THE TOTAL COST OF FIRE IN THE UNITED STATES

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Abstract

The total cost of fire in the United States is defined to be a combination of the losses caused by fire and the money spent to prevent worse losses, by preventing fires, containing them, detecting them quickly, and suppressing them effectively. For 2005, that total cost is estimated at $267-294 billion, or roughly 2 to 2½% of U.S. gross domestic product. Property loss – reported or unreported, direct or indirect – represents only $12.7 billion of this total. The net costs of insurance coverage ($15.9 billion), the cost of career fire departments ($30.7 billion), building costs for fire protection ($45.9 billion), other economic costs ($39.9 billion), the monetary value of donated time from volunteer firefighters ($80-107 billion), and the estimated monetary equivalent for the deaths and injuries due to fire ($41.6 billion), all are larger components than property loss.

Keywords: fire statistics, cost, loss estimates, fire losses

Acknowledgements

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We are grateful to the Insurance Information Institute and the U.S. Census Bureau for expenditure and loss data used in this report.

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Executive Summary

In 2005, property losses due to fire (direct and indirect, reported and unreported) totaled an estimated $12.7 billion. After adjustment for inflation using the Consumer Price Index, this represented a 32% decrease from 1980.

Other economic costs of fire in 2005 included: the cost of career fire departments ($30.7 billion, up 127% from 1980 after adjusting for inflation), the net difference between fire-related insurance premiums paid and NFPA's estimate of economic losses eligible for insurance coverage ($15.9 billion, up 63% from 1980 after adjusting for inflation), and new building construction costs for fire protection ($45.9 billion, up 82% from 1980 after adjusting for inflation).

The core total cost of fire is defined as the sum of these four cost estimates and therefore was $105.2 billion in 2005, up 57% from 1980 after adjusting for inflation.

Other economic costs that are not re-estimated each year but only updated for inflation cost an estimated $39.9 billion. Human losses are estimated at $41.6 billion, using formulas developed by the U.S. Consumer Product Safety Commission and with acknowledgement that no amount of money can compensate for the loss of a loved one. The monetary value of donated time from volunteer firefighters is estimated at $80-107 billion.

Therefore, the complete total cost of fire is estimated at $267-294 billion, or roughly 2 to 2½% of U.S. gross domestic product.

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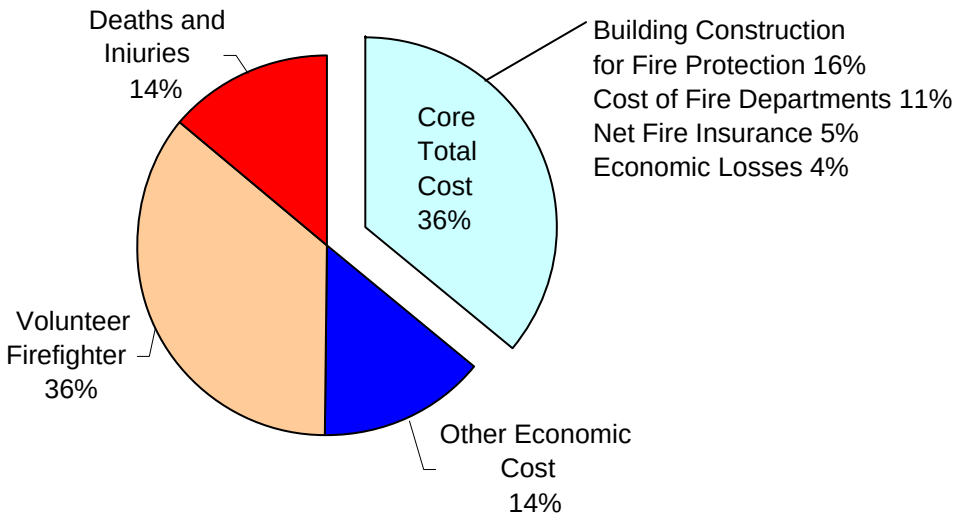
The Total Cost of Fire in 2005

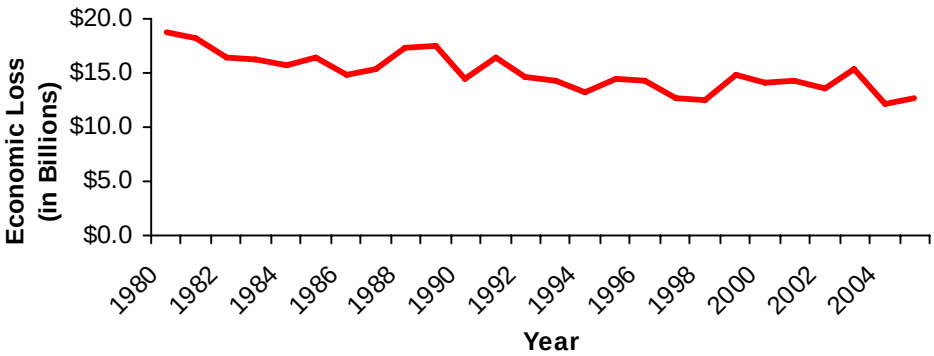
In 2005, the total cost of fire was an estimated $267-294 billion, or 2-2½ percent of U.S. gross domestic product (GDP). The total cost of fire includes the losses that fire causes, such as lives lost, medical treatments, property damage, business interruption, etc.; and the cost of provisions to prevent or mitigate the cost of fire, such as fire departments, insurance, and fire protection equipment and construction.

Total Cost of Fire 2005



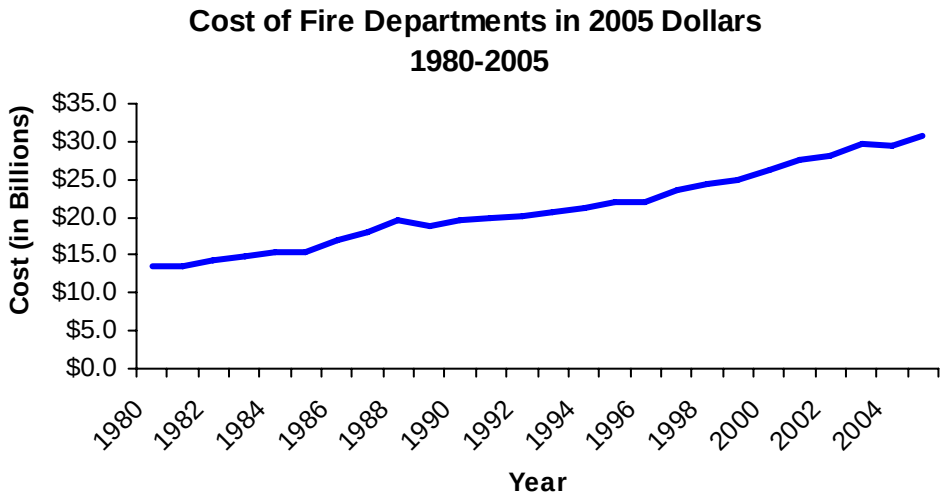
In 2005, property losses to fire (direct and indirect, reported and unreported) totaled an estimated **$12.7 billion**.

Economic Losses to Fire in 2005 Dollars
1980-2005



FACT: Fires in 2005 caused $10.7 billion in direct property damage, 84% of economic loss that year.

Career fire departments[1] cost **$30.7 billion** in 2005.



FACT: Part of cost increase is due to shift from volunteer to career fire departments.

Building construction for fire protection cost an estimated **$45.9 billion** in 2005.

FACT: Building construction costs include passive protection, such as compartmentation, and active protection, such as detection and sprinkler systems.

[1]A fire department is a public or private organization that provides fire prevention, fire suppression, and associate emergency and non-emergency services to a jurisdiction such as a county, municipality, or organized fire district.

Introduction

The "total cost" of fire is defined to include the losses that fire causes, directly and indirectly, and the cost of provisions to prevent or mitigate the losses caused by fire. For several years, NFPA has provided information on the total cost of fire - that is, losses plus the costs of protection - to the World Fire Statistics Centre in Geneva.* This report updates these calculations through 2005.

The challenge in any assessment of the total cost of fire is twofold - deciding what impacts of fire should be counted as costs and finding good bases for including the elements selected. Some elements are fairly straightforward, such as direct costs of career fire departments. Some clearly are costs of fire prevention or mitigation but are hard to estimate with available data, such as the portion of annual construction expenditures that is spent only to provide fire protection.

The methodology used in this report has evolved over the years. In particular, the current methodology incorporates several concepts and calculations from a 1991 study by William Meade.**

The elements of total cost are presented in stages in this report. First, those elements that involve actual transaction costs (where money changes hands) and can be calculated annually are combined in a "core" total cost. The core is defined as economic loss in fire, whether direct or indirect, whether reported or unreported; government expenditures on local fire protection; the portion of new construction expenditures related to fire protection; and the net of insurance premiums for fire hazards over NFPA estimates of fire losses covered by that insurance. Second, those elements that have been estimated only in one-time special studies are addressed.

Finally, the economic value of the donated time of volunteer firefighters, a “cost” which does not pass through any explicit market, is addressed. This sequence should allow readers to draw their own conclusions about what is and is not appropriately considered a cost of fire.

Our best data on direct fire losses begins in 1980, when all major fire data bases stabilized their methods in essentially the form they use today, so the figures shown here begin with that year. Notes on the sources of the estimates are included to help readers who may wish to test the effect of making different assumptions or even conduct research to develop more sophisticated models.

* The World Fire Statistics Centre at 12 Kylestrome House, Ebury Street, London, England SW1W 9JT, has conducted studies of comparative national fire statistics for more than a decade. See http://www.genevaassociation.org. Beginning with 1979 statistics, the WFSC has collected total cost statistics from numerous industrialized countries, and Wilmot's studies represent one of the few continuing systems that track international fire statistics. The World Health Organization's annual tallies of death certificates have even wider coverage of countries than the WFSC.

** William P. Meade, *A First Pass at Computing the Cost of Fire Safety in a Modern Society*, NIST-GCR-91-592, Gaithersburg, MD: National Institute of Standards and Technology, Building and Fire Research Laboratory, June 1991.

Estimates of Economic Loss

Direct economic loss (also called direct property damage) is estimated each year for reported fires by NFPA, and the estimates are published in *NFPA Journal*, usually in the September/October issue. (See Table 1.) Estimates from a 1984 survey of unreported fires indicate that unreported home fires add 4.0 to 6.5% to the dollar loss total for reported home fires, so a middle figure of 5.3% has been used across the board for all unreported-fire loss.* (See Tables 1-2.) In 2001, this multiplier is not applied to the losses in the unique events of September 11.

Indirect loss refers to costs of temporary housing, missed work, and lost business; and may refer to intangible losses, such as heirlooms or pets. Indirect loss also has been systematically and comprehensively analyzed only for home fires.** NFPA review of this study leads to the use of a 10% figure for indirect loss as a fraction of direct loss in home fires.

Prior to 1991, a 10% multiplier was used in this study across the board for indirect fire losses in properties other than homes. Meade's analysis led to a renewed examination of this cost component, but his approach of estimating that indirect loss averaged twice direct loss was not adopted for this study.***

To provide a better basis for estimating indirect loss, 109 incidents from 1989 were reviewed in a one-time study of business-interruption losses recorded by highly-protected-risk insurance carriers. (Note that much of the business interruption loss is offset, from society's point of view, by increased business for competitors who fill the gap created by the closed businesses. That offset is not reflected in these calculations.) These incidents were used to develop multipliers appropriate to each major occupancy group.

This analysis led to the following estimating rules:

1. Each year, 2% of reported non-residential structure fires, excluding fires in storage facilities and special structures (e.g., vacant properties, properties under construction, structures that are not buildings) result in business closings. Other references have cited much higher percentages, but a search of the literature has not found an alternative estimate that is specific as to the size of fire considered, the property uses examined, or the data used to develop the estimate. For the purposes of this analysis, a closing was estimated to imply indirect losses equal to four times reported average direct loss in those types of fires. (Business interruption claims apparently are not paid when a business closes, so Meade's analysis was used as a basis for

* *1984 National Sample Survey of Unreported Residential Fires*, Final Technical Report for Contract No. C-83-1239 to US Consumer Product Safety Commission, Princeton, NJ: Audits & Surveys - Government Research Division, June 13, 1985, calculated from figures on pp. ii and v.

** Michael J. Munson and James C. Ohls, *Indirect Costs of Residential Fires*, FA-6, Federal Emergency Management Agency, Washington, DC, April 1980. This study also includes medical and other costs related to deaths and injuries, which are handled separately in this report.

*** Meade's analysis also doubled NFPA's figures for direct damage in stores and offices and in manufacturing, industrial, and storage properties to cover self-insured losses, but NFPA's figures are not limited to insured losses and that multiplier is too high as an estimate of unreported losses in those properties. William P. Meade, *A First Pass at Computing the Cost of Fire Safety in a Modern Society*, NIST-GCR-91-592, Gaithersburg, MD: National Institute of Standards and Technology, Building and Fire Research Laboratory, June 1991.

assigning a value.) This component of indirect loss is therefore estimated as 4 x 2% x (direct damage in non-residential structures excluding storage and special structures).

2. Indirect losses (principally business interruption costs) also add the following amounts to direct loss, reported or unreported, based on property class (see Table 1):

- 65% for manufacturing and industrial properties,
- 25% for public assembly, educational, institutional, store, and office properties,
- 10% for residential, storage, and special-structure properties, and
- 0% for vehicle and outdoor fires.

NFPA's percentages are much lower than Meade's, roughly one-tenth his average multiplier. It is likely that Meade's factors, being based on direct estimates by selected experts, were biased by the tendency to remember larger, more serious fires as disproportionately common. The tendency to remember well-publicized vivid incidents more often than lesser incidents and to overrate their frequency and share of the total is a phenomenon that shows up in many contexts.

As a side note, our analysis shows a low correlation between the size of the direct loss and the size of the business interruption cost. The percentage of variation explained, using business interruption as the dependent variable and direct damage as the independent variable, was only 20%. In other words, *any* formula that estimates indirect loss as a multiple of direct loss is on shaky ground, but at this writing, there seems to be no alternative.

It is not difficult to identify large, well-publicized fires in which the cost of business interruption far exceeds direct property loss. One type of fire where this can happen involves a property that offers lodging or workspace and suffers so much damage that the slack capacity of the facility or even the community is not sufficient to absorb the displaced demand. An example is the MGM Grand Hotel fire, where the hotel claimed total direct damage and business interruption costs of $211 million, while NFPA's best information placed direct damage at $30-50 million.*

Sometimes, though, it can be difficult to determine what the true net loss due to business interruption is – what constitutes an "interruption." Compare two large high-rise office building fires.** Fire destroyed four floors of a 62-story high-rise bank building in California in 1988 but also took the entire building out of service for six months – a true business "interruption," because the property reopened after repairs. By contrast, a 1991 Pennsylvania high-rise office building fire destroyed more floors in a shorter high-rise office building (38 stories) and the building never reopened. The dozens of firms, occupying nearly a million square feet of office space, had to seek new permanent homes, but the real estate community estimated, a year after the fire, that vacancy rates would still be 11-12% *after* every displaced firm had been absorbed. This building represented an estimated 2.5% of office space in its metropolitan area, while a 1980 Nevada hotel fire represented a larger share of hotel rooms in its metropolitan area. These are all factors in determining how easily a market can compensate for interruption of capacity

*"MGM Fire Litigation," *Business Insurance*, January 2, 1984, p. 10; and "Fire at the MGM Grand," *Fire Journal*, January 1982, pp. 19 ff.

** Thomas J. Klem, "Los Angeles High-Rise Bank Fire," *Fire Journal*, May/June 1989, p. 85; and David M. Halbfiner, "Incalculable Cost of One Meridian Fire," *Philadelphia Business Journal*, February 24, 1992, pp. 1, 30.

from one provider. Similar concerns arise for fires in any type of large multi-unit residential or health care occupancy.

Analogous issues arise if fire in a large manufacturing, storage, or retail facility significantly reduces availability of a class of products. Most products have production and distribution chains that are too well dispersed, with too much redundancy, to create vulnerability to such an interruption from a single fire.

The most clearcut examples of widespread vulnerability involve critical elements of the nation's infrastructure. Fears of great damage from a widely distributed computer virus have so far not materialized, and two major interruptions to the Northeast electrical power grid in the last third of the 20th century were not due to fire, but there have been three telephone exchange fires causing widespread and prolonged telephone service outages, including a well-publicized 1988 Illinois fire.* (The other two were in New York City in 1975 and 1987.) A total of 38,000 customers were served by that telephone exchange office. The majority were still without service 5 days later, and some did not regain service until 9 days after the fire. An estimated 9,000 businesses were affected, including a nationwide hotel chain's reservation service, a florist delivery service networked to 12,500 florists around the country, and communications between a Federal Aviation Administration control tower and both of Chicago's major commercial airports. The most conservative estimate of the costs of the associated delays and lost business would exceed the estimated $40-60 million in direct damage.

Summary of economic loss formulas

Direct damage in reported fires = statistical projections from the NFPA survey, as reported in annual loss article

Direct damage in unreported fires = 5.3% x (direct damage in reported fires)

Indirect damage in fires [see point 2 on pp. 2-3 for first three terms and point 1 on p. 2 for the last term] =
[65% x (direct damage in manufacturing or industrial structures)]
+ [25% x (direct damage in public assembly, educational, institutional, store, or office structures)]
+ [10% x (direct damage in residential, storage, or special structures)]
+ [4 x 2% x (direct damage in non-residential, structures excluding storage and special structures)]

*Michael S. Isner, *Fire Investigation Report – Telephone Central Office, Hinsdale, Illinois, May 8, 1988*, NFPA Fire Investigations Division, Quincy, MA, 1989.

Costs of Fire Departments

Each year, the U.S. Bureau of the Census calculates expenditures on local fire protection, which is presumed to mean all costs of local career fire departments and direct purchases by volunteer fire departments using funds from special taxes or transfers from other local agencies. These results appear in the annual *Statistical Abstract of the United States* and also appear earlier on-line in the source reports and tables cited in the *Statistical Abstract*. (See Tables 1-2.)

Statistics on Federal and state government expenditures are difficult to come by, but it is assumed that these combined expenditures are quite small, relative to the nearest $100 million threshold used for rounding in this report. Statistics on the costs of industrial fire brigades have not been located and are not included in this report but are also believed to be small relative to the billions of dollars represented by the primary items in this analysis. Apparatus and other equipment for volunteer fire departments also are not included if they were purchased through donations.

Net Fire Insurance

This component is meant to estimate the difference between the premium money taken in by fire insurers and the money paid out for claims. Estimation is complicated because much of the premium money is contained in multiple-peril policies and because the insurance industry does not publish statistics on claims paid but only its own estimates of total fire loss, including losses for which no claim was paid (e.g., a loss to an uninsured property). (Multiple-peril policies are policies that cover a number of hazards including but not limited to fire.) (See Table 1.)

Prior to 1991, the figure used to estimate claims had been the NFPA total for direct property damage reported to fire departments. Fire department estimates are used because insurance industry loss estimates are not limited to what they pay out but include deductibles and estimates of uncovered losses in uninsured and underinsured properties. Use of the fire department loss figures is not a perfect solution to this problem, but it should make the various figures somewhat more compatible.

Two changes have been made to this formula. First, it was recognized that the premium calculation does not include the fire portion of insurance premiums for automobiles or other vehicles. Therefore, losses in vehicle fires and outdoor fires are not subtracted from premiums. Second, it was estimated that half the indirect losses are reimbursed by insurance companies, reflecting the fact that many policies, especially for homes, do not extend to these kinds of losses. Therefore, the loss figure used to calculate the net fire insurance component now includes half the estimated indirect loss, where before it did not include any indirect loss.

Switching to the estimation of the fire portion of insurance premiums, a study conducted in the late 1970s by three students from Worcester Polytechnic Institute (WPI) estimated a 45% figure for the fire portion of multiple-peril policies.* With the huge increases in liability insurance in the mid-1980s, however, this estimate was no longer viable. Based on a conversation in the early 1990's with a staff person at the Insurance Services Office (ISO), we estimate that a 21% figure is now more appropriate. This change did not occur all at once, so as a rough reflection of the transition, this study uses figures of 40% for 1984, 27% for 1985, and 21% for 1986 and later years.

This early 1990's estimate has been checked against actual data from more recent years and found still to be well-supported. Beginning with 1998 data, the Insurance Information Institute has provided some additional detail on where premium dollars go for homeowner and commercial multi-peril policies. Fire and lightning claims averaged 22% of homeowner premiums during 1998-2002 and averaged 35% of total non-liability claims. For commercial policies, data is provided on the liability vs. non-liability shares but not on the fire share specifically. If we use the fire and lightning share of non-liability claims from homeowner policies – and recognizing that liability is a much larger share for commercial than for homeowner – we find an average of 20% of commercial premiums during 1998-2002 was estimated to be fire and lightning. Total homeowner multi-peril premiums are higher than total commercial multi-peril premiums. When you combine these calculations (22% of homeowner premiums and 20% of commercial premiums) you end up with an overall percentage of 21%, the same as has been used in NFPA total-cost reports since the mid-1980s.

* John J. Apostolow, David L. Bowers, and Charles M. Sullivan III, "The Nation's Annual Expenditure for the Prevention and Control of Fire," Project Report, Worcester Polytechnic Institute, Worcester, MA, December 21, 1978.

Two cautions must be applied here. First, there is considerable year-to-year variation and the range has widened as more years of data have occurred. Second, there are other allocations that could be applied and would further widen the range of percentages. For example, the homeowner policy percentages do not include an allocation of expenses other than claims, such as administrative costs and costs associated with selling and marketing.

Not all of the net fire insurance figure may be safely attributed to insurance industry operating expenses, other costs, and profits. There is a disparity between the NFPA's estimates of fire losses based on fire department reports and the insurance industry's estimates, as reported in *The I.I.I. Fact Book*, which is published annually by the Insurance Information Institute of New York (I.I.I.). Tables 1-2 list the parts of net fire insurance as "incremental loss" and "other". Incremental loss is calculated as I.I.I. estimated economic losses minus NFPA total economic loss (including indirect and unreported). Note that incremental loss was actually negative (NFPA loss was higher) for most years before 1994 and has become a large positive component consistently only since 2001.

NFPA estimates (including indirect and unreported loss) rose 61% from 1980 to 2005, and the portion of loss (direct structure fire loss plus half of estimated indirect loss) used to calculate the net fire insurance figure rose 63% in the same period. Both increases are considerably less than the 137% rise in the consumer price index, which is less than the rise in the I.I.I. estimate of 271% over the same period. It is not known how much of this represents changes in the I.I.I. formula for estimating uninsured and unreported losses, and how much represents a widening gap between the losses occurring in fires reported to insurance companies and the losses occurring in fires reported to fire departments. This could be an interesting subject for further research. In 2005, nearly two-thirds of the "net fire insurance" total corresponded to the difference in the two estimates of fire loss.

Summary of net fire insurance component:

Net fire insurance =
[Fire insurance premiums]
+ [21% x (homeowner, commercial, and farm owner multi-peril premiums)]
- [NFPA estimate of direct property damage in fires reported to fire departments, excluding vehicle and outdoor properties]
- [(½) x (NFPA estimate of indirect loss)]

Incremental loss = (I.I.I. estimates of fire loss, including estimates for uninsured and underinsured loss) – (NFPA estimate of total economic loss, including indirect and unreported)

Other (i.e., net fire insurance other than incremental loss) = (Net fire insurance) – (Incremental loss)

Building Construction for Fire Protection

The costs included here are estimates of construction expenditures that are needed solely because of fire safety and fire protection considerations, such as compartmentation features, built-in fire protection systems, and treatments of or limitations on exterior surfaces. Indirect costs, such as the need to maintain minimum spacings between buildings, which are a barrier to high-density development, are not reflected. (See Table 1.)

The annual figures on the value of new construction are collected by the U.S. Bureau of the Census, but they are sometimes updated for a short time after first publication. To obtain more up-to-date figures, this report derived 1980-84 totals from the 1988 edition of the *Statistical Abstract of the United States* and 1985-2005 totals from later editions and on-line source tables that sometimes are available earlier.* Built-in fire protection for vehicles is not covered.

The estimate is built up from percentages applied to components of the value of new construction. The original percentages were developed by the WPI students mentioned earlier through architect and engineer estimates based on a few reference building designs. At that time, there were four categories of construction, and the evolution of the formulas will be described in terms of these four categories:

- Private residential construction. The original percentage of 2.5% is still used.

- Public building construction. The original percentage of 4.0% is still used. However, beginning in 2003, the reporting of construction expenditures does not use a single umbrella category called public building construction. In its absence, public building construction is estimated as total state and local government construction minus presumptively non-building construction listed under runways, railroads, power, highways and streets, sewage and waste disposal, water supply, and conservation and development.

- Private nonresidential construction. The original percentage was 9.0%. The Meade study referenced earlier proposed a higher percentage of 12.0%, which has been adopted here and applied retroactively to all years of this study. Meade's higher figure was based on conversations with knowledgeable people in a few companies and was actually lower than most of the figures the interviewers cited. While there is a substantial risk that the interviewees were taken disproportionately from the more fire-safety-conscious end of American industry, whose spending patterns may provide more fire protection than is typical, Meade's approach is at least as well-documented as the study that led to the original formulas. Therefore, we now use Meade's factor. Also, in 2003, private construction other than residential was no longer reported in two umbrella categories of nonresidential and other. Nonresidential private building construction is now calculated as total nonresidential construction minus presumptively non-building construction listed under communications, power, and railroad.

*The figures are taken from the "Value of New Construction Put in Place" table in *Statistical Abstract of the United States*, Washington: U.S. Bureau of the Census.

- Other private building construction. The original percentage of 3.0% was used for this relatively small fourth component until 2002. Beginning in 2003, all private building construction is listed under more specific categories, each of which, is either residential or nonresidential. Hence, there is no "other" private building construction expenditure to use.

For 2005, these translate into $16.1 billion for private residential construction (2.5% of $642.3 billion), $25.0 billion for private nonresidential construction (12.0% of $208.5 billion), and $4.8 billion for public building construction (4.0% of $120.4 billion). The total is $45.9 billion, which is based on summing the components before they are rounded.

A key weakness in this formula is that it does not treat built-in fire protection as a *capital* expenditure, which it is. The ups and downs of the construction business, which dominate year-to-year changes in this component under the current formula, may have little to do with the real fluctuations in value of the fire protection built into our inventory of buildings.

Summary of construction for fire protection component:

Cost of building fire protection =
[2.5% x value of private residential building construction)]
+ [12.0% x (value of nonresidential construction excluding communications, power, and railroad)]
+ [4.0% x (value of state and local government construction excluding runways, railroads, power, highways and streets, sewage and waste disposal, water supply, conservation and development)]

Summary of the Core of Total Cost of Fire

Tables 1 and 2 provide an overview of the core of the total cost of fire and its principal components for all years from 1980 to 2005. For 2001, figures are shown with and without the losses in the unique events of September 11 (including estimated indirect losses, computed with the standard formula).

Table 1 shows the size (in current dollars for the year indicated) of each total cost component, the percentage share of the total accounted for by each component, and the total adjusted to 2005 dollars using the consumer price index. Table 2 shows all costs in 2005 dollars.

Table 3 shows how much each has changed between 1980 and 2005, both as a share of the total and in absolute size, with and without adjustment for inflation.

Fire service costs have risen most of all. Increases in the number of career firefighters explain part but not all of this increase. Other possible explanations for this trend could include (1) faster-than-inflation increases in the costs of health and retirement benefits, (2) expanded responsibilities for many departments, such as emergency medical service or hazardous material response and safety, with associated needs for expanded resources, and (3) increases in staff or overtime costs, to cover for reductions in the work week, in part because of the application of the Fair Labor Standards Act to municipal fire departments. Economic losses have risen much less than inflation. Building construction due to fire protection is a larger share of total cost than it was in 1980.

Table 1. Estimated Core Total Cost of Fire in the U.S.A. (in Billions)

Component of cost	1980		1981		1982		1983		1984	
Economic losses	$7.9	28%	$8.5	28%	$8.1	26%	$8.3	25%	$8.4	23%
Reported	($6.3)	(22%)	($6.7)	(22%)	($6.4)	(20%)	($6.6)	(20%)	($6.7)	(18%)
Unreported	($0.3)	(1%)	($0.4)	(1%)	($0.3)	(1%)	($0.3)	(1%)	($0.4)	(1%)
Indirect	($1.3)	(5%)	($1.4)	(5%)	($1.3)	(4%)	($1.4)	(4%)	($1.3)	(4%)
Costs of fire departments	$5.7	20%	$6.3	21%	$7.0	22%	$7.6	23%	$8.2	22%
Net fire insurance	$4.1	14%	$3.9	13%	$4.6	15%	$4.8	15%	$5.6	15%
Incremental loss	(-$2.3)	(-8%)	(-$2.9)	(-10%)	(-$2.2)	(-7%)	(-$2.0)	(-6%)	(-$0.8)	(-2%)
Other	($6.4)	(23%)	($6.8)	(23%)	($6.8)	(22%)	($6.8)	(21%)	($6.4)	(17%)
Building construction	$10.6	37%	$11.5	38%	$11.6	37%	$12.1	37%	$14.7	40%
Total	$28.3	100%	$30.2	100%	$31.3	100%	$32.8	100%	$36.9	100%
Total in 2005 dollars	$67.2		$64.8		$63.3		$64.3		$69.3	

Component of cost	1985		1986		1987		1988		1989	
Economic losses	$9.1	23%	$8.3	21%	$8.9	21%	$10.5	23%	$11.1	23%
Reported	($7.3)	(19%)	($6.7)	(17%)	($7.2)	(17%)	($8.4)	(19%)	($8.7)	(18%)
Unreported	($0.4)	(1%)	($0.4)	(1%)	($0.4)	(1%)	($0.4)	(1%)	($0.5)	(1%)
Indirect	($1.4)	(4%)	($1.2)	(3%)	($1.3)	(3%)	($1.8)	(4%)	($2.0)	(4%)
Costs of fire departments	$8.5	22%	$9.6	24%	$10.5	25%	$11.8	26%	$11.9	25%
Net fire insurance	$4.5	12%	$5.0	12%	$5.7	13%	$4.2	9%	$3.8	8%
Incremental loss	(-$1.3)	(-3%)	($0.2)	(0%)	(-$0.4)	(-1%)	(-$0.9)	(-2%)	(-$1.6)	(-3%)
Other	($5.8)	(15%)	($4.8)	(12%)	($6.1)	(14%)	($5.1)	(11%)	($5.4)	(11%)
Building construction	$16.9	43%	$17.2	43%	$17.6	41%	$18.4	41%	$20.6	43%
Total	$39.0	100%	$40.1	100%	$42.7	100%	$44.9	100%	$47.4	100%
Total in 2005 dollars	$70.7		$71.5		$73.4		$74.2		$74.7	

Note: Sums may not equal totals because of rounding error. Unless otherwise indicated, figures are not adjusted for inflation; they are the figures reported in those years. "Economic losses" include reported and unreported direct property damage and indirect loss, including business interruption. Costs of fire departments are for local career departments only. Net fire insurance is an estimate of the net of premium income over claims paid, based primarily on damages in fires reported to fire departments. Net fire insurance is separated into incremental loss (or the excess of insurance industry loss estimates over NFPA fire department based loss estimates) and other. Building construction is the estimated fire protection part of the value of new construction.

Sources: NFPA survey; *Statistical Abstract of the United States*; *The I.I.I. Fact Book*; websites related to data sources; formulas from special studies.

Table 1. Estimated Core Total Cost of Fire in the U.S.A. (in Billions) (Continued)

Component of Cost	1990		1991		1992		1993		1994	
Economic losses	$9.6	19%	$11.5	25%	$10.5	22%	$10.5	20%	$10.1	18%
Reported	($7.8)	(15%)	($9.5)	(20%)	($8.3)	(18%)	($8.5)	(16%)	($8.2)	(15%)
Unreported	($0.4)	(1%)	($0.5)	(1%)	($0.4)	(1%)	($0.5)	(1%)	($0.4)	(1%)
Indirect	($1.4)	(3%)	($1.5)	(3%)	($1.7)	(4%)	($1.5)	(3%)	($1.5)	(3%)
Costs of fire departments	$13.2	26%	$13.8	30%	$14.4	31%	$15.4	30%	$16.1	29%
Net fire insurance	$4.9	9%	$3.1	7%	$4.5	10%	$4.8	9%	$6.7	12%
Incremental loss	(-$0.1)	(-0%)	(-$0.2)	(-0%)	($3.1)	(7%)	(-$0.5)	(-1%)	($2.7)	(5%)
Other	($5.0)	(10%)	($3.3)	(7%)	($1.4)	(3%)	($5.3)	(10%)	($4.0)	(7%)
Building construction	$24.0	46%	$18.0	39%	$17.6	37%	$21.1	41%	$23.0	41%
Total	$51.7	100%	$46.4	100%	$47.0	100%	$51.8	100%	$55.9	100%
Total in 2005 dollars	$77.3		$66.5		$65.5		$70.0		$73.7	

Component of Cost	1995		1996		1997		1998		1999	
Economic losses	$11.3	19%	$11.5	18%	$10.4	15%	$10.4	14%	$12.6	17%
Reported	($8.9)	(15%)	($9.4)	(15%)	($8.5)	(12%)	($8.6)	(12%)	($10.0)	(13%)
Unreported	($0.5)	(1%)	($0.5)	(1%)	($0.5)	(1%)	($0.5)	(1%)	($0.5)	(1%)
Indirect	($1.9)	(3%)	($1.6)	(3%)	($1.5)	(2%)	($1.3)	(2%)	($2.1)	(3%)
Costs of fire departments	$17.1	29%	$17.7	28%	$19.4	28%	$20.3	28%	$21.3	28%
Net fire insurance	$5.9	10%	$6.1	10%	$7.0	10%	$7.8	11%	$6.0	8%
Incremental loss	($0.6)	(1%)	($1.0)	(2%)	($2.5)	(4%)	($1.1)	(2%)	($2.4)	(3%)
Other	($5.3)	(9%)	($5.1)	(8%)	($4.5)	(7%)	($6.7)	(9%)	($3.6)	(5%)
Building construction	$24.7	42%	$27.4	44%	$31.4	46%	$34.3	47%	$35.8	47%
Total	$59.0	100%	$62.7	100%	$68.2	100%	$72.8	100%	$75.7	100%
Total in 2005 dollars	$75.6		$78.1		$83.0		$87.3		$88.7	

Note: Sums may not equal totals because of rounding error. Unless otherwise indicated, figures are not adjusted for inflation; they are the figures reported in those years. "Economic losses" include reported and unreported direct property damage and indirect loss, including business interruption. Costs of fire departments are for local career departments only. Net fire insurance is an estimate of the net of premium income over claims paid, based primarily on damages in fires reported to fire departments. Net fire insurance is separated into incremental loss (or the excess of insurance industry loss estimates over NFPA fire department based loss estimates) and other. Building construction is the estimated fire protection part of the value of new construction.

Sources: NFPA survey; *Statistical Abstract of the United States*; *The I.I.I. Fact Book*; websites related to data sources; formulas from special studies.

Table 1. Estimated Core Total Cost of Fire in the U.S.A. (in Billions) (Continued)

Components of Cost	2000		2001 (Including Events of 9/11)		2001 (Excluding Events of 9/11)		2002		2003	
Economic losses	$12.4	15%	$54.7	44%	$12.9	15%	$12.5	15%	$14.5	15%
Reported	($10.2)	(13%)	($44.0)	(35%)	($10.6)	(13%)	($10.3)	(12%)	($12.3)	(13%)
Unreported	($0.5)	(1%)	($0.6)	(0%)	($0.6)	(1%)	($0.5)	(1%)	($0.7)	(1%)
Indirect	($1.7)	(2%)	($10.2)	(8%)	($1.8)	(2%)	($1.6)	(2%)	($1.6)	(2%)
Costs of fire departments	$23.1	28%	$25.0	20%	$25.0	30%	$26.0	30%	$27.9	29%
Net fire insurance	$6.8	8%	$7.8	6%	$7.8	9%	$12.0	14%	$14.8	16%
Incremental loss	($3.3)	(4%)	($6.5)	(5%)	($6.5)	(8%)	($7.2)	(8%)	($8.8)	(9%)
Other	($3.5)	(4%)	($1.3)	(1%)	($1.3)	(2%)	($4.8)	(6%)	($6.0)	(6%)
Building construction	$38.8	48%	$38.5	31%	$38.5	46%	$35.4	41%	$37.4	40%
Total	$81.1	100%	$126.0	100%	$84.2	100%	$85.9	100%	$94.6	100%
Total in 2005 dollars	$92.0		$139.0		$92.9		$93.2		$100.5	

Components of Cost	2004		2005	
Economic losses	$11.7	12%	$12.7	12%
Reported	($9.8)	(10%)	($10.7)	(10%)
Unreported	($0.5)	(1%)	($0.6)	(1%)
Indirect	($1.4)	(1%)	($1.5)	(1%)
Costs of fire departments	$28.3	29%	$30.7	29%
Net fire insurance	$16.1	16%	$15.9	15%
Incremental loss	($9.1)	(9%)	($10.0)	(10%)
Other	($7.0)	(7%)	($5.9)	(6%)
Building construction	$41.6	43%	$45.9	44%
Total	$97.7	100%	$105.2	100%
Total in 2005 dollars	$101.1		$105.2	

Note: Sums may not equal totals because of rounding error. Unless otherwise indicated, figures are not adjusted for inflation; they are the figures reported in those years. "Economic losses" include reported and unreported direct property damage and indirect loss, including business interruption. Costs of fire departments are for local career departments only. Net fire insurance is an estimate of the net of premium income over claims paid, based primarily on damages in fires reported to fire departments. Net fire insurance is separated into incremental loss (or the excess of insurance industry loss estimates over NFPA fire department based loss estimates) and other. Building construction is the estimated fire protection part of the value of new construction.

Sources: NFPA survey; *Statistical Abstract of the United States*; *The I.I.I. Fact Book*; websites related to data sources; formulas from special studies.

Table 2. Estimated Core Total Cost of Fire in the U.S.A. (in Billions, Adjusted for Inflation to 2005 Dollars)

Components of Cost	1980		1981		1982		1983		1984	
Economic losses	$18.7	28%	$18.2	28%	$16.4	26%	$16.3	25%	$15.8	23%
Reported	($15.0)	(22%)	($14.4)	(22%)	($12.9)	(20%)	($12.9)	(20%)	($12.6)	(18%)
Unreported	($0.7)	(1%)	($0.9)	(1%)	($0.6)	(1%)	($0.6)	(1%)	($0.8)	(1%)
Indirect	($3.1)	(5%)	($3.0)	(5%)	($2.6)	(4%)	($2.7)	(4%)	($2.4)	(4%)
Costs of fire departments	$13.5	20%	$13.5	21%	$14.2	22%	$14.9	23%	$15.4	22%
Net fire insurance	$9.7	14%	$8.4	13%	$9.3	15%	$9.4	15%	$10.5	15%
Incremental loss	(-$5.5)	(-8%)	(-$6.2)	(-10%)	(-$4.4)	(-7%)	(-$3.9)	(-6%)	(-$1.5)	(-2%)
Other	($15.2)	(23%)	($14.6)	(23%)	($13.7)	(22%)	($13.3)	(21%)	($12.0)	(17%)
Building construction	$25.2	37%	$24.7	38%	$23.4	37%	$23.7	37%	$27.6	40%
Total	$67.2	100%	$64.8	100%	$63.3	100%	$64.3	100%	$69.3	100%

Component of Cost	1985		1986		1987		1988		1989	
Economic losses	$16.5	23%	$14.8	21%	$15.3	21%	$17.3	23%	$17.5	23%
Reported	($13.2)	(19%)	($11.9)	(17%)	($12.4)	(17%)	($13.9)	(19%)	($13.7)	(18%)
Unreported	($0.7)	(1%)	($0.7)	(1%)	($0.7)	(1%)	($0.7)	(1%)	($0.8)	(1%)
Indirect	($2.5)	(4%)	($2.1)	(3%)	($2.2)	(3%)	($3.0)	(4%)	($3.2)	(4%)
Costs of fire departments	$15.4	22%	$17.1	24%	$18.0	25%	$19.5	26%	$18.8	25%
Net fire insurance	$8.2	12%	$8.9	12%	$9.8	13%	$6.9	9%	$6.0	8%
Incremental loss	(-$2.4)	(-3%)	($0.4)	(0%)	(-$0.7)	(-1%)	(-$1.5)	(-2%)	(-$2.5)	(-3%)
Other	($10.5)	(15%)	($8.6)	(12%)	($10.5)	(14%)	($8.4)	(11%)	($8.5)	(11%)
Building construction	$30.6	43%	$30.7	43%	$30.3	41%	$30.4	41%	$32.5	43%
Total	$70.7	100%	$71.5	100%	$73.4	100%	$74.2	100%	$74.7	100%

Note: Sums may not equal totals because of rounding error. "Economic losses" include reported and unreported direct property damage and indirect loss, including business interruption. Costs of fire departments are for local career departments only. Net fire insurance is an estimate of the net of premium income over claims paid, based primarily on damages in fires reported to fire departments. Net fire insurance is separated into incremental loss (or the excess of insurance industry loss estimates over NFPA fire department based loss estimates) and other. Building construction is the estimated fire protection part of the value of new construction.

Sources: NFPA survey; *Statistical Abstract of the United States*; *The I.I.I. Fact Book*; websites related to data sources; formulas from special studies.

Table 2. Estimated Core Total Cost of Fire in the U.S.A. (in Billions, Adjusted for Inflation to 2005 Dollars)

Component of Cost	1990		1991		1992		1993		1994	
Economic losses	$14.4	19%	$16.5	25%	$14.6	22%	$14.2	20%	$13.3	18%
Reported	($11.7)	(15%)	($13.6)	(20%)	($11.6)	(18%)	($11.5)	(16%)	($10.8)	(15%)
Unreported	($0.6)	(1%)	($0.7)	(1%)	($0.6)	(1%)	($0.7)	(1%)	($0.5)	(1%)
Indirect	($2.1)	(3%)	($2.2)	(3%)	($2.4)	(4%)	($2.0)	(3%)	($2.0)	(3%)
Costs of fire departments	$19.7	26%	$19.8	30%	$20.1	31%	$20.8	30%	$21.2	29%
Net fire insurance	$7.3	9%	$4.4	7%	$6.3	10%	$6.5	9%	$8.8	12%
Incremental loss	(-$0.1)	(-0%)	(-$0.3)	(-0%)	($4.3)	(7%)	(-$0.7)	(-1%)	($3.6)	(5%)
Other	($7.5)	(10%)	($4.7)	(7%)	($1.9)	(3%)	($7.2)	(10%)	($5.3)	(7%)
Building construction	$35.9	46%	$25.8	39%	$24.5	37%	$28.5	41%	$30.3	41%
Total	$77.3	100%	$66.5	100%	$65.5	100%	$70.0	100%	$73.7	100%

Component of Cost	1995		1996		1997		1998		1999	
Economic losses	$14.5	19%	$14.3	18%	$12.7	15%	$12.5	14%	$14.8	17%
Reported	($11.4)	(15%)	($11.7)	(15%)	($10.3)	(12%)	($10.3)	(12%)	($11.7)	(13%)
Unreported	($0.6)	(1%)	($0.6)	(1%)	($0.6)	(1%)	($0.6)	(1%)	($0.6)	(1%)
Indirect	($2.4)	(3%)	($2.0)	(3%)	($1.8)	(2%)	($1.6)	(2%)	($2.5)	(3%)
Costs of fire departments	$21.9	29%	$22.1	28%	$23.6	28%	$24.3	28%	$25.0	28%
Net fire insurance	$7.6	10%	$7.6	10%	$8.5	10%	$9.4	11%	$7.0	8%
Incremental loss	($0.8)	(1%)	($1.2)	(2%)	($3.0)	(4%)	($1.3)	(2%)	($2.8)	(3%)
Other	($6.8)	(9%)	($6.4)	(8%)	($5.5)	(7%)	($8.0)	(9%)	($4.2)	(5%)
Building construction	$31.6	42%	$34.1	44%	$38.2	46%	$41.1	47%	$41.9	47%
Total	$75.6	100%	$78.1	100%	$83.0	100%	$87.3	100%	$88.7	100%

Note: Sums may not equal totals because of rounding error. "Economic losses" include reported and unreported direct property damage and indirect loss, including business interruption. Costs of fire departments are for local career departments only. Net fire insurance is an estimate of the net of premium income over claims paid, based primarily on damages in fires reported to fire departments. Net fire insurance is separated into incremental loss (or the excess of insurance industry loss estimates over NFPA fire department based loss estimates) and other. Building construction is the estimated fire protection part of the value of new construction.

Sources: NFPA survey; *Statistical Abstract of the United States*; *The I.I.I. Fact Book*; websites related to data sources; formulas from special studies.

Table 2. Estimated Core Total Cost of Fire in the U.S.A. (in Billions, Adjusted for Inflation to 2005 Dollars)

Component of Cost	2000		2001 (Including Events of 9/11)		2001 (Excluding Events of 9/11)		2002		2003	
Economic losses	$14.1	15%	$60.4	43%	$14.2	15%	$13.6	15%	$15.4	15%
Reported	($11.6)	(13%)	($48.6)	(35%)	($11.7)	(13%)	($11.2)	(12%)	($13.1)	(13%)
Unreported	($0.6)	(1%)	($0.7)	(0%)	($0.7)	(1%)	($0.5)	(1%)	($0.7)	(1%)
Indirect	($1.9)	(2%)	($11.3)	(8%)	($2.0)	(2%)	($1.7)	(2%)	($1.7)	(2%)
Costs of fire departments	$26.2	28%	$27.6	20%	$27.6	30%	$28.2	30%	$29.6	29%
Net fire insurance	$7.7	8%	$8.6	6%	$8.6	9%	$13.0	14%	$15.7	16%
Incremental loss	($3.7)	(4%)	($7.2)	(5%)	($7.2)	(8%)	($7.8)	(8%)	($9.4)	(9%)
Other	($4.0)	(4%)	($1.4)	(1%)	($1.4)	(2%)	($5.2)	(6%)	($6.4)	(6%)
Building construction	$44.0	48%	$42.4	31%	$42.4	46%	$38.4	41%	$39.7	40%
Total	$92.0	100%	$139.0	100%	$92.9	100%	$93.2	100%	$100.5	100%

Component of Cost	2004		2005	
Economic losses	$12.1	12%	$12.7	12%
Reported	($10.1)	(10%)	($10.7)	(10%)
Unreported	($0.5)	(1%)	($0.6)	(1%)
Indirect	($1.4)	(1%)	($1.5)	(1%)
Costs of fire departments	$29.3	29%	$30.7	29%
Net fire insurance	$16.7	16%	$15.9	15%
Incremental loss	($9.4)	(9%)	($10.0)	(10%)
Other	($7.2)	(7%)	($5.9)	(6%)
Building construction	$43.1	43%	$45.9	44%
Total	$101.1	100%	$105.2	100%

Note: Sums may not equal totals because of rounding error. "Economic losses" include reported and unreported direct property damage and indirect loss, including business interruption. Costs of fire departments are for local career departments only. Net fire insurance is an estimate of the net of premium income over claims paid, based primarily on damages in fires reported to fire departments. Net fire insurance is separated into incremental loss (or the excess of insurance industry loss estimates over NFPA fire department based loss estimates) and other. Building construction is the estimated fire protection part of the value of new construction.

Sources: NFPA survey; *Statistical Abstract of the United States*; *The I.I.I. Fact Book*; websites related to data sources; formulas from special studies.

Table 3. Changes in Components of Core of Total Cost of Fire 1980 - 2005

Component of Cost	Percent Change 1980 - 2005		1980 Percent Share	2005 Percent Share
	Not Adjusted for Inflation	Adjusted for Inflation		
Economic loss	+61%	-32%	28%	12%
Costs of fire departments	+439%	+127%	20%	29%
Net fire insurance	+288%	+63%	14%	15%
Building construction for fire protection	+333%	+82%	38%	44%
Total	+272%	+57%	100%	100%
Consumer price index*	+137%	N.A.	N.A.	N.A.

*In other words, $1.00 in 1980 consumer goods would have cost $2.37 in 2005. The increase in dollars estimated for the core of the total cost of fire is more than the increase due to inflation.

Note: Sums may not equal totals because of rounding error.

Sources: Table 1; consumer price index data from U.S. Bureau of the Census, *Statistical Abstract of the United States 2006*.

Other Fire Protection Costs

Meade's report provided one-time estimates of several cost components that NFPA's previous reports had not attempted to estimate.* They totaled $27.8 billion in 1991 and consist of the following:

1. Costs of meeting "fire grade" standards in the manufacture of equipment, particularly electrical systems equipment and "smart" equipment with its greater use of computer components ($18.0 billion). "Fire grade" is Meade's term for equipment that complied with Underwriters Laboratories or other standards designed to reduce the propensity of products to contribute to fires as a heat source or fuel source.

2. Costs of fire maintenance, which was defined to include system maintenance, industrial fire brigades, and training programs for occupational fire protection and fire safety ($6.5 billion).

3. Costs of fire retardants and all product testing associated with design for fire safety ($2.5 billion).

4. Costs of disaster recovery plans and backups ($0.6 billion).

5. Costs of preparing and maintaining standards ($0.2 billion).

The largest piece by far is the first one. Meade's interviewees provided estimates of the add-on cost of making products fire grade that ranged over two orders of magnitude, from 20% to 2,000%. He settled on 30%, which seems conservative. Out of the fraction of equipment that could be affected by these costs, his estimate of the share that is built to these more demanding standards is not conservative, however, and again raises the concern that the fire safety spending habits of industry's most fire-conscious companies have been treated as typical of all of industry. The same concern may be raised for each of the other components. In this area of costs however, no alternative approach to Meade's has emerged as persuasive. It seems preferable to treat this segment of the total cost of fire as a sidebar for the time being.

Based on the Consumer Price Index, the $27.8 billion estimated by Meade for 1991 would translate to $39.9 in 2005 dollars.

*William P. Meade, *A First Pass at Computing the Cost of Fire Safety in a Modern Society*, NIST-GCR-91-592, Gaithersburg, MD: National Institute of Standards and Technology, Building and Fire Research Laboratory, June 1991.

Estimates of Human Loss

Each year, NFPA estimates civilian fire deaths and injuries and fire service injuries reported to fire departments. NFPA also individually tabulates fire service deaths. All these figures are published annually in *NFPA Journal*, firefighter deaths usually in July/August, firefighter injuries usually in November/December, and civilian casualties usually in September/October. (See Table 4 for a summary.) Fire service (fatal and non-fatal) injuries do not all occur as a result of fires or even as a result of any type of emergency response, but all are included in this calculation.

The published figures do not include fire deaths and injuries not reported to fire departments. Unreported civilian fire deaths have been estimated as 6.4% of reported civilian fire deaths.* And a 1984 survey indicated that there are 9.1 unreported civilian fire injuries in homes for every one that is reported, or about 240,000 to 280,000 per year.** These unreported injuries tend to be much less serious on average than the reported injuries and are estimated to add 3.7 to 13.6% to the equivalent cost of reported injuries. A middle figure of 8.7% is used for these calculations and is applied to civilian injuries only.***

The specifications of a dollar equivalent for human losses, particularly for loss of life, remains an extremely controversial subject. It is important to re-emphasize that no one means to suggest that there is an acceptable price for losing one's life. Rather, these figures are intended to reflect a social consensus on the value of changes in the *risk* of death by fire. For example, if most people say they would be willing to pay $1,500 to reduce their lifetime risk of dying in a fire from, say, one chance in 500 to one chance in 1,000, then a simple way of restating that is that people value a life saved at $1,500 for 1/1000 of a life, or $1.5 million per life.

Economists at the U.S. Consumer Product Safety Commission (CPSC) have an ongoing program of studies of injury costs. Periodically, they review the literature, including their own studies, and select dollar values for use in policy analysis of fire safety and other product hazard analysis.

It is useful to keep in mind the very wide variation in the estimates and valuations and the implied uncertainty as to what values are reasonable. For example, a landmark 1981 study cited sources for implied values of statistical life that varied by a factor of 16.**** More recent valuations have been higher generally but still vary widely.

* A. Gomberg and L.P. Clark, *Rural and Non-Rural Civilian Residential Fire Fatalities in Twelve States*, NBSIR 82-2519, National Bureau of Standards, June 1982, Washington, DC, p. 33

** *1984 National Sample Survey of Unreported Residential Fires*, Final Technical Report for Contract No. C-83-1239 to US Consumer Product Safety Commission, Princeton, NJ: Audits & Surveys - Government Research Division, June 13, 1985, calculated from figures on pp. ii and v.

*** John R. Hall, Jr., "Expected Changes in Fire Damage From Reducing Cigarette Ignition Propensity,: Final Report to Technical Study Group of Cigarette Safety Act of 1984," National Fire Protection Association, Quincy, MA, July 16, 1987.

**** John D. Graham and James W. Vaupel, "Value of a Life: What Difference Does It Make," *Risk Analysis*, March 1981.

This study uses the values of $5 million per death and $166,000 per injury as 1993 values, then uses the Consumer Price Index to calculate corresponding values for later years for injuries only, all in accordance with the practices of CPSC economists.* The 1980 value of statistical life is estimated at $1 million, which is based on practices at that time and creates a much larger difference from the 1997 value of a statistical life than would be inferred from inflation alone.

The total dollar equivalent for reported and unreported deaths and injuries, calculated in this way, was $41.9 billion in 2005. Given the rules indicated, this total is up 116% from 1980, despite a declining trend in the number of deaths and, to a lesser extent, the number of injuries. It would be a decline of 3% after adjusting for inflation.

There are actual expenditures associated with deaths and injuries, of which the largest appear to be successful liability claims. Meade estimated product liability costs, insured or otherwise, at $3.6 billion and noted that "most liability claims are injury related."**

Liability claims and medical costs may be more reflective of how money changes hands in the U.S.A. as a result of fire deaths and injuries, but they hardly reflect a fair approach to placing dollar equivalents on human losses. In the American system, a small handful of victims receive much larger pain-and-suffering awards per injury which are further inflated by associated process costs (e.g., legal, administrative), while most victims receive no compensation for pain and suffering and many do not even obtain basic medical care. The CPSC valuations are dominated by pain and suffering valuations.

One of the deadliest fires of the past 40 years illustrates the link between the litigation following high-profile fires and estimates used to establish dollar equivalents for deaths and injuries. Four years after the 1980 MGM Grand Hotel fire, an article in *Variety*, the weekly magazine of the entertainment business, reported that total funds awarded to victims – e.g., injured survivors and families of fatal victims – had reached $113 million and were expected to reach $152-160 million once all claims were settled.*** NFPA's fire investigations report estimated 85 fatal victims and 635 civilian and firefighter injuries at the fire.**** This victim total, if combined with a dollar evaluation of $1 million per fatal victim (the value we use for 1980) and $110,000 per non-fatal victim would roughly approximate the estimated final total for the victims fund, and $110,000 in 1980 is roughly consistent with the current injury value used of $166,000 in 1993 and consumer price index inflation from 1980 to 1993.

* Letter from Dale R. Ray, CPSC staff economist, to John Hall, NFPA, January 29, 1999.

** Meade's figure on product liability cost is a rough estimate, based on applying the fire and other burns share of all accidental injuries to a special study's estimate of the total cost of all tort litigation. This may be an over-estimate, because many burn injuries are not fire-related.

*** Bill Willard, "MGM Grand Fire Litigation Continuing," *Variety*, December 5, 1984, p. 101.

****"The MGM Hotel Fire – Part 2," *Fire Service Today*, February 1982, p. 18.

Value of Donated Time of Volunteer Firefighters

The primary determinant of staffing for fire departments is the need to provide coverage and readiness to respond for a certain area, that is, the ability to provide a safe, effective response in a certain response time. This suggests that the primary factor in costs is not workload but geographical area, and the low-density rural areas covered by volunteer fire departments would require more personnel than more compact areas of equal population covered by career fire departments.

Communities seeking to set such fire protection coverage at an appropriate level might begin with a response time objective. The part of response time that is most related to resource decisions is travel time, which may be treated as proportional to travel distance. If one thinks of a typical response area as a circle with the fire station in the middle, one can see that travel distance is proportional to the square root of area. For example, if the distance from the fire station to the edge of the response area doubles, that is equivalent to doubling the radius of a circle, whose area then is quadrupled. This also means that if the same population is spread out over an area four times as large, it will need twice as many fire stations to provide equivalent travel times. Therefore the needed number of firefighters may be treated as inversely proportional to one divided by the square root of the population density.

In 2000, the metropolitan statistical areas of the U.S. had 80.3% of U.S. population in 20.0% of the area. If one assigns all the remaining area and population to volunteers (which is a rough approximation), then the metropolitan population density (proportional to 80.3% divided by 20.0%) exceeds the non-metropolitan population density (proportional to 19.7% divided by 80.0%) by a factor of 16.3.

Recall that two paragraphs above it was argued that the number of firefighters needed for coverage of an area is proportional to one divided by the square root of the population density. The ratio of two square roots is equal to the square root of the ratio. Therefore, if metropolitan population density divided by non-metropolitan population density is 16.3, then the number of firefighters needed to cover non-metropolitan areas divided by the number needed to cover metropolitan areas would be equal to the square root of 16.3, or 4.0. Finally, this means coverage of the non-metropolitan areas would require four times as many firefighters as provide coverage of metropolitan areas. And if metropolitan is equated to career and non-metropolitan to volunteer (a reasonable simplification), then the cost of coverage of non-metropolitan areas – the value of volunteer firefighters – can be estimated as four times the cost of career firefighters.

Personnel costs are typically 87% of a career fire department budget.* The available figures on fire department costs include an unknown fraction for non-personnel costs of volunteer fire departments. Therefore, suppose we estimate the personnel costs of career firefighters as 65-87% of the total figure for local fire protection.

The result is a range of $80-107 billion in 2005 for the value of time donated by volunteer firefighters.

* Since 1986, the International City Management Association's annual *Municipal Year Book* has included figures on average per capita expenditures on personnel, capital, and other items for municipal fire departments. The sum of these three components is always higher than the indicated total, possibly because of problems with incomplete responses on the survey. Based on comparing the personnel cost to the sum, the personnel share is usually 87%, so the rest is usually 13%.

Table 4. Human Losses in Reported U.S. Fires or Involving On-Duty Career or Volunteer Firefighters

Type of Casualty	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Civilian deaths	6,505	6,700	6,020	5,920	5,240	6,185	5,850	5,810	6,215	5,410
Firefighter deaths	138	136	128	113	119	128	120	132	136	118
Civilian injuries	30,200	30,450	30,525	31,275	28,125	28,425	28,825	28,215	30,800	28,250
Firefighter injuries	98,070	103,340	98,150	103,150	102,300	100,900	96,450	102,600	102,900	100,700

Type of Casualty	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Civilian deaths	5,195	4,465	4,730	4,635	4,275	4,585	4,990	4,050	4,035	3,570
Firefighter deaths	108	108	75	79	105	97	96	99	91	112
Civilian injuries	28,600	29,375	28,700	30,475	27,250	25,775	25,550	23,750	23,100	21,875
Firefighter injuries	100,300	103,300	97,700	101,500	95,400	94,500	87,150	85,400	87,500	88,500

		2001					
Type of Casualty	2000	Including 9/11	Excluding 9/11	2002	2003	2004	2005
Civilian deaths	44,045	6,196	3,745	3,380	3,925	3,900	3,675
Firefighter deaths	103	443	103	97	105	104	87
Civilian injuries	22,350	21,100	20,300	18,425	18,125	17,875	17,925
Firefighter injuries	84,550	82,250	82,250	80,800	78,750	75,840	80,100

Note: Firefighter death totals are continuously updated and in many cases are higher than the figures previously published. These figures reflect those updates. Also, in a typical year, roughly half of all on-duty firefighter casualties (deaths or injuries) occur at the fireground. This might be taken as a reason to exclude the costs of the other firefighter casualties as not related to fire effects or response to fire emergencies, but all occur as a result of arrangements made to provide and maintain emergency-response capability, principally for fire. On that basis, all firefighter casualties are considered relevant to the total cost of fire.

Source: NFPA survey and Fire Incident Data Organization (FIDO).

Conclusion

The core of the total cost of fire was $105.2 billion in 2005. Other cost components that have been estimated only in one-time special studies may add about $39.9 billion to the total. Human losses, which many people resist converting to dollar equivalents, would add $41.6 billion in 2005 if valued along the lines discussed in this report. And the value of the donated time of volunteers is very roughly estimated in a range of $80-107 billion, using the rough bases of valuation discussed here.

Adding these all together produces a total value affected by fire - lost to fire, spent to avoid or deal with fire, or donated to avoid or deal with fire - of $267-294 billion, or about 2 to 2½% of U.S. gross domestic product.

It should be clear by this point that most of the analysis supporting these estimates is soft and has wide bands of uncertainty. Nevertheless, the conclusion that fire has a tremendous impact on the way the U.S. uses its scarce resources is indisputable.

It also is clear that we have a dual interest in reducing U.S. fire losses – which include human losses that are among the highest per capita in the industrial world – and in seeking ways to achieve equivalent fire safety at lower costs, since the growth in total cost of fire has been led not by the fire losses but by the other cost components. This provides a clear indication of need for product innovations or other programs (e.g., educational) that can improve fire safety at the same or lower costs. It also shows the need for improved methods (e.g., models) for calculating fire performance and costs, so the implications of different choices can be considered and judged more comprehensively.