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November 21, 2024

Attn: Lon Payne
California Energy Commission
STEP Division, Siting Office
1516 Ninth Street, MS 15
Sacramento CA 95814-5512

Reference: Fountain Wind Project (23-OPT-01) Wildfire Supplemental Information and Response to County of Shasta's AB 205 Review and Comments Dated 10/2/2024

Dear Mr. Payne,

On behalf of Fountain Wind, LLC (Applicant), I am writing to provide supplemental information and responses to the wildfire-related comments outlined in the County of Shasta's AB 205 Review and Comment letter regarding the Fountain Wind Project (Project; Docket #23-OPT-01). PyroAnalysis has reviewed Shasta County's comments related to wildfire and finds its' conclusions to lack merit.

The County has provided no information that refutes the accuracy of the conclusions in the PyroAnalysis report ("Fountain Wind Impacts on Fire Behavior and Aerial Firefighting") dated December 4, 2023 (PyroAnalysis Report). Shasta County instead reaches fire behavior conclusions that are not credible, based on clear assumptions or methods, or reflective of an understanding of fire science.

In this letter, PyroAnalysis reaffirms the accuracy of the conclusion that any adverse impacts related to wildfire from Project construction are mitigable to a less-than-significant level—the same conclusion reached by Shasta County's own 2021 Environmental Impact Report.

Expert Qualifications

As the basis for its new allegations, the County retained REAX Engineering (REAX) to evaluate the PyroAnalysis Report. As stated on their website, REAX is a fire protection engineering firm specializing in designing and evaluating fire protection systems for buildings and structures, and its staff are neither wildfire behavior nor wildfire control experts. In addition, as reflected in the REAX staff resumes (Attachment A), REAX's fire modeler is not a Fire Behavior Analyst (FBAN) or an experienced wildland firefighter.

A qualified FBAN must have extensive wildland fire leadership experience, receive specialized training and certifications, and perform as an FBAN trainee under the supervision of a Qualified FBAN on numerous wildfire incidents before being recognized as a fire behavior expert who can interpret the complex fire prediction models used to extrapolate fire growth, spread rates, and spotting potential in real-life scenarios. Lacking this training, REAX staff are therefore not adequately trained to interpret the fire behavior models being used to evaluate fire spread rates, flame lengths, or the resulting spotting potential for this Project. They are not qualified to interpret complex wildland fire behavior models, opine on the effectiveness of aerial firefighting, or reach the conclusions expressed in their letter.

Conversely, PyroAnalysis' models were run by a qualified FBAN and fire behavior expert trained in using and interpreting results from these models. Pyroanalysis' FBAN is recognized by both the California Incident Command Certification System and the internationally recognized Incident Qualification and Certification System. He serves on a Type 1 Incident Management Team that responds to wildfires throughout the United States, is a National Wildland Coordinating (NWCG) Group's S-590: Advanced Fire Behavior Interpretations Course instructor and member of the Group's steering committee. As a result, PyroAnalysis' FBAN is qualified to provide an accurate analysis of wildfire behavior and control.

Accuracy of Fire Behavior Analysis

PyroAnalysis' assessment used two industry-standard fire behavior modeling programs, the Interagency Fuel Treatment Decision Support System (IFTDSS) and BehavePlus (v.6), to evaluate fire behavior for the Fountain Wind. These programs are industry-standard, specifically designed to model wildfire behavior, rely upon agency-vetted and project-region-specific datasets, use accurate modeling inputs to produce conservative and reproducible results, include a self-check to validate results and are interpreted by a qualified FBAN. REAX's analysis meets none of these criteria.

IFTDSS and BehavePlus (v.6) rely upon the widely accepted and repeatedly proven Rothermal equation, which is specific to fire behavior in wildland settings. IFTDSS is a geospatial fire behavior modeling program that allows users to assess changes in wildfire risk quantitatively through the application of fuel breaks and other fuel modifications. BehavePlus was used to predict fire spread rates and ember spotting distances based on a point source ignition and to validate the fire behavior findings from IFTDSS. Both models are designed for use by an FBAN experienced and trained in evaluating the data used to model fire behavior and interpreting the resulting model-generated fire behavior predictions.

For this Project, modeling inputs were based on large, agency-vetted datasets gathered within the Project region. Inputs included 25 years of wind data recorded at the Remote Automated Weather Station located closest to the Project site and LANDFIRE fuels data compiled by the U.S. Forest Service and U.S. Department of the Interior. Modeling parameters were purposefully chosen to compare expected fire behavior under current conditions with expected fire behavior after the completion of Project-related fuel treatments. IFTDSS ember spotting potential was enabled and outputs were shown as a factor of the Minimum Travel Time fire spread. BehavePlus was used to analyze rates of spread and flame lengths by randomly selecting areas within the Project site for point source ignition fire behavior runs. Spotting potential was also enabled in the BehavePlus modeling runs, resulting in post-fuel-treatment spotting distances of less than 300 feet.

Officials at CAL FIRE have confirmed the accuracy of the conclusions in the PyroAnalysis report related to the benefits of the Project's fuel management compared to existing conditions and the lack of significant impacts with respect to aerial firefighting. The REAX assessment presents no rationale or data indicating why the PyroAnalysis fire behavior results are incorrect. REAX simply reports different results without providing methods or inputs to support their conclusions.

As noted, REAX's fire modeler is not an FBAN or an experienced wildland firefighter. It may be due to this lack of qualification and expertise that REAX's fire behavior modeling technician used FlamMap rather than IFTDSS to analyze the proposed fuel treatments. Though IFTDSS uses the same mathematical fire spread calculations as FlamMap, IFTDSS is widely accepted as the fire modeling tool used to model fire behavior in wildland settings and is specifically designed to examine the "before-and-after" effect of proposed fuel treatments on wildfire behavior.

In this instance, FlamMap, as described by REAX, is used incorrectly to answer the question presented (whether the proposed fuel modifications would reduce fire risk), and REAX provides no description of its methodologies so that its assumptions can be evaluated. Most importantly, REAX's conclusions related to the effect of fuel reduction on flame lengths, specifically that the Project's fuel reduction and fuel management would have no impact on flame lengths, fire spread rates, or ember spotting, are not supported by basic fire science, widespread fire modeling, and empiric results from CAL FIRE fuel reduction initiatives. Finally, due to their lack of qualifications and experience, REAX's modeler is not qualified to interpret fire behavior modeling results. The REAX conclusions must be rejected for this reason.

Response to County Comments

The following sections outline PyroAnalysis' specific responses to each of the County's comments.

<u>County Comment 1a</u>

"Application Wildfire and Analysis and Project Impacts: The Application technical report by PyroAnalysis, *Fountain Wind Impacts on Fire Behavior and Aerial Firefighting*, dated December 4, 2024 (TN 253505) ("Report"), is incomplete and only represents results from a fire modeling study for an area encompassing 12 wind turbines."

<u>Applicant Response</u>

PyroAnalysis' models accurately evaluate conditions for the Project as a whole based on a representative area encompassing 12 turbines. REAX presents no data (or even a rationale) for why the 12-turbine area modeled fails to accurately represent the site as a whole. It is neither customary nor necessary to model fire behavior across an entire study area when that study area possesses similar fuels, terrain, and fuel mitigation regimes. In fact, a study area analysis typically relies upon a model run on a sample area to analyze wildfire behavior. For this Project's analysis, a representative section with 12 turbines was selected. The FBAN then interpreted the modeling from the representative sample area to predict fire behavior across the entire Project area. Therefore, the allegation that the report "is incomplete and only presents results from a fire modeling study on an area encompassing 12 wind turbines" demonstrates the REAX modeling technician's limited understanding of standard wildland fire behavior modeling techniques.

<u>County Comment 1b</u>

"The County's fire modeling shows much greater flame lengths and potential for up to 10x the fire rate of spread in the Project area. The Report does not evaluate the potential of ember spotting."

Applicant Response

The inaccuracy of REAX's fire modeling results and the reasons for it are addressed above. REAX is incorrect in assuming that the PyroAnalysis report lacks an evaluation of ember spotting. PyroAnalysis modeled ember spotting potential using IFTDSS and BehavePlus, and the results are reflected in the technical report's fire behavior findings on pages 7-14. To summarize, PyroAnalysis' FBAN reduced fuel loading assumptions and raised the canopy height in areas with planned fuel treatments (accounting for fuels remaining after treatment). Modeling results show that Project-related fuel treatments *reduced* extreme fire behavior in treated areas, with ember spotting less than 300 feet across most of the Project area. In addition, as stated in the technical report and according to agency-vetted data, 90% of the wind gusts recorded in the Project region are 14 mph or less. Thus, a 12-mph wind was used in PyroAnalysis' modeling to represent a reasonable worst-case wildfire spread scenario.

County Comment 1c

"The Report does not discuss Project ignition risk or the influence of climate change on wildfire risk."

Applicant Response

Ignition risk is analyzed in a number of prior submittals, including the Wildfire Effects Review memorandum (TN 248297-3), response to data request WILDFIRE-06 (TNs 250341 and 250320), and PyroAnalysis' wildfire presentation to CEC (TN 256430). As outlined in the PyroAnalysis Report, our analysis, which REAX has not refuted, shows that the Project will reduce wildfire and fire ignition risk compared to baseline conditions by changing land use and enhancing immediate access through the new and improved road systems, creating shaded fuel breaks, and removing vegetation within the 2.5 acres surrounding each turbine. This conclusion is corroborated by the fact that the best-available surrogate for post-construction conditions, the Hatchet Ridge Wind Project, which is adjacent to the proposed Project and uses older, less fire-safe technology, has never experienced a fire incident since its construction. This fact is confirmed by CAL FIRE Chief O'Hara (TN 255883).

The Applicant is committed to fire prevention strategies proposed in 2021 by the Shasta County Fire Department to prevent wildfire ignitions during Project construction and as an integral part of the Fountain Wind site safety plan. These safety measures, which were not commented upon by REAX, further mitigate ignition risk associated with Project construction and even that associated with logging operations or recreational use of the lands by hunters and sportsmen (i.e., unattended campfires).

With respect to the County's second assertion about including an analysis of the effects of climate change on wildfire risk, neither the Applicant nor the CEC is required to assess the effects of climate change on wildfire risk under CEQA or the Warren Alquist Act. Rather, the requirement is to assess the impacts of a Project on the environment, here, wildfire risk. The task is not to assess the impacts of the environment (climate change) on the Project. In all events, the development of wind energy will reduce global warming by displacing electricity generation by fossil fuels and thus reduce the emissions of greenhouse gases.

County Comment 1d

"The Report does not adequately evaluate the restrictions on fixed-winged aircraft in aerial firefighting operations and does not quantify the effects of reduced air tanker access to the Project area."

Applicant Response

PyroAnalysis' considerable firsthand experience with aerial firefighting informs our conclusion that aerial firefighting aircraft can safely work within the Project area, as thoroughly detailed in the technical report (pages 15-21). As previously discussed, REAX is a fire protection engineering firm specializing in designing and evaluating fire protection systems for buildings and structures, and staff are not considered wildfire behavior or control experts and do not have the requisite knowledge, training, or experience required to authoritatively evaluate aerial firefighting tactics or capabilities. Conversely, PyroAnalysis' experts possess decades of firsthand experience as aerial and wildland firefighters and have served in statewide, incident-specific, and CAL FIRE command roles. As a result, they have unparalleled experience with the particular type of fire response that would be required for a wildland fire at the Project site.

REAX's ignorance of standard aerial firefighting tactics and response aircraft are highlighted in their erroneous assumptions. For example, REAX claims to be able to model the effects of VLATs (Very Large Air Tankers) on the suppression and control of fire spread during severe fire weather conditions. This cannot be accomplished for several reasons.

First, VLATs are not part of CAL FIRE's standard wildland initial attack aircraft response and would not be dispatched in the initial response to a fire at or near the Project site. The availability of a VLAT for use on an emerging fire in the Project area is limited since there are only four (DC-10s) in operation in the U.S., all of which are currently on contract with the U.S. Forest Service. Even if they were available for response to a CAL FIRE incident because they provide response coverage nationwide, the chance that one would be available to respond within the initial phases of a wildfire incident is doubtful. Therefore, as described in the technical report, S-2s, Type 1 helicopters, and Large Air Tankers would be most effective and widely available in responding to a wildland fire in the Project region.

Second, the most extreme and erratic fire behavior occurs during severe weather conditions, which may preclude using any size aircraft for incident response. In such severe fire weather conditions, firefighting aircraft may not be safely deployed, and their use should not be modeled with any hope of accurate results.

Third, the effects of VLATs on the suppression and control of fire spread by dropping retardant simply cannot be modeled using standard wildland fire behavior software programs (i.e., IFTDSS and BehavePlus). No model currently exists that can accurately predict the influence of aerially applied fire retardant on fire suppression and control. Results of all studies conducted on the effectiveness of aerial fire retardants have shown that their effectiveness depends primarily on the availability and timing of ground firefighters to support aerial operations rather than on the size of the aircraft deploying the retardant.

Last, REAX's supposition that aircraft would not be able to fly near Project turbines is wholly incorrect, as outlined in PyroAnalysis' wildland fire presentation (TN 256430). Fixed-wing and helicopter-based firefighting are routinely and safely conducted in, around, and between turbines on wind projects in California, even at altitudes below blade-tip height. In addition, despite REAX's claims, CAL FIRE does not restrict fire retardant application near waterways. CAL FIRE Fixed Wing Standards only require notification to the Incident Commander and completion of a chemical reporting form if retardant is dropped within 300 feet of a waterway.

REAX's claims regarding modeling capabilities and aircraft and retardant application procedures are patently untrue and highlight their ignorance of standard modeling procedures and wildland firefighting tactics, aircraft, and limitations.

Very Sincerely,

Shane Lauderdale, CFPS, OSC1
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Shane@pyroanalysis.com
530-520-7297

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Senior Consultant
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Attachment A: Resumes of REAX Staff – Fernandez-Pello, Theodori

Carlos Fernandez-Pello, PhD

Professional Profile

Dr. Carlos Fernandez-Pello is an internationally recognized mechanical/aeronautical engineer specializing in thermo-fluids with emphasis on fire physics, fluid mechanics, heat transfer, and thermodynamics. His primary areas of specialty include ignition and fire spread in solid and liquid fuels; self heating and spontaneous ignition of combustible materials; smoldering; wildland fire spotting ignition by metal fragments and embers and subsequent fire propagation; metal particle and embers trajectories in high winds. In addition to teaching, he has conducted research in the above areas funded by NASA, DOD, DOE, NIST, NSF and several industries. He has also consulted for research organizations, government agencies and industrial companies in a variety of subjects ranging from LNG spills to aircraft fire safety. Dr. Fernandez-Pello is currently a Professor of Mechanical Engineering at the University of California at Berkeley where he has been a faculty member since 1980.

A significant component of his consulting activities for the last 30 years has included forensic work on mechanical and aeronautical engineering, with emphasis on fire physics. This work includes cause, fires and explosions, with emphasis on the analysis, testing and modeling of the incident. His litigation activities have involved many areas such as: spot ignition and fire spread of wildland fires by metal particles and embers; ignition and fire spread of combustible materials; aircraft and vehicle fires; liquid pool fire burning; self heating and spontaneous combustion; smoldering and flaming; pyrotechnic explosions; pressure failure of containers and pipelines; explosive boiling;; warehouse and industrial fires and explosions; television and laptop fires; smoke detector failure; fire reconstruction and modeling; and several other areas. He has testified as an expert witness in State and Federal courts.

Education

PhD – Engineering Science, University of California, San Diego, 1975
MS – Engineering Science, University of California, San Diego, 1973
Dr. Engineering – Aeronautical Engineering, Polytechnic University of Madrid, Spain, 1972
Engineering – Aeronautical Engineering, Polytechnic University of Madrid, Spain, 1968

Work History

2008 – present **Reax Engineering**, *Partner*

1986 – present **University of California, Berkeley** Dept. of Mechanical Engineering, *Professor*

2010 – 2019 **University of California, Berkeley** Dept. of Mechanical Engineering, *Almy C. Maynard and Agnes Offield Maynard Endowed Chair Professor of Mechanical Engineering*

2003 – 2013 **University of California, Berkeley** Graduate Division, *Associate Dean*

1982 – 1986 **University of California, Berkeley** Dept. of Mechanical Engineering, *Associate Professor*

1980 – 1982 **University of California, Berkeley** Dept. of Mechanical Engineering, *Assistant Professor*

1980 – present **Freelance technical consultant for liability-related litigation and industry**

1977 – 1980 **Princeton University** Dept. of Mechanical and Aerospace Engineering, *Research Staff Member*

1975 – 1976 **Harvard University** Division of Engineering and Applied Physics, *Post-doctoral research fellow*

Expert Witness and Engineering Practice

Between 1980 and 2011, Dr. Fernandez-Pello has served as a consultant to law firms, industry and government organizations for work related to combustion, fire, and explosions.

Representative litigation/expert witness clients include:

- **Beardsley, Jensen & Von Wald** (Rapid City, SD) – Wildland fire involving power lines (deposition)

- **Begs & Lane** (Pensacola, FL) – Fire and crash of a general aviation aircraft
- **Bishop, Barry, Howe, Haney & Ryder** (San Francisco, CA) – Explosion of liquid fuel (depo & testimony)
- **Berger Kahn,** (Irvine CA) Wildland fire spot ignition by metal particles
- **Burke & Bauermeister** (Anchorage, AK) – Structure fire involving large television (deposition)
- **Cozen & O'Connor** (Atlanta, GA) – Fire in a enamel drying industrial facility (deposition)
- **Cozen & O'Connor** (Philadelphia, PA) – Fire in an industrial oven facility (deposition)
- **Cozen & O'Connor** (Philadelphia, PA) – Industrial fire involving naphthalene (deposition)
- **Cozen & O'Connor** (Philadelphia, PA) – Electrical heater fire in warehouse (deposition & testimony)
- **Cozen & O'Connor** (Chicago, Ill) – Ignition of cellulose insulation in an attic(deposition)
- **Dale Sprik & Associates** (Grand Rapids, MI) – Residential fire originating in a kitchen (deposition)
- **Ernest M. Thayer** (Oakland, CA) – Automobile/structure fire (deposition & testimony)
- **Fetterly & Gordon** (Minneapolis, MN) – Rack storage fire in a paper recycling warehouse (deposition)
- **Fetterly & Gordon** (Minneapolis, MN) – Smoke detector product liability in structure fire (deposition)
- **Fowler et al.** (Miami, FL) – Crash and subsequent fire of a general aviation airplane (deposition)
- **Gordon & Rees** (San Francisco, CA) – Electrical transformer fire
- **Griffin & Laser** (Houston, TX) – Ignition of spilled solvent by water heater pilot
- **Haight Brown & Bonesteel** (Santa Ana, CA) – Residential fire involving ignition of a solvent (deposition)
- **Hallmark et al.** (Portland, OR) – General aviation airplane crash and fire
- **HellerEhrman** (San Francisco, CA) – Modeling of wildland fire involving power lines
- **Herrick, Hart, Duchemin, Spaeth, Sullivan & Schumacher** (Eau Claire, WI) – Tanker fire (deposition)
- **Hillsinger & Costenco** (San Diego, CA) – General aviation airplane fire (deposition)
- **Kirtland & Packard** (Los Angeles, CA) – Smolder initiated structure fire (deposition)
- **Knox et al.** (Oakland, CA) – Smolder initiated fire in a commercial building (deposition & testimony)
- **LA DWP** (Los Angeles, CA) – Office building fire involving transformer (deposition & testimony)
- **Laser, Proctor & Cole** (Houston, TX) – Oil well gas ignition and explosion (deposition)
- **Mackenroth, Ryan, Jacobson, Fong** (Sacramento, CA) – Fire in general aviation aircraft
- **Maloney & Smith** (Dallas, TX) – General aviation aircraft fire (deposition)
- **Martin** (Reno, NV) – Propane gas explosion and smolder initiated fire (deposition)
- **Martin, Ryan, & Andrada** (Oakland, CA) – Propane container explosion
- **Morgenstein & Jubelirer** (San Francisco, CA) – Residential fire involving a laptop
- **Morgenstein & Jubelirer** (San Francisco, CA) – Structure fire involving electrical heater (deposition)
- **Morris, Haynes & Hornsby** (Birmingham, AL) – Residential fire involving a gas heater (deposition)
- **Murchison & Cumming** (Los Angeles, CA) – Spontaneous ignition in coal loader (deposition & testimony)
- **Murchison & Cumming** (Los Angeles, CA) – Wildland fire involving power lines (deposition & testimony)
- **O'Melveny & Myers** (Los Angeles, CA) – Gasoline pipeline failure and fire
- **O'Melveny & Myers** (Los Angeles, CA) – Spontaneous ignition of chemical product
- **Paine, Hamblen, Coffin, Brooke & Miller** (Spokane, WA) – Wildland fire
- **Pretzel & Stouffer** (Chicago, IL) – Fuel tanker truck fire (deposition)
- **Pretzel & Stouffer** (Chicago, IL) – Rack storage fire in a cold storage facility
- **San Diego Gas & Electric** (San Diego, CA) – Wildland fire (deposition & testimony)
- **Schwartz & Cera** (San Francisco, CA) – Hydrogen explosion in gas mixing and storage facility (deposition)
- **Shield & Smith** (Los Angeles, CA) – General aviation airplane fire
- **St. Clair, McFertridge, & Griffin** (San Francisco, CA) – Pier fire (deposition)
- **Subrogors Committee** (Las Vegas, NV) – Explosion in a rocket propellant plant
- **Youngerman & McNutt** (Los Angeles, CA) – pyrotechnic explosion (deposition & testimony)

Consulting for other institutions:

- **National Institute of Standards and Technology, NIST** (Gaithersburg, MD)
- **National Aeronautics and Space Administration, NASA** (Cleveland, OH)
- **National Research Council, NRC** (Washington, DC)
- **Lawrence Livermore National Laboratories, LLNL** (Livermore, CA)
- **Sandia National Laboratories** (Albuquerque, NM)
- **Bechtel Corporation** (San Francisco, CA)

- **Failure Analysis/Exponent** (Menlo Park, CA)
- **Exxon** (Florham Park, NJ)
- **Fire Science Applications** (San Carlos, CA)
- **IHI** (Tokyo, Japan)
- **SENER** (Madrid, Spain)

Selected Research Topics

Ignition of Natural Fuel Beds by Embers and Heated/Burning Metal Particles (NSF)

- The objective of this work is to develop quantitative predictive capabilities for determining whether or not an ember or hot/burning particle will ignite a fuel bed based on particle properties, fuel bed characteristics, and ambient conditions.
- Experiments and numerical modeling are conducted investigate the ignition of vegetation fuel beds by woody embers, hot molten and burning metal particles.

Tackling CFD Modeling of Flame Spread on Practical Solid Combustibles (NSF)

- Project involves the development of a generalized pyrolysis model that can simulate the pyrolysis and burning of real-world materials encountered in fires.
- The computer model is coupled to an existing CFD code and used to calculate flame spread on real-world solid combustibles over a range of length scales.

Smoldering Combustion and its Transition to Flaming in Spacecraft (NASA Space Flight Program)

- Research concerns smoldering and the transition to flaming of foams, composite, and cellulosic materials.
- Experimental studies performed at normal gravity and in reduced gravity in the Space Shuttle.

Test Method for Materials Flammability in Spacecraft (NASA Space Flight Program)

- Work leading to the development of a new test method for the fire properties of materials used in aircraft and spacecraft.
- The test is based on the piloted ignition (hot spot or spark) of materials exposed to external heating.

Ignition, Flame Spread and Extinction in Solid and Liquid Fuels (NIST/NSF)

- Research on the initiation and spread of flames over solid and liquid fuels.
- Includes studies of fuel ignition, the subsequent spread of flames and steady burning, and flame extinction.

Transport and Combustion of Embers and Metal Particles in Wild-land Fires (Various)

- Objective is to model the trajectory of embers and burning metal particles generated in wildland fires to predict fire spotting.
- Results of the project could help predict wildland fire development to help fire fighters to direct fire efforts in wild-land fires.
- Results could also protect the life of firefighters that are often caught in the middle of two propagating fires due to fire spotting by flying embers.

Liquid Fuel Spray Ignition (ARO/TACOM)

- Studies of the mechanisms of ignition and burning of liquid fuel droplets and sprays under supercritical conditions for diesel engines applications.

Liquid Fuel Pool Fires and Boilover Burning of Fuels Spilled on Water (Various)

- Collaboration with ENSMA, Poitiers, France to study the boilover burning of heavy hydrocarbon fuels (diesel oil, heating oil, etc.) spilled on water.

PhD Dissertation and MS Thesis Advising

- Chaired 30 PhD dissertations and 72 MS Theses in UC Berkeley Department of Mechanical Engineering

Selected Publications

Co-author of the book *Fundamentals of Combustion Processes*, Springer Publishing. Five book chapters. Over 250 peer reviewed publications in technical journals in the fields of combustion, fire, and heat transfer. Over 250 other publications.

1. Tse S.D. & Fernandez-Pello, A.C. "On the Flight Paths of Metal Particles and Embers Generated by Power Lines in High Winds and Their Potential To Initiate Wildland Fires," *Fire Safety Journal* **30**: 333-356 *(*1998).
2. Anthenien, R.A., Walther, D.C., & Fernandez-Pello, A.C. "Smolder Ignition of Polyurethane Foam: Effect of Oxygen Concentration," *Fire Safety Journal* **34**: 343-359 (2000).
3. Alvares, N. & Fernandez-Pello, A.C. "Fire Initiation and Spread in Overloaded Communication System Cable Trays," *Experimental Thermal and Fluid Science* **21**: 51-57 (2000).
4. Stevanovic, A., Mehta, S., Zhou, Y.Y., Walther, D., & Fernandez-Pello, A.C., "Effect of Fiberglass Concentration on the Piloted Ignition Delay of Polypropylene Fiberglass Composites," *Combustion Science and Technology* **174**: 169-185 (2002).
5. Alvares, N. & Fernandez-Pello, A.C. "A Methodology to determine Pre-crash Fuel quantity from Post-crash Fire Thermal Damage to Aircraft Structure" *Fire and Explosion Hazards: Proceedings of the 4th International Seminar* (2004).
6. Fernandez-Pello, A.C, Rein, G., Bar-Ilan, A., and Alvares, N. "Estimating the Performance of Enclosure Fire Models by Correlating Forensic Evidence of Accidental Fires" *Interflam 2004* (2004).
7. Anthenien, R., Tse, S. & Fernandez-Pello, A.C. "On the Trajectories of Embers Initially Elevated or Lofted by Ground Fire Plumes in High Winds," *Fire Safety Journal* **41**: 349-363 (2006).
8. Rein, G., Bar-Ilan, A., Fernandez-Pello, A.C. & Alvares, N., "A Comparison of Three Fire Models in the Simulation of Accidental Fires," *Journal of Fire Protection Engineering* **16**: 183-209 (2006).
9. Lautenberger, C., Torero, J.L., & Fernandez-Pello, A.C, "Understanding Material Flammability," Chapter 1 in *Flammability Testing of Materials in Building, Construction, Transport and Mining Sectors*, V. Apte, Editor, Woodhead Publishing, pp. 1-21 (2006).
10. Sardoy, J., Consalvi, J., Porterie, B., Loraud, J., & Fernandez-Pello, A.C., "Modeling Transport and Combustion of Firebrands from Burning Trees," *Combustion and Flame* **150**: 151-169 (2007).
11. Chetehouna, K., Barboni, T., Zarguili, I., Leoni, E., Simeoni A., & Fernandez-Pello, A.C., "Investigation on the Emission of Volatile Organic Compounds from Heated Vegetation and their Potential to Cause an Eruptive Forest Fire," *Combustion Science and Technology* **181**: 1273-1288 (2009).
12. McAllister, S., Fernandez-Pello, C., Ruff, G., & Urban D., "Effect of Pressure and Oxygen Concentration on Piloted Ignition Delay of Combustible Solids," *Combustion and Flame* **157**: 1753–1759 (2010).
13. Hadden, R., Scott, S., Lautenberger, C. & Fernandez-Pello, C., "Ignition of Combustible Fuel Beds by Hot Particles: An Experimental and Theoretical Study," *Fire Technology* **47**: 341 (2011).
14. Fernandez-Pello, A.C., "On Fire Ignition," plenary paper at the *10th International Symposium on Fire Safety Science*, University of Maryland (2011).
15. A. B. Dodd, C. Lautenberger, C. Fernandez-Pello "Computational Modeling of Smolder Combustion and Spontaneous Transition to Flaming *Combustion and Flame*, V. 159, 1,448-461 (2012)
16. A. Osorio, A.C. Fernandez-Pello, D. Urban, and G. Ruff "Limiting Conditions for Flame Spread in Fire Resistant Fabrics" *Proceedings of the Combustion Institute*, **34**, 2691-2697 (2012)
17. S. Manzello, T. Yamada, A. Jeffers, Y. Ohmiya, K. Himoto and A. C. Fernandez-Pello "Summary of Workshop for Fire Structure Interaction and Urban and Wildland-Urban Interface (WUI) Fires-Operation Tomodachi-Fire Research" *Fire Safety Journal*, V 59, 122-131 (2013)
18. C. Fernandez-Pello, C. Lautenberger, D. Rich, C.Zak, J. Urban, R. Hadden, S. Scott, and S. Fereres "Spot Fire Ignition of Natural Fuel Beds by Hot Metal Particles, Embers and Sparks" *Combustion Science and Technology*, 187:1-2, 269-295 (2014)
19. J.L. Urban, C.D. Zak, and C. Fernandez-Pello "Cellulose Spot Fire Ignition by Hot Metal Particles" *Proceedings of the Combustion Institute*, DOI:10.1016/j.proci.05.081 (2014)
20. J. L. Urban, C.D. Zak, and C. Fernandez-Pello "Spot Fire Ignition of Natural Fuels by Hot Aluminum Particles" 14th International Conference of Fire and Materials, San Francisco, CA 2-4 February 2015
21. M. Thomsen, X. Huang, D. Murphy, C. Fernandez-Pello, D. Urban and G. Ruff "Flammability Limits of Fire Resistant Fabrics" 8th International Seminar on Fire and Explosion Hazards, Hefei, China, April 25-28, (2016)
22. K. Miyamoto, X. Huang, N. Hashimoto, O. Fujita and C Fernandez-Pello, "Limiting Oxygen Concentration of Polyethylene Insulated Wires under Varying External Radiation" *Fire Safety Journal*. V.86, 32–40, (2016)
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29. J. L. Urban and A.C. Fernandez-Pello, "Ignition" *Encyclopedia of Wildfires and Wildland-Urban Interface (WUI) Fires,* Manzello, S (Eds) Springer, (2018)
30. S. N. Scott, R. M. Keedy, V. E. Brunini, M. W. Kury, A. B. Dodd, J. L. Urban and C. Fernandez-Pello, "Validation of PMDI-based Polyurethane Foam Model for Fire Safety Applications" Proceedings of the Combustion Institute, 37, 4009–4016, (2019)
31. M. Thomsen, X. Huang, C. Fernandez-Pello, G. A. Ruff and D. L. Urban, "Concurrent Flame Spread over Externally Heated Nomex under Mixed Convection Flow" Proceedings of the Combustion Institute, 37, 3801-3808, (2019)
32. Y. Lu, X. Huang, L. Hu and C. Fernandez-Pello "Concurrent Flame Spread and Blow-off over Horizontal Thin Electrical Wires" Fire Technology (2019).
33. Y. Liu, J. Urban, C. Xu and C. Fernandez-Pello "Temperature and Motion Tracking of Metal Spark Sprays" Fire Technology, (2019) https://doi.org/10.1007/s10694-019-00847-3
34. C. Fernandez-Pello and S. McAllister "On Flame Spread" Journal of the Combustion Society of Japan, V. 61, No. 196, 112-119 (2019).
35. J.L. Urban, J. Song, S. Santamaria, C. Fernandez-Pello "Ignition of a Spot Smolder in a Moist Fuel Bed by an Ember". J. Fire Science, 108, (2019), https://doi.org/10.1016/j.firesaf.2019.102833
36. L. Manzello, S. Suzuki, M. J. Gollner, A. C. Fernandez-Pello "The Importance of Firebrand Mechanisms on Large Outdoor Fire Spread" Progress in Energy and Combustion Science" 76, 135-140. (2020)

Awards

- H. Emmons Award of the International Association of Fire Safety Science
- Distinguished Alumnus Award University of California San Diego
- Combustion Institute Fellow
- ASME Fellow
- Member of The Royal Academy of Engineering of Spain
- Pi Tau Sigma Award for Excellence in Teaching
- Fellowships from Fulbright Foundation, Juan March Foundation, the Japan Society for the Promotion of Science and MITI, Japan, the French and Italian CNR

Conference/Journal Advisory Boards

- Combustion Institute (2014-present)
- *Combustion Science and Technology* (1992-2002)
- *Journal of Combustion* (2010-2012)
- *Progress in Energy and Combustion Science* (1995-2006)
- *Combustion and Flame* (1994-2001)

Maria F. Theodori, MSc, PE

Professional Profile

Maria Theodori is a licensed Fire Protection Engineer with expertise in wildland fire modeling and performance-based design engineering. She recently transitioned from full-time to part-time as an Associate with Reax Engineering Inc. to focus her pursuit on a PhD in wildland fire with UC Berkeley's Department of Mechanical Engineering. Her doctoral research focus is on quantifying community fire risk to support decision-making and improve resilience against extreme fires that encroach the wildland-urban interface. As a professional consultant working in the Bay Area, and previously for the engineering design firm Arup in New York City, Maria's breadth of experience in fire protection/life safety strategy development and code consulting ranges from projects in energy infrastructure to single-family homes, to international airports and historic preservations. She is passionate in helping clients and communities understand fire hazards and reduce risk by curating holistic and actionable mitigation strategies. Her work incorporates relevant research and analyses on fire science, climate change, and new technologies with an evaluation of building/fire code and related standards. Maria is a member of the Society of Fire Protection Engineers and the International Association for Fire Safety Science and has served a combined 8 years in various committee leadership positions for the two organizations.

Professional Licensure

Licensed Professional Engineer, State of California, # FP2088 (Fire Protection Engineering)

Education

PhD – Mechanical Engineering, University of California, Berkeley, August 2020 - In progress

- Major focus area: Combustion; Minor focus areas: Environmental Studies, Computational Techniques

MS – Fire Protection Engineering, University of Maryland, College Park, January 2015 - May 2016

- Thesis title: "Data-driven wildfire propagation modeling with FARSITE-EnKF"

BS – Fire Protection Engineering, University of Maryland, College Park, January 2011 - December 2014

- Double Minor in Project Management and Modern Greek Language

Professional Experience

11/19 – present **Reax Engineering Inc.** Berkeley, CA *Associate Engineer*

Responsibilities include:

- Fire protection engineering – code consulting, fire/life safety systems, performance-based design, analysis and justification of alternate means and methods
- Wildland fire consulting – hazard and risk analysis, fire spread and behavior modeling, climate change, risk mitigation, policy guidance and resilience strategy at multiple scales, emergency preparedness and response planning
- Fire modeling – smoke alarm/detector activation, heat detector/sprinkler activation, time to untenability or incapacitation by smoke and heat
- Building evacuation modeling – human behavior and egress design analysis, time required for safe egress of occupants

3/19 – 11/19 **Arup Advanced Technology + Research** San Francisco, CA *Fire Engineer/Wildfire Specialist*

Representative activities:

- Served as lead wildfire subject matter expert across the global firm of over 14,000 employees, both an internal- and external-facing role.
- Contributed to projects and research activities as part of a multi-disciplinary team of experts on natural hazards and climate change.

6/16 – 3/19 **Arup Fire** New York, NY *Fire Engineer*

Representative activities:

- Assisted clients with design and engineering of fire protection and life safety systems, including building code and fire code consultation and performance-based approaches for justification of alternative means and methods.

- Appointed Deputy Project Manager on various projects; coordinated across stakeholders and engineering disciplines to ensure a high quality of work production and delivery of projects on-time and within budget constraints.
- Contributed to internal initiatives for digital transformation of the fire engineering practice, including workflow process automation, digital upskilling, and advanced data manipulation.

Selected Project Work

Large outdoor fires and multi-hazard:

- Quantitative wildland fire risk and detection effectiveness analyses for a water resource restoration project
- Technical and project management support for development of a near-term fire risk forecast model to improve electrical grid resiliency under a grant from the California Energy Commission (California)
- Evaluation of wildfire-related standard operating procedures, fire protection equipment, and associated training documents for a gas transmission entity spanning several states (United States)
- Quantitative analysis of greenhouse gas emissions from wildland fire caused by ignition from overhead powerline (California)
- Development of a wildfire mitigation strategy for an 8,600 ft^2 single-family residence on a 17-acre property (St. Helena, CA)
- Assessment of wildland fire hazard and risk, and subsequent development of vegetation management and fire risk reduction plan, for a mixed-use campus of over 20 buildings (Marin County, CA)
- Development of a wildfire policy strategy and CEQA wildfire impact compliance review for a masterplan development at the wildland-urban interface (Concord, CA)
- Assessment of community evacuation and wildland fire risk under CEQA regulations for an asphalt plant development in a high-risk fire area (Willits, CA)
- Analysis of wildland fire hazard and risk, both qualitatively and quantitatively, for a global portfolio of data centers as part of a multi-hazard resiliency assessment (Global)
- Development of design fire scenarios for external urban fire spread analysis to inform creche fire safety strategy in informal settlement communities (South Africa)
- Analysis of wind hazard and probabilistic risk to proposed energy infrastructure for due diligence of site selection (Indonesia)
- Assessment and data collection of telecommunication buildings susceptibility to various disasters (flood, wind, hurricane, fire), used to calibrate fragility curves as input to risk models (US)

Fire protection engineering:

- Fire service access planning for a large, mixed-use commercial campus (Sunnyvale, CA)
- Design and fire code consulting for outdoor storage of hazardous materials at a chemical storage facility (Fairfield, CA)
- Design and fire code consulting for a cannabis manufacturing facility (Hayward, CA)
- Delivery of fire/life safety consulting and several performance-based design solutions for an 8-million-square-feet airport terminal building (Mexico City, MX)
- Quantitative analysis of apron fuel spill fire risk and exposure to structures and occupants in the fixed link boarding bridges of a new-design airport (Mexico City, MX)
- Development of fire models using computational fluid dynamics software to inform smoke control design for an enclosed train station located in a parking structure (Mexico City, MX)
- Design of fire/life safety strategy for a multi-modal transportation center (Mexico City, MX)
- Design of high-rise fire/life safety strategy, smoke control system design, and project documentation for authority approvals and permitting (San Francisco, CA)
- Fire/life-safety code compliance and performance-based design strategy for a mixed-use, high-rise development (Mexico City, MX)
- Peer review and due diligence assessment of an existing historic performance venue for a potential acquisition (New York, NY)
- Analysis of code changes and cost impact of each change during construction administration of a border crossing facility campus (Alexandria Bay, NY)
- Review of fire alarm shop drawings and voltage drop calculations for a school campus consisting of nine buildings (Frederick, MD)

- Assurance surveying of rail stations for contractor compliance with plan-approved installations of fire alarm and suppression systems (New York, NY)
- Analysis of fire and smoke movement using computational fluid dynamics software for a historic government building featuring open stairwells, high ceilings, and an atrium (Washington, D.C.)
- Inspection and reporting of fire code deficiencies for a 29-building campus of various occupancy types including laboratory, assembly, mechanical, utility, storage, and office (Laurel, MD)

Human behavior and evacuation analysis:

- Collaboration with integrated planners to determine optimal rail station design based on analysis of pedestrian movement using human behavior modeling software (London, UK)
- Calculation of occupant evacuation times for various exiting configurations of an underground research facility located 8,000 feet below grade (Lead, SD)
- Development of evacuation models using human behavior modeling software to evaluate occupant egress under various fire conditions in a non-sprinklered, historic building (New York, NY)
- Analysis of human behavior and egress using pedestrian modeling software under various fire and emergency scenarios for a sports stadium of 52,400-persons capacity (New Brunswick, NJ)
- Development of evacuation models of airport terminals to compare egress times for various occupant density scenarios, including during peak travel seasons and weather delay events (Atlanta, GA)
- Calculation of time for "reverse evacuation" of deplaning passengers to reach a point of safety within the terminal building, away from hazardous conditions on the apron (Mexico City, MX)
- Computer-Aided Design of emergency evacuation route diagrams per ASTM E-2238 for 29 buildings of various occupancy types including laboratory, assembly, mechanical, utility, storage, and office (Laurel, MD)

Selected Research Activities

- *Threat of Wildfires at the Urban-Rural Interface*, Arup, New York, 2017
  Lead investigator on research of global status of the threat of wildfires to communities at the rural-urban interface. Findings include risk factors; resilience, adaptation, mitigation and preparedness strategies; new technologies; policies and regulations.
- *Data-driven Wildland Fire Propagation Modeling*, University of MD, College Park, 2016
  Analysis of the effects of topography, wind, and vegetation on the propagation of a wildfire. Integrated existing wildfire prediction software FARSITE with data assimilation methods to model an algorithm that could improve forecast of fire line propagation.
- *Homeowner's Wildfire Risk Assessment*, Forest Research Institute, Athens, Greece, 2013
  Development of a home risk-assessment evaluation form for residents at the wildland-urban interface in Greece. Studied literature on fire dynamics and fire modeling to determine effective mitigation methods.

Leadership and Volunteer Activities

- **International Association for Fire Safety Science** *Large Outdoor Fire & the Built Environment Committee*
  10/19 – present Co-lead of the Emergency Management & Evacuation Working Group
- **Society of Fire Protection Engineers** *Continuing Professional Development Committee*
  3/18 – present Co-lead of the Emerging Professionals of SFPE Subcommittee
- **Society of Fire Protection Engineers** *Board of Directors Nominating Committee*
  1/20 – present Member of the 2020 Nominating Committee
- **Society of Fire Protection Engineers** *Community Outreach and Advocacy Committee*
  10/16 – 12/19 Member of the Strategic Alliances Subcommittee
- **Society of Fire Protection Engineers** *New York Metropolitan Chapter*
  8/16 – 3/19 Served on the Board of Directors
- **University of Maryland Alumni Network,** *Greater New York City*
  8/17 – 3/19 Board Member

Conference Presentations and Invited Talks

1. Theodori, M., Hogan, J. "Real-time Wildfire Prediction, Detection, and Response in California". Course on Environmental Governance and Climate Resilience, Stanford University, CA. February 2020.
2. Panelist, "Situational Awareness and Fire/Weather Modeling". Edison Electric Institute Wildfire Technology Summit. Dallas, TX. February 2020.

3. Theodori, M. "WUI Resilience: Answering to Climate Change". Society of Fire Protection Engineers, North American Conference. Montreal, Canada. October 2017.

Awards

- Top 5 Under 35, Society of Fire Protection Engineers, 2019
- Chairman's Award, University of Maryland, Department of Fire Protection Engineering, 2014