15 July 2020

To the Adjudicating Officer:

The United States Department of Energy (DOE) is actively funding research into the development of fuel cells, as they are clean and efficient providers of power and heat. One particularly important fuel cell is the Solid Oxide Fuel Cell (SOFC), which is a highly efficient, fuel flexible, and comparatively low-cost option for clean energy. A primary fuel for an SOFC is coal syngas (synthesized coal gas); however, this fuel can lead to a decreased lifespan for an SOFC due to anode degradation caused by trace impurities in the syngas fuel. Dr. Karl Feuerbach, a researcher in a DOE-funded project alongside myself at the University of Alabama, has collaborated in developing a physics-based mathematical model using computational fluid dynamics (CFD) to predict the patterns of degradation in SOFCs. This model is being implemented by fuel cell designers to help mitigate the problem of anode degradation. Thus, Feuerbach's research has already made a significant contribution to the development of more durable fuel cells. I can attest that his continued research in computational fluid dynamics will lead to better clean energy solutions in the future.

My roles in our research on high temperature syngas-powered fuel cells were that of technical manager and principal investigator. As the adviser to Dr. Feuerbach's PhD dissertation on copper migration degradation and a professor of Mechanical Engineering at the University of Alabama, I feel fully qualified to provide a testament to importance of Dr. Feuerbach's work as a researcher. My credentials in Mechanical Engineering include an MS from MIT and a PhD from the University of British Columbia. I have served as a materials engineering consultant for the Department of Defense and have carried out research in Mechanical Engineering for over 20 years, which has led up to my distinguished work on fuel cells at the University of Alabama.

During our project investigating SOFC degradation, Dr. Feuerbach was a primary researcher in the development of CFD algorithms and computational models. He also worked directly with the state and federal agencies that funded the research, including the DOE and the Alabama State Energy Research Agency (ASERA), to prepare the report deliveries concerning our findings. Since the completion of his PhD and of our project together, I have come to view Dr. Feuerbach as a leading expert in the development of CFD-based models, especially those concerning fuel cells. His credentials are evidence of this expertise. Dr. Feuerbach has a PhD in Mechanical Engineering and an M.Sc. in Defense Technologies. He has applied his wealth of knowledge in his professional roles as an Optical Technologies Consultant in the United Kingdom and as a Senior Engineer for the East Berlin Aircraft Consultancy. Dr. Feuerbach is an exceptional researcher—and moreover, he has shown that his research can be applied in a variety of sectors.

Dr. Feuerbach's work has received significant recognition in the field—as well as in the mainstream press, when the Guardian covered one of his 2017 articles and caught the attention of more than one million readers. Dr. Feuerbach's DOE-backed research at the University of Alabama has resulted in eight peer-reviewed publications, including those in *Journal of Power Sources*, *Combustion Physics*, and *Topics in Electrochemistry*. These publications have been cited internationally (currently, 455 times) in journals such as *Power Sources Journal* and *Journal of Reactor Safety* and his research findings have appeared in 39 journal papers and 43 conferences. Notably, Dr. Feuerbach's model for error estimation was implemented at Tokyo

University to determine CFD uncertainty level. Most recently, scientists from Cal Tech, Chinese Academy of Sciences, and Indiana University-Bloomington used the results of Dr. Feuerbach's model as validation of their study on fuel cell lifespan in *Fuel Cells*.

Dr. Feuerbach's research on copper migration is of extreme importance because it directly responds to a difficult problem in the development of syngas-operated SOFCs. These SOFCs create fuel by oxidizing syngas and consequently operate at high temperatures. In this process, phosphine, an impurity found in syngas, reacts with copper to create compounds which can melt at these high temperatures, causing copper migration to the cell's surface and ultimately altering and damaging the cell. Using computational fluid dynamics, this research resulted in the development of a mathematical model which employs experiments and simulations to predict the copper migration, and thus outline the patterns of degradation to the fuel cell. This model is the first of its kind.

Fuel cell designers are able to create better, more durable SOFCs, thanks to these mathematical models, co-authored by Dr. Feuerbach, which outline the patterns of anode degradation by coal syngas. Research into the use of coal syngas in fuel cells is of particular importance to American national interests. The United States have the largest reserves of coal in the world. The benefits of developing syngas-powered SOFCs are vast; fuel cells have a wide variety of applications and serve as power solutions in all energy sectors, including energy for commercial, residential, industrial, and transportation ventures. Computational models that improve the lifespan of syngas-powered SOFCs ultimately benefit the country's energy security, environmental harm reduction efforts, and national economic interests when it comes to power. Furthermore, SOFCs have a unique market appeal due to their easy maintenance, high reliability, fast recharging, and minimal operating noise. Thus, the potential for growth of the United States' economy through the development of syngas-powered fuel cells is significant.

As I have outlined, Feuerbach's contribution to the development of SOFCs is evidence that his continued research in computational fluid dynamics will benefit the future of clean energy conversion, as well as the greater interests of the United States.

Sincerely,

Dr. Alexandra Jayson