manufacturers are also incorporating electronic engines into their product lines, to replace older engines that were designed in the 1950s and 1960s.

Investment in new engines has been made possible by the increased, sustained activity within the drilling industry over the last three years. Investment is a function of profitability and drilling contractors see emissions reduction and energy efficiency in direct relation to the natural process of reinvestment in new energy efficient, durable technology, as old capital wears out. As industrial engines wear out, contractors are faced with the decision to rebuild the engine or replace it. On the margin, the new technology and better overall industry cash flow slants this decision toward replacement, which has substantial environmental as well as cost implications. Capital replacement will accelerate as more of this technology is adopted in the industry and establishes itself as an industry standard and, perhaps, as a competitive advantage. This study will illustrate that this evolution has substantial implications for energy use and emissions within the drilling industry.

5.0 STUDY METHODOLOGY

The study compares the increase in fuel efficiency of contractor diesel engines and trucks by comparing the average fuel consumption of an inventory of engines and trucks owned by eight contractors in 1991 and 1995. The results are on a "net" basis in that the net change in the quantity of a particular engine variety is aggregated into one of two categories, "Added" "Deleted". As some of the contractors participating in the survey have Crown through acquisition since 1991, the "Added" category contains more engines and trucks than the "Deleted" category. Therefore, the actual reported increase in fuel efficiency may be somewhat low, due to the dilution effect of the additional units but, nevertheless, the increase is significant.

5.1 Rig Engines

There are 40 varieties of engines in this study from two different manufacturers, Detroit Diesel and Caterpillar. As roughly 88% of the engines reported in the survey came from these two manufacturers, for the sake of simplicity, all other engine manufacturers were omitted. The total complement of engines in the study for 1991 and 1995 were 611 and 758, respectively. The net change from 1991 to 1995 was classified into two groups "Added" and "Deleted". Each category was aggregated and then averaged to obtain the overall average fuel consumption per hour. The category average was then calculated through simple averaging of fuel consumption per hour per engine. The engine fuel consumption per hour was obtained using, the following formula:

$$\frac{\text{bhp x lbs/hp*hr}}{8.54} = \text{Imp. Gallons/hrs. (Imp. Gallons/hr x 4.54 = litres/hr.)}$$

The data for the formula was obtained using manufacturers' engine performance curves and the engine data was rated using the following specifications:

- where possible engines were rated at 1800 rpm (some older engines were rated at 1200, as they were not designed for 1800 rpm);
- a standard 60% load factor was applied to the rated power at 1800 rpm (or 1200 rpm), given in bhp (brake horsepower); and
- from the fuel curve at 1800 rpm (or 1200 rpm), the specific fuel consumption was recorded (measured in lbs./bhp*hrs.).

APPENDIX I
Stationary Rig Engines

Manufacturer	Type	Quantity 1991	Quantity 1995	Net Change	Imperial Gallons per Hour @ 60%
Detroit Diesel	Series 40	0	40	40	4.54
Detroit Diesel	Series 50	1	52	51	7.06
Detroit Diesel	Series 60	2	7	5	8.11
Detroit Diesel	16V149-T1	1	1	0	37.90
Detroit Diesel	12V92-TA	0	3	3	15.99
Detroit Diesel	12V71-T	4	10	6	10.98
Detroit Diesel	12V71-N	11	0	-11	11.52
Detroit Diesel	8V71-N	34	7	-27	7.64
Detroit Diesel	8V71-T	6	0	-6	8.69
Detroit Diesel	6-71-Twin	135	137	2	11.99
Detroit Diesel	6-71-T	2	1	-1	5.31
Detroit Diesel	4-71-N	14	18	4	3.82
Detroit Diesel	4-71-T	10	9	-1	4.03
Detroit Diesel	3-71-N	19	27	8	2.89
Detroit Diesel	3-53-N	1	1	0	2.37
Detroit Diesel	6V92-T	2	2	0	7.05
Detroit Diesel	6V92-TA	0	1	1	7.03
Detroit Diesel	8V92-TA	0	1	1	10.59
Caterpillar	3512-DITA	0	2	2	43.04
Caterpillar	3412	5	12	7	10.40
Caterpillar	3412-TA	12	22	10	14.02
Caterpillar	3412-DITA	18	9	-9	20.42
Caterpillar	3408	19	17	-2	7.9
Caterpillar	3408-TA	21	21	0	9.74
Caterpillar	3408-DITA	7	7	0	12.31
Caterpillar	3406-TA	15	33	18	7.44
Caterpillar	3406-DITA	4	11	7	9.25
Caterpillar	3306-TA	34	56	22	5.48
Caterpillar	3306-DITA	0	11	11	7.17
Caterpillar	3304-TA	19	24	5	7.01
Caterpillar	3304-DITA	0	3	3	5.50
Caterpillar	D399	17	14	-3	30.82
Caterpillar	D398-TA	73	70	-3	24.48
Caterpillar	D379	57	65	8	14.05
Caterpillar	D353-TA	49	54	5	9.59
Caterpillar	D343-TA	5	2	-3	8.89
Caterpillar	D333	0	2	2	4.43
Caterpillar	D320	1	1	0	2.69
Caterpillar	D315	3	1	-2	2.81
Caterpillar	D311	10	4	-6	1.76
	TOTAL	**611**	**758**		