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ELECTRICITY CASE: ECONOMIC COST ESTIMATION FACTORS FOR ECONOMIC ASSESSMENT OF TERRORIST ATTACKS

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Abstract

The major economic effects of electric power outages are usually associated with three potential outcomes: the loss of human life and health; business losses; and declines in property value (some of which are encompassed within business losses).

This report sets forth economic factors for quantifying the cost of loss of human life and injuries and business losses (including those to critical infrastructure that supports social and economic activity) as a basis for accounting for the economic outcomes of terrorist attacks. Although they have been developed for estimating effects of attacks on electric power, these factors are broadly applicable to other kinds of attacks involving deaths, injury or business loss. A variety of alternative measures and values are presented to enable users flexibility in how they are applied.

This report is intended to accompany the "Electricity Case: Main Report – Risk, Consequences, and Economic Accounting" (May 31, 2005).

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ECONOMIC COST ESTIMATION FACTORS FOR ECONOMIC ASSESSMENT OF TERRORISM ATTACKS

INTRODUCTION

The major economic effects of electric power outages are usually associated with three potential outcomes: the loss of human life and health; business losses; and declines in property value (some of which are encompassed within business losses). Unquestionably, social-psychological impacts of these outcomes influence behavior, which in turn creates yet another level of economic effect, and readers are referred to other literature that covers this area (for example, Butler, Panzer and Goldfrank, editors 2003; Fischhoff 2002).

This report sets forth economic factors for quantifying the cost of loss of human life and injuries and business losses (including those to critical infrastructure that support social and economic activity) as a basis for accounting for the economic outcomes of terrorist attacks. Although they have been developed to estimate effects of attacks on electric power, these factors are broadly applicable to other kinds of events involving deaths, injury or business loss. A variety of alternative measures and values are presented to enable users flexibility in how they are applied. These measures have been developed for different geographic areas and conditions, and may produce wide variations from one another if translated into common units.

The Economic Accounting Concept

In order to estimate total economic effects of a terrorism attack, an economic accounts or economic accounting frame has been adopted here, which starts with the identification and development of cost factors that can be applied to a given population (or other measures of a target) where the size is known or otherwise defined. The concept of "economic accounting" is used here, whose purpose has been defined as providing "economic information about a household, organization, or government" (Nordhaus and Kokkelenberg, editors 1999: 12). It borrows from but is also distinct from income and asset accounting, for example, the method used by the U.S. National Income and Product Accounts (NIPA). NIPA's principle or purpose is to "measure production and income that arise primarily from the market economy" (Nordhaus and Kokkelenberg, editors 1999: 1) and how that measure has been broadened to include non-market factors resource values in terms of "assets and production activities associated with natural resources and the environment" (Nordhaus and Kokkelenberg, editors 1999: 2). As used in this report, economic accounting is restricted to cost factors in the following areas applicable to potential effects of terrorist attacks: valuation of human life and injury, business loss, and property value loss. The estimates draw from both conventional literature and the literature on extreme events.

Description of Cost Factor Categories for Economic Accounting

Valuation of human life and injury is more than a century old, dating back to law suits that attempted to determine the compensation to be paid to a worker killed on the job or someone killed through the fault of another. The initial focus was on lost wages, later expanded to a person's "willingness to pay" to avoid a small chance of being killed. Yet, terrorism may pose new dimensions that have to be considered. Although it has been argued that consequences are similar regardless of causes of disruption, a finer analysis may prove otherwise to capture different consequences that terrorism poses. The approach to valuation of human life and injury has taken a number of different directions. The human capital approach values life based on wages earned, and raises issues of equity, implicitly valuing those with smaller incomes as less than those earning more. The willingness to pay approach has been based on two approaches. The first is expressed preferences, typically based on survey techniques that try to elicit how much people are willing to pay for risks. The second is revealed preferences, observing people's behavior to determine how much they actually do pay. A recent survey of this literature was undertaken by Viscusi and Aldy (2003) and also by U.S. EPA (1999: H-8).

Valuation of business losses varies dramatically in approach, since business dependency on electric power is very variable. Some approaches are case-based, relying on the experiences of individual firms and economic sectors. Other approaches rely on computations involving the gross domestic product (GDP) and also input-output techniques. Business loss encompasses losses to essential public services in addition to the primary production it supports, such as infrastructure that in turn affects other activities economically. This report emphasizes losses primarily to sectors affected by electric power outages rather than impacts on the electric power industry itself, except where such estimates were available.

Property value loss estimation involves a relatively conventional and well-known technique usually in the form of a regression equation where property value changes are predicted as a function of characteristics of location, the property itself, and of particular interest here, vulnerability to some threat. Property value is usually measured as assessed value and less commonly in terms of sales value where enough properties have been sold. Property value loss is not considered here as a separate category for a couple of reasons. First, it is usually included within business losses. For example, of the 23.3 billion payments as business losses in connection with the September 11, 2001 attacks, $16 billion of the business payments were for property damage, but it is unclear how much of this is associated with valuation changes (Dixon and Stern, 2004: xxix). Second, although property value loss can be substantial, it often readjusts after a catastrophe has passed, as happened with the Manhattan real estate market after the WTC attacks.

Cost Factors

Below is a summary table of estimates that can be used to provide an accounting of the economic costs of a terrorist attack once the consequences are known, including the population or some other measure of the size of the target affected. As is apparent from table entries, estimates vary widely in the terms in which they are expressed. Although the summary may make comparisons among different bases difficult, it provides flexibility where the base to which it is applied has different units. For example,

- costs per capita are used in conjunction with consequences that are in terms of numbers of people affected

- costs per hour of disruption or outage are used in conjunction with consequences in terms of duration, which is particularly common in electric power outages

- costs per dollar of economic output or gross domestic product can be used where the magnitude of economic activity in an affected area is known

The estimates are drawn from studies of events and conditions ranging from catastrophic events, some terrorist related, to nuisance conditions such as congestion caused by traffic delays. Many sources provided total figures for economic impacts, however sources useful to this effort had to provide units of activity or population to which the costs applied in order to be useful in developing unitized estimates.

Table 1. Summary of Cost Factors

Source	Measure	Value	Explanations and references
Value of Life and Injuries			
U.S. EPA	Per capita for loss of life	$4.9 million ($5.8 million in 2005 dollars)	Developed for benefits of air quality
U.S. DOJ; Special Master	Per capita for loss of life	$250,000 to $7 million	Individual death compensation amounts. http://www.usdoj.gov/opa/pr/2004/April/04_civ_207.htm
RAND (Dixon and Stern 2004)	Per capita for loss of life and injuries (civilians)	$3.1 million	Based on payouts to civilians following the September 11, 2001 attacks
U.S. DOJ; Special Master	Per capita for injuries	$500 to $7.9 million	Compensation for physical injuries following the September 11 2001 attacks. http://www.usdoj.gov/opa/pr/2004/April/04_civ_207.htm
National Safety Council	Per capita for loss of life	$20,000	National Safety Council estimates
Business Loss			
1. GDP per capita per day	GDP per person per day	$112.84	Calculation by Lave based on Census of Population and GDP estimates.
2.Per establishment (8/14/03 blackout)			
OMA	per establishment	$88,000	ELCON, 2/2/04 for 12,300 companies or 55% of Ohio's manufacturing establishments
Restaurant Assoc. for NYC	per establishment	$3,409 to $4,545	$75-100 million: lost food and business – NYC 22,000 restaurants
Digital industry	per establishment per year	$23,000	985 businesses: digital economy, continuous process manufacturing, fabrication and essential services (40% of GDP). (CEIDS 2001)
3.Per unit time			
CrainTech	Per hr. of outage: 25% of sample 4% of sample	 $50,000 $1 million	ELCON, 2/2/04
Lawrence-Berkeley National Labs – *Industry*	1 minute outage 3 minute outage 1 hour outage	$1,477 $2,107 $7,795	985 businesses: digital economy, continuous process manufacturing, fabrication and essential services (40% of GDP). (CEIDS 2001)
Residential	Per customer: Moment/1 Hour	$5.85/6.90	LaCommare and Eto (2004)
Commercial	Moment/1 Hour	$1,230/1,859	LaCommare and Eto (2004)
Industrial	Moment/1 Hour	$23,097/59,983	LaCommare and Eto (2004)

Table 1 (continued)

Source	Measure	Value	Explanations and References
Public Services: Surface Transportation Congestion/Delay			
1.Vehicle-based			Schrank and Lomax (2004)
(a) Per hour			
Commercial truck	Dollars per hour per vehicle	$71.05	Federal Highway Administration's HERS computer model (2002)
Truck	Dollars per hour per vehicle	$35	U.S. DOT FHWA (2000)
Personal car	Dollars per hour per vehicle	$22	U.S. DOT FHWA (2000)
(b) Per passenger mile traveled (see text for more detail)	Passenger-mile traveled, average occupancy:		
Average car	1.42	$1.024	Victoria Transportation Policy Institute (VTPI) (2003)
Compact car	1.42	$0.942	VTPI (2003)
Electric car	1.42	$1.087	VTPI (2003)
Van or pickup	1.42	$1.182	VTPI (2003)
Rideshare passenger	1.00	$0.209	VTPI (2003)
Diesel bus	10.20	$8.387	VTPI (2003)
Electric trolley	14.00	$12.636	VTPI (2003)
Motor-cycle	1.00	$1.396	VTPI (2003)
Bicycle	1.00	$0.446	VTPI (2003)
Walk	1.00	$1.108	VTPI (2003)
Telework	1.00	$0.262	VTPI (2003)
2.Income of Passenger based			
$15,000 income	$/person-hour	$2.64	Brod (1995). NCHRP 2-18.
$55,000 income	$/person-hour	$5.34	Brod (1995). NCHRP 2-18.
$95,000 income	$/person-hour	$8.05	Brod (1995). NCHRP 2-18.
Public Services: Air Travel			
Personal travel	Passenger cost per hour	$31.50	U.S. DOT (2003)
Business travel	Passenger cost per hour	$45.00	U.S. DOT (2003)
Crew	Passenger cost per hour	$28.60	U.S. DOT (2003)

HUMAN DEATH AND INJURY

Value of life and injury estimates associated with major disasters draw from a wide variety of sources, and range from mortality and morbidity for individuals to mass casualties. The literature is not cause-specific, and in general inferences have to be made from other sources to apply to terrorism.

The major sources for these estimates are government agencies, such as the U.S. EPA estimates for value of a life in connection with air quality, insurance, jury awards, and reviews of regulatory decisions (Morrall 1986). Estimates come in the form of per capita estimates, per unit of insurance purchased, and are often broken down by type of injury. The ranges as one would expect given the uncertainties and variations in condition are very wide. For example, Morall's now historical work gave a range for cost per life saved, as implied in 44 regulations, from $100,000 for steering column protection to $72 billion for formaldehyde regulation (Morall 1986: 30). The U.S. EPA has summarized valuation estimates ranging from the mid-1970s through the early 1990s, and Viscusi and Aldy (2003) provide more recent estimates. The U.S. EPA (1997: H-8) summary gives labor market based estimates ranging from $0.6 million to $13.5 million in 1990 dollars and contingent value-based estimates ranging from $2.7 million to $3.8 million in 1990 dollars.

Estimates by Governmental Line Agencies, the Private Sector, and the Courts

Government Agency Estimates

A number of U.S. government agencies have confronted the problem of how to place dollar values on premature death or injury. In 1980 President Reagan issued Executive Order 12291 requiring all agencies to use benefit-cost analysis in designing new rules and deciding whether to promulgate a new regulation. Although enforcement of the executive order has been uneven, every president since Reagan has issued a new executive order or reaffirmed a previous one (see, for example, http://www.ncedr.org/tools/othertools/costbenefit/module1.htm). Congress has required the Office of Management and Budget to publish an annual analysis of the benefits and costs of existing regulations (http://www.mercatus.org/regulatorystudies/article.php/705.html).

The Department of Transportation has used dollar values in doing benefit-cost analyses of measures to prevent air crashes and uses dollar values for benefit-cost analyses of programs to prevent highway fatalities (http://www.edrgroup.com/edr1/library/lib_guides_special/index.shtml). The Mine Safety and Health Administration uses dollar values in the prevention analysis. MSHA comments that the "indirect cost" to an employer is more than twice the direct cost, indicating that the costs of injury are quite substantial (http://www.msha.gov/s&hinfo/costgenerator/costgenerator.htm).

The U.S. Environmental Protection Agency has been most explicit in deriving and using dollar values for estimating the benefits of preventing premature death and illness due to air pollution. The 1990 Clean Air Act requires EPA to estimate the costs and benefits of the air pollution control regulations. A first study looked retrospectively at the benefits and costs from 1970 to 1990. A second study examined the period from 1990 to 2010. A third study is underway examining the period from 2010 to 2030 (http://www.epa.gov/oar/sect812/appen_i.pdf). These estimates have been approved by the U.S. Office of Management and Budget (OMB), and are widely used. OMB permits a range of estimates - but only within the range. Their estimate for life lost is $4.8 million (in 1990 dollars).

Estimating the cost of air pollution regulations is difficult and controversial. However, the controversy is small compared to that in estimating the dollar value of preventing premature death and illness, as well as a loss of intelligence due to exposure to lead. The EPA analysis was guided by The Clean Air Compliance Council, an advisory committee of university professors. It was subject to extensive review by scientists, and was the subject of a good deal of public comment. While no one claims that the numbers are perfect, they represent the best estimates of the dollar value of preventing premature death, illness, and loss of intelligence.

Reflecting the controversy and uncertainty, EPA provides a range of estimates for the dollar values. Below is a summary of the central estimates.

Table 2. Selected estimates for Death and Injuries, U.S. EPA, 1997

	(in 1997 dollars)
Premature death	$4,800,000
Chronic Bronchitis	$260,000
Severe Bronchitis	$729,000
Hypertension	$680/case/year
Congestive Heart Failure	$8,300/case
Ischemic Heath Disease	$10,300/case
Upper Respiratory Symptoms	$19/case
Work Loss Days	$83/day
Minor Restricted Activity Days	$38/day

U.S. Environmental Protection Agency, The Benefits and Costs of the Clean Air Act, 1970-1990, U.S. EPA, October 1997. http://www.epa.gov/oar/sect812/appen_i.pdf
http://www.msha.gov/s&hinfo/costgenerator/costgenerator.htm This report notes that the "indirect cost" to an employer is more than twice the direct cost – this means the costs of injury are quite substantial.

Updated to 2005 dollars using the CPI (multiply by 1.2), the amount per premature death is: $5.8 million. The EPA numbers include the medical treatment costs. Obtaining comparable data for injury, one could get a figure for an emergency room visit, but there is no general value for someone who is hospitalized or who must seek periodic medical treatment in the future.

Another approach has been used by the Department of Health and Human Services. To guide policy decisions concerning research and treatment, researchers at the department have estimated the "cost of illness," an estimate of the lost income and cost of treatment for various diseases.
http://www.epa.gov/oppt/coi/toc.html
http://bmj.bmjjournals.com/cgi/content/full/320/7245/1335

Private Organizations

Another source is the National Safety Council, which provides private estimates for lost wages and medical costs. Their estimate of $4 million per life lost is based on willingness to pay and is comparable to the EPA estimates. The National Safety Council provides the following:

"Because obtaining information on the number and severity of nonfatal injuries for home, public nonmotor-vehicle, and work is difficult, the best approach is to estimate total costs on the Aper death@ basis using the following averages. These averages are based on their respective injury/death ratio:

Table 3. Average Economic Cost of Fatal and Nonfatal Injuries by Class of Injury, 2003

Home injuries, per death	$4,100,000
Public nonmotor-vehicle injuries, per death	$4,500,000
Work injuries, per death,	
without uninsured employer costs	$31,700,000
with uninsured employer costs	$34,700,000

Multiplying the number of deaths by these average costs provides an estimate of the economic loss due to both deaths and injuries in these categories."

NSC provides another set of averages:

Table 4. Average Comprehensive Cost by Injury Severity, 2003

Death	$3,610,000
Incapacitating injury	$181,000
Non-incapacitating evident injury	$46,200
Possible injury	$22,000
No injury	$2,000

Source: http://www.nsc.org/lrs/statinfo/estcost.htm

In general, workers compensation information is considered less useful for estimating value of life. Values are generally far out of date and are much lower than the amounts that juries award in the case of wrongful death or injury. The values are not relevant in getting a social valuation of injury. This is evidenced by the tendency for injured workers to be unwilling to accept the Workers Compensation settlement and the tendency of juries to supplement the award. Under Workers Comp, the injured worker cannot sue the employer. However, lawyers have extended the reach of who is sued, such as equipment makers. If juries thought that the worker had received adequate compensation, they would reject the attempt to obtain additional compensation through a law suit. Thus, some consider Worker's Comp estimates are not helpful for this kind of analysis.

Court Verdicts and Settlements

In law suits, valuation is based on the expected loss in future earnings of the individual who has been killed or injured. This value may be summed without discounting or may be discounted at a specified discount rate. Medical costs are added to the loss of income, either in terms of costs incurred before death or the expected medical costs that will be incurred as a result of the injury over the individual's life time. These are the "direct" costs. Indirect costs may be added to these to compensate for pain and suffering, loss of consortation, or other services that the individual may have given as a spouse, parent, or child. Various books written by lawyers for other lawyers give detailed settlement numbers from cases, e.g., http://www.shoplrp.com/product/p-2200.html.

Dixon and Stern estimate that at the time of writing their report in September 2004, "no compensation had been awarded through the tort system" (Rand Research Brief p. 1). Tort estimates from the literature, they point out, are typically "several hundred thousand to $1-2 million per child" (Dixon and Stern 2004: 22).

Worker Compensation and Other Insurance

In Terms of Wages

Table 6. Selected State Policies for Temporary and Permanent Disability

	Temporary Disability	Permanent Disability	Reference
Federal	The injured employee is entitled to continuation of pay (COP) from the employing agency for up to 45 days of disability	If the employee has no dependents, compensation is generally payable at the rate of two-thirds of pre-disability gross wages tax-free; if the employee has one or more dependants, compensation is payable at the rate of three-fourths of pre-disability gross wages, tax-free.	http://www.dol.gov/esa/regs/compliance/owcp/91-18.htm
CA	A general rule, you are paid two-thirds of the gross (pre-tax) wages you lose after your third day off work while recovering from an injury. Maximum of $840 per week	The number of weekly payments you will receive is determined by a permanent disability rating, based on (a) your medical condition, (b) your date of injury, (c) your age when injured, and (d) your occupation.	http://www.dir.ca.gov/chswc/CHSWCworkercompguidebook.pdf

	Temporary Disability	Permanent Disability	Reference
NY	Two-thirds of average weekly wage adjusted for percent disability equals the weekly benefit. Weekly benefit cannot exceed $400.	Two-thirds of average weekly wage adjusted for percent disability equals the weekly benefit. Weekly benefit cannot exceed $400.	http://www.wcb.state.ny.us/content/main/onthejob/wc03005.htm

By Type of Injury and Unit of Insurance Purchased

This table lists values of various injuries per unit of insurance purchased:

Table 7. Per Unit of Insurance Cost Estimates for Selected Injuries

"Loss of life	$20,000
Both eyes	$20,000
Both hands/arms	$20,000
Both feet/legs	$20,000
One hand/arm and one foot/leg	$20,000
One eye	$10,000
One hand/arm	$10,000
One foot/leg	$10,000
One toe	$1,000
One finger	$800
Dislocated hip	$2,000
Dislocated knee, foot or ankle	$800
Dislocated wrist	$700
Dislocated elbow	$600
Dislocated shoulder	$400
Dislocated collarbone	$300
Dislocated multiple fingers or toes	$140
Dislocated single finger or toe	$60
Hip, thigh, pelvis or skull fractures	$2,000
Broken arm, above the elbow	$1,100
Broken arm, below the elbow	$800
Broken shoulder blade or leg	$1,100
Broken ankle, kneecap, collarbone	$800
Broken foot, hand or wrist	$800
Broken jaw	$400
Broken nose	$300
Multiple broken ribs, fingers or toes	$300
Single rib broken	$140"

Bannister, Paul. "Insuring Your Body, Piece by Piece," Bankrate.com., September 23, 2003. Accessed on April 25, 2005: http://origin.bankrate.com/brm/news/insurance/body-worth1.asp

These estimates have limited utility, since the amount paid depends on the size of the policy. Given that those earning more can afford more insurance, these values become a function of income. The numbers are adequate since they imply that the loss of both eyes, both arms, both legs, or one arm and one leg is equivalent to death, in terms of compensation. Thus, if the EPA estimate of $5.8 million per premature death is used, loss of both eyes, both arms, both legs, or one arm and one leg would be valued at $5.8 million. However, when the compensation amount for lesser injuries, such as a broken nose, are used, the valuation is clearly too high: 300/20,000 = 0.015. This would imply a compensation of $87,000 for a broken nose, which seems excessive.

Valuations based on lost wages are not useful for public policy; indeed, they are repugnant. For those dying in the World Trade Center, the brokers on the top floor earned perhaps 100 times more than the janitors. The master making the awards decided that he would pay an amount for every death that was greater than the earning valuation would give for the lowest paid workers. He also decided that he would not award the amounts due to the highest earning workers on the basis of income.

Perhaps more repugnant is the fact that some of the people who died were children or adults who had retired or were not employed. The present discounted earning for a child would be small; that of a housewife would be even smaller. The income loss for a retired individual would be zero. 9-11 reiterated the obvious: On average blacks and Hispanics earn less than whites and women earn less than men. It is unpleasant to say, as a matter of public policy, that the government should not spend any money to prevent the death or injury of retired people, should spend less to prevent the death or injury of women or blacks or Hispanics or children. Thus, whatever the ethics of using lost income as a basis for settling law suits, it is not a satisfactory basis for public policy.

Insurance claims paid by states under Workers Compensation

These are based on National Council on Compensation Insurance (NCCI) data, adjusted to current benefits and inflation (Private Communication from Jack Seaquest, 03 May 2005 18:11:00 –0400).

Range of state averages for life threatening injuries

> Long term disability: $500,000 to $1,600,000
> Moderate injuries: $50,000 to $120,000
> Minor injuries: Cluster around $1,000

Note: These are unofficial numbers, with wide distribution within each category in each state.

Estimates Based on Extreme Events

Terrorism – September 11

The total estimated cost of the September 11, 2001 attacks was $38.1 billion expressed in terms of benefits paid for deaths and injury to civilians and emergency responders and the cost of business losses and other losses. The table below summarizes those costs and the number of people or businesses affected. Funds came from several sources: $19.6 billion from government, $15.8 billion from insurance, and $2.7 billion from charity. Private sources, not accounted for in these categories, are not known. The payouts were not evenly distributed across these sources with insurance paying two-thirds of the worker costs and charity the other third. Government paid anywhere from two-thirds to over 80% of the costs to civilians, businesses, environmental exposures, and emotional costs.

Table 8. Compensation to 9/11 Victims

		Losses Compensated
	Number of people	Total Losses (billions of $s)
Total (billions)[(a)]		38.1
Total deaths and seriously injured	3226	
Civilians	2766	8.7 ($3.15 million per capita)[(b)]
Emergency Responders	460	1.9 (4.13 million per capita) [(c)]
Deaths only (in NY, PA and DC)	2976	
Civilians	2551	
Emergency Responders	425 (415-438)	
Seriously injured only	250	
Civilians	215[(d)]	
Emergency Responders	35	
Businesses[(e)]		23.3
Other		
Environmental Exposures		0.66
Emotional		0.21
Residents		0.92
Workers		1.7
Unallocated		0.65

Source: Lloyd Dixon and Rachel Kaganoff Stern (2004) Compensation for Losses from the 9/11 Attacks, Santa Monica, CA: Rand Institute for Civil Justice.

Notes to Table 8:
Column 3, total benefits are from Dixon and Stern p. 132.
(a) This amount excludes cost of rebuilding public infrastructure in NYC (xviii)
(b) This differs from the average of $1.8 million awarded by the special master, though the range was 250,000 to 7.1 million (Department of Justice, 2004: http://www.usdoj.gov/opa/pr/2004/April/04_civ_207.htm), the midpoint of that range approximates the $3.1 million estimate from the Rand report. Thus, the $1.8 million is a more conservative estimate than $3.1 million average from the Rand estimates. The distribution of deaths by location was 2,752 at the WTC, 40 in PA, and 184 at the Pentagon (Dixon and Stern 2004: 15-16)
(c) Comparing civilians and emergency responders, this equals "1.1 million more on average than a civilian with similar economic loss."
(d) 250 were hospitalized for one day or more; 133,000 contacted the Red Cross (Dixon and Stern 2004: 16)
(e) This category includes "major property damage, disrupted operations, and loss of customers," and an estimated $16 billion of $23.3 billion for the business payments was for property damage (Dixon and Stern 2004: xxix).
The Main report by Dixon and Stern contains data tables on p. 135, 136, and 160.

Congress wanted to compensate the victims of 9-11 rather than have them bring lawsuits against various parties. A special master was appointed who based his compensation values on the loss of future earning, medical costs, and imposed lower and upper limits on the compensation in the interests of equity. The Department of Justice commented: "The average amount of compensation paid to date to the families of deceased victims is $1.8 million. Individual death compensation amounts have ranged from $250,000 to $7 million. Those physically injured as a result of the attacks have received Fund compensation ranging from $500 to $7.9 million," (Department of Justice, 2004: http://www.usdoj.gov/opa/pr/2004/April/04_civ_207.htm).

However distasteful it seems to the ordinary person, workers' compensation, law suits for wrongful injury or death, and public policy place dollar values on premature death, injury, or illness. Several dollar values have been used: The special master for 9-11 awarded $1.8 million on average; civilians were awarded a total of $3.1 million and emergency responders were awarded an additional $1.1 million. In its analyses of the benefits of environmental regulation, EPA values a premature death at $5.8 million. If the larger EPA figure were used, the almost 3,000 people killed in the World Trade Center attacks represent a social loss of almost $15 billion. If the people who were injured or sickened by the attack were valued at the EPA valuations or the workers' compensation rates, the loss would be much higher. For example, if people who lost both eyes, both arms, both legs, or one arm and one leg were valued at the same amount as a premature death, the losses would be substantially larger. If people with broken arms and legs were valued at 1/20 of the amount of a premature death, the dollar losses would be substantial. Thus, a future terrorist attack could cost society tens of billions of dollars in terms of premature death, injury, and illness.

Blackouts

Deaths have not accompanied all blackouts. During the 1977 blackout, rioting, arson, looting, and deaths did occur. The Congressional Research Service (CRS) (U.S. Congress 1978) report estimates that total costs would have been 40% lower if no deaths and other social costs had been incurred – there were 2 deaths reported during the 1977 blackout (Corwin and Miles 1978: 15).

Business costs associated with the 1977 blackout (distribution based only on Emergency Aid Commission grants) totaled $61.8 million: 80% of those receiving funds had damages under $50,000; 88% of the businesses damaged employed 10 people or less (CRS 1978: 5).

>$5,000	27%
$5-10,000	15
$10-25,000	20
$25-50,000	16
$50-100,000	12
Unknown	3

BUSINESS LOSSES

The Department of Commerce estimates that U.S. GDP is currently $12 billion per year, which provides a backdrop for gauging the relative effect of business losses.

Losses to business due to power outages take a number of different forms. For example CEIDS (2001: 2-9) identifies the following kinds of costs: "net lost production (or net lost sales), labor, materials loss or spoilage, equipment damage, backup generation (includes cost to run and/or rent backup generation), overhead, other restart costs." Savings exist as well, which they identify as "unused materials, savings on energy bill, and unpaid labor."

In addition to direct losses to business, delays in public services result in business interruption by delaying or preventing workers from traveling to work places and goods and services in the form of resources required for production and finished products from reaching their destinations.

Estimates of Direct Losses to Business

Per Capita

Business losses might be approximated by examining the amount of economic activity that is interrupted. The loss of electricity essentially stops all business. The best approximation for business losses is based on daily economic activity. There are reasons to believe that this is an underestimate and reasons to believe that it is an overestimate. If U.S. Gross Domestic Product (GDP) is not available for an area, the analysis should divide GDP of $12.1917 trillion (http://www.bea.gov/bea/newsrel/gdpnewsrelease.htm) by U.S. population of 295,734,134 (July

2005 estimate, http://www.cia.gov/cia/publications/factbook/fields/2119.html) divided by 365 days in a year. The result is $112.84 of GDP per person per day. On August 14, 2003, 50 million people were without electric power for a day and so it estimated to have cost $5.6 billion, which is within the range of the estimates that have been published.

Per Establishment

Estimates on the basis of establishments is so variable that it is not much use for estimating economic impacts, unless there are a large number of estimates for firms in a single industry. A few cases are given in Table 1. For broad categories, total estimates have been derived; for example, LaCommare and Eto (2004) divide the total of $79 billion from 24 combined surveys as $57 billion for the commercial sector, $20.4 billion for industry and only $1.5 billion for residences.

Per Unit of Duration of Outage

Duration as an influence in the cost of outages has received a lot of attention. Several indices are used to measure reliability in terms of duration and its effect on customers. They are expressed in terms of customers affected by various measures of duration divided by the total number of customers (LaCommare and Eto 2004: 5). Economic damage as a function of duration of outages has shown mixed results. LaCommare and Eto (2004) drawing on 24 independent customer surveys, find that the annual number of interruptions lasting more than 5 minutes is about 1.3, with 5.5 interruptions lasting less than 5 minutes. Since there are four times as many, they find that the cost of outages of very short duration produce higher damages than outages of longer duration. The total annual cost of electricity interruptions is $79 billion, with $52 billion due to the very momentary interruptions and $26 billion due to sustained interruptions. By broad sector, the differences in cost per outage per customer by duration they cite in the context of conducting a sensitivity analysis are very dramatic (LaCommare and Eto 2004: 38):

	Duration	
	Momentary	60 Minutes
Residential	$ 5.85	6.90
Commercial	1,230	1,859
Industrial	23,097	59,983

For the August 2003 blackout, ICF Consulting (undated c.2003-2004: 2) traced duration and estimated the cost of the blackout over time, using varying assumptions based on information about power restoration. While some customers lost power for 72 hours, most had their power restored within 24 hours.

Table 9. Costs of the 2003 Blackout Over Time

Approximate Start Time	Lost MW	MWh	Cost: Lower Bound ($ Billion)	Cost: Upper Bound ($ Billion)
8/14-4pm	61,800	247,200	1.8	2.8
8/14-8pm	30,900	309,000	2.3	3.4
8/15-6am	15,450	61,800	0,5	0.7
8/15-10am	13,200	184,800	1.4	2.1
8/16-12am	6,600	66,000	0.5	0.7
8/16-10am	2,000	40,000	0.3	0.4
8/17-6am	1,000	10,000	0.1	0.1
Total			6.8	10.3

A survey of 604 commercial/industrial customers blacked out was conducted at the end of 2003 by Ariu (2004: 2). The shortest and longest durations showed the following costs at the level of establishments, not taking into account number of customers (Ariu 2004: 2).

	Manufacturing	Service	Hospital
Less than 30 min.	>$5,000	$5,000	>$5,000
One day or over	$359,580	$40,000	$19,000

A survey of 985 businesses after the 2003 blackout revealed that the cost outages increased with duration (CEIDS 2001).

Duration	All Establishments
1 min.	$1,477
3 min.	$2,107
1 hr.	$7,795

The 2003 blackout in Seattle in 1988 lasted for four days. Estimates of damages for the four days are (U.S. Congress, Office of Technology Assessment 1990: 21):

Bon Marche	$500,000
Restaurants	10,000-45,000

Thus, factors by duration are useful indicators to estimate cost where duration is known, however, they are best if tailored to specific industries.

Per Sectoral Product

ICF Consulting (2003) has derived estimates of the economic costs of a simulated outage in California involving a 25% reduction in power. What is useful in that analysis are the percentages of Sectoral Product derived by sector which can potentially be extrapolated to other scenarios. They indicated that the impact was a function of the dependency on electricity.

Table 10. Selected Estimates by Sector

Sector	$ MM	% Sector Product
Manufacturing	592	0.31%
Wholesale/Retail Trade	597	0.29
F.I.R.E.	839	0.29
Mining	26	0.29
Services	877	0.27
Others	544	0.17
Lost Tourism	5,800	7.7

Interruption of Public Services: Surface Transportation

The cost of travel time can be considered for both the cost per vehicle and the cost per person. Within these categories, values exist for both the hourly (or sometimes annual) cost and the per mile cost.

Vehicle-based Estimates

Per Unit Time

The Federal Highway Administration's HERS computer model provides estimates of travel time as cost per hour per vehicle. The model looks at current conditions and the cost/benefit of improvements, and then provides cost estimates in order to optimize highway investment.

Table 11. Value of travel time in dollars per hour per vehicle-2002

Variable	Median	Lower	Upper
Personal Car	$22.00	$15.00	$25.00
Trucks	$35.00	$25.00	$45.00

Source: Federal Highway Administration. *Highway Economic Requirements System Technical Report*, U.S. Department of Transportation, December 2000.

Shrank and Lomax (2004) provided estimates of travel time for commercial trucks as having a value of $71.05 per commercial truck-hour in 2002.

The value of vehicle operating expenses associated with commuting (including car depreciation and gasoline costs) has been estimated by Weisbrod, Vary and Trayz (2001: 48) as $16.67 cents per minute or $10 per hour.

Per Mile

Personal cars tend to have high fixed costs (ownership and parking) and lower variable costs (operations and travel time) while taxis or car shares have the opposite. Walking has a high travel time cost.

Table 12. Cost of vehicle-mile traveled, average travel (2002)

Mode	
Average Car	$1.024
Compact Car	$0.942
Electric Car	$1.087
Van or Pickup	$1.182
Rideshare	
Passenger	$0.209
Diesel Bus	$8.387
Electric Trolley	$12.636
Motor-cycle	$1.396
Bicycle	$0.446
Walk	$1.108
Telework	$0.262

Source: Transportation Cost Analysis Spreadsheets, Victoria Transport Policy Institute (www.vtpi.org), 28 April 2003

Person-based Estimates

According to a report by the Victoria Transport Policy Institute, factors influencing a person's travel time values include type of trip, traveler preferences, travel conditions, and vehicle features (including amenities). Some general observations on travel time costs include the following:

- Personal travel time is generally calculated to be one-quarter to one-half of the wage rate. Business travel time is usually higher, up to 100% of wage rate.
- Travel time costs tend to increase with income, and are therefore lower for children, retirees, and unemployed people.
- Costs tend to be higher for unexpected delays and for congested conditions.
- People vary in their preference for transit versus driving, making the relative travel time cost subjective to the person (Litman 2002).

Per person-hour

According to Schrank and Lomax (2004) travel time had a value of $13.45 per person-hour in 2002

Percentage of wage rate

Miller (1989) came to the following values by synthesizing a number of different studies that created models for estimating travel time costs for travelers.

Table 13. Value of travel time in dollars per *person* hour

Category	Percent of Wage Rate
Drivers	60%
Drivers in congestion	90%
Pedestrians	60%
Pedestrians in congestion	90%
Cyclists	60%
Cyclists in congestion	90%
Passengers	40%
Passengers in congestion	60%

Miller, T., "The Value of Time and the Benefit of Time Savings: A Literature Synthesis and Recommendations on Values for Use in New Zealand". The Urban Institute (March 1989).

The U.S. Department of Transportation recommends these values for calculating the value of travel time.

Table 14. Value of travel time in dollars per *person* hour

Category	Reference	Value
In-vehicle personal (local)	Of Wages	50%
In-vehicle personal (intercity)	Of Wages	70%
In-vehicle business (local and intercity)	Of Total Compensation**	100%
Excess* Personal	Of Wages	100%
Excess* Business	Of Total Compensation**	100%

*Excess is waiting, walking, or transfer time

**Averages about 120% of wages

ECONNORTHwest and PBQD, Estimating the Benefits and osts of Public Transit Projects. TCRP Report 78, (http://gulliver.trb.org/publications/tcrp78/index.htm), TRB (www.trb.org), 2002.

Office of the Secretary of Transportation, guidance for the Valuation of Travel Time in Economic Analysis, U.S. Department of Transportation, April 1997.

Income

This model was derived from surveys of stated preference regarding the value highway users place on travel-time savings and predictability. The results were then stratified by annual household income.

Table 15. Value of travel time in dollars per *person* hour

Annual HH Income level	**Value per hour**
$15,000	$2.64
$55,000	$5.34
$95,000	$8.05

Hickling Lewis Brod, Institute of Transportation Studies, University of California, Irvine, Center for Urban Transportation Research, University of South Florida (August 1995). NCHRP 2-18.

These values are from the Federal Highway Administration's HERS computer model. The model looks at current conditions and the cost/benefit of improvements, and then provides cost estimates in order to optimize highway investment.

- Labor costs equal average hourly compensation and wages multiplied by average occupancy rate.
- Vehicle cost for autos equals average vehicle cost per year (5-year life span, 15% residual value at end) divided by 2,000 hours/year (hours in service).
- Vehicle cost for trucks equals average vehicle cost per year divided by number of hours in service (assumed to be 2,000 for 6-tire and 4 axle comb; 2,200 for 5-axle comb; and 1,600 for 3-4 axle truck).
- Inventory costs are derived from multiplying the average value of shipment times a computer hourly discount rate.
- "Other Trips" assumes travel time is valued at 55% to 65% of wage rate (Weisbrod, Vary, and Treyz 2001).

Miscellaneous Costs

Table 16. Value of travel time in dollars per *person* hour (1995 dollars)

	Autos		Trucks				
Category	Small	Medium	4-Tire	6-Tire	3-4 Axle	4-Axle Comb.	5-Axle Comb.
On-the-clock*							
Labor (wages/fringe benefits	$26.27	$26.27	$8.02	$21.88	$18.22	$21.95	$21.95
Vehicle Costs	$1.72	$2.02	$2.18	$3.08	$8.80	$7.42	$7.98
Inventory (transport cost)	$0.00	$0.00	$0.00	$0.00	$0.00	$1.65	$1.65
Total	$27.99	$28.29	$10.20	$24.96	$27.02	$31.02	$31.58
Other Trips**	$12.78	$14.33	$15.08	$25.27	$27.91	$31.64	$32.25

*Trips taken as part of work
**Trips taken for commuting, personal business, and leisure activity

Federal Highway Administration, *The Highway Economic Requirement System: Technical Report* (updated 3/97).

By vehicle

These values are derived from multiplying cost of vehicle-mile traveled (see table above) by average vehicle occupancy values.

Table 17. Cost of Passenger-Mile Traveled, Average Travel (2002)

Mode	Average Occupancy	Cost
Average Car	1.42	$0.746
Compact Car	1.42	$0.687
Electric Car	1.42	$0.791
Van or Pickup	1.42	$0.861
Rideshare Passenger	1.00	$0.209
Diesel Bus	10.20	$0.801
Electric Trolley	14.00	$0.871
Motor-cycle	1.00	$1.396
Bicycle	1.00	$0.446
Walk	1.00	$1.108
Telework	1.00	$0.262

Transportation Cost Analysis Spreadsheets. Victoria Transport Policy Institute (www.vtpi.org) 28 April 2003.

City Size

Methodology for deriving average cost values can be found in TTImethodolgy.pdf, pages 23-25.

Table 18. Annual Congestion Costs on the Average Traveler-2002

Population Group	Average Cost ($)	Average Delay (hours)	Average Fuel (gallons)
Very Large Areas	1,104	62	97
Large Areas	676	38	63
Medium Areas	448	25	42
Small Areas	219	12	20
85 Area average	829	46	74

Schrank, David and Tim Lomax. "2004 Annual Urban Mobility Report," Texas Transportation Institute, (http://mobility.tamu.edu/ums/) September 2004.

This table compares costs for urban peak and urban non-peak travel at high, medium, and low densities. It uses 50% of average local wage for commuting cost and 25% of average local wage for other travel costs.

Table 19. Travel Time Costs in Two Cities

($ per passenger mile)		BOSTON			PORTLAND, MA		
		High	Medium	Low	High	Medium	Low
Expressway	Peak	0.243	0.152	0.11	0.111	0.1	0.77
	Off-Peak	0.096	0.08	0.08	0.078	0.071	0.06
Non-Expressway	Peak	0.404	0.243	0.2	0.199	0.166	0.124
	Off-Peak	0.239	0.159	0.14	0.131	0.112	0.098
Commuter Rail	Peak	0.289	0.198	0.19	n/a	n/a	n/a
	Off-Peak	0.227	0.14	0.13	n/a	n/a	n/a
Rail Transit	Peak	0.401	0.281	n/a	n/a	n/a	n/a
	Off-Peak	0.286	0.253	n/a	n/a	n/a	n/a
Bus	Peak	0.505	0.505	0.51	0.426	0.426	0.302
	Off-Peak	0.398	0.398	0.4	0.335	0.335	0.238
Bicycle	Peak	0.606	0.606	0.61	0.498	0.498	0.498
	Off-Peak	0.478	0.478	0.48	0.392	0.392	0.392
Walk	Peak	2.43	2.02	2.02	1.66	1.66	1.66
	Off-Peak	1.59	1.59	1.59	1.31	1.31	1.31

Source: Conservation Law Foundation (1994) *The Cost of Transportation: Final Report*, Boston: Conservation Law Foundation, p. 119-120

Interruption of Public Services: Air Transportation

Table 20. Costs of Air Travel Delays

	Reference				
Item Estimated	AIA	ATA	CALTRANS	U.S. DOT	Allan, Gaddy, and Evans
Costs per person per hour of delay					
Passenger-general (or personal/business combined	$32.50 (2000)			$37.20 (2003)	
Passenger-personal		$33.00	$28.60	$31.50 (2003)	$26.70
Passenger-business				$45.00 (2003)	
Crew				$28.60 (2003)	
Costs per hour of delay					
Aircraft operating costs				$1,495.00 (1995)	
Aircraft operating costs					$3,093

Sources:

Aerospace Industries Association (AIA) (2002) The National Economic Impact of Civil Aviation. Retrieved on March 1, 2005 from http://www.aia-aerospace.org/aianews/press/2002/rel_09_30_02.cfm.

Air Transport Association (ATA) (2004) System Capacity: The Cost of Air Traffic System Delays (Under Construction). Retrieved on March 22, 2005, from http://www.airlines.org/econ/d.aspx?nid=5773.

Allan, S. S., Gaddy, S. G., and Evans, J. E. (2001) Delay Causality and Reduction at the New York City Airports Using Terminal Weather Information Systems. Port Authority of New York and New Jersey. Retrieved on March 30, 2005, from http://www.ll.mit.edu/AviationWeather/atc-291.pdf.

CALTRANS (2005) Categories of Travel Time. Division of Transportation Planning, California Department of Transportation. Retrieved on March 23, 2005, from http://www.dot.ca.gov/hq/tpp/offices/ote/Benefit_Cost/benefits/travel_time/categories.html.

U.S. Department of Transportation (DOT) (2003) Section 1: Treatment of Values of Passenger Time in Air Travel. Department of Transportation. Retrieved on March 30, 2005, from http://api.hq.faa.gov/economic/742SECT1.pdf.

REFERENCES CITED

Aerospace Industries Association (AIA) (2002) *The National Economic Impact of Civil Aviation*. Retrieved on March 1, 2005 from http://www.aia-aerospace.org/aianews/press/2002/rel_09_30_02.cfm.

Air Transport Association (ATA) (2004) *System Capacity: The Cost of Air Traffic System Delays (Under Construction)*. Retrieved on March 22, 2005, from http://www.airlines.org/econ/d.aspx?nid=5773.

Allan, S. S., Gaddy, S. G., and Evans, J. E. (2001) *Delay Causality and Reduction at the New York City Airports Using Terminal Weather Information Systems*. Port Authority of New York and New Jersey. Retrieved on March 30, 2005, from http://www.ll.mit.edu/AviationWeather/atc-291.pdf.

Ariu, T. (2004) *Impact of the North America Blackout – How Did Commercial/Industrial Customers React?* CRIEPI News.

Bannister, Paul. "Insuring Your Body, Piece by Piece," Bankrate.com., September 23, 2003. Accessed on April 25, 2005: http://origin.bankrate.com/brm/news/insurance/body-worth1.asp

Brod, H.L. (1995) Institute of Transportation Studies, University of California, Irvine, Center for Urban Transportation Research, University of South Florida (August). NCHRP 2-18.

Butler, A.S., Panzer, A.M. and Goldfrank, L.R., editors (2003) *Preparing for the Psychological Consequences of Terrorism. A Public Health Strategy*. Washington, DC: The National Academies Press.

CALTRANS (2005) *Categories of Travel Time. Division of Transportation Planning, California Department of Transportation*. Retrieved on March 23, 2005, from http://www.dot.ca.gov/hq/tpp/offices/ote/Benefit_Cost/benefits/travel_time/categories.html.

Conservation Law Foundation (1994) *The Cost of Transportation: Final Report.* Boston, MA: CLF.

Consortium for Electric Infrastructure to Support a Digital Society (CEIDS) (2001) The Cost of Power Disturbances to Industrial & Digital Economy Companies. Madison, WI: CEIDS.

Corwin, J.L. and Miles, W.T. (1978) "Impact Assessment of the 1977 New York City Blackout." Palo Alto: Systems Control Inc. Typed ms. Prepared for Lester H. Fink, Div. of Electric Energy Systems, U.S. Department of Energy. Preliminary copy, July.

Dixon, L. and Stern, R.K. (2004) *Compensation for Losses from the 9/11 Attacks*, Santa Monica, CA: Rand Institute for Civil Justice.

ECONNORTHwest and PBQD*, Estimating the Benefits and Costs of Public Transit Projects. TCRP Report 78*, (http://gulliver.trb.org/publications/tcrp78/index.htm), TRB (www.trb.org), 2002.

Electricity Consumers Resource Council (ELCON) (2004) *The Economic Impacts of the August 2003 Blackout*. ELCON.

Fischhoff, B. (2002) "Assessing and Commujnicating the Risks of Terrorism," in Teiche, A.H., Nelson, S.D. and Lita, S.J. editors, *Science and Technology in a Vulnerable World*. Washington, DC: AAAS, pp. 51-64.

ICF Consulting (undated c.2003-2004) *The Economic Cost of the Blackout. An issue paper on the Northeastern Blackout, August 14, 2003*. 3pp. www.icfconsulting.com.

ICF Consulting (Summer 2003) *Measuring the Economic Costs of Terrorist Attacks*. 2pp.

LaCommare, K.H. and Eto, J.H. (2004) "Understanding the Cost of Power Interruptions to U.S. Electricity Customers," Berkeley, CA: UC-Berkeley, Lawrence Berkeley National Laboratory.

Litman, T. (2002) "Transport Cost and Benefit Analysis-Travel Time Costs" Victoria Transport Policy Institute. 18 March 2005. (http://www.vtpi.org/tca/tca0502.pdf)

Miller, T. (1989) "The Value of Time and the Benefit of Time Savings: A Literature Synthesis and Recommendations on Values for Use in New Zealand," Washington, DC: The Urban Institute, March.

Mine Safety and Health Administration. Available at http://www.msha.gov/s&hinfo/costgenerator/costgenerator.htm

Morall III, J.F. (1986) A Review of the Record, Regulation, November/December.

Nordhaus, W.D. and Kokkelenberg, E.C. editors (1999) *Nature's Numbers. Expanding the National Economic Accounts to Include the Environment*. Washington, DC: National Academy Press.

Office of the Secretary of Transportation, guidance for the Valuation of Travel Time in Economic Analysis, U.S. Department of Transportation, April 1997.

Rand Corporation (2004) *Rand Research Briefs. Compensating Victims for 9/11*. Research Brief. Santa Monica, CA.

Schrank, D. and Lomax, T. (2004) "2004 Annual Urban Mobility Report," Texas Transportation Institute, (http://mobility.tamu.edu/ums/) September.

Schrank, D. and Lomax, T. (2005) "2005 Annual Urban Mobility Report," Texas Transportation Institute, (http://mobility.tamu.edu/ums/) September.

U.S. Congress, Congressional Research Service (CRS) Library of Congress (1978) "The Cost of an Urban Blackout: The Consolidated Edison Blackout, July 13-14, 1977." Washington, DC: U.S. Government Printing Office. 1978.

U.S. Congress, Office of Technology Assessment (1990) Physical Vulnerability of Electric System to Natural Disasters and Sabotage," Washington, DC: U.S. GPO. June. OTA-E-453.

U.S. Department of Justice, 2004: http://www.usdoj.gov/opa/pr/2004/April/04_civ_207.htm

U.S. Department of Transportation (DOT) (2003) Section 1: Treatment of Values of Passenger Time in Air Travel. Department of Transportation. Retrieved on March 30, 2005, from http://api.hq.faa.gov/economic/742SECT1.pdf.

U.S. Department of Transportation, Federal Highway Administration (1997) The Highway Economic Requirement System: Technical Report (updated 3/97).

U.S. Department of Transportation, Federal Highway Administration (2000) *Highway Economic Requirements System Technical Report,* U.S. Department of Transportation, December.

U.S. Department of Transportation, Office of the Secretary of Transportation (1997) Guidance for the Valuation of Travel Time in Economic Analysis, U.S. Department of Transportation, April.

U.S. Environmental Protection Agency, The Benefits and Costs of the Clean Air Act, 1970-1990, U.S. EPA, October 1997. http://www.epa.gov/oar/sect812/appen_i.pdf

U.S. Environmental Protection Agency (EPA) (1999) *The Benefits and Costs of the Clean Air Act 1990 to 2010, EPA Report to Congress,* November, pp. 70-71.

Victoria Transport Policy Institute (2003) Spreadsheets. www.vtpi.org.

Viscusi, K. and Aldy, J.E. (2003) The Value of a Statistical Life: A Critical Review of Market Estimates Throughout the World, Vol 27, J. of Risk and Uncertainty, pp. 5-76.

Weisbrod, G., Vary, G. and Treyz, G. (2001) "NCHRP REPORT 463: Economic Implications of Congestion," Transportation Research Board.