SPRINKLER USE DECISIONING

***Sprinkler Use Decisioning** works best with Firefox 3.6.10 and Internet Explorer 7.0.*

OBJECTIVE

Sprinkler Use Decisioning is a Web-tool designed to facilitate economic analysis of residential fire sprinklers at the homeowner- and community-level.

SCOPE

Sprinkler Use Decisioning (SPUD) is designed on the economic framework presented in NISTIR 7451: *Benefit-Cost Analysis of Residential Fire Sprinkler Systems*, which was used to measure the economic performance of a fire sprinkler system installed in a newly constructed, single-family dwelling in the United States. The benefit-cost and sensitivity analyses used by SPUD are consistent with ASTM E 1185: *Guide for Selecting Economic Methods for Evaluating Investments in Buildings and Building Systems*; [1] ASTM E 1369: *Guide for Selecting Techniques for Treating Uncertainty and Risk in the Economic Evaluation of Building and Building Systems*;[2] ASTM E 1074: *Practice for Measuring Net Benefits for Investments in Buildings and Building Systems*.[3]

TOOL STRUCTURE

The tool is comprised of four labeled 'tabs.' Two tabs are used to input the baseline and sensitivity analysis values. The other two tabs summarize the baseline and sensitivity analysis results. A help feature is also provided. This document represents the help feature. The input and results tabs are described below.

INPUTS: BASELINE ANALYSIS

This tab is used to enter data for the baseline analysis. There are three categories of required inputs: ***Study Parameters***, ***Costs***, and ***Benefits***.

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[1] ASTM International. "Guide for Selecting Economic Methods for Evaluating Investments in Buildings and Building Systems," E 1185, *Annual Book of ASTM Standards: 2006*. Vol. 04.11. West Conshohocken, PA: ASTM International.
[2] ASTM International. "Guide for Selecting Techniques for Treating Uncertainty and Risk in the Economic Evaluation of Building and Building Systems," E 1369, *Annual Book of ASTM Standards: 2006*. Vol. 04.11. West Conshohocken, PA: ASTM International.
[3] ASTM International. "Practice for Measuring Net Benefits for Investments in Buildings and Building Systems," E 1074, *Annual Book of ASTM Standards: 2006*. Vol. 04.11. West Conshohocken, PA: ASTM International.

Study Parameters define the length of the study and the way future benefits and costs will be valued today.

Costs include installation costs, maintenance and repair costs, and any additional annually reoccurring costs.

Benefits include increased occupant safety (i.e., less fatalities and injuries), decreased uninsured property losses (structure and content), decreased uninsured indirect costs (e.g., costs related to temporary shelter, legal expenses, childcare, missed work), homeowner's insurance savings, and any additional annually occurring benefits.

Benefit values can be populated three different ways: (1) with all user defined data; (2) with national statistics, augmented with user defined data; and (3) with city statistics (matched by ZIP code), augmented with user defined data. The national and city statistics were derived from fire data reported in the National Fire Incident Reporting System (NFIRS).[4] Selecting the 'National' or 'ZIP Code' radio button populates some (but not all) of the *Damages*, *Fire Statistics*, *Insurance Info*, and *Other* input categories. See Table 1 (below) for a statistical summary of the national and city data. Data is populated as a '0' when national or city data does not exist. These need to be supplied by the user.

Both the national and city data defaults provide data on fire risk (annual number of fires per 10 000 houses; fire loss-to-value ratio; number of fatalities per 10 000 house fires in unsprinklered houses; number of injuries per 10 000 house fires in unsprinklered houses). Data is reported only for those cities that had at least 30 NFIRS-reported fires in unsprinklered houses over the 2002 to 2007 study period. Data exists for 1365 cities (See cities). Sprinkler-related benefit statistics (reduction in fire loss-to-value; reduction in probability of death due to sprinkler use; reduction in probability of injury due to sprinkler use) are only reported nationally. Because of the small number of cities with at least 30 fires in sprinklered houses, the sprinkler-related benefits were not estimated.

After the inputs on the **Inputs: Baseline Analysis** tab have been entered, the **Results: Baseline Analysis** tab is available for viewing.

[4] United States Fire Administration. *National Fire Incident Reporting System*, National Fire Data Center.

Table 1. Summary of default national and city statistics.

INPUTS	UNIT	BASELINE	MINIMUM	MAXIMUM
National Statistics[i]				
Annual number of fires per 10,000 houses		35	34	36
Fire loss-to-value ratio		0.21	0.20	0.23
Number of fatalities per 10,000 house fires in unsprinklered houses		77	61	90
Number of injuries per 10,000 house fires in unsprinklered houses		390	354	433
Reduction in fire loss-to-value ratio	%	78	0	96
Reduction in probability of death due to sprinkler use	%	100	100	100
Reduction in probability of injury due to sprinkler use	%	59	28	89
City Statistics[ii]				
Annual number of fires per 10,000 houses		33	5	111
Fire loss-to-value ratio		0.24	0	1
Number of fatalities per 10,000 house fires in unsprinklered houses		85	0	729
Number of injuries per 10,000 house fires in unsprinklered houses		63	0	2594
Reduction in fire loss-to-value ratio	%	n/a	n/a	n/a
Reduction in probability of death due to sprinkler use	%	n/a	n/a	n/a
Reduction in probability of injury due to sprinkler use	%	n/a	n/a	n/a

[i]The baseline is for the period 2002 to 2007. The minimum and maximum values were derived from annual estimates (i.e., each minimum and maximum shown correspond to a specific year).

[ii]The baseline is the average over all cities for the period 2002 to 2007. The minimum and maximum values were derived from the city statistics (i.e., each minimum and maximum shown correspond to a specific city). Due to small sample sizes, sprinkler benefit information (reduction in fire loss-to-value ratio, reduction in probability of death due to sprinkler use, reduction in probability of injury due to sprinkler use) were not computed.

INPUTS: SENSITIVITY ANALYSIS

This tab is used to enter data for the sensitivity analysis. By default, any data entered in the **Inputs: Baseline Analysis** tab will carry forward and populate the baseline values in the **Inputs: Sensitivity Analysis** tab. These can be modified, however.

The Monte Carlo analysis is used for addressing the effects of uncertainty. Monte Carlo simulation varies a small set of data inputs according to an experimental design. Associated with each data input is a probability distribution function from which values are randomly sampled. A Monte Carlo simulation complements the baseline analysis by evaluating the changes in output measures when selected data inputs are allowed to vary around their baseline values.

In SPUD, the Monte Carlo sensitivity analysis requires the most-likely, minimum and maximum values to parameterize a triangular distribution for each input. (A constant can be created by setting the minimum and maximum to the baseline.) In SPUD, the most-likely value is set equal to the baseline value. The triangular distribution is recommended whenever the range of input value is finite and continuous and a clustering about some central value is expected. SPUD, by default, runs 10 000 simulations. The simulations are re-run every time the **Results: Sensitivity Analysis** tab is re-selected. To re-run the simulation, simply select another tab and then return to the **Results: Sensitivity Analysis** tab.

After the inputs on the **Inputs: Sensitivity Analysis** tab have been entered, the **Results: Sensitivity Analysis** tab is available for viewing.

RESULTS: BASELINE ANALYSIS

This tab is used to view the results of the baseline analysis. Shown are the present value benefits, present value costs, and the present value net benefits (present value benefits minus present value costs). Present value net benefits (PVNB) greater than zero indicates that the life-cycle benefits are greater than the life-cycles costs. The individual present value benefits and costs information can be used to identify the largest and smallest drivers of the total economic performance of fire sprinklers.

RESULTS: SENSITIVITY ANALYSIS

This tab is used to view the results of the sensitivity analysis. The figure, labeled *Cumulative Probability*, shows the probability of the true PVNB being less than or equal to the corresponding PVNB.[5] The table that is presented in this tab shows the minimum, maximum, median, mean, and 50^{th} and 75^{th} percentiles for each of the present value benefits, present value costs, and PVNB. Both the figure and table can be used to understand how uncertainty affects the results.

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[5] The 'true' PVNB is not known, but resides somewhere between the minimum and maximum simulated PVNB.

For example, the baseline PVNB can be compared to the sensitivity analysis results, using the figure. Mapping the baseline PVNB to the corresponding probability level shows the probability at which the true PVNB is less than or equal the baseline PVNB. For instance, if the baseline PVNB corresponds to a 0.50 probability, this means there exists a 50 % chance that the true PVNB is less than or equal to the baseline. (It also means that there exists a 50 % chance that the true PVNB is greater than or equal to the baseline [= 100 % — 50 %].) In addition, mapping the PVNB of $0 to the corresponding probability level determines the probability at which the true PVNB is negative (or no greater than zero). In this case, the smaller the corresponding probability, the greater the likelihood that the true PVNB is positive (i.e., sprinklers are cost-effective).

The minimum and maximum values show the range of possible values, given uncertainty, of each of the benefits, costs, and PVNB. The median and mean values provide measures of central tendency (i.e., the likely true value, given uncertainty). The 25th and 75th percentiles, in conjunction with the other measures, provide an understanding of the spread of the distribution, with a smaller spread of the distribution corresponding to a greater likelihood that the true PVNB clusters around the median or mean.

EXAMPLE

This example demonstrates the key features of the Sprinkler Use Decisioning tool. This example is meant only for demonstration purposes.

<u>This is not an actual benefit-cost analysis of residential fire sprinklers.</u>

INPUTS

The following values were input into the tool. A summary of all the values needed to conduct the baseline and sensitivity analysis is presented in Table 2. The BASELINE values (see Table 2) were input into their respective fields found on **Input: Baseline Analysis** tab (see Figure 1). The MINIMUM and MAXIMUM values were input into their respective fields on the **Input: Sensitivity Analysis** tab (see Figure 2).

The *User Defined* radio button was selected because no preloaded data based on national or city statistics were used in this example. All the baseline data corresponds to the BASELINE column found in Table 2.

The *Minimum* and *Maximum* values correspond to the MININUM and MAXIMUM columns found in Table 2. The *Baseline* values carried forward from the fields in **Input: Baseline Analysis** tab being populated. The *Baseline*, *Minimum*, and *Maximum* values are used to parameterize the triangular distribution for the Monte Carlo sensitivity analysis. At least one value must vary (i.e., the *Minimum* or *Maximum* must be different from the *Baseline*) to conduct the sensitivity analysis (otherwise the analysis would replicate the *Baseline Results*).

Table 2. Summary of the values used in the example. All values are used.

INPUTS	UNIT	BASELINE	MINIMUM	MAXIMUM
Study Parameters				
Discount rate	%	4.8	4.8	4.8
Study period	years	30	30	30
Cost-Related Inputs				
House size	ft^2	3000	3000	3000
Installed cost	$\$/ft^2$	1.10	0.38	2.40
Annual Maintenance & Repair	$	0	0	25
Other Annual Costs	$	0	0	0
Benefit-Related Inputs				
Value of a statistical life	$	8,750,000	5,000,000	8,750,000
Value of a statistical injury	$	189,198	150,000	200,000
Total value of structure & contents	$	250,000	250,000	250,000
Fire loss-to-value ratio		0.21	0.00	1.00
Annual number of fires per 10,000 houses		35	25	45
Reduction in probability of death due to sprinkler use	%	100	80	100
Number of fatalities per 10,000 house fires in unsprinklered houses		77	61	90
Reduction in probability of injury due to sprinkler use	%	59	28	89
Number of injuries per 10,000 house fires in unsprinklered houses		390	354	433
Reduction in fire loss-to-value ratio	%	33	0	78
Annual insurance premium	$	754	700	800
Reduction in insurance due to sprinkler	%	8	5	15
Other annual benefits	$	0	0	0

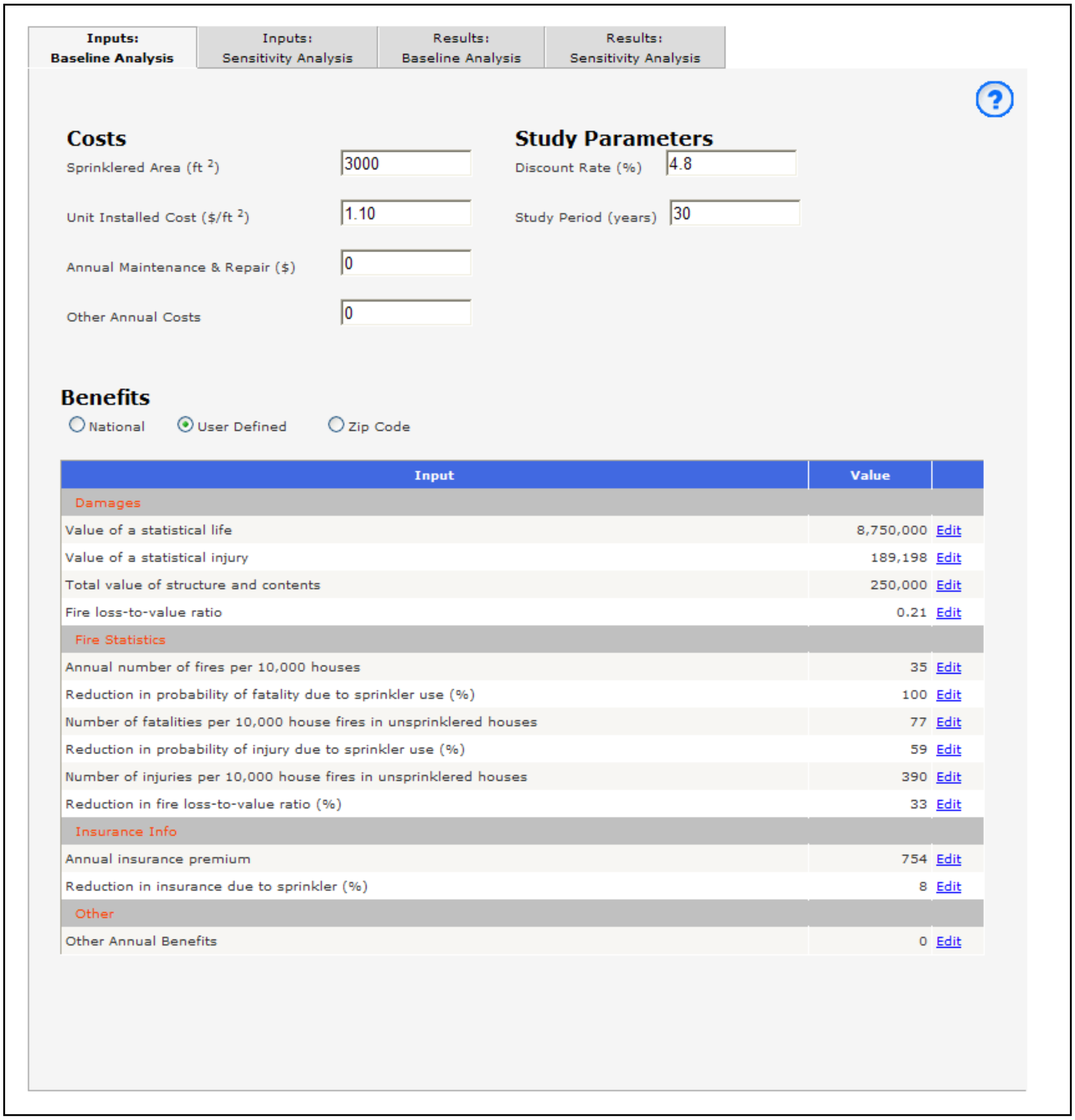


Figure 1. Screen capture of the Input tab populated with data from Table 1.

Inputs: Baseline Analysis | **Inputs: Sensitivity Analysis** | Results: Baseline Analysis | Results: Sensitivity Analysis

Inputs for Monte Carlo Analysis

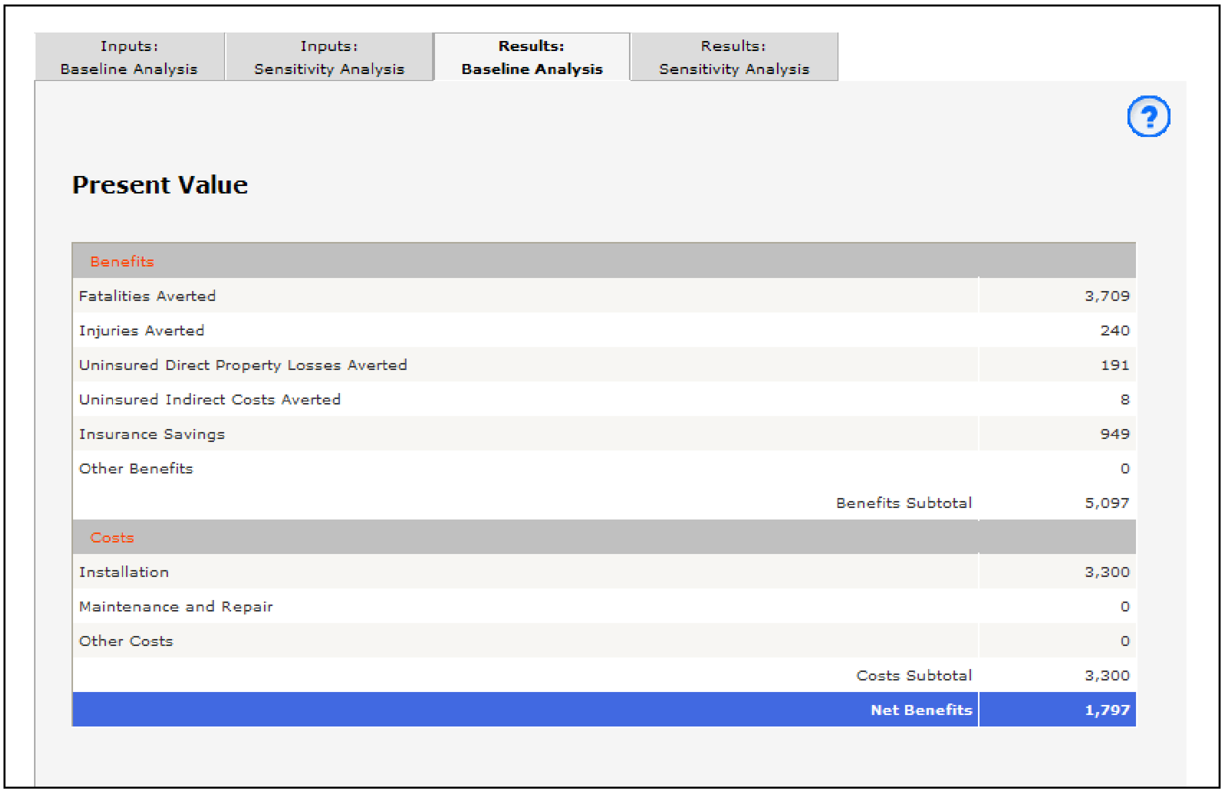
Input	Baseline	Minimum	Maximum	
Costs				
Sprinklered Area	3,000	3,000	3,000	Edit
Unit Installed Cost	1.10	0.38	2.40	Edit
Annual Maintenance & Repair	0	0	25	Edit
Other Annual Costs	0	0	0	Edit
Damages				
Value of a statistical life	8,750,000	5,000,000	8,750,000	Edit
Value of a statistical injury	189,198	150,000	200,000	Edit
Total value of structure and contents	250,000	250,000	250,000	Edit
Fire loss-to-value ratio	0.21	0.00	1.00	Edit
Fire Statistics				
Annual number of fires per 10,000 houses	35	25	45	Edit
Reduction in probability of fatality due to sprinkler use (%)	100	80	100	Edit
Number of fatalities per 10,000 house fires in unsprinklered houses	77	61	90	Edit
Reduction in probability of injury due to sprinkler use (%)	59	28	89	Edit
Number of injuries per 10,000 house fires in unsprinklered houses	390	354	433	Edit
Reduction in fire loss-to-value ratio (%)	33	0	78	Edit
Insurance Info				
Annual insurance premium	754	700	800	Edit
Reduction in insurance due to sprinkler (%)	8	5	15	Edit
Other				
Other Annual Benefits	0	0	0	Edit

Figure 2. Screen capture of the Sensitivity Analysis input tab populated with data from Table 1.

A value with the *Minimum* and *Maximum* set to the *Baseline* is handled as a constant in the sensitivity analysis (e.g., see *House Size* in the Figure 2). In this example, *House Size* and *Total value of structure and contents* were set as constants. Thus, the results are then only relevant to a 3000 ft^2 house, valued at \$250 000. Constants can be used to examine very specific scenarios, whereas, variation can be used to examine more broad or general conditions. For instance, varying the House Size might be done to explore the benefit-cost performance of residential sprinklers in a community, which is made up of several different housing configurations.

Baseline Results

The results of the baseline analysis are summarized in the **Results: Baseline Analysis** tab (see Figure 3). The **Results: Baseline Analysis** tab shows the individual net benefit and cost components, and the present value net benefits. In this example, the present value net benefit of $1797 indicates the life-cycle benefits stemming from sprinkler use were larger than the life-cycle costs—i.e., for this case, residential sprinklers were cost-effective.



Benefits	
Fatalities Averted	3,709
Injuries Averted	240
Uninsured Direct Property Losses Averted	191
Uninsured Indirect Costs Averted	8
Insurance Savings	949
Other Benefits	0
Benefits Subtotal	5,097
Costs	
Installation	3,300
Maintenance and Repair	0
Other Costs	0
Costs Subtotal	3,300
Net Benefits	**1,797**

Figure 3. Screen capture of the Baseline Result tab summarizing the results of the baseline analysis.

The calculations used to generate the results are summarized in Table 3.

Table 3. A summary of the baseline calculations used in the example.

CATEGORY	CLASS	VALUE	CALCULATION
Uniform present value		15.73	$= \{(1 + [4.8 / 100])^{30} – 1\} / \{[4.8 / 100] \times (1 + [4.8 / 100])^{30}\}$
Present value of total installed cost	COST	$3300	= 3000 x 1.10
Present value of maintenance & repair cost	COST	$0	= 0 * 15.73
Present value of other costs	COST	$0	= 0 * 15.73
Present value of fatalities averted	BENEFIT	$3709	= (100 / 100) x 8,750,000 x (35 / 10,000) x (77 / 10,000) x 15.73
Present value of injuries averted	BENEFIT	$240	= (59 / 100) x 189,198 x (35 / 10,000) x (390 / 10,000) x 15.73
Present value of uninsured direct property losses averted [i]	BENEFIT	$191	= (33 / 100) x (138,830 x 0.21) x 0.20 x 15.73
Present value of uninsured indirect costs averted [ii]	BENEFIT	$8	= (33 / 100) x (138,830 x 0.21) x 0.20 x 0.10 x 0.40 x 15.73
Present value of insurance savings	BENEFIT	$949	= 754 x (8 / 100) x 15.73
Present value of other benefits	BENEFIT	$0	= 0 x 15.73
Present value net benefits		***$1797***	***= sum of benefits – sum of costs***

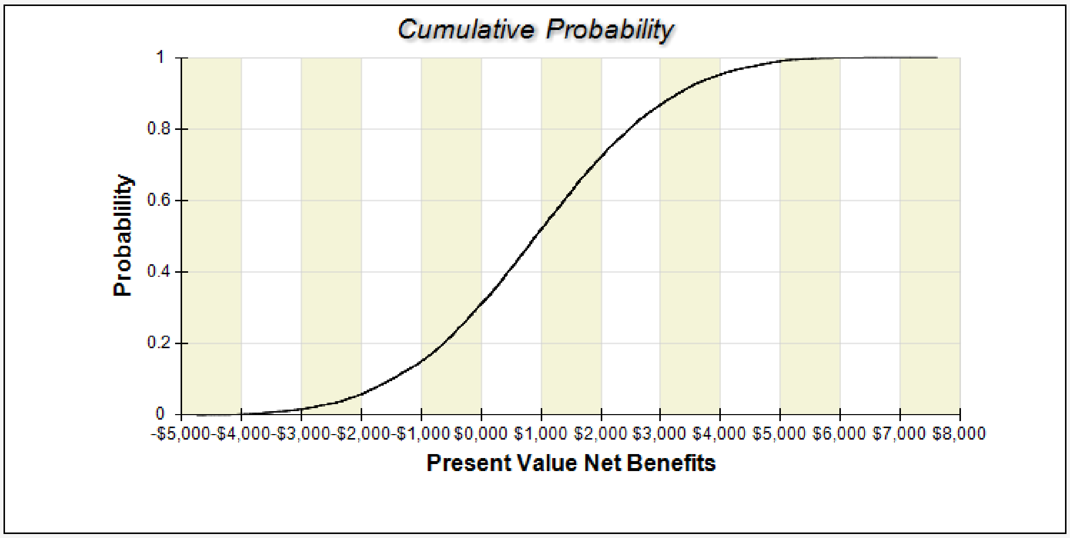
[i] It is assumed that 20 % of total direct property losses are uninsured.
[ii] It is assumed that indirect costs are 10 % the size of direct property losses, and that 40 % are uninsured.

Sensitivity Analysis Results

The results of the sensitivity analysis were summarized in the **Results: Sensitivity Analysis** tab (see Figure 4). The **Results: Sensitivity Analysis** tab presents the minimum, 25th percentile, median (50th percentile), 75th percentile, maximum, and mean simulated values for the individual net benefit and cost components, and the present value net benefits.

Inputs: Baseline Analysis | Inputs: Sensitivity Analysis | Results: Baseline Analysis | **Results: Sensitivity Analysis**

Sensitivity Analysis Statistics



Present Value

Item	Minimum	25%	Median	75%	Maximum	Mean
Net Benefits	**-4,752**	**-338**	**906**	**2,155**	**7,618**	**909**
Fatalities Averted	978	2,245	3,015	3,820	5,540	3,055
Uninsured Direct Property Losses Averted	0	161	372	746	2,444	509
Injuries Averted	67	175	227	284	497	233
Uninsured Indirect Costs Averted	0	6	15	30	99	20
Insurance Savings	577	916	1,080	1,283	1,825	1,105
Other Benefits	0	0	0	0	0	0
Installation	1,186	2,970	3,773	4,744	7,171	3,882
Maintenance and Repair	0	54	116	195	391	131
Other Costs	0	0	0	0	0	0

Figure 4. Screen capture of the Sensitivity Analysis Results tab summarizing the results of the baseline analysis.

Note that due to the random nature of Monte Carlo analysis, sensitivity analysis results will not be exact upon replication. They should be similar, however. In addition, the minimum, 25th percentile, median, 75th percentile, maximum, and mean benefit and cost values do not necessarily correspond to those for the present value net benefits. For example, the maximum present value net benefits do not correspond to the sum of the individual maximum benefits (fatalities averted, injuries averted, property losses, indirect cost averted, insurance credit, and other benefits) minus the sum of the individual maximum costs (installation, maintenance and repair, and other costs).

In this example, the mean PVNB is positive ($909), as is the median value ($906). Not all simulated PVNB values are positive. The Cumulative Probability graph, shown in Figure 4, maps the probability of the true PVNB being less than or equal to the corresponding PVNB. For instance, in this particular example, the results indicate that there was a 50 % likelihood (0.5 probability) that the true (i.e., certain) PVNB was less than or equal to $906 (the median). (It also indicated that there was a 50 % likelihood that the true PVNB was greater than or equal to $891.) The probability that corresponds to a $0 PVNB is of particular interest. In this example, a $0 PVNB corresponded with a 0.31 probability (approximate), or a 31 % likelihood that the true PVNB was less than or equal to $0. Given the uncertainty underlying the baseline data, there was a 69 % probability that residential fire sprinkler would be cost-effective.

DATA SOURCES

The national and city statistics were developed using four primary data sources.

- ***U.S. Fire Administration***
  National Fire Incident Reporting System (NFIRS)
  Years: 2002-2007

- ***National Fire Protection Association (NFPA)***
  The U.S. Fire Problem: One- and two-family home fires (includes manufactured homes).
  Years: 2002-2007

- ***U.S. Census Bureau***
  American Housing Survey
  Years: 2001, 2003, 2005, 2007

- ***Federal Emergency Management Agency***
  HAZUS-MH MR4 (HAZUS)
  Building Count by Occupancy
  Years: 2000

The national statistics were created following the framework detailed in NISTIR 7451. The only deviation was the inclusion of data from 2006 and 2007. The default national minimum and maximum values provided in the Sensitivity Analysis are based on the minimum and maximum annual values from 2003 to 2007. (The annual statistics from 2002 were not considered due to having less than 30 reported fires [i.e., a small sample size] in sprinklered houses).

The city statistics were generated after aggregating the NFIRS incident data from the ZIP code level to city level. ZIP codes were assigned to cities using a ZIP code GIS (ZIP Code Boundaries [layer], ESRI Data & Maps). City statistics were generated for only those cities with at least 30 reported fires in unsprinklered houses. The statistics were created following the framework detailed in NISTIR 7451, except the NFIRS-based ZIP code data was not scaled. Only cities with reported fire data were included.

The Building Count by Occupancy data in HAZUS was used to provide city level single-family house estimates, so the number of fires per 10 000 houses could be estimated. No sprinkler-benefit statistics (e.g., reduction in probability of death due to sprinkler use) were estimated at the city level due to the small number of reported sprinkler fires (the maximum reported fires in sprinkler houses was 30). City level statistics are provided for 1365 cities (See cities). The default city minimum and maximum values provided in the Sensitivity Analysis are based on the minimum and maximum statistics across all cities (after the upper and lower tails of the distribution had been trimmed 1 % to limit the influence of outliers).

The formulas for the benefit and cost calculations can be found in the next section. Of particular note, (1) the direct uninsured property losses are assumed to be 20 % of the total direct property losses; and (2) the indirect costs are assumed to be 10 % of the total direct property losses, with 60 % covered by insurance (see NISTIR 7451 for details).

SPUD does not provide information on residential sprinkler costs. For a discussion of sprinkler costs, see NISTIR 7451 or the Fire Protection Research Foundation report, "Home Fire Sprinkler Cost Assessment."

FORMULAS

BENEFITS

Present Value of Fatalities Averted

Annual number of fires per 10 000 houses: *F*
Number of fatalities per 10 000 house fires in unsprinklered houses: *D*
Reduction in probability of fatality due to sprinkler use: Δ_D
Estimated dollar value of fatality averted: VSL
Uniform present value: *UPV*

$$= (F/10000) * (D/10000) * \Delta_D * VSL * UPV$$

Present Value of Injuries Averted

Annual number of fires per 10 000 houses: *F*
Number of injuries per 10 000 house fires in unsprinklered houses: *I*
Reduction in probability of fatality due to sprinkler use: Δ_I
Estimated dollar value of injury averted: VSI
Uniform present value: *UPV*

$$= (F/10000) * (I/10000) * \Delta_I * VSI * UPV$$

Present Value of Uninsured Direct Property Losses Averted

Annual number of fires per 10 000 houses: *F*
Total value of structure and contents: $\$_D$
Fire loss-to-value ratio: *LVR*
Predicted fractional reduction in fire loss-to-value ratio: Δ_{LVR}
Uniform present value: *UPV*

$$= (F/10000) * (0.2 * \$_D * LVR) * \Delta_{LVR} * UPV$$

Present Value of Uninsured Indirect Costs Averted
Annual number of fires per 10 000 houses: F
Total value of structure and contents: $\$_D$
Loss-to-value ratio: LVR
Predicted fractional reduction in fire loss-to-value ratio: Δ_{LVR}
Uniform present value: UPV

$$= (F/10000) * [0.1 * 0.4 * (0.2 * \$_D * LVR)] * \Delta_{LVR} * UPV$$

Present Value of Insurance Savings
Annual insurance premium: P
Reduction in insurance due to sprinkler: Δ_P
Uniform present value: UPV

$$= P * \Delta_P * UPV$$

Other Benefits
Other annual benefits: B
Uniform present value: UPV

$$= B * UPV$$

COSTS

Installation
Sprinklered area: H
Unit installed cost: X

$$= H * X$$

Present Value of Maintenance and Repair
Annual maintenance and repair: M
Uniform present value: UPV

$$= M * UPV$$

Present Value of Other Costs
Other annual costs: *C*
Uniform present value: *UPV*

$$= C * UPV$$

OTHER

Uniform Present Value[6]
Discount rate: *R*
Study period: *T*

$$= (1+R)^{T}-1/R(1+R)^{T}$$

Present Value Net Benefits

= Sum of present value benefits – Sum of present value costs

[6] As *R* approaches zero, the uniform present value approaches *T*. In the tool, if a discount rate of zero is used, the uniform present value is set to the number of years of the study period.

GLOSSARY OF TERMS

Annual Maintenance & Repair
The annual preventive maintenance and repairs costs for a sprinklered house, if applicable.

Annual Insurance Premium
The cost of the annual homeowner's insurance.

Annual Number of Fires per 10 000 houses
This provides the likelihood of a house fire. The likelihood of a house fire is assumed unaffected by sprinklers.

Discount Rate
The rate of interest reflecting the investor's time value of money, used to determine discount factors for converting benefits and costs occurring at different times to a base time.[7] The discount factor used is in percent.

Fire Loss-to-Value Ratio
The value of structure and contents lost due to fire divided by the total value of structure and contents.

Monte Carlo Simulation
A means for addressing the effects of uncertainty. Monte Carlo simulation varies a small set of data inputs according to an experimental design. Associated with each data input is a probability distribution function from which values are randomly sampled. A Monte Carlo simulation complements the baseline analysis by evaluating the changes in output measures when selected data inputs are allowed to vary about their baseline values.

Net Benefits
Benefits minus costs.

Number of Fatalities per 10 000 House Fires in Unsprinklered Houses
This provides the likelihood of fatalities in an unsprinklered house fire.

Number of Injury per 10 000 House Fires in Unsprinklered Houses
This provides the likelihood of injuries in an unsprinklered house fire.

Other Annual Costs
Costs in addition to installation, maintenance and repair that occur on an annual basis.

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[7] ASTM International. "Standard Terminology of Building Economics," E 833, *Annual Book of ASTM Standards: 2006*. Vol. 04.11. West Conshohocken, PA: ASTM International.

Present Value
The value of a benefit or cost found by discounting future cash flows to the base time.[8]

Reduction in Fire Loss-to-Value Ratio due to Sprinkler Use (%)
The percent reduction in the fire loss-to-value ratio because of sprinkler use.

Reduction in Insurance due to Sprinkler Use (%)
The percent reduction in the homeowner's insurance premium for having a residential sprinkler system.

Reduction in Probability of Fatality due to Sprinkler Use (%)
The percent reduction in the probability of a fatality because of sprinkler use.

Reduction in Probability of Injury due to Sprinkler Use (%)
The percent reduction in the probability of an injury because of sprinkler use.

Sprinklered Area
The sprinklered area of the house in ft^2. Multiplied by the Unit Installed Cost yields the total sprinkler installation cost.

Study Period
The length of time over which an investment is analyzed.[9] The study period used is in years.

Total Value of Structure and Contents
The structure and content losses directly resulting from a fire in an unsprinklered house. This is the total loss (i.e., before insurance).

Triangular Distribution
A probability distribution often used in a Monte Carlo simulation. Specification of the triangular distribution requires three data points, the minimum value, the most likely, and the maximum value. In Sprinkler Use Decisioning, the most likely value is set equal to the baseline value. The triangular distribution is recommended whenever the range of input value is finite and continuous and a clustering about some central value is expected.

Uniform Present Value
Used to discount a series of uniform end-of-product payments occurring over a fixed time period into a present value.[10]

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[8] *Ibid*.
[9] *Ibid*.
[10] *Ibid*.

Unit Installed Cost
The unit cost of sprinkler installation in $/ft^2. This value should account for all the first costs of installation. Multiplied by the Sprinklered Area yields the total sprinkler installation cost.

Value of a Statistical Injury
The economic (monetized) value of an injury avoided.

Value of a Statistical Life
The economic (monetized) value of a fatality avoided.

Disclaimer Regarding Non-Metric Units: The policy of the National Institute of Standards and Technology is to use metric units in all its published materials. Because this report is intended for those who use U.S. customary units, it is more practical and less confusing to use U.S. customary rather than metric units. Measurement values in this report are therefore stated in U.S. customary units first, followed by the corresponding values in metric units within parentheses.