

Transportation Based Solutions to New Jersey's Energy Crisis

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Transportation Based Solutions to New Jersey's Energy Crisis

The United States is in an energy crisis. While the dimensions of this crisis are multifaceted, the cause is quite simple: the country's excessive reliance upon fossil fuels. Absent federal leadership on the crisis, states and cities across the country have begun to take steps to curb their reliance on fossil fuels, and to mitigate the negative impacts of their consumption. However, most efforts are still focused on stationary energy users, and neglect the role that transportation plays in the crisis. This paper will examine New Jersey's responsibilities in the transportation sector, and will attempt to calculate the energy savings new policies could create.

These recommendations could be incorporated into the New Jersey Energy Master Plan (EMP), the second edition of which is currently being drafted by the NJ Board of Public Utilities (BPU). This plan, though laudable, is heavily focused on the electricity market. As the EMP is meant to create energy related goals for every relevant state agency, it should expand its transportation section, and work in close cooperation with the New Jersey Transit and its parent organization, the New Jersey Department of Transportation (NJDOT). This is particularly important as a review of the NJDOT's long range planning document, *Transportation Choices 2025* reveals that the agency does not presently list the reduction of energy use as a policy goal (NJDOT & NJ Transit, 2001).

Definition of the Crisis

There are three major dimensions to the energy crisis: the environmental effects of dependence on fossil fuels, the threat to national security that such dependence causes, and perhaps most importantly, the precarious nature of dependency upon finite energy sources.

The primary environmental concern associated with the burning of fossil fuels is global warming. Most scientists now agree that human beings are responsible for recent climate change. Energy's role in this crisis cannot be overstated: ninety percent of man-made carbon dioxide emissions come from the burning of fossil fuels, primarily for energy use (Roberts, 2004, p. 118). These issues are particularly important for New Jersey since as a coastal state it will be greatly affected by sea level rise.

Second, America's reliance on the Middle East as a fuel source has put the nation in a strategically weak position, and forced it into alliances which do not benefit its long term national interests. At present 86 percent of the nation's energy comes from fossil fuels, much of which is found in the Middle East (DOE, 2006). As a result, the country is overly-invested in the outcomes of political struggles in that region.

Lastly, even the most optimistic energy analysts admit that fossil fuels, whether oil, coal, or natural gas, are by their very nature finite. As transportation is so heavily dependent upon petroleum, this fuel source warrants additional attention. Experts differ on whether the oil production peak has yet occurred, but all agree that a peak is eventual. Both the state and the nation must prepare for the end of oil.

Transportation's Role

The energy crisis thus defined, transportation's importance becomes clear. Transportation uses 27 percent of the nation's energy, 66 percent of its oil and is responsible for 32 percent of its carbon emissions (DOE, 2002, Tables 1-13, 2-1, 11-04). In New Jersey these figures are even higher. In 2001, transportation accounted for over 33 percent of total energy use in the state (BTS, 2001, Table 7-2). Moreover, according to the state's 1990 Greenhouse Gas Inventory, the last year for which such statistics are

available, transportation is responsible for 38 percent of the state's greenhouse gas emissions (NJDEP, 2002, p. 3).

In addition, whereas the power generation industry uses a variety of fuel sources, transportation is dependent upon petroleum for 96 percent of its total energy needs (DOE, 2004, Table 2-2). As such, the sector is especially reliant upon the Middle East, which is home of most of the world's proven oil reserves. The lack of diversity in fuel sources has left transportation especially vulnerable to disruptions in the petroleum market, and to the eventual end of oil.

There are three main objectives the state energy plan should pursue in the transportation sector. First, the state should reduce the total number of vehicle miles traveled on an annual basis. Second, for those vehicle trips which remain necessary, the state must set policies to reduce congestion on the roads and to encourage drivers to use the most fuel efficient vehicles available. Lastly, New Jersey should promote, or even mandate, the use of alternative fuels.

Methodology

This report will outline policies the state could enact to reduce passenger and freight transportation energy use. A comparison of the likely effects of each policy is shown in the policy matrix found at the back of this document. The state's primary mechanism for tracking success will be in energy consumption, or "energy intensity", measured in British Thermal Units (BTUs). A BTU is a unit of energy equivalent to the amount of heat necessary to raise one pound of water by one degree Fahrenheit. If the state wishes to reduce its energy consumption, it should pursue a decline in total BTU use in the transportation sector. For example, the Department of Energy estimates that the private, single occupancy vehicle uses 5,623 BTU per passenger mile, while train travel

requires only 2,714 (DOE, 2004, Table 2-11). Therefore the state should promote a modal shift to rail travel.

This report will not calculate the greenhouse gas emissions or overall air quality associated with each proposed policy. The scope of this document is limited to fossil fuel energy intensity. This indicator is closely correlated with emissions and air quality, and so it can be assumed that a reduction in fossil fuel energy intensity will lead to benefits in these areas as well.

Since 99 percent of New Jersey's transportation energy comes from fossil fuels, energy consumption and fossil fuel energy consumption are essentially equivalent in the transportation sector (DOT, 2005a, Table 7-1). The one area in which this statement is not true is in regard to alternative fuels. To assess alternative fuel policies this document will measure life cycle energy intensity. To clarify this point: while diesel burns at the rate of 129,500 BTU/gallon and pure biodiesel at 118,296 BTU/gallon, biodiesel is less energy intensive when life cycle costs are taken into account (DOE & USDA, 1998, cited in MDA, 2006). This issue will be explored further in the alternative fuels section.

Assumptions

The report's passenger-based policies will focus solely upon work trips, as previous studies have revealed that modal choice is most elastic for this type of travel. Necessary information can be gleaned from several existing data sets. The US Department of Energy records the energy intensities for most vehicle modes and fuel types, while the United States Department of Agriculture and the National Biodiesel Board have assembled figures on alternative fuel energy intensities. The US Department of Transportation's Bureau of Transportation Statistics tracks the state's vehicle registrations and the amount of fuel sold within the state on an annual basis. The

decennial Census Transportation Planning Package 2000 (CTPP) reports on modal choice for New Jersey commuters.

Table 1 shows the results of a CTPP analysis of New Jersey commute patterns. As the table demonstrates, single occupancy vehicles (SOVs) represent the dominant mode of transportation within the state. However, 9.4 percent of commuters travel to work by some type of transit, while nearly 11 percent commute by carpool.

Table 1: Modal choice, work trip, New Jersey, 2000.

	Trips	
	Number	Percent
Single Occupancy Vehicle	2,828,312	73.0%
2 Person Carpool	311,091	8.0%
3 Person Carpool	55,191	1.4%
4 or More Person Carpool	45,931	1.2%
Bus	213,039	5.5%
Rail	98,797	2.5%
Transit Rail	51,742	1.3%
Other	272,161	7.0%
Total	3,876,264	100.0%

Source: Census Transportation Planning Package (2000).
 * Transit Rail includes both light and heavy rail.

The US Department of Energy's Transportation Energy Data Book (2004) has been used to assess the fuel efficiency of each mode in Table 2 below.

Table 2: Energy intensity per passenger mile (in BTUs).

<u>Auto</u>		<u>Light Truck</u>		Bus	Rail	Transit Rail*
SOV	Carpool	SOV	Carpool			
5,623	2,510	7,081	3,161	4,127	2,714	3,268

Sources: CTPP (2000), DOE (2004)
 * Transit Rail includes light and heavy rail

Automobiles account for 70 percent of the state's private vehicles, while light trucks make up the remainder (US DOT, 2005b, Table 5-1).¹ In order to calculate total energy use figures, however, the average commute distance was needed. According to

James DeRose at the New Jersey Department of Transportation, the average New Jersey round trip commute to work was approximately 30 miles in 2000, the last year for which data is available (J. DeRose, personal communication, December 13, 2005).

Strategies to Reduce Vehicle Miles Traveled

As previously mentioned, there are three objectives the state should pursue in its attempt to reduce energy use in the transportation sector. These include the reduction of vehicle miles traveled (VMT), increased fuel efficiency through the use of fuel efficient vehicles and the reduction of congestion, and the increased use of alternative fuels. Of these three objectives, VMT reduction is by far the most important, and also the most difficult to enact.

Americans are wedded to their cars, and to a lifestyle in which excessive auto use is common. In 2001, New Jersey drivers lost 261 million hours a year to congestion, the equivalent of 45 hours per licensed driver (NJIT, 2001). While New Jersey's per capita annual VMT is lower than the national average, the high level of congestion on state highways meant that state residents spend an inordinate amount of time on the road (US DOT, 2005, Table 5-3). In order to induce New Jersey drivers to cut back on their driving, the state must enact a creative mix of push and pull policies, to reduce the appeal of single occupancy vehicles, and to entice drivers into mass transit and/or more walkable/bikeable communities.

Push Policies

Motor Fuels Tax At present, New Jersey's gasoline tax is the fourth lowest in the nation (Regional Plan Association, 2006, p. 6). While Governor Corzine has recently decided not to raise the fuel tax, it is worth considering the effect such an increase would have upon commuters' habits. Existing information on fuel tax elasticities suggest that a

ten percent fuel tax increase can lead to a 1.5 percent reduction in vehicle miles traveled in the short run, and a 3 percent decline in the long run (Litman, 2005, p. 22). Table 3 calculates what these elasticities would mean in New Jersey. Figures are based upon the assumption that carpoolers' travel demand would be entirely inelastic, and that all behavior change would be found amongst those commuting in single occupancy vehicles. Therefore, a 1.5 percent reduction in VMT would translate to a 1.5 percent reduction in the percentage of single occupancy vehicles, assuming all commute distances are equal.

Table 3. Effect of fuel tax increase on work trips amongst New Jersey residents.

	<u>Existing Trips</u>		<u>Change in Short Run</u>		<u>Change in Long Run</u>	
	Percent	Number	Percent	Number	Percent	Number
SOV	73.0%	2,828,312	-1.5%	-42,425	-3.0%	-84,849
Automobile	51.1%	1,979,818	-1.5%	-29,697	-3.0%	-59,395
Light Truck	21.9%	848,494	-1.5%	-12,727	-3.0%	-25,455
Carpool	10.6%	412,213	5.5%	22,542	10.9%	45,084
Automobile	7.4%	288,549	5.5%	15,780	10.9%	31,559
Light Truck	3.2%	123,664	5.5%	6,763	10.9%	13,525
Bus	5.5%	213,039	5.5%	11,650	10.9%	23,300
Rail	2.5%	98,797	5.5%	5,403	10.9%	10,806
Transit Rail	1.3%	51,742	5.5%	2,830	10.9%	5,659
Other	7.0%	272,161	-	-	-	-
Total Reduction in SOV Trips	---	---	-1.5%	-42,425	-3.0%	-84,849
Total	100.0%	3,876,264	100.0%	3,876,264	100.0%	3,876,264

Sources: U.S. Census (2000); Litman (2005)

* Transit Rail includes light and heavy rail.

In determining which modes would be adopted by commuters who formerly traveled by single occupancy vehicles (SOVs), it was assumed that carpooling, bus, rail, and transit rail would maintain their existing shares of the non-SOV market. For example, rail accounts for nearly 14 percent of total non-SOV trips at present. As SOV trips are

distributed to other modes, rail's percentage would be maintained. Further study of this issue is warranted, as real elasticities would surely be more nuanced.

Table 3 only records shifts in total trips by travel mode, not actual energy savings. However, the policy matrix at the end of the document shows that a ten percent increase in the gasoline tax could lead to a .6 percent decrease in transportation energy use in the short run, and a 1.3 percent decline in the long run. Moreover, this report only attempts to calculate the effects of a ten percent tax increase, as this is the only figure for which data was readily available. As the New Jersey gas tax is presently 14.5 cents per gallon, a ten percent increase would mean about a penny of additional tax. However, recent attempts to raise the gas tax have all focused on larger increases which would likely have a greater impact on overall state VMT.

Additional Benefits of the State Motor Fuels Tax A motor fuels tax increase could raise badly needed revenues for the state's Transportation Trust Fund, which finances New Jersey Transit's capital projects. An increase in the state's contribution to transit could lead to direct improvements in transit service. However, New Jersey voters have shown that they are strongly opposed to increasing the gas tax, and so politically it would be very difficult to enact such a measure.

Parking A state with as excellent a public transportation system as New Jersey's should do everything it can to encourage transit use amongst its citizenry. However, New Jersey policies appear to often work at cross-purposes with one another. On the one hand, the state subsidizes mass transit and bemoans the congestion on its roadways. On the other, it encourages, subsidizes, and at times directly *requires* the provision of free parking to its workers and shoppers. The 2006 Energy Master Plan allows New Jersey the

opportunity to synchronize its goals. An alignment of state parking, energy, and land use policies is an excellent place to start. Recent research has shown that the provision of free parking is in fact a greater incentive to drive than the provision of free gasoline (Shoup, 2004). Free parking is especially common at the worksite, where the majority of employers provide free parking to their employees (Shoup, 2004). Some states have begun considering ways to address this issue. New Jersey's own State Development and Redevelopment Plan lists the "cashing out" of free employee parking as a transportation demand management strategy worthy of further consideration (New Jersey State Planning Commission, 2001).

California was the pioneer in parking cash-out policies. In 1992 it enacted legislation requiring employers to offer their employees the option to receive the financial equivalent of their annual parking space, instead of the parking space itself (Hill, 2002, p. 6). Among those worksites where staff were offered the option to cash out their parking spaces, commuter parking demand declined 13 percent, from 3.2 spaces per 1,000 square feet of building area, to 2.8 spaces (Shoup, 2004, p. 263). Assuming that similar reductions in parking demand could be realized at participating New Jersey worksites, the state would do well to investigate enacting parking cash-out legislation of its own, given that 73 percent of its commuters drive to work alone (U.S. Census, 2000).

In order to assess the total energy savings such a program could realize, it would be necessary to first determine the number of worksites in the state that provide free parking. Furthermore, court tests have shown that parking cash out programs can only be implemented in a limited number of situations. In California, for example, the program only applied to employers who leased, rather than owned the free parking they provided

to their employees, thus limiting the program to only 16 percent of total worksites (Hill, 2002, p. 7).

A similar situation would likely be found in New Jersey. Local zoning laws, which often require parking ratios designed for maximum demand situations, are largely responsible for this situation. While local planning boards are wise to consider travel demand, it is misguided to ignore the large role that parking supply plays in the decision to drive. Although the elimination of free parking might incense commuters, the choice of free parking or cash would likely be more palatable. A parking cash out program could be one of the least politically contentious of the policies listed in this document.

Zoning Requirements Despite the obstacles formed by New Jersey's home-rule system, the state can offer guidelines for planning, as it did with the creation of the 1992 State Development and Redevelopment Plan. The state should build upon its pioneering work in this area and offer new guidance principles on the amount of parking a municipality should require of its developers. Many employees commuting to jobs within the state could easily make their morning and evening trips by mass transit or carpool, but have little incentive to do so given the free parking spot that awaits the end of their journey. While the state has little control over local zoning requirements, it could educate town planners and zoning boards on the importance of parking.

Pull Policies

Improved Transit Service In addition to raising vehicle operation costs via fuel taxes and reduced parking options, the state could also invest in mass transit in an effort to reduce VMT. Such an investment would be considered a "pull" policy, serving to entice residents into new travel behaviors rather than penalizing them for existing habits. Todd Litman of the Victoria Transportation Policy Institute averaged the results of

several transit demand elasticity studies and determined that a one percent improvement in transit service can lead to a short term ridership increase of between .5 and .7 percent, and long term ridership growth of .7 to 1.1 percent (Litman, 2005, p. 42).

Table 4 below demonstrates the short and long term effects of a one percent service improvement in New Jersey. As the state is better served by transit than many areas included in the Litman research, the high end estimate was chosen for both the short and long term calculations. It was assumed that transit growth would be distributed evenly across the three transit modes (bus, rail, and transit rail), while VMT reductions would be evenly distributed amongst single occupancy vehicles and carpools.

Table 4. Effect of a one percent service improvement on transit ridership amongst New Jersey residents.

	<u>Existing</u>		<u>Change in Short Term</u>		<u>Change in Long Term</u>	
	<u>Percent</u>	<u>Number</u>	<u>Percent</u>	<u>Number</u>	<u>Percent</u>	<u>Number</u>
SOV	73.0%	2,828,312	0.1%	-2,221	-0.1%	-3,491
Automobile	50.0%	1,979,818	0.1%	-1,555	-0.1%	-2,443
Light Truck	21.4%	848,494	0.1%	-666	-0.1%	-1,047
Carpool	10.6%	412,213	0.1%	-324	-0.1%	-509
Automobile	7.5%	288,549	0.1%	-227	-0.1%	-356
Light Truck	3.2%	123,664	0.1%	-97	-0.1%	-153
Bus	6.3%	213,039	0.7%	1,491	1.1%	2,343
Rail	3.0%	98,797	0.7%	692	1.1%	1,087
Transit Rail	1.4%	51,742	0.7%	362	1.1%	569
Other	7.2%	272,161	0.0%	0	0.0%	0
Total Transit Ridership Increase	-	-	0.7%	2,545	1.1%	3,999
Total	100.0%	3,876,264	100.0%	3,876,264	100.0%	3,876,264

Sources: U.S. Census (2000); Litman (2005)

* Includes light and heavy rail.

As the policy matrix at the end of this document shows, a one percent improvement in transit service could lead to a 38 billion BTU reduction in annual state energy use in the short term, and a 60 billion BTU reduction in the long term. Studies

indicating the elasticity of transit demand with respect to larger service improvements were not available, but it can be assumed that greater service improvements would lead to greater energy savings.

Relatively few New Jersey residents or politicians are categorically opposed to transit improvements. However, if service improvements were coupled with tax increases, they would be significantly less palatable. Moreover, service improvements would have to be well planned in order to develop broad community support.

Possible Revenue Sources for New Jersey Transit Improvements to service operation are currently difficult given the state of New Jersey's transportation finances. Both New Jersey Transit and the State Department of Transportation receive their capital budgets from the state's Transportation Trust Fund (TTF), which is on track to financial disaster. The fund will be forced to spend its entire budget on repaying the interest on old bonds beginning in July 2006 (Regional Plan Association, 2006, p.3). Governor Corzine's debt-based solution, proposed in late February 2006, will avert this crisis if approved by the State Legislature. However, many critics argue that the Corzine plan will only refinance existing debt, and return the state to an equally precarious position in just five years time (Hester, 2006).

The Transportation Trust Fund is funded by a variety of sources. First among them is the state's motor fuels tax, which, as already discussed, is among the lowest in the nation. An increase in the state motor fuels tax, coupled with a change to the amount of the tax dedicated to the TTF, would improve the quality of the state's transportation finances.

Aside from gas tax revenues, the Transportation Trust Fund is also funded by New Jersey Turnpike Authority toll revenue. However, the NJ Turnpike Authority gives its contribution to the TTF by way of the state General Fund. Unfortunately, since FY2002 the Treasurer's Office has chosen to keep the Turnpike Authority's contribution, shortchanging the TTF \$24.5 million a year (Regional Plan Association, 2005, p. 9). To secure this income for transit, the state constitution could be rewritten so as to dedicate Authority's contribution directly to the TTF.

Strategies to Improve Vehicle Efficiency

While the previous strategies focused on the trip to work, assuming that residents would be less likely to switch modes for personal trips, improvements to vehicle efficiency would affect every trip type. There are two major varieties of initiative that New Jersey could undertake in this area. First, the state could incentivize the use of fuel-efficient vehicles. Second, it could undertake policies designed to minimize the amount of time New Jersey drivers spend sitting in congestion. Both policies offer the opportunity to make significant changes to the state's energy use without changing the existing infrastructure.

Scaled Registration Fees

New Jersey should encourage the purchase of more fuel efficient vehicles via scaled registration fees. Such a program is clearly needed. New Jersey now ranks sixth in the nation in its ratio of SUVs to licensed drivers (Gebeloff, 2004, p. A1). Not only do the state's drivers face severe congestion, they also select the least fuel-efficient vehicles in which to spend their time. While drivers should be free to purchase the vehicles they choose, the state can and should internalize a portion of the costs associated with the most fuel-consumptive vehicles. The NJ Motor Vehicle Commission could impose a system in

which vehicle registration fees would vary according to a vehicle's fuel economy or size. At present, the only difference in registration fees is a \$25 differential in the cost of registration for vehicles above and below 3,500 pounds (Regional Plan Association, 2005, p. 7). Given that vehicle size is often so closely correlated with fuel efficiency, the state could choose to enact a registration fee that incentivizes fuel efficient vehicles.

The revenue from the raised fees on fuel inefficient could be used in a variety of ways to improve the enforcement abilities of the vehicle inspection program. If revenues could be transferred out of the MVC, monies could be used to help finance public transportation projects. A recent Regional Plan Association report suggested creating a third tier of vehicle registration rates, which would charge those vehicles weighing over 6,000 pounds \$200. If implemented, this plan could raise \$46 million a year (Regional Plan Association, 2005, p. 7). Additional tiers could raise even more money.

No research is available which examines the relationship between the elasticity of vehicle demand and registration fees. It can be assumed that higher registration fees will not make a considerable difference in drivers' purchasing decisions, especially when car buyers are considering purchases of \$30,000 or more. However, these fees could be used to raise funds for other initiatives.

Congestion Pricing

New Jersey is in an enviable position with regard to congestion pricing given its existing system of toll roads. It would not be administratively difficult to implement a system of raised tolls during the morning and evening rush hours to reduce peak hour congestion. It would, of course, be a political challenge, as would many of the policies listed in this document. In fact, the state already has a mild form of congestion pricing in place, although the difference between peak and off peak rates is minimal.

Elimination of the E-Z Pass Rush Hour Discount E-Z Pass users, who account for roughly 65 percent of toll road drivers in the state, already enjoy a discount for using E-Z passes instead of cash (Malinconico, 2004, p.16). The state considered eliminating the E-Z pass discount during the morning and evening rush hours in 2004, but opted against doing so (Malinconico, 2004, p.16). While the elimination of the rush hour E-Z pass discount may not reduce vehicle miles traveled, it could reduce congestion slightly, as drivers shift their travel to other times of day. This is a worthy policy goal, as fuel efficiencies in congestion are worse than in free flow traffic.

Raised Tolls During the Peak Hour If New Jersey government wishes to go a step further, it could significantly raise tolls and then send the revenue to mass transit. Such a policy would go beyond affecting drivers' choice of travel time, and would likely affect total vehicle miles traveled. London's Mayor Ken Livingstone gained great fame for implementing congestion pricing in London in 2003, with a guarantee to send the majority of raised revenues toward mass transit. The program has been successful, and the monies raised for mass transit have been substantial enough to support the ridership boom that accompanied the policy change (Transport for London, April 2005). Unfortunately, no readily translatable figures were available on the elasticity of travel demand with regard to road prices.

As has been demonstrated, New Jersey has two options with regard to congestion pricing. First, the elimination of the E-Z pass rush hour discount could be used to reduce congestion. Second, a more severe London-style congestion pricing plan could be used to reduce VMT altogether. Both of these topics warrant further study, and presumed elasticities must be estimated.

Strategies to Promote Alternative Fuels

For those trips that cannot be avoided, alternative fuels offer a way to reduce fossil energy consumption. While alternative fuel technologies like compressed natural gas or hydrogen fuel cells offer great promise for the future, these technologies are not yet ready for widespread use in the state of New Jersey. Therefore, it is recommended that New Jersey's alternative fuel policies focus on ethanol and biodiesel.

Ethanol

Ethanol is a gasoline substitute made from agricultural products, usually corn or other grains. While pure ethanol may be best for the environment, it cannot be used in standard gasoline engines, and is generally mixed with standard petroleum-based fuels. For example, a fuel mixture of 90 percent gasoline and 10 percent ethanol would be known as E10. Although all US vehicles are able to run on E10 it is still disputed whether unconverted gasoline engines can safely operate on higher ethanol mixtures (Dartmouth, n.d.a.).

The energy benefits of switching to ethanol are best understood in terms of life cycle costs. Earlier policies focused solely on energy consumption in the final use. For example, rail's energy intensity is estimated at 2,714 BTU/passenger mile and is therefore preferred to SOV travel, which averaged 5,623 BTUs/passenger mile (DOE, 2004, Table 2-11). As over 99 percent of all transportation energy in New Jersey is derived from fossil fuels, the differences in life cycle costs of automobile and rail travel are minimal (USDOT, 2005b, Table 7-1).

However, the life cycle costs of alternative fuels are significantly different from those of nonrenewable fuels. The Natural Resources Defense Council, in its analysis of

alternative fuels, focused on the “energy return on nonrenewable energy investment.”

This was defined as:

“the ratio of the total energy contained in a liter of ethanol to the nonrenewable energy consumed during production of the same ethanol, including cultivating crops, transporting them, and converting them into ethanol. In this equation, if the energy in the ethanol is equal to the nonrenewable energy input in the production process, the energy return on investment is one. Values less than one mean that more nonrenewable energy was consumed during the production of ethanol than the amount of energy contained in the ethanol” (NRDC, 2006, pp. 1-2)

Using a similar methodology, the U.S. Department of Agriculture conducted a life cycle inventory of gasoline and ethanol in a 2002 study, “Estimating the Net Energy Balance of Corn Ethanol: An Update” and found that one unit of fossil fuel could create 1.34 units of pure ethanol, but only .81 units of gasoline diesel (USDA, 2002, cited in MDA, 2006).

Using these figures, the table below compares the energy return of standard petro-gasoline, pure ethanol (E100), and the ethanol mixture E10. E100’s life cycle energy intensity (62,985 BTU/gallon), is 59 percent below that of pure gasoline, and E10’s is nine percent more efficient than gasoline.

Table 5. Life cycle energy intensities of gasoline, E10, and E100.

	BTU/gallon	Units of Fossil Fuel Used to Create 1 Unit of Fuel	Life Cycle Energy Intensity (in BTU/gallon)
Gasoline	125,000	1.24	155,280
E10	120,900	1.16	140,827
E100	84,400	0.75	62,985

Source: USDA (1998)

This report, however, will focus only on E10. Although the United States does not have a federal requirement mandating the sale of ethanol, Minnesota already requires that

all gasoline sold in the state contain ten percent ethanol, and Montana and Hawaii have passed similar legislation (McCallum, 2005). New Jersey could consider following suit.

Over 4.4 billion gallons of gasoline were sold in New Jersey in 2004 (US DOT, 2005b, Table 7-4). If the state were to mandate the sale of E10, it could reduce gasoline energy use by over nine percent, as Table 6 shows.

Table 6. Annual energy savings (in billion BTU) in New Jersey if E10 sold statewide.

	2004 Levels	Change in energy use if E10 were sold statewide	
NJ	683,230	-63,591	-9.3%

Source: USDA (2002)

Ethanol is several cents cheaper per gallon than traditional petroleum-based gasoline, and is higher octane. Therefore, politically it might not be difficult for the state to convince drivers to accept E10. However, New Jersey lacks the vast corn fields found in Minnesota, and so ethanol does not have direct economic benefits to the state's economy.

One of the greatest challenges ethanol faces is the question as to its effectiveness. While the Department of Energy, Department of Agriculture, and the Natural Resources Defense Council confirm that ethanol's lower life cycle costs reduce fossil fuel energy use, doubts remain (DOE 2005, NRDC 2006, USDA in MDA 2006). For example, a research team from Cornell and Berkeley has reported that ethanol is more resource consumptive than gasoline, and a debate still rages on this issue (Free Energy News, 2006).

Biodiesel

While previous sections of this document have focused on passenger travel, a biodiesel program would target commercial freight vehicles. In 2004, 899 million gallons

of diesel were sold in New Jersey (DOT, 2005b, Table 7-4). If the vehicles presently filling up on diesel were to convert to biodiesel, the state could realize significant energy savings.

Biodiesel is a substitute for petroleum-based diesel fuel, and can be made out of vegetable oils or animal fats. It offers users the chance to reduce their dependence on fossil fuels and has cleaner emissions and lower carbon dioxide levels (National Biodiesel Board, 2006). Pure biodiesel has a tendency to congeal in cold weather, however, and is generally mixed with petroleum-based diesel. Mixtures containing up to 20 percent biodiesel (known as B20) function well in most climates, and in fact, most vehicles that run on petro-diesel can run on B20 without being retrofitted (National Biodiesel Board, 2006).

As with ethanol, understanding the life cycle costs of biodiesel is essential. The U.S. Department of Energy and U.S. Department of Agriculture conducted a “cradle to grave” study of the fuel in their 1998 study, “Life Cycle Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus” and found that one unit of fossil fuel could create 3.2 units of pure biodiesel, but only .83 units of petroleum diesel (DOE & USDA, 1998, cited in MDA, 2006).

Using these figures, the table below compares the total fossil fuel energy efficiency of standard petro-diesel, pure biodiesel (B100), and the biodiesel mixtures B2 and B20. As the table shows, B100’s fossil fuel energy intensity is 76 percent below that of petroleum diesel, while even a two percent biodiesel mix (B2) is nearly six percent below petroleum diesel.

Table 7. Life cycle energy intensities of diesel, B2, B20 and B100.

	BTU/gallon	Units of Fossil Fuel Used to Create 1 Unit of Fuel	Life Cycle Energy Intensity (in BTU/gallon)
Diesel	129,500	1.20	155,332
B2	129,276	1.13	146,684
B20	127,259	0.76	97,147
B100	118,296	0.31	36,795

Source: USDA (1998)

Although the savings that could be realized by using B20 or B100 are impressive, it is recommended that the state focus first on B2. At present there are few retail stations selling biodiesel in New Jersey. However, biodiesel is growing across the country, and a half dozen states are considering mandating its use (Steil & Pugmire, 2005). In fact, in 2003 Minnesota became the first state to require biodiesel's use when it passed legislation mandating that all diesel sold in the state contain 2 percent biodiesel, and the law took effect in September of 2005 (Steil & Pugmire, 2005).

Minnesota's legislation could again be a useful model for New Jersey leaders interested in advancing the state's energy future. While New Jersey lacks Minnesota's vast soybean fields, there is considerable spare capacity in the biodiesel market which would allow New Jersey to import biodiesel. Alternately, the state could import the raw materials and make the fuel itself. In fact, the state already possesses a nascent biodiesel industry. The Environmental Alternatives plant in Newark generates biodiesel using material purchased from Maryland, and other entrepreneurs are considering building more plants (M. Barruso, Environmental Alternatives, personal communication, March 9, 2006; E. Bourbon, Clean Cites Program, personal communication, December 14, 2005).

Table 8 attempts to calculate the potential energy savings of a statewide conversion to B2, which would lead to a decline in energy use in the freight sector by 7,775 billion BTU, or 5.6 percent.

Table 8. Annual energy savings (in billion BTU) in New Jersey if B2 biodiesel sold statewide.

	2004 Levels	Change in energy use if B2 were sold statewide	
		Annual BTU	BTUs
NJ	139,643	7,775	-5.6%

Source: DOE and USDA (1998)

However, at present, the cost of pure biodiesel is \$.30 to .35/gallon over the cost of petro-diesel (E. Bourbon, personal communication, December 14, 2005). Therefore, the state would likely need to subsidize the biodiesel. The NJ Board of Public Utilities already administers a biodiesel rebate program that offers qualifying government entities \$.35/gallon to make up for the incremental costs of purchasing biodiesel over diesel fuels (BPU, 2003; E. Bourbon, personal communication, December 14, 2005). This initiative is a part of the Department of Energy’s Clean Cities Program, and is severely under-funded. According to Clean Cities Program Coordinator Ellen Bourbon, the BPU has already committed its initial \$600,000 budget, and its future budget is uncertain (E. Bourbon, personal communication, December 14, 2005).

A public biodiesel program would therefore require a significant new source of revenue. Several of the initiatives mentioned earlier in this document, such as an increase to the motor fuels tax, raised vehicle registration fees, or the use of congestion pricing could be used to support such a measure. Politically, biodiesel would likely have broad public support, as the general public would endorse the idea of a renewable fuel source. However, the public would likely be opposed to the means by which the state would raise

funds to subsidize the fuel. As with ethanol, New Jersey does not grow the right crops for biodiesel manufacture. Therefore, the program would likely not be as popular as it might be in Midwestern states like Minnesota. In addition, although the US Departments of Energy and Agriculture have issued studies showing its lower life cycle costs, biodiesel, like ethanol, still has its doubters. However, the trucking industry would likely present the greatest opposition to mandated biodiesel. Although the American Trucking Association, the advocacy organization for the trucking industry, recently endorsed the use of B5, it is vehemently opposed to biodiesel mandates (American Trucking Association, 2006).

Conclusion

Table 9 demonstrates the potential reductions in energy use that would result from each of the policies listed earlier. As the table indicates, the use of alternative fuels, particularly ethanol, would have the greatest effect upon total energy use in the state. However, a note of caution is warranted. The effects of motor fuels tax increases and transit service improvements were only measured in regard to their effect upon *work* trips. The use of alternative fuels, however, was assumed to affect every trip type in the state, thereby inflating the effect of alternative fuels in comparison to other policies.

Table 9. Policy matrix showing effect of policies in New Jersey.

	Total Reduction in Energy Intensity (in billions BTU)	Revenue Generating Proposal	Available Research to Support Proposal	Political Feasibility
10% Increase in Gasoline Tax -Short Term	-931	x	x	Low
10% Increase in Gasoline Tax -Long Term	-1,862	x	x	Low
Parking Cash Out Policy	n/a			Medium
Transit Service Improvements -Short Term	-38		x	High
Transit Service Improvements -Long Term	-60		x	High
Vehicle Registration Fees	n/a	x		Medium
Congestion Pricing -Reduction of EZ Pass Discount	n/a	x		Medium
Congestion Pricing -Raised Tolls During Rush Hour	n/a	x		Low
E10	-63,591		x	High
B2	-7,775		x	Medium

Sources: Census (2000), DOE (2004), DOE & USDA (2002), DOT (2005), National Biodiesel Board (2005), USDA (1998).

n/a = no data available

Note: Fuel tax increase figures are low because calculations assumed non-work trips were inelastic with regard to fuel price.

A comparison of the two alternative fuels shows that the mandated use of E10 would have a far greater effect on state energy use than the use of B2. The reasons for this are twofold. First, as earlier tables demonstrated, the E10 offers greater fuel savings on a per-gallon basis than B2. For example, E10 is 9.3 percent more energy efficient, per

gallon, than petroleum-based gasoline, while B2 is only 5.6 percent more energy efficient than petro-diesel. The second reason for E10's larger effect on state energy use is simply a matter of scale. While 4.4 billion gallons of gasoline were sold in the state in 2004, only 899 million gallons of diesel were purchased.

Turning toward non-alternative fuel policies, an evaluation of the fuel tax increase and transit service improvement policies reveals that a fuel tax increase would have nearly thirty times the effect of a transit service improvement. For example, in the long term a 10 percent fuel tax increase would reduce state VMT by 1.27 percent, while a one percent service improvement would only reduce VMT by .05 percent. This conforms to established research showing that commuters are more responsive to push policies.

It should be emphasized that the research presented in this document is only preliminary. For example, the only fuel tax policy studied was that of a ten percent increase. Additional research would be necessary to establish the effect of larger tax increases. Similarly, the transit service improvement section only examined a one percent service improvement, while the alternative fuel sections only studied E10 and B2, although E85 or B20 could also have been examined.

Figures could not even be established for several policies due to a shortage of data. For example, the lack of baseline data on the number of New Jersey employees who receive free parking at work prevented the calculation of elasticity of demand with respect to a parking cash out policy. Meanwhile, previous reports indicating the elasticity of vehicle demand with respect to registration fees could not be located to run calculations on this policy. Similarly, effect of congestion pricing could not be estimated for the New Jersey environment for lack of appropriate studies.

Finally, the state should be mindful that although alternative fuels are appealing as a big-result, low-political cost option, they should not be prioritized over policies that would reduce total vehicle miles traveled. Crop space is limited, the intensive cultivation of plant matter is resource exhaustive, and the use of the private vehicle facilitates sprawling land use patterns which in turn increase overall energy consumption. In the long run, the best solution for energy reduction in the transportation sector is a reduction in total vehicle miles traveled, no matter how politically contentious policies tied to this goal may be.

Notes

¹ Although motorcycles account for 2 percent of registered vehicles statewide, these vehicles were not included in energy spreadsheets, as the CTPP does not provide information on their popularity as a mode of transportation, grouping them as it does with taxis and “other”. Therefore, automobiles were rounded up from 69 percent of total vehicles to 70, while light trucks were rounded from 29 to 30 percent.

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Appendix 1: Existing energy use (in BTU).

	<u>Trips</u>		<u>Multipliers</u>			BTU/year (total)
	Percent	Number	Average Commute (miles)	Work Year (days)	BTU/passenger mile	
SOV	73.0%	2,828,312				
Automobile Light	51.1%	1,979,818	30	250	5,623	83,493,891,474,000
Truck	21.9%	848,494	30	250	7,081	45,061,373,862,000
Carpool	10.6%	412,213				
Automobile Light	7.4%	288,549	30	250	2,510	5,432,516,482,031
Truck	3.2%	123,664	30	250	3,161	2,931,910,968,415
Bus	5.5%	213,039	30	250	4,127	6,594,089,647,500
Rail	2.5%	98,797	30	250	2,714	2,011,012,935,000
Transit Rail	1.3%	51,742	30	250	3,268	1,268,196,420,000
Other	7.0%	272,161	-	-	-	-
Total	100.0%	3,876,264	-	-	-	146,792,991,788,946

Source: Census Transportation Planning Package (2000), DOE (2004), NJDOT (2005)

Appendix 2: Short term effect of a ten percent fuel tax increase (in BTUs).

	<u>Trips</u>		<u>Multipliers</u>				
	<u>Percent</u>	<u>Number</u>	<u>Average Commute (miles)</u>	<u>Work Year (days)</u>	<u>BTU/passenger mile</u>	<u>BTU/year (total)</u>	<u>Change in BTU/year</u>
SOV	71.9%	2,785,887					
Automobile	50.3%	1,950,121	30	250	5,623	82,241,483,101,890	-1,252,408,372,110
Light Truck	21.6%	835,766	30	250	7,081	44,385,453,254,070	-675,920,607,930
Carpool	11.2%	434,755					
Automobile	7.9%	304,329	30	250	2,510	5,729,597,491,407	297,081,009,376
Light Truck	3.4%	130,427	30	250	3,161	3,092,244,595,157	160,333,626,742
Bus	5.8%	224,689	30	250	4127	6,954,692,107,681	360,602,460,181
Rail	2.7%	104,200	30	250	2714	2,120,986,600,901	109,973,665,901
Transit Rail	1.4%	54,572	30	250	3268	1,337,548,638,955	69,352,218,955
Other	7.0%	272,161	30	250	-	-	-
Total	100.0%	3,876,264	-	-	-	145,862,005,790,062	-930,985,998,884

Source: Census Transportation Planning Package (2000), DOE (2004), NJDOT (2005)

Appendix 3: Long term effect of a ten percent fuel tax increase (in BTUs).

	<u>Trips</u>		<u>Multipliers</u>				Change in BTU/year
	Percent	Number	Average Commute (miles)	Work Year (days)	BTU/ passenger mile	BTU/year (total)	
SOV	70.8%	2,743,463					
Automobile	49.5%	1,920,424	30	250	5,623	80,989,074,729,780	-2,504,816,744,220
Light							
Truck	21.2%	823,039	30	250	7,081	43,709,532,646,140	-1,351,841,215,860
Carpool	11.8%	457,297					
Automobile	8.3%	320,108	30	250	2,510	6,026,678,500,783	594,162,018,752
Light							
Truck	3.5%	137,189	30	250	3,161	3,252,578,221,898	320,667,253,483
Bus	6.1%	236,339	30	250	4,127	7,315,294,567,863	721,204,920,363
Rail	2.8%	109,603	30	250	2,714	2,230,960,266,803	219,947,331,803
Transit Rail	1.5%	57,401	30	250	3,268	1,406,900,857,911	138,704,437,911
Other	7.0%	272,161	30	250	-	-	-
Total	100.0%	3,876,264	-	-	-	144,931,019,791,178	-1,861,971,997,769

Source: Census Transportation Planning Package (2000), DOE (2004), NJDOT (2005)

Appendix 4: Short term effect of one percent transit service improvement (in BTUs).

	<u>Trips</u>		<u>Multipliers</u>			BTU/year (total)	Change in BTU/year
	<u>Percent</u>	<u>Number</u>	<u>Average Commute (miles)</u>	<u>Work Year (days)</u>	<u>BTU/passenger mile</u>		
	SOV	72.9%	2,826,091				
Automobile	50.0%	1,978,263	30	250	5,623	83,428,316,977,732	-65,574,496,268
Light Truck	21.4%	847,827	30	250	7,081	45,025,983,525,773	-35,390,336,227
Carpool	10.6%	411,889					
Automobile	7.5%	288,322	30	250	2,510	5,428,249,888,087	-4,266,593,945
Light Truck	3.2%	123,567	30	250	3,161	2,929,608,301,939	-2,302,666,476
Bus	6.3%	214,530	30	250	4,127	6,640,248,275,033	46,158,627,532
Rail	3.0%	99,489	30	250	2,714	2,025,090,025,545	14,077,090,545
Transit Rail	1.4%	52,104	30	250	3,268	1,277,073,794,940	8,877,374,940
Other	7.2%	272,161	30	250			
Total	100.0%	3,876,264				146,754,570,789,048	-38,420,999,899

Source: Census Transportation Planning Package (2000), DOE (2004), NJDOT (2005)

Appendix 5: Long term effect of one percent transit service improvement (in BTUs).

	<u>Trips</u>		<u>Multipliers</u>				BTU/year (total)	Change in BTU/year
	Percent	Number	Average Commute (miles)	Work Year (days)	BTU/passenger mile			
SOV	72.9%	2,824,821						
Automobile	50.0%	1,977,375	30	250	5,623	83,390,845,837,007	-103,045,636,993	
Light Truck	21.4%	847,446	30	250	7,081	45,005,760,476,500	-55,613,385,500	
Carpool	10.6%	411,704						
Automobile	7.5%	288,193	30	250	2,510	5,425,811,834,404	-6,704,647,627	
Light Truck	3.2%	123,511	30	250	3,161	2,928,292,492,524	-3,618,475,891	
Total Transit	9.5%	367,577						
Bus	6.3%	215,382	30	250	4,127	6,666,624,633,623	72,534,986,123	
Rail	3.0%	99,884	30	250	2,714	2,033,134,077,285	22,121,142,285	
Transit Rail	1.4%	52,311	30	250	3,268	1,282,146,580,620	13,950,160,620	
Other	7.2%	272,161	30	250	-	-	-	
Total	100.0%	3,876,264	-	-	-	146,732,615,931,963	-60,375,856,984	

Source: Census Transportation Planning Package (2000), DOE (2004), NJDOT (2005)

Appendix 6. Statewide energy use using petro-gasoline or E10 ethanol (in BTUs).

	Gallons of gasoline purchased in NJ	BTU/gallon (factoring in life cycle costs)	Energy Use (in BTUs)	Change in BTUs	
				Number	Percent
Gasoline	4,400,000,000	155,280	683,229,813,664,596	-	-
E10	4,400,000,000	140,827	619,638,905,066,977	-63,590,908,597,619	-9.3%

Source: DOE and USDA (1998)

Appendix 7. Statewide energy use using petro-diesel and B2 biodiesel.

	Gallons of diesel purchased in NJ	BTU/gallon (factoring in life cycle costs)	Energy Use (in BTUs)	Change in BTUs	
				Number	Percent
Diesel	899,000,000	155,332	139,643,157,010,915	-	-
B2	899,000,000	146,684	131,868,484,533,532	-7,774,672,477,383	-5.6%

Source: DOE and USDA (1998)