BENCHMARKING FUEL USE AND EMISSION RATES FOR HEAVY DUTY DIESEL HIGHWAY MAINTENANCE EQUIPMENT

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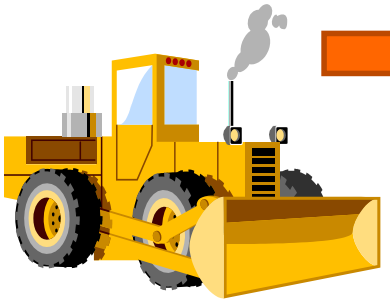
Heavy Duty Diesel Equipment Emissions

6 Billion Gallons of Diesel Fuel



2 Million Items of Nonroad Equipment

NO_x = 657,000 tons

PM = 63,000 tons

CO = 1,100,000 tons

CO_2= 67,000,000 tons

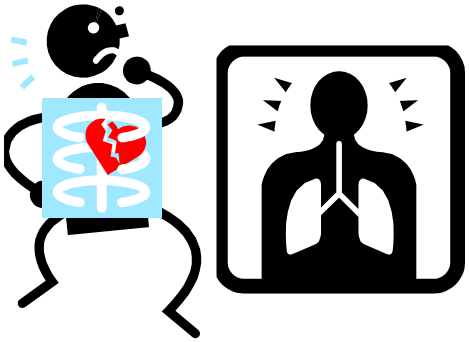
HC Precursor to Ground Level Ozone

Diesel Emissions Impacts

HEALTH

Allergies

Asthma



Heart/Lung Issues

ENVIRONMENT

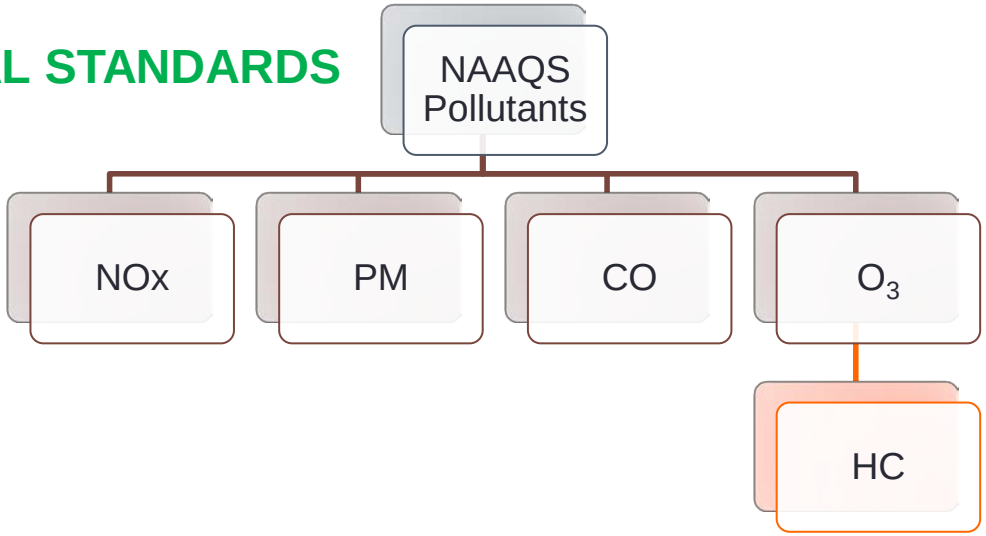
Smog

Acid Rain

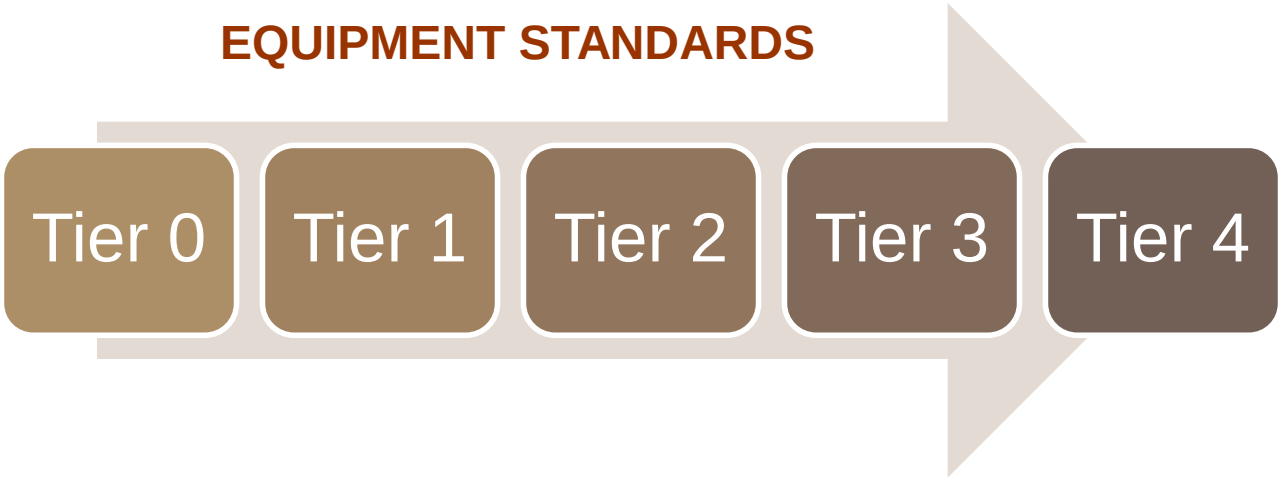
Global Warming

EPA Diesel Emissions Regulations

ENVIRONMENTAL STANDARDS



EQUIPMENT STANDARDS



Emissions Reductions

Other emissions reduction strategies:

- Install diesel retrofit devices;
- Maintain, repair, rebuild, or repower existing engines;
- Replace older vehicles and equipment in the current fleet;
- Improve equipment operational strategies
- Use cleaner fuels including natural gas and propane; and

Biodiesel

Objective

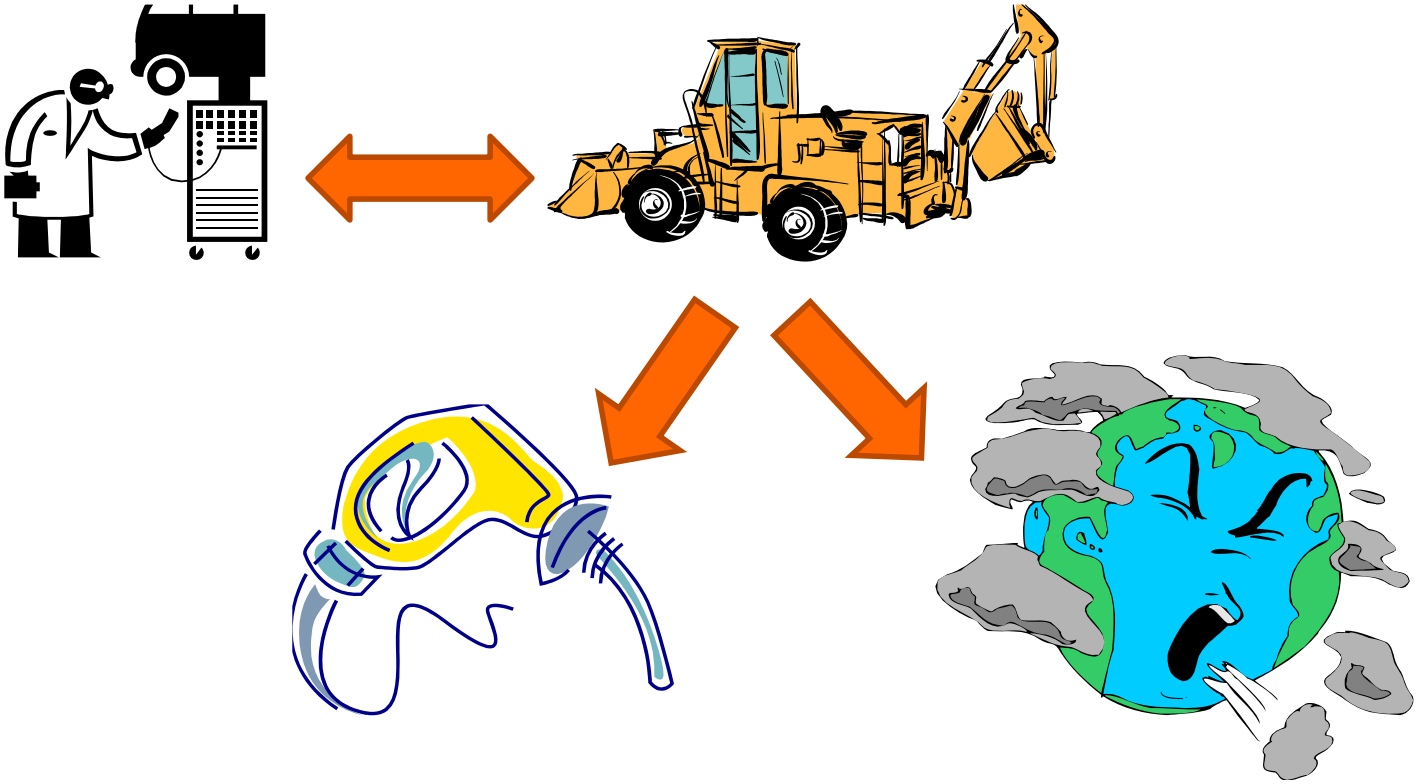
Compare the pollutant emissions rates of biodiesel and petroleum diesel for equipment used for maintenance operations.

Research Questions

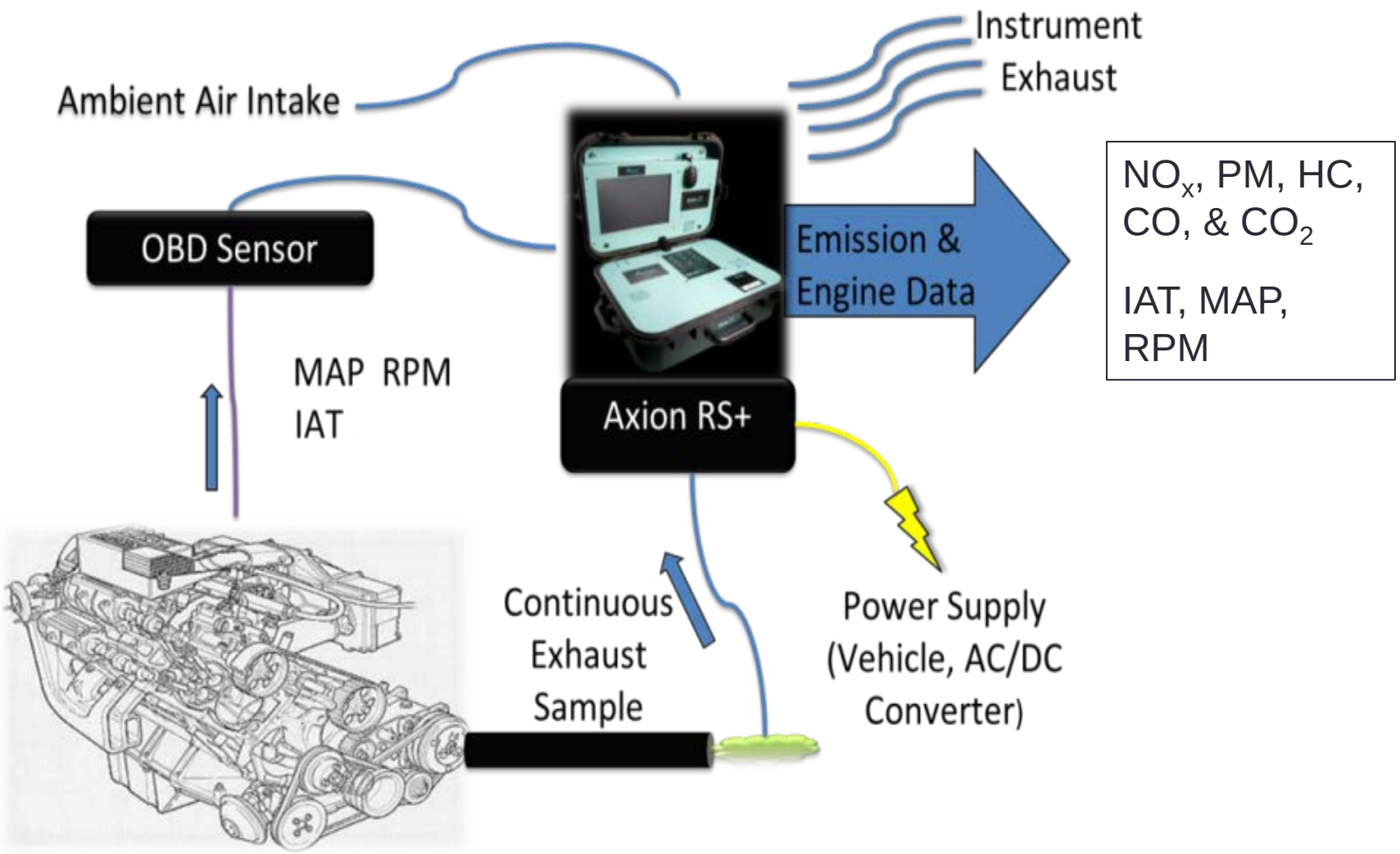
- How do mass per time pollutant emissions rates compare for biodiesel versus diesel when categorized by equipment type?
- How do mass per time emissions rates compare for biodiesel versus diesel when categorized by engine tier classification?
- What is the percentage change (increase or decrease) in pollutant emissions rates for biodiesel versus diesel?

Research Approach

Real World Data Collection from In-Use Equipment



Equipment Data Collection



Case Study Fleet

Equipment	Horsepower (HP)	Displacement (Liters)	Model Year	Engine Tier
Backhoe 1	88	4.0	2004	2
Backhoe 2	88	4.2	1999	1
Backhoe 3	88	4.2	2000	1
Backhoe 4	97	3.9	2004	2
Backhoe 5	97	4.5	2004	2
Motor Grader 1	195	8.3	2001	1
Motor Grader 2	195	7.1	2004	2
Motor Grader 3	195	8.3	2001	1
Motor Grader 4	167	8.3	1990	0
Motor Grader 5	160	8.3	1993	0
Motor Grader 6	198	7.2	2007	3
Wheel Loader 1	149	5.9	2004	2
Wheel Loader 2	130	5.9	2002	1
Wheel Loader 3	130	5.9	2002	1
Wheel Loader 4	126	5.9	2002	1
Wheel Loader 5	133	6.0	2005	2

Diesel Emissions by Equipment Type

Equipment	Tier	Fuel Use (gal/h)	NO_x (g/h)	HC (g/h)	CO (g/h)	CO_2 (g/h)	PM (g/h)
BH 1	2	0.5	64	6.0	5.0	4,611	0.3
BH 2	0	1.8	206	27	154	18,175	2.1
BH 3	1	2.1	222	24	73	20,795	2.2
BH 4	1	0.8	112	7.0	52	8,035	0.7
BH 5	2	0.5	69	6.0	10	4,764	0.4
	Average	***1.1***	***135***	***14***	***59***	***11,276***	***1.1***
MG 1	1	5.5	643	53	67	54,615	4.9
MG 2	2	1.7	192	50	48	16,956	1.0
MG 3	1	2.5	275	152	29	25,085	2.8
MG 4	0	2.9	596	95	141	28,845	2.3
MG 5	0	2.6	423	26	134	26,013	1.9
MG 6	3	2.5	163	21	17	24,893	1.8
	Average	***3.0***	***382***	***66***	***73***	***29,401***	***2.5***
WL 1	1	1.6	195	33	38	15,534	1.5
WL 2	1	0.9	131	8.0	18	9,250	0.4
WL 3	1	1.2	156	15	12	11,691	1.1
WL 4	2	0.8	78	8.0	23	7,819	0.5
	Average	***1.1***	***140***	***16***	***23***	***11,074***	***0.9***

B20 Emissions by Equipment Type

Equipment	Tier	Fuel Use (gal/h)	NO_x (g/h)	HC (g/h)	CO (g/h)	CO_2 (g/h)	PM (g/h)
BH 1	2	0.6	77	9.0	6.0	5,994	0.3
BH 2	0	1.8	213	25	125	18,290	2.0
BH 3	1	2.0	178	19	64	19,575	2.1
BH 4	1	1.2	111	42	105	11,388	1.6
BH 5	2	0.4	69	2.0	6.0	4,346	0.3
	Average	***1.2***	***130***	***19***	***61***	***11,919***	***1.3***
MG 1	1	5.1	561	62	64	49,997	4.2
MG 2	2	1.7	233	16	34	17,102	0.5
MG 3	1	3.8	364	47	53	36,710	2.1
MG 4	0	1.3	201	36	NA	12,658	0.0
MG 5	0	3.4	600	47	92	33,443	1.9
MG 6	3	2.7	166	55	28	26,869	1.4
	Average	***3.0***	***354***	***44***	***54***	***29,463***	***1.7***
WL 1	1	1.0	126	8.0	28	9,637	0.7
WL 2	1	1.2	166	22	16	11,735	0.6
WL 3	1	2.2	253	30	38	21,130	1.6
WL 4	2	1.5	137	8.0	37	14,495	1.0

Diesel Emissions by Engine Tier

Equipment	Tier	Fuel Use (gal/h)	NO_x (g/h)	HC (g/h)	CO (g/h)	CO_2 (g/h)	PM (g/h)
BH 2	0	1.8	206	27	154	18,175	2.1
MG 4	0	2.9	596	95	141	28,845	2.3
MG 5	0	2.6	423	26	134	26,013	1.9
	Average	***2.4***	***408***	***49***	***143***	***24,344***	***2.1***
BH 3	1	2.1	222	24	73	20,795	2.2
BH 4	1	0.8	112	7.0	52	8,035	0.7
MG 1	1	5.5	643	53	67	54,615	4.9
MG 3	1	2.5	275	152	29	25,085	2.8
WL 1	1	1.6	195	33	38	15,534	1.5
WL 2	1	0.9	131	8.0	18	9,250	0.4
WL 3	1	1.2	156	15	12	11,691	1.1
	Average	***2.1***	***248***	***42***	***41***	***20,715***	***1.9***
BH 1	2	0.5	64	6.0	5.0	4,611	0.3
BH 5	2	0.5	69	6.0	10	4,764	0.4
MG 2	2	1.7	192	50	48	16,956	1.0
WL 4	2	0.8	78	8.0	23	7,819	0.5
	Average	***0.9***	***102***	***18***	***23***	***8,576***	***0.6***
MG 6	3	2.5	163	21	17	24,893	1.8
	Average	***2.7***	***166***	***55***	***28***	***26,869***	***1.4***

B20 Emissions by Tier

Equipment	Tier	Fuel Use (gal/h)	NO_x (g/h)	HC (g/h)	CO (g/h)	CO_2 (g/h)	PM (g/h)
BH 2	0	1.8	213	25	125	18,290	2.0
MG 4	0	1.3	201	36	NA	12,658	0.0
MG 5	0	3.4	600	47	92	33,443	1.9
	Average	***2.2***	***338***	***36***	***109***	***21,464***	***1.3***
BH 3	1	2.0	178	19	64	19,575	2.1
BH 4	1	1.2	111	42	105	11,388	1.6
MG 1	1	5.1	561	62	64	49,997	4.2
MG 3	1	3.8	364	47	53	36,710	2.1
WL 1	1	1.0	126	8.0	28	9,637	0.7
WL 2	1	1.2	166	22	16	11,735	0.6
WL 3	1	2.2	253	30	38	21,130	1.6
	Average	***2.0***	***252***	***36***	***61***	***20,125***	***1.6***
BH 1	2	0.6	77	9.0	6	5,994	0.3
BH 5	2	0.4	69	2.0	6	4,346	0.3
MG 2	2	1.7	233	16	34	17,102	0.5
WL 4	2	1.5	137	8.0	37	14,495	0.6
	Average	***1.1***	***129***	***9.0***	***21***	***10,484***	***0.5***
MG 6	3	2.7	166	55	28	26,869	1.4
	Average	***2.7***	***166***	***55***	***28***	***26,869***	***1.4***

B20 vs. Biodiesel

Equipment	Tier	Fuel Use (%)	NO_x (%)	HC (%)	CO (%)	CO_2 (%)	PM (%)
BH 2	0	0	3	-7	-19	1	-5
MG 4	0	-55	-66	-62	NA	-56	-100
MG 5	0	31	42	81	-31	29	0
	Average	***-11***	***-17***	***-27***	***-24***	***-12***	***-38***
BH 3	1	-5	-20	-21	-12	-6	-5
BH 4	1	50	-1	500	102	42	129
MG 1	1	-7	-13	17	-4	-8	-14
MG 3	1	52	32	-69	83	46	-25
WL 1	1	-38	-35	-76	-26	-38	-53
WL 2	1	33	27	175	-11	27	50
WL 3	1	83	62	100	217	81	45
	Average	***-3***	***2***	***-17***	***46***	***-3***	***-17***
BH 1	2	20	20	50	20	30	0
BH 5	2	-20	0	-67	-40	-9	-25
MG 2	2	0	21	-68	-29	1	-50
WL 4	2	88	76	0	61	85	100
	Average	***22***	***29***	***-21***	***3***	***27***	***6***
MG 6	3	8	2	162	65	8	-22
	Average	***8***	***2***	***162***	***65***	***8***	***-22***

Conclusions

B20 resulted in reduction (or no change) in emissions:

- NOx (8 units)
- HC (10 units)
- CO (7 units)
- PM (10 units)

B20 showed reduction in emissions in about half the fleet