

5.12 Resource Consumption External Costs

This chapter describes external costs of resource consumption (particularly petroleum and other forms of energy), and therefore benefits of conservation and increased efficiency. These include economic and security costs from petroleum imports, environmental and health damages from resource production, depletion of non-renewable resources, and economic subsidies.

Chapter Index

5.12.2	Definitions.....	1
5.12.3	Discussion	2
	Macroeconomic Impacts and National Security Risks	2
	Environmental Damages	3
	Human Health Risks.....	4
	Financial Subsidies for Resource Extraction.....	4
	Depletion of Non-Renewable Resources	4
	Transportation Resource Consumption & Dependency.....	5
	Factors Affecting Energy Consumption and Climate Change Emissions	8
	Fuel Prices and Subsidies.....	8
5.12.4	Estimates.....	11
5.12.5	Variability.....	16
5.12.6	Equity and Efficiency Issues.....	17
5.12.7	Conclusions.....	17
5.12.8	Information Resources	18
	Energy Consumption Calculators.....	18
	Other Resources	19

5.12.2 Definitions

Resource Consumption External Costs refers to costs of resources consumed in motor vehicle production and operation not borne directly by users. This primarily refers to energy but can include other natural resources such as metals and water. External costs can include macroeconomic impacts, national security risks, health risks, environmental damage, depletion of non-renewable resources, and various financial subsidies.¹ These cost estimates indicate the value to society of resource conservation and efficiency.

Lifecycle impact analysis (LIA) refers to total resource costs, including costs incurred during production, distribution, use and disposal. Energy used in production and distribution is sometimes called *embodied energy*. *Material input per unit of service (MIPS)* measures the quantity of materials used to provide a given unit of service, such as person-miles (for personal travel) or ton-miles (for freight travel).² LIA and MIPS are generally the most appropriate way to measure resource consumption.

¹ EC, (2005), *ExternE: Externalities of Energy - Methodology 2005 Update*, Directorate-General for Research Sustainable Energy Systems, European Commission (www.externe.info).

² MIPS (*Material Input Per Service Unit*) Method, Dictionary of Sustainable Management; at www.sustainabilitydictionary.com/m/mips_material_input_per_service_unit_method.php.

5.12.3 Discussion

Consumption of natural resources such as petroleum can impose a number of costs on society not borne directly by their consumers, or put another way, resource conservation and reduced dependence on imported resources can provide a variety of benefits to society. Specific categories of these impacts are described below.

Macroeconomic Impacts and National Security Risks

Dependency on imported resources imposes various economic costs and risks. These are widely acknowledged: They are cited by the petroleum industry to justify easing standards that restrict oil production, by conservation advocates to justify energy conservation programs, and by industries to justify subsidies for research into new energy technologies. The following economic costs are associated with petroleum imports:³

- *Energy Security*: This includes economic and military costs associated with protecting access to petroleum resources. US petroleum supply military costs are estimated to range from about \$10 billion to well over \$100 billion annually. One report suggests that US oil related military expenditures increased from \$49 billion in 2003 to \$138 billion in 2006.
- *Transfer of wealth via monopoly pricing*: Petroleum imports transfer wealth to oil producing regions. According to DeCicco and Ross “*Money spent on oil imports is mostly lost to the U.S. economy, and gasoline purchases provide relatively few jobs per dollar spent.*”⁴ This reduces demand for U.S. goods and services, and lowers economic growth.
- *Economic vulnerability*: dependence on imported petroleum makes a region vulnerability to economically harmful price shocks (sudden price increases) and supply disruptions. For example, the last three major oil price shocks were followed by an economic recession.
- *Higher world oil prices*: Because North America consumes over 25% of total world oil production, its demand has a monopsonistic effect. High U.S. demand increases international oil prices (the elasticity of world oil price with respect to U.S. demand is estimated at 0.3 to 1.1), imposing a financial cost on all oil consumers.

Energy dependence economic and political costs are particularly large in regions that rely significantly on imported energy, where per capita energy consumption is large, and at times when energy prices increase. During most of the last century the U.S. produced much of the petroleum it consumed and the real price of energy (adjusted for inflation) has declined, minimizing these problems. Most experts predict that dependency on imported oil and world oil prices are likely to increase significantly in the future (see box below), increasing resource consumption external costs.

³ Harold Hubbard (1991), “The Real Cost Of Energy,” *Scientific American*, Vol. 264, No. 4, (www.sciam.com) April; David Greene and N.I. Tishchishyna (2001), *The Costs of Oil Dependence: A 2000 Update*, ORNL/TM-2000/152, Oak Ridge National Lab, US Department of Energy (www.doe.gov).

⁴ DeCicco and Ross (1994), “Improving Automotive Efficiency,” *Scientific American*, (www.sciam.com).

Peak Oil

Petroleum will not suddenly run out, but it is expected to become more expensive as demand grows and production peaks. The point beyond which depletion of existing supply exceeds the development of new supply, is called *Peak Oil* or the *Big Rollover*. This has already occurred in many countries, including the United States, and is projected to occur worldwide between 2007 and 2015. Below are references about this and its economic implications.

Association For The Study Of Peak Oil & Gas (www.peakoil.net) is an organization that explores future petroleum supply and the implications of depletion.

Robert L. Hirsch, Roger Bezdek and Robert Wendling (2005), *Peaking Of World Oil Production: Impacts, Mitigation, & Risk Management*, U.S. Department of Energy (www.netl.doe.gov/publications/others/pdf/Oil_Peaking_NETL.pdf)

King Hubbert, *The Hubbert Peak of Oil Production* (www.hubbertpeak.com). This website discusses the future of petroleum production.

L.B. Magoon (2000), *Are We Running Out of Oil?* US Geological Survey summary poster <http://pubs.usgs.gov/of/2000/of00-320/of00-320.pdf>.

ODAC (2001), *Submission to the UK Cabinet Office Energy Review*, Oil Depletion Analysis Centre, www.cabinetoffice.gov.uk/strategy/~media/assets/www.cabinetoffice.gov.uk/strategy/odac%20pdf.ashx.

A 2005 US Department of Energy report states that as the peak of world oil production nears fuel price volatility will increase dramatically, and that unless appropriate measures are taken the economic and social costs could be unprecedented:

Virtually certain are increases in inflation and unemployment, declines in the output of goods and services, and a degradation of living standards. Without timely mitigation, the long-run impact on the developed economies will almost certainly be extremely damaging, while many developing nations will likely be even worse off.⁵

Environmental Damages

Resource exploration, extraction, processing and distribution cause environmental damages, including wildlife habitat disruption; noise air and water pollution; and solid waste, some of which is hazardous. Although resource extraction industries have changed practices to reduce and mitigate these impacts, there are still significant residual damages. The American Petroleum Institute argues that regulations internalize environmental costs,⁶ but although they may reduce damages, there are still external costs to people and the environment.

⁵ Robert L. Hirsch, Roger Bezdek and Robert Wendling (2005), *Peaking of World Oil Production: Impacts, Mitigation & Risk Management*, US Department of Energy (www.doe.gov), pp. 30-31; at www.netl.doe.gov/publications/others/pdf/Oil_Peaking_NETL.pdf.

⁶ Donald Norman (1993), *Energy Prices and Externalities*, American Petroleum Institute (www.api.org).

Human Health Risks

Resource exploration, extraction, processing and distribution can cause various health risks to people, including pollution-related illnesses, and injuries from accidents during processing and distribution.

Financial Subsidies for Resource Extraction

Petroleum and mining industries benefit from various financial subsidies and tax exemptions that increase their consumption and overprice more resource efficient goods.⁷ Selected exemptions to broad-based taxes function the same as if all taxpayers paid the tax and revenues were then returned as a subsidy payment.⁸ Vehicle fuel is often exempt from general taxes. Loper concludes that general taxes on vehicle fuel (excluding special road taxes) are 30% lower than average general taxes.⁹ This is particularly true of countries where fuel prices are below production costs and market prices.¹⁰

Depletion of Non-Renewable Resources

World petroleum supply is limited, and experts project that between 2007 and 2015 production will peak (see box below), resulting in higher energy prices, increased conflict over energy resources, and declining resources available for future generations. Ecological economists consider over-consuming non-renewable resources unfair to future generations.¹¹ They argue that putting prices on irreplaceable natural resources is like auctioning the Mona Lisa to a small group; the price would be ridiculously low since other parties, including people living in the future, cannot bid.¹²

⁷ Economist (2002), “How Many Planets? A Survey of the Global Environment,” *The Economist* (www.economist.com), 6July 2002.

⁸ Douglass Lee (1994), *Full Cost Pricing of Highways*, Volpe National Transportation Center (www.volpe.dot.gov), p. 9 and 31.

⁹ Joe Loper (1994), *State and Local Taxation: Energy Policy by Accident*, Alliance to Save Energy (www.ase.org).

¹⁰ Gerhard Metschies (2005), *International Fuel Prices 2005, with Comparative Tables for 172 Countries*, German Agency for Technical Cooperation (www.gtz.de/en/); at www.internationalfuelprices.com

¹¹ WB (1995), *Defining and Measuring Sustainability*, World Bank (www.worldbank.org), p. 11; NAP (1994), *Assigning Economic Value to Natural Resources*, National Academy Press (www.nap.edu).

¹² John Gowdy and Sabine O’Hara (1995), *Economic Theory for Environmentalists*, St. Lucie Press (www.crcpress.com), p. 93.

Transportation Resource Consumption

Transport activities consume about a quarter of total US energy use and about two-thirds of petroleum, which exceeds total domestic production.¹³ Tables 5.12.3-1 through 5.12.3-4, and Figure 5.12.3 compare various modes' energy consumption.

Table 5.12.3-1 2006 Energy Consumption by Transport Sector¹⁴

	Trillion BTUs	Percent Total
Cars and motorcycles	9,305	33.6%
Light trucks (including vans and SUVs)	7,518	27.2%
Heavy trucks	5,188	18.7%
Aviation	2,496	9.0%
Water	1,455	5.3%
Pipeline	842	3.0%
Railroads	670	2.4%
Buses	196	0.7%
<i>Total</i>	<i>27,670</i>	<i>100.0%</i>

Table 5.12.3-2 Freight Modes Compared (per ton-mile)¹⁵

	Costs	Fuel	Hydrocarbons	CO	NOx
<i>Units</i>	<i>Cents</i>	<i>Gallons</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>
Barge	0.97	0.002	0.09	0.20	0.53
Rail	2.53	0.005	0.46	0.64	1.83
Truck	5.35	0.017	0.63	1.90	10.17

Table 5.12.3-3 Energy Use by Mode (Passenger-Miles Per Gallon of Gasoline Equivalent)¹⁶

Mode	Average	Maximum
Bicycle	653	653
Light rail	510	1400
High speed (TGB) train	500	630
Neighborhood electric vehicle	260	870
Commuter train (BART)	244	520
Walking	235	235
Express commuter bus	230	330
City bus (London)	115	330
Airplane	67	85
Hybrid car (Prius)	60	230
Average automobile	20	40
Helicopter	4	20

¹³ ORNL (2008), *Transportation Energy Data Book*, Oak Ridge National Laboratories, U.S. Department of Energy (www.ornl.gov), annual report, <http://cta.ornl.gov/data/index.shtml>.

¹⁴ ORNL (2008), Table 2.5.

¹⁵ TRB (2002), "Comparison of Inland Waterways and Surface Freight Modes," *TR NEWS* 221, Transportation Research Board (www.trb.org), July-August, p. 17.

¹⁶ Wikipedia (2007), *Fuel Efficiency in Transportation*, Wikipedia (<http://en.wikipedia.org>); at http://en.wikipedia.org/wiki/Fuel_efficiency_in_transportation.

Table 5.12.3-4 Energy Use by Mode (MJ/Passenger km)¹⁷

Urban				Non-Urban			
Mode	Fuel	Embodied	Total	Mode	Fuel	Embodied	Total
Bicycle	0.3	0.5	0.8	Bus	1.0	0.3	1.3
Private Bus	1.2	0.5	1.7	Rail	1.2	0.7	1.9
Light Rail	1.4	0.7	2.1	International Air	2.2	0.9	3.1
Bus	2.1	0.7	2.8	Domestic Air	3.1	2.7	5.7
Heavy Rail	1.9	0.9	2.8	Regional Air	4.3	5.4	9.7
Car, Petrol	3.0	1.4	4.4	Charter Air	8.7	9.1	17.8
Car, Diesel	3.3	1.4	4.8	Private Air	6.5	12.4	18.9
Car, LPG	3.4	1.4	4.8				
Ferry	4.3	1.2	5.5				

This table summarizes estimated average energy requirements for travel by various modes, including fuel consumption and embodied energy (energy used to produce vehicles).

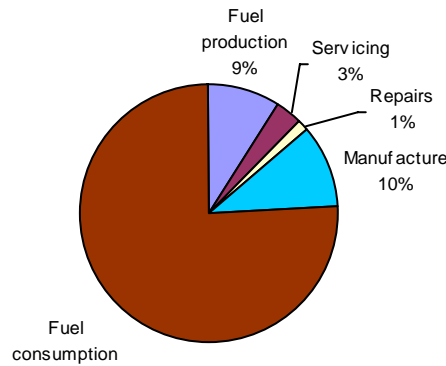
Energy consumption should generally be evaluated using lifecycle analysis which accounts for upstream energy used in fuel production and resources embodied in vehicles and infrastructure.¹⁸ Embodied energy typically represents 25-50% of total energy use. Motor vehicle production uses major portions of total aluminum, steel, lead, and rubber consumption, illustrated in the table above and figure below. Most vehicle metals can be recycled, but reprocessing involves substantial energy consumption and pollution. Building, operating and maintaining roadways and parking facilities also adds significantly to a typical vehicle’s total resource footprint.¹⁹

¹⁷ Manfred Lenzen (1999), “Total Requirements of Energy and Greenhouse Gases for Australian Transport,” *Transportation Research D*, Vol. 4, No. 4, (www.elsevier.com/locate/trd) July, pp. 265-290.

¹⁸ Mikhail Chester and Arpad Horvath (2008), *Environmental Life-cycle Assessment of Passenger Transportation*, UC Berkeley Center for Future Urban Transport, (www.its.berkeley.edu/volvocenter); at www.sustainable-transportation.com.

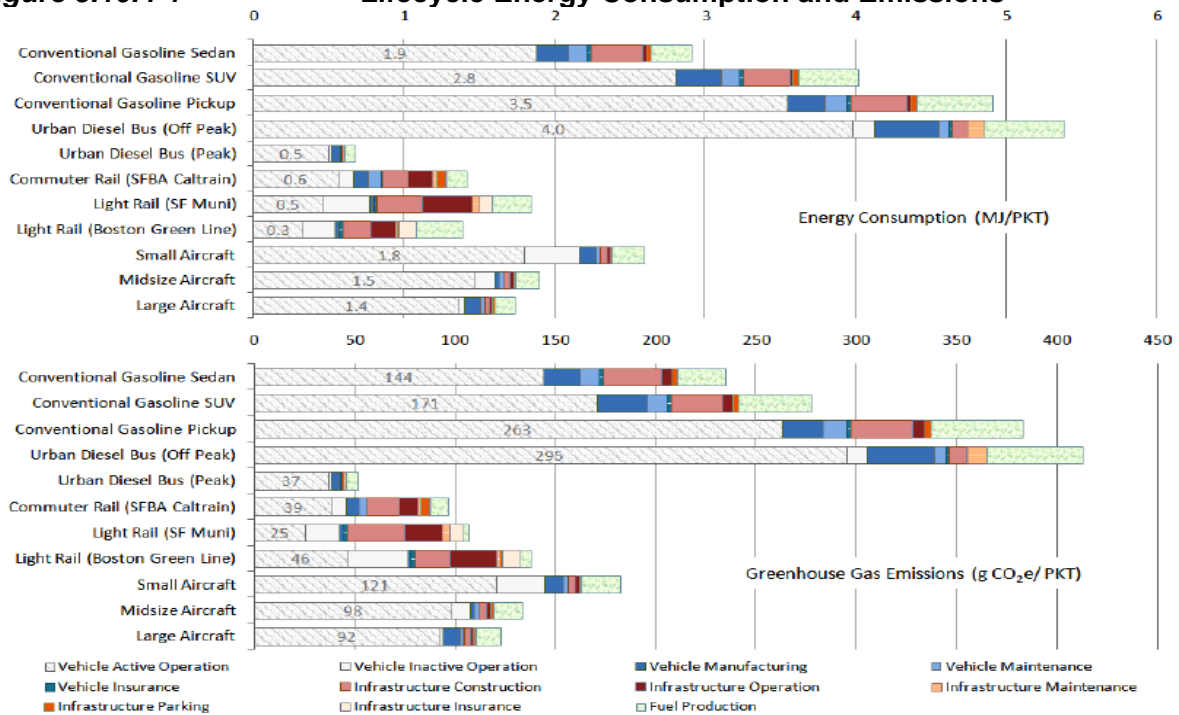
¹⁹ Luc Gagnon (2006); *Greenhouse Gas Emissions from Transportation Options*, Hydro Quebec (www.hydroquebec.com); at www.hydroquebec.com/sustainable-development/documentation/pdf/options_energetiques/transport_en_2006.pdf.

Figure 5.12.4-1 Typical Car Lifetime Energy Consumption²⁰



This illustrates the energy used to produce and power a typical car.

Figure 5.10.4-1 Lifecycle Energy Consumption and Emissions²¹



Energy consumption should generally be evaluated using lifecycle analysis which accounts for upstream energy used in fuel production and resources embodied in vehicles and infrastructure. Direct typically represent 50-75% of total energy use.

²⁰ Heather L. MacLean and Lester B. Lave (1998), “A Life Cycle Model of an Automobile,” *Environmental Science & Technology*, pp. 322A-330A, July; summarized in *Automobiles: Manufacture vs. Use*, Institute for Lifecycle Environmental Assessment (<http://iere.org/ILEA/index2.html>).

²¹ Mikhail V Chester and Arpad Horvath (2009), “Environmental Assessment Of Passenger Transportation Should Include Infrastructure And Supply Chains,” *Environmental Research Letters*, Vol. 4.

Factors Affecting Energy Consumption

Numerous factors affect transportation energy consumption including prices²² and land use patterns.²³ The *Alternative Fuels Data Center* (www.eere.energy.gov/afdc) and the *Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation* (GREET) Model indicate lifecycle energy use of various fuels.²⁴ The *Highway Economic Requirements System* includes factors affecting vehicle fuel consumption rates.²⁵

Fuel Prices and Subsidies

Fuel price data is available from the *International Energy Agency* (www.iea.org), the *American Petroleum Institute* (www.api.org), the *Canadian Petroleum Communication Foundation* (www.centreforenergy.com), the *Transportation Energy Data Book* (<http://cta.ornl.gov/data/index.shtml>), and *International Fuel Prices* (www.internationalfuelprices.com). The report, *International Fuel Prices 2005* provides information on gasoline and diesel prices of 172 countries, including time series of prices from 1991 – 2004, fuel tax rates, fuel tax revenue (as a portion of total national tax revenue), fuel purchasing power (relative to the cost of chicken eggs).

Table 5.12.3-5 Selected Country Gasoline Prices (www.international-fuel-prices.com)

Country	2004 Gasoline Price Per Liter	Country	2004 Gasoline Price Per Liter
Iraq	\$0.03	South Africa	\$0.81
Venezuela	\$0.04	Brazil	\$0.84
Saudi Arabia	\$0.24	Australia	\$0.85
Kuwait	\$0.24	Greece	\$1.14
Indonesia	\$0.27	Poland	\$1.20
Egypt	\$0.28	Spain	\$1.21
Malaysia	\$0.37	Japan	\$1.21
China	\$0.48	South Korea	\$1.35
Philippines	\$0.52	Turkey	\$1.44
United States	\$0.54	Sweden	\$1.51
Mexico	\$0.59	Hong Kong	\$1.54
Canada	\$0.68	United Kingdom	\$1.56
New Zealand	\$0.77	Netherlands	\$1.62

This table indicates average 2004 gasoline retail prices in some of the 172 countries listed in the 2005 International Fuel Prices report. This report also provides data on other fuels and tax rates.

²² VTPI (2008), “Transportation Elasticities: How Prices and Other Factors Affect Travel Behavior” *Online TDM Encyclopedia*. (www.vtpi.org); at www.vtpi.org/tdm/tdm11.htm.

²³ Todd Litman (2005), *Land Use Impacts on Transport*, VTPI (www.vtpi.org); at www.vtpi.org/landtravel.pdf.

²⁴ ANL (2008), *Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model*, Argonne National Lab; at www.transportation.anl.gov/modeling_simulation/GREET/index.html

²⁵ FHWA (2002), *Highway Economic Requirements System: Technical Report*, Federal Highway Administration, USDOT (www.fhwa.dot.gov/infrastructure/asstmgmt/hersindex.htm); at <http://isddc.dot.gov/OLPFiles/FHWA/010945.pdf>.

There is considerable discussion concerning what constitutes energy externalities and subsidies. The following discussion was written by the authors of the *GTZ International Fuel Prices* report (www.internationalfuelprices.com) and published in “Subsidy Watch,” Vol. 10, March 2007 (www.globalsubsidies.org).

What does “subsidizing” fuel mean in the transport sector? It is not always a simple matter to determine whether fuel prices are actually subsidised in a specific country. We take a simplified approach: fuels are considered subsidised if the actual price is below a (hypothetical) reference price (“benchmark”). Ideally, this benchmark price would be based on the price set by the private sector in competitive markets, excluding tax. However, as competitive benchmark prices are difficult to observe precisely in every market, for practical reasons and to allow worldwide application, we deem prices to be subsidised if they are below the average US prices, less road taxes averaging USD 0.10 per litre (i.e., those charged in the USA). As a rough estimate, it can be assumed that the difference between the actual pump price and the benchmark price approximately represents taxes of some sort.

We believe that transport fuel taxation should be based on three fundamental principles:

1. Fuel taxation should be based on the “users pay” principle, i.e. through the fuel tax road users should be charged the full cost of providing a country’s road network.
2. Transport should contribute to state finances. We maintain that fuel is a normal good just as any other good and should be subject to full VAT (Value Added Tax, i.e., normal sales tax). VAT should be charged in addition to the fuel tax, and possibly even additional or sumptuary taxation can be levied. Tax revenue from the transport sector could make a major contribution towards financing core state functions, such as health services, education and security, particularly since it is a relatively easy tax to administer.
3. Prices in transport always have a guiding function. Taxation should thus be designed to avoid undesired price distortions; for example, between different forms of transport such as private transport, local public transport, rail transport etc.

In the case of uncongested infrastructure, some transport economists suggest that it is more efficient to pay for maintenance and renewal costs from general tax revenues in order not to suppress the use of the facility. There is, however, a strong trade-off between efficiency and cost coverage (road users directly paying roadway costs). In the absence of an efficient income tax system the most practical way to generate sufficient revenues to build and finance transport infrastructure is to incorporate those charges into user fees. We emphasize the need for cost coverage.

In addition, fuel taxation can be used to spur improvements in fuel efficiency, encourage the use of alternative and cleaner fuels, and promote less polluting

forms of transport. Indeed, fuel taxes can be designed to help promote positive side effects. For example, introducing a higher tax rate on high-sulphur fuels can help shift consumption to low-sulphur fuels. fuel tax revenue can be used to cross-subsidize local public transport. Based on GTZ's worldwide research, the following minimum guidelines can be regarded as a general guide for tax levels:

Table 5.12.3-6 Minimal Transportation Taxes

Purpose of tax	Minimum fuel tax
Road tax for highways	USD 0.10 per litre
Transport tax for urban roads and local public transport	USD 0.03 - 0.05 per litre
Energy taxes, eco-taxes, taxes to combat fuel smuggling	Variable, often depending on the price level in neighbouring countries
Levy for national fuel stockpile	Variable
Funding measures to improve road safety	Variable; approx. 1.5% of transport spending

This table defines minimal transportation tax levels. Tax rates below this level can be considered subsidies of fuel consumption and motor vehicle travel.

The above goals can be summarised in a step-by-step procedure for implementing progressively higher fuel taxes.

Step 1: Cut subsidies that bring pump fuel prices below crude oil prices. This is the challenge currently facing countries such as Egypt and Yemen.

Step 2: Increase prices up to the price for unsubsidised fuel. (The benchmark could be the average US pump price less USD 0.10 per litre), then let the price vary in line with changes in world prices.

Step 3: Add a tax sufficient to cover the costs of maintaining the road infrastructure. In the United States, such taxes average USD 0.10 per litre. Fuel prices should also be subject to the regular value-added tax (VAT), revenues from which go into the general state budget.

Step 4: If, general taxes are not reliable sources for funding road construction and cross-subsidizing public transport, raise fuel taxes to the level that would be sufficient to finance these activities, as well as road maintenance. In Europe, such taxation levels are reflected in the legislated minimum European fuel prices, which are subject through EU harmonisation to minimum tax rates of EUR 0.287 (USD 0.37) per litre for unleaded petrol and EUR 0.245 (USD 0.31) per litre for diesel.

Step 5: This entails taxing fuel at levels currently seen in European countries such as Germany and the UK, which in addition to covering the full direct costs of the transport sector generate revenue for other sectors, such as education, health and security. Fuel tax rates in Germany, for example, are EUR 0.65 (USD 0.73) per litre of petrol and EUR 0.47 (USD 0.53) per litre of diesel. Increased tax rates apply to high-sulphur fuels and leaded petrol.

5.12.4 Estimates

All values are in U.S. dollars unless otherwise indicated.

Summary Table

Table 5.12.4-1 Resource Consumption Costs Summary Table – Selected Studies

Publication	Costs	Cost Value	2007 USD
Paul N. Leiby (2007)	US non-military	\$13.60 per barrel (2004)	\$14.96
			\$54 billion/yr**
		Range \$6.70 to \$23.25	\$7.37 - 25.58
NDCF (2007)	Military	\$137.8 billion (2006)	\$141.9 billion/yr
	Total	\$825.1 billion	\$849.9 billion/yr
Apogee Research (1994)	Non-military	51¢ per gallon gasoline*	\$0.71
Greene and Duleep (1993)	Energy security & wealth transfer.	1.7¢ per vehicle mile**	\$0.024
Koplow (2004)	Energy subsidies (incl. Non-transportation)	\$37 - \$64 billion (2003)	\$42 – 72 billion/yr
Lee (1995)	Tax exemptions & Strategic Petroleum Reserve	\$32.1 billion/yr*	\$43.7 billion/yr
		1.3¢ per vehicle mile**	\$0.018
Miller and Moffet (1993)	External	\$45 to \$150 billion/yr	\$64 – 215 billion/yr
		1.5¢ to 5¢ per VMT	\$0.021 - 0.072
NRC (2001)	Non-GHG	14¢ per gallon*	\$0.16

More detailed descriptions of these studies are found below, along with summaries of other studies. 2007 Values have been adjusted for inflation by Consumer Price Index. * The currency year is assumed to be the same as the publication year. ** Extrapolated from estimates in study.

- A 2007 U.S. Department of Energy report notes increased costs for energy dependency.²⁶ It estimates the external costs of U.S. imported oil is \$13.60 per barrel (2004 dollars), with a range of \$6.70 to \$23.25. This is described as “a measure of the quantifiable per-barrel economic costs that the U.S. could avoid by a small-to-moderate reduction in oil imports.” This estimate omits any costs for military programs. If 2007 US net oil imports²⁷ are multiplied by \$14.96 (\$13.60 adjusted to \$2007 dollars by CPI), this equals about \$54 billion.
- An Environmental Law Institute study estimates federal subsidies for fossil fuel and renewable energy production for Fiscal Years 2002-2008.²⁸ It concludes that over this six-year period subsidies totaled approximately \$72 billion for fossil fuels and \$29 billion for renewable energy. These include foregone tax revenues due to special tax provisions and under-collection of offshore lease royalty payments; and direct spending on research and development, and other programs. Fossil fuel subsidies

²⁶ Paul N. Leiby (2007), *Estimating the Energy Security Benefits of Reduced U.S. Oil Imports*, Oak Ridge National Laboratory (www.ornl.gov).

²⁷ IEA (2008) *Petroleum Navigator: U.S. Net Imports by Country*, (www.eia.doe.gov); at http://tonto.eia.doe.gov/dnav/pet/pet_move_net_i_a_epc0_IMN_mbbldpd_a.htm.

²⁸ ELI (2009), *Estimating U.S. Government Subsidies to Energy Sources: 2002-2008*, Environmental Law Institute (www.eli.org); at www.elistore.org/Data/products/d19_07.pdf.

consisted primarily of tax breaks, such as the Foreign Tax Credit (\$15.3 billion) and the Credit for Production of Nonconventional Fuels (\$14.1 billion). About half of the subsidies for renewables are attributable to corn-based ethanol.

- Greene and Tishchishyna argue that higher petroleum import prices reduce national GDP and may cause recessions and estimate that oil market upheavals of the last 30 years have cost the U.S. economy \$7 trillion (net present value) in reduced output, with a range of \$3.5 to \$14.6 trillion.²⁹ These estimates do not include military, strategic or political costs associated with U.S. and world dependence on oil imports.
- The National Defense Council Foundation estimates that the external costs of US oil imports increased from \$305 billion in 2003 to \$825 billion in 2006³⁰. A similarly rapid increase is estimated for job losses. They estimate the external or ‘hidden costs’ of US oil imports as listed below:

Table 5.12.4-2 External Costs of US Oil Imports 2003 and 2006

	2003	2006
Oil-Related Defense Expenditures	\$ 49.1 billion	\$137.8 billion
Loss Current Economic Activity Due to Capital Outflow	\$36.7 billion	\$117.4 billion
Loss of Domestic Investment	\$123.2 billion	\$394.2 billion
Loss of Government Revenues	\$13.4 billion	\$42.9 billion
Cost of Periodic Oil Supply Disruptions	\$ 82.5 billion	\$132.8 billion
Total	\$304.9 billion	\$825.1 billion
<i>Job Loss</i>	828,400	2,241,000

- Francis estimates that for US citizens the full cost of Middle East oil could be over \$300 a barrel, including US military expenditures in the region, US deaths, lost productivity for reservists engaged in military activities, and lifetime medical expenses, and lost productivity for wounded military personnel.³¹
- Apogee Research estimates external energy costs including government subsidies, tax breaks, maintenance of the Strategic Petroleum Reserve, and trade effects to total approximately 51¢ per gallon of gasoline, or about 2.5¢ per vehicle mile.³²
- An extensive review of economic and political issues concludes that, “if U.S. motor vehicles did not use petroleum, the U.S. would reduce its defense expenditures in the long run by roughly \$0.8 to \$8.5 billion per year.”³³

²⁹ David Greene and Nataliya I. Tishchishyna (2000), *Costs of Oil Dependence: A 2000 Update*, Oak Ridge National Laboratory, ORNL-TM-2000/152 (www.osti.gov/bridge).

³⁰ NDCF (2007), *Hidden Cost of Oil: An Update*, National Defense Council Foundation (www.ndcf.org).

³¹ Diane Francis (2007) “Iraq war hikes true cost of oil to US\$300,” *Financial Post*, 22 Nov. 2007; at www.financialpost.com/story.html?id=d09989e3-1c24-4b7b-ba38-9a7b69a2bd94

³² CLF (1994) *The Costs of Transportation: Final Report*, Conservation Law Foundation (www.clf.org).

- A European Energy Agency study estimates that economic subsidies to the energy sector in Europe were approximately EUR 29 billion in 2001, much of this for coal production.³⁴ These subsidies include direct grants to producers and consumers, low-interest loans, preferential tax treatments, trade restrictions, direct investment in energy infrastructure, public research and development, regulations that favor the energy sector, and failure to charge for security and environmental impacts.
- Greene and Duleep estimate the value of U.S. motor vehicle fleet fuel conservation, including \$5.7 billion in energy security savings, and \$32.4 billion in reduced wealth transfer out of the US.³⁵ Benefits total about \$50 billion for 150 billion gallons saved over a 30-year period imply a cost of about 33¢ per gallon, or 1.7¢ per vehicle mile.
- Koplow estimates that US federal energy sector subsidies totaled \$37 to \$64 billion in 2003, based on a review of roughly 75 programs/tax breaks (not all for transportation energy).³⁶ Koplow and Dernbach identify the following major energy subsidies:³⁷
 - Defending oil shipping lanes in the Persian Gulf.
 - Subsidized water infrastructure heavily used by coal and oil industries.
 - Federal spending on energy research and development.
 - Accelerated depreciation of energy-related capital assets.
 - Underaccrual for reclamation and remediation at coal mines and oil and gas wells.
 - The ethanol exemption from the excise fuel tax.
 - Payments to deal with black lung problems in coal miners.
- Lenzen compares the energy use of various modes, including both fuel consumption and energy embodied in vehicle production, as summarized in the following table.

³³ Mark Delucchi and James Murphy (2004), *U.S. Military Expenditures To Protect The Use Of Persian-Gulf Oil For Motor Vehicles: Report #15 in the series: The Annualized Social Cost of Motor- Vehicle Use*, ITS (www.its.berkeley.edu); at www.its.ucdavis.edu/people/faculty/delucchi/index.php

³⁴ EEA (2004), *Energy Subsidies In The European Union*, European Energy Agency (www.eea.europa.eu).

³⁵ David Greene and K.G. Duleep (1993), “Costs and Benefits of Automotive Fuel Economy Improvement: A Partial Analysis,” *Transportation Research A*, Vol. 27A, No. 3, pp. 217-235.

³⁶ Doug Koplow (2004), *Federal Subsidies to Energy in 2003 - A First Look*, by EarthTrack (www.earthtrack.net) for the National Commission on Energy Policy (www.energycommission.org); in *Developing Better Energy Technologies for the Future: Technical Appendix Chapter 6*. Also see, Doug Koplow (2007), *Subsidy Reform and Sustainable Development: Political Economy Aspects*, OECD (www.oecd.org); at www.earthtrack.net/earthtrack/library/SubsidyReformOptions.pdf.

³⁷ Doug Koplow and John Dernbach (2001), “Federal Fossil Fuel Subsidies and Greenhouse Gas Emissions: A Case Study of Increasing Transparency for Fiscal Policy,” *Annual Review of Energy and the Environment*, Vol. 26, (<http://arjournals.annualreviews.org/loi/energy>) pp. 361-389;

Table 5.12.4-3 Energy Use by Mode (MJ/Passenger km)³⁸

Urban				Non-Urban			
Mode	Fuel	Embodied	Total	Mode	Fuel	Embodied	Total
Bicycle	0.3	0.5	0.8	Bus	1.0	0.3	1.3
Private Bus	1.2	0.5	1.7	Rail	1.2	0.7	1.9
Light Rail	1.4	0.7	2.1	International Air	2.2	0.9	3.1
Bus	2.1	0.7	2.8	Domestic Air	3.1	2.7	5.7
Heavy Rail	1.9	0.9	2.8	Regional Air	4.3	5.4	9.7
Car, Petrol	3.0	1.4	4.4	Charter Air	8.7	9.1	17.8
Car, Diesel	3.3	1.4	4.8	Private Air	6.5	12.4	18.9
Car, LPG	3.4	1.4	4.8				
Ferry	4.3	1.2	5.5				

This table summarizes estimated energy requirements for travel by various modes.

- Lee estimates that motor vehicle’s share of oil producer tax subsidies is \$9 billion a year, Strategic Petroleum Reserve maintenance is \$4.4 billion per year, and local, state and federal sales tax exemptions for fuel total \$18.7 billion. This totals \$32.1 billion annually or about 1.3¢ per vehicle mile.³⁹
- M. Maibach, et al. assert that energy dependence external cost estimates were only available for the US, but suggest that EU figures would be lower due to lower military expenditures.⁴⁰
- Metschies provides vehicle fuel price data from 172 countries, identifying direct subsidies in some countries.⁴¹ He recommends a 10¢ per liter minimum vehicle fuel tax to recover basic roadway expenses, and a higher tax may be justified to internalize other costs associated with fuel production and automobile use. He identifies approximately 40 countries where gasoline and fuel retail prices are below international petrol prices, indicating a subsidy.
- A major study by the National Research Council released in 2009 provided an extensive review of energy consumption external costs, including costs resulting from the extraction (including land disruption), distribution, consumption and pollution emissions of various types of energy.⁴² It estimated emissions of criteria

³⁸ Manfred Lenzen (1999), “Total Requirements of Energy and Greenhouse Gases for Australian Transport,” *Transportation Research D*, Vol. 4, No. 4, (www.elsevier.com/locate/trd) July, pp. 265-290.

³⁹ Volpe Center (1995), *Full Cost Pricing of Highways*, Volpe Center (www.volpe.dot.gov), p. 12.

⁴⁰ M. Maibach, et al. (2008), *Handbook on Estimation of External Cost in the Transport Sector*, CE Delft (www.ce.nl); at

http://ec.europa.eu/transport/costs/handbook/doc/2008_01_15_handbook_external_cost_en.pdf

⁴¹ Gerhard P. Metschies (2005), *Fuel Prices and Taxation: With Comparative Tables for 160 Countries*, Deutsche Gesellschaft für Technische Zusammenarbeit (www.gtz.de/en/); at

www.internationalfuelprices.com

⁴² NRC (2009), *Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use*, Committee on Health, Environmental, and Other External Costs and Benefits of Energy Production and Consumption; National Research Council, National Academy of Sciences (www.nap.edu/catalog/12794.html).

(conventional air pollution) and climate change gases (CO₂-equivalent per vehicle-mile), and their unit costs (per vehicle-mile and gallon of fuel) for various vehicle fuels and time periods. It provided the following estimates of motor vehicle fuel external costs:

- The aggregate national damages to health and other non-GWP effects would have been approximately \$36.4 billion per year for the light-duty vehicle fleet in 2005; the addition of medium-duty and heavy-duty trucks and buses raises the aggregate estimate to approximately \$56 billion. These estimates are likely conservative, as they do not fully account for the contribution of light-duty trucks to the aggregate damages, and of course should be viewed with caution, given the significant uncertainties described above in any such analysis.
 - Electric vehicles and grid-dependent hybrid vehicles showed somewhat higher damages than many other technologies for both 2005 and 2030. Although operation of the vehicles produces few or no emissions, electricity production at present relies mainly on fossil fuels and, based on current emission control requirements. In addition, battery and electric motor production added up to 20% to the damages from manufacturing.
 - Depending on the extent of projected future damages and the discount rate used for weighting them, the range of estimates of marginal damages spanned two orders of magnitude, from about \$1 to \$100 per ton of CO₂-eq, based on current emissions. Approximately one order of magnitude in difference was attributed to discount-rate assumptions, and another order of magnitude to assumptions about future damages from emissions used in the various IAMs.
 - At \$30/ton of CO₂-eq, motor vehicle climate change damage costs begin to approach the value of non-climate damages.
- A National Research Council study estimates that external costs resulting from fuel consumption averages 26¢ per gallon.⁴³ This consists of 12¢ per gallon of global climate change impacts, 2¢ from other environmental damages, and 12¢ from the negative economic impacts of importing petroleum.
 - Taylor, Matthew and Winfield estimate that Canadian government subsidies for the oil and gas industry totaled CA\$1,446 million in 2002, averaging about CA\$50 per capita.⁴⁴ Their analysis includes federal grants, tax benefits (such as the Resource Allowance and the Accelerated Capital Cost Allowance for oil sands), and government expenditures that directly support oil, gas and oil sands industries.
 - Telecommuting incurs a minor energy cost from increased residential energy use from heating, cooling and office equipment.⁴⁵

⁴³ NRC (2001), *Effectiveness and Impact of Corporate Average Fuel Efficiency (CAFE) Standards*, National Academy Press (www.nap.edu); at www.nap.edu/html/cafe

⁴⁴ Amy Taylor, Matthew Bramley and Mark Winfield (2005), *Government Spending on Canada's Oil and Gas Industry: Undermining Canada's Kyoto Commitment*, Pembina Institute (www.pembina.org).

⁴⁵ Mokhtarian, Handy, and Salomon (1995), "Methodological Issues in the Estimation of The Travel, Energy and Air Quality Impacts of Telecommuting," *Transportation Research*, 29A, No.4, pp. 283-302; at <http://repositories.cdlib.org/itsdavis/UCD-ITS-REP-95-38>.

- A 2003 UN study provided the following summary of energy subsidies:⁴⁶
 - Energy subsidies are widespread but vary depending on definitions, analysis methodologies, fuel type and location.
 - Few studies attempt to quantify total world energy subsidies due to limited data. The most well known global study, carried out by Larsen and Shah in 1992, put world fossil-fuel consumption subsidies from under-pricing alone at around \$230 billion per year. The Former Soviet Union accounted for around two-thirds of that and developing countries for most of the rest. An OECD study, published the same year, estimated net global consumption subsidies at \$235 billion per year, with \$254 billion of net subsidies in non-OECD countries offsetting \$19 billion in net energy taxes in the OECD. A more recent multi-country study analysis by Myers and Kent estimated fossil fuel subsidies world wide at \$133 billion. Other recent studies confirm that energy consumption subsidies are much bigger in non-OECD countries. A 1997 World Bank study estimated annual fossil-fuel subsidies at \$48 billion in twenty of the largest countries outside the OECD and \$10 billion in the OECD, although the scope of the subsidies considered was narrow. A related OECD study looks at ending coal-production subsidies as part of a broader assessment of the environmental effects of liberalising trade in fossil fuels.
 - The overall size of energy subsidies has fallen sharply since the 1980s, mainly due to economic reform and structural adjustment programmes in the former communist bloc and other non-OECD developing countries. Subsidies dropped by over half in the five years to 1996 according to a 1997 World Bank study. A 1999 IEA study, which examined eight of the largest non-OECD countries covering almost 60% of total non-OECD energy demand, put the total value of energy subsidies in those countries at around \$95 billion in 1998. End-use prices were found to be about a fifth below market levels in those countries.
 - Producer subsidies, usually in the form of direct payments or support for research and development, are most common in OECD countries. By contrast, most subsidies in developing countries and transition economies go to consumers – usually through price controls that hold end-user prices below the full cost of supply. In all regions, the fossil-fuel and nuclear industries get the lion's share of subsidies. In the United States, for example, renewables and energy conservation together receive only 5% of total federal energy subsidies, according to studies carried out by the Government in 1999. However, the trend in OECD countries is towards an increasing share of support for renewable and alternative energy technologies.

5.12.5 Variability

This cost depends on total energy use, including direct fuel consumption and indirect uses such as vehicle production energy. There may be considerable differences depending on the country of consumption, particularly when military expenditures are included or if oil importing and exporting countries are compared.

⁴⁶ UNEP (2003), *Energy Subsidies: Lessons Learning In Assessing Their Impacts And Designing Policy Reforms*, United Nations Environment Programme (www.unep.org); at www.unep.ch/etu/publications/energySubsidies/Energysubreport.pdf

5.12.6 Equity and Efficiency Issues

These are external costs and therefore horizontally inequitable and inefficient. Lower income households tend to devote a relatively large portion of income to fuel so internalizing these costs through higher taxes or fees may be regressive, although equity impacts ultimately depend on how revenues are used and the alternatives available.

5.12.7 Conclusions

Resource consumption imposes various external costs. Estimates of U.S. petroleum external costs range from about \$30 to \$850 billion annually, with military expenditures alone estimated as high as \$142 billion per year. Most estimates only include a portion of total external cost categories. This cost is conservatively estimated at \$120 billion per year or 4¢ per mile under urban off-peak conditions.⁴⁷ Climate change emissions are excluded from this estimate to avoid double counting, as the full lifecycle emissions of transportation are covered in chapter 5.10. However, other upstream pollution is included in these estimates; such as pollution from steel used in cars and roadway construction.

This 4¢ per mile value is used for an average car under Urban Off-Peak conditions, with higher values for Urban-Peak and lower values for Rural driving to reflect relative fuel efficiency and vehicle wear. The costs of other vehicles are estimated based on their relative fuel consumption. Electric car resource costs are estimated to be half that of an efficient automobile to reflect lower external costs of this energy source.⁴⁸ Rideshare passengers are each estimated to add 2% incremental costs. Electric buses and trolleys are estimated to impose 1/3rd diesel bus costs. Telework energy costs are estimated at 10% of an average automobile for increased equipment and residential heating energy.

Table 5.12.7-1 Estimate External Resource Costs (2007 USD per Vehicle Mile)

Vehicle Class	Urban Peak	Urban Off-Peak	Rural	Average
Average Car	0.046	0.040	0.034	0.038
Compact Car	0.038	0.033	0.028	0.031
Electric Car	0.019	0.016	0.014	0.016
Van/Light Truck	0.060	0.052	0.044	0.050
Rideshare Passenger	0.001	0.001	0.001	0.001
Diesel Bus	0.232	0.200	0.168	0.192
Electric Bus/Trolley	0.077	0.067	0.056	0.064
Motorcycle	0.019	0.016	0.013	0.015
Bicycle	0.000	0.000	0.000	0.000
Walk	0.000	0.000	0.000	0.000
Telework	0.004	0.004	0.004	0.004

Automobile Cost Range

Minimum and maximum values are based on the range of estimates in the literature.

<u>Minimum</u>	<u>Maximum</u>
\$0.011	\$0.150

⁴⁷ \$120 billion / 3,000 billion vehicle-miles = \$0.04/mile.

⁴⁸ At 0.5 kWh/mile electric cars consume the same total energy as a 30 mpg car. External costs of electric power depend on the marginal electrical power source.

5.12.8 Information Resources

Resources below provide information on transport energy supply, demand and consumption.

Energy Consumption Calculators

- *Business Energy Analyzer* (www.energyguide.com). The Business Energy Analyzer is designed to provide a comprehensive analysis of energy use in your business along with customized energy efficiency improvement recommendations.
- *Density Effects Calculator* (www.sflcv.org/density). Indicates how neighborhood density impacts the environment (land, materials, energy and driving).
- *Emissions Calculator* (www.airhead.org/Calculator). This emissions calculator tabulates a user's aggregate monthly emissions of seven air pollutants (in pounds) from electricity and natural gas consumption, airplane trips, and vehicle miles traveled (auto or sport utility vehicle/truck) and compares them with average national emissions.
- *Greenhouse Gas Equivalencies Calculator* (www.epa.gov/cleanenergy/energy-resources/calculator.html). It translates greenhouse gas (GHG) reductions from units that are typically used to report reductions (e.g., metric tons of carbon dioxide equivalent) into terms that are easy to conceptualize.
- *MetroQuest* (www.envisiontools.com). Evaluates the consequences of different long-term planning strategies.
- *Personal CO₂ Calculation* (www3.iclei.org/co2/co2calc.htm). This worksheet determines yearly direct personal carbon dioxide emissions. Results include yearly personal carbon dioxide emissions and a per capita comparison chart to other industrialized countries.
- *Tool For Costing Sustainable Community Planning* (www.cmhc-schl.gc.ca/en/inpr/su/sucopl/index.cfm) allows users to estimate costs of community development, particularly those that change with different forms of development (e.g., linear infrastructure), and to compare alternative development scenarios.
- *Travel Matters Emissions Calculators* (www.travelmatters.org). TravelMatters! from the Center for Neighborhood Technology provides a trio of resources - interactive emissions calculators, online emissions maps, and a wealth of educational content that emphasize the relationship between more efficient transit systems and lower greenhouse gas emissions. The site also offers transport emissions by county for all contiguous states.

Other Resources

Alternative Fuels Data Center by the U.S. Department of Energy; at www.eere.energy.gov/afdc/

American Petroleum Institute (www.api.org), provides fuel supply, demand and price data.

BP Statistical Review of World Energy (www.bp.com/worldenergy), provides fuel supply, demand and price data.

Mikhail Chester and Arpad Horvath (2008), *Environmental Life-cycle Assessment of Passenger Transportation: A Detailed Methodology for Energy, Greenhouse Gas and Criteria Pollutant Inventories of Automobiles, Buses, Light Rail, Heavy Rail and Air v.2*, UC Berkeley Center for Future Urban Transport, (www.its.berkeley.edu/volvocenter/), Paper vwp-2008-2; at www.sustainable-transportation.com.

Mark Delucchi (2005), *The Social-Cost Calculator (SCC): Documentation of Methods and Data, and Case Study of Sacramento*, UCD-ITS-RR-05-37, Institute of Transportation Studies (www.its.ucdavis.edu); at www.its.ucdavis.edu/publications/2005/UCD-ITS-RR-05-18.pdf.

Mark Delucchi and James Murphy (2004), *U.S. Military Expenditures To Protect The Use Of Persian-Gulf Oil For Motor Vehicles*, Report #15 in *The Annualized Social Cost of Motor-Vehicle Use in the United States, Based on 1990-1991 Data*, Institute of Transportation Studies UC Davis (www.its.ucdavis.edu); at www.its.ucdavis.edu/publications/2004/Delucchi%20UCD%20Social%20Cost%2015.pdf.

Mark Delucchi (2002-2007), Has published numerous studies under the subject headings: *The Annualized Social Cost of Motor- Vehicle Use in the United States* and *Lifecycle Emissions Analysis*, Institute of Transportation Studies UC Davis (www.its.ucdavis.edu); at www.its.ucdavis.edu/people/faculty/delucchi/index.php.

Earth Track (www.earthtrack.net) documents energy subsidies and market distortions.

EC, (2005), *ExternE: Externalities of Energy - Methodology 2005 Update*, Directorate-General for Research Sustainable Energy Systems, European Commission (www.externe.info).

EIO-LCA Model (www.eiolca.net) is a computer model that quantifies the economic and environmental impacts of producing goods or services, including total energy consumption and pollution emissions.

ELI (2009), *Estimating U.S. Government Subsidies to Energy Sources: 2002-2008*, Environmental Law Institute (www.eli.org); at www.elistore.org/Data/products/d19_07.pdf.

Energy Information Administration (www.eia.doe.gov) provides information on energy production, consumption and prices.

European Environment Agency (www.eea.europa.eu) provides international energy data.

Environmental Valuation Reference Inventory (www.evri.ca) is a searchable storehouse of empirical studies on the economic value of environmental benefits and human health effects.

FHWA (2002), *Highway Economic Requirements System: Technical Report*, Federal Highway Administration, USDOT (www.fhwa.dot.gov); at <http://isddc.dot.gov/OLPFiles/FHWA/010945.pdf>

Luc Gagnon (2006); *Greenhouse Gas Emissions from Transportation Options*, Hydro Quebec (www.hydroquebec.com); at www.hydroquebec.com/sustainable-development/documentation/pdf/options_energetiques/transport_en_2006.pdf

Robert L. Hirsch, Roger Bezdek and Robert Wendling (2005), *Peaking of World Oil Production: Impacts, Mitigation & Risk Management*, US Department of Energy (www.doe.gov), pp. 30-31; at www.netl.doe.gov/publications/others/pdf/Oil_Peaking_NETL.pdf

ICF (2007), *Public Transportation and Petroleum Savings in the U.S.: Reducing Dependence on Oil*, American Public Transportation Association (www.apta.com); at www.apta.com/research/info/online/documents/apta_public_transportation_fuel_savings_final_010807.pdf

ICTA (2003 / 2005), *The Real Price of Gasoline; An Analysis Of The Hidden External Costs Consumers Pay To Fuel Their Automobiles*, International Center for Technology Assessment (www.icta.org); at <http://209.200.74.155/doc/Real%20Price%20of%20Gasoline.pdf> with a 2005 update at www.icta.org/doc/RPG%20security%20update.pdf.

ILEA (1998), *Automobiles: Manufacture vs. Use*, Institute for Lifecycle Environmental Assessment (<http://iere.org/ILEA/index2.html>); at <http://iere.org/ILEA/lcas/macleanlave1998.html>

International Energy Agency (www.iea.org), provides fuel supply, demand and price data.

IEA (2005), *Saving Oil in a Hurry*, International Energy Agency (www.iea.org); at www.iea.org/Textbase/publications/free_new_Desc.asp?PUBS_ID=1474

International Fuel Prices (www.internationalfuelprices.com) is a website with information on international fuel price reports from GTZ (a German international development agency) and other sources.

Doug Koplow and John Dernbach (2001), “Federal Fossil Fuel Subsidies And Greenhouse Gas Emissions: A Case Study of Increasing Transparency for Fiscal Policy,” *Annual Review of Energy and Environment* (www.annualreviews.org), Vol. 26, pp. 361-389.

Doug Koplow (2007), “Subsidies and Market Interventions,” *The Encyclopedia of the Earth*, (www.eoearth.org); at www.eoearth.org/article/Subsidies_and_market_interventions

Paul N. Leiby (2007) *Estimating the Energy Security Benefits of Reduced U.S. Oil Imports*, Oak Ridge National Laboratory (www.ornl.gov); at <http://pzl1.ed.ornl.gov/Leiby2007%20Estimating%20the%20Energy%20Security%20Benefits%20of%20Reduced%20U.S.%20Oil%20Imports%20ornl-tm-2007-028%20rev2007Jul25.pdf>

Gerhard Metschies (2005), *International Fuel Prices 2005, with Comparative Tables for 172 Countries*, German Agency for Technical Cooperation (www.internationalfuelprices.com).

Natural Resources Canada (www.nrcan.gc.ca) provides Canadian energy data.

NRC (2009), *Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use*, Committee on Health, Environmental, and Other External Costs and Benefits of Energy Production and Consumption, National Research Council, National Academy of Sciences (www.nap.edu/catalog/12794.html).

ORNL (annual reports), *Transportation Energy Book*, Oak Ridge National Laboratories, U.S. Department of Energy (www.doe.gov); at <http://cta.ornl.gov/data/index.shtml>, updated annually. Provides information on energy production and consumption, average vehicle mileage and fuel use, and how this is affected by factors such as vehicle speed.

PRé Consultants (www.pre.nl) provides information for evaluating lifecycle resource costs.

TC (2009), *The Urban Transportation Emissions Calculator* (wwwapps.tc.gc.ca/prog/2/UTEC-CETU/menu.aspx?lang=eng) is a user-friendly, Internet-based tool developed by Transport Canada that estimates greenhouse criteria air emissions from various different vehicle types (e.g., cars, commercial trucks, buses, light rail), fuel technologies (e.g., gasoline, diesel, hybrid, ethanol, biodiesel, etc.), and planning horizons (2006-2031).

UNEP (2003), *Energy Subsidies: Lessons Learning In Assessing Their Impacts And Designing Policy Reforms*, United Nations Environment Programme (www.unep.ch); at www.unep.ch/etu/publications/energySubsidies/Energysubreport.pdf

USEPA (1999), *Indicators of the Environmental Impacts of Transportation*, Office of Policy and Planning, USEPA (www.itre.ncsu.edu/cte).

USEPA (annual reports), *Green Vehicle Guide*, USEPA (www.epa.gov); at www.epa.gov/autoemissions reports vehicle emission and fuel consumption rates for specific model years.

VTPI (2008), “Energy and Emission Reductions,” *Online TDM Encyclopedia*, VTPI (www.vtpi.org); at www.vtpi.org/tdm/tdm59.htm

VTPI (2008), “*Transportation Elasticities: How Prices and Other Factors Affect Travel Behavior*” *Online TDM Encyclopedia*. (www.vtpi.org); at www.vtpi.org/tdm/tdm11.htm

Wikipedia (2007), *Fuel Efficiency in Transportation*, Wikipedia (http://en.wikipedia.org/wiki/Fuel_efficiency_in_transportation)

The *Zerofootprint Calculator* (www.zerofootprint.net) enables you to measure and understand the impact of your *ecological footprint*, taking into account both direct and indirect resource consumption. *Zerofootprint Cities* is an initiative designed for Mayors of the world's cities to engage their citizens around climate change.