

Appendix H

Transportation and Land Use Policy Recommendations

Summary List of MCAC Recommendations

Policy No.	Policy Option	GHG Reductions (MMtCO ₂ e)			Net Present Value 2009–2025 (Million \$)	Cost-Effectiveness (\$/tCO ₂ e)	Level of Support
		2015	2025	Total 2009–2025			
TLU-1	Promote Low-Carbon Fuel Use in Transportation	2.6	5.9	53	\$820	\$16	Unanimous
TLU-2	Eco-Driver Program	1.1	2.2	22	–\$3,921	–\$176	Unanimous
TLU-3	Truck Idling Policies	0.36	0.76	7.0	–\$596	–\$85	Unanimous
TLU-4	Advanced Vehicle Technology	0.01	0.03	0.19	\$281	\$1,458	Unanimous
TLU-5	Congestion Mitigation	0.08	0.18	1.7	–\$135	–\$81	Unanimous
TLU-6	Land Use Planning and Incentives	0.14	0.43	3.2	–\$598	–\$189	Unanimous
TLU-7	Transit and Travel Options	0.13	0.54	3.5	\$655	\$185	Unanimous
TLU-8	Increase Rail Capacity, and Address Rail Freight System Bottlenecks	0.10	0.19	2.0	\$69	\$35	Unanimous
TLU-9	Great Lakes Shipping	0.24	0.27	2.5	NQ	NQ	Unanimous
	Sector Totals	4.76	10.5	95.1	–\$3,425	–\$36	N/A
	Sector Total After Adjusting for Overlaps	4.76	10.5	95.1	–\$3,425	–\$36	N/A
	Reductions From Recent Actions	0	0	0	\$0	\$0	N/A
	Sector Total Plus Recent Actions	4.76	10.5	95.1	–\$3,425	–\$36	N/A

GHG = greenhouse gas; MMtCO₂e = million metric tons of carbon dioxide equivalent; \$/tCO₂e = dollars per metric ton of carbon dioxide equivalent.

Note: Negative numbers indicate cost savings.

TLU-1. Promote Low-Carbon Fuel Use in Transportation

Policy Description

Reduce the greenhouse gas (GHG) emissions from the use of transportation fuels through a package of incentives, education, and standards, including recommendations by the Michigan Renewable Fuels Commission (RFC). Renewable fuels and electric propulsion provide significant opportunities to reduce GHG emissions from the transportation sector if promoted in a way that emphasizes the reduction of GHG emissions on a life cycle basis.

Policy Design

Goals: Reduce GHG emissions from the transportation sector by reducing the average carbon “intensity” of on-road transportation fuels sold within the state, measured on a life cycle basis. Achieve 5% reduction of GHG emissions on a life cycle carbon dioxide (CO₂) basis by 2015 and 10% reduction by 2025 compared with business as usual (BAU) forecasts.

Timing: See Goals, Above

Parties Involved: Michigan legislature, Michigan Department of Environmental Quality (MDEQ), Michigan Department of Agriculture (MDA), Michigan Department of Natural Resources (MDNR), fuel providers, agricultural producers, utilities, and auto companies.

Other: None identified.

Implementation Mechanisms

In its June 2007 report, the Michigan RFC recommended a variety of actions to stimulate the production and use of renewable, low-carbon fuels within the state. These include:

Low Carbon Fuels Policy:

While a federal low-carbon fuel policy could make further action in Michigan unnecessary, there is no clear time frame for such action or any guarantee that Congress will act. Michigan should encourage federal policy in this area, and should also consider taking the lead and establishing its own state policy.

If implemented at the state level, the governor should initiate the development of a strategy to enact a low-carbon emission transportation fuels program in Michigan. This strategy should be integrated into and be consistent with an overall carbon reduction strategy for the state, as well as development of a regional model standard through the Midwestern Governors Association Climate Initiative. Policymakers should consider the likelihood of near-term federal policy action, as well as the potential competitive advantage to the state in encouraging a low-carbon fuels industry by providing policy leadership, when deciding on the appropriate course of action.

The implementation recommendations of the MCAC are subject to further economic analysis, which would be expected to provide more information about the costs and benefits of alternative ways to pursue this policy.

Establish a Next-Generation Renewable Fuels Feedstock Program:

This would encourage the sustainable production of next-generation bioenergy and biomass materials while reducing risk to landowners. For more information on the production of biofuels, see AFW-2. In addition, the state will achieve 10% use of renewable fuels with lower GHG emissions than petroleum-based fuels by 2012 and 25% by 2025.¹ A goal of achieving a minimum of 10% alternative fuel use in the transportation sector is a critical first step towards significant biofuel consumption. This goal is considered on a volumetric level, and includes starch-based ethanol production already in place as of 2008.

Create a Green Fuels Retailers Program (Tax Incentives for E85 and Biodiesel Sales): The state should establish a Green Fuels Retailers Program that rewards retail and wholesale outlets that attain benchmarks in the sale of biofuels. This would provide state recognition for achievement and provide important cost savings to both the seller and the consumer of biofuels. (To provide alternative fuel choice to consumers, promote state energy security needs and reduce GHG emissions.) Access to alternative fuels should address both gasoline and diesel fuels. A Green Fuels Retailer designation would be provided by the state to any retail outlet that sells a minimum level of gasoline biofuel (E85). Note: The notations E85 and E100 are used to show the percentage of ethanol in a gallon of fuel. E85 contains 85% ethanol and 15% gasoline. B20 contains 20% biodiesel and 80% conventional diesel fuel.

A Green Fuels Retailer will receive incentives to support the infrastructure development needed for E85 and to help ensure that the retailer is able to provide value-based pricing (ethanol's lower energy content requires a lower price per gallon to offset the fuel economy reduction) for sustainable consumer use. The applicable incentive will be a reduction in the payment of motor fuel tax on all gasoline sold at the facility. These incentives are needed in the early stages of E85 growth to accelerate the development of new production, distribution, and retail channels.

The same incentives should apply to diesel transportation fuels. A Green Fuels Retailer designation would apply for similar minimum levels of B20 biofuel sales.

As an alternative to the application of incentives to the Green Fuels Retailer described above, a feebate approach could be considered where increases to the motor fuel tax (fee) are used to create a fund that would provide Green Retailers with an incentive (rebate) amount for each gallon of E85 or B20 sold. Such a public-private partnership is critically needed to accelerate consumer access to alternative fuels and to support consumer value, setting the stage for increased use of renewable fuels in the transportation sector beyond low-level blends.

Related Policies/Programs in Place

Motor Fuels Tax program.

¹ The goals of 10% by 2012 and 25% by 2025 are both included in the Michigan Renewable Fuels Commission final report. The goal of 25% by 2025 is included in the Midwestern Governors Association Energy Platform.

Type(s) of GHG Reductions

Carbon Dioxide (CO₂)

Estimated GHG Reductions and Net Costs or Cost Savings

Quantification Methods:

This analysis looks specifically at how biofuels could reduce the carbon content of fuel and therefore reduce overall transportation emissions. The included quantification does not model the recommendations by the RFC. Electric propulsion was also not considered in this analysis, although it could potentially reduce the carbon content associated with fuels. Expanded use of hybrid electric vehicles is considered in TLU-4.

The gallons of diesel fuel and gasoline forecast to be used in Michigan vehicles comes from the Michigan Inventory and Forecast (I&F). The goal is to reduce the life cycle emissions of these fuels by 5% by 2015 and by 10% by 2025. Please note that the implementation path outlined here only achieves part of these reductions (4.3% reduction in 2015 and 9.9% in 2025). This implementation path is based on the maximum feasible quantity of biofuels that could be produced in the state of Michigan, as found in the Agriculture, Forestry, and Waste Management (AFW) option AFW-2 (see Appendix J).

Table H-1-1 shows the gallons of gasoline and diesel fuel that are forecast to be Michigan's on-road consumption. The life cycle emissions factors used for gasoline (11.26 kilograms of carbon dioxide equivalent per gallon [kg CO₂e/gal]) and for diesel (11.25 kg CO₂e/gal) are from the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model (Argonne National Laboratory [ANL], 2008). The life cycle emissions of these fuels are also shown in Table H-1-1. These Green Fuels Retailer life cycle emissions are higher than the emissions estimates for transportation in the I&F because the emissions figures in the I&F are direct emissions from combustion of fuel, rather than the life cycle emissions (which include refining and transporting the fuel). The difference between direct combustion emissions and life cycle emissions is typically around 20%–25% for petroleum-based fuel.

Table H-1-1. Life cycle emissions of fuel consumption in Michigan

Year	Gasoline Gallons (million)	Diesel Gallons (million)	Total Life Cycle Gasoline Emissions (MMtCO ₂ e)	Total Life Cycle Diesel Emissions (MMtCO ₂ e)
2008	4,554	1,095	51.3	12.3
2009	4,563	1,118	51.4	12.6
2010	4,557	1,138	51.3	12.8
2011	4,514	1,143	50.8	12.9
2012	4,448	1,142	50.1	12.8
2013	4,380	1,140	49.3	12.8
2014	4,322	1,141	48.7	12.8
2015	4,272	1,144	48.1	12.9

Year	Gasoline Gallons (million)	Diesel Gallons (million)	Total Life Cycle Gasoline Emissions (MMtCO ₂ e)	Total Life Cycle Diesel Emissions (MMtCO ₂ e)
2016	4,233	1,146	47.7	12.9
2017	4,194	1,148	47.2	12.9
2018	4,156	1,150	46.8	12.9
2019	4,119	1,152	46.4	13.0
2020	4,088	1,156	46.0	13.0
2021	4,073	1,167	45.9	13.1
2022	4,068	1,180	45.8	13.3
2023	4,071	1,195	45.8	13.4
2024	4,079	1,213	45.9	13.6
2025	4,059	1,222	45.7	13.7

MMtCO₂e = million metric tons of carbon dioxide equivalent.

The level of biofuel consumption used in this analysis is set to match the achievable levels of production found by AFW-2. This will serve to reduce the life cycle emissions of GHGs by 5% by 2015 and by 10% by 2025. The three fuels being considered in this analysis are biodiesel, cellulosic ethanol, and corn ethanol. The implementation path of the goal and the goal for the consumption of each individual fuel is shown in Table H-1-2. The implementation path indicates the percentage reduction in CO₂e emissions compared to conventional fuel consumption. Cellulosic ethanol production does not begin until 2011 and increases steadily from then on. Corn ethanol makes up the remaining portion of the total biofuels.

The figure for gasoline/diesel gallons replaced is determined based on the different heat contents of the biofuels (e.g., the heat content for gasoline is higher than that of ethanol but lower than that of diesel fuel) (Energy Information Administration [EIA], 2007). This means that in order to replace 1 gallon of gasoline, more than 1 gallon of ethanol is needed to provide the same energy. The life cycle emissions per British thermal unit (Btu) are shown in Table H-1-2.

Table H-1-2. Life cycle CO₂e emissions per million Btu

Type of Fuel	kg CO ₂ e/Million Btu
Gasoline	90.01
Diesel	81.11
Corn ethanol (E100)	72.66
Cellulosic ethanol (E100)	12.07
Biodiesel (B100)	48.26

kg CO₂e = kilograms of carbon dioxide equivalent; Btu = British thermal unit; E100 = 100% ethanol; B100 = 100% biodiesel.

The amount of each biofuel required in the policy is shown in Table H-1-3. The emissions reductions of these biofuels are calculated by multiplying the gallons of fuel being replaced by the difference in GHG emission factors between the conventional fuel and the biofuel. Only

gallons of corn-based ethanol beyond current levels of production are considered towards the emissions reductions. Therefore, the emissions reduction in 2010 only accounts for the reductions from 18 million gallons of corn ethanol.

Table H-1-3. Biofuel quantities and the associated emissions reductions from the implementation path

Year	Million Gallons of Biodiesel (B100)	Million Gallons of Cellulosic Ethanol (E100)	Million Gallons of Corn Ethanol (E100)	Total Life Cycle Emissions Savings (MMtCO ₂ e)	Life-Cycle Emissions Reduction
2009	0	0	267	0.00	0.0%
2010	0	0	285	0.03	0.0%
2011	1	98	325	0.73	1.2%
2012	2	230	326	1.61	2.6%
2013	3	280	333	1.95	3.1%
2014	4	334	334	2.31	3.8%
2015	6	379	345	2.63	4.3%
2016	7	406	374	2.85	4.7%
2017	8	454	380	3.18	5.3%
2018	9	503	386	3.52	5.9%
2019	10	552	391	3.85	6.5%
2020	11	600	397	4.18	7.1%
2021	12	649	407	4.52	7.7%
2022	13	698	419	4.86	8.2%
2023	14	747	434	5.21	8.8%
2024	16	795	451	5.56	9.3%
2025	18	844	458	5.90	9.9%
Total				52.9	

MMtCO₂e = million metric tons of carbon dioxide equivalent.

The costs of this option are calculated on the basis of the difference in cost between conventional fuels and biofuels. The cost estimates for gasoline, diesel, corn ethanol, and biodiesel come from the Annual Energy Outlook (AEO) 2008, High Price Case. The cost estimates for cellulosic ethanol come from the analysis of the cost of producing cellulosic ethanol done for AFW-2. This break-even cost for cellulosic producers ranges from \$1.87 to \$1.60 per gallon. Added to this cost is the profit margin for the producers and distributors, which also comes from AEO 2008. The difference in cost between the wholesale and retail price of corn ethanol found in the AEO was applied to cellulosic ethanol for each year. This resulted in a cost for cellulosic ethanol ranging between \$2.05 and \$2.42 per gallon. The total costs of each biofuel are shown in Table H-1-4.

Table H-1-4. Cost of biofuels in TLU-1

Year	Additional Cost of Biodiesel (Million \$)	Additional Cost of Cellulosic Ethanol (Million \$)	Additional Cost of Corn Ethanol (Million \$)	Additional Cost of all Biofuels (Million \$)
2009	0	0	0	0
2010	0	0	5	5
2011	0	40	18	58
2012	1	59	18	78
2013	1	60	-3	58
2014	2	39	-6	35
2015	2	-21	-22	-41
2016	3	68	-1	70
2017	3	93	0	97
2018	4	69	1	74
2019	4	41	0	45
2020	5	-32	-1	-28
2021	5	-110	-5	-109
2022	6	-105	-15	-114
2023	6	-31	-12	-37
2024	7	31	-13	24
2025	8	16	-13	12

Numbers may not sum due to rounding errors.
Negative numbers indicate costs savings.

The prices of cellulosic and corn ethanol are lower on a per gallon basis than that of gasoline for the entire policy period. However, because more gallons of ethanol are needed to provide the same amount of energy as a gallon of gasoline, this price difference is significantly reduced. In years where the price of ethanol is predicted to be low (such as 2015), then both cellulosic and corn ethanol are cost-effective when compared with the predicted price of gasoline. On the other hand, in years (such as 2012) where the price of ethanol is higher compared with that of gasoline (on a per Btu basis), then there is a net cost for using ethanol compared with using gasoline. Biodiesel has a lower energy content than traditional diesel fuel and is estimated to have slightly higher costs than traditional diesel fuel throughout the policy period. The costs of fuel in 2015 and 2025 are shown in Table H-1-5.

Table H-1-5: Fuel Costs in 2015 and 2025

Year	Gasoline (\$/gal)	Diesel (\$/gal)	Biodiesel (B100) (\$/gal)	Corn Ethanol E100 (\$/gal)	Cellulosic Ethanol (E100) (\$/gal)
2015	3.12	3.09	3.26	1.82	2.05
2025	3.52	3.57	3.74	2.31	2.39

If this policy were implemented as written, it would exceed the amount of ethanol that could be consumed through the use of E10 in gasoline. It would therefore require the introduction of additional flex-fuel vehicles capable of running on E85. According to AEO 2008, the additional cost of a mid-sized vehicle that can run on flex-fuel is \$400. The number of vehicles that would be required to run on flex-fuel is calculated by assessing the amount of ethanol produced beyond 10% (which can be burned in all gasoline engines as E10), and the number of new vehicles that would have to be sold to burn the additional quantities of ethanol. The estimate for new vehicle sales is calculated in TLU-4. The total costs of the TLU-1, in terms of biofuels and vehicle costs are shown in Table H-1-6. It is possible that the cost of these vehicles is being overestimated, because Michigan already has a significant number of flex-fuel vehicles on the road. More than 272,000 flex-fuel vehicles were registered in Michigan in 2007, and this number is estimated to increase by 52,000 every year. At that rate, there would be sufficient flex-fuel vehicles on the road for the entire policy period.

Table H-1-6. Costs of Vehicle Modifications in TLU-1

Year	Estimated New Vehicle Sales	% Gasoline Replaced (volumetrically)	% of Cars Needed to be Flex-Fuel Vehicles	Number of Cars Needed to be Flex-Fuel Vehicles	Additional Cost of Flex-Fuel Vehicles (MM\$)
2009	627,795	5.84%	0.00%	0	\$0
2010	630,493	6.24%	0.00%	0	\$0
2011	632,541	9.35%	0.00%	0	\$0
2012	634,595	12.48%	2.48%	18,527	\$7
2013	636,656	13.94%	3.94%	29,488	\$12
2014	638,723	15.40%	5.40%	40,576	\$16
2015	640,798	16.87%	6.87%	51,792	\$21
2016	641,965	18.34%	8.34%	62,965	\$25
2017	643,134	19.81%	9.81%	74,223	\$30
2018	644,305	21.29%	11.29%	85,567	\$34
2019	645,479	22.77%	12.77%	96,997	\$39
2020	646,654	24.26%	14.26%	108,520	\$43
2021	646,869	25.77%	15.77%	120,022	\$48
2022	647,083	27.29%	17.29%	131,597	\$53
2023	647,297	28.81%	18.81%	143,247	\$57
2024	647,512	30.34%	20.34%	154,970	\$62
2025	647,727	31.85%	21.85%	166,540	\$67
Total				1,285,032	\$514

To sell these higher quantities of gasoline, more service stations must provide E85 pumps. E85 pumps are different from traditional gasoline pumps, because ethanol is more susceptible to contamination by mixing with water. Therefore, pumps must be modified to avoid any possible condensation/contamination. The cost of these pumps is estimated to be an additional \$75,000

for each service station. Table H-1-7 shows the costs of these modifications for the State of Michigan.

Table H-1-7. Costs of service station equipment to sell E-85

Year	% of Service Stations That Need to Sell E85	Stations in Michigan That Need to Sell E85	Cost of Service Station Upgrades (Million \$)
2009	0.00%	0	\$0.0
2010	0.00%	0	\$0.0
2011	0.00%	0	\$0.0
2012	2.92%	122	\$9.2
2013	4.63%	194	\$5.4
2014	6.35%	266	\$5.4
2015	8.08%	339	\$5.4
2016	9.81%	411	\$5.4
2017	11.54%	484	\$5.4
2018	13.28%	557	\$5.5
2019	15.03%	630	\$5.5
2020	16.78%	703	\$5.5
2021	18.55%	778	\$5.6
2022	20.34%	852	\$5.6
2023	22.13%	927	\$5.6
2024	23.93%	1,003	\$5.7
2025	25.71%	1,078	\$5.6
Total			\$80.8

Table H-1-8 shows the total costs of TLU-1, including the additional cost of using biofuels compared with using conventional gasoline/diesel fuel, as well as the additional cost of flex-fuel vehicles and additional costs for service stations to enable them to sell biofuels.

Table H-1-8. Total costs of TLU-1

Year	Additional Cost of all Biofuels (\$MM)	Additional Cost of Vehicles (\$MM)	Additional Cost of Gas Stations (\$MM)	Total Cost of TLU-1 (\$MM)
2009	0	0	0	0
2010	5	0	0	5
2011	58	0	0	58
2012	78	7	9	95
2013	58	12	5	75
2014	35	16	5	56
2015	-41	21	5	-15
2016	70	25	5	100

Year	Additional Cost of all Biofuels (\$MM)	Additional Cost of Vehicles (\$MM)	Additional Cost of Gas Stations (\$MM)	Total Cost of TLU-1 (\$MM)
2017	97	30	5	132
2018	74	34	5	114
2019	45	39	5	89
2020	-28	43	6	21
2021	-109	48	6	-56
2022	-114	53	6	-56
2023	-37	57	6	26
2024	24	62	6	92
2025	12	67	6	84
Total				\$820

Numbers may not sum due to rounding.
Negative numbers indicate costs savings.

Table H-1-9 shows the overall costs and GHG savings estimated in the TLU-1 analysis.

Table H-1-9. Summary of TLU-1

	2015	2025	Units
GHG emission reductions	2.6	5.9	MMtCO ₂ e
Net present value (2009–2025)		\$820	\$ Million
Cumulative emissions reductions (2009–2025)		53	MMtCO ₂ e
Cost-effectiveness (2009–2025)		\$16	\$/tCO ₂ e

GHG = greenhouse gas; MMtCO₂e = million metric tons of carbon dioxide equivalent; \$/tCO₂e = dollars per metric ton of carbon dioxide equivalent.

Data Sources:

U.S. EIA, February 2007. “Biofuels in the U.S. Transportation Sector,” available at: <http://www.eia.doe.gov/oiaf/analysispaper/pdf/tbl12.pdf> (accessed August 11, 2008).

U.S. EIA, 2008. “The New World of Biofuels: Implications for Agriculture and Energy” Available at: <http://www.eia.doe.gov/oiaf/aeo/conf/collins/collins.ppt> (accessed on August 14, 2008).

U.S. EIA, June 2008. “Annual Energy Outlook High Price Estimate,” available at: <http://www.eia.doe.gov/oiaf/aeo/aeohighprice.html> (accessed on September 17, 2008).

ANL. 2008, “GREET Model 1.8” available at: http://www.transportation.anl.gov/modeling_simulation/GREET/index.html

Key Assumptions:

Key Uncertainties

There are significant uncertainties in predicting the cost of fuel over a long period of time. Depending on the cost difference between conventional gasoline/diesel fuel and biofuels, the cost figures for this option could change significantly. The price of cellulosic ethanol is particularly difficult to estimate, because it is not currently available on a commercial scale; thus, fuel cost estimates are largely speculative.

Emissions factors for these fuels come from national estimates. Depending on the blending, components, and production practices, emissions factors can be significantly affected.

Some service stations have had difficulties installing E85 pumps. Issues such as the potential for leakage, fire safety concerns, and uncertain fuel quality make some station operators uneasy with installing the new technology. Improved standardization/certification of E85 pumps might help reduce these concerns.

There is considerable uncertainty in modeling the indirect effects (land use changes) of biofuels production.

Additional Benefits and Costs

Other benefits or costs of a low carbon fuel standard that are not quantified here include:

- impact (positive or negative) on other air pollutants of concern
- sustainability of production
- flexibility to adjust based on the emergence of other technologies that might result in greater or more cost-effective GHG reductions
- impact on food prices
- impact on fuel tax revenue
- impact on the cost of goods delivery (i.e. fuel prices)
- other environmental impacts such as water quality and quantity, and conservation of land.

Feasibility Issues

Implementation of TLU-1 relies heavily upon cellulosic ethanol. Uncertainties exist concerning cellulosic ethanol's feedstock availability, logistics, and conversion technology.

According to the National Biofuels Action Plan (October, 2008):

“Although R&D [research and development] on cellulosic ethanol has made progress in reducing estimated conversion costs, production costs remain too high for biomass-based fuels to compete in the

marketplace. Transformational breakthroughs in basic and applied science will be necessary to make plant fiber-based biofuels economically viable.”²

Cellulosic ethanol technology and production capacity have not yet been proven on a commercial scale, and this raises concerns about the viability for volumes of cellulosic and biodiesel fuel.

Status of Group Approval

Approved

Level of Group Support

Unanimous

Barriers to Consensus

None

² U.S. Department of Energy and U.S. Department of Agriculture, National Biofuels Action Plan, October, 2008. (Available at: <http://www.afdc.energy.gov/afdc/pdfs/nbap.pdf>)

TLU-2. Eco-Driver Program

Policy Description

Driving behavior can significantly influence a vehicle's fuel economy performance. Eco-driving principles incorporate a wide range of initiatives that can help drivers maximize the fuel efficiency from their existing vehicles by better understanding the direct impact that driving style, driving patterns, vehicle technologies, and vehicle maintenance have on a vehicle's fuel economy. A properly designed eco-driving program not only enhances driver awareness and understanding in the short term but also provides a systematic program framework that can alter driver behavior and yield tangible environmental and consumer cost benefits.

Eco-driving programs leverage driver behavior across the entire fleet of existing vehicles in use. The primary focus of an eco-driving campaign would target light-duty vehicles where driver education on eco-driving principles would have the greatest benefit. Michigan drivers consume more than 5 billion gallons of gasoline per year, which generates more than 44 million metric tons of CO₂ (MMtCO₂) emissions. Eco-driving training programs in Europe and Canada have documented reductions in fuel consumption ranging from 16% to 25% for individual drivers. An integrated eco-driving program in Michigan can be designed to achieve a fuel-economy increase (and corresponding GHG reduction) of at least 10% in the mid-term with long-term benefit potential of up to 20%.

Policy Design

A properly designed eco-driving program must move beyond a list of driver "tips" and focus on providing the appropriate tools and programs to systematically change driver behavior.

Key eco-driving principles must cover

- Driving style
 - *Acceleration*—accounts for 50% of a vehicle's fuel consumption in city driving
 - *Speed limits*—driving at 65 miles per hour (mph) requires 15% more fuel than driving at 55 mph
 - *Safe driving distances*—20% less fuel is required to accelerate from 5 mph than from a full stop
- Starting and idling
- Trip planning
- Vehicle drag/weight
 - *Excess cargo*—fuel economy drops 1% for every 25–50 lbs of additional weight
 - *Vehicle drag*—Open windows/truck bed covers/vehicle add-ons
- Proper maintenance

- Engine tuning
- Correctly inflated tires
- Vehicle technology applications
 - Use of instantaneous fuel economy readouts
 - Use of navigation/direction systems

A Michigan eco-driving program must consider the following program initiatives:

Direct Driver Training Initiatives

- **Scope:** Provide direct, hands-on training from professional eco-driving instructors who provide a credible real-world basis for individual drivers to understand the direct impact their driving decisions have on fuel consumption and costs. This direct interaction could start with new drivers who need to pass a driver education course. In addition, eco-driving seminars and training can be linked with corporate/coalition initiatives to highlight specific eco-driving benefits.
- **Key Enablers:**
 - Development of an eco-driving module to be incorporated into all new driver course instruction. Module must include both written (online materials) and hands-on driving practice with the driving instructor.
 - Eco-driving course instruction and hands on training for all instructors licensed to train new drivers. Training can be provided by professional eco-drivers in a series of state-sponsored training courses.
 - State support for eco-driving training seminars in partnership with key auto coalition sponsors (e.g., American Automobile Association [AAA] and automakers). The goal is to document average savings for typical drivers that could be used in a media event that highlights the impact of eco-driving habits. A typical training package used in Europe and Canada targets drivers age 50 and older and includes (1) fuel economy monitoring during a 20-mile course (city/highway), (2) eco-driving instruction and discussion, and (3) repeat of the 20-mile course with the eco-driving instructor to define improvement.
- **Goal:** Newly trained drivers will gradually pass along what they learn to friends and neighbors, extending the impact of the program beyond the formal participants. Full implementation for new drivers programs by 2010. State-supported training in partnership with corporate/coalition members should target 5–10 regional events per year to leverage media focus.

General Eco-Driving Education

- **Scope:** Highlight the importance of ongoing eco-driving education by incorporating the review of an eco-driving training module as part of the state's driver's license renewal requirement.
- **Key Enablers:** Development of an interactive, online eco-driving module. Development of this module can leverage existing resources provided by automakers and other auto-related groups.

- **Goal:** Statewide implementation by 2010.

Vehicle Maintenance

- **Scope:** Proper inflation of tires is one of the most direct eco-driving actions that can be taken, and it can increase fuel economy by 2%–5%.
- **Key Enablers:**
 - Encourage all fuel stations to provide free air and accurate tire pressure gauges by providing a tax credit for up to 50% of the equipment cost. By 2010, require that all fuel stations (exempting low-volume operators) have a tire pressure gauge in place.
 - Encourage all repair and oil-change facilities to adjust tire pressure as part of their service—along with an eco-driving checklist—and create a state-sponsored “eco-star” program that highlights repair and oil-change facilities that incorporate eco-driving initiatives.
 - Require aftermarket tire manufacturers to display fuel economy ratings (rolling resistance standards) from tire manufacturers.
- **Goal:** Full customer access to tire pumps by 2010. Ensure that by 2012, 90% of all service stations follow a repair and oil-change checklist that includes a tire pressure check.

Vehicle Applications

- **Scope:** Real-time fuel economy indicators on vehicle instrument panels are one of the best means for encouraging eco-friendly driving because they provide prompt, quantitative feedback to drivers. Unfortunately, the State of Michigan acting alone cannot require manufacturers to offer such indicators on all vehicles, and it does not seem to be practical at present to install such indicators as after-market devices. Therefore, we have not included a goal relating to fuel-economy indicators.
- **Key Enablers:** Pursue a resolution with the governor and state officials to encourage manufacturers to offer real-time fuel economy indicators more widely.
- **Goal:** 90% of new vehicles have real-time fuel economy indicators by 2015.

Implementation Mechanisms

The low-rolling-resistance (LRR) tire program should include an information campaign aimed at making people more aware (at the point of sale) of the potential for fuel savings from LRR tires.

There may be difficulties in compelling currently licensed drivers to undergo additional driver training, but if the costs of such a program were low (or completely state funded), then it is possible that some people would participate to save money on fuel.

It may be possible to incorporate direct eco-driver training to the process of commercial truck licensing. Because the process for getting a commercial truck license is much more stringent than that for getting a regular driver’s license, adding an eco-driver program would be less difficult.

Related Policies/Programs in Place

None cited.

Type(s) of GHG Reductions

CO₂

Estimated GHG Reductions and Net Costs or Cost Savings

The GHG reductions from various eco-driver actions and the costs and cost saving are shown in Tables 2-1 through Table H-2-9, below.

Quantification Methods:

Four methods of improving Michigan's driving and vehicle maintenance habits were considered in this analysis: (1) LRR tires, (2) proper tire inflation, (3) direct eco-driver training, and (4) general eco-driver training. While the benefits of these programs have a definite potential for overlap, other eco-driving initiatives that are not considered in this analysis will likely have further savings that are not quantified. Other potential eco-driver initiatives include in-car vehicle readouts to show fuel efficiency and general vehicle maintenance to ensure optimal efficiency.

Low-Rolling-Resistance Tires

Rolling resistance reduces the amount of engine power that can be transferred to moving a vehicle along the road. This policy is intended to encourage the use of LRR tires as replacement tires, because new vehicles often use LRR tires to achieve their corporate average fuel economy (CAFÉ) requirements. The fuel efficiency savings possible from installing LRR tires was estimated at 3% according to the California Energy Commission (CEC, 2003). The fuel efficiency savings from trucks is even more significant, with an average savings of 3.9% (Ang-Olson and Schroeer, 2001).³ Life cycle gasoline emissions for passenger cars were estimated to be 11.74 kg CO₂e/gal, while life cycle diesel fuel emissions for freight trucks were estimated to be 12.69 kg CO₂e/gal (ANL, 2008). Both of these emissions factors come from the GREET model. The implementation path represents the percentage of vehicles that will have LRR tires that otherwise would not have them. The path chosen can have a dramatic impact on the savings possible with an LRR tire program. The implementation path used and the GHG savings from LRR tires is shown in Table H-2-1.

³ The 3.9% figure is an average of the Bridgestone and Michelin Study on LRR tires.

Table H-2-1. Implementation path and greenhouse gas savings of low-rolling-resistance tires

Year	Implementation Path (tire improvements)	Reduction in Fuel Use, LRR Tires, Passenger Cars	Reduction in Fuel Use, LRR Tires, Freight Trucks	GHG reduction, LRR Tires (MMtCO ₂ e)
2008	0%	0.00%	0.00%	0.00
2009	1.2%	0.04%	0.05%	0.03
2010	2.4%	0.07%	0.09%	0.05
2011	3.5%	0.11%	0.14%	0.08
2012	4.7%	0.14%	0.18%	0.10
2013	5.9%	0.18%	0.23%	0.12
2014	7.1%	0.21%	0.28%	0.15
2015	8.2%	0.25%	0.32%	0.17
2016	9.4%	0.28%	0.37%	0.19
2017	10.6%	0.32%	0.41%	0.22
2018	11.8%	0.35%	0.46%	0.24
2019	12.9%	0.39%	0.50%	0.26
2020	14.1%	0.42%	0.55%	0.28
2021	15.3%	0.46%	0.60%	0.31
2022	16.5%	0.49%	0.64%	0.33
2023	17.6%	0.53%	0.69%	0.36
2024	18.8%	0.56%	0.73%	0.38
2025	20%	0.60%	0.78%	0.41

MMtCO₂e = million metric tons of carbon dioxide equivalent.

Estimates of the number of vehicles in the program were made by multiplying the passenger vehicles or commercial trucks registered in Michigan by the implementation path (Bureau of Transportation Statistics [BTS], 2008). The costs of this policy were based on the additional cost of four LRR tires, estimated to be \$100 (Snyder, 2008). These costs were applied to all vehicles in the program in their first year and then every 3 years after that. For trucks, the same cost factor was used, but was applied to 18 wheels rather than 4. The costs of this policy are shown in Table H-2-2. Taking into account the fuel savings over the course of the policy period, the use of LRR tires is a net cost savings.

Table H-2-2. Costs and cost savings from low-rolling -resistance tires

Year	Cost, LRR Tires, Passenger Cars (Million \$)	Cost, LRR Tires, Freight Trucks (Million \$)	Cost Savings, Passenger Cars (Million \$)	Cost Savings, Diesel Freight Trucks (Million \$)	Total Cost, LRR Tires (Million \$)
2008	\$0	\$0	\$0.0	\$0.0	\$0.0
2009	\$9.5	\$0.4	\$4.6	\$1.5	\$3.9
2010	\$12.7	\$0.5	\$9.5	\$2.9	\$0.9
2011	\$15.9	\$0.7	\$14.3	\$4.6	-\$2.3
2012	\$19.1	\$0.8	\$18.9	\$6.1	-\$5.1
2013	\$22.2	\$1.0	\$23.6	\$7.8	-\$8.3
2014	\$25.4	\$1.1	\$28.5	\$9.6	-\$11.6
2015	\$28.6	\$1.2	\$33.0	\$11.4	-\$14.5
2016	\$31.8	\$1.4	\$37.9	\$13.2	-\$18.0
2017	\$34.9	\$1.5	\$43.1	\$15.3	-\$21.9
2018	\$38.1	\$1.6	\$48.0	\$17.3	-\$25.6
2019	\$41.3	\$1.8	\$53.3	\$19.5	-\$29.7
2020	\$44.5	\$1.9	\$58.8	\$21.7	-\$34.2
2021	\$47.6	\$2.0	\$65.2	\$24.4	-\$39.8
2022	\$50.8	\$2.2	\$70.9	\$26.9	-\$44.8
2023	\$54.0	\$2.3	\$76.1	\$29.2	-\$49.0
2024	\$57.2	\$2.4	\$81.8	\$31.8	-\$53.9
2025	\$60.4	\$2.6	\$85.8	\$34.0	-\$56.9

LRR = low-rolling-resistance [tires]. Negative numbers indicate costs savings.

Proper Tire Inflation

The General Accounting Office (GAO) estimated that 25% of vehicles have tires that are 8 pounds per square inch (psi) or more underinflated (GAO, 2008). In passenger cars, tires at 1 psi below optimal inflation reduce fuel efficiency by 0.4% (Carcare, 2008). Freight trucks with underinflated tires are estimated to have a reduced fuel efficiency of 0.6% (Ang-Olson and Schroeer, 2001). This policy involves modeling a tire inflation campaign for the State of Michigan after a similar program adopted in Sarasota, Florida. The implementation path used for this policy approaches 20%, and therefore 20% of drivers that otherwise would have had underinflated tires are assumed to now be practicing proper tire maintenance. The implementation path of the policy can be seen in Table H-2-3. The reduction in fuel consumption from the proper tire inflation campaign is determined by multiplying the percent of fuel improvement possible for both passenger cars and trucks by the amount of fuel consumed in the state by the emissions factor for a gallon of each fuel. The total GHG reductions possible with this policy are shown in Table H-2-3.

Table H-2-3. Implementation path and greenhouse gas reduction from proper tire inflation

Year	Implementation Path (tire improvements)	Fuel Improvement Possible, Tire Inflation, Passenger Cars	Fuel Improvement Possible, Tire Inflation, Commercial Trucks	GHG reduction, Tire Inflation (MMtCO ₂ e)
2008	0%	0.00%	0.00%	0.00
2009	1.2%	0.01%	0.01%	0.01
2010	2.4%	0.02%	0.01%	0.01
2011	3.5%	0.03%	0.02%	0.02
2012	4.7%	0.04%	0.03%	0.02
2013	5.9%	0.05%	0.04%	0.03
2014	7.1%	0.06%	0.04%	0.03
2015	8.2%	0.07%	0.05%	0.04
2016	9.4%	0.08%	0.06%	0.05
2017	10.6%	0.08%	0.06%	0.05
2018	11.8%	0.09%	0.07%	0.06
2019	12.9%	0.10%	0.08%	0.06
2020	14.1%	0.11%	0.08%	0.07
2021	15.3%	0.12%	0.09%	0.07
2022	16.5%	0.13%	0.10%	0.08
2023	17.6%	0.14%	0.11%	0.08
2024	18.8%	0.15%	0.11%	0.09
2025	20%	0.16%	0.12%	0.09

MMtCO₂e = million metric tons of carbon dioxide equivalent.

The costs of the tire inflation campaign were modeled after the Sarasota, Florida, tire information campaign (Florida, 2008).⁴ These costs were adjusted to Michigan's population relative to that of Sarasota and scaled to an annual cost of \$2.7 million. The cost savings come from reduced fuel use. The costs and cost savings are shown in Table H-2-4.

⁴ This program aims to reduce tire waste and promote better tire care and maintenance. It is possible that a campaign aimed only at improving tire maintenance and inflation could be run at a lower cost.

Table H-2-4. Costs and cost savings from proper tire inflation program

Year	Cost of Tire Inflation Campaign (Million \$)	Cost Savings, Tire Inflation (Million \$)	Net Costs, Tire Inflation (Million \$)
2008	\$0.0	\$0.0	\$0.0
2009	\$2.7	\$1.4	\$1.3
2010	\$2.7	\$3.0	-\$0.2
2011	\$2.7	\$4.5	-\$1.8
2012	\$2.7	\$6.0	-\$3.2
2013	\$2.7	\$7.5	-\$4.8
2014	\$2.7	\$9.1	-\$6.3
2015	\$2.7	\$10.5	-\$7.8
2016	\$2.7	\$12.1	-\$9.4
2017	\$2.7	\$13.8	-\$11.1
2018	\$2.7	\$15.5	-\$12.7
2019	\$2.7	\$17.2	-\$14.5
2020	\$2.7	\$19.0	-\$16.3
2021	\$2.7	\$21.1	-\$18.4
2022	\$2.7	\$23.0	-\$20.3
2023	\$2.7	\$24.8	-\$22.0
2024	\$2.7	\$26.7	-\$24.0
2025	\$2.7	\$28.1	-\$25.4

Negative numbers indicate costs savings.

Eco-Driver Training

Direct eco-driver training encourages driving habits that reduce fuel consumption. These habits include shifting to a higher gear earlier, using cruise control, coasting to stoplights, and accelerating more gradually. Habits such as these have both environmental and economic benefits to the driver. An eco-driving course in Europe found that reductions in fuel consumption of 15%–25% were quite possible for drivers in the first year (Ecodrive, 2007). This improvement typically decreases as old driving habits return, so subsequent years had an average of 6.3% reduction in fuel consumption (Ecodrive, 2007). This policy was applied only to drivers of passenger vehicles, because it is assumed that while eco-driving techniques could save fuel in freight trucks, they are likely to have costs and benefits different from a program aimed at cars. The reduction in fuel consumption and GHG benefits are shown in Table H-2-5.

Table H-2-5. Implementation path and greenhouse gas savings of direct eco-driver training

Year	Implementation Path (behavior changes)	Percentage Fuel Reduction From Driver Training (passenger cars only)	GHG Reduction, Direct Driver Education
2008	0.00%	0.00%	0.00
2009	2.94%	0.59%	0.32
2010	5.88%	0.76%	0.41
2011	8.82%	0.93%	0.49
2012	11.76%	1.10%	0.58
2013	14.71%	1.28%	0.66
2014	17.65%	1.45%	0.73
2015	20.59%	1.62%	0.81
2016	23.53%	1.79%	0.89
2017	26.47%	1.96%	0.97
2018	29.41%	2.13%	1.04
2019	32.35%	2.31%	1.12
2020	35.29%	2.48%	1.19
2021	38.24%	2.65%	1.27
2022	41.18%	2.82%	1.35
2023	44.12%	2.99%	1.43
2024	47.06%	3.17%	1.52
2025	50.00%	3.34%	1.59

GHG = greenhouse gas.

The costs for direct eco-driver training for Michigan were estimated based on a cost of 2 million Euros to train 6,500 driving instructors in a similar program in the Netherlands (Wilbers et al., 2006). Ninety-two percent of these driving instructors said that they would take into account the methods taught in the course, and therefore it is assumed that 92% of driving instructors will begin teaching eco-driving methods (Wilbers et al., 2006). These training costs were multiplied to the number of drivers assumed to be taking an eco-driving course, as shown in the implementation path, reaching 50% of the population by 2025. The costs of direct eco-driver training are shown in Table H-2-6.

Table H-2-6. Costs of direct eco-driver training

Year	Cost of Driver Training (Passenger Cars) (Million \$)	Cost Savings, Driver Training (Passenger Cars) (Million \$)	Net Costs, Driver Training (Million \$)
2008	\$0.0	\$0.0	\$0.0
2009	\$93.3	\$76.6	\$16.7
2010	\$93.3	\$101.8	-\$8.5
2011	\$93.3	\$125.4	-\$32.2
2012	\$93.3	\$147.5	-\$54.2
2013	\$93.3	\$170.7	-\$77.4
2014	\$93.3	\$194.5	-\$101.2
2015	\$93.3	\$216.1	-\$122.9
2016	\$93.3	\$240.3	-\$147.0
2017	\$93.3	\$266.0	-\$172.7
2018	\$93.3	\$290.4	-\$197.2
2019	\$93.3	\$316.7	-\$223.4
2020	\$93.3	\$344.3	-\$251.0
2021	\$93.3	\$376.4	-\$283.1
2022	\$93.3	\$405.0	-\$311.8
2023	\$93.3	\$430.4	-\$337.1
2024	\$93.3	\$458.3	-\$365.0
2025	\$93.3	\$477.4	-\$384.1

Negative numbers indicate costs savings.

General Eco-Driving Initiative

The general eco-driving initiative seeks to encourage all drivers to operate their vehicles in a safer manner, with the emphasis on reduced highway speeds. The implementation path used for this program assumes that 5% of drivers will modify their driving habits and thus reduce their typical highway speed from 70 to 60 mph. It is likely that the true benefits of this program will be different: more than 5% of the population is likely to change their driving habits in some small way, and some drivers will reduce their highway speed, but only some of the time or only by a few miles per hour. However, this estimate should serve as an example of the fuel reductions that can come from a general eco-driver initiative aimed at encouraging reduced highway speeds.

The fuel savings of this program were estimated by multiplying the implementation path by the average amount of high speed (>55 mph) driving for both cars (24%) (Federal Highway Administration [FHWA], 2008) and trucks (50%) (Ang-Olson and Schroerer, 2001). The result was then multiplied by the reduction in fuel efficiency that comes with driving at 70 mph rather than at 60 mph. This fuel efficiency improvement for cars was estimated to be 16% (Speed

Figure, 2007),⁵ while the improvement for freight trucks is 14% (Ang-Olson and Schroeer, 2001). The GHG benefits of the General Eco-Driver Initiative are shown in Table H-2-7.

Table H-2-7. Implementation path and GHG benefits of General Eco-Driver Initiative

Implementation Path (behavior changes)	General Eco-Driver Initiative (passenger cars)	General Eco-Driver Initiative (freight trucks)	GHG Reduction, General Eco-Driver Initiative
0.00%	0.00%	0.00%	0.00
0.29%	0.01%	0.02%	0.01
0.59%	0.02%	0.04%	0.02
0.88%	0.03%	0.06%	0.03
1.18%	0.05%	0.08%	0.04
1.47%	0.06%	0.10%	0.04
1.76%	0.07%	0.12%	0.05
2.06%	0.08%	0.14%	0.06
2.35%	0.09%	0.16%	0.07
2.65%	0.10%	0.19%	0.08
2.94%	0.11%	0.21%	0.09
3.24%	0.13%	0.23%	0.09
3.53%	0.14%	0.25%	0.10
3.82%	0.15%	0.27%	0.11
4.12%	0.16%	0.29%	0.12
4.41%	0.17%	0.31%	0.13
4.71%	0.18%	0.33%	0.14
5.00%	0.20%	0.35%	0.15

The costs of this eco-driver initiative were based on a similar eco-driver initiative in the Netherlands (Senternovem, 2004).⁶ The cost savings of this policy come from the reduced cost of fuel over the policy period. The costs of the eco-driver program are shown in Table H-2-8.

⁵ The average of these seven different efficiencies was used in this analysis.

⁶ The largest year for this policy was 2002 which had a budget of 7 million Euros. This amount was used for our costs, and then adjusted according to differences in the Netherlands/Michigan population and exchange rates. The result is an investment of \$6.3 million annually.

Table H-2-8. Costs and cost savings of eco-driver initiative

Year	Cost of Eco-Driver Information Program (Million \$)	Cost Savings of Eco-Driver Program (Million \$)	Net Costs, Eco-Driver Program (Million \$)
2008	\$0.0	\$0.0	\$0.0
2009	\$6.3	\$2.1	\$4.2
2010	\$6.3	\$4.4	\$1.9
2011	\$6.3	\$6.7	-\$0.3
2012	\$6.3	\$8.9	-\$2.5
2013	\$6.3	\$11.2	-\$4.9
2014	\$6.3	\$13.6	-\$7.2
2015	\$6.3	\$15.8	-\$9.5
2016	\$6.3	\$18.3	-\$11.9
2017	\$6.3	\$20.9	-\$14.5
2018	\$6.3	\$23.4	-\$17.0
2019	\$6.3	\$26.1	-\$19.7
2020	\$6.3	\$28.9	-\$22.5
2021	\$6.3	\$32.1	-\$25.8
2022	\$6.3	\$35.2	-\$28.8
2023	\$6.3	\$37.9	-\$31.5
2024	\$6.3	\$40.9	-\$34.5
2025	\$6.3	\$43.2	-\$36.9

Negative numbers indicate costs savings.

The entire Eco-Driver policy requires a significant investment on the part of the state of Michigan, but these investments all reap significant rewards in terms of fuel savings. The combined costs, cost savings and GHG benefits of the four eco-driver initiatives considered are shown in Table H-2-9.

Table H-2-9. Total costs, cost savings, and GHG reductions from TLU-2

Year	Total Costs (Million \$)	Total Savings (Million \$)	Net Costs, TLU-2 (Million \$)	Gas Gallons Saved (Million)	Diesel Gallons Saved (Million)	Emissions Savings (MMtCO _{2e})
2008	\$0.0	\$0	\$0.0	0.0	0.0	0.00
2009	\$112.3	\$86	\$26.0	29.4	0.8	0.36
2010	\$115.6	\$122	-\$6.0	39.8	1.7	0.49
2011	\$118.9	\$155	-\$36.6	49.7	2.5	0.62
2012	\$122.2	\$187	-\$65.1	59.1	3.4	0.74
2013	\$125.5	\$221	-\$95.3	68.2	4.2	0.85
2014	\$128.9	\$255	-\$126.3	77.1	5.0	0.97
2015	\$132.2	\$287	-\$154.7	86.0	5.9	1.08
2016	\$135.5	\$322	-\$186.3	94.8	6.7	1.20
2017	\$138.8	\$359	-\$220.3	103.5	7.6	1.31
2018	\$142.1	\$395	-\$252.5	112.1	8.5	1.42
2019	\$145.4	\$433	-\$287	120.5	9.3	1.53
2020	\$148.7	\$473	-\$324	128.9	10.2	1.64
2021	\$152.0	\$519	-\$367	137.7	11.2	1.76
2022	\$155.4	\$561	-\$406	146.8	12.1	1.88
2023	\$158.7	\$598	-\$440	156.2	13.2	2.00
2024	\$162.0	\$639	-\$477	165.8	14.3	2.13
2025	\$165.3	\$669	-\$503	174.3	15.3	2.24
Total			-\$3,921			22.2

MMtCO_{2e} = million metric tons of carbon dioxide equivalent. Negative numbers indicate costs savings.

Data Sources:

California Energy Commission. 2003. "California State Fuel Efficient Tire Report: Volume 1," available at: http://www.energy.ca.gov/reports/2003-01-31_600-03-001F-VOL1.PDF

ANL. 2008. GREET Model 1.8, available at: http://www.transportation.anl.gov/modeling_simulation/GREET/index.html

Wilbers et al. 2006. "Monitoring and evaluation of behavioral programmes," available at: http://www.iapsc.org.uk/presentations/0606_Kroon_combined.pdf (accessed on August 14, 2008).

Ecodrive. April 11, 2007. "CIECA internal project on 'Eco-driving' in category B driver training & the driving test," available at: http://www.ecodrive.org/fileadmin/dam/ecodrive/Downloads/CIECA_Eco-driving_project_final_report_EN.pdf (accessed on August 12, 2008).

Florida. 2008. "Waste Tire Source Reduction and Public Awareness Program," available at: http://www.dep.state.fl.us/waste/quick_topics/publications/shw/recycling/InnovativeGrants/IGyear5/fullprop/SarasotaCounty.pdf (accessed on August 12, 2008).

GAO. 2008. <http://www.gao.gov/new.items/d07246r.pdf> (accessed on August 10, 2008).

Carcare. 2008. http://www.carcare.org/tires_wheels/inflation.shtml (accessed on August 12, 2008).

Ang-Olson, J. and W. Schroeer. 2001. "Energy Efficiency Strategies for Freight Trucking: Potential Impact on Fuel Use and Greenhouse Gas Emissions." The 3.9% figure is an average of the Bridgestone and Michelin Study on LRR tires.

BTS. 2008. http://www.bts.gov/publications/state_transportation_statistics/michigan/html/fast_facts.html

Snyder, J. "A big fuel saver: Easy-rolling tires (but watch braking)," *Automotive News*, July 21, 2008.

Senternovem. 2004. http://www.senternovem.nl/mmfiles/Engelse%20folder%20april%202004_tcm24-192328.pdf. The largest year for this policy was 2002 which had a budget of 7 million Euros. This amount was used to calculate the costs of an eco-driver program, and then adjusted according to differences between the Netherlands and Michigan populations and exchange rates. The result is an investment of \$6.3 million annually.

FHWA. 2008. <http://www.fhwa.dot.gov/ohim/tvtw/08juntvt/08juntvt.pdf>. Assumes that speed on interstate highways is above 55 mph and speed on non-interstate highways is below 55 mph.

Speed Figure. 2007. <http://bioage.typepad.com/shared/image.html?/photos/uncategorized/2007/05/01/fordspeed1.png> (accessed August 14, 2008). This figure shows seven different vehicles, and the efficiency reductions that came with travelling at higher speeds. The average of these seven different efficiencies was used in this analysis.

Key Assumptions: Noted in discussion.

Key Uncertainties

None cited.

Additional Benefits and Costs

LRR tires can require additional stopping distance at highway speeds, thus creating safety concerns.

Conversely, encouraging reduced speeds through the general eco-driving program can help improve highway safety.

Feasibility Issues

None cited.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None cited.

TLU-3. Truck Idling Policies

Policy Description

This policy option aims to reduce GHG and other emissions from unnecessary idling of heavy-duty vehicles, including trucks and buses. The U.S. Environmental Protection Agency (EPA) estimates that truck idling consumes 1 billion gallons of fuel annually, emitting 11 MMtCO₂. Michigan has 3.66% of the total U.S. truck and bus registrations, so the Michigan estimates are 36.6 million gallons and 0.4 million metric tons of CO₂. Much of this idling takes place during mandatory rest periods to provide heating or cooling of the truck's cabin air. Substantial reductions in fuel consumption and GHG emissions could be realized by providing alternate means for cabin air conditioning.

Additional idling occurs during vehicle operation, for example, when loading and unloading buses and trucks. The implementation of public and private fleet anti-idling policies and ordinances, targeted education of bus and truck operators, and creation of low-cost means to access available EPA-verified technologies could help encourage emissions reductions from heavy-duty diesel engines.

Policy Design

Goals:

Reduce heavy-duty engine idling by providing increased availability of electrification at privately owned truck stops or encouraging greater use of auxiliary power units (APUs; on-board generators) for heating, cooling, and other creature comforts on heavy-duty vehicles. Provide financial assistance (e.g., low-interest revolving loans) to truck-stop operators and truck owners/operators for infrastructure development or equipment purchase. Undertake targeted educational activities as appropriate with truck, bus, and truck-stop owners and operators. Achieve diesel idling reductions from heavy-duty diesel engines of 40% by 2015 and 80% by 2025, relative to baseline.

Adopt a Michigan anti-idling law based on the EPA Model State Idling Law (<http://www.epa.gov/SmartwayLogistics/documents/420s06001.pdf>) and/or encourage adoption of local ordinances to address idling during operation of buses and heavy trucks.

Timing:

Parties Involved: Truck and bus fleet owners and operators, Michigan Department of Transportation (MDOT), truck-stop owners and operators, school districts (for school buses), and state police (enforcement).

Other: Issues to be resolved include the choice of implementing one EPA-verified technology over another (e.g., electrification versus APUs), costs and benefits associated with providing anti-idling infrastructure and facilities at public rest areas versus private truck stops, costs and benefits to fleet operators and to the state, and enforcement mechanisms that would be required.

Potential funding sources include funding from the gas tax and from Congestion Mitigation and Air Quality (CMAQ) and other federal agency grants.

Implementation Mechanisms

Adopt a Michigan anti-idling law based on the EPA Model State Idling Law (<http://www.epa.gov/SmartwayLogistics/documents/420s06001.pdf>) and/or encourage adoption of local ordinances to address idling during operation of buses and heavy trucks.

Many other states have low-interest loans to finance idling reduction technology, but this is not the case in Michigan. Such a program would help provide the capital necessary to defray the up-front costs of investing in these efficiency improvements.

There are also difficulties in this program that come from misplaced incentives for efficiency improvement. For example, if the truck owner is responsible for truck maintenance (and therefore any upgrades to the truck) but the truck driver is responsible for fuel costs, then there is no incentive for either to make an investment toward efficiency improvement. Any implementation of this policy should try to account for this potential barrier to implementation.

Clean School Bus USA's newly launched National Idle Reduction Campaign is a public information campaign that recognizes the important role of the school bus driver as a professional who is responsible for the safety and security of children. The National Idle Reduction Campaign provides an opportunity for bus drivers, transportation managers, teachers, and children to learn about air quality and diesel emissions. It recognizes the positive contributions being made by school bus drivers. In addition, this program promotes idle reduction as an easy way to save money by saving fuel, reducing wear and tear on engines, protecting driver's health and the health of children, and improving air quality.

Related Policies/Programs in Place

No state programs exist for truck stop anti-idling. Numerous trucking firms have encouraged reducing idling through grants from EPA and other sources. The City of Ann Arbor has a draft policy on truck idling reduction based on EPA recommendations.

Type(s) of GHG Reductions

CO₂

Estimated GHG Reductions and Net Costs or Cost Savings

Table H-3-1. Estimated GHG reductions and cost-effectiveness

	2015	2025	Units
GHG emission savings	0.36	0.76	MMtCO ₂ e
Net present value (2009–2025)		–\$596	\$million
Cumulative emissions reductions (2009–2025)		7.0	MMtCO ₂ e
Cost-effectiveness		–\$85	\$/tCO ₂ e

GHG = greenhouse gas; MMtCO₂e = million metric tons of carbon dioxide equivalent; \$/tCO₂e = dollars per metric ton of carbon dioxide equivalent. Negative numbers indicate costs savings.

Data Sources:

American Transportation Research Institute (ATRI). February 2006. "Idle Reduction Technology: Fleet Preferences Survey." Source for technology and maintenance costs.

EPA SmartWay Transportation Partnership. <http://www.epa.gov/otaq/smartway/transport/what-smartway/idling-reduction.htm>. Source for average idling hours and technology costs.

ANL. June 2000. "Analysis of Technology Options to Reduce the Fuel Consumption of Idling Trucks," ANL/ESD-43, Transportation Technology R&D Center. Source for information on technology impacts.

Data from EPA's MOBILE6 model to estimate the proportion of CO₂ emissions attributable to Class 8 trucks. <http://www.epa.gov/otaq/m6.htm>

Data from AEO 2008 to estimate the amount of fuel consumed annually per truck.

Truck-Stop Electrification data based on a study done by ANTARES Group Inc. for the DeWitt Service Area facility in New York state, available at: <http://www.epa.gov/smartway/documents/dewitt-study.pdf>.

Ang-Olson, J. and W. Schroerer. 2001. "Energy Efficiency Strategies for Freight Trucking: Potential Impact on Fuel Use and Greenhouse Gas Emissions," Transportation Research Board. Data for APU diesel consumption.

ATRI. August 2007. "Fuel Savings/Emissions Reducing Technologies and Incentives: Use and Preferences Among Diesel Truck Owners in the Baltimore Region."

U.S. EPA. National Idle Reduction Campaign and Idle Reduction Calculator. Used to estimate costs and GHG savings for Michigan school bus retrofits, available at: <http://www.epa.gov/cleanschoolbus/antiidling.htm>

Quantification Methods:

The estimated reduction in CO₂ emissions from reduced idling was calculated by first estimating the portion of emissions and fuel consumption in the Michigan transportation inventory that were attributable to Class 8 diesel trucks. Class 8 trucks are defined by the Federal Highway Administration as heavy duty trucks with less than five axles, used for medium-haul delivery. Then, the portion of the total fuel consumption that would be consumed during idling was estimated. Idle reduction percentages for each year was interpolated from 2010 to 2025 based on the Michigan reduction targets of 40% by 2015 and 80% by 2025 (Table 3-2).

Table H-3-2. Truck idling activities, idling reduction percentages, and diesel savings

Year	Estimated Number of Class 8 Trucks in Michigan	Diesel Consumption in Class 8 Truck Idling (million gallons)	Idling Reduction Percentage Applied	Diesel Saved From Idling Reduction (million gallons)
2009	124,617	92.2	0%	0
2010	124,551	93.9	7%	6.3
2011	124,357	94.3	13%	12.6
2012	125,482	94.2	20%	18.8
2013	127,274	94.1	27%	25.1
2014	128,805	94.1	33%	31.4
2015	130,037	94.4	40%	37.7
2016	131,254	94.5	44%	41.6
2017	132,932	94.7	48%	45.5
2018	134,267	94.9	52%	49.3
2019	135,414	95.1	56%	53.2
2020	136,509	95.4	60%	57.3
2021	138,226	96.3	64%	61.6
2022	140,376	97.4	68%	66.2
2023	142,648	98.6	72%	71.0
2024	145,028	100.1	76%	76.0
2025	146,407	100.8	80%	80.7
Total Reductions				734

For the purpose of this analysis, emissions from the usage of APUs for truck idling were quantified. Specifically, it was assumed that auxiliary diesel engines burn 0.2 gallons of fuel per hour of idling (Ang-Olson and Schroerer, 2001). The CO₂ emissions saved from idle reduction were then netted against the CO₂ emitted from APU usage. The emissions for all gallons of diesel fuel consumed used the life cycle emissions factor of 11.25 tCO₂e/1,000 gal consumed. Table H-3-3 shows the APU diesel consumption and the net CO₂ reduced from idling.

Table H-3-3. APU emissions and net CO₂ savings from truck idle reduction

Year	Diesel Consumed From APU Usage (million gallons)	CO ₂ Emissions From APU Usage (MMtCO ₂ e)	Net CO ₂ Saved From Idle Reduction (MMtCO ₂ e)
2009	0.00	0.00	0.00
2010	1.1	0.01	0.06
2011	2.3	0.03	0.12
2012	3.4	0.04	0.17
2013	4.5	0.05	0.23
2014	5.6	0.06	0.29
2015	6.8	0.08	0.35
2016	7.5	0.08	0.38
2017	8.1	0.09	0.42
2018	8.8	0.10	0.46
2019	9.5	0.11	0.49
2020	10.3	0.12	0.53
2021	11.0	0.12	0.57
2022	11.9	0.13	0.61
2023	12.7	0.14	0.66
2024	13.6	0.15	0.70
2025	14.4	0.16	0.74
Total Reductions	131	1.48	6.78

The cost analysis assumes a 5-year lifetime for idling technology equipment, applied to an incremental percentage of Class 8 vehicles starting in 2010, at a cost of \$6,000 per vehicle.⁷ The AEO 2008 diesel fuel prices for the High Energy Price Case were used for estimating fuel savings. APU operating costs were based on the cost of burning 0.2 gallons of fuel per hour of idling. APU annual maintenance costs were not included in this analysis, because these costs were not adequately reported in surveys. However, ATRI indicated in a study that \$300 per year can be saved in truck engine maintenance when using APU for idling. Table H-3-4 shows the costs and savings from idle reduction on a year-to-year basis.

⁷ ATRI. February 2006. "Idle Reduction Technology: Fleet Preferences Survey," for idle-reduction technology costs.

Table H-3-4. Costs estimated from truck anti-idling policies

Year	Fuel Cost (\$/gallon) High Energy Price Scenario	Annualized Capital Cost of Idle Retrofits (million \$)	Direct Fuel Savings Using APU (million \$)	Total Annual Capital Cost + Fuel Savings (million \$)
2009	\$2.83	\$0.00	\$0	\$0
2010	\$2.82	\$11.51	\$18	-\$3
2011	\$2.92	\$22.98	\$37	-\$7
2012	\$2.92	\$34.78	\$55	-\$10
2013	\$3.00	\$47.04	\$75	-\$15
2014	\$3.06	\$59.50	\$96	-\$19
2015	\$3.09	\$72.08	\$117	-\$24
2016	\$3.14	\$80.04	\$131	-\$27
2017	\$3.23	\$88.43	\$147	-\$32
2018	\$3.28	\$96.76	\$162	-\$36
2019	\$3.34	\$105.09	\$178	-\$41
2020	\$3.41	\$113.51	\$195	-\$47
2021	\$3.50	\$122.60	\$216	-\$54
2022	\$3.55	\$132.29	\$235	-\$61
2023	\$3.55	\$142.34	\$252	-\$65
2024	\$3.57	\$152.75	\$271	-\$70
2025	\$3.57	\$162.32	\$288	-\$74

APU = auxiliary power unit. Negative numbers indicate cost savings.

Reduced School Bus Idling

There are approximately 18,000 school buses in Michigan based on estimates provided by the Michigan State Police, who inspect all Michigan school buses annually. EPA's National Idle-Reduction Campaign calculator was used to estimate the potential fuel savings and fuel costs for a school bus idle reduction campaign. Based on a 30-minute reduction in idling each school day, it was estimated that 45 gallons per year in diesel fuel would be saved (Table H-3-5). The buses were assumed to have installed engine block preheaters to be used in cold weather. These preheaters cost approximately \$1,500; fuel costs are one-sixteenth those of traditional engine idling. Engine costs are considered as an annualized cost over 20 years, with a 5% discount rate. Because reduced engine idling also reduces engine wear, there would likely be savings in the cost of maintenance. These savings are not considered in this analysis.

Table H-3-5. Cost savings and greenhouse gas benefits from reduced school bus idling

	Michigan Total, Diesel Gallons (million)	Bus Savings, Diesel Gallons (thousand)	Emissions Reduction (MMtCO ₂ e)	Cost Savings From Reduced Fuel Use (million \$)	Installation Costs (million \$)	Net Costs (million \$)
2008	1,095	810	0.010	2.5	\$2.2	-\$0.4
2009	1,118	827	0.010	2.3	\$2.2	-\$0.2
2010	1,138	842	0.011	2.4	\$2.2	-\$0.2
2011	1,143	845	0.011	2.5	\$2.2	-\$0.3
2012	1,142	845	0.011	2.5	\$2.2	-\$0.3
2013	1,140	843	0.011	2.5	\$2.2	-\$0.4
2014	1,141	844	0.011	2.6	\$2.2	-\$0.4
2015	1,144	846	0.011	2.6	\$2.2	-\$0.4
2016	1,146	847	0.011	2.7	\$2.2	-\$0.5
2017	1,148	849	0.011	2.7	\$2.2	-\$0.6
2018	1,150	851	0.011	2.8	\$2.2	-\$0.6
2019	1,152	852	0.011	2.9	\$2.2	-\$0.7
2020	1,156	855	0.011	2.9	\$2.2	-\$0.8
2021	1,167	863	0.011	3.0	\$2.2	-\$0.9
2022	1,180	873	0.011	3.1	\$2.2	-\$0.9
2023	1,195	884	0.011	3.1	\$2.2	-\$1.0
2024	1,213	897	0.011	3.2	\$2.2	-\$1.0
2025	1,222	904	0.011	3.2	\$2.2	-\$1.1
			0.195			-\$10.6

MMtCO₂e = million metric tons of carbon dioxide equivalent. Negative numbers indicate cost savings.

Table H-3-6 shows the total costs and the total GHG reductions that come from reduced school bus idling and reduced commercial truck idling.

Table H-3-6. Costs and GHG savings of TLU-3

Year	GHG Savings, Reduced Truck Idling (MMtCO ₂ e)	GHG Savings, Reduced School Bus Idling (MMtCO ₂ e)	Total GHG Savings (MMtCO ₂ e)	Net Costs, Reduced Truck Idling (million \$)	Net Costs, Reduced School Bus Idling (million \$)	Net Costs, Total (million \$)
2008	0.00	0.010	0.01	\$0	-\$0.4	-\$0.4
2009	0.00	0.010	0.01	\$0	-\$0.2	-\$0.2
2010	0.06	0.011	0.07	-\$3	-\$0.2	-\$3.2
2011	0.12	0.011	0.13	-\$7	-\$0.3	-\$7.5
2012	0.17	0.011	0.18	-\$10	-\$0.3	-\$10.7
2013	0.23	0.011	0.24	-\$15	-\$0.4	-\$15.1
2014	0.29	0.011	0.30	-\$19	-\$0.4	-\$19.7
2015	0.35	0.011	0.36	-\$24	-\$0.4	-\$24.1
2016	0.38	0.011	0.39	-\$27	-\$0.5	-\$27.7

Year	GHG Savings, Reduced Truck Idling (MMtCO ₂ e)	GHG Savings, Reduced School Bus Idling (MMtCO ₂ e)	Total GHG Savings (MMtCO ₂ e)	Net Costs, Reduced Truck Idling (million \$)	Net Costs, Reduced School Bus Idling (million \$)	Net Costs, Total (million \$)
2017	0.42	0.011	0.43	-\$32	-\$0.6	-\$32.7
2018	0.46	0.011	0.47	-\$36	-\$0.6	-\$36.7
2019	0.49	0.011	0.50	-\$41	-\$0.7	-\$41.6
2020	0.53	0.011	0.54	-\$47	-\$0.8	-\$47.5
2021	0.57	0.011	0.58	-\$54	-\$0.9	-\$55.3
2022	0.61	0.011	0.62	-\$61	-\$0.9	-\$61.6
2023	0.66	0.011	0.67	-\$65	-\$1.0	-\$65.6
2024	0.70	0.011	0.71	-\$70	-\$1.0	-\$71.1
2025	0.74	0.011	0.76	-\$74	-\$1.1	-\$75.1
Total			7.0			-\$596

GHG = greenhouse gas; MMtCO₂e = million metric tons of carbon dioxide equivalent. Negative numbers indicate cost savings.

Key Assumptions: This analysis assumes that idle reductions are achieved only by the Class 8 diesel truck population, that these trucks idle for an average of 6 hours per day, that they consume 1 gallon of diesel per hour during idling,⁸ and that a 40% (by 2015) or 80% (by 2025) reduction of diesel idling from these Class 8 trucks will be achieved.

Program administration costs, enforcement costs, and fines have not been factored into the cost analysis. Reduced vehicle maintenance costs have also not been factored into the analysis.

Key Uncertainties

Buses, as well as other diesel trucks that have not been quantified here, could achieve a small additional reduction in idling emissions. The distribution of technologies that would be selected by these trucks or fleets to reduce their emissions is highly uncertain, which would have a significant impact on the overall cost/cost savings of this measure.

Use of these technologies would also cause a slight decrease in the CO₂ and fuel consumption reductions achieved. For example, the use of truck stop electrification (TSE) would increase emissions from electricity generation. Based on a study done at a TSE service area near Syracuse, New York, about 2,670 kilowatt-hours (kWh) of electricity was consumed using TSE each year for each parking space.⁹ Using Michigan electricity CO₂ emission factors,¹⁰ this equals about 2.1 tCO₂ emitted per year per electrified space. If Michigan were to have 1,000 TSE

⁸ EPA SmartWay Transportation Partnership, available at: <http://www.epa.gov/otaq/smartway/transport/what-smartway/idling-reduction.htm>. Source for idle assumption.

⁹ Truck-Stop Electrification data based on a study done by ANTARES Group Inc. for the DeWitt Service Area facility in New York state, available at: <http://www.epa.gov/smartway/documents/dewitt-study.pdf>.

¹⁰ MI electric emission factors from Appendix F of "Instructions for Form EIA-1605 Voluntary Reporting of Greenhouse Gases," available at: http://www.eia.doe.gov/oiaf/1605/pdf/EIA1605_Instructions_10-23-07.pdf

spaces by 2025, the CO₂ emissions from electric consumption would be 0.002 MMtCO₂, a negligible number.

Equipment cost and lifetime will also vary by technology employed. The cost value selected was based on cost data summarized by ATRI, and it represents the capital costs of a variety of idle reduction technologies. The cost of \$6,000 per vehicle represents a mix of costs for higher and lower technologies. The cost analysis does not take into account the number of vehicles that have already installed idle reduction technologies. The fuel cost assumed here is based on long-term projected fuel costs. Increases in this assumed fuel cost will lead to greater cost savings for this measure.

Additional Benefits and Costs

Reductions in idling will also reduce emissions of toxics, nitrogen oxides (NO_x), and particulate matter (PM). The primary co-benefits for Michigan of this policy will be in reducing PM-2.5 [particulate matter 2.5 micrometers in diameter and smaller] precursor emissions, such as PM-2.5 and NO_x emissions in the state's PM-2.5 non-attainment areas. The currently designated PM-2.5 non-attainment area in Michigan is Detroit–Ann Arbor. Therefore, initial implementation of this policy option should be in that non-attainment area.

Reducing fine particle pollution, according to EPA studies, will mean improved health due to fewer cases of asthma, lost workdays, hospital visits, and premature deaths. Idle emission reductions will reduce wear from engine operation, thus leading to a cost savings from reduced maintenance costs.

Feasibility Issues

None cited.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None cited.

TLU-4. Advanced Vehicle Technology

Policy Description

Create a policy that will expand the development and use of more efficient vehicle design and/or hybrid propulsion systems.

Policy Design

Goals:

- Make loans and subsidies available to municipalities, local governments, and waste management organizations to encourage more rapid adoption of advanced vehicles by public fleets (transit agencies and schools) with a goal of achieving the use of advanced vehicle technologies (hybrid or hydrogen technology) in 10% of the fleet by 2025.

Timing: The timing for advanced vehicle technology improvements will have a direct correlation with the consumer market based on fuel prices and a desire for Michigan and the United States to become more energy independent.

Parties Involved: Public utilities, consumers, original equipment manufacturers (OEMs; battery manufacturers, automakers), municipalities, local governments, waste management, and the freight industry.

Other: Incentives will build a market that encourages OEMs to produce more efficient vehicle and propulsion designs. This will stimulate the ancillary manufactures to further improve the efficiency of products to support the OEMs. The majority of the subsidies and incentives will come at the inception of approval of these policies to encourage the market. Subsidies and incentives will slowly taper off until the full potential of market penetration has been realized and the technologies have become economically competitive.

Implementation Mechanisms

The Michigan at a Climate Crossroads study considered an alternative vehicle technology incentive measure that was designed to provide tax credits to consumers for purchasing alternative vehicle technologies. However, the models that they had available for examining such an implementation mechanism were unable to consistently capture the market pull effect of providing a tax credit to consumers for advanced vehicle technology purchases. The state tax credit that they modeled was estimated to be \$1,500 per vehicle, on average.

This policy option does not include specifics about recommended state actions or about the amounts that might be invested by the state to increase the probability that low-GHG-emitting advanced vehicle technologies could be sold and operated in Michigan. Funding might be used for state tax credits or other incentives that would induce fleet managers to purchase more expensive (in initial purchase cost) advanced technology vehicles. This investment might need to be on the order of a few thousand dollars per light-duty vehicle sold until the market penetration of advanced technology vehicles is sufficient to provide the economies of scale associated with large production volumes.

Related Policies/Programs in Place

Michigan hybrid electric vehicle laws and incentives include the following:

Hybrid Electric Vehicle Research and Development Tax Credit: For tax years beginning on or after January 1, 2008, and ending before January 1, 2016, a manufacturer engaged in R&D on a qualified hybrid system primarily for propelling a motor vehicle may claim a tax credit under the Michigan Business Tax law. This tax credit is equal to 3.9% of all wages, salaries, fees, bonuses, commissions, or other payments made in the taxable year for the benefit of employees for services performed in a qualified facility.

Alternative Fuel Research and Development Tax Exemption: The Michigan Strategic Fund has designated an alternative energy zone (AEZ) within Wayne State University's Research and Technology Park in Detroit to promote the research, development, and manufacturing of alternative energy technologies, including alternative fuel vehicles (AFVs). Businesses located within the AEZ that are engaged in qualified activities are eligible for exemption from state and local taxes, which would be determined by the Michigan NextEnergy Authority (MNEA). Alternative energy technology companies located in the AEZ may also be eligible for a refundable payroll credit under the Michigan Business Tax law.

Alternative Fuel Development Property Tax Exemption: A tax exemption may apply to industrial property that is used for high-technology activities or for the creation or synthesis of biodiesel fuel. High-technology activities include those related to advanced vehicle technologies such as electric, hybrid, or AFVs and their components.

Acquisition and Alternative Fuel Use Requirement: The Department of Management and Budget (DMB) is required to continue to comply with the requirements of the federal Energy Policy Act of 1992. The DMB must include hybrid electric vehicles within the state's fleet if the vehicles are determined to be cost-effective and capable of meeting the state's transportation needs. In addition, as the state's public fueling infrastructure for alternative fuel continues to develop, state motor fleet AFVs are required to fuel with alternative fuels to the extent possible. The DMB will develop rules to encourage or require the use of diesel fuel with the highest percentage of biodiesel content available for diesel-powered vehicles in the state fleet.

Electric Smart Grid collaborative expansion to include Plug-in Electric Hybrid Vehicle (PHEV) pilot projects: On April 24, 2007, a Commission Order was issued in Case No. U-15278 commencing a Smart Grid collaborative. In this collaborative, all Commission regulated electric distribution companies are required to participate in the investigation of technologies that will help the grid to become more flexible, efficient, and reliable.

On March 11, 2008, pursuant to the April 24, 2007 Commission Order, an Order was issued that required all Commission regulated electric distribution companies to expand the scope of their collaborative participation to include PHEV pilot projects. Commission staff shall draft annual reports on PHEV advancements regarding the smart grid collaborative with the first report scheduled to be filed by June 30, 2009.

The order contained the following tasks for the PHEV aspect of the collaborative:

- Technology pilot programs using actual vehicles, some of which incorporate Vehicle to Grid systems, if and when available.
- An analysis of the environmental effects in Michigan of PHEVs at low, medium, and, high levels of adoption, with and without Vehicle to Grid capability.
- A comprehensive analysis of the effect of PHEVs on Michigan utility and regional electric system load duration curves and the effect of PHEV market penetration on generation mix and capacity requirements.
- An analysis of metering and time-based pricing policies for electricity used to charge electric vehicles.

Type(s) of GHG Reductions

CO₂

Estimated GHG Reductions and Net Costs or Cost Savings

Quantification Methods:

GHG Benefits of Advanced Vehicle Technology

Light Duty Vehicles

While this analysis considers only two vehicle technologies—plug-in hybrid vehicles and hydrogen fuel cell vehicles—it should be recognized that other technologies (e.g., battery-electric vehicles) can also provide benefits. To determine the number of vehicles in the program, the number of fleet vehicles (cars, trucks, and buses) in Michigan in a given year were estimated (Wards, 2007),¹¹ and then multiplied by the implementation path in order to achieve 10% of fleet vehicles by 2025. The implementation path and advanced vehicle purchases in the policy are shown in Table H-4-1. There were just over 46,000 cars in Michigan’s fleet, as well as 70,000 trucks and 16,000 buses. Trucks were not included in this analysis, due to the significant difference in the size, fuel economy and cost of different truck types. Fleet buses (both school and transit buses were included) are considered in this analysis, and that information is provided in the next section. The AEO 2008 forecast did not have plug-in hybrids available to the mass market until 2012 and did not have hydrogen fuel cell vehicles available on a large scale until 2013. Thus, those are the first years that those vehicle types are considered in this analysis.

¹¹ The estimate was made on the basis of the retail sales of new vehicles in the country, multiplied by the percentage of vehicle registrations that take place in Michigan. This figure was increased according to growth factors within the Michigan I&F.

Table H-4-1. Implementation path of advanced light-duty vehicles

Year	Estimated Fleet Vehicles	VMT per Vehicle	Percent of fleet from advanced vehicles	Total fleet plug-in hybrids	Total fleet hydrogen vehicles
2008	47,269	12,221	0.00%	0	
2009	47,472	12,273	0.00%	0	
2010	47,677	12,326	0.00%	0	
2011	47,831	12,366	0.00%	0	
2012	47,987	12,406	0.7%	343	
2013	48,143	12,447	1.4%	550	138
2014	48,299	12,487	2.1%	758	277
2015	48,456	12,528	2.9%	968	417
2016	48,544	12,550	3.6%	1,177	556
2017	48,632	12,573	4.3%	1,388	697
2018	48,721	12,596	5.0%	1,599	837
2019	48,810	12,619	5.7%	1,811	979
2020	48,899	12,642	6.4%	2,023	1,120
2021	48,915	12,646	7.1%	2,233	1,260
2022	48,931	12,650	7.9%	2,444	1,401
2023	48,947	12,655	8.6%	2,654	1,541
2024	48,963	12,659	9.3%	2,865	1,682
2025	48,980	12,663	10%	3,076	1,822

Numbers may not sum due to rounding errors. VMT = vehicle miles traveled.

The costs (except for plug-in hybrids) and miles per gallon efficiency of these two advanced vehicle technologies as well as for conventional gasoline vehicles come from the AEO 2008. The estimate of the price difference between plug-in hybrids and traditional vehicles comes from the California Air Resources Board for the years 2012–2017. The cost difference is estimated to be \$10,000 for the years 2018–2025, based on personal communication with the TWG on September 24, 2008. The average VMT per vehicle for 2005 was estimated to be 12,013 (Wards, 2007) and that figure was estimated to increase according to VMT growth factors from the Michigan I&F. The gasoline used in a conventional vehicle in a typical year is determined by dividing VMT per vehicle by average miles per gallon (mpg) from the AEO 2008. The gasoline used in a hydrogen fuel cell vehicle or plug-in hybrid is calculated in the same way, and the difference between the conventional and advanced vehicle is the gallons of fuel saved. For this analysis, it was assumed that these vehicles will be on the road for an average of 10 years. The gallons of fuel saved was then multiplied by the emissions factor for gasoline (11.74 metric tons/1,000 gal) to determine the CO₂e savings from the advanced vehicles (ANL, 2008). The GHG benefits of the policy are shown in Table H-4-2.

Table H-4-2. GHG benefits of advanced light-duty vehicle technologies

Year	Million Gallons of Fuel Saved, All Plug-Ins	Million Gallons of Fuel Saved, Hydrogen Fuel Cell	MMtCO ₂ e Reduced, Plug-Ins	MMtCO ₂ e Reduced, Hydrogen Fuel Cell	MMtCO ₂ e Reduced, Total
2008	0.00	0.00	0.000	0.000	0.00
2009	0.00	0.00	0.000	0.000	0.00
2010	0.00	0.00	0.000	0.000	0.00
2011	0.00	0.00	0.000	0.000	0.00
2012	0.06	0.00	0.001	0.000	0.00
2013	0.09	0.02	0.001	0.000	0.00
2014	0.11	0.04	0.001	0.000	0.01
2015	0.15	0.05	0.002	0.001	0.01
2016	0.17	0.06	0.002	0.001	0.01
2017	0.19	0.06	0.002	0.001	0.01
2018	0.22	0.07	0.002	0.001	0.01
2019	0.25	0.08	0.003	0.001	0.01
2020	0.28	0.09	0.003	0.001	0.02
2021	0.31	0.10	0.003	0.001	0.02
2022	0.34	0.11	0.004	0.001	0.02
2023	0.37	0.12	0.004	0.001	0.02
2024	0.40	0.13	0.004	0.002	0.02
2025	0.43	0.15	0.005	0.002	0.03
Totals			0.04	0.01	0.19

MMtCO₂e = million metric tons of carbon dioxide equivalent.

Cost of Advanced Light-Duty Vehicle Technologies

The difference between the cost of a conventional vehicle and an advanced vehicle was calculated for all years in the policy. There are also cost savings that come from reduced fuel use. The initial analysis considers 50% of the advanced vehicles sold to be compact and 50% of them to be mid-sized. In years where only compact or mid-sized vehicles are available, then 100% of sales are in those categories. While the price difference between the advanced and conventional vehicles is declining from year to year, the additional cost is between \$25,000 and \$45,000 for hydrogen fuel cell vehicles and between \$10,000 and \$25,000 for plug-in hybrids. The additional cost of hydrogen fuel cell vehicle technologies comes from the AEO 2008. PHEV costs are those estimated by the California Air Resources Board (2008). The price of gasoline comes from the AEO 2008 and is shown in Tables 4-3 and 4-4. The cost savings and total costs for plug-in hybrids are shown in Table H-4-3 and those for hydrogen fuel cell vehicles are shown in Table H-4-4.

Hydrogen fuel cell vehicles will also come with additional infrastructure costs, because separate hydrogen refueling stations will be required. It was assumed that these stations would be centralized in Southeast Michigan, and that the cost of a hydrogen fueling station would be \$4 million. The number of fueling stations required was determined based on the number of vehicles registered in the state (8.1 million) divided by the number of fueling stations required to fuel conventional vehicles in the state (50,000). This gave a figure of 162 vehicles per fueling station. The number of new hydrogen fueling stations is estimated to be the number of new hydrogen fuel cell vehicles divided by this figure (162). These costs were then discounted back to 2005 dollars. One advantage of plug-in hybrid electric vehicles is that the necessary electricity infrastructure is already in place.

Table H-4-3. Costs and cost savings of plug-in hybrids

Year	Additional Cost, Plug-In Hybrids (MM\$)	Million Gallons of Fuel Saved, All Plug-In Hybrids	Gasoline (\$/gal)	Cost Savings (Fuel), Plug-In Hybrids (MM\$)	Net Cost, Plug-In Hybrids (MM\$)
2008	0.0	0.00	3.05	0.0	0.0
2009	0.0	0.00	2.85	0.0	0.0
2010	0.0	0.00	2.94	0.0	0.0
2011	0.0	0.00	2.98	0.0	0.0
2012	8.6	0.06	3.00	0.2	8.4
2013	5.2	0.09	3.05	0.3	4.9
2014	2.6	0.11	3.11	0.4	2.2
2015	2.6	0.15	3.12	0.5	2.2
2016	2.6	0.17	3.17	0.5	2.1
2017	2.1	0.19	3.23	0.6	1.5
2018	2.1	0.22	3.27	0.7	1.4
2019	2.1	0.25	3.33	0.8	1.3
2020	2.1	0.28	3.40	1.0	1.2
2021	2.1	0.31	3.49	1.1	1.0
2022	4.2	0.34	3.53	1.2	3.0
2023	4.2	0.37	3.53	1.3	2.9
2024	4.2	0.40	3.55	1.4	2.8
2025	4.2	0.43	3.52	1.5	2.7
Total					\$37
\$/ton					\$986

Table H-4-4. Costs and cost savings of hydrogen fuel cell vehicles

Year	Additional Cost, Hydrogen Fuel Cell Vehicles (MM\$)	Discounted Hydrogen Infrastructure Costs (\$MM)	Million Gallons of Fuel Saved, Hydrogen Fuel Cell Vehicles	Gasoline (\$/gal)	Cost Savings (Fuel), Hydrogen Fuel Cell Vehicles	Net Cost, Hydrogen Fuel Cell Vehicles (\$MM)
2008	0.0	0.0	0.00	3.05	0.0	0.0
2009	0.0	0.0	0.00	2.85	0.0	0.0
2010	0.0	0.0	0.00	2.94	0.0	0.0
2011	0.0	0.0	0.00	2.98	0.0	0.0
2012	0.0	0.0	0.00	3.00	0.0	0.0
2013	6.3	1.2	0.02	3.05	0.1	7.4
2014	6.0	1.1	0.04	3.11	0.1	7.0
2015	5.8	1.1	0.05	3.12	0.2	6.7
2016	5.5	1.0	0.06	3.17	0.2	6.3
2017	5.1	1.0	0.06	3.23	0.2	5.9
2018	4.9	0.9	0.07	3.27	0.2	5.6
2019	4.7	0.9	0.08	3.33	0.3	5.3
2020	4.6	0.8	0.09	3.40	0.3	5.1
2021	4.4	0.8	0.10	3.49	0.4	4.8
2022	8.4	1.5	0.11	3.53	0.4	9.5
2023	8.2	1.4	0.12	3.53	0.4	9.2
2024	7.9	1.4	0.13	3.55	0.5	8.8
2025	7.7	1.3	0.15	3.52	0.5	8.5
Total						\$90
\$/ton						\$7,338

GHG Benefits of Hybrid Buses

The potential GHG savings from hybrid school buses was also considered in this analysis. Both transit and school buses could take advantage of this technology. This analysis focuses on school buses because there are many more school buses than there are transit buses in Michigan. First, the number of school buses was estimated based on the Ward's Motor Vehicle Facts and Figures 2007 publication and increased out through 2025 based on the VMT growth rate for each year after 2005. The number of hybrid buses in Michigan is predicted to increase steadily starting in 2012 (the same year as the other hybrid vehicles), and to increase to make up 10% of the vehicle fleet in 2025. The number of hybrid buses purchased is shown in Table H-4-5. The GHG savings were determined by dividing the average VMT for a Michigan school bus (Wards, 2007) by the fuel efficiency figure for a conventional bus (2.5 mpg) compared to a hybrid bus, which gets 3.2 mpg (Chandler and Walkowitz, 2006). These fuel savings are then multiplied by the life cycle emissions factor for diesel fuel (11.25 mtCO_{2e}/1000 gals). The total MMtCO_{2e} saved from Hybrid Buses is shown in Table H-4-5.

Table H-4-5. Greenhouse gas savings from hybrid school buses

	Estimated School Bus Fleet	Total New Buses	Million Gallons Saved	MMtCO ₂ e Saved
2008	18,031	0	0.0	0.000
2009	18,108	0	0.0	0.000
2010	18,186	0	0.0	0.000
2011	18,245	0	0.0	0.000
2012	18,304	131	0.1	0.001
2013	18,364	262	0.2	0.003
2014	18,423	395	0.4	0.004
2015	18,483	528	0.5	0.005
2016	18,517	661	0.6	0.007
2017	18,550	795	0.7	0.008
2018	18,584	929	0.8	0.009
2019	18,618	1,064	1.0	0.011
2020	18,652	1,199	1.1	0.012
2021	18,658	1,333	1.2	0.014
2022	18,664	1,466	1.3	0.015
2023	18,671	1,600	1.5	0.016
2024	18,677	1,734	1.6	0.018
2025	18,683	1,868	1.7	0.019
Total				0.143

Cost of Hybrid Bus Technology

The costs of the hybrid bus program were estimated based on the cost differential between conventional buses and hybrid buses, estimated to be \$200,000 (Chandler and Walkowitz, 2006). Fuel savings are also taken into account. The gallons of diesel saved are multiplied by the estimated diesel cost, from AEO 2008. All of these costs are shown in Table H-4-6.

Table H-4-6. Total Costs of Hybrid Bus Technology

	Total New Buses	Million Gallons Saved	Diesel (\$/gal)	Diesel Costs Reduced (\$MM)	Discounted Hybrid Vehicle Cost (MM\$)	Net Cost
2008	0	0.0	3.14	0.0	0.0	0.0
2009	0	0.0	2.83	0.0	0.0	0.0
2010	0	0.0	2.82	0.0	0.0	0.0
2011	0	0.0	2.92	0.0	0.0	0.0
2012	131	0.1	2.92	0.3	18.6	18.2
2013	262	0.2	3.00	0.7	17.8	17.1
2014	395	0.4	3.06	1.1	17.1	16.0
2015	528	0.5	3.09	1.5	16.4	14.9

	Total New Buses	Million Gallons Saved	Diesel (\$/gal)	Diesel Costs Reduced (\$MM)	Discounted Hybrid Vehicle Cost (MM\$)	Net Cost
2016	661	0.6	3.14	1.9	15.6	13.7
2017	795	0.7	3.23	2.3	14.9	12.6
2018	929	0.8	3.28	2.8	14.2	11.5
2019	1,064	1.0	3.34	3.2	13.6	10.4
2020	1,199	1.1	3.41	3.7	13.0	9.3
2021	1,333	1.2	3.50	4.2	12.2	8.0
2022	1,466	1.3	3.55	4.7	11.7	7.0
2023	1,600	1.5	3.55	5.1	11.1	6.0
2024	1,734	1.6	3.57	5.6	10.6	5.0
2025	1,868	1.7	3.57	6.1	10.1	4.0
					Total Cost	\$154
					\$/ton	\$1,077

The total costs of the advanced vehicle technologies considered in this analysis are shown in Table H-4-7.

Table H-4-7. Total costs of TLU-4

Year	Total Cost, Plug-Ins	Total Cost, Hydrogen Fuel Cell Vehicles	Total Cost, Hybrid Buses	Total Cost TLU-4
2008	0.0	0.0	\$0	0.0
2009	0.0	0.0	\$0	0.0
2010	0.0	0.0	\$0	0.0
2011	0.0	0.0	\$0	0.0
2012	21.1	0.0	\$18	39.4
2013	12.3	18.5	\$17	48.0
2014	5.7	17.6	\$16	39.3
2015	5.4	16.8	\$15	37.1
2016	5.2	15.9	\$14	34.9
2017	3.7	14.7	\$13	31.0
2018	3.5	14.0	\$11	29.0
2019	3.2	13.4	\$10	27.0
2020	2.9	12.8	\$9	25.1
2021	2.6	12.1	\$8	22.7
2022	7.4	23.9	\$7	38.2
2023	7.2	23.0	\$6	36.2
2024	7.0	22.2	\$5	34.1

Year	Total Cost, Plug-Ins	Total Cost, Hydrogen Fuel Cell Vehicles	Total Cost, Hybrid Buses	Total Cost TLU-4
2025	6.8	21.4	\$4	32.3
Total	\$94	\$226	\$154	\$474
\$/Ton	\$986	\$7,338	\$1,077	\$1,763

Table H-4-8 summarizes the GHG savings and costs of TLU-4.

Table H-4-8. Summary of TLU-4

	2015	2025	Units
GHG emission reductions	0.01	0.03	MMtCO ₂ e
Net present value (2009–2025)		\$281	\$ Million
Cumulative emissions reductions (2009–2025)		0.19	MMtCO ₂ e
Cost-effectiveness (2009–2025)		\$1,458	\$/tCO ₂ e

GHG = greenhouse gas; MMtCO₂e = million metric tons of carbon dioxide equivalent; \$/tCO₂e = dollars per metric ton of carbon dioxide equivalent.

Data Sources:

U.S. EIA. Annual Energy Outlook 2008 Supplement. Table 59. New Light-Duty Vehicle Fuel Economy and Table 60. New Light-Duty Vehicle Prices. <http://www.eia.doe.gov/oiaf/aeo/supplement/index.html> (accessed August 27, 2008).

ANL. 2008. GREET Model 1.8, available at: http://www.transportation.anl.gov/modeling_simulation/GREET/index.html

Wards. 2007. "Motor Vehicle Facts & Figures 2007." Wards Automotive Group.

California Environmental Protection Agency Air Resources Board. February 2008. "Initial Statement of Reasons. 2008 Proposed Amendments to the California Zero Emissions Vehicle Program Regulations."

Chandler, K. and Walkowicz K. "King County Metro Transit Hybrid Articulated Buses." NREL. December 2006. <http://www.nrel.gov/vehiclesandfuels/fleetttest/pdfs/40585.pdf>

Key Assumptions: While the light-duty vehicle quantification analysis above focuses on plug-in hybrid and hydrogen fuel cell technologies, there are other alternative light-duty vehicle technologies that are expected to be introduced to the marketplace in the near future that also are expected to provide GHG emissions reductions. These include battery electric vehicles and clean diesel. Some of the attributes of these technologies are summarized below.

On September 23, 2008, Chrysler unveiled three electric vehicles and said that it would bring one of them to market by 2010. In at least the near-term, battery electric vehicles are expected to

be limited in their range (100 miles or fewer on a charge). Automakers say the following factors may make electric cars mainstream products: (1) government incentives for zero emission vehicles, (2) help from power companies in creating a recharging infrastructure, (3) financial and social pressure for consumers to buy greener cars, (4) lower long-term cost of operating electric vehicles, and (5) progress in cutting battery costs and improving performance. Having the ability to recharge batteries at home and via charging stations in long-term parking areas is part of the needed infrastructure for the success of this technology. In addition, some manufacturers suggest that batteries be leased to customers so that during long trips, drivers will be able to stop at service stations to swap a depleted battery for a fresh one.

Clean diesel technology is currently available in a limited number of light-duty vehicle models, with more models to be available in the next 1–2 years. Diesel-powered highway engines and vehicles for 2007 and later model years are designed to operate only with ultra-low-sulfur diesel fuel. Today's clean diesels can offer better fuel economy and produce fewer GHGs than some gas–electric hybrids. During 2008, diesel is selling for a premium relative to gasoline, but AEO projections show expected long-term gasoline and diesel prices to be comparable. Diesel fuel economy is about 25% better than that for a comparable gasoline model, and diesel engines have longer lifetimes than spark-ignited engines.

Key Uncertainties

The direct costs of the advanced vehicle technologies are uncertain in advance of vehicles reaching the production stage. The cost of these technologies may change as technology advances occur and production volumes increase to a high enough level to produce economies of scale.

The mpg figure from the AEO is not entirely clear with regard to plug-in hybrid and hydrogen vehicles. Plug-in hybrid vehicles consume both gasoline and electricity, so it is not certain how the electricity consumption calculated in the AEO is converted into an mpg figure. There is a figure for mpg in the AEO 2008 for both plug-in hybrid and hydrogen technologies, and that is used as a stand-in for the energy consumption of these vehicles. It is assumed that the AEO 2008 mpg values are an attempt to compute fuel cost equivalent.

In addition, the electricity generation mix for Michigan includes more coal than the national average. This could contribute to an underestimation of the emissions that come from a plug-in hybrid vehicle, if the AEO 2008 information accounts for electricity emissions on a national level.

Additional Benefits and Costs

This policy could serve to reestablish Detroit as a leader of automotive research, which would have benefits across the state. In addition, progress on advanced vehicle technology can have benefits far beyond the borders of Michigan in terms of energy security, economic growth, and environmental quality.

The impact of increased use of plug-in electric technology on Michigan's electricity supply is not considered in this analysis. Because the number of plug-in hybrid electric vehicles (PHEVs) is relatively small, the impact is not likely to be dramatic, but it could nonetheless have an impact

on the overall demand or load profile for the state. Through advances in advanced metering infrastructure and Smart Grid technologies, increase in demand can be delayed to take advantage of the underutilized off-peak capacity and allow for a much cheaper fuel price and far lower emissions when compared to conventional combustion engine fuel.

It is likely that there will be CO₂ emissions that result from charging PHEVs at night. These emissions were not considered in this analysis because of difficulty in estimating the associated electricity demand and emissions factor.

Feasibility Issues

The primary feasibility issue with advanced technologies is whether they can be produced at a cost that will be attractive to consumers. Some technologies may also need supporting re-fueling or re-charging infrastructure.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None cited.

TLU-5. Congestion Mitigation

Policy Description

Improve traffic flow and travel time through expanding the use of intelligent transportation systems (ITS). In conjunction with expanding ITS, the following actions should also be considered: identifying and improving key bottlenecks, constructing modern roundabouts at appropriate intersections, and continuing the use of the MDOT courtesy patrol on congested roadways. A four-day workweek and flex-time should be encouraged to reduce congestion. All of these elements contribute to reducing travel delay for both recurring and nonrecurring congestion.

Promoting the development of intermodal freight terminals will facilitate freight shipment on rail and air thus reducing the volume of freight on Michigan roadways. By supporting these efforts, the congestion mitigation policy option will allow for more efficient travel and increased economic output.

Policy Design

Goals: The goals for this policy are as follows:

- Reduce travel time delay from recurring and nonrecurring congestion in Michigan's major urban areas (metro Detroit and Grand Rapids) by 10% by 2025.
- Reduce travel time related to nonrecurring congestion (i.e., road construction) by continuing to implement and refine the Michigan Work Zone Safety and Mobility Policy. This policy sets a 10-minute threshold for congestion related to road work. If a vehicle is delayed more than 10 minutes the department is notified to review and modify its standards.

Timing: 2010–2025.

Parties Involved: MDOT, FHWA, and metropolitan planning organizations (MPOs).

Implementation Mechanisms

Congestion reduction in the major metropolitan areas can be achieved through implementing an appropriate combination of the methods described in the policy description. In 2005, metro Detroit drivers had 54 hours of delay annually and Grand Rapids drivers had 24 hours of delay annually. (Delay estimates are for one driver versus free-flow conditions for a single year.)

Funding for intermodal freight initiatives such as the Detroit Intermodal Freight Terminal (DIFT) and the West Detroit Rail Junction will be provided to increase rail efficiency and reduce the number of long-haul shipments on Michigan roadways. (This measure is addressed in TLU-8.)

Related Policies/Programs in Place

None cited.

Type(s) of GHG Reductions

CO₂

Estimated GHG Reductions and Net Costs or Cost Savings

Table H-5-1. Summary of TLU-5 congestion mitigation

	2015	2025	Units
GHG emission savings	0.08	0.18	MMtCO ₂ e
Net present value (2006–2025)		–\$135	\$ Million
Cumulative emissions reductions (2006–2025)		1.68	MMtCO ₂ e
Cost-effectiveness		–\$80.63	\$/tCO ₂ e

GHG = greenhouse gas; MMtCO₂e = million metric tons of carbon dioxide equivalent; \$/tCO₂e = dollars per metric ton of carbon dioxide equivalent.

Table H-5-2. Summary of Detroit and Grand Rapids congestion mitigation

	2015	2025	Units
GHG emission savings	0.05	0.12	MMtCO ₂ e
Net present value (2006–2025)		–\$21	\$ Million
Cumulative emissions reductions (2006–2025)		1.12	MMtCO ₂ e
Cost-effectiveness		–\$21.56	\$/MtCO ₂ e

GHG = greenhouse gas; MMtCO₂e = million metric tons of carbon dioxide equivalent; \$/tCO₂e = dollars per metric ton of carbon dioxide equivalent.

Table H-5-3. Summary of statewide nonrecurring congestion mitigation

	2015	2025	Units
GHG emission savings	0.03	0.06	MMtCO ₂ e
Net present value (2006–2025)		–\$114	\$ Million
Cumulative emissions reductions (2006–2025)		0.56	MMtCO ₂ e
Cost-effectiveness		–\$204.67	\$/MtCO ₂ e

GHG = greenhouse gas; MMtCO₂e = million metric tons of carbon dioxide equivalent; \$/tCO₂e = dollars per metric ton of carbon dioxide equivalent.

Data Sources:

D.L. Schrank, T. J. Lomax, Texas Transportation Institute (TTI), 2007. *Urban Mobility Report*.
http://tti.tamu.edu/publications/catalog/record_detail.htm?id=32636

FHWA. *Highway Economic Requirements System* model.
<http://www.fhwa.dot.gov/infrastructure/asstmgmt/hersindex.cfm>

Quantification Methods: Analysis of congestion mitigation was undertaken by applying the stated goals of a 10% reduction in travel time delay from congestion in metro Detroit and Grand Rapids by 2025 using fuel savings and congestion delay equations from the TTI 2007 Urban Mobility Report. The amount of delay for each metro area was forecast using historical data from

TTI going back to 1982. The quantity of fuel wasted was then calculated for each year using the TTI equation relating fuel loss due to various congestion levels from time delays in traffic (a nonlinear relationship). Then the analysis calculates the amount of fuel wasted if delay were to be reduced 10% in 2025 and by proportionally less during the phase-in period of 2010–2025. The difference represents the fuel savings due to the Detroit/Grand Rapids congestion reduction program. The statewide program to reduce delays from nonrecurring congestion (e.g., road work and traffic incidents) was estimated to provide approximately half the benefits of the program for recurring and nonrecurring congestion.

Costs were estimated using a methodology derived from the federal Highway Economic Reporting System model, which examines the range of bottleneck relief, capacity expansion, and operational improvements (e.g., ramp-metering and ITS applications) that can be cost-effectively implemented and selects the most cost-effective measures as those to be implemented. Benefits from the congestion reduction are based on savings from reduced fuel consumption using a value of \$3.82 per gallon (the average price of fuel year-to-date for 2008) along with other vehicle operating costs. A 1.1 to 1.0 ratio of benefit to cost was estimated (i.e., improvements would be undertaken to the point where an overall 1.1 benefit-to-cost ratio was maintained) for the investments needed to generate the desired 10% congestion relief in Detroit and Grand Rapids, with a respective cost of \$208 million and benefit of \$229 million. For the statewide nonrecurring congestion effort (centered on the Michigan Work Zone Safety and Mobility Policy, but also including real-time traveler information, incident management, variable message signs, and other operational deployments potentially available through 2025), a net benefit of \$114 million was estimated.

It should be noted that benefits of \$2,043 million were estimated in travel time savings using the TTI Urban Mobility Report methodology. Because these savings are an indirect benefit, they were not included in our estimate of direct benefits, but they are very important to bear in mind.

Key Uncertainties

The effects of the statewide nonrecurring congestion reduction measures are somewhat speculative because there is not much data on congestion and delays on roads and highways outside of metropolitan areas.

Additional Benefits and Costs

As mentioned above, the most important co-benefit is reduced travel times and improved travel reliability. These congestion mitigation measures also provide benefits from energy savings, reduced air pollution, and public health.

Feasibility Issues

Funding for the ITS and capacity expansion/bottleneck relief measures is dependent on state budget and fiscal status and policymakers' approval.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None cited.

TLU-6. Land Use Planning and Incentives

Policy Description

Implement state policies and programs that encourage local and regional planning and development strategies in order to reduce the projected growth of VMT and corresponding GHG emissions. The state will enable each region to adopt a unique mixture of policies to reach reduction goals in its own manner. Strategies include

- Promoting and expanding regional growth management options that result in more compact mixed-use, transit-oriented, walkable development;
- Transportation system management and pricing that allows for greater investment in alternatives to the single-occupancy vehicle, such as public transit; and
- Use of other land-use-related economic development tools as recommended in the Michigan Land Use Leadership Council's Report (2003)¹².

Policy Design

Goals:

- To reduce low density development and the conversion of greenfield open land to development 25% by 2015, 50% by 2025, and 80% by 2050 compared with Michigan's land use growth pattern of 2000–2005.
- To encourage communities to utilize an “infill” approach for both new and redevelopment projects by focusing on areas where infrastructure already exists. On a local and regional basis, track and compare private and public percentage of investments of infill development/redevelopment versus greenfield development.
- Beginning in 2009, work to ensure that at least 60% of new/future statewide growth utilizes more compact development or transit-oriented development design.

These goals can be accomplished through

- Multi-jurisdictional land use planning and zoning policies, tax base sharing, and providing state and local incentives.
- Market-based approaches in future land development and housing policies that focus public and private investments toward achieving higher density, transit-oriented, and compact or mixed-use development (where appropriate), while conserving natural resources and protecting our land-resource-based industries.
- Integrated transportation policies, investments, system management, and pricing to offer Michigan residents and visitors access to an energy-efficient and cost-effective variety of travel options.

¹² Michigan's Land, Michigan's Future: Final Report of the Michigan Land Use Leadership Council, August 15, 2003. <http://www.michiganlanduse.org/finalreport.htm>

- Enactment of a new Statewide Comprehensive Planning Law. This could be focused on public participation in creating a locally driven comprehensive planning process for local units of government to follow in meeting key statewide goals for economic, social, and environmental priorities. If plans are enacted by a certain date, those communities would qualify for priority funding from state government programs.

Timing: Governor and appropriate Cabinet members should initiate planning and administrative activities in 2009 to shape transportation and land development plans and policies that support this goal in 2010 and beyond. Prepare additional enabling legislation for the 2009–2010 legislative session supporting the goal.

Parties Involved: MDOT, MDEQ, MDNR, and Michigan Departments of Labor and Economic Growth and Agriculture; local governments and MPOs; transportation planning regions; real estate development and homebuilding industry; economic development interests; and environmental, conservation, and community interest groups.

Implementation Mechanisms

To achieve these land use goals, the state and local communities will need to use some or all of the following strategies, which have been used in other states and regions.

Priority Areas Designated for Planned Growth

Establish a process to designate types of priority growth areas within the state. Priority growth areas could include town centers, downtowns, regional centers, neighborhood centers, transit corridors, and transit station areas. Establish a process to encourage higher density housing and employment growth; mixed-use and mixed-income development; and bicycle, pedestrian, and transit-friendly development within these areas. Priority growth areas could include brownfields (old commercial or industrial sites), as appropriate in the context of the study of redevelopment of contaminated sites in Michigan. Development and redevelopment within these areas would be promoted through incentives, technical assistance, and/or regulation.

School Siting and Accessibility

Review and revise school siting laws in Michigan to remove excessive acreage requirements that drive schools into undeveloped areas. Encourage the development or rehabilitation of schools in priority growth areas to make it easier for children, teachers, and parents to get to school on foot, by bicycle, or by transit.

Jobs–Housing Balance

Plan and zone for new housing development to be prioritized near existing jobs and plan and zone for new commercial development near existing housing. Implement financial incentives and/or regulation to encourage a range of housing types and affordability levels that support a community's local work force, which will create a stronger jobs–housing balance and reduce the length and number of vehicle trips.

Smart Growth Planning, Modeling, and Tools

Institute statewide and municipal planning requirements and/or incentives to implement TLU-6. Provide technical assistance to communities on best practices in zoning, parking, and street

design to increase walking, bicycling, and transit use; to encourage higher density transit and walking-oriented development; and to balance regional residential, commercial, and industrial needs. (See Oregon's Transportation and Growth Management technical assistance program for Oregon communities, available at: <http://www.lcd.state.or.us/LCD/TGM/index.shtml>.)

Create an integrated transportation and land-use forecasting model for use statewide. This tool would enable communities to predict increased VMT and GHG emissions based on proposed developments.

Targeted Open Space Protection

Establish programs and/or requirements to preserve key forestlands, natural areas, agricultural land, and parkland, which will help guide development and redevelopment into targeted/priority growth areas.

Transportation Investments for Transit- and Pedestrian-Oriented Development

Plan for and invest in transit- and pedestrian-oriented corridors that will draw and support higher density, mixed-use development along public transit corridors.

Complete Streets and Well-Connected Streets

Develop statewide guidance and technical support for complete streets and well-connected streets to shorten trip distances, to make walking in general and walking to transit safer and more convenient, to reduce the need for overly large urban arterial roads, and to support higher density development.

Development Characteristics

Incorporate principles such as Creative Cities—green accounting that identifies natural features and functions as assets—and Leadership in Energy and Environmental Design–Neighborhood Development (LEED-ND) for their potential to reduce CO₂ emissions into development standards.

Identification and mapping of all natural assets within a geographical area should be completed and incorporated within the planning process to promote better and more efficient land use planning within a community destined for growth or redevelopment. Green infrastructure has quantifiable economic, environmental, and aesthetic values. A typical asset/liability budget approach for development/redevelopment should be used, whereby biological and environmental (assets) should be preserved and growth should be shifted to more suitable low-cost (liability) areas. By preserving green infrastructure within a community, more GHGs can be sequestered while providing a broader more comprehensive planning approach to achieving higher standards of environmental quality. These assets may be mapped onto geographic information system (GIS) layers and used as an overlay with other base layers (e.g., infrastructure, commercial, and residential) to determine the most effective land use budget for development/redevelopment of an urban/suburban/exurban neighborhood.

The LEED-ND rating system integrates the principles of smart growth, urbanism, and green building into the first national system for neighborhood design. LEED certification provides independent, third-party verification that a development's location and design meet accepted high levels of environmentally responsible, sustainable development. Currently in its pilot

period, LEED-ND is a collaboration of the U.S. Green Building Council, the Congress for the New Urbanism, and the Natural Resources Defense Council.

Funding

Target new and existing environmental bond, tax credit, tax increment financing, transportation, and housing dollars from regional, state, and federal sources to those projects that help meet these land use and development goals.

The implementation of various transportation demand management (TDM) measures (e.g., carpools, parking cash-out) and provision of transit will facilitate the land use and VMT reduction goals of other related TLU policy options presented here. The TDM measures are not quantified here, although the costs for transit service necessary to support more compact development are included here (transit is analyzed separately as a stand-alone measure in TLU-7).

Related Policies/Programs in Place

TBD

Type(s) of GHG Reductions

CO₂:

Estimated GHG Reductions and Net Costs or Cost Savings

Table H-6-1. Summary of TLU-6 land use planning and incentives

	2015	2025	Units
GHG emission savings	0.14	0.43	MMtCO ₂ e
Net present value (2006–2025)		–\$598	\$ Million
Cumulative emissions reductions (2006–2025)		3.16	MMtCO ₂ e
Cost-effectiveness		–\$189	\$/tCO ₂ e

GHG = greenhouse gas; MMtCO₂e = million metric tons of carbon dioxide equivalent; \$/tCO₂e = dollars per metric ton of carbon dioxide equivalent. Negative numbers indicate cost savings.

Table H-6-2. Speculative projection of TLU-6 land use planning and incentives for 2050

	2050	Units
GHG emission savings	1.15	MMtCO ₂ e
Net present value (2006–2025)	Net savings	\$ Million
Cumulative emissions reductions (2006–2025)	23.02	MMtCO ₂ e
Cost-effectiveness	Net savings	\$/tCO ₂ e

GHG = greenhouse gas; MMtCO₂e = million metric tons of carbon dioxide equivalent; \$/tCO₂e = dollars per metric ton of carbon dioxide equivalent.

Data Sources:

Total population and population density by Census tract, 1990 and 2000.

Per-capita VMT by Census tract population density in Michigan, from Center for Urban Transportation Research (CUTR) VMT forecasting model.

Forecast statewide population growth.

Transit Cooperative Research Program (TCRP). 2000. "The Costs of Sprawl," TCRP Report 74, National Academy of Sciences.

Growing Cooler, Urban Land Institute, 2007.

Quantification Methods:

The State of Michigan will help growth and development efforts achieve land use goals through a series of policies that includes implementation mechanisms identified below. Scientific research shows that VMT reduction in urban areas is quantifiable through improved planning software. Michigan agencies will assist local and/or regional governments in using the latest planning technology that measures VMT impacts to assist with decision making on future growth and development. The more aggressively the policies are pursued, the greater the potential reduction in VMT.

The quantification effort was most suited to using the parameters stated in the third goal of this measure ("at least 60% of new/future statewide growth utilizes more compact development"), and so the parameters stated in the other goals (e.g., "reduce the conversion of greenfield open land to development 25% by 2015, 50% by 2025, and 80% by 2050") were considered but not explicitly quantified. For example, the percent of growth to occur in low-density development (less than 500 persons/square mile—a proxy for greenfield development) was reduced for 2025 from 34% in the BAU case to 11% in the case of implementing this measure.

This analysis considers potential GHG reductions from fewer personal (noncommercial) VMT as a result of a shift toward more compact development patterns. The analysis relies on estimates of per capita VMT by Census tract population density range, as developed by Polzin, et al. for the Center for Urban Transportation Research (CUTR) VMT forecasting model. The CUTR model is based on analysis of 2001 Nationwide Household Travel Survey data. The model provides estimates of per capita VMT by state for five density ranges. The model is currently set up for years 2005, 2035, and 2055; for this analysis, results were interpolated for Center for Climate Strategies (CCS) analysis years.

The observed relationship between per capita VMT and population density is a rough proxy for the effects of Smart Growth development, as described above. Higher levels of population density are associated with overall shorter trips because destinations are closer together. In addition, areas with higher population densities are more likely to have pedestrian-friendly design (e.g., walkability and mixed-use development) and to support transit service. It is difficult to separate the individual effects of the various Smart Growth strategies at this aggregate level of analysis, but the analysis should provide an indicator of what can be achieved through a combined set of Smart Growth policies.

The specific method used to estimate GHG benefits of Smart Growth strategies is as follows:

- Total population in 2000 is identified by five Census tract density ranges as identified in the CUTR model (<500, 500–1,999, 2000–3,999, 4,000–9,999, and 10,000 or more persons per square mile).
- The change in population from 1990 to 2000, and associated share of change by density range, is identified from Census data.
- For the Baseline scenario, new population growth between 2000 and 2020 (as determined from CCS baseline assumptions) is allocated to tract density ranges based on the share of growth in the 1990–2000 time frame.
- The proportion of existing housing stock (population) that would be redeveloped over this time frame is estimated at 15%, of which two-thirds is redeveloped in place and one-third is redeveloped elsewhere, with this redevelopment allocated to tract density ranges based on the 1990–2000 share of population growth. (The 15% and two-thirds figures come from the 2007 Growing Cooler report, Section 1.7.3, citing analysis of Census data by Nelson [2006]¹³. For the Climate Action scenario, a significant shift in the proportion of new development and relocated redevelopment is assumed to take place, with higher density tracts (>2,000 persons per square mile) receiving 60% of new development under this scenario compared with – 17% (a flight from denser areas) under the Baseline scenario. Total population by tract density under this scenario is then calculated.
- Total personal-travel VMT is calculated under the Baseline and Climate Action scenarios, based on VMT per capita (from the CUTR model) and total 2025 population by tract density range, and the percent reduction in personal-travel VMT is also calculated.
- The percent reduction in VMT is adjusted by 90% to estimate the percent reduction in GHG emissions. This factor is the same as that used in the Growing Cooler report to account for the fact that higher density areas may experience somewhat lower travel speeds and therefore slightly reduced fuel economy.

Costs for implementing land use planning processes (\$79 million) were estimated based on a \$62 million cost for implementing visioning/planning programs in 15 Michigan metropolitan areas/cities for 2010–2025, \$4 million for state policy/code revision and implementation, and \$13 million for municipal policy/code revisions across the state. The provision of additional transit services necessary to support and facilitate land use changes was estimated at \$798 million, assuming a 20% mode share for transit in compact development and transit-oriented development (TOD) locations by using the same cost methodology as applied in TLU-7.

Cost savings for avoided infrastructure provision (roads, water, and sewer) were estimated at \$546 million based on density-derived cost estimates from TCRP Report 74. Fuel cost savings of \$930 million were estimated based on the VMT reductions, a fuel cost of \$3.82 per gallon, and fuel economy projections from the AEO 2007. The net result of the costs and savings was approximately \$600 million in net savings.

¹³ Reid Ewing, Keith Bartholomew, Steve Winkelman, Jerry Walters, and Don Chen. “Growing Cooler: The Evidence on Urban Development and Climate Change.” Urban Land Institute. 2008.

Key Assumptions:

- Fraction of new population growth and redevelopment by Census tract density, under Baseline scenario.
- Assumed shift in the fraction of new population growth and redevelopment from lower-density to higher density Census tracts under Climate Action versus Baseline scenarios.
- Percent of residential building stock redeveloped (off-site) over the analysis time frame.

Key Uncertainties

Smart Growth scenario analysis depends on patterns of development that involve decisions of many individual property owners and private capital investors. As result, the scenarios show what is possible under a development scenario but should not be considered as predicted outcomes.

VMT has remained relatively flat in Michigan since 2002. A variety of factors may be contributing to this, in particular, the economic slowdown seen in Michigan and increases in fuel prices. Changes in local economic conditions and fuel prices could both have significant impacts on VMT in the state.

Advancement in alternative fuel technology and the corresponding use of new fuel sources that either reduce or eliminate GHG emissions by vehicles in Michigan could alter the priority to reduce VMT. Therefore, more holistic and comprehensive land use development patterns that protect Michigan farmland and other natural resources will provide more carbon sinks rather than sources, and thereby further help reduce net GHGs.

The estimates developed using this methodology are consistent with results found in meta-analysis in the published literature, such as the recent *Growing Cooler* report from the Urban Land Institute (ULI). Table H-6-3 shows estimates calculated by using the methodology provided in *Growing Cooler*.

Table H-6-3. Growing Cooler methodology for TLU-6 land use planning and incentives

	2015	2025	Units
GHG emission reductions	0.14	0.41	MMtCO ₂ e
Net present value (2006–2025)		Net savings	\$ Million
Cumulative emissions reductions (2006–2025)		3.08	MMtCO ₂ e
Cost-effectiveness		Net savings	\$/tCO ₂ e

GHG = greenhouse gas; MMtCO₂e = million metric tons of carbon dioxide equivalent; \$/tCO₂e = dollars per metric ton of carbon dioxide equivalent.

Additional Benefits and Costs

Smart growth generally has very low direct costs to implement, such as cost to the government of altering regulations and zoning and the costs of providing education and technical assistance. Tax incentives are an income transfer that results in a public sector cost but offsets developer revenue. As most smart growth policies (e.g., allowing higher density and mixed use, reducing parking requirements) are deregulatory, they are opening the development market and have

significant indirect benefits. An exception is growth boundaries, which restrict the land use market and have an indirect cost.

Alternative patterns of development have a large number of additional impacts, which may provide both benefits and costs. Smart growth provides a range of co-benefits that are well documented elsewhere. Prominent among these is the reduced cost of providing utilities and infrastructure because smart growth makes better use of existing facilities and infrastructure and, on average, has lower demand. Improved air quality, public health (e.g., due to walking), and quality of life are also notable co-benefits.

VMT is considered by some economists to be a leading economic indicator—one that foreshadows the greater economic trend. In the current economic climate, Michigan cannot afford to impose strict cap limits on VMT. The focus must remain on encouraging infill development and more compact or transit-oriented land use patterns, which will in turn lead to reductions in the growth of VMT.

Feasibility Issues

Smart growth policies are being considered and implemented around the country in a wide range of communities. Because most policies are deregulatory in nature, this significantly lowers political barriers.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None cited.

TLU-7. Transit and Travel Options

Policy Description

Reduce the number of single-occupant vehicle trips and improve the efficiency of daily travel by

- Creating, enhancing, and promoting public transit options such as commuter rail, light rail, streetcars, and bus rapid transit;
- Enhancing transit service through route expansion, increased service frequency, longer service hours, and/or better system coordination; and
- Facilitating increased carpooling, vanpooling, biking, and walking.

These actions will reduce GHG emissions by decreasing or slowing the growth of VMT, thus reducing fuel consumption.

Policy Design

Goals: Goals for this policy are as follows (from a 2002 baseline);

- Double transit ridership by 2015 and double it again by 2025 (line-haul systems).
- Double the number of carpool and vanpool participants by 2015 and double again by 2025.

Timing: 2009–2025

Parties Involved: Michigan legislature, MDOT, regional transit operators, local governments, Amtrak, freight railroads, and schools.

Implementation Mechanisms

The following are several actions that would be necessary to achieve the goals listed above.

- Amend the Michigan Constitution to provide a broader range of funding mechanisms for public transit. The section of the Constitution that needs to be addressed is Article IX, section 9. This is the section that dictates the divide between road and transit funding.
- Build additional park-and-ride lots to encourage and enable increased transit ridership. Ensure that these lots have bicycle storage facilities. Also construct carpool lots to provide more opportunity for ridesharing in Michigan.
- Provide incentives for TOD and focus growth in areas already served by transit.
- Incorporate bike lanes into roadway construction and reconstruction plans wherever possible.
- Encourage/require sidewalks in new developments and encourage their addition in areas where they are now absent.

- Implement metropolitan transit plans, including Southeast Michigan’s Transit Vision, Grand Rapids’ Great Transit, Grand Tomorrows study, and other existing plans throughout the state.
- Pursue implementation of inter-city transit service where it is cost-effective and provides the greatest GHG benefits in relation to other transit options.
- Undertake a public education campaign to identify, quantify, and effectively communicate the benefits of public transit to people who don’t currently use it. Such a campaign will be necessary to generate the support needed for local tax initiatives to fund transit improvements.

Related Policies/Programs in Place

Existing transit systems have experienced a 15% increase in urban ridership between 2005 and 2008.

Type(s) of GHG Reductions

CO₂

Estimated GHG Reductions and Net Costs or Cost Savings

Table H-7-1. Summary of reductions from TLU-7

	2015	2025	Units
GHG emission savings	0.13	0.50	MMtCO ₂ e
Net present value (2009–2025)		\$655	\$ Million
Cumulative emissions reductions (2009–2025)		3.54	MMtCO ₂ e
Cost-effectiveness (2009–2025)		\$185	\$/tCO ₂ e

GHG = greenhouse gas; MMtCO₂e = million metric tons of carbon dioxide equivalent; \$/tCO₂e = dollars per metric ton of carbon dioxide equivalent.

Data Sources:

Transportation Research Board. 2001. “Making Transit Work: Insight From Western Europe, Canada, and the United States—Special Report 257,” Washington, DC.

Current and historical transit ridership, by mode type (urban/rural, bus, or paratransit) from National Transit Database.

Marginal Greenhouse Gas Reduction Benefits of Transit, Cambridge Systematics, 2008.

Improving Transportation Choices, Natural Resources Defense Council, 2007.

The Broader Connection between Public Transportation, Energy Conservation and Greenhouse Gas Reduction, ICF International, 2008.

Table H-7-2. Michigan Transit System Data

2006 Michigan Transit Data (NTD)	Mode	Vehicle Or Train Revenue Miles	Unlinked Passenger Trips	Passenger Miles	Operating cost	Fare Revenue	Capital cost	Federal cost share	Total cost	Net Cost/VRM
Detroit Transportation Corporation	Automated									
	Guideway	608,222	2,307,909	3,231,073	12,295,052	991,814				\$ 20.21
Bay Metropolitan Transit Authority	Bus	1,001,407	518,490	2,736,135	4,615,650	612,597				\$ 4.61
Battle Creek Transit	Bus	457,586	517,949	1,854,257	2,578,862	295,541				\$ 5.64
Suburban Mobility Authority for Regional Transportation	Bus	11,437,915	10,684,202	87,025,343	79,829,748	10,121,712				\$ 6.98
Suburban Mobility Authority for Regional Transportation	Bus	337,192	233,537	499,340	0	0				\$ -
Mass Transportation Authority	Bus	2,798,210	4,584,462	15,766,906	11,917,500	1,981,690				\$ 4.26
Interurban Transit Partnership	Bus	3,911,464	7,048,057	26,289,253	21,622,993	3,392,574				\$ 5.53
City of Jackson Transportation Authority	Bus	336,643	559,435	1,622,397	1,550,841	263,011				\$ 4.61
Kalamazoo Metro Transit System	Bus	1,546,154	2,782,397	7,948,428	9,029,419	1,502,367				\$ 5.84
Capital Area Transportation Authority	Bus	2,968,101	9,572,798	25,998,915	22,513,206	3,328,804				\$ 7.59
Muskegon Area Transit System	Bus	432,497	478,873	2,236,337	2,282,930	245,831				\$ 5.28
Saginaw Transit Authority Regional Service	Bus	681,292	687,694	2,730,145	4,690,854	459,237				\$ 6.89
Ann Arbor Transportation Authority	Bus	2,403,730	5,338,018	17,401,939	18,529,134	2,907,408				\$ 7.71
City of Detroit Department of Transportation	Bus	14,949,745	37,083,344	200,196,964	174,619,203	23,444,999				\$ 11.68
Twin Cities Area Transportation Authority	Bus	53,294	17,132	56,394	177,667	6,826				\$ 3.33
City of Holland Macatawa Area Express	Bus	275,870	92,090	328,128	1,007,404	72,434				\$ 3.65
Blue Water Area Transportation Commission	Bus	375,248	495,069	1,286,931	1,715,093	75,515				\$ 4.57
University of Michigan Parking and Transportation Services	Bus	956,788	5,682,304	13,906,872	5,284,619	1,327,051				\$ 5.52
Interurban Transit Partnership	Vanpool	17,821	1,800	62,942	46,824	15,518				\$ 2.63
Interurban Transit Partnership	Vanpool	26,145	921	64,839	46,824	15,518				\$ 1.79
Kalamazoo Metro Transit System	Vanpool	24,531	12,178	197,066	74,254	47,864				\$ 3.03
Total	Total	45,599,855	88,698,659	411,440,604	374,428,077	51,108,311	78,192,296	96,284,513	305,227,548	\$ 6.69

Operating cost per passenger and per passenger-mile, by mode type (urban/rural, bus, or paratransit) from National Transit Database.

Revenue per passenger and per passenger-mile, by mode type (urban/rural, bus, or paratransit) from National Transit Database.

Quantification Methods:

This analysis examines the reductions in GHGs possible by shifting from personal motor vehicles to transit, which emits fewer GHGs per passenger mile. The calculation of GHG reductions must account for the reduction in the number of private VMT and also account for the partially offsetting increase in transit VMT. In addition to these direct reductions from individuals' shift of modes, two more long-term, indirect effects are estimated: (1) the shifting of trips from personal vehicles to transit can reduce the number of vehicles on the road and thus the amount of congestion in urban areas, and (2) reducing congestion improves traffic flow and can improve actual average vehicle fuel economy. Studies have also demonstrated that increased transit service can help shape land use patterns, enabling densities and proximity to the center of urban areas. This has been shown to result in reduced VMT by those living in transit corridors, even if they never use transit.

Direct quantification was undertaken for improvements in service frequency, reductions in travel time, and the introduction of new routes and the expansion of existing routes and services for bus, bus rapid transit (BRT), commuter rail, and vanpools.

Travel time improvements provide a well-documented means of improving transit service and ridership. There is a direct benefit to riders because the improved service reduces the “generalized cost” (time cost plus financial cost) of their trip. In addition to co-benefits in improving service frequency, there is about a -0.4 elasticity for transit travel time.

Service frequency increases ridership by existing riders and attracts new riders. As waiting time between vehicles has been shown to be valued about two times more strongly on average than actual travel time, this mechanism can prove very effective. There is a reported 0.5 elasticity for service frequency alone (time between buses), while the aggregate impacts for service improvements in time between vehicles and travel time have shown an elasticity of between 0.6 and 1.0, incorporating the time and frequency impacts of aggregate increases in service miles provided. The aggregate elasticity, using a value of 1.0, was applied to the total increase in vehicle revenue service miles to capture both factors together.

For service expansions and introduction, both the literature and a first-order statistical analysis show a long-run elasticity for service expansion of between 0.6 and 1.0. An elasticity of 1.0 was applied to service increases.

The total operations and capital costs for providing the additional transit services were totaled and then reduced by the federal cost share for these expenditures. Operating costs, which are very highly correlated with the amount of service being provided, were obtained from the National Transit Database (NTD) for 2006, and average costs per vehicle-mile of service were calculated. Because both capital costs and federal cost sharing are somewhat more volatile from year to year based on current needs, data were obtained for each of these for the 5-year period of

2002–2006 and then averaged to determine typical annual amounts. Based on the historical trends between the provision of service and costs, the latter were calculated to increase proportionately with service (see Key Assumptions).

The cost savings for avoided provision of roads and highways and for vehicle operating cost savings (at the Internal Revenue Service [IRS] reimbursement rate of \$0.505, which incorporates fuel, tires, oil, maintenance, repairs, and depreciation) were then subtracted to provide the above result of approximately \$655 million in net costs.

Key Assumptions:

Transit services can be expanded and introduced at the same average operating cost as current services. A mix in transit modes that includes BRT, commuter rail, and vanpools decreases the average net operating cost of bus service, which is almost the only service being offered.

New or improved services will be able to attract ridership in a manner consistent with service improvements in other similar areas of the country (i.e., the transit market is not at saturation). Current fuel price increases provide a strong argument for this assumption. An elasticity of 1.0 (i.e., that ridership increases proportionately to new service), which is at the high end of the range found in the literature, was selected to model the effects of service expansion. This was selected as the goal of this strategy is to maximize ridership increases. Alternative transit service goals for might include increasing mobility and accessibility to given areas, improving transportation equity, congestion reduction, etc.

Key Uncertainties

Funding availability for the provision of additional transit service is uncertain, especially for the dramatic increases proposed here.

Additional Benefits and Costs

The provision of transit service provides other benefits and cost impacts. The ability of transit to encourage and facilitate land use changes toward more compact development is very important. This benefit is strongest with fixed guideway (rail and BRT) routes but is associated with all transit service. Related to this is the role transit plays in helping to improve the quality of life and attractiveness of cities and to maintain urban populations.

Transit services have a large number of additional impacts which provide additional benefits. Transit service provides mobility, accessibility, and safety benefits that are not included in the analysis above. Important other co-benefits include improved air quality, public health (e.g., due to walking), and quality of life. Transit benefits in reducing congestion and those in facilitating land use patterns such as transit-oriented development and smart growth are very significant and as noted are partially reflected in the analysis above.

Typically, transit service (dominated by bus services, but also for light rail) averages slower travel times for users than personal vehicles.

Feasibility Issues

Funding availability for the provision of additional transit service is uncertain, especially for the dramatic increases proposed here. To a significant extent, the ability to implement this measure depends on the budget and financial condition of the state, and the willingness of state and local policy-makers to provide dedicated, long-term funding for services. The rapid implementation envisioned here may also have barriers in the ability to procure vehicles and build infrastructure rapidly enough.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None cited.

TLU-8. Increase Rail Capacity and Address Rail Freight System Bottlenecks

Policy Description

Michigan can reduce GHG emissions in the transportation sector by encouraging more energy efficient freight movement. Making or facilitating transportation infrastructure improvements that increase rail capacity, support connectivity, and reduce rail freight system bottlenecks will help accomplish this shift.

Most freight shipment is undertaken by the private sector. Truck transportation is the most common means of moving freight in Michigan, but rail transport is more energy efficient. Whether goods move by rail, truck or other modes, private sector shipping decisions are based on the need to ship those goods at the lowest possible cost within an appropriate time frame.

For short hauls, truck freight is, and will likely continue to be, the mode of choice; intermodal rail freight tends to be most effective for trips of 700-800 miles or longer. As the price of diesel fuel continues to increase, however, rail freight will become more cost-competitive, perhaps at shorter distances. Michigan should be prepared to take advantage of this opportunity for both environmental and economic reasons.

Policy Design

Goals: To reduce transportation sector GHG emissions from freight movement by making system improvements with the goal of increasing tonnage of rail freight traveling to, through and from Michigan an additional 50% by 2020.

The most recent data available from the U.S. Department of Transportation (USDOT)¹⁴ indicates that freight tonnage for shipments to, through, and from Michigan is expected to increase from 752 million tons in 2002 to 1540 million tons in 2035, an increase of 105%. Tonnage is expected to increase on all freight modes, but by far the majority of this increase is anticipated to be truck freight, with a projected 576 million ton increase between 2002 and 2035. In the same period, rail freight tonnage is projected to increase by 67.4 million tons.

Increasing the projected tonnage of rail freight an additional 50% by 2020 potentially shifts a projected 17 million tons of cargo that would otherwise travel by truck. Using the national standard of 80,000 pounds¹⁵ as the upper weight limit for trucks, this would potentially remove an estimated 200,000 trucks from the roads.

It is important to recognize that shipping decisions are made by the private sector, and are not under the control of government. Investment to encourage greater use of rail lines and intermodal shipping must be made with that reality in mind.

¹⁴ USDOT State by State Freight Analysis Framework 2.2

¹⁵ Michigan's legal truck weight limits allow for 164,000-pound trucks, but fewer than 5% of the trucks on Michigan's roads travel at that weight.

A variety of approaches will be necessary to accomplish this:

- **Construct Intermodal Terminals:** The use of intermodal containers and intermodal shipping allows many goods to travel by either truck or rail, depending on the length of the trip. Construction or improvement of intermodal terminals in Michigan offers a real opportunity to improve connectivity and encourage the timely and cost-effective shipment of goods by rail rather than truck.
- **Preserve Existing Service:** Michigan's peninsular geography is an obstacle, not only to increasing the capacity of freight rail service but also to preserving existing rail service, particularly in the northern reaches of the state. As part of any policy to improve rail freight service, attention must also be focused on preserving existing rail lines. In the short term, this will require continued state investment in these lines, which often do not generate sufficient revenues for the private sector operator to make adequate investments of its own.
- **Preserve Right-of-Way for Future New Service:** It is unlikely that additional rail freight lines will be constructed in Michigan on new rights-of-way, but for the long term, it is important to keep the option of future rail service available on existing rights-of-way. One means of preserving right-of-way for future rail service, whether freight or passenger, is for the state to continue to expand present efforts to develop abandoned rail lines as trailways.

Timing:

The Detroit Intermodal Freight Terminal project will consolidate and expand a complex of railroad intermodal terminals in the Detroit metropolitan area to accommodate growth through 2025. Improvements will also be made to railroad connections and terminal access roads to improve efficiencies for both trucks and trains. Construction of the project is anticipated to begin in fiscal year 2010 (FY2010) and the full build-out will occur over approximately 10 years. The project is a public-private partnership, with the railroads providing approximately 40% of the estimated \$611.7 million total cost.

The West Detroit Junction rail project involves the construction of a new connecting track at one of the busiest rail junctions in Michigan, which handles 50–60 trains per day. The new track will primarily accommodate Amtrak trains and allow significant improvements in on-time performance. Engineering work for the estimated \$12 million project will begin in summer 2008, with construction beginning in 2009.

Parties Involved: Private sector railroad companies (e.g., Canadian National, CSX Railways, and Norfolk Southern), auto manufacturers, MDOT, Federal Railroad Administration (FRA), Michigan Trails and Greenways Alliance (MTGA), MDNR, and nonmotorized stakeholders

Implementation Mechanisms

As described under "Timing:"

- The Detroit Intermodal Freight Terminal project;
- The West Detroit Junction rail project;
- An additional intermodal terminal outside of the Detroit area; and,

- 250 miles of additional track improvements.
- Preservation of existing system and rights-of-way.

Related Policies/Programs in Place

The Detroit Intermodal Freight Terminal project.

The West Detroit Junction rail project.

Type(s) of GHG Reductions

CO₂

Estimated GHG Reductions and Net Costs or Cost Savings

Table H-8-1. Summary of TLU-8 Analysis

	2015	2025	Units
GHG emission reductions	0.10	0.19	MMtCO ₂ e
Net present value (2009–2025)		\$69	\$ Million
Cumulative emissions reductions (2009–2025)		2.01	MMtCO ₂ e
Cost-effectiveness (2009–2025)		\$35	\$/tCO ₂ e

GHG = greenhouse gas; MMtCO₂e = million metric tons of carbon dioxide equivalent; \$/tCO₂e = dollars per metric ton of carbon dioxide equivalent.

Data Sources:

US Department of Transportation. Highway Statistics, 2006, Federal Highway Administration, Washington DC. <http://www.fhwa.dot.gov/policy/ohim/hs06/index.htm>

U.S. EPA. SmartWay Partnership, available at: <http://www.epa.gov/smartway/>

American Association of Railroads (AAR). September 2007. “National Rail Freight Infrastructure Capacity and Investment Study,” available at: http://www.aar.org/IndustryInformation/National_Capacity_Study/~media/Files/National_CAP_Study_docs/natl_freight_capacity_study.ashx

American Association of State Highway and Transportation Officials (AASHTO). December 2007. “Freight Demand and Logistics Bottom Line Report,” available at: http://downloads.transportation.org/DR_3%20Freight%20Demand_Report-12-07.pdf

American Trucking Association (ATA). October 2007. “Strategies for Further Reduction of the Trucking Industry’s Carbon Footprint.” Sustainability Task Force.

North American Commission for Environmental Cooperation. August 2001. “North American Trade and Transportation Corridors: Environmental Impacts and Mitigation Strategies,” available at: http://www.tam.cec.org/files/PDF/POLLUTANTS/Trade_Corridors_Final-e1_EN.PDF

Texas Transportation Institute. Center for Ports and Waterways. "A Modal Comparison of Domestic Freight Transportation Effects on the General Public." The Texas A&M University System, College Station, TX. December 2007. <http://tti.tamu.edu/documents/TTI-2007-5.pdf>

U.S. DOT. Intermodal Transportation and Inventory Cost – State Tool, available at: http://www.fhwa.dot.gov/policy/otps/061012/iticst_info.htm

Quantification Methods:

Quantification involved the following steps:

Existing rail tonnage was increased linearly from 2011 to 2020 to reach the goal of a 50% increase in rail tonnage. Consistent with the freight commodity mix transported to and from Michigan, the preponderance of this growth is expected to occur from intermodal cargo diverted from trucking. In this analysis, all diversion from rail to truck was considered to be intermodal trailers and containers.

Rail fuel consumption was increased proportionally with tonnage. While in reality rail fuel efficiency is improving, the same is true for trucking, and so the ratio between them, which is what is most important for this analysis, was assumed to remain constant.

The ratio of truck fuel consumption to intermodal rail fuel consumption (including both switch locomotive fuel use, railyard activity, and drayage truck fuel use for the portion of the transportation between the railyard and the origin/final destination) was researched in the literature, and a consensus value of 2.62 was used to calculate truck fuel consumption avoided.

The diesel emission factor of 10,802 grams of CO₂/gallon was used to calculate metric tons reduced.

Costs were identified from the implementation measures above, namely The Detroit Intermodal Freight Terminal project and The West Detroit Junction rail project. Additional costs were estimated as including \$50 million for the additional intermodal terminal(s); this number is consistent with a single large additional intermodal yard or several smaller yards in multiple locations in the state. An average figure of \$2 million/mile was utilized for approximately 250 miles of additional track upgrades. This figure would typically represent signal and train control upgrades but would also include the addition of some rail sidings, double-tracking, system and right-of-way preservation, and/or the alleviation of rail system bottlenecks. These capital costs were then allocated evenly over the years 2011–2020 and discounted to 2005 dollars.

Key Assumptions:

The rate of fuel efficiency improvements for rail and trucks will be similar in future years.

All diversion comes from intermodal rail traffic.

Key Uncertainties

Whether sufficient appropriate cargo exists to allow this increase is uncertain. Because intermodal rail cargo is only a portion of all rail cargo, the rate of increase for this area would actually be significantly higher than 50%.

Additional Benefits and Costs

Modal shifts from truck to rail also provide benefits in congestion reduction, safety, and air quality.

Feasibility Issues

Whether sufficient appropriate cargo exists to allow this increase is uncertain. As intermodal rail cargo is only a portion of all rail cargo, the rate of increase for this area would actually be significantly higher than 50%.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None cited.

TLU-9. Great Lakes Shipping

Policy Description

Marine transportation is the most energy-efficient form of surface transportation to move cargo over long distances (150 miles or more). Michigan's commercial ports typically accommodate 85–95 million tons of cargo annually, most of which are bulk materials including stone, iron ore, coal, and cement. While Great Lakes shipping decisions and services are private sector responsibilities, the public sector has a role in providing navigation channels and related infrastructure.

Policy Design

Goals:

- Reduce transportation sector GHG emissions by maintaining the existing marine infrastructure, including maintaining federal navigation channels to their congressionally authorized depths. Without adequate maintenance of infrastructure, continued operation of some ports or marine terminals is in jeopardy, with a resultant shift of traffic from marine to truck transportation.
- Improve the marine infrastructure by deepening commercial navigation channels at selected commercial ports to Seaway standard depths. This will allow greater cargo volumes to be carried on each vessel and reduce the number of trips needed.
- Encourage the development or expansion of “short sea shipping” (also known as “marine highway”) within the Great Lakes. This could include carrying truck trailers or containers on specialized Great Lakes vessels, which would decrease the number of truck miles driven on the highways. The focus of this policy is on increased shipping within the Great Lakes—not on increasing traffic through the St. Lawrence Seaway.
- Consider the use of ferry boats to move people and cars.
- Consider a biodiesel program at Michigan ports if it is feasible to burn this fuel in marine diesel engines. Other alternative fuels might include wood biomass and garbage.

Timing:

Parties Involved: U.S. Army Corps of Engineers (USACE), Lake Carriers Association.

Other:

Implementation Mechanisms

For infrastructure maintenance, the Governor's office should lobby Congress to appropriate money from the Harbor Maintenance Trust Fund surplus to meet urgent needs in Michigan.

Related Policies/Programs in Place

Federal Harbor Maintenance Trust Fund

Great Lakes policy is shaped in part by the Lake Carriers Association, which represents the shipping companies. This group strongly supports the Jones Act and keeping foreign vessels out of the Great Lakes. The Jones Act prohibits Canadian vessels from picking up and delivering in the United States.

Type(s) of GHG Reductions

CO₂

Estimated GHG Reductions and Net Costs or Cost Savings

The binational Great Lakes St. Lawrence Seaway (GLSLS) system, which includes the St. Lawrence Seaway, stretches over 2,300 miles. The 1959 opening of the Montreal–Lake Ontario (MLO) section of the Seaway was the final step in establishing a navigation system that allows deep draft ocean vessels to move between the Atlantic Ocean and Great Lakes ports. Although traffic volumes in recent years have been about half the peak levels of the 1970s and early 1980s, the Seaway continues to play a key role in the shipment of grain, iron ore, and steel. Seaway trade is particularly important for Canada, which paid more than 70% of the total cost of the original seaway navigation project and continues to play a greater role than its U.S. partner in financing and operating the waterway.

Forecasting future Seaway traffic has historically been problematic because of the multitude of economic and political forces affecting trade, both within the Great Lakes region and beyond.

As the Seaway enters its sixth decade of service, its future role within the Great Lakes transportation system is unclear. This observation does not imply that the waterway has no future role, but rather that this role remains difficult to anticipate because of numerous uncertainties. On one hand, the Seaway's infrastructure is in need of major renovation to ensure its continuing reliability, and the waterway's locks can accommodate only a decreasing fraction of world vessel capacity as the growth of container shipping leads to the building of ever larger vessels. However, the Seaway offers an alternative to increasingly congested land-based routes, particularly for cargo movements, where the relatively long transit times and seasonality of the navigation season can be accommodated. Furthermore, the growth of hub ports for container shipping on North America's eastern seaboard may provide opportunities to develop feeder services into the Great Lakes through the Seaway. The overall influence of global climate change on Seaway navigation is also uncertain, with the possibility that the adverse effects of lower water levels may be offset to some extent by a longer navigation season.

Maintaining navigation channels through the GLSLS depends, in part, on ensuring that all channels in the system have a minimum navigable depth. In addition to dredging, there is also a need to maintain aids to navigation such as buoys, channel markers, and range markers.

Maintenance dredging is needed only in limited sections of the system—proportionally less than is required for other North American navigational systems. Sedimentation is minimal in the majority of the navigation channels and generally consists of recirculation of local sediments. On average, maintaining channel depth costs the equivalent of \$20 million/year for dredging itself and for managing the dredged material. Funding for this work is contingent on congressional approval. To put these statistics in perspective, an average of about 185 million tons annually is

shipped through the GLSLS upstream of Montreal. Dredging 3 million m³/year represents roughly one ton of dredged material for every 40 tons of goods passing through the system.

Of the 2–4 million m³ of annual maintenance dredging, some 10% consists of contaminated sediments. USACE records indicate that some 32% of sediments from maintenance dredging are clean enough to allow for open water disposal, and 12% of the sediments dredged are reintroduced into the coastal zone as beach nourishment. Where containment is required, the development of approved sediment containment sites is both lengthy and costly. As a result, dredging costs in the Great Lakes average \$8/yd³, considerably higher than the average of \$3/yd³ across North America. The capacity of contaminated sediment disposal sites is an ongoing concern for port operators throughout the system. Dredging costs in the St. Lawrence River typically run significantly higher because of a lack of dredging contractors and the higher mobilization costs associated with use of contractors from the Great Lakes. In addition, contaminated upland spoiling of dredged materials is typically required in this area and, if it is contaminated, the dredged material has to be transported to a special landfill.

The annual maintenance dredging needed in Michigan each year is approximately 1 million yd³. The estimated annual cost to do this is \$7.5 million. Shippers pay a tax to recover the costs of such maintenance. This money goes into the Federal Harbor Maintenance Trust Fund, which currently has a \$3–\$4 billion surplus. There is a dredging backlog because these monies are not being appropriated.

Any analysis of the cost of deeper dredging would need to be port-specific. This would involve borings and channel surveys to estimate the cubic yards of material that would have to be dredged. In addition, the dredging cost would vary according to the type of material that would need to be dredged in each port.

Data Sources:

Transportation Research Board. 2008. “Great Lakes Shipping, Trade, and Aquatic Invasive Species,” TRB Special Report 291, Washington, DC.

Winebrake J.J., J.J. Corbett, A. Falzarano, et al. 2008. “Assessing Energy, Environmental, and Economic Trade in Intermodal Freight Transportation,” *Journal of the Air & Waste Management Association (JAWMA)*, 58(08):1004–13.

Great Lakes St. Lawrence Seaway Study. Fall 2007. Transport Canada, U.S. Army Corps of Engineers, U.S. Department of Transportation, The St. Lawrence Seaway Management Corporation, Saint Lawrence Seaway Development Corporation, Environment Canada, U.S. Fish and Wildlife Service. <http://www.glsls-study.com>

Quantification Methods:

The initial analysis of the GHG benefit of providing deeper channels for marine vessel cargo transport is based on a 10% change in the number of trips (and associated fuel consumption) by marine vessels. Based on the 2015 and 2025 Commercial Marine Vessel (CMV) CO₂e emissions, a 10% efficiency improvement in each year from 2015 on would reduce associated GHG emissions by 0.24 MMt in 2015 and 0.27 MMt in 2025.

Table H-9-1 provides CO₂ emission factors from the recent Winebrake et al. JAWMA paper for the three primary freight transport modes. These factors can be used to estimate how shifting 100,000 20-foot equivalent units (TEUs)/shipping containers from rail and truck to ships in Michigan might affect GHG emissions.

Table H-9-1. Data for transport modes for case studies

Mode of Transport	Cost (\$/TEU-mile)	Energy (Btu/TEU-mile)	CO ₂ (g/TEU-mile)	PM-10 (g/TEU-mile)	SO _x (g/TEU-mile)
Truck	0.87	10,704	1,001	0.12	0.22
Rail	0.55	2,590	201	0.09	0.04
Ship	0.50	13,040	1,094	0.98	3.33

\$/TEU-mile = dollars per 20-ft equivalent units-mile; Btu = British thermal unit; CO₂ = carbon dioxide; g/TEU-mile = grams per 20-ft equivalent units-mile; PM10 = particulate matter 10 microns in diameter or smaller; SO_x = sulfur oxides.

Recognize that ships vary significantly in their sizes, speeds and installed power, which means that their energy and emission characteristics vary. The information in Table H-9-1 is based on ship characteristics that have been highlighted favorably in recent Short Sea Shipping reports, because this policy option was intended to represent a short movement of freight. The ship used in this analysis is a roll-on/roll-off vessel capable of speeds up to about 25 knots with about 11,000 kilowatts (kW) of power, which carries about 200 TEUs. Using the characteristics of other vessel groups would produce different results than the comparison shown in Table H-9-1.

The Rochester Institute of Technology and the University of Delaware through the Sustainable Intermodal Freight Transportation Research Program are developing a model that could be used to evaluate the advantages and disadvantages of increased shipping on the Great Lakes. A report on that model should be available in September 2008. The overall approach in this project is the integration of three modal networks (road, rail, and water) in a single geographic information system (GIS) intermodal network. The decision tool that is developed will allow users to conduct route analyses based on various network attributes, including cost, time-of-delivery, distance, energy use, and emissions. The initial work phase will involve constructing the network model for the Great Lakes region and collecting data to characterize cargo flows and their energy and environmental impacts along that network.

Key Assumptions: Noted in discussion.

Key Uncertainties

None cited.

Additional Benefits and Costs

Because of the potential harm of further spreading of aquatic invasive species populations within the Great Lakes near Michigan, increased intra-lake shipping has potential ecosystem costs. These costs include the potential to reduce fish populations and reduce the catch of Michigan's

commercial fishing operations. However, if the ships involved do not leave the Great Lakes and enter the ocean, the potential for harming the commercial fishing industry may be limited.

Shifting freight traffic from truck or rail to marine vessels could increase PM-10 and sulfur dioxide (SO₂) emissions.

Feasibility Issues

Any policy option affecting Great Lakes Shipping needs to consider the effect on aquatic invasive species (AIS). The Transportation Research Board just released Special Report 291: Great Lakes Shipping, Trade, and Aquatic Invasive Species (see Data Sources section). This report evaluates the issues regarding invasive species in the Great Lakes and proposes some recommended actions. The committee's recommendations include a comprehensive technology-based AIS program targeting all vessels transiting the seaway, a requirement for all transoceanic and coastal vessels transiting the seaway to conduct ballast water exchange (BWE) or salt water flushing, the adoption of a single set of ballast water standards for the Great Lakes equivalent to the proposed International Maritime Organization (IMO) ballast water management (BWM) standards, and a binational surveillance program to monitor for the presence of new AIS in the Great Lakes.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Unanimous Barriers to Consensus

None cited.

