The New Hampshire Climate Change Policy Task Force

New Hampshire Climate Action Plan

A Plan for New Hampshire's Energy, Environmental and Economic Development Future

Appendix 7.3:

Transportation and Land Use

Carbon Emissions and Economic Modeling: Approach and Assumptions

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Introduction

This document details the approach taken and the assumptions made in order to provide emissions and economic analyses of potential Actions proposed by the Working Groups and the Task Force. The results of the analyses are presented separately in the Analysis Results table. Detailed descriptions of the potential Actions are presented in the Action Reports produced by the Working Groups.

Total State Emissions Business-as-Usual Model:

The business-as-usual New Hampshire fossil fuel greenhouse gas emissions by sector were projected out to 2050 by extrapolating historical emissions data. Linear extrapolations of 1990-2005 emissions data[1] were used to project emissions in the Transportation, Residential, Commercial, and Industrial sectors. Emissions in the Electricity Generation sector were calculated differently because the historical New Hampshire emissions record is punctuated by large fluctuations due to the expansion and retirement of major generation plants. Linear extrapolation of total New England generation was extrapolated, and future New Hampshire generation was projected based on the assumption that New Hampshire will continue to contribute 17.3% of New England generation. Projected emissions were calculated based on the assumption that all future expansion of New Hampshire generation capacity is provided by natural gas plants.

Carbon Emissions Model:

Light-Duty Model

The light-duty automobile model addresses vehicles of gross vehicle weight rating (GVWR) less than 8,500 lbs. The model explicitly accounts for: vehicle sales rates[2], vehicle retirement rates[3], number of vehicles[4], vehicle age, fuel efficiency[5], vehicle miles travelled[6], and fuel carbon

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[1] EPA report: "Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2006"
[2] http://www.nada.org/NR/rdonlyres/C18D7380-0175-4D46-BC65-AF2AA8A2C268/0/NADA_DATA_2007_NewVehicle_Department.pdf ; http://www.econstats.com/autos/wauto_a.htm
[3] Based on analysis by Chris Skoglund, NH DES, using equations from Mobile 6 model and NH registration and NADA data.
[4] Number of vehicles is modeled as the result of annual vehicle gains (new vehicle sales) and losses (vehicle retirements). Vehicle in-migration (the net addition of cars to the state resulting from population migration) was analyzed using NH Office of Energy and Planning data and was found to represent approximately 0.4% of total vehicles. Because vehicle in-migration is relatively difficult to predict and has a negligible effect on the total number of vehicles, it was not incorporated in the model.
[5] http://dmses.dot.gov/docimages/pdf99/426721_web.pdf
[6] http://www.eia.doe.gov/emeu/rtecs/chapter3.html ; http://www.fhwa.dot.gov/policy/ohim/hs02/vm1.htm
Annual VMT reduction per year of vehicle age from analysis by Chris Skoglund, NH DES, from Mobile 6 model.

intensity[7]. Cars and light trucks are modeled separately. New vehicles, with characteristic fuel efficiency and vehicle miles traveled, are 'added' to the model according to sales rates. These vehicles age each year and are eventually removed from the model according to retirement rate distribution. Tables 1 and 2 present the values for some of these parameters which were determined and projected from best available state (Department of Motor Vehicles, NH Department of Transportation) and national (National Automobile Dealers Association, Federal Highway Administration) data. Fuel efficiency (historical and projected CAFE) and fuel carbon intensity values (Table 3) were applied to the VMT traveled by each vehicle age and to calculate emissions.

Heavy-Duty Model

The heavy-duty vehicle model addresses vehicles of GVWR greater than 8,500 lbs. The model allocates heavy-duty vehicle miles traveled into heavy single-unit trucks and combination trucks. 2.4% and 2.2% annual increases in total VMT were applied to heavy single-unit trucks and combination trucks, respectively, based on Transportation Data Energy Book tables[8]. Table 4 presents the values for selected parameters determined from best available state (Department of Motor Vehicles, NH Department of Transportation) and national (Transportation Data Energy Book) data. Fuel efficiency and fuel carbon intensity values (Table 3) were applied to the VMT to calculate emissions.

[7] http://www.eia.doe.gov/oiaf/1605/coefficients.html
[8] http://cta.ornl.gov/data/index.shtml

	Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2020	2030	2040	2050
sales growth rate																	
1.20%	**Cars and Small SUV Sales**	48,502	49,329	46,963	45,182	42,431	41,852	42,748	43,385	46,558	47,117	47,682	48,254	54,368	61,256	69,016	77,760
1.20%	**Trucks and SUV Sales**	45,706	47,410	48,506	48,590	50,322	52,193	51,735	48,627	46,558	47,117	47,682	48,254	54,368	61,256	69,016	77,760
	Number of Cars and Small SUVs	656,685	660,801	662,390	662,266	659,770	657,283	656,108	655,411	657,301	659,159	661,157	663,409	723,341	817,091	920,610	1,037,244
	Number Trucks and SUVs	462,871	475,647	489,456	503,246	518,586	535,495	551,485	563,720	573,037	581,872	590,073	597,537	648,260	724,164	815,909	919,278
	Car and Small SUV MPG New Car Fuel Efficiency	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5
	Truck and SUV MPG New Car Fuel Efficiency	20.7	20.7	20.7	20.7	20.7	20.7	21.0	21.6	22.2	22.7	23.4	23.7	23.7	23.7	23.7	23.7
annual VMT %reduction	**Car and Small SUV VMT/vehicle**																
2.8%	new	15,082	15,086	15,162	15,310	15,529	15,819	16,181	16,614	17,119	17,119	17,119	17,119	17,119	17,119	17,119	17,119
annual VMT %reduction	**Truck and SUV VMT/vehicle**																
2.8%	new	15,082	15,086	15,020	14,881	14,671	14,390	14,037	13,613	13,117	13,117	13,117	13,117	13,117	13,117	13,117	13,117
	Car and Small SUV Total VMT																
	TOTAL CAR VMT (million miles)	7,537	7,696	7,811	7,896	7,944	7,991	8,063	8,154	8,306	8,451	8,591	8,728	10,224	11,602	13,072	14,728
	AVERAGE VMT / CAR (miles)	11,477	11,646	11,792	11,923	12,040	12,158	12,290	12,441	12,636	12,820	12,994	13,157	14,134	14,199	14,199	14,199
	Truck and SUV Total VMT																
	TOTAL TRUCK VMT (million miles)	5,510	5,759	6,009	6,239	6,470	6,698	6,884	6,987	7,023	7,049	7,066	7,076	7,193	8,011	9,026	10,170
	AVERAGE VMT / TRUCK (miles)	11,904	12,109	12,277	12,398	12,477	12,508	12,482	12,395	12,255	12,114	11,976	11,841	11,096	11,062	11,062	11,062

Table 1: Selected parameters used in NH Light-Duty BAU model

Table 2: Vehicle retirement rates used in NH Light-Duty BAU model[9]

Vehicle age [years]	Car scrap rate	Truck scrap rate
1	0.0%	0.0%
2	0.0%	0.2%
3	0.0%	0.6%
4	0.1%	1.2%
5	0.3%	2.0%
6	0.7%	3.0%
7	1.2%	4.3%
8	2.0%	5.8%
9	3.1%	7.5%
10	4.6%	9.5%
11	6.5%	11.8%
12	9.1%	14.3%
13	17.8%	17.2%
14	26.1%	20.4%
15	26.1%	24.0%
16	26.1%	27.9%
17	26.1%	32.3%
18	26.1%	37.1%
19	26.1%	42.4%
20	26.1%	48.2%
21	26.1%	54.6%

Table 3: Carbon intensity of automotive fuels (EIA)

Emissions factors [lb CO2/gallon]	
Gasoline	19.564
Diesel	22.384

Table 4: Selected parameters used in NH Heavy-Duty BAU model[10]

VMT (million miles/year)	
Heavy Duty Gasoline Vehicles	495.9
Heavy Duty Diesel Vehicles	720.7

Truck Lifetime	
20	useful life of trucks in US (years)
5%	Annual fleet turnover percentage

Fuel Economy (MPG)	
Heavy single-unit trucks [gasoline]	8.8
Heavy single-unit trucks [diesel]	8.8
Combination trucks [diesel]	5.9

	2006	2007	2008	2009	2010	2020	2030	2040	2050
BAU NH Vehicle Miles (millions) [2005]									
Heavy single-unit trucks	443	453	464	475	487	617	782	991	1257
Combination trucks	802	819	837	856	874	1087	1351	1680	2088

[9] Based on analysis by Chris Skoglund, NH DES, using equations from Mobile 6 model and NH registration and NADA data.
[10] Total NH Heavy Duty Vehicle miles from Highway Performance Monitoring System data.

Emission Reduction Potential Calculation Assumptions:

TLU Action 1.A.1 - Support Stricter Corporate Average Fuel Economy Standards
Combined average fuel economy of new cars and light trucks linearly phased in to 35, 40, 45, or 50 MPG by 2020.[11]

TLU Action 1.A.2 – Support Fuel Economy Standards for Heavy-Duty Vehicles
Fuel efficiency improvement of 58% applied at annual fleet turnover percentage.[12]

TLU Action 1.A.3 - Adopt California Low Emission Vehicle (CALEV) Standards
Applied CALEV standards[13] for new cars tabulated below. Subtracted from a separate light duty business-as-usual case based on a characterization of current average total CO_2-equvialent emissions (g/mi).[14]

Tier	Year	CO2-equivalent emission standard (g/mi)	
		PC/LDT1 (Passenger cars and small trucks/SUVs)	LDT2 (Large trucks/SUVs)
Near-term	2009	323	439
	2010	301	420
	2011	267	390
	2012	233	361
Mid-term	2013	227	355
	2014	222	350
	2015	213	341
	2016	205	332

TLU Goal - 1.B: Influence Consumer Demand for Higher Fuel Economy Vehicles.

TLU Action 1.B.1 - Create a Point-of-Sale Financial Incentive for Higher Efficiency Vehicles
Modeled as a 14% and 22% increase in new light duty vehicle fuel efficiency (resulting from a new car point of sale cost differential of $500 and $1000 per 0.01 gallon per mile, respectively).[15]

TLU Action 1.B.2 - Implement a Carbon-Based Vehicle Registration Fee Structure
Modeled as a 14% and 22% increase in new light duty vehicle fuel efficiency (resulting from a new car registration fee differential of $500 and $1000 per 0.01 gallon per mile, respectively).[16]

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[11] CAFE levels suggested by working group.
[12] Fuel economy targets from American Council for Energy Efficient Economy - Energy Savings Through Increased Fuel Economy for Heavy-Duty Trucks, February 11, 2004 (Table 2).
http://www.bipartisanpolicy.org/files/news/finalReport/III.4.a%20-%20Heavy-Duty%20Trucks.pdf
[13] California Pavely Amendment Fact Sheet.
[14] California Pavely Amendment Fact Sheet.
[15] ORNL report: Greene, D, P. Patterson, M.Singh, and J. Li. 2005. "Feebates, Rebates and gas-Guzzler Taxes: A Study of Incentives for Increased Fuel Economy." Energy Policy, 33 (6): 757-775.
[16] ORNL report: Greene, D, P. Patterson, M.Singh, and J. Li. 2005. "Feebates, Rebates and gas-Guzzler Taxes: A Study of Incentives for Increased Fuel Economy." Energy Policy, 33 (6): 757-775.

TLU Action 1.C.1. - Adopt a Low-Carbon Fuel Standard
Assumed fuel contains 10% less carbon per gallon by 2025, linearly phased in from year 2015.[17]

TLU Action 1.C.2. - Promote Advanced Technology Vehicles and Supporting Infrastructure
Complementary action but not individually quantified.

Electric Cars
Linear growth in electric car sales as a percentage of total Light Duty vehicle sales is modeled in four scenarios: 1% by 2020 (3.5% by 2050), 5% by 2020 (17.5% by 2050), 10% by 2020 (35.0% by 2050), and 20% by 2020 (70.0% by 2050). Electric Car retirement rates and VMT/year are calculated as the average of "Car and Small SUV" and "Truck and SUV values" so that total vehicles and total VMT remain constant between electric car scenarios and the BAU.

Electric car efficiency is assumed to be 3.5 miles/kWh.[18] Note: it is assumed that electric cars are charged off-peak. The implementation of electric cars may require 'Smart Grid' technologies, but these technologies are not investigated in this limited study.

TLU Action 1.C.3. - Install Retrofits to Reduce Black Carbon Emissions
An emissions factor of 0.0000081987 short tons of black carbon/gallon was assumed. Black carbon emissions were multiplied by 2 to calculate black carbon + organic matter (which are emitted at a ratio of 1:1). The ratio of warming impact of fossil fuel black carbon plus organic matter to CO_2 ranges from 220:1 to 500:1. The model uses the central value of 360:1.[19]

All solutions assume retrofit of all heavy duty diesel vehicles by 2025 (linearly phased-in from 2009). Modeled for 3 types of retrofits: Diesel Oxidation Catalysts (DOCs) which reduce PM by 25%, Flow through Filters (FTFs) which reduce PM by 50%, and Active Diesel Particulate Filters (DPFs) which reduce PM by 85% but increase diesel fuel use 3%.[20]

[17] Reduction level and phase-in period suggested as feasible by TLU Working Group.
[18] Pluginamerica.org
[19] http://www.ccap.org/Connecticut/2003-Oct-24--CT--Transp--Diesel_Black_Carbon--Fact_Sheet.pdf; Mark Z. Jacobson, "Control of fossil-fuel particulate black carbon and organic matter, possibly the most effective method of slowing global warming," Journal of Geophysical Research, Vol. 107, No. D19, p. ACH 16-1 to 16-22, 2002.
[20] http://www.ccap.org/Connecticut/2003-Oct-24--CT--Transp--Diesel_Black_Carbon--Fact_Sheet.pdf; Mark Z. Jacobson, "Control of fossil-fuel particulate black carbon and organic matter, possibly the most effective method of slowing global warming," Journal of Geophysical Research, Vol. 107, No. D19, p. ACH 16-1 to 16-22, 2002.

TLU Action 1.D.1. Reduce Speed limits

- Enforce Current Speed Limits on Highways
Modeled as a reduction in average highway speed from 70 to 65, resulting in a 8.2% efficiency gain. [21] Efficiency gains applied only to highway miles (40% of total VMT).[22]

- Lower Posted Speed Limits on Highways
Modeled as a reduction in average highway speed from 70 to 55, resulting in a 17.1% efficiency gain.[23] Efficiency gains applied only to highway miles (40% of total VMT).[24]

TLU Action 1.D.2. Reduce Vehicle Idling
Based on average emissions savings per avoided idling hour.[25] Total number of heavy duty truck idling hours in New Hampshire estimated from: annual average idled hours per truck and annual average mileage per truck.[26] Estimation of total annual heavy duty VMT described above.

89	MTCO2e avoided from avoiding 10,000 hours of idling
0.0089	MTCO2e avoided per avoided idling hour
250	average hours idled per year per truck
111,631	Annual milage per truck
0.00224	average hours idled per mile travelled

Results show that total emissions from *all* idling of single-unit and combination unit trucks is approximately 0.03, 0.04, and 0.07 $MMTCO_2e$/year in 2012, 2025, and 2050 respectively. Truck stop electrification could only act to reduce a fraction of the total heavy duty fleet idling. The carbon emissions savings are reported as a 50% reduction in total heavy duty fleet idling emissions.

TLU Action 1.D.3. Improve Traffic Flow
Assumes a 1% fuel efficiency gain for the portion of NH fleet in the 4 most populated counties (i.e., for roughly 70% of NH fleet or total NH VMT, based on 2000 Census population figures and assuming that VMT distribution is closely related to population distribution) resulting from all

[21] Estimates for the effect of speed on MPG are based on a study by West, B.H., R.N. McGill, J.W. Hodgson, S.S. Sluder, and D.E. Smith, *Development and Verification of Light-Duty Modal Emissions and Fuel Consumption Values for Traffic Models*, Oak Ridge National Laboratory, Oak Ridge, Tennessee, March 1999.
[22] From NH Department of Transportation data.
[23] Estimates for the effect of speed on MPG are based on a study by West, B.H., R.N. McGill, J.W. Hodgson, S.S. Sluder, and D.E. Smith, *Development and Verification of Light-Duty Modal Emissions and Fuel Consumption Values for Traffic Models*, Oak Ridge National Laboratory, Oak Ridge, Tennessee, March 1999.
[24] From NH Department of Transportation data.
[25] Center for Clean Air Policy: Transportation Emissions Guidebook Part Two: Vehicle Technology and Fuels, Section 1.9.
[26] Heavy-Duty Truck Idling Characteristics: Results from a Nationwide Truck Survey, Nicholas Lutsey, Christie., Joy Brodrick, Daniel Sperling, and Carollyn Oglesby; Transportation Research Record: Journal of the Transportation Research Board No. 1880, 2004.

improvements to traffic flow (e.g., traffic signalization, roundabouts, access management). This fuel efficiency gain is modeled to reach full effectiveness (0.7% increase in fuel efficiency of NH light duty fleet) by 2025, with continuing investments to sustain this reduction going forward.[27]

TLU Action 1.D.4 - Reduce Emissions through Enhanced Vehicle Inspection Programs
Modeled as 50% of new vehicle sales being 3% more efficient than BAU.[28]

TLU Goal 2 - Reduce Vehicle Miles Traveled
Applied reductions of 5, 10, 20, 30, 40, and 50% in vehicle miles travelled, separately for light duty and heavy duty vehicles[29]. These goals will be reached by implementing a combination of supporting actions. The carbon emissions savings resulting from supporting actions are individually quantified where possible.

TLU Action 2.A.1. Implement Commuting Trip Reduction Initiative
Modeled as 3% reduction in light duty VMT for lower 4 counties (about 70% of total NH VMT) from a broad Commuting Trip Reduction initiative phased in by 2025 and continuing at same level through 2050. This is equivalent to a 2.1% reduction in light duty VMT statewide.

This VMT reduction estimate is based in part on 2000 Census population estimates. Roughly 70% of NH's population lives in the 4 southern-southeastern counties: Hillsborough, Merrimack, Rockingham and Strafford. This action is applied to these areas only because these counties are expected to have greater travel options available to them in the near future than other parts of NH.[30]

TLU Action 2.A.2 - Implement Congestion Pricing
This action is assumed to only affect light-duty vehicle (~90% of vehicles on toll roads) commuter travel during peak periods (equals ~27% of VMT) (non-commuter travel is assumed to shift to other times of day rather than move to alternative modes) on the interstate highway system (equals ~30% of VMT) in the four most populated counties within NH (70% of population). An elasticity of -0.1 is assumed, given the limited availability of alternatives for travel. So, total VMT affected by congestion pricing is calculated as: Affected VMT = [(((Total NH VMT*0.7)*0.9)*0.3)*0.27 = 5% of Total NH VMT. A $1 increase per toll is about a 100% increase in the price of tolls, resulting in a 10% decline in travel (with elasticity of -0.1). A 10% reduction of travel affecting 5% of total NH VMT results in a 0.5% reduction in total NH VMT.[31]

[27] 1-4% fuel savings with traffic light optimization from Center for Clean Air Policy Guidebook: http://www.ccap.org/safe/guidebook/guide_complete.html
[28] http://www.ccap.org/safe/guidebook/guide_complete.html
[29] Suggested by TLU Working Group.
[30] Apogee (1994), Costs and Cost Effectiveness of Transportation Control Measures; A Review and Analysis of the Literature, National Association of Regional Councils (www.narc.org). Various individual techniques were estimated to result in 3-12% reduction in VMT. VMT reduction scenario based on NHDES analysis.
[31] Victoria Transport Policy Institute (updated August 2008 - http://www.vtpi.org/tdm/tdm35.htm), indicate a price elasticity of –0.1 to –0.4 for urban highways (10% increase in toll rates reduces vehicle use by 1-4%), depending on a number of factors. Interstate VMT in the four most populated counties is about 30% of total VMT in those counties (HPMS 2002 data). USDOT, FHWA, Summary of Travel Trends: 2001 National Household Travel Survey

TLU Action 2.A.3 - Create a VMT-Based Insurance Premium Structure
Modeled as a range of reductions in total light duty VMT (2.7%, 5%, and 7%).[32]

TLU Action 2.A.4 - Implement VMT-Based Vehicle Registration Fees
Modeled as a range of reductions in total light duty VMT (2.7%, 5%, and 7%).[33]

TLU Action 2.A.5 - Increase the State Gasoline Tax
Assumed that with a $1 increase in the price of fuel (about a 36% increase), VMT is reduced by 4% in 2012, 11% in 2025, and 18% in 2050, (assuming elasticities of -0.1, -0.3, and -0.5, respectively).[34]

TLU Action 2.B.1.a - Expand Local/Intra-Regional Transit (Bus) Service
Calculated with TLU Action 2.B.1.b. (see description below under 2.B.1.b.)

TLU Action 2.B.1.b - Improve Existing Local/Intra-Regional Transit (Bus) Service
Roughly 1.2-2.6 million additional trips are associated with the improvements and expansion of local/intra-regional bus service (NHDOT 2008). Assuming an average 10 mile trip ("Average trip length, all purposes" from NHTS, 2004), a 26 million mile reduction in annual VMT is estimated by 2012 (assuming a high degree of land use coordination occurs). By 2025, increased bus ridership could reduce passenger VMT in the 4 most-populated counties (assumed to represent 70% of total NH VMT based on 2000 Census population distribution) by 5% with increased transit (assuming NH attains national average for % trips on transit - roughly 5% of all trips 2000-2004 from USDOT). Approximately 50% of this reduction is attributed to local/intraregional transit, assuming 85% of trips are local/regional with an average length of 10 miles. Approximately 15% of this reduction is attributed to inter-regional trips with an average length of 45 miles (based on US Census data indicating that roughly 15% of commuters working outside of their county of residence and roughly 15% having travel times greater than 45

(Dec 2004) indicates that commute VMT is about 27% of total VMT. NHDOT toll data (Bureau of Turnpikes FY 2008 data) indicates that roughly 90% of toll traffic is light-duty automobiles.

[32] Jason E. Bordoff and Pascal J. Noel (2008), Pay-As-You-Drive Auto Insurance: A Simple Way to Reduce Driving-Related Harms and Increase Equity, The Brookings Institution (www.brookings.edu); at www.brookings.edu/~/media/Files/rc/papers/2008/0417_payd_bordoff/0417_payd_bordoff.pdf. Driving reduction from PAYD insurance for NH specifically is 7% with a 5.9¢ premium per mile according to Bordoff and Noel, 2008. Todd Litman (2001), Distance-Based Vehicle Insurance Feasibility, Benefits and Costs: Comprehensive Technical Report, VTPI (www.vtpi.org); at www.vtpi.org/dbvi_com.pdf. VMT based registration creates a 2.7% reduction in VMT with a 1.5¢ premium per mile (Litman, 2001).

[33] Jason E. Bordoff and Pascal J. Noel (2008), Pay-As-You-Drive Auto Insurance: A Simple Way to Reduce Driving-Related Harms and Increase Equity, The Brookings Institution (www.brookings.edu); at www.brookings.edu/~/media/Files/rc/papers/2008/0417_payd_bordoff/0417_payd_bordoff.pdf. Driving reduction from PAYD insurance for NH specifically is 7% with a 5.9¢ premium per mile according to Bordoff and Noel, 2008. Todd Litman (2001), Distance-Based Vehicle Insurance Feasibility, Benefits and Costs: Comprehensive Technical Report, VTPI (www.vtpi.org); at www.vtpi.org/dbvi_com.pdf. VMT based registration creates a 2.7% reduction in VMT with a 1.5¢ premium per mile (Litman, 2001).

[34] Victoria Transport Policy Institute (updated August 2008) "Fuel Taxes: Increasing Fuel Taxes and Fees" http://www.vtpi.org/tdm/tdm17.htm.

minutes). By 2050, increased transit service is assumed to reduce VMT in the 4 counties by 10%, of which 50% is attributed to local/intraregional transit. The 50-50 split for intercity and local travel is further supported by 2002 HPMS data, which indicate that about 50% of VMT is associated with interstate and lane highway travel.[35] Based on these assumptions, total statewide VMT is modeled to be reduced by 0.16%, 1.8%, and 3.5% in 2012, 2025, and 2050 respectively.

TLU Action 2.B.1.c - Expand and Improve Bicycle and Pedestrian Infrastructure
Modeled as a 1.4% reduction in light duty VMT (2% reduction of VMT in 4 populated counties accounting for 70% of total VMT), linearly phased-in by 2025 and constant from 2025 to 2050.[36]

TLU Action 2.B.2.a - Maintain and Expand Passenger Rail Service
According to NHDOT, up to roughly 3.1 million additional trips are associated with the improvements and expansion of passenger rail from Newburyport to Kittery and Lowell to Manchester and improved/new intermodal facilities serving both bus and rail. Assuming each rail trip offsets a 45 mile trip by Single Occupancy Vehicle (SOV), this is equivalent to a 0.8% reduction in VMT, which could be achieved between 2020-2025 (negligible reductions could be achieved by 2012). By 2025, it is assumed that increased transit service of all types (bus and rail) reduces VMT from the 4 most populated counties (assumed to represent 70% of total NH VMT) by 5% (assumes NH attains national average for % trips on transit - roughly 5% of all trips 2000-2004, USDOT). 50% of this reduction is attributed to inter-city transit and rail (assuming 85% of trips are local/regional with an average length of 10 miles). 15% is attributed to inter-regional trips with an average length of 45 miles (based on US Census data indicating that roughly 15% of commuters working outside of their county of residence and roughly 15% having travel times greater than 45 minutes). By 2050, increased transit service is assumed to reduce VMT in the 4 counties by 10%, of which 50% is attributed to inter-regional transit and rail (25% to rail alone). The 50-50 split for intercity and local travel is further supported by 2002 HPMS data, which indicate that about 50% of VMT is associated with interstate and lane highway travel.[37]

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[35] NHDOT 2008. Draft Final Bus Transit Needs Analysis for Long-Range Transportation Plan – Technical Memo calculations. Provided to NHDES by NHDOT.
National Household Travel Survey, FHWA, http://nhts.ornl.gov/2001/pub/STT.pdf US. Department of Transportation (USDOT), Research and Innovative Technology Administration, Bureau of Transportation Statistics, http://www.bts.gov/publications/journal_of_transportation_and_statistics/volume_08_number_03/html/paper_03/figures_03_06.html

[36] Pedestrian-oriented design is estimated to reduce site-level VMT by 1%; Bicycle improvement policies are estimated to reduce area-wide VMT by 1-5% (http://www.ccap.org/safe/guidebook/guide_complete.html).

[37] NHDOT 2008. Draft Final Bus Transit Needs Analysis for Long-Range Transportation Plan – Technical Memo calculations. Provided to NHDES by NHDOT. US. Department of Transportation (USDOT), Research and Innovative Technology Administration, Bureau of Transportation Statistics, http://www.bts.gov/publications/journal_of_transportation_and_statistics/volume_08_number_03/html/paper_03/figures_03_06.html Association of American Railroads (www.aar.org/PubCommon/Documents/AboutTheIndustry/RRState_NH.pdf), indicates that in 2006 there were 96,124 carloads through NH, totaling 7,590,551 tons. Traffic originating or terminating in NH was 2,064,011 tons.

TLU Action 2.B.2.d -Implementation Recommendations of the I-93 Transit Investment Study

NHDOT estimates ridership levels to be 10,200-10,400 people daily (roundtrip) on either bus-on-shoulder or rail service at $2.50 per gallon of gasoline. Ridership was estimated to increase by 16% at gas prices of $5/gallon. Assuming each trip replaces an average 90 mile trip by SOV, this action reduces VMT in 2012 by about 340 million, or about 2.1% from BAU. It is assumed that bus-on-shoulder is implemented immediately, and either continued or replaced with rail service, and will maintain a constant % reduction in VMT over time.[38]

TLU Action 2.B.2.e - Expand Park-and-Ride Infrastructure

NH currently has 28 park and ride locations with over 4000 spaces (with 56% usage). By 2012, 1,150 additional spaces will be available (7% increase in spaces/year). The model assumes an average usage of 75% of the proposed facilities (approximately 3,863 spaces used per day on average) in 2012. The model also assumes that each use of a space displaces a 60 mile roundtrip by SOV (average trip by park-and-ride user is assumed to be slightly longer than the average trip length for NH). In 2012, this is modeled to result in a 0.8% reduction in total statewide VMT would be reduced. Assume continued expansion of park-and-ride facilities to maintain 0.8% VMT reduction through 2050.[39]

TLU Action 2.B.2.g - Expand Inter-City Bus Service

Calculated with TLU Action 2.B.2.h. (see description below under 2.B.2.h.)

TLU Action 2.B.2.h - Improve Existing Inter-City Bus Service to Increase Ridership

Based on NHDOT 2008, roughly 893,000 additional trips are associated with the immediate improvements and expansion of inter-city bus service. A 40 million mile reduction in annual VMT by 2012 is estimated assuming an average trip length of 45 miles (assuming a high degree of land use coordination occurs). By 2025, increased bus ridership is modeled to reduce passenger VMT in the 4 most-populated counties (assumed to represent 70% of total NH VMT) by 5% with increased transit of all forms (assuming NH attains national average for % trips on transit - roughly 5% of all trips 2000-2004, USDOT). Approximately 50% of this reduction is attributed to inter-city transit (estimate assumes 85% of trips are local/regional, with an average length of 10 miles, and 15% are inter-regional trips with an average length of 45 miles based on US Census data indicating that roughly 15% of commuters working outside of their county of residence and roughly 15% having travel times greater than 45 minutes). By 2050, increased transit service is assumed to reduce VMT in the 4 counties by 10%, of which 50% is attributed to inter-regional transit and rail (25% to inter-regional bus). The 50-50 split for intercity and local travel is further supported by 2002 HPMS data, which indicate that about 50% of VMT is associated with interstate and lane highway travel.[40] Based on these

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[38] NHDOT communication (see Action Evaluation Report) based on preliminary results of I-93 Transit Investment Study. This action overlaps (partially) other 2B actions involving rail and bus service expansions.

[39] NHDOT 2008. Draft Final Bus Transit Needs Analysis for Long-Range Transportation Plan – Technical Memo calculations. Provided to NHDES by NHDOT.

[40] NHDOT 2008. Draft Final Bus Transit Needs Analysis for Long-Range Transportation Plan – Technical Memo calculations. Provided to NHDES by NHDOT. US. Department of Transportation (USDOT), Research and Innovative Technology Administration, Bureau of Transportation Statistics,

assumptions, total statewide VMT is modeled to be reduced by 0.25%, 0.9%, and 1.8% in 2012, 2025, and 2050 respectively.

<u>TLU Goal 2.C - Develop Land Use Patterns that Support a Balanced Multi-Modal Transportation System and Reduce Vehicle Miles Traveled</u>
Three estimates represent (1) directing in-community only growth to their center areas [0%, 0.5%, and 2% reduction in light duty VMT in 2012, 2025, and 2050 respectively]; (2) directing 60% of all NH growth to center areas of 14 largest, densest communities in central/southern/southeastern NH with walkable design and an integrated mix of uses [0%, 4%, and 8% reduction in light duty VMT in 2012, 2025, and 2050 respectively]; and (3) directing 90% of total NH growth to these 14+ centers [0%, 7%, and 11% reduction in light duty VMT in 2012, 2025, and 2050 respectively]. White paper on estimates and current land use patterns/transportation in NH forthcoming from Carolyn Russell, NHDES.

Economic Model:

The CSNE economic modeling team took an "efficient analysis" approach to estimating the economic impacts of different actions proposed by the working groups, given the many different policy options considered. The modeling assumptions used in estimating economic costs and benefits are provided below.

The objective of the economic analysis was to estimate approximate "levels of magnitude" of the economic impacts of each proposed action item. Given the short time frame of analysis and large number of action items under consideration, this economic analysis is not as detailed as previous UNH economic studies of RPS and RGGI. It is instead meant to provide economic context to assist in the decision making process for the task force.

The analysis provided for the task force is limited to direct New Hampshire costs/benefits and does not include assessment of society wide impacts. As much as possible, direct employment impacts are estimated along with costs and benefits. The analysis does not consider potential benefits associated with actions such as reduced health costs due to reduced air pollution emissions and also does not include avoided costs in calculating economic impacts.

However where appropriate, an economic multiplier was used to estimate the broader state-wide economic impacts of cost savings, such as for reduced fuel consumption. An economic multiplier is used to estimate economy-wide impacts of specific economic changes. The UNH Economic team—based on its significant knowledge of the NH economy and to be conservative—chose a $1 economic multiplier for each $1 of savings attributed to an action.

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http://www.bts.gov/publications/journal_of_transportation_and_statistics/volume_08_number_03/html/paper_03/figures_03_06.html

The assumptions section discusses whether the economic multiplier was applied to any given action. The 1:1 multiplier is considered conservative.[41]

The economic analysis does not discount costs and benefits of climate change policies to reflect timing or uncertainty. This is consistent with the approach used for NH RGGI and RPS analysis and used in the Stern Report. Ken Arrow, Nobel Laureate Economist, reviewed the Stern Report[42] and concluded that discounting for time and uncertainty did not change conclusions.[43]

In the analysis spreadsheet summarizing the carbon and economic impacts of each action item, levels of magnitude and qualitative information are provided, not precise figures for costs and benefits or the exact timing of those costs and benefits. The economic analysis section below provides an overview of the approach and assumptions use to model the economic costs and benefits of each action.

To help provide some context for the expected costs and benefits, the New England Economic Partnership forecasts that New Hampshire's Gross Domestic Product (GDP) will be $58 billion dollars in 2012. The NH GDP is the most comprehensive measure of NH economic activity and is calculated for all states by the U.S. Bureau of Economic Analysis.

Implementation Costs

- Low — 0-$2.5 million
- Moderately Low — $2.5 million to $25
- Moderate — $25 million to $125 million
- Moderately high — $125 million to $500 million
- High — $500 million to $1 billion
- Very high — Greater than $1 billion

- Uncertain: Economic implementation costs were not easily determined without significant research beyond the scope of this part of the analysis.
- Study: Means that the action proposed by the working group is a study to further look at issue, this is meant to avoid confusion in comparison of the costs of different actions.

Potential economic benefits

- Low — 0-$2.5 million
- Moderately Low — $2.5 million to $25
- Moderate — $25 million to $125 million
- Moderately high — $125 million to $500 million
- High — $500 million to $1 billion
- Very high — Greater than $1 billion

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[41] Federal Reserve Bank, 2002.
[42] Stern Review on the economics of climate change. 2006.
http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/stern_review_report.cfm
[43] "The case for cutting emissions," Ken Arrow, 2007.

- Uncertain: Economic implementation costs were not easily determined without significant research beyond the scope of this part of the analysis.

<u>Timing of Costs</u>

- Immediate/higher upfront: The majority of economic cost is experienced in the relative short term with the longer term economic cost being less significant
- Constant/even: The economic cost tends to be relatively constant on an annual basis
- Low short-term/Mostly long-term: The majority of economic cost is experienced in the relative long term with the shorter term economic cost being less significant
- Uncertain: Economic implementation costs were not easily determined without significant research beyond the scope of this part of the analysis

<u>Timing of Economic Benefits</u>

- Immediate/higher upfront: The majority of economic benefit is experienced in the relative short term with the longer term economic benefit being less significant
- Constant/even: The economic benefit tends to be relatively constant on an annual basis
- Low short-term/Mostly long-term: The majority of economic benefit is experienced in the relative long term with the shorter term economic benefit being less significant
- Uncertain: Economic benefits were not easily determined without significant research beyond the scope of this part of the analysis

<u>Who Experiences the Significant Portion of the Costs</u>

- Consumer (Evenly Distributed, Concentrated on particular groups)
- Government (State, Local)
- Business (Evenly Distributed, Concentrated on particular groups)

<u>Who Experiences the Significant Portion of the Benefits</u>

- Consumer (Evenly Distributed, Concentrated on particular groups)
- Government (State, Local)
- Business (Evenly Distributed, Small, Medium, Large)

In the above, "Evenly distributed" means that costs and/or benefits are shared relatively equally across the respective group. "Concentrated on particular groups" means that costs and/or benefits are disproportionately borne by, for example, upper or lower income groups.

Economic analysis uses latest (2008) US-DOE EIA (Energy Information Administration) Energy Outlook in constant $2008. The EIA fuel forecast only goes out to 2030, the assumption was made that the 2030 price continues through 2050 in constant dollars. The only exception is the electricity price which was taken from the Independent Service Operator New England (ISO-NE) CELT (Capacity, Energy, Loads, and Transmission) forecast. The report projects prices specifically for NH out to 2017. The 2017 price was assumed to continue through 2050 in constant dollars.

If current prices are indicative the EIA forecasts are low, however the same fuel forecasts are applied consistently across all sectors for fuel savings. Therefore economic benefits based on fuel savings are appropriate as a comparative tool in the decision making process. It is also important to note that all dollars reported in the economic sections including fuel costs are in constant 2008 dollars. This allows for the reporting of costs and benefits in a dollar value in today's values.

CSNE Fuel Forecast ($2008)

	Units	2012	2025	2050
LPG	Gallon	$ 1.87	$1.89	$ 1.97
Residual Oil	Gallon	$ 1.48	$1.44	$ 1.57
Distillate Oil	Gallon	$ 2.59	$2.61	$ 2.78
Natural Gas	Therm	$ 0.87	$0.90	$ 0.99
Electricity- NH Specific	kWh	$ 0.15	$0.15	$ 0.15
Motor Gasoline	Gallon	$ 2.76	$2.71	$ 2.80
Diesel Fuel (distillate fuel oil)	Gallon	$ 2.75	$2.75	$ 2.91

Source: EIA Annual Energy Outlook for 2008

Economic Calculation Assumptions:

TLU Action 1.A.1 - Support Stricter Corporate Average Fuel Economy Standards

The table below lists the assumed average incremental cost per new vehicle.[44] All new cars at the respective MPG are assumed to have the same incremental cost in $2008 throughout the period of analysis. New car sales were based on modeling performed by CSNE carbon team. Economic savings due to reduced fuel consumption were based on fuel consumption reductions calculated by CSNE carbon analysis team and forecasted fuel prices derived from the Energy Information Administration 2008 Energy Outlook. Also included in economic benefits is a $1 economic multiplier for each $1 saved from reduced fuel consumption.

MPG	Incremental Vehicle Cost ($2008)
35 MPG	$2000
40 MPG	$2500
45 MPG	$3000
50 MPG	$4000

[44] Suggested by TLU Working Group.

	Cost of Implementation (Annual $2008 Millions)			Economic Benefits (Annual $2008 Millions)		
	2012	2025	2050	2012	2025	2050
35 MPG	$ 198	$ 231	$ 311	$ (59)	$ (689)	$ (1,170)
40 MPG	$ 247	$ 289	$ 389	$ (96)	$ (1,001)	$ (1,669)
45 MPG	$ 297	$ 346	$ 467	$ (132)	$ (1,247)	$ (2,057)
50 MPG	$ 395	$ 462	$ 622	$ (165)	$ (1,448)	$ (2,367)

TLU Action 1.A.2 – Support Fuel Economy Standards for Heavy-Duty Vehicles

Assumed 16% improvement in fuel economy based on weighted average of VMT derived from CSNE Carbon Analysis at 7% improvement for trucks 10,000-33,000 GVW and 22% improvement for trucks with GVWR over 33,000.[45] Commercial trucks in NH were assumed to be 24,000[46]. Cost of implementation was assumed to be $6500 per truck for a total one-time implementation cost of $150 million. Economic benefits include fuel savings based on CSNE carbon analysis and also included in economic benefits is a $1 economic multiplier for each $1 saved from reduced fuel consumption.

Cost of Implementation (Annual $2008 Millions)			Economic Benefits (Annual $2008 Millions)		
2012	2025	2050	2012	2025	2050
$ 150	$ 0	$ 0	$ (78)	$ (92)	$ (166)

TLU Action 1.A.3 - Adopt California Low Emission Vehicle (CALEV) Standards

Administrative costs of $100,000 annually assumed to audit dealerships.[47] The incremental cost per vehicle was assumed to be $1100 per vehicle with an impact of $160 in consumer savings expected annually per vehicle.[48] Additional economic benefits calculated using a $1 economic multiplier for each $1 saved from reduced consumer expenditure.

Cost of Implementation (Annual $2008 Millions)			Economic Benefits (Annual $2008 Millions)		
2012	2025	2050	2012	2025	2050
$ 109	$ 127	$ 171	$ (16)	$ (238)	$ (325)

TLU Action 1.B.1 - Create a Point-of-Sale Financial Incentive for Higher Efficiency Vehicles

Modeled as a 14% increase in new light duty vehicle fuel efficiency (resulting from a feebate of $500 per 0.01 gallon per mile) and a 22% increase in new light duty vehicle fuel efficiency

[45] Suggested by TLU Working Group.
[46] New Hampshire: 2002, 2002 Economic Census, Vehicle Inventory and Use Survey", September 2004, Available online at http://www.census.gov/prod/ec02/ec02tv-nh.pdf
[47] Based on assumptions from TLU Working Group.
[48] NESCAUM Mobile Sources web site, Available online at http://www.nescaum.org/topics/mobile-source-controls-and-programs

(resulting from a feebate of $1000 per 0.01 gallon per mile.)[49] Implementation costs were assumed to be revenue neutral except for $100,000 for administrative.[50]

	Cost of Implementation (Annual $2008 Millions)			Economic Benefits (Annual $2008 Millions)		
	2012	2025	2050	2012	2025	2050
Feebate of $500 per 0.01 gallon/mile (new vehicles 14% more fuel efficient)	$0.1	$0.1	$0.1	($49)	($571)	($970)
Feebate of $1000 per 0.01 gallon/mile (new vehicles 22% more fuel efficient)	$0.1	$0.1	$0.1	($54)	($630)	($1,070)

<u>TLU Action 1.B.2 - Implement a Carbon-Based Vehicle Registration Fee Structure</u>
Same analysis as TLU Action 1.B.1

	Cost of Implementation (Annual $2008 Millions)			Economic Benefits (Annual $2008 Millions)		
	2012	2025	2050	2012	2025	2050
New car registration fee differential of $500 per 0.01 gallon/mile (new vehicles 14% more fuel efficient)	$0.1	$0.1	$0.1	($49)	($571)	($970)

<u>TLU Action 1.C.1. - Adopt a Low-Carbon Fuel Standard</u>
Assumption of 10% lower carbon fuel standard, linearly phased in from 2009 and $200,000 annually for administrative costs.[51] Though a variety of competing technologies can be used to meet the standard, it was assumed that cellulosic ethanol would be the technology that other fuels would compete with and therefore set the market price. It was assumed that ethanol has 2/3 the energy content of an equivalent gallon of gasoline. Assumed cost of ethanol was $1.90 per gallon or a 53% reduction to the fuel forecasts used in this analysis.[52] Additional economic benefits calculated using a $1 economic multiplier for each $1 saved from reduced fossil fuel expenditures.

Cost of Implementation (Annual $2008 Millions)			Economic Benefits (Annual $2008 Millions)		
2012	2025	2050	2012	2025	2050
$ 0.2	$ 0.2	$ 0.2	$ (28)	$ (76)	$ (110)

<u>TLU Action 1.C.2. - Promote Advanced Technology Vehicles and Supporting Infrastructure</u>

[49] Based on feedback from NHDES derived from ORNL report: Greene, D, P. Patterson, M.Singh, and J. Li. 2005. "Feebates, Rebates and gas-Guzzler Taxes: A Study of Incentives for Increased Fuel Economy." Energy Policy, 33 (6): 757-775.
[50] TLU working group assumption
[51] Based on assumptions from TLU Working Group.
[52] Putting the Pieces Together: Commercializing Ethanol from Cellulose, The Institute for Local Self-Reliance, September 2006, Available online at http://www.newrules.org/agri/celluloseethanol.pdf

Vehicles estimated to be 82% more efficient than gas powered vehicles.[53] Incremental vehicle cost was assumed to be $4000.[54] This scenario is comparable to Action 1.A.1 (50 MPG) scenario both in terms of costs and benefits.

Cost of Implementation (Annual $2008 Millions)			Economic Benefits (Annual $2008 Millions)		
2012	2025	2050	2012	2025	2050
$ 395	$ 462	$ 622	$ (165)	$ (1,448)	$ (2,367)

TLU Action 1.C.3. - Install Retrofits to Reduce Black Carbon Emissions

Incremental vehicle cost was assumed to be $2000 for a reduction of PM by 25%, $4000 for a reduction of PM by 50%, and $10,000 for a 85% reduction (plus $400 in annual maintenance an increase in fuel use 3%.)[55] The existing fleet number was assumed to be 24,000 (see action 1.A.2). There are not expected to be significant direct economic benefits due to this policy. However, an indirect benefit that was not calculated would be to improved human health through reduced PM.

	Cost of Implementation (Annual $2008 Millions)		
	2012	2025	2050
Employ DOCs (reduce PM emissions by 25%)	$48		
Employ FTFs (reduce PM emissions by 50%)	$96		
Employ DPFs (reduce PM emissions by 85%, increase diesel fuel use by 3%)	$240	$23	$33

TLU Action 1.D.1. Reduce Speed limits

- Enforce Current Speed Limits on Highways

Policy was assumed to be revenue neutral in terms of costs.[56] Economic savings due to reduced fuel consumption were based on fuel consumption reductions calculated by CSNE carbon analysis team and forecasted fuel prices derived from the Energy Information Administration 2008 Energy Outlook. Also included in economic benefits is a $1 economic multiplier for each $1 saved from reduced fuel consumption.

[53] Crunching the Numbers on Alternative Fuels, Popular Mechanics, May 2006, Available online at http://www.popularmechanics.com/science/earth/2690341.html?page=2
[54] Based on assumptions from TLU Working Group.
[55] Based on assumptions from NH DES
[56] Based on assumptions from TLU Working Group.

Cost of Implementation (Annual $2008 Millions)			Economic Benefits (Annual $2008 Millions)		
2012	2025	2050	2012	2025	2050
$-	$-	$ -	$ (35)	$ (110)	$ (156)

- Lower Posted Speed Limits on Highways

Policy was assumed to be insignificant in terms of costs.[57] Economic savings due to reduced fuel consumption were based on fuel consumption reductions calculated by CSNE carbon analysis team and forecasted fuel prices derived from the Energy Information Administration 2008 Energy Outlook. Also included in economic benefits is a $1 economic multiplier for each $1 saved from reduced fuel consumption.

Cost of Implementation (Annual $2008 Millions)			Economic Benefits (Annual $2008 Millions)		
2012	2025	2050	2012	2025	2050
$-	$-	$ -	$ (68)	$ (212)	$ (301)

TLU Action 1.D.2. Reduce Vehicle Idling

Economic analysis was of truck stop electrification. Cost was based on the number of truck idling hours avoided provided by CSNE carbon multiplied times $1.50 per hour (Amount charged by a New York truck stop for electrical hookup).[58] Fuel savings were calculated by multiplying the idling hours avoided times an EPA estimate of 0.8 gallons of diesel per hour of idling.[59] Also included in economic benefits is a $1 economic multiplier for each $1 saved from reduced fuel consumption.

Cost of Implementation (Annual $2008 Millions)			Economic Benefits (Annual $2008 Millions)		
2012	2025	2050	2012	2025	2050
$ 2	$ 3	$ 4	$ (6)	$ (8)	$ (14)

TLU Action 1.D.3. Improve Traffic Flow.

There are estimated to be 4-5 eligible projects each year.[60] Roundabout construction is site specific, which complicates the analysis as not all possible intersections are candidates for roundabout construction for many reasons. Literature review suggests a range of maximum daily roundabout traffic between 16,000 and 50,000 vehicles per day.[61] Therefore the assumption was made that 2 projects would be good candidates for roundabouts per year at a daily average of 25,000 vehicles per day. Informal review of other traffic projects discussed in US DOT planning documentation listed an average roundabout cost of ~ $3.2 million, compared to average reported cost of intersection by the TLU working group of $2.5 million. In this

[57] Based on assumptions from TLU Working Group.
[58] Center for Clean Air Policy: Transportation Emissions Guidebook Part Two: Vehicle Technology and Fuels
[59] Smartway Transport Partnership, US EPA, Available online at http://epa.gov/smartway/idle-questions.htm
[60] Based on assumptions from TLU Working Group.
[61] Planning documentation, US DOT, Available online at http://www.tfhrc.gov/safety/00-0673.pdf

analysis each roundabout constructed represented an incremental cost of $700,000. Also assumed in annual costs is $500,000 for additional administrative.[62]

Traffic benefits from previous experience with roundabouts in NH are a 16% in delays and 10% reduction in vehicle stops.[63] This appears to be corroborated by a roundabout installed in Keene Turn Roundabout, Brattleboro, Vermont in 1999. Analysis of this roundabout with daily traffic of ~28,000 estimates a 31,000 gallons annual reduction in fuel usage due to this form of stop(assumed fuel reduction for all roundabouts in this analysis).[64] Also included in economic benefits is a $1 economic multiplier for each $1 saved from reduced fuel consumption.

Cost of Implementation (Annual $2008 Millions)			Economic Benefits (Annual $2008 Millions)		
2012	**2025**	**2050**	**2012**	**2025**	**2050**
$ 2	$ 2	$ 2	$ (1)	$ (5)	$ (15)

TLU Action 1.D.4 - Reduce Emissions through Enhanced Vehicle Inspection Programs

Expanded program expected to cover an additional 300,000 vehicles.[65] Inspection cost increase of $15 per vehicle was assumed. Fuel savings benefits were based on a 1% failure rate(3000 vehicles) and a 10% improvement in fuel economy (2.4 MPG.)[66] The average mileage for failed vehicles was assumed to be 15,000 miles based on CSNE carbon analysis of average light duty truck (assumed to be same for medium). Also included in economic benefits is a $1 economic multiplier for each $1 saved from reduced fuel consumption.

Cost of Implementation (Annual $2008 Millions)			Economic Benefits (Annual $2008 Millions)		
2012	**2025**	**2050**	**2012**	**2025**	**2050**
$ 2	$ 2	$ 2	$ (1)	$ (1)	$ (1)

TLU Goal 2 - Reduce Vehicle Miles Traveled

In the actions analyzed the implementation costs were determined for each policy, economic benefits that are related to VMT reduction were based on fuel savings, a $1 economic multiplier for each $1 of fuel saved and the savings estimated due to reduced car crash and congestion. The savings of reduced car crash and congestion (time only) was assumed to be $0.20 per VMT.[67] Although stakeholder feedback suggested benefits due to reduced infrastructure

[62] Based on assumptions from TLU Working Group.
[63] Based on assumptions from TLU Working Group.
[64] Redington, Tony, Modern Roundabouts, Global Warming, and Emissions Reductions, and opportunities for North America, Available online at http://www.nh.gov/oep/resourcelibrary/referencelibrary/r/roundabouts/documents/vermontctrfpaper.doc
[65] Vital Signs 2008: Economic & Social Indicators for NH 03-06, NH Employment Security
[66] New Hampshire OBD and Safety Testing Program: Frequently Asked Questions for Motorists, State of NH Department of Safety and Department of Environmental Services

[67] "Crashes vs. Congestion – What's the Cost to Society?, Cambridge Systematics, Inc, Available online at http://www.aaanewsroom.net/Assets/Files/200835920140.CrashesVsCongestionExecutiveSummary2.28.08.pdf

requirements, this analysis did not attempt to calculate a reduction in road construction and maintenance costs associated with reduced VMT as there are other factors that would need to be considered, such as a reduction in gasoline tax and toll receipts which directly go towards funding this area.

Light Duty

	Economic Benefits (Annual $2008 Millions)		
	2012	2025	2050
5%	$ (24)	$ (144)	$ (507)
10%	$ (49)	$ (289)	$ (1,014)
20%	$ (97)	$ (577)	$ (2,028)
30%	$ (146)	$ (866)	$ (3,042)
40%	$ (195)	$ (1,154)	$ (4,056)
50%	$ (243)	$ (1,443)	$ (5,070)

Heavy Duty

	Economic Benefits (Annual $2008 Millions)		
	2012	2025	2050
5%	$ (4)	$ (30)	$ (140)
10%	$ (8)	$ (60)	$ (281)
20%	$ (17)	$ (121)	$ (561)
30%	$ (25)	$ (181)	$ (842)
40%	$ (34)	$ (242)	$ (1,122)
50%	$ (42)	$ (302)	$ (1,403)

TLU Action 2.A.1. Implement Commuting Trip Reduction Initiative

Costs were assumed to be $125,000 in ongoing administrative costs.[68] Also assumed was a tax credit of $500 for businesses with more than 100 employees.[69] In 2005, there were approximately 2000 NH busineses have over 100 employees.[70] Business growth rate was based on assumptions provided by CSNE Carbon analysis. Assumed achieves a 2% reduction in light duty VMT.[71]

Cost of Implementation (Annual $2008 Millions)			Economic Benefits (Annual $2008 Millions)		
2012	2025	2050	2012	2025	2050

Schrank, David, The 2007 Urban Mobility Report, Texas Transportation Institute, The Texas A&M University System, Available online at http://financecommission.dot.gov/Documents/Background%20Documents/mobility_report_2007_wappx.pdf

[68] Based on assumptions from TLU Working Group.
[69] CSNE Economic team assumption
[70] Statistics of U.S. Businessess: 2005, All Industries: NH, U.S. Census Bureau, Available online at http://www.census.gov/epcd/susb/2005/nh/NH--.HTM
[71] Assumption provided by NH DES

$ 2	$ 2	$ 3	$ (10)	$ (58)	$ (203)

TLU Action 2.A.2 - Implement Congestion Pricing

The cost of a new facility and existing facility retrofit of $42 million was used for the initial cost.[72] Annual salary cost and maintenance estimated at $500,000.[73] Assumed achieves a 0.5% reduction in light duty VMT.[74]

Cost of Implementation (Annual $2008 Millions)			Economic Benefits (Annual $2008 Millions)		
2012	2025	2050	2012	2025	2050
$ 42	$ 0.5	$ 0.5	$ (2)	$ (14)	$ (51)

TLU Action 2.A.3 - Create a VMT-Based Insurance Premium Structure

The policy is expected to be cost neutral at the consumer level with the exception of an incremental cost of $6 per vehicle for the annual mileage audit. A 10% uninsured rate was assumed.[75] Also included in costs was $100,000 for administrative costs.[76] Economic benefits were based on a 2.7%, 5% and 7% VMT reduction range.[77]

	Cost of Implementation (Annual $2008 Millions)			Economic Benefits (Annual $2008 Millions)		
	2012	2025	2050	2012	2025	2050
2.7% reduction in total light duty VMT	$7	$7	$7	($13)	($78)	($274)
5% reduction in total light duty VMT	$7	$7	$7	($25)	($145)	($507)
7% reduction in total light duty VMT	$7	$7	$7	($34)	($202)	($710)

TLU Action 2.A.4 - Implement VMT-Based Vehicle Registration Fees

Only assumed cost was $100,000 for administrative costs.[78] No additional costs expected as it is assumed to be implemented in a way that is revenue neutral to State. Economic benefits were based on a 2.7%, 5% and 7% VMT reduction range.[79]

[72] Based on assumptions from TLU Working Group.
[73] CSNE Economic team assumption
[74] Assumption provided by NH DES
[75] Compulsory Auto/Uninsured Motorists, Insurance Information Institute, August 2008, Available online at http://www.iii.org/media/hottopics/insurance/compulsory/
[76] Based on assumptions from TLU Working Group.
[77] Provided by NH DES
[78] Based on assumptions from TLU Working Group.
[79] Provided by NH DES

	Cost of Implementation (Annual $2008 Millions)			Economic Benefits (Annual $2008 Millions)		
	2012	2025	2050	2012	2025	2050
2.7% reduction in total light duty VMT	$0.1	$0.1	$0.1	($13)	($78)	($274)
5% reduction in total light duty VMT	$0.1	$0.1	$0.1	($25)	($145)	($507)
7% reduction in total light duty VMT	$0.1	$0.1	$0.1	($34)	($202)	($710)

TLU Action 2.A.5 - Increase the State Gasoline Tax

Assumed a $1 increase in the NH gas tax. and $400,000 in start-up costs .[80] VMT is reduced by 4%, 11%, and 18% in 2012, 2025, and 2050, respectively (assuming elasticities of -0.1, -0.3, and -0.5, respectively).[81] Economic benefits include VMT reduction and the additional revenue generated from the gas tax. These benefits will vary significantly depending on how the State chooses to use the funds from the gas tax. It is important to note that this is a **preliminary analysis** and that this is an area requiring significant further analysis to fairly represent all of the expected economic costs and benefits of implementing a gas tax.

Cost of Implementation (Annual $2008 Millions)			Economic Benefits (Annual $2008 Millions)		
2012	2025	2050	2012	2025	2050
$ 619	$ 643	$ 736	$ (524)	$ (947)	$ (3,384)

TLU Action 2.A.6. - Apply a Surcharge to High Carbon Fuels

Only assumed cost was $125,000 to study the policy.[82] Supporting mechanism for VMT reduction.

TLU Action 2.A.7 - Create Initiative to Reduce Availability of Free and Inexpensive Parkin

Only assumed cost was $125,000 for administration and marketing .[83] Supporting mechanism for VMT reduction.

TLU Action 2.B.1.a - Expand Local/Intra-Regional Transit (Bus) Service & TLU Action 2.B.1.b - Improve Existing Local/Intra-Regional Transit (Bus) Service

Assumed an annualized cost of $18.5 ($2005) million per year .[84] Light duty VMT is reduced by 0.16%, 1.8%, and 3.5% in 2012, 2025, and 2050, respectively.[85]

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[80] Based on assumptions from TLU Working Group.
[81] Provided by NH DES
[82] Based on assumptions from TLU Working Group.
[83] Based on assumptions from TLU Working Group.
[84] Based on assumptions from TLU Working Group.
[85] Provided by NH DES

Cost of Implementation (Annual $2008 Millions)			Economic Benefits (Annual $2008 Millions)		
2012	2025	2050	2012	2025	2050
$ 21	$ 21	$ 21	$ (0.8)	$ (52)	$ (355)

TLU Action 2.B.1.c - Expand and Improve Bicycle and Pedestrian Infrastructure
Assumed an annualized cost of $17.2 ($2005) million per year.[86] Light duty VMT is reduced by 1.4% in 2012, 2025, and 2050.[87]

Cost of Implementation (Annual $2008 Millions)			Economic Benefits (Annual $2008 Millions)		
2012	2025	2050	2012	2025	2050
$ 19	$ 19		$ (7)	$ (40)	$ (142)

TLU Action 2.B.2.a - Maintain and Expand Passenger Rail Service
Assumed an annualized cost of $100 ($2005) million per year.[88] Estimated annual economic impact was based on the Amtrak Downeaster study released in March 2008.[89] Economic benefits included construction, transportation savings and visitor spending. For Rockingham and Strafford county, the study estimated an annual impact of ~$550 million (construction activity of $3 billion was annualized over 30 year period). The annual economic benefit was $1300 per capita (based on Census estimate of 416,000 for 2006 for the two counties). This per capita impact was applied to NH's Hillsborough county population estimate of 403,000 (2006 Census Estimate) as it contains both Nashua and Manchester. Annual estimated economic benefit was $532 million for that county for a total impact of passenger rail of $1.1 billion per year.

TLU Action 2.B.2.b - Maintain and Expand Freight Rail Service
Assumed an annualized cost of $100 ($2005) million per year.[90] Insufficient information to calculate economic benefits at time of analysis.

TLU Action 2.B.2.c - Implement Dedicated Funding Stream to Support Public Transportation
Assumed a cost of $400,000 to study action.[91] Supporting mechanism for VMT reduction.

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[86] Based on assumptions from TLU Working Group.
[87] Provided by NH DES
[88] Based on assumptions from TLU Working Group.
[89] Amtrak Downeaster: Overview of Projected Economic Impacts, Center for Neighborhood Technology, March 2008, Available online at http://www.amtrakdowneaster.com/documents/AmtrakDowneasterOverviewofProjectedEconomicImpacts2.pdf
[90] Based on assumptions from TLU Working Group.
[91] Based on assumptions from TLU Working Group.

TLU Action 2.B.2.d -Implementation Recommendations of the I-93 Transit Investment Study
Assumed an initial cost of $237 ($2005) million.[92] Light duty VMT is reduced by 2.1% in 2012, 2025, and 2050.[93]

Cost of Implementation (Annual $2008 Millions)			Economic Benefits (Annual $2008 Millions)		
2012	2025	2050	2012	2025	2050
$ 266			$ (10)	$ (61)	$ (213)

TLU Action 2.B.2.e - Expand Park-and-Ride Infrastructure
Assumed an annualized cost of $3.1 ($2005) million per year.[94] Light duty VMT is reduced by 0.6% in 2012, 2025, and 2050.[95]

Cost of Implementation (Annual $2008 Millions)			Economic Benefits (Annual $2008 Millions)		
2012	2025	2050	2012	2025	2050
$ 3.5	$ 3.5	$ 3.5	$ (3)	$ (17)	$ (61)

TLU Action 2.B.2.f - Provide Financial Support of Transportation Management Associations
Assumed a cost of $750,000 per year for admin costs. Supporting mechanism for VMT reduction.

TLU Action 2.B.2.g - Expand Inter-City Bus Service & TLU Action 2.B.2.h - Improve Existing Inter-City Bus Service to Increase Ridership
Assumed an annualized cost of $9.2 ($2005) million per year. [96] Light duty VMT is reduced by 0.25%, 0.9%, 1.8% in 2012, 2025, and 2050 respectively.[97]

Cost of Implementation (Annual $2008 Millions)			Economic Benefits (Annual $2008 Millions)		
2012	2025	2050	2012	2025	2050
$10	$10	$10	$ (1)	$ (26)	$ (183)

TLU Goal 2.C - Develop Land Use Patterns that Support a Balanced Multi-Modal Transportation System and Reduce Vehicle Miles Traveled
Three estimates represent (1) directing in-community only growth to their center areas [0%, 0.5%, and 2% reduction in light duty VMT in 2012, 2025, and 2050 respectively]; (2) directing 60% of all NH growth to center areas of 14 largest, densest communities in central/southern/southeastern NH with walkable design and an integrated mix of uses [0%, 4%,

[92] Based on assumptions from TLU Working Group.
[93] Provided by NH DES
[94] Based on assumptions from TLU Working Group.
[95] Provided by NH DES
[96] Based on assumptions from TLU Working Group.
[97] Provided by NH DES

and 8% reduction in light duty VMT in 2012, 2025, and 2050 respectively]; and (3) directing 90% of total NH growth to these 14+ centers [0%, 7%, and 11% reduction in light duty VMT in 2012, 2025, and 2050 respectively]. [98]

	Economic Benefits (Annual $2008 Millions)		
	2012	**2025**	**2050**
Directing in-community only growth to their center areas [0%, 0.5% and 2% light duty VMT reduction by 2012, 2025, and 2050 respectively]	$ -	$ (14)	$ (203)
Directing 60% of all NH growth to center areas of 14 largest, densest communities in central / southern / southeastern NH with walkable design and an integrated mix of uses [0%, 4% and 8% light duty VMT reduction by 2012, 2025, and 2050 respectively]	$ -	$ (115)	$ (811)
Directing 90% of all NH growth to center areas of 14 largest, densest communities in central / southern / southeastern NH with walkable design and an integrated mix of uses [0%, 7% and 11% light duty VMT reduction by 2012, 2025, and 2050 respectively]	$ -	$ (201)	$ (1,115)

TLU Action 2.C.1.a - Assess GHG Development Impact Fees

Assumed a cost of $50,000 per year for administration costs any additional permit cost may be offset by savings associated with action 2.C.1.b.[99] Supporting mechanism for VMT reduction.

TLU Action 2.C.1.b - Streamline Approvals for Low-GHG Development Projects

Assumed a cost of $50,000 per year for administration costs. Per TLU permitting process helps offset cost of action 2.C.1.a.[100] Supporting mechanism for VMT reduction.

[98] Provided by NH DES
[99] Based on assumptions from TLU Working Group.

TLU Action 2.C.2 - Develop Model Zoning to Support Bus/Rail Transit

Assumed a cost of $115,000 per year for administration costs.[101] Supporting mechanism for VMT reduction.

TLU Action 2.C.3 - Develop Model Zoning for Higher-Density, Mixed-Use Development

Assumed a cost of $115,000 per year for administration costs.[102] Supporting mechanism for VMT reduction.

TLU Action 2.C.4 - Use State Funding and Grants to Encourage Low-GHG-Impact Development

Assumed a cost of $25,000 for first 2 years for administration costs.[103] Supporting mechanism for VMT reduction.

TLU Action 2.C.5 - Enable/Apply a Two-Rate Tax Structure Based on GHG-Impact

Assumed a cost of $25,000 for first 2 years for administration costs.[104] Supporting mechanism for VMT reduction.

TLU Action 2.C.6 - Promote Availability and Use of Location Efficient Mortgages

Only cost assumed to be an annual cost of $100,000 for admin costs.[105] Mortgage savings were estimated to be $1000 per loan[106] and apply to mortgages in NH's more densely populated cities with some level of access to public transit: Concord, Dover, Manchester, Nashua, Portsmouth, Keene and Rochester (~approximately 25% of total population.)[107] It was assumed that all mortgages in these areas were eligible for the incentive. Annual number of sales for existing home sales estimated to be 20,000, based on existing home sales for NH from Realtor.org for 2008, new homes derived from CSNE carbon calculations (approximately 6,200 per year). Total annual listings estimated at 27,000. Therefore 6750 mortgages each year would qualify to be location efficient. Also included in economic benefits is a $1 economic multiplier for each $1 saved from the $1,000 per loan.

Economic Benefits (Annual $2008 Millions)		
2012	2025	2050
$ (14)	$ (14)	$ (14)

TLU Action 2.C.7 - Establish Entity(ies) to Support Compact Land Use Patterns and Open Space Preservation

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[100] Based on assumptions from TLU Working Group.
[101] Based on assumptions from TLU Working Group.
[102] Based on assumptions from TLU Working Group.
[103] Based on assumptions from TLU Working Group.
[104] Based on assumptions from TLU Working Group.
[105] Based on assumptions from TLU Working Group.
[106] Invest in Green Projects and Mortgages, Environmental Defense Fund, Available online at http://www.edf.org/page.cfm?tagid=1574
[107] New Hampshire QuickFacts from the US Census Bureau, US Census, Available online at http://quickfacts.census.gov/qfd/states/33000.html

Assumed an initial cost of $625,000 for admin costs and $100,000 recurring (recouped through permit fees.) [108] Supporting mechanism for VMT reduction.

TLU Action 2.C.8 - Continue/Expand Funding, Education and Technical Assistance to Municipalities

Assumed TLU initial cost of $500,000 for admin costs and $500,000 recurring (recouped through permit fees.)[109] Supporting mechanism for VMT reduction.

[108] Based on assumptions from TLU Working Group.
[109] Based on assumptions from TLU Working Group.