

Community Land and Water Coalition
Plymouth, MA 02360

Planning Board
Town of Wareham
54 Marion Road
Wareham, MA 02571

By email to: Kenneth Buckland, Director of Planning and Community Development

Re: 33-21 Wareham PV 1 LLC, 0 Route 25 proposed solar

To the Mr. Buckland and the Members of the Wareham Planning Board:

Community Land and Water Coalition would like to respectfully submit two expert testimonies on the safety of solar battery energy storage systems (BESS), which were first provided to the Massachusetts Energy Facility Siting Board in September 2022.

These comments are submitted by Community Land & Water Coalition, a project of Save the Pine Barrens, Inc. ("CLWC") a non profit group whose mission is to protect, preserve and steward the land and water resources of Southeastern Massachusetts, including the Plymouth Carver Sole Source Aquifer. CLWC members live, work and recreate in Wareham and are specifically impacted by decisions made regarding land and water management in this area.

Exhibit 1

September 29, 2022, Direct Prefiled Testimony of John Hinckley, Q.E.P., on Behalf of Save the Pine Barrens, prepared by John Hinckley, Q.E.P.

Air pollution expert, John Hinkley, submitted his testimony to the Energy Facility Siting Board about the toxic air emissions from a potential emergency thermal runaway event at Cranberry Point battery energy storage site.

Exhibit 2

September 29, 2022, Direct Prefiled Testimony of Milosh T. Puchovsky on Behalf of Save the Pine Barrens, prepared by Miosh T. Puchovsky

Fire safety expert, Milosh T. Puchovsky, Professor of Practice in the Department of Fire Protection Engineering at Worcester Polytechnic Institute, submitted his testimony to the Energy Facility Siting Board to give his "analysis and expert opinions concerning certain matters related

to the safety and potential for future emergency incidents,” at large battery energy storage sites, and “related to emergency planning for such incidents.” Professor Puchovsky identifies the risks and hazards of Cranberry Point and the “deficiencies in emergency response planning to address and mitigate hazards.”

Please feel free to contact me at this address if you have any questions or we can provide any additional information.

Very truly yours,

Katherine Harrelson
Community Land & Water Coalition
Plymouth, MA

The Commonwealth of Massachusetts
Energy Facilities Siting Board

EFSB 21-02

**DIRECT PREFILED TESTIMONY OF
JOHN HINCKLEY, Q.E.P.**

ON BEHALF OF INTERVENOR SAVE THE PINE BARRENS

EXHIBIT STPB-JH-1

September 29, 2022

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1 **I. Introduction**

2 **Q. Please state your name.**

3 A. My name is John Hinckley.

4 **Q. Please state your occupation, current place of employment, and business**
5 **address.**

6 A. I am a Senior Managing Consultant with ALL4 LLC (ALL4), a nationally
7 recognized environmental consulting firm with expertise in air quality and other
8 environmental media. My business address is 2393 Kimberton Road, Kimberton, PA
9 19442, but I usually work remotely in Vermont.

10 **Q. Please describe your educational background and relevant work experiences.**

11 A. I earned a B.S. in Natural Resources from the University of Vermont in 1994 and
12 an M.S. in Environmental Science & Engineering from the University of Virginia in
13 1998. I am certified as a Qualified Environmental Professional (“Q.E.P.”) in the area of
14 air pollution control by the Institute for Professional Environmental Practice (“IPEP”). I
15 also have specialized training from the U.S. EPA Air Pollution Training Institute and in
16 air quality modeling. I have over 22 years of experience in air emissions permitting, air
17 dispersion modeling, accidental emissions release modeling, air toxics evaluations, air
18 emissions reporting (including greenhouse gas reporting), and air pollution control
19 technology assessments. My curriculum vitae is attached to my testimony as Exhibit 1.

20 **Q. Have you previously testified in any formal hearing before regulatory**
21 **bodies?**

1 A. I have testified in in two New York State Department of Environmental
2 Conservation (“NYSDEC”) adjudicatory hearings, two Massachusetts Department of
3 Environmental Protection (“MassDEP”) adjudicatory hearings, two Vermont
4 Environmental Court proceedings, and in at least five Vermont Act 250 District
5 Commission hearings.

6 **II. Purpose of Testimony**

7 **Q. Are you aware of Cranberry Point Energy Storage LLC’s (“Cranberry**
8 **Point”), pending petition before the Energy Facilities Siting Board (“Siting Board”)**
9 **to construct a battery energy storage system (“BESS”) facility in the Town of**
10 **Carver Massachusetts (the “Project” or “Facility”), docket EFSB21-02?**

11 A. Yes.

12 **Q. What is the purpose of your testimony?**

13 A. I am providing this testimony to the Siting Board to present my analysis and
14 expert opinions concerning ambient (*i.e.*, outdoor) air pollution produced by potential
15 emergency thermal runaway events (*i.e.*, fires) at the Facility.

16 **Q. How is your testimony organized?**

17 A. My testimony is provided in Section III below with supporting information in the
18 attached exhibits. Section III testimony is organized into the following sections:

- 19 1. Summary of recent thermal runaway events at other facilities.
20 2. Comments on documents submitted to the Siting Board.

- 1 3. Review of literature sources addressing emissions from lithium-ion battery
- 2 fires.
- 3 4. Description of potential air pollutant emissions from thermal runaway events.
- 4 5. Summary of local meteorological data and prevailing wind patterns.

5 **Q. Are you presenting any exhibits in addition to your testimony and the**
6 **curriculum vitae you previously identified?**

7 A. My list of exhibits and curriculum vitae are as follows:

- 8 1. Curriculum Vitae
- 9 2. EFSB Petition and Analysis (EFSB Exhibit 2)
- 10 3. Draft Emergency Response Plan (EFSB Exhibit 16)
- 11 4. Table 1: Thermal Runaway Event Summary
- 12 5. Table 2: Emissions Summary Table
- 13 6. Thermal Runaway Event Emissions Literature Sources
- 14 7. Figure 1 – Stand Alone Wind Rose
- 15 8. Figure 2 – Wind Rose Superimposed on Study Area
- 16 9. Figure 3 – Proximity to Plymouth Municipal Airport

17 **III. Analysis of Potential Air Emissions and Dispersion Due**
18 **to a Thermal Runaway Event at the Proposed Facility**

19 **A. Scope of Analysis**

20 **Q. What were you and ALL4 asked to do?**

21 A. ALL4 was asked by Save the Pine Barrens (“STPB”) to evaluate potential air
22 quality impacts (Evaluation) resulting from air pollutants (or “air emissions”) that may be

1 released during a thermal runaway event at the proposed Facility, specifically a 150
2 megawatt (MW)/300 megawatt-hour (MWh) standalone BESS to be located in the Town
3 of Carver, MA.

4 **Q. What did you consider to be a thermal runaway event?**

5 A. For the purposes of this testimony, a thermal runaway event was assumed to be an
6 unintended (*i.e.*, emergency) event where lithium-ion batteries overheat and ignite,
7 thereby releasing various air pollutants (to be described later in this testimony) at levels
8 that can potentially be injurious to human health.

9 **Q. What did your Evaluation include?**

10 A. As part of the Evaluation, ALL4 conducted five analyses:

- 11 1. **Summary of Thermal Runaway Events at Other Facilities.** Developed a
12 summary table of recent thermal runaway events including, but not limited to,
13 the, facility location, facility size, dates when the event occurred, approximate
14 duration of thermal runaway event, and Internet sources.
- 15 2. **Review of documents submitted to the EFSB.** Reviewed and commented on
16 certain documents uploaded to the EFSB docket.
- 17 3. **Review of Thermal Runaway Event Literature.** Compiled and reviewed
18 literature describing the air pollutants that are potentially released during
19 lithium-ion battery combustion.
- 20 4. **Thermal Runaway Event Air Emissions.** Using information developed from
21 the literature review, ALL4 developed a list of air pollutants that could be
22 released during a thermal runaway event and that are regulated by MassDEP

1 and/or by the U.S. Environmental Protection Agency (U.S. EPA) as hazardous
2 air pollutants (HAP) and criteria pollutants for other types of air pollution
3 sources (*e.g.*, manufacturing plants, power plants). Refer to Table 2 (Exhibit
4 5) for a summary of these air pollutants.

5 **5. Meteorological Data Analysis.** Evaluated prevailing wind patterns. ALL4
6 compiled meteorological data from the Plymouth Municipal Airport from the
7 last five complete calendar years (2017 to 2021) to characterize prevailing
8 wind patterns (*i.e.*, wind speed and wind direction) at the Facility.

9 **Q. Could you explain in more detail why you performed these five tasks?**

10 A. As I will explain in my testimony, I found little to no data or analysis in the
11 documents submitted by Cranberry Point to the EFSB about the potential air pollutants
12 that could be released at the Facility in the event of a thermal runaway event. I therefore
13 had to develop an understanding of that potential risk, in the absence of data and analysis
14 from Cranberry Point.

15 I began by simply doing some recent historical research to see if other thermal
16 runaway events had occurred at facilities like this one to develop an understanding of
17 some of the characteristics of those events. As I will testify, I identified several recent
18 events, which varied in their characteristics.

19 Having established that thermal runaway events have occurred in the recent past, I
20 then analyzed certain of Cranberry Point's submissions into the EFSB docket, to
21 determine the data and analyses that Cranberry Point has presented to the EFSB
22 concerning a potential thermal runaway event. As I will testify, while I identified some

1 general statements acknowledging that a thermal runaway event could cause the release
2 of air pollutants, I did not see an extended discussion, analysis, or supporting data to
3 sufficiently understand the characteristics including the spatial extent of such an event.

4 Because of that lack of data and analysis, my next step was to review the available
5 literature to identify the air pollutants that could potentially be emitted if a thermal
6 runaway event were to occur at the Facility. I was most interested in and am limiting my
7 testimony to those pollutants that have been shown to cause adverse health effects by
8 being listed as either criteria pollutants, HAPs, or air toxics under either or both U.S.
9 EPA or MassDEP regulations.

10 Following that, I used the results of my literature review to create a list of the
11 potential air pollutants that could be released if a thermal runaway event were to occur at
12 the Facility. Refer to Table 2 (Exhibit 5) for the list of air pollutants.

13 Finally, I compiled meteorological data from the nearest suitable location to the
14 proposed site of the Facility. In this case, that was the Plymouth Municipal Airport. I
15 compiled that data to develop an understanding of how the air pollutants I identified for
16 my air pollutants list could potentially disperse if a thermal runaway event were to occur.

17 **Q. Why did you choose to do these five tasks?**

18 A. As described in more detail below, Cranberry Point's submission to the EFSB
19 acknowledges that a thermal runaway event could release air pollutants but does little to
20 explain or quantify the potential air quality risks to surrounding areas during thermal
21 runaway events. This highlights an unknown risk factor that the EFSB should consider
22 when evaluating Cranberry Point's petition. Therefore, the five tasks I described above

1 were undertaken to help understand and explain the nature of this potential risk and the
2 reasons why the EFSB should closely evaluate the data provided by Cranberry Point and
3 consider whether it is sufficient for the EFSB’s decision-making.

4 **B. Review of Thermal Runaway Events at Other Facilities**

5 **Q. What thermal runaway information did ALL4 compile?**

6 A. ALL4 compiled information concerning the characteristics of thermal runaway
7 events that have occurred at four similar facilities within the past three years. Please note
8 that this list is not intended to be exhaustive and additional thermal runaway events may
9 have occurred within this timeframe, which ALL4 did not identify. Details concerning
10 that research are set forth below; please refer to Table 1 (Exhibit 4) with documentation
11 for the sources of that information.

Facility	Location	Facility Size	Date	Duration
AES Corporation	Chandler, Arizona	10 MW	April, 2022	13 days
Neoen	Victoria, Australia	300 MW	July, 2021	Approximately 3 days
APS-Energy Storage Systems	Surprise, Arizona	2 MW	April 19, 2019	No specifics identified, appears to have been contained in less than one day.
Vista Energy Storage Facility	Moss Landing, California	300 MW	February 13, 2022 and September 4, 2022	Appears to have been contained in less than one day.

12

1 **C. Review of EFSB Docket Documents**

2 **Q. What did you learn from the documents you reviewed in the EFSB docket?**

3 A. My review focused on the EFSB Petition and Analysis (Exhibit 2) and the Draft
4 Emergency Response Plan (Exhibit 3). Both documents address air pollutant emissions
5 from the Facility. My comments regarding Exhibit 2 and Exhibit 3 are provided below.

6 **Exhibit 2.** Section 4.1 addresses air pollutant emissions and states the “*Project*
7 *will contribute near zero emissions. In fact, the Project may displace conventional*
8 *generation facilities and thereby reduce emission of carbon, particulates, and other*
9 *pollutants.*” While this statement may be accurate for normal operating conditions, the
10 document does not include, or reference corresponding information quantifying expected
11 air pollutant emissions that could potentially be released during a thermal runaway event,
12 which is not a normal operating condition.

13 **Exhibit 3.** The top of page 11 discusses the potential quantities and types of air
14 pollutants that may be released during a thermal runaway event. Page 11 states that:
15 “*There are five major risks posed by lithium-ion battery failures. They are electric shock,*
16 *arc flash, fire, explosion, and the by-product from off-gassing. During failure, a lithium-*
17 *ion battery may emit tens to hundreds of liters of off gas, and larger failures may emit*
18 *thousands of liters of gas.*” Page 11 also states “*Lithium-ion batteries release flammable*
19 *and toxic chemicals when subjected to electrical or physical damage, including fire.*
20 *Chemicals release can also pose an inhalation hazard.*”

21 The types of air emissions are *partially* identified in the middle of page 11 as
22 hydrogen, carbon, monoxide, carbon dioxide, methane, ethane, and other flammable

1 hydrocarbons. I say “partially” because the document does not say that it includes all
2 possible emissions that could be released. Further, Exhibit 3 provides the “typical
3 composition” that an off-gassing event “may” include.

4 Page 12, bullet (6), second sub-bullet describes the location of the closest
5 neighbor and provides a setback (*i.e.*, safety) distance of 650. “...*the closest proposed*
6 *battery enclosures are approximately 650' away, and are **sufficiently distant** such that*
7 *smoke or off-gas from the battery container are not expected to pose a risk.*” (emphasis
8 added) I was unable to identify information supporting the basis for the safety distance of
9 650 feet. Thus, while the document states that these neighbors are “sufficiently distant,” it
10 does not provide the information that was that was used to determine that 650 feet is an
11 adequate distance for the neighbors during a thermal runaway event.

12 Page 12, bullet (7) states that “*Full firefighter protective gear shall be worn in*
13 *any response to a fire and/or explosion event or any indication a fire may be present.*
14 *This shall include proper use of Self-Contained Breathing Apparatus (SCBA).*” While
15 SCBA gear may be worn for protection from many other types of fires (*e.g.*, burning
16 buildings), the requirement to wear SCBA gear suggests that the level of air pollutant
17 emissions that could be released during a thermal runaway event poses a potential
18 inhalation risk..

19 The last paragraph of page 15 to first paragraph of page 16 states “*Following*
20 *partial or complete consumption of the system by fire, batteries may continue to emit low*
21 *levels of flammable gases and dangerous levels of toxic gases for an extended period of*
22 *time. Continuous monitoring of gas levels in and around the incident location is*

1 *recommended to be conducted and use of mechanical ventilation may be utilized to*
2 *manage gas levels. Full firefighter PPE and SCBA shall be utilized until gas levels are*
3 *confirmed to be at a safe level.” This quote underscores the possibility that air pollutant*
4 *emissions may not be released over a short period of time and that their levels should be*
5 *monitored in ambient air following an event. I was unable to identify any documents that*
6 *describe monitoring equipment or protocols to be followed if such an event were to*
7 *occur.*

8 **D. Air Pollutant Literature Review**

9 **Q. What literature did you review concerning potential air pollutants that may**
10 **result from a thermal runaway event?**

11 A. There are many studies that have been performed to identify the types and
12 quantities of air pollutants released by lithium-ion batteries, which can be extrapolated to
13 thermal runaway events at battery storage facilities. Studies have been published by a
14 range of sources such as the U.S. Naval Research Laboratory (“U.S. NRL”), U.S.
15 Department of Energy (“U.S. DOE”), Tsinghua University (Beijing, China), and the
16 Energy and Environmental Science Journal (Royal Society of Chemistry). I have
17 included 13 documents that address potential thermal runaway emissions that are
18 collectively called Exhibit 6.

19 **E. Potential Thermal Runaway Event Emissions Information**

20 **Q. What did you use this literature to determine?**

1 A. As previously mentioned, I found it notable that Cranberry Point did describe
2 emissions related to a thermal runaway event in the EFSB docketed documents that I
3 reviewed. Therefore, I used my literature review to create a list of potential air pollutants
4 that could be released if such an event were to occur. Given this is based on a literature
5 review and that certain Facility documents such as Safety Data Sheets (SDS) were not
6 available at the time of my review, I cannot say with certainty either that all these
7 pollutants would be released or that other pollutants that I have not identified would not
8 be released. I believe that this list is nonetheless useful to highlight the importance of
9 having such a list and why the absence of one in Cranberry Point's documents is both
10 notable and of relevant to the EFSB's decision-making process. These documents were
11 used to develop the emissions information described below and summarized in Table 2
12 (Exhibit 4).

13 **Q. Please describe the air pollutants list you created.**

14 A. The air pollutants that could be released during a thermal runaway event are
15 particulate or gaseous in nature. The air pollutant list developed by ALL4 is limited to air
16 pollutants that are regulated by the U.S. EPA and MassDEP for other facilities that are
17 subject to Federal and Commonwealth of Massachusetts air pollution control regulations
18 respectively. While U.S. EPA and MassDEP do not necessarily regulate thermal runaway
19 emissions from battery storage facilities, these air pollutants are regulated from other
20 types of facilities (*e.g.*, fossil power plants, manufacturing plants, and
21 colleges/universities) and are regulated because they can adversely affect human health.

1 The emissions information includes criteria pollutants¹ and HAP² that are
2 regulated by both U.S. EPA and MassDEP and air toxics³ that are regulated only by
3 MassDEP. Refer to Table 3 (Exhibit 5) for the list of air pollutants and their respective
4 pollutant category and the primary reference used for that pollutant.

5 While I am not myself an expert in the potential adverse health effects of these
6 pollutants, the U.S. EPA and other regulatory agencies provide such information. The
7 U.S. EPA's Health Effects Notebook for Hazardous Air Pollutants can be accessed
8 through this link: [https://www.epa.gov/haps/health-effects-notebook-hazardous-air-](https://www.epa.gov/haps/health-effects-notebook-hazardous-air-pollutants)
9 pollutants.

10 **F. Meteorological Data Review**

11 **Q. Please describe the meteorological data that you developed.**

12 A. ALL4 developed meteorological data in a format suitable for air dispersion
13 modeling (*i.e.*, air quality modeling), which is required by MassDEP in some
14 circumstances for certain emissions sources.

15 **Q. Why did you develop that data?**

16 A. It is my understanding that air quality modeling has not been performed, nor has
17 any regulatory agency such as MassDEP required it to be performed. But even in the

¹ Available at: <https://www.epa.gov/criteria-air-pollutants/naaqs-table>

² Available at: [https://www.epa.gov/haps/initial-list-hazardous-air-pollutants-](https://www.epa.gov/haps/initial-list-hazardous-air-pollutants-modifications)
modifications

³ <https://www.mass.gov/service-details/massdep-ambient-air-toxics-guidelines>

1 absence of such a requirement, understanding the prevailing wind patterns by evaluating
2 meteorological data helps to show where air pollutants would potentially travel if a
3 thermal runaway event were to occur. This meteorological data in tandem with the air
4 pollutants list helps to illustrate that if a thermal runaway event were to occur at the
5 Facility, air pollutants could travel in all directions away from the Facility.

6 **Q. Where did you get these data?**

7 A. ALL4 processed meteorological data from the closest weather recording station
8 that can be considered representative of the weather conditions at the Facility. Therefore,
9 ALL4 developed surface hourly weather data (“Surface Data”) from the Plymouth
10 Municipal Airport surface observation station, located approximately 3.1 miles from the
11 Facility. Refer to Exhibit 8 for a map showing the proximity of the Plymouth Municipal
12 Airport to the Facility. As customary for air dispersion modeling, ALL4 processed upper
13 air data from the Gray, Maine upper air station (“Upper Air Data”).

14 **Q. Please describe the quality of these data.**

15 A. Data was available for at least 90% of the five-year period; therefore, 43,848
16 hours of data were developed. This level of data availability is suitable for determining
17 prevailing wind speeds and directions.

18 **Q. What did you do with these data?**

19 A. ALL4 used the Surface Data to develop a Wind Rose. A Wind Rose is a graphical
20 representation of wind speed and direction. As shown in Exhibit 7 and Exhibit 8 wind
21 speed and direction are illustrated with pie wedges. The direction the wind is blowing
22 towards is indicated by the narrow end of the wedge.

1 **Q. What did those Wind Roses show?**

2 A. As shown in both figures, wind blows from all directions; however, there are
3 three prevailing wind directions: from the southwest to the northeast, from the northeast
4 to the southwest, and from the west-northwest towards the east-southeast. According to
5 Exhibit 8, wind speeds range from approximately one mile per hour (mph) to greater than
6 25 mph. The approximate time when there is no observable wind speed (i.e., calms) is
7 1.38% of the time; therefore, there are measurable winds approximately 98.6% of the
8 time.

9 Exhibit 8 shows the wind rose superimposed on an aerial image of the Facility
10 location and the surrounding area. The surrounding area includes residential areas,
11 cranberry bogs, and the Carver Elementary School. Given that measurable winds occur
12 most of the time and given the diversity of wind directions; it is likely that some
13 emissions generated by a thermal runaway event would be transported outside of the
14 Facility's property boundary.

15 **IV. Professional Opinions**

16 **Q. What, if any, professional opinions have you formed about the Facility?**

17 A. Based on my analysis, I have several opinions regarding potential thermal
18 runaway events at the Facility.

19 First, Cranberry Point has acknowledged that air pollutants would be released if a
20 thermal runaway event were to occur at the Facility. However, Cranberry Point has not
21 provided sufficient information (e.g., data, analysis of data) to thoroughly understand the

1 extent of inhalation risk in the areas surrounding the Facility. In particular, I could not
2 determine from Cranberry Point's submissions all the specific pollutants that may be
3 released, the emissions rates for those pollutants, and the extent to which those pollutants
4 could travel offsite and into surrounding areas that include residential populations,
5 cranberry bogs, and at least one school during a thermal runaway event.

6 Second, any significant thermal runaway event will likely result in the release of
7 air pollutants that have been classified by U.S. EPA and/or MassDEP as impactful to
8 human health. Therefore, given the meteorological data that was evaluated, a thermal
9 runaway event would bring with it the potential that emissions that are known to impact
10 human health may travel offsite.

11 Third, there is reason to be concerned with the lack of data and analysis provided
12 by Cranberry point about air pollutants released during a potential thermal runaway
13 event. Based both on recent historical events and Cranberry Point's own submissions
14 that: (1) the risk of a thermal runaway event is not zero; (2) a thermal runaway event
15 brings with it the risk of a fire and the release of air pollutants; (3) such an event could
16 release air pollutants at levels that workers and emergency responders at the Facility
17 would need to wear SCBA equipment, and (4) the safety distance of 650 feet could not be
18 verified. I believe the Siting Board should be aware of and should consider this lack of
19 information during its decision-making process in this proceeding.

20 **V. Conclusion**

21 **Q. Does this conclude your direct testimony?**

- 1 A. Yes, but I reserve the right to supplement this testimony if any additional
- 2 information becomes available due to later-filed discovery responses or other materials.

Affidavit of John Hinckley

I, John Hinckley, affirm under the pains and penalties of perjury that:

1. I am testifying in the Energy Facilities Siting Board's proceeding docketed as number EFSB21-02;
2. This prefiled testimony was prepared by me or at my direction, under my supervision and control; and
3. The information contained in this prefiled testimony is true and accurate to the best of my knowledge and belief at the time I signed this affidavit.



John Hinckley

EXHIBIT 1



JOHN HINCKLEY, QEP SENIOR MANAGING CONSULTANT

CREREDENTIALS

- ◆ M.S., Environmental Science & Engineering, University of Virginia, 1998
- ◆ B. S., Natural Resources, University of Vermont, 1994
- ◆ U.S. EPA Air Pollution Training Institute, North Carolina State University (2002-2003)
- ◆ AERMOD Training (2018)
- ◆ Member, Institute for Professional Environmental Practice (IPEP)
- ◆ Member, Air and Waste Management Association (AWMA)
- ◆ Qualified Environmental Professional (2003 - present)

PROFESSIONAL EXPERIENCE

- ◆ **May 2020-Present:** ALL4, Kimberton, PA – Senior Project Manager
- ◆ **March 2018-March 2020:** GeoInsight, Inc., Manchester, NH – Associate/Air Compliance Specialist
- ◆ **July 1998-March 2018:** RSG, Inc., White River Junction, VT – Director

TECHNICAL EXPERTISE

- ✓ New/modified source air permit application preparation;
- ✓ Air emissions dispersion modeling for criteria pollutants and air toxics using the AERMOD modeling system;
- ✓ Pollution Control Technology Assessments including BACT/LAER and Vermont HMSER;
- ✓ Federal air quality regulations including, NSPS and NESHAPs;
- ✓ State level air toxics evaluations including New Hampshire Env-A 1400, Vermont HMSER; and New York Part 212;
- ✓ Accidental release modeling using SLAB, DEGADIS, and ALOHA;
- ✓ Mobile source emissions estimation with MOVES and dispersion modeling with AERMOD; and
- ✓ Vermont Act 250 Permitting.

PROFESSIONAL OVERVIEW

Mr. John Hinckley possesses over 22 years of air quality consulting experience focusing on air emissions permitting, air dispersion modeling (including accidental release modeling), and air pollution control technology assessments. Mr. Hinckley has worked with a variety of clients in the institutional (education, public health), renewable energy (biomass, biogas, landfill gas to energy, renewable natural gas), forest products, manufacturing, hot mix asphalt, aggregate, dimension stone, concrete and ski area sectors from Maine to Alaska. Mr. Hinckley's primary interest and career work focuses on helping clients understand how to design and operate their facilities in compliance with complex federal and state air pollution control regulations. His experience with emissions estimation, pollution control technology assessments, and air dispersion modeling are used to evaluate regulatory applicability and to develop compliance solutions. He has guided clients through feasibility studies for new facilities, evaluating facility design and operation requirements, resolving odor and dust nuisance issues, responding to federal/state enforcement actions, permitting first-of-their-kind projects, evaluating safety from accidental releases of air emissions, and providing litigation support and expert testimony.



JOHN HINCKLEY, QEP
SENIOR MANAGING CONSULTANT

PROJECT HISTORY

Compressor Station Peer Review. Town of Weymouth, MA. Senior Project Manager: *Performed peer review of a proposed natural gas-fired compressor station on behalf of Town of Weymouth, MA. Reviewed emissions calculations, air dispersion modeling, and pollution control technology evaluation prepared for the compressor station's permit application. Conducted independent air dispersion modeling evaluation of start-up emissions using U.S. EPA AERMOD model. Performed accidental release modeling evaluation using U.S. EPA ALOHA model. Prepared prefiled testimony and provided expert witness testimony at MassDEP Boston separately for air permit application review and accidental release modeling.*

Consent Decree Representation for Massachusetts Industrial Facility. Confidential Industrial Client: Provided technical assistance to an industrial Massachusetts facility that was sued by the Massachusetts Attorney General. Provided on-site representation in meetings between the Facility and the Massachusetts Attorney General. Assisted facility with an emission control evaluation for pollution control equipment selection. Reviewed and commented on draft consent decrees.

Enforcement Action Representation for Massachusetts Industrial Facility. Confidential Industrial Client: Provided technical assistance to an industrial Massachusetts facility that was inspected and later received a Letter of Deficiency from U.S. EPA Region 1. Assisted the facility with emissions testing and equipment changes to comply with federal air pollution control requirements. Participated in meeting with the Facility and U.S. EPA at the Region 1 office in Boston, MA.

Consent Decree Representation for New Hampshire Commercial Facility: Provided technical assistance to a New Hampshire commercial facility to comply with a consent decree with the New Hampshire Department of Environmental Services (NHDES). Assisted with meetings at the NHDES office in Concord, pollution equipment improvements, and source emission testing.

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JOHN HINCKLEY, QEP
SENIOR MANAGING CONSULTANT

Nuclear Power Plant Cooling Tower. Evaluation, Riverkeeper, Buchanan, NY, Senior Project Manager: Retained by Riverkeeper (New York State non-profit) to evaluate the feasibility of permitting cooling towers for the 2000-megawatt Indian Plant Energy Center (IPEC) in Buchanan, NY. Evaluated emissions control from mist eliminators, estimated emissions, and performed air dispersion modeling to demonstrate that Riverkeeper's proposed cooling tower design would meet the National Ambient Air Quality Standards (NAAQS) for fine and coarse particulate matter. Modeling findings were affirmed by the New York State Department of Environmental Conservation (NYSDEC). Provided expert witness testimony on three occasions at NYSDEC headquarters in Albany, NY.

Permitting and Representation for Hot Mix Asphalt Plant and Rock Crushing Plants. Graniteville, VT. Senior Project Manager: Provided air permitting, air dispersion modeling, emissions control, and expert witness testimony for North East Materials Group, for its hot mix asphalt plant and rock crushing plants in Graniteville, VT. Provided expert testimony at Act 250 District Commission hearings in Vermont Environmental Court Proceedings.

Permitting and Representation for Hot Mix Asphalt Plant. Irasburg, VT. Senior Project Manager: Provided air permitting, emissions control, and expert witness testimony for J. Hutchins, Inc. for its hot mix asphalt plant and rock crushing plant in Irasburg, VT. Provided expert testimony at Act 250 District Commission hearing.

Hot Mix Asphalt Plant Peer Review. Permitting, Mediation. Colchester, VT. Senior Project Manager: Involved as intervenor, then facility consultant, then mediator regarding odor and dust issues regarding the FW Whitcomb Construction Company. Initially hired by neighboring commercial office complex to evaluate and identify a solution to odors generated by a hot mix asphalt plant. Worked with the neighbor and Whitcomb to design odor control equipment for the hot mix plant. Was later hired by Whitcomb to provide air permitting services for additional equipment changes. Recently represented Whitcomb to work with neighbor as part of mediation to resolve additional odor issues.

Permitting and Representation of Hot Mix Asphalt Plant and Rock Crushing Plants. Graniteville, VT. Senior Project Manager: Have provided air permitting, air dispersion modeling, emissions control, and expert witness testimony for North East Materials Group (NEMG) for their hot mix asphalt plant and rock crushing plant in Graniteville, VT. Provided expert testimony in separate Vermont Environmental Court Proceedings.

Bulk Heated Storage Tank Peer Review. Senior Managing Consultant: Assisted the City of South Portland, Maine with evaluating a proposed odor control system for bulk heated storage tanks located at Global Companies, LLC's (Global) petroleum storage and distribution facility in South Portland. ALL4 was retained by the City of South Portland, Maine to evaluate the potential effectiveness of the equipment and to address South Portland citizen's concerns regarding the equipment. Prepared findings report and testified at public hearings.

The Commonwealth of Massachusetts
Energy Facilities Siting Board

EFSB 21-02

DIRECT PREFILED TESTIMONY OF
MILOSH T. PUCHOVSKY

ON BEHALF OF INTERVENOR SAVE THE PINE BARRENS

EXHIBIT STPB-MTP-1

September 29, 2022

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1 **I. Introduction**

2 **Q. Please state your name and business address.**

3 A. My name is Milosh T. Puchovsky. My business address is 100 Institute Road,
4 Worcester, MA, 01609.

5 **Q. Please state your occupation and current place of employment.**

6 A. I am Associate Department Head and Professor of Practice in the Department of
7 Fire Protection Engineering at Worcester Polytechnic Institute (“WPI”).

8 **Q. Please describe your educational background and relevant work experiences.**

9 A. I hold both a B.S. and M.S. from WPI in Mechanical Engineering and Fire
10 Protection Engineering. I possess 34 years of experience with evaluating fire hazards, the
11 selection and design of fire and life safety systems, and the application and revision of
12 associated regulations. I am a member of numerous industry committees including those
13 of the National Fire Protection Association (NFPA), the Society of Fire Protection
14 Engineers (“SFPE”) and Underwriters Laboratories (UL). I teach graduate level courses
15 and industry seminars on a range of technical fire safety subjects. I am Past President
16 and a Fellow of SFPE, served as Secretary to NFPA’s Standards Council, overseeing the
17 development of all NFPA’s codes and standards, and led the development of NFPA’s
18 performance-based codes initiative facilitating the greater application of calculation
19 methods and computer fire models in fire safety design. I am registered professional fire
20 protection engineer in the state of Massachusetts. Specific to Energy Storage Systems
21 (“ESS”) I have lead projects at WPI, observed ESS fire tests and worked as a subject

1 matter expert (“SME”) with UL in the development of UL 9540A, *Standard for Test*
2 *Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage*
3 *Systems* and with the City of New York in the development of protocols for ESS
4 installations. I have provided expertise to the NFPA technical committee responsible
5 for NFPA 855, *Standard for the Installation of Stationary Energy Storage Systems* and
6 presented at NFPA, SFPE and the International Association of Arson Investigators –
7 Massachusetts Chapter conferences and seminars. A copy of my curriculum vitae is
8 attached to my testimony as Exhibit A.

9 **Q. Have you previously testified in any formal hearing before regulatory**
10 **bodies?**

11 A. I have testified in court three times on fire safety systems. I have been deposed
12 numerous times on matters concerning fire safety.

13 **II. Purpose of Testimony**

14 **Q. Are you aware of Cranberry Point Energy Storage LLC’s (“Cranberry**
15 **Point”), pending petition before the Energy Facilities Siting Board (“Siting Board”)**
16 **to construct a battery energy storage system (“BESS”) facility in the Town of**
17 **Carver Massachusetts (the “Project”)?**

18 A. Yes.

19 **Q. What is the purpose of your testimony?**

20 A. I am providing this testimony to the Siting Board in support of Save the Pine
21 Barrens (“STPB”) presentation of evidence concerning the Project. Specifically, in my

1 testimony, I present my analysis and expert opinions concerning certain matters related to
2 the safety and potential for future emergency incidents at the Project and related to
3 emergency planning for such incidents.

4 **Q. How is your testimony organized?**

5 A. In **Part III**, I provide some foundational background for my testimony by
6 describing the design and operation of lithium-ion battery energy storage systems such as
7 the one proposed by Cranberry Point, including key design features from a fire safety
8 perspective.

9 In **Part IV**, I describe the risks associated with such energy storage systems,
10 including those associated with the Facility proposed for Carver.

11 In **Part V**, I describe relevant fire safety regulations and how they pertain to
12 Cranberry Point’s proposed project, the deficiencies in the Cranberry Point project’s
13 compliance with these regulations, and the potential consequences of the failure to
14 comply with these regulations and emergency events at the proposed facility.

15 **Q. Are you presenting any exhibits in addition to your testimony and the**
16 **curriculum vitae you previously identified?**

17 A. No.

18 **III. Overview of Battery Energy Storage Systems**

19 **Q. What is a lithium-ion battery energy storage system?**

20 A. A lithium-ion battery energy storage system—abbreviated “BESS”—is an
21 electrochemical energy storage system utilizing lithium-ion battery chemistry to store

1 electrical energy for later use. Manufacturers continue developing batteries with higher
2 energy densities, allowing for greater energy capacity of BESS.

3 **Q. Please elaborate on the term “lithium ion.”**

4 A. The term “lithium-ion” does not represent a specific battery, but rather a family of
5 batteries with a wide array of differing chemistries. However, this group of batteries are
6 all characterized by the transfer of lithium ions between the electrodes during the charge
7 and discharge cycles.

8 A lithium-ion battery contains three fundamental components: (1) electrodes; (2)
9 the separator; and (3) the electrolyte. Electrodes are conductors through which electricity
10 enters or exits the battery. Between the positive electrode (called the “cathode”) and
11 negative electrode (called the “anode”) lies a separator which can be composed of a
12 micro-perforated plastic. During the charging process, lithium-ions move between the
13 anode and the cathode. The liquid electrolyte, commonly composed of a lithium salt and
14 a flammable organic solvent, allows the lithium-ions to move through the separator from
15 the cathode to the anode. There are two tabs per lithium-ion cell, one per electrode –
16 cathode and anode. These tabs allow an electrical connection to be made during the
17 transfer of lithium-ions. During the charge/discharge process, the electrons flow through
18 the external electrical circuit, while lithium-ions move between the cathode and the
19 anode.

20 **Q. What distinguishes lithium-ion batteries from other types of batteries?**

21 A. Lithium-ion batteries are often used in BESS applications because of their
22 improved ability to retain charge. As batteries age, their capacity fades, meaning that as

1 those batteries get older, they can no longer reach a full charge. This is true of all
2 batteries, including lithium-ion batteries. Lithium-ion batteries, however, only lose ¼ the
3 amount of charge typically lost per month in other standard batteries such as lead-acid or
4 nickel-cadmium. Additionally, lithium-ion batteries possess a greater energy storage
5 capacity and density as compared to other battery types.

6 **Q. What are the design features of a typical BESS?**

7 A. Variation exists in the designs of energy storage systems based on manufacturer
8 specifications and proprietary technology with systems continuing to evolve. For this
9 reason, and as I will testify later, this injects several unknown variables when quantifying
10 risks and planning for emergencies associated with BESS facilities. Put simply, at this
11 point there is not really a “typical” BESS installation.

12 That said, the basic components and their orientation can be described in at least a
13 generic manner. The individual components of a BESS installation consist of cells,
14 modules, racks, and storage container units. Cells are the basic building blocks of the
15 system and are connected to comprise a module (sometimes installed on a tray) of
16 batteries. Multiple modules are electrically interconnected to form a rack (sometimes
17 referred to as a unit). An array of racks can be arranged within a storage unit or container
18 to form a large-scale BESS installation. Differing terminology can occur amongst battery
19 manufacturers and testing protocols.

20 **Q. What is a “cell”?**

21 A. A cell is essentially a single lithium-ion battery. Manufacturers produce different
22 cell sizes and formats such as cylindrical, prismatic, or pouch. The cells can have vents

1 to prevent internal over-pressurization. Each cell format is available in various sizes
2 corresponding to variation in the cell mass, energy density, amperage, etc.

3 **Q. What is a “module”?**

4 A. A module is a series of cells electrically interconnected in series and/or parallel to
5 provide higher voltages and capacities. Modules can be equipped with electrical
6 protection (fuses) and sensors for monitoring of voltages and (sometimes) temperatures,
7 and either passive or active ventilation provisions. Modules are placed and electrically
8 interconnected with a Battery Management System (BMS) and Junction Box (JB) in
9 vertical racks. Modules can also be equipped with a Thermal Management System
10 (TMS) to maintain suitable operating temperatures.

11 **Q. What is a “rack”?**

12 A. A rack within an energy storage system consists of a series of modules electrically
13 interconnected to provide a larger energy output at a required voltage. A rack typically
14 has multiple drawers/trays. Within each tray there will be single or multiple modules
15 depending on the size and formats of the cells utilized. Each rack can have a rack-level
16 battery management system that communicates with the module sensors, and one or more
17 DC connectors and fuses.

18 **Q. What other components are associated with a BESS installation?**

19 A. A containerized ESS storage unit consists of arrays of lithium-ion battery racks
20 arranged to obtain a desired energy/power output. Within this system will be a device,
21 often referred to as an inverter, to convert the energy from DC to AC and vice versa to
22 allow the stored energy to be utilized on an electrical grid or other electrical distribution

1 network. The container can be equipped with a system level Battery Management
2 System (BMS) for electrical control, a Heating Ventilation Air Conditioning (HVAC)
3 system, and a fire detection and suppression system. Interactions with power supply and
4 discharge systems occur via an external Power Conversion System and Energy
5 Management System. The units have doors for operating and maintenance personnel and
6 for installation and replacement of equipment. There can also be vents on the units to
7 facilitate cooling and the release of toxic and ignitable gases during abnormal conditions.

8 Utility scale containerized ESSs can be contained within standard ISO-
9 Containers. However, some manufactures use custom designed containers. The
10 container is typically rectangular, made of steel, and intended for the transport and
11 storage of materials without unloading the cargo. In large ESS facilities, there are often
12 multiple containers placed adjacent to each other. The number of ESS containers is
13 usually dependent on the power/energy demand of the facility. The greater the number of
14 containers and the closer their proximity to each other on an given site, the greater the
15 overall likelihood of a thermal runaway and fire event and resulting consequences.

16

17 **IV. Risk of Potential Emergency Events at Battery Energy**
18 **Storage Systems**

19 **A. Risks and Hazards Associated with BESS Installations.**

20 **Q. You've described for us the general components to a BESS installation. Are**
21 **there hazards associated with lithium-ion BESS installations?**

22 **A. Yes.**

1 **Q. Please elaborate on those hazards.**

2 A. Lithium-ion batteries' primary hazard is that there is a potential risk of thermal
3 runaway resulting in fire or explosion. Once started, lithium-ion battery fires have proven
4 difficult to extinguish and are known to produce dangerous gases. The National Fire
5 Protection Association ("NFPA") ESS Safety Fact Sheet identifies thermal runaway,
6 stranded energy, toxic and flammable gas generation and deep-seated fires as key hazards
7 associated with ESS installations.

8 **Q. Before we talk more about those risks, please tell us about the NFPA.**

9 A. The NFPA is a non-profit organization that, among other activities, creates and
10 publishes codes and standards for fire, electrical, and related hazards. Regulatory
11 authorities, experts and emergency responders among others typically use NFPA
12 standards with respect to such hazards.

13 **Q. What NFPA standard is relevant to this Facility?**

14 A. NFPA 855, *Standard for the Installation of Stationary Energy Storage Systems*,
15 2023 Edition, identifies the following hazards with respect to ESS installations: fire and
16 explosion, chemical (hazardous materials), electrical including stranded or stored energy,
17 and physical (burn, ruptured lines, projectiles). The hazards can vary by battery
18 technology and can also vary under normal operating conditions compared with
19 emergency and abnormal conditions.

20 **Q. What is "thermal runaway"?**

21 A. Thermal runaway is a term used for the rapid uncontrolled release of heat energy
22 from a battery cell. It is a condition when a battery creates more heat than it can

1 effectively dissipate. Thermal runaway in a single cell can result in a chain reaction that
2 heats up neighboring cells. As this process continues, it can result in a battery fire or
3 explosion. This thermal runaway can be the ignition source for larger battery fires.

4 **Q. Is thermal runaway of concern with this Facility?**

5 A. Yes.

6 **Q. Are there other unique hazards associated with BESS thermal runaway**
7 **events?**

8 A. Yes. The hazard concerns “stranded” or stored electrical energy. Stranded energy
9 is energy that can be accumulated and reserved for future use. As with most electrical
10 equipment, stranded energy in a BESS presents a shock hazard. But what is more
11 interesting and unique about BESS is that often, even after a thermal runaway event and
12 fire or explosion, there is still energy retained or stranded within the BESS.

13 That stranded energy presents both a significant challenge and hazard. Because
14 the BESS equipment including terminals are often damaged by a thermal runaway, fire,
15 or explosion, discharging that stranded energy can be difficult. That difficulty in turn
16 creates a number of hazards. First, it is hazardous to first responders and others who
17 perform firefighting and related emergency response services at such a BESS installation.
18 Second, the lingering, stranded energy can also cause reignition of the fire hours or even
19 days after an initial fire or explosion. In other words, even when a BESS fire is contained
20 and extinguished, it can unexpectedly reignite at a later time because of that stranded
21 energy.

22 **Q. Are these stranded energy hazards a concern with this Facility?**

1 A. Yes.

2 **Q. Are fire and explosions a concern with BESS installations?**

3 A. Yes. Fire and explosion hazards associated with lithium-ion BESS installations
4 are centered on the lithium-ion battery's flammable organic electrolyte and its highly
5 reactive electrodes. The high performance of lithium-ion batteries is attributed to the
6 unique combination of materials used, which under normal operating conditions does not
7 pose a problem. However, when lithium-ion batteries undergo a failure, the separation
8 layer is breached allowing the electrodes to react with the electrolyte, producing high
9 temperatures, pressures, and eventually resulting in a fire or explosion. The heat released
10 from lithium-ion battery fires can be significant, posing fire propagation hazards which
11 accumulate with subsequent failures.

12 Any one of several fault conditions, including electrical faults, overcharging, and
13 particulate/moisture contamination, can lead to an escalated temperature in one lithium-
14 ion cell, causing deterioration and eventual failure of the cell separator, with subsequent
15 electrolyte decomposition and elevated vapor pressure. This leads to a thermal runaway
16 venting in the cell that can then propagate to many other cells in an energy storage battery
17 module. The vented thermal runaway causes flammable gas to be emitted into the battery
18 enclosure, where the resulting flammable mixture can be ignited by hot module casings,
19 electrical connectors, or ejected sparks from the involved module.

20 **Q. What conditions can cause deterioration of the cell, leading to thermal**
21 **runaway?**

1 A. A lithium-ion battery can result in a fire due to electrical, mechanical or thermal
2 failures. Electrical failures consist of overcharge or over-discharge of the battery cells.
3 Mechanical failures consist of manufacturing defects, internal short circuit of the battery
4 system, or physical damage to the battery due to puncture, dent or tear. Other conditions
5 such as low ambient pressure, vibration, shock, corrosion, or impact can also initiate a
6 mechanical failure event within a lithium-ion battery. A lithium-ion battery can also
7 encounter a mechanical failure if a particle is inadvertently lodged into the cell during the
8 manufacturing process. A dendrite or “particle” in the cell can cause localized resistance
9 heating around the particle, which causes an internal short-circuit, and an increase in
10 internal temperature and pressure within the cell. Thermal failures include overheating or
11 internal localized heating. The batteries can become overheated by an external fire/heat
12 source or from ambient temperatures that exceed the battery’s thermal stability limits.
13 Both electrical and mechanical failures develop internal localized heating within a
14 lithium-ion battery which contributes to a thermal degradation of the cell as described
15 above.

16 All failure modes within lithium-ion batteries generate heat and stimulate further
17 thermally-driven chemical reactions within the cell until an ultimate failure point known
18 as thermal runaway is reached resulting in fire.

19 **Q. How do failure conditions cause thermal runaway?**

20 A. Fire can erupt in a lithium-ion battery once it undergoes one of the failure modes.
21 A thermal, electrical, or mechanical failure, or combination thereof, can lead to thermal
22 runaway. A lithium-ion battery goes into thermal runaway when the cell temperature

1 reaches a threshold that causes an uncontrollable rapid release of energy and
2 corresponding temperature rise resulting in a thermal event, such as a fire. The stability
3 of a lithium-ion cell is primarily dependent on temperature. The temperature of the cell is
4 determined based on the heat generation/dissipation rates. If the heat cannot be dissipated
5 linearly at an equivalent rate of generation, then the internal chemical reactions become
6 stimulated by the increasing temperature and induce the cells into thermal runaway.

7 Thermal runaway results in increased temperatures that can cause a rapid increase
8 in pressure within the battery. Under these conditions, the pressure initiates a violent
9 ejection of the flammable volatiles, resulting in a self-sustaining fire or explosion. As
10 combustion endures, the cells continue to swell and release bursts of flames. More
11 flames continue to be produced from the batteries with greater intensity and magnitude,
12 while gaseous products from the lithium-ion combustion reaction are emitted. Once a
13 lithium-ion battery within a BESS ignites, the other cells have the potential to overheat
14 and initiate propagating thermal runaway reactions between adjacent batteries, modules,
15 and racks within the BESS. During a propagating thermal runaway event, the energy
16 release is extremely hazardous and difficult to control, signifying the ultimate failure
17 point of a Li-ion BESS.

18 **Q. How do explosions result from failure conditions?**

19 A. There have been two types of explosions associated with BESS: flammable gas
20 explosions due to gases generated in battery thermal runaway events, and electrical arc
21 explosions, both of which can lead to structural failure of battery electrical enclosures and
22 significant injury. The thermal runaway gas explosion scenarios, which can be initiated

1 by various electrical faults, can be either prompt ignitions soon after a large flammable
2 gas mixture is formed, or delayed ignitions associated with late entry of air such as when
3 a door to a BESS enclosure is opened by first responders and/or loss of gaseous fire
4 suppression agent in the BESS enclosure if so equipped. The electrical explosions have
5 resulted from limited electrical protection to prevent high energy arcs within electrical
6 boxes associated with the BESS enclosure that are vulnerable to arc induced high
7 magnitude pressures and thermal loads.

8 **Q. Are there other hazards associated with BESS thermal runaway events?**

9 A. Yes. There are two other hazards I would like to address: (1) those associated
10 with toxic and flammable gases, and (2) those associated with “deep-seated” fires.

11 **Q. Please elaborate on the hazards associated with toxic and flammable gases.**

12 A. Toxic and flammable gases are generated and released when batteries undergo
13 thermal runaway and combustion. If the gases do not ignite before the lower explosive
14 limit is reached, an explosive atmosphere inside of the BESS room or container can be
15 created. Toxic and corrosive gases can also be produced and released as can oxidizing
16 gases which accelerate the combustion process.

17 During failure conditions such as thermal runaway, fire, and abnormal faults,
18 some BESS, in particular electrochemical lithium-ion batteries and capacitors, begin off-
19 gassing flammable and toxic gases, which can include mixtures of CO, H₂, ethylene,
20 methane, benzene, HF, HCl, and HCN. Among other things, these gases present an
21 explosion hazard that needs to be mitigated. Explosion control or venting can be provided
22 to mitigate this hazard.

1 **Q. What are the dangers and difficulties associated with deep-seated fires?**

2 A. A deep-seated fire can be described as a fire that is difficult to reach from a
3 firefighting perspective. BESS installations usually comprise of batteries that are housed
4 in a protective metal or plastic casing within larger cabinets. These layers of protection
5 help prevent damage to the batteries. But the same protection that can prevent damage
6 may also prevent water or other fire-fighting agents from reaching the seat of the fire.
7 Often, emergency responders will use water as a fire-fighting agent to dissipate the heat
8 associated with a BESS fire. The protective casing and structures associated with BESS,
9 however, means that it takes greater effort and larger amounts of water to effectively
10 reach the fire source and dissipate the heat generated from BESS fires. Cooling the
11 hottest part of the fire is often difficult because it is shielded from water discharge. That
12 difficulty can prolong the duration of a BESS fire. Furthermore, delayed thermal
13 runaways and reignition can occur hours or days after an initial event.

14 **Q. Are these toxic and flammable gas and deep-seated fire hazards potential**
15 **hazards that are associated with BESS installations?**

16 A. Yes.

17 **Q. How do emergency and abnormal conditions differ from normal operating**
18 **conditions?**

19 A. Hazards associated with BESS can vary by technology, but can also vary under
20 normal operating conditions, e.g. routine charging and discharging operations, compared
21 with emergency and abnormal conditions, e.g. thermal runaway. Under normal operating
22 conditions, fire and explosion hazards can be due to heat sources such as live parts that

1 can be in contact with combustible materials during service or maintenance, or to ignition
2 of combustible concentrations or ignitable fluids and solids that can occur as part of the
3 normal operation of ESS, such as hydrogen off-gassing from batteries with aqueous
4 electrolytes that are open to the atmosphere.

5 Under abnormal operating conditions, fires or explosions can be the direct result
6 of (i) the development of an ignitable atmosphere due to overheating and venting of
7 flammable gases in the presence of hot surfaces, live electrical equipment, or other
8 sources of ignition, (ii) short circuits and thermal runaway causing overheating of
9 electrical parts or ignitable plastic casings. As noted above thermal runaway can lead to a
10 cascade failure of several modules or racks, and extensive fire damage, and (iii) the
11 production of an oxidizing gas from a thermal runaway or other event which increases the
12 intensity of a fire.

13 **Q. Could you please comment on fire and explosion hazards during these**
14 **emergency or abnormal operating conditions that you just explained?**

15 A. Fire and explosion hazards differ during emergency or abnormal conditions due to
16 the overheating and venting of flammable gases from battery cells. If that venting occurs
17 near an overheated component—which serves as an ignition source—or another form of
18 ignition source, then there is the risk of a fire or explosion. A fire or explosion may occur
19 if concentrations of flammable gases—for example, hydrogen—are sufficient to create
20 combustible or flammable mixtures in the presence of those overheated BESS
21 components or other ignition sources.

22 **Q. Is this type of hazard of concern with this Facility?**

1 A. Yes.

2 **B. Examples of BESS Installation Risks and Hazards Resulting in**
3 **Actual Emergency Events.**

4 **Q. Are these hazards just theoretical or are you aware of actual incidents**
5 **involving these hazards and BESS installations?**

6 A. These hazards are not just theoretical. I am aware of a number of BESS
7 installations that have experienced incidents involving fires and explosions.

8 **Victoria Australia:** A fire of a Tesla Megapack BESS installation in Victoria,
9 Australia on July 30, 2021 spread to an adjacent BESS unit and required 150 fire fighters,
10 30 vehicles and 3-days to fully extinguish. Since the fire could not be truly extinguished,
11 the firefighters were limited to cooling the outside of the containers to stop the
12 spread/damage to adjacent containers.

13 **Surprise, Arizona:** Another BESS installation fire occurred on April 19, 2019 in
14 Surprise, Arizona, 28 miles northwest of Phoenix, AZ. This incident required the aid of a
15 HAZMAT team due to the presence of toxic gases emanating from the unit. An
16 explosion ensued when firefighters opened the unit door to extinguish the fire. The blast
17 wave pressures and velocities propelled the firefighters causing significant injuries. The
18 emerging jet flame from the energy storage unit (“ESU”), which was observed to be at
19 least 23 m in length and 6 m high, produced severe burn injuries. Four HAZMAT
20 firefighters were hospitalized, and several other firefighters needed HCN
21 decontamination and overnight monitoring in a hospital.

1 **Monterey, California:** More recently on Tuesday, September 20th, 2022 a Tesla
2 battery ESU at a utility site in Monterey County, California caught fire, triggering the
3 shutdown of the state’s scenic coastal highway and shelter-in-place warnings for local
4 residents. It’s not clear how the utility’s 182.5-megawatt Tesla battery ESU caught fire,
5 but the site had to be disconnected from the grid. The utility’s facility is located adjacent
6 to another 400-megawatt battery storage site, which has experienced two overheating
7 incidents in the past year that forced part of the system to shut down. A warning by
8 Monterey County officials asked residents to “Please shut your windows and turn off
9 your ventilation systems.” In a tweet from the Public Information for Monterey County
10 account, officials reported on the Megapack battery fire at the Elkhorn facility, saying,
11 “While the fire is considered fully controlled, smoke may still occur in the area for
12 several days.”

13 As these prior incidents demonstrate, fires at BESS installations can be extremely
14 difficult to extinguish. That is largely because of the battery chemistry and arrangement
15 of the installations, and the exothermic process involved. Indeed, in many cases,
16 emergency responders are simply unable to extinguish the fires, and, instead, must allow
17 each fire need to burn itself out. Significant amounts of water are often needed for fire
18 suppression operations and to cool adjacent structures so those additional structures do
19 not also ignite.

20 **Q. Could any or all of the above failure conditions be present at the proposed**
21 **Cranberry Point facility?**

1 A. Cranberry Point’s proposed facility comprises at least 82 Tesla Megapack 2 XL
2 enclosures, each potentially containing up to 24 AC battery modules, with potential for
3 addition of more enclosures up to 150 MW. See Cranberry Point Response to STPB
4 Information Request 1-47 and Exhibit STPB 2-1. Note that the number of proposed
5 enclosures and battery modules is inconsistent amongst the documents submitted.

6 As described in Part V below, the materials submitted lack sufficient and
7 necessary detail to properly assess the relevant hazards and proposed means of
8 mitigation. What can be determined is that in the unlikely event of a fire, explosion, or
9 thermal runaway event, the consequences could mirror those seen in Victoria, Phoenix
10 and Monterey County, and it is unclear if first responders will be properly equipped with
11 the resources and knowledge necessary to effectively and safely suppress such a fire and
12 control its related effects.

13 **V. Deficiencies in Emergency Response Planning to Address**
14 **and Mitigate Hazards**

15 **Q. Could you please briefly explain what you wish to accomplish in this Section**
16 **of your testimony?**

17 A. In the prior two Sections of my testimony, I explained the basics of how BESS
18 installations work and the potential hazards and risks associated with BESS installations.
19 In this Section, and with that background and foundation, I provide my opinions about
20 Cranberry Point’s proposed emergency response planning for this Facility.

21 **Q. How does one address the risk of fire at BESS installations?**

1 A. Fire is generally a rare event. But as we all know, fires do occur. When a fire does
2 occur, its impact can be devastating from a life safety, property protection, mission
3 continuity, community livelihood and environmental perspective.

4 We must therefore design facilities to account for that risk of fire and we must
5 plan for it. Numerous regulations are adopted to address unwanted fire and its effects on
6 our society that address both fire prevention (minimize likelihood of ignition) and fire
7 protection (manage impact of fire once ignition has occurred). Fire prevention and fire
8 protection measures address design features built into an installation and operational
9 aspects such as pre-incident planning, emergency response and training. To account for
10 uncertainty in operational effectiveness and potential safety system failure, fire
11 regulations include a certain level of redundancy in their provisions and the use of
12 specially evaluated equipment and systems.

13 As I have already testified, BESS installations introduce a risk of fire with real
14 world examples of that risk resulting in an actual fire. With respect to BESS, more robust
15 measures are necessary based on our real-world experience that these fires can and do
16 occur, and when they happen they can be significant, sustained events. In particular, in
17 my opinion, robust design and emergency planning and training are necessary for any
18 BESS installation. Such design, planning and training is informed by a hazard mitigation
19 analysis (“HMA”).

20 **Q. What is an HMA?**

21 A. An HMA is an evaluation of potential BESS failure modes and the safety-related
22 consequences attributed to the failures. An HMA is a tool to inform more robust designs,

1 equipment, and emergency operations plans, or “EOP”. An HMA would characterize the
2 potential hazards and their likelihood of occurring in an explicit and quantifiable manner.

3 **Q. What is an EOP?**

4 A. A document that identifies and sufficiently characterizes potential emergency
5 events at a facility or location, and provides detailed information (strategies, tactics,
6 procedures, equipment, etc.) to be employed by responding personnel. The EOP along
7 with an associated comprehensive training program is a key resource used by responding
8 personnel in effectively managing incidents and events for the protection of occupants,
9 first responders, property, the environment, and other assets at risk.

10 **Q. What is an Emergency Response Plan (“ERP”)?**

11 A. Depending upon its contents and intent for a given project an ERP can serve to
12 satisfy a portion of or the entirety of an EOP. NFPA 855 identifies details of an ERP and
13 calls for the following contents: introduction (purpose, limitations, facility description,
14 plan review and revision), emergency response management (overall organization, roles
15 and responsibilities, preparation and planning for emergencies, communications, operator
16 safety and equipment, safety training), emergency response (discovery, initial
17 response/notification procedures, sustained actions, post-emergency reporting
18 procedures), fire incidents (conditions associated with ESS, response to a fire incident,
19 employee training and education, site maintenance and housekeeping), medical
20 emergency, security incidents, severe weather, and cybersecurity.

21

1 **C. NFPA 855’s Requirements for This Facility.**

2 **Q. Is there a specific standard that governs these aspects of planning and**
3 **mitigating the risks of fire at BESS installations?**

4 A. Yes. NFPA 855 is a key regulatory document addressing the design, construction,
5 installation, commissioning, operation, maintenance, and decommissioning of stationary
6 energy storage systems, and the storage of lithium metal or lithium-ion batteries. The
7 most current version of NFPA 855 is the 2023 edition.

8 **Q. How does NFPA 855 apply to this Facility?**

9 A. For the Facility at Cranberry Point, NFPA 855 requires a HMA, emergency
10 planning and training, and an EOP. The HMA is to be provided to the Authority Having
11 Jurisdiction (AHJ) for review and approval. Details on emergency planning and training
12 are to be provided by the owner of the BESS or their authorized representative so that
13 BESS facility operations and maintenance personnel and emergency responders can
14 address foreseeable hazards associated with the on-site systems. NFPA 855 provides
15 specific details on the information to be addressed and included by an HMA and ERP.

16 **Q. What does NFPA 855 specifically require for an EOP for this Facility?**

17 A. As required by NFPA 855, the EOP must include the following:

- 18 1. Procedures for safe shutdown, de-energizing, or isolation of equipment and
19 systems under emergency conditions to reduce the risk of fire, electric shock, and
20 personal injuries, and for safe start-up following cessation of emergency
21 conditions;

- 1 2. Procedures for inspection and testing of associated alarms, interlocks, and
- 2 controls;
- 3 3. Procedures to be followed in response to notifications of system alarms or out-of-
- 4 range conditions that could signify potentially dangerous conditions, including
- 5 shutting down equipment, summoning service or repair personnel, and providing
- 6 agreed-upon notification to fire department personnel, if required;
- 7 4. Emergency procedures to be followed in case of fire, explosion, release of liquids
- 8 or vapors, damage to critical moving parts, or other potentially dangerous
- 9 conditions;
- 10 5. Response considerations similar to a safety data sheet (SDS) that will address
- 11 response safety concerns and extinguishment when an SDS is not required;
- 12 6. Procedures for dealing with ESS equipment damaged in a fire or other emergency
- 13 event, including contact information for personnel qualified to safely remove
- 14 damaged ESS equipment from the facility;
- 15 7. Other procedures as determined necessary by the AHJ to provide for the safety of
- 16 occupants and emergency responders; and
- 17 8. Procedures and schedules for conducting drills of these procedures.

18 **Q. Does NFPA 855 require anything else with respect to this Facility?**

19 A. NFPA 855 additionally requires fire and explosion testing to be conducted on a

20 representative BESS in accordance with UL 9540A or equivalent test standard.

21 UL9540A determines the capability of a battery to go into a thermal runaway condition

22 and then evaluates the fire and explosion hazard characteristics. This is not a pass-fail

1 test. It is an evaluation that should be used to determine criteria such as spacing between
2 the systems, fire protection, ventilation, etc. The report is to be provided to a qualified
3 person, such as a fire protection engineer, to provide such criteria. As noted on the UL
4 website: "As a test method, UL 9540A testing does not provide a certification, UL Mark,
5 or pass/fail results," said Maurice Johnson, business development engineer with UL's
6 Energy Systems and e-Mobility group." The information from UL 9540A testing
7 supports important safety decisions about how the BESS will be installed and used. The
8 best way for manufacturers to share that their energy storage battery products have been
9 tested for thermal runaway is to list them in the UL 9540A test database."

10 **D. Cranberry Point's Draft ERP and Other Submissions Do Not**
11 **Satisfy NFPA 855 Requirements And Are Otherwise Inadequate**
12 **to Address and Mitigate the Facility's Potential Risks and**
13 **Hazards.**

14 **Q. Have you reviewed Cranberry Point's submissions for this Facility in**
15 **relation to NFPA 855?**

16 A. Yes.

17 **Q. In your opinion, do those submissions satisfy NFPA 855's requirements?**

18 A. No.

19 **Q. Why not?**

20 A. To date, only a draft ERP dated 3 August 2021 ("CP ERP") has been submitted to
21 address fire safety related concerns. In my review, I did not see that Cranberry Point has
22 submitted an HMA. Moreover, in my opinion, the CP ERP does not contain the required
23 content or detail necessary to satisfy NFPA 855's requirements.

1 **Q. In your opinion, what are the deficiencies with the CP ERP?**

2 A. The CP ERP speaks to some of the information to be addressed as required by
3 NFPA 855, as listed above, but it is incomplete and lacks sufficient detail to effectively
4 assess the related hazards and means of effective mitigation. Additionally, the CP ERP
5 lacks details on necessary procedures, resources and training for Fire Department and
6 other emergency responder personnel.

7 **Q. Can you elaborate on those deficiencies?**

8 A. Yes. I believe the easiest way to address them is to progress through the document
9 in the order I see them.

10 **Section 4 (System Specific Fire Protection & Safety Controls):**

11 **Section 4.1 (Condition Monitoring & Alarming):** Statements in the CP ERP are
12 made that "...risk of fire or explosion exists." (See section 4.1.) These risks are not
13 identified or quantified. The completion of an HMA would identify and quantify these
14 risks. As I testified, an HMA is required for exactly that reason. The absence of an HMA
15 from Cranberry Point's submission is therefore problematic.

16 **Section 4.2 (Considerations for Incidents and Emergencies)**

17 **Section 4.2.2.1 (Thermal Runaway/Fire):** Statements in the CP ERP
18 indicate that testing for the Tesla Megapack has shown that a propagating thermal
19 runaway event due to internal causes is very unlikely. But no specific test reference is
20 provided. A unit level UL 9540A test report has been submitted on September 22, 2022.
21 It is unclear if this is the test report on which the CP ERP relies, or if the test report
22 addresses the specific Tesla Megapack's proposed for installation in Carver.

1 In any event, this report addresses one scenario of a thermal runaway event and
2 does not include cell level and module level testing. Accordingly, the following necessary
3 details are absent: (1) the methodology required to initiate thermal runaway for testing;
4 (2) gas composition, volume and explosibility parameters; (3) number of initiating cells
5 required for propagation of thermal runaway; and (4) heat, smoke and flammable gas
6 release rates and total release quantity.

7 The UL 9540A report that Cranberry Point submitted also only addresses one
8 failure mode of a thermal runaway event. An HMA—which should have been prepared
9 but has not been submitted in this proceeding—would address other possible failure
10 modes and how they are to be mitigated. There can be no doubt that other failure modes
11 are possible because the CP ERP acknowledges other failure modes: “External factors,
12 including a large impact that damages many cells at once or a pro-longed exposure to an
13 intense external fire, could create a propagating thermal runaway event that may spread
14 throughout the entire enclosure.” However, only a vague reference to a means of
15 mitigation is provided with the following statement: “In such a case, it is likely that all
16 battery modules will consume themselves. In the event of a fire, the design approach is
17 for the Megapack contents to be fully consumed based upon data from UL 9540A
18 installation level tests.” No test reports supporting this statement have been provided.

19 Beyond those deficiencies, the ERP also states that if a propagating thermal
20 runaway occurs “all faults are monitored passively by the Tesla computer system which
21 then will be relayed to the Network Operations Center (NOC) that will review and act
22 accordingly.” The ERP is silent, however, with respect to any meaningful details and

1 procedures about how this will happen. Cranberry Point provides no details with respect
2 to what it means to operate accordingly or the location of the NOC.

3 Additionally, the ERP places the decision on application of manual firefighting
4 operations on the incident commander. But the ERP does not provide sufficient guidance
5 to the incident commander on the need for the application of external suppression, in
6 what manner and in what quantity. (“[T]he decision to apply external suppression to the
7 troubled enclosure and adjacent units is ultimately at the discretion of the incident
8 commander.”) An HMA would identify these specific hazards and the means of
9 mitigation including necessary procedures, equipment and quantity and delivery of water.
10 Training of fire department personnel would also be expected. None of this detail,
11 however, is provided in the ERP or elsewhere.

12 **Section 4.2.2.2 (Explosion/Deflagration Control):** The CP ERP refers to
13 explosion and deflagration hazards and the use of over-pressure vents and a proprietary
14 sparker system to prevent a dangerous buildup of gases within the enclosure of
15 combusting flammable off-gases during a runaway event. Where explosion hazards
16 exist, NFPA 855 requires an explosion prevention system designed, installed, operated,
17 maintained, and tested in accordance with NFPA 69, or deflagration venting installed and
18 maintained in accordance with NFPA 68. Explosion prevention and deflagration venting
19 are not required where approved by the AHJ based on fire and explosion testing, and a
20 deflagration hazard study demonstrating that flammable gas concentrations cannot
21 exceed 25 percent of the lower flammable limit (“LFL”). Such approval and
22 documentation of a study documenting data on gas composition and release rates has not

1 been submitted. Additionally, no information or test reports are referenced validating the
2 effective and long-term performance of the vents and proprietary sparker system
3 including its activation (such as use of gas detection) and maintenance.

4 The CP ERP also states that “Emergency responders and others may observe a
5 continual sparking within cabinets at certain locations. This is a normal operational
6 feature of the unit, *i.e.*, the ‘sparker system’, which is part of the automatic safety system
7 to prevent a dangerous build-up of gases within the enclosure.” No details on fire
8 department training and operational tactics on this proprietary system are provided.

9 **Section 5 (Potential Hazards):**

10 Section 5 of the CP ERP addresses risks posed by lithium-ion battery failures.
11 Electric shock, arc flash, fire, explosion, and the by-product from off-gassing are noted.
12 The ERP specifically states that “During failure, a lithium-ion battery may emit tens to
13 hundreds of liters of off gas, and larger failures may emit thousands of liters of gas.”
14 While these risks are noted in a generic manner, no details specific to the Facility
15 installation are provided and quantified. An HMA would identify and quantify the
16 specific risks for the installation under consideration.¹ I have already testified to the
17 absence of an HMA from the materials I have reviewed.

¹ The CP ERP does acknowledge specific hazards through the following statements. BESS electrical equipment: “There are disconnects that will de-energize select parts of the system, but the batteries themselves will remain energized.” BESS battery fire: “Battery fires present unique hazards, including stranded energy and re-ignition risk.” BESS off-gassing: “Lithium-ion batteries release flammable and toxic chemicals when subjected to electrical or physical damage, including fire. Chemicals released can also pose an inhalation hazard.”

1 With certain hazards, the CP ERP requires action by first responders. But the CP
2 ERP does not provide guidance about what action is required. For example, for BESS
3 explosion/deflagration hazards, the CP ERP states that “responders should be aware that
4 unexpected situations may arise and a safe standoff distance from the troubled enclosure
5 is recommended.” This statement provides no actual guidance about what the actual
6 “safe standoff distance” would be in the event of an “unexpected situation.”

7 With respect to water run-off the CP ERP states that “Water run-off could be
8 considered contaminated, and all efforts should be taken to minimize unnecessary
9 firefighting water contamination of the surrounding environment. Robust drainage and
10 water run-off features are included in the design of the facility to capture credible worst
11 case water discharge.” The CP ERP refers to water quality treatment and control of peak
12 discharge from 2-year and 10-year storms, but no correlation to necessary water flows for
13 firefighting purposes has been submitted. In fact, there is no discussion as to the quantity
14 and flow rate of firefighting water needed. An HMA would be address this.

15 **Section 6 (Potential Site-Specific Hazards):**

16 Section 6 of the CP ERP addresses potential site-specific hazards. These include
17 residential exposures; electrical substation; adjacent buildings and structures; wetland and
18 cranberry bogs; and surrounding wooded area. For these hazards, statements are made to
19 the effect that the risks are “minimal” or “are not expected to pose a risk”. No
20 justification is made for these statements and no detail or analysis is provided to support
21 those statements.

1 Other statements refer to “requisite protective measures, including standoff
2 distances”, “other precautions”, and “should be monitored and cooled should it be
3 necessary” without providing sufficient guidance or other qualifying information.
4 Specific detail is to be provided considering the uniqueness of BESS risks as noted in
5 section 5 of the CP ERP.

6 **Section 7 (Required Personal Protective Equipment):**

7 Section 7 of the CP ERP addresses required personal protective equipment. The
8 statement “if no fire or explosion risk is present” is made. No detail is provided as to
9 how such risks in this context are to be identified and assessed by first responders, in
10 relation to developing their own policies and procedures with respect to personal
11 protective equipment.

12 **Section 8 (Emergency Response Recommendations):**

13 Section 8 of the CP ERP addresses emergency response recommendations which
14 call for an initial scene assessment to be conducted and conveyed to incoming
15 responders. No details are provided as to how the assessment is to be conducted with
16 respect to site specific ESS hazards and by whom. A HMA would address this.

17 **Section 9 (Specific Recommendations by Type of Emergency):**

18 Section 9 of the CP ERP addresses specific recommendations by type of
19 emergency. These emergencies include fire, deflagration/explosion, electric shock, arc
20 flash, chemical release and drainage and water run-off.

21 Overall, the hazards are described in a generic fashion lacking detailed assessment
22 and quantification. Specific countermeasures to adequately address the hazards are also

1 presented in a generic fashion without sufficient justification supporting their
2 effectiveness provided. Various warnings about the hazards are presented but without
3 detailed strategies, procedures and tactics for mitigating them.

4 Statements such as “a safe stand-off distance”, “extinguish the fire only if
5 imminent threat to life safety exists”, “allow the BESS to burn in a controlled fashion”, “
6 protect exposures as needed and let the unit burn itself out”, “utilizing water to cool and
7 protect adjacent exposures and mitigate the spread of fire”, and “considerable stored
8 energy in the batteries that poses a potential electric shock hazard” are made. However,
9 no detail is provided as to how fire responders are to effectively plan, prepare and act on
10 these statements and warnings.

11 The CP ERP states that “Chemicals released during a fire or explosion will be in a
12 gaseous form and primarily pose an inhalation hazard. A fog pattern from a handline or
13 monitor nozzle may be an effective way to control the off-gassing event on the exterior of
14 the battery container from migrating to unwanted areas. However, if water is used in
15 extinguishing flames, these gases can become acids which may cause skin irritation.
16 Water curtains or hose streams may be applied to adjacent exposures for cooling
17 purposes. If any indicators are present of damage or heat to an adjacent system, the BMS
18 data shall be closely monitored for the adjacent system and relayed to the appropriate
19 individual within the Incident Command System. Following partial or complete
20 consumption of the system by fire, batteries may continue to emit low levels of
21 flammable gases and dangerous levels of toxic gases for an extended period of time. The
22 risk of battery re-ignition and/or secondary ignition remains present for hours or even

1 days after the smoke/flame was initially detected. Even if a lithium-ion battery fire has
2 been extinguished, there is still a risk of re-ignition.” No detail is provided as to how fire
3 responders are to effectively plan, prepare and act on these statements and warnings.

4 **Section 10 (System Specific Fire Protection & Safety Controls):**

5 Section 10 of the CP ERP addresses system specific fire protection and safety
6 controls. Much of this section remains a work in progress with many details to be
7 determined as noted in the ERP.

8 **Appendix A:**

9 Appendix A of the CP ERP addresses Safety Data Sheets. None have been
10 provided.

11 **Appendix D:**

12 Appendix D of the CP ERP addresses subject matter expert (SME) incident
13 response. The term “qualified SME” is used but no details are provided as to how such
14 qualifications are determined and verified. The term “certain thresholds” is used with
15 respect to remote monitoring and notification. No details are provided as what the
16 thresholds are and what is specifically being monitored. Upon notification, the SME is to
17 respond to the scene “within time frames acceptable to the local fire department.”
18 Information is lacking as to how the fire department is to establish this time frame. The
19 SME is to “provide guidance based on available data and expertise on how to contain the
20 fire or event.” The guidance referred to needs to be established for various scenarios as
21 determined through the HVA and coordinated with the fire department prior to any actual
22 events. Additionally, a training program on any response and tactics should be

1 completed and routinely drilled. Procedures for scene coordination and system
2 restoration need to be established, documented and approved by the fire department.

3 **E. Cranberry Point's ERP and Related Submissions Are Insufficient**
4 **to Show that Cranberry Point Has Engaged in Sufficient**
5 **Emergency Management and Other Planning for this Facility.**

6 **Q. What are the risks to emergency response personnel posed by the failure of**
7 **Cranberry Point to meet the requirements of NFPA 855 described above?**

8 A. Without a HMA and comprehensive emergency and training planning completed
9 as required by NFPA 855, the risks to fire fighters along with any mitigating measures
10 cannot be properly assessed.

11 As previously described, a key concern with lithium-ion chemistries is significant
12 generation of heat and venting of flammable gases that typically include a high
13 concentration of CO and CO₂. As the flammable gases vent, they may ignite and cause
14 jetting flames. If the gases do not ignite during venting, then an explosion hazard can
15 develop if the gases accumulate in an enclosed space like a BESS enclosure. These
16 potential fire, explosion, and toxicity hazards seriously jeopardize firefighter safety
17 unless a detailed EOP and training program based on an HMA is developed and approved
18 by the fire department.

19 When batteries are in thermal runaway, the electrical discharge from short
20 circuiting can cause localized Joule heating which may develop temperatures exceeding
21 flaming combustion. Flammable lithium-ion battery vent gases consist of hydrogen,
22 carbon monoxide, and hydrocarbons. Other battery materials such as plastics are also

1 involved. What complicates the fire response is that flaming fires are not needed to
2 perpetuate thermal runaways. The thermal runaways can continue independent of
3 burning and continue to produce flammable gases which can pose respiratory and
4 explosion hazards. A specific fire service concern which is not the case for typical
5 structure fires is that some lithium-ion batteries may release hydrogen fluoride in a
6 gaseous form due to the breakdown of fluoride compounds in the electrolyte. Exposure
7 to hydrogen fluoride is a respiratory hazard and there is also concern about its effects on
8 firefighter personal protective equipment.

9 Unlike a typical electrical or gas utility, a BESS installation does not have a single
10 point of disconnect. There are disconnects that will deenergize select parts of the system,
11 but batteries will typically remain energized. As previously discussed, stranded energy
12 within the batteries poses an electrical shock hazard to firefighters. When any battery fire
13 is extinguished, there is still stranded energy within the unaffected cells that will need to
14 be properly handled to reduce the risk of an additional fire or electrical shock hazard.

15 Firefighters need to be trained to understand and properly respond to the
16 associated BESS hazards of thermal runaway, thermal runaway propagation,
17 fire/explosion, toxic gas release and stranded energy. Otherwise, firefighters are placed
18 at great personal risk when responding to BESS incidents.

19 **VI. Conclusion**

20 **Q. Does this conclude your direct testimony?**

- 1 A. Yes, but I reserve the right to supplement this testimony if any additional
- 2 information becomes available due to later-filed discovery responses or other materials

Affidavit of Milosh T. Puchovsky

I, Milosh T. Puchovsky, affirm under the pains and penalties of perjury that:

1. I am testifying on behalf of the Intervenor, Save the Pine Barrens, in the Energy Facilities Siting Board's proceeding docketed as number EFSB21-02;
2. This prefiled testimony was prepared by me or at my direction, under my supervision and control; and
3. The information contained in this prefiled testimony is true and accurate to the best of my knowledge and belief at the time I signed this affidavit.
4. My analysis and conclusions are stated with a reasonable degree of scientific and engineering certainty.

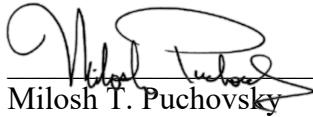

Milosh T. Puchovsky

EXHIBIT A

Milosh T. Puchovsky, PE, FSFPE

Professor: Fire Protection Engineer

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Professional Experience Summary

As WPI's only Professor of Practice in Fire Protection Engineering, Milosh is engaged in a wide range of industry activities bringing his unique experience and perspective to the modern-day classroom. He leads and advises research projects, develops and instructs numerous educational programs, and consults on a variety of fire safety subjects. He chairs and serves on numerous technical committees and panels responsible for the development and revision of fire safety regulations, design methods and industry standards.

Milosh is a registered professional engineer possessing over 30 years of experience with (a) fire protection, suppression and detection systems including sprinklers, standpipes, fire pumps, water supplies, clean and gaseous agents and foam; (b) design, installation and inspection standards such as NFPA 13, 14, 20, 25, 72 and 101, (c) means of egress & occupant response; and (d) building codes, fire regulations and testing procedures; and (e) fire hazard analysis including that of lithium ion battery Energy Storage Systems and (f) the application of computer fire models and third party reviews.

Through his professional practice, Milosh provides analysis and litigation support specific to fire and life safety system design, installation, and performance. He authors and reviews technical publications, speaks at industry conferences, and serves prominent roles with the National Fire Protection Association (NFPA), Society of Fire Protection Engineers (SFPE), Fire Protection Research Foundation (FPRF) and Underwriter's Laboratories (UL).

As Standards Council Secretary and Assistant Vice President at NFPA, Milosh oversaw the technical and procedural development of all NFPA codes and standards. He also led NFPA's performance-based codes initiative facilitating the greater application of engineering methods in fire safety design. Milosh worked in the insurance industry evaluating fire risks and protection systems, and as an engineering consultant designing systems, specifying products, and developing fire safety strategies.

Milosh is Past President and Fellow of SFPE, a member of the Society's Engineering Licensing Committee and technical editor for Systems Chapters of the Handbook of Fire Protection Engineering. He is also a principal member of the UL Fire Council that advises UL on its product test standards and fire safety initiatives. Milosh holds two engineering degrees, and an engineering license in Fire Protection.

Skills and Qualifications Highlights

- Full-time professor and subject matter expert teaching, researching, and advising
- Litigation support providing expert analysis and testimony for fire loss, system malfunction and patent dispute
- Fire protection system design and performance evaluation
- Building and fire code development and consultation
- Calculation of fire behavior and effects using computer models and numerical techniques
- Occupant egress analysis including timed egress studies
- 3rd party design and code compliance reviews
- Standardized fire testing protocols and procedures
- Insurance loss control services and inspections
- Technical program development and delivery in traditional and virtual formats
- Engineering project management for domestic and international projects
- Business development including engaging prospective clients, writing proposals and marketing services
- Professional society leadership & strategic planning
- Author, editor and technical reviewer for key industry publications

Puchovsky Curriculum Vitae

Employment History

Worcester Polytechnic Institute, Department of Fire Protection Engineering, Worcester, MA

2017 – Present Associate Department Head, and Principal Industry Liaison
2008 – Present Professor of Practice, and Director of Corporate & Professional Education
2003 – 2007 Adjunct Associate Professor

Milosh Puchovsky & Associates, LLC, Mendon, MA

2008 - Present, Principal

National Fire Protection Association, Quincy, MA

2007- 2008 Assistant Vice President – Codes & Standards Administration; Standards Council Secretary
2003 – 2007 Principal Fire Protection Engineer – Building and Life Safety Codes
1993 – Present Principal Instructor – NFPA Technical Fire Safety Seminars

Arup, (Ove Arup & Partners Massachusetts Inc.) Cambridge, MA

2001 – 2003 Senior Consulting Fire Engineer

National Fire Protection Association, Quincy, MA

2000-2001 Director, Codes and Standards Development – Standard Administration
1996-2000 Senior Fire Protection Engineer - Systems and Applications Engineering
1993-1996 Fire Protection Engineer – Systems and Applications Engineering

Chubb Group of Insurance Companies, Boston, MA

1992-1993 Risk Engineer

Foehl Sherman, Inc. Burlington, Ma

1991 Consulting Fire Protection Engineer and Building Code Consultant

Rolf Jensen and Associates, Inc. Concord, CA (Fire Protection Engineering Consulting Firm)

1988-1989 Fire Protection Engineer & Building Code Consultant

Education

- M.S. (Fire Protection Engineering) Worcester Polytechnic Institute, Worcester, MA, 1991
- B.S. (Mechanical Engineering) Worcester Polytechnic Institute, Worcester, MA, 1988

Registration

Registered Professional Engineer (Fire Protection), Massachusetts (License number 38530)

Professional Affiliations

National Fire Protection Association
Society of Fire Protection Engineers
Underwriters Laboratories

Honors

Fellow – SFPE (2008); Hats Off Award – SFPE (2015); Faculty Achievement Award – WPI (2016, 2020)

Puchovsky Curriculum Vitae

Teaching, Training and Course Development Responsibilities

WPI Department of Fire Protection Engineering - Graduate Engineering Courses (responsible for development and delivery; traditional face-to-face, virtual and blended delivery methods)

- FP 553 – Fire Protection Systems – Students who complete FP 553 will have developed a practical technical understanding of design principles for automatically activated fire protection systems including sprinkler, standpipe, fire pump and water supply. Relevant physical phenomena, functionality and purpose of these systems are introduced, as are associated calculation and assessment techniques, regulations, equipment requirements, and product approval evaluations. (Co-instructed prior to full time appointment at WPI in 2008)
- FP 554 – Advanced Fire Suppression – Students who complete FP 554 will have developed a practical technical understanding of the purpose and design principles for water spray, water mist, residential sprinkler, clean agent, halon, carbon dioxide, foam, and wet chemical fire suppression systems and devices. Structural support and bracing of fire suppression systems are also introduced.
- FP 555 – Detection, Alarm and Smoke Control - Students who complete FP 555 will have developed a practical technical understanding of design principles for: (a) fire detection systems using flame, heat and smoke detector technology, (b) fire alarm, occupant notification and control systems, and (c) smoke control systems based on buoyancy and pressure differences across barriers for the purpose of occupant survivability.
- FP 570 – Building Fire Safety – Students who complete FPE 570 will have developed a practical technical understanding of the building design process and the roles of project stakeholders in addressing fire and life safety concerns principally through the application of building regulations, standards of practice, construction features, passive and active systems, means of egress, fire test methods, and the use of interior finish materials.
- FP 571 – Performance Based Design – Students who complete FPE 571 will have developed a practical technical understanding of the differences between applying traditional code mandated prescribed fire protection, and the need for implementing computer models and other calculation techniques in developing and assessing solutions for specific fire safety concerns. (Co-instructed prior to full time appointment at WPI in 2008)
- FP 580B – Business Practices in Fire Protection Engineering – This course introduces and strengthens business concepts, skills and services associated with fire protection engineering. Students learn how technical and engineering skills need to be blended into a professional business practice environment. Students develop an understanding of financial considerations, managerial responsibilities and the soft skills necessary for successful engineering and research operations. Students monetize services and products, prepare business plans, identify customers, and develop technical and cost proposals, workflow timelines, project budgets, invoice and cash flow models, and professional quality technical reports. Written and oral communication skills are advanced. Executives from the FPE industry will provide guest lectures and insight on key topics.

WPI Department of Fire Protection Engineering - Undergraduate Engineering Courses

- FP 3070 – Fundamentals of Fire Safety – Guest lecturer
- FP 3080 – Introduction to Building Fire Safety System Design – Content development and lead instructor

Northeastern University - Industry Related Seminars (traditional face-to-face program, 1995 - 2002)

- Professional Engineering Exam Preparation Course for Fire Protection Engineering

NFPA – Industry Related Seminars (traditional face-to-face programs, 1993 – present)

- Installation of Sprinkler Systems (NFPA 13)
- Inspection, Maintenance and Testing of Water-Based Fire Protection Systems (NFPA 25)
- Fire Pumps (NFPA 20)
- Sprinkler System Hydraulics
- Automatic Sprinkler Systems & Fire Alarm Systems Plans Review
- Life Safety Code Essentials, Life Safety Code for Health Care, Plans Review (NFPA 101)
- Health Care Facilities (NFPA 99)
- National Fire Alarm & Signaling Code (NFPA 72)
- Special Suppression Systems (NFPA 11, NFPA 12, NFPA 15, NFPA 17, NFPA 17A, NFPA 750, NFPA 2001, and NFPA 2010)
- Code Requirements for Maintaining Fire & Life Safety Systems
- Smoke Control Systems (NFPA 92)
- Fixed Guideway Transit & Passenger Rail Systems (NFPA 130)

Puchovsky Curriculum Vitae

Technical Committees, Panels and Boards

NFPA TC on Fire Pumps (NFPA 20) – Chair, 2018 – Present; Member 2001-2003, 2009-2018; Staff Liaison, 1996-2001

NFPA TC on Sprinkler System Discharge Criteria (NFPA 13) – Member, 2001-2003, 2014 – Present; Staff Liaison, 1996-2000

NFPA TC on Safety to Life Fundamentals (NFPA 101, NFPA 5000) – Member, 2001-2003, 2009 - Present

NFPA TC on Residential Sprinkler Systems (NFPA 13D & 13R) - Member, 2010 – Present; Staff Liaison, 1996 -2000;

SFPE: President 2016; Board of Directors 2017-2007; Strategic Planning Committee Chair, 2014

Underwriters Laboratories Fire Council – Member, 2010 – Present

UL Standards Technical Panel 199 – Sprinkler Equipment for Fire Protection – Member, 2015 - Present

SFPE Professional Engineering Exam Licensing Committee – Member, 2003 - Present

FPRF Technical Panel on Fire Risk Terminology – Member, 2019

FPRF Technical Panel on Oxygen Reduction Systems for Warehouse Storage Applications – Member, 2018

SFPE Executive Director Search Committee – Member, 2008 – 2009

NFPA TC on Commissioning & Integrated Testing (NFPA 3 & NFPA 4), Member 2011 - Present

NFPA Technical Committee on Water Mist Systems (NFPA 750) - Member 2009 – Present; Staff Liaison, 1994 - 1997

NFPA TC on Cultural Resources (NFPA 909, 914) - Member 2009 – present; Staff Liaison, 2003 - 2007

NFPA TC on Contents & Furnishings (NFPA 101 & NFPA 5000) -Member 2010 – Present; Staff Liaison, 2003 – 2007

NFPA TC on Health Care Facilities – Fundamentals (NFPA 99) – Member 2014 - Present

FPRF Technical Advisory Panel on Residential Sprinkler Systems – 2008 - 2009

NFPA Standards Council – Secretary, 2007 - 2008

FPRF Research Advisory Panel – Member, 2007 – 2008

ANSI Executive Standards Council – Member, 2007 - 2008

FPRF Technical Advisory Panel on Risk Methods – Member, 2006 – 2007

FPRF Technical Advisory Panel on Evacuation of High-Rise Occupants – Member, 2006 - 2007

NFPA High-Rise Building Safety Advisory Committee – Secretary, 2004 – 2007

NFPA TC on Fire Risk Assessment Methods (NFPA 550, NFPA 551) Staff Liaison, 1999-2001, 2003-2007

NFPA TC on Industrial and Storage Occupancies (NFPA 101 and NFPA 5000) Staff Liaison, 2003 – 2007

NFPA TC on Fire Safety Features (NFPA 101 and NFPA 5000) - Staff Liaison, 2003 – 2007

NFPA TC on Mercantile and Business Occupancies (NFPA 101 and NFPA 5000) - Staff Liaison, 2003 – 2007

NFPA TC on Smoke Control Systems (NFPA 92, NFPA 204) - Staff Liaison, 2003 – 2007

NFPA TC on Fire Doors (NFPA 80, NFPA 105) - Staff Liaison, 2003 – 2007

NFPA In-house Task Group on Performance-Based Codes – Chair, 1993 – 2001, 2003 – 2007

NFPA In-house Resource Team on Homeland Security and Critical Infrastructure – Member, 2005 - 2008

SFPE Task Group on Performance-Based Design and Analysis – Member 2003 – Present

Puchovsky Curriculum Vitae

TC on Hazards and Risk of Contents and Furnishings (NFPA 555, NFPA 556, NFPA 557) - Staff Liaison, 2003 – 2007

Inter-jurisdictional Regulatory Collaboration Committee (International Performance-Based Building Codes) - Member, 2003 – 2007

NFPA TC on Fire Tests (30 fire test standards) - Staff Liaison, 2003 – 2005

NFPA TC on Manufactured Housing (NFPA 225, NFPA 501, NFPA 501A) – Staff Liaison, 2003 - 2005

NFPA TC on Automatic Sprinkler Systems (NFPA 13, NFPA 13D, NFPA 13R) Staff Liaison, 1996 -2000, Principle Member, 2001-2003

SFPE Design Team Liaison Task Group – Member, 1999 - 2003

NFPA TC on General Storage (NFPA 231, 231, NFPA 231D, NFPA 231E, NFPA 231F, NFPA 46) Staff Liaison, 1993-2000

ISO TC 21/SC5 – Sprinkler and Water Spray Extinguishing Systems – Secretary, 1996 – 2001

NFPA TC on Standpipe Systems (NFPA 14) Staff Liaison, 1993-1997

NFPA TC on Private Water Supply Piping (NFPA 24, NFPA 291) Staff Liaison, 1993 – 1997

NFPA TC on Water Spray Systems (NFPA 15) Staff Liaison, 1993-1997

NFPA TC on Foam Water Sprinkler Systems (NFPA 16, NFPA 16A) Staff Liaison, 1993-1997

NFPA TC on Record Protection (NFPA 232, NFPA 232A) Staff Liaison, 1993-1997

Puchovsky Curriculum Vitae

Selected Engineering Design Experience

OMMA Concert Hall, Athens, Greece

Project leader responsible for conducting an NFPA 101 fire and life safety analysis for Greece's premier concert hall expansion. Served as primary contact for this Athens based architectural and construction firm. The project, most of which was underground, included two new concert halls (one of which was 13 stories in height), parking facilities, banquet facilities, exhibition center and numerous vertical openings. A combination of prescriptive and performance-based design methods was employed.

High Museum, Atlanta, GA

Conducted fire engineering analysis involving computational fluid dynamics computer program to form the basis of a code variance for a sprinkler system installation. Fire development and sprinkler response were assessed to identify options for preserving the unique ceiling structure proposed by the architect. Successfully negotiated the approach and solution with the building official.

Downtown Transit Center, New York City, NY

Conducted fire, life safety and risk assessments for the redevelopment of the former World Trade Center site. Included analysis of potential extreme events including those associated with fire, blast and biochemical threats.

Massachusetts Institute of Technology, Main Group Master Plan, Cambridge, MA

Conducted fire protection and life safety master plan for the renovation of MIT's main group buildings. Identified options for preserving the historic character and functionality of this cluster of historic buildings that function as a single structure.

King Abdulaziz Airport, Jeddah, Saudi Arabia

Project included a major airport expansion project including airport terminal building and parking facilities. Client was an architect based in the Hague, Netherlands. Conducted an NFPA 101 analysis and developed alternate means of protection.

Dulles Airport Expansion, Sterling, Virginia

Code analysis, fire safety strategy development, computational fire and smoke management study for the construction of a new midfield concourse and APM station. Included CFD computer modeling, egress analysis and assessment of fire size and growth for APM vehicles.

Unified Science Center, Hamilton College, Clinton, New York

Smoke management study for the renovation of a 1920's era building. Included strategy development and smoke movement calculations for a complex new atrium.

Honolulu International Airport, Honolulu, HI

Development and expansion of new international airport terminal. Prepared overall fire protection strategy, conducted code analysis, and identified and resolved code issues.

Harvard University, Cambridge, MA

Master plan survey and evaluation of various university buildings including hospitals, dormitories and academic buildings to identify deficiencies with regard to code compliance and fire protection systems.

Leeds School of Business, Boulder, CO

Smoke management system and life safety analysis for a new atrium building.

Ritz Carlton Hotel, San Francisco, CA

Renovation of a historic college building to a new luxury hotel. Prepared overall fire protection program, conducted egress analysis, and developed and negotiated alternative means of fire protection and life safety to preserve historic character of the building.

Downtown Plaza, Sacramento, CA

Development of six city blocks into a new covered shopping mall and entertainment complex. Prepared overall fire and life safety program, conducted egress analysis, and identified and developed alternative means of protection where strict compliance with building and fire code requirements was not possible.

FuelCell Energy, Torrington, CT

Fire hazard analysis of process equipment used in the production of fuel cells. Developed plan to mitigate associated fire and explosion hazards.

ABC Studios, New York, NY

Development of specifications for maintenance and testing of building fire protection systems. Sprinkler system design for storage areas.

Baker Library, Dartmouth College, Hanover, NH

Retrofit of automatic sprinkler system into historic library. Designed sprinkler and fire pump systems to achieve overall fire protection goals while maintaining the unique character of the building.

Puchovsky Curriculum Vitae

Publications and Technical Programs

Texts

SFPE Handbook of Fire Protection Engineering, 6th edition, SFPE, Technical Editor, Chapters on Design Calculations for Fire Protection Systems – Sprinklers, Hydraulics & Water Supplies, Detection & Alarm, Smoke Control, Hydraulics, Halon, Clean Agents, Carbon Dioxide, Water Mist, Foam) – In Preparation

“Automatic Sprinkler System Calculations,” SFPE Handbook of Fire Protection Engineering, 6th edition, SFPE (In Preparation)

“Engineering Considerations for Fire Protection System Selection,” SFPE Handbook of Fire Protection Engineering, 6th edition, SFPE, (In Preparation)

“The Role of Performance-Based Codes and Standards in Fire Safety Design,” Section 4, Chapter 13, Fire Protection Handbook, 20th ed, NFPA, (In Preparation)

NFPA 20 Stationary Fire Pump Handbook, 2019 Edition, NFPA (Contributing Author)

“Interrelationship of NFPA Standards Pertaining to a Fire Pump Installation” Supplement 2, Stationary Fire Pumps Handbook, 5th Edition, NFPA, 2016.

Automatic Sprinkler Systems for Residential Occupancies Handbook, 2016 Edition, NFPA (Contributing Author)

SFPE Handbook of Fire Protection Engineering, 5th edition, SFPE, 2015 (Section Technical Editor for chapters on Design Calculations for Fire Protection Systems)

“Engineering Considerations for Fire Protection System Selection,” SFPE Handbook of Fire Protection Engineering, 5th edition, SFPE, 2015

Automatic Sprinkler Systems for Residential Occupancies Handbook, 2013 Edition, NFPA (Contributing Author)

Stationary Fire Pumps Handbook, 2013 Edition, NFPA (Contributing Author)

“Section 12, Structural Fire Protection”, Fire Protection Handbook, 20th edition, NFPA, 2008 (Section Technical Editor)

“Performance-Based Fire Codes and Standards,” Section 4, Chapter 13, Fire Protection Handbook, 19th ed, NFPA, 2003

“The Application of Performance-Based Design Concepts for Fire and Life Safety”, Supplement 7, Life Safety Code Handbook, 9th and 10th editions, NFPA, 2003, 2006

“Section 10, Water Based Fire Protection Systems”, Fire Protection Handbook, 19th edition, NFPA, 2003 (Section Technical Editor)

“Fire Pump Controllers and Electric Power Supplies for Fire Pumps”, Section 10, Chapter 8, Fire Protection Handbook, 19th edition, NFPA, 2003 (with James Nasby)

“Automatic Sprinkler Systems”, Section 10, Chapter 11, Fire Protection Handbook, 19th edition, NFPA, 2003

“Pumps for Fire Protection,” 1st edition, NFPA, 2002 (with Ken Isman)

“A Brief Introduction to Sprinkler Systems for Life Safety Code Users,” Supplement 3, Life Safety Code Handbook, 8th edition, NFPA, 2000

“Automatic Sprinkler Systems Handbook” 8th edition, NFPA 1999

"Fire Pump Handbook," 1st edition, NFPA, 1998 (with Ken Isman)

"Automatic Sprinkler Systems Handbook" 7th edition, NFPA 1996

"Performance-Based Fire Codes and Standards," Section 11, Chapter 9, Fire Protection Handbook, 18th ed, NFPA, 1997

"General Indoor Storage," Section 9, Chapter 18, Fire Protection Handbook, 18th edition, NFPA, 1997

"Outdoor Storage Practices," Section 9, Chapter 19, Fire Protection Handbook, 18th edition, NFPA 1997

Puchovsky Curriculum Vitae

Reports & Periodicals

- “Pump Speed as a Design Consideration,” *Consulting Specifying Engineer Magazine*, June 2022.
- “Increased Functionality & Cost Effectiveness of Smart Building Technologies Incorporating Addressable Fire Alarm Notification,” (w/ C. Cyr and D. Parrow), Worcester Polytechnic Institute, Worcester, MA, May 2021.
- “Case Study in the Application of an Exterior Automated Fire Suppression System: A Graduate Independent Study Research Project,” (with A. Riley and J. Troio), Worcester Polytechnic Institute, Worcester, MA, December 2018.
- “Case Studies in the Application of Electronic Sprinkler Technology for Warehouse Operations: A Graduate Independent Study Research Project,” (with A. Riley and J. Troio), Worcester Polytechnic Institute, Worcester, MA, December 2018.
- “Addressing the Impact of Excess Fire Pump Pressures”, *Consulting Specifying Engineer Magazine*, November 2018.
- “Addressable versus Conventional Fire Alarm Notification: An Observation of Installation and Material Costs,” White Paper prepared for Johnson Controls Inc, May 2018.
- “Li-Ion Battery Energy Storage Systems - Effect of Separation Distances based on a Radiation Heat Transfer Analysis: A Graduate Independent Study Research Project” (with V. Hutchison), Worcester Polytechnic Institute, Worcester, MA, June 2017
- “The Cookbook Approach: Just Follow the Recipe for Success”, *Fire Protection Engineering Magazine*, President’s Column, SFPE, 4th Quarter, 2016
- “The Most Interesting Person in the World”, *Fire Protection Engineering Magazine*, President’s Column, SFPE, 3rd Quarter, 2016
- “Home Sweet Home” *Fire Protection Engineering Magazine*, President’s Column, SFPE, 2nd Quarter, 2016
- “Do Your Job” *Fire Protection Engineering Magazine*, President’s Column, SFPE, 1st Quarter, 2016
- “Forensic Fire Scene Analysis Using Computational Fluid Dynamics (CFD): A Major Qualifying Project Report”, (with F. Kang, R. Kennedy, D. Savva, T. Ravidou, C. Wood), Worcester Polytechnic Institute, Worcester, MA, May 2016
- “Occupant Egress Time: An Interactive Qualifying Project Report”, (with C. Parisi, L. Renner, A. Teliska, L. Waugh), Worcester Polytechnic Institute, Worcester, MA, May 2016
- “Piping Arrangements for Fire Pumps” *Consulting Specifying Engineer Magazine*, March 2015
- “Inspection, Testing and Maintenance Of Fire Safety Systems in Oil Refineries” *Conference Proceedings - 5th SFPE Saudi Arabian Chapter Conference*, Dammam, Saudi Arabia, September 2014
- “The Effect Wood Pallets Have on Warehouse Sprinkler System Design: Graduate Student Project Report,” Worcester Polytechnic Institute, Worcester, MA, January 2014
- “Deciding on Fire Protection Systems: What Factors Come into Play?” *Consulting Specifying Engineer Magazine*, May 2013
- “New Approaches for Designing Fire Pump Installations”, *Consulting Specifying Engineer Magazine*, December 2012
- “Evaluating Occupant Load Factors For Business Operations” (with T. Muha, B. Merrifield, T. Thackeray and T. Wood), Fire Protection Research Foundation, Quincy, MA, April 2012.
- “New Design Considerations for Clean Agent Fire Suppression Systems”, *Consulting Specifying Engineer Magazine*, May 2011
- “High Concept - Life Safety in Tall Buildings”, *NFPA Journal*, March/April 2007
- “Performance Design Anxiety”, *Engineering News Record*, February 21, 2005 (Contributing Author)
- “Smoke Control: to CFD or not to CFD – M/E Roundtable”, *Consulting Specifying Engineer*, January 2005
- “Fire Protection Engineer, At Your Service,” *Consulting Specifying Engineer*, January 2005
- “Peak Pump Performance,” *NFPA Journal*, May/June 2000.
- “Performance-Based Design from Start to Finish”, *NFPA Journal*, January/February 2000
- “NFPA 13: What You Need to Know About the 1999 Edition,” *NFPA Journal*, May/June 1999

Puchovsky Curriculum Vitae

- “Fire Protection Strategies for Lumber Storage Yards,” *Journal for Lumberyard Operators*, August 1998
- “Restructuring NFPA’s Sprinkler Project,” *Sprinkler Age*, February 1998.
- “What’s New In Sprinklers,” *NFPA Journal*, January/February 1998 (contributing author)
- “Just Ask – Sprinklers Systems,” *NFPA Journal*, September/October 1997
- "Sprinkler Obstructions - How NFPA 13 Deals with Them," *Sprinkler Age*, June 1997
- "Performance-Based Versus Prescriptive Fire Safety Codes," *Skylines*, October 1996
- “Thirty Years of Suppression Systems,” *NFPA Journal*, September/October 1996 (contributing author)
- "NFPA's Perspectives on Performance-Based Codes and Standards," *Fire Technology*, Nov/Dec 1996
- "Changes to NFPA's Sprinkler Standard," *Plumbing Engineer*, June 1996
- "Entering the Next 100 Years of Standardized Sprinkler System Technology," *Sprinkler Age*, March 1996
- “Changes to NFPA 13D,” *Sprinkler Age*, March 1996
- "Developing Performance-Based Documents One Step at a Time," *NFPA Journal*, Jan/Feb 1996
- "NFPA's Future in Performance-Based Codes and Standards," National Fire Protection Association, July 1995 (with A. Cote, R. Coté, R. Fahy, C. Crant, J. Hall, and R. Vondrasek)
- NFPA’s Standards Making System, *Sprinkler Age*, October 1993

Technical Peer Reviews

- “A Competency Framework for Fire Safety Engineering,” *Fire Safety Journal*, Manuscript ID: FISJ-D-21-00136, May, 2021.
- “Effects of Discharge Area and Atomizing Gas Type in Full conde Twin-fluid Atomizer on Extinguishing Performance of Heptane Pool Fire with Different Heat Release Rates,” *Applied Sciences*, Manuscript ID: applsci-1139162, March 2021.
- “Numerical Investigation of the Required Quantity of Inert Gas Agents in Fire Suppression Systems,” *Energies*, Manuscript ID: energies-787546, April 2020.
- “Combatting Wildfire Fast and Cost Effectively with a New Technology,” *Environmental Science and Pollution Research*, Ms. No. ESRP-D-19-03479, March 2020.
- “The Development and Deployment of Water Mist Fire Suppression Technology,” DiNenno Prize Nomination, Subject Matter Expert Peer Review, (<http://www.nfpa.org/dinenno>), January 2020.
- “Ensuring Fire Safety of Closed Warehouses by Optimizing the Number of Fire-Fighting Devices,” *Safety & Fire Technology*, Ms. Ref. SFT-00037-2019-01, December 2019.
- “Reliability of Automatic Sprinkler Systems for Fire Protection: How to Collect, Analyze, and Present Reliability Data,” (pre-publication proposal review), CRC Press, December 2018.
- “An Efficacy Evaluation of Water Mist Protection of Solid Combustible Fires in an Open Environment,” *Fire Technology*, Ms. Ref. FIRE-D-18-00095
- “Post Construction Fire Safety Regulation in England: Shutting the Door Before the Horse Has Bolted,” *Policy and Practice in Health and Safety*, Ms. Ref. No.: TPHS-2018-0016
- “Assessing Vulnerability and Fire Risk in Old Urban Areas: The Case of the Historical Center of Guimaraes,” *Fire Technology*, Ms. Ref. No.: FIRE-D-18-00052, March 2018.
- “Tenability Analysis in a Tobacco Workshop with an Enclosure Fire Zone Model,” *Fire & Materials*, Ms. Ref. No.: FAM-15-0125, February, 2016.
- “Characterization of Water Mist Systems using Full-scale Tests and Computer Modeling”, *Fire Technology*, Ms. Ref. No.: FIRE-D-15-00204, August, 2015.
- “2014 Assessment Report of the Halon Technical Options Committee”, United Nations Environment Programme (UNEP), Ozone

Puchovsky Curriculum Vitae

Secretariate, P.O. Box 30552, Nairobi, Kenya, 2014.

“Probabilistic Assessment of Occupant Load Density in Retail Buildings”, *Fire Safety Journal*, Ms. Ref. No.: FISJ-D-14-00014, April 2014.

“Distinction of Fire Source from Smoke using Discrete Probability Distribution and Neural Networks”, *Fire Technology*, Ms. Ref. No.: FIRE-D-13-00134, January 2014.

“Comparative Investigation of Smoke Control Modes in Long Corridor of High-rise Buildings”, *Fire Technology*, Ms. Ref. No.: FIRE-D-13-00006, April 2013.

“Theoretical Analyses and Experimental Studies on Flashover Inhibition by Water Mist”, *Fire Technology*, Ms. Ref. No.: FIRE-D-12-00589, January 2013.

“A Review of State of Art in Pyrolysis / Evaporation Model and Integrated Artificial Neural Network (ANN)-Genetic Algorithm (GA) for Model’s Property Estimation”, *Fire and Materials*, Ms. Ref. No.: FAM-12-0022, June 2012.

“Assessment of Fire Safety for Mezzanine Floors Compared with Prescriptive Code Requirements”, *Fire Safety Journal*, Ms. Ref. No.: FISJ-D-11-00106, July 2011.

Technical Programs & Presentations

“Factors Impacting NFPA 101 Means of Egress Provisions,” *Florida Fire Marshalls and Inspectors Association Annual Seminar*, Sarasota, FL, October 2022.

“Fire Alarm Systems - An Analysis of Addressable Fire Alarm Notification Appliances” (with C. Cyr & D. Parrow), *NFPA Conference and Exposition*, Boston, MA, June 2022.

“Fire Pumps and the 2022 Edition of NFPA 20,” SFPE Greater Atlanta Chapter Annual Seminar (Virtual), Atlanta, GA, March 16-17, 2021.

“The Feasibility of Protecting Residential Structures from Wildfires using a Fixed Exterior Fire Fighting System,” (with A. Simeoni, E. Han, D. Parrow and A. Rozen, SFPE New England Chapter Meeting, Norwood, MA, Feb 3, 2020.

“A Case Study in Utilizing an Existing High-Rise Building’s Fire Protection System Infrastructure for Fighting Exterior Façade Fires,” (with Zachary Magnone), *Suppression, Detection and Signaling Research and Applications Conference (SUPDET)*, Denver, CO, September 17-20, 2019

“Case Studies in the Application of Electronic Sprinkler Technology for Warehouse Operations”, *NFPA Conference and Expo*, San Antonio, TX, June 17-20, 2019

2nd Annual Center for Global Public Safety Industry Stakeholders’ Forum – *Energy Initiatives & Their Impact on Public Safety*, Organizer and Moderator, Worcester Polytechnic Institute, March 27, 2019.

“Heroic Science: What is Fire Protection Engineering,” (with E. Brecher, V. Hutchison and V. Kimmerly), 2018 Annual National Collegiate Honors Council, Boston, MA, November 9, 2018.

“Large-Scale Fire Testing to Determine Fire Protection Requirements for Battery Energy Storage Systems,” (with Adam Barowy), *SFPE Conference and Expo*, Nashville, TN, October 29, 2018

2nd Annual Global Public Safety Symposium - *New Frontiers in Global Public Safety*, Organizer and Moderator, Worcester Polytechnic Institute, September 17, 2018.

“Introductory Overview on Using UL 9540A Data for Fire Safety Design Applications,” *Sustainable CUNY / SERTA Stakeholder Workshop*, New York, NY, August 27, 2018

Center for Global Public Safety Industry Stakeholder’s Forum – *Focus on Fire Protection, Water Security, Food Safety and Emergency Response*, Organizer and Moderator, Worcester Polytechnic Institute, April 30, 2018.

“Addressing Excess Fire Pump Pressures,” 2018 Fire Protection Symposium - *New England Association of Fire Protection System Designers*, Bartlett, New Hampshire, March 2018

“A Radiation Heat Transfer Analysis of Lithium-Ion Battery Energy Storage Systems (ESS)” *SFPE Conference and Expo*, Montreal, Quebec, Canada, October 10, 2017

Puchovsky Curriculum Vitae

- “Lithium-Ion Battery Energy Storage Systems: Characterizing Fire Incidents and Effective Protection Schemes,” (with V. Hutchison), NFPA Conference and Expo, Boston, MA, June 6, 2017
- “Fire Safety Engineering Practice – Graduate and Undergraduate Education and Research,” (with T. El-Korchi), *First Workshop on Fire Safety Engineering*, University of Campinas, Campinas, Brazil, March 23, 2017
- “Advanced Design Concepts and Calculations for Fire Alarm Systems,” *Seminario: Bombas Contra Incendio Basado en NFPA 72*, Fire Prevention Institute, Mexico City, Mexico, February 28-29, 2017
- “An Overview of the Fire Hazards Associated with Lithium Ion Batteries,” (with V. Hutchison), *International Association of Arson Investigators – Massachusetts Chapter Technical Seminar*, Auburn, MA, November 17, 2016
- “Advanced Topics on the Application and Use of Fire Pumps,” *Seminario: Bombas Contra Incendio Basado en NFPA 20*, Fire Prevention Institute, Mexico City, Mexico, November 14-15, 2016
- “Careers in Fire Protection,” *Massachusetts STEM Summit 2016*, (with A. Kimball, K. Bigda, J.C. Harrington) Worcester, MA, November 1, 2016
- “Using FDS for Fire Scene Analysis,” *SFPE Conference and Expo*, (with B. Rabidou, D. Savva, F. Kang, R. Kennedy, C. Wood) Denver, CO, September 2016
- “Recent Changes to NFPA 13 and the SFPE Handbook of Fire Protection Engineering,” *SFPE United Arab Emirates Chapter Meeting*, Dubai, UAE, April, 2016
- “Computer Fire Modeling & Sprinkler System Design,” *SFPE New York Metro Chapter Technical Seminar*, New York, NY, March 2016.
- “New Design Options for Fire Pump Installations,” 2016 NEAFPSD 25th Chapter Anniversary & Fire Protection Symposium, Bartlett, New Hampshire, March 2016
- “The Proper Use of Fire Pumps & the 2016 Edition of NFPA 20,” *Fire Sprinkler Americas Conference*, International Fire Sprinkler Association, Medellin, Columbia, February 2016
- “SFPE’s Strategic Plan”, *Technical Committee Meeting of the Fire Suppression Systems Association*, Fajardo, Puerto Rico, February 2016
- “The Critical Impact of Fire Protection System Maintenance”, *SFPE United Arab Emirates Chapter Meeting*, Dubai, UAE, November 2015
- “Designing for Inspection, Testing and Maintenance of Fire Protection Systems”, *NFPA Conference and Exposition*, Chicago, IL, June 2015
- “Using Fire Modeling to Establish Sprinkler System Design Criteria”, *SFPE Minnesota Chapter Meeting*, Roseville, MN, May 2015
- “New Means of Egress Provisions for NFPA 101”, *SFPE United Arab Emirates Chapter Meeting*, Dubai, UAE, February 2015.
- “SFPE’s New Strategic Plan”, *SFPE Conference and Expo*, Long Beach, CA, October 2014
- “Fire Pumps, NFPA 20 and Tall Buildings”, *SFPE United Arab Emirates Chapter Meeting*, Abu Dhabi, UAE, September 2014
- “Fire Pump Installations for Tall Buildings”, *NFPA Conference and Exposition*, Las Vegas, NV, June 2014.
- “Explosion Hazard Classification and the Use of Electrical Equipment”, *Technical Workshop for Riley Power, Inc.*, Worcester, MA, February 2014.
- “Fire Pumps: What You Need to Know”, *Fire Sprinkler America’s Conference*, Panama City, Panama, February 2014.
- “Setting Sprinkler System Performance Criteria when NFPA 13 Won’t Cut It”, *SFPE Rocky Mountain Chapter 1st Annual Fire Protection Symposium*, Boulder, CO, April 2013.
- “Update on SFPE Activities,” *SFPE New York Metro Chapter Meeting*, New York, NY, March 2013.
- “New Design Considerations for Fire Pump Installations,” *SFPE Engineering Technology Conference*, Savannah, GA October 2012
- “Sprinklers in Fire Engineered Solutions,” *9th International Fire Sprinkler Conference*, Paris, France, June 28-29, 2012

Puchovsky Curriculum Vitae

“Appropriateness of Current Occupant Load Factors for Business Occupancies,” *NFPA Conference and Exposition*, Las Vegas, NV, June 2012

“New Options for Fire Pump Installations,” *SFPE New York Metro Chapter Annual Seminar*, Brooklyn, NY, February 2012.

“Systems Selection for Fire Protection – Factors that Should Influence a FPE’s Decision Making Process,” *SFPE Engineering Technology Conference*, Portland, OR, October 2011

“Fire Protection Overview,” *Consulting Specifying Engineer Magazine, Fire & Life Safety Channel, On-line Video Series*, May 2011.

“Update on NFPA-2001: Clean Agent Fire Extinguishing Systems,” *Consulting Specifying Engineering Webcast: Update on Fire Codes, Standards and Guidelines*, April 21, 2011.

“Fire Protection System Selection for Special Hazards,” *SFPE Greater Atlanta Chapter 7th Annual Fire Safety Conference*, Duluth, GA, March 2011.

“Applying NFPA 101, Life Safety Code,” *General Services Administration Regional Seminar*, Mashantucket, CT, October 2010.

“Training Future Fire Protection Engineers,” *NFPA Conference and Exposition*, Las Vegas, NV, June 2010.

“Advocating Sprinklers – A Report on Research, Code Changes and Other Initiatives at NFPA,” *New England Fire Protection Symposium*, West Dover, VT, March 2008.

“Predicting Detector Actuation,” *Fire Protection Research Foundation Suppression and Detection Symposium*, Orlando, FL, March 2008 (session moderator)

“NFPA and Fire Safety in High Rise Buildings: A Status Report,” *NFPA World Safety Conference and Exposition*, Boston, MA, June 2007.

“Using Risk Concepts in Codes and Standards Development,” *NFPA World Safety Conference and Exposition*, Boston, MA, June 2007.

“An Approach for Applying Risk Concepts in the Development of Codes and Standards,” *NFPA World Safety Conference and Exposition*, Boston, MA, June 2007.

“NFPA Regulations – Notices of Intent to Make a Motion for the National Electrical Code”, *NFPA Electrical Inspectors Forum*, Quincy, MA, May 2007.

“NFPA High-Rise Building Safety Advisory Committee and the NIST/WTC Recommendations” *Fire Safety Directors Association of Greater New York – Spring Seminar*, New York, NY, May 2007.

“Fire Detection, Alarm Systems and Human Behavior,” *Fire Protection Research Foundation Suppression and Detection Symposium*, Orlando, FL, March 2007 (session moderator)

“Code Options for Rehabilitating Historic Buildings,” *Traditional Buildings Exhibition and Conference*, Boston, MA, March 2007

“High Rise Buildings – Where Are the Codes Heading?” *Society of Fire Protection Engineers – New England Chapter*, Norwood, MA, November 2006 (with B. Tubbs)

“NFPA 914 – Code for Fire Protection of Historic Structures and Building Rehabilitation,” *Protection Heritage International Conference*, Ljubljana, Slovenia, May 2006

“Property and Life Safety in Health Care Facilities” *NFPA Niagara Frontier Chapter 2006 Spring Seminar*, Buffalo, NY, May 2006

“Status Report on NFPA’s Response to the NIST WTC Recommendations,” *National Institute for Building Sciences – Multi-hazard Mitigation Council*, Washington, D.C., May 2006

“The Concept of Fire Risk and Its Potential Impact on the Role of Sprinkler Systems,” *NFSA 2006 Annual Seminar*, South Hampton, Bermuda, April 2006

“New Code Provisions for Building Rehabilitation,” *Traditional Buildings Exhibition and Conference*, Chicago, IL, April, 2006

“NFPA’s Perspectives on High Rise Safety,” *National Council of Structural Engineering Associations*, Kansas City, MO, October 2005

“NFPA’s Comments on Building and Fire Codes & Practices”, *Technical Conference on the Federal Building and Fire Safety Investigation of the World Trade Center Disaster*, National Institute of Standards and Technology, Gaithersburg, MD, September 2005

Puchovsky Curriculum Vitae

“NFPA Comments to NIST’s Federal Building and Fire Safety Investigation of the World Trade Center Disaster” National Fire Protection Association, August, 2005 (with R. Solomon, R. Fahy, *et al.*)

“Rehabilitating Tall Buildings in a Post 9/11 World,” *Traditional Building Exhibition and Conference*, Philadelphia, PA, April 2005

“NFPA Comments to NIST’s Report of the Technical Investigation of the Station Nightclub Fire,” National Fire Protection Association, March 2005 (with R. Solomon, R. Cote, R. Fahy, *et al.*)

“Balancing Life Safety with the Historic Preservation of Tall Buildings,” *Council on Tall Buildings & Urban Habitat International Conference on Tall Buildings in Historical Cities - Culture & Technology for Sustainable Cities*, Seoul, South Korea, October 2004

“A Bottom-Up Analysis for Performance Designs” *5th International Conference on Performance-Based Codes and Fire Safety Design Methods*, Luxembourg, October 2004

“Making Old Buildings Work: Building Rehab Code Provisions for Safety” *Restoration & Renovation Conference*, Boston, MA, April 2004 (with Marilyn Kaplan)

“Sprinkler Systems as a Design Option for Historic Buildings”, *New England Fire Protection Symposium*, West Dover, VT, March 2004

Global Policy Summit on the Role of Performance-Based Building Regulations in Addressing Societal Expectations, International Policy, and Local Needs, Washington, D.C., November 2003 (Session Chair and member of organizing committee)

NIST Workshop on Fire Safety Design and Retrofit of Structures, Baltimore, MD, September 2003 (Work Group Facilitator)

“NFPA’s Comments to the American Society for Healthcare Engineering of the American Hospital Association Alcohol-Based Hand Rub Solution Fire Modeling Analysis Report”, NFPA, July 2003 (w/ R. Solomon)

“An Overview of Hanging and Bracing Requirements for Sprinkler Systems”, *Fire Prevention Association of Massachusetts - 17th Annual Educational Seminar*, Amherst, MA, April 2003

“Sprinkler Systems – Which System for What Hazard?” *Massachusetts Building Commissioners and Inspectors Association – Monthly Meeting*, Sturbridge, MA, November 2002

“Design Vision, Building Codes and Fire Engineering”, *Build Boston - Boston Society of Architects*, Boston, MA, November 2002 (with Jeff Tubbs)

“Consideration of Extreme Events in Building Management and Design”, *Build Boston - Boston Society of Architects*, Boston, MA, November 2002 (with Brian Meacham and Jeff Tubbs)

“Sprinklers as A Code Solution,” *4th International Fire Sprinkler Conference*, Prague, Czech Republic, July 2002

“Sprinkler Systems for Storage and Bulk Retail,” *Fire Prevention Association of Massachusetts – 16th Annual Educational Seminar*, Amherst, MA, April 2002

Performance-Based Design Requirements for the First Edition of the NFPA Building Code, *4th International Conference on Performance-Based Codes and Fire Safety Design Methods*, Melbourne, Australia, March 2002 (with Greg Harrington)

“Using Fire Models to Demonstrate Sprinkler System Effectiveness,” *New England Fire Protection Symposium*, Bartlett, NH, March 2002

“An Overview of NFPA’s New Project on Fire Risk Assessment Methods,” *The International Conference on Engineered Fire Protection Design*, San Francisco, CA, June 2001 (with Ken Richardson)

“Electric Power Supply Requirements for Fire Pumps,” *Society of Fire Protection Engineers - New England Chapter Annual Technical Seminar*, Randolph, MA, March 2001. (with Larry Wenzel)

“An Overview of Organizational and Technical Changes for the 1999 edition of NFPA 13,” *NFPA Fall Meeting*, Orlando, FL, November 2000

“Future Considerations for NFPA 13” *New England Fire Protection Symposium*, Bartlett, NH, March 2000.

“Electrical Power Supply Requirements of NFPA 20”, *New England Fire Protection Symposium*, Bartlett, NH, March 2000

“Automatic Sprinkler Systems” *Wisconsin Code Enforcement Officials Special Seminar*, Madison and Wausau, WI, February 2000

“NFPA Overview and Technical Changes ½ Day Program,” *Wisconsin Building Code Refresher Program*, University of Wisconsin, Madison, WI, February 2000

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"Implementing Performance-Based Design through the Application of Fire Safety Regulations," *2nd Conference on Fire Safety Design in the 21st Century*, Worcester, MA, June 1999

"NFPA 13 – Major Changes for the 1999 edition," *SFPE Southern Ontario Chapter Meeting*, Toronto, Canada, January 2000

"Technical and Organizational Changes for the 1999 Edition of NFPA 13," *SFPE New England Chapter Meeting*, Norwood, MA, December 1999

"An Introduction to NFPA 13," *NFPA Regional Conference*, Kuala Lumpur, Malaysia and Hong Kong, China, November, 1999

"NFPA 13 Plans Review Seminar," *Rhode Island Fire Marshall's Association*, Providence, RI, October 1999

"NFPA 13 Changes ½ Day Program," *American Fire Sprinkler Association*, New Orleans, LO, September 1999. (with R. Huggins and B. Caputo)

"NFPA 13 – The Next Century" *Fire Marshall's Association of North America - Delaware Valley Chapter Meeting*, Philadelphia, PA, September 1999

"Electric Power Supply for Motor Driven Fire Pumps," *National Fire Sprinkler Association Annual Seminar*, Chicago, IL, September, 1999

"NFPA 13 / NFPA 25 Surveyor Training Course," *National Health Care Finance Administration*, Denver, CO, June 1999.

"Major Proposed Changes and Additions to the Next Edition of NFPA 13," *American Society of Plumbing Engineers - Boston Chapter Meeting*, Randolph, MA, January 1999

"The Reorganization and Expansion of NFPA 13," *3rd International Fire Sprinkler Conference*, Glasgow, Scotland, July 1998

"Seminar on Fire Protection Systems – Sprinklers and Fire Pumps," *NFPA Special Meeting*, Bangkok, Thailand, July 1998. (with D. Hague)

"An Overview of NFPA 13, NFPA 231 and NFPA 20," *NFPA Special Meeting and Workshop*, Kuala Lumpur, Malaysia, July 1998.

"An Introduction to Performance-Based Codes and Design Approaches," *South Carolina Fire Inspectors Association Spring Seminar*, Myrtle Beach, SC, June 1998.

"Technical Differences Between the 1991 and the 1996 editions of NFPA 13," *Montana Fire Marshall's Association – Monthly Meeting*, Helena, MT, June 1998

"Domestic Fire Protection Using Residential Sprinklers and Inspection, Testing and Maintenance Procedures for Water Based Fire Protection Systems," *Fire-X '98*, Birmingham, England, May 1998

"Sprinkler Technology and the Application of NFPA's Sprinkler Standards," *NFPA Regional Conference*, Mexico City, Mexico, April 1998

"Reorganization of NFPA's Sprinkler Project," *NEAFPSD New England Fire Sprinkler Technical Seminar*, Bethel, ME, March 1998

"NFPA 13 – Major Changes," *American Society of Plumbing Engineers – Miami Chapter*, Miami, FL, February 1998

"Proposed Changes to NFPA 231 and NFPA 231C," *American Fire Sprinkler Association's 16th Annual Convention*, Albuquerque, New Mexico, October 1997

"Performance Codes and the Role of NFPA," *Performance Codes: How Will They Happen*, American Institute for Architects, San Francisco, CA, October 1997

"Supervision of Automatic Sprinkler Systems," *Pennsylvania Tri-State Fire Alarm Seminar*, Philadelphia, PA, September 1997

"Performance-Based Regulations - What Role Will They Play," *Proceedings of the Fire Risk and Hazard Assessment Symposium*, National Fire Protection Research Foundation, San Francisco, CA, June 1997

"Performance-Based Language in Existing NFPA Codes," *SFPE Design Workshop – Introduction to Performance-Based Design for AHJ's*, Los Angeles, CA, May 1997

"Current Issues Facing Water-Based Fire Protection Systems," *NFPA Annual Meeting*, Los Angeles, CA, May 1997.

"New Orleans Warehouse Fire," *NFPA Annual Meeting*, Los Angeles, CA, May 1997

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- “Pumps for Fire Protection, and Fire Protection Technology Update” Fire-X '97, Birmingham, England, May 1997 (with K. Isman and M. Riffey)
- “NFPA’s Future in Performance-Based Codes and Standards,” *Building Performance: What Is It?*, American Institute for Architects, Washington, D.C., April 1997
- “Fire Sprinklers – NFPA 13 and 13D Update,” *NFPA Western Regional Meeting*, Sacramento, CA, April 1997
- “An Introduction to Performance-Based Codes and Design Approaches,” *Connecticut Fire Marshall’s Annual Seminar*, New Haven, CT, March 1997
- “NFPA 101 and Sprinkler Protection,” *New England Fire Sprinkler Technical Seminar*, Bethel, ME, March 1997
- “NFPA 13 – An Overview of Major Changes,” *New England Association of Fire Protection System Designers Monthly Meeting*, Westborough, MA, March 1997
- “Review of NFPA 13 Code Changes,” *American Society of Plumbing Engineers/Society of Fire Protection Engineers – Empire Chapter Joint Meeting*, Syracuse, NY, December 1996
- “An Introduction to Fire Pumps,” *NFPA Fall Meeting*, Nashville, TN, November 1996
- “Recent NFPA Fire Investigations,” *NFPA Fall Meeting*, Nashville, TN, November 1996 (with R. Bielen and Ed Comeau)
- “Performance-Based Language in Existing NFPA Codes,” *SFPE Design Workshop – Introduction to Performance-Based Design for AHJ’s*, Nashville, TN, November 1996
- “NFPA 13 Update,” *New England Association of Fire Protection System Designers 3rd Biennial Fire Protection Product Show and Seminar*, Randolph, MA, October 1996
- “Performance-Based Codes and Standards and Their Effect on Building Design,” *International Performance Codes: The Coming Impact on Your Practice*, American Institute for Architects, Vancouver, Canada, October 1996
- “A Dual Track Performance / Prescriptive Based Approach for Fire Safety Codes and Standards,” *Proceedings - Fire Safety Conference on Performance Based Concepts*, Federal Institute of Technology, Zurich, Switzerland, October, 1996
- “Sprinkler and Fire Suppression System Plan Review,” *Connecticut Fire Marshall’s Association Technical Seminar*, Fairfield, CT, August 1996
- “NFPA 750 – NFPA’s New Standard on Water Mist Systems, and Changes to the 1996 edition of NFPA 13” *National Fire Sprinkler Association Area 1 Seminar*, Saratoga Springs, NY, July 1996
- “Update on Residential Sprinkler Systems,” *Fire Marshall’s Association of Colorado Annual Conference*, Vail, CO, July 1996
- “Creating Performance-Based Documents at the NFPA,” *Proceedings of the Fire Risk and Hazard Assessment Symposium*, National Fire Protection Research Foundation, San Francisco, CA, June 1996
- “Perspectives on the Transition to Performance-Based Codes – Panel Discussion,” *NFPA Annual Meeting*, Boston, MA, May 1996.
- “Keeping Pace with Water-Based Technology,” *NFPA Annual Meeting*, Boston, MA, May 1996
- “NFPA’s Perspective on Performance-Based Codes and Standards,” *International Meeting of the Confederation of Fire Protection Associations*, Boston, MA, May 1996
- “Fire Investigation Report - Warehouse Fire, New Orleans, Louisiana”, National Fire Protection Association, March 1996 (with Edward Comeau)
- “Supplementing NFPA’s Codes and Standards with Performance-Based Provisions,” *Proceedings for Interflam '96*, Cambridge, England, March 1996
- “NFPA's Objectives in Pursuing Performance-Based Codes and Standards,” *Proceedings of the International Conference on Performance-Based Codes and Fire Safety Design Methods*, Society of Fire Protection Engineers, Ottawa, Canada, 1996
- “Implementing Emerging Technologies Through Fire Safety Codes and Standards,” *Demonstration of Limited Water Supply Fire Suppression Technologies*, National Institute of Standards and Technology, Gaithersburg, MD, March 1996
- “An Overview of the 1996 edition of NFPA 13,” *American Society of Plumbing Engineers – NYC Chapter Meeting*, New York, NY, February 1996

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“NFPA’s Future in Performance-Based Codes and Standards”, *NFPA Fall Meeting*, Chicago, IL, November 1995

“Performance Based Design in the United States,” *Proceedings of the International Conference on Fire Research and Engineering*, Society of Fire Protection Engineers, Orlando, FL, September 1995

“Performance-Based Standards from the NFPA Perspective,” *Urban Fire Marshall’s Forum*, Quincy, MA, August, 1995

“NFPA Standards Adopted by the Uniform Fire Code,” *Western Fire Chiefs / International Fire Code Institute Annual Meeting*, Las Vegas, NV, July 1995

"Performance Based Design in United States," *Pacific Rim Conference of Building Officials*, Darwin, Australia, May 1995

“Fire Case Studies – The Builders Square Fire – Panel Discussion,” *NFPA Annual Meeting*, San Francisco, CA, May 1994

“Water Mist Systems for Fire Protection,” *Video Fuego Technical Conference*, Badajoz, Spain, May 1994

“Fire Protection Standards for Records, Record Centers and Archives Facilities,” *ARMA – Boston Chapter Meeting*, Boston, MA, April 1994 (with R. Ortisi-Best)

“Technical Changes to NFPA’s Storage Standards,” *NFPA Fall Meeting*, Phoenix, AZ, November 1993