EMISSIONS FROM UTILITY EQUIPMENT USE IN CALIFORNIA

FINAL REPORT

EXECUTIVE SUMMARY

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By:

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EXECUTIVE SUMMARY

The purpose of this study was to develop an emission inventory for a category of sources known as "utility equipment." This category includes nearly all equipment powered by internal combustion engines of less than 25 horsepower -- primarily lawn mowers, chain saws, garden tractors, edgers, trimmers, air compressors, electric generators and the like. Household, as well as commercial, use of this equipment was evaluated. Two additional categories were used to classify equipment used commercially. The first category - "lawn and garden, other" - includes trenchers, spreaders, rollers, sod cutters, and other lawn maintenance equipment that is not normally used by households. The second category - "home utility, other" - is a misnomer because it actually includes all commercial equipment that has not been classified elsewhere. This category includes pumps, post hole diggers, mixers, welding machines, and many other types of equipment. The final product was an inventory for the State as a whole and for each county within the State. Prior to completion of this study, the ARB staff had developed an emisison inventory that was based on nation-wide sales data for utility equipment and a variety of reasonable assumptions about California equipment populations and use patterns. This study provides a check on the ARB's methodology and suggests an alternative methodology based on information collected in California.

Two separate surveys were performed to collect information on household and commercial equipment populations and use patterns. Household information was collected from telephone interviews of 1,926 households that were selected to provide a random statistical sample of the entire State. Random digit dialing was used in order to interview households with unlisted as well as listed phone numbers. Respondents were asked to provide information on numbers and types of equipment owned, horsepower ratings, annual hours of use, age of equipment, and also information on home ownership, type of dwelling, and household income. Commercial information was collected from mail interviews of representative businesses that were expected to use utility equipment. They were asked to classify equipment users according to their occupational categories so that typical equipment use patterns could be developed for each occupation. Questionnaires were mailed to 785 businesses and 154 responses were received. The responding firms provided information similar to that compiled in the household survey for 4,200 pieces of utility equipment.

Household survey results were expanded to represent the entire State on the basis of numbers of households in each area of interest. Published employment data (by occupational category) were used to expand the commercial survey results. The results are shown in the table on the following page for the State as a whole. Standard errors are also tabulated for each of the parameters that were derived from survey data. The main

SUMMARY OF STATEWIDE EQUIPMENT POPULATIONS AND USAGE

Type of Equipment	Household				Commercial			
	Population	Annual Hours	Average HP	Load* Factor	Population	Annual Hours	Average HP	Load* Factor
Lawn and Garden								
Walk-Behind Mowers								
2-Cycle	1,063,000 (61,000)	25 (1)	2.9 (0.1)	.31	10,500 (2,500)	578 (76)	3.8 (0.3)	.31
4-Cycle	1,874,000 (79,000)	18 (1)	2.9 (0.1)	.31	17,100 (4,400)	618 (58)	4.6 (0.2)	.31
Riding Mowers	61,000 (18,000)	24 (6)	7.8 (1.2)	.34	9,000 (2,400)	901 (72)	17.3 (2.5)	.34
Tillers	368,000 (44,000)	18 (5)	5.3 (0.2)	.40	600 (600)	151 (60)	6.6 (0.9)	.40
Garden Tractors	79,000 (18,000)	25 (9)	11.5 (2.3)	.54	3,100 (1,900)	712 (91)	22.2 (1.9)	.54
Blowers	44,000 (18,000)	15 (3)	3.5 (1.3)	.30	3,100 (1,600)	414 (118)	3.5 (1.2)	.30
Edgers/Trimmers	604,000 (61,000)	12 (2)	1.9 (0.1)	.30	10,100 (2,600)	552 (115)	2.3 (0.2)	.30
Shredders	53,000 (18,000)	10 (5)	4.1 (0.6)	.30	300 (400)	500 (236)	22.8 (18.6)	.30
Yard Vacuums	35,000 (9,000)	15 (13)	2.8 (0.6)	.30	1,100 (900)	382 (118)	10.4 (1.8)	.30
Other	-0-	--	--	--	6,200 (2,900)	368 (177)	8.9	.30
Chain Saws	736,000 (53,000)	26 (4)	2.0 (0.2)	.50	54,500 (8,800)	349 (37)	2.7 (0.2)	.50
Home Utility								
Electric Generators	79,000 (18,000)	64 (60)	3.5 (0.8)	.50	22,600 (7,400)	244 (40)	4.8 (0.6)	.50
Air Compressors	35,000 (9,000)	42 (31)	2.9 (0.5)	.50	26,000 (6,400)	294 (42)	9.3 (1.0)	.50
Other	-0-	--	--	--	85,500 (18,000)	348 (173)	8.9	.50

*Taken from the current ARB inventory.

Source: CIC Research, Inc., "California Utility Equipment Use Survey," 1981-1982.

Values in ( ) indicate the standard errors of the estimates.

report contains a more detailed discussion of uncertainties of estimates from the residential and commercial surveys. Lawn mowers are the most prevalent type of equipment, followed by chain saws and edgers/trimmers. Residential ownership is far greater than commercial ownership.

Before the computation of emissions was undertaken, the literature on emission factors was reviewed. A set of new emission factors was derived from published experimental data to replace the conventional emission factors which do not correspond closely enough to the observed horsepower ratings of the equipment in use in California. These new factors were used to derive the inventories for this study. The results were compared with emissions computed using conventional factors as shown below (emissions from timbercutting are not included):

	Tons/Year, State-Wide	
Pollutant	Factors From This Study	Conventional Factors
HC	22,109	21,675
CO	119,674	126,511
NO_x	2,197	1,600

The emission computations from this study do not include evaporative HC, SO_x or TSP. These emissions are generally small and have a negligible impact on the total inventory. The results are indistinguishable from one another in view of

the fact that both sets of emission factors are based on experiments that indicate variations of about 50 percent in replicate tests of supposedly identical engines. Nevertheless, the authors of this report recommend the new factors as being more representative of the California equipment population.

The table on the following page shows a comparison of the equipment populations and use patterns from this survey and the ARB estimate based on sales data and assumed use patterns. Agreement is reasonable for most types of equipment, but the CIC survey shows a much larger percentage of lawn mowers with 2-stroke engines than had been assumed by the ARB. The CIC survey also showed that 99.8 percent of the tillers were in household use instead of 56 percent assumed by the ARB; however, the total number of tillers is so small that the impact on the overall inventory is minimal. Statewide emissions as derived from this study and the ARB are as follows:

	Tons/Year, State-Wide	
Pollutant	This Study	ARB Inventory
HC	22,212	14,272
CO	119,905	119,720
NO_x	2,198	1,720

In general, the agreement is very good and indicates that both methodologies are reasonable and provide adequate results. The ARB estimate of hydrocarbon emissions would be increased if the

COMPARISON OF THIS SURVEY AND PREVIOUS ARB ESTIMATES

Type of Equipment	Equipment Population				Annual Hours of Use				Annual Use	
	Residential		Commercial		Residential		Commercial		Res.& Comm. Hrs. Per 10^6 Units	
	CIC	ARB	CIC	ARB	CIC	ARB	CIC	ARB	CIC	ARB
Walk-Behind Mower	2,968,000	2,014,240	27,600	99,262	20.5	30	603	319	77.5	92.1
Riding Mower	61,000	60,445	9,000	11,338	24	38	901	380	9.6	6.6
Garden Tractor	79,000	22,341	3,100	4,191	25	30	712	180	4.2	1.4
Tiller	368,000	96,641	600	76,352	18	18	151	72	6.7	7.2
Misc. Lawn and Garden	702,000	796,508	20,800	36,484	12	17	500	190	18.8	20.5
Chain Saws	780,000	537,374	54,500	39,106	26	10	349	296	39.3	16.9
General Utility	114,000	381,752	134,100	233,442	57	48	320	96	49.4	40.7
Percent of Lawn and Garden with 2-Stroke Engines	39.2%	4.0%	33.7%	4.0%						

Source: CIC Research, Inc., "Survey of Utility Equipment Use," 1981-1982 and Air Resource Board 1979 Emission Inventory

observed proportion of 39 percent 2-stroke mowers was used in their calculation instead of the assumed 4 percent. It is recommended that either the CIC methodology or the ARB methodology with corrections for 2-stroke mowers be used for routine inventories. Both methods are tedious, and the final choice might be based on convenience rather than any compelling technical arguments. The CIC methodology provides for easy updating by substituting more recent data on households and employment that are available at regular intervals from State agencies.

To gain some perspective on utility equipment emissions, it is instructive to compare them with emissions from other source categories. Selected data from the 1979 ARB inventory are given below:

Category	Tons/Day, State-Wide		
	HC	CO	NO_x
Total, All Sources	1,603,000	6,256,000	1,294,000
Passenger Cars	464,000	3,088,000	351,000
Other Off-Road Vehicles	189,000	1,670,000	315,000
Utility Equipment, Exhaust (CIC)	22,212	119,905	2,198
Petroleum Marketing	79,600	-0-	-0-

It is apparent that utility equipment contributes less than 2 percent of the total emissions, depending on the pollutant under consideration.

An attempt was made to estimate the uncertainty in the calculated emissions by considering the uncertainties in each of the three major parameters: equipment populations, use patterns, and emission factors. Since emission factors were taken from literature, it was not possible to make a formal calculation of errors; however, replicate tests were reported for six identical models of a 4 HP, 4-cycle engine, and the emission factors varied by about 50 percent. In actual use, the emissions would probably vary even more because of variations in maintenance practices, loads and duty cycles. The uncertainties in equipment populations and use patterns as measured by this survey are estimated to be about an order of magnitude less than the uncertainties in the emission factors. The most effective way to improve the utility equipment inventory is to improve the emission factors. The utility equipment category includes such a diverse collection of equipment types that an extensive program would be required to provide all the data necessary for a truly accurate estimate of emissions. Probably, in most cases, the need would not be sufficient to justify the effort.