Greenhouse Gas Action Plan for the Transportation Sector in Iowa

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PREFACE

It has become widely recognized that greenhouse gases, whether natural or generated by activities on earth, lead to warming of the earth-atmosphere system. Such warming has the potential to influence meteorological phenomena such as droughts and floods, sea levels, and regional air temperatures.

While the implications and potential magnitude of global warming continue to be debated, public policymakers are searching for practical means to reduce the levels of greenhouse gases produced by human activities. Because carbon dioxide (CO_2) is the largest human-induced form of greenhouse gas, it is receiving the most attention.

The purpose of this research has been to identify ways in which the state of Iowa can do its part in reducing greenhouse gas emissions in its transportation sector. Because Iowa has the 15^{th} highest level of per capita greenhouse gas emissions, a real need exists for these emissions to be reduced.

A variety of strategies and policy actions for reducing greenhouse gas emissions in Iowa are explored in this report. Some of these actions would be relatively easy to implement, while others would require significant changes in how people live and travel. Our objective is to foster discussion of ways to reduce greenhouse gas emissions, not to narrow the acceptable methods too quickly.

Our work on this research effort has been conducted in tandem with a larger study to develop a greenhouse gas action plan for Iowa. The resulting plan suggests actions that could be taken in other sectors to reduce greenhouse gas emissions. Among the actions examined are those pertaining to agriculture, utilities, industry, and residences.

Research for this project was carried out jointly by the Public Policy Center and the Center for Global and Regional Environmental Research, both at the University of Iowa. Funding was provided by the U.S. Department of Transportation, University Transportation Centers Program, with supplemental funding contributed by the Iowa Department of Natural Resources.

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INTRODUCTION

The greenhouse gas effect is an accepted scientific principle which helps to explain the earth's climate. Under the greenhouse effect, atmospheric trace gases, principally carbon dioxide and water vapor, act as a blanket to warm the earth by an estimated 33° C (degrees Celsius) or 59° F (degrees Fahrenheit) beyond the projected temperature of the earth in the absence of the gases. Global warming theory states that as concentrations of greenhouse gases increase, their influence on the earth's temperature will also increase.

Gravity exerted by the mass of the earth acts to hold a thin layer of gases close to the earth's surface. These gases, principally nitrogen and oxygen, make up the atmosphere. Three-fourths of the earth's surface is covered by water, therefore water vapor is also a significant portion of the atmospheric composition. Water vapor, carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons are among atmospheric constituents known as greenhouse gases. Greenhouse gases (both natural and anthropogenic) allow short wave radiation from the sun to reach the planet, thus adding energy into the earth-atmosphere system. These same gases are opaque to long-wave radiation which the earth surface attempts to re-radiate back into space. The resulting energy balance allows a portion of the solar radiation to remain trapped within the earth-atmosphere system. This energy is exhibited in the form of heat—heat which makes the earth's surface inhabitable. Global warming has the potential to trap excess heat by increasing greenhouse gases. It also has the potential to increase the severity of droughts and floods, sea level rise, shifts in geographical patterns of species, and changes in agriculture.

THE GREENHOUSE GASES

The most common natural greenhouse gas is water vapor; however, its concentration remains relatively constant in the atmosphere because the driving mechanisms are the water bodies covering the earth. Since water vapor does not primarily result from human activity, it is most often excluded from the analysis of human-induced, or anthropogenic, greenhouse gas emissions. However, water vapor does provide an important positive feedback effect in a warmer world, where increased evaporation results in increased water vapor in the atmosphere, further increasing the greenhouse effect.

Because anthropogenic greenhouse gases are commonly used substances, reductions in these emissions is a difficult task. Among human-induced greenhouse gases, carbon dioxide (CO_2) is the largest contributor. Because of this status, it has become the measuring stick by which other greenhouse gases are evaluated, and emissions of greenhouse gases are often expressed in terms of equivalent effects (carbon dioxide-equivalents). CO_2 is released primarily from the combustion of carbon-containing fuels: coal, natural gas and oil products. Smaller amounts of carbon dioxide are created through industrial processes. Carbon is a basic element found in organic materials on earth. The desirable properties of fuel arise from their carbon content, with combustion used to liberate the carbon as carbon dioxide and release energy in usable forms.

Methane (CH_4) is the second most common anthropogenic greenhouse gas. Because of a longer atmospheric lifetime compared to carbon dioxide, a molecule of methane exerts the same influence as 22 molecules of carbon dioxide. This is expressed in a measure called global warming potential (GWP). Methane emissions arise from natural gas and oil production and distribution systems, from coal mining, wet agriculture, manure management, and from anaerobic decay processes. Methane emissions are increasing at a more rapid pace than carbon dioxide emissions, resulting in a renewed focus on the importance of this greenhouse gas.

Nitrous oxide (N_2O) possesses a global warming potential of 270 compared to CO_2 (each molecule exerts the same influence as 270 molecules of carbon dioxide). Because nitrous oxide is primarily emitted from the application of nitrogen fertilizers, it is an important greenhouse gas emission from agricultural areas such as Iowa.

Chlorofluorocarbons are known for their depletion of the stratospheric ozone layer which increases the amount of ultraviolet radiation reaching the earth's surface. They are discussed here, however, as potent greenhouse gases with global warming potentials of up to 10,000 per molecule, relative to carbon dioxide. Because these chemicals are extremely non-reactive in the atmosphere, they have a long lifetime in which to exhibit their greenhouse properties.

MODELING CLIMATIC RESPONSE

The scientific community has been involved in modeling the earth's response to changes in the radiative equilibrium that has been brought about through the increased input of greenhouse gases into the atmosphere by humans. General circulation models (GCMs) attempt to estimate the climatological responses to an increase in mean global temperature.

There are many complex phenomena that must be more fully understood in order to accurately model the atmosphere's response to increased temperature. Weather patterns and large storm systems act to redistribute air masses of differing temperatures and moisture content both horizontally from polar regions into the mid-latitudes, but also vertically from the upper troposphere to ground level. In the tropics, nearly chaotic convection brings torrential rains to equatorial and subtropical lands, and wreaks death and destruction in the form of powerful hurricanes, but also provides sustenance in the form of fresh water. All of the processes that lead to the development of these weather systems are complex and interactive, creating much difficulty for those trying to gain exact results from global GCMs.

How would a warmer climate affect the weather patterns seen on earth? Some speculate that cloud cover would dramatically increase, actually reducing the earth's temperature in some locations. Others estimate that weather events would range to greater extremes. Many hypothesize that the polar ice caps would begin to melt, leading to dramatic rises in sea levels which could inundate large population centers around the world. The models attempt to predict these occurrences, yet the complexity presented by all of these factors leads to much uncertainty about the true effects of global climate change.

In summary, the greenhouse effect is an accepted scientific principle for a phenomenon that is real and vitally important to life on earth. The questions of whether global climate change is occurring, whether human-induced climate change will occur in the future, or even whether that change will be negative or a benefit to humans, are questions that cannot be definitively answered. The trend of increasing greenhouse gas concentrations in the atmosphere presents a reason to be concerned. Seven of the eight warmest years on record (global mean temperature) have been recorded in the past decade, and in fact, 1990 and 1995 were the second warmest years ever recorded. Steep cutbacks in carbon dioxide emissions (75 percent) would be necessary to level off carbon dioxide concentrations in the atmosphere by the middle of the 21st century. The lifetimes of the greenhouse gases in the atmosphere ensure that their influence will be felt long after future emissions are limited. It is for this reason that so many are concerned about the possible occurrence of global climate change.

REGIONAL AND LOCAL RISKS AND VULNERABILITIES

Many studies have been undertaken to predict effects that may occur at particular locations as a result of climate change. These studies point to changes in growing seasons, utility usage patterns, effects on flora and fauna development, and effects on the human population.

The current resolution of the global climate models is so coarse that temperature variations cannot be predicted on a regional scale; the variance is too high. In addition, the models are not fully capable of modeling responses to warming such as increased cloud cover or changes in precipitation patterns and their additive or subtractive effects to predicted changes in temperature on a regional scale.

In general, climate models predict that mid-continents such as the midwestern U.S. will become hotter and drier by the middle of the next century. In an early look at the problem, Wetherald and Manabe (1986) estimated that soil moisture in the Midwest would be 50 percent less during the month of July when corn pollinates. This would render agriculture as is presently practiced difficult, but irrigated agriculture or new hybrid seed might alleviate the problem. Droughts, heat stress on elderly people, increased severity of storms, increased air conditioning needs, and changing ecology are all concerns at the regional scale.

We are currently in a relatively warm climate pattern. The global average surface temperature of the earth is ~0.5° C warmer than the earliest period of record, 1860. But this temperature change is still within the interannual variability of temperature due to large-scale circulation patterns (El-Niño Southern Oscillation events, etc.), which we do not fully understand. Seven out of eight of the warmest years during the 130-year period on record have occurred since 1980 (1980–1995). 1992 and 1993 were relatively cool because SO_2 and ash particles were blown high into the atmosphere (over 35,000 feet) by the eruption of the Mt. Pinatubo volcano. All of these observations have been modeled with some successes and failures using GCMs. Iowa weather has fit this general pattern with some exceptions: 1993 was a record flood year while 1988 was a record drought year.

GCMs predict that global precipitation will increase in the 21st century under a scenario of one percent per year increasing greenhouse gases, but the geographic distribution is uncertain. Various models differ on the locations where precipitation will change the most.

Northern hemisphere sea-ice will be reduced by warming in the 21st century according to GCMs. The models suggest polar amplification of global warming, and Arctic land areas will experience wintertime warming.

Mean sea level is projected to rise at an accelerating rate in the 21st century, at first due to thermal expansion of the ocean as its surface warms, and then due to the melting of pole ice and the breaking off and melting of the ice shelf in Antarctica. Sea level has risen 3.9±0.8 mm/year in 1993 and 1994. Most models estimate the rate of sea level rise as five to 40 cm by the year 2050. The U.S. economy would be influenced by sea level rise, but it would not affect Iowa directly.

One of the greatest economic effects on Iowa of a drier, warmer climate would be health-related. The number of days with temperatures over 100° F would increase significantly, resulting in heat stress and possible death to sensitive, elderly citizens. Iowa has the second oldest population in the United States and the greatest percentage of citizens over 85 years of age. Iowa has the 15th highest level of emissions per capita of greenhouse gases in the U.S. We are thus a state that stands to benefit greatly from efforts to curb greenhouse gas emissions and limit nonrenewable energy consumption.

1990 IOWA GREENHOUSE GAS EMISSIONS AND BASELINE FORECAST

Figure 1 presents historical data and baseline forecasts for energy and carbon dioxide emissions in Iowa from 1960 to 2010.

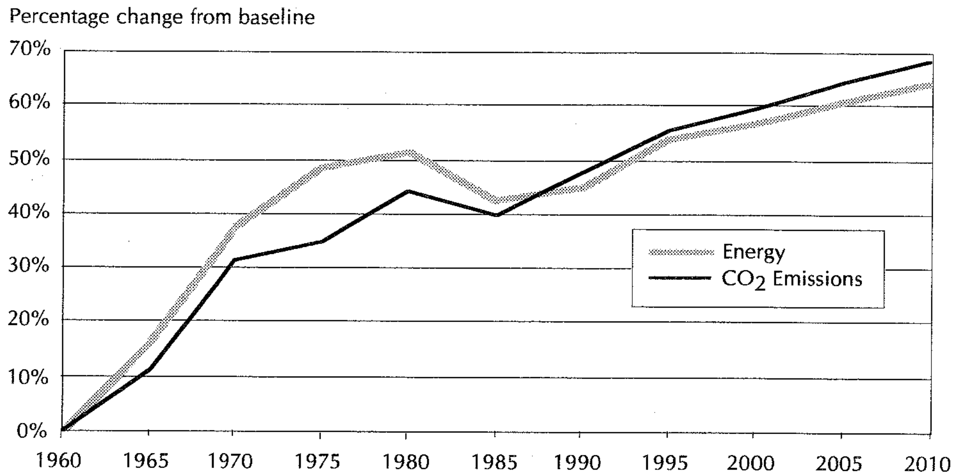

Figure 1. Cumulative growth rates, energy versus CO_2 emissions

The Energy Bureau of the Iowa Department of Natural Resources has forecast energy consumption through the year 2010 using Energy Information Administration forecasting techniques and trends. The projection assumes continued moderate economic growth such as that experienced by Iowa in recent years. Projections begin with 1993 and show increases in total energy consumption, on a Btu basis, of roughly 0.65 percent annually. Figure 2 shows the forecast through the year 2010, with total energy consumption equaling 1,011 trillion Btu per year (tBtu/yr) in 2000, and 1,082 tBtu/yr in 2010.

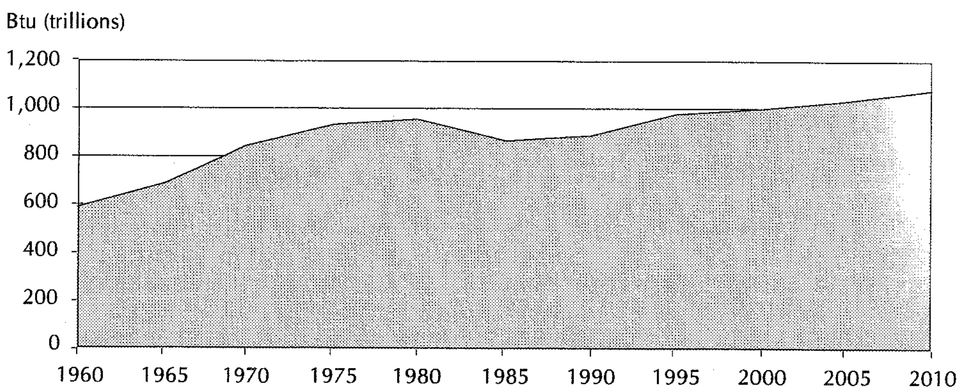

Figure 2. Historical and projected Iowa energy consumption

Emissions of carbon dioxide (CO_2) are forecast to increase at a slightly faster rate than total energy consumption (Figure 3). This is due to a predicted future reliance upon coal-fired electricity generation, based on faster increases in coal consumption as compared to natural gas or petroleum fuels. Coal is forecast to provide 47 percent of total energy needs in 2000 and 48 percent in 2010. Natural gas is predicted to provide 18 percent of energy needs in both 2000 and 2010, and petroleum products are forecast to provide 34 percent of energy needs in 2000 and 2010. Carbon dioxide emissions from energy consumption are forecast to be 12.5 percent higher in 2000 than 1990 emissions, and year 2010 emissions are predicted to be 22.4 percent higher than 1990 emissions.

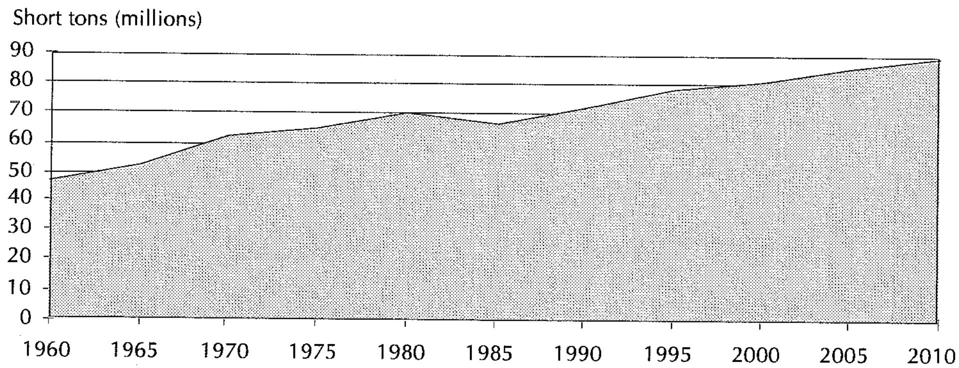

Figure 3. Historical and projected Iowa CO_2 emissions

ELECTRIC UTILITIES

Electric generation is predicted to grow rapidly in the future (Figure 4). Energy consumption for electric generation is predicted to increase by 21.2 percent from 1990 through the year 2010. While this seems by itself to be a staggering growth rate, it pales in comparison to the consumption increase of 153 percent seen from 1970 to 1990, or the 38 percent increase seen for the decade of 1980 through 1990. Although the forecast may be reasonably conservative, it still does not present a picture consistent with greenhouse gas reduction goals.

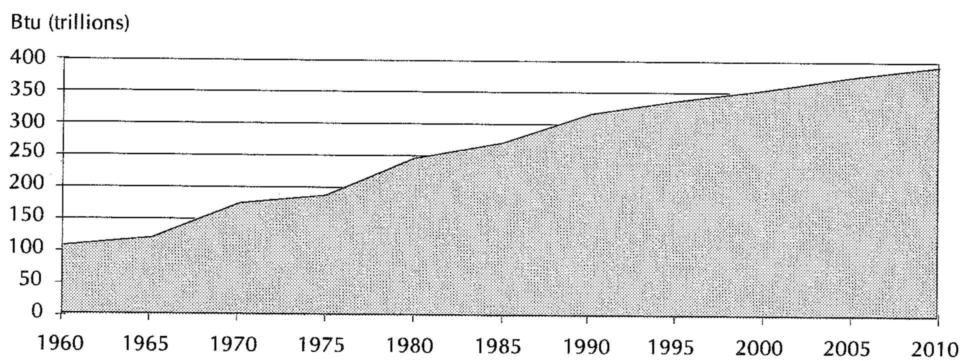

Figure 4. Electric utility energy consumption baseline forecast

COMMERCIAL SECTOR

Energy consumption is a mixed forecast for the commercial sector which includes many farms as well as small- to moderately sized businesses (Figure 5). (Some farms are classified across commercial and industrial sectors.) Energy consumption is assumed to increase by 17.2 percent over the years 1990 to 2000; however, the peak is forecast to occur in 1993, followed by a slow but steady decrease, reflective of increased energy efficiency in the sector.

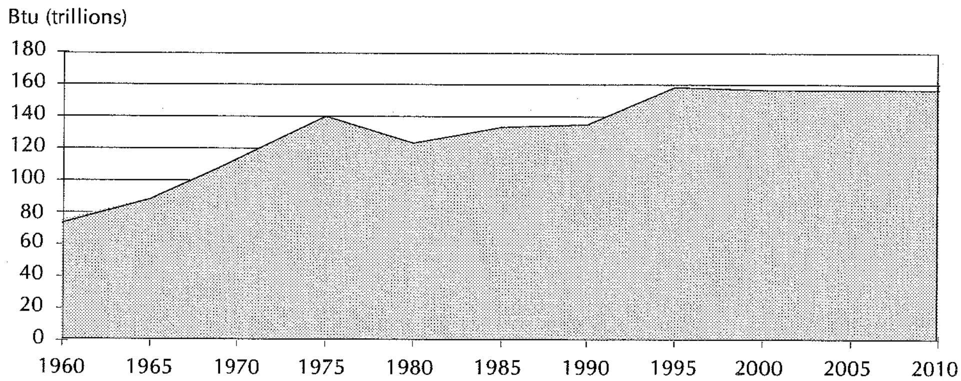

Figure 5. Commercial energy consumption baseline forecast

INDUSTRIAL SECTOR

The industrial sector is forecast to grow steadily through the year 2010, reflecting the current experience of industrial expansion in the state and the overall strength of the U.S. economy (Figure 6). For the period 1990 through 2010, the industrial sector is predicted to be the fastest growing of Iowa's economic sectors. Growth rates are presumed to remain steady at approximately 1.2 percent per year through 2010. Even at that seemingly small growth rate, energy consumption of 326.9 trillion Btu in 1990 becomes 428.7 trillion Btu in 2010, making the industrial sector the largest energy-consuming sector of the Iowa economy.

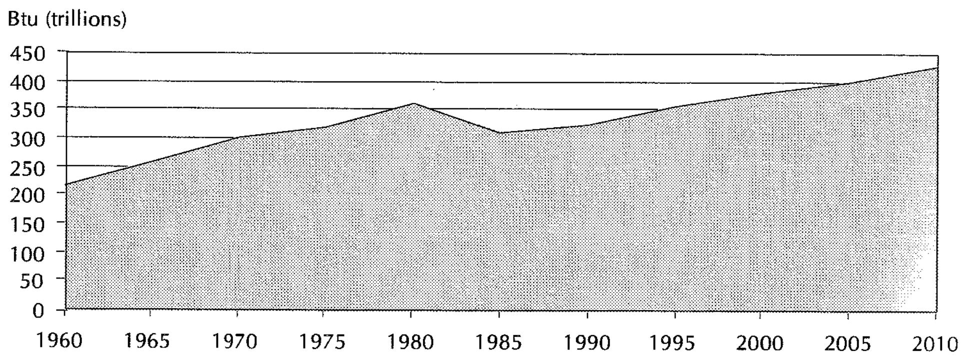

Figure 6. Industrial energy consumption baseline forecast

RESIDENTIAL SECTOR

A decrease in energy consumption is forecast for the residential sector beyond the year 1995, reflecting slow expansion of the Iowa population, renewal of Iowa housing stock, and the resulting energy efficiency increases (Figure 7). Energy consumption for the residential sector of 202.9 trillion Btu is forecast to increase to 220.3 trillion Btu by 1995, but then decrease through 2010, resulting in the consumption of 213.8 trillion Btu.

TRANSPORTATION SECTOR

The transportation sector is predicted to be the third fastest growing sector of the Iowa economy, behind the industrial and electric utility sectors (Figure 8). An increase in energy consumption of slightly over 21 percent is forecast for transportation from 1990 to 2010. The primary source for this predicted growth is

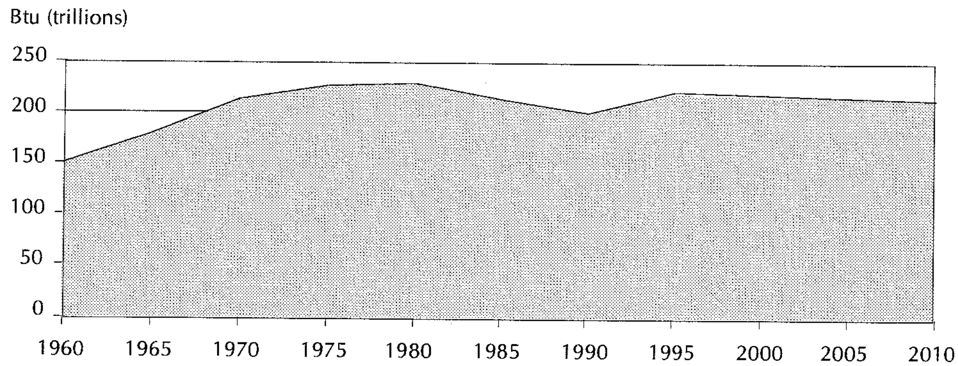

Figure 7. Residential energy consumption baseline forecast

increases in vehicle miles traveled; no increases in vehicle fuel efficiency are forecast. Based on 1990 greenhouse gas emissions for Iowa, 25.2 percent of all CO_2-equivalent emissions were contributed by the transportation sector, primarily due to the combustion of gasoline and diesel fuel. (Ethanol combustion in motor vehicles contributed less than one percent of greenhouse gas emissions.) Changes in public policy would be necessary to reduce this large proportion (25.2 percent) of emissions from the transportation sector.

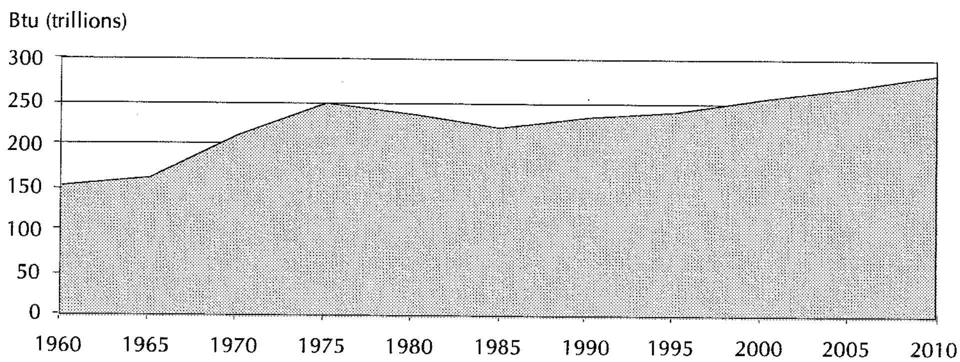

Figure 8. Transportation energy consumption baseline forecast

TRANSPORTATION STRATEGIES

The broad national policies suggested by the Office of Technology Assessment (OTA) and the strategies outlined in *The Climate Change Action Plan* (President and Vice President 1993) have varying appeal in Iowa. Based on Iowa's characteristics, the policy options that appear to have the most potential for influencing energy use in the short term are for the state to increase fuel taxes; discourage single occupancy vehicle trips; promote transit use; and improve fuel economy and vehicle emissions through tax incentives, regulation, and technology improvements. Each strategy is discussed in turn.

INCREASE FUEL TAX

Using fuel tax rates to influence travel choices has many advantages. Increasing the relative cost of driving an automobile would have a number of short-term benefits: it would promote carpooling, deter some trip-making, and encourage transit use where available and practical. Over the longer term, a higher fuel tax would increase incentives for individuals to buy vehicles with better fuel efficiency, and even support the development of land use patterns that rely less on vehicular travel for mobility.

The overall level of travel in Iowa has grown steadily during the last several decades. Figure 9 shows how vehicle-miles of travel (VMT) per person have increased from 1960 to the early 1990s. In 1960, people in the U.S. and in Iowa traveled on average about 4,000 miles each year. By 1992, the average was about 8,700 miles per year. Iowans traveled somewhat fewer miles per person than was true nationally from the late 1970s through the early 1990s, but the amount of travel is now about equal.

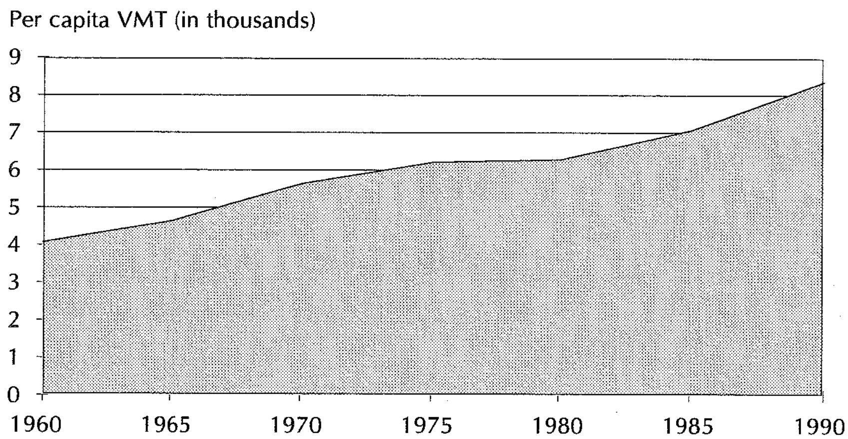

Figure 9. Iowa per capita vehicle miles traveled

When vehicles burn gasoline, they emit CO_2. Figure 10 shows how the level of CO_2 emissions from gasoline has changed from 1960. In 1977, emissions of CO_2 grew to 160 percent of the 1960 level but fell back to about 130 percent in the early 1990s. The share of all emissions of CO_2 that gasoline is responsible for was about 85 percent in the early 1960s. Since then, this proportion has dropped to about 70 percent, a level reached in 1982 and maintained since then. Emissions per unit of travel have declined significantly over the last 20 years. In the 1960s, about 1,200 VMT of travel produced one ton of CO_2. By 1980, it took 1,400 VMT to emit one ton, and by 1992, almost 2,000 VMT were needed to produce one ton.

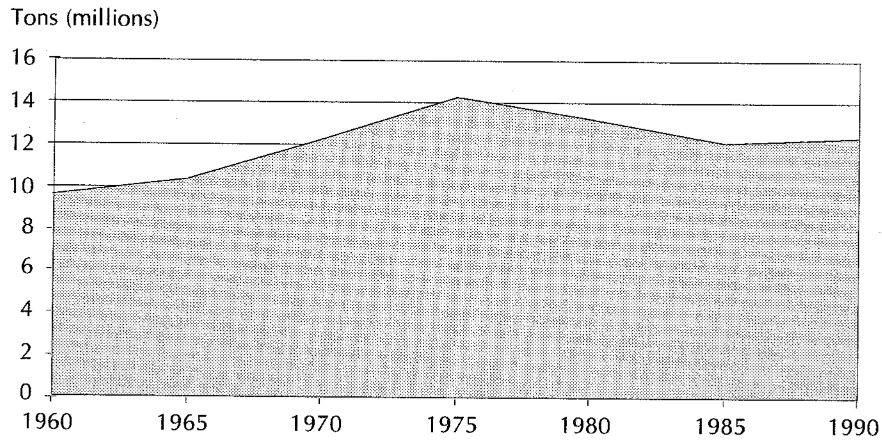

Figure 10. Iowa CO_2 emissions from gasoline

Limiting emissions by increasing fuel taxes

One goal of state policy could be to stabilize emissions of CO_2 from gasoline. In other words, the emissions level in 1990 could be used as a target for the year 2000. The level of emissions in 1990 was estimated to be 12.36 million tons of CO_2. The annual growth rate of VMT in Iowa from 1980 to 1993 was about 2.5 percent per year. Taking into account a declining population, the per capita VMT growth rate was about 2.8 percent per year (Table 1).

If we assume that travel will grow from 1993 to 2000 at the same 2.5 percent growth rate, total VMT in Iowa will be 30,188 million VMT. The amount of CO_2 that would be emitted in 2000 would depend crucially on the emissions per unit of travel of the vehicle fleet in that year. About five percent of Iowa's fleet is purchased new each year, and the fuel efficiency of the average new car today is about 12 miles per gallon better than that of a new automobile a decade ago (BTS 1994); by 2000, over one-quarter of Iowa's automobile fleet should be much more fuel-efficient than the oldest cars in today's fleet. More research would be needed to precisely determine the magnitude of this efficiency effect.

If the policy objective were to limit total CO_2 emissions in 2000 to 1990's level of 12.36 million tons, the number of miles traveled per ton of CO_2 would have to rise from 2,000 (today's level in Iowa) to about 2,442, an increase of 22 percent. Given the 40 percent improvement achieved from 1980 to 1992, it may well be possible to improve efficiencies by this amount with fleet replacement alone. To the extent that such further efficiency is not possible or realistic, total travel could be reduced by increasing fuel taxes. If efficiencies increased by 15 percent, the balance of the goal, about seven percent, could be addressed by fuel taxes.

It is important to note that changing fuel taxes is a strategy rather limited in its ability to influence overall automobile costs, especially in comparison to earlier decades. In 1994, the cost of operating an automobile was $4,665 per 10,000 miles, in 1990 dollars (BTS 1994). Of this total cost, $910 (19.5 percent) was related to variable costs of operating a car, primarily the purchase of gasoline and oil, maintenance, and the cost of tires. In 1975, the variable cost was $1,566 in 1990 dollars, almost twice as high in real terms. In the late 1990s, given stable overall energy prices, it is clear that only large changes in fuel taxes have any prospect of significantly impacting the total costs of owning and operating an automobile.

Table 1. Selected trends in travel and emissions, U.S. and Iowa, 1960–1993

	VMT per capita (miles)		Iowa CO_2 emissions			
Year	U.S.	Iowa	From gasoline*	Index with 1960=100	State total*	Share accounted for by gasoline
1960	3,994	4,082	9.59	100	11.37	84%
1961	4,029	4,158	9.73	101	11.54	84%
1962	4,125	4,236	9.87	103	11.71	84%
1963	4,269	4,364	10.01	104	11.89	84%
1964	4,423	4,485	10.15	106	12.06	84%
1965	4,588	4,644	10.29	107	12.23	84%
1966	4,760	4,866	10.90	114	13.27	82%
1967	4,872	5,064	11.50	120	14.31	80%
1968	5,096	5,368	12.11	126	15.35	79%
1969	5,318	5,541	12.71	133	16.39	78%
1970	5,499	5,669	12.26	128	15.90	77%
1971	5,753	5,800	13.32	139	17.43	76%
1972	6,091	5,939	13.78	144	18.11	76%
1973	6,198	6,179	15.06	157	19.55	77%
1974	6,101	6,046	14.17	148	18.79	75%
1975	6,173	6,197	14.25	149	18.94	75%
1976	6,476	6,363	15.15	158	19.76	77%
1977	6,719	6,530	15.36	160	20.11	76%
1978	6,957	6,671	15.44	161	20.05	77%
1979	6,809	6,502	14.49	151	19.89	73%
1980	6,713	6,282	13.24	138	18.21	73%
1981	6,751	6,414	12.65	132	17.34	73%
1982	6,864	6,668	12.44	130	17.76	70%
1983	7,039	6,786	12.74	133	17.61	72%
1984	7,260	7,053	12.36	129	17.74	70%
1985	7,459	7,104	12.05	126	17.06	71%
1986	7,641	7,336	12.07	126	16.86	72%
1987	7,929	7,526	12.19	127	17.47	70%
1988	8,286	7,888	12.57	131	18.04	70%
1989	8,494	8,123	12.66	132	18.26	69%
1990	8,622	8,342	12.36	129	18.16	68%
1991	8,615	8,449	12.48	130	17.59	71%
1992	8,781	8,709	12.25	128	17.58	70%

*In millions of tons.

SOURCES: VMT data for U.S. and Iowa from Iowa DOT 1995. Population data from U.S. Department of Commerce 1994, Table 26; 1988, Table 21; 1986, Table 12; 1978, Table 11; 1975, Table 11; 1971, Table 12; 1966, Table 9; 1961, Table 6; 1952, Table 10; 1944–1945, Table 8. Emissions from motor gasoline in Iowa from Ney and Schnoor 1995, p. 74.

Carpooling

One interesting side effect of increases in fuel prices is that they promote carpooling as well as exerting downward pressure on the overall amount of travel. Ferguson (1994) analyzed Census and Nationwide Personal Transportation Survey (NPTS) data on carpooling for the period from 1970 to 1990. Since oil prices rose significantly in the 1970s and then fell as much in the 1980s, he used a comparative statistics approach to estimate the elasticity of carpooling with respect to gasoline prices (which allows for changes in fuel efficiencies). Based on this analysis, Ferguson estimated that the elasticity of carpooling with respect to gasoline prices is 26.1 percent. That is to say, as gasoline prices change by 100 percent, carpooling will increase by 0.261. He further estimated that it would take an increase of 51 cents per gallon in gasoline prices to offset the ongoing decline in the carpooling rate associated with other factors and an increase of $1.31 per gallon to restore the 1980 carpooling rate (19.7 percent) by the year 2000 (pp. 2–10, 2–11).

A significant tax increase has a number of serious disadvantages. Rural residents do not have as many modes to choose from as their urban counterparts, and are not able to reduce their trip-making by as much. Similarly, lower income people are less able to purchase newer cars with higher fuel efficiency ratings and so may bear a larger burden. Finally, there are important state border issues that would arise if Iowa had a significantly higher gasoline tax than its neighbors. As the tax differential increased, the incentive to purchase fuel elsewhere would also increase, thus undermining the rationale for the policy. In the worst case scenario, more travel would be undertaken to evade the tax, and travel patterns would remain unchanged otherwise. Another approach would be to impose a small gas tax of four cents per gallon, which would not be a burden on the economy but would raise $32 million per year to help fund the Greenhouse Gas Action Plan.

DISCOURAGE SINGLE OCCUPANCY VEHICLE TRIPS

Although increasing fuel taxes is the most direct way to influence the relative costs that people confront when deciding to use an automobile, a number of other policy levers also discourage the use of single occupancy vehicles, especially in urban areas and for work trips.

Parking regulations and controls

In areas out of attainment with federal clean air regulations, the Clean Air Act Amendments of 1990 require that all employers with over 100 workers introduce and maintain programs to reduce the number of commute trips (Office of Air and Radiation 1992). The goal for programs in nonattainment areas is that the average vehicle occupancy for commute trips increase by 25 percent. Even if such programs are implemented successfully, Orski (1993) questioned whether the overall impact would be very significant. Studying the Los Angeles area, he found that only 25 percent of all trips were to and from work, and only 40 percent of these were to employers with over 100 workers. A 25 percent reduction in work trips to large work sites, if achieved, would only reduce total trips by about two to three percent. While this is an important amount, it is likely to be mitigated quickly by the general trend toward higher numbers of trips.

The Principal Financial Group in Des Moines is concerned about the financial and environmental effects of their employees commuting to and from work. There are limited downtown parking spaces for their employees; 500 parking stalls were lost to the Hillside Development. This reduction in parking spaces, along with traffic congestion, increased air pollution and fuel savings were important factors in The Principal's decision to adopt transportation policies that encourage their employees to take buses and carpool.

Combined with the 475 existing bus riders, The Principal had a total of 840 employees who commuted by bus last June. New employees of The Principal visit with bus line representatives to learn about commuting options. The Principal fully subsidizes the Des Moines Metropolitan Transit Authority (METRO) $22 monthly bus pass for their employees and has doubled their inter-city MTA Ankeny and Five Oaks bus subsidies.

Ride-share incentives have also been offered by The Principal. Quarterly drawings have been held for cash prizes: $25 for two people per vehicle, $35 for three people per vehicle, and $50 for four people per vehicle. In addition, two employees who carpooled from July 1, 1993 through December 31, 1993 won a grand prize of $300 in travel certificates.

Telecommuting

Telecommuting is an option that could help to revitalize small towns in Iowa. Telecommuting employees spend most or part of their work time at home, and complete their assignments and correspondence electronically by computer. Because there are relatively few commuters in Iowa compared to other states, this option would not result in major CO_2 emission reductions, but it is a trend in some companies (e.g., Principal Financial) that should continue. Regional satellite offices could be established for large companies in rural Iowa (where costs are low) that would reduce commuting distances and be linked to other offices by computer.

Changing tax treatment of parking

In 1990, drivers reported that they paid nothing for parking on 99 percent of their automobile trips (Shoup 1995). Somewhat similarly, 95 percent of all respondents reported that they paid nothing for commuting trips to work. Since commuting accounts for a significant share of all trips and vehicle miles, especially in peak hours, the fact that parking is provided at no cost to so many drivers may lead to more use of automobiles than is socially desirable.

Employer Paid Parking

A number of studies have found that the removal of employer-paid parking does have an effect on the share of work trips taken by single drivers in automobiles. Studies to investigate this phenomenon have looked at the removal of such parking (before/after study) or compared similar groups of workers with and without this benefit (with/without study). Shoup reported that seven studies from 1969 to 1991, mostly in Los Angeles, found that the modal share of solo drivers falls on average from 67 percent when employers pay for parking, to 42 percent when employees pay. The price elasticity of demand is –0.15, indicating that as the price of parking increases by 100 percent, the demand for it will fall by 15 percent.

In general, no significant public policy issue arises with an employer-paid benefit such as parking. Employers and employees are free to negotiate terms of employment that both are willing to offer and accept. There are two reasons why employer-provided parking may not provide for a socially optimal level of automobile use. First, the tax treatment of employer-provided parking is not neutral. Under the tax rules in effect at the federal level in most states, the value of the parking that is provided for employees is not taxed. An employee who receives parking worth $100 per year does not have to pay tax (either federal, state or local) on the additional income thus received. This advantage is likely to lead employers to provide parking as an employee benefit more than is socially desirable. Second, offering parking as a benefit to employees is not a uniform benefit, and favors automobile use. If an employer offers free parking to those who desire it, and nothing to those who do not, no incentive is created to use other modes, such as cycling or transit, even though society would gain through the resources not used to provide parking and the accompanying reduction in energy use and emissions.

In 1992, California passed legislation requiring employers who lease parking spaces for employees to offer an equivalent cash amount to all employees who do not use a space. The legislation has three important advantages:

- the price of parking is "revealed";
- employees now have a choice and an incentive not to use parking; and
- employers have little added cost, as only spaces currently leased from outside entities are affected.

The state of Iowa could adopt a plan to address the effects of employer-provided parking on energy consumption and environmental emissions. The basic features of such a plan would include one or both of the following policy changes:

- Require employers to offer a "cash-out" plan for parking. Such a requirement could initially cover only spaces leased on the commercial market, or could be designed to include the cost of spaces provided by the employer directly. This second approach would require the employer to set a monetary value on such parking spaces.
- Include the value of employer-provided parking spaces in the taxable income of those employees who benefit. Alternatively, disallow the cost of providing such spaces as a deduction from corporate income.

The simplest change, requiring a "cash-out" for currently purchased parking spaces, would be relatively straightforward to administer. The employers involved already know the cost of parking, who parks and who does not, and offering a choice should be administratively easy. A "cash-out" policy should be relatively popular, as employees are not required to stop using automobiles but simply encouraged to consider other ways to get to work. Employers would not be burdened by extra costs above and beyond those already borne.

These changes would be more difficult to engender political support for and administer if they also applied to parking spaces not currently bought and sold, or if employees' tax liabilities were to increase as a result.

A number of demonstration programs have been conducted to test the effectiveness of "cash-outs." In Seattle, for example, two demonstration programs were undertaken between 1992 and 1994 (Wong and Woo 1994). In the first program, called "Parking Pass," workers at five major employers in downtown Seattle were offered four free or reduced-cost parking vouchers each month if they bought a monthly bus pass. The "Parking Pass" program had limited success in making workers who had driven to work alone change to monthly bus passes. Of all the participants in the program (about half of all workers at the sites), the bulk had already been using buses or a mixture of modes. Only nine percent had been driving single occupancy vehicles. The program's major successes were in allowing bus riders to have a few days of parking for use when needed, and in encouraging bus riders to buy monthly passes instead of paying cash each day. In the second program, "Cash in Your Car," commuters working for three employers who agreed to forgo a free or subsidized parking space were given a cash payment instead. This program was even less effective than the "Parking Pass" program. Only 26 workers out of an estimated 277 who were eligible (e.g., sales staff, who received free parking but were not required to have a car at work) participated in the program. Most of those who enrolled used buses to commute.

When considering these findings and how they apply to Iowa, we should stress that the "Cash in Your Car Program" was only tested with employers located in areas where the monthly parking charge exceeded $30. The limited appeal of the program even in this kind of environment suggests that the impact in most urban areas in Iowa would be very modest.

The state is much more limited in its ability to tax the value of parking since federal tax rates are so much higher than state tax rates. An employee who had to pay only state tax on a parking benefit would feel much less impact than if the federal government adopted this kind of policy.

PROMOTE TRANSIT USE

The most important market for public transit has traditionally been the journey to work. Job sites are often concentrated close together and the fact that many users wish to make a trip at approximately the same time of day allows transit operators to schedule services close together. Promoting increased use of transit as a way to limit automobile use will have to be successful for work trips if this strategy is to have any significant effect on overall transportation use.

Transit is used in a rather low share of work trips in the state of Iowa. Transit provides only 1.2 percent of all journeys to work. In the group of 24 larger cities, transit provides 2.5 percent of all trips. This average is raised by university communities in Iowa City and Ames, which have far higher transit shares (10.0 percent in Iowa City and 7.8 percent in Ames). In fact, the low overall transit share of work trips (1.2 percent statewide) masks a 0.3 percent share outside the 24 larger cities and a 2.5 percent share within them. Any policy adopted in Iowa to promote transit has to focus on larger towns in order to build on established transit systems. Introducing new systems outside these cities would be expensive and almost certain not to attract significant numbers of users.

In the short to medium term, transit use in Iowa can be promoted most effectively through one of two objectives:

- further increase usage in communities with relatively high transit use, or
- stimulate the use of transit in communities where the current level of usage is relatively low.

To have a significant effect on current modes used by Iowans, the state would need to adopt coordinated measures involving employers, parking availability, land use controls, and increased transit services. Because of the trend at the federal level to reduce support for transit services, the state would have to commit funds to increase transit services. While improving transit use in already well-served communities is probably more likely to be achieved, this increase would be costly. More realistic is to expect only relatively small increases and even then, only for work trips. Currently available transit resources are unlikely to be able to perform a big role in Iowa for nonwork trips in the foreseeable future.

IMPROVE FUEL ECONOMY AND VEHICLE EMISSIONS THROUGH REGULATIONS AND IMPROVEMENT OF TECHNOLOGY

During the energy crisis of the mid-1970s, Congress adopted a regulatory policy to improve the energy efficiency of automobiles. A set of Corporate Average Fuel Efficiency (CAFE) standards were established. Automobile manufacturers had to meet a fleet-wide average level of fuel efficiency that was set for 1978's model year at 18.0 miles per gallon (mpg) for automobiles, rising to 27.5 mpg for the 1985 model year. Standards for light trucks were about one-quarter lower (NHTSA 1993).

The improvements in fuel efficiency that CAFE standards and higher energy prices have precipitated are starting to level off. Greene notes that 1992 and 1993 probably represented two consecutive years of declines in average miles per gallon for the fleet of automobiles and light trucks in the U.S. (Greene and Fan 1995). The increasing efficiency of each automobile has been offset by two factors:

- the number of people in each vehicle has declined, although data on average vehicle occupancy is only collected occasionally; and
- more people are buying light trucks, minivans, or vehicles with four-wheel drive.

On average, passenger cars in 1972 carried just over two people (Greene and Fan 1995). By 1990, occupancy averaged only 1.62 people, indicating that average occupancy fell by 21.7 percent in two decades. The occupancy of light trucks fell a smaller amount, from 2.02 people per vehicle in 1972 to 1.72 in 1990, for a decline of 14.9 percent.

Light trucks and minivans comprise a larger share of new vehicle sales in the 1990s than was true in the 1970s. This trend has led fuel consumption of the new vehicle fleet to be somewhat higher than would have been expected otherwise, given the improvement in the fuel efficiency of automobiles.

Greene estimates that the falling occupancy rate is largely responsible for keeping the level of energy use higher than would be expected given increases in fuel efficiency (Greene and Fan 1995). Changes in buyers' preferences for light trucks have also contributed to this trend, but to a much smaller degree.

Many economists have argued that a regulatory approach such as CAFE standards is an inefficient mechanism for increasing energy conservation. For example, Nivola and Crandall (1995) contend that CAFE standards have had two effects that work counter to its intent, given a stable real cost of gasoline. First, because newer vehicles are more fuel-efficient, CAFE standards have reduced the marginal cost of driving for people using newer vehicles. Secondly, because the standards have increased the real cost of new vehicles, there is an incentive to keep older, less fuel-efficient vehicles on the road longer. Instead, Nivola and Crandall argued that a policy focused on increasing the cost of fuel would have just as much impact on energy consumption but with fewer other costs. They estimate that a tax of 25 cents per gallon if it had been introduced in 1986 as oil prices fell, would have led to as much energy saving as CAFE standards over the entire period of 1978 to 1992 (p. 56).

Figure 11 depicts two basic problems regarding transportation in Iowa. The top panel shows that the number of old vehicles (1982 models and older) is a relatively large fraction of the total. These older vehicles do not have efficient emission control devices for carbon monoxide, nitrogen oxides, and hydrocarbons. They also give low fuel efficiencies (low miles per gallon). Second, the trend in the mixture of vehicles sold increasingly favors multipurpose autos (vans and light trucks) with a major

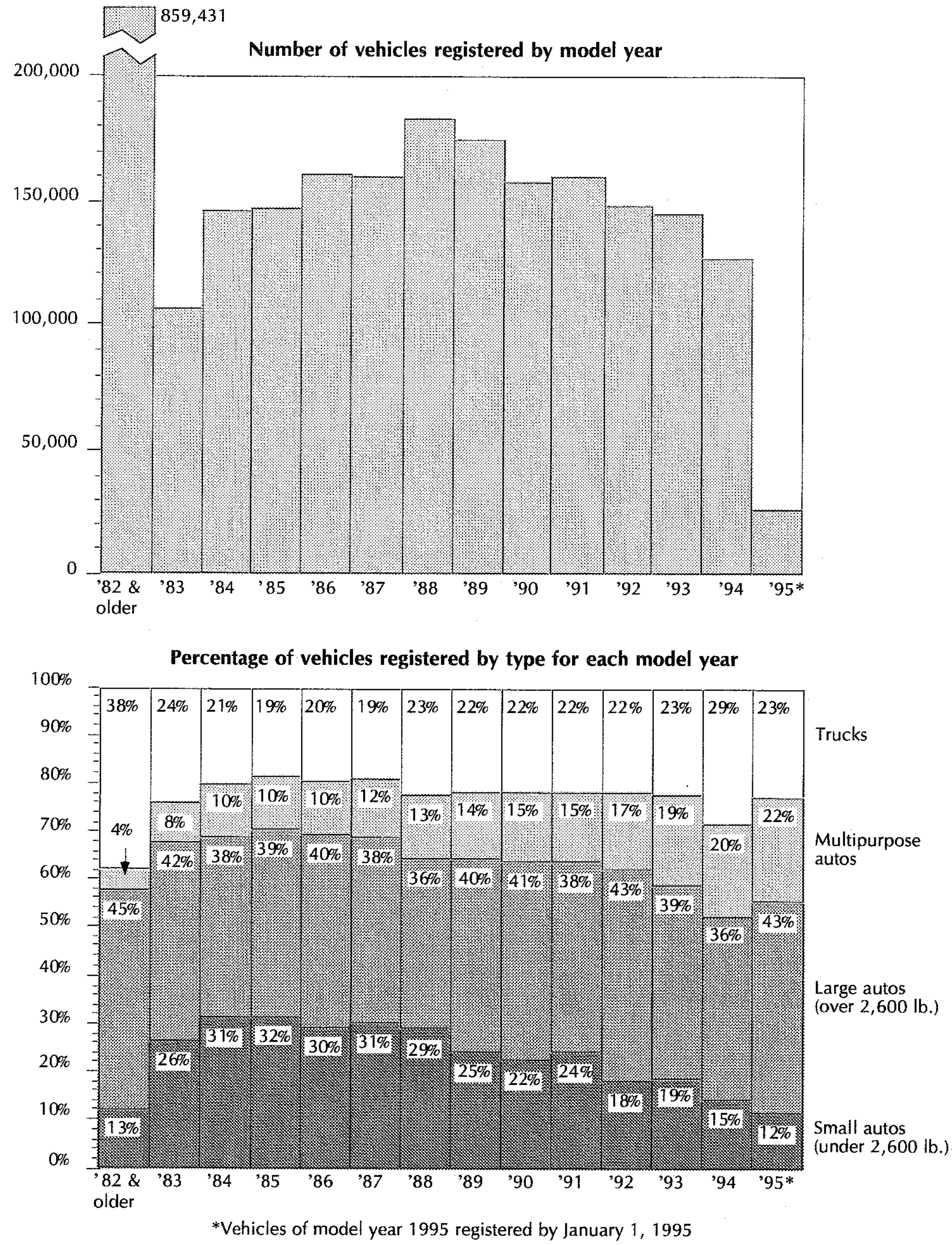

Figure 11. Registered vehicles in Iowa by model year and type, 1994

SOURCE: Iowa DOT 1996.

decrease in the sale of small, fuel-efficient autos since 1988. This is a federal trend that is difficult to address with state policy.

Economic incentive programs

An alternative policy mechanism to encourage people to purchase fuel-efficient vehicles has been proposed by Johnston (1994). He devised a modified automobile registration system whereby purchases of new vehicles attaining greater than a specified fuel efficiency would receive a rebate. Those purchasing vehicles with less than this level of fuel efficiency would pay a fee. The rebate or fee would increase for vehicles with fuel efficiencies farther above or below the reference level. Johnston suggested that after accounting for administrative costs, the rebate/fee system should be essentially revenue-neutral.

While this pricing system would only affect the new car fleet, it could provide a significant economic incentive to purchase fuel-efficient and less polluting vehicles. Table 2 illustrates how a rebate/fee system could influence the price of new automobiles. In the table, Johnston demonstrates one possible rebate/fee schedule; the rebate or fee level is linear with the amount by which a vehicle's fuel efficiency differs from the sales-weighted average of all vehicles. Table 2 does not include all possible models of new automobiles, and as such it is only illustrative. Also, sales are national; an Iowa rebate/fee schedule should be based on prior-year sales within the state because the vehicle mix is likely to be different from that of the nation.*

It is difficult to estimate accurately the increase in fuel efficiency a rebate/fee system such as this would contribute. It would depend on the price elasticity of demand for different classes of new vehicles. The magnitude of the impact would also depend on how aggressively the rebate/fee system is structured. If the system were able to raise the average fuel efficiency within Iowa by two miles per gallon by the year 2000, about one million fewer tons of CO_2 would be emitted annually.

The advantages of this pricing system are twofold. First, unlike CAFE standards, it is market-based, at least to a degree. Second, it can be dynamic (e.g., as the average fuel efficiency of new vehicles increases, the reference level can be raised correspondingly).

Alternative fuel use

Another way to achieve lower emissions is to use fuels other than gasoline and diesel. A recent report by the Organization for Economic Cooperation and Development (OECD) examined the air quality and greenhouse gas effects of different alternative fuels that could be adopted (European Conference of Ministers of Transport 1993). The report concludes that governments have different policy choices depending on other policy considerations.

In situations where self-sufficiency is important, governments should promote alternative fuels that are abundant locally, such as natural gas in Norway. If governments wish to pursue economic efficiency, then only liquefied petroleum gas (LPG) and natural gas appear desirable in some locations. If the major goal is to achieve short-term environmental benefits, then natural gas and LPG look most promising. In the longer term, the most desirable sources of fuel are nonfossil fuels (if practical), along with hydrogen, electric, and fuel cell sources.

The OECD researchers also conclude that, for the near future, if the goal is to decrease emissions of gases that may promote global warming, governments can only seek to "dramatically reduce overall consumption of fuels" (p. 13).

At present, the number of vehicles that run on alternative fuels in the U.S. is quite low but growing rapidly. In 1995, an estimated 418,626 vehicles in the U.S. used such fuels, dominated by the 299,000 LPG vehicles (BTS 1995, Table 3–3, p. 52). These vehicles represented only 0.2 percent of all vehicles in use.

* It should be noted that in Johnston's example, rebates account for only 70 percent of the fees collected. Because administrative costs are not likely to be very substantial, it would be possible to raise this percentage, perhaps as high as 95 percent. Note, too, that the sales and rebate/fee figures in Table 6 are national, hence, the large values.

Table 2. Fees and REBATES for the 60 top-selling automobiles in model year (MY) 1993

Automobile (MY '94)	Size class	Fuel economy (mpg) City	Highway	Average	Vehicle price	Fee or (rebate)	Adjusted price	Percentage change	Domestic sales (MY '93)	Revenue from fees
Ford Taurus GL	I	19.0	28.0	23.5	$16,140	$507	$16,647	3.14%	409,751	$207,908,646
Honda Accord DX Sedan	I	23.0	30.0	26.5	$15,080	($215)	$14,865	–1.43%	329,751	($70,962,070)
Ford Escort 3dr	C	25.0	33.0	29.0	$9,035	($703)	$8,332	–7.78%	263,622	($185,369,109)
Chevrolet Lumina Coupe Euro	I	19.0	29.0	24.0	$16,875	$374	$17,249	2.22%	218,144	$81,678,281
Chevrolet Cavalier Coupe VL	C	23.0	33.0	28.0	$8,845	($518)	$8,327	–5.86%	212,374	($110,101,786)
Pontiac Grand Am SE Coupe	C	22.0	32.0	27.0	$12,514	($320)	$12,194	–2.56%	210,332	($67,310,606)
Toyota Camry Coupe DX 5M	I	21.0	28.0	24.5	$16,148	$247	$16,395	1.53%	208,177	$51,393,211
Ford Tempo 2dr GL	C	22.0	27.0	24.5	$10,735	$247	$10,982	2.30%	207,173	$51,145,351
Saturn SC1	S	26.0	35.0	30.5	$12,495	($958)	$11,537	–7.66%	196,126	($187,799,181)
Chevrolet Beretta/Corsica Sedan	C	21.0	29.0	25.0	$13,145	$124	$13,269	0.95%	166,625	$20,732,097
Honda Civic DX Hatchback	S	29.0	36.0	32.5	$11,780	($1,260)	$10,520	–10.70%	145,967	($183,946,401)
Buick LeSabre Sedan	L	19.0	28.0	23.5	$20,860	$507	$21,367	2.43%	138,409	$70,229,060
Cadillac Fleetwood	L	17.0	25.0	21.0	$33,990	$1,267	$35,257	3.73%	135,270	$171,425,078
Toyota Corolla Sedan LE 4ECT	C	26.0	32.0	29.0	$16,088	($703)	$15,385	–4.37%	133,321	($93,746,330)
Oldsmobile Cutlass Cierra S	I	19.0	29.0	24.0	$15,675	$374	$16,049	2.39%	117,292	$43,916,903
Mercury Sable GS	I	20.0	29.0	24.5	$17,740	$247	$17,987	1.39%	116,623	$28,791,031
Lincoln Town Car Executive	L	18.0	25.0	21.5	$34,750	$1,101	$35,851	3.17%	115,075	$126,716,893
Buick Century Sedan	I	25.0	31.0	28.0	$15,495	($518)	$14,977	–3.35%	114,273	($59,242,946)
Nissan Sentra E 2dr	S	26.0	35.0	30.5	$11,699	($958)	$10,741	–8.18%	113,973	($109,134,108)
Pontiac Grand Prix SE Sedan	I	19.0	29.0	24.0	$16,174	$374	$16,548	2.31%	103,517	$38,759,217
Pontiac Bonneville SE Sedan	L	19.0	28.0	23.5	$20,424	$507	$20,931	2.48%	97,944	$49,697,022
Mercury Grand Marquis GS	L	18.0	25.0	21.5	$20,330	$1,101	$21,431	5.42%	94,607	$104,178,189
Ford LTD Crown Victoria	L	18.0	25.0	21.5	$19,300	$1,101	$20,401	5.71%	92,506	$101,864,635
Buick Regal Custom Coupe	I	19.0	29.0	24.0	$17,999	$374	$18,373	2.08%	91,672	$34,324,168
Chevrolet Caprice Sedan	L	17.0	25.0	21.0	$18,995	$1,267	$20,262	6.67%	88,972	$112,752,510
Dodge Shadow 2dr	C	22.0	27.0	24.5	$9,206	$247	$9,453	2.68%	87,074	$21,496,191
Ford Thunderbird LX	L	18.0	25.0	21.5	$16,830	$1,101	$17,931	6.54%	84,186	$92,702,919
Geo Metro XFi Coupe	S	46.0	49.0	47.5	$7,195	($2,718)	$4,477	–37.77%	83,173	($226,037,730)
Mercury Topaz GS	C	22.0	27.0	24.5	$11,270	$247	$11,517	2.19%	80,755	$19,936,202
Oldsmobile Cutlass Supreme S	I	17.0	26.0	21.5	$17,375	$1,101	$18,476	6.34%	80,195	$88,308,158
Oldsmobile Eighty-Eight Royale	L	19.0	28.0	23.5	$20,875	$507	$21,382	2.43%	75,517	$38,317,508
Geo Prizm LSi	C	26.0	32.0	29.0	$11,500	($703)	$10,797	–6.11%	74,346	($52,277,321)
Plymouth Acclaim Sedan 21A	I	22.0	27.0	24.5	$13,170	$247	$13,417	1.87%	73,220	$18,076,017
Pontiac Sunbird LE Coupe	C	23.0	31.0	27.0	$9,764	($320)	$9,444	–3.28%	72,563	($23,221,666)
Oldsmobile Achieva S Coupe	C	22.0	32.0	27.0	$14,075	($320)	$13,755	–2.27%	71,805	($22,979,090)

Table 2. Fees and rebates for the 60 top selling automobiles in model year (MY) 1993 (continued)

Automobile (MY '94)	Size class	Fuel economy (mpg) City	Highway	Average	Vehicle price	Fee or (rebate)	Adjusted price	Percentage change	Domestic sales (MY '93)	Revenue from fees
Plymouth Sundance 3dr	C	22.0	27.0	24.5	$8,806	$247	$9,053	2.80%	66,734	$16,474,801
Dodge Spirit Sedan 21A	I	22.0	27.0	24.5	$13,170	$247	$13,417	1.87%	65,847	$16,255,825
Ford Probe 3dr	C	22.0	31.0	26.5	$13,685	($215)	$13,470	–1.57%	63,659	($13,699,350)
Buick Skylark Sedan	C	22.0	32.0	27.0	$13,599	($320)	$13,279	–2.35%	63,007	($20,163,548)
Buick Park Avenue Sedan	L	19.0	27.0	23.0	$26,999	$646	$27,645	2.39%	59,836	$38,663,798
Chevrolet Camaro	I	17.0	26.0	21.5	$13,399	$1,101	$14,500	8.22%	56,909	$62,666,363
Subaru Legacy L 2WD Sedan	C	21.0	27.0	24.0	$17,050	$374	$17,424	2.20%	55,116	$20,636,736
Mercury Cougar XR7	L	19.0	26.0	22.5	$16,280	$791	$17,071	4.86%	54,557	$43,159,517
Mitsubishi Eclipse	C	20.0	25.0	22.5	$12,659	$791	$13,450	6.25%	53,712	$42,491,045
Mazda 626 DX Sedan	C	23.0	31.0	27.0	$14,255	($320)	$13,935	–2.24%	52,612	($16,836,932)
Buick Roadmaster Sedan	L	17.0	25.0	21.0	$23,999	$1,267	$25,266	5.28%	44,801	$56,775,449
Mercury Tracer 2dr	S	25.0	33.0	29.0	$10,250	($703)	$9,547	–6.86%	43,127	($30,325,290)
Chrysler Lebaron Sedan LE 22P	I	20.0	28.0	24.0	$15,121	$374	$15,495	2.48%	42,946	$16,080,000
Cadillac Seville Luxury Sedan	L	16.0	25.0	20.5	$40,999	$1,441	$42,440	3.52%	41,152	$59,320,479
Lincoln Continental Executive	L	18.0	26.0	22.0	$33,850	$943	$34,793	2.78%	38,458	$36,250,723
Oldsmobile Ninety-Eight Regency	L	19.0	27.0	23.0	$25,875	$646	$26,521	2.50%	35,597	$23,001,458
Nissan Stanza Altima XE	C	21.0	29.0	25.0	$14,699	$124	$14,823	0.85%	30,615	$3,809,231
Eagle Talon DL	C	20.0	25.0	22.5	$11,982	$791	$12,773	6.60%	29,911	$23,662,304
Cadillac Eldorado Coupe	L	16.0	25.0	20.5	$37,290	$1,441	$38,731	3.87%	27,527	$39,680,084
Mazda MX-6 Coupe	C	23.0	31.0	27.0	$17,195	($320)	$16,875	–1.86%	26,555	($8,498,151)
Plymouth Laser Hatchback 2dr	C	20.0	25.0	22.5	$8,806	$791	$9,597	8.98%	24,494	$19,376,967
Pontiac Firebird Formula Coupe	I	19.0	28.0	23.5	$17,995	$507	$18,502	2.82%	21,501	$10,909,659
Chrysler New Yorker LHS Sedan	L	18.0	26.0	22.0	$30,283	$943	$31,226	3.11%	19,761	$18,626,827
Dodge Intrepid Sedan	I	20.0	28.0	24.0	$17,251	$374	$17,625	2.17%	13,367	$5,004,921
Mitsubishi Mirage Coupe ES	S	28.0	32.0	30.0	$10,839	($876)	$9,963	–8.08%	10,880	($9,526,270)
Net Revenue Generated from Fees										$636,017,590
Gross Revenue Generated from Fees										$2,127,195,475
Gross Revenue Paid Back to Rebates										$1,491,177,886
Percentage of Gross Revenues Paid Back to Rebates										70%

SOURCE: Johnston 1994, pp. 77–92.

Given this low base of use and the relatively short-term focus of this research, it is unlikely that Iowa can promote the use of alternative fuels as a significant measure. The OECD's conclusion that limiting overall consumption is the primary short-term approach that can be used reinforces this policy direction.

Advance vehicle technology

The Office of Technology Assessment has examined the potential impact of advance vehicle technology (OTA 1995). They used two assumptions in evaluating possible future designs. First, vehicles would have to have the performance characteristics of 1995 automobiles, so vehicles with ranges of only 50 or 60 miles were not considered. Second, vehicles would have to be capable of being produced in large numbers so they could have a significant impact on overall emissions and fuel use.

Improvements that technology could bring about include better construction of conventional automobiles (lighter steel), use of electric vehicles, hybrid electric designs, and fuel cell vehicles. OTA concluded that the technical potential exists to have vehicles in 2015 that are 50 to 100 percent more fuel-efficient than those produced in the mid-1990s. OTA estimates that these advanced vehicles will cost substantially more, however, and that the potential for commercialization is therefore somewhat limited, without a substantial increase in the price of fuel.

Adopting advance technology as a means of improving efficiency is an attractive policy because it does not directly require that fuel prices be increased as a deliberate governmental action. Nationally, progress toward limiting CO_2 emissions to 1990 levels by the year 2000 has been reported as unlikely to be achieved; the Clinton administration is pursuing an improved technical efficiency strategy as a major way to resume progress (New York Times 1995).

In the short run, Iowa cannot significantly reduce emissions by regulating fuel or emission standards directly. The state is too small to adopt independent standards. Moreover, standards have been found to be a very blunt tool at the national level, so fuel tax changes should be used to improve efficiency if this is desired. Iowa could, however, modify its new automatic registration system to include a rebate/fee component. Alternative fuel use is unlikely to be widely adopted until well into the next century. Ethanol use has some environmental benefits but does not produce dramatic reductions in emissions, such as may be possible with nonfossil fuel electric vehicles in decades ahead. Advance technology is also likely to bear significant fruit in future decades, and progress is likely to be driven by national policies and not those of individual states.

Nationally, there is a gradual increase occurring in trailer-on-flatcar (TOFC) railroad freight transportation. TOFC transportation has significant implications for energy and emissions because longer so-called "unit trains" consume far less fuel on a per-ton-mile basis than semitrailer trucks do. According to Blevins and Gibson (1991), trucks produce 3.78 times more CO_2 than unit trains. OECD places the ratio at approximately ten to one (European Conference of Ministers of Transport 1994).

Iowa is a bridge state, meaning that enormous amounts of cargo traverse the state both east/west and north/south. To the extent that the state can facilitate rail freight transportation, the level of CO_2 emissions along major transportation corridors could be reduced greatly. To be sure, the emergence of TOFC as a means of long haul freight transportation is much more a result of market realities than public policy. Rising truck driver labor costs in particular are influencing modal choices. Yet by making rail transportation across the state as expeditious as possible, Iowa can facilitate TOFC transportation.

A variety of public policy options exist to reduce the amount of energy consumed by the transportation sector in Iowa. Generally, such actions will result in diminished CO_2 emissions and thereby help reduce the threat of undesirable changes in climate patterns. We dismissed a number of these options to focus on approaches that could be adopted by the state of Iowa. To provide a context for the analysis, we first review two major national documents that explore how transportation policy can help reduce CO_2 emissions. Some of the recommendations in these documents are more relevant to Iowa than others. We take the recommendations that are pertinent to Iowa into account in the primary analysis, that of policy actions that could be taken within the state.

Travel circumstances in Iowa are different from those in many other, more urbanized states. While it has the nation's highest labor participation rate, the state is not dense enough to support public transit to any great extent. Almost three-quarters of all work trips are in single occupant vehicles. Iowans' vehicles on average are older and less fuel-efficient than is the case nationally.

Taking Iowa's travel circumstances into account, we analyzed four classes of policy options to reduce CO_2 emissions in the state's transportation sector. The first is to increase motor fuel taxes. We conclude that a sizable fuel tax increase would help, but by itself it probably would not greatly reduce vehicle miles of travel. This is because most rural trips are not very conducive to alternative transportation modes. Equity issues are serious, as well.

Discouraging single occupancy is a second type of policy action. Cashing out employer-provided parking has some potential in denser urban areas, of which Iowa has few. In most communities within the state, the monthly parking charge would be too small to make much of a difference in the commuting choices of employers.

A third type of policy action is to promote public transit. With only 2.5 percent modal share for transit in Iowa's 24 largest communities, a very large percentage increase in transit trips would need to occur for significant reductions in vehicle-generated CO_2 emissions to be accomplished. Worse still, the potential for any increases in transit ridership is not large. With the state's low population densities and the dispersed nature of many trips—especially those in rural areas—transit is unlikely to make significant inroads.

It is the fourth type of policy action that has the greatest potential to foster reductions in CO_2 emissions: improving vehicle fuel efficiency. One way to do this is through a modified registration system for new vehicles that involves a rebate for vehicles with comparatively high fuel efficiency and a fee for those who achieve fewer miles per gallon. Depending on how aggressively the rebate/fee system is structured, significant economic incentives can be created to purchase fuel-efficient automobiles. The state can also provide incentives to motorists for them to burn relatively clean fuels. Finally, it can encourage railroad shipping by working to remove barriers such as vehicle-rail conflicts at grade crossings.

Beyond adopting public policies that directly affect travelers within its borders, Iowa can work with other states to influence the adoption of Federal policies to conserve energy and reduce CO_2 emissions.

APPENDIX: INVENTORY OF IOWA GREENHOUSE GAS EMISSIONS FOR THE YEAR 1990

CARBON DIOXIDE EMISSIONS: 1970 VERSUS 1990

Analysis of CO_2 emissions by sector for 1970 and 1990 indicate that energy consumption has increased and shifted within the Iowa economy (Figure A–1).

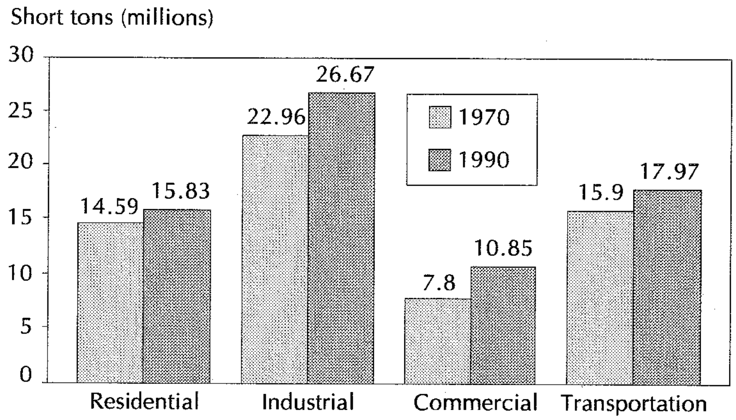

Figure A–1. Iowa CO_2 emissions by sector, 1970 versus 1990

In 1970 transportation emitted 26 percent of Iowa's total emissions of greenhouse gases from energy consumption. By 1990, this number had decreased to 25 percent, despite a large increase in the number of vehicles and number of miles they were being driven. Increased efficiency in the transportation sector has a very large incremental effect on greenhouse gas emissions, making it an attractive sector in which to influence the net emission of greenhouse gases in Iowa (Table A–1).

Table A–1. Percentage of Iowa CO_2 emissions by sector, 1970 versus 1990

Sector	1970	1990
Residential	24%	22%
Industrial	37%	38%
Commercial	13%	15%
Transportation	26%	25%

Growth of the industrial sector has led to carbon dioxide emissions that are greater than emissions from the residential and commercial sectors combined. Much-needed energy efficiency gains in the residential sector, as well as urban tree planting and reforestation programs, can be effective in reducing net emissions of greenhouse gases and improving Iowa's standing relative to other states.

The growth of the residential sector contribution is also significant when you consider that the Iowa population has remained relatively steady, yet the residential sector share of energy-driven CO_2 emissions has increased from 22 to 24 percent.

TRANSPORTATION SECTOR TRENDS

Emissions of CO_2 from the transportation sector have been relatively flat since the inception of the CAFE vehicle mileage standards in the early 1970s (Figure A–2). The increasing efficiency of newer automobiles has acted to maintain emissions despite large increases in the number of vehicles and vehicle miles traveled.

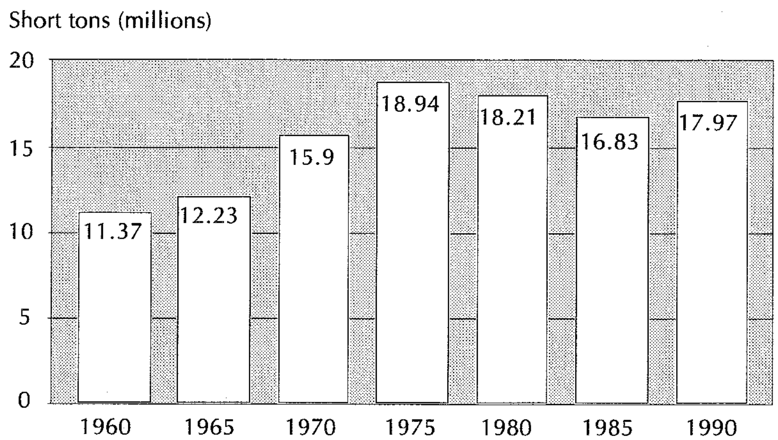

Figure A–2. Carbon dioxide from energy use in the Iowa transportation sector

PRELIMINARY ANALYSIS OF GREENHOUSE GAS EMISSIONS FROM ETHANOL

This simple analysis only presents the impact on greenhouse gas emissions from the transportation sector of using ethanol as a substitute for gasoline. Although emissions of greenhouse gases occurring during production and delivery of these fuels are believed to be significant, no attempt is made to quantify emissions that occur during the production of either ethanol or gasoline.

The values presented in Figure A–3 are emission factors for carbon dioxide generation from fuel combustion for ethanol (0.076 tons CO_2/MM Btu), gasoline (0.0777 tons CO_2/MM Btu) and diesel fuel (0.0799 tons CO_2/MM Btu).

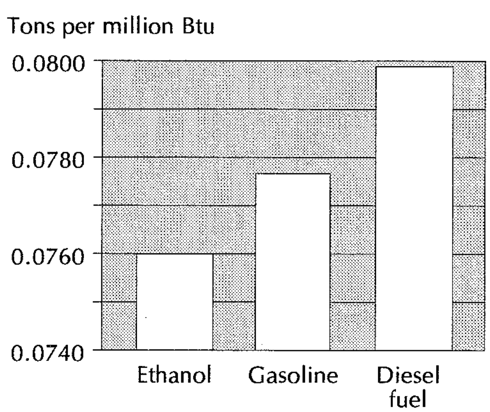

Figure A–3. Unit emission rates for transportation fuels

Table A–2. Iowa energy consumption estimates in physical units

Year	Coal (MM ST)	Natural gas (bil cu ft)	Asphalt/ road oil (MM bbl)	Aviation gasoline (MM bbl)	Distillate fuel (MM bbl)	Jet fuel (MM bbl)	Kerosene (MM bbl)	LPG (MM bbl)	Lube oils (MM bbl)	Motor gasoline (MM bbl)	Residual fuel (MM bbl)	Other (MM bbl)	Net interstate electricity (MM kWh)
1960	5.257	187.0	2.579	0.366	11.163	0.195	2.587	5.017	0.713	29.463	1.071	0.044	–2,370
1965	5.722	248.0	2.569	0.358	11.068	0.232	1.523	7.448	0.698	30.792	0.531	0.542	3,241
1970	6.166	349.0	2.914	0.256	13.677	0.725	0.490	11.038	0.700	35.701	0.401	0.627	1,618
1971	5.896	345.0	3.120	0.261	14.257	0.655	0.372	11.139	0.585	37.325	0.414	0.899	4,691
1972	6.945	345.0	2.970	0.239	14.941	0.730	0.506	12.506	0.626	38.404	0.509	0.984	6,282
1973	7.026	365.0	2.608	0.098	15.531	0.710	0.541	12.692	0.751	42.104	0.572	1.061	9,954
1974	6.173	368.0	2.567	0.232	14.825	0.749	0.357	13.369	0.719	38.847	0.697	1.090	12,414
1975	6.407	346.0	2.294	0.191	14.553	0.835	0.214	13.645	0.655	39.042	0.608	0.986	13,729
1976	8.311	311.0	2.439	0.206	15.088	0.964	0.215	18.586	0.728	40.738	0.931	3.121	12,874
1977	9.175	280.0	2.553	0.204	15.977	1.004	0.203	17.854	0.713	41.237	1.096	3.745	14,644
1978	10.110	238.0	2.843	0.214	16.915	1.127	0.202	15.698	0.766	40.927	0.921	4.069	22,524
1979	11.352	292.0	3.154	0.191	20.711	1.039	0.460	14.686	0.801	38.501	1.216	4.962	15,647
1980	12.340	270.0	1.699	0.184	15.930	0.813	0.171	11.167	0.714	35.394	0.415	5.236	13,041
1981	13.483	253.0	1.972	0.161	14.513	0.717	0.374	9.891	0.684	34.274	0.098	2.381	14,484
1982	13.033	237.0	1.915	0.111	16.235	0.635	0.450	11.953	0.624	33.030	0.334	1.850	17,193
1983	13.540	221.0	1.603	0.109	14.099	0.591	0.089	12.028	0.653	32.386	0.207	1.623	18,752
1984	13.624	235.0	1.841	0.089	15.360	0.615	0.180	7.336	0.697	32.223	0.140	1.890	9,868
1985	14.342	226.0	2.023	0.083	15.490	0.592	0.155	8.507	0.649	31.458	0.182	1.778	6,022
1986	13.862	207.0	2.038	0.151	15.962	0.595	0.115	8.774	0.635	31.356	0.508	1.041	8,942
1987	15.191	203.0	1.788	0.110	15.762	0.779	0.110	6.098	0.718	31.614	0.117	1.069	6,760
1988	16.114	239.0	2.213	0.145	15.946	0.713	0.107	6.612	0.692	32.552	0.258	1.037	4,806
1989	17.126	226.0	1.710	0.111	14.961	0.750	0.071	7.174	0.710	32.558	0.183	1.013	3,738
1990	17.929	218.0	1.537	0.099	15.223	0.891	0.081	6.355	0.731	31.502	0.126	1.128	532
1991	18.741	233.0	1.563	0.082	14.605	0.892	0.051	7.255	0.654	32.461	0.096	1.146	–1,953
1992	17.992	231.0	1.406	0.075	16.370	0.803	0.042	8.976	0.666	31.720	0.107	1.211	368

SOURCE: Energy Information Administration 1995. MM ST = million short tons; bil cu ft = billion cubic feet; MM bbl = million barrels; MM kWh = million kilowatt-hours.

Table A–3. Iowa energy consumption by fuel type (trillion Btu)

Year	Coal	Natural gas	Asphalt/ road oil	Aviation gasoline	Distillate fuel	Jet fuel	Kerosene	LPG	Lube oils	Motor gasoline	Residual fuel	Other	State total
1960	124.5	192.6	17.1	1.8	65.0	1.1	14.7	20.1	4.3	154.8	6.7	0.3	603.1
1965	135.6	255.4	17.0	1.8	64.5	1.3	8.6	29.9	4.2	161.8	3.3	3.2	686.6
1970	146.1	359.5	19.3	1.3	79.7	4.0	2.8	44.3	4.2	187.5	2.5	3.7	854.8
1971	139.7	355.4	20.7	1.3	83.0	3.6	2.1	44.7	3.5	196.1	2.6	5.2	857.9
1972	164.5	355.4	19.7	1.2	87.0	4.0	2.9	50.2	3.8	201.7	3.2	5.7	899.3
1973	166.4	376.0	17.3	0.5	90.5	3.9	3.1	50.9	4.6	221.2	3.6	6.2	944.1
1974	146.2	379.0	17.0	1.2	86.4	4.1	2.0	53.6	4.4	204.1	4.4	6.3	908.8
1975	151.8	356.4	15.2	1.0	84.8	4.6	1.2	54.7	4.0	205.1	3.8	5.7	888.3
1976	196.9	320.3	16.2	1.0	87.9	5.3	1.2	74.5	4.4	214.0	5.9	18.2	945.9
1977	217.4	288.4	16.9	1.0	93.1	5.5	1.2	71.6	4.3	216.6	6.9	21.8	944.7
1978	239.5	245.1	18.9	1.1	98.5	6.2	1.1	63.0	4.6	215.0	5.8	23.7	922.6
1979	268.9	300.8	20.9	1.0	120.6	5.7	2.6	58.9	4.9	202.2	7.6	28.9	1,023.1
1980	292.3	278.1	11.3	0.9	92.8	4.5	1.0	44.8	4.3	185.9	2.6	30.5	949.0
1981	319.4	260.6	13.1	0.8	84.5	4.0	2.1	39.7	4.1	180.0	0.6	13.9	922.9
1982	308.8	244.1	12.7	0.6	94.6	3.5	2.6	47.9	3.8	173.5	2.1	10.8	904.9
1983	320.8	227.6	10.6	0.6	82.1	3.3	0.5	48.2	4.0	170.1	1.3	9.5	878.6
1984	322.8	242.1	12.2	0.4	89.5	3.4	1.0	29.4	4.2	169.3	0.9	11.0	886.2
1985	339.8	232.8	13.4	0.4	90.2	3.3	0.9	34.1	3.9	165.2	1.1	10.4	895.6
1986	328.4	213.2	13.5	0.8	93.0	3.3	0.7	35.2	3.9	164.7	3.2	6.1	865.8
1987	359.9	209.1	11.9	0.6	91.8	4.3	0.6	24.5	4.4	166.1	0.7	6.2	880.0
1988	381.7	246.2	14.7	0.7	92.9	3.9	0.6	26.5	4.2	171.0	1.6	6.0	950.1
1989	405.7	232.8	11.3	0.6	87.1	4.1	0.4	28.8	4.3	171.0	1.2	5.9	953.2
1990	424.7	224.5	10.2	0.5	88.7	4.9	0.5	25.5	4.4	165.5	0.8	6.6	956.8
1991	444.0	240.0	10.4	0.4	85.1	4.9	0.3	29.1	4.0	170.5	0.6	6.7	995.9
1992	426.2	237.9	9.3	0.4	95.4	4.4	0.2	36.0	4.0	166.6	0.7	7.1	988.3

SOURCE: Energy Information Administration 1995.

Table A–4. Iowa total carbon content by fuel type (million tons)

Year	Coal	Natural gas	Asphalt/ road oil	Aviation gasoline	Distillate fuel	Jet fuel	Kerosene	LPG	Lube oils	Motor gasoline	Residual fuel	Other	Total
1960	3.61	3.07	0.39	0.04	1.43	0.02	0.32	0.38	0.10	3.31	0.16	0.01	12.83
1965	3.92	4.07	0.39	0.04	1.42	0.03	0.19	0.56	0.09	3.46	0.08	0.07	14.33
1970	4.23	5.73	0.44	0.03	1.75	0.09	0.06	0.84	0.09	4.01	0.06	0.08	17.41
1971	4.04	5.67	0.47	0.03	1.83	0.08	0.05	0.84	0.08	4.20	0.06	0.12	17.46
1972	4.76	5.67	0.45	0.03	1.91	0.09	0.06	0.95	0.08	4.32	0.08	0.13	18.52
1973	4.82	6.00	0.39	0.01	1.99	0.09	0.07	0.96	0.10	4.73	0.09	0.14	19.38
1974	4.23	6.05	0.39	0.02	1.90	0.09	0.04	1.01	0.10	4.37	0.10	0.14	18.45
1975	4.39	5.68	0.35	0.02	1.86	0.10	0.03	1.03	0.09	4.39	0.09	0.13	18.17
1976	5.70	5.11	0.37	0.02	1.93	0.12	0.03	1.41	0.10	4.58	0.14	0.40	19.90
1977	6.29	4.60	0.39	0.02	2.05	0.12	0.03	1.35	0.10	4.64	0.16	0.48	20.22
1978	6.93	3.91	0.43	0.02	2.17	0.14	0.02	1.19	0.10	4.60	0.14	0.52	20.18
1979	7.79	4.80	0.48	0.02	2.65	0.12	0.06	1.11	0.11	4.33	0.18	0.64	22.28
1980	8.46	4.44	0.26	0.02	2.04	0.10	0.02	0.85	0.10	3.98	0.06	0.67	20.99
1981	9.25	4.16	0.30	0.02	1.86	0.09	0.05	0.75	0.09	3.85	0.01	0.31	20.72
1982	8.94	3.89	0.29	0.01	2.08	0.08	0.06	0.91	0.08	3.71	0.05	0.24	20.34
1983	9.29	3.63	0.24	0.01	1.81	0.07	0.01	0.91	0.09	3.64	0.03	0.21	19.94
1984	9.34	3.86	0.28	0.01	1.97	0.07	0.02	0.56	0.09	3.62	0.02	0.24	20.09
1985	9.84	3.71	0.31	0.01	1.99	0.07	0.02	0.64	0.09	3.54	0.03	0.23	20.46
1986	9.51	3.40	0.31	0.02	2.05	0.07	0.01	0.67	0.09	3.52	0.08	0.13	19.85
1987	10.42	3.33	0.27	0.01	2.02	0.09	0.01	0.46	0.10	3.55	0.02	0.14	20.43
1988	11.05	3.93	0.33	0.02	2.04	0.09	0.01	0.50	0.09	3.66	0.04	0.13	21.89
1989	11.75	3.71	0.26	0.01	1.92	0.09	0.01	0.54	0.10	3.66	0.03	0.13	22.20
1990	12.30	3.58	0.23	0.01	1.95	0.11	0.01	0.48	0.10	3.54	0.02	0.14	22.47
1991	12.85	3.83	0.24	0.01	1.87	0.11	0.01	0.55	0.09	3.65	0.01	0.15	23.36
1992	12.34	3.79	0.21	0.01	2.10	0.10	0.01	0.68	0.09	3.57	0.02	0.16	23.06

SOURCE: Energy Information Administration 1995.

Table A–5. Iowa carbon available for combustion by fuel type (million tons)

Year	Coal	Natural gas	Asphalt/ road oil	Aviation gasoline	Distillate fuel	Jet fuel	Kerosene	LPG	Lube oils	Motor gasoline	Residual fuel	Other	Total
1960	3.61	3.07	0.00	0.04	1.43	0.02	0.32	0.38	0.05	3.31	0.16	0.01	12.39
1965	3.92	4.07	0.00	0.04	1.42	0.03	0.19	0.56	0.05	3.46	0.08	0.07	13.89
1970	4.23	5.73	0.00	0.03	1.75	0.09	0.06	0.83	0.05	4.01	0.06	0.08	16.92
1971	4.04	5.67	0.00	0.03	1.83	0.08	0.05	0.84	0.04	4.20	0.06	0.11	16.94
1972	4.76	5.67	0.00	0.03	1.91	0.09	0.06	0.94	0.04	4.32	0.08	0.12	18.02
1973	4.82	6.00	0.00	0.01	1.99	0.09	0.07	0.95	0.05	4.73	0.09	0.13	18.92
1974	4.23	6.05	0.00	0.02	1.90	0.09	0.04	1.00	0.05	4.37	0.10	0.14	18.00
1975	4.39	5.68	0.00	0.02	1.86	0.10	0.03	1.02	0.04	4.39	0.09	0.13	17.76
1976	5.70	5.11	0.00	0.02	1.93	0.12	0.03	1.39	0.05	4.58	0.14	0.40	19.46
1977	6.29	4.60	0.00	0.02	2.05	0.12	0.03	1.34	0.05	4.64	0.16	0.48	19.77
1978	6.93	3.91	0.00	0.02	2.17	0.14	0.02	1.18	0.05	4.60	0.14	0.52	19.68
1979	7.79	4.80	0.00	0.02	2.65	0.12	0.06	1.10	0.05	4.33	0.18	0.63	21.73
1980	8.46	4.44	0.00	0.02	2.04	0.10	0.02	0.84	0.05	3.98	0.06	0.66	20.67
1981	9.25	4.16	0.00	0.02	1.86	0.09	0.05	0.74	0.05	3.85	0.01	0.30	20.37
1982	8.94	3.89	0.00	0.01	2.08	0.08	0.06	0.90	0.04	3.71	0.05	0.23	19.99
1983	9.29	3.63	0.00	0.01	1.81	0.07	0.01	0.90	0.04	3.64	0.03	0.21	19.64
1984	9.34	3.86	0.00	0.01	1.97	0.07	0.02	0.55	0.05	3.62	0.02	0.24	19.76
1985	9.84	3.71	0.00	0.01	1.99	0.07	0.02	0.64	0.04	3.54	0.03	0.23	20.10
1986	9.51	3.40	0.00	0.02	2.05	0.07	0.01	0.66	0.04	3.52	0.08	0.13	19.49
1987	10.42	3.33	0.00	0.01	2.02	0.09	0.01	0.46	0.05	3.55	0.02	0.14	20.10
1988	11.05	3.93	0.00	0.02	2.04	0.09	0.01	0.50	0.05	3.66	0.04	0.13	21.51
1989	11.75	3.71	0.00	0.01	1.92	0.09	0.01	0.54	0.05	3.66	0.03	0.13	21.89
1990	12.30	3.58	0.00	0.01	1.95	0.11	0.01	0.48	0.05	3.54	0.02	0.14	22.19
1991	12.85	3.83	0.00	0.01	1.87	0.11	0.01	0.54	0.04	3.65	0.01	0.15	23.07
1992	12.34	3.79	0.00	0.01	2.10	0.10	0.01	0.67	0.05	3.57	0.02	0.15	22.80

SOURCE: Energy Information Administration 1995.

Table A–6. Iowa carbon oxidized from energy uses (million tons)

Year	Coal	Natural gas	Asphalt/ road oil	Aviation gasoline	Distillate fuel	Jet fuel	Kerosene	LPG	Lube oils	Motor gasoline	Residual fuel	Other	Total
1960	3.57	3.06	0.00	0.04	1.42	0.02	0.32	0.37	0.05	3.28	0.16	0.01	12.27
1965	3.89	4.05	0.00	0.04	1.40	0.03	0.19	0.55	0.05	3.43	0.08	0.07	13.75
1970	4.19	5.70	0.00	0.03	1.74	0.09	0.06	0.82	0.05	3.97	0.06	0.08	16.75
1971	4.00	5.64	0.00	0.03	1.81	0.08	0.05	0.83	0.04	4.15	0.06	0.11	16.77
1972	4.72	5.64	0.00	0.02	1.90	0.09	0.06	0.93	0.04	4.27	0.08	0.12	17.84
1973	4.77	5.97	0.00	0.01	1.97	0.08	0.07	0.94	0.05	4.69	0.08	0.13	18.73
1974	4.19	6.02	0.00	0.02	1.88	0.09	0.04	0.99	0.05	4.32	0.10	0.14	17.82
1975	4.35	5.66	0.00	0.02	1.85	0.10	0.03	1.01	0.04	4.34	0.09	0.12	17.59
1976	5.64	5.08	0.00	0.02	1.91	0.11	0.03	1.38	0.05	4.53	0.14	0.39	19.27
1977	6.23	4.58	0.00	0.02	2.03	0.12	0.02	1.33	0.05	4.59	0.16	0.47	19.57
1978	6.86	3.89	0.00	0.02	2.15	0.13	0.02	1.17	0.05	4.55	0.14	0.51	19.48
1979	7.71	4.77	0.00	0.02	2.63	0.12	0.06	1.09	0.05	4.28	0.18	0.62	21.52
1980	8.38	4.41	0.00	0.02	2.02	0.10	0.02	0.83	0.05	3.94	0.06	0.66	20.46
1981	9.15	4.14	0.00	0.02	1.84	0.09	0.05	0.73	0.05	3.81	0.01	0.30	20.17
1982	8.85	3.87	0.00	0.01	2.06	0.08	0.05	0.89	0.04	3.68	0.05	0.23	19.79
1983	9.19	3.61	0.00	0.01	1.79	0.07	0.01	0.89	0.04	3.60	0.03	0.20	19.44
1984	9.25	3.84	0.00	0.01	1.95	0.07	0.02	0.55	0.05	3.59	0.02	0.24	19.56
1985	9.74	3.69	0.00	0.01	1.97	0.07	0.02	0.63	0.04	3.50	0.03	0.22	19.90
1986	9.41	3.38	0.00	0.02	2.03	0.07	0.01	0.65	0.04	3.49	0.07	0.13	19.29
1987	10.31	3.32	0.00	0.01	2.00	0.09	0.01	0.45	0.05	3.52	0.02	0.13	19.90
1988	10.94	3.91	0.00	0.02	2.02	0.08	0.01	0.49	0.05	3.62	0.04	0.13	21.29
1989	11.63	3.69	0.00	0.01	1.90	0.09	0.01	0.53	0.05	3.62	0.03	0.13	21.67
1990	12.17	3.56	0.00	0.01	1.93	0.11	0.01	0.47	0.05	3.51	0.02	0.14	21.96
1991	12.72	3.81	0.00	0.01	1.85	0.11	0.01	0.54	0.04	3.61	0.01	0.14	22.84
1992	12.22	3.78	0.00	0.01	2.08	0.10	0.01	0.67	0.04	3.53	0.02	0.15	22.57

SOURCE: Energy Information Administration 1995.

Table A–7. Iowa carbon dioxide from energy uses (million tons)

Year	Coal	Natural gas	Asphalt/ road oil	Aviation gasoline	Distillate fuel	Jet fuel	Kerosene	LPG	Lube oils	Motor gasoline	Residual fuel	Other	Total
1960	13.09	11.21	0.00	0.14	5.19	0.08	1.16	1.37	0.18	12.02	0.58	0.02	44.98
1965	14.25	14.86	0.00	0.14	5.15	0.10	0.68	2.03	0.17	12.57	0.29	0.25	50.40
1970	15.35	20.92	0.00	0.10	6.36	0.32	0.22	3.01	0.17	14.57	0.22	0.29	61.41
1971	14.68	20.68	0.00	0.10	6.63	0.29	0.17	3.03	0.14	15.23	0.22	0.41	61.48
1972	17.29	20.68	0.00	0.09	6.95	0.32	0.23	3.41	0.15	15.67	0.28	0.45	65.41
1973	17.49	21.88	0.00	0.04	7.22	0.31	0.24	3.46	0.18	17.18	0.31	0.49	68.69
1974	15.37	22.06	0.00	0.09	6.90	0.33	0.16	3.64	0.18	15.85	0.38	0.50	65.33
1975	15.95	20.74	0.00	0.07	6.77	0.36	0.10	3.72	0.16	15.93	0.33	0.45	64.48
1976	20.69	18.64	0.00	0.08	7.02	0.42	0.10	5.06	0.18	16.62	0.50	1.44	70.66
1977	22.84	16.78	0.00	0.08	7.43	0.44	0.09	4.86	0.18	16.83	0.59	1.72	71.76
1978	25.17	14.26	0.00	0.08	7.87	0.49	0.09	4.28	0.19	16.70	0.50	1.87	71.43
1979	28.26	17.50	0.00	0.07	9.63	0.45	0.21	4.00	0.20	15.71	0.66	2.29	78.89
1980	30.72	16.18	0.00	0.07	7.41	0.35	0.08	3.04	0.18	14.44	0.22	2.41	75.03
1981	33.57	15.16	0.00	0.06	6.75	0.31	0.17	2.69	0.17	13.99	0.05	1.10	73.94
1982	32.45	14.20	0.00	0.04	7.55	0.28	0.20	3.26	0.15	13.48	0.18	0.85	72.57
1983	33.71	13.25	0.00	0.04	6.56	0.26	0.04	3.28	0.16	13.22	0.11	0.75	71.30
1984	33.92	14.09	0.00	0.03	7.15	0.27	0.08	2.00	0.17	13.15	0.08	0.87	71.72
1985	35.71	13.55	0.00	0.03	7.21	0.26	0.07	2.32	0.16	12.84	0.10	0.82	72.98
1986	34.51	12.41	0.00	0.06	7.43	0.26	0.05	2.39	0.16	12.80	0.27	0.48	70.74
1987	37.82	12.17	0.00	0.04	7.33	0.34	0.05	1.66	0.18	12.90	0.06	0.49	72.98
1988	40.12	14.32	0.00	0.06	7.42	0.31	0.05	1.80	0.17	13.28	0.14	0.48	78.07
1989	42.64	13.55	0.00	0.04	6.96	0.33	0.03	1.95	0.17	13.29	0.10	0.47	79.45
1990	44.64	13.07	0.00	0.04	7.08	0.39	0.04	1.73	0.18	12.85	0.07	0.52	80.53
1991	46.66	13.97	0.00	0.03	6.79	0.39	0.02	1.98	0.16	13.25	0.05	0.53	83.75
1992	44.79	13.85	0.00	0.03	7.62	0.35	0.02	2.45	0.16	12.94	0.06	0.56	82.75

SOURCE: Energy Information Administration 1995.

Table A–8. Iowa carbon oxidized from energy uses (million metric tons)

Year	Coal	Natural gas	Asphalt/ road oil	Aviation gasoline	Distillate fuel	Jet fuel	Kerosene	LPG	Lube oils	Motor gasoline	Residual fuel	Other	Total
1960	3.24	2.77	0.00	0.03	1.28	0.02	0.29	0.34	0.04	2.97	0.14	0.01	11.14
1965	3.52	3.68	0.00	0.03	1.27	0.02	0.17	0.50	0.04	3.11	0.07	0.06	12.49
1970	3.80	5.18	0.00	0.02	1.57	0.08	0.05	0.74	0.04	3.60	0.05	0.07	15.22
1971	3.63	5.12	0.00	0.02	1.64	0.07	0.04	0.75	0.04	3.77	0.06	0.10	15.24
1972	4.28	5.12	0.00	0.02	1.72	0.08	0.06	0.84	0.04	3.88	0.07	0.11	16.21
1973	4.33	5.41	0.00	0.01	1.79	0.08	0.06	0.86	0.05	4.25	0.08	0.12	17.02
1974	3.80	5.46	0.00	0.02	1.71	0.08	0.04	0.90	0.04	3.92	0.09	0.12	16.19
1975	3.95	5.13	0.00	0.02	1.67	0.09	0.02	0.92	0.04	3.94	0.08	0.11	15.98
1976	5.12	4.61	0.00	0.02	1.74	0.10	0.02	1.25	0.04	4.11	0.12	0.36	17.50
1977	5.65	4.15	0.00	0.02	1.84	0.11	0.02	1.20	0.04	4.16	0.15	0.43	17.78
1978	6.23	3.53	0.00	0.02	1.95	0.12	0.02	1.06	0.05	4.13	0.12	0.46	17.69
1979	6.99	4.33	0.00	0.02	2.38	0.11	0.05	0.99	0.05	3.89	0.16	0.57	19.54
1980	7.60	4.00	0.00	0.02	1.83	0.09	0.02	0.75	0.04	3.57	0.06	0.60	18.58
1981	8.30	3.75	0.00	0.02	1.67	0.08	0.04	0.67	0.04	3.46	0.01	0.27	18.31
1982	8.03	3.51	0.00	0.01	1.87	0.07	0.05	0.81	0.04	3.33	0.04	0.21	17.97
1983	8.34	3.28	0.00	0.01	1.62	0.06	0.01	0.81	0.04	3.27	0.03	0.18	17.66
1984	8.39	3.48	0.00	0.01	1.77	0.07	0.02	0.49	0.04	3.25	0.02	0.22	17.76
1985	8.83	3.35	0.00	0.01	1.78	0.06	0.02	0.57	0.04	3.18	0.02	0.20	18.07
1986	8.54	3.07	0.00	0.01	1.84	0.06	0.01	0.59	0.04	3.17	0.07	0.12	17.52
1987	9.36	3.01	0.00	0.01	1.81	0.08	0.01	0.41	0.04	3.19	0.02	0.12	18.07
1988	9.93	3.54	0.00	0.01	1.84	0.08	0.01	0.45	0.04	3.29	0.03	0.12	19.33
1989	10.55	3.35	0.00	0.01	1.72	0.08	0.01	0.48	0.04	3.29	0.02	0.12	19.67
1990	11.04	3.23	0.00	0.01	1.75	0.10	0.01	0.43	0.04	3.18	0.02	0.13	19.94
1991	11.54	3.46	0.00	0.01	1.68	0.10	0.01	0.49	0.04	3.28	0.01	0.13	20.74
1992	11.08	3.43	0.00	0.01	1.88	0.09	0.00	0.61	0.04	3.20	0.01	0.14	20.49

SOURCE: Energy Information Administration 1995.

Table A–9. Energy consumption in Iowa's transportation sector by fuel type, 1960–1992 (trillion Btu)

Year	Natural gas	Aviation gasoline	Distillate fuel	Jet fuel	LPG	Lube oils	Motor gasoline	Residual fuel	Ethanol	State total
1960	9.2	1.8	10.0	1.0	0.1	3.1	123.4	1.4	0.0	150.0
1965	11.2	1.8	11.6	1.3	0.2	2.9	132.5	0.1	0.0	161.6
1970	18.5	1.3	25.3	4.1	0.2	2.9	157.8	0.2	0.0	210.3
1971	20.0	1.3	30.8	3.7	0.3	2.4	171.5	0.0	0.0	230.0
1972	20.5	1.2	32.9	4.1	0.2	2.6	177.4	0.0	0.0	238.9
1973	16.7	0.5	38.1	4.0	0.2	3.1	193.9	0.0	0.0	256.5
1974	17.4	1.2	38.6	4.2	0.2	2.9	182.4	0.0	0.0	246.9
1975	16.2	1.0	39.9	4.7	0.2	3.0	183.5	0.0	0.0	248.5
1976	8.9	1.0	43.3	5.4	0.2	3.4	195.0	0.1	0.0	257.3
1977	7.0	1.0	46.3	5.6	0.2	3.2	197.7	0.1	0.0	261.1
1978	4.9	1.1	45.3	6.3	0.3	3.4	198.7	0.0	0.0	260.0
1979	10.8	1.0	51.4	5.9	0.1	3.6	186.5	0.0	0.0	259.3
1980	12.7	0.9	46.2	4.6	0.1	3.2	170.4	0.0	0.0	238.1
1981	10.9	0.8	43.1	4.0	0.4	3.0	162.8	0.0	0.1	225.1
1982	8.9	0.6	51.0	3.6	0.4	2.8	160.1	0.0	0.4	227.8
1983	8.0	0.6	46.1	3.3	0.4	2.9	164.0	0.0	0.4	225.7
1984	10.7	0.4	50.8	3.4	0.5	3.1	159.1	0.0	0.3	228.3
1985	10.5	0.4	46.8	3.3	0.3	2.9	155.1	0.0	0.3	219.6
1986	7.3	0.8	46.2	3.3	0.5	2.8	155.4	0.0	0.3	216.6
1987	8.2	0.6	50.8	4.4	0.2	3.2	156.9	0.1	0.3	224.7
1988	10.7	0.7	51.8	4.0	0.2	3.1	161.8	0.0	0.3	232.6
1989	10.6	0.6	53.5	4.2	0.2	3.1	163.0	0.0	0.3	235.5
1990	9.2	0.5	56.3	5.0	0.2	3.2	159.1	0.0	0.3	233.8
1991	6.7	0.4	49.2	5.0	0.2	2.9	160.6	0.0	0.3	225.3
1992	7.0	0.4	51.2	4.5	0.2	3.0	157.7	0.0	0.4	224.4

SOURCE: Energy Information Administration 1995.

Table A–10. Total carbon content of fuels consumed in Iowa's transportation sector by fuel type, 1960–1992 (million tons)

Year	Natural gas	Aviation gasoline	Distillate fuel	Jet fuel	LPG	Lube oils	Motor gasoline	Residual fuel	Ethanol	State total
1960	0.15	0.04	0.22	0.02	0.00	0.06	2.64	0.03	0.00	3.16
1965	0.18	0.04	0.26	0.03	0.00	0.05	2.84	0.00	0.00	3.40
1970	0.30	0.03	0.56	0.09	0.00	0.05	3.38	0.00	0.00	4.41
1971	0.32	0.03	0.68	0.08	0.01	0.05	3.67	0.00	0.00	4.83
1972	0.33	0.02	0.72	0.09	0.00	0.05	3.80	0.00	0.00	5.01
1973	0.27	0.01	0.84	0.09	0.00	0.06	4.15	0.00	0.00	5.41
1974	0.28	0.02	0.85	0.09	0.00	0.05	3.90	0.00	0.00	5.20
1975	0.26	0.02	0.88	0.10	0.00	0.06	3.93	0.00	0.00	5.25
1976	0.14	0.02	0.95	0.12	0.00	0.06	4.17	0.00	0.00	5.48
1977	0.11	0.02	1.02	0.12	0.00	0.06	4.23	0.00	0.00	5.57
1978	0.08	0.02	1.00	0.14	0.01	0.06	4.25	0.00	0.00	5.56
1979	0.17	0.02	1.13	0.13	0.00	0.07	3.99	0.00	0.00	5.51
1980	0.20	0.02	1.02	0.10	0.00	0.06	3.65	0.00	0.00	5.05
1981	0.17	0.02	0.95	0.09	0.01	0.06	3.48	0.00	0.00	4.78
1982	0.14	0.01	1.12	0.08	0.01	0.05	3.43	0.00	0.01	4.85
1983	0.13	0.01	1.01	0.07	0.01	0.05	3.51	0.00	0.01	4.81
1984	0.17	0.01	1.12	0.07	0.01	0.06	3.40	0.00	0.01	4.85
1985	0.17	0.01	1.03	0.07	0.01	0.05	3.32	0.00	0.01	4.66
1986	0.12	0.02	1.02	0.07	0.01	0.05	3.33	0.00	0.01	4.62
1987	0.13	0.01	1.12	0.10	0.00	0.06	3.36	0.00	0.01	4.79
1988	0.17	0.01	1.14	0.09	0.00	0.06	3.46	0.00	0.01	4.94
1989	0.17	0.01	1.18	0.09	0.00	0.06	3.49	0.00	0.01	5.01
1990	0.15	0.01	1.24	0.11	0.00	0.06	3.40	0.00	0.01	4.98
1991	0.11	0.01	1.08	0.11	0.00	0.05	3.44	0.00	0.01	4.81
1992	0.11	0.01	1.13	0.10	0.00	0.06	3.37	0.00	0.01	4.79

SOURCE: Energy Information Administration 1995.

Table A–11. Carbon available for combustion in Iowa's transportation sector by fuel type, 1960–1992 (million tons)

Year	Natural gas	Aviation gasoline	Distillate fuel	Jet fuel	LPG	Lube oils	Motor gasoline	Residual fuel	Ethanol	State total
1960	0.15	0.04	0.22	0.02	0.00	0.03	2.64	0.03	0.00	3.13
1965	0.18	0.04	0.26	0.03	0.00	0.03	2.84	0.00	0.00	3.37
1970	0.30	0.03	0.56	0.09	0.00	0.03	3.38	0.00	0.00	4.38
1971	0.32	0.03	0.68	0.08	0.01	0.02	3.67	0.00	0.00	4.80
1972	0.33	0.02	0.72	0.09	0.00	0.02	3.80	0.00	0.00	4.99
1973	0.27	0.01	0.84	0.09	0.00	0.03	4.15	0.00	0.00	5.38
1974	0.28	0.02	0.85	0.09	0.00	0.03	3.90	0.00	0.00	5.18
1975	0.26	0.02	0.88	0.10	0.00	0.03	3.93	0.00	0.00	5.22
1976	0.14	0.02	0.95	0.12	0.00	0.03	4.17	0.00	0.00	5.44
1977	0.11	0.02	1.02	0.12	0.00	0.03	4.23	0.00	0.00	5.54
1978	0.08	0.02	1.00	0.14	0.01	0.03	4.25	0.00	0.00	5.52
1979	0.17	0.02	1.13	0.13	0.00	0.03	3.99	0.00	0.00	5.48
1980	0.20	0.02	1.02	0.10	0.00	0.03	3.65	0.00	0.00	5.02
1981	0.17	0.02	0.95	0.09	0.01	0.03	3.48	0.00	0.00	4.75
1982	0.14	0.01	1.12	0.08	0.01	0.03	3.43	0.00	0.01	4.82
1983	0.13	0.01	1.01	0.07	0.01	0.03	3.51	0.00	0.01	4.78
1984	0.17	0.01	1.12	0.07	0.01	0.03	3.40	0.00	0.01	4.82
1985	0.17	0.01	1.03	0.07	0.01	0.03	3.32	0.00	0.01	4.64
1986	0.12	0.02	1.02	0.07	0.01	0.03	3.33	0.00	0.01	4.59
1987	0.13	0.01	1.12	0.10	0.00	0.03	3.36	0.00	0.01	4.76
1988	0.17	0.01	1.14	0.09	0.00	0.03	3.46	0.00	0.01	4.91
1989	0.17	0.01	1.18	0.09	0.00	0.03	3.49	0.00	0.01	4.98
1990	0.15	0.01	1.24	0.11	0.00	0.03	3.40	0.00	0.01	4.95
1991	0.11	0.01	1.08	0.11	0.00	0.03	3.44	0.00	0.01	4.78
1992	0.11	0.01	1.13	0.10	0.00	0.03	3.37	0.00	0.01	4.76

SOURCE: Energy Information Administration 1995.

Table A–12. Carbon oxidized from energy uses in Iowa's transportation sector by fuel type, 1960–1992 (million tons)

Year	Natural gas	Aviation gasoline	Distillate fuel	Jet fuel	LPG	Lube oils	Motor gasoline	Residual fuel	Ethanol	State total
1960	0.15	0.04	0.22	0.02	0.00	0.03	2.61	0.03	0.00	3.10
1965	0.18	0.04	0.25	0.03	0.00	0.03	2.81	0.00	0.00	3.33
1970	0.29	0.03	0.55	0.09	0.00	0.03	3.34	0.00	0.00	4.34
1971	0.32	0.03	0.67	0.08	0.01	0.02	3.63	0.00	0.00	4.75
1972	0.33	0.02	0.72	0.09	0.00	0.02	3.76	0.00	0.00	4.94
1973	0.27	0.01	0.83	0.09	0.00	0.03	4.11	0.00	0.00	5.33
1974	0.28	0.02	0.84	0.09	0.00	0.03	3.86	0.00	0.00	5.13
1975	0.26	0.02	0.87	0.10	0.00	0.03	3.89	0.00	0.00	5.17
1976	0.14	0.02	0.94	0.12	0.00	0.03	4.13	0.00	0.00	5.39
1977	0.11	0.02	1.01	0.12	0.00	0.03	4.19	0.00	0.00	5.48
1978	0.08	0.02	0.99	0.14	0.01	0.03	4.21	0.00	0.00	5.47
1979	0.17	0.02	1.12	0.13	0.00	0.03	3.95	0.00	0.00	5.42
1980	0.20	0.02	1.01	0.10	0.00	0.03	3.61	0.00	0.00	4.97
1981	0.17	0.02	0.94	0.09	0.01	0.03	3.45	0.00	0.00	4.70
1982	0.14	0.01	1.11	0.08	0.01	0.03	3.39	0.00	0.01	4.77
1983	0.13	0.01	1.00	0.07	0.01	0.03	3.47	0.00	0.01	4.73
1984	0.17	0.01	1.11	0.07	0.01	0.03	3.37	0.00	0.01	4.77
1985	0.17	0.01	1.02	0.07	0.01	0.03	3.29	0.00	0.01	4.59
1986	0.12	0.02	1.01	0.07	0.01	0.03	3.29	0.00	0.01	4.54
1987	0.13	0.01	1.11	0.09	0.00	0.03	3.32	0.00	0.01	4.71
1988	0.17	0.01	1.13	0.09	0.00	0.03	3.43	0.00	0.01	4.86
1989	0.17	0.01	1.17	0.09	0.00	0.03	3.45	0.00	0.01	4.93
1990	0.15	0.01	1.23	0.11	0.00	0.03	3.37	0.00	0.01	4.90
1991	0.11	0.01	1.07	0.11	0.00	0.03	3.40	0.00	0.01	4.73
1992	0.11	0.01	1.12	0.10	0.00	0.03	3.34	0.00	0.01	4.71

SOURCE: Energy Information Administration 1995.

Table A–13. Carbon dioxide emissions from energy uses in Iowa's transportation sector by fuel type, 1960–1992 (million tons)

Year	Natural gas	Aviation gasoline	Distillate fuel	Jet fuel	LPG	Lube oils	Motor gasoline	Residual fuel	Ethanol	State total
1960	0.54	0.14	0.80	0.08	0.01	0.11	9.59	0.12	0.00	11.37
1965	0.65	0.14	0.93	0.10	0.01	0.10	10.29	0.01	0.00	12.23
1970	1.08	0.10	2.02	0.32	0.01	0.10	12.26	0.02	0.00	15.90
1971	1.16	0.10	2.46	0.29	0.02	0.08	13.32	0.00	0.00	17.43
1972	1.19	0.09	2.63	0.32	0.01	0.09	13.78	0.00	0.00	18.11
1973	0.97	0.04	3.04	0.32	0.01	0.11	15.06	0.00	0.00	19.55
1974	1.01	0.09	3.08	0.33	0.01	0.10	14.17	0.00	0.00	18.79
1975	0.94	0.08	3.19	0.37	0.01	0.10	14.25	0.00	0.00	18.94
1976	0.52	0.08	3.46	0.43	0.01	0.12	15.15	0.01	0.00	19.76
1977	0.41	0.08	3.70	0.44	0.01	0.11	15.36	0.01	0.00	20.11
1978	0.29	0.08	3.62	0.50	0.02	0.12	15.44	0.00	0.00	20.05
1979	0.63	0.08	4.10	0.47	0.01	0.12	14.49	0.00	0.00	19.89
1980	0.74	0.07	3.69	0.36	0.01	0.11	13.24	0.00	0.00	18.21
1981	0.63	0.06	3.44	0.32	0.03	0.10	12.65	0.00	0.01	17.24
1982	0.52	0.05	4.07	0.28	0.03	0.10	12.44	0.00	0.03	17.51
1983	0.47	0.05	3.68	0.26	0.03	0.10	12.74	0.00	0.03	17.35
1984	0.62	0.03	4.06	0.27	0.03	0.11	12.36	0.00	0.03	17.50
1985	0.61	0.03	3.74	0.26	0.02	0.10	12.05	0.00	0.03	16.83
1986	0.42	0.06	3.69	0.26	0.03	0.10	12.07	0.00	0.02	16.66
1987	0.48	0.05	4.06	0.35	0.01	0.11	12.19	0.01	0.02	17.27
1988	0.62	0.05	4.14	0.32	0.01	0.11	12.57	0.00	0.02	17.84
1989	0.62	0.05	4.27	0.33	0.01	0.11	12.66	0.00	0.02	18.07
1990	0.54	0.04	4.50	0.39	0.01	0.11	12.36	0.00	0.02	17.97
1991	0.39	0.03	3.93	0.39	0.01	0.10	12.48	0.00	0.03	17.36
1992	0.41	0.03	4.09	0.36	0.01	0.10	12.25	0.00	0.03	17.28

SOURCE: Energy Information Administration 1995.

Table A–14. Carbon oxidized from energy uses in Iowa's transportation sector by fuel type, 1960–1992 (million metric tons)

Year	Natural gas	Aviation gasoline	Distillate fuel	Jet fuel	LPG	Lube oils	Motor gasoline	Residual fuel	Ethanol	State total
1960	0.13	0.03	0.20	0.02	0.00	0.03	2.37	0.03	0.00	2.81
1965	0.16	0.03	0.23	0.03	0.00	0.02	2.55	0.00	0.00	3.03
1970	0.27	0.02	0.50	0.08	0.00	0.02	3.03	0.00	0.00	3.94
1971	0.29	0.02	0.61	0.07	0.01	0.02	3.30	0.00	0.00	4.31
1972	0.30	0.02	0.65	0.08	0.00	0.02	3.41	0.00	0.00	4.48
1973	0.24	0.01	0.75	0.08	0.00	0.03	3.73	0.00	0.00	4.84
1974	0.25	0.02	0.76	0.08	0.00	0.02	3.51	0.00	0.00	4.65
1975	0.23	0.02	0.79	0.09	0.00	0.03	3.53	0.00	0.00	4.69
1976	0.13	0.02	0.86	0.11	0.00	0.03	3.75	0.00	0.00	4.89
1977	0.10	0.02	0.91	0.11	0.00	0.03	3.80	0.00	0.00	4.98
1978	0.07	0.02	0.90	0.12	0.01	0.03	3.82	0.00	0.00	4.96
1979	0.16	0.02	1.02	0.12	0.00	0.03	3.58	0.00	0.00	4.92
1980	0.18	0.02	0.91	0.09	0.00	0.03	3.28	0.00	0.00	4.51
1981	0.16	0.01	0.85	0.08	0.01	0.03	3.13	0.00	0.00	4.27
1982	0.13	0.01	1.01	0.07	0.01	0.02	3.08	0.00	0.01	4.33
1983	0.12	0.01	0.91	0.06	0.01	0.02	3.15	0.00	0.01	4.29
1984	0.15	0.01	1.00	0.07	0.01	0.03	3.06	0.00	0.01	4.33
1985	0.15	0.01	0.92	0.06	0.01	0.02	2.98	0.00	0.01	4.16
1986	0.11	0.01	0.91	0.06	0.01	0.02	2.99	0.00	0.01	4.12
1987	0.12	0.01	1.00	0.09	0.00	0.03	3.02	0.00	0.01	4.27
1988	0.15	0.01	1.02	0.08	0.00	0.03	3.11	0.00	0.01	4.41
1989	0.15	0.01	1.06	0.08	0.00	0.03	3.13	0.00	0.01	4.47
1990	0.13	0.01	1.11	0.10	0.00	0.03	3.06	0.00	0.01	4.45
1991	0.10	0.01	0.97	0.10	0.00	0.02	3.09	0.00	0.01	4.29
1992	0.10	0.01	1.01	0.09	0.00	0.03	3.03	0.00	0.01	4.28

SOURCE: Energy Information Administration 1995.

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