FAU/FIU JOINT CENTER for Environmental & Urban Problems

An Exploration of Trends in Transportation, Air Quality, and Energy in Florida

July, 2000

Prepared for:
Florida Department of Transportation

Prepared by:
Florida Atlantic University/Florida International University
Joint Center for Environmental and Urban Problems

Jaap Vos, Ph.D., FAU Department of Urban & Regional Planning
John O'Brien, FAU/FIU Joint Center
Marie L. York, FAU/FIU Joint Center

This report was prepared by the Florida Atlantic University/
Florida International University Joint Center for Environmental
and Urban Problems for:

The Florida Department of Transportation
Contract No. BC-450

FAU/FIU Joint Center
220 SE 2nd Ave, Suite 709
Fort Lauderdale, FL 33301(954) 762-5255
www.fau.edu/jointcenter

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Introduction

Transportation planning at the local, state, and federal levels has changed dramatically over the last decade. Regulations such as the Clean Air Act Amendments of 1990 and 1997, the Intermodal Surface Transportation Efficiency Act (ISTEA), and the Transportation Equity Act for the 21 Century (TEA-21) have forced transportation agencies to reexamine their mission. According to Hewitt and Althshuler, this legislation brings changes to transportation "more profound than any since the adoption of the Interstate Highway System in 1956."[1] Much like the Highway Act of 1956 provided the mandate for DOTs for nearly four decades, the new laws will affect how DOTs do business for decades to come. In addition to their traditional role as road builders, they are now expected to involve the public early in the planning process, more closely coordinate activities with Metropolitan Planning Organizations and local governments, and protect and enhance the environment.

As part of FDOT's update to the Florida Transportation Plan 2020, the Florida Atlantic University/Florida International University Joint Center for Environmental and Urban Problems (Joint Center) has been asked to examine the environmental trends relevant to transportation planning. It is important to realize that traditionally transportation decisions are based on the projected demand for transportation. Typically this demand is driven by population and economic factors. Although environmental considerations have become more important in transportation decisions, the environmental issues are primarily addressed at the project level. To a certain extent the project level is an appropriate place to address environmental concerns. Only at this level is it possible to determine the exact environmental effects and to

develop mitigation strategies. However, environmental concerns have changed from primarily local and regional issues to state, national and global issues. Where environmental concerns such as noise abatement and wetland mitigation could most effectively be addressed at the project level, the current issues require a long term, proactive approach. According to the Transportation Research Board (TRB), environmental problems such as air quality cannot be dealt with at the project level, and require longer-term, regional analysis. The TRB also brings up the point of cost effectiveness and argues that costly delays in projects can be avoided by integrating environmental issues early in the planning process, rather than when Environmental Impact Statements (EIS) are being prepared.[2]

Development of Environmental Policy in the United States

The history of environmental policy in the United States is not one of steady improvements. Instead in the past 30 years environmental policy has seen sharp discontinuities. The reason for this discontinuity can be found in short term political and economic forces such as elections, environmental calamities, economic cycles and energy supply shocks which alter the salience of environmental issues [3]. Although these shallow currents can have a temporary effect on environmental policy, they are typically difficult to predict and usually do not have a lasting effect on the long term direction of environmental policy. The increased interest from consumers in sport utility vehicles in the late 1990s, for instance, had profound effects on pollution from transportation but the effect is likely to be offset by the unexpected sharp increase in oil prices in the beginning of 2000, which drew consumers back to smaller, more efficient, automobiles.

What is more important is the deep current, which consists of fundamental changes in American values that for environmental issues started with the publication of Rachel Carson's Silent Spring in 1963. This deep current consists of an increased concern in quality of life issues such as the environment both among the general population and government.[4] The deep current suggests that in the coming decades environmental protection will become increasingly important and is likely to be more and more integrated in traditional political, economic and social decision-making. This integration is not only evident in international documents such as Our Common Future and Agenda 21 but also in publications of the Presidents Council for Sustainable Development and the Environmental Protection Agency's Strategic Plan. It is also becoming visible in federal and state transportation documents. The draft strategic plan of the Federal Highway Administration (FHA), for example, states environmental protection of as one of the major goals of the Administration:

> ***HUMAN AND NATURAL ENVIRONMENT***:
> Protect and enhance the natural environment and communities affected by highway transportation.
>
> *Strategic Objectives & Indicators:*
>
> > **Enhance community and social benefits of highway transportation.**
> > Increase public satisfaction with highway systems and highway projects as a beneficial part of their community (to be measured through surveys) .
> >
> > **Improve the quality of the natural environment by reducing highway-related pollution and by protecting and enhancing ecosystems.**
> > Reduce on-road mobile source emissions by 20 percent in 10 years.
> > Increase net wetland hectare area (acreage) resulting from Federal-aid highway projects by 50 percent in 10 years.[5]

Based on this goal the FHA formulated a strategic plan for environmental research. According to the FHA, "making effective decisions about transportation

requires a comprehensive look at the livability and sustainability of the natural and human environment".[6]

The deep current of environmental policy at the federal level will ultimately lead to stricter environmental quality standards. At the same time, environmental policy is likely to drift away from the traditional command-and-control approach and instead focus on the responsibility of regulated groups. This means an approach to environmental policy in which federal regulators set environmental quality standards and leave considerable freedom to regulated groups about how they want to meet the standards. This so-called performance based approach to environmental regulation started in the U.S. in the early 1990s and is not only likely to continue but also to gain momentum. The approach has considerable advantages for both regulators and regulated and has been very successful in other countries[7]. The main advantage is that it increases flexibility and innovation by allowing regulated interests to use those measures that are not only technically and economically feasible but also most efficient.

Besides this change in the regulatory approach to environmental problems there is also a change in the focus of environmental policy. U.S. environmental policy has always been based on the prevention of negative human health effects, but the concept of sustainable development is now slowly but steadily changing that focus. Sustainable development extends traditional environmental protection policy in a number of ways. It widens the application of impact assessment to all economic decisions, it broadens the scope to cover social as well as environmental criteria and it introduces inter-generational equity as a key issue[8]. According to the President's Council on Sustainable Development (PCSD), sustainable development in the United States has ten goals:

1: *Health And The Environment*
Ensure that every person enjoys the benefits of clean air, clean water, and a healthy environment at home, at work, and at play.

2: *Economic Prosperity*
Sustain a healthy U.S. economy that grows sufficiently to create meaningful jobs, reduce poverty, and provide the opportunity for a high quality of life for all in an increasingly competitive world.

3: *Equity*
Ensure that all Americans are afforded justice and have the opportunity to achieve economic, environmental, and social well-being.

4: *Conservation Of Nature*
Use, conserve, protect, and restore natural resources -- land, air, water, and biodiversity -- in ways that help ensure long-term social, economic, and environmental benefits for ourselves and future generations.

5: *Stewardship*
Create a widely held ethic of stewardship that strongly encourages individuals, institutions, and corporations to take full responsibility for the economic, environmental, and social consequences of their actions.

6: *Sustainable Communities*
Encourage people to work together to create healthy communities where natural and historic resources are preserved, jobs are available, sprawl is contained, neighborhoods are secure, education is lifelong, transportation and health care are accessible, and all citizens have opportunities to improve the quality of their lives.

7: *Civic Engagement*
Create full opportunity for citizens, businesses, and communities to participate in and influence the natural resource, environmental, and economic decisions that affect them.

8: *Population*
Move toward stabilization of U.S. population.

9: *International Responsibility*
Take a leadership role in the development and implementation of global sustainable development policies, standards of conduct, and trade and foreign policies that further the achievement of sustainability.

10: *Education*
Ensure that all Americans have equal access to education and lifelong learning opportunities that will prepare them for meaningful work, a high quality of life, and an understanding of the concepts involved in sustainable development.[9]

It is clear that the goals as formulated by the PCSD encompass much more than just environmental goals. Besides the three basic components of sustainable development, environment, economy and equity, it also includes education, population stabilization, environmental stewardship and quality communities. Interestingly enough,

the goals do not make any mention of energy conservation which is a major component of sustainable development in most other publications about sustainable development.[10]

Programs that aim to promote sustainable development can also be found at the local and regional level. Important for transportation are specific transportation-land use strategies that are being proposed, such as:

- Infill – development on under-utilized lands in urbanized districts,
- Revitalization/re-use/redevelopment of existing developed areas,
- Higher development densities,
- Compact development,
- Mixed use development,
- Transit-oriented development – providing for higher densities and higher intensity uses within walking distance of transit,
- Transit, bike, and pedestrian-oriented design – providing for comfortable, safe, convenient access in site design and street layout[11].

The changes in environmental policy from command and control to a more cooperative approach combined with the shift from purely health-based to a quality of life approach offers tremendous opportunities for the transportation sector. Although it is likely that environmental standards will become stricter, they will be less rigid and allow for creativity and innovation. The first step towards this approach is the 1995 Project eXellence and Leadership. Project XL is a national pilot program that allows businesses, federal agencies, states and local governments to develop innovative strategies to achieve better and more cost-effective environmental protection[12]. In return, the EPA issues regulatory, program, policy or procedural flexibilities. Project XL allowed Atlanta, Georgia, to receive federal money for the construction of an

interchange and multi-modal bridge even though Atlanta does not meet federal Clean Air Act standards and is not eligible for highway funding[13].

In order to take full advantage of these changes, it is important to have a good understanding of both the effects of transportation on the environment and trends in environmental policy.[14] The rest of this paper gives an overview of the effects of transportation on the environment, summarizes current regulations that pertain to these effects and discusses the direction of environmental policy for each effect.

Role of Transportation in the Occurrence of Environmental Problems

The most important negative environmental effects of transportation are air pollution, noise and habitat fragmentation. There are other negative effects such as the introduction of exotic species and soil and water pollution but they are of relevant less importance. The effects of transportation on the environment are caused by two different sources; the transportation devices themselves and transportation facilities. Transportation devices, such as automobiles, trucks, busses, trains, airplanes and boats, are mostly the source of air pollution problems and thus those problems that have a direct bearing on human health. Transportation facilities, such as roads, seaports, airports and maintenance facilities, mainly have effects on ecosystems. There are also problems that are caused by the interaction between transportation devices and facilities. The main source of highway noise for instance, is the interaction of vehicle tires with the highway surface[15]. It is important to realize that even when the transportation device is the source of the pollution, the design and quality of the transportation facility has a major effect on the amount of pollution. Air emission rates

from automobiles are strongly related to vehicle speed and driving conditions. Typically, emission rates from vehicles are lowest at moderate speeds and highest at low and or high speeds[16]. A 1997 study by the European Environment Agency (EEA) showed that NO_x emission from vehicles were lowest at speeds around 55 kilometers per hour (35 miles per hour)[17]. At slower speeds the emission rate almost doubled, while at higher speeds the emission rate tripled. Therefore, stop and go travel caused by traffic lights, congestion, or speed limits can have dramatic effects on the emission on air pollutants.

Table 1 gives an overview of the effects of transportation on the environment. Also included in this table are the environmental effects of the construction of transportation facilities. Although these effects are temporarily, they can be extensive. The table shows that the effects of transportation on the environment range from specific local effects, to regional, national and even global effects. It is important to realize that most environmental effects are locality specific. For instance, air pollution caused by transportation is typically a problem in urban areas where there are higher volumes of traffic and more congestion than in rural areas. Effects on ecosystems on the other hand are typically outside the urban areas, especially where roads run adjacent to or through natural areas.

(Table 1 on following page)

Table 1 - Effects of transportation on the environment

Source		Pollutant/Intervention
TRANSPORTATION DEVICES	Chemical	▪ Air pollutants: CO, CO_2, NO_x, VOCs, SO_2, N_20, HFCs, MTBE, Particulate Matter ▪ oil, antifreeze, tires ▪ waste and litter
	Physical	▪ noise ▪ vibrations ▪ light ▪ heat ▪ radiation
TRANSPORTATION FACILITIES	Biotic	▪ habitat fragmentation ▪ habitat destruction ▪ endangered species
	Soil and water	▪ soil, geology, geomorphology ▪ groundwater-flow ▪ surface water/watershed/wetlands ▪ storm water run-off
	Physical	▪ direct use of land/space ▪ indirect use of space (fragmentation, right of way, zoning, creation of barriers)
COMBINATION OF FACILITIES AND DEVICES		▪ deterioration of landscape, community, esthetics, history, culture ▪ traffic accidents ▪ noise ▪ risk of emission of hazardous waste from accidents ▪ road kill ▪ introduction of exotic species
CONSTRUCTION		▪ habitat destruction ▪ run-off ▪ erosion ▪ disturbance ▪ noise

The possible negative effects of transportation on the environment are regulated under a wide array of different environmental acts, ranging from the 1969 National Environmental Policy Act (NEPA) to the 1997 Clean Air Act amendments. Table 2 gives an overview of the most important environmental acts that either have a direct effect (such as NEPA and the 1973 Endangered Species Act) or an indirect effect (such as

the Clean Air Act) on transportation decision-making. The table is not exhaustive and does not include environmental requirements in Transportation Acts.

Table 2 - Federal Environmental Acts with a direct or indirect effect on transportation[18]

GENERAL LAWS ▪ National Environmental Policy Act (1969) ▪ Endangered Species Act (1973) ▪ Emergency Planning and Community Right to Know Act (SARA Title 3)
AIR QUALITY ▪ Clean Air Act (1965, 1970, 1977, 1990, 1997) ▪ Energy Policy Act (1992)
NOISE ▪ Housing and Urban Development Act (1965) ▪ Airport Noise and Capacity Act (1990) ▪ Control and Abatement of Aircraft Noise and Sonic Boom Act (1968) ▪ Noise Control Act (1972)
WATER QUALITY ▪ Wild and Scenic Rivers Act (1958) ▪ Fish and Wildlife Coordination Act (1958) ▪ Clean Water Act (1972, 1977, 1987) ▪ Coastal Zone Management Act (1972) ▪ Shore Protection Act (1988) ▪ Coastal Wetlands Planning, Protection, and Restoration Act (1990) ▪ Non-indigenous Aquatic Species, Nuisance Species Prevention and Control Act (1990)
SOLID AND HAZARDOUS WASTE ▪ Resource Conservation and Recovery Act (1976) ▪ Comprehensive Environmental Response, Compensation and Liability Act, "Superfund" (1980, 1986) ▪ Hazardous Materials Transportation Act

Chemical Emissions to the Air

The most profound effects of transportation are on air quality, especially the ambient concentration of Carbon Monoxide (CO), Nitrogen Oxides (NO_x), Volatile Organic Compounds (VOCs), Ozone (O_3) and Carbon Dioxide (CO_2). Table 3 shows that the

EPA estimates that transportation is responsible for 93 percent of all CO emissions, 52 percent of all NO_x emissions, 90 percent of all VOC emissions and 30 percent of all CO_2 emissions. It is difficult to determine the exact contribution to ambient O_3 concentrations since O_3 is a so-called secondary air pollutant and is not directly emitted, but formed by chemical reactions between VOCs and NO_x in the atmosphere. Since transportation is both a source of NO_x and VOC, over 90 percent of ground level O_3 in urban areas is probably directly or indirectly attributable to transportation.

Table 3 - Direct contribution of transportation to air pollution

Pollutant	Total Transportation Contribution	Relative Contribution
CO	60,794 Gg[1) 3)]	93 % [(3)]
CO_2	446.5 MMTCE[2)]	30% [(3)]
NO_x	10,519 Gg	52 % [(3)]
VOCs (Non methane)	6,949 Gg	90 % [(3)]
MTBE	no data available	
SO_2	1,252 Gg	15 % [(3)]
Particulate Matter	no data available	
N_2O	17.5 MMTCE	16 % [(3)]
HFCs	4.5 MMTCE	12 % [(3)]

1) Giga Grams = 1 kiloton
2) Metric Mega Ton Carbon Equivalent
3) From U.S. EPA Inventory of greenhouse gas emissions and sinks, 1999

Although these numbers by themselves are alarming enough, the contribution of transportation to total emissions in urban areas is even greater than indicated by the relative contribution in the table.[19] The reason for this is that the data in table 3 is based on national average emission rates of vehicles. Since emission rates increase dramatically during stop and go traffic, the actual emissions in urban areas are likely to

be considerably higher. For transportation, the air pollutants of main concern in urban areas are CO, NO_2, O_3, VOCs and particulate matter. All these pollutants can have a direct effect on human health and are regulated under the Clean Air Act. SO_2 is also regulated under the Clean Air Act but transportation is a relatively minor source for this pollutant. Table 4 shows the current ambient air standards for CO, NO_2, O_3 and particulate matter. Units of measure for the standards are parts per million (ppm) by volume, and micrograms per cubic meter of air ($\mu g/m^3$).

Table 4 - Ambient Air Quality standards for air pollutants relevant for transportation[20]

Pollutant	Average Time	Standard
CO	8-hour	9 ppm
	1-hour	35 ppm
Ozone[1)]	1-hour	0.12 ppm
	8-hour	0.08 ppm
NO_2	annual arithmetic mean	0.53 ppm
Particulate Matter 10	annual arithmetic mean	50 $\mu g/m^3$
	24-hour average	150 $\mu g/m^3$
Particulate Matter 2.5[1)]	annual arithmetic mean	15 $\mu g/m^3$
	24-hour average	65 $\mu g/m^3$

[1)]The implementation of the ozone 8-hour standard and the PM 2.5 standard, which EPA proposed in 1997, were blocked by a 1999 federal court ruling. EPA has asked the U.S. Supreme Court to reconsider that decision.

Carbon Monoxide

Carbon monoxide (CO) is an odorless and colorless gas produced by incomplete combustion of fuel and is produced when fuels are burned under less than optimal

conditions. Since the control of combustion processes in stationary sources is typically much tighter than for mobile sources, mobile sources account for most of the CO emissions. CO interferes with the hemoglobin's ability to absorb oxygen from the air and reduces the ability of blood to deliver oxygen to vital tissues in humans. It can also impair vision, cause dizziness, and can ultimately lead to unconsciousness and death. CO has no apparent effects on plants.

Nation-wide emissions of CO have declined since 1970, and since 1989 there has also been a 22 percent decline in CO emissions in Florida[21]. Still, CO concentrations in urban areas remain high, with a typical range of 5 to 50 ppm; while congested highways can range up to 100 ppm[22]. Although the ambient air standard for CO is 35 ppm, effects on human health have been reported at this level. Therefore, the federal standard has been criticized as not being strict enough and California's air quality standard has been set at 20 ppm[23]. Hourly concentrations of CO usually reflect city driving patterns, with peaks occurring during morning and afternoon rush hours on weekdays and a peak in the late afternoon during the weekends.

OZONE

Ozone is a severe irritant and causes damage to lung tissue, aggravates respiratory diseases and makes people more susceptible to respiratory infections[24]. Ozone can also inhibit plant growth, especially if elevated levels of SO_2 are also present. Ozone is a secondary pollutant, meaning that it is not actually directly emitted in the air. Instead Ozone is formed by a set of reactions between hydrocarbons and NO_x under the influence of sunlight. These reactions form a number of so-called photochemical oxidants of which Ozone is the most abundant. Since the formation of Ozone is not

only dependent on the presence of chemicals but also the intensity of sunlight, in most of the U.S. ozone is predominately a problem in the summer. In Florida, problems with Ozone occur from early spring to summer. The intensity of sunlight is not high enough in most of the state to cause problems in the winter, but during spring light intensity is already high enough to lead to the formation of Ozone. Because of afternoon thunderstorms and overcast conditions, Ozone becomes less of a problem during the later part of the summer, especially in the southern parts of the State.

High concentrations of ozone caused the U.S. Environmental Protection Agency to declare six counties in Florida (Broward, Dade, Duval, Hillsborough, Palm Beach and Pinellas) as *ozone nonattainment areas* in 1987. Under this designation, the State of Florida faced possible federal sanctions in the form of withheld highway construction funds and the potential of a moratorium on the construction of new industrial facilities. The Florida legislature responded to this designation by enacting the Clean Outdoor Air Law (COAL) which authorized the Motor Vehicle Inspection Program (MVIP)[25]. In 1991, the emissions testing programs were implemented in the six counties. MVIP established mandatory annual emission inspection of passenger cars and light duty trucks, model years 1975 and later, weighing 10,000 pounds or less, which were registered or primarily kept in any of the six counties[26]. Under MVIP, vehicles that fail the inspection had to be serviced and could then be retested. Vehicles that continued to fail the testing program were ultimately taken of the road. When MVIP started, failure rates were approximately 10 percent, after five years the failure rate had dropped to around 5 percent. According to the 1996 MVIP annual report, failure rates probably dropped because vehicles were better maintained and gross polluting vehicles were

taken out of service because of too costly repairs.[27] Estimates of the positive effects of the MVIP indicate that the program reduced hydrocarbon emissions by approximately 12 percent or 50 tons per day and CO emissions by 17 percent or 628 tons per day during 1995[28]. The EPA redesignated all six counties as attainment areas during 1995-1996 and the MVIP was eliminated in July 2000.

Although there are currently no ozone nonattainment areas in the State, Ozone remains a problem in Florida. For instance, according to the Florida Department of Environmental Protection, Escambia County violated the eight-hour ozone standard on March 29, 1999 and Hillsborough County violated the standard on May 15, 1999[29]. These violations might be the cause for designation as ozone nonattainment area for these two counties. This designation could occur in 2000 when the EPA will make its determination of the areas that will be designated nonattainment based on the three-year average of data from 1997 through 1999[30].

NO_2

The direct health effects of NO_2 are still uncertain but as mentioned before NO_2 plays an important role in the formation of groundlevel Ozone. Prolonged exposure to NO_2 has been linked to increased bronchitis in children[31]. NO_2 also reacts in the atmosphere to create Nitric Acid, which is an important component of acid deposition.

According to the 1996 MVIP annual report, NO_x is the most serious air pollution problem for Florida in the future[32]. The Clean Air Act requires that ambient NO_x concentrations do not exceed 1990 levels, or an area might be designated as a NO_x nonattainment area. The consequences of such a designation are similar as with the designation as an ozone nonattainment area and include the withholding highway

construction funds. Other reports support the notion that NO_x will be the most serious urban air problem in the coming years. In the EPA include short paragraph about EPA evaluation of 25 years of environmental policy The Florida Department of Environmental Protection (FDEP) has also indicated in its quarterly reports that NO_x is the air pollutant of greatest concern for Florida. However, in its December Quarterly Report, FDEP notes that NO_x emission dropped slightly in 1997. According to the report, air quality monitors measured annual averages for NO_2 ranging from 18-30 micrograms per cubic meter, which is considerably under the national standard of 100 micrograms per cubic meter[33]. According to FDEP, NO_2 has not been a threat to human health in Florida due to its relatively low concentration. The primary concern, stems from its role as a precursor to ground-level ozone.

The Air Quality Index

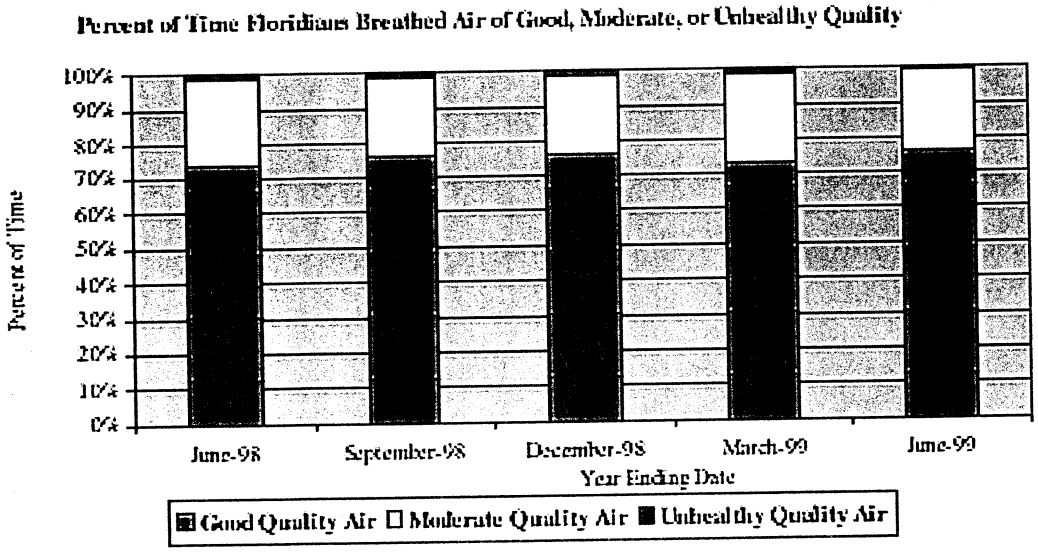
A simplified method to advise the public of possible adverse health effects due to air pollution is the Air Quality Index (AQI), also known as the Pollution Standard Index (PSI). The AQI converts air pollution concentrations for Ozone, CO, Particulate Matter, NO_2 and SO_2 in one number that can range from zero (0) to 500 which is then assigned a descriptive term from "good" to "hazardous" according to table 5. The AQI is currently determined, on a daily basis, in Florida's thirteen largest metropolitan counties.

Table 5 - PSI values and its air quality description

Numerical Value	Description
0-50	Good
51-100	Moderate
101-199	Unhealthful
200-299	Very Unhealthful
≥300	Hazardous

Figure 1 shows the percentage of time Floridians breathed air of good, moderate, or unhealthy quality from June 1998 to June 1999. The figure shows that between June 1998 and June 1999, just 76 percent of the time Floridians were exposed to "healthy air", while just over 23 percent of the time Floridians were exposed to "moderate air". Only 0.5 percent of the time were Floridians exposed to "unhealthy air".

Figure 1 - Air Quality Index for Florida from June 98 to June 99[34]



From 1996 to 1999 the AQI indicates that air quality in the State has decreased. In 1996, Floridians breathed air classified as "good" 83 percent of the time, in calendar year 1997 it was 80 percent of the time and in calendar year 1998 the percentage fell to 75.9 percent of the time[35]. Although the AQI for June 1998 to 1999 seems to have improved, this AQI was adjusted for the effects of wildfires in Florida and Mexico. The unadjusted AQI for April 1998 to March 1999 indicated that Floridians only were exposed to "healthy air" 72.9 percent of the time. At the same time Floridians were exposed to "unhealthy air" 1.86 percent of the time[36].

The AQI is an important indicator of air quality for residents but is of limited use for policy makers. The strength of the AQI is that it provides residents with one number that gives them a fair indication of possible health problems that they can encounter. However, the AQI does not show the pollutant that is causing the problem. The AQI is calculated by using the numbers in table 6, which shows individual AQI numbers corresponding to different concentrations of pollutants. For each pollutant a sub-AQI is determined. The final AQI is then determined by the highest sub-AQI. The problem with the AQI for decision-makers is that it does not show them what pollutant is causing health problems. In fact, the same qualification of "unhealthy air" can be caused by high concentrations of any of the 5 pollutants and a combination of two of them.

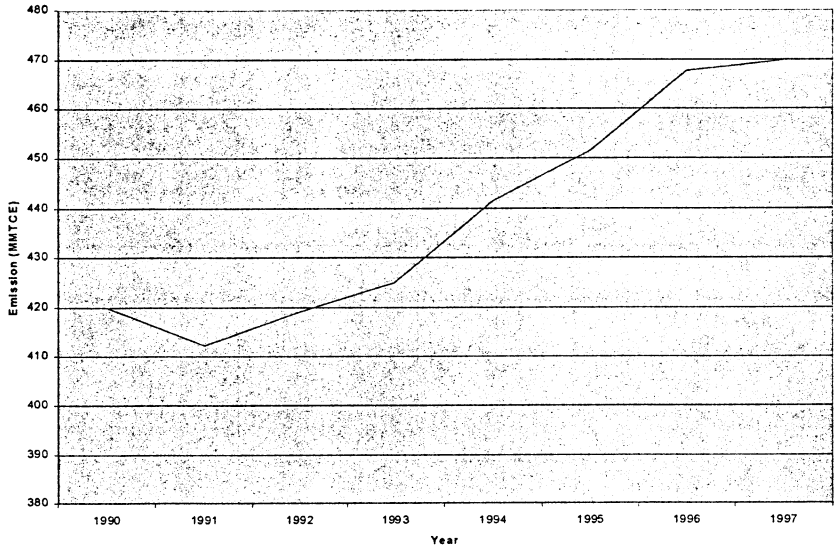
Table 6 - Breakpoints for the Calculation of the Air Quality Index[37]

Index	1-hour O3 $\mu g/m^3$	8-hour CO mg/m^3	24-hour TSP $\mu g/m^3$	24-hour SO2 $\mu g/m^3$	TSO x SO2 103 $(\mu g/m^3)^2$	1-hour NO2 $\mu g/m^3$
0	0	0	0	0	-	-
50	118	5	75	80	-	-
100	235	10	260	365	-	-
200	400	17	375	800	65	1130
300	800	34	625	1600	261	2260

Contribution to Climate Change

Increasingly important is the role of transportation in the emission of greenhouse gasses. According to estimates by the EPA, transportation is responsible for 26 percent of the total emission of greenhouse gasses in the U.S. (including all forms of transportation, CO_2, CH_4, N_2O, HFCs)[38]. Emissions of greenhouse gasses is not regulated under the Clean Air Act but with the signing of United Nations Framework Convention on Climate Change in June 1992, the U.S. committed itself to stabilization of greenhouse gas emissions at 1990 levels. In November 1998, the United States signed the Kyoto Protocol, which goes much further than a stabilization at 1990 levels and calls for a reduction of greenhouse gas emissions of seven percent below the1990 levels for the US[39]. Unfortunately, there has been a substantial increase in the emission of greenhouse gasses since 1990. According to the EPA, the total emission of greenhouse gasses in 1997 was 1,605 Million Metric Tons of Carbon Equivalents (MMTCE). Which constitutes an increase of 181.5 MMTCE, or 11.2 percent from 1990 to 1997. In 1997, transportation was responsible for almost 26 percent of the total emission of greenhouse gasses in the US, or a total of 469.9 MMTCE[40]. It is expected

Figure 2 - Greenhouse gas emission from transportation for 1990-1997



that transportation will be the fastest growing source of CO2 emissions through the coming years[41]. According to conservative estimates the US is responsible for more than 23 percent of the global emission of CO_2[42], this means that US transportation is responsible for 6 percent of global CO_2. Figure 2 shows the increase of greenhouse gas emissions from transportation in the period 1990-1997.

CO_2 accounts for around 95 percent of the total contribution to greenhouse gas emissions from transportation. Almost 4 percent is caused by N_2O and the remaining emissions are in the form of HFCs and CH_4.

Since CO_2 is the product of perfect combustion, the only technological solution to decreasing CO_2 emission from transportation is by increasing fuel efficiency. Currently, the average car in the U.S. gets 16.9 miles per gallon. Since each gallon produces about 19.5 pounds of CO_2, cars emit 1.15 pounds per mile[43]. With recent innovations such as the hybrid car, that has both a gasoline and an electric engine, it is possible to achieve a substantial reduction of emission rates (the Honda Insight allegedly gets 60 miles per gallon, which means that this car only emits .325 pounds of CO2 per mile, or a

70 percent reduction). It is important to realize that reductions in emission rates are directly off-set by increases in vehicle miles traveled (VMT). Since VMT increased by 15 percent nationwide from 1990-1996[44], the US is already looking at needed emission reductions of at least 20 percent. The 1993 Convention on Climate Action Plan called for developing measures to substantially reduce greenhouse gas emissions from personal vehicles. The goal of this plan was to improve fuel efficiency in new vehicles by 2 percent per year over a period of 10 to 15 years[45]. However, it seems clear that it will be impossible to reach a 7 percent reduction by improvements in fuel efficiency alone. The emission of greenhouse gasses is likely to force transportation planners to think about innovative transportation strategies. So far, these strategies involve telecommuting programs, changes in the Internal Revenue Code relating to employer-provided parking, virtual offices, smart cars and transit vehicles, mass transit finance and congestion pricing tolls[46].

Looking to the Future

It is very difficult to determine future environmental trends since these trends are strongly influenced by regulatory decisions, consumer behavior and technological innovations. For the effects of transportation on air quality, changes in VMT combined with changes in emission rates probably give the most accurate picture of what lies ahead. In this section, trends in emission rates and VMT are combined in an attempt to shed some light on the future trends in air pollution caused by transportation.

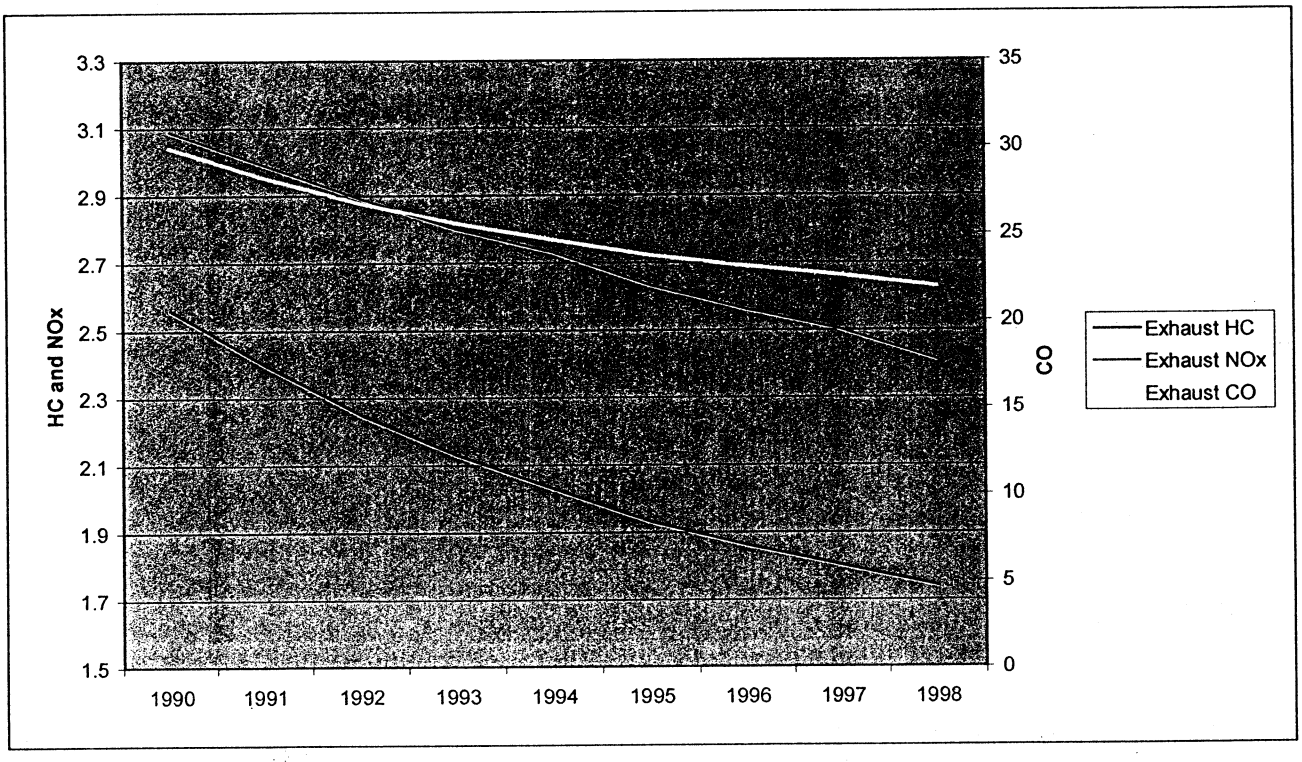
Table 7 - National Average Emissions Rates[47]

	1990	1991	1992	1993	1994	1995	1996	1997	1998
Gasoline									
Light-duty vehicles									
Exhaust and nonexhaust HC	3.09	2.91	2.77	2.65	2.57	2.49	----	2.36	2.29
Exhaust CO	24.68	23.42	22.40	21.65	21.10	20.52	20.14	19.86	19.52
Exhaust NOx	1.81	1.76	1.72	1.69	1.67	1.61	1.56	1.51	1.45
Light-duty trucks									
Exhaust and nonexhaust HC	4.68	4.34	4.01	3.77	3.57	3.38	3.24	3.14	3.01
Exhaust CO	36.32	34.01	31.78	30.03	28.62	27.41	26.83	26.38	25.69
Exhaust NO_x	2.36	2.25	2.16	2.10	2.04	1.97	1.95	1.92	1.87
Heavy-duty vehicles									
Exhaust and nonexhaust HC	11.89	10.90	10.06	9.24	8.49	7.89	7.30	6.70	6.11
Exhaust CO	131.19	120.49	111.05	101.92	93.61	85.10	76.97	69.13	61.07
Exhaust NO_x	6.49	6.28	6.05	5.85	5.69	5.48	5.36	5.25	5.05
Motorcycles									
Exhaust and nonexhaust HC	4.68	4.56	4.48	4.41	4.38	4.33	4.29	4.29	4.27
Exhaust CO	20.89	20.61	20.60	20.59	20.59	20.47	20.47	20.47	20.35
Exhaust NO_x	0.85	0.85	0.85	0.85	0.85	0.84	0.84	0.84	0.83
Diesel									
Light-duty vehicles									
Exhaust HC	0.73	0.74	0.75	0.75	0.76	0.77	0.76	0.74	0.71
Exhaust CO	1.68	1.71	1.72	1.73	1.74	1.74	1.74	1.71	1.67
Exhaust NO_x	1.65	1.67	1.68	1.68	1.66	1.64	1.60	1.55	1.48
Light-duty trucks									
Exhaust HC	1.08	1.14	1.15	1.14	1.13	1.11	1.09	1.05	0.98
Exhaust CO	2.03	2.10	2.09	2.07	2.04	2.02	1.99	1.95	1.88
Exhaust NO_x	1.97	2.00	1.99	1.97	1.94	1.90	1.85	1.78	1.67
Heavy-duty vehicles									
Exhaust HC	3.30	3.08	2.89	2.75	2.65	2.54	2.44	2.36	2.30
Exhaust CO	13.71	13.38	13.07	12.76	12.50	12.28	12.08	11.93	11.77
Exhaust NO_x	21.05	19.59	18.14	16.89	15.81	14.79	13.96	13.33	12.66
Average of all vehicles, gasoline and diesel									
Exhaust and nonexhaust HC	3.75	3.52	3.31	3.15	3.02	2.90	2.80	2.71	2.62
Exhaust CO	29.97	28.29	26.81	25.62	24.68	23.75	23.11	22.58	21.94
Exhaust NO_x	3.09	2.99	2.89	2.80	2.73	2.63	2.56	2.50	2.41

Table 7 shows the emissions of Carbon Monoxide (CO), Nitrogen Oxides (NO_x) and Hydrocarbons (HC) per vehicle type. The emission rates vary greatly by fuel and vehicle. According to the table, diesel engines produce considerably less CO and HC than their gasoline counterparts. For NO_x there is little difference between gasoline and diesel engines for light duty vehicles and light duty trucks but heavy duty diesel vehicles have a much higher emission rate than heavy duty gasoline vehicles. The table shows

that nationwide the average emission per vehicle per mile has decreased over the past ten years. Figure 3 gives a graphical representation of this trend for all vehicles combined. The figure shows that the emission rate for hydrocarbons was almost 30 percent lower in 1998 than in 1990, the emission rate for CO was 27 percent lower and the emission of NOx was 22 percent lower.

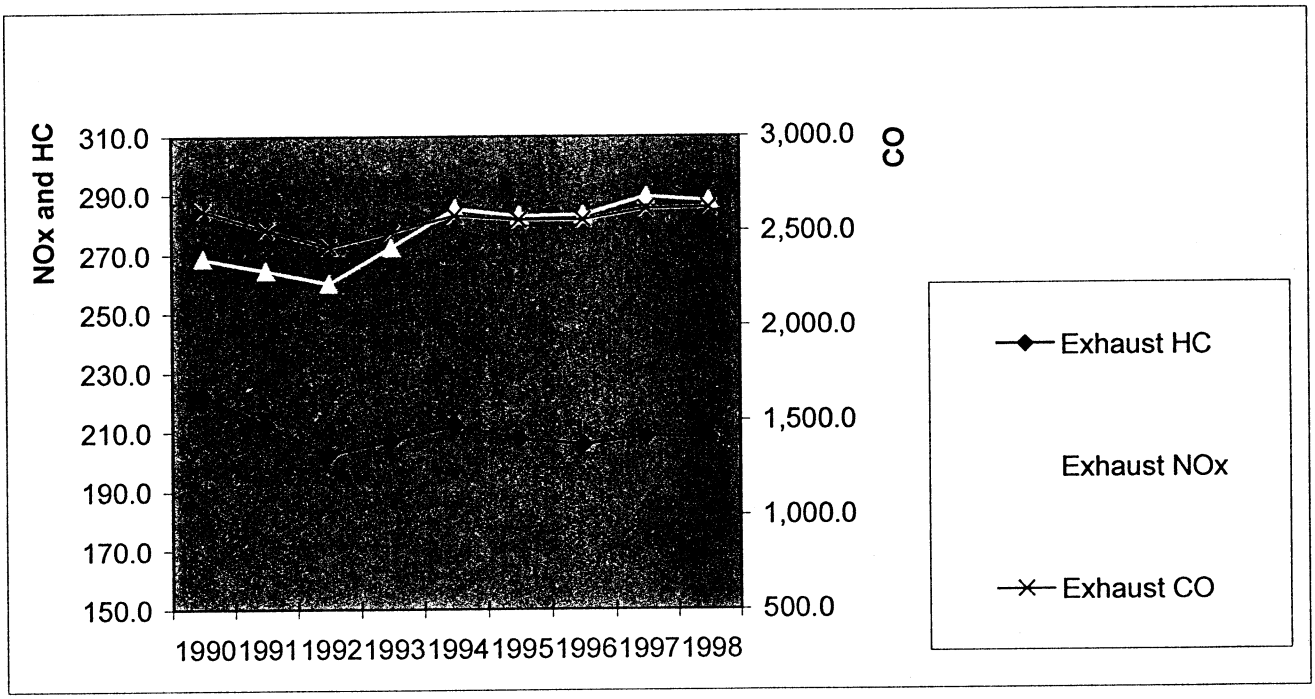
Figure 3 - Average Emission Rates



The numbers in table 7 and the graphical representation in figure 3 are misleading since they ignore both changes in the composition of the vehicle fleet and VMT. Since VMT has increased over that same period of time, the effective reduction in total emission is much lower. Figure 4 shows the total emission of air pollutants for Florida using national average emission rates and VMT for Florida. Figure 4 shows that

after correcting for the increase in VMT, the total emission of CO and NOx in Florida has actually increased despite decreasing emission rates. The picture looks slightly better for hydrocarbons for which the total emission seems to have leveled off but it is far from the 30 percent reduction that was found in the emission rates.

Figure 4 - Total emission of air pollution by transportation in Florida[48]



It is possible to calculate a better estimate of the total emission based on the vehicle emission rates and the VMT for each vehicle type. Unfortunately, VMT data per vehicle type for Florida was not available at the time of this report. Therefore, the calculation had to be based on use of the average emission rate per vehicle.

The calculations based on emission rates offer some interesting possibilities for the estimation of future trends in air quality. Based on future projections of population growth and VMT, it is possible to calculate responding increases in the emission of HC,

CO and NO_x for specific areas. Based on these calculations it is then possible to identify future problem areas. With specific information about local vehicle fleet composition and projected changes in fleet composition it would be possible to make even more accurate projections. Ideally a measure for congestion would be included since travel flow has substantial influence on emission rates. Ewing argues that instead of VMT, Vehicle Hours Traveled (VHT) should be used since this gives a much better indication of pollution.[49] If this data was available it would greatly increase the accuracy of the calculation of total emission. Even without this data however, it should be possible to identify hot spots based on the above describes calculations. As long as information is available about the amount and composition of traffic generated, it even seems possible to predict the consequences of expanding air and seaports for local air quality.

Energy and Transportation

Air quality is inexorably linked to energy consumption, regardless of the source of energy or the end-use sector. The transportation sector presents unique problems because of its "non-point" source of emissions. Florida's Department of Environmental Protection has made great strides in identifying, penalizing, and mitigating point source pollution from industrial plants and utilities. Measuring and controlling the air quality effects from millions of automobiles, buses, airplanes, trains, and trucks is considerably more complex. From the point of view of a Department of Transportation, there is little they can do to affect the chemicals contained in exhaust.

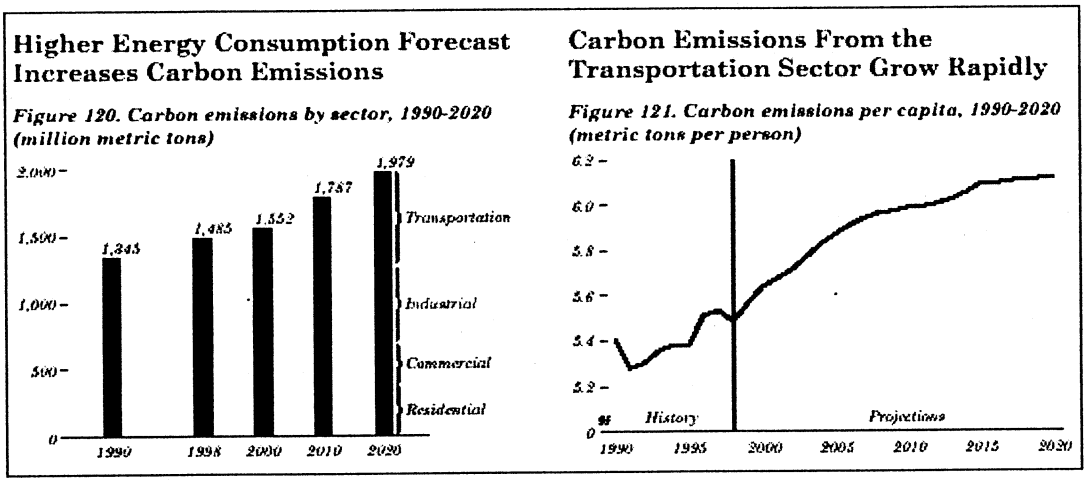
The transportation sector's share of energy use, however, is significant and growing and will be impacted by the increasing attention paid to greenhouse gas emissions. This chapter of the report examines some of the literature on transportation and energy, as well as different modes of transport. Also, transportation's reliance on fossil fuels will be examined as this has other important policy dimensions. In the transportation sector, the main culprit of emissions is the automobile.

Carbon Emissions from Transportation

One of the best sources of information on energy in the US is the Annual Energy Outlook published by the Department of Energy (AEO 2000).[50] Much of that report focuses on the affects of energy use on air quality. They demonstrate that petroleum products are the leading source of energy-related carbon emissions because of the continuing growth of the transportation sector, which is heavily dependent on petroleum. About 42 percent of all emissions, or 833 million metric tons of the total of 1,979 million

metric tons predicted in 2020, are from petroleum products, and about 82 percent of the petroleum emissions are from transportation uses.[51]

Figure 4 – Future Trends of Transportation's Carbon Emissions[52]



The AEO 2000 estimates that total energy consumption will increase at an average rate of 1.1 percent, per year from 94.9 quadrillion Btu in 1998 to 120.9 in 2020.[53] Over the same period, the transportation sector energy consumption is predicted to increase faster than total energy use. It is expected that transportation energy use will grow by 1.7 per cent annually, to a total of 37.5 quadrillion Btu in 2020. This represents 31 percent of all energy consumed in 2020. In fact, the Energy Department revised their figures upward from the 1999 Outlook as more travel is projected as older drivers are driving more than previously assumed.[54]

Florida's transportation energy consumption ranks high compared to other states. For example, Florida is the eight largest energy user in the country, but third in transportation energy use.[55] Even more dramatically, we rank 46th in *per capita* total energy use, but third in the nation in per capita petroleum use.

Congestion has become a hot political issue in Florida, as suburban roads begin to choke on the rapid growth of undeveloped areas. In response to the cries for help, Governor Bush recently implemented the Mobility program which promises to accelerate the spending of $6 billion transportation projects, including road widening and building.[56] As was suggested earlier, this may indeed reduce congestion and improve air quality – but for how long? Critics contend that the money would have been better spent on alternative modes of transportation, the subject of the next section.

Characteristics and Trends in Modes of Travel

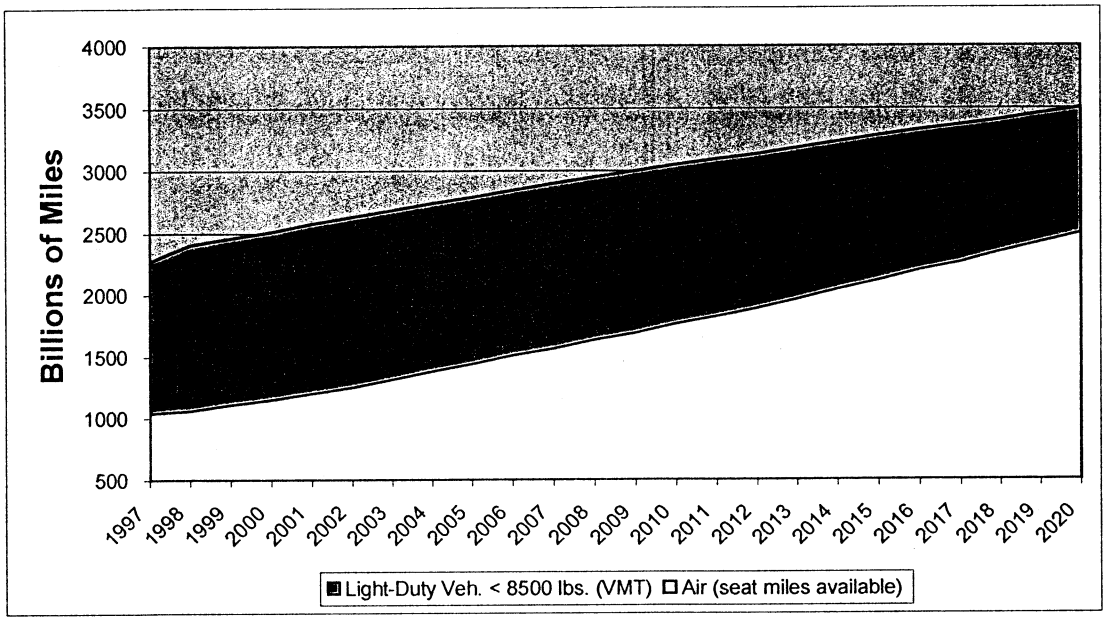
Table 8 shows that between 1998 and 2020 the mode of transport expected to experience the greatest increase in use is air travel, at an annual rate of 4.0 percent over the next 20 years.

Table 8 – Average Annual Increase in Travel 1997-2020[57]

Light-Duty Vehicles < 8500 lbs. (VMT)	1.70%
Freight Trucks > 10000 lbs .(VMT)	1.50%
Air (seat miles available)	4.00%
Comm. Light Trucks (VMT)	1.70%
Rail (ton miles traveled)	1.30%
Marine (ton miles traveled)	1.00%

As the figure 5 illustrates, light duty vehicles (autos, non-commercial trucks and SUV's) still dominate in terms of miles traveled in the year 2020, but air transport's share of the total transportation capacity is growing markedly. (Note: Air transport is measured in terms of seat miles available, which does not take into account occupancy levels.)

Figure 5 – Level of Travel Trends between Light-Duty Vehicles & Air Transport[58]



Policy Analysis

TEA-21 gives Departments of Transportation flexibility in spending their money, emphasizing transit or traffic demand management techniques rather than construction alone.[59] The lack of experience with transit in Florida, the decentralized nature of land development, and the high up-front costs have made transit a difficult option. Rail transit has the added difficulty of requiring a great deal of regional cooperation in deciding where to invest and in changing land use regulations to be more amenable to transit solutions. Traditional cost-benefit analysis further complicate decision-making because of the long-term horizons on returns on investment, as well as the difficulty in measuring the social benefits of providing transportation for underserved populations and of protecting the environment.

The social benefits are beyond the scope of this paper, but are significant and need to be researched. One way to measure the environmental benefits of different modes of transportation is by comparing their effects on air quality. Table 9 compares different types of personal transport, using emissions per passenger-mile as a measure. The table demonstrates that single-occupancy cars generate more harmful emissions than most other types of transportation on a per passenger-mile basis.

Table 9 – Steering a New Course - Comparison of Emissions Between Various Passenger-Transport Modes (1989)[60]

Mode	CO2	NMHC	CO	NO_x
Car single occupancy	0.51	2.57	20.36	1.61
Car - 3 passenger carpool	0.33	0.86	6.79	0.54
Bus (diesel)	0.29	0.12	0.60	0.90
Commuter Rail	0.24	1.04	1.44	4.10
Aircraft	0.53	0.05	0.52	1.08

This table, while useful for illustrative purposes, changes dramatically depending on the assumptions made. For example, for aircraft, it is assumed in this table that planes are flying over 300 miles with 65 percent of the seats taken. Automobile mileage changes considerably with the amount of congestion and age of the car. More importantly, measuring air quality per passenger mile does not take into account the effects on the physical environment, which may suffer inversely as roads are built or widened.

Energy use may therefore be a more comprehensive way of comparing different modes of transportation. Wright uses this approach and comes up with some interesting findings.[61] He suggests that while fixed rail is often touted as the best method of

transportation, this is true in only limited cases. They excel in long trips with heavy loads as the steel-wheel-on-steel-rail is much more energy efficient than rubber on pavement. The short distances between stops in urban rail, however, forces the train to accelerate from dead weight between stations, canceling out most other benefits. Also, comparing the typical small rail transit vehicle at 35 tons to a typical 12.6 metric ton bus, results in the bus having about 4.1 kg of dead weight per passenger (full capacity) while the rail car has 7.8 kg. These and other considerations are summed up in the Table 10, which compares the relative energy use of different modes of transport. Notice also that air transport is considered the least efficient while the previous table suggests it is one of the best in terms of air quality. The figures in the last column may be considered one measure of the social benefits of one mode compared to another. It shows that the passenger car is about 100 times as dangerous as the transit bus.

Table 10- Energy Use by Passenger Vehicle[62]

Mode	Load Factor Passenger km/vehicle km	Relative Energy Use Intercity bus = 1	Deaths per 100 million passenger km
Intercity Bus	41.8	1.00	.044
Commuter Rail	35.6	2.19	.082
Transit Bus	12.7	2.43	.006
Transit Rail	23.1	2.77	
Automobile	1.7	3.20	0.6
Air	89.3	3.82	.048

Alternative Fuels and Electric Cars

Presidential candidate Al Gore has recently (June 30, 2000) announced a proposal to promote energy efficiency if he gets elected. It calls for a tax credit of up to $15,000 for fuel-efficient 18-wheelers and provides families and consumers a $6,000 tax credit to purchase fuel-efficient cars or SUVs. Once again, trends in alternative fuel vehicles, like

so many environmental trends, can change depending on short-term political currents or who gets elected. The lessons learned after the oil embargo have been forgotten for a large share of the population.

One reason transportation uses so much energy is that only a small percentage of the potential energy in the fossil fuel is actually expended to create movement. An electric vehicle, which may appear to use little energy, may use up as much as a gasoline engine. Wright suggests taking two hypothetical 1,400 lb. vehicles, one gas powered and one electric.[63] When you account for the energy lost in generating and transmitting the electricity to the house, losses in the battery, motor, transmission, and accessories, only 10 percent of the original coal-produced heat energy is actually available at the wheels. An internal combustion engine is even less efficient as most of the energy stored in the gasoline is expended as heat, transmission and accessories, so that only 7.1 percent of the energy of the crude oil arriving at a refinery is actually used to make the wheels turn.

Policy Implications from Oil Consumption

While air quality is the greatest concern from *using* energy for transportation, extracting and delivering the fuel itself has serious economic and environmental impacts. The second law of thermodynamics states that energy cannot be created or destroyed. Fossil fuels epitomize this as there are fixed reserves of oil which cannot be replenished. Known reserves are extensive but will be much more quickly depleted as the third world industrializes.

If you define sustainability as creating a system whereby one generation's needs do not negatively affect the ability of the next generation to meet their needs, petroleum-

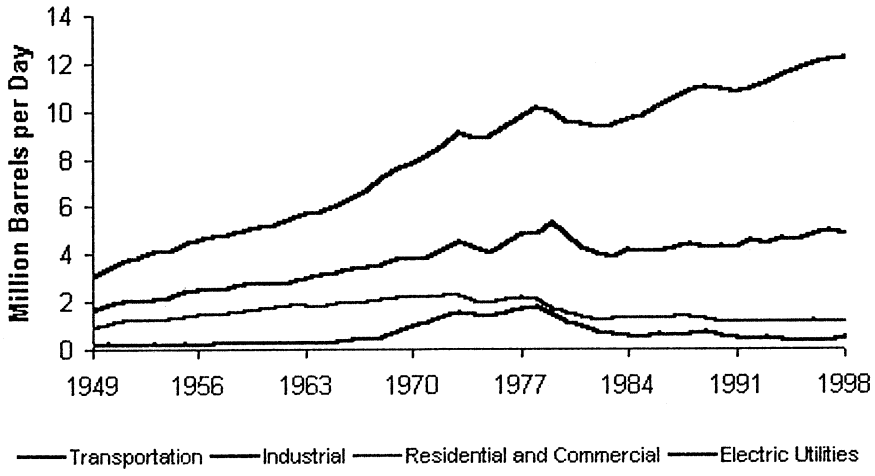
based transport systems are clearly unsustainable. Existing reserves are sufficient to maintain current levels of consumption for perhaps 30 years without major price increases. The US has about 27 billion gallons in reserves, enough for about 9 years' consumption.

One cannot ignore global transportation trends either, even though effects may not materialize for several decades. Consider that in 1987 the ratio of people to cars was 1.8 in the US, 34 in Costa Rica, and in China, 800 people per car. As these countries develop and car ownership increases (even if it never comes close to US levels) petroleum depletion and potential global warming would accelerate dramatically.[64]

Another reason for concerning ourselves with oil consumption is that it has significant policy implications at the national level. While no wars have been fought over traffic congestion (yet), many believe that the Gulf war was fought primarily to maintain our cheap supply of petroleum. In her book *Transportation, Energy, and the Environment,* Gordon considers this and other social, economic, and environmental factors as "hidden costs" of our transportation system.[65] She states that the oil embargo of 1973 led both the Carter and Nixon administrations to focus money on issues such as transit, alternative fuels, and the gas guzzler tax. Although some of these policies were reversed during the Reagan administration (remember those "shallow currents"?), the policies from the early 70's did have long lasting effects. 1973 marked the first year that the increase in energy consumption began to rise more slowly than the increase in GNP, a trend that continues today.[66]

While the commercial, residential, and industrial sectors have reduced their use of petroleum over the past two decades, the transportation sector's reliance on petroleum is nearly complete. Transportation's share of petroleum consumption is unmatched by any other sector at about 65 percent in 1998, to 70 percent in 2020. While energy efficiency gains are expected, this will be outweighed by increases in travel and the increased freight movement with an expanding economy. Figure 6, from the AEO 2000, illustrates this point.

Figure 6 – Transportation's increasing reliance on petroleum[67]



In the study of macroeconomics, the "oil shock" of 1973 was a watershed event, causing a great series of economic aftershocks for years to come. The assumptions made to predict economic trends had to be completely rethought. This is especially true for transportation. Table 11 shows the sensitivity of energy use to general economic conditions as well as changes in oil prices.

Table 11 – Sensitivity of energy use in five scenarios[68]

Sensitivity Factors	1997	1998	2020				
			Reference	Low Economic Growth	High Economic Growth	Low World Oil Price	High World Oil Price
Consumption (quadrillion Btu)							
Petroleum Products	36.43	37.21	49.05	44.99	53.27	51.73	47.71
Natural Gas	22.60	21.99	32.38	30.28	33.61	32.11	32.44
Coal	21.34	21.50	26.60	25.32	28.98	26.15	26.68
Nuclear Power	6.71	7.19	4.56	4.56	4.70	4.51	4.63
Renewable Energy	7.00	6.67	7.99	7.78	8.42	7.92	8.08
Other	0.33	0.32	0.36	0.34	0.38	0.37	0.34
Total Consumption	94.41	94.88	120.95	113.28	129.36	122.79	119.88
Prices (1998 dollars)							
World Oil Price (dollars per barrel)	18.71	12.10	22.04	20.99	23.11	14.90	28.04
GDP (annual change, 1998-2020)	—	—	2.2%	1.7%	2.6%	2.2%	2.2%
Carbon Emissions (million metric tons)	1,479	1,485	1,979	1,851	2,126	2,019	1,956
(annual change, 1998-2020)	—	—	1.3%	1.0%	1.6%	1.4%	1.3%

Conclusions

Future environmental trends are subject to the strong influence of regulatory decisions and technological changes. Transportation planners must therefore take into account trends in environmental policy as well as environmental conditions. Regulators have given state planning agencies greater discretion on how they spend federal transportation funds, using performance-based measures to evaluate results. Measuring performance in terms of indices, however, can be misleading. In terms of air quality for example, it was shown earlier how the "air quality index" may mask significant problems in underlying measures such as NO_x concentrations.

Another, more fundamental conflict arises from the goal of improving air quality by reducing congestion. This goal may call for increasing highway capacity and building new roads. However, increasing road capacity would negatively impact the physical environment. On the other hand, the goal of reducing VMTs may be beneficial to the physical environment. But by this measure a congested road would be beneficial as it reduces VMT![69]

One policy being implemented in Florida and elsewhere is the construction of multimodal facilities, which will encourage the use of alternative modes of travel. Measuring the effects of such policies on air quality is feasible with the right data. This data would include emission rates from different modes of transportation and the local vehicle fleet composition. Results would then be compared to emissions from the expected change in the vehicle fleet composition. Also, accuracy of the predicted emissions would be improved by measuring VHT rather than VMT.

One possible solution to measuring the long-term environmental effects of transportation decisions is to focus on reducing energy use.[70] For example, while a car sitting in traffic with the air conditioning on generates few VMTs, a great deal of energy is actually being expended. If that same car drives down an unobstructed road a longer distance, air quality may improve but more energy is expended by the vehicle. In both these examples, the goal of reducing energy consumption would lead to better policy.

This report only scratches the surface of the largely unexplored field of long-range environmental transportation planning. More research and data are needed to find measures that will lead to better transportation decisions. With the right information, environmental concerns can be integrated into the long-term transportation planning process, leading to a more sustainable transportation system.

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