2009 BFRL Project Description

Project Title: Sprinkler Decision Tool for Communities

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BFRL Program: Reduced Risk of Fire Spread in Buildings

Objective: To develop a community-centered economic benefit-cost model and implement it in a software application that enables local decision makers to assess the benefits and costs of fire sprinkler installation.

Problem:

What is the problem? Advancements in measurement science are needed to quantify the economic benefits and costs of residential fire sprinkler systems accruing to communities with sprinkler ordinances. Since the introduction of the residential sprinkler standard, NFPA 13D, in 1975, residential sprinkler systems have proven themselves as life safety systems. While there is growing recognition of the enhanced ability of residential sprinkler systems to protect life and property from fires, it is estimated that only 1 % of the one- and two-family homes in the United States have an automatic extinguishing system installed.[1] Earlier research[2,3,4] found residential fire sprinklers to be uneconomical. This research, however, was based on 20-year old technologies, their costs, and outdated estimates of the value of a fatality averted. Current research, using modern data, found residential sprinklers to be cost-effective.[5,6] This research only considered the benefits and costs that accrued to an individual (representative) homeowner, and ignored those that would have accrued to the community (e.g., reduction in firefighter fatalities). A measurement problem exists then, when communities estimate their net benefits as the summation of the individual homeowners'. Also, the current research provided only *national* estimates. Estimates from individual communities will vary due to local market differences.

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[1] Hall, J.R. 2007. "U.S. Experience With Sprinklers and Other Automatic Fire Extinguishing Equipment." National Fire Protection Association, Quincy, MA.
[2] Ruegg, R.T., and S.K. Fuller. 1984. "A Benefit-Cost Model of Residential Fire Sprinkler Systems." NBS Technical Note 1203. National Bureau of Standards, Gaithersburg, MD.
[3] Harmathy, T.Z. 1988. "On the Economics of Mandatory Sprinklering of Dwellings." Fire Technology 24:245-261.
[4] Juas, B., and B. Mattson. 1994. "Economics of Fire Technology." Fire Technology 24:468-477.
[5] Butry, D.T., M.H. Brown, and S.K. Fuller. 2007. "Benefit-Cost Analysis of Residential Fire Sprinkler Systems." NISTIR 7451. National Institute of Standards and Technology, Gaithersburg, MD.
[6] Butry, D.T. 2008. "Economic Performance of Residential Fire Sprinkler Systems." Fire Technology. (*In press*).

Why is it hard to solve? It is a hard problem to solve because it requires advancements in measurement science. Because the economic benefits of sprinkler use are largely unknown (not quantified) many homeowners feel that sprinkler protection against a low-probability fire event will not have a significant payoff to them. Today most homeowners think a house fire is independent of neighboring houses, although it is likely to be interdependent. Thus, a community perspective is not usually taken. Local decision makers responsible for sprinkler ordinances need help in evaluating recommendations that incorporate the benefits and costs to the community as a whole rather than only those accruing to the individual household.

How is it solved today, and by whom? It has not been solved, although progress has been made. In FY2007, OAE developed a community-centered benefit-cost model of fire sprinkler systems (STRS funded). This model was based, in part, on the homeowner-focused benefit-cost model developed also in FY2007 (USFA funded).[5] In FY2008, the benefits of sprinklers were estimated for select communities across the United States, and provided specific community-relevant statistics. In FY2008, the Fire Protection Research Foundation (FPRF) funded Newport Partners, LLC to head the Home Fire Sprinkler Cost Assessment. Combining the findings of the community cost study, with the estimated community benefits, will provide a clearer picture of the economic impact sprinkler ordinances will have on a community scale. What remains is to develop a software tool to facilitate community-scale benefit-cost comparisons.

Why NIST? Advancements in measurement science that provide communities with tools to evaluate the economics of fire protection decisions is closely aligned with BFRL's *Fire protection and fire spread within buildings and communities* core competency, BFRL's *Measurement science for innovative fire protection* strategic priority, and BFRL's mission. The decision tool will be solution-enabling, and will meet the needs of the U.S. building and fire safety industries, and communities, by providing a rigorous method to assess the cost-effectiveness of fire sprinkler technologies in one- and two-family dwellings.

Approach:

What is the new technical idea? The new technical idea is to develop a Web-based decision support tool that will allow users to conduct rapid benefit-cost analyses and sensitivity analyses for their specific community. Users will populate the inputs fields with either: (1) user-provided benefit-cost values; (2) default values based on peer-reviewed national estimates;[6] or (3) default values based on community estimates (benefits derived from previous work on this project and costs derived from Newport Partners LLC published findings). The Web-tool will facilitate the benefit-cost analysis, as users need only to agree on the inputs used, and will produce baseline estimates of the net present value benefits (present value benefits minus present value costs) resulting from residential fire sprinkler use. It will also perform sensitivity analysis, so users can examine the robustness of their baseline findings. For instance, users will be able to explore how changes in individual benefits and costs affect the results. Because such a small number of single family dwellings are currently equipped with fire sprinkler systems, statistics generated from national or community data contain uncertainty. Thus, sensitivity analysis is extremely important. Because the tool will allow users to determine the key drivers of the net present value benefits, it provides a natural prioritization of those drivers that could be measured or studied more closely. For example, if the probability of a fatality given a fire is the largest driver of the result, but there is a fair amount of uncertainty surrounding its estimate, then better

estimates (through improved measurement) of this variable will achieve a more precise result, than would any other driver in the analysis. Communities interested in further investigating the model inputs, would then be aided in how to best spend research dollars, given budget constraints.

Why can we succeed now? A significant amount of resources in time and funding have been allocated to this project in previous years, and these efforts have made great strides towards the solution. The remaining work requires the integration of the outputs from the previous work in the form a Web-based software tool as well as a user manual. BFRL economists and programmers on staff have conducted similar, successful models and software applications for other types of disaster protection. These tools have been adopted by EPA and DHS, and are widely used in the public and private sectors.

What is the research plan? The research plan is comprised of six major tasks: (1) design and development of the graphical user interface (GUI); (2) integration of the national and community benefit and cost data; (3) construction of the economic pseudo-code (programming logic and calculations); (4) programming of pseudo-code into a Web-based application (tool); (5) extensive testing of the draft and final versions of the application; and (6) publication of a User's Manual and deployment of the application. Major tasks 1-2 will be completed. Major tasks 3-4 will be completed. Major tasks 5-6, including the release of the Web-based decision tool, will be completed. Task 1-6 are modular by design and have been blueprinted as part of the Software Specification document. Stakeholder (e.g., FPRF, NFPA, USFA) involvement will be elicited during tasks 1 and 5.

The graphical user interface (GUI) will provide users (likely non-economists) a mechanism to perform benefit-cost analysis. It will also feature sensitivity analysis (e.g., Monte Carlo). The application will be designed to be Web-based, and therefore it will be platform independent to appeal to the maximum number of potential users. The GUI will run based on several (user supplied or default) inputs describing the benefits and costs of fire sprinklers. The inputs required include, for instance, the annual probability of a house fire, reduction in the probability of a fatality (given fire) due to sprinkler use, expected number of fatalities per house fire in house fires equipped with only smoke alarms, sprinkler installation costs, annual sprinkler maintenance and inspection costs, and insurance savings. The GUI will integrate the national and community benefit and cost data (collected in FY2007 and FY2008) so that users can use realistic default values based on national statistics, or those estimated for their community (if sufficient data existed). The GUI will also provide users with the flexibility to supplement or substitute these default values with their own. The construction of the economic pseudo-code will serve as a template for the actual software program, and the calculations will be based on previous published work.[5,6] Extensive testing will be conducted on each version (draft and final) of the software to ensure the results are accurate and consistent. Testing will also be conducted to ensure the software is user-friendly and easily accessible. On the date of final release and deployment of the Web-based application, a User's Manual will also be released as a NISTIR and integrated into the on-line Help function. The User's Manual will include a case-study illustration. The Web-based application and User's Manual will be WERB reviewed.

Recent Results:

Outputs:

Butry, D.T. 2008. "Economic Performance of Residential Fire Sprinkler Systems." Fire Technology. (*In press*).

Butry, D.T., M.H. Brown, and S.K. Fuller. 2007. "Benefit-Cost Analysis of Residential Fire Sprinkler Systems." NISTIR 7451. National Institute of Standards and Technology, Gaithersburg, MD.

Butry, D.T., and R.E. Chapman. 2007. "Benefit-Cost Model Framework for Evaluating a Community-wide Residential Fire Sprinkler System Ordinance." Unpublished White Paper.

Brown, M.H., and R.E. Chapman. 2007. "Benefit-Cost Analysis of Fire Sprinklers: Community and Home Owner Models." Unpublished White Paper.

Standards and Codes: This project impacts community adoption of NFPA 13D by providing communities with a tool to evaluate the economic viability of residential fire sprinkler ordinances.

Anticipated Impact: Based on national benefit-cost estimates, the tool will lead to greater adoption of sprinkler ordinances and decrease fire-related fatalities and losses nationwide.