Project Summary

Title: EFRI-RESIN Proposal, 21st Century National Energy and Transportation Infrastructures: Balancing Sustainability, Costs, and Resiliency (NETSCORE-21)

PI: James McCalley (EE) (The PI, all Co-PIs, and senior personnel are with Iowa State University (ISU))
Co-PIs: Dionysios Aliprantis (EE), Konstantina Gkritza (CE), Arun Somani (CprE), Lizhi Wang (IE)
Senior Personnel: Robert Brown (ME)

Summary: Most US energy usage is for electricity production and vehicle transportation, two interdependent infrastructures. The strength and number of these interdependencies will increase rapidly as hybrid electric transportation systems, including plug-in hybrid electric vehicles and hybrid electric trains, become more prominent. There are several new energy supply technologies reaching maturity, accelerated by public concern over global warming. DOE-EIA [1] suggests that national expenditures on electric energy and transportation fuels over the next 20 years will exceed $14 trillion, 6 times the 2008 federal budget [2]. Intentional and strategic energy system design at the national level will have very large economic impact. The proposed work is motivated by a recognition that tools, knowledge, and perspective are lacking to design a national system integrating energy and transportation infrastructures while accounting for interdependencies between them, new energy supply technologies, sustainability, and resiliency. Our goal is to identify optimal infrastructure designs in terms of future power generation technologies, energy transport and storage, and hybrid-electric transportation systems, with balance in sustainability, costs, and resiliency. We will characterize interdependencies between energy resource portfolio and energy/vehicular transportation systems. The project is uniquely suitable to EFRI-RESIN as it targets two critical national infrastructures with a transformative vision and an extremely strong and balanced research team of broad multidisciplinary skills and excellent track records.

Intellectual Merit: The national energy system and the national transportation system targeted in this research are uniquely large, geographically expansive, and capital intensive, consisting of multiple, diverse technologies interfaced with complex human organizations that manage them. The intellectual effort to model and characterize these systems and understand interdependencies between resource mix and wind, transportation patterns, and right-of-way; between gasification, carbon, and transportation; and between prices of petroleum, natural gas, and electricity, will join power system engineering, thermal design, power electronics, transportation engineering, communications and computing, environmental science, sociology, operations research, and macroeconomics. The underlying need is *systems-based*: identify the extent to which each technology should be deployed, when, and where, accounting for interdependencies while optimizing for sustainability, cost, and resiliency. The proposed work will have long-term impact on national economy and security, while revolutionizing engineering science via integrating knowledge of economics, sociology, and human behavior with systems engineering, interlaced with the full spectrum of energy technologies. We expect this project to transform engineering educational programs, creating a new breed of energy engineer having a multidisciplinary array of skills necessary for supporting the nation's 21st century needs.

Broader Impacts: The proposed research effort promises to address a national grand challenge: identify the nation's energy resource portfolio for the next 40 years, for optimal sustainability, cost, and resiliency. Successful achievement of this has potential for long-term impact at the trillion dollar level. The project will also stimulate cooperation between a large and diverse educational coalition, consisting of 6 faculty, 7 PhD students, 48 undergraduates, 4 McNair scholars (underrepresented students), several instructors and students from Iowa Lakes Community College, and 2 high-school teachers. We intend to reach out to social scientists to stimulate research and educational activities of this coalition, and there exist established ties to faculty in economics and in sociology to facilitate such efforts. Work will be widely disseminated through the usual forums (journals, conferences, website, courses, and seminars). In addition, the investigators either lead or have extremely close ties to six different organizations that will directly support and be supported by this work, including the ISU Information Infrastructure Institute (directed by Somani) [3], the ISU Office of Biorenewables Programs [4] and the ISU Center for Sustainable Environmental Technologies [5] (both directed by Brown), the Power Systems Engineering Research Center (McCalley is ISU Site Director) [6], the ISU Electric Power Research Center [7], and the ISU Center for Transportation Research and Education [8].