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Development of an Environmental and Economic Assessment Tool (Enveco Tool) for Fire Events

Executive Summary

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The impact of fire on a community is usually measured at a local level in terms of the number of fires, human casualties, and property damage. There are subtle impacts of fire that are not as easily estimated but contribute to the measure of overall performance of the fire service in protecting a community. A tool has been developed that provides a consistent methodology for assessing the performance of fire departments with respect to two of these impacts: environmental and economic. The work reported here is the first step toward the development of the Enveco tool; it is a feasibility study. If the results of this work appear promising, further work will be conducted in the future to expand and improve the capabilities of the tool.

Most existing risk and environmental assessment methods, and many economic assessment methods, require specialized knowledge that is outside the scope of most fire departments. The goal of this work is to develop a relatively easy-to-use methodology for estimating the environmental and economic impact of fires that will help communities understand the degree to which fire department activities influence a community's environmental and economic well-being. The components of this tool are Quantitative Risk Assessment (QRA) for predicting fire spread to adjacent structures, Life Cycle Assessment (LCA) for estimating the environmental impact of the fire, the fire response, and replacement of damaged materials, and Cost Benefit Analysis (CBA) for estimating the economic impact of the fire.

The Enveco tool makes use of a simple spreadsheet platform. The user enters data in the "Input" worksheet that is divided into four areas: Risk of Fire Spread, Warehouse Description, Contents Description, and Fire Service Response. Input can be in metric or British units. Default input values are given whenever possible and are based on referenced literature. The output is the probability of fire spread to adjacent structures (from the QRA), savings in terms of firefighter fatalities and injuries, property damage, job disruption, business interruption, fire service intervention and rent reduction (from the CBA), and savings in terms of global warming potential, acidification, eutrophication, ozone depletion, smog, ecotoxicity, and energy used (from the LCA).

The tool in this initial form is developed to be used on a case-by-case basis for warehouse fires in which water was the only suppression media used during the response. The Enveco tool analyzes fire service response to previously occurring warehouse fires in which a defensive strategy was used and makes a comparison with the predicted consequences of the same fire without fire service response, which is used as a theoretical baseline case.

The tool does not predict response outcomes for future fires. Nor does it provide predictions about the amount of damage incurred as a function of response time or fire growth within the structure; there is no fire growth model involved aside from a QRA of the spread of the fire from the original structure to adjacent structures in cases without fire service intervention. Future versions of this tool may be capable of additional functionality, such as applicability to commercial and/or residential fires, including predictive results in terms of response time, ability to handle hazardous chemicals, etc.

The burning warehouse is assumed to be located in an industrial park such that any adjacent structures that might be at risk from fire spread are similar to the burning warehouse with respect to size and occupancy. The Enveco tool is demonstrated on two case studies. The first case study was selected because it was surrounded by industrial structures on all sides, the fire vented through the roof, and the fire service adopted a defensive strategy using water to cool the adjacent structures. Another case study was also selected as a second opportunity to demonstrate the Enveco tool. This warehouse is very similar to the first case study warehouse, except it had one adjacent structure (also industrial).

Even though there are many uncertainties associated with the components of the Enveco tool due to non-specific input data, many of them become less severe when used in the comparison between the theoretical baseline case of no fire service intervention and the real case where the fire service intervenes. This is because some portion of these uncertain parameters used in the models are applied to both scenarios in the comparison and are therefore partially cancelled out of the results.

The most important factor is the ratio between radiated and total heat release rate, which determines a large portion of the difference between the two scenarios in terms of fire spread to adjacent structures. Other important factors are those that are related to the differences between the two scenarios, such as the area used to calculate property damage. There are three factors that are only present in one of the scenarios: firefighter fatalities, firefighter injuries, and the cost of the fire service intervention. Of these, firefighter fatalities have a high impact on the results, but have little uncertainty.

The Enveco tool can be updated with more accurate information as it becomes available. Likewise, as more information becomes available to the users through public or private databases, the tool will become easier to use and the quality of the input data can improve. The functionality of the tool can also be extended more easily as new information becomes available. This tool was originally intended for use by the fire service but it may have value for other interested parties as well.

The following points are suggestions for future improvements to the Enveco tool:

- Additional structure types (single family residences, commercial buildings, apartment buildings, mixed types, etc.) and locations (wildland area, suburban neighborhood, central business district, etc.) will be identified in the future. The inventory will include information related to the fire, for example the structure content and construction type.
- Allow comparisons of outcomes (predictions) when different levels of response are taken. Vary number of personnel and amount/types of equipment and use response time as a factor.
- When and if the methodology is expanded to include more structure types, sites, and situations it can be implemented on a larger scale, for example in the form of an online service accessible to the fire service. It can also be introduced to the major fire service organizations via NFPA channels such as the NFPA Annual Conference.
- The feature to input several fires could be implemented in the future, however this would require special conditions for the QRA.
- The current model does not cover materials with extreme flame temperatures such as magnesium. It covers fires for which the radiated HRR lies in the range 0.2 and 0.3. In a future model the X factor, ratio of radiated heat, could be made into an input parameter.
- The wind speed can be added as an input parameter to include the effect of tilted flames. This will be important for strong winds.

- A more advanced CBA with the fire station lifetime and NPV calculation based on several interventions could be implemented.
- Including costs of health degradation due to smoke and particles based on established studies could also be implemented.
- Include firefighter jobs and jobs created by the competitors of the business during the rebuilding phase.
- Possibly expand assumptions to address intentionally set vs accidental fires. Capture the value of fire investigative efforts.
- Include the impact/value of fire department salvage and overhaul operations.
- This study focused on a 'Defensive' fire response, future analysis would include offensive fires and successful interventions that will result in financial and environmental impacts within the primary fire occupancy as well.
- Distinguish between career and volunteer responses or assume something about the mix.