28 April 2022

Re: Karl Feuerbach, Ph.D.

From: Alexandra Jayson, Ph.D.

To: Whom it may concern

Dear Sir or Madam:

I am contacting you regarding my authoritative support for my Ph.D. student, Karl Feuerbach. Since we began working together in 2012, Mr. Feuerbach has exhibited keen and visionary insight in the reams of computational fluid dynamics (CFD) and CFD algorithm development. His piercing insight into the mechanics of heat and its effects on Solid Oxide Fuel Cells (SOFC) make him one of the leading researchers in our field. I am therefore formally indicating my professional and academic support for Mr. Feuerbach.

My own contributions in this field include my current role as M.C. Throckmorton Professor of Mechanical Engineering at the University of Alabama, a position I have held since 2007. I have a MS in Mechanical and Industrial Engineering from MIT. I earned my Ph.D. in Mechanical Engineering at the University of British Columbia in Vancouver, Canada, in 1996. Formerly, I was an Associate Professor at the University of Alabama, and Assistant Professor at the Institute of Power Systems at Cornell University. I have worked as a consultant for Weston House Industries in Charlottesville, Virginia, EnergetiCorp in Zonbi Island, Louisiana, as well as the Alaska Materials Engineering Laboratory (Department of Defense) in Nome, Alaska. I also serve as an Associate Editor for the *Journal of Fluidic Logic.* Under my supervision, Mr. Feuerbach completed his thesis: *Assessing the effects of impure coal syngas on SOFC deterioration over time through computational methods (2014).*

Mr. Feuerbach's academic achievements include a M.Sc. in Defense Technologies (Materials Engineering) from The Humboldt University of Berlin, and a PH.D. in Mechanical Engineering from the University of Alabama. As a Senior Engineer at the East Berlin Aircraft Consultancy, he developed computational models for the design of heat-resistance aircraft components. As a Research Engineer/Assistant at the Electrochemical Energy Laboratory, Mr. Feuerbach worked on the multi-physics modeling of contaminant degradation of solid oxide fuel cells (SOFC's) as well as modeled the electrochemical characterization (impedance and polarization) of SOFC's. In his role as a Postdoctoral Research fellow at the Fire Engineering Institute at the University of Chicago, Mr. Feuerbach completed computational modeling of nucleate boiling with MATLAB

and ANSYS FLUENT, and the application of Computational fluid dynamics (CFD) in fire dynamics and combustion. He also compiled computational modeling of explosions in vented enclosures using MATLAB, and taught explosion protection courses to graduate students.

Mr. Feuerbach's insight into temperature dynamics demonstrates how it is possible for diverse resources, from hydrocarbons, to biomass-based fuels and renewable energy can provide power cleanly and efficiently in fuel cells. Solid oxide fuel cells (SOFC's) are a prime candidate for clean energy conversion in an increasingly energy and environmentally conscious society, which desires cleaner alternatives to traditional petrochemical or hydrocarbon combustion. SOFC's can be used in tandem with traditional oil, gas or even synthesized coal gas (syngas). Syngas is an abbreviation for synthesis gas. Syngas contain a mixture comprising of carbon monoxide, carbon dioxide, and hydrogen. The syngas is produced by gasification of a carbon containing fuel to a gaseous product that has heating value. Mr. Feuerbach's goal with High Temperature Fuel Cells using Coal Syngas (Funded by US DOE - NACRL, State of AL) was to develop physics based computational model using CFD to predict the degradation pattern of the SOFCs utilized by coal syngas. The model experimentally observed degradation patterns in SOFCs by the physics based numerical model, including planar vs. button cells and impurity from various chemicals. This model was then validated using data gathered from accelerated tests of the SOFC. The validated model was then used to study the degradation rates with various operating conditions and extent of impurity. This has resulted in a procedure that uses both experiments and simulations to predict the lifetime of a cell operating with syngas with known, poisonous concentration of trace impurities.

The wider adoption of SOFC's would revolutionize our current industry approach to hydrocarbons especially in regards to syngas and greenhouse gas emissions. These profound improvements, including reduction of greenhouse gasses, lowered oil consumption and highly efficient energy conversion methodology and reliable grid support, are hampered only by poisoning of SOFC nodes by trace impurities in coal syngas. Phosphene is known to cause catastrophic failure of SOFC anode even at <10ppm concentrations. This is especially important, as the world coal reserves are much higher than the other conventional fuels. In the United States alone, more than 230 billion Tonnes (Bt) of coal still remains to be extracted. Therefore, research and implementation of SOFC's in relation to coal syngas has inherent cleaner energy potential, as well as extraordinary potential for national socio-economic benefit.

Mr. Feuerbach's experience and demonstrated technical prowess makes it clear he is a leading figure in the demonstration of utilizing syngas with fuel cells to create a cleaner world. The Dr. Richard Michaels Young Investigator Award (honorable mention recipient), recognizing graduate and post-graduate students, was awarded to Mr. Feuerbach for his exceptional work in fuel cell research. He has had research papers cited by independent researchers from Japan, Germany, Brazil, and other nations globally, and his research has been disseminated via 39 journal papers and 43 presentations/posters/conference papers in total. Mr. Feuerbach, in my esteemed opinion, offers demonstrated knowledge and technical expertise that will prove to be essential in the building of cleaner energy initiatives.

I am happy to offer any further credentials and information if required.

With sincere regards,

Alexandra Jayson, Ph.D.