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Memorandum

To: Adam Fieseler, Assistant Director Shasta County Department of Resource Management

From: David Rich., Principal, Reax Engineering Inc.

Date: May 27th, 2025

Subject: Evaluation of CEC's Staff Assessment for the Fountain Wind Energy Project – Wildland Fire Impacts

Dear Mr. Fieseler,

Reax Engineering has conducted a review of the California Energy Commission's (CEC) Staff Assessment and Environmental Impact review for the Fountain Wind Energy Project, dated March 25, 2025 (TN# 262350). The evaluation is requested by the Shasta County Department of Resource to the potential for causing either a direct physical change in the environment, or a reasonably foreseeable indirect physical change in the environment. Reax has assessed the adequacy of the assessment of wildland fire impacts by CEC Staff as set forth in the California Environmental Quality Act (CEQA). We have conducted our review in alignment with Article 10 – *Considerations in Preparing EIRs and Negative Declarations* of the State CEQA Guidelines sections 15140 through 15155.

Prior Docketed Comments Produced and Reviewed

Reax has reviewed the Staff Assessment and numerous docketed comments related to wildfire hazard, aerial firefighting and fire suppression activities. In addition, we have reviewed the following reports and comment letters.

- The CEC Staff Fountain Wind Project Staff Assessment dated March 25th, 2025.
- The applicant produced fire behavior modeling analysis of the impacts of the project in December 2023 (Stantec 2023c - TN253505) and a supplemental letter report by PyroAnalysis, dated April 2024, addressing information obtained by CEC staff from Chief O'Hara (Stantec 2024u - TN 255883).

- We have also reviewed a comment letter from the applicant (PyroAnalysis) regarding the REAX (Shasta County) fire spread modeling (Stantec 2024cc – TN 260271).

Reax has previously conducted a thorough, independent review, a fire behavior analysis and response to comments produced by applicant consultants as documented in the following.

- Fire Behavior Analysis and Review of Existing Project Documentation, Reax Engineering Inc. dated August 29th, 2024.
- Fountain Wind Project – Discussion of Fire Behavior Modeling Results dated September 19th, 2024.
- Fountain Wind Project – Discussion of fire behavior modeling results (Letter #2), dated November 15th, 2024.

The CEC's Evaluation of Wildland Fire Impacts Fails to Comply with CEQA - (Public Resources Code section 21000 et seq.)

We have reviewed the Staff Assessment and related documents for the Fountain Wind Energy Project and have determined that the CEC, as lead agency, has failed to satisfy the requirements of CEQA (Public Resources Code section 21000 et seq.) in its review of the fire impacts resulting from project implementation.

The EIR Fails to Thoroughly Describe Specific Hazards Associated with Construction in a Very High Fire Hazard Severity Zone and Lacks Substantial Evidence to Support the Determination that the Proposed Conditions of Certification (Facility Design) Constitute All Feasible Mitigation Measures.

For the reasons set forth below and to afford the public and decision makers their rightful critical examination of new essential information, we urge the CEC to address inadequacies identified in these comments and recirculate the EIR.

Information Contained in Chapter 4.1 (Facility Design) of the EIR Failed to Provide Meaningful Review of Anticipated Effects

Within Section 4.1, Facility Design, Staff lists the requirements for application of the Building Standards Code 2022, which includes the California Building and Fire Codes and referenced publications.

However, in addition to these minimum requirements, the elevated risk of fire during project construction, e.g., machinery, hot work, reduced availability of fire suppression resources, partial or not yet functioning fire safety systems, all in a high fire hazard severity zone, warrant identification of specific items which may exceed the letter of the code but, in alignment with the intent of the code, reduce risks to workers, the facility, nearby communities, and the environment.

- Assignment of a Fire Prevention Program Superintendent to interface with the stakeholders and coordinate fire watch and site fire prevention and response.
- Prohibition of hot work construction activities during Red Flag Warnings, which are issued for a stated period of time by the National Weather Service using pre-determined criteria to identify particularly critical wildfire danger in a particular geographic area.

- Implementation of tiered fire watches with increased staff tasked with monitoring for ignitions during hot work activities (fire watch). Fire watches are specified in the Building Code as being provided during hot work and continuing for a minimum of 30 minutes following completion of the hot work activities. In light of the elevated fire hazard, it would be advisable for the Fire Prevention Program Superintendent to determine during construction that this monitoring period be increased based on the potential for weather conditions that may increase the potential for sparks to be carried by the wind and result in ignition (i.e., the potential for high wind events, high temperature, and/or low relative humidity).
- Provision of expanded fire safety training for all construction crew members, including on the regulatory requirements set forth in code documents, the proper use of firefighting equipment, and procedures to be followed in the event of a fire. Training for employees prior to the start of construction to identify and report to the appropriate authority potential fire safety hazards, including the presence of sparks or smoke. Retention of training records which will be available for review by the local authority having jurisdiction (AHJ).
- Clearance of all dead and downed vegetation and dead or dry leaves and pine needles from the ground within a region that could reasonably be exposed to ignition sources including hot work on elevated platforms.
- Ongoing fire safety inspections and patrols of the construction site should be integrated into project site security procedures for the duration of construction. The assigned fire patrols verify the proper tools and equipment are on site, serve as a lookout for fire starts, including participating in a fire watch to make sure no residual fire exists following the completion of the construction activity.
- Specifications for fire-fighting equipment with consideration of factors impacting successful use of the equipment in a remote location with limited access to water and delays for response from community firefighting resources.
- Outreach and orientation services to responding fire stations including pre-staging measures prior to the start of hot work construction activities.
- During operation, monitoring by staff and by cameras. Project staff should be trained to identify and report to the appropriate authority potential fire safety hazards, including the presence of sparks or smoke.
- Prompt reporting to the AHJ of any fire ignited on site.

The CEC Fails to Explicitly Address the Increase in Fire Hazard and Resultant Impacts, Including to the Environment including Cultural Resources and Infrastructure, Resulting From the Project, And So Fails to Provide Substantial Evidence to Support the EIR's Determination that the Proposed Conditions of Certification (Section 5.1, Air Quality, Section 5.2 Biological Resources, Section 5.3 Greenhouse Gas Emissions) Include All Feasible Mitigation Measures.

<u>Failure to Address Wildfire Impacts Resulting from the Fountain Wind Project</u>

CEC Staff notes in Section 5.7-38, that "Wildfire risk at the project site is influenced by the rugged topography, increasingly hot dry climate during fire season, and wind patterns, however as most wildfires in California are human caused the **fire risk would be increased by FWP construction and operation**." (Emphasis added.)

Section 5.7-36 reports that "In the event of a large wildfire within the project site, Chief Sean O'Hara has indicated that the **turbines would impair aerial firefighting** at the site (CEC 2024i TN 254899, CEC 2024h TN 254875)." (Emphasis added.)

Furthermore, the Staff Assessment's conclusions regarding impaired aerial firefighting are untenable. Section 5.7-43 acknowledges that "The proposed project has the potential to impair aerial firefighting and thus reducing firefighting effectiveness in the event of a wildfire at the project site. The potential of the proposed project and Hatchett Ridge to impair aerial firefighting is specific to the area at and immediately adjacent to each project and would therefore be unlikely to be cumulatively considerable."

However, this conclusion is flawed. It is widely believed that firefighting effectiveness directly influences fire growth potential, e.g., more than 97% of US wildland fires between 1995–2005 were extinguished during initial attack while they were very small (Stephens and Ruth 2005)[1] and a study of fire between 1916 and 2003 showed that area burned in the western United States declined dramatically during this period of increasingly aggressive fire suppression (Littell et al. 2009)[2].

Since aerial firefighting in remote areas may be the first suppression resource on site, and these efforts can have high effectiveness in suppressing or slowing the fire, the impact of impaired aerial firefighting is **not** a localized issue specific to "the area at and immediately adjacent to each project site."

As wildfire spreads, its daily growth increments tend to increase at exponential rates.[3] The larger and more rapidly a fire grows, there is an increase in both the resources required to control it and the likelihood of negative consequences.[4] Additionally, the proposed project site and the Hatchett Ridge project site are approximately 2 miles apart at the northeastern-most wind turbine location proposed for the Fountain Wind site. It is not uncommon for embers to travel long distances in advance of a fire front, creating new spot fire ignitions. As such, the proximity of these projects presents a clear potential for cumulative impact on wildfire suppression capabilities, one that must be evaluated in the EIR.

The assertion that impacts to aerial firefighting are unlikely to be cumulatively considerable is unsupported. By omitting an assessment of the fire growth implications and the spatial interaction between the two sites, the Staff Assessment and EIR underrepresent the potential regional-scale hazard posed by reduced aerial firefighting effectiveness.

While assessment of wildland fire probability and increases in probability with environmental changes is challenging, qualitative assessments of the increased hazard associated with human, and equipment caused ignitions in wildland urban interface areas **are** available for analysis as are descriptions of the nature and frequency of wind turbine failures.

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[1] Stephens, Scott L., and Lawrence W. Ruth. 2005. Federal forest-fire policy in the United States. Ecological Applications 15 (2): 532–42

[2] Littell, Jeremy S., Donald McKenzie, David L. Peterson, and Anthony L. Westerling. 2009. Climate and wildfire area burned in western US ecoprovinces, 1916–2003. *Ecological Applications* 19 (4): 1003–21.

[3] Juang CS, Williams AP, Abatzoglou JT, Balch JK, Hurteau MD, Moritz MA. Rapid Growth of Large Forest Fires Drives the Exponential Response of Annual Forest-Fire Area to Aridity in the Western United States. Geophys Res Lett. 2022 Mar 16;49(5):e2021GL097131. doi: 10.1029/2021GL097131. Epub 2022 Mar 8. PMID: 35866067; PMCID: PMC9286820.

[4] Wildland Fire Management – Fiscal Year 2022 Annual Report and Large Fire Review, USDA Forest Service, https://www.fs.usda.gov/sites/default/files/fy23-wildfire-disaster-funding-adj-report.pdf

Furthermore, the social, cultural, environmental and health impacts of wildland fires can also be quantified and applied in post-wildland fire assessments. Quoting from a USDA publication assessing post fire values at risk[5],

> *Wildfire effects include loss of vegetative cover and changes to soil properties that may lead to secondary effects of increased runoff, erosion, flooding, sedimentation, and vulnerability to invasive weeds. These secondary effects may threaten human life and safety, cultural and ecological resources, land use, and existing infrastructure. Current Burned Area Emergency Response (BAER) assessment procedures require identification and valuation of values-at-risk (VAR) from the potential secondary effects of wildfires.*

Air quality is also a factor that has not been discussed beyond those topics covered in Section 5.1 on Air Quality which considers net increases in the criteria pollutants from Table 5.1.1, National and California Ambient Air Quality Standards.

The USDA publication "State of the Science on Wildland Fire Emissions[6] reports that,

> *"Wildland fires are a major source of pollutants resulting in both air quality impacts and climate interactions. Wildland fire smoke can trigger severe pollution episodes with substantial effects on public health and fire emissions can degrade air quality at considerable distances downwind, hampering efforts by air regulators to meet air standards. Fires are also a major global source of aerosols which affect the climate system by absorbing and scattering radiation and by altering optical properties, coverage, and lifetime of clouds".*

The EPA publication, "Wildland Fire, Air Quality, and Public Considerations Fact Sheet[7] states that

> *"Wildland fires – including both wildfires and prescribed fires – account for 44 percent of the nation's primary emissions of fine particulate matter (PM 2.5)." The fact sheet goes on to state that "The wildfire crisis is a public health crisis, including significant impacts on air quality. As wildfires increase in size and severity, the related public health impacts, including from smoke exposure, will continue to grow."*

As detailed above, the EIR confirms that construction and operation of the project would both increase wildland fire hazard and decrease wildland fire fighting effectiveness. Research shows that the increase in wildland fire frequency and severity could "impact human life and safety, cultural and ecological resources, air quality, climate change, land use, and existing infrastructure"[1].

CEC staff must address these concerns with characterization of wildland fire hazard and risk of significant impacts, pared with all feasible mitigation measures to reduce these significant impacts.

<u>Failure to Accurately Address Fire Hazards Resulting from the Fountain Wind Project</u>

CEC Staff provides a wide-ranging critique of the applicant's fire behavior modeling which they note lacks conservatism by" not fully accounting for the range of scenarios that could occur because it only accounts for average weather and wind conditions" [5.7-16]. They further note that the applicant's analysis lacks breadth by focusing on the role that road construction and fuel breaks would have on wildland fire,

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[5] Calkin, David E.; Hyde, Kevin D.; Robichaud, Peter R.; Jones, J. Greg; Ashmun, Louise E.; Loeffler Dan. 2007. Assessing post-fire values-at-risk with a new calculation tool. Gen. Tech. Rep. RMRS-GTR-205. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 32 p.
[6] https://research.fs.usda.gov/firelab/projects/stateofscience
[7] (https://www.epa.gov/system/files/documents/2024-02/pm-naaqs-wildland-fire-air-quality-fact-sheet-final.pdf)

especially without having accounted for “the continued presence of burnable fuel in the fire breaks, does not evaluate ember spotting in the rate of fire spread, and does not account for changes to wildfire risk due to climate change”[5.7-16].

In Section 5.7-16, the Staff Assessment explicitly notes the following regarding the applicants’ approach to fire modelling:

> *A more informative study would simulate hypothetical fire behavior resulting from potential ignitions starting along roadsides outside of the immediate project area. One of the common assumptions used in fire behavior modeling is that ignition locations are random. However, fire ignitions are highly spatially structured. Thus, an ignition surface that reflected the most probable locations for human and lighting-caused ignitions, in addition to considering the potential for increased frequency of ignitions, could have provided further insight into possible project impacts. Furthermore, given the tendency for invasive grass to establish along roadsides and within disturbed areas, simulation of ignitions in grassland fuels could have provided further insight into how fires might start and spread. Additionally, as pointed out by Shasta County (COS 2024k – TN 259437), the PyroAnalysis study fails to account for the continued presence of burnable fuel in the fire breaks, does not evaluate ember spotting in the rate of fire spread, and does not account for changes to wildfire risk due to climate change. Finally, the applicant's fire behavior study does not include evaluation of a worst-case scenario which would be needed to evaluate behavior under wind speeds that are at least as fast as those in the worst wind-driven fires in this and surrounding regions.*

In addition to the items discussed above, this updated modeling should be conducted and included in the EIR in order to fully address the concerns raised in the sections above with reference to Section 4.1 Facility Design, Section 4.4 Worker Safety and Fire Protection, Section 5.1 Air Quality, Section 5.2 Biological Resources, and Section 5.3 Climate Change and Green House Gas Emissions, and Section 5.7 Hazards, Hazardous Materials and Wildfires. The CEC is obligated to inform the public of the increased probability of fire associated with the increased hazard associated with the project and how this hazard increases the potential destructiveness of the fires.

Maria Theodori, M.S., PE

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Reax Engineering

David Rich, PhD

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Profile

Maria Theodori is a licensed Fire Protection Engineer with expertise in fire science, fire modeling, risk analysis, and performance-based design. She has over ten years of experience in professional consulting and is currently a doctoral candidate in the Fire Research Lab with the Department of Mechanical Engineering at the University of California, Berkeley. Maria's research focuses on advancing wildland-urban fire behavior models to better simulate fire spread in urban areas, improving the ability to quantify wildfire hazard and risk to communities. Her key contributions include parameterizing urban fuels based on physical heat transfer and ignition processes and developing methods to accurately represent real-world conditions for input to fire spread and risk models. Maria is a member of the Society of Fire Protection Engineers, the International Association of Wildland Fire, and the International Association for Fire Safety Science, where she has held various volunteer leadership roles for more than a decade.

Professional Licensure

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

Education

Ph.D. Mechanical Engineering (In progress) – University of California, Berkeley – Expected August 2025

- Major: Heat Transfer ▪ Minors: Wildland Fire Science, Risk & Data Science
- Research: Development and optimization of wildland-urban fire spread models and risk analysis methods using semi-physical modeling, data science, and machine learning.
- Advisor: Professor Michael J. Gollner

M.S. Fire Protection Engineering – University of Maryland, College Park – May 2016

- Thesis: *Data-driven wildfire propagation modeling with FARSITE-EnKF*
  This study explored the integration of wildland fire behavior simulation software (FARSITE) with data assimilation methods (ensemble Kalman filter) to model an algorithm that could improve near-term forecasts of fire line propagation.
- Advisor: Professor Arnaud Trouvé

B.S. Fire Protection Engineering – University of Maryland, College Park – December 2014

- Minors: Project Management and Modern Greek Language

Professional Experience

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

- Technical contributor with responsibilities in project management and business development
- Wildland fire consulting – hazard and risk analysis, fire spread and behavior modeling, code and performance-based risk mitigation, emergency preparedness and response planning
- Fire protection engineering – code consulting, fire/life safety systems, performance-based design, analysis and justification of alternate means and methods
- 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

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

- Lead wildfire subject matter expert for the global firm of over 14,000 employees.
- Collaborated on projects 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*

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

Technical Skills

- Fire Modeling: Expert in **ELMFIRE** and **FlamMap/FARSITE** wildland fire models, with comprehensive knowledge of required data inputs, fire behavior submodels, and interpretation of results. Proficient with **FireFamilyPlus**, **WindNinja**, and **Fire Dynamics Simulator** (FDS).
- Programming: Proficient in **Python** and **Bash**; working knowledge of **R** (stats, databases) and **FORTRAN**.
- GIS & Tools: **QGIS**, **GitHub**, **Visual Studio Code**
- Data & Analytical: Skilled in data pipelines, statistical analysis, ML, optimization, and handling large geospatial datasets

Publications

- Lautenberger, C., **Theodori, M**., & Seeburger, D. (in press). Modeling of wildland fires and WUI fires. In *SFPE Handbook of Fire Protection Engineering* (Chapter 103). Springer. (Forthcoming May 2025)
- Zamanialaei, M., San Martin, D., **Theodori, M**., Purnomo, D.M.J., Tohidi, A., Qin, Y., & Gollner, M. (2025). *Isolating the primary drivers of fire risk to structures in WUI regions in California* [Manuscript under review]. Nature Portfolio. https://doi.org/10.21203/rs.3.rs-5776626/v1
- Purnomo, D.M.J., Qin, Y., **Theodori, M.,** Zamanialaei, M., Lautenberger, C., Trouvé, A., & Gollner, M. (2024). Reconstructing modes of destruction in wildland–urban interface fires using a semi-physical level-set model. *Proceedings of the Combustion Institute*, 40(1-4), 105755.
- Purnomo, D.M.J., Qin, Y., **Theodori, M.,** Zamanialaei, M., Lautenberger, C., Trouvé, A., & Gollner, M. (2024). Integrating an urban fire model into an operational wildland fire model to simulate one dimensional wildland-urban interface fires: a parametric study. *International Journal of Wildland Fire*, 33(10).
- Elhami-Khorasani, N., Kinateder, M., Lemiale, V., Manzello, S. L., Marom, I., Marquez, L., Suzuki, S., **Theodori, M.**, Wang, Y., & Wong, S. D. (2023). Review of Research on Human Behavior in Large Outdoor Fires. *Fire Technology, 59(4), 1341-1377.* https://doi.org/10.1007/s10694-023-01388-6
- Hakes, R. S. P.*, **Theodori, M.***, Lautenberger, C., Qian, L., & Gollner, M. J. (2022). Community-level risk assessment of structure vulnerability to WUI fire conditions in the 2017 Tubbs Fire. *Advances in Forest Fire Research* 2, 552-557. https://doi.org/10.14195/978-989-26-2298-9_86
  *These authors have contributed equally to this work.
- Miller, R. K., Richter, F., **Theodori, M.**, & Gollner, M. J. (2022). Professional wildfire mitigation competency: a potential policy gap. *International Journal of Wildland Fire* 31, 651-657. https://doi.org/10.1071/WF22012
- Wang, Y., Wadhwani, R., Suzuki, S., **Theodori, M.**, et al. (2022). Case studies of large outdoor fires involving evacuations. Part 2. Zenodo. https://doi.org/10.5281/zenodo.6544760
- Ronchi, E., Wong, S., Suzuki, S., **Theodori, M.**, et al. (2021). Case studies of large outdoor fires involving evacuations. Zenodo. https://doi.org/10.5281/zenodo.4504853
- Gollner, M., **Theodori, M.**, et al. "Preparing for Disaster: Workshop on Advancing WUI Resilience." Fire Protection Research Foundation. San Francisco, CA. March 2021.

Conference Presentations and Invited Talks

- "Parameterization of Building Fuel Models for Simulating Wildland-Urban Fires," *7th International Fire Behavior and Fuels Conference.* Boise Centre, Boise, Idaho, April 2024.
- "Community-level risk assessment of structure vulnerability to WUI fire conditions in the 2017 Tubbs Fire," *IX International Conference on Forest Fire Research.* Coimbra, Portugal, November 2022.
- "Real-time Wildfire Prediction, Detection, and Response in California," *Course on Environmental Governance and Climate Resilience*. Stanford University, California, February 2020.
- "Situational Awareness and Fire/Weather Modeling," *Edison Electric Institute Wildfire Technology Summit*. Dallas, Texas, February 2020.
- "WUI Resilience: Answering to Climate Change". *Society of Fire Protection Engineers, North American Conference*. Montreal, Canada. October 2017.

Selected Professional Project Work

Large outdoor fires and multi-hazard:

- Quantitative wildland fire risk and detection effectiveness analyses for a water resource restoration project (Klamath, CA and OR)

- 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)
- Quantitative wildland fire hazard and risk analysis for an electric utility entity that services over one million customers (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 home 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)
- Fire protection/life safety code compliance peer review and due diligence assessment of an existing historic performance venue for a potential acquisition (New York, NY)
- Analysis of code changes and the 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 MassMotion (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 MassMotion 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 MassMotion 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 using 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, storage, and office (Laurel, MD)

Leadership and Volunteer Activities

SheCanCode Mentoring Program

- 9/21 – 5/22 Coached young women in developing countries on preparation skills for the job search and interview processes, particularly in computer science and technology career fields.

International Association for Fire Safety Science

- 10/19 – 5/21 Large Outdoor Fires & the Built Environment Committee, Co-lead of the Emergency Management & Evacuation Working Group

Society of Fire Protection Engineers *Global*

- 1/20 – 10/20 Board of Directors Nominating Committee
- 3/18 – 10/20 Co-lead of the Emerging Professionals of SFPE Subcommittee
- 10/16 – 12/19 Community Outreach and Advocacy Committee, Strategic Alliances Subcommittee

University of Maryland Alumni Network *Greater New York City*

- 8/17 – 3/19 Board Member

Society of Fire Protection Engineers *New York Metropolitan Chapter*

- 8/16 – 3/19 Board of Directors

ACE Mentor Program of America *New York City*

- 9/16 – 6/18 Mentor for high school students to encourage and guide their interest in architecture, engineering, and construction careers.

Honors and Awards

- Graduate Student Engagement Fellow, Science Advisory Panel to California's Wildfire and Forest Resilience Task Force, 2023
- Top 5 Under 35, Society of Fire Protection Engineers, 2019
- Sarah Bryan Scholarship, UMD, Department of Fire Protection Engineering, 2014-2015
- Philip L. DeCamara, Jr. Memorial Award, Center for Life Safety Education, American Fire Sprinkler Association, 2014-2015
- John L. Bryan Graduate Research Assistantship, UMD, Department of Fire Protection Engineering, 2014
- Chairman's Award, UMD, Department of Fire Protection Engineering, 2014
- Edwards Scholarship, UTC Fire & Security, 2013-2014
- Phillip L. Turner Fire Protection Scholarship Award, Fire Apparatus Manufacturers' Association, 2013

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Professional Profile

Dr. Rich is a founding partner and Principal Engineer at Reax Engineering Inc., a thermal sciences consulting firm based in San Francisco's Bay Area. He is a fire expert with comprehensive experience in the fire testing laboratory and with large scale fire testing supported by sophisticated analysis and modeling tools. David is an experienced designer and peer reviewer of building fire safety systems, especially performance-based systems supported by computational methods and scale modeling. He applies similar tools to wildland fire hazard assessments supported by computational modeling and experiments. He has been qualified as an expert in court to testify on the subjects of wildland fire hazard assessment and fire personal injury and has testified before numerous boards of supervisors and planning commissions on these subjects. He has broad experience as an expert in assisting with fire scene investigations, reviewing expert opinions, evidence collection, legal matters, systems analysis, experimental investigations, computational fire modeling and graphics support for trial and mediation. He also works with Spark Thermionics, a clean energy concepts R&D, multi-physics modeling, i.e., coupled heat, structural, fluids and reacting flows in Ansys. He designs and executes experiments, performs laboratory experiments and provides prototyping support. He brings a diverse background to engineering with research and development experience in combustion both in academia and the private sector and bioengineering and mechanical design combined with practical experience as a Rescue Captain and Paramedic in the San Francisco Fire Department. He earned his PhD in the Combustion and Fire Processes Laboratory at the University of California at Berkeley working on NASA funded research to better understand the behavior of polymer fire behavior in zero gravity conditions. He lecturered in thermo-fluid sciences in the Department of Mechanical Engineering at UC Berkeley for a decade and similarly in the graduate program for Fire Protection Engineering at Cal Poly San Luis Obispo. He has been a technical advisor to IEC Technical Committee 108 on safety of electronic equipment within the field of audio/video, information and communication technology, and a voting member of the U.S. 108 Technical Advisory Group (TAG) where he provides expertise in flammability behavior of electronics, relevant fire test methods, and regulatory requirements, especially relating to polymer enclosures. He is also a member of IEC TC 89 U.S. TAG on Fire Hazard Testing.

Education and Teaching

PhD – Mechanical Engineering, University of California at Berkeley, 2006

- Dissertation – "Ignition Delay & Flame Spread Characteristics of Polymers used on Space Craft"
- Major field: Combustion, Minor field: Materials

BS/MS – Mechanical Engineering, University of California, Berkeley, 2000-2002

Professional Experience

2008 – present **Reax Engineering Inc.** Berkeley, CA, *Founding Partner, and Engineer*

- Over a 16 year period, Reax Engineering has been engaged in more than 1500 separate consulting projects in areas of peer review, design, testing, modeling, expert witness services, policy, and code development. Dr. Rich has been a partner, coordinator and principal investigator of numerous projects and director of junior engineers. He has interacted with architects, legal professionals, and industry and government partners in a broad range of matters related to thermo-fluid sciences and fire in the built and wildland urban interface.

2021-Present **Spark Thermionics, Berkeley, Consulting Researcher**

- Mechanical engineering support for clean energy concepts R&D, multi-physics modeling, i.e., coupled heat, structural, fluids and reacting flows in Ansys. Design and execution of experiments, design and fabrication of parts in SolidWorks. Lab work and prototyping support, end mill and lathe, brazing/and small-scale stick welding. Design of products for manufacture by outside vendors including design for additive manufacturing. Vacuum system and glove box experience.

2013-2024 **University of California, Berkeley,** *Lecturer*

- Thermo-fluid sciences, 1-2 courses per annum. Thermodynamics ME 40, Heat Transfer ME 109.

2011-2018 **California Poly San Luis Obispo, Program in Fire Protection Engineering,** *Instructor*

- Developed and taught Flammability Assessment Methods, Smoke Management and Special Hazards, 2 courses per annum.

2008-2011 **Santa Clara University, Department of Mechanical Engineering,** *Adjunct Professor*

- Graduate and Undergraduate courses in Fluid Mechanics, Thermodynamics, Combustion, Fire Dynamics, and Internal Combustion Engine Technology

2008 – 2011 **University of California, Berkeley** *Doctoral, Post-Doctoral Researcher, Staff Researcher*

- Development of carbon neutral fuels from cellulosic feedstock, Scale model and laser imaging of building smoke flows for innovative ventilation (under floor, natural) systems and validation of FDS models, Combustion testing and modeling to characterize fuels and measure energy efficiency of specially developed stoves for use in developing countries. Developed a forced ignition and flame spread test for polymer materials intended for use in the microgravity conditions of spacecraft.

2007 – 2008 **Arup Fire, San Francisco, CA** *Fire Protection Specialist*

- Worked in conjunction with engineering teams, architects, and approving authorities, to develop integrated fire safety strategies for buildings and transportation systems.

1991 – 1999 **San Francisco Fire Department, San Francisco, CA,** *Paramedic/Rescue Captain*

- Provided 911 emergency services, conducted community disaster training, and implemented federal multi-agency programs to manage causalities of weapons of mass destruction.

Professional Licensure and Certifications

- Paramedic
- Private Instrument Pilot
- Hazardous Materials First Responder Operational

Selected Publications

1. Bar-Ilan, A., Rich, D., Rein, G., & Fernandez-Pello, A.C., "Flow-Assisted Flame Propagation through a Porous Combustible in Microgravity," *Western sec./The Combustion Institute*, San Diego, CA, 2002.
2. Cheng, E.S., Rich, D., Dibble R.W., & Buckholz, B.A., "Quantifying the Contribution of Lubrication Oil to Particulate Emissions from a Diesel Engine," *Journal, Society of Automotive Engineers*, 2003.
3. Lautenberger, C., Stevanovic, A., Rich, D., & Torero, J., "Effect of Material Composition on Ignition Delay of Composites," *Composites 2003*, Anaheim CA, October 2003.
4. Lautenberger, C., Stevanovic, A., Rich, D., Torero, J. & Fernandez-Pello, A.C., "An Experimental and Theoretical Study on the Ignition Delay Time of Composite Materials," *Western States Section/The Combustion Institute*, Los Angeles CA, October 2003.
5. Rich, D., Lautenberger, C., Stevanovic, A., Metha, S., Torero, J., Yuan, Z., Ross, H., Fernandez-Pello, C., "Piloted Ignition of Polypropylene/Glass Composites in a Forced Air Flow," *7th International Workshop on Microgravity Combustion and Chemically Reacting Systems*, Cleveland, OH, 2003.
6. Lautenberger, C., Rich, D., Yuan, Z., & Fernandez-Pello, C., "Modeling Ignition of Solid Combustibles in Normal and Micro Gravity," Work in progress poster presented at the *30th International Symposium on Combustion*. Chicago, IL, 2004.
7. Rich, D., Lautenberger, C., Hernandez, J., & Fernandez-Pello, A.C. "Effect of Environmental Variables on Critical Pyrolysate Mass Flux for Piloted Ignition of PMMA and PP/GL Composite," *Proceedings of the 4th Mediterranean Combustion Symposium*, Lisbon, Portugal, 2005.
8. Rich, D., Lautenberger, C., McAllister, S. & Fernandez-Pello, A.C., "Microgravity Flame Spread Rates Over Samples of Polymer and Polymer/Glass Composites," *Western States Section/The Combustion Institute*, Boise ID, March 2006.
9. Lautenberger, C., McAllister, S., Rich, D., & Fernandez-Pello, C., "Modeling the Effect of Environmental Variables on Opposed-Flow Flame Spread Rates with FDS," *International Congress on Fire Safety in Tall Buildings*, Santander, Spain, October 2006.
10. Rich, D., Lautenberger, C., Torero, J.L., Quintiere, J.G. & Fernandez-Pello, C., "Mass Flux of Combustible Solids at Piloted Ignition," *Proceedings of the Combustion Institute* **31** 2653-2660 (2007).
11. McAllister, S., Rich, D., Lautenberger, C., & Fernandez-Pello, C., "Modeling Microgravity and Normal Gravity Opposed Flame Spread over Polymer/Glass Composites," *45th AIAA Aerospace Sciences Meeting and Exhibit*, Reno, NV, January 2007, AIAA Paper 2007-740.
12. Lautenberger, C., McAllister, S., Rich, D., & Fernandez-Pello, C., "Effect of Environmental Variables on Flame Spread Rates in Microgravity," *45th AIAA Aerospace Sciences Meeting*, Reno, NV, Jan. 2007, AIAA 2007-383.

13. McAllister, S., Rich, D., Lautenberger, C., Fernandez-Pello, C. & Yuan, Z.G., “Modeling Microgravity and Normal Gravity Flame Spread Rates over Samples of Polymer and Polymer/Glass Composites,” *Fifth* International Seminar on Fire and Explosion Hazards, Edinburgh, UK, April 2007.
14. Shaw, Susan D., Blum, A., Weber, R., Kurunthachalam, K., Rich, D., et.al., “Halogenated Flame Retardants: Do the Fire Safety Benefits Justify the Risks?”, *Reviews on Environmental Health,* Volume 25, No. 4 2010.
15. Babrauskas, V., Rich, D., Singla, V., and Blum, A., “Toxic Chemicals and Toxic Money: The Science and Politics of Flammability Standards,” IAFSS Newsletter, August 2012
16. Rich, D., “Effectiveness vs. toxicity of flame retardants, Featured Article for the incoming issue (No. 36)”, International Association of Fire Safety Science Newsletter, No. 36, In Review, January 2014.

Professional Societies (current and former)

- Society of Fire Protection Engineers (SFPE), *Member*
- National Fire Protection Association (NFPA), *Member*
- American Society for Testing and Materials (ASTM), *Member*
- International Association of Fire Safety Scientists (IAFSS), *Member*

Journal Referee / Peer Review (current and former)

- *Fire Safety Journal*
- *Journal of Building and Environment*
- *Fire Technology*
- *Fire Science and Technology*
- *Proceedings of the Combustion Institute*
- *Mediterranean Combustion Symposium*