3 Full Cost Analysis of Petroleum Consumption[1]

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Petroleum production and distribution imposes various economic, social, and environmental costs, including many that are *nonmarket* (involving resources that are not normally traded in competitive markets, such as human health and environmental quality), and *external* (that is, costs are imposed on others).[2] It is important to consider all of these impacts when making policy and planning decisions, such as evaluating energy conservation policies and efficient fuel-tax levels.

This chapter provides a comprehensive review of various external costs resulting from petroleum production, importation, and distribution. It considers four major cost categories: financial subsidies, economic and national security costs of importing petroleum, environmental damages, and human health risks. This chapter does not account for the *internal* costs of petroleum (the direct costs to users) or the external costs that result from fuel use, such as the costs of building roadway facilities, vehicle congestion and accident costs, or tailpipe pollution costs, which are explored in other studies.[3]

Evaluating Costs

Cost refers to the loss of scarce and valuable resources, which can include money, land, productivity, human health and life, and natural resources such as clean air and water. What most people call a *problem* economists may call a *cost*, with the implication that its impacts can be quantified (measured).

Costs and benefits (together called *economic impacts*) have a mirror-image relationship: costs can be defined as loss of benefits, and benefits are often measured based on reductions in costs. For example, pollution-reduction benefits are measured based on the resulting reduction in damages to natural resources and human health.

Some impacts are relatively easy to quantify because they involve *market goods*—that is, resources commonly traded in a competitive market. For example, if pollution reduces fishery productivity the costs can be calculated based on fishers' lost income and profits. Impacts involving *nonmarket goods*—that is, resources that are not normally traded in a market, such as the value of enjoying recreational fishing—as well as the broader value of ecological integrity, tend to be more difficult to quantify. Several techniques, discussed below, are used to quantify and monetize nonmarket impacts.[4]

1. *Control or Prevention Costs*

A cost can be estimated based on prevention, control, or mitigation expenses. For example, if industry is required to spend $1,000 per ton to reduce emissions of a pollutant, we can infer that society estimates those emissions to impose costs at least that high. If both damage costs and control costs can be calculated, the lower of the two are generally used for analysis on the assumption that a rational economic actor would choose prevention if it is cheaper, but would accept damages if prevention costs are higher.

2. *Compensation Rates*

Legal judgments and other damage-compensation rates can sometimes help monetize nonmarket costs. For example, if pollution victims are compensated at a certain rate, this can be estimated to represent their damage costs. However, many damages are never compensated. For example, damages can result from many dispersed sources, making fault difficult to assign; damages are often difficult to monetize; ecological systems often lack legal status for compensation; and little compensation may be paid for the deaths of workers who have no dependents. In addition, it is considered poor public policy to provide very generous damage compensation, since this may encourage some people (those who place relatively low value on their injuries) to take excessive risks or even to cause accidents in order to receive compensation. As a result, total environmental and health costs, and society's willingness to prevent such damages, is often much greater than compensation costs.

3. *Hedonic Methods (also called "Revealed Preference")*

Hedonic pricing infers values for nonmarket goods from their effect on market prices, property values, and wages. For example, if houses on streets with heavy traffic are valued lower than otherwise comparable houses on low-traffic streets, the cost of traffic (conversely, the value of neighborhood quiet, clean air, safety, and privacy) can be estimated. If employees who face a certain discomfort or risk are paid more than otherwise comparable employees who don't, the costs of that discomfort or risk can be estimated.

4. Contingent Valuation (also called "Stated Preference")

Contingent valuation involves asking people how much they value a particular nonmarket good. For example, residents may be asked about their *willingness to pay* for a particular improvement in environmental quality or safety, or their *willingness to accept* compensation for a particular reduction in environmental quality or safety. Although the analysis methodologies are the same, the results often differ. For example, people may only be willing to pay a $20 per month rent premium for a 20 percent reduction in noise impacts (perhaps by moving to a quieter street or installing sound insulation in their homes), but would demand $100 per month in compensation for a 20 percent increase in residential noise, due to a combination of budget constraints (an inability to pay more rent) and consumer inertia (the tendency of people to become accustomed to a particular situation and so to place a relatively small value on improvements and a relatively large value on degradation). Which perspective is appropriate depends on *property right*—that is, people's right to impose impacts on others. If safety and environmental quality are considered rights, then traffic-crash risk and pollution-emission costs should be based on recipients' willingness to accept incremental harms. If people are considered to have a certain right to impose risk or release pollution, then crash and pollution costs should be calculated based on victims' willingness to pay for an incremental reduction in risk and environmental degradation.

5. Travel Cost

This method uses visitors' travel costs (monetary expenses and time) to measure consumer surplus provided by a recreation site such as a park or other public lands.

Many published cost estimates only reflect a portion of total damages.[5] For example, some pollution cost estimates reflect only direct impacts on a particular industry, or severe health impacts (those that require medical treatment or cause disability and death). Other losses, such as impacts on recreation activity, less-severe illnesses, and ecological integrity, are often excluded. It is important that people working with such values understand the scope and assumptions used in analysis. When reporting costs form a particular study, it is important to define which costs are included, and identify any possible costs that are excluded. For example, when reporting estimated air pollution costs, it would be most accurate to say that ozone and particulate costs average 5¢ per vehicle-mile than to say that air pollution costs average 5¢ per vehicle-mile.

As much as possible, cost estimates should be based on *lifecycle impact analysis* (LIA), which includes costs incurred during production, distribution, use, and disposal.[6] Energy used in production and distribution is sometimes called *embodied energy*. Embodied energy typically represents 25–50 percent of total transportation energy use, depending on mode, as illustrated in figure 3.1.

Petroleum Production, Consumption, and Spill Trends

Several trends will affect the magnitude of future external petroleum costs:

1. *Production*[7]

Production of conventional, land-based petroleum is currently declining in the United States and is expected to start declining worldwide in the next few years, a trend often called *peak oil*.[8] Total U.S. production is predicted to increase during the next three

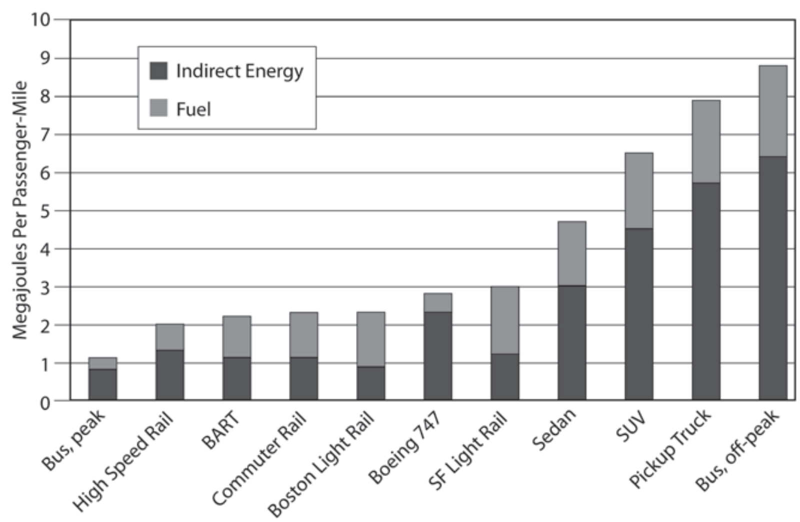

Figure 3.1 Life-cycle energy consumption and emissions: this figure compares fuel and indirect energy (energy used in vehicle and facility construction, as well as maintenance) for various transport modes. (Source: Aurbach [(http://pedshed.net/?p=219], based on Mikhail V. Chester and Arpad Horvath, "Environmental Assessment of Passenger Transportation Should Include Infrastructure and Supply Chains," *Environmental Research Letters* 4 [2009],

decades due to enhanced oil recovery techniques, increased offshore oil production and increased production of unconventional fuels (such as biofuels and liquefied coal), but these are expensive and speculative.[9] Petroleum will not suddenly run out, but is expected to become more expensive due to rising production costs and increasing international demand. For example, the U.S. Energy Information Administration's *International Energy Outlook 2011* "Reference Case" (most-likely scenario) predicts that real (inflation-adjusted) oil prices will be $95 per barrel in 2015 and increase slowly to $125 per barrel in 2035, but it is possible that prices will increase more rapidly. (At this writing inOctober 2012, international oil prices are already fluctuating around the $95 per barrel projected price.)

Higher oil prices are likely to increase the production of alternative fuels including offshore oil, tar sands, oil shales, liquified coal, and biofuels such as ethanol and biodiesel. These also have significant external costs, as summarized in table 3.1.

Table 3.1 Alternative transport fuels compared with conventional petroleum[1]

Fuel Type	Benefits	Costs
Offshore oil wells	Can increase domestic production	Additional environmental damages and risks associated with surveying and developing wells, as well as producing and transporting oil.
Biofuels (vegetable oils and ethanol)	Renewable; biodegradable; domestically produced; may reduce some air pollutants	Increases food costs; increases agricultural pollution (such as nitrogen loading of groundwater); nonrenewable fossil fuels are used in production; tends to reduce fuel economy.
Natural gas	Can increase domestic production; reduced air pollutants	Externalities of gas production and transport; nonrenewable fossil fuel source; driving range is generally reduced; limited availability; extra tank is often required, which reduces cargo space
Electricity	Zero tailpipe emissions; widely available	Externalities from electricity production; additional vehicle and battery costs; limited range and performance
Synthetic fuels (tar sands, oil shales, liquefied coal)	Abundant supply exists	Significant environmental damages from extraction and processing; high carbon emissions (10–20% higher per unit of energy than petroleum); high production costs

[1] Although there are many alternative fuels, all have significant external costs. Consumer Reports. *Alternative Fuels: How They Compare* (Greener Choices, 2006), www.greenerchoices.org/products.cfm?product=alternat&pcat=autos.

2. *Consumption*[10]

World oil consumption is currently about 86 million barrels per day (MBPD), and this is projected to increase to 112 MBPD in 2035.[11] The United States currently consumes about 18.7 MBPD, or 6.8 billion barrels annually.[12] U.S. residents consume about twice as much petroleum per capita as residents of other wealthy countries.[13] However, petroleum consumption has been flat or has declined in the United States and many other mature developed countries, while consumption is increasing rapidly in developing countries such as India and China, so the U.S. share of world petroleum consumption declining from 46 percent in 1960 to 22 percent in 2009, and this trend is expected to continue.[14] The United States currently imports about half the petroleum it consumes; this share is projected to decline in future years if domestic production increase as projected, but even optimistic scenarios predict that the United States will continue to import a major portion of its liquid fuels.[15]

3. *Oil Spills*

Petroleum production, processing, and distribution can result in oil spills that range from small to large. In response to regulations, liability costs, and public-image concerns, the oil industry (including shippers and distributors) has worked to reduce spills and their damages. The frequency and total volume of oil spills declined between 1970 and 2000, particularly by oil tankers, due to improved prevention.[16] However, there are still numerous major oil spills (more than 1,000 tonnes) every year, and catastrophic spills (more than 50,000 tonnes) at least once a decade, as shown in table 3.2. This indicates that, despite efforts to minimize accidents, major oil spills continue to occur.

For every major oil spill there are probably dozens or hundreds of smaller spills, including leaking storage tanks and careless disposal of waste oil by mechanics. In addition, some new petroleum-production techniques introduce new water pollution threats. For example, some enhanced oil-recovery techniques produce large quantities of brine, which may contain salts and various toxic and radioactive substances. Tar sands and oil shale processing often releases toxic chemicals into surface and groundwater during the separation process and through the drainage of rivers, and into the air due to the release of carbon dioxide and other emissions.

Major oil spills occur regularly, despite prevention efforts. This suggests that oil spills and water pollution are, to some degree, an unavoidable result of the production and distribution of petroleum and related products. Although oil spill prevention and cleanup technologies continue to improve, some risks are likely to increase, including those associated with offshore and Arctic area spills, and releases of pollutants into ground and surface water during the production of alternative fuels.

Table 3.2 Selected examples of major oil spills1

Name	Location and Date	Estimated Volume (tonnes)
Peace River Rainbow pipeline spill	Alberta, Canada, April 2011	3,800
Talmadge Creek oil spill	Calhoun, Michigan, July 2010	2,800–3,250
MT Bunga Kelana 3	Singapore, Singapore Strait, May 2010	2,000–2,500
2010 ExxonMobil oil spill	Nigeria, Niger Delta, May 2010	3,246–95,500
Deepwater Horizon	Gulf of Mexico, April–July 2010	492,000–627,000
Montara oil spill	Australia, Timor Sea, August 2009	4,000–30,000
2008 New Orleans oil spill	New Orleans, Louisiana, July 2008	8,800
2007 Statfjord oil spill	Norwegian Sea, December 2007	4,000
Korea oil spill	South Korea, Yellow Sea, December 2007	10,800
Jiyeh power station oil spill	Lebanon, July 2006	20,000–30,000
Bass Enterprises	Cox Bay, Louisiana, August 2005	12,000
Tasman Spirit	Pakistan, Karachi, July 2003	28,000
Erika	France, Bay of Biscay, December 1999	15,000–25,000
Sea Empress	United Kingdom, Pembrokeshire	40,000–72,000
MV Braer	United Kingdom, Shetland, January 1995	85,000
Aegean Sea	Spain, A Coruña, December 1992	74,000
Fergana Valley	Uzbekistan, March 1992	285,000
ABT Summer	Angola, May 1991	260,000
MT Haven	Mediterranean Sea, April 1991	144,000
Khark 5	Las Palmas de Gran Canaria, December 1989	70,000
Exxon Valdez	Prince William Sound, Alaska, March 1989	37,000–104,000
Odyssey	Nova Scotia, November 1988	132,000

Major oil spills occur regularly, despite prevention efforts.

[1] Wikipedia, *List of Recent Oil Spills*, en.wikipedia.org/wiki/List_of_oil_spills.

External Cost Categories

There are various categories of external petroleum costs, including production subsidies, economic and national security costs of importing oil, and environmental and human health damages from petroleum production and distribution. This chapter discusses each of these categories.

1. *Financial and Economic Subsidies*

Energy industries benefit from various financial subsidies and tax exemptions.[17] These include accelerated depreciation of energy-related capital assets, under-accrual for oil- and gas-well reclamation, low royalties for extracting resources from public lands, public funding of industry research and development programs, and subsidized water infrastructure for oil industries.[18] Koplow and Dernbach identify the following major energy subsidies:[19]

Defending Persian Gulf oil shipping lanes
Subsidizing water infrastructure for coal- and oil-industry use
Federal spending on energy research and development
Accelerated depreciation of energy-related capital assets
Under-accrual for reclamation and remediation at coal mines and oil and gas wells
The ethanol exemption from the excise fuel tax.

By considering approximately 75 programs and tax breaks, Koplow estimates that U.S. federal energy-sector subsidies totaled $49 to $100 billion annually in 2006, of which about half are for petroleum ($25 to $50 billion), indicating that petroleum subsidies average about $3.50 to $7.00 per barrel, and significantly more if state-level subsidies are also included.[20] Another study estimates that U.S. fossil-fuel subsidies, including obscure tax-code provisions such as the Foreign Tax Credit (which allows royalty payments to foreign governments to be considered as corporate income taxes) and the Credit for Production of Nonconventional Fuels (which provides a tax credit for the production of certain fuels including oil shales, tar sands and coal-based synthetic fuels) total approximately $10 billion annually, or about $1.50 per barrel.[21]

Other countries also provide large energy production subsidies. Metschies identifies approximately 40 countries where gasoline and fuel retail prices are below international gasoline prices, indicating significant subsidy.[22] International Monetary Fund analysis estimated that in 2010 global petroleum-product subsidies totaled almost $250 billion, and $740 billion including tax subsidies, or approximately 1 percent of global GDP.[23] The International Energy Agency estimates that energy subsidies (mostly for oil, gas, and coal) totaled $557 billion, and that eliminating energy subsidies would cut global GHG emissions 10 percent by 2050.[24]

2. *Economic and National Security Costs of Petroleum Importation*

Dependence on imported petroleum imposes macroeconomic costs (by reducing economic productivity, employment, and incomes). This cost is indicated by the fact that major oil-price spikes are often followed by economic recessions. Because North America consumes a major share of world petroleum production, high U.S. demand increases international oil prices, which is called a *pecuniary cost of oil use*.[25] This imposes financial costs on oil consumers and increases the wealth transfer from oil consumers to producers, exacerbating other economic costs. These are primarily economic transfers from oil consumers to producers, and so are not necessarily costs from a global perspective—but to the degree that they lead to recessions and reduce international productivity, they can impose international costs.

Petroleum and motor-vehicle imports are major contributors to the U.S. trade deficit. In 2009 the U.S. had a $381 billion trade deficit of which $253 billion was from oil imports and $160 billion from vehicle and vehicle-part imports, offset by $81 billion in vehicle exports, for a $332 net import burden, representing 87 percent of that year's trade deficit.[26] A major Federal study estimated that oil dependence cost the U.S. economy $150–250 billion in 2005 when petroleum prices were just $35–45 per barrel,[27] which suggests that, due to higher international oil prices, these costs now total $300 to $500 billion annually, equivalent to $85 to $140 per barrel of imported oil or $44 to $74 per total barrels of oil consumed in the U.S. These costs are relatively evenly divided between transfer of wealth from the United States to oil-producing countries, the loss of economic potential due to oil prices elevated above competitive market levels, and disruption costs caused by sudden and large oil-price changes. These estimates do not include military, strategic, or political costs associated with U.S. and world dependence on oil imports. A 2007 federal report estimates the external economic costs of importing oil to the U.S. (defined as "the quantifiable per-barrel economic costs that the U.S. could avoid by a small-to-moderate reduction in oil imports"), excluding military expenditures, totaled $13.60 per barrel (2004 dollars), with a range of $6.70 to $23.25, or about $54 billion annually for the U.S.[28]

Empirical evidence indicates that, all else being equal, low fuel prices reduce economic productivity, particularly in oil-consuming regions (where a significant portion of petroleum is imported), as indicated in figure 3.2. This occurs because low fuel prices encourage increased per-capita fuel consumption, and therefore petroleum importation costs, and tends to create automobile-dependent transport systems. This reduces regional employment and business activity, and it increases total transportation costs, including traffic congestion, infrastructure costs, accidents, and pollution damages.

Described differently, public policies that encourage energy conservation, such as high fuel taxes, tend to support economic development by reducing the economic burden of importing petroleum and reducing total transportation costs. This is true even in oil-producing regions. For example, although Norway is a major petroleum producer it maintains high fuel prices and energy conservation policies, which leaves more oil to export. As a result, Norway has one of the world's highest incomes, a competitive and expanding economy, a positive trade balance, and the world's largest legacy fund (an investment fund for future generations). Other oil producers, such as Saudi Arabia, Venezuela, and Iran, experience relatively less economic development due to low fuel prices that encourage inefficient fuel consumption and increased associated costs such as traffic congestion, accidents, and pollution emissions.

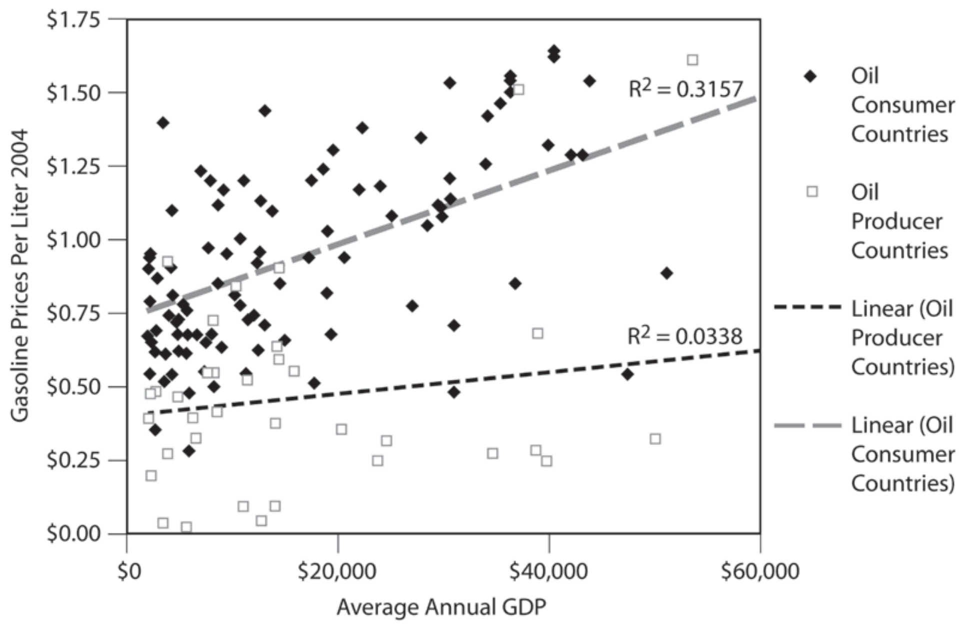

Figure 3.2 GDP versus fuel prices: economic productivity tends to increase with fuel prices, particularly in oil-consuming countries. (Source: Todd Litman, "Evaluating Transportation Economic Development Impacts" [VTPI (www.vtpi.org), 2010], www.vtpi.org/econ_dev.pdf.)

Dependence on imported resources imposes military, political, and economic costs associated with protecting access to foreign petroleum supplies. For example, Persian Gulf military expenditures currently average about $500 billion annually,[29] plus indirect and long-term costs, such as lost productivity and future disability costs from military casualties, uncompensated losses to civilians, and environmental damages.[30] Delucchi and Murphy estimate that 60 percent of Persian Gulf military costs are to maintain access to oil, representing about $300 billion annually.[31] These costs average at least $140 per imported barrel or $74 per total barrel consumed, and possibly significantly more.

Stern estimates that U.S. Middle East military intervention costs, intended to maintain U.S. access to petroleum resources, average about $500 billion annually.[32] He concludes that these military costs come in addition to economic costs of a comparable magnitude, implying that U.S. oil-dependence costs total about $1 trillion annually. The National Defense Council Foundation estimates that the external costs of

Table 3.3 External costs of U.S. oil imports, 2003 and 2006[1]

	2003	2006
Oil-related defense expenditures	$ 49.1 billion	$137.8 billion
Loss of 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
Job losses	828,400	2,241,000

[1] National Defense Council Foundation, *Hidden Cost of Oil: An Update* (NDCF [www.ndcf.org], 2007), ndcf.dyndns.org/ndcf/energy/NDCF_Hidden_Cost_2006_summary_paper.pdf.

U.S. oil imports increased from $305 billion in 2003 to $825 billion in 2006, as summarized in table 3.3.

There is debate concerning the portion of military costs that should be charged to petroleum consumers.[33] *Marginal analysis* (reflecting incremental changes in costs from incremental changes in consumption) tends to allocate relatively small costs to consumers since there may be other justifications for overseas military interventions (such as controlling terrorism and establishing democracy), and many military and political costs can be considered fixed in the short- and medium-term, so it is difficult to determine how these costs would decline with reduced fuel consumption.[34] *Cost-recovery analysis* (total costs are charged to users) allocates a larger share of national-security costs to petroleum consumers.

For evaluating policies that specifically affect the amount of petroleum that will be imported (such as the imposition of import duties), these costs should apply specifically to imported oil. For evaluating policies that affect total national fuel consumption (such as general fuel taxes or fuel-efficiency mandates), these costs should apply to total fuel consumed, since the marginal barrel of oil is imported.

3. *Environmental Damages*

Resource exploration, extraction, processing, and distribution cause environmental damages, including habitat disruption from exploration and drilling activity, shorelines spoiled by refineries, noise and water pollution, air pollution such as sour gas (hydrogen sulfide) and greenhouse-gas emissions (see chap. 1), and oil spills. Although newer policies and practices are intended to reduce these impacts, and some damages are compensated, there are significant residual damages, and many impacts are projected to increase with increased development of deep ocean wells and alternative fuels such as tar sands and oil shale.

Pollution emissions that occur during fuel production (as opposed to use) are called *upstream* emissions, which are said to be *embodied* into the final product.[35] According to detailed lifecycle analysis, embodied energy and emissions add about 16 percent to the energy and greenhouse emissions that occur during fuel use.[36]

Analysis of various U.S. oil spills indicates that cleanup and damage-compensation costs range from less than $300 per barrel ($7 per gallon) for the 1979 *Ixtoc I* spill in the Gulf of Mexico, up to more than $25,000 per barrel ($630 per gallon) for the 1980 *Exxon Valdez* spill in Alaska, with an average of approximately $672 per barrel ($16 per gallon).[37] To the degree that these damages are compensated, they are borne by the oil industry and passed on to consumers. However, many damages are never compensated because they are difficult to quantify, involve ecological services that lack legal status, or are limited by liability caps in state and federal laws.[38] According to surveys, the lower-bound estimate of the public's willingness to pay to avoid the *Valdez* spill's wildlife damages was $2.8 billion, compared with approximately $1.0 billion in total wildlife cleanup and compensation costs.[39] This suggests that total damage costs, and society's willingness to pay to avoid damages, are significantly (perhaps two to five times) higher than the financial costs borne by the oil industry.[40]

As an example, the 2010 *Deepwater Horizon* oil-spill cleanup and compensation costs are predicted to total $20–40 billion.[41] Assuming that one such catastrophic spill occurs each decade, this averages $2–4 billion a year. However, this only includes direct, legally recognized damages from major spills; it excludes smaller spills, "normal" environmental damages caused by petroleum production and processing (oil wells, refineries, and transport facilities), and uncompensated ecological costs, such as losses of existence value, as well as aesthetic value, from destruction of wildlife and landscapes. Production of alternative fuels such as oil sands and liquefied coal is generally considered more environmentally damaging than conventional oil production; it causes landscape damage, consumes large amounts of fresh water, and produces more climate-change emissions per unit of fuel.[42] Some damages, such as irreversible habitat destruction, can have very high costs but lack legal standing.

In addition to current losses, some economists argue that depleting nonrenewable resources deprives future generations of important benefits, implying a moral obligation to conserve resources for the sake of intergenerational equity.[43]

This suggests that the total environmental costs of petroleum production, processing, and distribution are probably many times larger than just current cleanup and compensation costs, perhaps $10–30 billion annually in the United States. This averages $1.50–4.50 per barrel, or 3.8–11.4¢ per gallon of petroleum products consumed.

4. *Human Health Risks*

Resource exploration, extraction, processing, and distribution cause various health risks to people, including processing and distribution accident injuries as well as pollution-related illnesses. In 2006 petroleum production workers had 20.8 fatalities per 100,000 workers, which is much higher than typical service-industry jobs but lower than other heavy industries such as truck drivers (27.5 deaths), coal miners (49.5 deaths), and loggers (87.4).[44] In addition, oil wells and petroleum refineries sometimes emit harmful air and water pollution that may endanger people nearby, leading some areas to be considered "cancer alleys," although the actual magnitude of such risks is difficult to determine.[45]

These costs are partly internalized through worker compensation and liability claims, but, as discussed previously, it is impossible to fully compensate some losses, because, from an individual's perspective, no amount of money can fully compensate for death or severe disability, and it is considered poor public policy to provide overly generous damage compensation because doing so may encourage some people to take excessive risks (for example, workers may be less cautious if they believe that even minor injuries will be generously compensated). These human-health pollution risks are often included in "environmental cost" categories, so it is important to avoid double-counting when calculating monetized cost estimates.

Conclusions

Petroleum production, importation, and distribution can impose a number of external costs. These are costs that people ultimately bear through higher taxes, reduced productivity, environmental damages, and health problems, but are widely dispersed rather than charged directly to consumers based on the amount of petroleum they consume and therefore their contribution to these costs. These external costs tend to be inefficient, because they encourage people to consume more petroleum, and therefore impose more total costs, than would occur if consumers bore these costs directly, and they are inequitable because they result in one individual or group imposing costs on others.

Table 3.4 summarizes the various estimates of external costs described in this chapter. It indicates that U.S. external costs of petroleum production, importation, and distribution probably total $635–1,080 billion annually, depending on assumptions, which averages $93–160 per barrel or $2.21–3.78 per gallon. This analysis suggests that for every dollar that consumers spend on petroleum (internal costs), their petroleum consumption imposes $0.63–1.08 in external costs (assuming $3.50 per gallon average prices).

Many published estimates of petroleum external costs only consider a portion of these impacts, and so underestimate total costs and the total benefits of energy conservation. Some of these costs are likely to increase in the future with increased exploitation of higher risk alternative fuels, such as offshore oil, tar sands and liquefied coal.

This analysis only accounts for the external costs of petroleum production, importation and distribution. It excludes the environmental costs of petroleum consumption (such as air pollution and climate-change emissions), and the external costs of vehicle use powered by petroleum products (such as road and parking-facility costs, traffic congestion, and accidents).[46]

Implications for Optimal Fuel Policy

This analysis indicates that petroleum production, importation and distribution impose significant external costs. Although cost estimates vary depending on perspective and assumptions, even lower-bound values indicate that petroleum is significantly underpriced. Vehicle fuel prices would have to increase by half or two-thirds if production subsidies and favorable tax policies were eliminated, if consumers paid directly for the economic and security costs of producing and importing petroleum, and if all environmental and human health costs were fully compensated. This does not include additional external costs of fuel use, such as greenhouse-gas emissions, nor the external costs of vehicle use, such as traffic congestion, parking subsidies, and uncompensated accident damages.

Fuel underpricing may have been justified in the past when petroleum, motor vehicle, and roadway systems were first growing and so were beginning to experience economies of scale (unit costs declined as total consumption increased), but these industries are now mature, and fuel consumption and motor vehicle travel impose significant external costs.

Advocates of underpricing often argue that low fuel prices benefit poor people, but the vast majority of these benefits go to non-poor people who tend to consume the majority of petroleum products.[47] Fuel taxes tend to be regressive (they represent a larger share of budgets for lower- than higher-income households), but this

Table 3.4 Summary of petroleum external costs

Name	Description	Estimates (annual billion dollars)
Production subsidies	Direct government subsidies and tax reductions for petroleum production	$25–50 billion
Economic costs	Economic costs of importing petroleum	$300–500 billion
Security costs	Military expenditures and other costs of maintaining access to foreign oil supplies	$300–500 billion
Environmental costs	Uncompensated environmental damages, including ground and surface water pollution, lost productivity,	$10–30 billion
Human health damages	Uncompensated injury and illness costs to workers and nearby residents resulting from petroleum production, distribution	???
Totals	Total external costs	$635–1,080 billion
Total per barrel		$93–160
Total per gallon		$2.21–3.78

Petroleum production, importation, and distribution impose various external costs. These estimates do not include the costs of petroleum consumption (such as pollution and climate-change emissions) nor the external costs resulting from vehicle use (such as road and parking-facility costs, congestion, and accidents), which are often internalized with fuel taxes.

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regressivity ultimately depends on the quality of transport options available and how revenues are used.[48] If fuel taxes are used to reduce other regressive taxes, finance new services valued by low-income households (such as walking, cycling, and transit service improvements, or better education and health care services), or are returned as cash rebates, then equity impacts can be neutral or progressive overall.[49]

This indicates that higher fuel taxes and other energy conservation strategies can support economic development and help create more equitable transport systems if implemented gradually and predictably, in conjunction with policies that increase transport-system efficiency and diversity, such as improved walking, cycling, and public transit service, as well as more accessible land-use development.[50]

Notes

1. This chapter summarizes "Resource Consumption External Costs" in: Todd Litman, *Transportation Cost and Benefit Analysis—Techniques, Estimates, and Implications* (publication of Victoria Transport Policy Institute, 2009), www.vtpi.org/tca/tca0512.pdf.

2. European Commission, *ExternE: Externalities of Energy—Methodology 2005 Update* (EC publication, 2005), www.externe.info/brussels/methup05a.pdf; see also: www.externe.info.

3. Litman, *Transportation Cost and Benefit Analysis*; see also: Huib van Essen et al., *Marginal Costs of Infrastructure Use—Towards a Simplified Approach* (publication of CE Delft [www.ce.nl], 2004), www.ce.nl/publicatie/marginal_costs_of_infrastructure_use_%96_towards_a_simplified_approach/456.

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