602.6**	8.3	1.6	33.9	5.0
250-500 kW	13.1	10.4	16.3	1.6	**41.3**	184.4	146.4	228.9	22.1	**581.8**	14.9	11.8	18.5	1.8
500-750 kW	3.5	5.5	0.0	0.0	**9.0**	120.5	187.4	0.0	0.0	**307.9**	11.1	17.3	0.0	0.0
750-1000 kW	5.8	12.0	9.4	0.2	**27.4**	198.2	410.0	319.8	6.1	**934.1**	18.2	37.7	29.4	0.6
1000-1500 kW	10.8	38.4	9.4	1.1	**59.7**	369.6	1307.4	321.1	36.0	**2034.0**	34.0	120.4	29.6	3.3
1500+ kW	8.7	25.5	3.6	0.0	**37.8**	295.6	870.0	121.4	0.0	**1287.1**	27.2	80.1	11.2	0.0
Total	**52.0**	**93.2**	**85.2**	**7.6**	**237.9**	**1309.6**	**2940.6**	**1646.4**	**131.8**	**6028.4**	**116.9**	**268.9**	**141.7**	**11.1**

County	**Galveston**	**PM10**	tons/yr			**Galveston**	**NOx**	tons/yr			**Galveston**	**VOC**	tons/yr	
Emissions (tons/yr)	Emergency	Peak	Baseload	Other	**Total**	Emergency	Peak	Baseload	Other	**Total**	Emergency	Peak	Baseload	Other
0-25 kW	0.3	0.0	1.8	0.1	**2.2**	4.6	0.0	25.3	0.8	**30.7**	0.4	0.0	2.0	0.1
25-50 kW	0.8	0.0	4.7	0.2	**5.6**	10.8	0.0	65.9	2.3	**79.0**	0.9	0.0	5.3	0.2
50-100 kW	1.3	0.0	5.0	0.1	**6.5**	18.2	0.0	71.0	1.8	**91.0**	1.5	0.0	5.7	0.1
100-250 kW	6.3	1.0	26.4	3.5	**37.3**	88.8	14.5	372.2	49.3	**524.8**	7.2	1.2	30.1	4.0
250-500 kW	11.2	6.7	10.2	1.5	**29.5**	157.2	94.3	143.2	21.1	**415.8**	12.7	7.6	11.6	1.7
500-750 kW	3.1	4.7	0.0	0.0	**7.7**	104.2	158.7	0.0	0.0	**262.9**	9.6	14.6	0.0	0.0
750-1000 kW	5.1	10.1	4.7	0.0	**19.9**	172.8	345.8	160.9	0.0	**679.5**	15.9	31.8	14.8	0.0
1000-1500 kW	9.4	31.8	7.7	0.8	**49.7**	319.2	1083.3	263.6	27.2	**1693.3**	29.4	99.7	24.3	2.5
1500+ kW	7.1	22.6	3.6	0.0	**33.2**	241.5	769.9	121.4	0.0	**1132.8**	22.2	70.9	11.2	0.0
Total	**44.4**	**76.9**	**64.1**	**6.1**	**191.6**	**1117.2**	**2466.5**	**1223.5**	**102.5**	**4909.8**	**99.7**	**225.9**	**105.1**	**8.6**

County	**Harris**	**PM10**	tons/yr			**Harris**	**NOx**	tons/yr			**Harris**	**VOC**	tons/yr	
Emissions (tons/yr)	Emergency	Peak	Baseload	Other	**Total**	Emergency	Peak	Baseload	Other	**Total**	Emergency	Peak	Baseload	Other
0-25 kW	1.4	0.0	10.2	0.4	**11.9**	19.2	0.0	143.1	5.6	**167.9**	1.6	0.0	11.6	0.5
25-50 kW	3.1	0.0	22.8	0.8	**26.7**	43.2	0.0	321.0	11.3	**375.4**	3.5	0.0	26.0	0.9
50-100 kW	5.1	0.0	36.6	1.1	**42.8**	72.3	0.0	515.6	15.3	**603.3**	5.9	0.0	41.7	1.2
100-250 kW	26.5	10.7	196.6	18.7	**252.6**	373.3	150.9	2768.9	263.6	**3556.7**	30.2	12.2	224.0	21.3
250-500 kW	49.5	46.8	127.3	22.8	**246.4**	696.9	658.7	1793.1	321.1	**3469.9**	56.4	53.3	145.0	26.0
500-750 kW	13.2	16.8	37.7	4.7	**72.4**	451.4	571.4	1285.1	160.8	**2468.7**	41.6	52.6	118.3	14.8
750-1000 kW	20.7	38.2	60.2	3.1	**122.2**	704.2	1303.4	2052.1	106.2	**4165.9**	64.8	120.0	188.9	9.8
1000-1500 kW	43.0	133.7	55.4	9.3	**241.4**	1465.0	4555.9	1888.4	317.4	**8226.7**	134.9	419.5	173.9	29.2
1500+ kW	34.3	95.5	24.9	2.8	**157.4**	1168.5	3253.9	849.8	94.1	**5366.2**	107.6	299.6	78.2	8.7
Total	**196.7**	**341.6**	**571.8**	**63.7**	**1173.9**	**4994.0**	**10494.1**	**11617.1**	**1295.4**	**28400.7**	**446.3**	**957.2**	**1007.6**	**112.4**

County	**Liberty**	**PM10**	tons/yr			**Liberty**	**NOx**	tons/yr			**Liberty**	**VOC**	tons/yr	
Emissions (tons/yr)	Emergency	Peak	Baseload	Other	**Total**	Emergency	Peak	Baseload	Other	**Total**	Emergency	Peak	Baseload	Other
0-25 kW	0.1	0.0	0.4	0.0	**0.5**	1.1	0.0	6.1	0.1	**7.3**	0.1	0.0	0.5	0.0
25-50 kW	0.1	0.0	1.1	0.0	**1.3**	1.9	0.0	15.4	0.5	**17.8**	0.2	0.0	1.2	0.0
50-100 kW	0.2	0.0	0.6	0.0	**0.8**	3.4	0.0	8.1	0.0	**11.5**	0.3	0.0	0.7	0.0
100-250 kW	1.0	0.0	0.3	0.0	**1.3**	13.9	0.0	4.4	0.2	**18.5**	1.1	0.0	0.4	0.0
250-500 kW	0.9	0.6	0.0	0.0	**1.5**	12.2	8.5	0.0	0.0	**20.7**	1.0	0.7	0.0	0.0
500-750 kW	0.7	0.0	0.0	0.0	**0.7**	23.5	0.0	0.0	0.0	**23.5**	2.2	0.0	0.0	0.0
750-1000 kW	1.1	1.3	0.0	0.0	**2.4**	36.3	44.3	0.0	0.0	**80.5**	3.3	4.1	0.0	0.0
1000-1500 kW	1.5	4.8	0.0	0.0	**6.3**	51.6	164.3	0.0	0.0	**215.9**	4.8	15.1	0.0	0.0
1500+ kW	0.6	0.6	0.0	0.0	**1.2**	21.3	20.9	0.0	0.0	**42.2**	2.0	1.9	0.0	0.0
Total	**6.2**	**7.3**	**2.4**	**0.1**	**16.0**	**165.2**	**238.0**	**34.1**	**0.8**	**438.0**	**14.8**	**21.8**	**2.8**	**0.1**

County	**Montgomery**	**PM10**	tons/yr			**Montgomer**	**NOx**	tons/yr			**Montgomer**	**VOC**	tons/yr	
Emissions (tons/yr)	Emergency	Peak	Baseload	Other	**Total**	Emergency	Peak	Baseload	Other	**Total**	Emergency	Peak	Baseload	Other
0-25 kW	0.3	0.0	1.9	0.1	**2.3**	4.7	0.0	26.4	0.8	**31.9**	0.4	0.0	2.1	0.1
25-50 kW	0.8	0.0	4.9	0.2	**5.8**	11.1	0.0	68.9	2.4	**82.3**	0.9	0.0	5.6	0.2
50-100 kW	1.4	0.0	5.0	0.1	**6.5**	19.3	0.0	71.0	1.9	**92.2**	1.6	0.0	5.7	0.2
100-250 kW	6.4	1.2	26.4	3.7	**37.8**	90.2	17.2	372.2	52.3	**532.0**	7.3	1.4	30.1	4.2
250-500 kW	11.2	7.4	12.5	1.5	**32.6**	158.1	104.0	175.7	21.1	**459.0**	12.8	8.4	14.2	1.7
500-750 kW	3.2	4.9	0.0	0.0	**8.0**	108.5	165.3	0.0	0.0	**273.8**	10.0	15.2	0.0	0.0
750-1000 kW	5.2	10.5	6.3	0.0	**22.0**	176.5	357.9	214.6	0.0	**749.0**	16.2	33.0	19.8	0.0
1000-1500 kW	9.6	33.1	7.7	0.8	**51.2**	328.2	1127.3	263.6	27.2	**1746.3**	30.2	103.8	24.3	2.5
1500+ kW	7.2	22.6	3.6	0.0	**33.4**	245.8	769.9	121.4	0.0	**1137.1**	22.6	70.9	11.2	0.0
Total	**45.3**	**79.6**	**68.3**	**6.4**	**199.6**	**1142.3**	**2541.7**	**1313.8**	**105.8**	**5103.6**	**102.0**	**232.7**	**113.0**	**8.9**

County	**Waller**	**PM10**	tons/yr			**Waller**	**NOx**	tons/yr			**Waller**	**VOC**	tons/yr	
Emissions (tons/yr)	Emergency	Peak	Baseload	Other	**Total**	Emergency	Peak	Baseload	Other	**Total**	Emergency	Peak	Baseload	Other
0-25 kW	0.1	0.0	0.5	0.0	**0.7**	2.0	0.0	7.1	0.3	**9.4**	0.2	0.0	0.6	0.0
25-50 kW	0.3	0.0	1.6	0.1	**2.0**	3.9	0.0	22.8	0.9	**27.6**	0.3	0.0	1.8	0.1
50-100 kW	0.4	0.0	1.2	0.0	**1.6**	5.3	0.0	16.5	0.5	**22.3**	0.4	0.0	1.3	0.0
100-250 kW	2.2	0.0	2.8	0.4	**5.5**	31.6	0.0	39.8	6.0	**77.4**	2.6	0.0	3.2	0.5
250-500 kW	3.2	0.6	0.0	0.0	**3.8**	44.8	8.5	0.0	0.0	**53.3**	3.6	0.7	0.0	0.0
500-750 kW	1.1	0.5	0.0	0.0	**1.6**	37.0	18.3	0.0	0.0	**55.3**	3.4	1.7	0.0	0.0
750-1000 kW	1.5	3.3	0.0	0.0	**4.8**	52.7	112.4	0.0	0.0	**165.2**	4.9	10.4	0.0	0.0
1000-1500 kW	3.2	9.0	0.0	0.3	**12.4**	109.0	305.4	0.0	9.2	**423.7**	10.0	28.1	0.0	0.8
1500+ kW	2.1	6.2	0.0	0.0	**8.3**	73.1	211.3	0.0	0.0	**284.3**	6.7	19.5	0.0	0.0
Total	**14.2**	**19.6**	**6.1**	**0.8**	**40.7**	**359.5**	**655.8**	**86.2**	**16.9**	**1118.4**	**32.1**	**60.3**	**7.0**	**1.5**