

ERC for Advancing Sustainability through Powered Infrastructure for Roadway Electrification (ASPIRE)

Utah State University (lead institution)

Mission: To improve health and quality of life by catalyzing sustainable and equitable electrification in transportation



A National Science
Foundation Engineering
Research Center
since 2020



Partner Institutions:

- *Purdue University*
- *University of Colorado*
- *University of Texas at El Paso*

Center Rationale

The ASPIRE center has been launched at a critical moment in U.S. history. Vehicles drive our national economy. In the U.S. alone, they transport more than 11 billion tons of freight and travel over 3 trillion miles per year. However, vehicle emissions have serious impacts on public health and the environment, and fluctuating oil prices affect household budgets as well as our national economic stability and security. Electric vehicles (EVs) offer tremendous opportunity to both reduce emissions and stabilize and reduce costs. But significant challenges remain in the pursuit of widespread adoption of EVs; these challenges are centered around range and the supporting charging infrastructure. At the same time, nationwide, both the transportation and electric utility infrastructure need extensive renovation, and major investments are expected in the near future (billions of dollars in the near term to hundreds of billions over the next 30 years). Now is the time to rethink these industries and set in motion plans to build for a future designed for widespread electrification, rather than rebuild the past.

The NSF ASPIRE ERC is the first of its kind in the world to take a holistic approach to eliminating range and charging as barriers for electrifying all vehicle classes, from passenger cars to heavy duty trucks. Our approach is to pursue innovative wireless and plug-in charging and infrastructure technology solutions that

bring the power to the vehicles—where they drive and park. The result will be smaller and longer-lasting batteries on vehicles, effectively unlimited EV range, and a seamless charging experience. EV users will no longer be concerned with when, where, or how they will charge, and EVs will be less expensive to purchase and operate than their gasoline and diesel counterparts. EVs will become a resource to decarbonize the electric grid and a perfect match with autonomous and connected vehicles.

The mission of the NSF ASPIRE ERC is to improve health and quality of life by catalyzing sustainable and equitable electrification in transportation. The ASPIRE vision is that of widespread electrification of all vehicle classes with shared charging infrastructure, leading to equitable reductions in greenhouse gas (GHG) emissions, improved air quality, reduced cost to move people and goods, and increased domestic job growth. The ASPIRE team and its influence will be central to infusing new technology and preparing for a future of autonomous and electric fleets as we invest as a nation to rebuild our aging roads and electric utility infrastructure.

At the heart of ASPIRE is a foundational focus on students, community, and society. The ASPIRE team will serve as a trusted guide for society on the EV transformation and as a champion for inclusive pathways from varied aspects of life into a diverse engineering workforce specially trained to support the ensuing

cross-industry transformations. The ASPIRE education programs will result in technology advances, methods, and tools, as well as a library of educational content at every level of education.

RESEARCH

The Long-Term Impact Goals for ASPIRE are aligned with its vision and are listed below with numerical targets by 2050 (20 years after graduation of ASPIRE from NSF ERC funding) to indicate the scale and scope of the undertaking at hand.

- Widespread electrification of all vehicle classes.
 - **Target: 70% of energy used in transportation is electric by 2050**
- Reduced GHG emissions and air pollutants from the transportation and electric utility industries, leading to climate sustainability and improved air quality, health, and quality of life.
 - **Target: 60% reduction in total annual GHG emissions and urban air pollution emissions from transportation**
- Reduced cost to move people and goods, leading to economic growth and improved prosperity.
 - **Target: 35% reduction in total average cost to move people and goods in the US**
- Domestic job growth in transportation and electric utility industries in engineering, research, manufacturing, construction, and renewable energy production from widespread transportation electrification and its associated charging infrastructure, leading to economic growth and prosperity.
 - **Target: creation of 5 million jobs and retooling of more than 10 million jobs through transformations in oil and gas, transportation, electric utilities, and construction**
- Diversity of participation in transformed electric utility and transportation industries and equity in economic and health benefits of transportation electrification, leading to increased productivity, better industry and policy decision making, greater societal buy-in of policies and systems, and sustainability of economic growth and prosperity.
 - **Target: diversity to reflect the populations they serve for more than 15 million jobs in the transformed industries that support electrified transportation**

Impacts at this scale will necessarily require solutions that address needs across all vehicle classes, user groups (e.g., private, shared, fleet), and regions (urban, interstate, aspects of rural). They will require electrification at ports (e.g., shipping ports, airports) and even portions of air and rail travel. They will require significant decarbonization of the electric grid and careful consideration of the environmental impact of batteries.

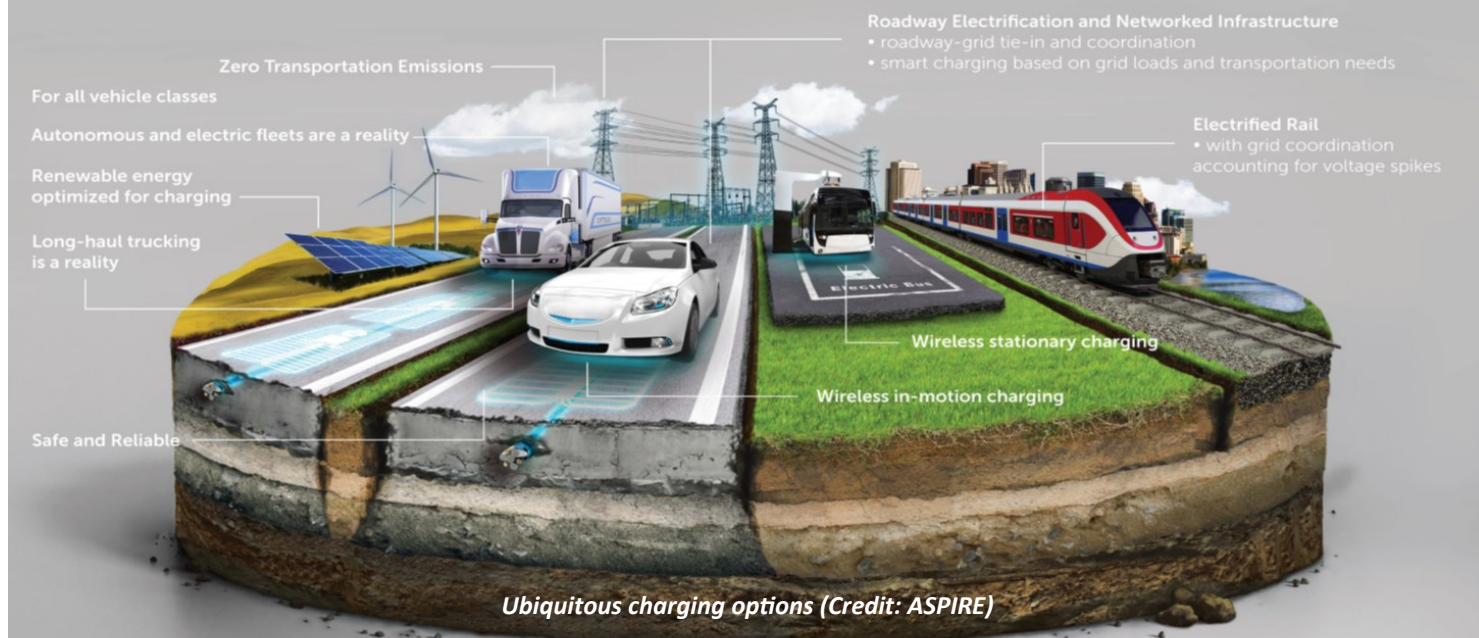
ASPIRE's 10-year goal is to reach the societal tipping point by 2030 at which the primary barriers are addressed, and sufficient momentum and funding are present to carry the transformation forward post-NSF ERC funding. This will require coordinated and strategic efforts across ASPIRE's Research, Engineering Workforce Development, Diversity and Culture of Inclusion, and Innovation foundational elements along with projects in all three areas of technology, workforce, and market development.

In addressing these challenges, ASPIRE's strategic technology focus is to target new, innovative solutions from a system-of-systems perspective to change the game on vehicle electrification—rethinking the boundaries and interactions among the electric grid, charging infrastructure, vehicles and users, and the roadway pavements they operate on. This is accomplished through seamless integration of wireless and wired charging solutions and co-optimized grid and vehicle networks that bring power to where vehicles operate, both parked and in-motion. The proposed advancements center around the themes of minimizing vehicle battery size and degradation, minimizing peak loading on the grid, and maximizing utility and charging infrastructure utilization.

While there are many important and interesting topics that can be addressed, we must commit our efforts within ASPIRE to those that will not be accomplished without the ERC. These are at the intersection and overlap between and among the ASPIRE research thrusts of transportation, adoption, power, and data.

All ASPIRE projects are required to include multiple research thrusts and to engage in fundamental research leading to deep integration across disciplines and convergence—charting new territory for system-of-systems thinking in the transformed transportation and electric utility industries.

Charging So Seamless You Won't Know You're Using It



Strategic team formation is being applied at all levels in ASPIRE to support convergence, starting at task-level leads within projects. The very structure of the projects and their oversight were developed with specific individuals, personalities, and expertise in mind among the ASPIRE researchers. It is critical that we as a center avoid isolated pockets of research, and instead lean on each other for new insights and lines of thinking. The project teams are organized to support diversity and professional growth and to catalyze open-minded, out-of-the-box thinking across disciplines. The cross-discipline projects have been grouped together as “umbrella projects” to make it easier to involve our industry and innovation partners. The umbrella projects are:

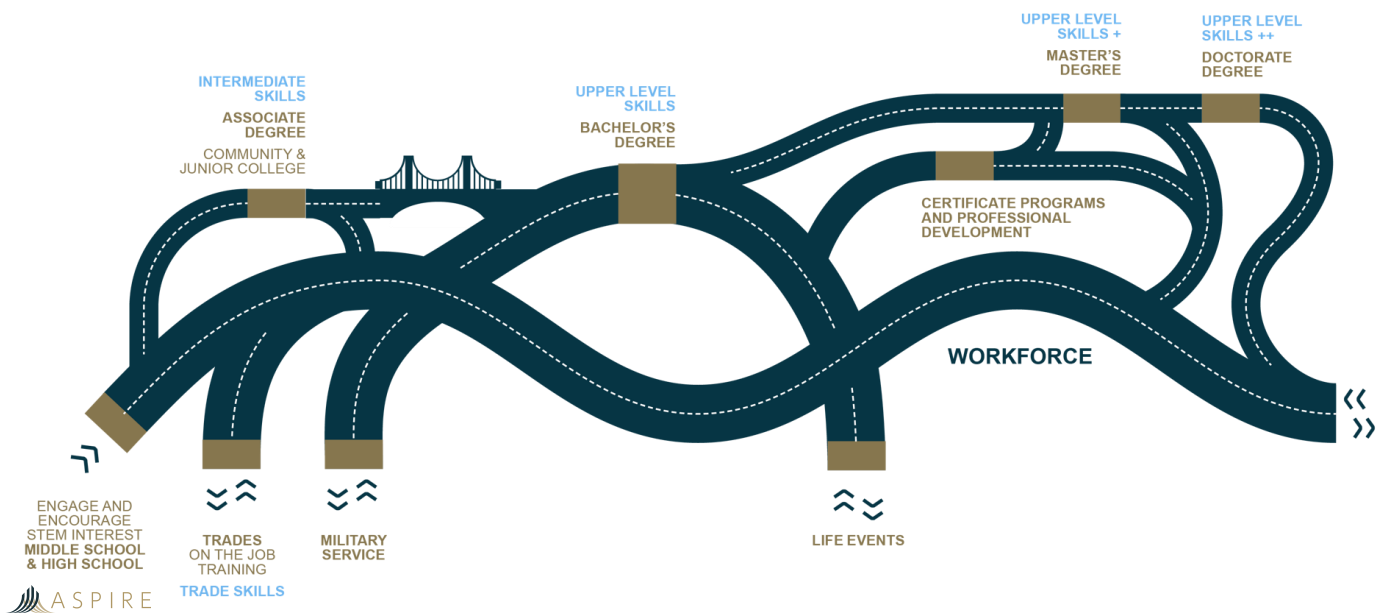
- Extreme Fast Charging
- Pavement Integrated Wireless Charging
- Smart and Secure Charge Management
- System-of-Systems Integration
- Market & Workforce Development.

EDUCATION

ASPIRE takes a comprehensive, research-based, inclusive approach to workforce development with the aim to support our envisioned cross-industry transformations, national-scale electric and transportation infrastructure projects, and significant domestic job growth. Our goal is to prepare the workforce and communities of the future to understand, operate within,

and design for sustainable electric infrastructure, integrating technical, professional, and social analytic capacities. We see opportunities for engagement, training, and retooling across the industries, from trades and community colleges, to undergraduate and graduate education, to ongoing professional development.

Our approach is informed by formal engineering education research, and our strategy to achieving our goals entails (1) building durable infrastructure pathways of inclusive structural and cultural support for diverse learners’ success; (2) developing an engineering curriculum that addresses key competencies in system-of-systems thinking by integrating technical knowledge, professional skills, and social context for sustainability, mobility, and equitably accessible infrastructure; and (3) deploying research-proven participatory learning strategies, from primary through undergraduate and graduate education, to the technical and professional workforce, and in informal settings for all ages. The ASPIRE programs will result in broad public dissemination of technology advances, methods, and tools, and a vast library of vetted precollege, undergraduate, graduate, professional, and community educational content.



Workforce Development Pathways and Roadways (Credit: ASPIRE)

DIVERSITY AND CULTURE OF INCLUSION

At the very heart of ASPIRE is our dedication to our people and our communities. The ultimate measure of success for our center is the success of its people. Achieving our goals requires careful and conscious attention to diversity and inclusion. A driving theme for ASPIRE is creating research, educational, workplace, and societal environments in which all can thrive and achieve their human potential. Understanding, valuing, and ensuring diversity and inclusion will be woven into the fabric of ASPIRE; the very identity of our team is shaped by this commitment. Our workforce development and inclusion leadership has been formed as one unified team across the core campuses who will take an integrated, intentional, and research-based approach. Our strategy creates inclusive pathways to success for diverse individuals and builds infrastructure to ensure opportunities for all. Our approach focuses on programs to: (1) Engage the Team, (2) Engage the Educators, (3) Engage the Students, (4) Engage the Community, and (5) Engage the Professionals. All research projects in ASPIRE include immersive workforce development and inclusion components that are reviewed and evaluated annually.

INNOVATION ECOSYSTEM

The ASPIRE Innovation Ecosystem (IE) strengthens engagement across the center with partners from the broad stakeholder community. The result is an accelerated and integrated approach to developing and transitioning technologies to the marketplace, while providing an inclusive and immersive experience for participants in the innovation process. Members of our Industry and Innovation Board (IIB) may participate in a wide range of activities, including: Research Partner projects and Public-Private-Partnership (P3) pilots, team engagement on policy and marketplace insights, internship and exchange opportunities, workforce and inclusion technical and professional development activities, and spurring entrepreneurial activity.

Our committed industry base has a combined annual revenue of over \$700 billion and our state and roadway innovation partners manage over 750,000 lane-miles of roads and multiple urban regions. We have the stakeholder base necessary to advance the ASPIRE vision. With the ASPIRE ERC, we now have the research enterprise necessary to drive convergence across these industries and bring society to the tipping point of transformations in the automotive, transportation, and electric grid industries.

Our Innovation programs include monthly brown bag webinars that highlight research and education updates and stakeholder partnerships; quarterly Thought Leadership workshops to discuss and address timely topics; a biannual international Conference on Electric Roads and Vehicles (CERV) (a conference successfully launched and hosted by Utah State University with the sixth biannual conference in 2020); industry ties to our student cohort programs and student internships; and the ASPIRE Annual Meeting program review, technology demonstrations, and student innovation pitch sessions.

FACILITIES

ASPIRE is headquartered at Utah State University and operated through strategic partnerships with core partners Purdue University, University of Colorado Boulder, The University of Texas at El Paso, and the University of Auckland New Zealand. Additional affiliated partners include Colorado State University, University of Colorado—Colorado Springs, Virginia Tech, and Cornell University. Key strategic partnerships exist with four national labs: Idaho National Laboratory, National Renewable Energy Laboratory, Oak Ridge National Laboratory, and Argonne National Laboratory.

Across the five core campuses there are 23 lab facilities and resources. These include:

Utah State University: Electric Vehicle and Roadway Research Facility, Systems Materials and Structural Health Lab, Battery Limits and Survivability Test Lab



Electric Vehicle and Roadway (EVR) Research Facility at Utah State University

Purdue University: Grainger Power Magnetics Fabrication Lab, Fauber Asphalt Research Lab, Accelerated Pavement Testing Facility, Concrete Materials Lab, Energy Conversion/Microgrid Lab, Alternative Energy Grid Integration and Systems Lab, EV Systems Lab, Transportation Lab, Purdue Policy Research Institute

University of Colorado Boulder: System-level Simulation and Visualization Platform, Colorado Power Electronics Lab, Massive Data Systems Lab, Teach Engineering Program

University of Texas El Paso: Materials Testing Lab, Power and Renewable Energy Systems Lab, Intelligent Systems Engineering Lab, Concrete Testing/Hot Mix Asphalt Lab

University of Auckland: Wireless Power Transfer Lab, Center for Advanced Composite Materials and Engineering Materials Lab, Thermal Characterization Lab.

The ASPIRE Center Director is supported by full-time staff roles of: Managing Director, Administrative Director, Program Director, and Innovation Director. Additional leadership roles are: Campus Directors at each of the five core campuses, three Innovation Ecosystem Directors, two Engineering Workforce Development Directors, a Pre-college Director, and two Diversity and Culture of Inclusion Directors. Co-directors were chosen for each area to bring in a diversity of ideas and opinions and to distribute the workload to reduce burnout.

CENTER CONFIGURATION, LEADERSHIP, TEAM STRUCTURE

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CENTER HEADQUARTERS

ERC for Advancing Sustainability through Powered
Infrastructure for Roadway Electrification (ASPIRE)

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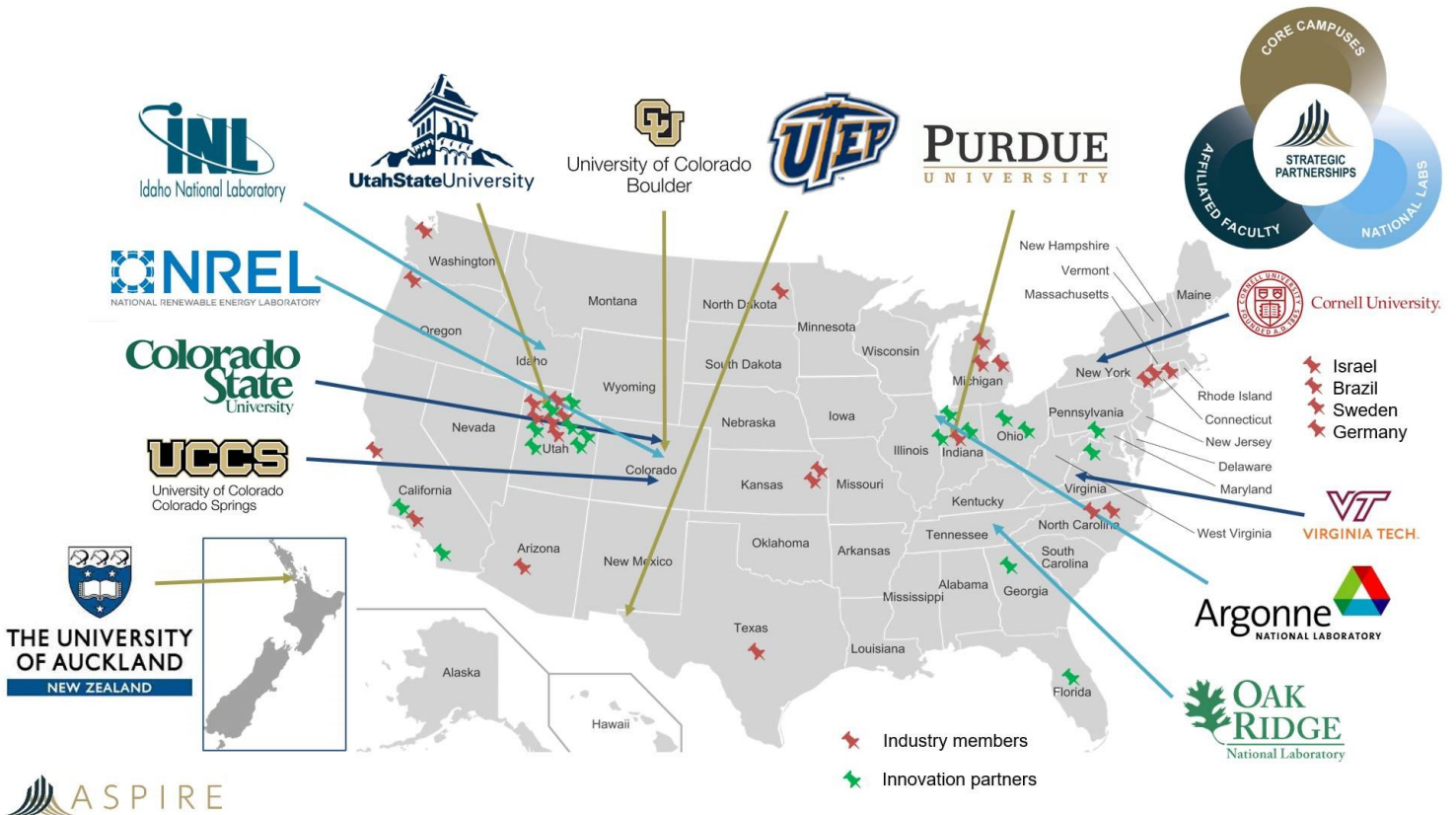
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(Credit: ASPIRE)

