THE FIRE PROTECTION RESEARCH FOUNDATION

Technology Assessment: Home Cooking Fire Mitigation

Development of an Action Plan

Workshop Summary and Key Action Items

Background

Cooking related fires are a leading cause of U.S. fire loss. Beginning in the mid 1980's, the National Institute of Standards and Technology, Consumer Product Safety Commission, and the home appliance industry undertook a comprehensive review[1] of strategies to mitigate death, injury and property loss from cooking fires with a focus on cooking range technologies. In February of 2010, a Vision 20/20 workshop on this topic was convened in Washington D.C. Participants recommended that an additional study be undertaken to identify the barriers to the utilization of these technologies and to develop an action plan towards improving cooking fire safety.

The Fire Protection Research Foundation has been asked by the National Institute of Standards and Technology to develop an action plan to mitigate loss from home cooking fires by investigating safety technologies related to home cooking. Elements of the study include an in-depth assessment of cooking fire scenarios, a review of current and emerging technologies, and development of an assessment methodology to consider the utility and effectiveness of mitigation technologies against a range of fire and use scenarios and other criteria. On July 14, leaders in the fire safety community met together in Baltimore Maryland to review the results of the Foundation study.

Workshop Goal

The goal of the workshop was to develop an action plan for research, product development and technology transfer to address the goal of mitigating fire loss from home cooking through technology.

Overview of Workshop Agenda

Approximately 30 leaders from the fire safety community participated in the workshop. Kathleen Almand, Executive Director of the Foundation, provided an overview of the study, which is sponsored by the National Institute of Standards and Technology. John Hall, Director of NFPA's Fire Analysis and Research Division, presented an indepth analysis of cooking fire incidents which was designed to inform the study. Hughes Associates, who conducted the technology assessment portion of the Foundation's study, presented a review of cooking fire mitigation technologies in the marketplace. Tom Fabian, Underwriters Laboratories, John Donovan, State Farm Insurance, and Andrew Trotta, Consumer Product Safety Commission, presented overviews of related research activities at their organizations. Hughes

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[1] CPSC Study (with AHAM Support): "Technical, Practical, and Manufacturing Feasibility of Technologies to Address Surface Cooking Fires." May 22, 2001. Arthur D. Little

Associates then presented a methodology to evaluate the performance of cooking fire mitigation technologies against a range of parameters including fire protection effectiveness, usability, and cost. They then presented the application of this methodology to cooking fire mitigation technology classes, including detection of imminent or occurring fires with warning, control/containment technologies, suppression technologies, and fire prevention technologies. Participants provided feedback on the method and its limitations and suggested enhancements.

The agenda, participants and presentations from this plenary session of the workshop are appended.

Participants then divided into three breakout groups to discuss elements of an action plan. Each group was asked to address needed improvements in the assessment method, needed research, and needed technology transfer programs that would address the goal. The results of each breakout group are appended. Each group reported their action item recommendations to the plenary.

The workshop concluded with a commitment from participants to continue to participate in activities to achieve the goal of reducing cooking fire loss through technology solutions.

Summary of Key Action Items

Research

- Develop standard fire scenarios and create test methods and performance criteria which can feed into standards development
- Improve understanding of pre-ignition detection
  - Research time to detection vs. time to ignition
  - Further research on pre-ignition indicators
- Conduct a societal cost/benefit study

Product Development

- Pursue a multi-sensor or multi-threshold approach
- Product development should have a specific design focus:
  - Type of range (gas, electric, flat top, or induction)
  - Specific population (elderly, low income, students)
  - Items first ignited (clothing, oil)
  - High risk cooking such as deep fat fryers, high heat Asian cooking

Technology Transfer

- Develop standard performance criteria and integrate into UL 858(electric) and UL Z2121(gas) as supplemental requirements for fire mitigation which would receive a special listing (gold star)
- Market as an option for consumer choice
- Conduct comprehensive consumer education

Appendices

Workshop Agenda

Workshop Attendance

Breakout Group Notes

List of Action Items

Workshop Presentations

THE FIRE PROTECTION RESEARCH FOUNDATION

Technology Assessment: Home Cooking Fire Mitigation

Development of an Action Plan

9:30 a.m. – 3:30 p.m.
Thursday, July 14th, 2011, BWI Airport Marriott

AGENDA

1. Welcome/Background/Workshop Objective	Dan Madrzykowski, NIST
2. Overview – Fire Protection Research Foundation Project	Kathleen Almand, FPRF
3. Analysis of Cooking Fire Incidents	John Hall, NFPA
4. Technologies for Cooking Fire Mitigation	Josh Dinaburg, Hughes Associates
5. Recent Research:	
a. Stove Top Retrofit Technology Performance	John Donovan, State Farm
b. Prototype Stovetop Technology Assessment	Andrew Trotta. CPSC
c. Smoke Characterization Applied to Cooking Fire Mitigation	Tom Fabian, UL

LUNCH

6. Technology Assessment and Gap Analysis	Josh Dinaburg
7. Elements of an Action Plan:	Discussion/Breakouts

   a. Cooking Fire Mitigation Technology Research and Development
   b. Assessment Methodology Next Steps
   c. Technology Transfer

8. Conclusion

Attendees

Mike Love, representing Vision 20/20
Andrew Trotta, CPSC
Tom Fabian, Underwriters Laboratories Inc.
Wayne Morris, AHAM
Dan Madrzykowski, NIST Engineering Laboratory
John Donovan, State Farm Insurance
Brian Merrifield, FPRF
Kathleen Almand, FPRF
John Hall, NFPA
Dan Gottuk, Hughes Associates, Inc.
Joshua Dinaburg, Hughes Associates, Inc.
Jason Averill, NIST
Mike Gerdes, BSH Home Appliances
Steve Polinski, Miele
Larry Bell, BSH Home Appliances
Marty Walsh, BSH Home Appliances
Joseph Musso, Underwriters Laboratories Inc.
Bob DellaValle, Underwriters Laboratories Inc.
Amanda Robbins, BRANZ

Jim Crawford, Vision 20/20
David Klein, Veterans Affairs
George Morgan, U.S. Navy
Lawrence McKenna, U.S. Fire Administration
Sandy Facinoli, US Fire Administration
Maggie Wilson, FEMA
Candace Ahwah-Gonzalez, Safe Kids Worldwide
Debra Carlin, Dallas Fire Rescue Department
Meredith Hawes, Grand Traverse (MI) Metro Fire Department
David Kerr, Plano (TX) Fire Rescue
Meri-K Appy, Safe Kids Worldwide
Doug Crawford, Ontario Deputy Fire Marshal
William Downing, Baltimore City Fire Department
Wayne Senter, South Kitsap (WA) Fire & Rescue
Amy Carpenter, WRT Design
Kevin McSweeney, Center for Campus Fire Safety

Breakout Group Notes

Blue Group:

- Research:
  - Any further research must be sure to include a diverse constituency (i.e. manufacturers, consumer testing, etc)
  - Strongly support a multi-sensor or multi-threshold approach. Consider a sequence of events such as warning of immanent hazard first, then as time and the situation continues: automatically shut-off source, automatically suppress, and consider notifying the Fire Department or other authorities to check in on the situation.
    - Ex: computer – power save mode, sleep mode, turn off
    - Ex: Pre-action sprinkler system: smoke detector sounds the alarm and charges the system but the extinguishment requires a secondary confirmation (heat) to prevent accidental discharges
  - Investigate current high hazard protection such as the UK Potato Chip fire incidents
  - Research should have a specific design focus such as a product specifically designed for the:
    - Type of range (gas, electric, flat top, or induction)
    - Specific population (elderly, low income, students)
    - Items first ignited (clothing, oil)
  - Consider either one product for all types of ranges (which will work for all but not be as effective for some) vs. a specific product for each niche market (much more effective for each, but not uniform across industry)
  - Continue CPSC's current research
  - Product design must be inexpensive, easy to install, and easy to use to make jump into larger market.
- Method:
  - Consider incorporating TFPG goals into method to mesh common ideas easier
  - Refine method to apply to specific range types (gas, electric, flat top, induction)
  - "Reliability Internationally"
  - "Drill further into fire statistics"
  - Elaborate further to quantify cost, effectiveness, and reliability.
  - Change the way information is displayed in graphs to show % change in loss measures, preferably with uncertainty bars.
    - Consider using John Hall's chart with percentage of events that occur in each category to easily quantify the % impact of the results.
  - Perhaps use the current method created to "triage" the mass amount of products to narrow the field to those most likely to make the largest impact then dig deeper quantifying for the fewer options.
  - "Use Delphi panels at least for a use scale where you can't get data"
  - Current method does not take product effectiveness in specific niches into account, only general applicability.
  - Very subjective guesses were made, consider using a very large sampling group to evaluate parameter importance.
- Technology Transfer

  - Focus technology on high fire risk areas and styles of cooking (i.e. deep fryers and high heat Asian cooking).
  - Strengthen links between research and standards.
  - Consider developing performance criteria for specific niche types of ranges rather than product specifications (i.e. Performance Based Design style where a design criteria is established for certain types of ranges where so long as a product meets that classification, it is considered usable for that type of range)
  - Market first then mandate after experience (similar to airbags)
    - Put options on the market to introduce idea. "You can get a regular stove, but with your higher risk with children around, can I suggest a "safer" option." Make it a desired safety item and consumers will adapt.
    - Market focused approaches:
      - i.e. AARP focusing on importance to baby boomers getting older
  - Instead of mandating a specific technology, consider allowing substitutions to meet intent such as allowing a non-regulated stove top to be installed only if a sprinkler system is installed in the kitchen. (Allowed to cook with larger flames if passive or active protection is added in place of regulated temperature or type of stove).
  - Electric seems easier to input control unit, gas and induction should be researched more
  - Further define parameters (i.e. timers – specific lengths of time, ignore button)
  - Change standard design criteria such as having single deep widths rather than double to prevent users from reaching over active burners.
    - Similar debate to where the knobs should be (on front of stove allows access for kids to play with but behind the store encourages users reaching over burners, which is more dangerous?)

<u>Red Group:</u>

- Research and Development
  - Pre-ignition detection and control
    - Research time to detection vs. time to ignition
  - More work on promising technologies that are currently available
  - Consumer research on available technologies
  - Create and test methods and performance criteria based on standard fire scenarios
  - Further research pre-ignition indicators
  - # of nuisance alarm evaluation and correction
  - NFIRS
    - Deeper diving into cooking fire stats
    - Special studies
    - CPSC
    - Reliability?
- Action Implementation
  - CPSC action
    - Expand beyond temperature control
  - Clear regulatory/approval/standards/listing paths for retrofit technology.
  - Drivers for new product entry:
    - Regulation

        - Consumer education
        - Develop case for society – cost benefit analysis
        - Market for high risk groups initially
    - Barriers:
        - Legal issues – Optional safety features
        - Life safety code provisions
            - Extra safety features for high risk groups
    - Not in product standard

<u>Green Group:</u>

In general the discussion focused upon setting performance goals for the implementation of devices. The need for standards to identify a level for acceptable products was emphasized.

The group recommends that fire mitigation is included in UL 858 and UL Z2121 (gas ranges) to identify performance requirements for temperature limiting devices (burner control).

The fire mitigation would be included in the standard as a supplemental requirement. Any device meeting the additional requirement would get a "gold star" or other special listing. It was noted that this is how coffee makers can be listed for "hospitality" use as an example.

In order to begin work on this process a new STP would need to be organized and beginning working off the single performance goal of "Prevent ignition of a pot of 100% corn oil." It was felt that prevention of this single fire would indicate an ability to prevent numerous other fire scenarios due to the ease of ignition of this test.

It was also discussed that the consumer performance goals should be dictated by the customers. We also noted that when the consumer is a property manager or similar, the allowable impact to cooking is not as important as the need to prevent fires. The opposite may be true when the consumer is the person who will be using such a device.

With regard to the presentations, it was generally felt that more statistical data is necessary to fully carry through such an analysis.

Action Items

I Performance Assessment Method Enhancements:

- Refine method to apply to specific range types (gas, electric, flat top, induction)
- Elaborate further to quantify cost, effectiveness, and reliability using for example international data sources, deeper exploration of NFIRS and other studies, etc.
- To remove subjectivity, consider using a very large sampling group to evaluate parameter importance or use Delphi Panels.
- Consider incorporating TFPG goals into method to mesh common ideas easier
- Change the way information is displayed in graphs to show % change in loss measures, preferably with uncertainty bars.
- Perhaps use the current method to "triage" the mass amount of products to narrow the field to those most likely to make the largest impact; then dig deeper into quantification of a smaller number of more promising options.
- *Provide more weight in the method on cooking performance by breaking that out as a separate factor and combining other issues like cleaning/maintenance into the cost section;
- *Review the statistics to determine if there is a way to place at least a judgment value on the effectiveness of various technologies (ie instead of assuming that they are always effective if they are present);
- *Adjust the work to focus on stove top fires only
- *Refine the unattended fire analysis.
- *Provide a written description of the input, identifying the limitations in input values.

* Identified in the general session, not the breakout sessions

II Research:

Test Methods and Performance Criteria

- Develop standard fire scenarios and create test methods and performance criteria which can feed into standards development

Detection

- Improve understanding of pre-ignition detection
  - Research time to detection vs. time to ignition
  - Further research on pre-ignition indicators

Consumer Studies

- Research consumer attitudes/reaction to available technologies
- Conduct societal cost/benefit study

General Studies

- Study the number of nuisance alarms, their causes and strategies to reduce them
- Study reliability over time measures
- Explore tamper resistance (identified in general session, not breakout)
- Continue to monitor and enrich understanding of cooking fire incidents through deeper dives into NFIRS, conduct of special studies either through CPSC or through fire departments
- Any further research must be sure to include a diverse constituency (i.e. manufacturers, consumer testing, etc)

III Product Development

- Pursue a multi-sensor or multi-threshold approach. Consider a sequence of events such as warning of imminent hazard first, then as time and the situation continues: automatically shut-off source, automatically suppress, and consider notifying the Fire Department or other authorities to check in on the situation.
- Investigate analogous strategies such as current high hazard protection - UK Potato Chip fire incidents
- Product development should have a specific design focus such as a product specifically designed for the:
  - Type of range (gas, electric, flat top, or induction)
  - Specific population (elderly, low income, students)
  - Items first ignited (clothing, oil)
  - High risk cooking such as deep fat fryers, high heat Asian cooking
- Continue CPSC's current research and extend beyond temperature control technologies
- Focus product development on these characteristics to speed market entry: inexpensive, easy to install
- Focus product development on promising technologies that are currently available
- Focus on gas and induction as most focus to date has been on electric
- Further define parameters (i.e. timers – specific lengths of time, ignore button)
- Consider other product development approaches such as depth of range to prevent users reaching over active burners; timers, ignore buttons

IV Technology Transfer

Standards Development

- Strengthen links between research and standards.
- Develop performance classes for niches (cooking, high risk groups)
- Develop a code approach which would explore detection, passive, suppression options
- Standard performance criteria should be developed and integrated in to UL 858(electric) and UL Z2121(gas) as supplemental requirements for fire mitigation which would receive a special listing (gold star)
- Form a new Standards Technical Panel with a single performance goal of "Prevent ignition of a pot of 100% corn oil." It was felt that prevention of this single fire would indicate an ability to prevent numerous other fire scenarios due to the ease of ignition of this test.
- Consumer performance goals should be dictated by the customer
- Clear regulatory/approval/standards/listing paths for retrofit technology.

Marketing and Consumer Education

- Market first then mandate after experience (similar to airbags)
- Market as an option for consumer choice
- Consumer education
- Educate on societal cost/benefit
- Market for high risk groups initially

Technology Assessment: Home Cooking Fire Mitigation

Development of an Action Plan

July 14, 2011

Workshop Goal

Develop an **action plan** to mitigate loss from home cooking fires by furthering the implementation of proven effective safety technologies related to home cooking.

Foundation Background

- Independent not for profit formed by NFPA in 1983
- Mission – to plan, manage and communicate research in support of the NFPA fire safety mission
- Major research programs in sprinkler protection, smoke alarms, hazardous materials protection and electrical safety

All Reports Available on Foundation Website

www.nfpa.org/Foundation

Project Background

- Cooking-equipment related fires are a leading cause of U.S. fire loss.
- 1980’s CPSC study on attributes of cook top mitigation technologies
- Voluntary standards development activities initiated
- TPFG developed by UL STP – focus on cooking performance
- Since the 1980’s no advances in applied technology

Project Background

- February 2010 Vision 20/20 Workshop
- Recommendation to study barriers to implementation and develop an action plan
- Key Element – assessment of technologies – reference 1980s A.D. Little Study

Project Tasks

- Define major cooking fire scenarios based on fire incident data
- Identify new and existing promising technologies
- Develop an assessment methodology
- Assess technologies
- Identify gaps – action plan

Action Plan

- Research and technology development
- Performance criteria and conformity assessment methodologies
- Standards development
- Other actions

Agenda

- Analysis of Cooking Fire Incidents
- Technologies for Cooking Fire Mitigation
- Recent Research
- **LUNCH**
- Technology Assessment and Gap Analysis
- Breakout Discussion: Elements of an Action Plan

Action Plan Items

- Research and Development related to promising technologies – e.g. field testing, new sensors, etc
- Further refinement of the technology assessment method –
- Needed technology transfer – items that will lead to/remove barriers – standards, performance criteria, market focused approaches…..

Technologies for Cooking Fire Mitigation

Joshua Dinaburg, Hughes Associates Inc.
Dan Gottuk, Ph.D., Hughes Associates Inc.

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FIRE SCIENCE & ENGINEERING

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Baltimore, MD
July 14, 2011

Objective

- Identify technological options for reducing the threat of cooking fires started by household range tops
- Identify the current developmental status of existing and potential technologies
  - Existing products
  - Laboratory scale experiments
  - Potential concepts

Approach

- Conduct literature and patent review
- Identify technologies capable of reducing losses from home range top fires
  - Potential losses include deaths, injuries, and property damages
  - Any device or system that could prevent these losses were considered, but none requiring a user to actively fight fires after ignition
  - Technologies sorted according to method of mitigating fire threats (i.e. warning, suppression, prevention, etc.)

Methods of Mitigating Fire Losses

- *Group 1*: Detect an occurring fire and provide a warning
  - May prevent deaths and injuries by alerting occupants to danger and increasing the likelihood of escape
- *Group 2:* Detect an imminent fire condition and provide a warning
  - Occupants may intervene prior to ignition if within range of the warning alarm
- *Group 3*: Control fire/prevent fire spread
  - Contain a fire to the range top and prevent fire spread and growth, may prevent fire from reaching a state capable of inflicting injuries or death

Methods of Mitigating Fire Losses (cont.)

- *Group 4*: Provide automatic suppression
  - Detect an occurring fire and take automatic actions to suppress the flames
- *Group 5*: Prevent fire from occurring
  - Imminent fire conditions are detected and the system is capable of eliminating the ignition hazard
  - Also includes devices that inherently do not allow certain ignition scenarios to occur rather than through detection and control

Group 1: Detect Occurring Fire and Provide Warning

- Detect flames or heat on or around the range
- Provide an audible and/or visual warning
- Intended to alert the occupants to evacuate and contact the fire department
  - Active fire fighting should not be recommended
  - Effective use dependent upon cooking fire education
- Potential detection methods include:
  - Fusible link placed over range top (i.e. hood installation)
  - Non-optical temperature sensor placed over range top
  - Optical temperature sensor observing range top
  - Video Image Detection (VID) observing range top
  - Optical Flame Detector (OFD) observing range top
  - Thermal imaging of range top

Group 2: Detect Imminent Fire and Provide Warning

- Detect potential ignition conditions on or around range top
- Provide an audible and/or visual warning
- Should provide adequate warning to allow occupants to take steps to safely prevent the ignition
  - Actions may include turn off/lower burner, remove combustibles from burner, etc.
- Potential detection methods include:
  - Air temperature sensor (lower threshold than Group 1)
    - Optical or Non-optical
  - Smoke detector
  - Pan/Burner temperature sensor
    - Contact or Non-contact
  - Unattended range detection
    - Motion sensor
    - Timer
    - Can combine operation with range power or temperature sensor

Group 3: Contain Fire/Prevent Fire Spread

- Prevent fires on range top from spreading beyond range and increasing hazards and damage
- Does not reduce the number of fire incidents, only the resulting losses through control
- Not intended to provide users additional opportunity to fight fires (education)
- Potential containment methods include:
  - Passive containment: fire resistive materials surrounding range top do not allow fires to spread to surrounding cabinets, walls, or other combustibles
  - Active containment: moveable exhaust chamber that detects the presence of a fire and physically moves to prevent spreading of flames

Group 4: Provide Automatic Suppression

- Requires a sensor to detect a fire and a system to initiate a fire suppressant
- Detection technologies for occurring fires same as Group 1
  - Include heat and flame sensing options
- Suppressants include sprinklers, wet and dry chemical suppressants
- Does not reduce the number of fire incidents, only the resulting losses through suppression
  - Property damages costs may be greater in some cases than the fire due to release of suppressant

Group 5: Prevent Fire

- Prevent ignition of fires regardless of user actions
- May be limited in types of fires prevented
- Detection technologies for imminent fire conditions same as Group 2
  - Prevent unattended cooking through motion sensors or timers, may include temperature or power level sensors
  - Prevent food ignitions through temperature detection
    - Pan contact sensor or optical sensor
    - Burner temperature sensor (only for electric stovetops)
    - Mechanically actuated sensor – bi-metallic strip or expandable liquid
    - Applicable to overheat conditions through fixed temperatures, gradients (boil over/dry), or user defined cooking settings

Group 5: Prevent Fire

- Once an ignition condition is detected, the system takes steps to prevent the ignition automatically
  - Reduce or eliminate power supply to the burners
- Other prevention options may simply eliminate ignition scenarios without detection
  - Induction range does not allow for ignition of clothing due to cool burner surface temperature, also does not operate if pot not detected on surface

Market Status and Existing Products

- Home Kitchen Suppression Systems
  - Various temperature detectors, sprinklers, wet and dry chemical agents already in market
  - UL 300A – Proposed method for testing such devices
  - ***StoveTop Fire Stop*** – small canister of sodium bicarbonate mounted above range top and releases through gravity when heated

- Motion Detection to Prevent Unattended Cooking
  - ***HomeSenser*** – alarm after 6 minutes of unattended cooking, shutdown after 8 minutes, only for electric ranges
  - ***StoveGuard*** – Automatic shutoff after user defined time sensing no motion, 1 minute is default time

- Contact Burner Temperature with Control
  - ***Safe-T-Element*** – Solid cast iron plate with TC fits over top of an electric coil, prevents burner surface from overheating by controlling burner surface temperature

Market Status and Existing Products

- Optical Temperature with Control
  - ***Innohome Stove Alarm*** – Sensor mounts over range top and alerts to overheat condition, an additional controller can use the sensor to cutoff power to electric ranges
- Smoke Detection with range power control
  - ***Fidepro Intelligent Smoke Alarm*** – Smoke alarm that can cutoff power to entire rooms, areas, or individual devices, applicable to electric range tops
- Induction Range
  - Magnetic field induces heating in ferrous utensils, can eliminate clothing ignitions or accidental heating without a pan on the burner

Evaluated Technologies

Detect occurring fire and provide warning	Fusible link	
	Non-optical temperature sensor	
	Optical temperature sensor	
	Video image detection	
	Optical flame detector	
	Thermal imaging	
Detect imminent fire condition and provide warning	Non-optical temperature sensor	
	Optical temperature sensor	
	Smoke detector	
	Pan temperature sensor - Contact Sensor	
	Pan temperature sensor - Non-contact sensor	
	Burner surface temperature sensor	
	Unattended Cooking Warning Alarm	Motion Sensor
		Motion Sensor + Temperature Sensor
		Motion Sensor + Power Sensor
		Timer
		Timer + Temperature Sensor
		Timer + Power Sensor
Control fire/prevent fire spread	Passive 3 wall system	
	Active drop down hood	

Evaluated Technologies (cont)

Provide Automatic Suppression	Fusible link		
	Non-optical temperature sensor		
	Optical temperature sensor		
	Video image detection		
	Optical flame detector		
	Thermal imaging		
Prevent Fire	Prevent unattended cooking through burner control	Motion Sensor	
		Motion Sensor + Temperature Sensor	
		Motion Sensor + Power Sensor	
		Timer	
		Timer + Temperature Sensor	
		Timer + Power Sensor	
	Prevent ignition through burner temperature control	Fixed Temperature Control	Utensil contact temperature
			Burner temperature
			Non-contact temperature sensor
			Mechanical actuation
		Temperature Gradient for boil over/ spills	Utensil contact temperature
			Burner temperature
			Non-contact temperature sensor
		User selected cook-type or temperature option with microprocessor control	Utensil contact temperature
			Burner temperature
			Non-contact temperature sensor
		Smoke Detection	
	Induction range		


Questions?

Technology Assessment and Gap Analysis

Part II

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July 14, 2011

Objective & Approach

- Develop a methodology for comparing potential range cooking fire mitigation technologies
- Compare the potential impact of technologies utilizing statistical fire incident data (John Hall)
- Analyze each concept based upon non-fire characteristics, including use of the product and costs involved
- Determine which protection options could provide the highest reduction in fire losses while limiting influence on user behavior and cost
- Determine where gaps exist with regard to product evaluation and the current developmental design status

Scoring System Overview

- Each technology given a score from 1-10 in each of three general criteria
  - Fire Protection Effectiveness
    - Assuming technology is always 100% operational and successful, score represents the percentage of potential fire scenarios that could be addressed by total adoption of the technology
  - Overall Effect upon the Use of the Cooking Range
    - Includes contributions of effects upon cooking, functional and operational considerations, and user responsibilities
  - Total Cost
    - Includes contributions of purchasing, installation, maintenance, and operation

Fire Protection Effectiveness

- The final fire protection effectiveness score
  - Represents the maximum possible reduction in losses if:
    - The technology is immediately installed on all applicable devices
    - The technology operates ideally in each installation with no failures
  - Scored from 1-10 representing the percentage of potential fire loss reductions (10=100%)
  - A sum of the contribution of the technology to reducing fire losses on gas and electric range tops
  - Based upon statistical fire incident data (Hall)
    - Includes contributions of ignition factors, fire locations, clothing ignitions, and gas and electric range tops
  - Calculated independently for each fire loss category
    - Fire Incidents
    - Deaths
    - Injuries
    - Property Damages

Effect Upon Use of the Cooking Range

- A representation of the effect of the product in a real installation
- Represents the state of the technology in its current design stage
  - Future advancements in improving product functionality and use could improve overall scoring
- Includes
  - Cooking Performance
    - Cooking Time
    - Cooking Quality
  - Consumer Responsibilities
    - Cook behavioral modifications
    - Cleaning/maintenance required for proper operation
    - Additional safety risks to users
  - Functional Considerations and Reliability
    - Restoration of range after actuation
    - Potential for and consequences of false actuation
    - Fail-safe operation
    - Operate with reasonable user error or misuse
- Criteria scored as 1, 5 or 9

Total Cost

- A representation of all the costs involved in installing the technology in a real kitchen
- Represents the state of the technology in its current design stage
  - Future advancements in improving product costs could improve overall scoring
- Includes
  - Initial Purchasing Cost
  - Installation Cost
  - Product Life-cycle Costs
    - Serviceability
    - Durability
  - Cookware applicability
- A high score in cost is reflective of low total costs
- Criteria scored as 1, 5 or 9

Scoring

- Effect upon the use of the range and total cost criteria each scored:
  - 1 – Low product performance or high impact of technology
  - 5 – Medium performance or some impact
  - 9 – High performance or no impact
- Scores from each sub-criteria are calculated as the geometric mean
  - The product of the scores is taken to the root of the number of scores
  - A score of one in any category will have a greater impact upon the overall score for the technology
- Example (Scores = 1,9,9)
  - Geometric mean = $(1 \times 9 \times 9)^{1/3} = 4.3$
  - Average = (1+9+9)/3 = 6.3

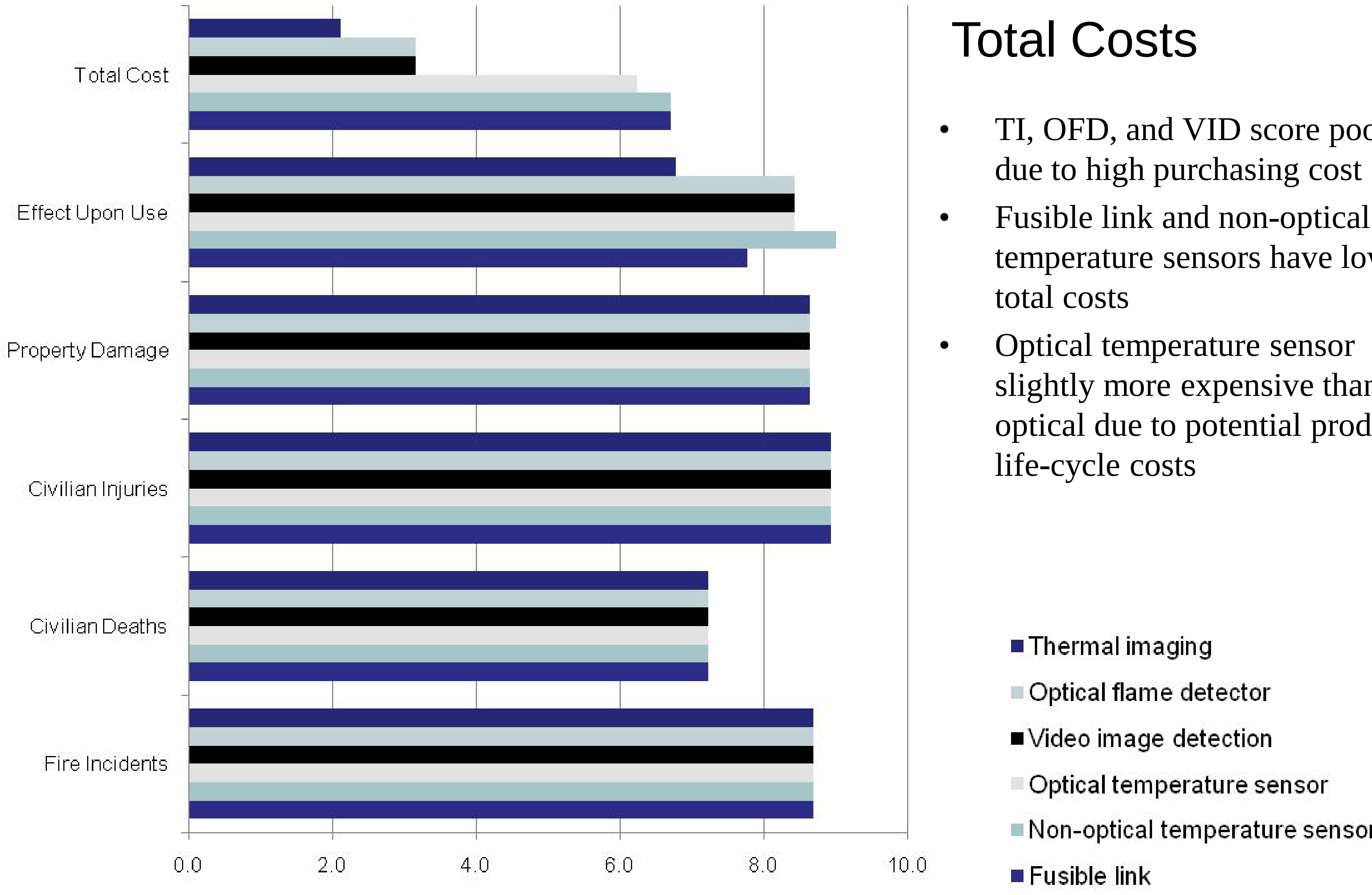
Technologies to be Evaluated

Detect occurring fire and provide warning		Fusible link
		Non-optical temperature sensor
		Optical temperature sensor
		Video image detection
		Optical flame detector
		Thermal imaging
Detect imminent fire condition and provide warning		Non-optical temperature sensor
		Optical temperature sensor
		Smoke detector
		Pan temperature sensor - Contact Sensor
		Pan temperature sensor - Non-contact sensor
		Burner surface temperature sensor
	Unattended Cooking Warning Alarm	Motion Sensor
		Motion Sensor + Temperature Sensor
		Motion Sensor + Power Sensor
		Timer
		Timer + Temperature Sensor
		Timer + Power Sensor
Control fire/prevent fire spread		Passive 3 wall system
		Active drop down hood

Technologies to be Evaluated

<table>
<tr><td rowspan="6">Provide Automatic Suppression</td><td colspan="3">Fusible link</td></tr>
<tr><td colspan="3">Non-optical temperature sensor</td></tr>
<tr><td colspan="3">Optical temperature sensor</td></tr>
<tr><td colspan="3">Video image detection</td></tr>
<tr><td colspan="3">Optical flame detector</td></tr>
<tr><td colspan="3">Thermal imaging</td></tr>
<tr><td rowspan="18">Prevent Fire</td><td rowspan="6">Prevent unattended cooking through burner control</td><td colspan="2">Motion Sensor</td></tr>
<tr><td colspan="2">Motion Sensor + Temperature Sensor</td></tr>
<tr><td colspan="2">Motion Sensor + Power Sensor</td></tr>
<tr><td colspan="2">Timer</td></tr>
<tr><td colspan="2">Timer + Temperature Sensor</td></tr>
<tr><td colspan="2">Timer + Power Sensor</td></tr>
<tr><td rowspan="10">Prevent ignition through burner temperature control</td><td rowspan="4">Fixed Temperature Control</td><td>Utensil contact temperature</td></tr>
<tr><td>Burner temperature</td></tr>
<tr><td>Non-contact temperature sensor</td></tr>
<tr><td>Mechanical actuation</td></tr>
<tr><td rowspan="3">Temperature Gradient for boil over/ spills</td><td>Utensil contact temperature</td></tr>
<tr><td>Burner temperature</td></tr>
<tr><td>Non-contact temperature sensor</td></tr>
<tr><td rowspan="3">User selected cook-type or temperature option with microprocessor control</td><td>Utensil contact temperature</td></tr>
<tr><td>Burner temperature</td></tr>
<tr><td>Non-contact utensil temperature sensor</td></tr>
<tr><td colspan="3">Smoke Detection</td></tr>
<tr><td colspan="3">Induction range</td></tr>
</table>

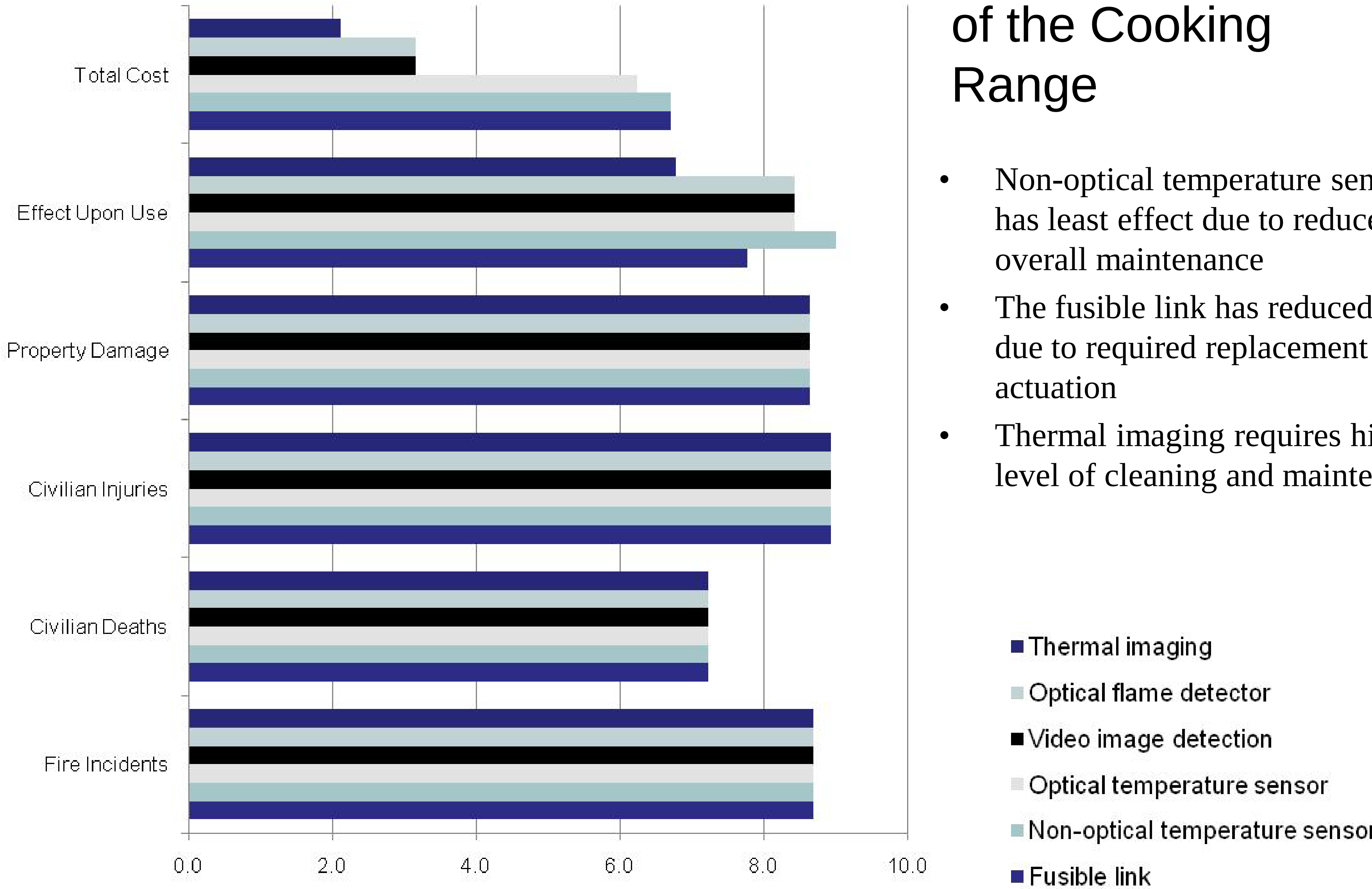
Mitigation Group 1: Detect Occurring Fire and Provide Warning



Total Costs

- TI, OFD, and VID score poorly due to high purchasing cost
- Fusible link and non-optical temperature sensors have lowest total costs
- Optical temperature sensor slightly more expensive than non-optical due to potential product life-cycle costs

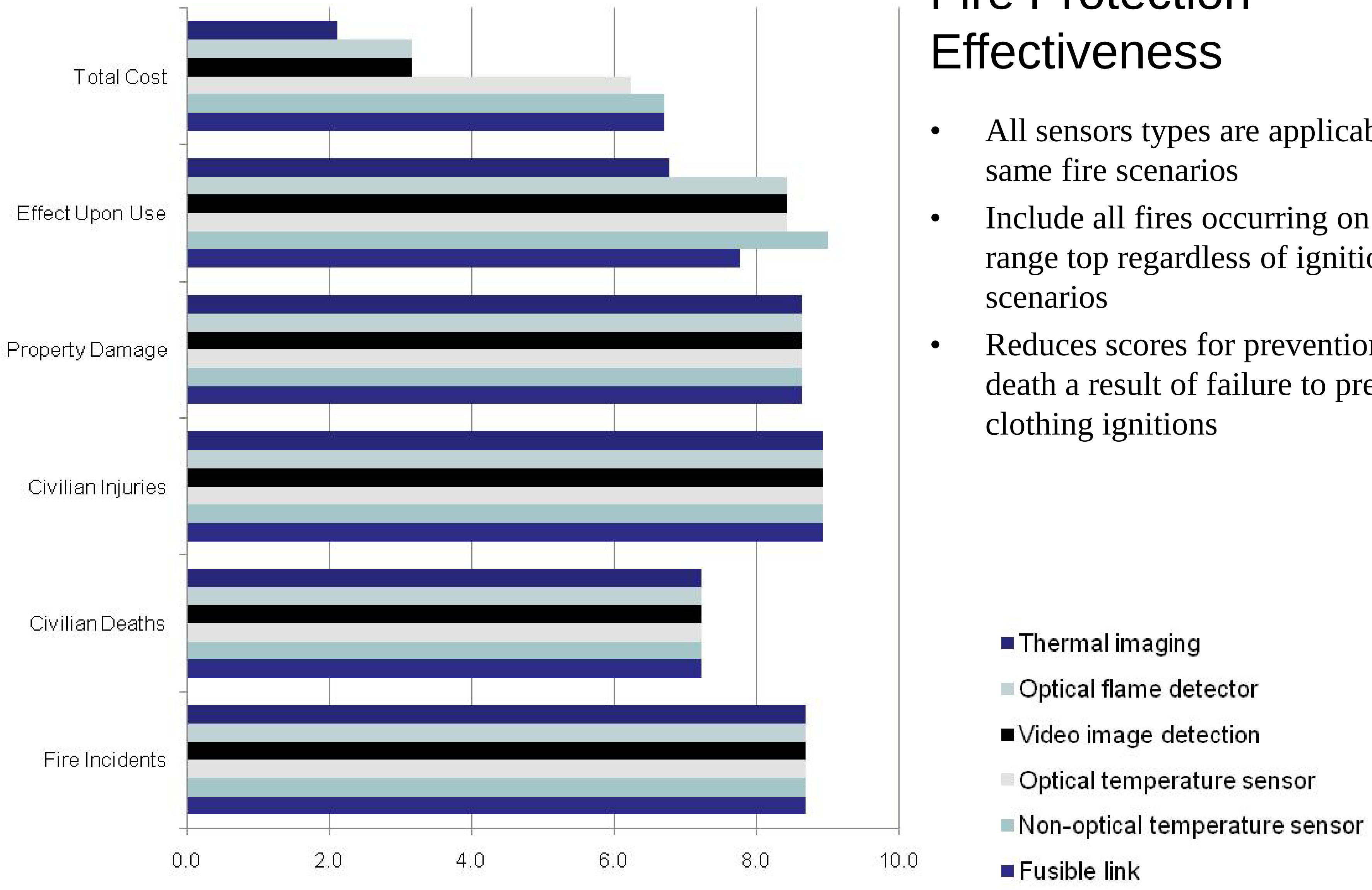
Mitigation Group 1: Detect Occurring Fire and Provide Warning



Effect Upon Use of the Cooking Range

- Non-optical temperature sensor has least effect due to reduced overall maintenance
- The fusible link has reduced score due to required replacement after actuation
- Thermal imaging requires high level of cleaning and maintenance

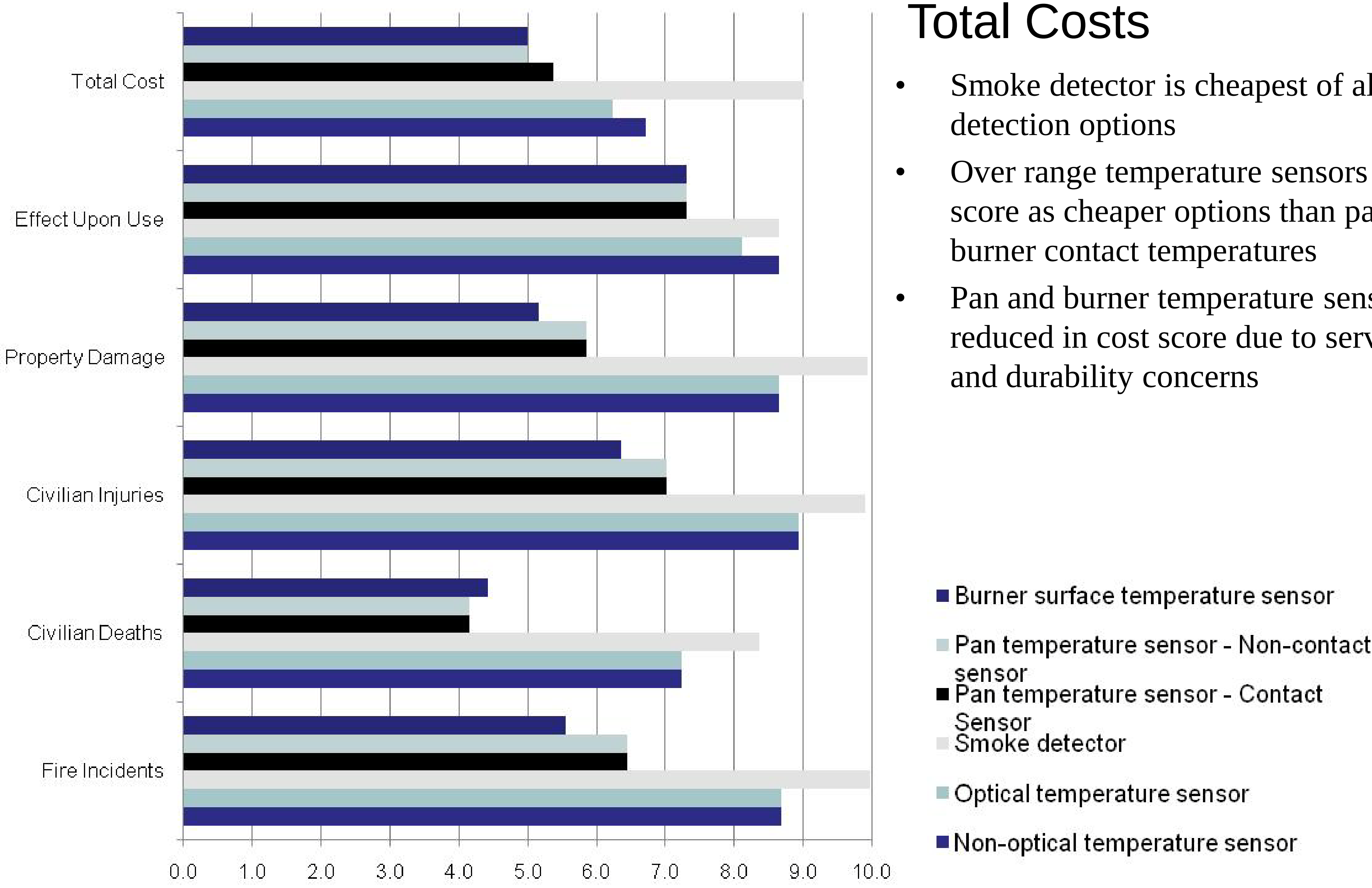
Mitigation Group 1: Detect Occurring Fire and Provide Warning



Fire Protection Effectiveness

- All sensors types are applicable to same fire scenarios
- Include all fires occurring on the range top regardless of ignition scenarios
- Reduces scores for prevention of death a result of failure to prevent clothing ignitions

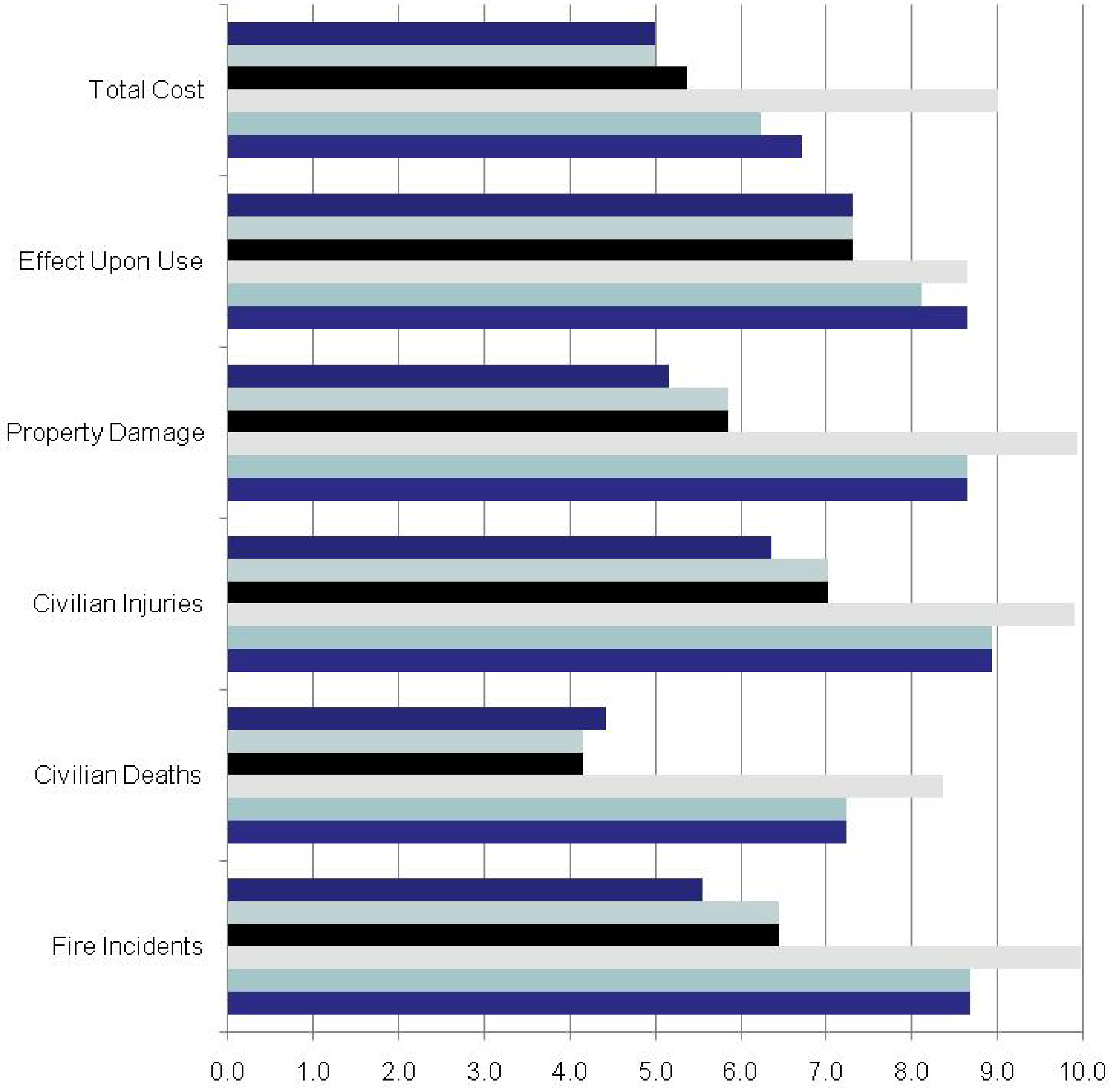
Mitigation Group 2-a: Detect Imminent Fire from Pre-ignition Conditions and Provide Warning



Total Costs

- Smoke detector is cheapest of all detection options
- Over range temperature sensors score as cheaper options than pan or burner contact temperatures
- Pan and burner temperature sensors reduced in cost score due to service and durability concerns

Mitigation Group 2-a: Detect Imminent Fire from Pre-ignition Conditions and Provide Warning

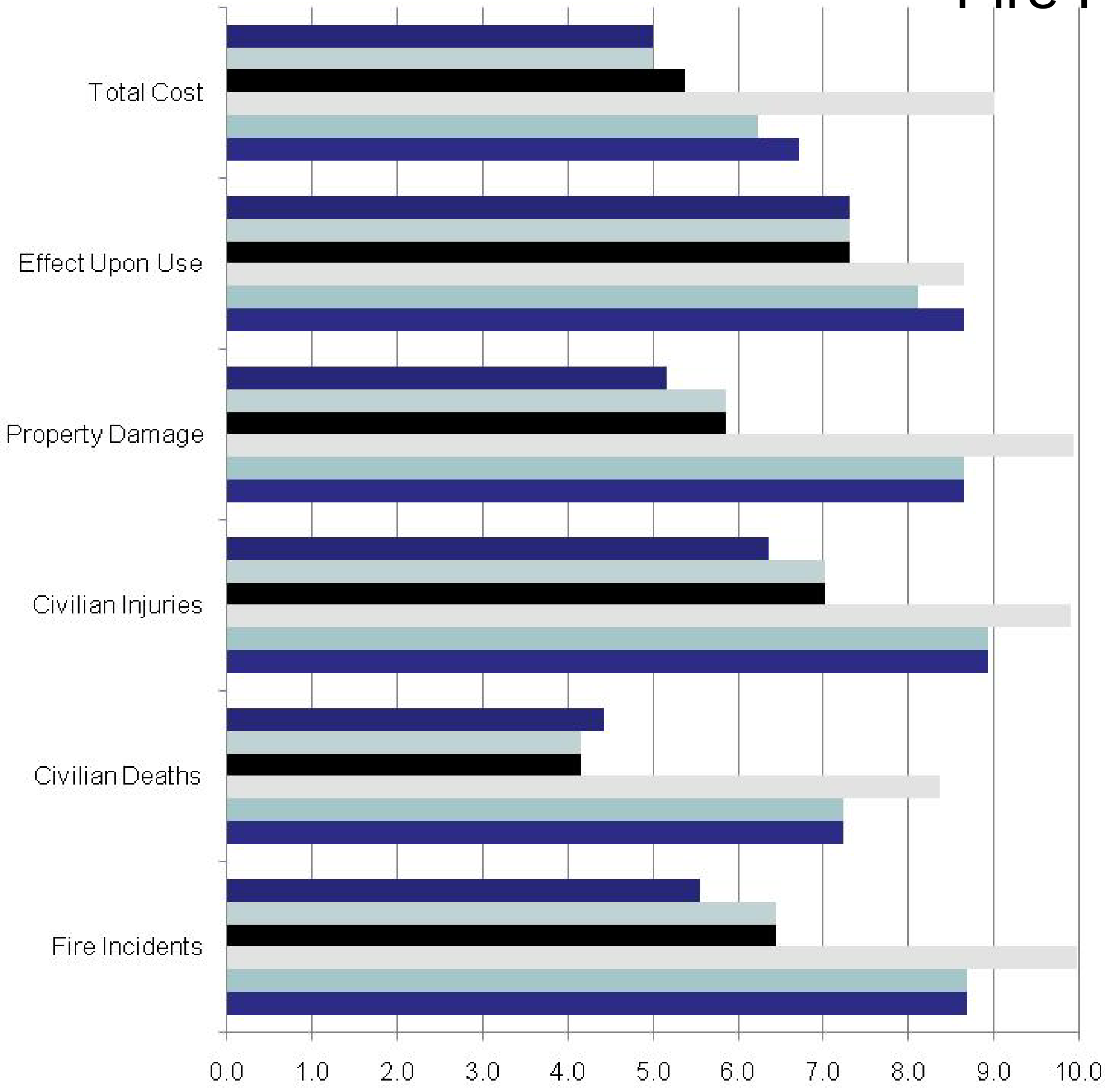


Effect Upon the Use of the Cooking Range

- Smoke detector rates as least effect upon use of range in a tie with a non-optical temperature sensor
- Optical temperature sensor reduced use score from non-optical due to potential cleaning requirements
- All pan and burner temperature sensors require user to constantly interact with the sensor, rather than being hidden in the hood

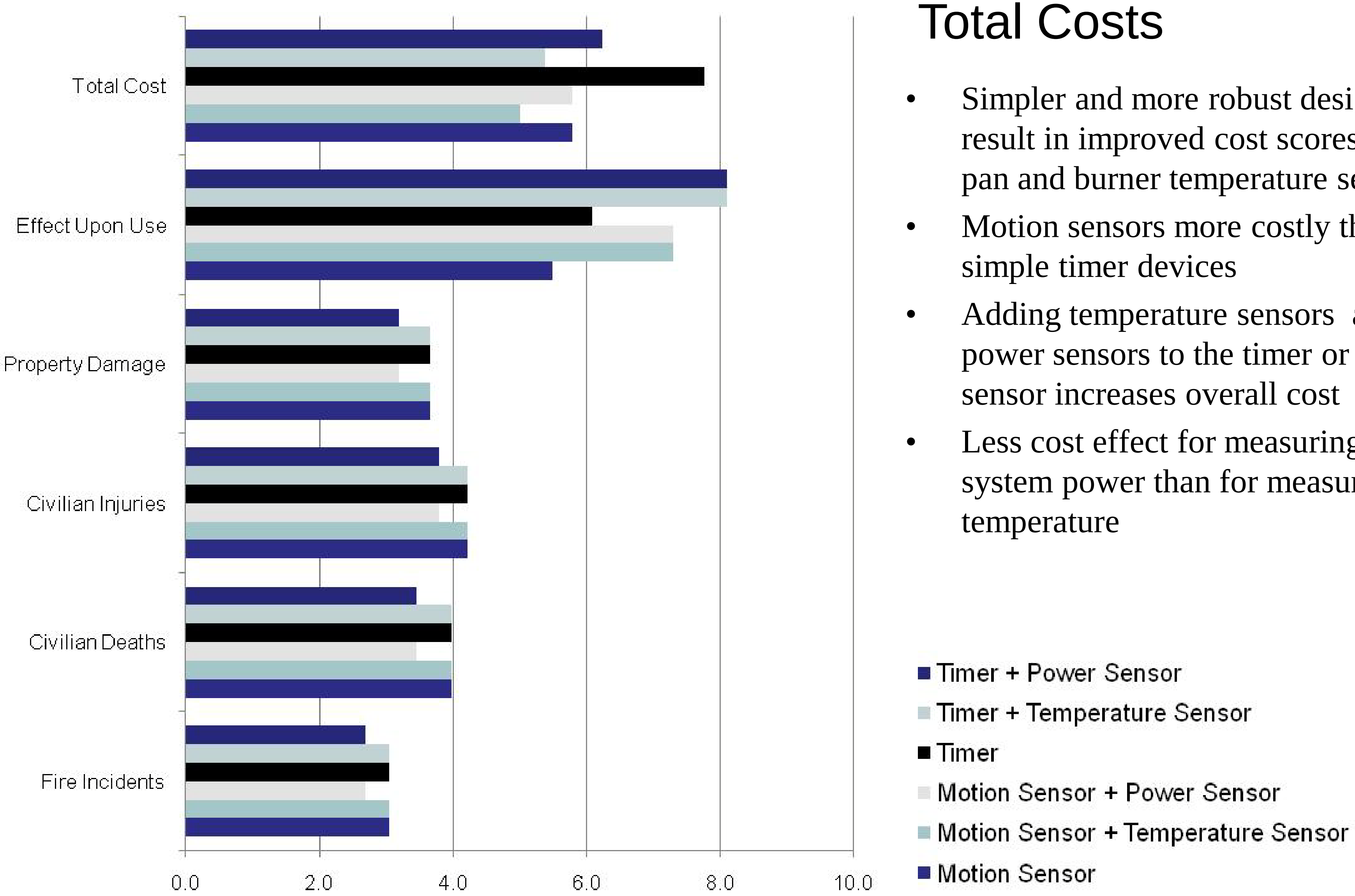
Mitigation Group 2-a: Detect Imminent Fire from Pre-ignition Conditions and Provide Warning

Fire Protection Effectiveness



- Smoke detector capable of addressing all range fire scenarios
  - Can not prevent the ignition of clothing, thus reducing the FPE for civilian deaths
- Burner surface temperature scores reduced from other pan temperatures by eliminating influence on gas ranges
  - Only slight decrease, electric range fires are more prevalent
- Over range temperature sensors capable of addressing more ignition scenarios than pan or burner sensors

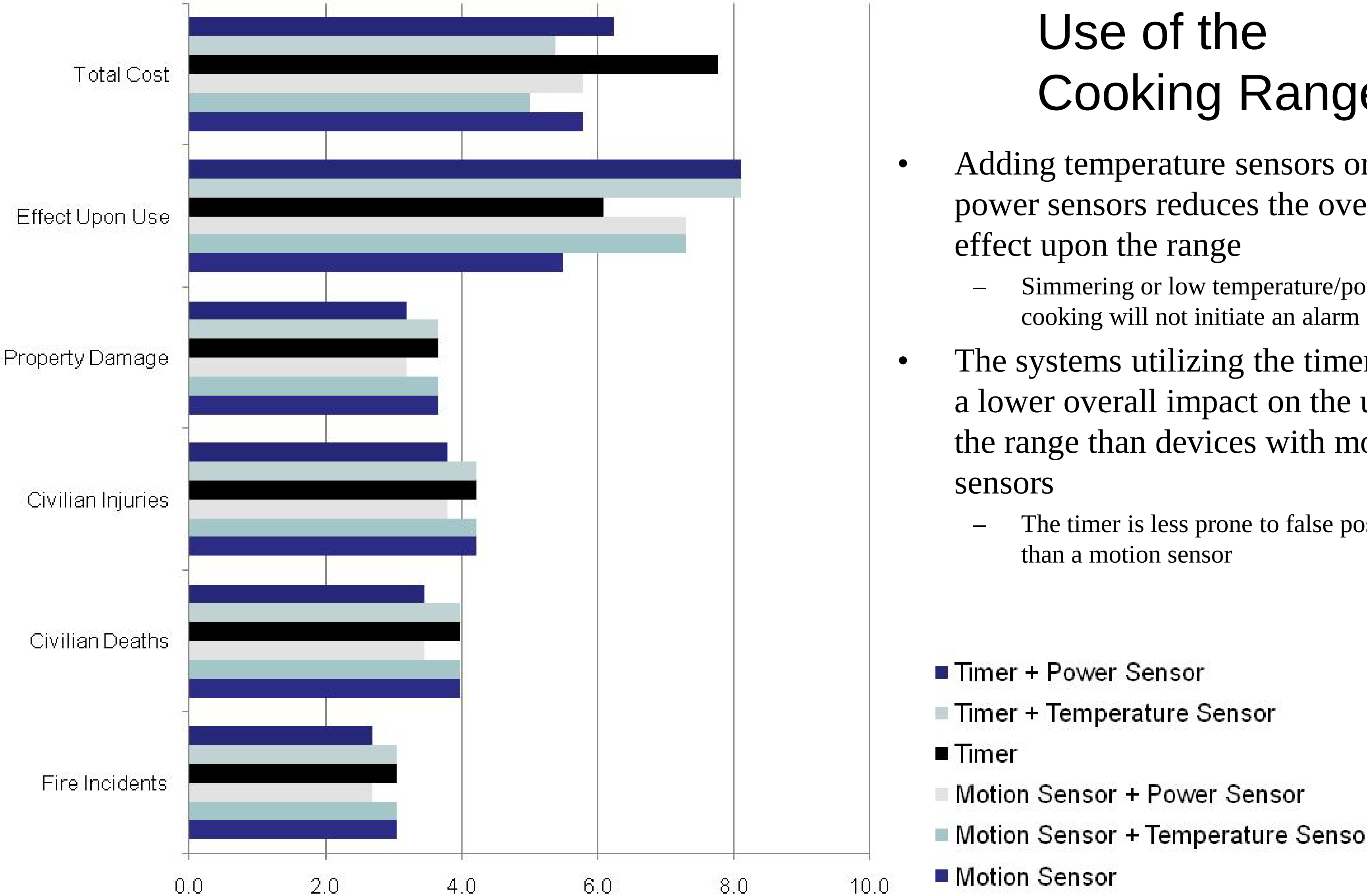
Mitigation Group 2-b: Detect Unattended Cooking and Provide Warning



Total Costs

- Simpler and more robust designs result in improved cost scores vs. pan and burner temperature sensors
- Motion sensors more costly than simple timer devices
- Adding temperature sensors and power sensors to the timer or motion sensor increases overall cost
- Less cost effect for measuring system power than for measuring temperature

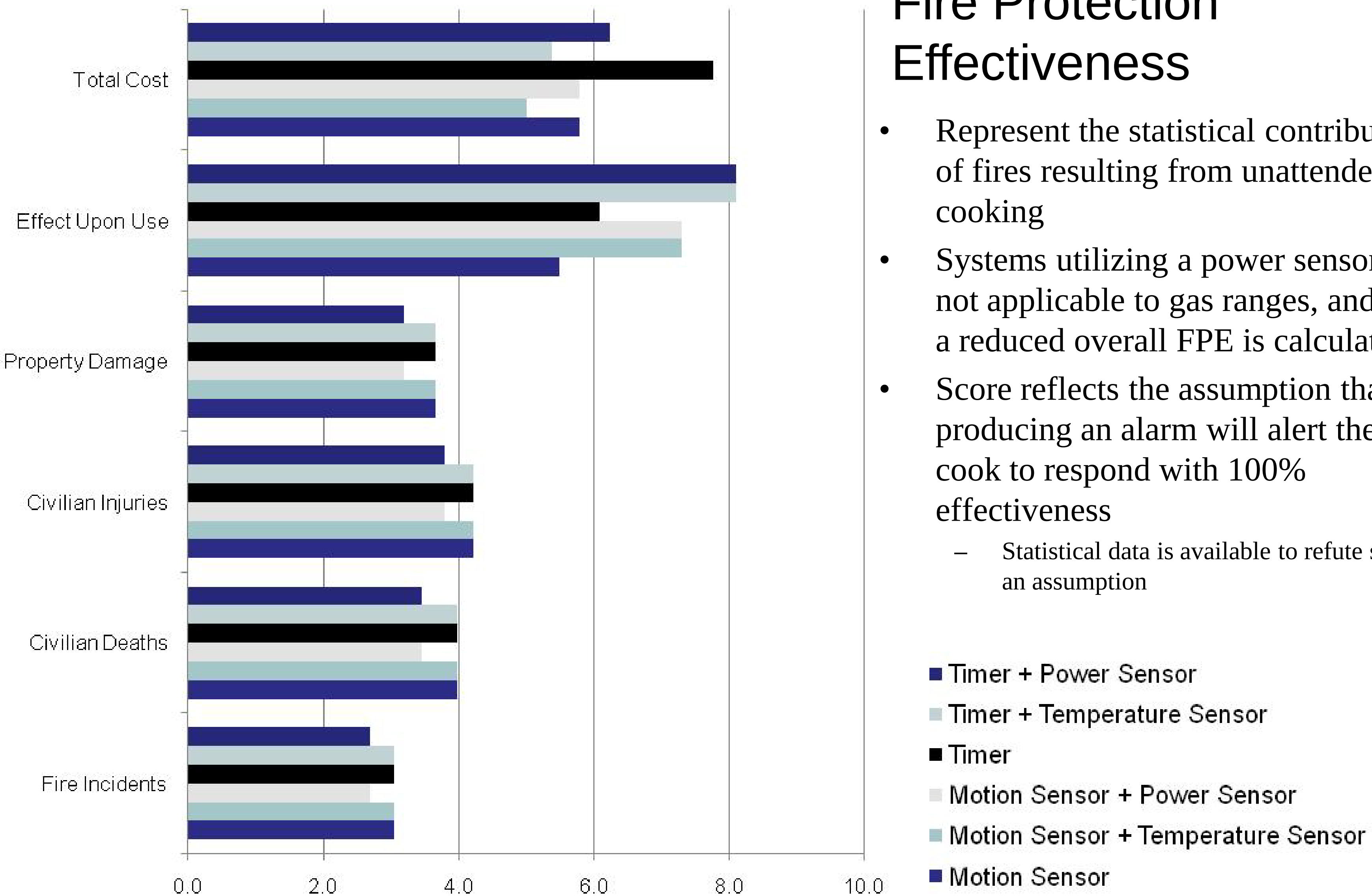
Mitigation Group 2-b: Detect Unattended Cooking and Provide Warning



Effect Upon the Use of the Cooking Range

- Adding temperature sensors or power sensors reduces the overall effect upon the range
  - Simmering or low temperature/power cooking will not initiate an alarm
- The systems utilizing the timer have a lower overall impact on the use of the range than devices with motion sensors
  - The timer is less prone to false positives than a motion sensor

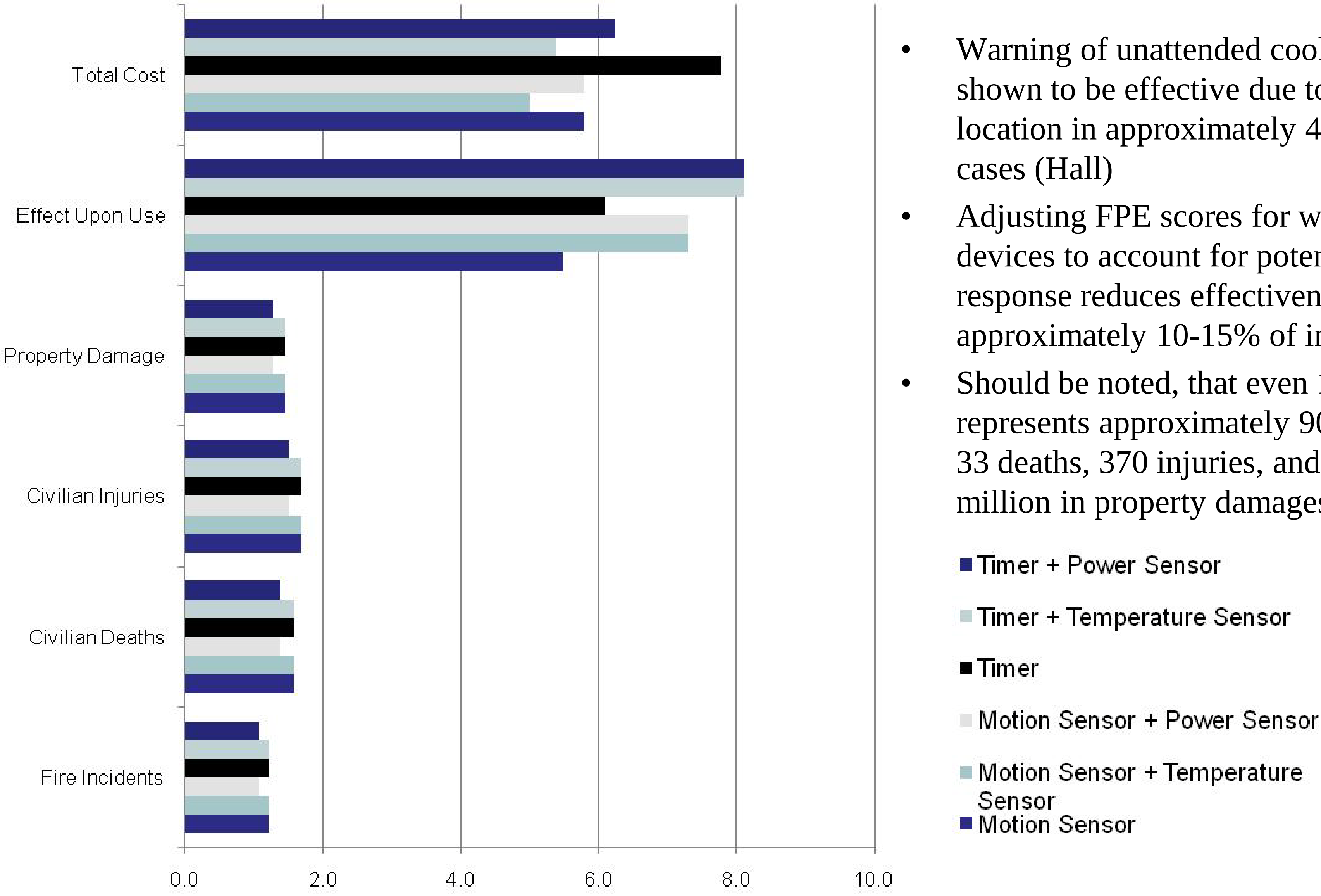
Mitigation Group 2-b: Detect Unattended Cooking and Provide Warning



Fire Protection Effectiveness

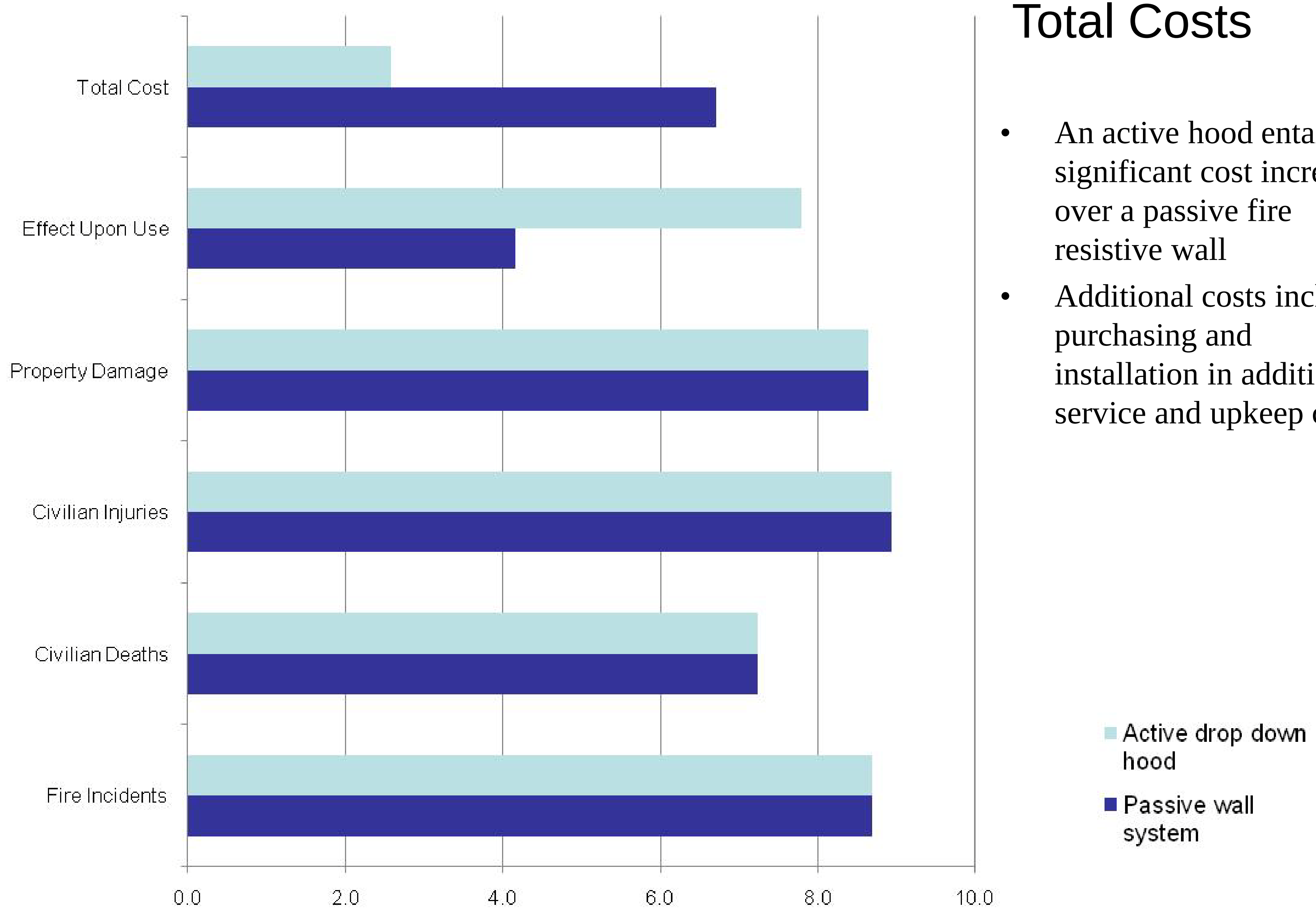
- Represent the statistical contribution of fires resulting from unattended cooking
- Systems utilizing a power sensor are not applicable to gas ranges, and thus a reduced overall FPE is calculated
- Score reflects the assumption that producing an alarm will alert the cook to respond with 100% effectiveness
  - Statistical data is available to refute such an assumption

Mitigation Group 2-b: Detect Unattended Cooking and Provide Warning – Adjusted for Cook Location



- Warning of unattended cooking shown to be effective due to cook location in approximately 40% of cases (Hall)
- Adjusting FPE scores for warning devices to account for potential response reduces effectiveness to approximately 10-15% of incidents
- Should be noted, that even 10% represents approximately 9000 fires, 33 deaths, 370 injuries, and $54 million in property damages

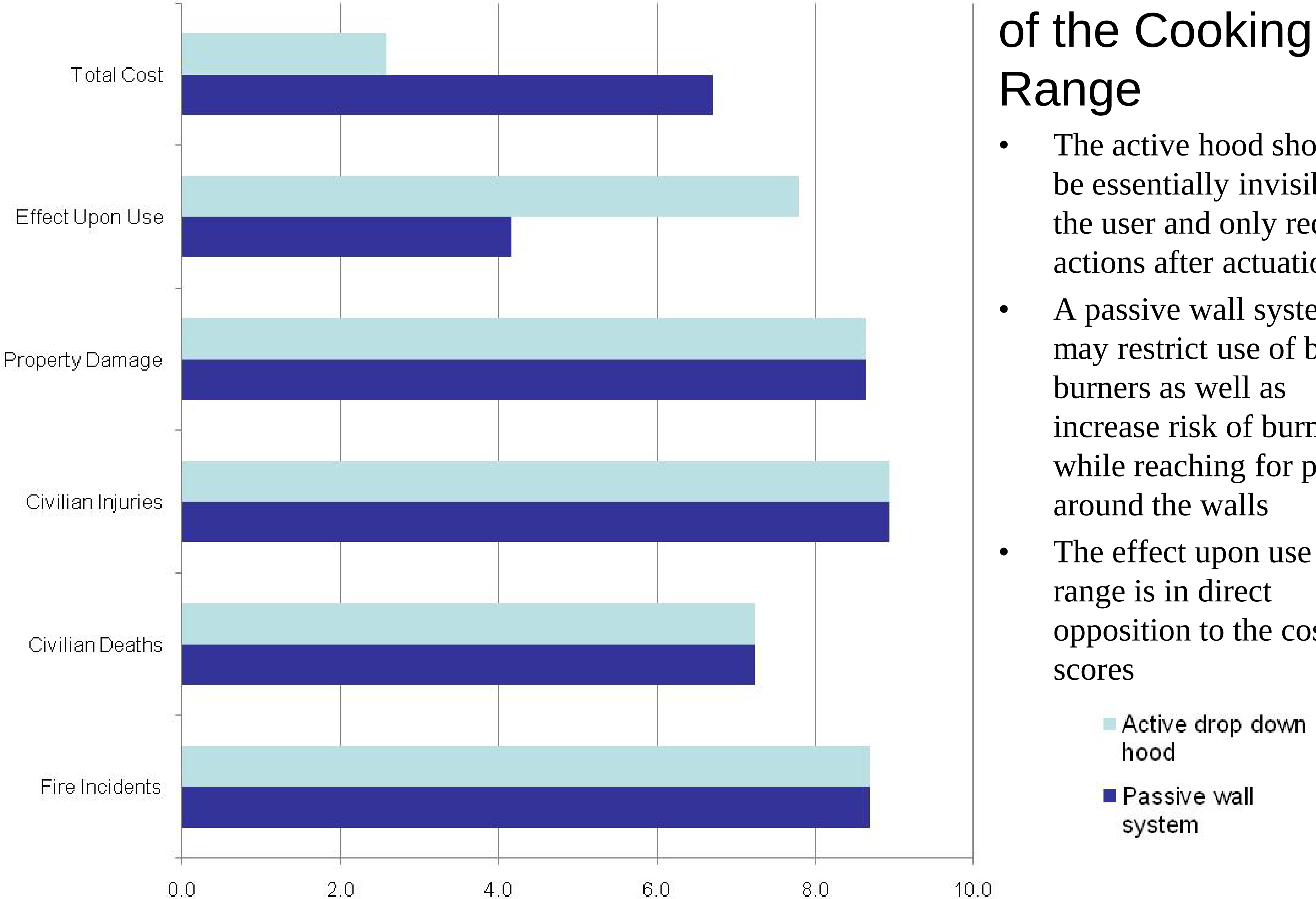
Mitigation Group 3: Contain Fire/Prevent Fire Spread



Total Costs

- An active hood entails significant cost increases over a passive fire resistive wall
- Additional costs include purchasing and installation in addition to service and upkeep costs

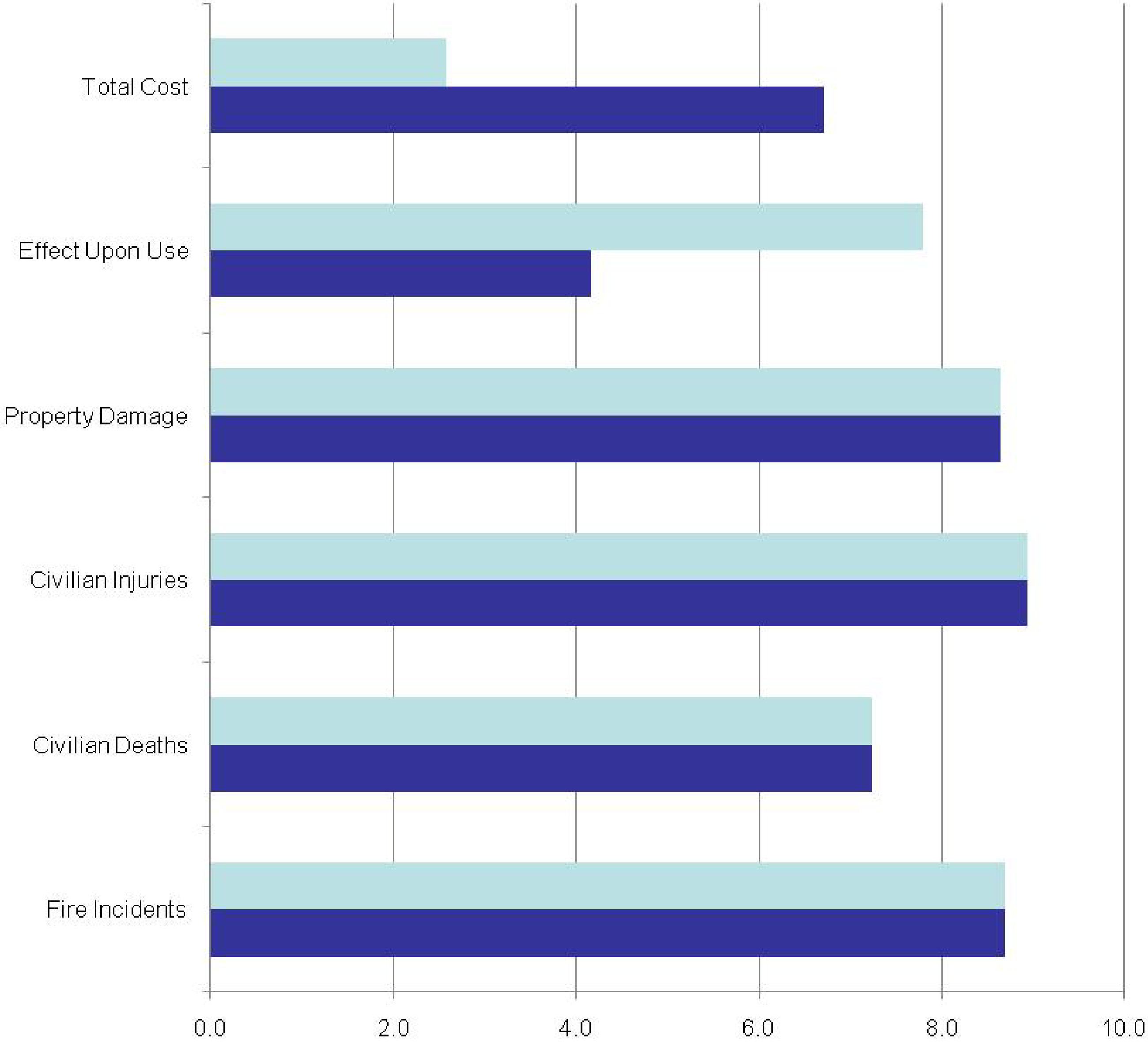
Mitigation Group 3: Contain Fire/Prevent Fire Spread



Effect Upon Use of the Cooking Range

- The active hood should be essentially invisible to the user and only require actions after actuation
- A passive wall system may restrict use of back burners as well as increase risk of burns while reaching for pans around the walls
- The effect upon use of the range is in direct opposition to the cost scores

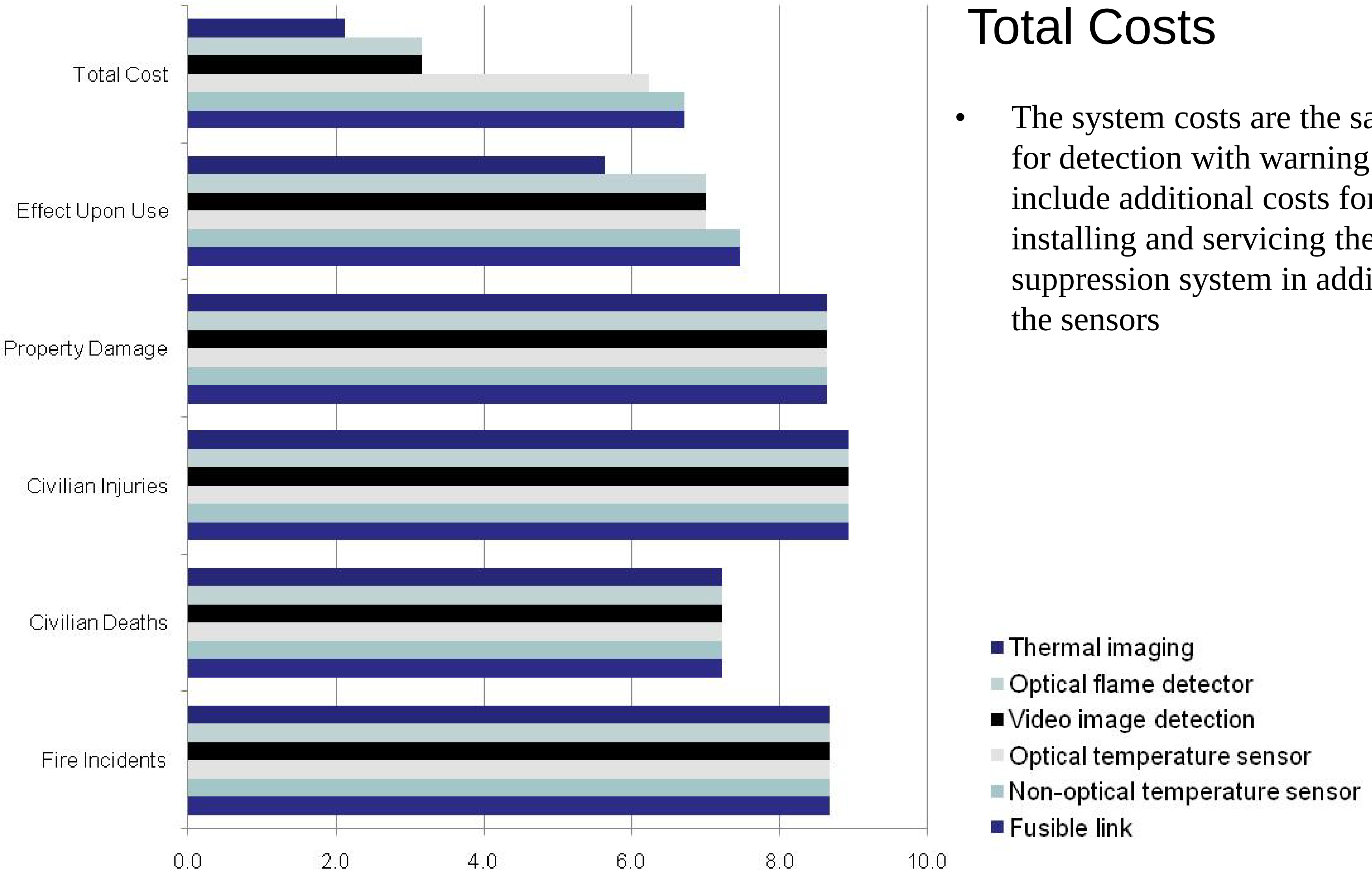
Mitigation Group 3: Contain Fire/Prevent Fire Spread



Fire Protection Effectiveness

- Both technologies would address the same fire scenarios and are thus given the same scores
- Reduced scores for civilian deaths are a result of failure to prevent clothing ignitions
- Numerous fire scenarios are addressed by containment to the range top (70-90% of fire losses)

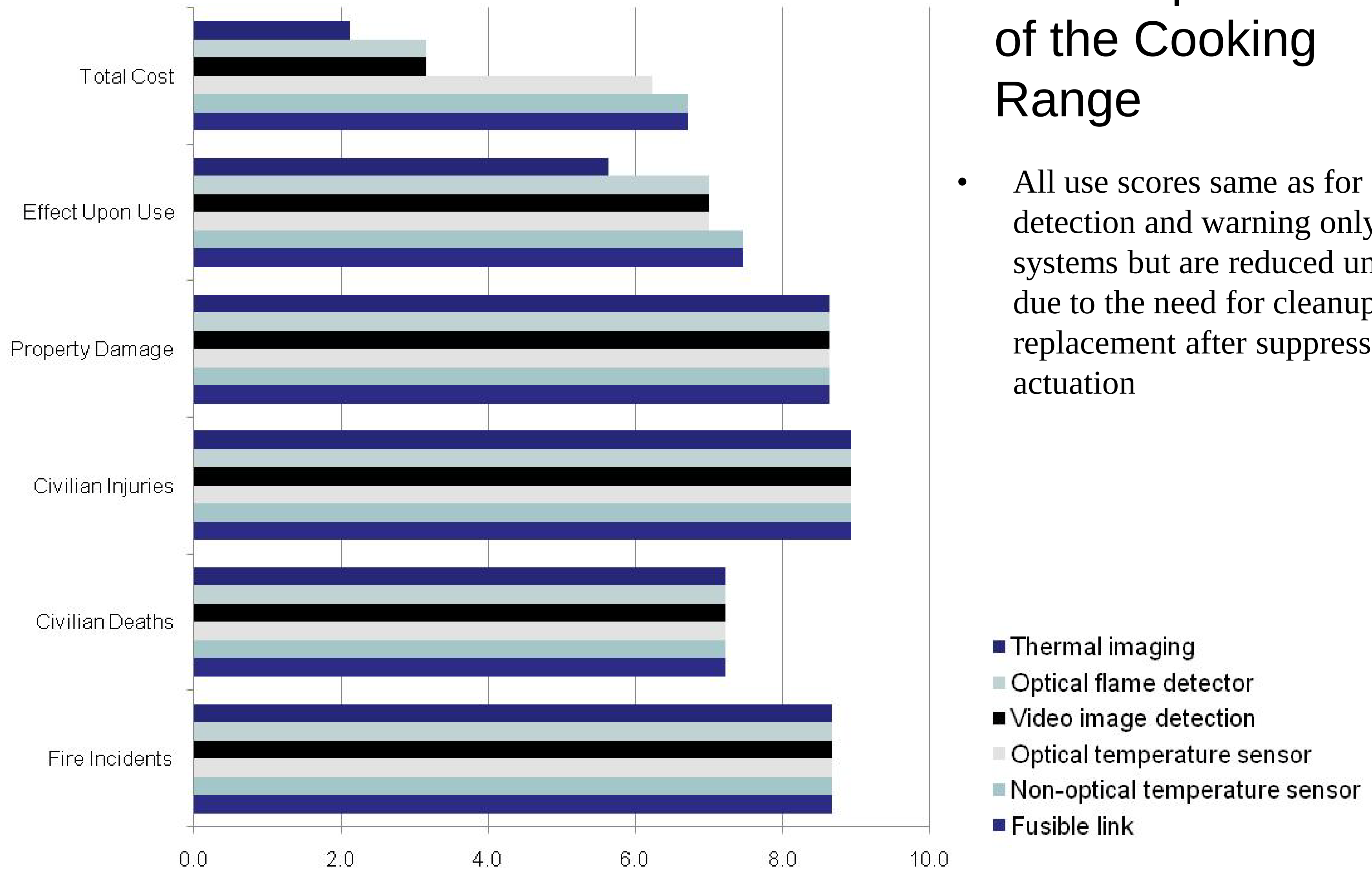
Mitigation Group 4: Detect Occurring Fire and Provide Automatic Suppression



Total Costs

- The system costs are the same as for detection with warning but include additional costs for installing and servicing the suppression system in addition to the sensors

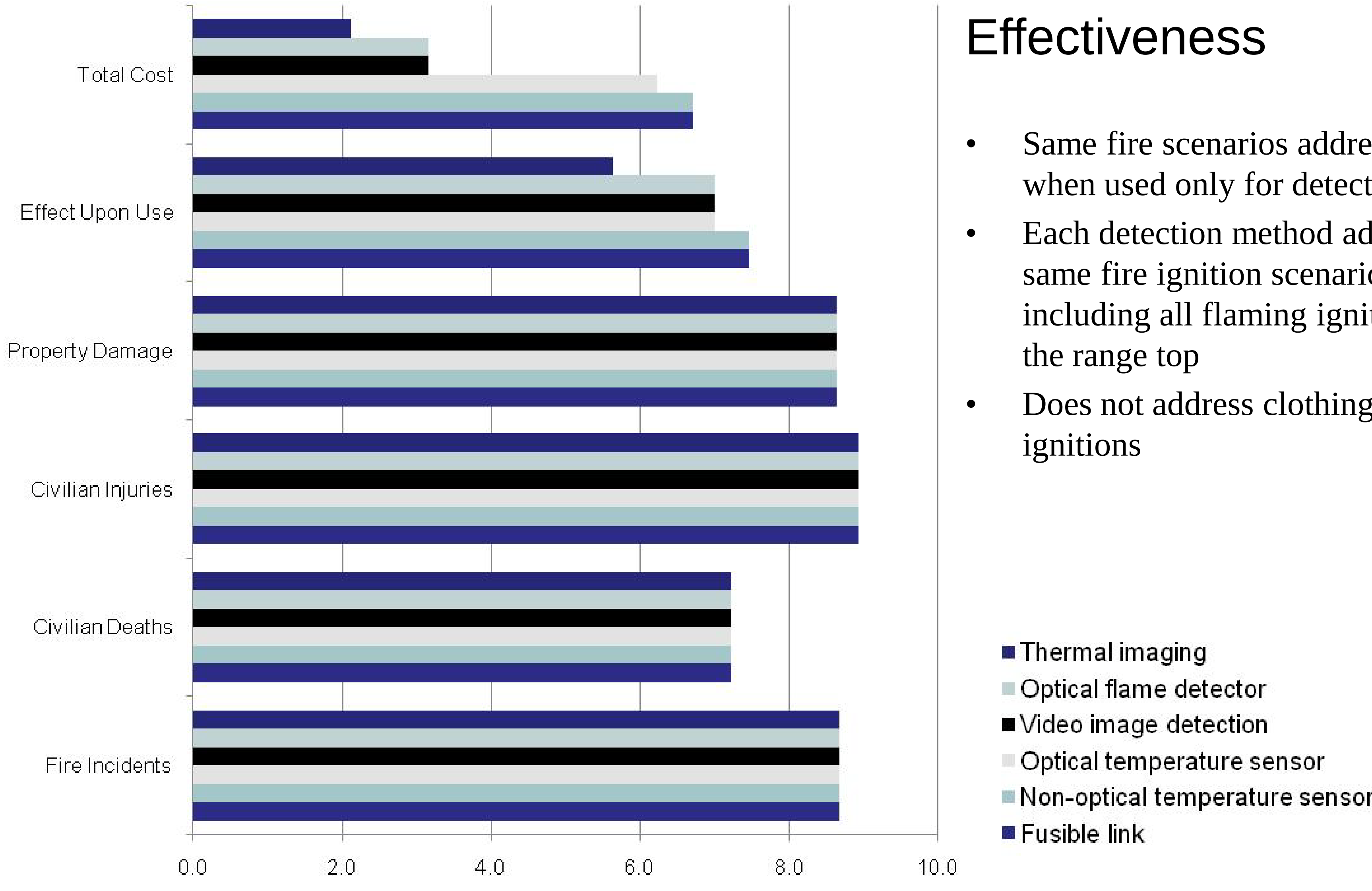
Mitigation Group 4: Detect Occurring Fire and Provide Automatic Suppression



Effect Upon Use of the Cooking Range

- All use scores same as for detection and warning only systems but are reduced uniformly due to the need for cleanup and replacement after suppression actuation

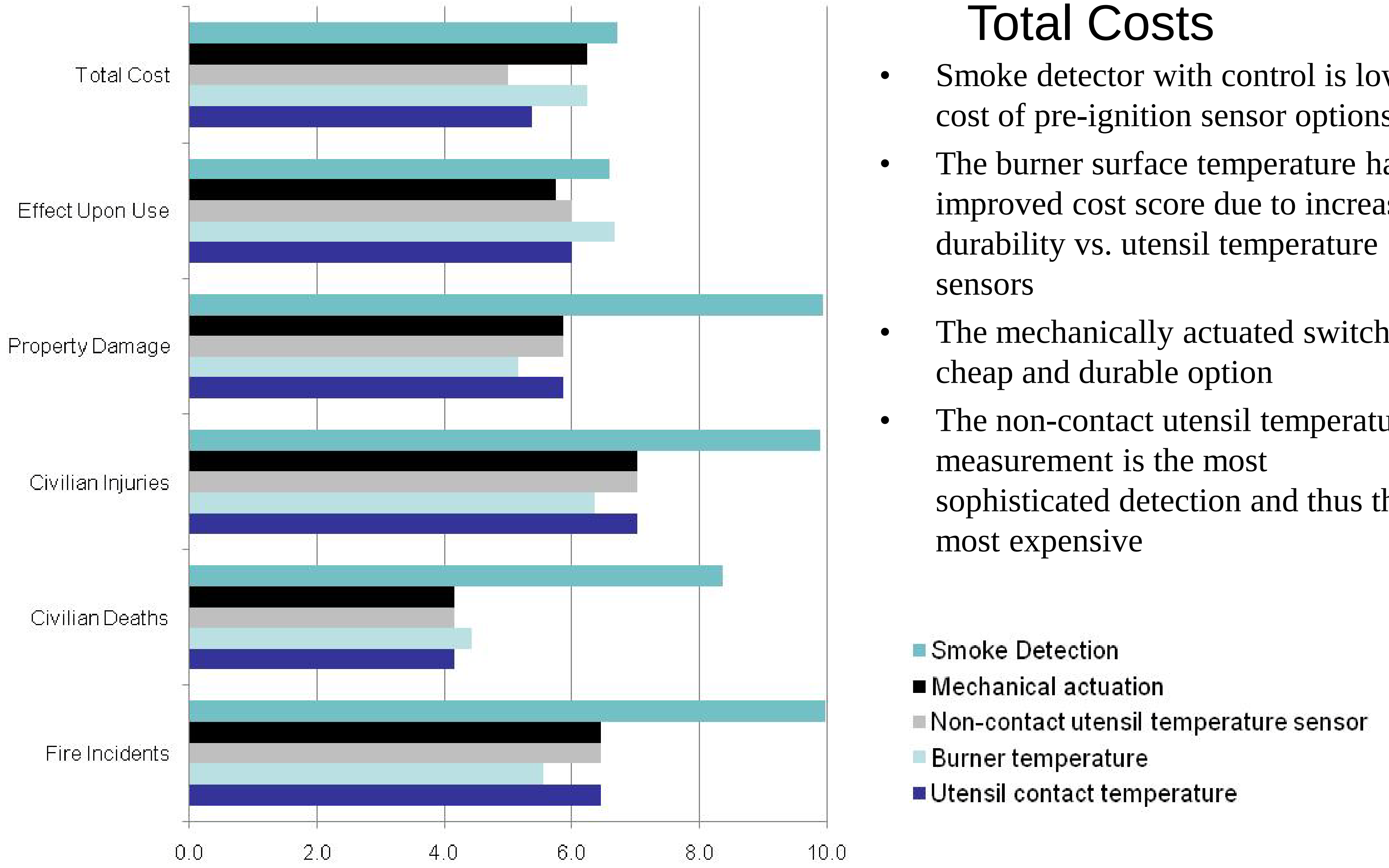
Mitigation Group 4: Detect Occurring Fire and Provide Automatic Suppression



Fire Protection Effectiveness

- Same fire scenarios addressed as when used only for detection
- Each detection method addresses same fire ignition scenarios, including all flaming ignitions on the range top
- Does not address clothing ignitions

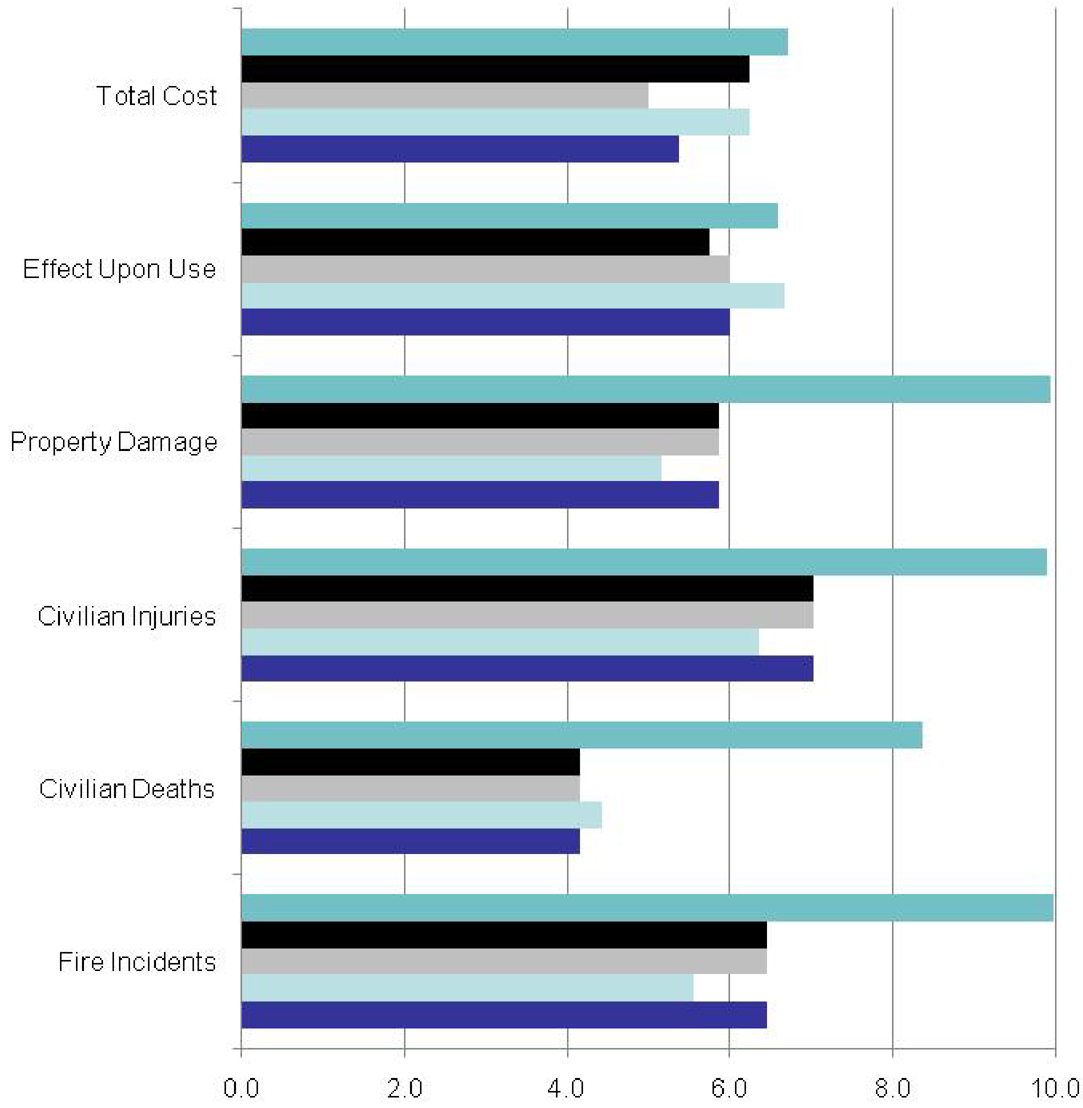
Mitigation Group 5-a: Detect Imminent Fire – Fixed Temp or Smoke Pre-ignition Conditions and Control Burner



Total Costs

- Smoke detector with control is lowest cost of pre-ignition sensor options
- The burner surface temperature has improved cost score due to increased durability vs. utensil temperature sensors
- The mechanically actuated switch is a cheap and durable option
- The non-contact utensil temperature measurement is the most sophisticated detection and thus the most expensive

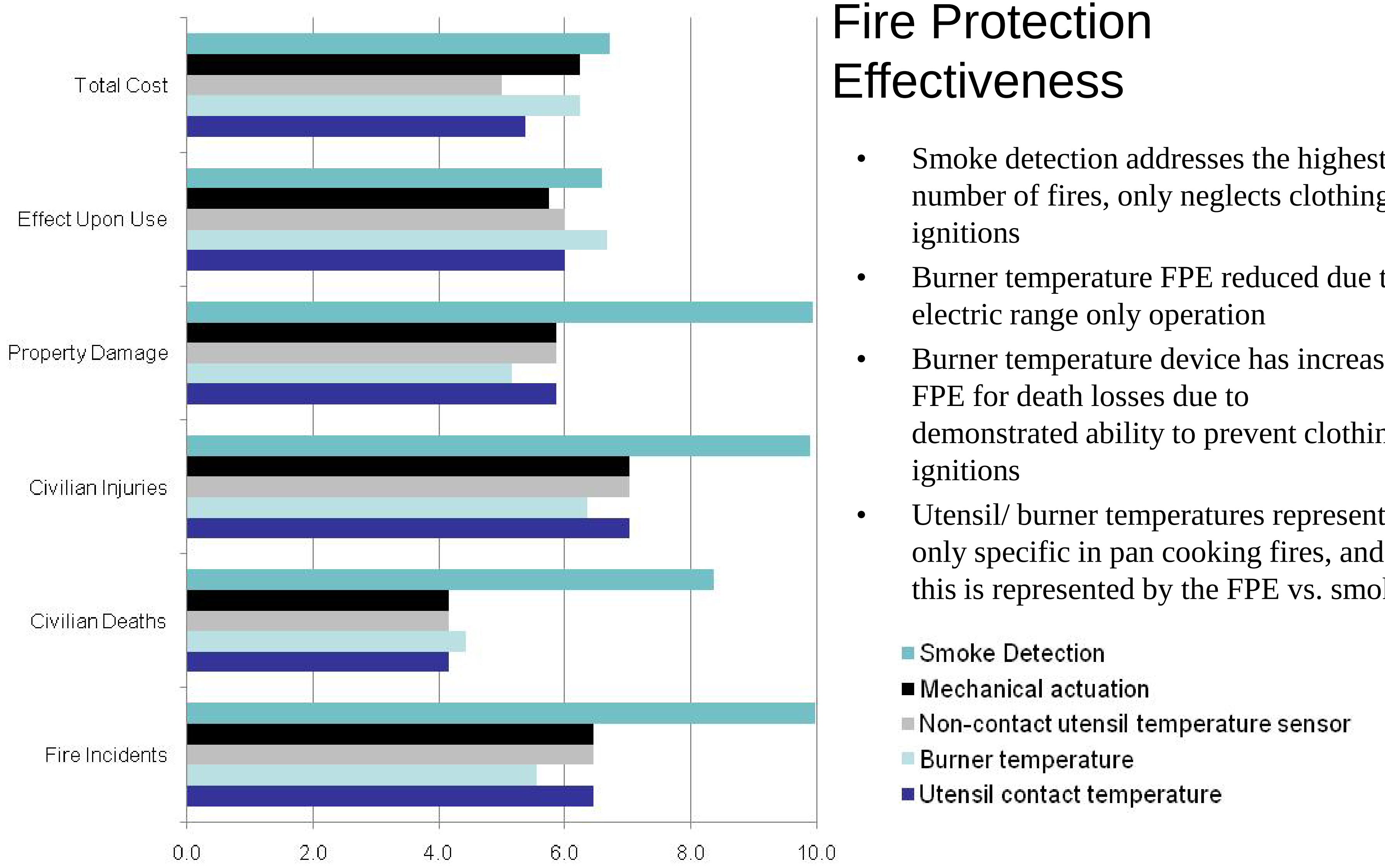
Mitigation Group 5-a: Detect Imminent Fire – Fixed Temp or Smoke Pre-ignition Conditions and Control Burner



Effect Upon Use of the Cooking Range

- Most devices are comparable in the effect upon the use of the cooking range
  - They all have some affect upon the ability to cook on the range by controlling the burners
- The smoke detection score reflects complete burner shutdown and its potential for nuisance alarms
- Also analyzed gradient control for boil over and user controlled temperature settings
  - Fixed temperature applicable to more fires than gradient
  - Fixed temperature produced less effect upon the use of the range than user controlled

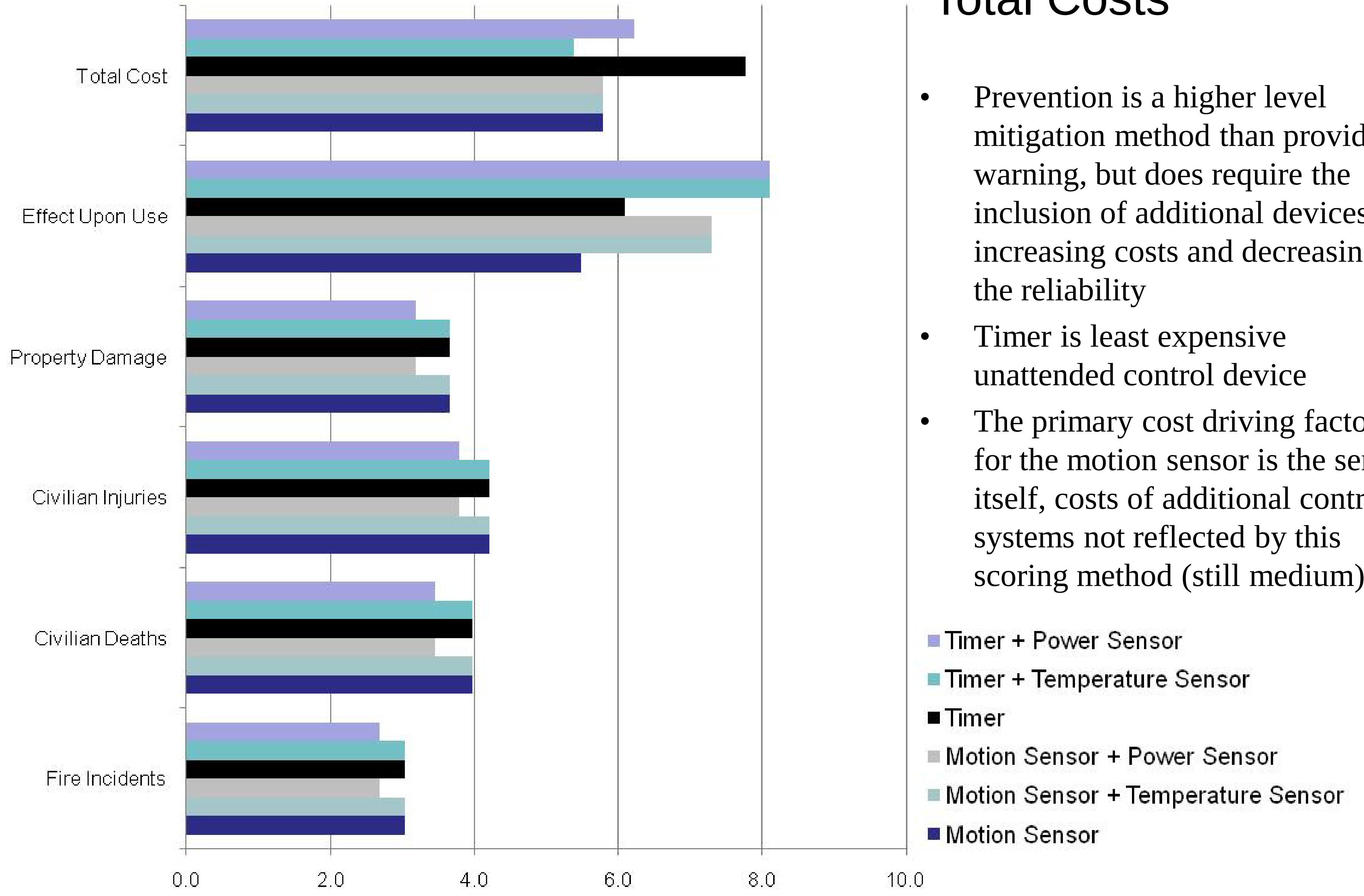
Mitigation Group 5-a: Detect Imminent Fire – Fixed Temp or Smoke Pre-ignition Conditions and Control Burner



Fire Protection Effectiveness

- Smoke detection addresses the highest number of fires, only neglects clothing ignitions
- Burner temperature FPE reduced due to electric range only operation
- Burner temperature device has increased FPE for death losses due to demonstrated ability to prevent clothing ignitions
- Utensil/ burner temperatures represent only specific in pan cooking fires, and this is represented by the FPE vs. smoke

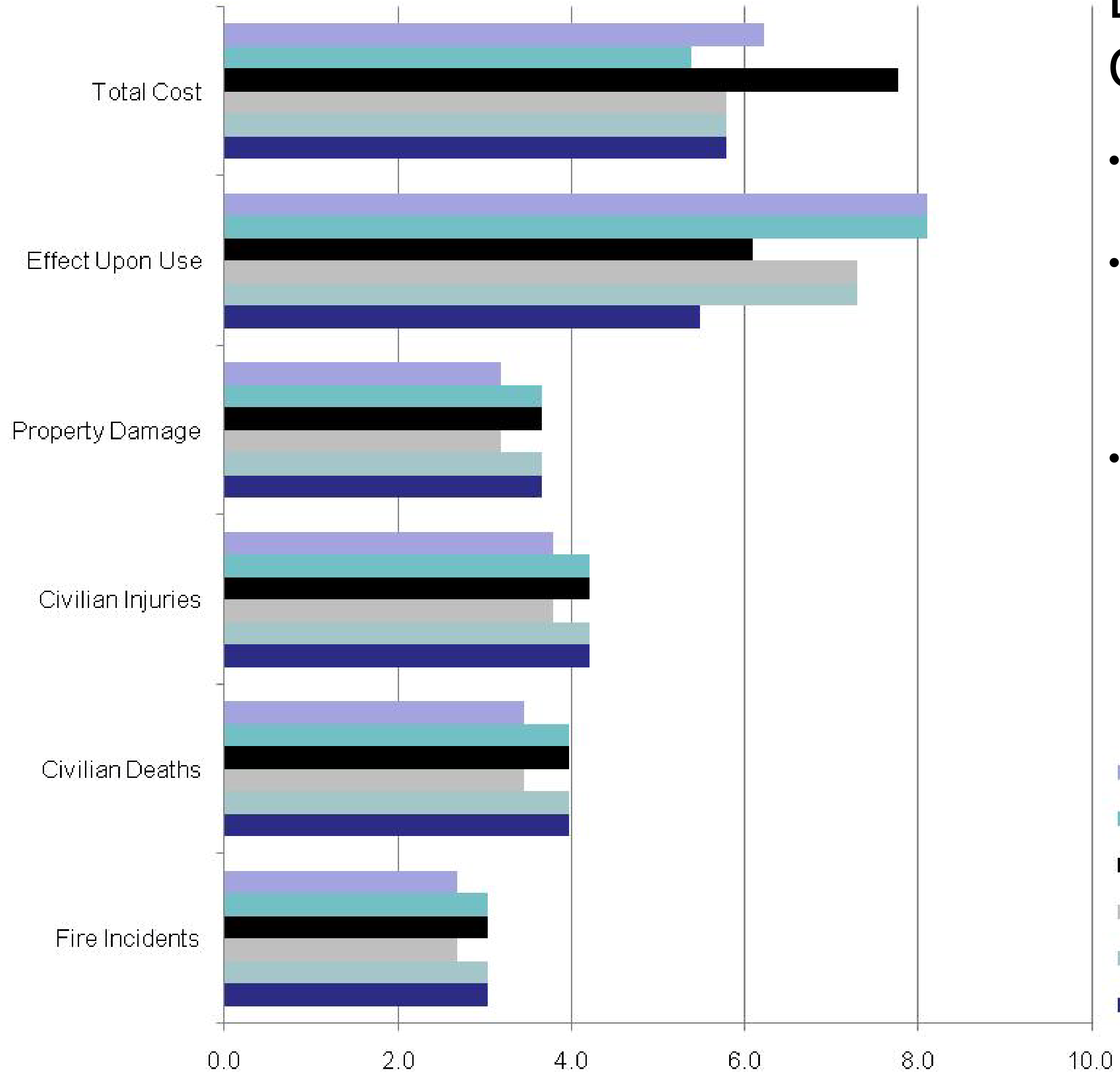
Mitigation Group 5-b: Detect Unattended Cooking with Control



Total Costs

- Prevention is a higher level mitigation method than providing warning, but does require the inclusion of additional devices, increasing costs and decreasing the reliability
- Timer is least expensive unattended control device
- The primary cost driving factor for the motion sensor is the sensor itself, costs of additional control systems not reflected by this scoring method (still medium)

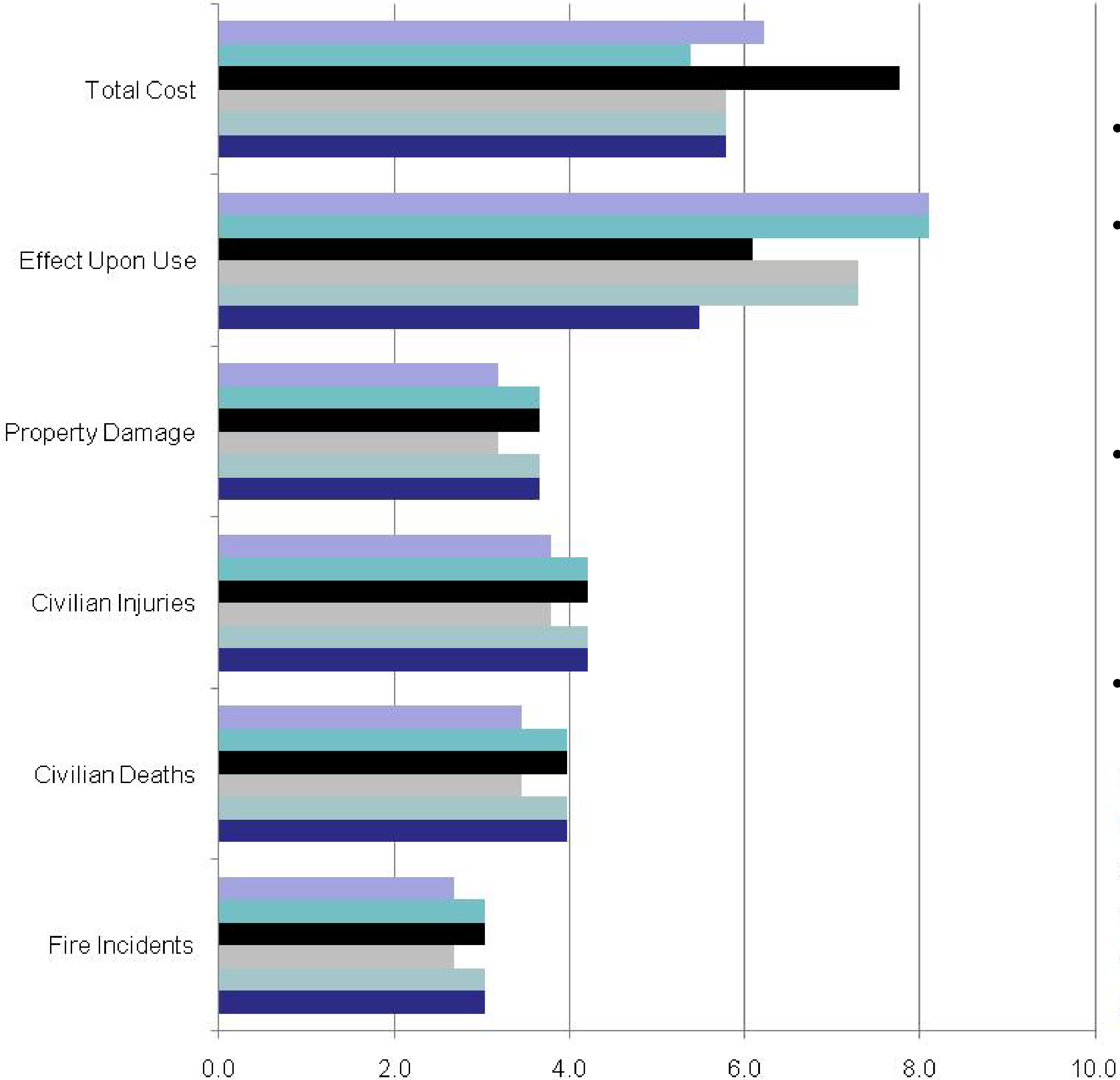
Mitigation Group 5-b: Detect Unattended Cooking with Control



Effect Upon Use of the Cooking Range

- User required to change cooking habits or range will not operate
- The addition of a high temperature of high power requirements reduces the impact of using the devices
- Timer has better use score due to less potential for false positives when compared to the motion sensor

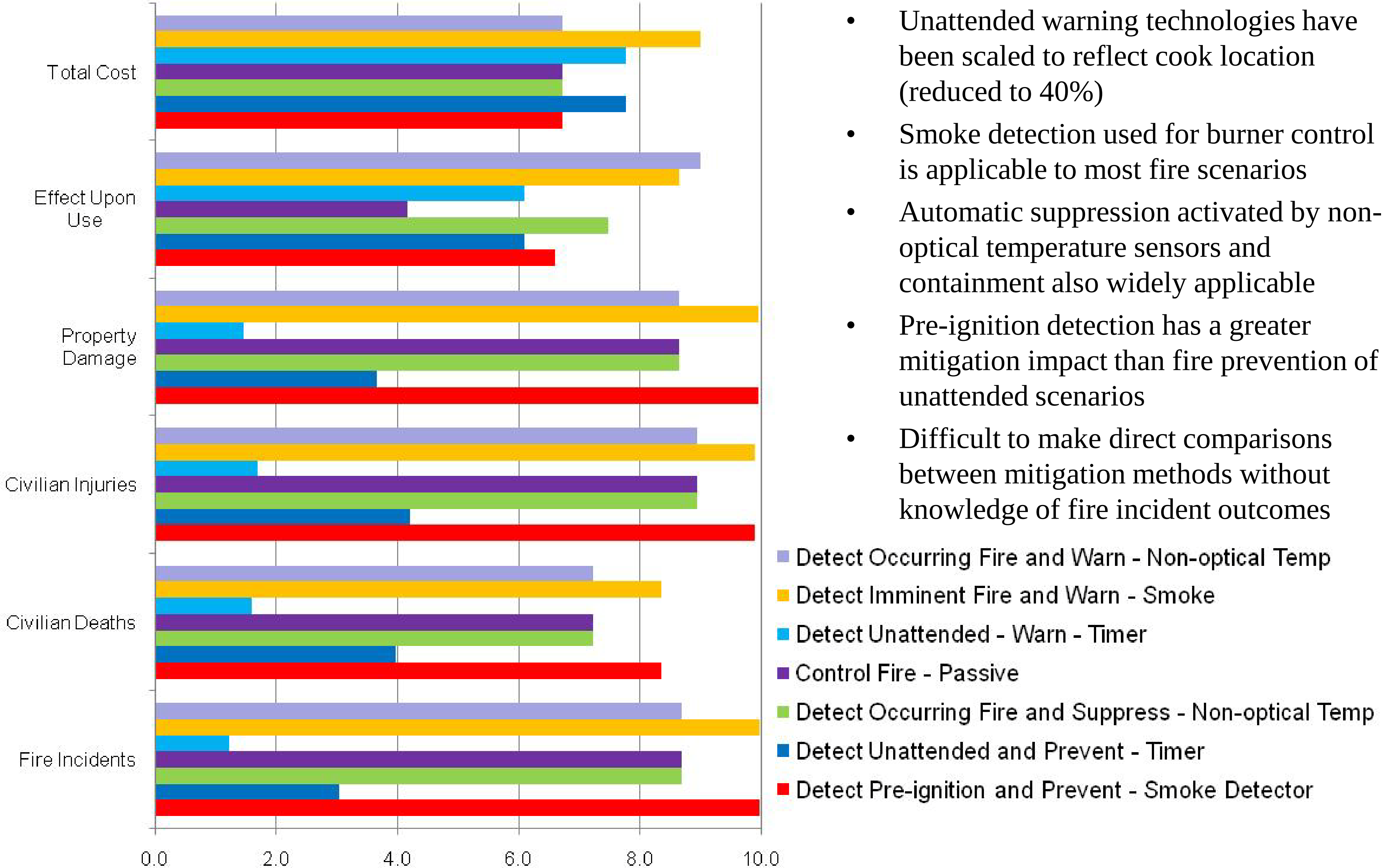
Mitigation Group 5-b: Detect Unattended Cooking with Control



Fire Protection Effectiveness

- Results same as unattended sensors used for warning
- By eliminating the warning and directly preventing ignition, the technologies become applicable to 30-40% of fire losses vs. 10-15% for warning only devices
- Unattended cooking fires represent lower number of addressed fires when compared to detection of pre-ignition conditions (30-40% vs. 40-100%)
- Devices with power sensors only applicable to electric ranges

Comparison in Scoring Between Various Mitigation Groups



- Unattended warning technologies have been scaled to reflect cook location (reduced to 40%)
- Smoke detection used for burner control is applicable to most fire scenarios
- Automatic suppression activated by non-optical temperature sensors and containment also widely applicable
- Pre-ignition detection has a greater mitigation impact than fire prevention of unattended scenarios
- Difficult to make direct comparisons between mitigation methods without knowledge of fire incident outcomes

Technologies Compared Between Groups

Technology			Mean Score	Overall Rank
Detect Occurring Fire and Provide Warning	Non-Optical Temperature Sensor		7.6	2
	Optical Temperature Sensor		7.2	4
Detect Imminent Fire and Provide Warning	Pre-ignition Conditions	Smoke Detector	8.7	1
		Non-optical Temperature Sensor	7.5	3
	Unattended Cooking	Timer	4.2	38
		Timer + Power Sensor	4.1	39
Control Fire/Prevent Fire Spread	Passive		5.9	11
	Active		5.3	28
Provide Automatic Suppression	Fusible Link		7.1	8
	Non-Optical Temperature Sensor		7.1	8
Prevent Fire	Pre-ignition Conditions	Smoke Detector	7.2	6
		Fixed Temperature Burner Temp	5.7	15
	Unattended Cooking	Timer	5.7	14
		Timer + Power Sensor	5.6	16

Mean score is the geometric mean of **(FPE_{DEATH}), Use, and Cost Scores**

Ranking of technologies as compared to all 44 evaluated technologies

Conclusions

- Smoke detection provides most universally applicable detection method
  - Smoke detection is still one of the most reliable and universally applicable methods of detecting pre-ignition conditions
  - Rate of nuisance alarms key difficulty in using smoke detection for prevention rather than warning
- Significant Fire Loss Reductions
  - Detect Fire and Provide Automatic Suppression
  - Control Fire/Prevent Fire Spread
- Warning systems are not as effective options as prevention technologies
  - Cook locations and activities
  - Products requiring less intervention and onus on consumers is preferred
  - Focus of product development should be in automatic fire prevention
- Prevention of clothing ignitions is a key factor for prevention of deaths in cooking fires (35% of fatalities only 0.5% of incidents)

Conclusions

- Technology Scoring Considerations
  - Scoring system is a snapshot of the current status of technologies
  - Product development status could significantly change scores
  - In some cases, a low score does not imply a technology does not have potential value, but rather that additional work is required to bring the technology to a marketable state
- Many prevention options are tailored to specific ignition scenarios and/or range types
  - Differentiating all these details not possible in assessment methodology
  - Niche options can be considered (only applicable to gas or electric, only for ranges with hoods, etc.)
  - Scoring could change dramatically if evaluated for niche applications (e.g. electric coil ranges)

Information Gaps and Future Work

- Implementation
  - How quickly could a product penetrate into existing homes? Retro-fit v. new install?
  - Marketing of existing products generally focused on infirmed and group homes, what steps to move to more universal acceptance?
  - Criteria constituting mandating use of technologies? Cost benefit analysis?
- What aspects of ranking constitute real value?
  - Scoring not intended to eliminate technologies from future consideration
  - Statistical data needed to fully differentiate warning vs. control technologies (e.g. impairments, response of occupants, etc.).
- International work driving product development
  - Most existing cooking fire mitigation products are international
  - Introduction of actual products lagging in U.S. markets, still most work in theoretical stages or niche markets
  - Scientific evaluations have shown numerous viable solutions
- Potential product reliability and durability still unclear in most cases, especially for technologies existing in concept only
- Assigning numeric values to expected costs rather than rough low, medium, high assignments could give more accurate picture


Questions?

Home Stovetop Fires: Specifying Scenarios for Use in Evaluation Method

John R. Hall, Jr., Ph.D.
National Fire Protection Association
November 2010

Restating the assignment

- Assignment: Develop a fire scenario structure with quantification, showing the number (or share) of fires and losses per year associated with each selected scenario.
- For any fire prevention or mitigation technology or strategy, this will provide a comprehensive set of fire challenges.
- Each technology or strategy will need to be evaluated for its expected percent reduction in fires and losses for each identified strategy.

Restating the assignment (continued)

- One step is to separate stovetop fires from other reported range fires.
- A second step is to separate stovetop fires beginning during cooking activities from other stovetop fires.
- A third step is to separate stovetop fires associated with cooking activities where the cook is absent (unattended cooking) from stovetop cooking-activity fires with cook present.

Restating the assignment (continued)

- A technology that detects overheated food might prevent stovetop cooking fires but not other stovetop fires

- A technology that detects overheated heating elements might prevent all stovetop fires

- A technology that detects presence or absence of cooks might prevent all unattended cooking fires but not other stovetop fires

Restating the assignment (continued)

- An educational program might lower the likelihood of unattended cooking and so lower the likelihood of unattended cooking fires
- And so on.

Approach taken to the assignment

- First, we see what scenario structures are possible that are also consistent with the coding of fires reported to the NFIRS system.
- Then, we see what special databases may exist that can be used to convert an NFIRS-based scenario structure to a scenario structure useful for the assignment.

What can you get from NFIRS?

- You cannot isolate fires on the stovetop.
- You can only isolate fires in, on, or around the range
- Special databases will be needed to separate the stovetop fires from the other range fires.

What can you get from NFIRS?

- You cannot isolate fires beginning during cooking activities.
- You can identify fires by Factor Contributing to Ignition and by Item First Ignited
- Some of the codes for Item First Ignited make the connection to cooking clear (e.g., cooking materials). Others do not (e.g., flammable or combustible liquid with properties that could mean cooking oil or something else).

NFIRS-based categories

- Factor Contributing to Ignition can be reported with multiple factors identified.
- These categories are based on a hierarchical sorting.
- That means that each fire in Category X had no reported characteristics that would have assigned it to a Category numbered lower than X (e.g., Category 3 fires have no fires that would have qualified for Category 1A, 1B, or 2).

NFIRS-based categories (continued)

- Category 1A: Unattended (Factor Contributing) and Cooking materials (Item First Ignited)
- Category 1B: Not Unattended (Factor Contributing) and Cooking materials (Item First Ignited)
- Category 2: Unattended (Factor Contributing) and Not cooking materials (Item First Ignited)

NFIRS-based categories (continued)

- Category 3: Mechanical or electrical failure or malfunction; or design, manufacturing or installation deficiency (Factor Contributing)
- Category 4: Various behavioral errors possibly related to kitchen activity (Factor Contributing), such as heat source too close to combustible, which could refer to spilled food or an abandoned dishcloth too close to a burner.

NFIRS-based categories (continued)

- Category 5: Various behavioral errors clearly not related to kitchen activity (Factor Contributing), such as cutting or welding too close to combustibles.
- Category 6: Unknown, unclassified or none (Factor Contributing)

Groups we would like to have

- We would like to link fires more closely to the stovetop and to cooking activities
- Group 1: Fire beginning in food in a cooking vessel on a burner
- Group 2: Fire beginning on stovetop during cooking activities but not food in a cooking vessel on a burner
- Group 3: Fire beginning on stovetop but not during cooking activities

Groups we would like to have

- Group 4: Fire beginning in the oven part of the range and not on the stovetop
- Group 5: Fire beginning in or on or beside the range but not on the stovetop or in the oven

One more key limitation of the method we used

- We had enough data to set up mapping factors to indicate what fraction of Category X fires were estimated to belong to Group Y, where X goes from 1A to 6 (7 categories) and Y goes from 1 to 5 (5 groups).
- We did not have enough data to set up separate mapping factors for deaths, injuries, or property damage, or to set up separate mapping factors for gas vs. electric ranges (let alone more specific different types of ranges).

Mapping factors for Categories 1A and 1B

	Group 1: Fire begins in a cooking vessel on a burner	Group 2: Fire begins on stovetop during cooking activities but not in a cooking vessel on a burner	Group 3: Fire begins on stovetop but not during cooking activities	Group 4: Fire begins in oven	Group 5: Fire begins in or on range but not on stovetop or in oven
Category 1A (cooking materials and unattended; item first ignited = 76; factor contributing to ignition = 53)	1.000	0.000	0.000	0.000	0.000
Category 1B (cooking materials and not unattended; item first ignited = 76; factor contributing to ignition ≠ 53)	0.806	0.097	0.000	0.065	0.032

Mapping factors for Categories 2, 3 and 4

	Group 1: Fire begins in a cooking vessel on a burner	Group 2: Fire begins on stovetop during cooking activities but not in a cooking vessel on a burner	Group 3: Fire begins on stovetop but not during cooking activities	Group 4: Fire begins in oven	Group 5: Fire begins in or on range but not on stovetop or in oven
Category 2 (unattended but not cooking materials: item first ignited ≠ 76; factor contributing to ignition = 53)	0.400	0.200	0.200	0.200	0.000
Category 3 (mechanical or electrical failure or malfunction or design, manufacturing, or installation error and not cooking materials: item first ignited ≠ 76; factor contributing to ignition ≠ 53; factor contributing to ignition 20-44)	0.000	0.055	0.111	0.111	0.722
Category 4 (not cooking materials and behavioral errors: item first ignited ≠ 76; factor contributing to ignition ≠ 20-44, 53; factor contributing to ignition 10-12,14,17, 19,51-52,54-58)	0.000	0.000	0.794	0.147	0.059

Mapping factors for Categories 5 and 6

	Group 1: Fire begins in a cooking vessel on a burner	Group 2: Fire begins on stovetop during cooking activities but not in a cooking vessel on a burner	Group 3: Fire begins on stovetop but not during cooking activities	Group 4: Fire begins in oven	Group 5: Fire begins in or on range but not on stovetop or in oven
Category 5 (not cooking materials and factors not related to cooking behaviors: item first ignited ≠ 76; factor contributing to ignition ≠ 10-12,14,17,19,20-58; factor contributing to ignition 13,15-16,18,60-75)	0.000	0.000	0.000	0.000	1.000
Category 6 (not cooking materials and unclassified or unknown factors: item first ignited ≠ 76; factor contributing to ignition ≠ 01-99; factor contributing to ignition 00,NN,UU, blank)	0.000	0.259	0.646	0.095	0.000

Range fires, 2005-09 average, by type of fuel or power

Type of Fuel or Power	Fires	Civilian Deaths	Civilian Injuries	Direct Property Damage (in Millions)
Gas	15,200	84	500	$86
Electric	74,640	247	3,187	$461
Other	280	0	10	$1
Total	90,120	330	3,697	$548

Gas range fires, 2005-09 average, by Category

Type of Fuel or Power	Fires	Civilian Deaths	Civilian Injuries	Direct Property Damage (in Millions)
Category 1A	2,730 (17.9%)	22 (26.8%)	127 (25.5%)	$17 (19.9%)
Category 1B	6,370 (41.9%)	3 (4.0%)	160 (32.1%)	$24 (27.5%)
Category 2	520 (3.4%)	3 (4.0%)	34 (6.8%)	$8 (9.3%)
Category 3	1,300 (8.6%)	3 (4.0%)	31 (6.2%)	$6 (7.1%)
Category 4	2,470 (16.3%)	27 (31.7%)	86 (17.1%)	$16 (18.4%)
Category 5	350 (2.3%)	0 (0.0%)	10 (2.0%)	$1 (1.0%)
Category 6	1,460 (9.6%)	25 (29.5%)	51 (10.2%)	$14 (16.7%)
Total	15,200 (100.0%)	84 (100.0%)	500 (100.0%)	$86 (100.0%)

Electric range fires, 2005-09 average, by Category

Type of Fuel or Power	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Category 1A	21,050	(28.2%)	96	(38.9%)	1,221	(38.3%)	$135	(29.2%)
Category 1B	34,490	(46.2%)	31	(12.7%)	1,303	(40.9%)	$163	(35.4%)
Category 2	3,110	(4.2%)	32	(12.9%)	185	(5.8%)	$41	(8.9%)
Category 3	2,700	(3.6%)	12	(5.1%)	42	(1.3%)	$16	(3.5%)
Category 4	6,910	(9.3%)	54	(22.0%)	277	(8.7%)	$64	(13.8%)
Category 5	570	(0.8%)	0	(0.0%)	8	(0.3%)	$3	(0.6%)
Category 6	5,820	(7.8%)	21	(8.5%)	149	(4.7%)	$39	(8.5%)
Total	74,640	(100.0%)	247	(100.0%)	3,187	(100.0%)	$461	(100.0%)

Gas range fires, 2005-09 average, by Group

Group	Fires	Civilian Deaths	Civilian Injuries	Direct Property Damage (in Millions)
Group 1. Fire begins in a cooking vessel on a burner	8,070 (53.1%)	26 (31.6%)	270 (54.1%)	$39 (45.8%)
Group 2. Fire begins on stovetop during cooking activities but not in a cooking vessel on a burner	1,170 (7.7%)	8 (9.1%)	37 (7.5%)	$8 (9.2%)
Group 3. Fire begins on stovetop but not during cooking activities	3,150 (20.8%)	38 (45.5%)	111 (22.2%)	$24 (28.1%)
Group 4. Fire begins in oven	1,160 (7.7%)	7 (9.0%)	38 (7.6%)	$8 (8.7%)
Group 5. Fire begins in or on but not on stovetop or in oven	1,640 (10.8%)	4 (4.9%)	43 (8.6%)	$7 (8.1%)
Total	15,200 (100.0%)	84 (100.0%)	500 (100.0%)	$86 (100.0%)

Electric range fires, 2005-09 average, by Group

Group	Fires	Civilian Deaths	Civilian Injuries	Direct Property Damage (in Millions)
Group 1. Fire begins in a cooking vessel on a burner	50,090 (67.1%)	134 (54.3%)	2,345 (73.6%)	$282 (61.3%)
Group 2. Fire begins on stovetop during cooking activities but not in a cooking vessel on a burner	5,630 (7.5%)	16 (6.3%)	205 (6.4%)	$35 (7.6%)
Group 3. Fire begins on stovetop but not during cooking activities	10,160 (13.6%)	64 (26.0%)	359 (11.3%)	$86 (18.7%)
Group 4. Fire begins in oven	4,730 (6.3%)	20 (8.0%)	181 (5.7%)	$34 (7.3%)
Group 5. Fire begins in or on but not on stovetop or in oven	4,030 (5.4%)	13 (5.4%)	97 (3.0%)	$24 (5.1%)
Total	74,640 (100.0%)	247 (100.0%)	3,187 (100.0%)	$461 (100.0%)

Other analyses done & useful in elaborations of method

- We developed statistics by Group for civilian fire deaths due to ignitions of clothing on a person.
- They accounted for one-third of deaths for gas ranges and about one-tenth of deaths for electric ranges.
- Some technologies that can prevent ignition of food may not prevent ignition of fabric, and clothing ignitions are a major category of non-food fatal ignitions.

Other analyses done & useful in elaborations of method

- We developed statistics on where the absent cooks were and what they were doing.
- Using all databases combined, weighting each study equally but not each case equally, we get 32% of cooks outside building, 28% inside building but distracted or asleep, and 40% inside building and not distracted or asleep.
- This could be useful in estimating audibility and alerting effectiveness of an alarm triggered by a sensor detecting absence of cook.

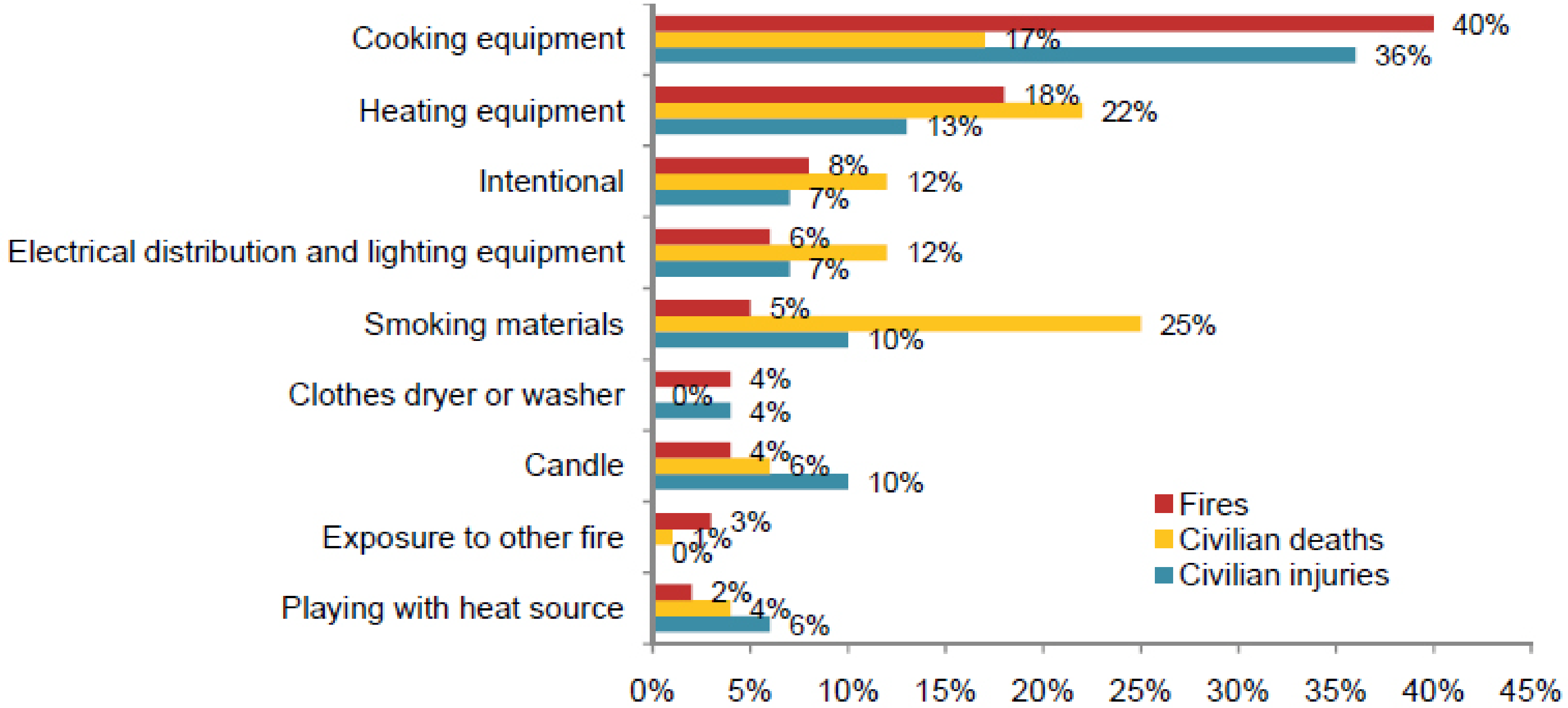
Other analyses done & useful in elaborations of method

- We referenced statistics developed elsewhere on cooking time prior to ignition, by type of cooking.
- For example, ignition took place in 14 minutes or less for 83% of frying fires but only 6% of boiling fires.
- This could be useful in estimating how often prevention technologies will activate before ignition and how long before ignition they will activate.

Cooking Fire Prevention

Tom Fabian, Ph.D.
Underwriters Laboratories

Leading Causes of Reported Home Structure Fires between 2003-2007



- M Ahrens, "Home Structure Fires", NFPA (March 2010)

CPSC Sponsored Research on Detection of Cooking Fires

- Temperature, smoke particulate, and hydrocarbon gases are strong indicators for impending ignition.
- No single sensor technology performed faultlessly for predicting impending ignition; a combination of a gas sensor on the range hood and a thermocouple contacting the bottom of the pan were found to be most effective.
- Standard household smoke alarms identify pre-ignition conditions well but generate a significant number of false alarms.

- E.L. Johnsson, "Study of Technology for Detecting Pre-Ignition Conditions of Cooking-Related Fires Associated with Electric and Gas Ranges and Cooktops, Phase I Report", NISTIR 5729, October 1995.
- E.L. Johnsson, "Study of Technology for Detecting Pre-Ignition Conditions of Cooking-Related Fires Associated with Electric and Gas Ranges and Cooktops, Final Report", NISTIR 5950, January 1998.

CPSC Sponsored Research on Detection of Cooking Fires while Ventilating

Cooking experiments in conjunction with range hoods and ceiling fans:

- Pan bottom temperatures provided a good indication of pre-ignition condition.
- Gas sensors had generally low and variable responses until near ignition.
- Smoke detectors did not respond consistently.
- Range hoods and ceiling fans substantially depressed gas sensor and smoke detector responses.

- U.S. Consumer Product Safety Commission, “ Study of Technology for Detecting Pre-Ignition Conditions of Cooking Related Fires Associated with Electric and Gas Ranges: Phase III”, February 23, 1998.

UL Research on Prevention of Cooking Fires

Investigated if a common Japanese cooktop with a pan contact temperature sensor could reduce the risk of ignition:

- Effective but may interfere with certain types of cooking such as blackening
- Efficacy was found to depend on the Interaction between cookware and sensor

- D.G. Dubiel, S.K. Maltas, “Report of Research on Cooking Fires and Pan Contact Temperature Sensor”, Underwriters Laboratories Inc., August 11, 2003.
- D.A. Dini, S.K. Maltas, “Report of Research on Cooktop Pan Contact Temperature Sensor – Technical Feasibility and Performance Goals”, Underwriters Laboratories Inc., August 12, 2004.

UL-IIT Research into Cooking Fire Precursor Conditions

Visiting IIT student project

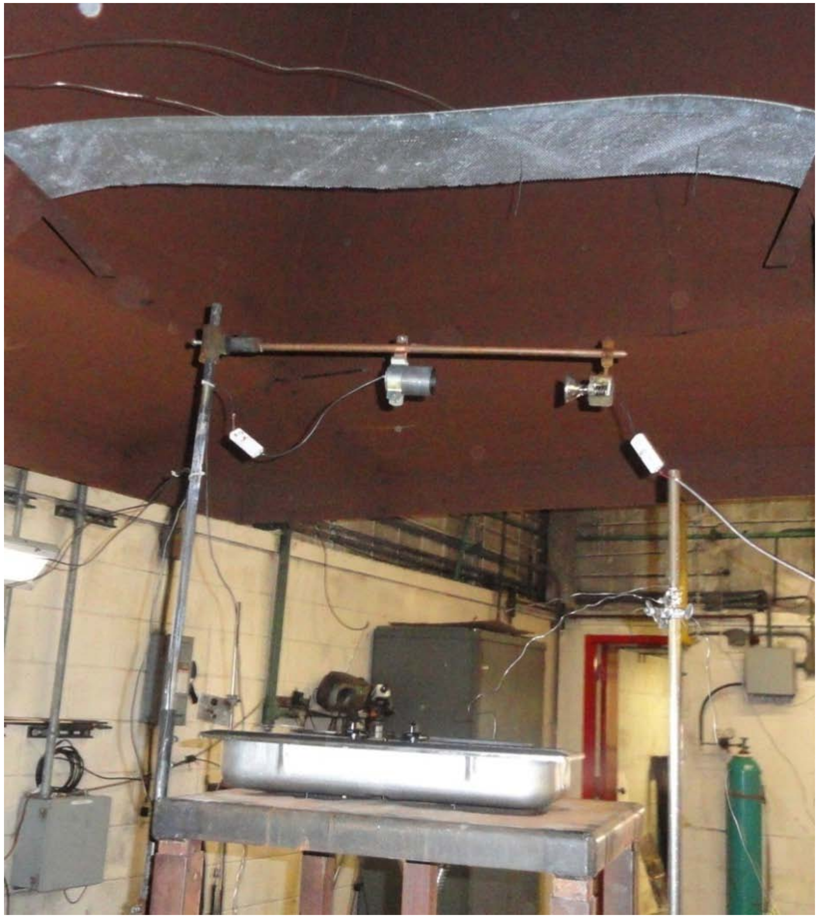
- Adnan Ansari
- Anchit Guarav
- Vivek Yadav

½" oil (canola, corn, or peanut) in a 12" diameter cast iron pan

Electric coil cooktop

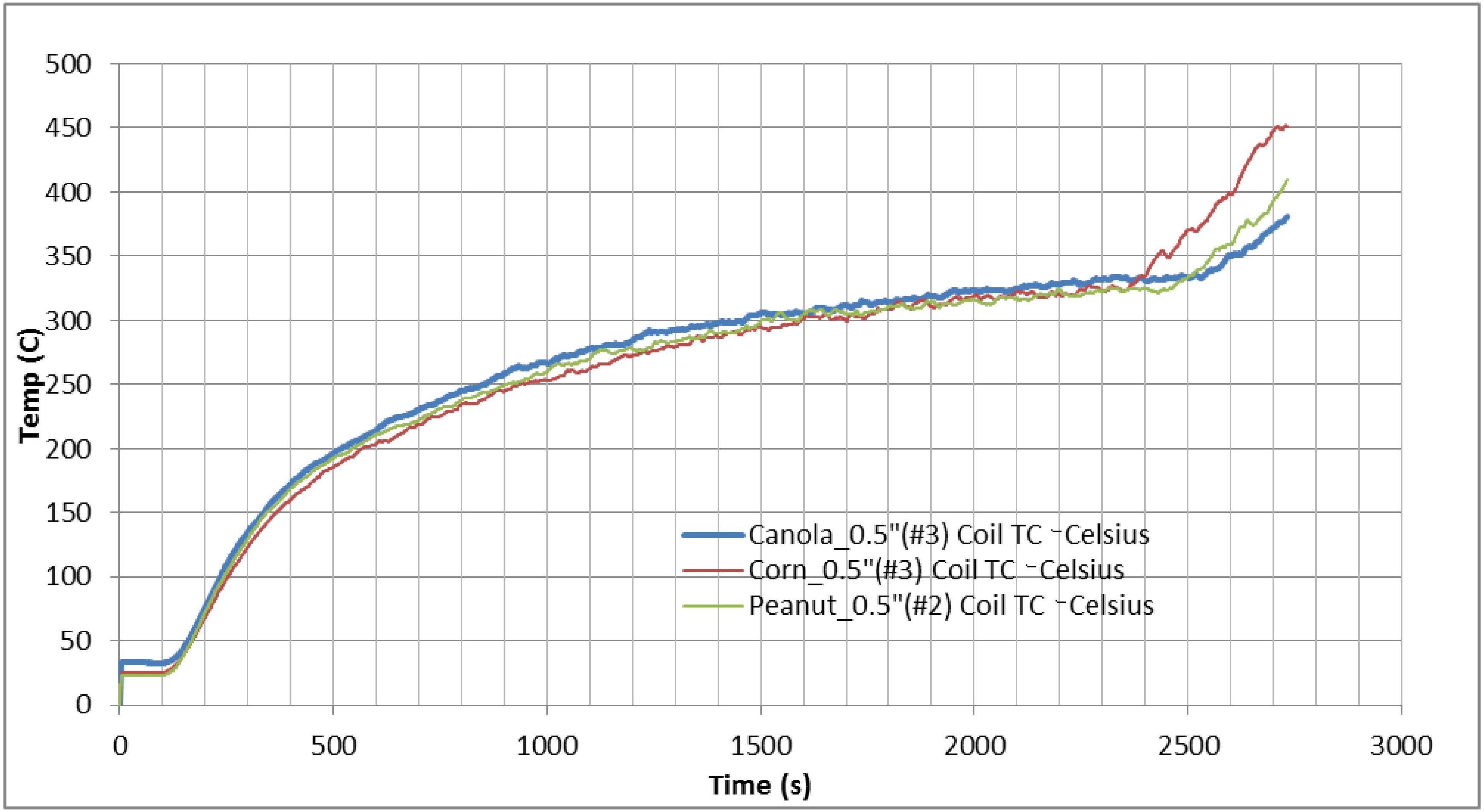
<u>Metrics</u>

- Temperature
- Smoke concentration

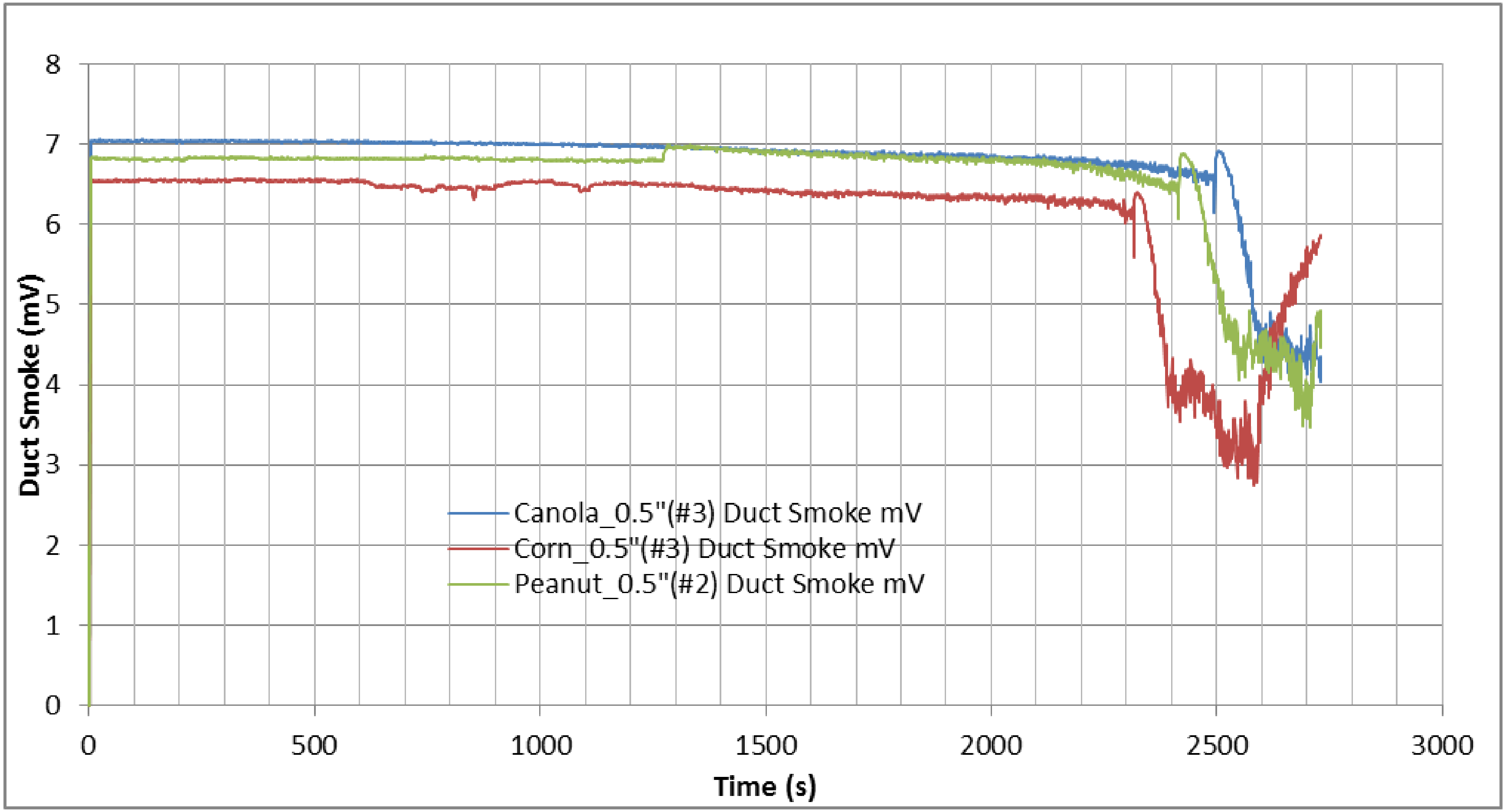


Imminent Cooking Fire Conditions

Coil Temperature for Different Oils

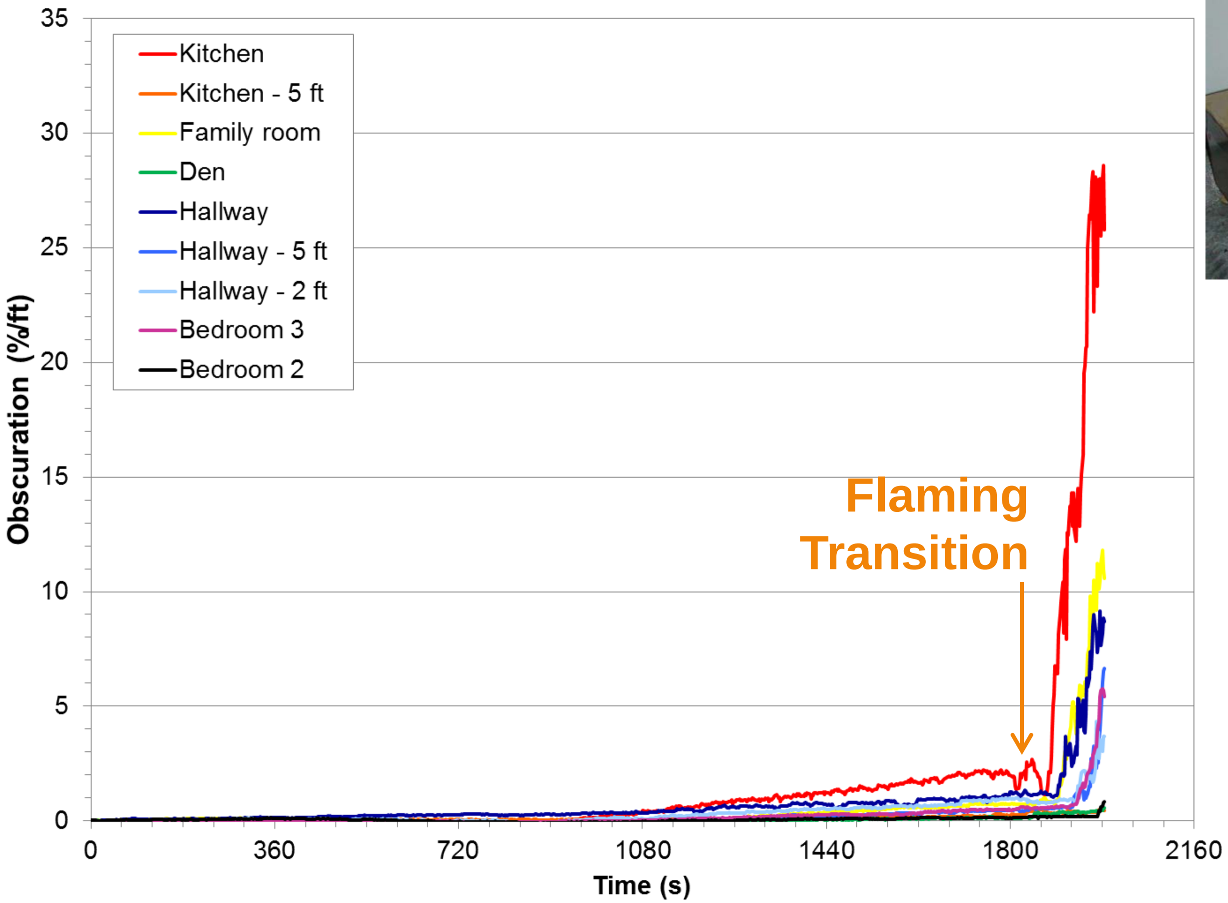


Smoke Density for Different Oils

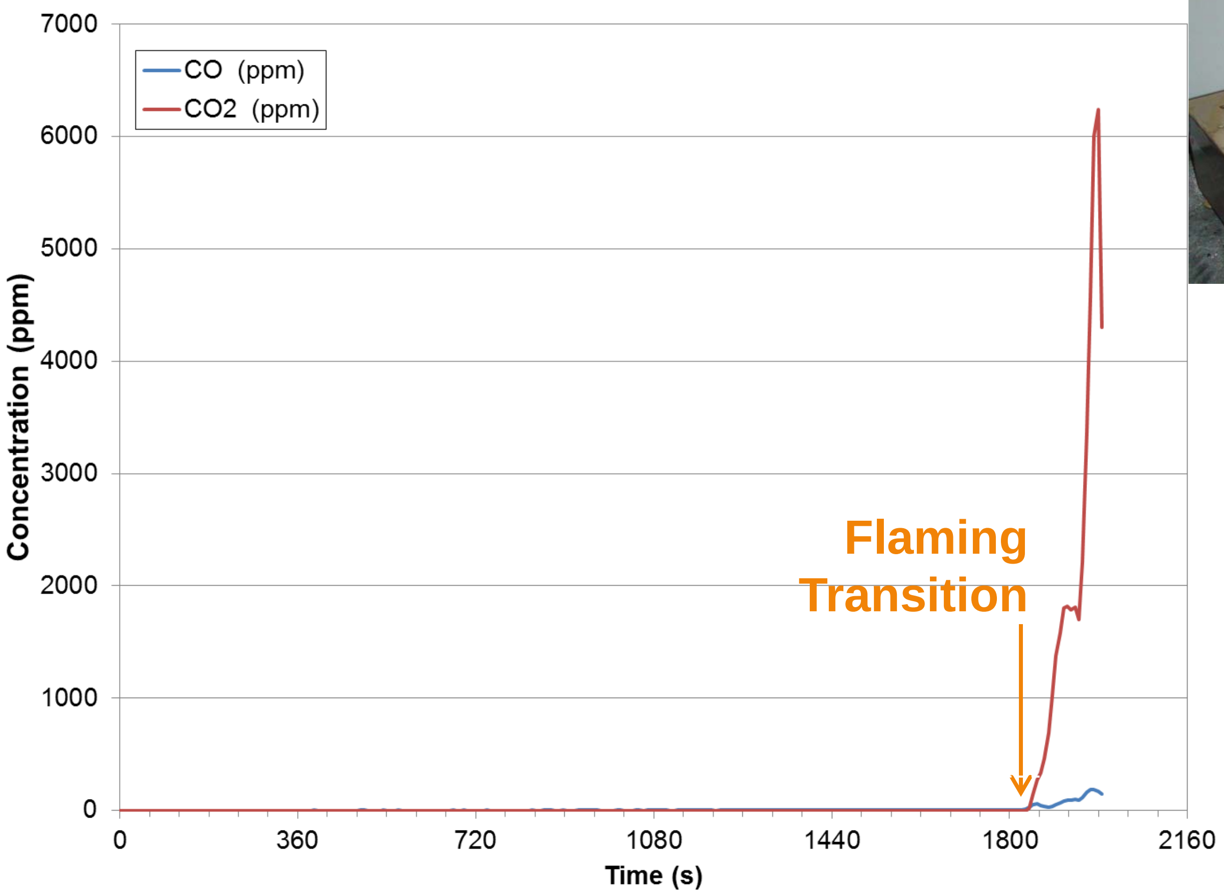


UL 2 Story, Open Floor Plan House Fire Tests

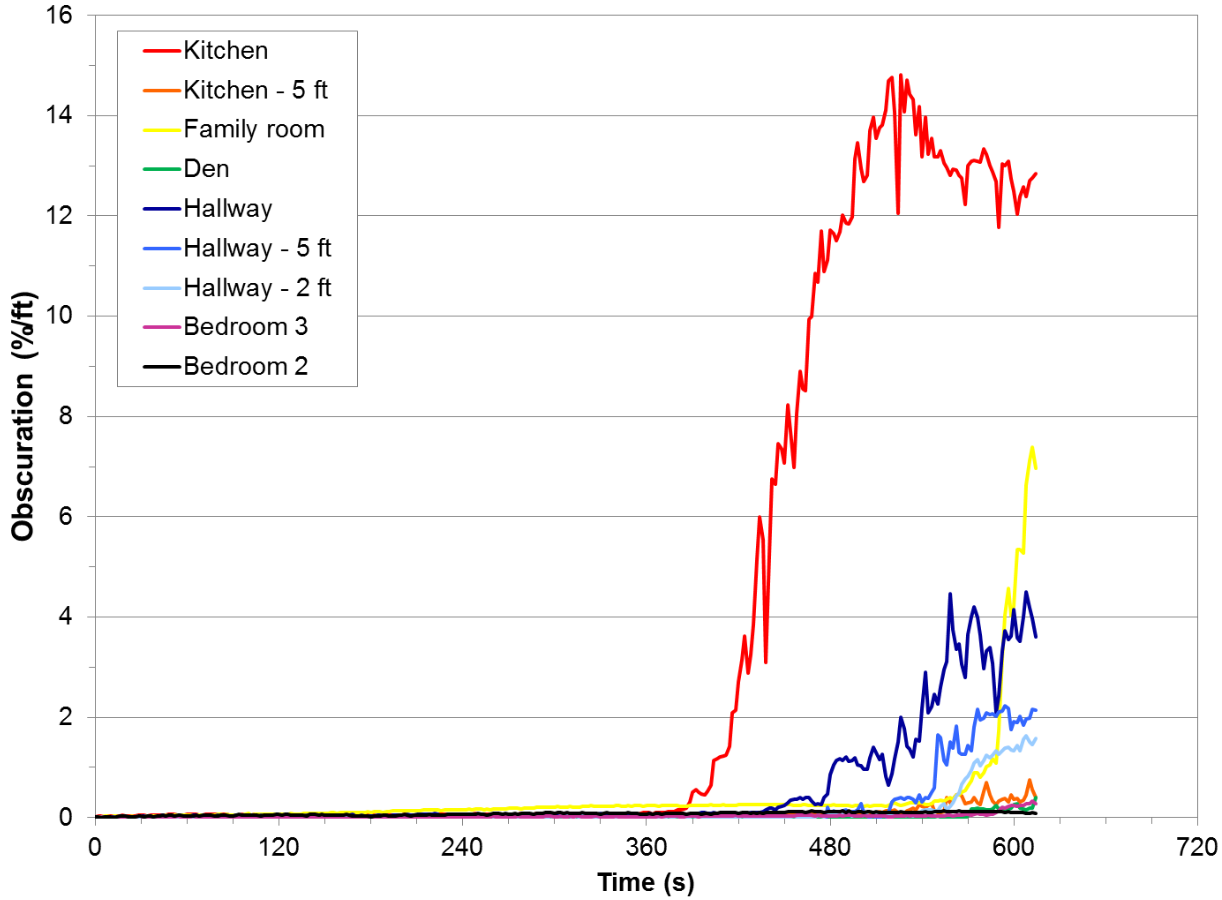
Corn Oil Cooking Scenario



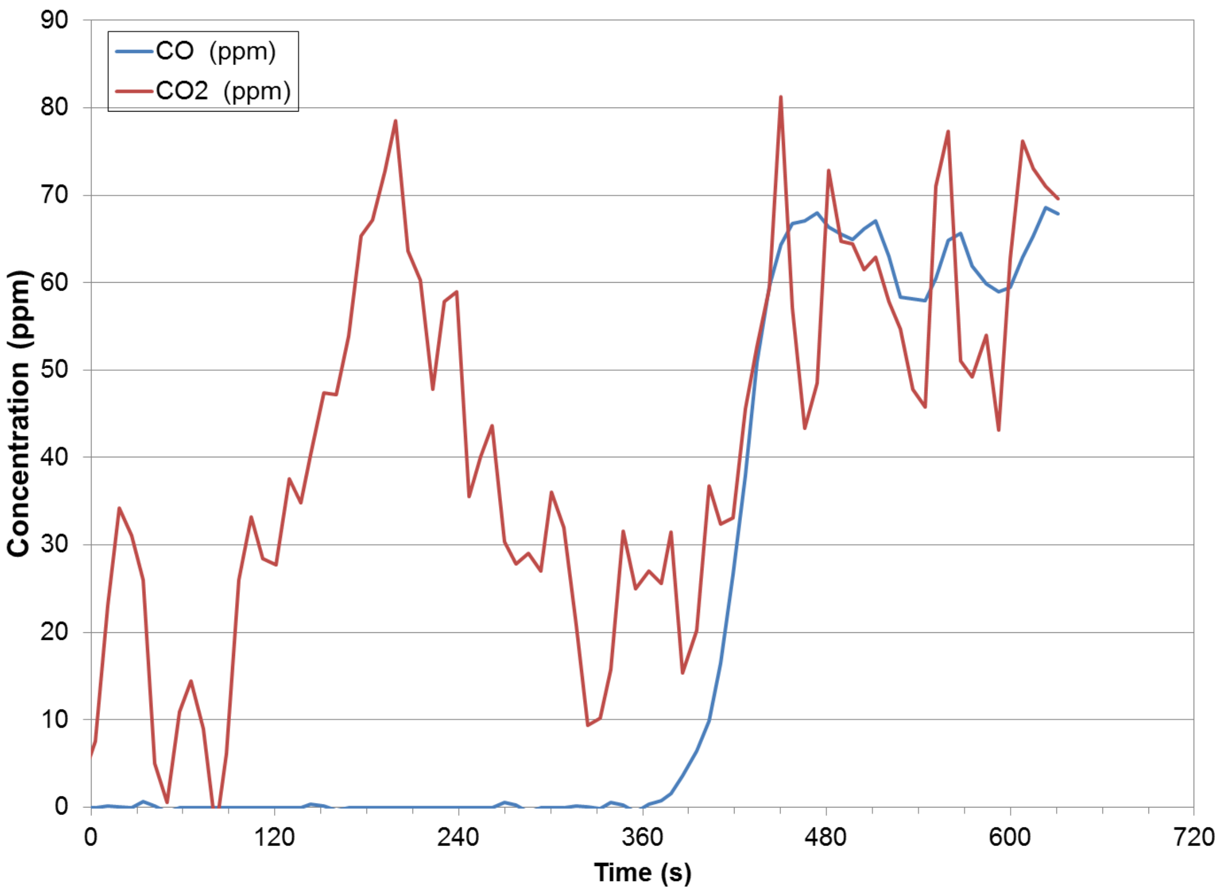
Corn Oil Cooking Scenario



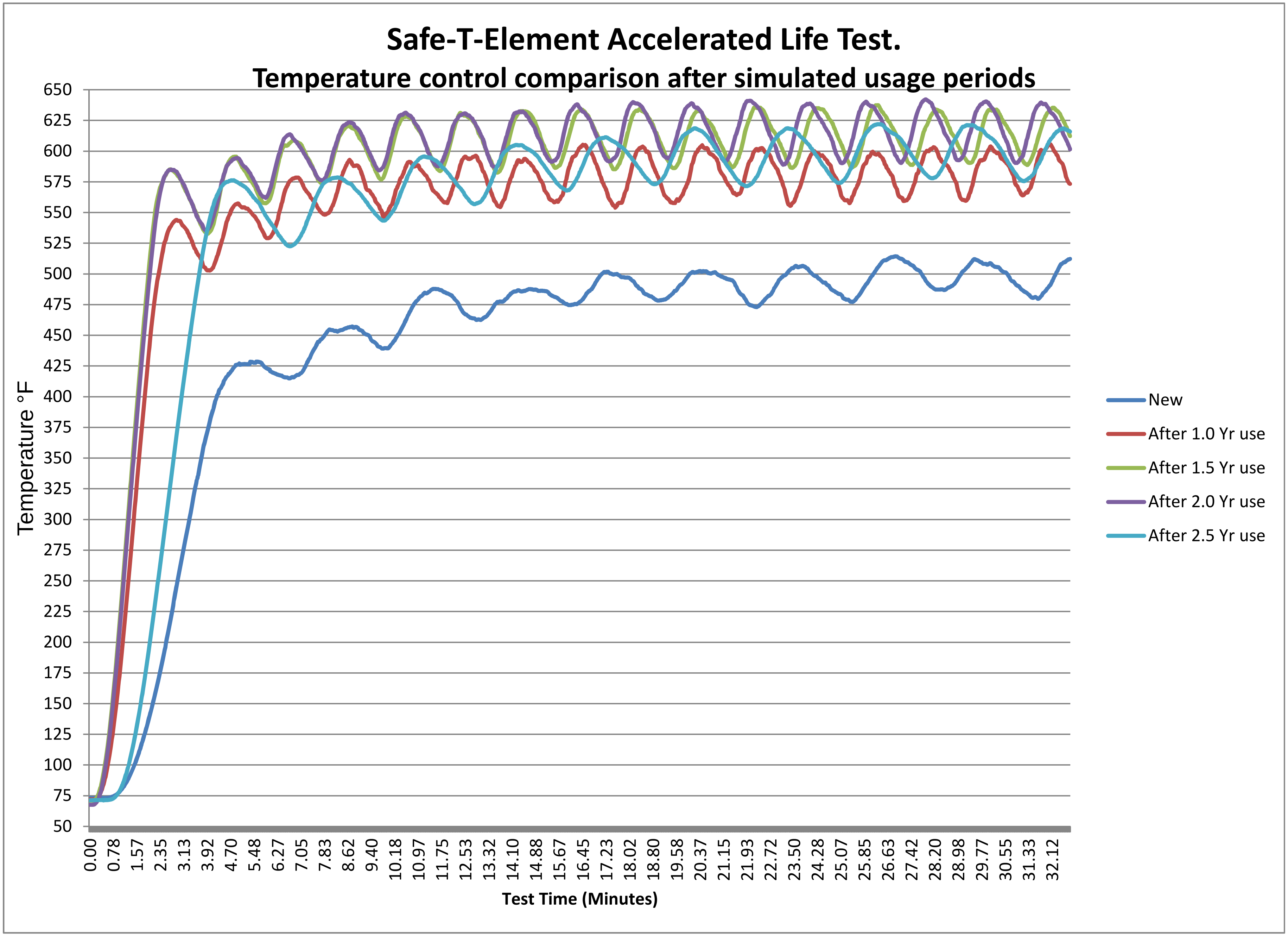
Overactive Toaster Scenario



Overactive Toaster Scenario



THANK YOU.


Safe-T-Element Accelerated Life Test.
Temperature control comparison after simulated usage periods
Temperature °F
650
625
600
575
550
525
500
475
450
425
400
375
350
325
300
275
250
225
200
175
150
125
100
75
50
0.00
0.78
1.57
2.35
3.13
3.92
4.70
5.48
6.27
7.05
7.83
8.62
9.40
10.18
10.97
11.75
12.53
13.32
14.10
14.88
15.67
16.45
17.23
18.02
18.80
19.58
20.37
21.15
21.93
22.72
23.50
24.28
25.07
25.85
26.63
27.42
28.20
28.98
29.77
30.55
31.33
32.12
Test Time (Minutes)
New
After 1.0 Yr use
After 1.5 Yr use
After 2.0 Yr use
After 2.5 Yr use