# EXHIBIT B

## CARNEGIE MELLON

**Jay F. Whitacre, Ph.D.**
Trustee Professor in Energy
Director, The Scott Institute for Energy Innovation
Department of Materials Science and Engineering
Department of Engineering and Public Policy
Carnegie Mellon University
Pittsburgh, Pennsylvania 15213-3890

**To:** the Audi CO2 Cy Pres Settlement Fund.

**White Paper Proposal:**

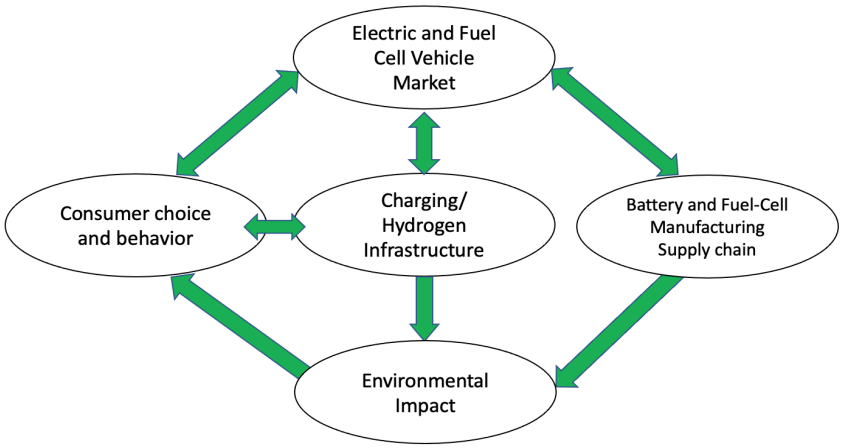
# Generating policy guidance by studying the relationships between vehicle electrification, drivetrain technology, and consumer behavior via a complex multi-attribute optimization model

## Executive Summary

In this work, a team at Carnegie Mellon University will be exploring and modeling the complex interactions that will deeply influence how the transportation sector is decarbonized. Specifically, the interdependence between consumer behavior, battery and fuel-cell vehicle market/supply chains, infrastructure, and the resulting environmental impact (both real and perceived) will be examined and modeled with the intent of generating reliable and actionable policy and technology recommendations. The proposed budget is $1M over three years.

## Project Description

We propose here a project covering 3 related research tasks that will be completed over three years (with cost share from CMU/Scott Institute and collaboration other ongoing work) with $1M in funding that is provided as a Directed Gift to the Scott Institute from the Audi CO2 Cy Pres Settlement Fund. The proposed research will examine the relationships depicted in the figure below.



They include the interactions between (a) consumer behavior, (b) battery and fuel-cell vehicle market/supply chain, and (c) infrastructure (charging and hydrogen stations). Our research will reflect and inform potential developments in the electric and fuel cell vehicle markets and predict the environmental impacts of potential scenarios. Consumer behavior will both be affected by and will determine the nature of the electric and fuel cell vehicle marketplace along with defining the necessary charging/$H_2$ infrastructure. Additionally, consumer behavior is also impacted by perceived and real environmental effects (which are determined by manufacturing/supply chain as well as the electricity/$H_2$ and battery manufacturing infrastructure).

If the industry (including manufacturers, legislators, regulators, capital markets) fail to understand and inform consumers, the technology will underperform its potential. Efficiently matching consumer needs and expectations will require behavioral research that is informed by technical knowledge of current and future options for vehicles and infrastructure, within the constraints of supply chain capabilities, economic realities, and environmental impacts.

Without a doubt, if society is to use non-internal combustion engine-based vehicles to improve the global environment, the complex dynamics between these sectors must be understood and modeled. To this end, our work is divided into three interrelated yet discrete tasks that will last three years:

1) United States consumer behavior & choice for battery and fuel cell-based vehicles and what factors will influence these patterns.

2) Life cycle/environmental impact/materials flow assessment of current and future battery-based and Fuel Cell based electric drive drain components.

3) Infrastructure challenges and opportunities associated with the wide implementation of battery- and fuel-cell powered vehicles.

Each of these tasks will have at least one graduate student working full time along with several principle investigators and a postdoctoral scholar who will oversee the interconnection between the tasks. In the first year of the work, each task will develop a study rubric and set of key metrics that allow for the communication of information between tasks such that the complex feedback loops described above may be studied and optimized.

In the second and third year of the work, a multi-attribute optimization model will be designed and implemented that will allow for the interplay between these tasks to be formalized. The model will produce results showing the relationships between consumer choice, vehicle use, and overall environment impact under a range of scenarios. For example, the impact of critical parameters such as carbon emissions pricing, degree of vehicle subsidization, enhanced infrastructure development, vehicles technical attributes, and key supply chain improvements will be studied individually and in concert to inform a series of deeply resolved policy recommendations that will be publicized in an event at CMU and on Capitol Hill in Washington DC.

**The CMU Team:**

Researchers affiliated with the Scott Institute for Energy Innovation at Carnegie Mellon are working deeply and collaboratively on critical topics related to carbon reduction and the future of transportation. Their work is ripe for an infusion of support for innovative research that is outside (and ahead of) current funding priorities. The Initiative for Decarbonized Transportation Technologies and Policies (IDTTP) at the Scott Institute is a convening nexus for such research. This proposed work will greatly expand this initiative's scope of work and result in a larger and more meaningful impact.

The IDTPP team is truly world class and are highly collaborative. Many have spoken before congress on various transportation related topics and are eager to generate work that can have real impact at a policy level (and are affiliated with the Engineering and Public Policy department at CMU).

*Key researchers who will participate in this work are:*

**Jay Whitacre** has been the Director of the Wilton E. Scott Institute for Energy Innovation since 2017 and is also a professor in the Materials Science & Engineering and Engineering & Public Policy departments. He started his career at the California Institute of Technology and the Jet Propulsion Laboratory, where he studied the fundamental and applied aspects of electrochemically functional materials. He came to CMU in 2007 and focuses his research on the synergistic fields of low carbon energy systems, renewable energy, and energy storage technologies. He developed a novel battery chemistry that was manufactured and sold by Aquion Energy, a company he founded in 2008, serving as CTO, and was acquired in 2017. His current work includes investigating novel materials for energy technologies, using cutting-edge computational techniques to optimize their application, and performing techno-economic assessments of complex energy systems for electric and fuel cell vehicles.

**Jeremy Michalek:** Professor Michalek directs the Vehicle Electrification Group, which studies technology, life cycle economic and environmental implications, consumer behavior, and public policy for electric vehicle technologies and other advanced vehicle technologies, including alternative fuels, ridesharing, and vehicle automation. Professor Michalek has presented policy briefs on Capitol Hill, within the US administration, and in California's state government, and his work has appeared in media outlets such as the New York Times and the Washington Post. For more information, including videos and podcasts: http://www.cmu.edu/me/ddl/jmichalek/

**Baruch Fischoff** holds the Howard Heinz University Professor and a faculty member in the department of Engineering and Public Policy. His work focuses on the intersection between human behavior, risk assessment, and technology. Among many honors, he is a member of the National Academy of Sciences and of the National Academy of Medicine. He is past President of the Society for Judgment and Decision Making and of the Society for Risk Analysis, and recipient of its Distinguished Achievement Award.

**Nicholas Muller:** Nicholas Muller is the Lester and Judith Lave Professor of Economics, Engineering, and Public Policy and works at the intersection of environmental policy and economics. His interdisciplinary research projects focus on estimating individual discount rates and risk preferences using historical pricing data, comparing air pollution and climate damages from electric vehicles to conventional vehicles, estimating air pollution damage from energy production, measuring the impact of transporting freight in the United State on air pollution and climate, and analyzing the inequality in

market and augmented measures of income. He teaches microeconomics and environmental and natural resource economics and has published papers in the *American Economic Review, Science,* and *Proceedings of the National Academies of Science*.

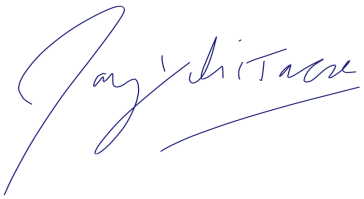
**Valerie Karplus** is an Associate Professor in the department of Engineering and Public Policy. Previously, Karplus served as an Assistant Professor of Global Economics and Management at the MIT Sloan School of Management. Karplus studies resource and environmental management in firms operating in diverse national and industry contexts, with a focus on the role of institutions and management practices in explaining performance. Karplus is an expert on international energy systems, including technology and business model innovation, market dynamics, energy system governance, and the management of air pollution and climate change. She works with a collaborative team of researchers to study the micro and macro determinants of clean energy transitions in emerging markets.

**Granger Morgan** is the Hamerschlag University Professor of Engineering at Carnegie Mellon University. He holds appointments in three academic units: the Department of Engineering and Public Policy; the Department of Electrical and Computer Engineering; and the H. John Heinz III College. His research addresses problems in science, technology and public policy with a particular focus on energy, electric power, environmental systems, climate change, the adoption of new technologies, and risk analysis. Much of his work has involved the development and demonstration of methods to characterize and treat uncertainty in quantitative policy analysis. At Carnegie Mellon, Morgan co-directs (with Jay Apt) the university's Electricity Industry Center.

**Kate Whitefoot is an associate professor** in the department of Engineering and Public Policy and in the department of Mechanical Engineering. Her research bridges engineering design theory and analysis with that of economics to inform the design and manufacture of products and processes for improved adoption in the marketplace. Her research interests include sustainable transportation and manufacturing systems, the influence of innovation and technology policies on engineering design and production, product lifecycle systems optimization, and automation with human-machine teaming.

**Alex Davis** is an Associate Professor in the Department of Engineering and Public Policy at Carnegie Mellon University. His research is at the intersection of behavioral science, technology, and public policy, with diverse applications to health, energy, climate change, the environment, and innovation. Specific recent work focuses on integrating expert judgment with machine learning to solve challenging technical problems, eliciting individual and group preferences, and using risk analysis, communication, and digital health to improve perinatal outcomes for pregnant individuals.

Respectfully,



Jay F. Whitacre, Ph.D.