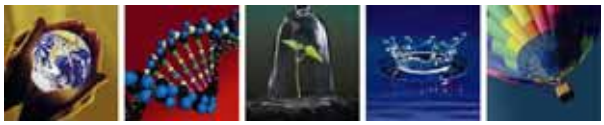

Cleaner Non-road Diesel Engine Project – Identification and Recommendation of Measures to Support the Uptake of Cleaner Non-road Diesel Engines in Australia

Final Report
Technical Appendices

Prepared for:
NSW Department of Environment, Climate Change and Water

On behalf of:
NSW Department of Environment, Climate Change and Water
and
Australian Government Department of the Environment, Water, Heritage and the Arts

Prepared by:
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List of Technical Appendices:

Appendix A: Emission Estimation Calculation Inputs for In-Service Non-road Diesel Equipment

In-Service Population, Power Ratings, Load Factors, Hours of Operation and Emission Performance Status:

Sector	Equipment Type	Diesel Equipment Numbers	Average Power Rating (Hp)	Load (%)	Annual Hours of Operation	Emission Performance Status (%)					
						Non-compliant	US Tier 1 Compliant	US Tier 2 Compliant	US Tier 3 Compliant	US Tier 4i Compliant	
Lawn and Garden Equipment	Rear engine riding mowers	1261	29	43	480	0.0	20.0	70.0	10.0	0.0	
	Lawn and Garden Tractors	41943	21	43	544	0.0	20.0	70.0	10.0	0.0	
	Wood splitters	15	58	43	265	100.0	0.0	0.0	0.0	0.0	
	Chippers/stump grinders	2739	144	43	465	100.0	0.0	0.0	0.0	0.0	
	Other equipment	29	41	43	433	100.0	0.0	0.0	0.0	0.0	
Airport	Airport support equipment	1398	184	59	732	0.0	0.0	100.0	0.0	0.0	
	Terminal tractors	4278	164	59	1257	0.0	0.0	100.0	0.0	0.0	
Recreational equipment	Specialty vehicle carts	270	53	21	435	100.0	0.0	0.0	0.0	0.0	
Light commercial equipment	Generators	15990	50	43	338	2.9	0.0	76.9	12.3	7.8	
	Pumps	3370	53	43	403	0.0	0.0	100.0	0.0	0.0	
	Air compressors	1266	83	43	815	0.0	0.0	100.0	0.0	0.0	
	Welders	8101	44	43	815	0.0	0.0	100.0	0.0	0.0	
	Pressure washers	318	53	43	145	0.0	0.0	100.0	0.0	0.0	
Industrial equipment	aerial lifts	992	49	21	384	0.0	0.0	100.0	0.0	0.0	
	forklifts	12943	94	59	1700	0.0	0.0	100.0	0.0	0.0	
	sweepers/scrubbers	2819	96	43	1220	0.0	0.0	100.0	0.0	0.0	
	other general industrial equipment	1480	116	43	878	0.0	0.0	100.0	0.0	0.0	
	other material handling equipment	424	126	21	421	0.0	0.0	100.0	0.0	0.0	
Construction equipment	Asphalt pavers	2740	124	59	821	3.6	2.7	74.2	8.8	10.6	
	plate compactors	249	8	43	484	3.6	2.7	74.2	8.8	10.6	
	concrete pavers	590	130	59	0	3.6	2.7	74.2	8.8	10.6	
	rollers	3887	119(c)	48(d)	760	7.1	0.5	74.6	12.4	5.3	
	scrapers	2859	396(c)	50(d)	914	0.0	0.0	0.0	100.0	0.0	
	paving equipment	4670	70	59	622	3.6	2.7	74.2	8.8	10.6	
	signal boards	2179	24	43	535	3.6	2.7	74.2	8.8	10.6	
	trenchers	5408	76	59	593	3.6	2.7	74.2	8.8	10.6	
	bores and drill rigs	832	176	43	466	3.6	2.7	74.2	8.8	10.6	
	excavators	8567	120(c)	34(d)	1092	0.5	0.3	20.8	55.2	23.3	
	concrete/industrial saws	14	48	43	70	3.6	2.7	74.2	8.8	10.6	
	cement and motar mixers	430	31	43	275	3.6	2.7	74.2	8.8	10.6	
Construction equipment	cranes	10531	194	43	990	2.8	97.2	0.0	0.0	0.0	

Sector	Equipment Type	Diesel Equipment Numbers	Average Power Rating (Hp)	Load (%)	Annual Hours of Operation	Emission Performance Status (%)					
						Non-compliant	US Tier 1 Compliant	US Tier 2 Compliant	US Tier 3 Compliant	US Tier 4i Compliant	
	graders	7500	198(c)	45(d)	962	0.0	0.0	20.7	79.3	0.0	
	off-highway trucks	1770	1123(c)	36(d)	1641	0.0	0.0	35.6	64.4	0.0	
	crushing/processing equipment	772	153	43	955	3.6	2.7	74.2	8.8	10.6	
	rough terrain forklifts	5766	97	59	662	3.6	2.7	74.2	8.8	10.6	
	wheeled loaders	22426	223(c)	45(d)	761	2.0	2.3	17.4	75.8	2.6	
	wheeled dozers	829	535(c)	52(d)	899	0.4	7.2	23.8	68.6	0.0	
	tractors/loaders/backhoes	31937	97(c)	35(d)	1135	0.9	0.0	90.4	86.1	4.3	
	crawler tractors	30613	154(c)	40(d)	1135	0.0	6.3	6.3	87.5	0.0	
	skid steer loaders	16067	54(c)	38(d)	818	0.0	0.0	19.0	64.9	16.1	
	off-highway tractors	4167	725	59	855	3.6	2.7	74.2	8.8	10.6	
	dumpers/tenders	21	33	59	606	3.6	2.7	74.2	8.8	10.6	
	other construction equipment	1268	347(c)	45(d)	1092	0.0	0.0	6.7	93.3	0.0	
Agricultural equipment	agricultural tractors	250360	85(c)	59	475	0.9	19.8	69.4	9.9	0.0	
	combines	22345	132	59	150	0.9	19.8	69.4	9.9	0.0	
	sprayers	904	92	59	90	0.9	19.8	69.4	9.9	0.0	
	Balers(f)	423	0	0	0	0.0	0.0	0.0	0.0	0.0	
	tillers (>5HP)	8	131	59	172	0.9	19.8	69.4	9.9	0.0	
	swathers	4972	79	59	110	0.9	19.8	69.4	9.9	0.0	
	hydro power units	235	62	43	790	0.9	19.8	69.4	9.9	0.0	
	other agricultural equipment	1793	172	59	381	0.9	19.8	69.4	9.9	0.0	
Logging equipment	Skidders	2803	194(c)	78(d)	1276	20.0	0.0	30.0	50.0	0.0	
	fellers/bunchers/delimbers	1413	203	59	1276	20.0	0.0	30.0	50.0	0.0	
Commercial marine	commercial boats	777(e)	24(c)	21(d)	313						

(a) In-service engine/equipment population data from PAE (2005)[(1)]; (b) Represents US-EPA NON-ROAD MOBILE 2008 default horsepower, load and operational hours given for each equipment type, except where noted. (c) Engine power ratings based on 2008 sales data (weighted averages); (d) Load ratings based on 2008 sales data (weighted averages); (e) 5% of engine population from PAE (2005) taken for marine <37 kW; (f) All balers used in Australia are non self-propelled (information provided by the TMA, September 2009); (g) Based on emission performance information for products sold in 2008, as documented in Section 5.5.

1 PAE (2005). Management Options for Non-road Engine Emissions in Urban Areas, Report compiled by Pacific Air and Environment on behalf of the Department of the Environment and Heritage, November 2005.

Emission Factors Established for In- Service Population:

Sector	Equipment Type	Emission Factors					
		PM_{10}(a)	CO(a)	VOC(a)	NO_X(a)	SO_X(b)	Units
Lawn and Garden Equipment	Rear engine riding mowers	0.5193	2.4640	0.3167	4.5670	0.0060	g/HP-hr
	Lawn and Garden Tractors	0.4080	3.4854	0.5024	4.2853	0.0060	g/HP-hr
	Wood splitters	1.2365	5.4625	1.3192	8.0960	0.0060	g/HP-hr
	Chippers/stump grinders	1.2365	5.4625	1.3192	8.0960	0.0060	g/HP-hr
	Other equipment	0.9892	5.4625	1.9787	6.9828	0.0060	g/HP-hr
Airport	Airport support equipment	0.2433	1.8323	0.3670	3.6644	0.0060	g/HP-hr
	Terminal tractors	0.3346	2.1377	0.4014	3.7598	0.0060	g/HP-hr
Recreational equipment	Speciality vehicle carts	3.8487	36.0793	10.3969	8.6830	0.0060	g/HP-hr
Light commercial equipment	Generators	0.3297	2.5886	0.3890	4.4757	0.0032	g/HP-hr
	Pumps	0.2968	2.4897	0.4042	4.7212	0.0032	g/HP-hr
	Air compressors	0.2968	2.4897	0.4042	4.7212	0.0032	g/HP-hr
	Welders	1.6321	10.6372	1.6009	5.9004	0.0032	g/HP-hr
	Pressure washers	0.2968	2.4897	0.4042	4.7212	0.0032	g/HP-hr
Industrial equipment	aerial lifts	1.6321	10.6372	1.6009	5.9004	0.0060	g/HP-hr
	forklifts	0.4411	5.8183	0.4358	4.3038	0.0060	g/HP-hr
	sweepers/scrubbers	0.2968	2.4897	0.4042	4.7212	0.0060	g/HP-hr
	other general industrial equipment	0.2226	0.9139	0.3714	4.1185	0.0060	g/HP-hr
	other material handling equipment	0.8769	6.0205	1.9511	5.1159	0.0060	g/HP-hr
Construction equipment	Asphalt pavers	0.4165	2.3470	0.3912	3.7955	0.0060	g/HP-hr
	plate compactors	0.6093	4.3787	0.6444	4.5541	0.0060	g/HP-hr
	concrete pavers	0.4165	2.3470	0.3912	3.7955	0.0060	g/HP-hr
	rollers	0.4499	2.5178	0.4085	3.9270	0.0634	g/HP-hr
	scrapers	0.3999	2.1227	0.1943	2.7566	0.0057	g/HP-hr
	paving equipment	0.5087	5.6966	0.4244	4.3131	0.0060	g/HP-hr
	signal boards	0.3626	2.3944	0.5302	4.6094	0.0060	g/HP-hr
	trenchers	0.5087	5.6936	0.4282	4.2803	0.0060	g/HP-hr
	bores and drill rigs	0.2038	0.9438	0.3386	4.0257	0.0060	g/HP-hr
	excavators	0.4929	2.0213	0.2553	2.9801	0.0060	g/HP-hr
	concrete/industrial saws	0.6390	3.8683	0.3956	4.4865	0.0060	g/HP-hr
	cement and motar mixers	0.4228	1.7533	0.3658	4.8320	0.0060	g/HP-hr
Construction equipment	cranes	0.3319	0.8306	0.3574	5.7824	0.0060	g/HP-hr
	graders	0.3676	1.8669	0.2481	2.9441	0.0056	g/HP-hr

Sector	Equipment Type	Emission Factors					
		PM_{10}(a)	CO(a)	VOC(a)	NO_X(a)	SO_X(b)	Units
	off-highway trucks	0.2739	1.9093	0.1945	3.9880	0.0057	g/HP-hr
	crushing/processing equipment	0.2676	1.0660	0.3639	4.1022	0.0060	g/HP-hr
	rough terrain forklifts	0.5158	5.7332	0.4323	4.2132	0.0060	g/HP-hr
	wheeled loaders	0.3931	1.9355	0.2565	3.1004	0.0056	g/HP-hr
	wheeled dozers	0.3630	2.1958	0.2002	3.2725	0.0054	g/HP-hr
	tractors/loaders/backhoes	2.8667	29.6479	2.8635	9.4549	0.0056	g/HP-hr
	crawler tractors	0.5622	2.1822	0.2402	2.9733	0.0056	g/HP-hr
	skid steer loaders	1.6085	14.4379	1.1111	4.5417	0.0060	g/HP-hr
	off-highway tractors	0.3414	3.7122	0.2626	3.8577	0.0060	g/HP-hr
	dumpers/tenders	1.5939	10.6175	1.7788	5.9308	0.0060	g/HP-hr
	other construction equipment	0.3894	2.1194	0.1944	2.8375	0.0060	g/HP-hr
Agricultural equipment	agricultural tractors	0.5809	5.8803	0.4634	4.4275	0.0060	g/HP-hr
	combines	0.4167	2.1704	0.3891	4.0089	0.0060	g/HP-hr
	sprayers	0.5845	5.8651	0.4700	4.4003	0.0060	g/HP-hr
	Balers(c)	NA	NA	NA	NA	NA	g/HP-hr
	tillers (>5HP)	0.4085	2.2342	0.3922	3.9811	0.0060	g/HP-hr
	swathers	0.5845	5.8281	0.4562	4.4298	0.0060	g/HP-hr
	hydro power units	0.5845	5.8781	0.4658	4.4268	0.0060	g/HP-hr
	other agricultural equipment	0.4166	2.2204	0.3986	4.0059	0.0060	g/HP-hr
Logging equipment	Skidders	0.6075	2.8182	0.3641	4.5639	0.0060	g/HP-hr
	fellers/bunchers/delimbers	0.6075	2.8182	0.3641	4.5639	0.0060	g/HP-hr
Commercial marine	commercial boats	0.2406	2.1110	0.5131	3.7847	0.0032	g/HP-hr

(a) Emission factors established for Australian in-service non-road diesel equipment based on US-EPA NON-ROAD MOBILE 2008 emission factors, but incorporating application-specific Transient Adjustment Factors, Deterioration Factors (assuming an average fleet age of 50% of the median life) and factoring in 2008 emission performance information.

(b) Emission factors taken from the Australian national Pollutant Inventory (NPI) Emissions Estimation Technique Manual for Combustion Engines (Version 3.0, June 2008), as given for various heavy duty diesel vehicles and stationary diesel engines based on an assumed fuel sulfur conent of 10 ppm (in line with post January 2009 automotive diesel specifications).

(c) All balers used in Australia are non self-propelled (information provided by the TMA, September 2009).

Appendix B. Agricultural tractor imports into Australia (2008), by country of origin and engine rating (Source: ABS, 2009)											
Country of Origin	<15 kW(a)	<15 kW(b)	15 – 30 kW	30 - 45 kW	45 - 60 kW	60 - 75 kW	75 - 90 kW	90 - 105 kW	>105 kW	Total	% of Total
United States of America	226	408	2,957	380	115	262	10	96	1,029	5,483	28.8
Japan	133	15	1,872	821	274	431	157	-	50	3,753	19.7
Germany	69	-	-	20	133	405	544	318	382	1,871	9.8
Italy	84	-	21	92	53	337	274	527	120	1,508	7.9
Korea, Republic of	-	-	346	395	220	161	90	-	88	1,300	6.8
India	-	-	180	212	736	28	8	-	-	1,164	6.1
China	82	3	399	311	57	36	16	-	17	921	4.8
Austria	-	-	-	-	-	1	7	359	238	605	3.2
Viet Nam	418	-	178	5	1	-	-	-	-	602	3.2
France	-	-	-	3	226	70	120	66	75	560	2.9
Canada	376	-	1	1	1	25	-	-	9	413	2.2
United Kingdom	1	12	-	4	-	24	140	71	127	379	2.0
Turkey	-	-	-	-	143	192	41	-	-	376	2.0
Finland	-	-	-	-	2	40	5	-	12	59	0.3
Brazil	-	-	-	-	20	1	-	-	-	21	0.1
Australia (Re-imports)	2	-	1	-	2	-	-	-	-	5	0.0
New Zealand	1	-	-	-	-	1	-	1	2	5	0.0
Netherlands	-	1	-	-	-	3	-	-	-	4	0.0
Pakistan	-	-	-	3	-	-	-	-	-	3	0.0
Cook Islands	-	-	-	-	1	-	-	-	-	1	0.0
Sweden	-	-	1	-	-	-	-	-	-	1	0.0
Switzerland	-	-	-	-	-	1	-	-	-	1	0.0
Total	1,392	439	5,956	2,247	1,984	2,018	1,412	1,438	2,149	19,035	
% of Total	7.3	2.3	31.3	11.8	10.4	10.6	7.4	7.6	11.3		

Source: ABS, 2009

(a) Agricultural tractors having an engine power of less than 15 Kw with a single P.T.O., rear axle mounted and rear facing and having rear hydraulic lift 3 point linkage.

(b) Agricultural tractors having an engine power of less than 15 Kw (excl. those with single P.T.O., rear axle mounted and rear facing and having rear hydraulic lift 3 point linkage).

Appendix C: ERG International Loose Diesel Engine and Gen Set Sales Data Set

Market Segmentation by Application

Loose diesel engine data are collected by ERG International across 21 engine brands including most leading brands, for the following market sectors: Automotive, Industrial, Marine, Agricultural, Power Generation Drive and Power Generation Sets. Loose non-road diesel engine data sales are available by states and territories, and by manufacturer – both excluding and including gen sets.

A summary of the market segments and application categories for which relevant loose non-road diesel engine sales data were obtained from ERG International is provided in the **Table C.1**. These market segments and application categories are representative of most of the main diesel engine applications listed in Section 2.2.

Engine Power Ratings

Engine power ratings are typically given in kilowatts (kw). It should be noted that the data relating to engine power is frequently incomplete.

There are three main ratings used in Australia, namely: maximum rating, continuous rating and intermittent rating. Typical rates used for specific market sectors are given in **Table C.2**.

Interpretation of Data Set

In the interpretation of the ERG data the following data set methods and limitations should be noted:

- ERG International collects data through having major diesel engine suppliers complete detailed statistical data input sheets.
- Information is collated from manufacturers and distributors and generally reflects the end-use applications for which the engine was sold.
- The loose diesel engine data does not include used or reconditioned diesel engines.
- Not all manufacturers and dealers/distributors monitor sales of diesel engines by applications. As a result assumptions have to be made by some manufacturers, distributors and dealers in the compilation of data for submission to ERG. Uncertainties arise in the accuracy of the data given by application and it is advised that these data be interpreted as an approximation only.
- Assumptions are made in the classification of engines. On occasion engines within one category may be applied in a different category, e.g. automotive and industrial engines may be used within the power generator category or for pump applications for irrigation and de-watering purposes. Alternatively, they may be installed in construction or agricultural equipment.
- Some Original Equipment Manufacturers in Australia import engines directly from overseas manufacturers, bypassing traditional distributor channels in Australia. As a

result, the overall engine demand (sales) reflected in the data collated by ERG International is likely to be understated.

- In the power generation segment, the sales data includes comprises less than 20% of the total gen set market.

The above mentioned limitations were taken into account during the course of study, with additional data collected directly from non-reporting industries to fill substantial data gaps.

Table C.1: Market segments and application categories for loose diesel engine data
Source: ERG International, 2009

Market Segment	Application	Description of Equipment Types
Industrial Engines sold for industrial applications including OEM	CME – Construction and Mining Equipment	Augers/drills/borers Compaction and paving equipment Portable compressors Mobile and stationary cranes Crawler dosers Crasler loaders Backhoe loaders Wheeled loaders Hydraulic excavators Crushers Material handling equipment Graders Skid steer loaders Scrapers Trenching machines Dump trucks Road heading machines Compressors and winches
	PUM – Pumps	Oil and gas processing equipment Concete pumping equipment Bulk haulage pumping and blowing equipment Fire pumps (sprinkler systems)
	OTH - Other	Waste removal equipment Road sweeping and cleaning equipment Other industrial equipment Hydraulic power packs Welding sets

Table C.1 continued: Market segments and application categories for loose diesel engine data

Market Segment	Application	Description of Equipment Types
Marine Propulsion Engines sold for marine applications including OEM	PLB – Pleasure Boats	Pleasure cruisers, planning and displacement hulls Yachts and motor sailers Sprots boats
	WOB – Work Boats	Off-shore service/supply vessels Ferries, tugs and barges Charter vessels Patrol boats Hovercrafts and catamarans
	FIB – Fishing Boats	Commercial fishing vessels and trawlers Pleasure fishing boats
Agricultural Engines sold for agricultural applications including OEM	PNI – Pumps and Irrigation	Commercial and residential Irrigation systems Water tanks Dams
	VEH – Vehicles	Farm tractors including repowers Combine harvesters and seeders Cherry pickers/orchard harvesters Other agricultural vehicles Forestry skidders Forwarders Haulers Off-highway logging trucks
	OTH - Other	Hay making machinery Oil presses Lawn and garden outdoor power equipment
Power Generation Drive Engines sold for the manufacture of generator sets	PRP – Prime Power	Market applications for power generation drives and sets are self explanatory and include most of the markets above.
	STP – Standby Power	
	MUX – Marine Auxiliary	
Power Generation Sets Engines incorporated in a power generator set which is actually sold as a power generator set, not a bare engine	GRP – Prime Power	
	GTP – Standby Power	
	GUX – Marine Auxiliary	

Table C.2: Engine power ratings used for loose diesel engines within specific market applications		
Market Segment	**Application**	**Engine Rating**
Automotive	Repower and Replacement	Intermittent
Industrial	Vehicles	Intermittent
	Pumps	Continuous
Marine Propulsion	Pleasure Boats	Intermittent
	Work Boats	Continuous
	Commercial Boats	Continuous
Agricultural	Pumps & Irrigation	Continuous
	Vehicles	Intermittent
Power Generation Drive	Prime Power	Continuous
	Standby Power	Intermittent
	Marine Auxiliary	Continuous
Power Generation Sets	Prime Power	Continuous
	Standby Power	Intermittent
	Marine Auxiliary	Continuous

Appendix D: Background Information on Selected Non-road Diesel Applications

Agricultural Equipment

Agricultual equipment engines are estimated to comprise over 30% of the total market of non-road diesel engines. Diesel-powered agricultural equipment include agricultural tractors, combines, sprayers, tillers, swathers (windrowers), hydro power units and other agricultural equipment. All balers used in Australia are non-self propelled according to the TMA.

PAE (2005) estimated that percentage of diesel equipment to be as follows for in-service agricultural equipment: agricultural tractors (99.8%), combines (99.2%), sprayers (11%), tillers (less than 0.1%), swathers or windrowers (60%), hydro power units (14%) and other agricultural equipment (74%)[(2)]. Overall diesel was given as powering 75% of the total estimated in-service agricultural equipment population of 372,500.

Agricultural tractors dominate the in-service diesel fleet, accounting for almost 90% of agricultural equipment, with combines (8%) and windrowers (2%) making up most of the remainder.

Taking into account the equipment numbers, operational hours and factors and emission rates, in-service agricultural equipment emissions were estimated by PAE (2005) to be dominated by agricultural tractors (72%) and windrowers (12%).

Information on non-road diesel equipment being used withn the agricultural sector were obtained from *the Executive Director of the Tractor and Machinery Association of Australia (TMA)* (27 April 2009).

Agricultural Tractors

Tractors represent the most significant non-road diesel equipment type operating in the agricultural sector in terms of both equipment imports, sales and emissions (ABS, 2009; PAE, 2005; TMA, 2009). According to the TMA, almost 12,000 new tractors were sold in Australia in the last financial year.

All tractors sold in Australia are imported and have been since the 1970's (TMA, 2009). Tractors are supplied from all over the world for sale in Australia (as indicated in **Appendix B**). Traditionally Europe and North America supplied the majority of tractors. Tractors continue to be imported from those factories but some tractors are now also supplied from manufacturing factories in South America and eastern Europe.

In recent years the numbers of tractors supplied from Asia has grown steadily. Initially these machines may have come from Japan but now China, India and Korea all supply a growing percentage of the tractors now sold in Australia. These machines are most likely to have more basic emission specifications according to the TMA Executive Director.

2 PAE (2005). Management Options for Non-road Engine Emissions in Urban Areas, Report compiled by Pacific Air and Environment on behalf of the Department of the Environment and Heritage, November 2005.

No tractors are manufactured specifically for the Australian market as Australian demand is only estimated to comprise 2% to 3% of world production.

Close to 20 suppliers of new tractors in Australia were identified during the study, of which there are a small number of leading brands which have a significant market share. Detailed information on market share could however not be obtained.

A Queensland Government Workplace Health and Safety Survey published in 2000 (after previous surveys in 1993 and 1998) represents the only comprehensive study on tractor usage known to the TMA. It found that the average age of operational tractors per farm was 18.1 years and these tractors were driven for 1,422 hours per farm. Overall there were 3.5 operational tractors per farm. There were significant variations in the numbers of tractors per farm and the operational hours of those tractors that appear to be determined by the type of farming enterprise.

Other Self-propelled Farm Machinery

Self-propelled equipment such as harvesters are imported. Sprayers and other smaller equipment are either imported or manufactured in Australia, however locally manufactured units are fitted with imported engines.

Other farm machinery using diesel engines include self propelled sprayers and windrower tractors though the combined total of sales nationally for these products totals in the several hundred per annum.

Two other farming activities utilise diesel engines, namely stationary irrigation pumps and grain shifters. The latter comprises grain augers that are too big to move manually, which are consequently self propelled.

Some of the self propelled sprayers sold in Australia are manufactured locally. The windrower tractors sold in Australia are however manufactured abroad.

Seven suppliers of self propelled sprayers and windrower tractors in Australia were identified during the course of study.

Logging Equipment

Logging (forestry) equipment includes chainsaws, shredders, skidders, fellers, bunchers and delimbers. According to PAE (2005) only skidders and fellers/bunchers/delimbers are diesel powered[(3)].

Given the relatively small number of in-service diesel logging equipment (estimated by PAE to be ~4,200), the low contribution of such emissions to overal non-road diesel equipment emissions (0.4%) and the fact that such emissions are non-urban, logging equipment is not considered a critical component of the current study. It is however worthy of noted that all forestry equipment is imported, generally from North America, Europe and Japan and that the majority of engines are expected to be US Tier 2 compliant (PAE, 2005).

3 PAE (2005). Management Options for Non-road Engine Emissions in Urban Areas, Report compiled by Pacific Air and Environment on behalf of the Department of the Environment and Heritage, November 2005.

Airport Service Equipment

The range of potential diesel equipment used at airports is given in **Table D.1**. In various instances use may be made of on-road certified engines. Such equipment is typically managed by ground handling agents, with several ground handling agents operating at each major airport.

Table D.1: Typical airport ground support service equipment (NPI, 2008)

Ground Support Equipment	Engine Power (kW)	Fuel	Comments
Ground power unit (GPU)	50 – 150	Diesel, petrol, gas	Electric system may be integrated into gate/bridge
Air conditioning / heater unit	150 – 220	Diesel or petrol	Electric PCA may be integrated into gate/bridge
Air starter unit	150 – 630	Diesel	Use depends on whether on-board APU is used
Narrow-body push out tractor	95	Diesel	Electric powered units available
Wide-body push out tractor	400	Diesel	
Passenger stairs	30 – 80	Diesel, petrol, gas	Non-powered and electric units available
Belt loader	33 – 80	Diesel, petrol, gas	Electric unit available
Baggage tug / tractor	30 – 80	Diesel, petrol, gas	Electric unit available
Cargo and container loader	60 – 100	Diesel or petrol	Different types available
Cargo delivery	30 – 80	Diesel or petrol	Different types available
Bobtail Truck	80 – 175	Diesel, petrol, gas	Highly variable
Catering/service truck	50 – 270	Diesel , petrol, gas	May use on-road certified engines
Lavatory truck; potable water truck	60 -175	Diesel, petrol, gas	May use on-road certified engines
Fuel hydrant truck	70 – 270	Diesel with pumps	May use on-road certified engines
Fuel tanker truck	130 – 300	Diesel with pumps	May use on-road certified engines
Maintenance lift	70 – 120	Diesel, petrol, gas	May use on-road certified engines
Passenger buses	100	Diesel, petrol, gas	May use on-road certified engines
Fork lift	30 – 100	Diesel, petrol, gas	Electric units available
Miscellaneous vehicles (cars, vans, trucks)	50 – 150	Diesel, petrol, gas	Usually on-road certified engines

According to PAE (2005) emissions from in-service Airport Service Equipment are dominated by terminal tractors (85%), with the remainder due to other airport service equipment[(4)]. It should be noted that the emission estimates were based on equipment populations and operational hours derived from US aircraft movement data and scaled for Australian airport aircraft movements. Airside vehicles were assumed to have a fleet breakdown of 61.5% petrol and 38.5% diesel, with airside plant having a breakdown of 27.4% petrol and 72.6% diesel. In-service *diesel* equipment population numbers were given as about 4,300 terminal tractors and 1,400 other airport service equipment.

Based on its discussions with industry PAE (2005) reported that approximately 50 pieces of lifting equipment and about 250 tow tractors are imported into Australia annually through two companies (Toyota and Harland). Import numbers are low, as equipment is rebuilt, with

4 PAE (2005). Management Options for Non-road Engine Emissions in Urban Areas, Report compiled by Pacific Air and Environment on behalf of the Department of the Environment and Heritage, November 2005.

engines replaced as equipment ages. Only one domestic manufacturer of airport service equipment was identified in Australia by PAE (Static Engineering, based in Adelaide).

Sales information was not available for non-road air service equipment and was therefore derived from ABS import data (lifting equipment and non-agricultural tractors).

Light Commercial and General Industrial Equipment

Light commercial engines generally comprise stationary engine types such as generators, pumps, compressors, welders and pressure washers. Only about 1% of pressure washers, 6% of generators and pumps, 8% of air compressors and 22% of welders were estimated by PAE (2005) to be diesel powered (based on US data)[(5)].

Generators, welders and pumps were identified as being the most significant sources of emission due to their estimated in-service population numbers, hours of usage and emission rates.

The emissions performance of light commercial equipment will be characterized based on the information for diesel engines within the Industrial – Pumps, Industrial – Other, and Power Generation Drives and Sets application categories.

General industrial equipment, not covered in other categories, include aerial lifts, forklifts, sweepers/scrubbers and general industrial and materials handling equipment. Diesel powered equipment was estimated by PAE (2005) to comprise 30% to 60% of in-service general industrial equipment in Australia. Due to their estimated in-service numbers (~13,000), operations and emission factors, diesel forklifts were estimated to be responsible for about 80% of the total emissions estimated for diesel general industrial equipment.

It is notable that the ratio of diesel equipment is significantly lower for new industrial equipment. Based on discussions with representatives of the Australian Industrial Truck Association (AITO) and Forkpro regarding industrial equipment such as forklifts, PAE (2005) indicated that new vehicle fleet is split 50:50 between battery-electric and internal combustion engines. Of the internal combustion engines, 10% are diesel and 90% petrol.

Only about 5% of new general industrial equipment such as forklifts is therefore expected to be diesel. The increase in battery-electric powered equipment is given as being partly due to petrol and diesel engines being outlawed for health and safety reasons for warehouse applications.

Light commercial and general industrial sales information was not available and was therefore derived from a combination of ABS import information and in-service equipment populations documented by PAE (2005) and NSW DECCW (2007).

Commercial Lawn and Gardening Equipment

Lawn and garden equipment is dominated by the use of petrol, and has been the focus of previous studies in terms of market characterisation, emissions testing, review of emission

5 PAE (2005). Management Options for Non-road Engine Emissions in Urban Areas, Report compiled by Pacific Air and Environment on behalf of the Department of the Environment and Heritage, November 2005.

management measures and cost-benefits for emission reduction measures[6] (NSW DEC, 2005; PAE, 2005; MMA, 2008). Emissions from petrol-driven equipment is scheduled to be regulated.

Diesel commercial and lawn and garden equipment sales information was unavailable with sales numbers being derived based on ABS import statistics (ride on and tractor mowers, all fuel types) and sales data available for petrol-powered mowers.

Although diesel is not used for domestic lawn and garden equipment, a portion of commercial lawn and garden equipment is diesel-powered. Such equipment is used by councils for public open spaces and in the private sector for golf courses and other commercial applications such as garden service businesses.

In its survey of councils and golf course operators as part of the NSW GMR Emissions Inventory, NSW DECCW (2007b) noted that 15% of the lawn and garden equipment used by councils and 30% of equipment used at golf courses was diesel powered. About 90% of such equipment was in the less than 37 kW power band in both instances. Individual **diesel** equipment inventoried for councils and their respective power bands were as follows:

Equipment Type:	<8 kW	8 - 37 kW	37 -56 kW	56 – 75 kW	75 – 130 kW	Total
Chippers and stump grinders			3%			3%
Commercial lawnmower	5%	26%	1%			32%
Other lawn mowing and garden equipment		2%	1			3%
Ride-on lawnmower	14%	13%				27%
Tractor		24%				24%
Turf equipment		9%		3%	1%	12%

PAE (2005) derived its estimate of national commercial lawn and garden equipment numbers from scaling up the NSW inventoried equipment using population figures. A total in-service diesel equipment population of about 46,000 were estimated, comprising 91% lawn and garden tractors, 6% chippers/stump grinders, 3% rear engine riding mowers. Emissions from diesel-fuelled Lawn and Garden applications were estimated by PAE to be dominated by lawn and garden tractors (68%) and chippers/stump grinders (32%) as illustrated in Section 3.

The emissions performance of commercial lawn and garden equipment was characterized based on information obtained for diesel engines for the Agricultural – Other application category, and through consultation with a leading commercial lawn and garden equipment supplier.

Commercial Marine

Recreational marine equipment is dominated by the use of petrol, and has been the focus of previous studies in terms of market characterisation, emissions testing, review of emission

6 PAE (2005). Management Options for Non-road Engine Emissions in Urban Areas, Report compiled by Pacific Air and Environment on behalf of the Department of the Environment and Heritage, November 2005.

management measures and cost-benefits for emission reduction measures[7] (NSW DEC, 2005; PAE, 2005;).

Sales information for commercial marine was sourced from loose engines industry data.

Commercial marine includes commercial boats, domestic shipping and international shipping. Commercial ships primarily use large, slow-speed and medium speed diesel engines. Ships normally also use diesel-powered generators to provide auxiliary power. Due to their engine size and their area of operation, domestic and international ships are excluded from non-road diesel engine/equipment regulations internationally.

Commercial boats are generally purchased by fishing and tour operators. To determine the percentage of commercial vessels comprising engines which may fall within the range of marine engines regulated under non-road diesel emission standards, reference was made to the detailed 2003 NSW GMR Emissions Inventory (NSW DECCW, 2007b). The following observations were made:

- Of the 31 diesel ferries operating in GMR in 2003, all have engine ratings above 224 kW, and so would be excluded from US non-road diesel rulemaking (despite provision being made for the regulation of such engines under US marine diesel rulemaking).
- A total of 4,266 licensed fishing vessels in GMR in 2003 were inventoried, of which 40% were diesel powered (1,716 vessels), and only 1.7% (74 vessels) were diesel powered and had engines of less than 50 kW.
- Other commercial boats in GMR in 2003 comprised a total of 1,751 engines (1211 vessels), of which 70% of vessels and 66% of engines were diesel powered. Of the total, 18% of the vessels were diesel and had engines of less than 50 kW (13% of the total engines were diesel powered and less than 50 kW).

Of the 7,400 registered commercial vessels in NSW in 2002-3, it was therefore estimated that only 3.9% of these (290 vessels) were fitted with diesel engines in the less than 50 kW range.

Total recreational boats in the GMR were given as 150,366 of which 69.4% have engine power ratings of less than 37 kW. Approximately 1% of all the recreational boats (18,796 vessels) are diesel powered.

Based on an analysis of new diesel engine sales data for 2008, which is estimated to account for over 60% of the national market, it was determined that only 23% of new marine diesel engines are in the less than 37 kW range (including 7% of fishing boat engines, 8% of work boat engines and 27% of pleasure boats).

The emissions performance of small marine engines was characterized based on information obtained for loose diesel engines in the Marine Propulsion application category.

7 PAE (2005). Management Options for Non-road Engine Emissions in Urban Areas, Report compiled by Pacific Air and Environment on behalf of the Department of the Environment and Heritage, November 2005.

Appendix E: Emission Performance Status of Non-road Diesel Engines/Equipment Sold in Australia during 2008

		Number of Engines/Equipment							
Segment	Application	US Tier 1 / EU Stage I	US Tier 2 / EU Stage II	US Tier 3 / Stage IIIa	US Tier 4i	Non-compliant	No Longer Sold	Unknown	Total
Agriculture	Agricultural tractors	2,399	8,398	1,200	-	104	-	-	12,101
Agriculture	Combine harvester-threshers	-	-	-	-	-	-	538	538
Agriculture	Engines for agricultural vehicles	-	-	-	-	-	-	20	20
Agriculture	Engines for 'Other' agricultural applications	-	-	-	-	-	-	60	60
Agriculture	Pumps & Irrigation	107	2,026	103	-	1,542	-	187	3,964
Agriculture	Self Propelled Sprayers	-	-	-	-	-	-	16	16
Agriculture	Windrowers	-	-	-	-	-	-	333	333
Forestry	Log Skidders	-	9	15	-	6	-	-	30
Industrial	Construction & Mining	86	2,327	276	334	113	-	287	3,422
Industrial	Construction & Mining Equipment	59	2,630	6,520	1,582	377	13	1,260	12,441
Industrial	Cranes and lifting equipment	2,810	-	-	-	82	-	-	2,892
Industrial	Forklifts	-	609	-	-	-	-	-	609
Industrial	Miscellaneous industrial engines	-	792	179	-	638	-	2	1,611
Industrial	Other industrial engines	209	2,773	205	290	238	-	11	3,726
Industrial	Pumps	111	417	191	363	1,603	-	218	2,903
Industrial	Tractors (expected to include airport equipment)	-	562	-	-	-	-	-	562
Lawn and Garden	Ride on or tractor lawn mowers	380	1,330	190	-	-	-	-	1,900
Light Commercial	Air compressors	-	130	-	-	-	-	-	130
Light Commercial	Pressure washers	-	30	-	-	-	-	-	30
Light Commercial	Welders	-	840	-	-	-	-	-	840
Marine	Fishing Boats	-	6	-	-	-	-	-	6
Marine	Pleasure Boats	-	410	8	23	-	-	-	440
Marine	Work Boats	6	20	0	1	-	-	-	28
Other	Vehicle Propulsion	-	-	-	-	1,199	-	-	1,199
Power Generation Drives	Marine Auxiliary	-	0	0	1	-	-	116	118
Power Generation Drives	Prime Power	-	902	-	-	-	-	418	1,320
Power Generation Drives	Standby Power	-	941	10	235	40	-	100	1,326
Power Generation Sets	Miscellaneous gen sets	3	481	63	-	322	-	-	869
Power Generation Sets	Marine Auxiliary	-	60	70	-	-	-	72	202
Power Generation Sets	Prime Power	-	770	196	-	60	-	356	1,382
Power Generation Sets	Standby Power	-	11	213	32	-	-	934	1,190
	Total	6,171	26,473	9,439	2,861	6,323	13	4,978	56,258

Appendix F: Methodology for Surveying of Large Non-road Diesel Engine/Equipment Users

Industries Surveyed

Construction (civil / building) - The following seven firms in the construction industry were invited to respond to the survey as they represent of the largest civil construction and building firms in Australia: Thiess, Boulderstone Hornibrook, ABI Group, Downer EDI Works, Brookfield multiplex, Bovis Lend Lease and Clough. Of these firms, four completed surveys were received.

Manufacturing - The following manufacturing firms were invited to respond to the survey as they were considered to represent a cross section of the largest manufacturing industry firms within NSW: Orica, Quenos, CSR, Boral, Shell and Blue Scope Steel. Of these firms, four responses and three completed surveys have been received.

Ports - The following port owners and stevedoring companies were invited to respond to the survey as they represented Australia's major port and stevedoring operators: DP World, Patricks Stevedores, Sydney Ports, Port of Melbourne, Port of Fremantle and 'Confidential Respondent'. One of the respondents requested that their name not be included in the report. They are listed as 'confidential respondent'. Of these port operators and stevedoring companies, four responded to ENVIRON's initial request and two completed survey were obtained.

Airports and Airlines - The following airport owners / airlines were invited to respond to the survey as they represented Australia's major airport/air services and airline operators: Qantas, Virgin, Sydney International, Melbourne Airport, Brisbane Airport, Canberra Airport, Menzies Air-services and Aerocare. Of these firms ENVIRON has received three responses and one completed survey.

Mining – Three major mining companies were invited to respond to the survey, namely Rio Tinto, BHP Billiton and Xstrata Coal. Of these firms, two completed surveys.

Waste - The following major landfill operators in NSW were invited to provide a response to the survey: Transpacific, WSN, Sita and Muswellbrook Shire Council. Of these firms, two responses were received including one completed survey.

The table below presents a summary of the the number of surveys sent to firms in each industry sector and the number of responses received.

Sector	Surveys Sent	Responses Received	Completed Surveys Received
Construction	7	4	4
Industry (Manufacturing)	6	4	3
Ports	6	3	2
Airports	8	3	1
Mining	3	2	2
Waste	4	2	1
Total	**32**	**18**	**13**

The companies who responded but did not complete the survey were those who declined to participate in the process.

An example of the survey format is given overleaf.

ENVIRON

CLEANER OFF ROAD DIESEL EQUIPMENT - USER SURVEY

Thank you for your assistance. Your responses will inform the NSW Department of Environment and Climate Change about the opinions and attitudes of non-road diesel equipment users towards the adoption of less polluting non-road diesel engines and equipment.

Your response would be appreciated by 5th of May 2009.

Survey Instructions:

- Please check the relevant box by clicking on it.
- Please add additional comments in the space provided, what ever information you can provide is useful.

Background Information	
What is your name?	
What is your position?	
Contact information	E-mail:
	Phone:
Types of non-road diesel equipment your company purchases:	☐ Diesel dozers ☐ Diesel chippers ☐ Diesel compressors ☐ Diesel cranes ☐ Diesel crushing equipment ☐ Diesel forklifts ☐ Diesel generators ☐ Diesel loaders ☐ Diesel off road trucks ☐ Diesel backhoes ☐ Diesel trenchers
	Other types of equipment not listed:

Awareness and sources of information	
Are you familiar with the different levels of non road diesel engine air emission certification?	☐ Very familiar: ☐ Mostly familiar: ☐ Somewhat familiar: ☐ Not familiar:

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Does your non-road diesel equipment supplier provide information about the air-emission performance of the equipment it sells?	☐ Yes ☐ No
	If so what sort of information?
What sources are you aware of which provide information regarding the air-emission performance of diesel equipment?	1. 2. 3. 4. 5.

Process for purchasing off-road diesel equipment	
Who in your company is responsible for deciding which type of non-road diesel equipment to purchase?	Position:
	Department:
Are the air emissions produced by non-road diesel equipment a consideration when purchasing new equipment and replacement engines?	☐ Yes ☐ No
	Comments / further information:
Does your firm have a documented policy governing the purchase of low emission non road diesel equipment?	☐ Yes ☐ No
	Comments / further information:

Measures taken / being considered to reduce emissions

Does your firm have an air quality management plan (As part of EMS or stand alone)?	☐ Yes ☐ No
	Comments / further information:
Does your firm have any plans for the abatement of air emissions in any area?	☐ Yes ☐ No
	Comments:
Are plans for the abatement of air emissions from non-road diesel equipment included in this plan?	☐ Yes ☐ No
	Comments:
Have there been any specific measures taken to reduce the air-quality emissions from non road diesel equipment?	☐ Yes ☐ No
	Comments:

Trends affecting future non road diesel equipment purchases	
Does your firm have any major plans for the replacement of non-road diesel equipment in the foreseeable future?	☐ Yes ☐ No

	If yes which type of equipment?
Have you firm participated in any of voluntary schemes for the reduction of air emissions?	☐ Yes ☐ No
	If Yes, which programs?
Would your firm be willing to participate in a voluntary scheme for the reduction of air-emissions from non-road diesel equipment?	☐ Yes ☐ No
	Any comments?
What do you think the most effective way for the government to reduce air-emissions from non-road diesel engines and diesel equipment	☐ Mandatory regulations ☐ Guidelines ☐ Improved consumer information ☐ Financial incentives ☐ No action
	Any comments?

THANK YOU FOR YOUR ASSISTANCE

For questions or comments you have about the survey please contact:

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Appendix G: Results from the Surveying of Large Non-road Diesel Engine/Equipment Users

The aggregated responses to each of the questions asked in the survey are presented here along with selected additional comments provided by the responding firm. Tables are also presented listing responses by respondent (identified by industry sector) to enable conclusions to be drawn on differences between the attitudes of companies within the different sectors surveyed.

Question	Very familiar	Mostly Familiar	Somewhat Familiar	Not familiar
Level of Familiarity with non-road diesel certification levels:	0	1	3	9

Of the completed surveys received, only one indicated that they were mostly familiar with the different levels of non-road diesel engine certification with none indicating that they were very familiar and a significant majority indicating no familiarity. The firms whose response was either somewhat or mostly familiar were firms which also indicated that their non-road diesel equipment suppliers provided information about the air emission certification of the equipment they were purchasing.

Question	Yes	No
Does your non-road diesel equipment supplier provide information about the air-emission performance of the equipment it sells?	5	8

The majority of firms indicated that their non-road diesel equipment supplier did not supply any information about the emission performance of the equipment they were purchasing or leasing. Additional comments also indicated that smaller suppliers were less forthcoming with information than larger equipment suppliers.

> *'Heavy Equipment suppliers provide information on their engine particulate emissions and certification levels. Some information regarding expected fuel burn rate is also supplied. Smaller suppliers may not always provide the same level of specification information.'*
>
> *'Euro Emission level information is available'*
>
> *'May be provided if requested'*
>
> *'When buying fuel consumption and emission levels (if available) are taken into consideration.'*

Question	Yes	No
Are the air emissions produced by non-road diesel equipment a consideration when purchasing new equipment and replacement engines?	7	5

* One respondent failed to answer question

The firms who indicated that air emission performance was not currently a consideration when purchasing / leasing non-road diesel equipment also commented that it was often a lack of information which prevented them including air emission performance as an element in their purchasing decisions.

> *'We can decide what brand of engine, after that the emission level choice is usually set by what is currently available.'*
>
> *'Lack of information makes comparison between most non-road diesel products difficult'*
>
> *'Air emissions are identified as part of the corporate Aspects Impacts and Controls Register.'*

Question	Yes	No
Does your firm have a documented policy governing the purchase of low emission non-road diesel equipment?	3	8

* Two respondents failed to answer question

The majority of firms indicated that they do not currently have a documented policy governing the purchase of low emission non-road diesel equipment. Those which do have a policy referred to generic environmental purchasing policies rather than something specific to diesel or non-road diesel equipment.

> *'Emissions are assessed as part of the pre-purchase process and subcontractor pre-selection process, however there are no guidelines or policies in place regarding minimum standards that must be met'*
>
> *'as part of a sustainability strategy'*

Question	Yes	No
Does your firm have an air quality management plan (As part of EMS or stand alone)?	9	4

The majority of firms indicated that they have an air quality management plan. A number of the respondents have environmental licenses for which air quality emission limits are imposed. From the additional comments provided, the focus of these plans is on primary sources of air emissions and not on sources such as non-road diesel equipment.

'Predominantly focuses dust particulates from mining'

'Whilst there is not an over-arching air quality management plan, a project specific air quality management sub plan is developed for all projects. This plan covers exhausts, green house gasses and dust and mainly covers legal and contractual requirements for air quality'

'Air quality is covered in our EMP document'

'and not on non-road diesel equipment'

''Relatively low emission source relative to other emission sources.'

'Air quality monitored as per DECCW licence for overall site emissions.'

Question	Yes	No
Does your firm have any plans for the abatement of air emissions in any area?	9	4

The majority of firms indicated they have plans for the abatement of air emissions from their operations. These firms were generally from sectors including manufacturing, mining, and waste for which air-emissions are regulated by DECCW.

'Predominantly related to abatement of dust emissions from our operation.'

'We are aware of the increased requirements of greenhouse gas reporting and are considering developing a policy regarding this, however will probably be included in the Environmental and Community policy'

'Gas Management Plan currently being drafted to abate landfill gas emissions.'

Question	Yes	No
Are plans for the abatement of air-emissions from non-road diesel included in this plan?	5	8

The majority of respondents indicated that the abatement of emissions from non-road diesel were not included as part of their overall air-emission abatement plans. Very few specific comments were received from responding companies. The firms who have abatement plans

but indicated that non-road diesel was not included were manufacturing/industrial firms, for whom the emissions from non-road diesel equipment represent a small element of their overall emission profile.

> *'Comments: Currently very few items on our building projects use fuel most are electrically powered.'*

'This is now being looked at during equipment selection process.'

Question	Yes	No
Have any specific measures taken to reduce the air-quality emissions from non-road diesel equipment?	7	6

The majority of firms indicated that they have undertaken specific measures which focus on reducing the air emissions from non-road diesel equipment. The majority of these actions however, focus on fuel use and maintenance practices. Only one of the respondents indicated that the choice of engine and supplier was a factor in the management of air emissions from non-road diesel equipment. This may reflect the lack of information apparently available when sourcing non-road diesel equipment.

> *'Regular maintenance programme. Engine re-powers. Investigations into fuel additives and fuel management systems.'*

> *'Specific measures such as the use of ultra low sulfur diesel fuel and engine efficiency etc. are only adopted if regularly stipulated in client contracts.'*

> *'Plant performance is monitored on a daily basis and manufacture service guidelines are adhered to*.'

Question	Yes	No
Does your firm have any major plans for the replacement of non-road diesel equipment in the foreseeable future?	3	10

The majority of responses indicated that equipment was replaced on an as-needed basis. Only one respondent indicated that there is a larger project underway to replace non-road diesel equipment with equivalent electric equipment.

'There is a project to replace diesel with electric powered loading shovels'.

'Non-road diesel plant will be replaced on an as needs basis, at this stage there are no major plans to replace large quantities of plant.'

'No major but earth moving equipment replaced on a four year cycle.'

Question	Yes	No
Has you firm participated in any of voluntary schemes for the reduction of air emissions?	6	7

The firms which indicated that they have participated in voluntary schemes for the reduction of air emissions listed voluntary actions on air-emissions, or participation in greenhouse gas offset schemes.

'We have undertaken voluntary measures in the area of air emissions'

'Greenhouse Challenge Plus'

'Firm actively involved in the comment/drafting of proposed and current legislation.'

Question	Yes	No
Would your firm be willing to participate in a voluntary scheme for the reduction of air-emissions from non-road diesel equipment?	8	5

The majority of the firms indicated that they would be willing to participate in a voluntary scheme to reduce air emissions from non-road diesel equipment however the additional comments provided by some respondents indicated that clear incentives would be required for participation.

'The scheme would need to provide clear financial benefits to the company. Financial benefits may include a better market reputation, however a scheme would need to be endorsed and promoted by significant government departments.'

'Unnecessary at this point in time as we are grappling with the government's current raft of legislation.'

Question	Mandatory Regulation	Guidelines	Improved Information	Financial Incentives
What do you think the most effective way for the government to reduce air-emissions from non-road diesel engines and diesel equipment	4	7	7	8

* The numbers presented in the table above do not add up to the number of respondents to the survey as some responses indicated more than one option.

Responding firms favoured guidelines, improved information, and financial incentives as effective measures for the government to reduce air-emissions from non-road diesel engines and diesel equipment.

There was, however, a significant minority who favoured mandatory regulation as a means of creating a level playing field for all participants in an industry.

'Regulations which the whole industry has to adhere to and which give clear direction would at least create a level playing field in the market place for all.'

'Guidelines combined with information detailing the benefits of reducing air emissions, which will lead to financial benefits, will be very attractive to private industry.'

'Financial incentives provided by clients are necessary to ensure that companies who reduce air emissions and incur a cost in doing so are not at a disadvantage during the tendering process when compared to companies who do not provide reduced air emissions.'

The following tables present the responses by respondent (identified by industry sector) to enable conclusions to be drawn on differences between the attitudes of companies within the different sectors surveyed.

Awareness and sources of information			
	Are you familiar with the different levels of non-road diesel engine certification?	Does your non-road diesel equipment supplier provide information about the air-emission performance of the equipment it sells?	What sort of information is supplied?
Construction	Not Familiar	No	
Construction	Not Familiar	No	
Construction	Not Familiar	No	
Construction	Somewhat Familiar	Yes	Euro Emission Levels
Airports	Not Familiar	Yes	Air Emission test levels
Ports	Not Familiar	No	
Ports	Not Familiar	No	Limited Information on sales brochures
Waste	Mostly Familiar	Yes	Manufacturer specifications and guidelines
Manufacturing	Not Familiar	No	
Manufacturing	Not Familiar	No	
Manufacturing	Not Familiar	No	
Mining	Somewhat Familiar	Yes	Engine particulate emissions and certification levels
Mining	Somewhat Familiar	Yes	Emission standards

Process for Purchasing Non-road Diesel Equipment			
	Are the air emissions produced by non-road diesel equipment a consideration when purchasing new equipment and replacement engines?	Does your firm have a documented policy governing the purchase of low emission non-road diesel equipment?	Who in your company is responsible for deciding which type of non-road diesel equipment to purchase?
Construction	No	No	Plant manager
Construction	No	No	Plant manager
Construction	Yes	No	Plant manager
Construction	Yes	No	Plant manager
Airports	No	No	Ramp department
Ports	No	No	Operations
Ports	Yes	Yes	Port development management
Waste	Yes	No answer	Fleet and business unit management
Manufacturing	N/A	N/A	Hire/Contractors make purchasing decisions
Manufacturing	Yes	No	Hire/Contractors make purchasing decisions
Manufacturing	No	No	Mechanical Engineer
Mining	Yes	Yes	Maintenance
Mining	Yes	Yes	Operations

Measures taken / being considered to reduce emissions				
	Does your firm have an air quality management plan (As part of EMS or stand alone)?	Does your firm have any plans for the abatement of air emissions in any area?	Are plans for the abatement of air emissions from non-road diesel equipment included in this plan?	Have there been any specific measures taken to reduce the air-quality emissions from non-road diesel equipment?
Construction	No	No	No	No
Construction	Yes	Yes	Yes	Yes
Construction	Yes	No	No	No
Construction	Yes	No	No	Yes
Airports	No	No	No	No
Ports	No	Yes	Yes	Yes
Ports	No	Yes	Yes	No
Waste	Yes	Yes	No	Yes
Manufacturing	Yes	Yes	No	No
Manufacturing	Yes	Yes	No	Yes
Manufacturing	Yes	Yes	No	No
Mining	Yes	Yes	Yes	Yes
Mining	Yes	Yes	Yes	Yes

Trends affecting future non-road diesel equipment purchases				
	Does your firm have any major plans for the replacement of non-road diesel equipment in the foreseeable future?	Have you firm participated in any of voluntary schemes for the reduction of air emissions?	Would your firm be willing to participate in a voluntary scheme for the reduction of air-emissions from non-road diesel equipment?	What do you think the most effective way for the government to reduce air-emissions from non-road diesel engines and diesel equipment
Construction	No	No	Yes	Guidelines, Improved Information, Financial Incentives
Construction	Yes	No	Yes	Guidelines, Improved Information, Financial Incentives
Construction	No	No	No	Mandatory regulation
Construction	No	No	Yes	Guidelines, Improved Information, Financial Incentives
Airports	No	No	No	Financial Incentives
Ports	No	No	Yes	Guidelines, Financial Incentives
Ports	No	Yes	Yes	Mandatory regulation, Guidelines, , Improved Information
Waste	No	Yes	Yes	Guidelines, Improved Information, Financial Incentives
Manufacturing	No	Yes	No	No response
Manufacturing	No	Yes	Yes	Mandatory regulation
Manufacturing	No	Yes	No	Improved Information
Mining	Yes	Yes	Yes	Mandatory regulation, Guidelines, Improved Information, Financial Incentives
Mining	Yes	No	No	Financial Incentives

Appendix H: Emission Factors Applied to Quantify Non-road Diesel Engine Emissions

Particulate matter (PM), oxides of nitrogen (NO_x), sulfur dioxide (SO_2), carbon monoxide (CO) and volatile organic compounds (VOC) emissions were estimated. The first four species are exhaust emissions, emitted directly as a result of diesel fuel combustion in the engine. VOC emissions include both exhaust and evaporative components. The exhaust component comprises hydrocarbons (HCs) emitted as products of combustion, with the evaporative component including compounds released from unburned fuel during engine operation (termed 'crankcase emissions').

Emission factors used in the quantification of non-road diesel engine exhaust and evaporative emissions are given below.

Exhaust Emission Calculation

Exhaust emissions were estimated using the following equation[8]:

$$I_{exh} = EF_{exh} * A * L * P * N$$

I_{exh} = exhaust emissions (grams/hour)

EF_{exh} = exhaust emission factor (gram/hp-hr)

A = equipment activity (operating hours/year)

L = load factor (average portion of rated power used during operation, percent)

P = average rated power (hp)

N = equipment population (units)

Emissions are converted and reported as tonnes/annum.

Equation inputs differ between sub-populations of equipment, such as engine/equipment application and type, rated power class and emissions performance (expressed as non-compliant, tier 1, tier 2, tier 3, tier 4 interim and tier 4 final).

Engine/Equipment Population

The engine/equipment population was based on the inventoried 2008 sales figures as documented in **Section** Error! Reference source not found.. Annual new engine/equipment numbers for the 2009 to 2030 period were assumed equivalent to the numbers sold during 2008. The engine/equipment population does however not remain constant from year to year, but varies as a function of equipment sales and scrappage rates which vary by engine/equipment category.

Scrappage rates were estimated based on the annual operating hours, load factors and the equipment median life[9]. Engines are taken to persist in the equipment population over two

8 US-EPA (2004). Exhaust and Crankcase Emission Factors for Non-road Engine Modelling – Compression Ignition, EPA420-P-04-009, April 2004.

9 The median life represents the period of time over which 50% of the engines in a given model-year cohort are scrapped. The value assumes that engines are run at full load until failure and equipment scrappage follows a scrappage curve.

median lives; during the first median life, 50% of the engines are scrapped, and over the second the remaining 50% are scrapped.

Exhaust Emission Factor

Use was made of NON-ROAD2008 emission factors, as extracted from the model database, with reference to application methodologies documented by the US-EPA. Reference was made to engine application/rating specific annual activity (A), load factors (L), useful life and emission deterioration factors from the US-EPA NON-ROAD2008 model. Information on engine life, load factors and annual hours of operation obtained from some engine/equipment distributors supplying the Australian market confirmed, collated during the emission performance survey, were used to confirm the applicability and supplement the inputs obtained from the NON-ROAD2008 model. Use was made of engine/equipment specific average rated power obtained from the survey conducted, supplemented with values from NON-ROAD2008 where not locally available.

NON-ROAD2008 exhaust emission factors comprise three components: a 'zero-hour' emission level (ZHL), a transient adjustment factor (TAF) and a deterioration factor (DF). The ZHL represents the emission rate for recently manufactured engines with few operating hours and is typically derived directly from laboratory measurements conducted on new or nearly new engines across several commonly used duty cycles.

Given that the emission measurement data used for ZHL have been collected under steady-state conditions (constant engine speed and load), it is necessary to apply a TAF to account for in field operations which typically involve transient conditions (variable speed and load). The baseline emission factor is therefore the product (ZHL* TAF).

Deterioration factors are applied to account for increased emissions during subsequent years. Such factors are calculated and applied as a function of the operational age of the engine/equipment (i.e. A*L). Engines/equipment are assumed to deteriorate to the median engine/equipment life (i.e. life at which 50% of the sub-population is retired), following which they are assumed to maintained at the same state.

The DF for a specific pollutant/tier/year is calculated as follows:

$$DF = 1+d_{pollutant,tier}\ (age_{year}/annualized\ median\ life)$$

Where, *d* is the relative deterioration rate for a given pollutant (% increase in emission factor/% useful life expended) and regulatory tier; *age* is the age of a specific model-year group of engines; and *annualized median life* is calculated as the median life in hours divided by the product of activity and load factor.

NOx Emission Estimation

NO_x emissions were estimated based on the generic exhaust emission calculation given previously.

PM Emission Estimation

In the estimation of PM emissions it is necessary to apply an additional adjustment to the emission factor to account for the in-use sulfur level of diesel fuel. The PM emission factor was adjusted by subtracting S_{PMadj} (g/hp-hr) which is calculated as follows:

$$S_{PMadj} = BSFC * m_{PM,S} * 0.01 * (S_{base} – S_{in\text{-}use})$$

Where,

BSFC = brake-specific fuel consumption (g/fuel/hp-hr)

$m_{SO4,S}$ = constant, representing the sulphate fraction of total particulate sulfur (7.0 g PM SO_4/g PMS)

0.01 = conversion factor from wt% to wt fraction

S_{base} = base sulfur level included in NON-ROAD emission factors (i.e. 0.33 wt%, 3300 ppm for non-compliant and Tier 1 engines; 0.2 wt%, 2000 ppm for Tier 2-3 engines

$S_{in\text{-}use}$ = in use diesel sulfur levels (wt%)

Although some non-road engines and equipment may be operated using fuels that do not meet the Australian Fuel Standard for Automotive Diesel, no quantitative information could be obtained on the use of such fuels (see **Section 5.6**). Given that most large industrial facilities and mines source their diesel from major petrochemical suppliers (compliant fuel), and the absence of quantitative information on off-spec diesel use for non-road applications, it was assumed that fuel compliant with fuel standards are being used for the purpose of estimating emissions. The Fuel Standard (Automotive Diesel) Determination 2001, incorporating the Fuel Standard (Automotive Diesel) Amendment Determination 2009 (No. 1), specified a sulfur content of 10 mg/kg (10 ppm) for the post 1 January 2009 period. This sulfur content was assumed for the 2009 to 2030 period for both base case and controlled emission scenarios.

VOC Emission Estimation

The emission factor for crankcase emissions is estimated as a fraction of the exhaust emission factor as follows: $EF_{crank,HC,year} = 0.02 * EF_{exh,HC,year}$.

Exhaust and crankcase hydrocarbon emissions are converted to VOCs by multiplying the total HC (THC) estimated by 1.053 to account for the addition of oxygenated species to THC. Exhaust and crankcase VOC emissions are then summed.

SO_2 Emissions

SO_2 emissions were estimated based on emission factors given in the Australian National Pollutant Inventory (NPI) Emissions Estimation Technique Manual for Combustion Engines (Version 3.0, June 2008). These emission factors were calculated for various heavy duty diesel vehicles and stationary diesel engines based on the assumption of a fuel sulfur content of 10 ppm (in line with post January 2009 automotive diesel specifications). A synopsis of the emission factors applied is given in **Table H.1**.

Table H.1: Base case (business as usual) emissions from non-road diesel (2020)		
Vehicle/Engine Type		SO_2 Emission Factor g/kWh
Industrial vehicles	Track-type tractor	0.0073
	Wheeled tractor	0.0073
	Wheeled dozer	0.0073
	Scraper	0.0077
	Motor grader	0.0075
	Wheeled loader	0.0075
	Track-type loader	0.0075
	Off-highway truck	0.0077
	Roller	0.085
	Miscellaneous industrial vehicle	0.008
Stationary engines	Large stationary engines (>450 kW)	4.9×10^{-6}
	Small stationary engines (<450 kW)	0.0043

The miscellaneous industrial vehicle emission factor was applied within the agricultural sector for tractors and other self-propelled heavy equipment, and for log skidders within the forestry sector.

Summing of Exhaust Emissions

Exhaust emissions were summed over all engine/equipment types, rated power classes and model-year cohorts as follows[10]:

$$I_{\text{exh,poll}} = \overbrace{\sum}^{\text{sum over all equipment types}} \left[\overbrace{\sum}^{\substack{\text{sum over all rated-power classes} \\ \text{within an equipment type}}} \left[\overbrace{\sum}^{\substack{\text{sum over all model-year cohorts} \\ \text{within a rated-power class}}} \left(\sum \left(E_{\text{exh,poll}} \cdot A \cdot L \cdot P \cdot N \right) \right) \right] \right]$$

Emission inputs used in the exhaust calculations for engine/equipment sub-populations are given in **Appendix I.**

Speciation of PM and VOCs

Detailed PM and VOC speciation profiles are lacking for most non-road diesel engine/equipment sub-populations. The latest (version 4.2) US-EPA Speciate Database is, for example, primarily

10 US-EPA (2004). Exhaust and Crankcase Emission Factors for Non-road Engine Modelling – Compression Ignition, EPA420-P-04-009, April 2004.

restricted to profiles for on-road diesel. Following an extensive review of diesel speciation literature by Hsu and Mullen (2007), Hsu and Divita (2009) highlighted non-road diesel engines as a priority for speciation profile development[11][12].

For the purpose of the current study it was decided to focus on major air toxics for which provision is made in the US-EPA land-based non-road diesel VOC emission estimate, namely benzene, formaldehyde, acetaldehyde, 1.3-butadiene and acrolein. The fractions used for each air toxics pollutant is given in **Table H.2**.

Table H.2: Air toxics as fractions of VOC emissions[13]

Benzene	Formaldehyde	Acetaldehyde	1,3-Butadiene	Acrolein
0.020	0.118	0.053	0.002	0.003

$PM_{2.5}$ emissions were estimated as a component of PM_{10} emissions, the less than 2.5 micrometer fraction being estimated to compose 97% of PM_{10} emissions[14]. This 0.97 $PM_{2.5}$ fraction represents a revision of the earlier fraction of 0.92 used, based on updated analysis of diesel engine size distribution data.

11 Hsu Y and Mullen M (2007). Compilation of Diesel Emissions Speciation Data, Final Report, compiled for the Coordinating Research Council and National Renewable Energy Laboratory by E.H. Pechan & Associates Inc, October 2007.
12 Hsu Y and Divita F (2009). Speciate 4.2, Speciation Database Development Documentation, Prepared for the US EPA Office of Research and Development, EPA/600-R-09/038, June 2009.
13 US-EPA (2004). Exhaust and Crankcase Emission Factors for Non-road Engine Modelling – Compression Ignition, EPA420-P-04-009, April 2004.
14 US-EPA (2004). Exhaust and Crankcase Emission Factors for Non-road Engine Modelling – Compression Ignition, EPA420-P-04-009, April 2004.

Appendix I: New (2008) Non-road Diesel Enging/Equipment Emission Estimation Input Parameters

#NOTE: Emission factors, operating hours, load factors and median lives were allocated and emissions calculated based on engine/equipment-specific engine ratings, with emission factors and hence emissions varying to reflect increased emissions due to engine/equipment deterioration over the 2009-2030 period. To make possible the presentation of information, emission factors, operating hours, load factors and median lives are presented as averages by engine rating class. Similarly, emission factors are presented by engine rating class as averages over specific emission factors allocated by individual engine/equipment power rating and model (i.e. reflecting deterioration factors for 2009 to 2030 models).

Market Segment	Equipment Type / Application	Engine Rating Class (kW)	Standard Complied with (Upper Bound Base Case)	No. of Engines (2020)	No. of Engines (2030)	Median Life (hours)	Hours of Operation (hrs/annum)	Load (%)
Agricultural	Agricultural tractors	56 - 130	Non-compliant	1,036	1,544	4,667	475	59
Agricultural	Agricultural tractors	56 - 130	US Tier 1	23,891	35,630	4,667	475	59
Agricultural	Agricultural tractors	56 - 130	US Tier 2	83,618	124,706	4,667	475	59
Agricultural	Agricultural tractors	56 - 130	US Tier 3	11,945	17,815	4,667	475	59
Agricultural	Combine harvester-threshers	56 - 130	Non-compliant	5,827	9,614	2,500	150	59
Agricultural	Engines for agricultural vehicles	37 - 56	Non-compliant	207	326	4,667	381	59
Agricultural	Engines for 'Other' agricultural applications	37 - 56	Non-compliant	622	978	4,667	381	59
Agricultural	Pumps & Irrigation	<8	Non-compliant	4,001	5,695	2,500	403	43
Agricultural	Pumps & Irrigation	<8	US Tier 2	5,417	7,710	2,500	403	43
Agricultural	Pumps & Irrigation	130 - 560	Non-compliant	568	931	4,667	403	43
Agricultural	Pumps & Irrigation	130 - 560	US Tier 1	332	545	4,667	403	43
Agricultural	Pumps & Irrigation	130 - 560	US Tier 2	127	210	5,056	403	43
Agricultural	Pumps & Irrigation	130 - 560	US Tier 3	146	239	4,959	403	43
Agricultural	Pumps & Irrigation	19 - 37	Non-compliant	58	82	2,500	403	43
Agricultural	Pumps & Irrigation	19 - 37	US Tier 1	58	82	2,500	403	43
Agricultural	Pumps & Irrigation	19 - 37	US Tier 2	1,416	2,015	2,500	403	43
Agricultural	Pumps & Irrigation	19 - 37	US Tier 3	260	370	2,500	403	43
Agricultural	Pumps & Irrigation	37 - 56	Non-compliant	344	564	4,667	403	43
Agricultural	Pumps & Irrigation	37 - 56	US Tier 1	344	564	4,667	403	43
Agricultural	Pumps & Irrigation	37 - 56	US Tier 2	538	882	4,667	403	43
Agricultural	Pumps & Irrigation	37 - 56	US Tier 3	323	529	4,667	403	43
Agricultural	Pumps & Irrigation	56 - 130	Non-compliant	518	850	4,667	403	43
Agricultural	Pumps & Irrigation	56 - 130	US Tier 1	404	663	4,667	403	43
Agricultural	Pumps & Irrigation	56 - 130	US Tier 2	613	1,005	4,667	403	43
Agricultural	Pumps & Irrigation	56 - 130	US Tier 3	314	515	4,667	403	43
Agricultural	Pumps & Irrigation	8 - 19	Non-compliant	10,904	14,988	2,500	472	43
Agricultural	Pumps & Irrigation	8 - 19	US Tier 2	11,532	16,414	2,500	403	43
Agricultural	Pumps & Irrigation	8 - 19	US Tier 3	29	41	2,500	403	43
Agricultural	Self Propelled Sprayers	56 - 130	Non-compliant	3,705	6,389	2,500	90	59
Agricultural	Windrowers	56 - 130	Non-compliant	735	1,252	2,500	110	59
Forestry	Log Skidder	130 - 560	Non-compliant	37	37	4,667	1,276	59

Market Segment	Equipment Type / Application	Engine Rating Class (kW)	Standard Complied with (Upper Bound Base Case)	No. of Engines (2020)	No. of Engines (2030)	Median Life (hours)	Hours of Operation (hrs/annum)	Load (%)
Forestry	Log Skidder	130 - 560	US Tier 2	49	49	4,667	1,276	59
Forestry	Log Skidder	130 - 560	US Tier 3	74	74	4,667	1,276	59
Forestry	Log Skidder	56 - 130	US Tier 2	6	6	4,667	1,276	59
Forestry	Log Skidder	56 - 130	US Tier 3	19	19	4,667	1,276	59
General Industrial	Cranes and lifting equipment	19 - 37	Non-compliant	482	482	2,500	990	43
General Industrial	Cranes and lifting equipment	19 - 37	US Tier 1	16,527	16,527	2,500	990	43
General Industrial	Forklifts	56 - 130	US Tier 2	2,843	2,843	4,667	1,700	59
General Industrial	Miscellaneous Industrial Engines	130 - 560	Non-compliant	787	1,095	5,834	878	43
General Industrial	Miscellaneous Industrial Engines	130 - 560	US Tier 2	774	1,030	4,667	878	43
General Industrial	Miscellaneous Industrial Engines	130 - 560	US Tier 3	9	12	4,667	878	43
General Industrial	Miscellaneous Industrial Engines	19 - 37	Non-compliant	377	378	2,500	878	43
General Industrial	Miscellaneous Industrial Engines	19 - 37	US Tier 2	1,606	1,611	2,500	878	43
General Industrial	Miscellaneous Industrial Engines	19 - 37	US Tier 3	449	451	2,500	878	43
General Industrial	Miscellaneous Industrial Engines	37 - 56	Non-compliant	1,567	2,085	4,667	878	43
General Industrial	Miscellaneous Industrial Engines	37 - 56	US Tier 2	2,148	2,857	4,667	878	43
General Industrial	Miscellaneous Industrial Engines	37 - 56	US Tier 3	645	858	4,667	878	43
General Industrial	Miscellaneous Industrial Engines	56 - 130	Non-compliant	3,042	4,047	4,667	878	43
General Industrial	Miscellaneous Industrial Engines	56 - 130	US Tier 2	1,097	1,459	4,667	878	43
General Industrial	Miscellaneous Industrial Engines	56 - 130	US Tier 3	9	12	4,667	878	43
General Industrial	Miscellaneous Industrial Engines	8 - 19	US Tier 2	747	749	2,500	878	43
General Industrial	Miscellaneous Industrial Engines	8 - 19	US Tier 3	258	259	2,500	878	43
General Industrial	Other Industrial Engines	<8	US Tier 2	5,795	5,813	2,500	878	43
General Industrial	Other Industrial Engines	<8	US Tier 3	254	255	2,500	878	43
General Industrial	Other Industrial Engines	<8	US Tier 4	85	85	2,500	878	43
General Industrial	Other Industrial Engines	>560	US Tier 2	173	265	7,000	878	43
General Industrial	Other Industrial Engines	>560	US Tier 3	71	109	7,000	878	43
General Industrial	Other Industrial Engines	>560	US Tier 4	142	218	7,000	878	43
General Industrial	Other Industrial Engines	130 - 560	Non-compliant	157	208	4,667	878	43
General Industrial	Other Industrial Engines	130 - 560	US Tier 1	74	98	4,667	878	43
General Industrial	Other Industrial Engines	130 - 560	US Tier 2	341	454	4,667	878	43
General Industrial	Other Industrial Engines	130 - 560	US Tier 3	280	373	4,667	878	43
General Industrial	Other Industrial Engines	130 - 560	US Tier 4	273	363	4,667	878	43
General Industrial	Other Industrial Engines	19 - 37	US Tier 2	2,449	2,457	2,500	878	43
General Industrial	Other Industrial Engines	19 - 37	US Tier 3	271	272	2,500	878	43
General Industrial	Other Industrial Engines	19 - 37	US Tier 4	426	427	2,500	878	43
General Industrial	Other Industrial Engines	37 - 56	Non-compliant	1,567	2,085	4,667	878	43
General Industrial	Other Industrial Engines	37 - 56	US Tier 1	1,567	2,085	4,667	878	43
General Industrial	Other Industrial Engines	37 - 56	US Tier 2	572	760	4,667	878	43
General Industrial	Other Industrial Engines	37 - 56	US Tier 3	88	118	4,667	878	43

Market Segment	Equipment Type / Application	Engine Rating Class (kW)	Standard Complied with (Upper Bound Base Case)	No. of Engines (2020)	No. of Engines (2030)	Median Life (hours)	Hours of Operation (hrs/annum)	Load (%)
General Industrial	Other Industrial Engines	37 - 56	US Tier 4	612	814	4,667	878	43
General Industrial	Other Industrial Engines	56 - 130	Non-compliant	575	765	4,667	878	43
General Industrial	Other Industrial Engines	56 - 130	US Tier 1	288	383	4,667	878	43
General Industrial	Other Industrial Engines	56 - 130	US Tier 2	1,318	1,754	4,667	878	43
General Industrial	Other Industrial Engines	56 - 130	US Tier 3	260	346	4,667	878	43
General Industrial	Other Industrial Engines	56 - 130	US Tier 4	195	260	4,667	878	43
General Industrial	Other Industrial Engines	8 - 19	US Tier 2	8,373	8,398	2,500	878	43
General Industrial	Other Industrial Engines	8 - 19	US Tier 3	330	331	2,500	878	43
General Industrial	Other Industrial Engines	8 - 19	US Tier 4	537	538	2,500	878	43
General Industrial	Industrial Pumps	<8	US Tier 2	58	82	2,500	403	43
General Industrial	Industrial Pumps	>560	Non-compliant	45	76	7,000	403	43
General Industrial	Industrial Pumps	>560	US Tier 4	492	841	7,000	403	43
General Industrial	Industrial Pumps	130 - 560	Non-compliant	4,086	6,699	4,667	403	43
General Industrial	Industrial Pumps	130 - 560	US Tier 1	360	591	4,667	403	43
General Industrial	Industrial Pumps	130 - 560	US Tier 2	448	735	4,667	403	43
General Industrial	Industrial Pumps	130 - 560	US Tier 3	241	395	4,667	403	43
General Industrial	Industrial Pumps	130 - 560	US Tier 4	1,639	2,687	4,667	403	43
General Industrial	Industrial Pumps	19 - 37	Non-compliant	5,576	7,936	2,500	403	43
General Industrial	Industrial Pumps	19 - 37	US Tier 1	29	41	2,500	403	43
General Industrial	Industrial Pumps	19 - 37	US Tier 2	853	1,214	2,500	403	43
General Industrial	Industrial Pumps	19 - 37	US Tier 3	302	430	2,500	403	43
General Industrial	Industrial Pumps	19 - 37	US Tier 4	289	411	2,500	403	43
General Industrial	Industrial Pumps	37 - 56	Non-compliant	3,000	4,919	4,667	403	43
General Industrial	Industrial Pumps	37 - 56	US Tier 1	548	899	4,667	403	43
General Industrial	Industrial Pumps	37 - 56	US Tier 2	387	635	4,667	403	43
General Industrial	Industrial Pumps	37 - 56	US Tier 4	86	141	4,667	403	43
General Industrial	Industrial Pumps	56 - 130	Non-compliant	3,877	6,357	4,667	403	43
General Industrial	Industrial Pumps	56 - 130	US Tier 1	256	420	4,667	403	43
General Industrial	Industrial Pumps	56 - 130	US Tier 2	1,774	2,909	4,667	403	43
General Industrial	Industrial Pumps	56 - 130	US Tier 3	142	233	4,667	403	43
General Industrial	Industrial Pumps	56 - 130	US Tier 4	778	1,276	4,667	403	43
General Industrial	Industrial Pumps	8 - 19	Non-compliant	2,099	2,988	2,500	403	43
General Industrial	Industrial Pumps	8 - 19	US Tier 2	763	1,086	2,500	403	43
General Industrial	Industrial Pumps	8 - 19	US Tier 3	1,198	1,705	2,500	403	43
General Industrial	Industrial Pumps	8 - 19	US Tier 4	543	773	2,500	403	43
General Industrial	Airport tractors	56 - 130	US Tier 2	3,542	3,542	4,667	1,257	59
Heavy Industrial	Backhoe Loader	19 - 37	US Tier 2	21	32	4,667	1,135	21
Heavy Industrial	Backhoe Loader	37 - 56	US Tier 3	10	16	4,667	1,135	21
Heavy Industrial	Backhoe Loader	56 - 130	EU Stage II	144	223	4,667	1,135	21

Market Segment	Equipment Type / Application	Engine Rating Class (kW)	Standard Complied with (Upper Bound Base Case)	No. of Engines (2020)	No. of Engines (2030)	Median Life (hours)	Hours of Operation (hrs/annum)	Load (%)
Heavy Industrial	Backhoe Loader	56 - 130	EU Stage III	113	175	4,667	1,135	21
Heavy Industrial	Backhoe Loader	56 - 130	Unknown (assumed Non-compliant)	31	48	4,667	1,135	21
Heavy Industrial	Backhoe Loader	56 - 130	US Tier 2	123	191	4,667	1,135	21
Heavy Industrial	Backhoe Loader	56 - 130	US Tier 3	2,527	3,923	4,667	1,135	21
Heavy Industrial	Backhoe Loader	56 - 130	US Tier 3 / EU stage III	205	319	4,667	1,135	21
Heavy Industrial	Backhoe Loader	56 - 130	US Tier 4	144	223	4,667	1,135	21
Heavy Industrial	Crawler Loader	130 - 560	US Tier 3	10	16	4,667	1,135	21
Heavy Industrial	Crawler Loader	56 - 130	US Tier 1	10	16	4,667	1,135	21
Heavy Industrial	Crawler Loader	56 - 130	US Tier 2	10	16	4,667	1,135	21
Heavy Industrial	Crawler Loader	56 - 130	US Tier 3	134	207	4,667	1,135	21
Heavy Industrial	Construction & Mining Engines	<8	US Tier 2	1,727	1,727	2,500	2,500	59
Heavy Industrial	Construction & Mining Engines	>560	US Tier 2	367	367	7,000	2,500	59
Heavy Industrial	Construction & Mining Engines	>560	US Tier 3	81	81	7,000	2,500	59
Heavy Industrial	Construction & Mining Engines	>560	US Tier 4	86	86	7,000	2,500	59
Heavy Industrial	Construction & Mining Engines	130 - 560	Non-compliant	216	216	4,667	2,500	59
Heavy Industrial	Construction & Mining Engines	130 - 560	US Tier 1	141	141	4,667	2,500	59
Heavy Industrial	Construction & Mining Engines	130 - 560	US Tier 2	1,907	1,907	4,768	2,500	59
Heavy Industrial	Construction & Mining Engines	130 - 560	US Tier 3	579	579	4,879	2,500	59
Heavy Industrial	Construction & Mining Engines	130 - 560	US Tier 4	773	773	4,667	2,500	59
Heavy Industrial	Construction & Mining Engines	19 - 37	Non-compliant	5	5	2,500	2,500	59
Heavy Industrial	Construction & Mining Engines	19 - 37	US Tier 1	5	5	2,500	2,500	59
Heavy Industrial	Construction & Mining Engines	19 - 37	US Tier 2	393	393	2,500	2,500	59
Heavy Industrial	Construction & Mining Engines	19 - 37	US Tier 3	15	15	2,500	2,500	59
Heavy Industrial	Construction & Mining Engines	19 - 37	US Tier 4	18	18	2,500	2,500	59
Heavy Industrial	Construction & Mining Engines	37 - 56	Non-compliant	22	22	4,667	2,500	59
Heavy Industrial	Construction & Mining Engines	37 - 56	US Tier 1	22	22	4,667	2,500	59
Heavy Industrial	Construction & Mining Engines	37 - 56	US Tier 2	134	134	4,667	2,500	59
Heavy Industrial	Construction & Mining Engines	37 - 56	US Tier 3	38	38	4,667	2,500	59
Heavy Industrial	Construction & Mining Engines	37 - 56	US Tier 4	38	38	4,667	2,500	59
Heavy Industrial	Construction & Mining Engines	56 - 130	Non-compliant	2,798	3,782	4,150	2,027	59
Heavy Industrial	Construction & Mining Engines	56 - 130	US Tier 1	101	101	4,667	2,500	59
Heavy Industrial	Construction & Mining Engines	56 - 130	US Tier 2	347	347	4,667	2,500	59
Heavy Industrial	Construction & Mining Engines	56 - 130	US Tier 3	154	154	4,667	2,500	59
Heavy Industrial	Construction & Mining Engines	56 - 130	US Tier 4	88	88	4,667	2,500	59
Heavy Industrial	Construction & Mining Engines	8 - 19	US Tier 2	513	513	2,500	2,500	59
Heavy Industrial	Construction & Mining Engines	8 - 19	US Tier 3	30	30	2,500	2,500	59
Heavy Industrial	Construction & Mining Engines	8 - 19	US Tier 4	40	40	2,500	2,500	59

Market Segment	Equipment Type / Application	Engine Rating Class (kW)	Standard Complied with (Upper Bound Base Case)	No. of Engines (2020)	No. of Engines (2030)	Median Life (hours)	Hours of Operation (hrs/annum)	Load (%)
Heavy Industrial	Miscellaneous Construction & Mining Equipment	130 - 560	Non-compliant	357	490	7,000	899	59
Heavy Industrial	Miscellaneous Construction & Mining Equipment	56 - 130	Non-compliant	13,535	17,892	4,667	855	59
Heavy Industrial	Dozers	>560	US Tier 1	122	168	7,000	899	59
Heavy Industrial	Dozers	>560	US Tier 2	461	632	7,000	899	59
Heavy Industrial	Dozers	>560	US Tier 3	75	103	7,000	899	59
Heavy Industrial	Dozers	130 - 560	Unknown (assumed Non-compliant)	8	9	4,667	899	59
Heavy Industrial	Dozers	130 - 560	US Tier 1	24	26	4,667	899	59
Heavy Industrial	Dozers	130 - 560	US Tier 2	16	18	5,834	899	59
Heavy Industrial	Dozers	130 - 560	US Tier 3	1,134	1,473	5,834	899	59
Heavy Industrial	Dozers	56 - 130	US Tier 2	16	18	4,667	899	59
Heavy Industrial	Dozers	56 - 130	US Tier 3	152	167	4,667	899	59
Heavy Industrial	Off-highway dump trucks	>560	US Tier 1	-	-	7,000	1,641	59
Heavy Industrial	Off-highway dump trucks	>560	US Tier 2	1,753	1,780	7,000	1,641	59
Heavy Industrial	Off-highway dump trucks	>560	US Tier 3	873	886	7,000	1,641	59
Heavy Industrial	Off-highway dump trucks	130 - 560	US Tier 2 / EU stage II	7	7	7,000	1,641	59
Heavy Industrial	Off-highway dump trucks	130 - 560	US Tier 3	1,263	1,282	7,000	1,641	59
Heavy Industrial	Off-highway dump trucks	130 - 560	US Tier 3 / EU stage III	1,034	1,050	6,708	1,641	59
Heavy Industrial	Hydraulic excavators	<8	US Tier 3	43	43	2,500	1,092	59
Heavy Industrial	Hydraulic excavators	>560	US Tier 2	467	576	7,000	1,092	59
Heavy Industrial	Hydraulic excavators	>560	US Tier 3	141	174	7,000	1,092	59
Heavy Industrial	Hydraulic excavators	130 - 560	Non-compliant	43	43	4,667	1,092	59
Heavy Industrial	Hydraulic excavators	130 - 560	US Tier 2	412	419	4,667	1,092	59
Heavy Industrial	Hydraulic excavators	130 - 560	US Tier 2 / EU stage II	233	242	5,515	1,092	59
Heavy Industrial	Hydraulic excavators	130 - 560	US Tier 3	2,933	3,143	5,667	1,092	59
Heavy Industrial	Hydraulic excavators	130 - 560	US Tier 3 / EU stage III	1,909	2,056	5,334	1,092	59
Heavy Industrial	Hydraulic excavators	130 - 560	US Tier 3 / EU Stage IIIa	412	419	4,667	1,092	59
Heavy Industrial	Hydraulic excavators	19 - 37	US Tier 2	829	829	2,500	1,092	59
Heavy Industrial	Hydraulic excavators	19 - 37	US Tier 2 / EU stage II	572	572	2,500	1,092	59
Heavy Industrial	Hydraulic excavators	19 - 37	US Tier 3	1,639	1,639	2,500	1,092	59
Heavy Industrial	Hydraulic excavators	19 - 37	US Tier 4	2,535	2,535	2,500	1,092	59
Heavy Industrial	Hydraulic excavators	37 - 56	EU Stage II	43	43	4,667	1,092	59

Market Segment	Equipment Type / Application	Engine Rating Class (kW)	Standard Complied with (Upper Bound Base Case)	No. of Engines (2020)	No. of Engines (2030)	Median Life (hours)	Hours of Operation (hrs/annum)	Load (%)
Heavy Industrial	Hydraulic excavators	37 - 56	US Tier 2	426	433	4,667	1,092	59
Heavy Industrial	Hydraulic excavators	37 - 56	US Tier 2 / EU stage II	235	238	4,667	1,092	59
Heavy Industrial	Hydraulic excavators	37 - 56	US Tier 3	1,286	1,306	4,667	1,092	59
Heavy Industrial	Hydraulic excavators	37 - 56	US Tier 3 / EU stage III	121	123	4,667	1,092	59
Heavy Industrial	Hydraulic excavators	37 - 56	US Tier 4	576	585	4,667	1,092	59
Heavy Industrial	Hydraulic excavators	56 - 130	Non-compliant	99	101	4,667	1,092	59
Heavy Industrial	Hydraulic excavators	56 - 130	US Tier 2	867	880	4,667	1,092	59
Heavy Industrial	Hydraulic excavators	56 - 130	US Tier 2 / EU stage II	426	433	4,667	1,092	59
Heavy Industrial	Hydraulic excavators	56 - 130	US Tier 3	4,108	4,171	4,667	1,092	59
Heavy Industrial	Hydraulic excavators	56 - 130	US Tier 3 / EU stage III	640	650	4,667	1,092	59
Heavy Industrial	Hydraulic excavators	56 - 130	US Tier 3 / EU Stage IIIa	227	231	4,667	1,092	59
Heavy Industrial	Hydraulic excavators	8 - 19	US Tier 1	51	51	2,500	1,092	59
Heavy Industrial	Hydraulic excavators	8 - 19	US Tier 2	424	424	2,500	1,092	59
Heavy Industrial	Hydraulic excavators	8 - 19	US Tier 2 / EU stage II	66	66	2,500	1,092	59
Heavy Industrial	Hydraulic excavators	8 - 19	US Tier 3	1,433	1,433	2,500	1,092	59
Heavy Industrial	Hydraulic excavators	8 - 19	US Tier 4	942	942	2,500	1,092	59
Heavy Industrial	Hydraulic excavators	8 - 19	US Tier 4	191	191	2,500	1,092	59
Heavy Industrial	Landfill and Earthworks	130 - 560	US Tier 2	9	11	7,000	1,092	59
Heavy Industrial	Landfill and Earthworks	130 - 560	US Tier 3	120	145	6,222	1,092	59
Heavy Industrial	Motorgrader	130 - 560	US Tier 2	604	644	4,959	962	59
Heavy Industrial	Motorgrader	130 - 560	US Tier 3	1,536	1,652	4,846	962	59
Heavy Industrial	Motorgrader	130 - 560	US Tier 3 / EU stage III	209	221	4,667	962	59
Heavy Industrial	Motorgrader	56 - 130	US Tier 2	131	139	4,667	962	59
Heavy Industrial	Motorgrader	56 - 130	US Tier 3	1,089	1,156	4,667	962	59
Heavy Industrial	Road Roller	<8	Non-compliant	11	11	2,500	760	59
Heavy Industrial	Road Roller	130 - 560	US Tier 2	1,136	1,364	4,667	760	59
Heavy Industrial	Road Roller	130 - 560	US Tier 3	9	10	4,667	760	59
Heavy Industrial	Road Roller	130 - 560	US Tier 3 / EU stage III	9	10	4,667	760	59
Heavy Industrial	Road Roller	19 - 37	EU Stage II	245	245	2,500	760	59
Heavy Industrial	Road Roller	19 - 37	Non-compliant	251	251	2,500	760	59
Heavy Industrial	Road Roller	19 - 37	US Tier 2	178	178	2,500	760	59
Heavy Industrial	Road Roller	19 - 37	US Tier 2 / EU stage II	11	11	2,500	760	59

Market Segment	Equipment Type / Application	Engine Rating Class (kW)	Standard Complied with (Upper Bound Base Case)	No. of Engines (2020)	No. of Engines (2030)	Median Life (hours)	Hours of Operation (hrs/annum)	Load (%)
Heavy Industrial	Road Roller	19 - 37	US Tier 3 / EU stage III	11	11	2,500	760	59
Heavy Industrial	Road Roller	19 - 37	US Tier 4	122	122	2,500	760	59
Heavy Industrial	Road Roller	37 - 56	US Tier 2 / EU stage II	-	-	4,667	760	59
Heavy Industrial	Road Roller	56 - 130	EU Stage I	35	42	4,667	760	59
Heavy Industrial	Road Roller	56 - 130	Non-compliant	17	21	4,667	760	59
Heavy Industrial	Road Roller	56 - 130	US Tier 2	2,844	3,415	4,667	760	59
Heavy Industrial	Road Roller	56 - 130	US Tier 3	607	729	4,667	760	59
Heavy Industrial	Road Roller	56 - 130	US Tier 3 / EU stage III	147	177	4,667	760	59
Heavy Industrial	Road Roller	8 - 19	Non-compliant	17	17	2,500	760	59
Heavy Industrial	Road Roller	8 - 19	US Tier 2	45	45	2,500	760	59
Heavy Industrial	Road Roller	8 - 19	US Tier 3 / EU stage III	-	-	2,500	760	59
Heavy Industrial	Road Roller	8 - 19	US Tier 4	95	95	2,500	760	59
Heavy Industrial	Scraper	130 - 560	US Tier 3	65	89	7,000	914	59
Heavy Industrial	Skid Steer Loaders	19 - 37	US Tier 3	8,928	12,748	2,500	818	21
Heavy Industrial	Skid Steer Loaders	19 - 37	US Tier 4 / EU Stage IIIa / Japanese Tier 3	888	1,268	2,500	818	21
Heavy Industrial	Skid Steer Loaders	19 - 37	US Tier 4	-	-	2,500	818	21
Heavy Industrial	Skid Steer Loaders	37 - 56	EU Stage II	3,993	6,555	4,667	818	21
Heavy Industrial	Skid Steer Loaders	37 - 56	US Tier 1	11	18	4,667	818	21
Heavy Industrial	Skid Steer Loaders	37 - 56	US Tier 2	1,098	1,802	4,667	818	21
Heavy Industrial	Skid Steer Loaders	37 - 56	US Tier 3	6,221	10,213	4,667	818	21
Heavy Industrial	Skid Steer Loaders	37 - 56	US Tier 4 / EU Stage IIIa	-	-	4,667	818	21
Heavy Industrial	Skid Steer Loaders	37 - 56	US Tier 4	4,165	6,838	4,667	818	21
Heavy Industrial	Skid Steer Loaders	56 - 130	US Tier 2	301	495	4,667	818	21
Heavy Industrial	Skid Steer Loaders	56 - 130	US Tier 3	2,970	4,877	4,667	818	21
Heavy Industrial	Skid Steer Loaders	8 - 19	EU Stage II	627	896	2,500	818	21
Heavy Industrial	Skid Steer Loaders	8 - 19	US Tier 2	-	-	2,500	818	21
Heavy Industrial	Skid Steer Loaders	8 - 19	US Tier 3	1,477	2,109	2,500	818	21
Heavy Industrial	Wheel Loaders	>560	US Tier 1	167	244	7,000	761	59
Heavy Industrial	Wheel Loaders	>560	US Tier 2	39	57	7,000	761	59
Heavy Industrial	Wheel Loaders	>560	US Tier 3	98	143	7,000	761	59
Heavy Industrial	Wheel Loaders	130 - 560	US Tier 2	325	401	5,250	761	59
Heavy Industrial	Wheel Loaders	130 - 560	US Tier 2 / EU stage II	9	10	4,667	761	59
Heavy Industrial	Wheel Loaders	130 - 560	US Tier 3	3,092	3,998	5,600	761	59

Market Segment	Equipment Type / Application	Engine Rating Class (kW)	Standard Complied with (Upper Bound Base Case)	No. of Engines (2020)	No. of Engines (2030)	Median Life (hours)	Hours of Operation (hrs/annum)	Load (%)
Heavy Industrial	Wheel Loaders	130 - 560	US Tier 3 / EU stage III	1,015	1,280	5,445	761	59
Heavy Industrial	Wheel Loaders	130 - 560	US Tier 3 / EU Stage IIIa	132	181	5,834	761	59
Heavy Industrial	Wheel Loaders	19 - 37	Non-compliant	100	100	2,500	761	59
Heavy Industrial	Wheel Loaders	19 - 37	US Tier 2	17	17	2,500	761	59
Heavy Industrial	Wheel Loaders	19 - 37	US Tier 4	150	150	2,500	761	59
Heavy Industrial	Wheel Loaders	37 - 56	US Tier 2	9	10	4,667	761	59
Heavy Industrial	Wheel Loaders	37 - 56	US Tier 3	35	42	4,667	761	59
Heavy Industrial	Wheel Loaders	37 - 56	US Tier 3 / EU stage III	35	42	4,667	761	59
Heavy Industrial	Wheel Loaders	56 - 130	Non-compliant	17	21	4,667	761	59
Heavy Industrial	Wheel Loaders	56 - 130	Unknown (assumed Non-compliant)	9	10	4,667	761	59
Heavy Industrial	Wheel Loaders	56 - 130	US Tier 1	61	73	4,667	761	59
Heavy Industrial	Wheel Loaders	56 - 130	US Tier 2	1,187	1,425	4,667	761	59
Heavy Industrial	Wheel Loaders	56 - 130	US Tier 3	1,655	1,986	4,667	761	59
Heavy Industrial	Wheel Loaders	56 - 130	US Tier 3 / EU stage III	1,031	1,237	4,667	761	59
Heavy Industrial	Wheel Loaders	56 - 130	US Tier 3 / EU Stage IIIa	9	10	4,667	761	59
Lawn and Garden	Ride on or tractor lawn mowers	8 - 19	US Tier 1	3,329	4,063	2,500	544	43
Lawn and Garden	Ride on or tractor lawn mowers	8 - 19	US Tier 2	11,652	14,222	2,500	544	43
Lawn and Garden	Ride on or tractor lawn mowers	8 - 19	US Tier 3	1,665	2,032	2,500	544	43
Light Commercial	Air compressors	19 - 37	US Tier 2	913	928	2,500	815	43
Light Commercial	Pressure washers	8 - 19	US Tier 2	335	572	2,500	145	43
Light Commercial	Welders	19 - 37	US Tier 2	8,541	13,094	2,500	643	21
Marine	Fishing Boats	8 - 19	US Tier 2	13	13	2,500	2,000	60
Marine	Pleasure Boats	<8	US Tier 2	9	15	2,500	300	21
Marine	Pleasure Boats	<8	US Tier 3	9	15	2,500	300	21
Marine	Pleasure Boats	<8	US Tier 4	27	46	2,500	300	21
Marine	Pleasure Boats	19 - 37	US Tier 2	2,839	4,847	2,500	300	21
Marine	Pleasure Boats	19 - 37	US Tier 3	27	46	2,500	300	21
Marine	Pleasure Boats	19 - 37	US Tier 4	80	137	2,500	300	21
Marine	Pleasure Boats	8 - 19	US Tier 2	1,723	2,942	2,500	300	21
Marine	Pleasure Boats	8 - 19	US Tier 3	49	84	2,500	300	21
Marine	Pleasure Boats	8 - 19	US Tier 4	147	251	2,500	300	21
Marine	Work Boats	19 - 37	IMP Marine T1	9	9	2,500	2,500	70
Marine	Work Boats	19 - 37	US Tier 2	26	26	2,500	2,500	70

Market Segment	Equipment Type / Application	Engine Rating Class (kW)	Standard Complied with (Upper Bound Base Case)	No. of Engines (2020)	No. of Engines (2030)	Median Life (hours)	Hours of Operation (hrs/annum)	Load (%)
Marine	Work Boats	19 - 37	US Tier 3	1	1	2,500	2,500	70
Marine	Work Boats	19 - 37	US Tier 4	2	2	2,500	2,500	70
Marine	Work Boats	8 - 19	US Tier 2	3	3	2,500	2,500	70
Power Generation Drive	Marine Auxiliary	8 - 19	Non-compliant	1,163	1,750	2,500	338	43
Power Generation Drive	Marine Auxiliary	8 - 19	US Tier 2	2	2	2,500	1,500	35
Power Generation Drive	Marine Auxiliary	8 - 19	US Tier 3	2	2	2,500	1,500	35
Power Generation Drive	Marine Auxiliary	8 - 19	US Tier 4	6	6	2,500	1,500	35
Power Generation Drive	Prime Power	<8	US Tier 2	15	15	2,500	2,000	70
Power Generation Drive	Prime Power	130 - 560	US Tier 2	349	349	4,667	2,000	70
Power Generation Drive	Prime Power	19 - 37	US Tier 2	348	348	2,500	2,000	70
Power Generation Drive	Prime Power	37 - 56	US Tier 2	107	107	4,667	2,000	70
Power Generation Drive	Prime Power	56 - 130	US Tier 2	322	322	4,667	2,000	70
Power Generation Drive	Prime Power	8 - 19	Non-compliant	4,190	6,305	2,500	338	43
Power Generation Drive	Prime Power	8 - 19	US Tier 2	865	865	2,500	2,000	70
Power Generation Drive	Standby Power	<8	Non-compliant	23	27	2,500	300	80
Power Generation Drive	Standby Power	<8	US Tier 2	428	515	2,500	300	80
Power Generation Drive	Standby Power	>560	US Tier 2	41	64	4,667	300	80
Power Generation Drive	Standby Power	130 - 560	US Tier 2	41	64	4,667	300	80
Power Generation Drive	Standby Power	19 - 37	US Tier 2	1,197	1,438	2,500	300	80
Power Generation Drive	Standby Power	19 - 37	US Tier 4	798	959	2,500	300	80
Power Generation Drive	Standby Power	37 - 56	US Tier 2	205	318	4,667	300	80
Power Generation Drive	Standby Power	37 - 56	US Tier 4	164	254	4,667	300	80
Power Generation Drive	Standby Power	56 - 130	US Tier 2	103	159	4,667	300	80
Power Generation Drive	Standby Power	56 - 130	US Tier 3	21	32	4,667	300	80
Power Generation Drive	Standby Power	56 - 130	US Tier 4	62	95	4,667	300	80
Power Generation Drive	Standby Power	8 - 19	Non-compliant	1,325	1,896	2,500	313	68
Power Generation Drive	Standby Power	8 - 19	US Tier 2	6,202	7,453	2,500	300	80
Power Generation Drive	Standby Power	8 - 19	US Tier 3	73	88	2,500	300	80
Power Generation Drive	Standby Power	8 - 19	US Tier 4	1,051	1,263	2,500	300	80
Power Generation Sets	Miscellaneous Gen sets	>560	Non-compliant	254	254	7,000	1,580	70
Power Generation Sets	Miscellaneous Gen sets	130 - 560	Non-compliant	407	407	4,667	1,580	70
Power Generation Sets	Miscellaneous Gen sets	130 - 560	US Tier 1	13	13	4,667	1,580	70
Power Generation Sets	Miscellaneous Gen sets	130 - 560	US Tier 2	97	97	4,667	1,580	70
Power Generation Sets	Miscellaneous Gen sets	19 - 37	US Tier 2	358	358	2,500	1,580	70
Power Generation Sets	Miscellaneous Gen sets	37 - 56	Non-compliant	733	733	4,667	1,580	70
Power Generation Sets	Miscellaneous Gen sets	37 - 56	US Tier 2	928	928	4,667	1,580	70
Power Generation Sets	Miscellaneous Gen sets	37 - 56	US Tier 3	267	267	4,667	1,580	70
Power Generation Sets	Miscellaneous Gen sets	56 - 130	Non-compliant	55	55	4,667	1,580	70
Power Generation Sets	Miscellaneous Gen sets	56 - 130	US Tier 2	208	208	4,667	1,580	70

Market Segment	Equipment Type / Application	Engine Rating Class (kW)	Standard Complied with (Upper Bound Base Case)	No. of Engines (2020)	No. of Engines (2030)	Median Life (hours)	Hours of Operation (hrs/annum)	Load (%)
Power Generation Sets	Miscellaneous Gen sets	8 - 19	US Tier 2	78	78	2,500	1,580	70
Power Generation Sets	Marine Auxiliary	<8	US Tier 2	10	10	2,500	1,500	35
Power Generation Sets	Marine Auxiliary	<8	US Tier 3	19	19	2,500	1,500	35
Power Generation Sets	Marine Auxiliary	19 - 37	US Tier 2	67	67	2,500	1,500	35
Power Generation Sets	Marine Auxiliary	19 - 37	US Tier 3	38	38	2,500	1,500	35
Power Generation Sets	Marine Auxiliary	8 - 19	Non-compliant	722	1,086	2,500	338	43
Power Generation Sets	Marine Auxiliary	8 - 19	US Tier 2	210	210	2,500	1,500	35
Power Generation Sets	Marine Auxiliary	8 - 19	US Tier 3	277	277	2,500	1,500	35
Power Generation Sets	Prime Power	<8	Non-compliant	55	55	2,500	2,000	70
Power Generation Sets	Prime Power	<8	US Tier 2	106	106	2,500	2,000	70
Power Generation Sets	Prime Power	>560	US Tier 3	170	170	7,000	2,000	70
Power Generation Sets	Prime Power	130 - 560	US Tier 3	144	144	5,056	2,000	70
Power Generation Sets	Prime Power	19 - 37	Non-compliant	15	15	2,500	2,000	70
Power Generation Sets	Prime Power	19 - 37	US Tier 2	231	231	2,500	2,000	70
Power Generation Sets	Prime Power	19 - 37	US Tier 3	95	95	2,500	2,000	70
Power Generation Sets	Prime Power	37 - 56	Non-compliant	13	13	4,667	2,000	70
Power Generation Sets	Prime Power	37 - 56	US Tier 3	47	47	4,667	2,000	70
Power Generation Sets	Prime Power	56 - 130	Non-compliant	60	60	4,667	2,000	70
Power Generation Sets	Prime Power	56 - 130	US Tier 3	74	74	4,667	2,000	70
Power Generation Sets	Prime Power	8 - 19	Non-compliant	3,569	5,370	2,500	338	43
Power Generation Sets	Prime Power	8 - 19	US Tier 2	1,074	1,074	2,500	2,000	70
Power Generation Sets	Prime Power	8 - 19	US Tier 3	59	59	2,500	2,000	70
Power Generation Sets	Standby Power	>560	US Tier 3	629	1,042	7,000	300	80
Power Generation Sets	Standby Power	130 - 560	US Tier 3	657	1,018	4,667	300	80
Power Generation Sets	Standby Power	19 - 37	US Tier 3	260	313	2,500	300	80
Power Generation Sets	Standby Power	56 - 130	US Tier 3	185	286	4,667	300	80
Power Generation Sets	Standby Power	8 - 19	Non-compliant	9,362	14,089	2,500	338	43
Power Generation Sets	Standby Power	8 - 19	US Tier 2	94	113	2,500	300	80
Power Generation Sets	Standby Power	8 - 19	US Tier 3	371	446	2,500	300	80
Power Generation Sets	Standby Power	8 - 19	US Tier 4	281	338	2,500	300	80
Vehicle Propulsion	Vehicle Propulsion	8 - 19	Non-compliant	8,940	9,317	2,500	749	43

Market Segment	Equipment Type / Application	Rating Class (kW)	Standard Complied with	Base Case Emission Factors (g/Hp-hr)				
				PM10	CO	THC	SO2	NOX
Agricultural	Agricultural tractors	56 - 130	Non-compliant	1.943	10.465	1.743	0.006	10.222
Agricultural	Agricultural tractors	56 - 130	US Tier 1	0.713	5.539	0.567	0.006	5.102
Agricultural	Agricultural tractors	56 - 130	US Tier 2	0.357	5.539	0.399	0.006	4.285
Agricultural	Agricultural tractors	56 - 130	US Tier 3	0.647	5.539	0.200	0.006	3.297
Agricultural	Combine harvester-threshers	56 - 130	Non-compliant	2.288	4.911	0.987	0.006	10.488

Market Segment	Equipment Type / Application	Rating Class (kW)	Standard Complied with	Base Case Emission Factors (g/Hp-hr)				
				PM10	CO	THC	SO2	NOX
Agricultural	Engines for agricultural vehicles	37 - 56	Non-compliant	2.276	10.236	1.995	0.006	10.146
Agricultural	Engines for 'Other' agricultural applications	37 - 56	Non-compliant	2.276	10.236	1.995	0.006	10.146
Agricultural	Pumps & Irrigation	<8	Non-compliant	1.000	5.000	1.500	0.003	10.000
Agricultural	Pumps & Irrigation	<8	US Tier 2	0.500	4.110	0.550	0.003	4.300
Agricultural	Pumps & Irrigation	130 - 560	Non-compliant	1.510	3.780	2.230	0.003	7.780
Agricultural	Pumps & Irrigation	130 - 560	US Tier 1	0.225	1.030	0.255	0.003	5.800
Agricultural	Pumps & Irrigation	130 - 560	US Tier 2	0.130	0.922	0.170	0.003	4.300
Agricultural	Pumps & Irrigation	130 - 560	US Tier 3	0.150	0.868	0.174	0.003	2.500
Agricultural	Pumps & Irrigation	19 - 37	Non-compliant	0.800	5.000	1.800	0.003	6.900
Agricultural	Pumps & Irrigation	19 - 37	US Tier 1	0.340	1.530	0.280	0.003	4.730
Agricultural	Pumps & Irrigation	19 - 37	US Tier 2	0.340	1.530	0.280	0.003	4.730
Agricultural	Pumps & Irrigation	19 - 37	US Tier 3	0.340	1.530	0.280	0.003	4.730
Agricultural	Pumps & Irrigation	37 - 56	Non-compliant	1.510	3.780	2.230	0.003	7.780
Agricultural	Pumps & Irrigation	37 - 56	US Tier 1	0.470	2.370	0.520	0.003	5.600
Agricultural	Pumps & Irrigation	37 - 56	US Tier 2	0.240	2.370	0.370	0.003	4.700
Agricultural	Pumps & Irrigation	37 - 56	US Tier 3	0.300	2.370	0.180	0.003	3.000
Agricultural	Pumps & Irrigation	56 - 130	Non-compliant	1.510	3.780	2.230	0.003	7.780
Agricultural	Pumps & Irrigation	56 - 130	US Tier 1	0.328	1.245	0.385	0.003	5.637
Agricultural	Pumps & Irrigation	56 - 130	US Tier 2	0.210	1.620	0.355	0.003	4.400
Agricultural	Pumps & Irrigation	56 - 130	US Tier 3	0.240	1.245	0.180	0.003	2.625
Agricultural	Pumps & Irrigation	8 - 19	Non-compliant	0.940	5.000	1.620	0.003	9.100
Agricultural	Pumps & Irrigation	8 - 19	US Tier 2	0.408	3.330	0.506	0.003	4.356
Agricultural	Pumps & Irrigation	8 - 19	US Tier 3	0.500	4.110	0.550	0.003	4.300
Agricultural	Self Propelled Sprayers	56 - 130	Non-compliant	2.276	8.843	2.447	0.006	7.097
Agricultural	Windrowers	56 - 130	Non-compliant	2.276	4.911	0.987	0.006	10.488
Forestry	Log Skidder	130 - 560	Non-compliant	1.352	6.089	0.662	0.006	10.308
Forestry	Log Skidder	130 - 560	US Tier 2	0.196	1.744	0.336	0.006	3.648
Forestry	Log Skidder	130 - 560	US Tier 3	0.323	1.744	0.200	0.006	2.746
Forestry	Log Skidder	56 - 130	US Tier 2	0.270	2.035	0.368	0.006	3.743
Forestry	Log Skidder	56 - 130	US Tier 3	0.470	2.035	0.200	0.006	2.746
General Industrial	Cranes and lifting equipment	19 - 37	Non-compliant	0.800	5.000	1.800	0.006	6.900
General Industrial	Cranes and lifting equipment	19 - 37	US Tier 1	0.340	1.530	0.280	0.006	4.730
General Industrial	Forklifts	56 - 130	US Tier 2	0.357	5.539	0.399	0.006	4.285
General Industrial	Miscellaneous Industrial Engines	130 - 560	Non-compliant	1.000	3.030	1.120	0.006	14.000
General Industrial	Miscellaneous Industrial Engines	130 - 560	US Tier 2	0.130	0.840	0.170	0.006	4.340
General Industrial	Miscellaneous Industrial Engines	130 - 560	US Tier 3	0.150	0.750	0.180	0.006	2.500
General Industrial	Miscellaneous Industrial Engines	19 - 37	Non-compliant	0.800	5.000	1.800	0.006	6.900
General Industrial	Miscellaneous Industrial Engines	19 - 37	US Tier 2	0.340	1.530	0.280	0.006	4.730
General Industrial	Miscellaneous Industrial Engines	19 - 37	US Tier 3	0.340	1.530	0.280	0.006	4.730
General Industrial	Miscellaneous Industrial Engines	37 - 56	Non-compliant	1.000	3.030	1.120	0.006	14.000
General Industrial	Miscellaneous Industrial Engines	37 - 56	US Tier 2	0.240	2.370	0.370	0.006	4.700
General Industrial	Miscellaneous Industrial Engines	37 - 56	US Tier 3	0.300	2.370	0.180	0.006	3.000
General Industrial	Miscellaneous Industrial Engines	56 - 130	Non-compliant	1.000	3.030	1.120	0.006	14.000
General Industrial	Miscellaneous Industrial Engines	56 - 130	US Tier 2	0.210	1.620	0.355	0.006	4.400

Market Segment	Equipment Type / Application	Rating Class (kW)	Standard Complied with	Base Case Emission Factors (g/Hp-hr)				
				PM10	CO	THC	SO2	NOX
General Industrial	Miscellaneous Industrial Engines	56 - 130	US Tier 3	0.300	2.370	0.180	0.006	3.000
General Industrial	Miscellaneous Industrial Engines	8 - 19	US Tier 2	0.385	3.135	0.495	0.006	4.370
General Industrial	Miscellaneous Industrial Engines	8 - 19	US Tier 3	0.270	2.160	0.440	0.006	4.440
General Industrial	Other Industrial Engines	<8	US Tier 2	0.500	4.110	0.550	0.006	4.300
General Industrial	Other Industrial Engines	<8	US Tier 3	0.500	4.110	0.550	0.006	4.300
General Industrial	Other Industrial Engines	<8	US Tier 4	0.276	4.110	0.550	0.006	4.300
General Industrial	Other Industrial Engines	>560	US Tier 2	0.130	0.760	0.170	0.006	4.100
General Industrial	Other Industrial Engines	>560	US Tier 3	0.130	0.760	0.170	0.006	4.100
General Industrial	Other Industrial Engines	>560	US Tier 4	0.132	0.760	0.170	0.006	4.100
General Industrial	Other Industrial Engines	130 - 560	Non-compliant	1.000	3.030	1.120	0.006	14.000
General Industrial	Other Industrial Engines	130 - 560	US Tier 1	0.238	0.890	0.283	0.006	5.690
General Industrial	Other Industrial Engines	130 - 560	US Tier 2	0.130	0.822	0.198	0.006	4.272
General Industrial	Other Industrial Engines	130 - 560	US Tier 3	0.150	0.790	0.176	0.006	2.500
General Industrial	Other Industrial Engines	130 - 560	US Tier 4	0.150	0.800	0.174	0.006	2.500
General Industrial	Other Industrial Engines	19 - 37	US Tier 2	0.340	1.530	0.280	0.006	4.730
General Industrial	Other Industrial Engines	19 - 37	US Tier 3	0.340	1.530	0.280	0.006	4.730
General Industrial	Other Industrial Engines	19 - 37	US Tier 4	0.202	1.530	0.280	0.006	4.730
General Industrial	Other Industrial Engines	37 - 56	Non-compliant	1.000	3.030	1.120	0.006	14.000
General Industrial	Other Industrial Engines	37 - 56	US Tier 1	0.470	2.370	0.520	0.006	5.600
General Industrial	Other Industrial Engines	37 - 56	US Tier 2	0.240	2.370	0.370	0.006	4.700
General Industrial	Other Industrial Engines	37 - 56	US Tier 3	0.300	2.370	0.180	0.006	3.000
General Industrial	Other Industrial Engines	37 - 56	US Tier 4	0.202	2.370	0.180	0.006	3.000
General Industrial	Other Industrial Engines	56 - 130	Non-compliant	1.000	3.030	1.120	0.006	14.000
General Industrial	Other Industrial Engines	56 - 130	US Tier 1	0.343	1.370	0.400	0.006	5.633
General Industrial	Other Industrial Engines	56 - 130	US Tier 2	0.210	1.620	0.355	0.006	4.400
General Industrial	Other Industrial Engines	56 - 130	US Tier 3	0.252	1.470	0.180	0.006	2.700
General Industrial	Other Industrial Engines	56 - 130	US Tier 4	0.211	1.620	0.180	0.006	2.750
General Industrial	Other Industrial Engines	8 - 19	US Tier 2	0.401	3.274	0.503	0.006	4.360
General Industrial	Other Industrial Engines	8 - 19	US Tier 3	0.423	3.460	0.513	0.006	4.347
General Industrial	Other Industrial Engines	8 - 19	US Tier 4	0.276	2.940	0.484	0.006	4.384
General Industrial	Industrial Pumps	<8	US Tier 2	0.500	4.110	0.550	0.003	4.300
General Industrial	Industrial Pumps	>560	Non-compliant	1.000	5.000	1.200	0.000	8.000
General Industrial	Industrial Pumps	>560	US Tier 4	0.132	0.760	0.170	0.000	4.100
General Industrial	Industrial Pumps	130 - 560	Non-compliant	1.000	5.000	1.200	0.003	8.000
General Industrial	Industrial Pumps	130 - 560	US Tier 1	0.238	0.890	0.283	0.003	5.690
General Industrial	Industrial Pumps	130 - 560	US Tier 2	0.130	0.814	0.210	0.003	4.243
General Industrial	Industrial Pumps	130 - 560	US Tier 3	0.150	0.795	0.175	0.003	2.500
General Industrial	Industrial Pumps	130 - 560	US Tier 4	0.150	0.810	0.173	0.003	2.500
General Industrial	Industrial Pumps	19 - 37	Non-compliant	0.800	5.000	1.800	0.003	6.900
General Industrial	Industrial Pumps	19 - 37	US Tier 1	0.340	1.530	0.280	0.003	4.730
General Industrial	Industrial Pumps	19 - 37	US Tier 2	0.340	1.530	0.280	0.003	4.730
General Industrial	Industrial Pumps	19 - 37	US Tier 3	0.340	1.530	0.280	0.003	4.730
General Industrial	Industrial Pumps	19 - 37	US Tier 4	0.202	1.530	0.280	0.003	4.730
General Industrial	Industrial Pumps	37 - 56	Non-compliant	1.000	5.000	1.200	0.003	8.000
General Industrial	Industrial Pumps	37 - 56	US Tier 1	0.470	2.370	0.520	0.003	5.600

Market Segment	Equipment Type / Application	Rating Class (kW)	Standard Complied with	Base Case Emission Factors (g/Hp-hr)				
				PM10	CO	THC	SO2	NOX
General Industrial	Industrial Pumps	37 - 56	US Tier 2	0.240	2.370	0.370	0.003	4.700
General Industrial	Industrial Pumps	37 - 56	US Tier 4	0.202	2.370	0.180	0.003	3.000
General Industrial	Industrial Pumps	56 - 130	Non-compliant	1.000	5.000	1.200	0.003	8.000
General Industrial	Industrial Pumps	56 - 130	US Tier 1	0.343	1.370	0.400	0.003	5.633
General Industrial	Industrial Pumps	56 - 130	US Tier 2	0.204	1.470	0.352	0.003	4.340
General Industrial	Industrial Pumps	56 - 130	US Tier 3	0.247	1.370	0.180	0.003	2.667
General Industrial	Industrial Pumps	56 - 130	US Tier 4	0.213	1.470	0.180	0.003	2.700
General Industrial	Industrial Pumps	8 - 19	Non-compliant	0.900	5.000	1.700	0.003	8.500
General Industrial	Industrial Pumps	8 - 19	US Tier 2	0.369	2.996	0.487	0.003	4.380
General Industrial	Industrial Pumps	8 - 19	US Tier 3	0.347	2.810	0.477	0.003	4.393
General Industrial	Industrial Pumps	8 - 19	US Tier 4	0.276	2.810	0.477	0.003	4.393
General Industrial	Airport tractors	56 - 130	US Tier 2	0.271	2.035	0.368	0.003	3.743
Heavy Industrial	Backhoe Loader	19 - 37	US Tier 2	0.824	6.028	0.672	0.006	5.073
Heavy Industrial	Backhoe Loader	37 - 56	US Tier 3	1.043	9.302	0.441	0.006	3.879
Heavy Industrial	Backhoe Loader	56 - 130	EU Stage II	0.578	9.302	0.882	0.006	5.044
Heavy Industrial	Backhoe Loader	56 - 130	EU Stage III	1.043	9.302	0.441	0.006	3.879
Heavy Industrial	Backhoe Loader	56 - 130	Unknown (assumed Non-compliant)	1.611	13.372	2.405	0.006	10.840
Heavy Industrial	Backhoe Loader	56 - 130	US Tier 2	0.578	9.302	0.882	0.006	5.045
Heavy Industrial	Backhoe Loader	56 - 130	US Tier 3	0.979	7.943	0.441	0.006	3.730
Heavy Industrial	Backhoe Loader	56 - 130	US Tier 3 / EU stage III	1.043	9.302	0.441	0.006	3.879
Heavy Industrial	Backhoe Loader	56 - 130	US Tier 4	0.202	2.370	0.180	0.006	3.000
Heavy Industrial	Crawler Loader	130 - 560	US Tier 3	0.529	2.938	0.441	0.006	3.234
Heavy Industrial	Crawler Loader	56 - 130	US Tier 1	1.143	9.302	1.260	0.006	6.014
Heavy Industrial	Crawler Loader	56 - 130	US Tier 2	0.442	3.412	0.819	0.006	4.399
Heavy Industrial	Crawler Loader	56 - 130	US Tier 3	0.764	3.412	0.441	0.006	3.234
Heavy Industrial	Construction & Mining Engines	<8	US Tier 2	0.750	9.624	0.609	0.006	0.551
Heavy Industrial	Construction & Mining Engines	>560	US Tier 2	0.197	1.790	0.179	0.006	0.162
Heavy Industrial	Construction & Mining Engines	>560	US Tier 3	0.235	1.790	0.179	0.006	4.098
Heavy Industrial	Construction & Mining Engines	>560	US Tier 4	0.162	1.170	0.170	0.006	4.330
Heavy Industrial	Construction & Mining Engines	130 - 560	Non-compliant	1.353	10.771	1.103	0.006	10.042
Heavy Industrial	Construction & Mining Engines	130 - 560	US Tier 1	0.363	2.073	0.307	0.006	5.182
Heavy Industrial	Construction & Mining Engines	130 - 560	US Tier 2	0.197	1.963	0.220	0.006	0.199
Heavy Industrial	Construction & Mining Engines	130 - 560	US Tier 3	0.323	1.993	0.186	0.006	4.185
Heavy Industrial	Construction & Mining Engines	130 - 560	US Tier 4	0.221	1.235	0.177	0.006	2.640
Heavy Industrial	Construction & Mining Engines	19 - 37	Non-compliant	1.205	11.705	1.974	0.006	6.289
Heavy Industrial	Construction & Mining Engines	19 - 37	US Tier 1	0.517	3.580	0.305	0.006	4.313
Heavy Industrial	Construction & Mining Engines	19 - 37	US Tier 2	0.517	3.580	0.305	0.006	0.276
Heavy Industrial	Construction & Mining Engines	19 - 37	US Tier 3	0.617	3.580	0.305	0.006	4.722
Heavy Industrial	Construction & Mining Engines	19 - 37	US Tier 4	0.202	1.530	0.280	0.006	4.730
Heavy Industrial	Construction & Mining Engines	37 - 56	Non-compliant	1.353	10.771	1.103	0.006	10.042
Heavy Industrial	Construction & Mining Engines	37 - 56	US Tier 1	0.713	5.539	0.567	0.006	5.102
Heavy Industrial	Construction & Mining Engines	37 - 56	US Tier 2	0.357	5.539	0.399	0.006	0.361
Heavy Industrial	Construction & Mining Engines	37 - 56	US Tier 3	0.647	5.539	0.200	0.006	4.690
Heavy Industrial	Construction & Mining Engines	37 - 56	US Tier 4	0.202	2.370	0.180	0.006	3.000

Market Segment	Equipment Type / Application	Rating Class (kW)	Standard Complied with	Base Case Emission Factors (g/Hp-hr)				
				PM10	CO	THC	SO2	NOX
Heavy Industrial	Construction & Mining Engines	56 - 130	Non-compliant	1.353	10.771	1.103	0.006	10.042
Heavy Industrial	Construction & Mining Engines	56 - 130	US Tier 1	0.517	3.203	0.434	0.006	5.140
Heavy Industrial	Construction & Mining Engines	56 - 130	US Tier 2	0.308	3.536	0.381	0.006	0.345
Heavy Industrial	Construction & Mining Engines	56 - 130	US Tier 3	0.515	2.911	0.200	0.006	4.246
Heavy Industrial	Construction & Mining Engines	56 - 130	US Tier 4	0.275	1.746	0.186	0.006	2.784
Heavy Industrial	Construction & Mining Engines	8 - 19	US Tier 2	0.613	7.800	0.559	0.006	0.505
Heavy Industrial	Construction & Mining Engines	8 - 19	US Tier 3	0.760	8.104	0.567	0.006	4.340
Heavy Industrial	Construction & Mining Engines	8 - 19	US Tier 4	0.276	3.460	0.513	0.006	4.347
Heavy Industrial	Miscellaneous Construction & Mining Equipment	130 - 560	Non-compliant	1.046	5.615	0.987	0.006	9.396
Heavy Industrial	Miscellaneous Construction & Mining Equipment	56 - 130	Non-compliant	1.208	7.141	0.935	0.006	9.272
Heavy Industrial	Dozers	>560	US Tier 1	0.295	1.790	0.315	0.005	5.615
Heavy Industrial	Dozers	>560	US Tier 2	0.196	1.790	0.179	0.005	3.743
Heavy Industrial	Dozers	>560	US Tier 3	0.235	1.790	0.179	0.005	4.098
Heavy Industrial	Dozers	130 - 560	Unknown (assumed Non-compliant)	1.045	5.615	0.987	0.005	9.396
Heavy Industrial	Dozers	130 - 560	US Tier 1	0.381	1.744	0.336	0.005	5.083
Heavy Industrial	Dozers	130 - 560	US Tier 2	0.196	1.859	0.257	0.005	3.800
Heavy Industrial	Dozers	130 - 560	US Tier 3	0.323	1.940	0.189	0.005	2.746
Heavy Industrial	Dozers	56 - 130	US Tier 2	0.270	2.035	0.368	0.005	3.743
Heavy Industrial	Dozers	56 - 130	US Tier 3	0.529	3.203	0.200	0.005	2.929
Heavy Industrial	Off-highway dump trucks	>560	US Tier 1	0.295	1.790	0.315	0.006	5.614
Heavy Industrial	Off-highway dump trucks	>560	US Tier 2	0.196	1.790	0.179	0.006	3.743
Heavy Industrial	Off-highway dump trucks	>560	US Tier 3	0.235	1.790	0.179	0.006	4.098
Heavy Industrial	Off-highway dump trucks	130 - 560	US Tier 2 / EU stage II	0.196	1.974	0.179	0.006	3.952
Heavy Industrial	Off-highway dump trucks	130 - 560	US Tier 3	0.323	2.216	0.179	0.006	2.746
Heavy Industrial	Off-highway dump trucks	130 - 560	US Tier 3 / EU stage III	0.323	1.945	0.181	0.006	2.746
Heavy Industrial	Hydraulic excavators	<8	US Tier 3	0.896	9.624	0.609	0.006	4.295
Heavy Industrial	Hydraulic excavators	>560	US Tier 2	0.196	1.790	0.179	0.006	3.743
Heavy Industrial	Hydraulic excavators	>560	US Tier 3	0.235	1.790	0.179	0.006	4.098
Heavy Industrial	Hydraulic excavators	130 - 560	Non-compliant	1.352	6.089	0.546	0.006	9.804
Heavy Industrial	Hydraulic excavators	130 - 560	US Tier 2	0.196	1.744	0.336	0.006	3.648
Heavy Industrial	Hydraulic excavators	130 - 560	US Tier 2 / EU stage II	0.196	1.828	0.279	0.006	3.759
Heavy Industrial	Hydraulic excavators	130 - 560	US Tier 3	0.323	1.896	0.191	0.006	2.746
Heavy Industrial	Hydraulic excavators	130 - 560	US Tier 3 / EU stage III	0.323	1.810	0.194	0.006	2.746
Heavy Industrial	Hydraulic excavators	130 - 560	US Tier 3 / EU Stage IIIa	0.323	1.744	0.200	0.006	2.746
Heavy Industrial	Hydraulic excavators	19 - 37	US Tier 2	0.516	3.580	0.305	0.006	4.313
Heavy Industrial	Hydraulic excavators	19 - 37	US Tier 2 / EU stage II	0.516	3.580	0.305	0.006	4.313
Heavy Industrial	Hydraulic excavators	19 - 37	US Tier 3	0.617	3.580	0.304	0.006	4.722
Heavy Industrial	Hydraulic excavators	19 - 37	US Tier 4	0.202	1.530	0.280	0.006	4.730
Heavy Industrial	Hydraulic excavators	37 - 56	EU Stage II	0.356	5.539	0.399	0.006	4.285
Heavy Industrial	Hydraulic excavators	37 - 56	US Tier 2	0.356	5.539	0.399	0.006	4.284
Heavy Industrial	Hydraulic excavators	37 - 56	US Tier 2 / EU stage II	0.356	5.539	0.399	0.006	4.284
Heavy Industrial	Hydraulic excavators	37 - 56	US Tier 3	0.646	5.539	0.200	0.006	3.297

Market Segment	Equipment Type / Application	Rating Class (kW)	Standard Complied with	Base Case Emission Factors (g/Hp-hr)				
				PM10	CO	THC	SO2	NOX
Heavy Industrial	Hydraulic excavators	37 - 56	US Tier 3 / EU stage III	0.646	5.539	0.200	0.006	3.297
Heavy Industrial	Hydraulic excavators	37 - 56	US Tier 4	0.202	2.370	0.180	0.006	3.000
Heavy Industrial	Hydraulic excavators	56 - 130	Non-compliant	1.352	6.089	0.546	0.006	9.804
Heavy Industrial	Hydraulic excavators	56 - 130	US Tier 2	0.319	4.006	0.385	0.006	4.048
Heavy Industrial	Hydraulic excavators	56 - 130	US Tier 2 / EU stage II	0.301	3.286	0.379	0.006	3.936
Heavy Industrial	Hydraulic excavators	56 - 130	US Tier 3	0.529	3.203	0.200	0.006	2.929
Heavy Industrial	Hydraulic excavators	56 - 130	US Tier 3 / EU stage III	0.497	2.574	0.200	0.006	2.830
Heavy Industrial	Hydraulic excavators	56 - 130	US Tier 3 / EU Stage IIIa	0.505	2.736	0.200	0.006	2.856
Heavy Industrial	Hydraulic excavators	8 - 19	US Tier 1	0.405	5.064	0.483	0.006	4.047
Heavy Industrial	Hydraulic excavators	8 - 19	US Tier 2	0.492	6.204	0.515	0.006	4.016
Heavy Industrial	Hydraulic excavators	8 - 19	US Tier 2 / EU stage II	0.406	5.064	0.483	0.006	4.047
Heavy Industrial	Hydraulic excavators	8 - 19	US Tier 3	0.514	4.742	0.444	0.006	4.494
Heavy Industrial	Hydraulic excavators	8 - 19	US Tier 4	0.276	2.648	0.468	0.006	4.405
Heavy Industrial	Hydraulic excavators	8 - 19	US Tier 4	0.276	2.160	0.440	0.006	4.440
Heavy Industrial	Landfill and Earthworks	130 - 560	US Tier 2	0.196	1.974	0.179	0.006	3.952
Heavy Industrial	Landfill and Earthworks	130 - 560	US Tier 3	0.323	1.897	0.186	0.006	2.746
Heavy Industrial	Motorgrader	130 - 560	US Tier 2	0.196	1.773	0.316	0.006	3.686
Heavy Industrial	Motorgrader	130 - 560	US Tier 3	0.323	1.762	0.198	0.006	2.746
Heavy Industrial	Motorgrader	130 - 560	US Tier 3 / EU stage III	0.323	1.744	0.200	0.006	2.746
Heavy Industrial	Motorgrader	56 - 130	US Tier 2	0.270	2.035	0.368	0.006	3.743
Heavy Industrial	Motorgrader	56 - 130	US Tier 3	0.470	2.035	0.200	0.006	2.746
Heavy Industrial	Road Roller	<8	Non-compliant	1.512	11.705	1.649	0.063	9.120
Heavy Industrial	Road Roller	130 - 560	US Tier 2	0.208	1.789	0.341	0.063	3.663
Heavy Industrial	Road Roller	130 - 560	US Tier 3	0.323	1.744	0.200	0.063	2.746
Heavy Industrial	Road Roller	130 - 560	US Tier 3 / EU stage III	0.323	1.744	0.200	0.063	2.746
Heavy Industrial	Road Roller	19 - 37	EU Stage II	0.516	3.580	0.305	0.063	4.313
Heavy Industrial	Road Roller	19 - 37	Non-compliant	1.205	11.705	1.974	0.063	6.289
Heavy Industrial	Road Roller	19 - 37	US Tier 2	0.516	3.580	0.305	0.063	4.313
Heavy Industrial	Road Roller	19 - 37	US Tier 2 / EU stage II	0.516	3.580	0.305	0.063	4.313
Heavy Industrial	Road Roller	19 - 37	US Tier 3 / EU stage III	0.617	3.580	0.305	0.063	4.722
Heavy Industrial	Road Roller	19 - 37	US Tier 4	0.202	1.530	0.280	0.063	4.730
Heavy Industrial	Road Roller	37 - 56	US Tier 2 / EU stage II	0.356	5.539	0.399	0.063	4.285
Heavy Industrial	Road Roller	56 - 130	EU Stage I	0.713	5.539	0.567	0.063	5.102
Heavy Industrial	Road Roller	56 - 130	Non-compliant	1.180	7.252	0.882	0.063	8.483
Heavy Industrial	Road Roller	56 - 130	US Tier 2	0.302	3.309	0.379	0.063	3.940
Heavy Industrial	Road Roller	56 - 130	US Tier 3	0.470	2.035	0.200	0.063	2.746
Heavy Industrial	Road Roller	56 - 130	US Tier 3 / EU stage III	0.529	3.203	0.200	0.063	2.929
Heavy Industrial	Road Roller	8 - 19	Non-compliant	1.352	11.705	1.869	0.063	7.752
Heavy Industrial	Road Roller	8 - 19	US Tier 2	0.406	5.064	0.483	0.063	4.047
Heavy Industrial	Road Roller	8 - 19	US Tier 3 / EU stage III	0.485	5.064	0.483	0.063	4.430
Heavy Industrial	Road Roller	8 - 19	US Tier 4	0.276	2.160	0.440	0.063	4.440
Heavy Industrial	Scraper	130 - 560	US Tier 3	0.323	1.974	0.179	0.006	2.746
Heavy Industrial	Skid Steer Loaders	19 - 37	US Tier 3	1.588	10.126	1.466	0.006	6.461
Heavy Industrial	Skid Steer Loaders	19 - 37	US Tier 4 / EU Stage IIIa	0.202	1.530	0.280	0.006	4.730
Heavy Industrial	Skid Steer Loaders	19 - 37	US Tier 4	0.202	1.530	0.280	0.006	4.730

Market Segment	Equipment Type / Application	Rating Class (kW)	Standard Complied with	Base Case Emission Factors (g/Hp-hr)				
				PM10	CO	THC	SO2	NOX
Heavy Industrial	Skid Steer Loaders	37 - 56	EU Stage II	0.926	15.626	1.924	0.006	5.841
Heavy Industrial	Skid Steer Loaders	37 - 56	US Tier 1	1.831	15.626	2.748	0.006	6.963
Heavy Industrial	Skid Steer Loaders	37 - 56	US Tier 2	0.926	15.626	1.924	0.006	5.841
Heavy Industrial	Skid Steer Loaders	37 - 56	US Tier 3	1.682	15.626	0.962	0.006	4.513
Heavy Industrial	Skid Steer Loaders	37 - 56	US Tier 4 / EU Stage IIIa	0.202	2.370	0.180	0.006	3.000
Heavy Industrial	Skid Steer Loaders	37 - 56	US Tier 4	0.202	2.370	0.180	0.006	3.000
Heavy Industrial	Skid Steer Loaders	56 - 130	US Tier 2	0.926	15.626	1.924	0.006	5.841
Heavy Industrial	Skid Steer Loaders	56 - 130	US Tier 3	1.682	15.626	0.962	0.006	4.513
Heavy Industrial	Skid Steer Loaders	8 - 19	EU Stage II	1.044	14.264	2.290	0.006	5.522
Heavy Industrial	Skid Steer Loaders	8 - 19	US Tier 2	1.044	14.264	2.290	0.006	5.522
Heavy Industrial	Skid Steer Loaders	8 - 19	US Tier 3	1.422	12.195	1.878	0.006	6.268
Heavy Industrial	Wheel Loaders	>560	US Tier 1	0.295	1.790	0.315	0.006	5.615
Heavy Industrial	Wheel Loaders	>560	US Tier 2	0.196	1.790	0.179	0.006	3.743
Heavy Industrial	Wheel Loaders	>560	US Tier 3	0.235	1.790	0.179	0.006	4.098
Heavy Industrial	Wheel Loaders	130 - 560	US Tier 2	0.196	1.802	0.297	0.006	3.724
Heavy Industrial	Wheel Loaders	130 - 560	US Tier 2 / EU stage II	0.196	1.744	0.336	0.006	3.648
Heavy Industrial	Wheel Loaders	130 - 560	US Tier 3	0.323	1.874	0.191	0.006	2.746
Heavy Industrial	Wheel Loaders	130 - 560	US Tier 3 / EU stage III	0.323	1.821	0.193	0.006	2.746
Heavy Industrial	Wheel Loaders	130 - 560	US Tier 3 / EU Stage IIIa	0.323	1.859	0.189	0.006	2.746
Heavy Industrial	Wheel Loaders	19 - 37	Non-compliant	1.205	11.705	1.974	0.006	6.289
Heavy Industrial	Wheel Loaders	19 - 37	US Tier 2	0.516	3.580	0.305	0.006	4.313
Heavy Industrial	Wheel Loaders	19 - 37	US Tier 4	0.202	1.530	0.280	0.006	4.730
Heavy Industrial	Wheel Loaders	37 - 56	US Tier 2	0.356	5.539	0.399	0.006	4.285
Heavy Industrial	Wheel Loaders	37 - 56	US Tier 3	0.646	5.539	0.200	0.006	3.297
Heavy Industrial	Wheel Loaders	37 - 56	US Tier 3 / EU stage III	0.646	5.539	0.200	0.006	3.297
Heavy Industrial	Wheel Loaders	56 - 130	Non-compliant	1.217	5.615	0.662	0.006	9.396
Heavy Industrial	Wheel Loaders	56 - 130	Unknown (assumed Non-compliant)	1.217	5.615	0.662	0.006	9.396
Heavy Industrial	Wheel Loaders	56 - 130	US Tier 1	0.565	3.787	0.467	0.006	5.130
Heavy Industrial	Wheel Loaders	56 - 130	US Tier 2	0.285	2.644	0.373	0.006	3.837
Heavy Industrial	Wheel Loaders	56 - 130	US Tier 3	0.495	2.535	0.200	0.006	2.824
Heavy Industrial	Wheel Loaders	56 - 130	US Tier 3 / EU stage III	0.505	2.736	0.200	0.006	2.856
Heavy Industrial	Wheel Loaders	56 - 130	US Tier 3 / EU Stage IIIa	0.470	2.035	0.200	0.006	2.746
Lawn and Garden	Ride on or tractor lawn mowers	8 - 19	US Tier 1	0.330	3.310	0.460	0.006	4.260
Lawn and Garden	Ride on or tractor lawn mowers	8 - 19	US Tier 2	0.330	3.310	0.460	0.006	4.260
Lawn and Garden	Ride on or tractor lawn mowers	8 - 19	US Tier 3	0.330	3.310	0.460	0.006	4.260
Light Commercial	Air compressors	19 - 37	US Tier 2	0.340	1.530	0.280	0.003	4.730
Light Commercial	Pressure washers	8 - 19	US Tier 2	0.270	2.160	0.440	0.003	4.440
Light Commercial	Welders	19 - 37	US Tier 2	0.670	3.940	0.640	0.003	5.340
Marine	Fishing Boats	8 - 19	US Tier 2	0.380	4.110	0.680	0.003	4.390
Marine	Pleasure Boats	<8	US Tier 2	0.380	4.110	0.680	0.003	4.390
Marine	Pleasure Boats	<8	US Tier 3	0.240	4.110	0.430	0.003	4.390
Marine	Pleasure Boats	<8	US Tier 4	0.240	4.110	0.430	0.003	4.390
Marine	Pleasure Boats	19 - 37	US Tier 2	0.230	1.530	0.540	0.003	3.710
Marine	Pleasure Boats	19 - 37	US Tier 3	0.180	1.530	0.410	0.003	3.710

Market Segment	Equipment Type / Application	Rating Class (kW)	Standard Complied with	Base Case Emission Factors (g/Hp-hr)				
				PM10	CO	THC	SO2	NOX
Marine	Pleasure Boats	19 - 37	US Tier 4	0.180	1.530	0.410	0.003	2.320
Marine	Pleasure Boats	8 - 19	US Tier 2	0.271	2.996	0.411	0.003	3.956
Marine	Pleasure Boats	8 - 19	US Tier 3	0.215	3.135	0.320	0.003	4.010
Marine	Pleasure Boats	8 - 19	US Tier 4	0.215	3.135	0.320	0.003	4.010
Marine	Work Boats	19 - 37	IMP Marine T1	0.340	1.530	1.530	0.003	4.730
Marine	Work Boats	19 - 37	US Tier 2	0.230	1.530	0.540	0.003	3.710
Marine	Work Boats	19 - 37	US Tier 3	0.180	1.530	0.410	0.003	3.710
Marine	Work Boats	19 - 37	US Tier 4	0.180	1.530	0.410	0.003	2.320
Marine	Work Boats	8 - 19	US Tier 2	0.380	4.110	0.680	0.003	4.390
Power Generation Drive	Marine Auxiliary	8 - 19	Non-compliant	0.900	5.000	1.700	0.003	8.500
Power Generation Drive	Marine Auxiliary	8 - 19	US Tier 2	0.500	4.110	0.550	0.003	4.300
Power Generation Drive	Marine Auxiliary	8 - 19	US Tier 3	0.500	4.110	0.550	0.003	4.300
Power Generation Drive	Marine Auxiliary	8 - 19	US Tier 4	0.276	4.110	0.550	0.003	4.300
Power Generation Drive	Prime Power	<8	US Tier 2	0.500	4.110	0.550	0.003	4.300
Power Generation Drive	Prime Power	130 - 560	US Tier 2	0.130	0.804	0.226	0.003	4.204
Power Generation Drive	Prime Power	19 - 37	US Tier 2	0.340	1.530	0.280	0.003	4.730
Power Generation Drive	Prime Power	37 - 56	US Tier 2	0.240	2.370	0.370	0.003	4.700
Power Generation Drive	Prime Power	56 - 130	US Tier 2	0.240	2.370	0.370	0.003	4.700
Power Generation Drive	Prime Power	8 - 19	Non-compliant	0.900	5.000	1.700	0.003	8.500
Power Generation Drive	Prime Power	8 - 19	US Tier 2	0.347	2.810	0.477	0.003	4.393
Power Generation Drive	Standby Power	<8	Non-compliant	1.000	5.000	1.500	0.003	10.000
Power Generation Drive	Standby Power	<8	US Tier 2	0.500	4.110	0.550	0.003	4.300
Power Generation Drive	Standby Power	>560	US Tier 2	0.130	0.760	0.170	0.000	4.100
Power Generation Drive	Standby Power	130 - 560	US Tier 2	0.130	1.085	0.170	0.002	4.220
Power Generation Drive	Standby Power	19 - 37	US Tier 2	0.340	1.530	0.280	0.003	4.730
Power Generation Drive	Standby Power	19 - 37	US Tier 4	0.202	1.530	0.280	0.003	4.730
Power Generation Drive	Standby Power	37 - 56	US Tier 2	0.240	2.370	0.370	0.003	4.700
Power Generation Drive	Standby Power	37 - 56	US Tier 4	0.202	2.370	0.180	0.003	3.000
Power Generation Drive	Standby Power	56 - 130	US Tier 2	0.240	2.370	0.370	0.003	4.700
Power Generation Drive	Standby Power	56 - 130	US Tier 3	0.220	0.870	0.180	0.003	2.500
Power Generation Drive	Standby Power	56 - 130	US Tier 4	0.202	2.370	0.180	0.003	3.000
Power Generation Drive	Standby Power	8 - 19	Non-compliant	0.933	5.000	1.633	0.003	9.000
Power Generation Drive	Standby Power	8 - 19	US Tier 2	0.385	3.135	0.495	0.003	4.370
Power Generation Drive	Standby Power	8 - 19	US Tier 3	0.385	3.135	0.495	0.003	4.370
Power Generation Drive	Standby Power	8 - 19	US Tier 4	0.276	3.135	0.495	0.003	4.370
Power Generation Sets	Miscellaneous Gen sets	>560	Non-compliant	1.000	5.000	1.200	0.000	8.000
Power Generation Sets	Miscellaneous Gen sets	130 - 560	Non-compliant	1.000	5.000	1.200	0.003	8.000
Power Generation Sets	Miscellaneous Gen sets	130 - 560	US Tier 1	0.250	0.750	0.310	0.003	5.580
Power Generation Sets	Miscellaneous Gen sets	130 - 560	US Tier 2	0.130	0.750	0.310	0.003	4.000
Power Generation Sets	Miscellaneous Gen sets	19 - 37	US Tier 2	0.340	1.530	0.280	0.003	4.730
Power Generation Sets	Miscellaneous Gen sets	37 - 56	Non-compliant	1.000	5.000	1.200	0.003	8.000
Power Generation Sets	Miscellaneous Gen sets	37 - 56	US Tier 2	0.240	2.370	0.370	0.003	4.700
Power Generation Sets	Miscellaneous Gen sets	37 - 56	US Tier 3	0.300	2.370	0.180	0.003	3.000
Power Generation Sets	Miscellaneous Gen sets	56 - 130	Non-compliant	1.000	5.000	1.200	0.003	8.000
Power Generation Sets	Miscellaneous Gen sets	56 - 130	US Tier 2	0.180	0.870	0.340	0.003	4.100

Market Segment	Equipment Type / Application	Rating Class (kW)	Standard Complied with	Base Case Emission Factors (g/Hp-hr)				
				PM10	CO	THC	SO2	NOX
Power Generation Sets	Miscellaneous Gen sets	8 - 19	US Tier 2	0.500	4.110	0.550	0.003	4.300
Power Generation Sets	Marine Auxiliary	<8	US Tier 2	0.500	4.110	0.550	0.003	4.300
Power Generation Sets	Marine Auxiliary	<8	US Tier 3	0.500	4.110	0.550	0.003	4.300
Power Generation Sets	Marine Auxiliary	19 - 37	US Tier 2	0.340	1.530	0.280	0.003	4.730
Power Generation Sets	Marine Auxiliary	19 - 37	US Tier 3	0.340	1.530	0.280	0.003	4.730
Power Generation Sets	Marine Auxiliary	8 - 19	Non-compliant	0.900	5.000	1.700	0.003	8.500
Power Generation Sets	Marine Auxiliary	8 - 19	US Tier 2	0.385	3.135	0.495	0.003	4.370
Power Generation Sets	Marine Auxiliary	8 - 19	US Tier 3	0.385	3.135	0.495	0.003	4.370
Power Generation Sets	Prime Power	<8	Non-compliant	1.000	5.000	1.500	0.003	10.000
Power Generation Sets	Prime Power	<8	US Tier 2	0.500	4.110	0.550	0.003	4.300
Power Generation Sets	Prime Power	>560	US Tier 3	0.130	0.760	0.170	0.000	4.100
Power Generation Sets	Prime Power	130 - 560	US Tier 3	0.150	0.892	0.173	0.003	2.500
Power Generation Sets	Prime Power	19 - 37	Non-compliant	0.800	5.000	1.800	0.003	6.900
Power Generation Sets	Prime Power	19 - 37	US Tier 2	0.340	1.530	0.280	0.003	4.730
Power Generation Sets	Prime Power	19 - 37	US Tier 3	0.340	1.530	0.280	0.003	4.730
Power Generation Sets	Prime Power	37 - 56	Non-compliant	1.000	5.000	1.200	0.003	8.000
Power Generation Sets	Prime Power	37 - 56	US Tier 3	0.300	2.370	0.180	0.003	3.000
Power Generation Sets	Prime Power	56 - 130	Non-compliant	1.000	5.000	1.200	0.003	8.000
Power Generation Sets	Prime Power	56 - 130	US Tier 3	0.247	1.370	0.180	0.003	2.667
Power Generation Sets	Prime Power	8 - 19	Non-compliant	0.900	5.000	1.700	0.003	8.500
Power Generation Sets	Prime Power	8 - 19	US Tier 2	0.385	3.135	0.495	0.003	4.370
Power Generation Sets	Prime Power	8 - 19	US Tier 3	0.385	3.135	0.495	0.003	4.370
Power Generation Sets	Standby Power	>560	US Tier 3	0.130	0.760	0.170	0.000	4.100
Power Generation Sets	Standby Power	130 - 560	US Tier 3	0.150	0.810	0.173	0.003	2.500
Power Generation Sets	Standby Power	19 - 37	US Tier 3	0.340	1.530	0.280	0.003	4.730
Power Generation Sets	Standby Power	56 - 130	US Tier 3	0.247	1.370	0.180	0.003	2.667
Power Generation Sets	Standby Power	8 - 19	Non-compliant	0.900	5.000	1.700	0.003	8.500
Power Generation Sets	Standby Power	8 - 19	US Tier 2	0.270	2.160	0.440	0.003	4.440
Power Generation Sets	Standby Power	8 - 19	US Tier 3	0.347	2.810	0.477	0.003	4.393
Power Generation Sets	Standby Power	8 - 19	US Tier 4	0.276	2.160	0.440	0.003	4.440
Vehicle Propulsion	Vehicle Propulsion	8 - 19	Non-compliant	0.900	5.000	1.700	0.003	8.500

			Controlled Scenario Emission Factors									
			Tier 4 Interim (2009-2015) (g/Hp-hr)					Tier 4 Final (2015 onwards) (g/Hp-hr)				
Segment	Equipment Type / Application	Rating (kw)	PM10	CO	THC	SO2	NOX	PM10	CO	THC	SO2	NOX
Agricultural	Agricultural tractors	56 - 130	0.202	2.370	0.180	0.006	3.000	0.009	0.360	0.130	0.006	0.280
	Combine harvester-threshers	56 - 130	0.324	1.330	0.190	0.006	2.640	0.009	0.130	0.130	0.006	0.280
	Engines for agricultural vehicles	37 - 56	0.202	2.370	0.180	0.006	3.000	0.009	0.360	0.130	0.006	0.280
	Engines for 'Other' agricultural	37 - 56	0.202	2.370	0.180	0.006	3.000	0.009	0.360	0.130	0.006	0.280
	Pumps & Irrigation	<8	0.276	4.110	0.550	0.003	4.300	0.009	0.410	0.130	0.003	0.280
		130 - 560	0.150	0.847	0.174	0.003	2.500	0.009	0.080	0.130	0.003	0.280
		19 - 37	0.202	1.530	0.280	0.003	4.730	0.009	0.150	0.130	0.003	0.280
		37 - 56	0.202	2.370	0.180	0.003	3.000	0.009	0.240	0.130	0.003	0.280
		56 - 130	0.214	1.370	0.180	0.003	2.667	0.009	0.140	0.130	0.003	0.280
		8 - 19	0.276	3.224	0.500	0.003	4.364	0.009	0.324	0.130	0.003	0.280
	Self Propelled Sprayers	56 - 130	0.202	2.370	0.180	0.006	3.000	0.009	0.360	0.130	0.006	0.280
	Windrowers	56 - 130	0.202	2.370	0.180	0.006	3.000	0.009	0.360	0.130	0.006	0.280
Forestry	Log Skidder	130 - 560	0.221	1.140	0.190	0.006	2.640	0.009	0.110	0.130	0.006	0.280
		56 - 130	0.324	1.330	0.190	0.006	2.640	0.009	0.130	0.130	0.006	0.280
General Industrial	Cranes and lifting equipment	19 - 37	0.202	1.530	0.280	0.006	4.730	0.009	0.150	0.130	0.006	0.280
	Forklifts	56 - 130	0.202	2.370	0.180	0.006	3.000	0.009	0.360	0.130	0.006	0.280
	Misc. industrial engines	130 - 560	0.150	0.902	0.174	0.006	2.500	0.009	0.086	0.130	0.006	0.280
		19 - 37	0.202	1.530	0.280	0.006	4.730	0.009	0.150	0.130	0.006	0.280
		37 - 56	0.202	2.370	0.180	0.006	3.000	0.009	0.240	0.130	0.006	0.280
		56 - 130	0.212	1.513	0.180	0.006	2.714	0.009	0.154	0.130	0.006	0.280
		8 - 19	0.276	2.810	0.477	0.006	4.393	0.009	0.283	0.130	0.006	0.280

			Controlled Scenario Emission Factors									
			Tier 4 Interim (2009-2015) (g/Hp-hr)					Tier 4 Final (2015 onwards) (g/Hp-hr)				
Segment	Equipment Type / Application	Rating (kw)	PM10	CO	THC	SO2	NOX	PM10	CO	THC	SO2	NOX
General Industrial	Other industrial engines	<8	0.276	4.110	0.550	0.006	4.300	0.009	0.410	0.130	0.006	0.280
		>560	0.132	0.760	0.170	0.006	4.100	0.028	0.080	0.130	0.006	2.390
		130 - 560	0.150	0.796	0.175	0.006	2.500	0.009	0.075	0.130	0.006	0.280
		19 - 37	0.202	1.530	0.280	0.006	4.730	0.009	0.150	0.130	0.006	0.280
		37 - 56	0.202	2.370	0.180	0.006	3.000	0.009	0.240	0.130	0.006	0.280
		56 - 130	0.213	1.470	0.180	0.006	2.700	0.009	0.150	0.130	0.006	0.280
		8 - 19	0.276	3.200	0.499	0.006	4.365	0.009	0.321	0.130	0.006	0.280
	Pumps	<8	0.276	4.110	0.550	0.003	4.300	0.009	0.410	0.130	0.003	0.280
		>560	0.132	0.760	0.170	0.000	4.100	0.028	0.080	0.130	0.000	2.390
		130 - 560	0.150	0.796	0.175	0.003	2.500	0.009	0.075	0.130	0.003	0.280
		19 - 37	0.202	1.530	0.280	0.003	4.730	0.009	0.150	0.130	0.003	0.280
		37 - 56	0.202	2.370	0.180	0.003	3.000	0.009	0.240	0.130	0.003	0.280
		56 - 130	0.214	1.410	0.180	0.003	2.680	0.009	0.144	0.130	0.003	0.280
		8 - 19	0.276	2.856	0.479	0.003	4.390	0.009	0.288	0.130	0.003	0.280
	Airport tractors	56 - 130	0.324	1.330	0.190	0.003	2.640	0.009	0.130	0.130	0.003	0.280
Heavy Industrial (Construction, Mining)	Backhoe loaders	19 - 37	0.202	1.530	0.280	0.006	4.730	0.009	0.390	0.130	0.006	0.280
		37 - 56	0.202	2.370	0.180	0.006	3.000	0.009	0.610	0.130	0.006	0.280
		56 - 130	0.246	2.351	0.213	0.006	3.015	0.009	0.557	0.130	0.006	0.280
	Crawler loaders	130 - 560	0.355	1.920	0.420	0.006	3.110	0.009	0.190	0.130	0.006	0.280
		56 - 130	0.441	2.265	0.360	0.006	3.083	0.009	0.318	0.130	0.006	0.280
	Construction & Mining Engines	<8	0.276	4.110	0.550	0.006	4.300	0.009	0.630	0.130	0.006	0.280
		>560	0.161	1.170	0.170	0.006	4.330	0.028	0.120	0.130	0.006	2.390
		130 - 560	0.221	1.260	0.178	0.006	2.640	0.009	0.125	0.130	0.006	0.280
		19 - 37	0.202	1.530	0.280	0.006	4.730	0.009	0.230	0.130	0.006	0.280
		37 - 56	0.202	2.370	0.180	0.006	3.000	0.009	0.360	0.130	0.006	0.280
		56 - 130	0.282	1.692	0.187	0.006	2.765	0.009	0.210	0.130	0.006	0.280
		8 - 19	0.276	3.401	0.510	0.006	4.351	0.009	0.521	0.130	0.006	0.280

			Controlled Scenario Emission Factors									
			Tier 4 Interim (2009-2015) (g/Hp-hr)					Tier 4 Final (2015 onwards) (g/Hp-hr)				
Segment	Equipment Type / Application	Rating (kw)	PM10	CO	THC	SO2	NOX	PM10	CO	THC	SO2	NOX
Heavy Industrial (Construction, Mining)	Construction & Mining Equipment	130 - 560	0.221	1.290	0.170	0.006	2.640	0.009	0.130	0.130	0.006	0.280
		56 - 130	0.324	1.330	0.190	0.006	2.640	0.009	0.130	0.130	0.006	0.280
	Dozers	>560	0.162	1.170	0.170	0.005	4.330	0.028	0.120	0.130	0.005	2.390
		130 - 560	0.221	1.248	0.181	0.005	2.640	0.009	0.123	0.130	0.005	0.280
		56 - 130	0.294	1.590	0.188	0.005	2.730	0.009	0.188	0.130	0.005	0.280
	Off-highway (dump) trucks	>560	0.161	1.170	0.170	0.006	4.330	0.028	0.120	0.130	0.006	2.390
		130 - 560	0.221	1.380	0.171	0.006	2.640	0.009	0.138	0.130	0.006	0.280
	Hydraulic excavators	<8	0.276	4.110	0.550	0.006	4.300	0.009	0.630	0.130	0.006	0.280
		>560	0.161	1.170	0.170	0.006	4.330	0.028	0.120	0.130	0.006	2.390
		130 - 560	0.221	1.209	0.183	0.006	2.640	0.009	0.119	0.130	0.006	0.280
		19 - 37	0.202	1.530	0.280	0.006	4.730	0.009	0.230	0.130	0.006	0.280
		37 - 56	0.202	2.370	0.180	0.006	3.000	0.009	0.360	0.130	0.006	0.280
		56 - 130	0.283	1.680	0.187	0.006	2.761	0.009	0.207	0.130	0.006	0.280
		8 - 19	0.266	2.180	0.424	0.006	4.472	0.009	0.333	0.130	0.006	0.280
	Landfill & earthworks equipment	130 - 560	0.221	1.247	0.176	0.006	2.640	0.009	0.124	0.130	0.006	0.280
	Motorgraders	130 - 560	0.221	1.152	0.188	0.006	2.640	0.009	0.112	0.130	0.006	0.280
		56 - 130	0.324	1.330	0.190	0.006	2.640	0.009	0.130	0.130	0.006	0.280
	Road rollers	<8	0.276	4.110	0.550	0.063	4.300	0.009	0.630	0.130	0.063	0.280
		130 - 560	0.234	1.164	0.190	0.063	2.640	0.009	0.113	0.130	0.063	0.280
		19 - 37	0.202	1.530	0.280	0.063	4.730	0.009	0.230	0.130	0.063	0.280
		37 - 56	0.202	2.370	0.180	0.063	3.000	0.009	0.360	0.130	0.063	0.280
		56 - 130	0.287	1.650	0.187	0.063	2.751	0.009	0.201	0.130	0.063	0.280
		8 - 19	0.276	2.160	0.440	0.063	4.440	0.009	0.330	0.130	0.063	0.280
	Scrapers	130 - 560	0.221	1.290	0.170	0.006	2.640	0.009	0.130	0.130	0.006	0.280

			Controlled Scenario Emission Factors									
			Tier 4 Interim (2009-2015) (g/Hp-hr)					Tier 4 Final (2015 onwards) (g/Hp-hr)				
Segment	Equipment Type / Application	Rating (kw)	PM10	CO	THC	SO2	NOX	PM10	CO	THC	SO2	NOX
Heavy Industrial (Construction, Mining)	Skid steer loaders	19 - 37	0.202	1.530	0.280	0.006	4.730	0.009	0.390	0.130	0.006	0.280
		37 - 56	0.202	2.370	0.180	0.006	3.000	0.009	0.610	0.130	0.006	0.280
		56 - 130	0.202	2.370	0.180	0.006	3.000	0.009	0.610	0.130	0.006	0.280
		8 - 19	0.258	2.003	0.400	0.006	4.513	0.009	0.518	0.130	0.006	0.280
	Wheel loaders	>560	0.162	1.170	0.170	0.006	4.330	0.028	0.120	0.130	0.006	2.390
		130 - 560	0.221	1.206	0.183	0.006	2.640	0.009	0.118	0.130	0.006	0.280
		19 - 37	0.202	1.530	0.280	0.006	4.730	0.009	0.230	0.130	0.006	0.280
		37 - 56	0.202	2.370	0.180	0.006	3.000	0.009	0.360	0.130	0.006	0.280
		56 - 130	0.300	1.535	0.188	0.006	2.711	0.009	0.175	0.130	0.006	0.280
Lawn and Garden	Ride on or tractor lawn mowers	8 - 19	0.276	2.160	0.440	0.006	4.440	0.009	0.330	0.130	0.006	0.280
Light Commercial	Air compressors	19 - 37	0.202	1.530	0.280	0.003	4.730	0.009	0.150	0.130	0.003	0.280
	Pressure washers	8 - 19	0.276	2.160	0.440	0.003	4.440	0.009	0.220	0.130	0.003	0.280
	Welders	19 - 37	0.202	1.530	0.280	0.003	4.730	0.009	0.390	0.130	0.003	0.280
Marine	Fishing Boats	8 - 19	0.240	4.110	0.430	0.003	4.390	0.240	4.110	0.430	0.003	4.390
	Pleasure Boats	<8	0.240	4.110	0.430	0.003	4.390	0.240	4.110	0.430	0.003	4.390
		19 - 37	0.180	1.530	0.410	0.003	2.320	0.180	1.530	0.410	0.003	2.320
		8 - 19	0.213	3.046	0.310	0.003	3.975	0.213	3.046	0.310	0.003	3.975
	Work Boats	19 - 37	0.180	1.530	0.410	0.003	2.320	0.180	1.530	0.410	0.003	2.320
		8 - 19	0.240	4.110	0.430	0.003	4.390	0.240	4.110	0.430	0.003	4.390
Power Generation Drive	Marine Auxiliary	8 - 19	0.276	3.623	0.523	0.003	4.335	0.009	0.363	0.130	0.003	0.280
	Prime Power	<8	0.276	4.110	0.550	0.003	4.300	0.009	0.410	0.130	0.003	0.280
		130 - 560	0.150	0.804	0.174	0.003	2.500	0.009	0.076	0.130	0.003	0.280
		19 - 37	0.202	1.530	0.280	0.003	4.730	0.009	0.150	0.130	0.003	0.280
		37 - 56	0.202	2.370	0.180	0.003	3.000	0.009	0.240	0.130	0.003	0.280
		56 - 130	0.202	2.370	0.180	0.003	3.000	0.009	0.240	0.130	0.003	0.280
		8 - 19	0.276	2.648	0.468	0.003	4.405	0.009	0.268	0.130	0.003	0.280

			Controlled Scenario Emission Factors									
			Tier 4 Interim (2009-2013) (g/Hp-hr)					Tier 4 Final (2015 onwards) (g/Hp-hr)				
Segment	Equipment Type / Application	Rating (kw)	PM10	CO	THC	SO2	NOX	PM10	CO	THC	SO2	NOX
Power Generation Drive	Standby Power	<8	0.276	4.110	0.550	0.003	4.300	0.009	0.410	0.130	0.003	0.280
		>560	0.132	0.760	0.170	0.000	4.100	0.018	0.080	0.130	0.000	0.460
		130 - 560	0.150	1.085	0.170	0.002	2.500	0.009	0.105	0.130	0.002	0.280
		19 - 37	0.202	1.530	0.280	0.003	4.730	0.009	0.150	0.130	0.003	0.280
		37 - 56	0.202	2.370	0.180	0.003	3.000	0.009	0.240	0.130	0.003	0.280
		56 - 130	0.207	1.995	0.180	0.003	2.875	0.009	0.203	0.130	0.003	0.280
		8 - 19	0.276	3.060	0.491	0.003	4.375	0.009	0.308	0.130	0.003	0.280
Power Generation Sets	Gensets Miscellaneous	>560	0.132	0.760	0.170	0.000	4.100	0.018	0.080	0.130	0.000	0.460
		130 - 560	0.150	0.765	0.178	0.003	2.500	0.009	0.072	0.130	0.003	0.280
		19 - 37	0.202	1.530	0.280	0.003	4.730	0.009	0.150	0.130	0.003	0.280
		37 - 56	0.202	2.370	0.180	0.003	3.000	0.009	0.240	0.130	0.003	0.280
		56 - 130	0.212	1.513	0.180	0.003	2.714	0.009	0.154	0.130	0.003	0.280
		8 - 19	0.276	4.110	0.550	0.003	4.300	0.009	0.410	0.130	0.003	0.280
	Marine Auxiliary	<8	0.276	4.110	0.550	0.003	4.300	0.009	0.410	0.130	0.003	0.280
		19 - 37	0.202	1.530	0.280	0.003	4.730	0.009	0.150	0.130	0.003	0.280
		8 - 19	0.276	2.940	0.484	0.003	4.384	0.009	0.296	0.130	0.003	0.280
	Prime Power	<8	0.276	4.110	0.550	0.003	4.300	0.009	0.410	0.130	0.003	0.280
		>560	0.132	0.760	0.170	0.000	4.100	0.018	0.080	0.130	0.000	0.460
		130 - 560	0.150	0.892	0.173	0.003	2.500	0.009	0.085	0.130	0.003	0.280
		19 - 37	0.202	1.530	0.280	0.003	4.730	0.009	0.150	0.130	0.003	0.280
		37 - 56	0.202	2.370	0.180	0.003	3.000	0.009	0.240	0.130	0.003	0.280
		56 - 130	0.213	1.470	0.180	0.003	2.700	0.009	0.150	0.130	0.003	0.280
		8 - 19	0.276	2.940	0.484	0.003	4.384	0.009	0.296	0.130	0.003	0.280
	Standby Power	>560	0.132	0.760	0.170	0.000	4.100	0.018	0.080	0.130	0.000	0.460
		130 - 560	0.150	0.810	0.173	0.003	2.500	0.009	0.077	0.130	0.003	0.280
		19 - 37	0.202	1.530	0.280	0.003	4.730	0.009	0.150	0.130	0.003	0.280
		56 - 130	0.214	1.370	0.180	0.003	2.667	0.009	0.140	0.130	0.003	0.280
		8 - 19	0.276	2.485	0.458	0.003	4.417	0.009	0.252	0.130	0.003	0.280

Appendix J: Emission Estimation Results for Post-2008 Non-road Diesel Engines and Equipment

		Upper Bound Base case Emissions (2020) emissions tpa									
Market Segment	Application / Equipment Type	PM10	CO	Nox	SO2	TVOCs	Benzene	Formaldehyde	Acetaldehyde	1,3-Butadiene	Acrolein
Agricultural	Agricultural tractors	1,801.94	19,135.37	14,617.25	19.75	1,523.63	30.47	179.79	80.75	3.05	4.57
	Combine harvester-threshers	169.44	345.81	717.06	0.41	72.79	1.46	8.59	3.86	0.15	0.22
	Engines for agricultural vehicles	6.76	28.45	27.13	0.02	5.76	0.12	0.68	0.31	0.01	0.02
	Engines for 'Other' agricultural	20.28	85.36	81.38	0.05	17.28	0.35	2.04	0.92	0.03	0.05
	Pumps & Irrigation	133.10	523.81	1,046.89	0.54	183.74	3.67	21.68	9.74	0.37	0.55
	Self Propelled Sprayers	43.31	163.07	128.50	0.11	47.71	0.95	5.63	2.53	0.10	0.14
	Windrowers	9.13	18.97	39.64	0.02	4.02	0.08	0.47	0.21	0.01	0.01
Agricultural Total		2,183.96	20,300.85	16,657.85	20.89	1,854.93	37.10	218.88	98.31	3.71	5.56
Forestry	Log Skidder	16.38	75.73	122.20	0.16	9.89	0.20	1.17	0.52	0.02	0.03
Forestry Total		16.38	75.73	122.20	0.16	9.89	0.20	1.17	0.52	0.02	0.03
General Industrial	Cranes and lifting equipment	135.40	532.97	1,509.60	1.86	109.94	2.20	12.97	5.83	0.22	0.33
	Forklifts	110.01	1,395.74	1,019.93	1.41	103.64	2.07	12.23	5.49	0.21	0.31
	Misc. Industrial engines	374.54	1,244.26	4,798.57	2.96	403.97	8.08	47.67	21.41	0.81	1.21
	Other industrial engines	213.20	958.51	3,037.24	3.34	233.38	4.67	27.54	12.37	0.47	0.70
	Pumps	414.35	2,058.90	3,783.75	1.82	528.43	10.57	62.36	28.01	1.06	1.59
	Airport tractors	84.66	539.58	948.35	0.81	101.27	2.03	11.95	5.37	0.20	0.30
General Industrial Total		1,332.17	6,729.96	15,097.44	12.20	1,480.64	29.61	174.72	78.47	2.96	4.44
Heavy Industrial	Backhoe loaders	82.80	680.81	306.14	0.43	40.57	0.81	4.79	2.15	0.08	0.12
	Crawler loaders	4.99	22.45	20.65	0.03	3.24	0.06	0.38	0.17	0.01	0.01
	Construction & Mining Engines	1,183.97	8,749.56	6,506.79	18.85	925.69	18.51	109.23	49.06	1.85	2.78
	Misc. Construction & Mining Equipment	1,518.96	9,564.64	9,108.26	5.40	997.85	19.96	117.75	52.89	2.00	2.99
	Dosers	190.72	1,178.55	2,048.35	3.19	124.86	2.50	14.73	6.62	0.25	0.37
	Dump trucks	1,529.47	10,530.89	19,823.59	30.88	1,046.85	20.94	123.53	55.48	2.09	3.14
	Hydraulic excavators	1,013.31	6,012.60	8,257.58	14.75	579.27	11.59	68.35	30.70	1.16	1.74
	Landfill & earthworks equipment	11.08	60.56	82.18	0.17	5.69	0.11	0.67	0.30	0.01	0.02
	Motorgraders	166.74	793.92	1,189.16	2.26	99.11	1.98	11.70	5.25	0.20	0.30
	Road rollers	124.54	902.02	1,224.34	20.89	127.60	2.55	15.06	6.76	0.26	0.38
	Scrapers	5.96	32.67	43.13	0.09	3.03	0.06	0.36	0.16	0.01	0.01
	Skid steer loaders	409.01	3,581.75	1,454.19	1.71	362.78	7.26	42.81	19.23	0.73	1.09
	Wheel loaders	384.74	1,999.99	3,030.75	5.34	231.97	4.64	27.37	12.29	0.46	0.70
Heavy Industrial Total		6,626.29	44,110.40	53,095.12	104.00	4,548.50	90.97	536.72	241.07	9.10	13.65
Lawn and Garden	Ride on or tractor lawn mowers	24.82	215.79	266.78	0.37	31.23	0.62	3.69	1.66	0.06	0.09
Lawn and Garden Total		24.82	215.79	266.78	0.37	31.23	0.62	3.69	1.66	0.06	0.09
Light Commercial	Air compressors	4.59	18.66	56.16	0.04	3.60	0.07	0.42	0.19	0.01	0.01
	Pressure washers	0.13	0.96	1.95	0.00	0.21	0.00	0.02	0.01	0.00	0.00
	Welders	30.58	163.48	216.09	0.13	28.01	0.56	3.30	1.48	0.06	0.08
Light Commercial Total		35.30	183.10	274.21	0.17	31.81	0.64	3.75	1.69	0.06	0.10

Marine (<37 kW)	Fishing Boats	0.07	0.65	0.67	0.00	0.11	0.00	0.01	0.01	0.00	0.00
	Pleasure Boats	1.84	13.79	27.99	0.02	3.97	0.08	0.47	0.21	0.01	0.01
	Work Boats	0.69	4.05	9.60	0.01	1.93	0.04	0.23	0.10	0.00	0.01
Marine Total		2.59	18.49	38.27	0.03	6.00	0.12	0.71	0.32	0.01	0.02
Power Generation Drive	Marine Auxiliary	3.83	19.82	32.04	0.01	6.91	0.14	0.82	0.37	0.01	0.02
	Prime Power	59.12	368.40	957.03	0.66	90.89	1.82	10.72	4.82	0.18	0.27
	Standby Power	23.96	155.31	293.51	0.17	29.08	0.58	3.43	1.54	0.06	0.09
Power Generation Drive Total		86.91	543.53	1,282.58	0.84	126.88	2.54	14.97	6.72	0.25	0.38
Power Generation Sets	Misc. generation sets	720.83	3,270.97	5,082.61	1.08	778.52	15.57	91.87	41.26	1.56	2.34
	Marine Auxiliary	4.59	26.07	42.04	0.02	6.53	0.13	0.77	0.35	0.01	0.02
	Prime Power	104.63	544.07	1,764.04	0.46	122.03	2.44	14.40	6.47	0.24	0.37
	Standby Power	72.31	388.98	1,328.19	0.30	108.50	2.17	12.80	5.75	0.22	0.33
Power Generation Sets Total		902.36	4,230.09	8,216.89	1.87	1,015.58	20.31	119.84	53.83	2.03	3.05
Grand Total		11,210.78	76,407.93	95,051.33	140.54	9,105.46	182.11	1,074.44	482.59	18.21	27.32

		Upper Bound Base case Emissions (2030) emissions tpa									
Market Segment	Application / Equipment Type	PM10	CO	Nox	SO2	TVOCs	Benzene	Formaldehyde	Acetaldehyde	1,3-Butadiene	Acrolein
Agricultural	Agricultural tractors	2,897.28	29,103.13	21,853.55	29.45	2,287.57	45.75	269.93	121.24	4.58	6.86
	Combine harvester-threshers	298.26	586.27	1,187.49	0.67	120.96	2.42	14.27	6.41	0.24	0.36
	Engines for agricultural vehicles	11.49	46.24	42.83	0.02	9.14	0.18	1.08	0.48	0.02	0.03
	Engines for 'Other' agricultural	34.46	138.72	128.48	0.07	27.41	0.55	3.23	1.45	0.05	0.08
	Pumps & Irrigation	216.23	795.42	1,592.84	0.83	280.76	5.62	33.13	14.88	0.56	0.84
	Self Propelled Sprayers	78.19	286.95	222.68	0.19	82.85	1.66	9.78	4.39	0.17	0.25
	Windrowers	16.37	33.01	67.71	0.04	6.88	0.14	0.81	0.36	0.01	0.02
Agricultural Total		3,552.28	30,989.74	25,095.58	31.28	2,815.57	56.31	332.24	149.23	5.63	8.45
Forestry	Log Skidder	16.38	75.73	122.20	0.16	9.89	0.20	1.17	0.52	0.02	0.03
Forestry Total		16.38	75.73	122.20	0.16	9.89	0.20	1.17	0.52	0.02	0.03
General Industrial	Cranes and lifting equipment	135.40	532.97	1,509.60	1.86	109.94	2.20	12.97	5.83	0.22	0.33
	Forklifts	110.01	1,395.74	1,019.93	1.41	103.64	2.07	12.23	5.49	0.21	0.31
	Misc. Industrial engines	537.10	1,704.32	6,510.18	3.93	548.12	10.96	64.68	29.05	1.10	1.64
	Other industrial engines	286.00	1,231.06	4,002.09	4.40	302.16	6.04	35.65	16.01	0.60	0.91
	Pumps	714.94	3,417.14	6,171.81	2.94	856.92	17.14	101.12	45.42	1.71	2.57
	Airport tractors	84.66	539.58	948.35	0.81	101.27	2.03	11.95	5.37	0.20	0.30
General Industrial Total		1,868.11	8,820.81	20,161.96	15.36	2,022.05	40.44	238.60	107.17	4.04	6.07
Heavy Industrial	Backhoe loaders	139.14	1,086.25	476.11	0.67	63.34	1.27	7.47	3.36	0.13	0.19
	Crawler loaders	8.39	35.80	32.13	0.05	5.05	0.10	0.60	0.27	0.01	0.02
	Construction & Mining Engines	1,296.29	9,470.45	7,088.53	19.18	995.81	19.92	117.51	52.78	1.99	2.99
	Misc. Construction & Mining Equipment	2,059.18	12,923.42	11,937.08	7.05	1,335.85	26.72	157.63	70.80	2.67	4.01
	Dosers	271.56	1,618.06	2,774.71	4.31	168.81	3.38	19.92	8.95	0.34	0.51
	Dump trucks	1,557.16	10,700.85	20,127.47	31.35	1,063.05	21.26	125.44	56.34	2.13	3.19
	Hydraulic excavators	1,108.90	6,572.50	9,131.80	16.26	630.43	12.61	74.39	33.41	1.26	1.89
	Landfill & earthworks equipment	14.00	74.79	100.07	0.21	6.93	0.14	0.82	0.37	0.01	0.02
	Motorgraders	182.38	862.74	1,283.87	2.44	106.75	2.14	12.60	5.66	0.21	0.32
	Road rollers	152.18	1,075.56	1,457.08	24.91	151.19	3.02	17.84	8.01	0.30	0.45
	Scrapers	8.65	45.55	58.84	0.12	4.15	0.08	0.49	0.22	0.01	0.01
	Skid steer loaders	685.01	5,815.00	2,276.67	2.70	569.89	11.40	67.25	30.20	1.14	1.71
	Wheel loaders	520.03	2,635.15	3,970.26	6.94	299.52	5.99	35.34	15.87	0.60	0.90
Heavy Industrial Total		8,002.87	52,916.11	60,714.62	116.21	5,400.78	108.02	637.29	286.24	10.80	16.20
Lawn and Garden	Ride on or tractor lawn mowers	31.50	266.09	326.01	0.45	38.25	0.77	4.51	2.03	0.08	0.11
Lawn and Garden Total		31.50	266.09	326.01	0.45	38.25	0.77	4.51	2.03	0.08	0.11
Light Commercial	Air compressors	4.69	18.99	57.09	0.04	3.66	0.07	0.43	0.19	0.01	0.01
	Pressure washers	0.23	1.66	3.34	0.00	0.36	0.01	0.04	0.02	0.00	0.00
	Welders	50.78	255.53	331.88	0.20	43.23	0.86	5.10	2.29	0.09	0.13
Light Commercial Total		55.70	276.18	392.31	0.24	47.24	0.94	5.57	2.50	0.09	0.14
Marine (<37 kW)	Fishing Boats	0.07	0.65	0.67	0.00	0.11	0.00	0.01	0.01	0.00	0.00

	Pleasure Boats	3.30	23.80	47.85	0.04	6.80	0.14	0.80	0.36	0.01	0.02
	Work Boats	0.69	4.05	9.60	0.01	1.93	0.04	0.23	0.10	0.00	0.01
Marine Total		4.05	28.50	58.12	0.05	8.84	0.18	1.04	0.47	0.02	0.03
Power Generation Drive	Marine Auxiliary	6.23	30.74	48.34	0.02	10.48	0.21	1.24	0.56	0.02	0.03
	Prime Power	67.76	407.78	1,015.74	0.68	103.75	2.08	12.24	5.50	0.21	0.31
	Standby Power	32.52	205.68	393.93	0.22	38.75	0.77	4.57	2.05	0.08	0.12
Power Generation Drive Total		106.52	644.20	1,458.01	0.92	152.98	3.06	18.05	8.11	0.31	0.46
Power Generation Sets	Misc. generation sets	720.83	3,270.97	5,082.61	1.08	778.52	15.57	91.87	41.26	1.56	2.34
	Marine Auxiliary	5.89	32.43	52.06	0.03	8.71	0.17	1.03	0.46	0.02	0.03
	Prime Power	111.99	577.61	1,814.05	0.48	132.99	2.66	15.69	7.05	0.27	0.40
	Standby Power	120.36	623.90	2,137.58	0.46	170.01	3.40	20.06	9.01	0.34	0.51
Power Generation Sets Total		959.07	4,504.91	9,086.31	2.05	1,090.23	21.80	128.65	57.78	2.18	3.27
Grand Total		14,596.48	98,522.28	117,415.12	166.73	11,585.83	231.72	1,367.13	614.05	23.17	34.76

		Controlled Emissions (2020) tpa									
Market Segment	Application / Equipment Type	PM10	CO	Nox	SO2	TVOCs	Benzene	Formaldehyde	Acetaldehyde	1,3-Butadiene	Acrolein
Agricultural	Agricultural tractors	30.44	1,191.31	926.58	19.75	462.06	9.24	54.52	24.49	0.92	1.39
	Combine harvester-threshers	0.63	8.85	19.06	0.41	9.50	0.19	1.12	0.50	0.02	0.03
	Engines for agricultural vehicles	0.02	0.96	0.74	0.02	0.37	0.01	0.04	0.02	0.00	0.00
	Engines for 'Other' agricultural	0.07	2.87	2.23	0.05	1.11	0.02	0.13	0.06	0.00	0.00
	Pumps & Irrigation	13.43	139.46	223.84	0.54	33.48	0.67	3.95	1.77	0.07	0.10
	Self Propelled Sprayers	0.17	6.50	5.06	0.11	2.52	0.05	0.30	0.13	0.01	0.01
	Windrowers	0.03	1.36	1.05	0.02	0.53	0.01	0.06	0.03	0.00	0.00
Agricultural Total		44.80	1,351.30	1,178.56	20.89	509.58	10.19	60.13	27.01	1.02	1.53
Forestry	Log Skidder	1.25	7.73	18.13	0.16	4.07	0.08	0.48	0.22	0.01	0.01
Forestry Total		1.25	7.73	18.13	0.16	4.07	0.08	0.48	0.22	0.01	0.01
General Industrial	Cranes and lifting equipment	2.86	46.70	87.18	1.86	43.47	0.87	5.13	2.30	0.09	0.13
	Forklifts	2.18	85.21	66.27	1.41	33.05	0.66	3.90	1.75	0.07	0.10
	Misc. Industrial engines	33.88	255.29	535.74	2.96	78.34	1.57	9.24	4.15	0.16	0.24
	Other industrial engines	36.00	298.64	854.54	3.34	91.59	1.83	10.81	4.85	0.18	0.27
	Pumps	45.58	313.51	929.61	1.82	104.30	2.09	12.31	5.53	0.21	0.31
	Airport tractors	2.32	32.79	70.62	0.81	35.22	0.70	4.16	1.87	0.07	0.11
General Industrial Total		122.83	1,032.14	2,543.97	12.20	385.97	7.72	45.54	20.46	0.77	1.16
Heavy Industrial	Backhoe loaders	7.25	95.79	100.80	0.43	13.17	0.26	1.55	0.70	0.03	0.04
	Crawler loaders	1.14	5.83	8.04	0.03	1.52	0.03	0.18	0.08	0.00	0.00
	Construction & Mining Engines	59.05	498.85	3,403.98	18.85	443.67	8.87	52.35	23.51	0.89	1.33
	Misc. Construction & Mining Equipment	8.32	117.53	253.14	5.40	126.23	2.52	14.90	6.69	0.25	0.38
	Dosers	45.20	295.17	1,215.07	3.19	90.72	1.81	10.71	4.81	0.18	0.27

	Dump trucks	315.83	2,016.06	13,401.97	30.88	804.35	16.09	94.91	42.63	1.61	2.41
	Hydraulic excavators	159.66	1,122.35	3,487.33	14.75	378.08	7.56	44.61	20.04	0.76	1.13
	Landfill & earthworks equipment	2.20	14.26	29.70	0.17	4.46	0.09	0.53	0.24	0.01	0.01
	Motorgraders	30.20	167.64	375.36	2.26	63.44	1.27	7.49	3.36	0.13	0.19
	Road rollers	29.36	180.37	338.85	20.89	52.54	1.05	6.20	2.78	0.11	0.16
	Scrapers	1.28	8.25	17.02	0.09	2.42	0.05	0.29	0.13	0.00	0.01
	Skid steer loaders	23.60	329.49	423.38	1.71	49.28	0.99	5.82	2.61	0.10	0.15
	Wheel loaders	82.09	478.63	1,250.70	5.34	150.80	3.02	17.79	7.99	0.30	0.45
Heavy Industrial Total		765.17	5,330.22	24,305.33	104.00	2,180.69	43.61	257.32	115.58	4.36	6.54
Lawn and Garden	Ride on or tractor lawn mowers	0.57	20.56	17.44	0.37	8.70	0.17	1.03	0.46	0.02	0.03
Lawn and Garden Total		0.57	20.56	17.44	0.37	8.70	0.17	1.03	0.46	0.02	0.03
Light Commercial	Air compressors	0.11	1.78	3.32	0.04	1.65	0.03	0.20	0.09	0.00	0.00
	Pressure washers	0.00	0.10	0.12	0.00	0.06	0.00	0.01	0.00	0.00	0.00
	Welders	0.37	15.74	11.30	0.13	5.64	0.11	0.67	0.30	0.01	0.02
Light Commercial Total		0.48	17.62	14.74	0.17	7.35	0.15	0.87	0.39	0.01	0.02
Marine (<37 kW)	Fishing Boats	0.04	0.63	0.67	0.00	0.07	0.00	0.01	0.00	0.00	0.00
	Pleasure Boats	1.40	13.61	20.15	0.02	3.06	0.06	0.36	0.16	0.01	0.01
	Work Boats	0.45	3.95	5.90	0.01	1.10	0.02	0.13	0.06	0.00	0.00
Marine Total		1.89	18.19	26.72	0.03	4.23	0.08	0.50	0.22	0.01	0.01
Power Generation Drive	Marine Auxiliary	0.04	0.85	1.07	0.01	0.53	0.01	0.06	0.03	0.00	0.00
	Prime Power	1.90	31.20	57.76	0.66	28.80	0.58	3.40	1.53	0.06	0.09
	Standby Power	4.73	53.48	93.75	0.17	12.89	0.26	1.52	0.68	0.03	0.04
Power Generation Drive Total		6.66	85.53	152.58	0.84	42.22	0.84	4.98	2.24	0.08	0.13
Power Generation Sets	Misc. generation sets	17.71	125.58	503.47	1.08	99.96	2.00	11.79	5.30	0.20	0.30
	Marine Auxiliary	0.13	2.45	3.08	0.02	1.09	0.02	0.13	0.06	0.00	0.00
	Prime Power	8.97	59.37	246.69	0.46	62.40	1.25	7.36	3.31	0.12	0.19
	Standby Power	18.15	107.99	493.25	0.30	48.88	0.98	5.77	2.59	0.10	0.15
Power Generation Sets Total		44.95	295.39	1,246.49	1.87	212.33	4.25	25.05	11.25	0.42	0.64
Grand Total		988.61	8,158.67	29,503.96	140.54	3,355.13	67.10	395.91	177.82	6.71	10.07

		Controlled Emissions (2030) tpa									
Market Segment	Application / Equipment Type	PM10	CO	Nox	SO2	TVOCs	Benzene	Formaldehyde	Acetaldehyde	1,3-Butadiene	Acrolein
Agricultural	Agricultural tractors	45.40	1,776.69	1,381.87	29.45	689.10	13.78	81.31	36.52	1.38	2.07
	Combine harvester-threshers	1.03	14.60	31.45	0.67	15.68	0.31	1.85	0.83	0.03	0.05
	Engines for agricultural vehicles	0.04	1.50	1.17	0.02	0.58	0.01	0.07	0.03	0.00	0.00
	Engines for 'Other' agricultural	0.12	4.51	3.51	0.07	1.75	0.03	0.21	0.09	0.00	0.01
	Pumps & Irrigation	10.13	113.89	185.85	0.83	41.93	0.84	4.95	2.22	0.08	0.13
	Self Propelled Sprayers	0.29	11.24	8.74	0.19	4.36	0.09	0.51	0.23	0.01	0.01
	Windrowers	0.06	2.31	1.80	0.04	0.90	0.02	0.11	0.05	0.00	0.00
Agricultural Total		57.06	1,924.74	1,614.38	31.28	754.29	15.09	89.01	39.98	1.51	2.26
Forestry	Log Skidder	0.25	3.04	7.59	0.16	3.79	0.08	0.45	0.20	0.01	0.01
Forestry Total		0.25	3.04	7.59	0.16	3.79	0.08	0.45	0.20	0.01	0.01
General Industrial	Cranes and lifting equipment	2.86	46.70	87.18	1.86	43.47	0.87	5.13	2.30	0.09	0.13
	Forklifts	2.18	85.21	66.27	1.41	33.05	0.66	3.90	1.75	0.07	0.10
	Misc. Industrial engines	15.93	151.27	316.73	3.93	94.85	1.90	11.19	5.03	0.19	0.28
	Other industrial engines	19.49	169.11	753.35	4.40	106.08	2.12	12.52	5.62	0.21	0.32
	Pumps	40.95	296.97	1,012.93	2.94	157.11	3.14	18.54	8.33	0.31	0.47
	Airport tractors	2.32	32.79	70.62	0.81	35.22	0.70	4.16	1.87	0.07	0.11
General Industrial Total		83.73	782.05	2,307.07	15.36	469.77	9.40	55.43	24.90	0.94	1.41
Heavy Industrial	Backhoe loaders	5.40	102.55	85.71	0.67	18.37	0.37	2.17	0.97	0.04	0.06
	Crawler loaders	0.80	5.09	6.80	0.05	1.76	0.04	0.21	0.09	0.00	0.01
	Construction & Mining Engines	50.44	433.33	3,293.25	19.18	448.84	8.98	52.96	23.79	0.90	1.35
	Misc. Construction & Mining Equipment	10.87	153.53	330.69	7.05	164.91	3.30	19.46	8.74	0.33	0.49
	Dosers	26.93	180.05	1,232.08	4.31	113.67	2.27	13.41	6.02	0.23	0.34
	Dump trucks	133.21	671.14	11,046.25	31.35	761.95	15.24	89.91	40.38	1.52	2.29
	Hydraulic excavators	47.81	465.76	2,572.73	16.26	382.61	7.65	45.15	20.28	0.77	1.15
	Landfill & earthworks equipment	0.60	6.07	12.99	0.21	4.99	0.10	0.59	0.26	0.01	0.01
	Motorgraders	4.64	54.46	129.27	2.44	61.11	1.22	7.21	3.24	0.12	0.18
	Road rollers	6.23	75.54	134.09	24.91	55.47	1.11	6.55	2.94	0.11	0.17
	Scrapers	0.62	5.09	10.69	0.12	3.07	0.06	0.36	0.16	0.01	0.01
	Skid steer loaders	18.65	374.03	353.52	2.70	68.80	1.38	8.12	3.65	0.14	0.21
	Wheel loaders	32.22	257.34	916.81	6.94	177.46	3.55	20.94	9.41	0.35	0.53
Heavy Industrial Total		338.43	2,783.99	20,124.89	116.21	2,263.01	45.26	267.04	119.94	4.53	6.79
Lawn and Garden	Ride on or tractor lawn mowers	0.70	25.09	21.29	0.45	10.62	0.21	1.25	0.56	0.02	0.03
Lawn and Garden Total		0.70	25.09	21.29	0.45	10.62	0.21	1.25	0.56	0.02	0.03
Light Commercial	Air compressors	0.11	1.81	3.37	0.04	1.68	0.03	0.20	0.09	0.00	0.01
	Pressure washers	0.01	0.16	0.21	0.00	0.10	0.00	0.01	0.01	0.00	0.00
	Welders	0.57	24.13	17.33	0.20	8.64	0.17	1.02	0.46	0.02	0.03
Light Commercial Total		0.69	26.11	20.91	0.24	10.43	0.21	1.23	0.55	0.02	0.03
Marine (<37 kW)	Fishing Boats	0.04	0.63	0.67	0.00	0.07	0.00	0.01	0.00	0.00	0.00

	Pleasure Boats	2.39	23.24	34.41	0.04	5.22	0.10	0.62	0.28	0.01	0.02
	Work Boats	0.45	3.95	5.90	0.01	1.10	0.02	0.13	0.06	0.00	0.00
Marine Total		2.88	27.82	40.98	0.05	6.39	0.13	0.75	0.34	0.01	0.02
Power Generation Drive	Marine Auxiliary	0.05	1.25	1.58	0.02	0.79	0.02	0.09	0.04	0.00	0.00
	Prime Power	1.96	32.69	59.65	0.68	29.75	0.59	3.51	1.58	0.06	0.09
	Standby Power	2.04	28.37	47.52	0.22	12.54	0.25	1.48	0.66	0.03	0.04
Power Generation Drive Total		4.05	62.31	108.75	0.92	43.08	0.86	5.08	2.28	0.09	0.13
Power Generation Sets	Misc. generation sets	9.67	76.15	258.73	1.08	96.97	1.94	11.44	5.14	0.19	0.29
	Marine Auxiliary	0.08	2.10	2.36	0.03	1.18	0.02	0.14	0.06	0.00	0.00
	Prime Power	6.76	46.85	176.97	0.48	62.35	1.25	7.36	3.30	0.12	0.19
	Standby Power	17.78	105.18	485.43	0.46	74.25	1.49	8.76	3.94	0.15	0.22
Power Generation Sets Total		34.29	230.27	923.49	2.05	234.74	4.69	27.70	12.44	0.47	0.70
Grand Total		522.07	5,865.42	25,169.35	166.73	3,796.13	75.92	447.94	201.19	7.59	11.39